412TW-PA-19221

Preliminary Reports of the X-24B Flight Records (Flights 1-9)

AF/NASA X-24B Project Team

AIR FORCE TEST CENTER
EDWARDS AFB, CA

20 Mar 69-13 Jan 70

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EDWARDS AIR FORCE BASE, CALIFORNIA
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X-24B Flts B-1-3- B-8-15
Flt B-3-5 Is Missing

PRELIMINARY RESULTS OF X-24B

FLIGHT B-1-3

1 AUGUST 1973

BY

AF/NASA X-24B PROJECT TEAM

X-24B Flight Request
28 June 1973

Flight No: B-1-~~2~~ 3

Scheduled Date: ~~20 July~~ 1 AUG 1973

Pilot: John Manke

Purpose:
1. First Flight Checkout.
2. Longitudinal Trim Curve Verification.
3. Lift and Drag Determination
4. Stability and Control Data

Launch: South Rogers Lakebed, Mag Heading 360° + Crosswind Correction Angle. 40,000 feet, 175 KIAS. Flap Bias "Manual", Upper Flaps = -20°, Lower Flaps = 10°, Rudder Bias "Manual", Rudder Bias = -10° (toe in). Aileron Bias = 7°, Aileron Bias Circuit Breakers Pulled. SAS Gains 4,3,2. Mach Repeater "Manual" = 1.0, KRA "AUTO".

Landing: Rogers Lakebed Runway 18

B-52 Track: See Attached Map

ITEM	TIME	ALT	A/S	α	Mn	EVENT
1	0	40	175	5	.60	Launch, Trim to 10°α
2	9	39	175	10	.59	Perform Roll Maneuver (±30°ϕ max)
3	25	36	210	10	.65	Perform Rudder and Aileron Doublets
4	34	34	220	10	.66	Perform Pitch Pulse
5	42	32	230	10	.66	Trim to 8°α, Evaluate Roll Control

ITEM	TIME	ALT	A/S	α	Mn	EVENT
6	55	30	240	8	.65	Trim to 5°α for Practice Approach, Set Mach Repeater to .3, Evaluate Roll Control
7	67	27	270	5	.68	Perform Practice Flare to 10°α, Evaluate Roll Control
8	86	24	235	10	.58	Level, Trim to 8°α, Set Mach Repeater to 1.0
9	95	24	205	8	.50	Perform Pushover-Pullup (2° to 15° to 8°α)
10	111	22	210	8	.50	Landing Rocket Check, Reset Upper Flap as Per NASA 1, if necessary
11	136	20	230	8	.50	Low Key, Start Left Turn
12	181	10	270	9	.50	Pushover to ≈6°α to Accelerate to 300 Kts. Mach Repeater to .3.
13	218	3.3	300	6	.48	Start Flare α ≈ 10°
14	229	2.4	250	7	.42	Level, Gear Down Below 240 Kts
15	240	2.3	190	11	.3	Touchdown

NOTES:

1. Nose Ballast = 160 lbs

	X-24B	Weight	cg
2.	Launch	8154 lbs	65%
	Landing (with H_2O_2)	8154 lbs	65%
	Landing (w/o H_2O_2)	7957 lbs	64.6%
3.	Pylon Adapter	5020 lbs	

GROUND RULES FOR NO LAUNCH

1. Angle of Attack Malfunction
2. Any Control System Malfunction
3. Any Landing Rocket Malfunction
4. Turbulence Below 10K in Excess of Light
5. Surface Winds 5 Kts Crosswind/10 Kts Max

ALTERNATE SITUATION BEFORE LAUNCH

For inadvertent gear extension while mated the X-24B will be launched at an alternate launch point for landing on Runway 18.

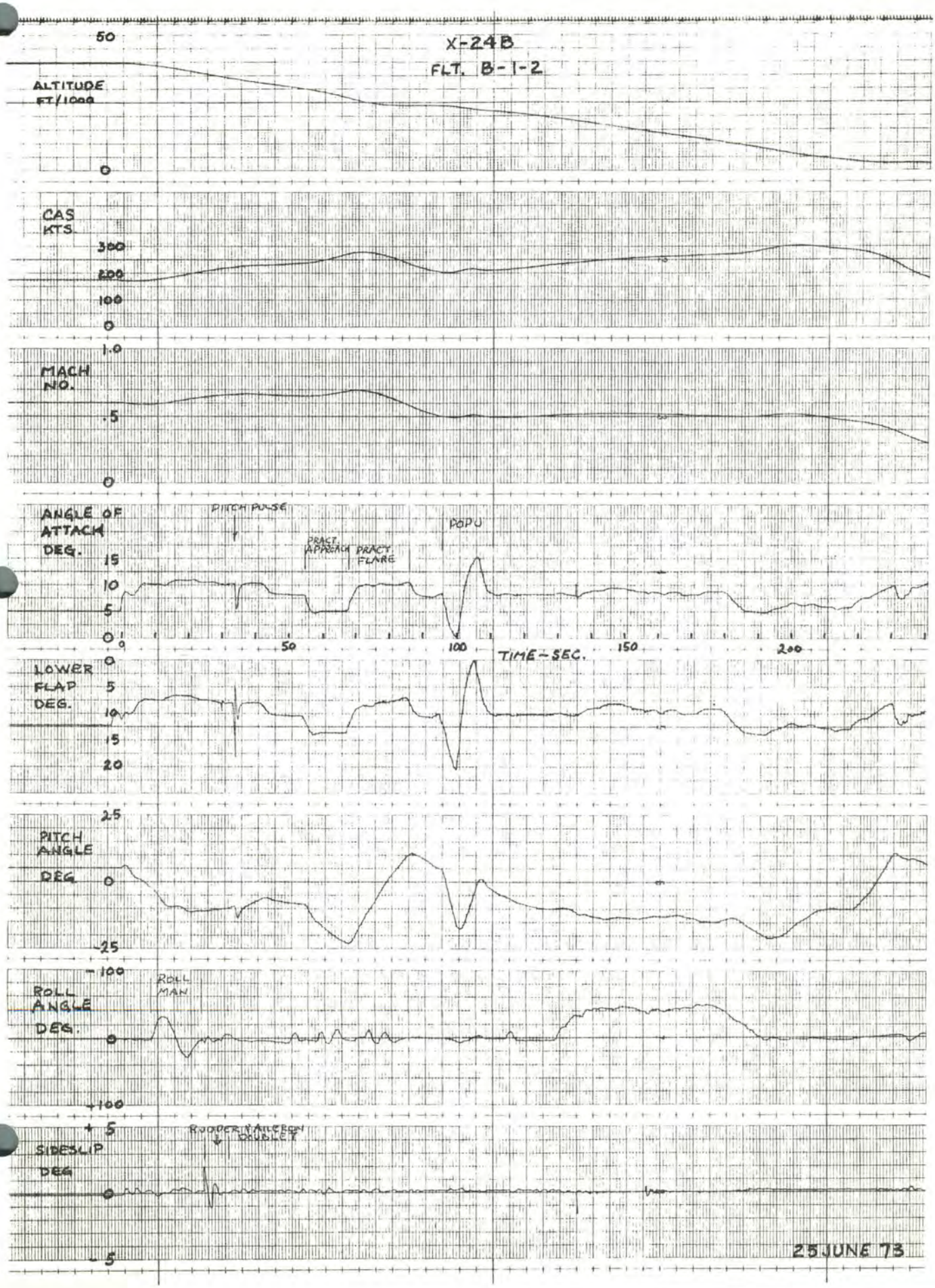
ALTERNATE SITUATIONS AFTER LAUNCH

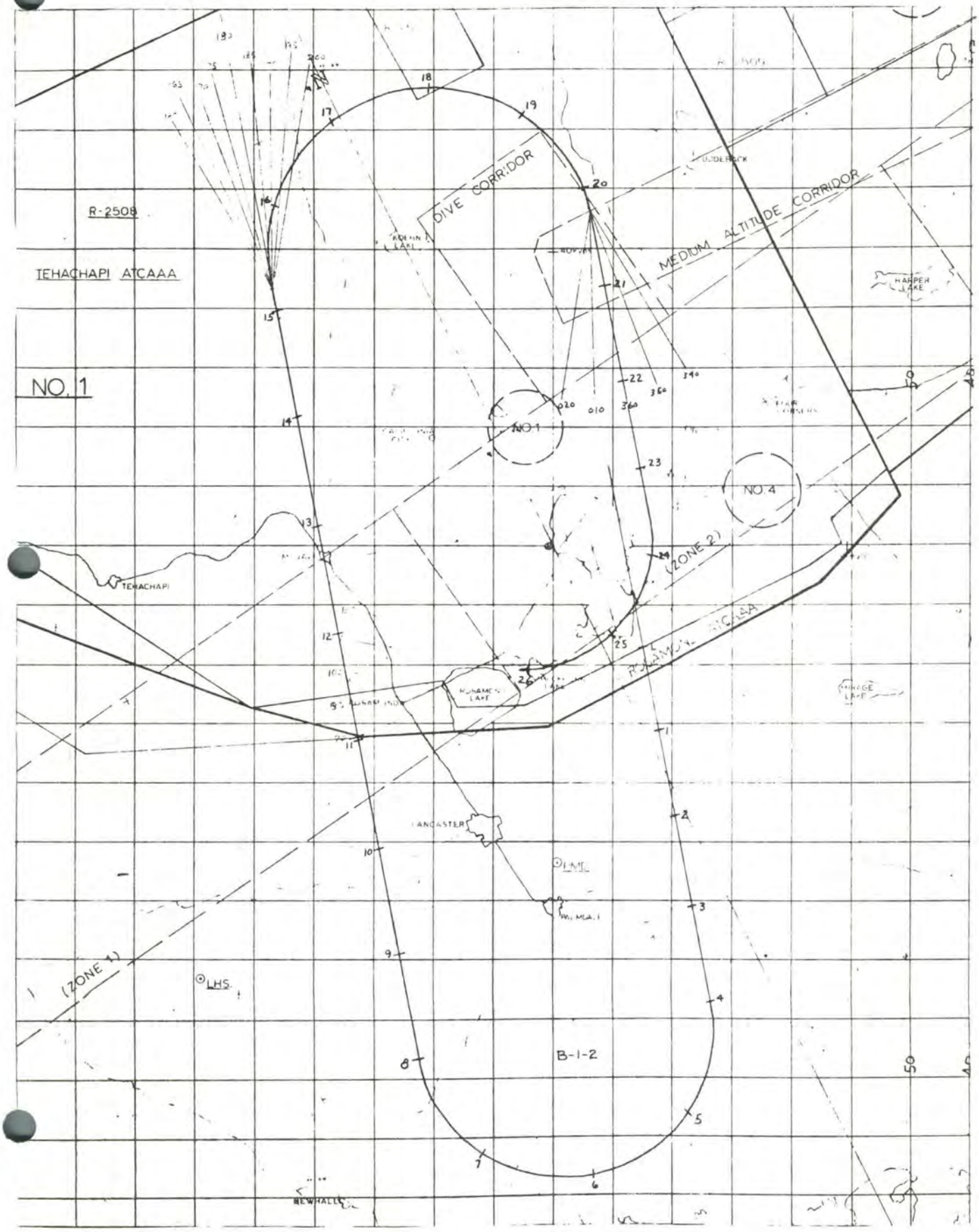
	Failure	Action
1.	Radio, Radar, PCM	Proceed as planned
2.	Airspeed, Altitude	Proceed as planned using α for primary control. Use $7°\alpha$ instead of $5°\alpha$ for practice approach to insure that Mach number will not exceed .7. Altitude calls from NASA 1. Airspeed and altitude calls from chase.

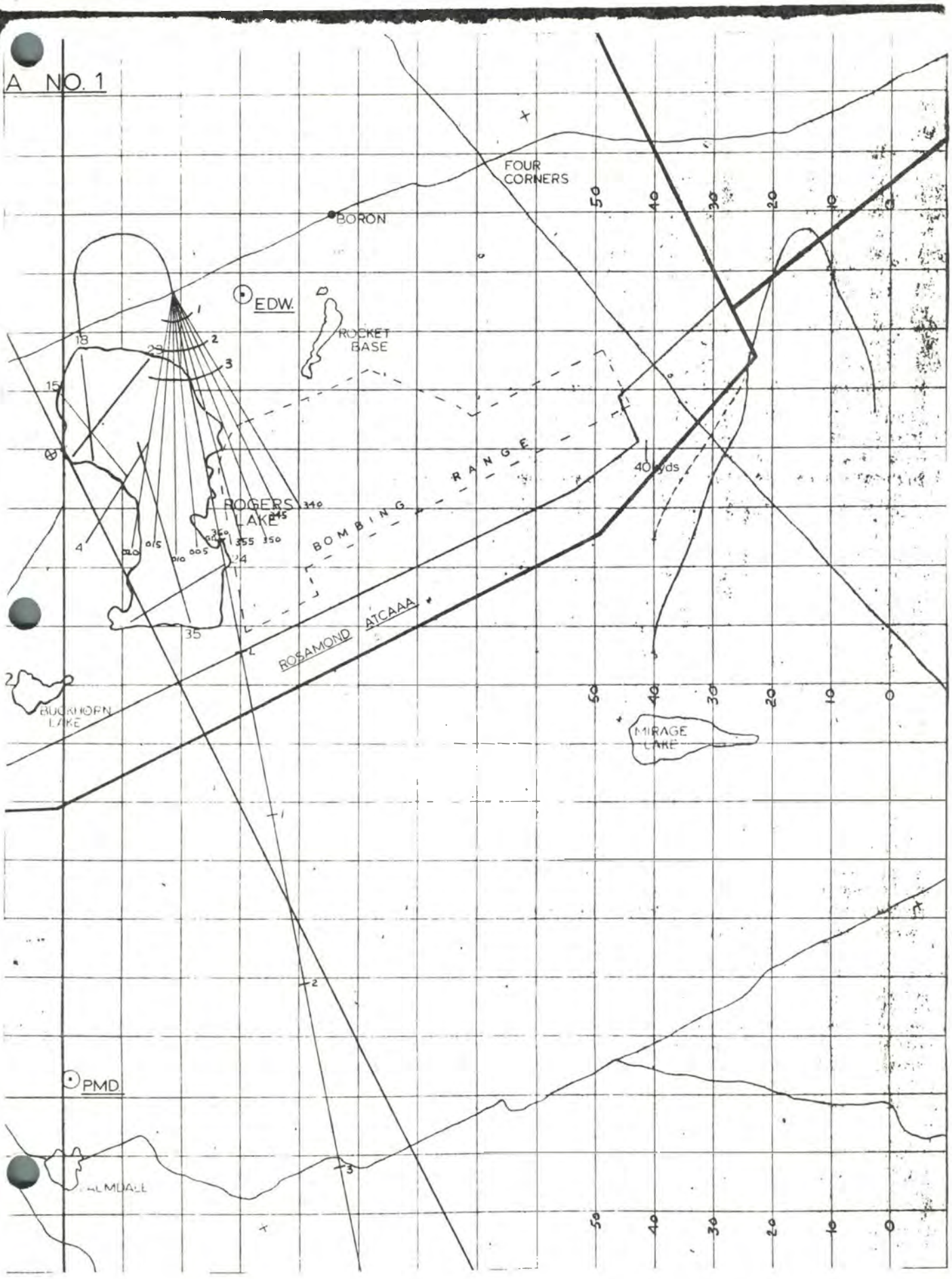
	Failure	Action
3.	Attitude System	Proceed as planned using backup attitude indicator and/or outside reference.
4.	Primary Angle of Attack Indicator Failure	KRA to "Manual" 10%, stick shaker "Off", proceed as planned using backup α indicator on ADI.
5.	Total Angle of Attack Failure	KRA to "Manual" 10%, stick shaker "Off". Fly 220 KIAS instead of α, proceed as planned except do not perform pushover-pullup.
6.	KRA "Auto" Failure	KRA to "Manual" 10%.
7.	Pitch Damper Failure	Proceed as planned limiting pushover-pullup to 12°α.
8.	Roll Damper Failure	Proceed as planned.
9.	Yaw Damper Failure	Proceed as planned setting Mach repeater to .3.
10.	All Axis Damper Failure	Mach repeater to .3, limit pushover-pullup to 12°α, pulses at pilot's discretion.
11.	Limit Cycle	Reduce gain setting in steps to 1, if limit cycle still excessive--turn damper off.

Robert G. Hoey
ROBERT G. HOEY

Jack L Kolf
JACK L. KOLF


X-24B
FLT. B-1-2
ALTITUDE FT/1000
50
0
CAS KTS.
300
200
100
0
MACH NO.
1.0
.5
0
ANGLE OF ATTACK DEG.
PITCH PULSE
PRACT APPROACH
PRACT FLARE
POPU
15
10
5
0
0
50
100
150
200
TIME-SEC.
LOWER FLAP DEG.
0
5
10
15
20
25
PITCH ANGLE DEG
0
-25
-100
ROLL ANGLE DEG.
ROLL MAN
0
+100
+5
SIDESLIP DEG
RUDDER/AILERON DOUBLET
0
-5
25 JUNE 73


R-2508
TEHACHAPI ATCAAA
NO. 1
DIVE CORRIDOR
MEDIUM ALTITUDE CORRIDOR
NO. 1
NO. 4
(ZONE 2)
(ZONE 1)
TEHACHAPI
LANCASTER
LHS
B-1-2


A NO. 1
FOUR CORNERS
BORON
EDW.
ROCKET BASE
ROGERS LAKE
BOMBING RANGE
ROSAMOND
ATCAAA
BUCKHORN LAKE
MIRAGE LAKE
PMD
40 yds

X-24B #551

FLIGHT: B-1-3 DATE: 8/1/73

PILOT: J. Manke L/P: V. Horton

NASA 1: B. Dana

24 Minutes to Launch

John: Okay Bill, SAS gains are 4, 3, 2. Are you ready for a calibrate? There's the calibrate.
NASA 1: Okay we saw the calibrate, John.
John: Cabin pressure altitude is about 16,000, X-24 air is still 29, pylon air is 600.
NASA 1: Roger, John.
John: 2 & 4 Hydraulics coming on. Okay, the pressures are about 31, lites are out.
NASA 1: Roger, John.
John: SAS Modes are on, got all circuit breakers in except brake and vehicle release.
NASA 1: Roger, John.
What kind of altitude are you reading right now, Dale?
B-52: 30,300.
NASA 1: Roger.

23 Minutes to Launch

John: Okay Mach repeater coming auto. α is reading 2°, A/S is 230, Ind Mach is .64 or .62, Mach repeater says about .65.
NASA 1: Roger, John.
John: And I guess there's no reason why we can't start into the controls check.
NASA 1: We're ready for controls check John.
John: Okay, Rudder mode switch coming auto. Mach repeater manual, set 1.1, KRA mode switch is manual. Here comes emergency flap 20, looks like 25.
NASA 1: Looks good John.
John: Okay they come all the way open.
NASA 1: 008 start a shallow left turn, I guess about 10° bank angle.
B-52: All right.
John: There's 32°, coming closed. Rudder mode switch in Manual, rudder bias toe out-then back in again, then to auto, and then its back in. Aileron bias switch going to backup, there's aileron bias: 5, 9, then normal, then to 7. The aileron bias is at 7 and how does that look for trim?
NASA 1: Looks good John.
John: Okay the aileron bias circuit breakers coming out.
NASA 1: Roger.
John: There's forward stick.
Chase: That looks good.
John: There's forward trim. Aft.

John: That should be about 10. Then some aileron. Left, right, then set to zero. Here comes our rudder.
Chase: Left rudder.
John: Then some yaw trim, and left, and center. KRA going to 50%. Are you still with me Bill?
NASA 1: Yeah, we're still here John.
John: Okay, here comes right stick. Right rudder, left, looks good.
NASA 1: Roger, and 008 tighten the turn a little.
B-52: 008.
John: Stick shaker test, and it works good.
NASA 1: Roger, John.
John: Stick shaker switches on....KRA going to zero, side stick, left. KRA going to emergency, right and left stick, no rudder. KRA going to 50, right and left and I get rudder. Back in auto and do you have any idea what the beeping is coming from on this frequency, Bill?
NASA 1: Yeah John, its on guard. If you want to go to.... Sorry its on primary now, John. We have no idea what it is.
John: Okay. KRA is auto, mach repeater is 1.1. Flap mode switch is manual, rudder mode switch going manual. Here comes the toe out, and toe in. Okay SAS servos going to auto.
NASA 1: Roger John.
John: Gains are 5-5-5 and here comes the old SMRD.
NASA 1: 008 roll out heading 185.
B-52: 008, Roger.
John: No lites, here comes the torque. No lites. Ones are off, and torque. 3 amber. Twos are off and a torque. 3 reds. Okay the servos are going back to auto and the lites are reset.
NASA 1: 008, roll out now.
B-52: 008, heading 187.
NASA 1: Roger.
John: Okay SAS is at 4,3, 2. Torque. No lites. SAS mode switches are on. Okay and I'll wait here for 14 minutes.
NASA 1: Okay John we're at about 15 and a half now.
John: Okay.
NASA 1: 008 come 10° right.
B-52: 10 right.
John: You maybe ought to make a weather determination before five minutes, Willie.
NASA 1: We'll do it John. We've got Chase 1a and he'll go have a look at it.
817: John and NASA 1, the turbulence is no problem only at most light from 2000 down to 1000 above the ground.
John: Okay, thanks a bunch, Fitz.
NASA 1: NASA 1 copy Fitz.
817: 10,000 down.
John: Okay, good.
NASA 1: Dale, we'd like to hear what your heading is.
B-52: Our heading is 195.
NASA 1: Thank you sir.

NASA 1: Okay, John Manke, 14 minutes to launch.

14 Minutes to Launch

John: Okay Bill, I'll swap hydraulics. Okay, 1 and 3 on, pressures are 27, the lites are out. I'm ready for pitch and yaw pulse, Dale.
B-52: Okay. Comes your pitch pulse now.
NASA 1: Good pitch pulse.
B-52: Here comes your yaw pulse.
NASA 1: Good yaw pulse.
John: Okay Bill if you're going to be on this heading a while I'll go to erect.
NASA 1: Stand by one, John. 008, come 5° left.
B-52: Roger.
NASA 1: When it gets level John, you can pick up item 14.
John: Okay, Bill
NASA 1: And Mr. Scherer just walked into the control room John. He says this will be your last flight. You've been traded to the white house for H.R. Haldeman and John Dean.
John: Okay, well I'll need a recorder.
Okay, we're level here, going to erect.
NASA 1: Roger, John.
John: Fast erect on.
NASA 1: Now that you're all erected John, 008 come 4° left.
B-52: 008
NASA 1: John Manke, we want a beep of left rudder trim.
John: Coming up on a beep. How's that?
NASA 1: Looks good John.
And its about 12 minutes to launch John.

12 Minutes to Launch

John: Okay, it's a good time for everybody to check trims here. My upper flaps are 20, lowers are 10, Ailerons are 0, rudders are 0, rudder bias is -10.
Chase: Looks good to chase John.
John: Okay, Tony, thanks.
NASA 1: John I want to confirm that your aileron bias switch is in normal.
John: Yes, the aileron bias switch is in normal, and the circuit breakers are out.
NASA 1: Roger. And 008 come 4° left.
B-52 008. I was heading 180.
NASA 1: Good call Dale, and John Manke, 11 minutes.

11 Minutes to Launch

John: Okay Bill, 11. Thank you. I'll set in 180 on my gyro.

NASA 1: John Manke, give us a beep of right aileron.
John: Okay, here it comes. How's that?
NASA 1: Chase 1-a we'd like you to swing around and check the weather in case we need a hold at 5 minutes.
Chase 1a: Roger, we're just approaching the launch point at this time.
NASA 1: I'll call this 10 minutes to launch John.
John: Roger, Bill, 10.

10 Minutes to Launch

John: #1 helium is 38 now, and #2 is 25. Control gas is about 475, Gov balance is about 435. Fuel tank is 30 and LOX is 21. Landing gear is about 31.
NASA 1: Roger, John. We'd like you to read #1 and #2 again, John.
John: #1 is 3800, #2 is...., I'm sorry...#1 is 2500, #2 is 38.
NASA 1: Roger, 9 minutes now John.
John: Okay Bill, 9 minutes.

9 Minutes to Launch

John: Erect switch coming to cutoff, fast erect is off, both attitude indicators are good.
NASA 1: Roger John.
John: And I'm reading a heading of south Dale, what do you got?
Chase: Chase 1 is 175.
John: Thank you, Tony.
NASA 1: 008 start a left turn, and John Manke, 8 minutes now.

8 Minutes to Launch

John: Okay 8 minutes, and Tony here comes my landing rockets.
Chase: Roger.
NASA 1: Look good here, John. They both look good here, John.
John: Okay.
NASA 1: 7 minutes now John.

7 Minutes to Launch

John: Okay Bill, I'm on X-24 radio and this is primary. You've been reading me okay, let's go secondary.
NASA 1: Roger going secondary. Chase 1-Able, NASA 1, how's it looking?
Chase 1a: 1-Able, looks good, there's that same patch that you had in the vicinity of base-leg turn, is where you'll hit it.
NASA 1: Mighty fine.
Chase: And there's good land marks available until that point, then there's enough holes to maintain navigation to that point.
NASA 1: Thank you sir.
John: Okay, Einar, you think it looks good from the 180 on in, affirm?
Chase: It looks real good down to the 180 and right in the base-leg its got parts broken and then about half way around the base-leg it looks good again.

John: Okay.

6 Minutes to Launch

NASA 1: Okay John, you're a little inside 6 minutes. Chase check your windshield heat.
Chase: Chase 1, 2, 2A.
NASA 1: Roger.
NASA 1: And tighten your turn a little Dale.
B-52: Roger.
NASA 1: Calling 5 minutes to launch.

5 Minutes to Launch

John: Okay going to battery. Emergency light has been reset, it is out. Swapping hydraulics.
NASA 1: Roger, 008, heading 005.
John: Okay, 2's and 4's are on, I got 3200 and the lites are out. ON the busses I got 105, 100, about 95 and maybe 5.
NASA 1: Roger, John.
L/P: Adaptor power is off and the ammeters are zero.
John: Gains are 5 and here comes the old SMRD. No lites. Torque. No lites. Ones are off, torque. 3 yellows. Twos are off and a torque. 3 reds.
NASA 1: 4 minutes now John.

4 Minutes to Launch

John: Okay, 4, 3, 2 and they're auto. Lites are reset, torque. No lites.
NASA 1: Okay John, looks good.
Chase 1: John your trim looks good.
John: Okay.
NASA 1: Calling 3 minutes to launch.

3 Minutes to Launch

John: Okay, oxygen going to X-24. Regulated pressure is about 85 and I've got 1800 in the cylinder. Going to X-24 air. Okay, X-24 air is 2800, cabin altitude is about 22,000.
NASA 1: Roger, John.
John: Defog is on heat and the forward canopy is on.
NASA 1: Roger, John.
L/P: B-52 air is off, set.
John: Suit vent is low, #1 Helium is 25, #2 is still 38. Control gas is 480. Governor balance 440. Erect switch going to erect. Fast erect on.
NASA 1: 2 minutes now John.

2 Minutes to Launch

John: Okay 2 minutes. Release pressure low lite is out. #1 and #3 hydraulics are on.
NASA 1: Roger, John.
L/P: Beacon's off and pressure's good, Bill.
NASA 1: Roger, Vic and 008 come 2° left.
B-52 008.
NASA 1: And John Manke 70 seconds.

70 Seconds to Launch

John: Okay Bill.
NASA 1: One minute, now.

1 Minutes to Launch

John: Okay got my clock started. The 1 and 2 sources are the same, my SAS lites are out, α is 6, β is about 3 1/2° needle left. Erect switch is to cutoff, fast erect is off.
NASA 1: Okay John, 30 seconds and it looks good here.

30 Seconds to Launch

John: Okay Bill. Release circuit breaker is in, camera and recorders are on.
Okay, there's 10 seconds.

10 Seconds to Launch

John: 5 seconds and here we go.

LAUNCH

NASA 1: Okay, John, get 10 α and a roll maneuver.
John: Okay, I guess maybe I was trimming for that 10. I've got a steady state sideslip.
NASA 1: Okay, see if you can trim it out. Stand by for doublets and a pitch pulse, John.
John: There's one.
NASA 1: You're a little high on profile and just a little bit left of track, John.
John: Okay.
NASA 1: Stand by for 8 α.
John: Okay. Airspeeds look reasonably good.
NASA 1: Okay let's bring her 5° right, John.
John: Good call.
Chase: 230, John.
John: Say again.
Chase: 230 knots.

NASA 1: And you're coming up on 30 thou, John. When you get there its 5 α and mach repeater to .3. Nice heading correction, John Manke. Check your airspeed and standby to flare.

John: A little buffet.

NASA 1: You're coming level at 25 thou, John. You're 3 miles from the highway. Let's go mach repeater, 2 miles to the highway, track is good.

John: And a oo-pu.

NASA 1: Okay, you're going a little high on profile, John, maybe a thousand feet. Okay, John, one mile to the highway, 10 α and check your lower flaps.

John: Okay.

NASA 1: Very slightly inside the track and about 1,000 high. Okay, let's get a rocket check. You're at the highway, John, camera on.

Chase: Looks good, John.

John: I'm in pretty tight.

Chase: 190, John.

John: Okay. Keep that turn coming for me, Bill, I'm IFR.

NASA 1: Hang in there.

Chase: Hard turn, John.

John: I'm okay now, Gary.

Chase: Okay.

John: I don't know how you're going to handle it.

Chase: I'm going to go wide and come back.

John: Okay. Guess I'll do the same. Gee, it's flying good. Going to .5. There's .3.

NASA 1: Okay, John, you may want to pull your speed brake in. Leave that up to you.

John: Yeah, they're coming in now.

NASA 1: When you have time get your mach repeater to .3, and check your KRA.

John: KRA is good and I'm at .3. We're in good shape, Bill.

Chase: About 295 on my clock.

John: Yeah, I got 290. That's great, Gary. We're in good shape.

Chase: 1200 feet, mark. 260K.

John: Okay, I'll get the gear at 240.

Chase: You've got 3 beauties.

John: Okay, Gary.

Chase: Okay, looking good. Holding about 20 feet. Okay, now about 8 feet....4....2 feet holding....good another foot....that's it, baby.

John: Wow!

NASA 1: Okay John Manke, stand by for 100 knots.

John: I got it down now, it's no problem. That nose sure looks low. I guess that's cause it is.
Okay, I'm screaching to a halt here. And we're stopped. Bill, let's get a good reading on our trims up there. I want you to see where I had to trim this thing to make it fly fairly straight.

Chase: All chase airplanes let's go normal tower frequency.
John: Bill, did you read that about the trim?
NASA 1: No sir, John, let's hear about the trim.
John: Yeah, take a good reading up there on this thing because I've got a lot of rudder trim in and quite a bit of aileron trim to make the thing fly straight. You may want to take a look at that.
NASA 1: Okay we'll copy them all, John. That was a good call.
John: I guess it's page 20 now, huh?
NASA 1: I think it's 21.
John: Okay and throttle is off, camera coming off. I didn't get the fin camera on.
NASA 1: Okay, John.
John: Here comes the calibrate. And recorder coming off. 6 SAS servos are off, hydraulic pumps are off. Bill, I want to give you a reading on trim here, okay?
NASA 1: Sure.
John: On my aileron gage it reads almost 9/10 degree right aileron, and my rudders here - there's about 3 1/2 to 4° left rudder trim. Okay, control gas is 490, Governor Balance is 450, #1 Helium 24, #2 is 32, landing gear is 25, O_2 is about 14, cabin air 800, radar switch coming off, stick shaker off.
NASA 1: Okay John, when you have time let's go KRA to manual.
John: KRA to manual. Okay all other switches are off, and I'll see you back there.
NASA 1: Okay, that was mighty fine John.

X-24B #551 POSTFLIGHT DATE: August 1, 1973

PILOT: Manke

Okay, this was flight B-1-3, today's the first of August; and it was a real dandy. I can't think of any hitches that we had at all starting off. Good F-104 flight this morning and the turbulence had been good, and the airplane was ready when I got out there. I guess we were just a few minutes late on our 7 o'clock takeoff, so everything went realy smoothly this morning. We'd been through our checklist enough times so that we don't have to worry about that thing anymore. I guess the only comments I had during the pre-launch area was that somebody seemed to be sending morse code on the radio. We got quite a few beeps on our frequency and Bill and Don say it was on two of our frequencies, so we'll run that problem down. Everything on the checklist went super, Bill. It seemed a good idea to start that control check a little earlier, and that sure worked out a little bit better, I think I'll just change that on the checklist, and go right into that thing.

Okay, the launch was absolutely beautiful. That's probably the smoothest launch I've ever had on a lifting body. I don't recall any roll-off at all. I don't think there was anything near zero g on it. It seemed like I had positive g on the airplane right away and we were flying right off the bat. I had 6° α indicated on mine at launch and that was exactly what we had planned for on the simulator so that all looked real good. I indicated about 2° needle left sideslip right before launch. We had seen that the other day, in fact we saw a little bit more the other day. This was less than I had seen on the aborted flight. That didn't seem to cause any roll-off problems. Right after launch we had expected about 8° α, instead it looked like it was going to trim right up at 10 or maybe a bit above 10. The airplane seemed just a little bit looser in pitch than we had seen in the simulator. The simulator showed a very tight airplane in pitch. It just trims right up and hangs right solid on wherever you have it trimmed. This thing seemed to creep a little bit, not nearly like we had on the M-2, where you really had to watch it but it seemed to creep up a little, and I would guess I probably trimmed down a little bit rather than trim up. So the trim up varied between 10 and 11 degrees, rather than 8 and 10. I guess that the first thing that I noticed, that got my attention a little bit, was the fact that we had about 3° sideslip flying right after launch. We'd been practicing in the simulator some very reduced derivatives and we decided if I had any controllability problems, why we'd open the flaps up, and I immediately thought that Armstrong had reduced my derivatives and we had a controllability problem. It turned out that the airplane was reasonably solid in yaw and I could fool with the rudder and it would still trim within 3° sideslip. So, I elected not to run the uppers out and use the yaw trim to trim the most of it out, and I was surprised at how much trim it took. I guess I probably used half my available yaw trim to get it back fairly close to zero, and I didn't think that I got it quite back to zero, but I elected to fly it where I had it. As I trimmed out the last half degree or so, it started taking quite a bit of aileron trim

to keep the wings level, so I thought that I had a pretty mistimmed airplane at that particular point. Whether or not this is Mach effect I don't know - I'll comment later - but as we slowed up, got our mach down approaching low key, I got the impression that mistrim was not nearly as great down there. I had left some mistrim in but as I got down to low key, that was all gone. I did notice some buffet in the airplane right after launch -- when I got up to around 10 or 11° α I could feel some buffet. Also, as the Mach number went down that buffet went away. So I would guess we do have some Mach buffet here and maybe we're not quite correct at 20° flap for our .7 Mach number - we may want a little bit more flap at .7.

Okay, trimming the airplane and all the good things that went with that, I got just a little bit behind, and Bill's call is just a little bit timely, because I don't think that I would have gotten everything done. The rudder pulse that I gave you wasn't a very hard rudder pulse, because of the mistrim. I was a little reluctant to kick it as much as I had in the simulator -- what pulsing we got seemed to be very well damped - they were running this in the simulator. The aileron pulse - like in the simulator you see much in with an aileron doublet - very little bank angle change. About this time we reached the point where we were to push over to start our practice flare at altitude. My airspeed at this point checked to within 5 knots of what I had seen in the simulator. I was running about 235 at this time and I had seen about 230 in the simulator so I felt good about that. The airplane handled very nicely in this area and I think that just about in this area, maybe a little bit lower that the buffet left and I didn't feel it from that point on. I started our flare at about 27 thousand feet and I had gone down to 5 α prior to that and I had done a few roll maneuvers there and the airplane is very nice in roll. It is very reponsive and I felt very pleased at how it handled in roll axis. I started the flare at 27 thousand and used a 10° α pull-up and we leveled at about a thousand feet higher than we had planned in the simulator.

So I just got the impression all the way along that we had a little more lift at 10° α than we had seen in the simulator. We did the roll maneuvers at 10° α than we had seen in the simulator. We did the roll maneuvers at 10° α like I promised you I would, Milty. Looked for a PIO problem and there was absolutely no trace of anything like that - the airplane was doggone beautiful in roll. Got our KRA back up again and did our push-over pull-ups. The push-over pull-ups went from 2° α, I pushed from 10° down to 2°, then back up to 15°, then back down to 10° again. I had expected to feel quite a bit of buffet when I went to 15°, but it turned out there wasn't any buffet at all. I didn't feel a trace of buffet, so we have a good push-over pull-up. Went down to 2, got to 15 and no buffet, no stick shaker. It handled very nicely. It was about this time that Bill called that we had arrived at low key, and that was really the first time that I had looked out of the airplane to see where we were. I had used his directions up until that time to get to the low key. To comment again, the mistrim seemed to have improved at this point. I didn't

really notice any mistrim. So I would guess that at least a third of that was mach number although I didn't take any of the trim back out of it. The trim that's in the airplane now is what I ended up with at about 35,000 feet. I'd be interested in finding out whether or not we had any mistrim on the approach.

Okay we were pretty high at the low key and I got the impression that I was in a little bit far, maybe a quarter of a mile. I guess the thing that concerned me a little bit was the winds were different than what they normally are around here. We normally fly with a west or a south-west wind and then we kind of get a stero-typed pattern. Today the winds were east to northeast so it makes a big change in the pattern. So, when I ended up high and inside why that just complicated it a little bit more. It turned out that this, like the X-24A's speed brakes or the upper flaps that we use for speed brakes, are very effective and as soon as I realized we were up too high approaching the 90° position, I went full out on the uppers which were 32° and it was just gorgeous the way the airplane changed L/D, and just started downhill and I realized right then that we were home free. Needed one more little maneuver to take care of the high energy and we swung out to the west of the runway and then S-turned back in again. From my standpoint it wasn't any problem. I know Gary Krier was just having a ball out there because I don't know how he could stay in with me. That's obviously it. We'd been practicing this for quite a while and we occasionally practice these types of approaches and so, good point Gary. Okay I went to 300 knots with the flaps all the way out and that looked like it was going to do just like I wanted it to and my aim point looked like it was holding well and at that point it started to drop a little. At that time Bill Dana called and said why don't you put your flaps back in again. That was a very timely call, it was the best call of the day. It would have taken me a little time to realize that I had left them out and I may have ended up just a little bit short, while this way it worked out perfectly. We pulled them back in and I was able then to move my aim point back. I had been using about 1/2 mile point for aim point back. I had been using about 1/2 mile point for an aim point for my final approach and I decided that on the day of the flight, if I could, once I had that made, try to drop it back a little bit so I could give myself a little bit more pad on runout. And it worked out just perfectly when you called at that time. My aim point ended up probably about a half mile down the runway. Our final approach was a 290 knot approach and it was very comfortable. Oh, let me back up just a little bit. Somewhere in the pattern we hit some turbulence. I guess it was light turbulence, no more than that. The airplane seemed to repond very nicely. I know we had gone through turbulence and I could feel just a little bit of, actually just side motion of the airplane. I don't recall much motion at all, just a little lateral-directional there but it probably manifested itself mostly in the seat of the pants. I'll just have to try to recall that later. We ran a pretty good bank angle at the time we went through the turbulence. And there just didn't seem to be any problem.

Okay, back on final approach at 290 knots, boy it was comfortable as the dickens. We got the mach repeater down to 3/10ths and just sat there and waited for the flare altitude to come. I suppose we had flattened some then because of pulling the flaps in and so this was probably a flatter approach than it would normally be with a constant 300 knots, very comfortable. Gary called 1200 or a thousand and I waited a little bit longer because I had plenty of time and a lot of energy. It was a smooth flare and we probably came level 50 feet above the lakebed with a lot of airspeed, probably over 270. Gary called me at 260 and reminded me of the gear and I told him I would wait until 240. We do have a gear limit at 240. At 240 I pulled the gear handle and the gear came right down. There is no, that I could tell, aerodynamic transient in the airplane at all when the gear comes down and I could barely feel the thing. The other airplanes you could really feel them clang down. This one here it wasn't that evident. Then I had just beautiful control of the airplane above the runway, no PIO tendency either in pitch or roll. It was one of the most pleasant flying things right above the runway that I've flown. I'll need about 100 more of them to make sure of that but it seems that that's going to be the story. Obviously, no crosswind so line-up was no problem. Gary's call on altitude really helped. When you fly a new airplane you're just a little bit hesitant on altitude. It's now quite clear just how high you are and I had thought I was a little bit lower than Gary's calls and bear in mind that it's difficult for a chase to call 8 or 15 feet or something like that at that particular point.

It is very easy to just ease the airplane down to the ground, and the touchdown was very smooth. I don't have any guess on the h-dot, but it was probably less than 2 feet per second. Gary's 2-foot call really helped. I felt very good when he called 2 feet, and dropped down a little bit and it just touched down. I don't know what the touchdown speed was, I didn't look. The nose comes through very rapidly, as everybody told me it would. There's nothing you can do about it. The main gear is so far behind that there is no moment with the full-back stick so when the mains come down, why the nose follows through shortly thereafter. It seems like it's going to go all the way into the lakebed. The noseboom just appears like its about 6 inches off the ground, I'm sure that it's more than that, but that's what it looks like from the cockpit. I guess the thing I noticed most when the nost came down was the very rapid deceleration. That's a pretty good way to decelerate an airplane, because I think you really load it up once you get down, and I could definitely feel deceleration, better than brakes. Okay, I had no directional problem at all. As the nose came down it just rolled true as a line. It went right smack down the runway. After the nose was down for a few seconds it appeared it wanted to go just a little bit to the left, and just a little right aileron and right rudder took care of that. I armed the nose gear steering at about 120 but I didn't use nose gear steering, I didn't have to. The airplane just went smooth as could be. I used a little bit right brake to hold it straight down the runway and used just a very small amount of braking from probably 30 knots on down to the stop. So, whatever we got for a roll-out will be a pretty good indication of what it would be without any braking at all for a roll-out. I guess that's all there is to it.

Question and Answers

Question: Did you do anything with the stick after touchdown?

Answer: Yeah, I did a little bit right aileron and I don't recall doing anything in pitch.

Question: Did you move the stick between main and nose gear touchdown?

Answer: No, not intentionally.

Question: From lakebed data it looks like you touched down about 170 knots.

Answer: Yeah, I had planned on touching down somewhere from 180 to 190. It took me a little longer to get down the last 2 or 3 feet than I had anticipated so I would guess that I did touch down slower than I had planned.

Question: It looks like h-dot was about 1.6 feet per second.

Answer: 1.6 okay, yeah it was a real smooth touchdown - no problem.

Question: Do you have any idea where your α was at touchdown?

Answer: No, I don't. None at all. We can get that off the cockpit film.

Question: What was the roll-out distance Jimmy?

Answer: Close to 7000 feet.

Comment: That's pretty darn good because that represents near zero braking. That's excellent.

Question: Did you have any visibility problems?

Answer: The visibility is outstanding on this airplane, just none at all. I wasn't ever aware of the nose being out there.

Any other question? Okay we'll go through NASA-1, the mothership and the chase and maybe you'll think of some other questions for John.

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-1C-1 DATE OF REPORT: 8/16/73

PILOT: Manke DATE OF FLIGHT: 7/19/73

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Roger's Dry Lake

PURPOSE OF FLIGHT: (1) Systems checkout at altitude

(2) Verification of checklist and timing

(3) Compatability of B-52/Adapter/X-24B

(4) Pilot familiarization

I. Discussion of Previous Operations

A. Minimum testing was accomplished on the nose gear steering system at the Martin plant during the X-24A to B modification, which necessitated extensive lab tests prior to installation on the vehicle. A bench test rig was built to check the actuator performance. Initially, the performance ie, hysteresis and deadband were unacceptable and required teardown and adjustment to improve the unit to a useable condition. A comparison was made with the system in the NASA F-104 to provide acceptance criteria. Final judgement of the system was to be based on the results of powered taxi tests.

B. The control system was functionally tested to determine if the new roll control was acceptable as delivered. Limit cycle and structural resonance tests were made to evaluate the operation of the complete system with SAS. The limit cycle criteria was essentially the same as on the X-24A, but a structural resonance was present in the aileron system. The resonance at 20 cps could be stopped by applying a light force to the aileron actuator servo valve input rod. This led to the development of an internal damper in the actuator rather then an electronic notch in the SAS system. The damper was developed and tested in the hydraulics laboratory by NASA personnel and the Martin field engineer.

C. The vehicle was configured as close to flight configuration as possible and weighed prior to mating to the B-52 for ground vibration tests to determine the probable flight dynamics characteristics of the X-24B/pylon adapter/B-52 combination. Data were gathered at several weight and e.g. configurations.

D. The vehicle was then moved to the Heat Facility for extensive loads calibration tests.

1. The L.H. strake/fin was removed and installed in a special fixture for proof loading of the new aileron and strake areas.

2. The fin was then installed in another fixture for loads calibration of the fin structural strain gages.

3. During this period the AFFTC Dynamics Test team accomplished a ground vibration survey of the R. H. fin/strake with the fin installed on the vehicle. At the completion of this test a modified aileron actuator was installed and evaluated for the 20 cps resonance. No resonances could be developed by either shaker inputs to the aileron surface or control system inputs.

4. The L.H. fin was reinstalled on the vehicle and moment of inertia and vertical c.g. determination tests were completed.

5. A series of landing gear load tests were made to qualify the new nose gear and forward structure. In addition a drag load was applied to the main gear to verify the adequacy of the main gear and backup structure. This test consisted of applying a 2500#/gear drag load while measuring the tendency of the gear overcenter lock to unlock. The L.H. gear showed no such tendency, but the R.H. gear moved .032 (.120 movement would cause the gear to unlock). The R.H. main gear actuator was reworked by shimming the locking device to allow a slight amount of shake in the actuator in the locked condition. The test was repeated and the R.H. gear showed no tendency to unlock.

6. A series of drop tests were then run by elevating the nose of the vehicle with the main gear tires restrained, and releasing the vehicle from predetermined heights. To produce drag loads in the nose gear the nose tires were rotated with a spinup device furnished by the AFFDL to approximately 200 knots prior to each drop.

   These tests were terminated when 80% of design load was achieved at selected areas of the vehicle.

7. The vehicle was then rematted to the B-52 for additional ground vibration testing with the AFFTC shakers to gather data not obtainable with the NASA equipment. Results of this test cleared the vehicle for light weight captive flight.

8. The vehicle was then returned to the Heat Facility for additional drop tests necessitated by the discovery that an incorrect calibration had been used to determine the loads during the first series of tests. The structure and nose gear functional as predicted through 15° elevation. (This produced loads in excess of those predicted for landings of 8 feet per second vertical velocity a touchdown.)

9. All control surfaces were then loaded to approximately 50% load to calibrate the surface hinge moment gages.

10. While the vehicle was suspended from a single cable for the yaw inertia measurement the SAS system was torqued through maximum gains to assess the probable free flight resonance characteristics.

E. An electrical load test was made to assess the power requirement change with the addition of the new aileron actuators. Inconclusive results were obtained because of the limitations of the power supply system available. The final evaluation was delayed until batteries would be available during subsequent tests.

F. A series of low speed taxi tests utilizing the L/D rocket motors was made to evaluate the nose gear steering system up to approximately 40 knots. No problems were encountered and three runs were made using the LR-11 engine to increase the speed to 75, 125 and finally 150 knots. The steering system was acceptable when adjusted. to the nominal gain of ±8° wheel angle for full rudder pedal travel.

The electrical demand with control activity was rechecked using battery power and found to be acceptable for at least glide flights.

G. A high speed taxi test while mated to the B-52 was made on the main runway to demonstrate X-24B/pylon adapter/B-52 integrity.

II. Vehicle Configuration Changes

A. The water alcohol jettison line was relocated from the X-24A position adjacent to the LR11 engine to the outboard side of the R.H. fin above the aileron control surface to inject the jettisoning fluid flow into a vortex located by windtunnel studies at the Air Force Institute of Technology.

B. Dampers installed in aileron actuators.

C. Because of the aft repositioning of the vehicle relative to the pylon adapter pitot ejection while mated is no longer possible. Redundant pylon hook release power system was installed on the adapter. This system consists of pressure storage vessel, control valve and hook release actuator controlled by the B-52 pilot separate from the original system controlled by the X-24B pilot.

D. The lox tank vent valve overboard line was relocated to prevent lox topoff overflow during captive flight from possible chilling of the L.H. gear door lock.

E. An H-Box (limit switch) was installed in the aileron bias system to provide control of the travel of the ailerons. In addition an independent backup system was installed to provide control in the event of primary system failure.

F. The main gear 10 ply tires utilized on the X-24A were replaced with 12 ply tires with the thread buffed off to provide up to 230 knot landing capability at the increased X-24B weight.

G. The wheel retainer nuts on the nose gear were machine down to provide an additional .20 inches clearance in the nose wheel well.

H. The cabin air precooling system used on the M2/F3 pylon was installed on the X-24B pylon.

III. Instrumentation Changes

A. None.

IV. Preflight Events

A. Preflight functionals were accomplished satisfactorily.

B. The vehicle was mated on July 18, 1973 and a dry run captive flight simulation was made with all personnel at their flight stations, the chase pilots viewed the aft area of the vehicle to familiarize themselves with control activities during the simulation.

V. Flight Events

A. Preflight servicing was accomplished with no problems.

B. The pilot reported canopy fogging during the climbout but traced the problem to his overboard exhalation hose which had become disengaged, after reengaging it the fog disappeared.

C. Pylon adapter/X-24B/B-52 damping and SAS were checked at various speeds up to 250 knots satisfactorily.

D. The PCM system developed excessive noise during the latter portion of the flight. When the electrical power was switched to battery the noise cleared up.

E. The stick shaker failed to operate in the test mode.

F. At the completion of the normal pre-launch checklist the B-52 made a minimum elapsed decent landing and taxi to the mating pit so that the landing gear could be deployed under us near flight conditions as possible. The gear can not be deployed while mated because of no ground clearance for main gear.

The gear was deployed over the pit with no problem.

G. With the exception of the PCM noise all systems worked satisfactorily.

Approved by: W P Albrecht
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: Norman E. DeMar
Norman E. DeMar
X-24B Project Engineer
Operations Engineering
Branch

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-A-2 DATE OF REPORT: 8/16/73

PILOT: Manke DATE OF FLIGHT: 7/24/73

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Roger's Dry Lake

PURPOSE OF FLIGHT: (1) First flight checkout

(2) Longitudinal trim curve verification

(3) Lift and drag determination

(4) Stability and control data

I. Discussion of Previous Operations

A. Captive flight B-1C-1 was flown on July 19, 1973 with an inoperative stick shaker and a PCM noise problem.

B. Flight B-1-2 was originally scheduled for July 20, 1973 but unavailability of acceptable batteries delayed the flight until July 24, 1973.

C. Following the operation on July 19, a large gas leak was discovered in the nose gear actuator when the gear handle was stowed. This caused no problem as the vehicle was mated to the B-52. The actuator was removed from the vehicle and operationally checked after a cold soak at approximately -40°F for 30 minutes. A very large gas leak across the piston seal was noted after which the actuator was disassembled and inspected. A rough bore in which an 'O' ring sealed was polished out and the unit was built up with new seal and rechecked at 0°F with no leakage. The actuator was reinstalled in the A/C.

II. Vehicle Configuration Changes!

A. A relief valve was installed in the hydraulic damper system of the landing gear system to eliminate the possibility of developing pressure in the damper system in the event of actuator piston seal leakage.

B. The electrical system was modified to provide battery power to the instrumentation system bus during captive flight to eliminate the PCM noise problem. To carry the load, approximately 25 amps for the additional time the 52.5 amp hr. battery was replaced by a 100 amp hr. type previously used in the M2 and HL-10 vehicles.

III. Instrumentation Changes

A. Wiring changed to put L/H Fin Camera on its own fuse instead of operating off cockpit switch panel power which also supplies tape recorder, other cameras, and calibrate function.

IV. Flight Events

A. The stick shaker was replaced.

B. Flight servicing was delayed approx. two hours when a problem arouse with the electrical system which was traced to a wiring error on the change IIB listed above.

C. In addition a jumper was installed around the main instrument panel to provide a circuit for the KRA system.

D. B-52 takeoff was approximately 2 hours late and the prelaunch checklist went smoothly until approximately 20 minutes to launch when the SAS SMRD test failed, and the launch was cancelled.

E. The noise problem with the PCM was solved by the battery power to the Instrumentation bus.

F. The checklist was continued with no further problems.

G. Following landing extensive troubleshooting took place to determine the cause of the SMRD test failure. Two SAS yaw/roll augmentation boxes which contain the yaw/roll gyro's were sent to Sperry Phoenix for failure analysis.

Approved by: _____
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: _____
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-1-3 DATE OF REPORT: 8/16/73

PILOT: Manke DATE OF FLIGHT: 8/1/73

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Roger's Dry Lake

PURPOSE OF FLIGHT: (1) First flight checkout

(2) Longitudinal trim curve verification

(3) Lift and drag determination

(4) Stability and control data

I. Discussion of Previous Operations

A. Flight B-1-2 was aborted because of what was found to be three failed gyro's in the yaw/roll augmentation boxes.

II. Vehicle Configuration Changes

A. There were no configuration changes.

III. Instrumentation Changes

A. Procedure changed along with necessary wiring changes to allow instrumentation to operate on battery power throughout flight including pre-launch.

IV. Preflight Events

A. All gyros in the SAS system were changed by Sperry Phoenix.

B. The main instrument panel disconnect was inspected and repaired to eliminate jumpers in the stick shaker and KRA circuits.

C. The electrical and SAS preflight functionals were repeated.

D. Flight servicing was accomplished with no problems.

E. The flight was performed as planned with no vehicle problems.

F. The vehicle was in good condition following the landing.

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William P. Albrecht
Chief, Operations
Engineering Branch

Written by: Norman E. DeMar
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

X-24B FLIGHT B-1-3 EVENTS

TOD	ALT.	KIAS	MACH	EVENT	Δt
07:54:15.8	—	—	—	LAUNCH	0.0
25.0	39148	167.9	.560	START ROLL MAN. (19°LEFT / 8° RIGHT)	9.2
37.0	37457	183.1	.585	END ROLL MAN.	21.2
39.0	37103	185.1	.586	START LEFT RUDDER TRIM (ONE MOTION)	23.2
45.9	35832	195.0	.599	END RUDDER TRIM (0.5" LEFT)	30.1
47.5	35523	197.6	.602	RIGHT AILERON TRIM (0.1°)	31.7
48.1	35413	198.4	.603	RUDDER DOUBLET (10.2°α) RT HM BUFFET	32.3
				WITH NOSE LEFT β	
51.1	34805	205.0	.613	AILERON DOUBLET (10.3°α)	35.3
55.2	33987	211.2	.620	PITCH PULSE (10.5°α) [RIGHT RUDDER	39.4
				HM CLEARED BELOW 8°α]	
↳50.8	34871	204.7	.613	START RH RUDDER HM BUFFET (α = 10.5°)	35.0
07:55:07.7	31634	221.5	.617	START PUSHOVER TO 8°α, START HEADING	51.9
				CHANGE f ROLL EVAL.	
08.6	31479	221.9	.616	END HM BUFFET (α = 8.5°)	52.8
18.4	29735	229.6	.613	START PUSHOVER TO 5°α (PRACTICE APPROACH)	62.6
22.0	29053	233.6	.614	MACH REPEATER TO 0.3	66.2
23.0	28843	235.8	.617	START ROLL EVAL.	67.2
29.1	27380	250.6	.634	PULL UP TO 10°α (PRACTICE FLARE 1.6g)	73.3
30.4	27038	254.1	.638	START RH RUDDER HM BUFFET (α = 7.5°)	74.6
31.9	26664	256.7	.6395	MAX MACH NO.	76.1
40.8	25091	247.3	.598	END RH RUDDER HM BUFFET (α = 9°)	85.0
51.0	24419	226.0	.542	START ROLL EVAL (10°α)	95.2
54.7	24364	215.4	.516	MACH REP. TO 1.1	98.9
57.4	24342	207.0	.497	START ROLL EVAL (10°α)	101.6
58.0	24342	205.5	.493	LEVEL	102.2
07:56:02.5	24287	194.5	.467	START PUSHOVER - PULL UP (10°α)	106.7
07.0	24045	192.5	.460	MIN α (1.5°) ZERO g	111.2
11.5	23528	194.6	.460	MAX α (16°α) 1.65g	115.7
13.0	23396	192.4	.454	RETURN TO 12°α	117.2
26.2	22406	187.2	.433	ROCKET CHECK	130.4
26.5	22384	187.2	.433	BANK FOR POSITION CHECK (24° φ)	130.7
34.5	21779	183.6	.420	START TURN (LOW KEY)	138.7
40.0	21262	186.1	.421	TURBULENCE STARTED	144.2
51.0	19502	206.3	.449	TURBULENCE ENDED	155.2
53.9	18931	214.7	.462	SPEED BRAKES START OUT (DIRECT TO 32° δ_{UB})	158.1
58.5	18040	224.9	.475	UPPER FLAPS STOP AT 32°	162.7
07:57:20.4	11675	281.3	.524	START RIGHT AILERON TRIM	184.6
22.8	10917	286.4	.526	END RIGHT AILERON TRIM (.5")	187.0
25.3	10148	289.6	.524	MAX A/S DURING PATTERN [NOT QUITE]	189.5
28.0	9324	288.8	.515	MAX BANK ANGLE	192.2
31.6	8291	286.0	.500	MACH REP. TO 0.3	195.8
37.8	6786	282.6	.481	SPEED BRAKES START IN (2 STEPS)	202.0
39.3	6468	281.3	.477	ROLL OUT OF LEFT TURN	203.5

TOD	ALT. i	KIAS	MACH i	EVENT	Δt
07:57:45.4	5260	278	.461	UPPER FLAPS RETURNED TO 20°	209.6
58.7	2888	293	.466	FLARE 6° TO 10° α (1.12 TO 1.68 g) [MAX A/S]	222.9
07:58:10.0	2087	256	.402	LEVEL	234.2
15.1	2087	232	.365	GEAR DOWN 8° α	239.3
27.3	2098	164	.258	MAIN GEAR TOUCHDOWN α = 13.5°	251.5
29.0	2098	156	.244	NOSE GEAR TOUCHDOWN	253.2

FLIGHT TIME = :04:11.5 (251.5 SEC)

Launch Dynamics

D. Richardson

Figure 1 compares the actual launch dynamics with the predicted launch dynamics from the AFFTC simulator. The lower flap setting used in the simulator was different from that used during the flight because the flight data shows that the vehicle trims at a higher angle of attack than predicted for the same flap setting.

The actual launch shows that the vehicle pitches up and rolls left sooner after launch than predicted. However, the pilot commented that this was the mildest launch that he has ever experienced in any air launched advanced research vehicle. The more abrupt pitch-up at launch is probably due to the fact the upper flaps are more effective than predicted. This is possibly due to two facts (1) the vehicle is oriented on the adapter at a higher carry angle; i.e., the tail end of the vehicle is oriented down into the airstream more than it was for the X-24A and (2) the nose of the adapter is not covered as it was for the X-24A program with the result that more air is allowed to flow through the adapter and over the upper flaps.

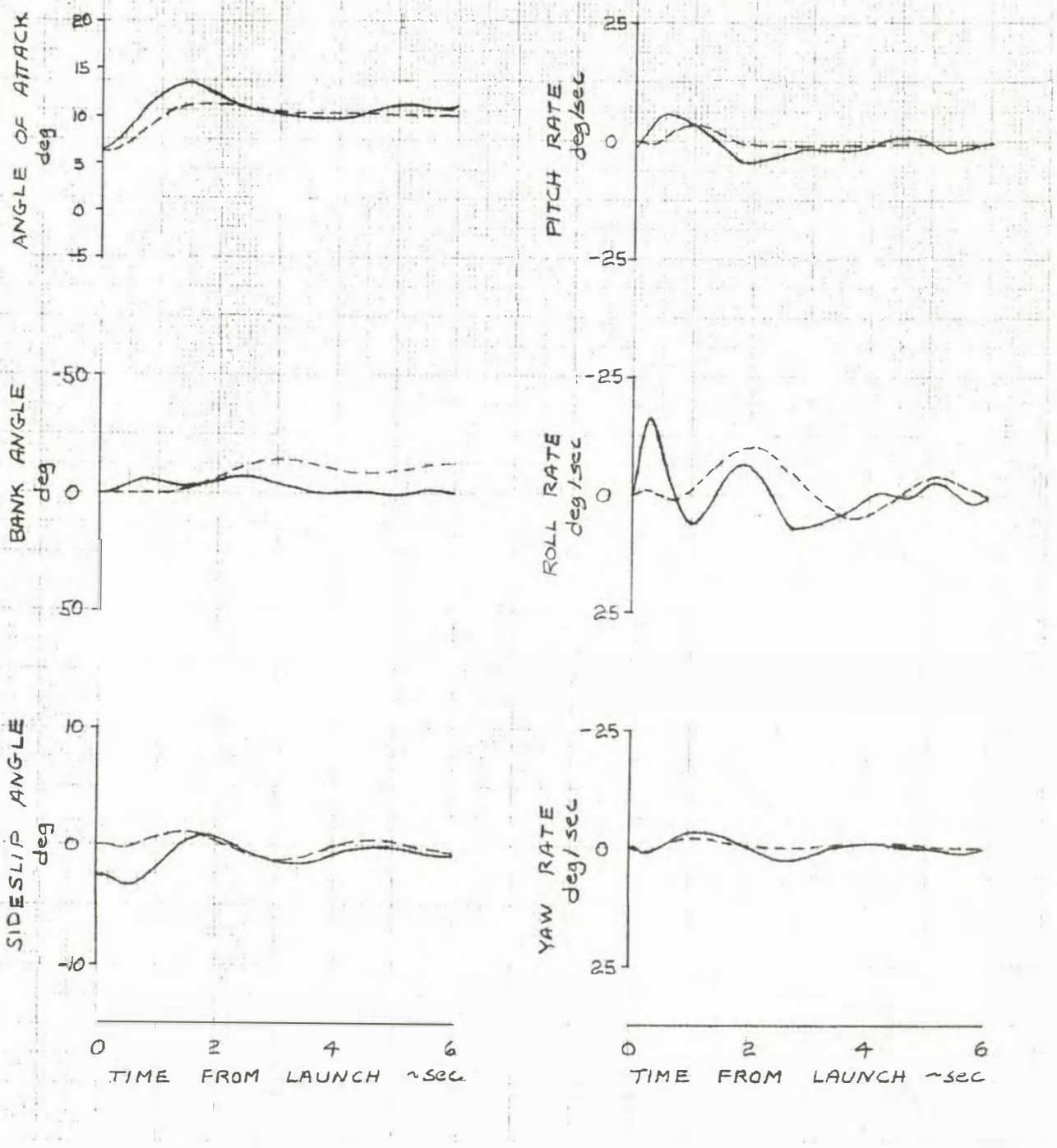
The B-52 cameras which filmed the launch confirmed that there was no clearance problem between the vehicle and the adapter at launch.

COMPARISON OF PREDICTED AND FIRST FLIGHT LAUNCH DYNAMICS — SAS ON

$\delta u = -20°$ $\delta R_B = -10°$ $\delta A_B = 7°$ CG = 65 %

– – – – PREDICTED
NO PILOT INPUTS
$\delta e_L = 6.8°$

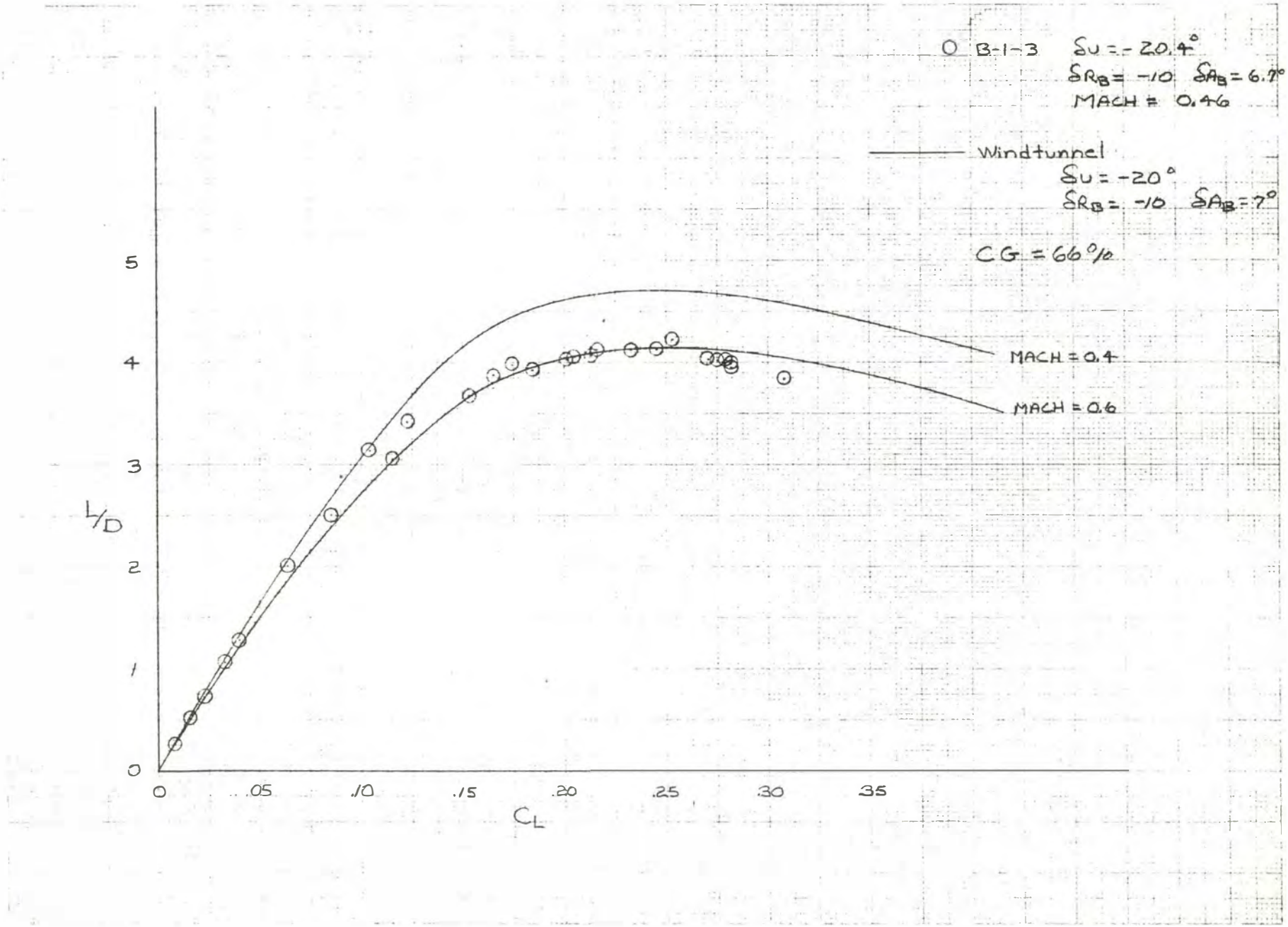
——— FIRST FLIGHT
WITH PILOT INPUTS
$\delta e_L = 10°$

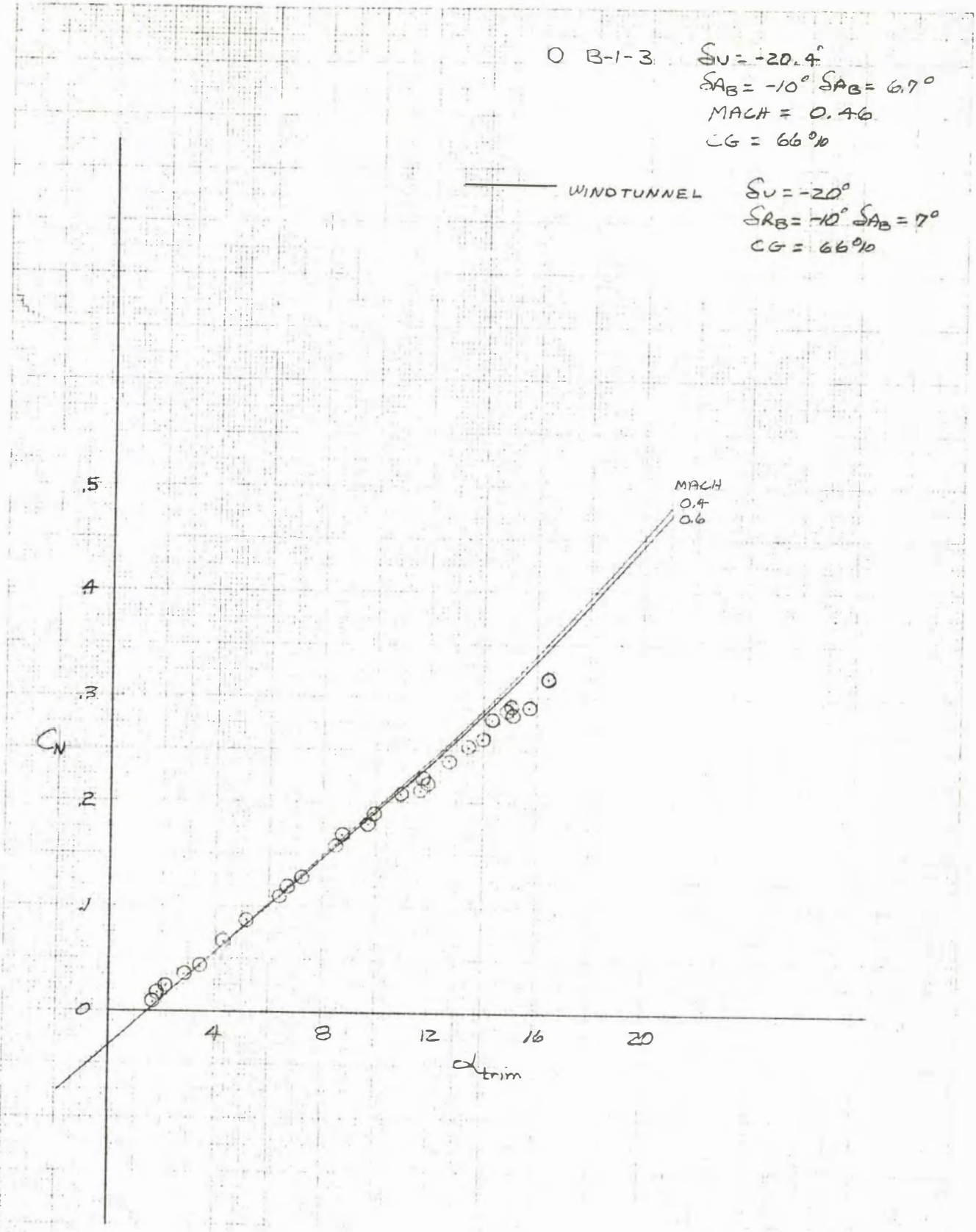


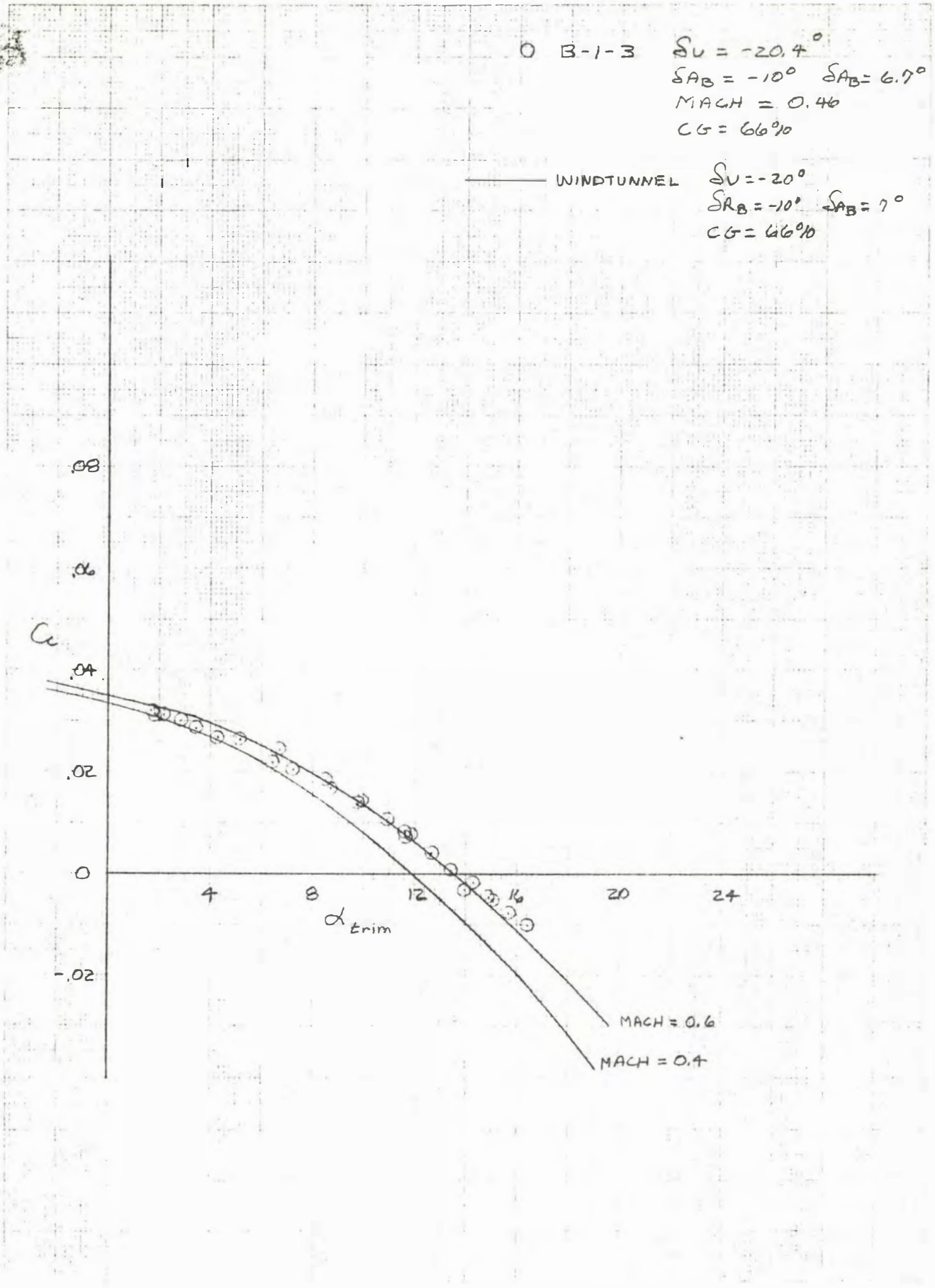
Performance

D. Richardson

The flight data are presented in Figures 4 through 6 for Mach number of 0.46. The data are corrected to the standard cg and zero pitch rate. The maximum lift-to-drag ratio of 4.15 is .1 to .2 lower than predicted. The slope C_{N_α} is less than predicted; however, the flight values of angle of attack are not corrected for upwash effects which would account for some of the reduction in C_{N_α} (Figure 5). The same comment on upwash holds true for the chord force which was larger than predicted at the higher angles of attack (Figure 6).


O B-1-3 δu = -20.4°
δR_B = -10 δA_B = 6.7°
MACH = 0.46
Windtunnel
δu = -20°
δR_B = -10 δA_B = 7°
CG = 66%
MACH = 0.4
MACH = 0.6
L/D
C_L
0
1
2
3
4
5
0
.05
.10
.15
.20
.25
.30
.35


O B-1-3 $\delta_U = -20.4°$
$\delta_{AB} = -10°$ $\delta_{AB} = 6.7°$
MACH = 0.46
CG = 66%
WINDTUNNEL
$\delta_U = -20°$
$\delta_{RB} = -10°$ $\delta_{AB} = 7°$
CG = 66%
MACH
0.4
0.6
.5
4
.3
C_N
.2
.1
0
4
8
12
16
20
α_{trim}


B-1-3 $\delta_U = -20.4°$
$\delta A_B = -10°$ $\delta A_B = 6.7°$
MACH = 0.46
CG = 66%
WINDTUNNEL $\delta U = -20°$
$\delta R_B = -10°$ $\delta A_B = 7°$
CG = 66%
.08
.06
C_L
.04
.02
0
-.02
4
8
12
16
20
24
α_{trim}
MACH = 0.6
MACH = 0.4

HANDLING QUALITIES SUMMARY

J. Armstrong

The attached table presents a summary of the pilot comments and Cooper-Harper ratings of the handling qualities of the vehicle observed during the first flight. Also attached is the recorded transcript of the entire technical debriefing.

X-24B HANDLING QUALITIES SUMMARY

FLT. B-1-3

LAUNCH TRANSIENT – MILDEST OF ANY LIFTING BODY

RECOVERY FROM LAUNCH – PITCH 3½, ROLL 2½

ROLL RESPONSE AFTER LAUNCH – 2½

PRACTICE APPROACH – PITCH 3, ROLL 2½

TURN TO FINAL – PITCH 2½, ROLL 2½

FINAL APPROACH – PITCH 2½, ROLL 2½

FLARE – PITCH 2½, ROLL 2½

NO H.Q. CHANGES AFTER GEAR DEPLOYMENT

NO PIO TENDENCIES BETWEEN GEAR DOWN & TOUCHDOWN

X-24B DERIVATIVES

By
Alex G. Sim
and
Paul W. Kirsten

From Flight B-1-3, four sets of derivatives were extracted from flight data using the NASA FRC Newton-Raphson digital computer program. Three of these sets were obtained in the lateral-directional mode, while one was obtained in the longitudinal mode. Two lateral-directional and one longitudinal maneuvers were analyzed using the AFFTC hybrid matching program.

The lateral-directional derivatives were obtained at angles of attack of 9.9°, 10.2°, and 11.3° with Mach numbers of 0.49, 0.61, and 0.58, respectively using the Newton-Raphson program. Lateral-directional data were obtained at α = 10.2° (M = 0.61) and α = 12° (M = 0.58) using the hybrid program. The maneuver at α = 10.2° was a rudder/aileron doublet set. All other lateral-directional maneuvers were roll evaluations. These data are shown in Figure 1. Trends in the derivatives are evident although they may be premature due to the small amount of flight data yet obtained. However, an overview of Figure 1 shows that C_{n_β}, C_{ℓ_β}, $C_{\ell_{\delta_a}}$ are slightly higher than predicted by wind-tunnel data. $C_{n_{\delta_r}}$ and C_{y_β} are near wind-tunnel values. $C_{n_{\delta_a}}$ and $C_{\ell_{\delta_r}}$ were lower than predicted. Note that two of the maneuvers were aileron maneuvers and thus did not yield rudder derivatives. The lateral-directional damping derivatives are in the same general area as estimates.

The longitudinal maneuver was obtained at an angle of attack of 8.8° and a Mach number of 0.62. This maneuver was overdamped due primarily to the stability augmentation system. As a result, the derivatives extracted may be of less than desired quality. However, the Newton-Raphson and hybrid matching programs gave almost identical values for all longitudinal derivatives obtained from this maneuver. Based on the one maneuver obtained, C_{m_α} and C_{m_q} are lower than expected, while $C_{m_{\delta_\ell}}$ is close to predictions

(see Figure). Note that for the longitudinal derivatives, the flight data were corrected to a center of gravity of 0.66 of chord which is further aft (less stable) than the actual flight value of 0.6503 of chord. The reduced pitch damping and static stability were also indicated by analysis of the pushover-pullup maneuver.

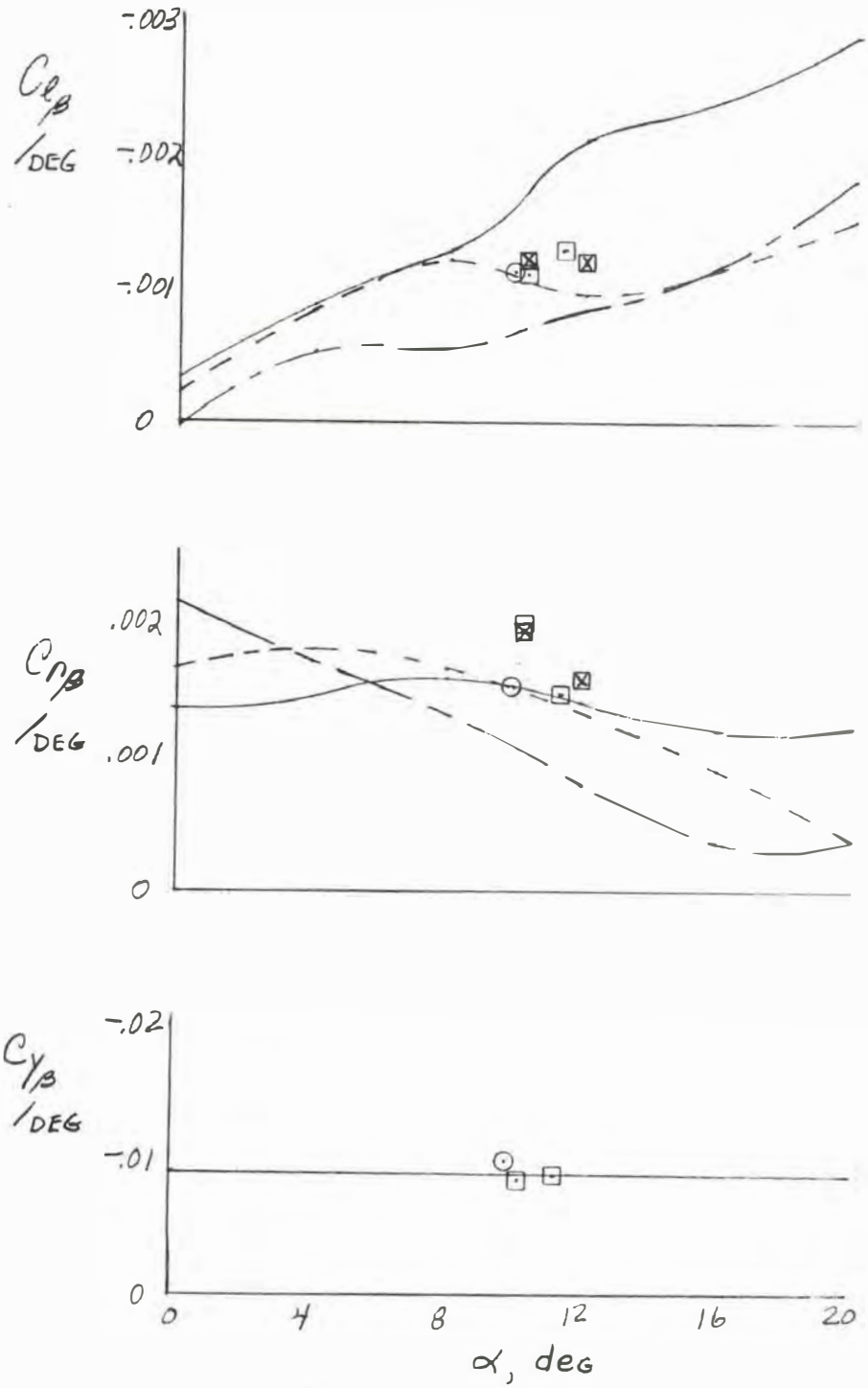
In summary, the first flight derivative results do not give an indication of any new problems. The fact that $C_{n_{\delta_a}}$ and $C_{\ell_{\delta_r}}$ are generally lower than predicted values would tend to reduce lateral-directional PIO tendencies. The lower than predicted values of C_{m_q} and C_{m_α} are of no concern for the approach and landing regime, but the trends with Mach number and flap configuration should be followed closely as the flight envelope is expanded.

X-24B
FLT B-1-3

$\delta_H = -20°$ $\delta_{RB} = -10°$

M
0.4
0.6
0.7
} WIND TUNNEL TRIM DATA
C.g. = 65%

FLIGHT RESULTS
N/R - SIM
○ M = 0.49
□ M ≈ 0.6
HYBRID
⊠ M = .58 (α=12)
⊠ M ≈ 0.6



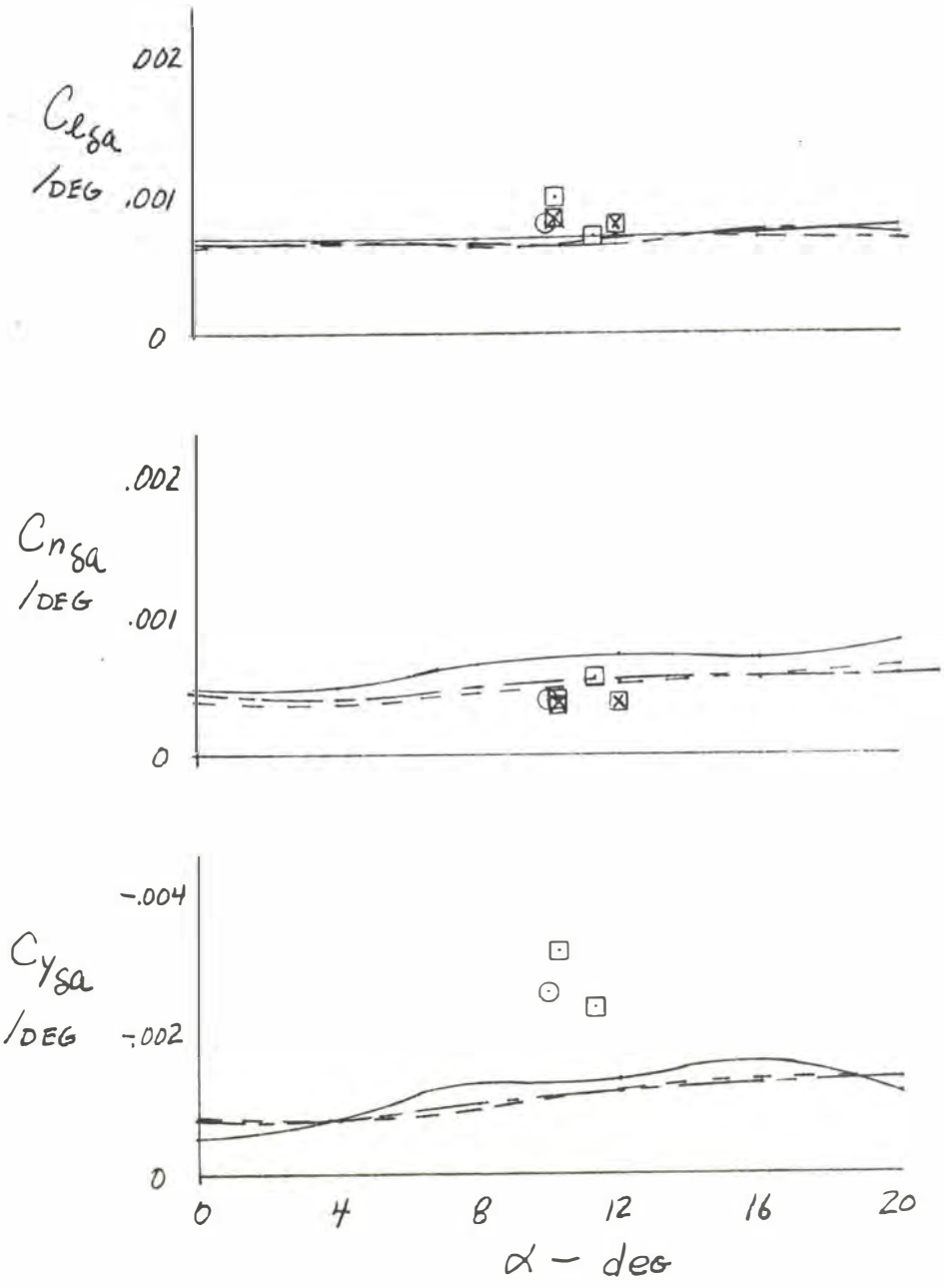
14 AUG 73

X-24B
FLT B-1-3

$\delta_U = -20°$ $\delta_{RB} = -10°$

Mn
0.4
0.6
0.7
} WIND TUNNEL TRIM DATA
C.G. = 65%

FLT. RESULTS
N/R - SIM
○ M = 0.49
□ M ≈ 0.6
HYBRID
⊠ M = .58 (α=12)
⊠ M ≈ .60



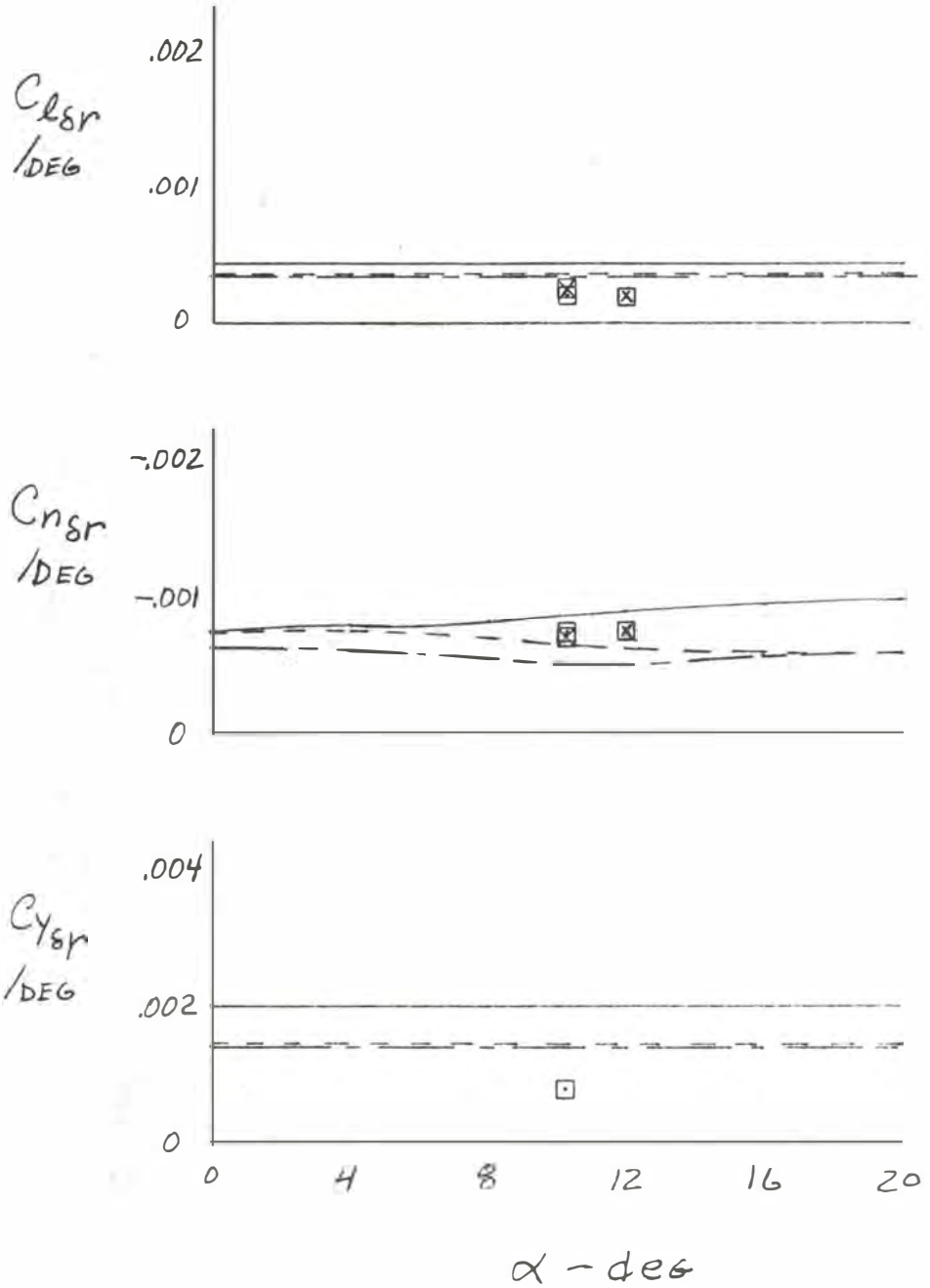
14 AUG 73

X-24B
FLT B-1-3

$\delta_4 = -20°$ $\delta_{R_B} = -10°$

M
0.4
0.6
0.7
} WIND TUNNEL TRIM DATA
C.G. = 65%

FLT. RESULTS
N/12 - SIM
○ M = 0.49
□ M ≈ 0.6
HYBRID
⊠ M = .58 (α=12)
⊠ M ≈ .60



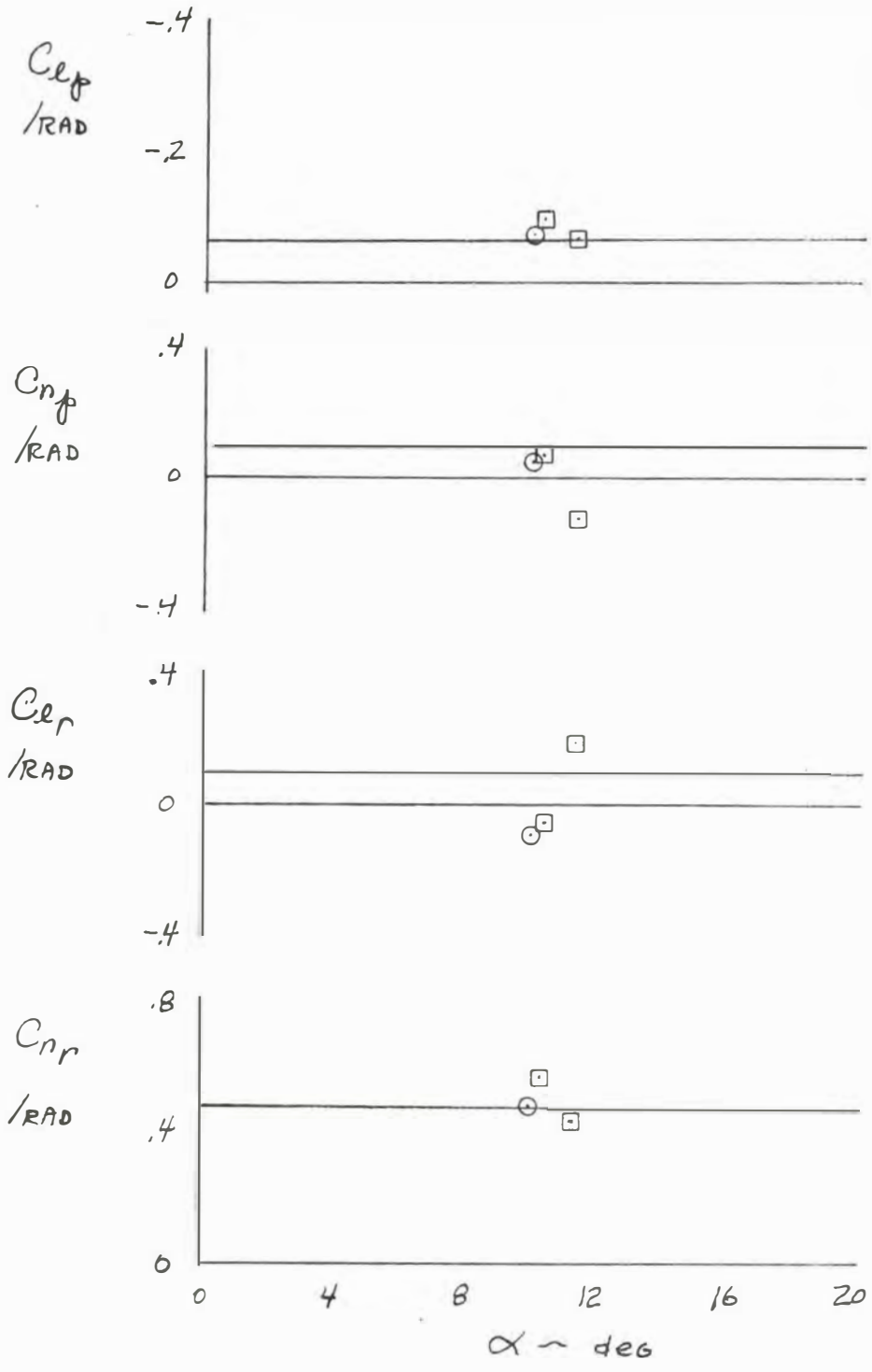
14 AUG 73

X-24B
FLT B-1-3

$\delta_4 = -20°$ $\delta_{R_B} = -10°$

M	
0.4	WIND TUNNEL TRIM DATA
0.6	
0.7	$c.g. = 65\%$

FLT RESULTS
N/R – SIM
○ M = 0.49
□ M = 0.6



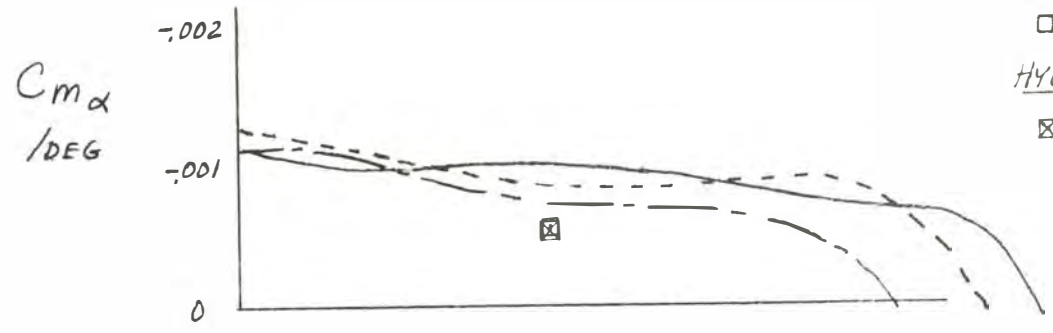
14 AUG 73

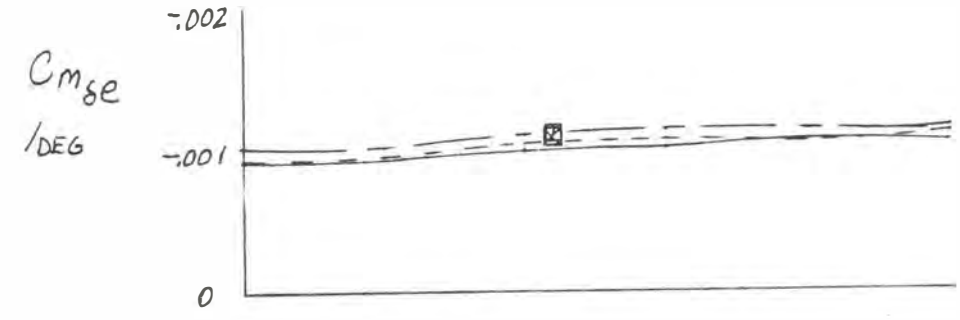
X-24B
FLT B-1-3

$\delta_H = -20°$ $\delta_{R_B} = -10°$

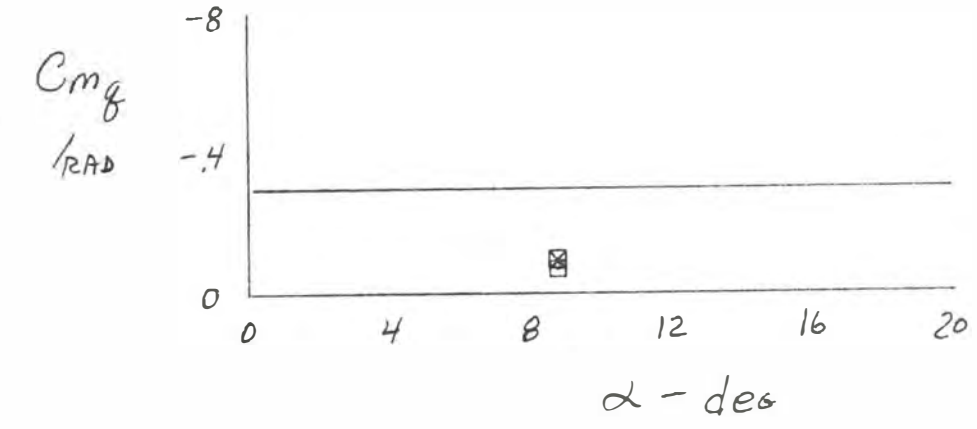
M
—— 0.4 } WIND TUNNEL
--- 0.6 } TRIM DATA
—·— 0.7 } C.g. = 66%

FLT. RESULTS
N/R - SIM
□ M = 0.62
HYBRID MATCHING
⊠ M = 0.62





NOTE: W/T VALUES FOR $C_{m_{\delta e}}$ ARE FOR $\delta e = 10°$ TO $20°$



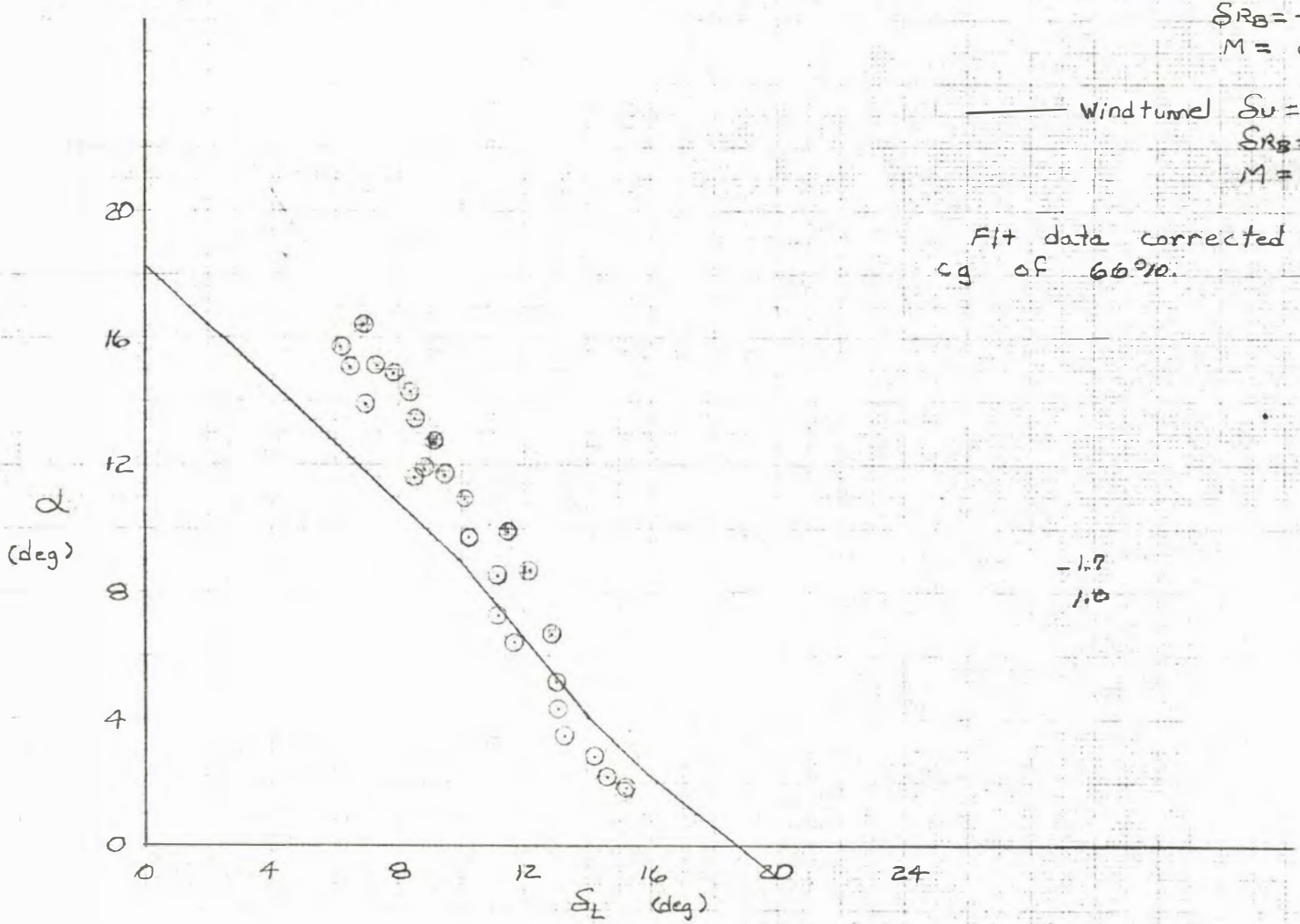
14 AUG 73

Longitudinal Trim

D. Richardson

The data from the pushover-pullup at Mach = 0.46 was corrected to the standard center of gravity and zero pitch rate (Figure 2). This data compared with the wind tunnel data shows that the flight vehicle trims at a higher angle of attack for the same lower flap setting. This is apparently due to a reduction in the derivative C_{m_α} as confirmed by a derivative match of the pitch pulse. This trim angle of attack data does not contain an upwash correction which would account for a reduction in C_{m_α}.

Figure 3 illustrates that there is very little, if any, aerodynamic landing gear transient. Any transient due to the change in center of gravity (cg) when the gear was extended was predicted to be negligible since the horizontal shift in the cg due to gear extension was only one-half inch forward. In any event, no perceptible change in aircraft attitude occurred when the pilot extended the landing gear.



○ B-1-3 $\delta_U = -20.4°$
$\delta_{RB} = -10$ $\delta_{AB} = 6.7°$
$M = 0.46$

—— Windtunnel $\delta_U = -20°$
$\delta_{RB} = -10°$ $\delta_{AB} = 7°$
$M = .4$ to $.6$

Fit data corrected to standard cg of 66.0%.

-1.7
1.0

B-1-3

WINDTUNNEL

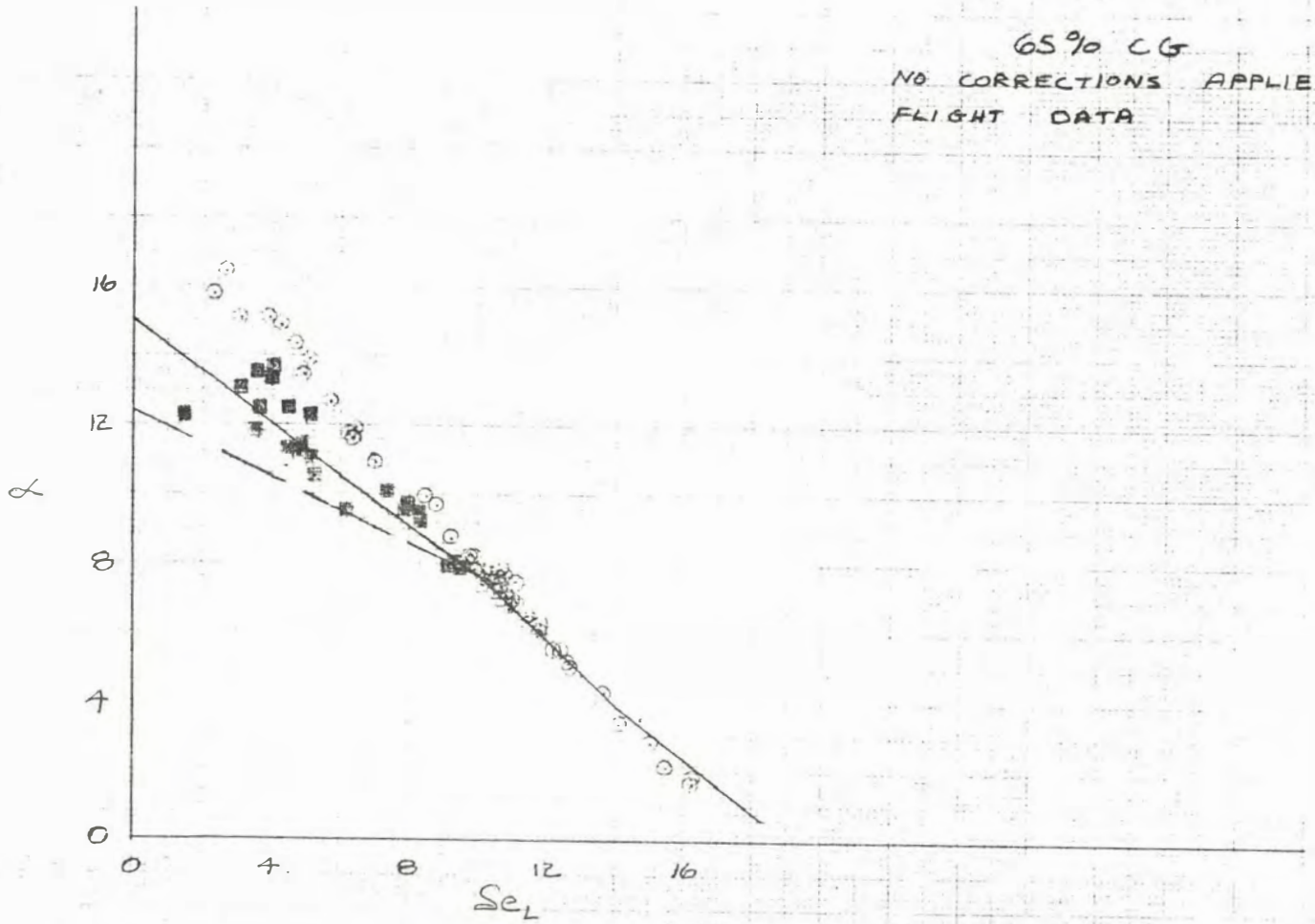
FLIGHT

○ Gear UP M = .39-.49

■ Gear Down M = .26-.39

65% CG

NO CORRECTIONS APPLIED TO THE FLIGHT DATA



SPEED BRAKE TRIM CHANGE

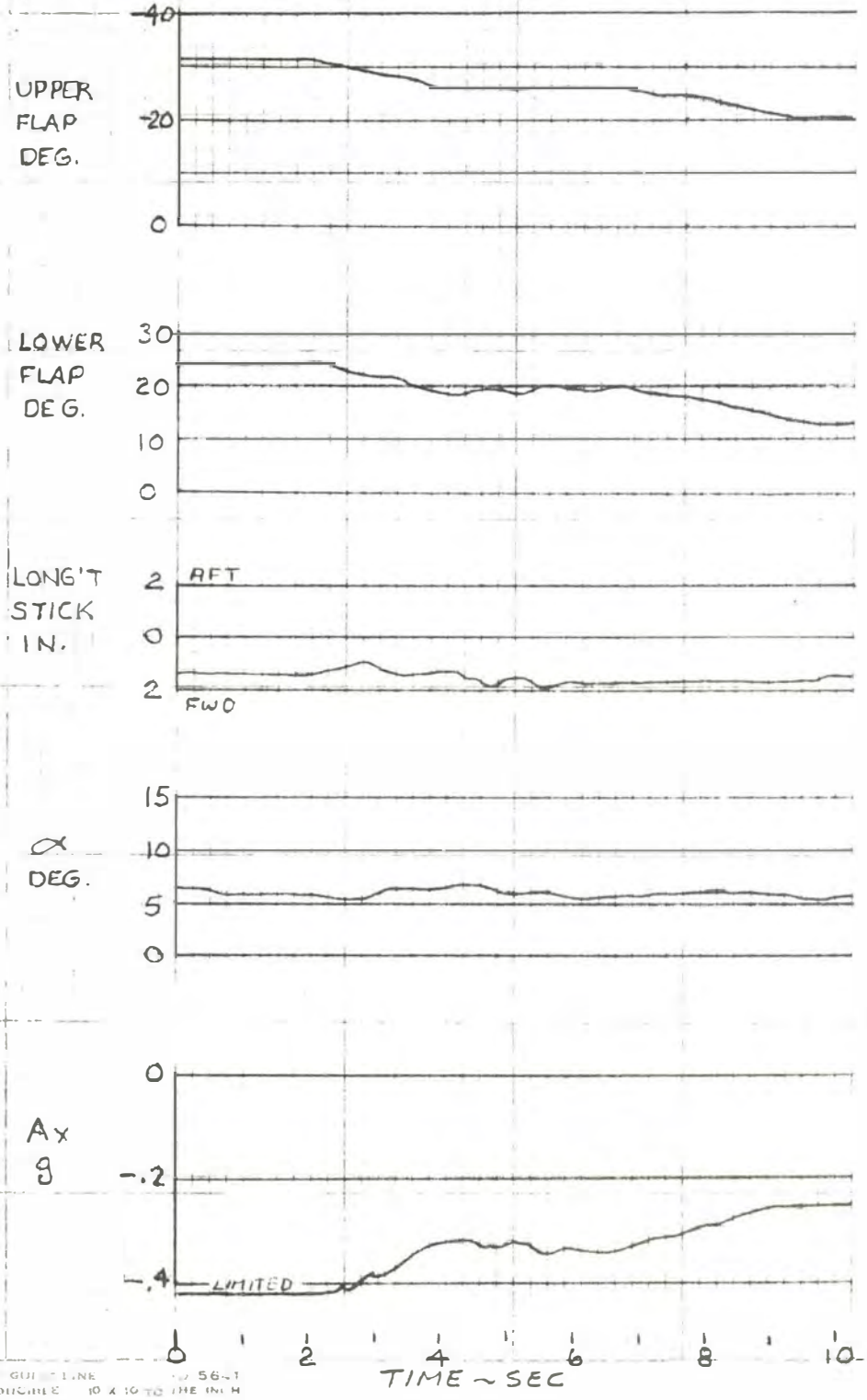
J. Armstrong

The attached figure shows the lack of longitudinal trim change with speed brakes as experienced during the first flight. The pilot retracted the speed brakes in two increments and as can be seen by inspection of the angle of attack and longitudinal stick position history no significant trim change occurred.

X-24B SPEED BRAKE TRIM CHANGE

FLT B-1-3

(FLAPS RETRACTING)



K&E ALBANENE GUIDELINE 10 X 10 TO THE INCH
NON REPRODUCIBLE

FLIGHT B-1-3
CONTROL SYSTEM PERFORMANCE

P. Kirsten

Surface Rate Limiting

None in ailerons
Rudders and lower flaps were limited at pulse inputs only

Upper Rudders--From Rudder Pulse

33°/s going left	Both
29°/s going right	Surfaces

Lower Flaps--From Pitch Pulse

42°/s down	Both
47°/s up	Surfaces

SAS

No SAS failures
No limit cycling
No resonance
SAS authority limits
- Not reached in yaw
- Limit was reached for one short time period in roll during roll evaluation
- Limit was reached in pitch during nose gear slap down at landing

Automatic KRA scheduling worked

In Summary, the entire system worked perfectly.

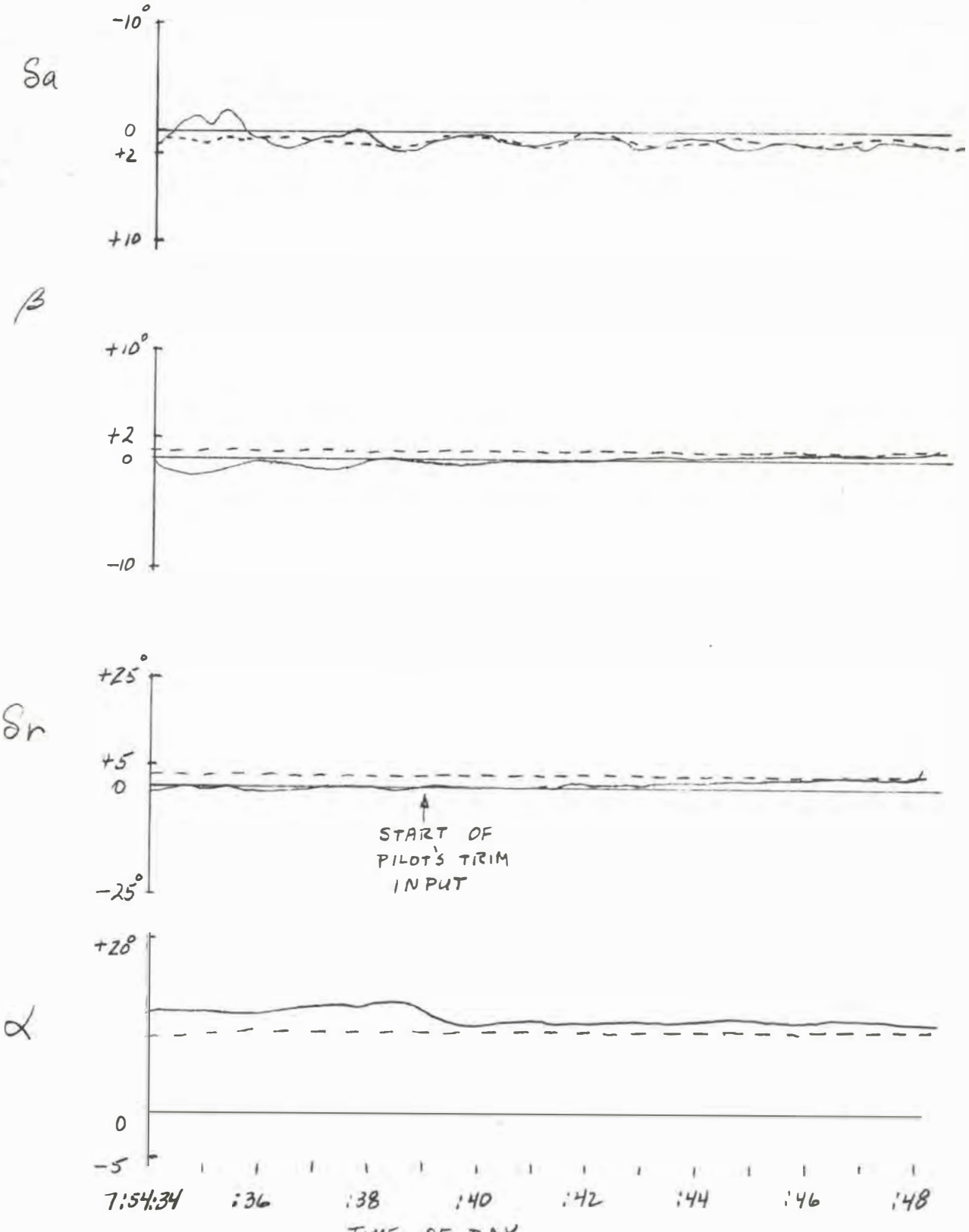
FLIGHT B-1-3 DIRECTIONAL MISTRIM

After launch on flight B-1-3, the pilot felt he had mistrim in the directional axis. He applied left rudder trim until he obtained what he felt was zero sideslip (using his β needle). Telemetered data on the ground indicated that he had about +1° of nose left sideslip instead of zero degrees however.

This condition was evaluated on the simulator after the flight. The same rudder trim that the pilot used in flight (+3° left rudder) was used in the simulator. The aileron required to hold wings level and the resulting sideslip angle were recorded and are compared with telemetered flight data in the figure. Simulator data and ground flight data compared well, indicating that a possible error exists in the vehicle's sideslip indicator. The indicator has been ground checked (after the flight) and appears to be working properly. The discrepancy will be investigated again during the next flight.

X-24B
POST FLIGHT EVALUATION
OF DIRECTIONAL MISTRIM
FLT B-1-3

—— GROUND FLT. DATA
--- SIMULATOR DATA



14 AUG 73

Tip Fin Flow Separation

R. Hoey

The characteristics of the right upper rudder hinge moment changed abruptly several times during the flight between a smooth, steady value and an irregular, erratic value. This same characteristic was observed on early X-24A flights and was found to be associated with a local flow separation or vortex impingement on the inboard fin and rudder. The flow separation was apparent to the pilot as buffet and occurred only on the right hand fin and rudder. (This is probably related to the 1° steady state right sideslip which existed throughout most of the flight.) Analysis of the Mach number and angle of attack where flow separation occurred indicated that the boundary was essentially the same as for the X-24A. Handling qualities were not affected by the tip fin flow separation.

X-24B R/H TIP FIN STALL

FLT. B-1-3

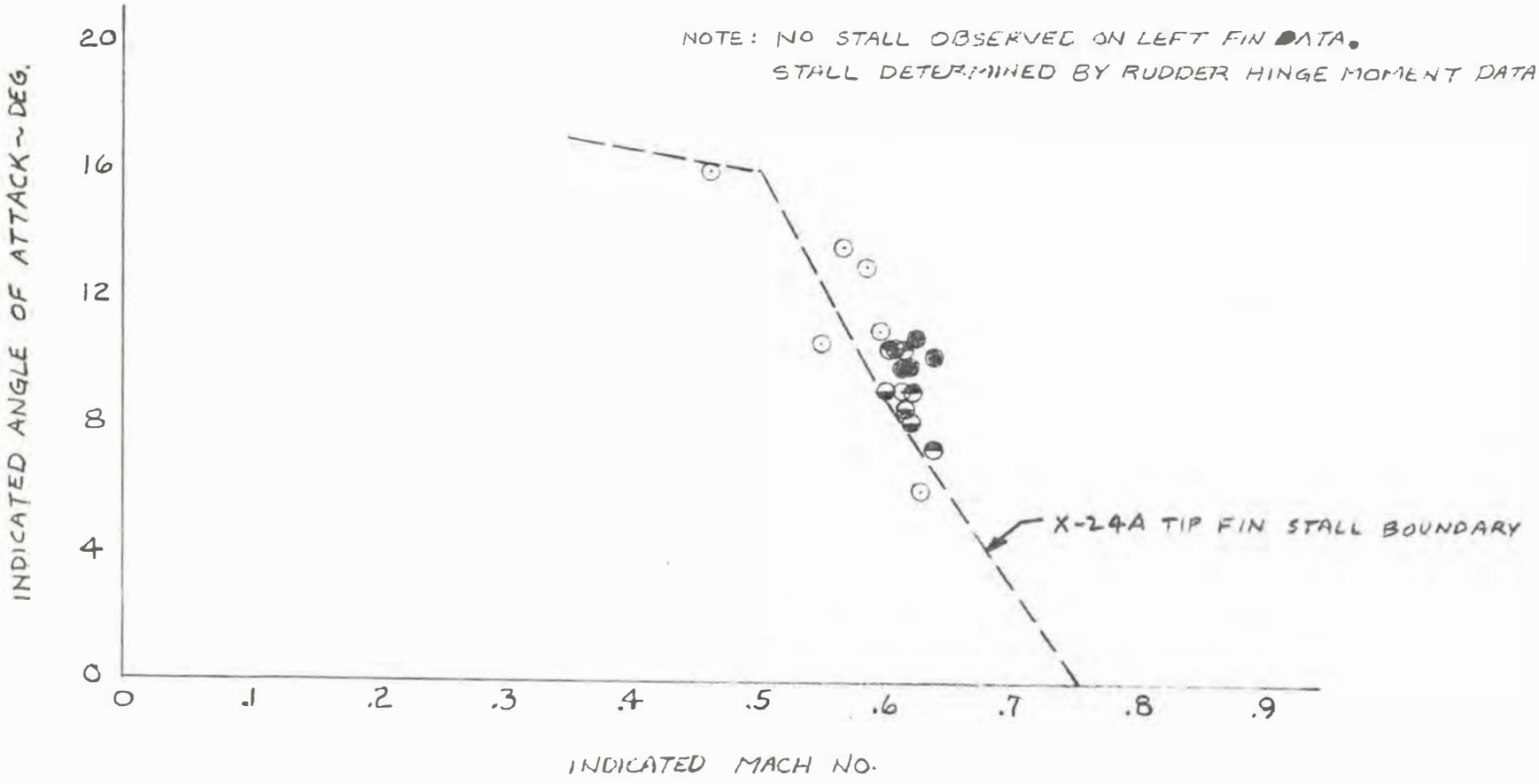
20° UPPER FLAP

○ UNSTALLED FIN

● STALLED FIN

◐ STALL BOUNDARY

NOTE: NO STALL OBSERVED ON LEFT FIN DATA.
STALL DETERMINED BY RUDDER HINGE MOMENT DATA

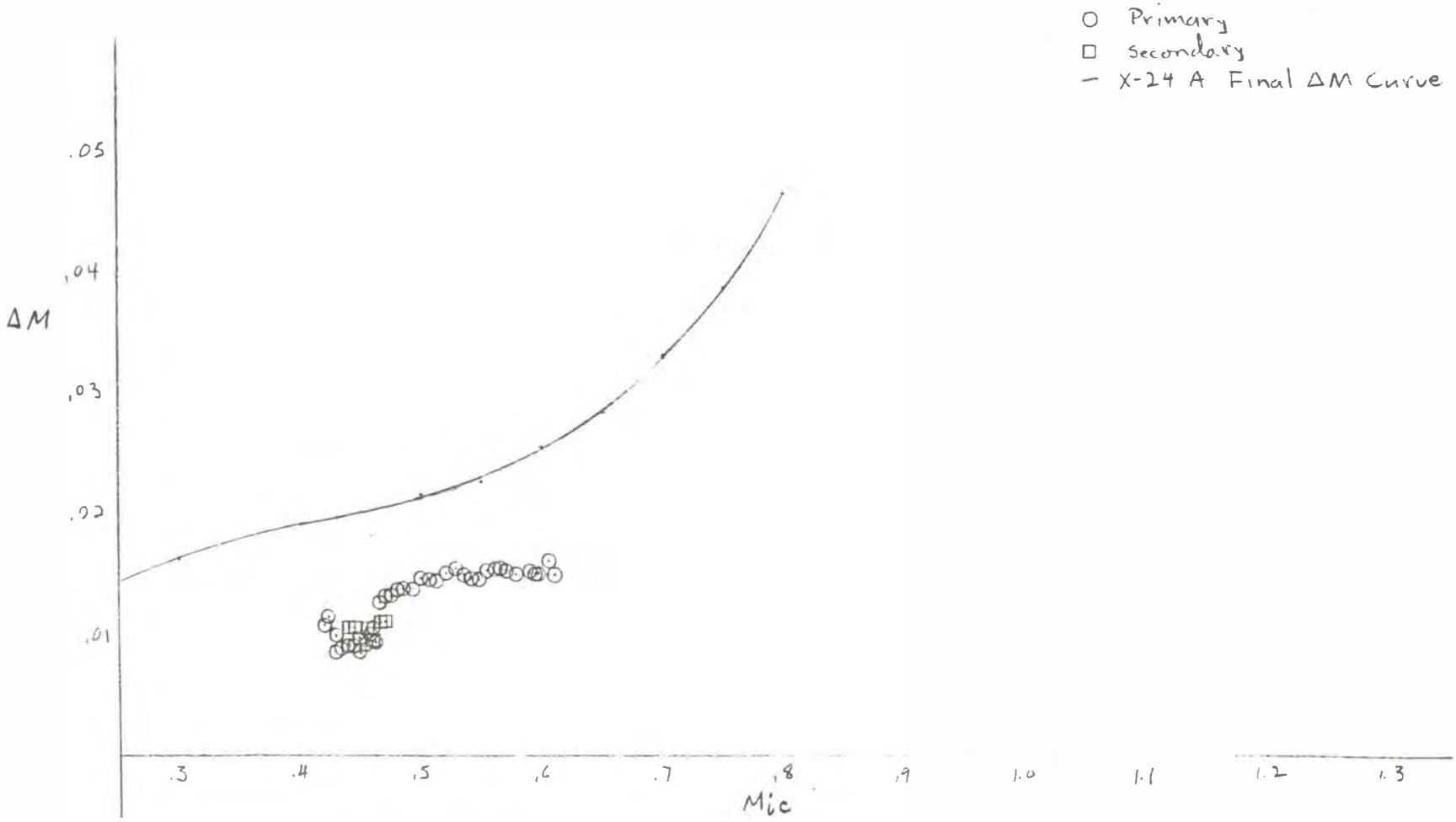


X-24B POSITION ERROR

C. Nagy

X-24B position error data for B-1-3 was obtained in the same manner as for the "A" vehicle. "Primary" data was obtained at $V_z < 150$ ft/sec during the practice flare. "Secondary" data was obtained at $V_z < 150$ ft/sec during the approach. The approach data is generally not as good since radar tracking often breaks down here. Some other points at $V_z > 150$ ft/sec were obtained but the results did not fit in well with the rest of the data. The position error curve at $M < .6$ for the X-24B is seen to be approximately 2/3 of the X-24A. This is consistent with the longer nose and gradual fairing of the X-24B vehicle.

X-24B
Position Error
B-1-3



CJN 13 August 73

B-1C-1; B-1-2; B-1-3 FLIGHT LOADS

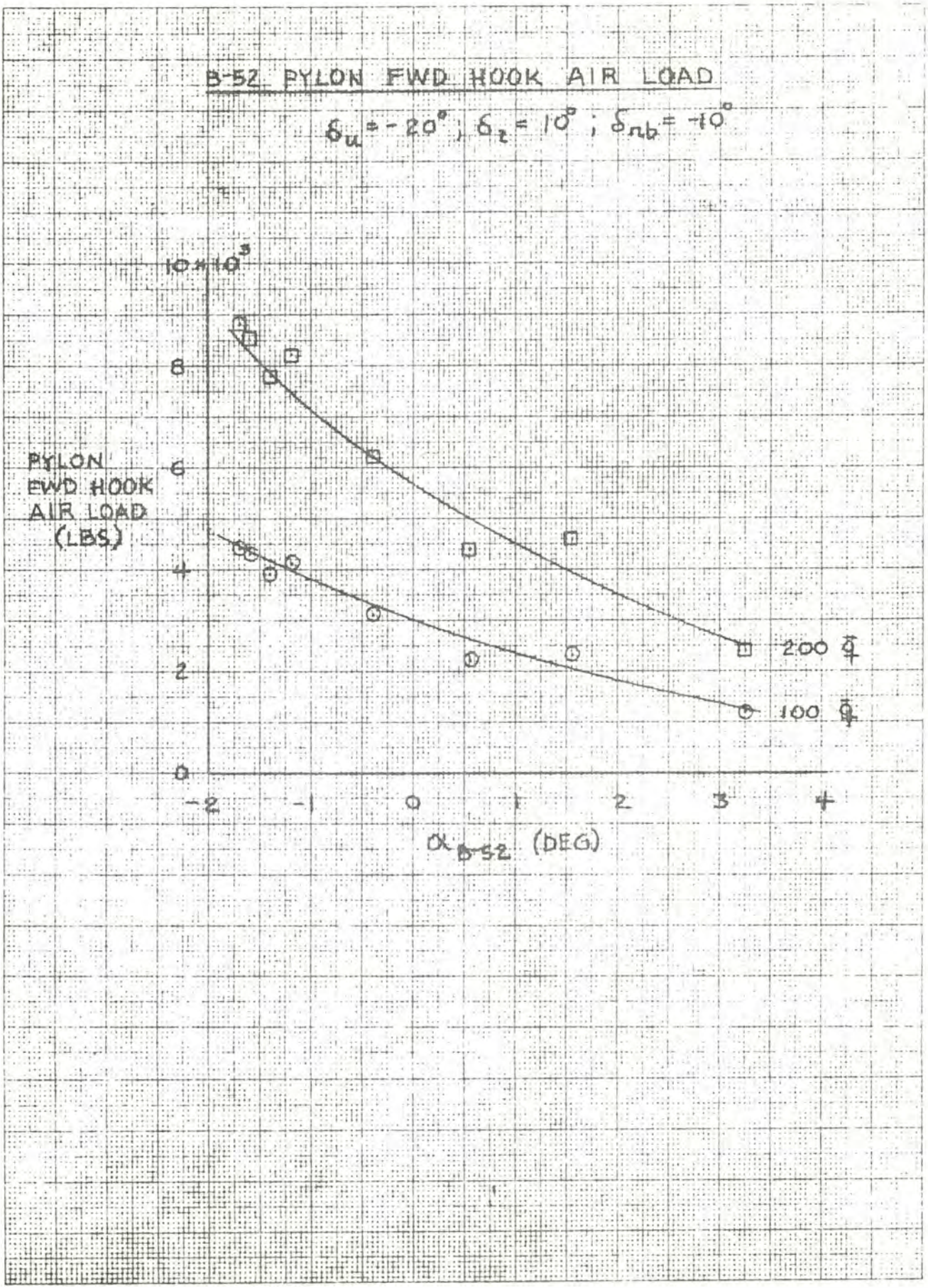
M. Tang

CAPTIVE HOOK LOADS:

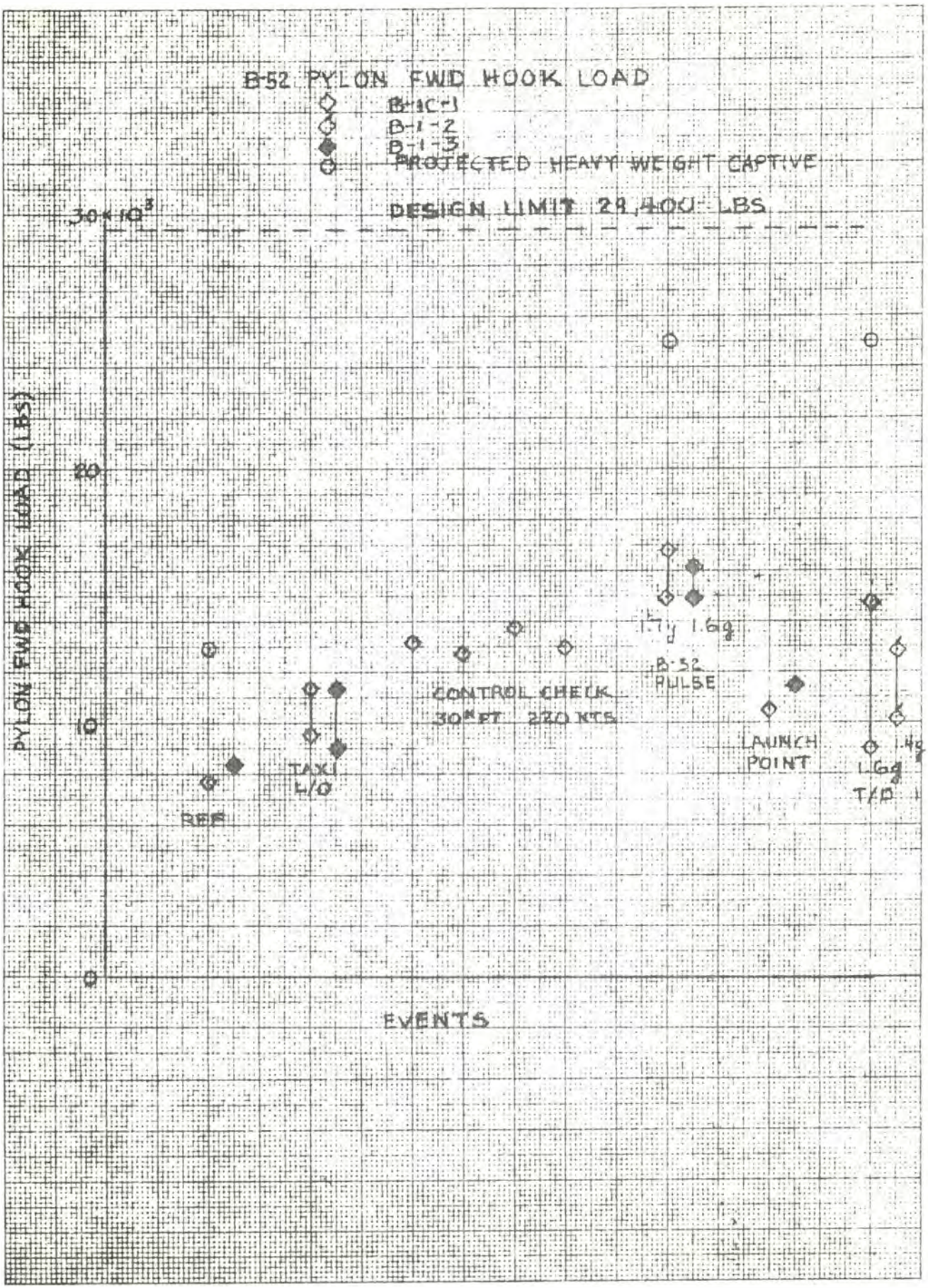
B-52 Pylon forward hook, X-24B forward hook and aft hook loads were measured during the three captive flights. The hook loads indicate that for lightweight B-52/X-24B captive flights, all hook loads will be lower than design limit loads.

CONTROL SURFACE HINGEMOMENTS & FIN LOADS

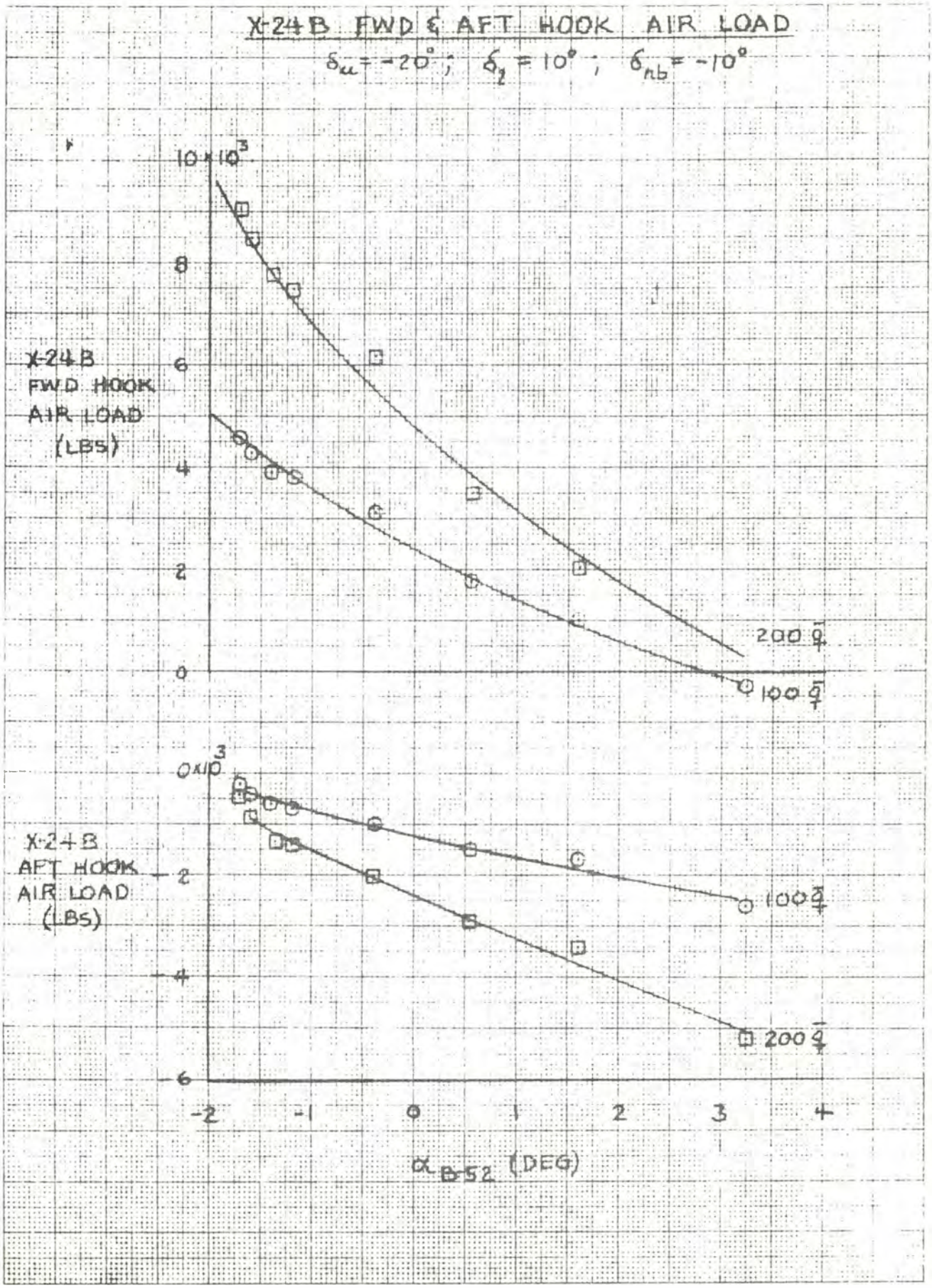
The ten control surfaces & the left fin strain gage loads instrumentation and the pressure transducers were operational during B-1-3. Preliminary analysis of the flight loads show reasonable correlation between the flight and the wind tunnel values; and that for the proposed flight envelope during the glide flight, all the control surface and fin loads will be well within the design limit loads.



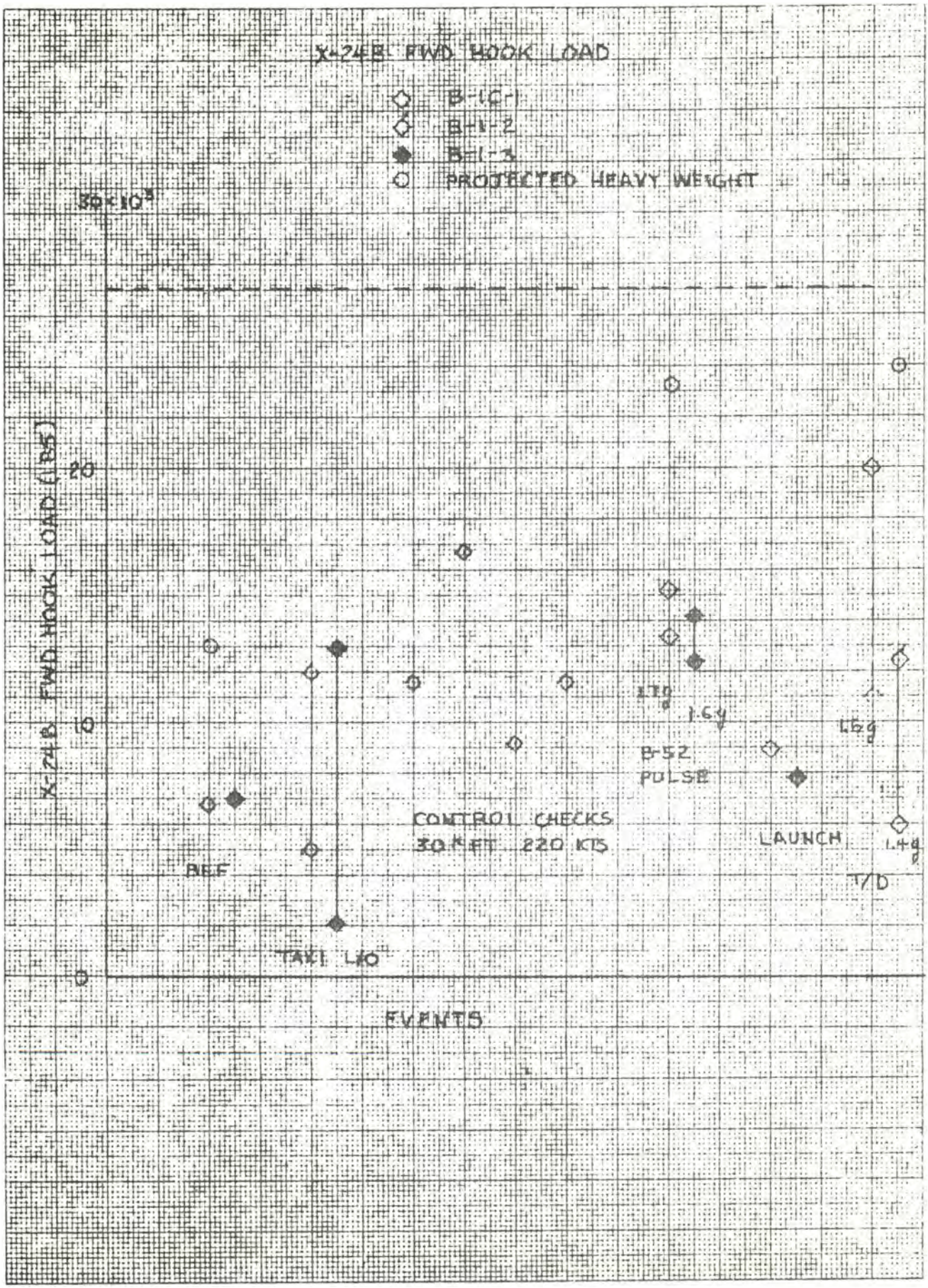
K+E 10 X 10 TO THE CENTIMETER 46 1513
KEUFFEL & ESSER CO.



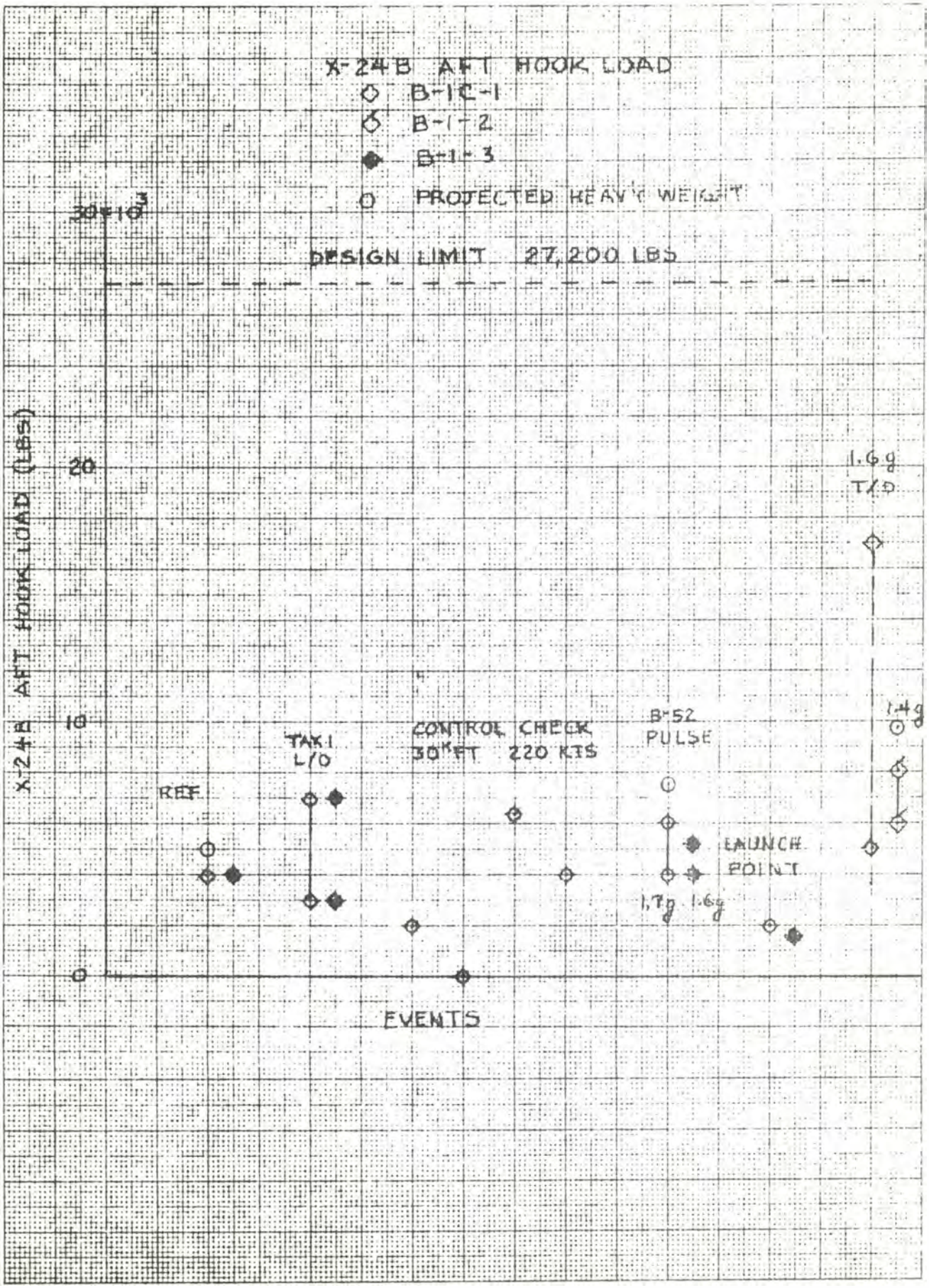
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM
MADE IN U.S.A.
KEUFFEL & ESSER CO.



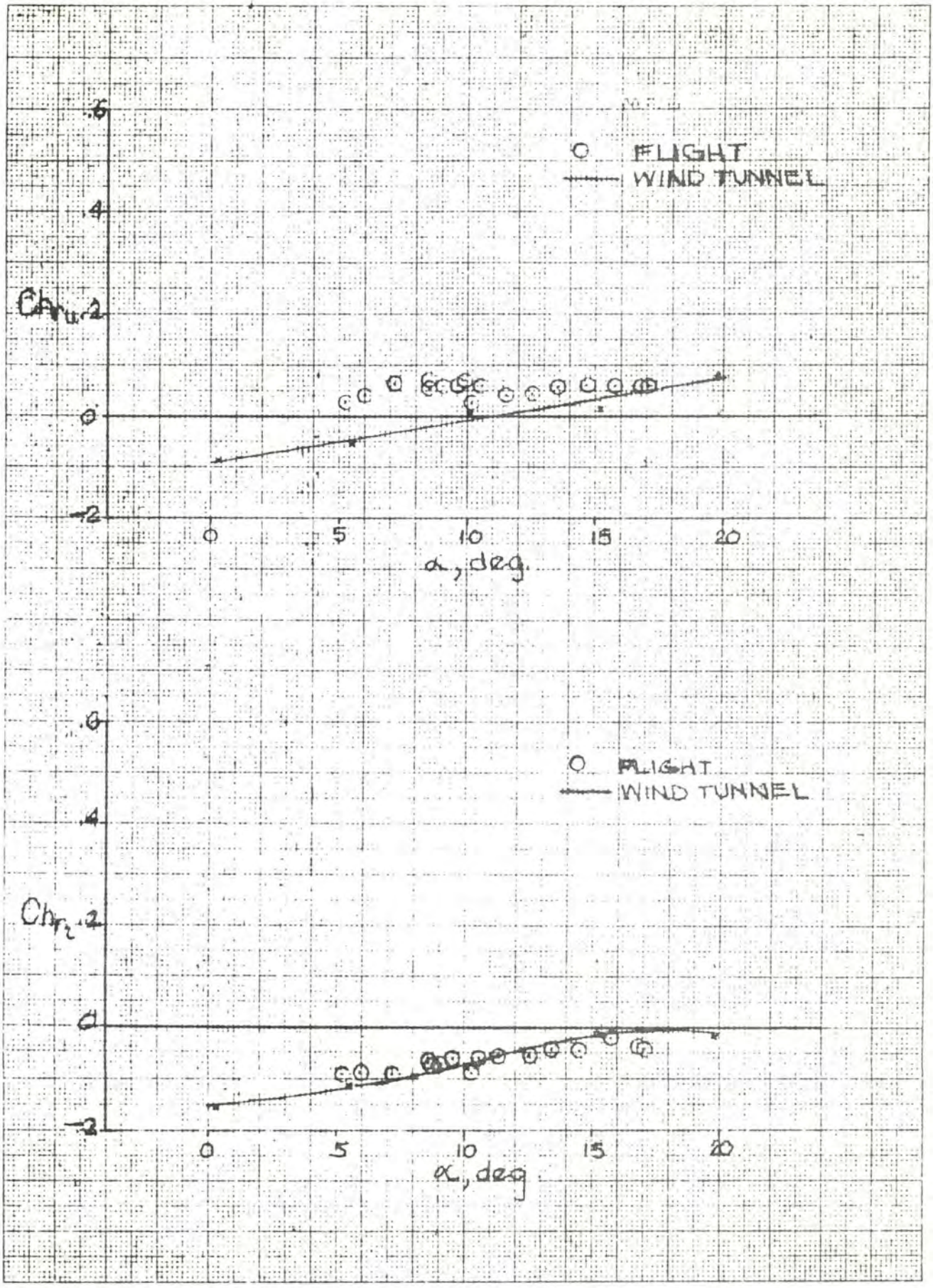
K&E 10 X 10 TO THE CENTIMETER 46 1513
KEUFFEL & ESSER CO



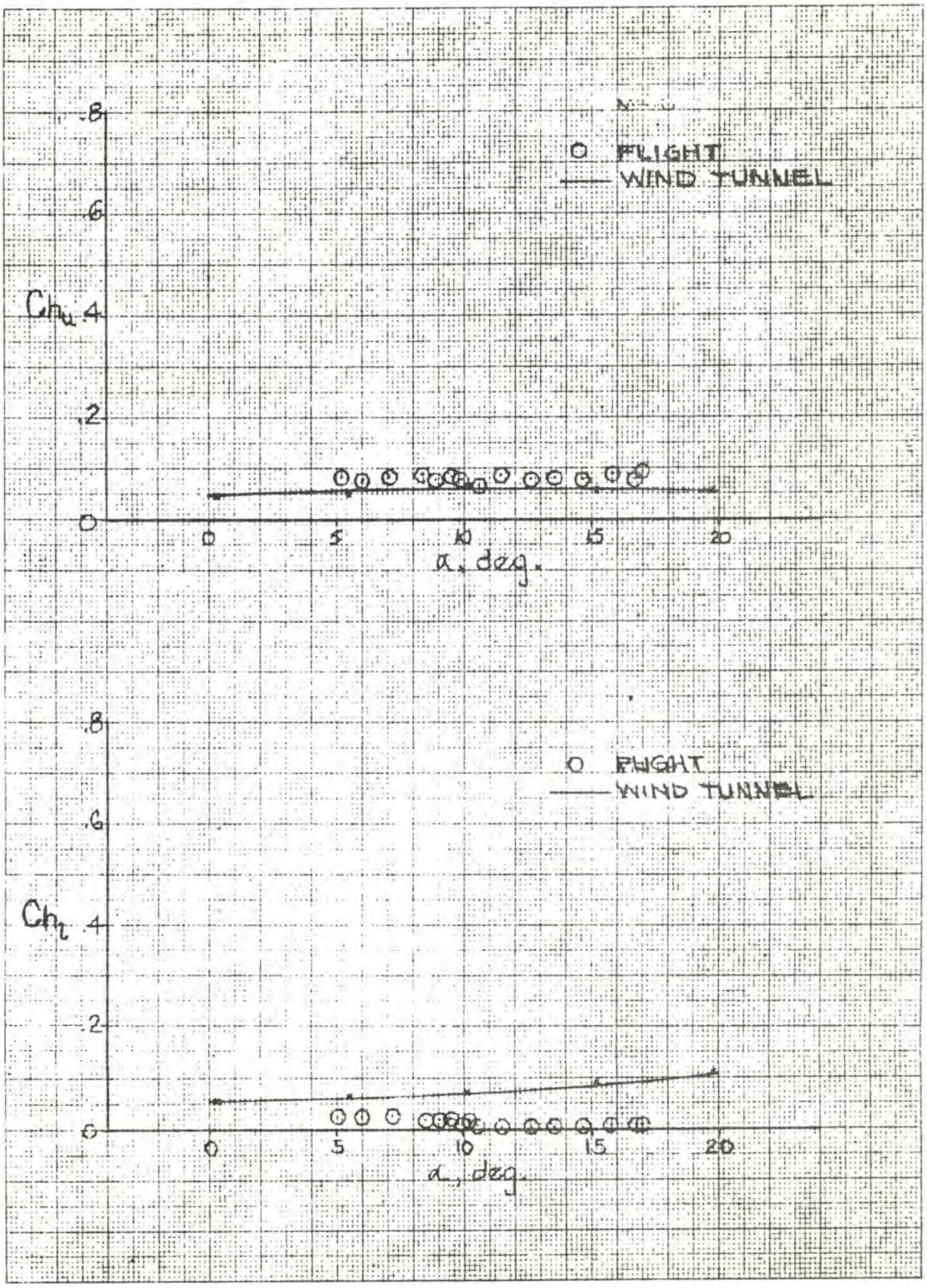
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM
MADE IN U.S.A.
KEUFFEL & ESSER CO.

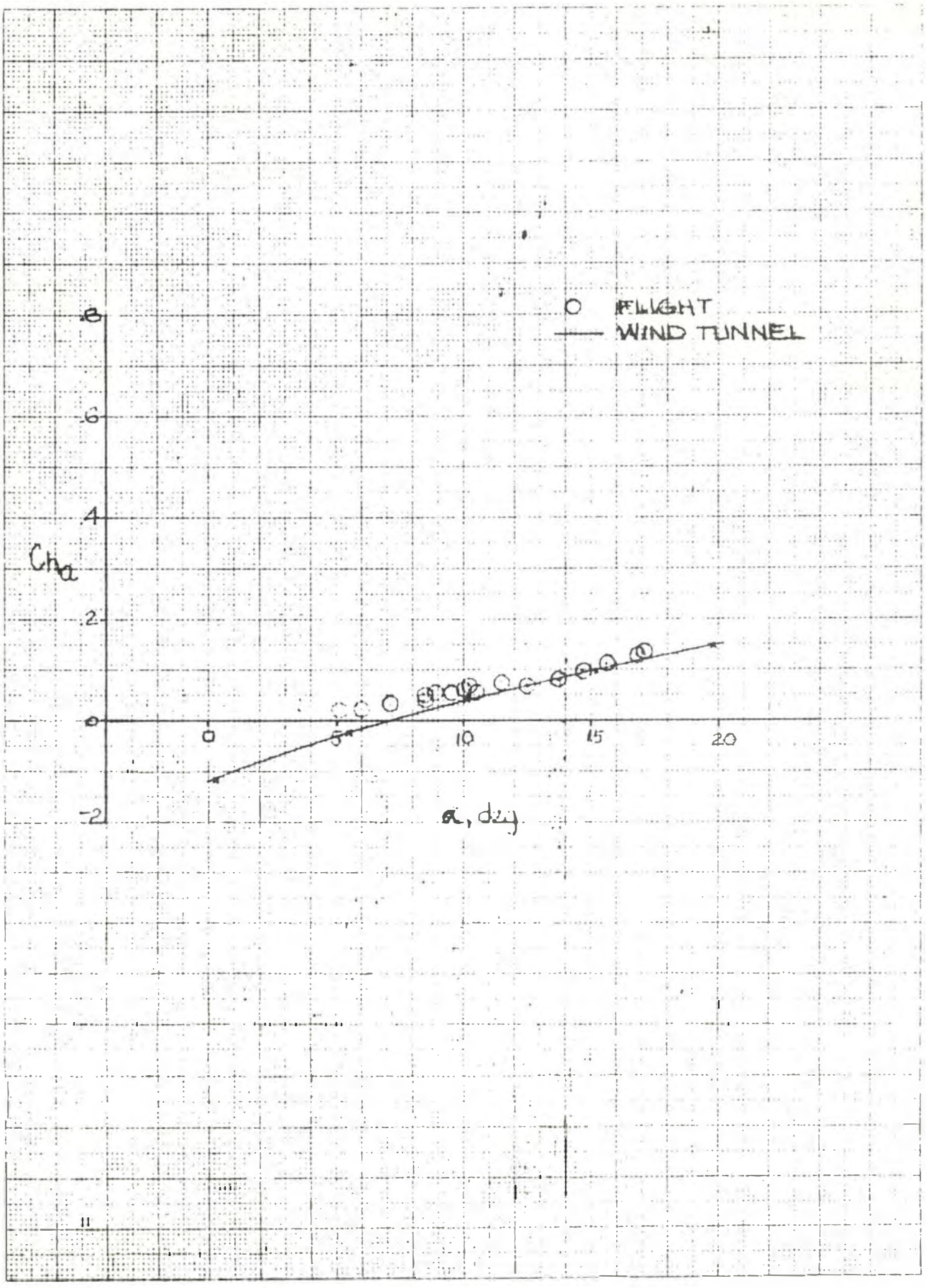


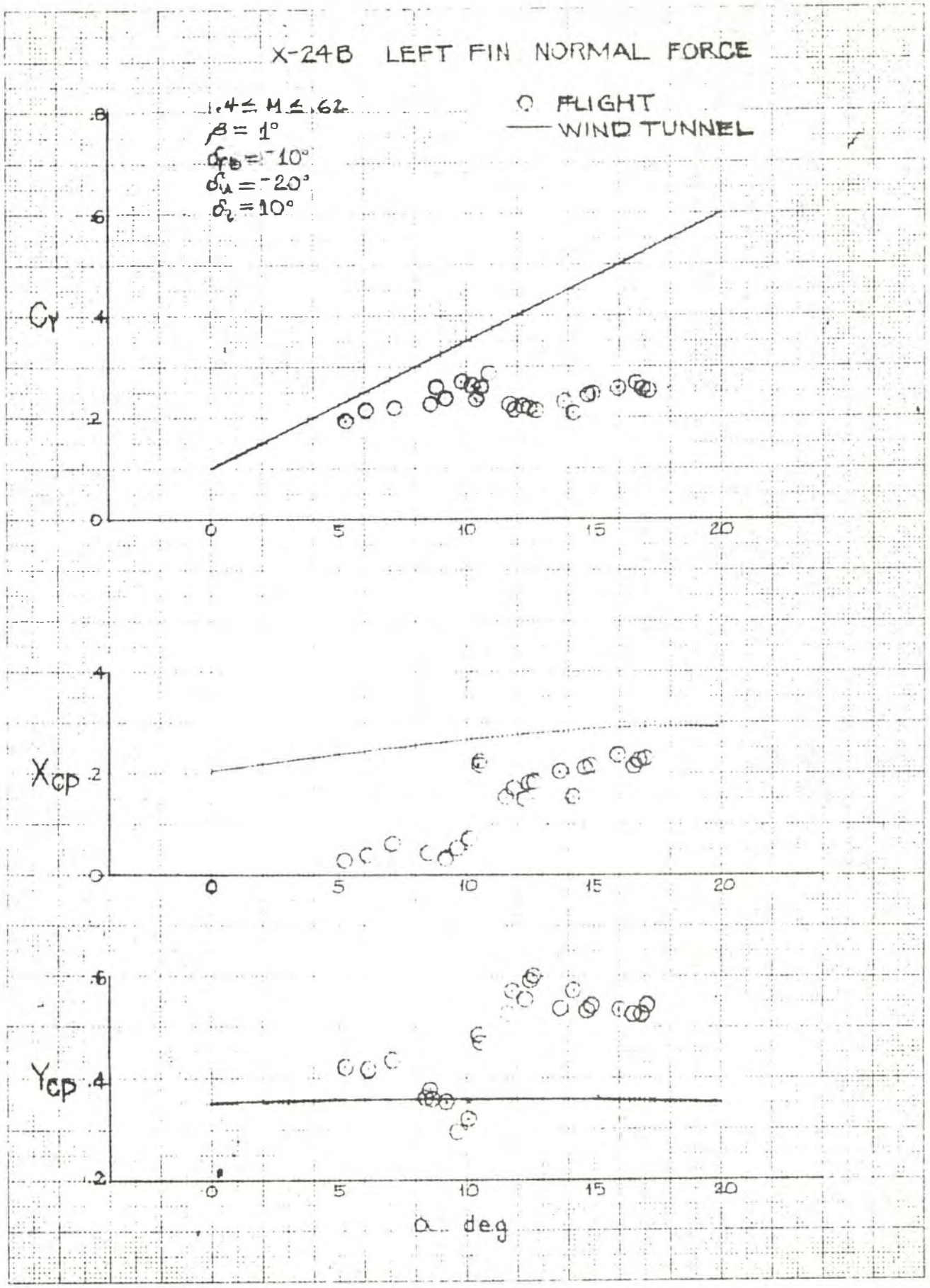
K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM
KEUFFEL & ESSER CO.



KEUFFEL & ESSER CO.


.8
.6
Ch_α .4
.2
0
FLIGHT
WIND TUNNEL
0
5
10
15
20
α, deg.
.8
.6
Ch_i .4
.2
0
FLIGHT
WIND TUNNEL
0
5
10
15
20
α, deg.


FLIGHT
WIND TUNNEL
.8
.6
.4
C_{h_α}
.2
0
-.2
0
5
10
15
20
α, deg

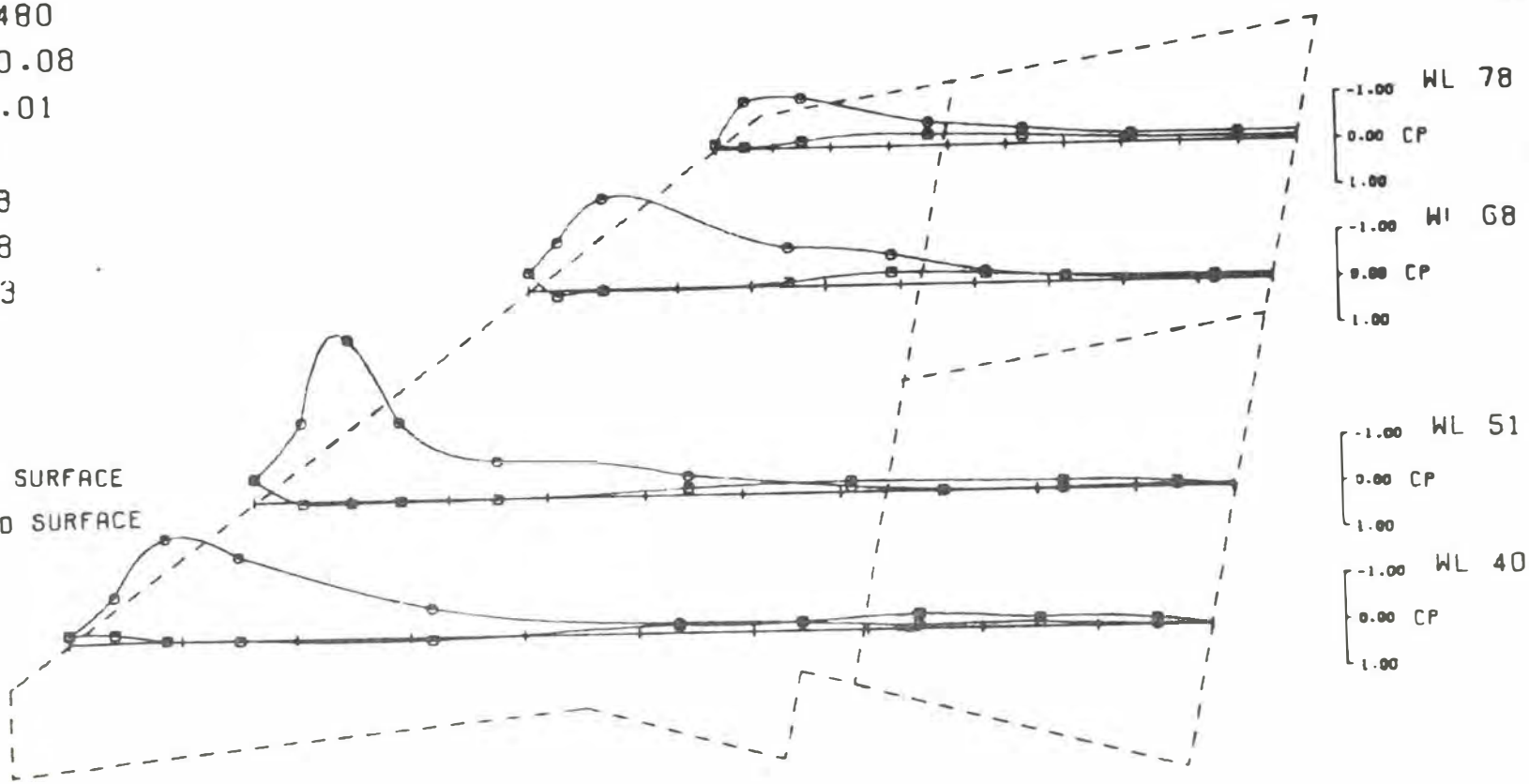

X-24B LEFT FIN NORMAL FORCE
.4 ≤ M ≤ .62
β = 1°
δrb = -10°
δu = -20°
δl = 10°
FLIGHT
WIND TUNNEL
Cy
Xcp
Ycp
α deg
0
5
10
15
20
.2
.4
.6
.8

X-24B CHORDWISE FIN PRESSURES

FLIGHT B-1-3 TIME 07-56-00-033

MACH= 0.480
ALPHA= 10.08
BETA= -1.01
Q= 130.5
D_{RU}= -7.8
D_{RL}= -9.8
D_U= -20.3
D_L= 8.3
D_A= 8.6

⊙ INBOARD SURFACE
⊡ OUTBOARD SURFACE

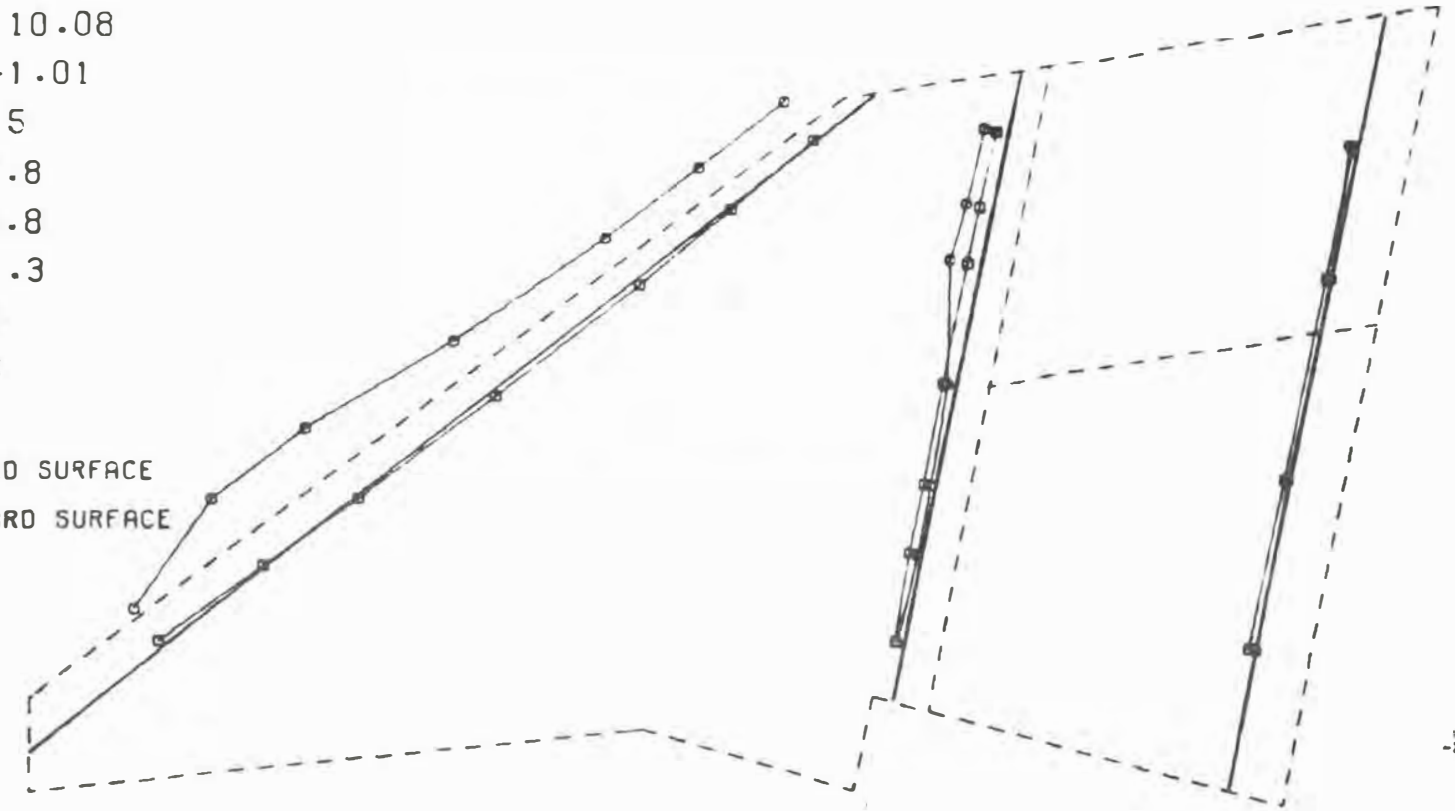


X-24B SPANWISE FIN PRESSURES

FLIGHT B-1-3 TIME 07-56-00-033

MACH= 0.480
ALPHA= 10.08
BETA= -1.01
Q= 130.5
D_{RU}= -7.8
D_{RL}= -9.8
D_U= -20.3
D_L= 8.3
D_A= 8.6

① INBOARD SURFACE
② OUTBOARD SURFACE



SCALE

-2.00 0.00 2.00
CP

Flare and Landing

D. Richardson

Figure 7 is a summary of the flare and landing. The pilots, drawing on their previous experience, say that the optimum time from flare initiation to touchdown is 24 seconds. This time interval for the first flare with the X-24B was more than adequate. The landing roll distance was about 2,000 feet less than that of the X-24A for the same touchdown airspeed. This is due to the fact that the X-24B ground attitude is -3° which results in a considerable negative lift force during roll-out.

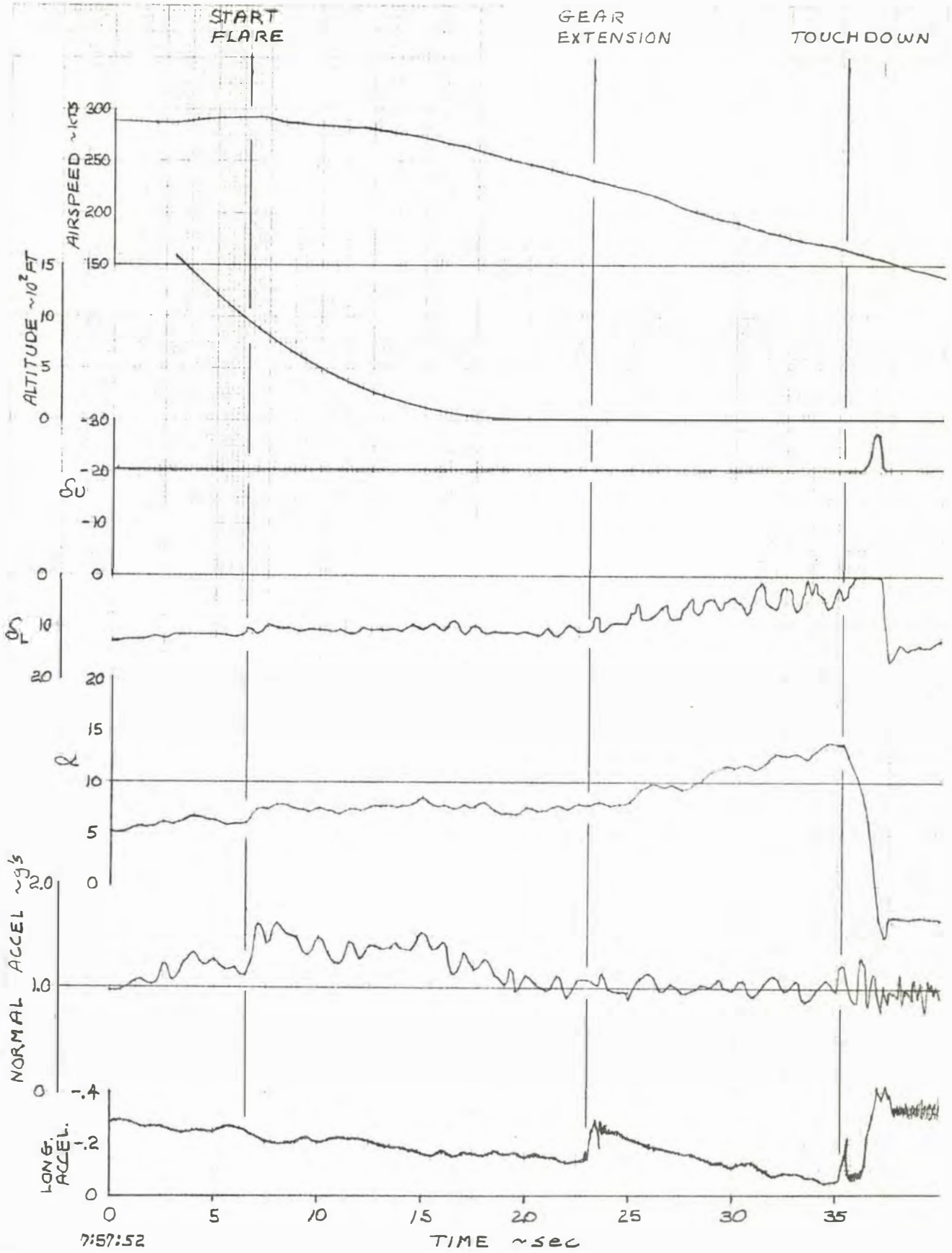
Figure 8 is a time history of the flare and landing. It illustrates that the flare was a constant angle of attack flare with a maximum normal acceleration of 1.5 g's. Pitch control did not crossover from the lower flaps to the upper flaps until after touchdown. The nose gear came down 1.6 seconds after main gear touchdown which was expected since there is very little capability to hold the nose off once the main gear touches down.

The pilot did not notice any visibility problems with the long nose and high angle of attack at touchdown. He commented that he was looking over the side and did not recall being aware of the nose up in front of him.

X-24B FIRST FLIGHT FLARE AND LANDING SUMMARY

Flare Initiation Airspeed	293 KIAS
Flare Initiation Altitude	950 Ft AGL
Gear Extension Airspeed	233 KIAS
Touchdown Airspeed	164 KIAS
Touchdown Angle of Attack	13.7 Deg
Time from Flare Initiation to Touchdown	28.7 Sec
Time from Gear Extension to Touchdown	12.2 Sec
Landing Roll Distance (No Braking)	6,864 Ft

FIRST FLIGHT FLARE and LANDING



Landing Loads

R. Hoey

A preliminary analysis of the landing loads from the first flight was received from AFFDL by telephone and is shown in the following table. The touchdown sink rate was quite low (1.7 fps) and landing loads were well below either the design values or the values measured during the drop tests. The trends in the data were similar to the predicted characteristics shown with the AFFDL landing computer program.

X-24B 1ST FLT. LANDING LOADS
(PRELIMINARY)

LOAD ~ LBS.

	VERT. R. MAIN	VERT. L. MAIN	N.G. VERT.	N.G. DRAG
INITIAL CONTACT	1000	1500	—	—
MAX. VALUE	6000	7200	4800	—
MAX. COMBINED	—	—	4400	2700
MAX GRND TEST	8050	8050	11,600	6500
DESIGN COMBINED	10,000	10,000	14,000	8400

ELECTRICAL LOADS

J. Armstrong

The following table presents a comparison of the electrical loads experienced during the first X-24B flight, with Flight 7 of the X-24A. The battery/hydraulic pump setup was the same for both flights--that is, two batteries powering four hydraulic pumps. During pre-launch, the current level was basically the same for both flights. However, the bus voltage for the "B" is apparently two volts less than the "A". During transient maneuvers, such as control pulses, the current increase and voltage decrease appear to be about the same for both flights.

For the "A", this load was considered high for a longer duration powered flight and eventually the initial portion of the "A" powered flight (to low key) was flown with only two hydraulic pumps operating to conserve battery power. It may be desirable to consider this approach for the X-24B.

X-24B & A ELECTRICAL LOAD COMPARISON

		FLT. X-7-11	FLT. B-1-3
PRE-LAUNCH	#1 VOLT	26.2	24.0
	#2 VOLT	26 2	24.0
	#1 AMP	180	190
	#2 AMP	174	170
TRANSIENT MANEUV.	#1 VOLT	22	20
	#2 VOLT	22	20
	#1 AMP	300+	330
	#2 AMP	300+	320

X-24B TECHNICAL DEBRIEFING

Flight Number: B-1-3 1 August 1973
Pilot: John Manke

1. Describe the launch transient and compare to other launch vehicles.

   Well, as I mentioned at the post-flight debriefing this was the mildest launch I have ever had in a lifting body. I guess that pretty much describes it. I don't guess we got more than 10 degrees bank angle out of it, if we got that much. It wasn't a problem; I wasn't concerned with roll at all. I felt like I came off the airplane and I was flying almost immediately. In addition to the very mild roll and yaw transients, the pitch transient was very mild too. You always expect to have everything fall out from under you for a second or two and this airplane felt like I came off the bomber and the airplane was flying.

2. Rate the recovery from the launch transient.

   I will rate the roll and yaw first and since there was no problem at all, the recovery didn't take any intentional action on my part. It was just apparently put in what we needed to come level so those would have to be rated 2 or 2 1/2. Now, on the pitch, I don't think there was a launch transient, but in the whole recovery itself you are involved with the transient plus the trim alpha and it turned out that I had expected to be trimmed at 8 degrees alpha and in fact we were trimmed somewhat higher than that. So I guess this question 2 and question 3 sort of combine together. When we rate the pitch, we have to keep in mind that I am rating it now with what I had expected to see on the airplane and on the next flight why the rating may change considerably because we'll know what to expect. I'd rate the pitch at 3 1/2 and that's only because it was different than I had expected.

3. Discuss and rate the task to achieve 10 degrees α after launch.

Pitch
The task to achieve 10 degrees alpha after launch in pitch was different than I had expected because we were trimmed higher. I was able to trim to the 10 degrees alpha but I was a little surprised that this airplane seemed a little bit looser in pitch than the simulator had indicated, not nearly as loose in pitch as the M2, mind you. The M2 required continuous pilot attention on pitch. This one here just appeared like it didn't want to really settle down on 10 degrees alpha; the nose kept drifting up a little bit and I'm sure you will find some forward trim going in to keep it down. I might mention that up in the 10 degrees alpha area, there was a noticeable buffet in the airplane; nothing like a F-104 buffet when you pull it back hard with takeoff flaps up or with flaps up, but it was noticeable, and it seemed to be a function of angle of attack, and it seemed to occur by about 9 degrees alpha and from there on up. I wasn't terribly concerned about it. I guess it was just there and I made a note to mention the thing, but I would guess that is part of the trim problem. Part of my problem trimming the 10 degrees alpha was the fact that we were getting buffet or airflow was breaking down at the back end of the airplane.

4. Discuss any out of trim conditions that existed after launch and what, if any, action you took.

OK, the out of trim, we talked about the out of trim in pitch which really isn't an out of trim. It was just a miscalculation on our part. The out of trim that is significant was I saw somewhere between 2 1/2 and 4 degrees on the needle left side slip. The first action I took was to try the rudder to see if it would come back in and see if the airplane felt solid. It was very much implanted in my mind the failure you guys had given me yesterday on the simulator where we reduced our $C_{n_{beta}}$ and $C_{L_{beta}}$. So, my first thought was I might have to get the upper flaps out if things didn't behave properly when I tried the rudder, but the airplane responded quite well with the left rudder so at that point I started trimming the rudder force out. Now, as I remember I trimmed the needle back, probably to

within a half of a degree of center. I still think I had a little bit of needle left when I finished trimming it; during the latter part of the trimming action, I started getting a little aileron out of trim so I had to, in addition to the yaw trim, trim a little bit on the aileron (right). OK, this all took a lot of time and I realized I was getting behind on the flight plan, so at that point the airplane looked good enough to me and I just forgot about the trim. OK, and if I was out of trim at that point I was out of trim for the rest of the flight and that's the reason a guy just can't spend a lot of time doing that sort of stuff. You have to take something that looks reasonable to you and then get on with the program and that's what I did.

5. Describe the roll response you observed after launch and compare with simulator.

OK, it's as good or better than the simulator on the roll response. The roll response as I recall was very good for the whole flight. It's better as I got down and got the airspeed up a little bit as the simulator indicates, but just from a harmony standpoint a stick force and everything else I prefer the airplane to the simulator in the roll axis. The roll rating 2 1/2, it's a superduper airplane in roll, at least it was on this flight.

6. Discuss the lateral-directional damping you observed at this point.

OK, well, the only thing I had to look at that I could get any feel for damping was on the rudder kick and I was satisfied that it was well damped and probably compared very favorably with the simulator. I didn't give you the rudder kick that I gave you in the simulator and the reason I didn't because I still wasn't convinced that I was absolutely in trim and I didn't want to drive in too far so it was a milder rudder kick than I hoped that I gave you.

7. Compare the vehicle's response to the rudder and aileron doublet with the simulator.

OK, that's a difficult one to do because there is no motion in the simulator other than the beta needle.

OK, I guess I would say that it compared very much to it. You don't get much vehicle response, you know with an aileron doublet, it's all over with before the vehicle has time to react and I think we probably saw that in the airplane just like you see it in the simulator. Rudder response was very much like in the simulator although I had been booting more rudder in the simulator.

8. Compare the vehicle's response to the pitch pulse with the simulator.

OK, that looked very much like I had seen in the simulator. The airplane is well damped in pitch. Do we have the records? I would like to look at them after; we don't have to now; I'd like to look at that. I got the impression it was darn well damped in pitch. Did you see that? It just looked like the nose went down and I let go of the stick and it came back up and that was all there was to it and if you ask me how many cycles why it would probably be less than one cycle that I could even see from the cockpit.
The question was, did I feel much force in the cockpit? I didn't feel a lot of force in the cockpit, and I didn't even feel those 2 1/2 or 3 degrees of sideslip that we had, that didn't reach right out and bang me in the face and say you got a lot of sideslip in, so apparently the side forces are rather low.

9. Discuss the practice approach. Describe the roll control at 5 degrees alpha with the Mach repeater at .3.

OK, the practice approach was much like the simulator. I started at 32,000 feet and I had about 235 knots when I started; that was very much like the simulator. I was really pleased with that. I went to 8 degrees alpha first and did some rolls, there 5 degrees alpha Mach repeater at .3, here again I knew right then that we had a nice rolling airplane. I was really tickled to death with it because that's the place where I had my first good look at what it was going to be like in the pattern from a roll standpoint and I liked what I saw, a very positive control and just about the right roll

rate for stick deflection. (Was the roll response difference between 1.1 and .3 Mach repeater setting obvious to you?) No, it was not obvious I couldn't sort that out of the thing, although I don't think we were very long at 1.1 on the Mach repeater at 5 alpha but it wasn't even obvious when I went to 10 degrees alpha. I think the only way to see this is to study the beta needle while you are doing these things. OK, on the practice flare in the pitch end of it why most of the pitch control was done through the trim button I normally do most of my pitch work with the trim button except in the pattern. So, if I recall correctly, I didn't have any problems getting to an alpha or staying on the alpha so I think we were back down now to where Mach number was reasonable and I didn't have this little bit of hunting in pitch and here again I'll have to look at that to verify that.

Rating in pitch 3.

The rating in roll and yaw doesn't mean much in here because I wasn't doing anything. Well, I was, I won't rate yaw because I didn't pay any attention to yaw. Roll 2 1/2 and I will not rate yaw.

10. Describe the practice flare and roll control at 10 degrees alpha.

OK, I trimmed it back to 10° alpha and I guess I had used a little hand force on it too because I let loose of it and it dropped down to 9° a little bit so I came back on up to 10° with the trim. I did some roll maneuvers at that point mostly looking for that PIO thing that we had talked about so I used whatever horizon or cloud that I could find and did a little controlling on it and you couldn't see any tendency at all for a PIO bit there. It felt like a real super airplane at that particular point and I guess from that point on I just forgot about this PIO problem because I was convinced at that point that we weren't going to have any problem.

11. Compare the pushover-pullup with the simulator. Did you note any characteristics that may have lead you

to conclude you crossed over from the lower to upper flaps? Did you feel any stick shaker operation? Any lateral asymmetry with alpha? Any buffet?

OK, very much like the simulator except here you get a lot of nose motion with the airplane that you don't get in the simulator and that's always the biggest difference between the pushover-pullup and a simulator in the airplane is that vehicle motion because it goes through a hell of a sweep when you do the pushover-pullup. I fully expected to see buffet on this thing because I had buffet before and I got all the way up to 15° alpha and I hadn't buffeted and I didn't really understand that but I guess because the Mach was down I had been at 10 degrees for quite awhile. We had slowed up I guess we were down to 200 knots indicated when I did the pushover-pullup, somewhere in that ballpark. So, the Mach number must have been down to .5 or just a little above that it was probably about .5. So the buffet was gone there wherever that was and I think that's a good point to look at because we had had buffet before in that practice flare as you reminded me at 10° alpha and yet just a few seconds later we didn't have any buffet at 15° alpha. No, I don't think we crossed over to the upper flaps. Did I feel any stick shaker operation? No, I did not. I did not notice any lateral asymmetry with alpha but that's the tough one because you unconsciously put in what you have to to keep the wings level and if there was any asymmetry, it wasn't a lot because it didn't really make an impression on me. I did not feel buffet; I answered that before. I thought I saw just a hair before 15° α but it was above 14° so I'd guess 14 3/4 or just a tad under 15 on the high point, and the low point was probably 2 1/4 or something like that. You sort of make a push for it and if you don't quite get it, you don't get it. You like to do it in one big motion so you watch the trend as it comes down and then back on up, you do the same thing coming up, so a guy can miss just a little bit but both of them were close. I guess that says quite a bit for the stick deflection per angle of attack because a guy bases his thing on a simulation and it felt very much like it had in the simulator to get down that far and back on up again.

12. Comment on your low key conditions.

High, in tight and a little difficult to see everything that one normally sees.

13. Discuss the turn to final. Performance.

This is going to be a difficult one because of the cloud cover and my starting point and the things that I had to do to get the airplane on the runway. We started high and in tight and we also had an east northeast wind today so all these things add up in the wrong direction and then to top it off, shortly after the turn was started we went into the clouds. I think a pilot's biggest fear of flying in the clouds in a turn like this is getting too deep. This is a thing that gets you right away. You say, gee I've got to keep the turn going because I get too deep and when I say deep, I mean a wide 90 degree position. If you get too deep, you just won't get back again, so you automatically put in a little bit more bank to keep the airplane in tight enough and as you would expect the thing that happened was I put a little bit more turn in than I would have wanted and when I broke out of the clouds why we were in close for the altitude we had and that we weren't in close as far as the flight plan goes but I was high on altitude and if I had been able to see all the way around, why I would have flown this pattern deeper than I did and that's the difference. So, at that point as soon as we could see that it was high, I ran the upper flaps out, I ran them all the way, pushed the nose down to pick up airspeed and it, God, it handled like a dream. Here, in pitch I don't recall any noticeable pitch change, but you know damn well that there was one but in this airplane when you put the flaps out the nose goes down just like you would like it to do. That's where you want it to go. This is what you are trying to do; you're trying to get the L/D down a little bit, the nose goes down and you can pick up a little speed. In addition to that, I flew the pattern just a little wider so that I could do a little S turn to get rid of some energy. Handling qualities in pitch were absolutely superb 2 1/2 and the same for roll. Yaw, I don't have any comments. I didn't do anything in yaw. (Were you aware of any motion of the nose?)

Not once did I ever notice the nose swinging around. I guess that concerned me a little bit too right after launch that I didn't see it swinging at all, so I didn't know whether I was statically starting to move out on me. I would have felt better if I could have seen it move a little bit but I didn't see it move. Now, bear in mind in the pattern, particularly the pattern like this, you're not looking directly at the nose at any particular time. One is looking back at the field and adjusting your airplane for that so you're never looking over the nose. So I wouldn't have seen anything there. Anyway, but you'd feel it if it was much and I didn't. Now back up a little bit, the largest amount of turbulence for the day was in that cloud and it was a pretty good jolt and I don't think I got any bank angle change to speak of, but here again I didn't have any outside reference and it felt to me like it was more of a seat-of-the-pants thing than anything else. Now, it's hard to relate the airplane motions because there wasn't a horizon or anything, I was on the gauges at that time but I would guess if there hadn't have been this seat-of-the-pants feeling, I probably wouldn't have recognized it because I don't recall any motions of the airplane. Maybe a little bit of directional bit but I don't think any rolling. The traces will call me a liar on that, but it wasn't anything that really came out and says, man, you really got a problem in turbulence; it felt real good.

14. Discuss the final approach.

OK, the first part of the final approach was flown at full upper flaps with 32 degrees upper flaps and it did just as I had hoped it would do, cut my L/D to hell and let us steepen up the glide and I went to 300 knots. I don't think we exceeded 300 knots indicated at that time (with 32 degrees upper flap). It appeared we were doing real well and just as it appeared that we were starting to fall a little bit low, Bill called me to remind me of the flaps and I think that was the best call of the day. It was very timely; I would have gotten them in probably, but I would have been a little bit late and his call came just at the right time and right after he called, I pulled the flaps in,

pulled the nose up a bit and the nose does come up by itself, I guess. It does on the simulator and it must have here because I didn't have any real noticeable problem putting the nose where I wanted to. As I mentioned to you before I have used the beginning of the dotted lines out there for my aim point on the glide and that's about a half a mile from the end of the runway. On the X-24A, I always use to use the end of the runway for the aim point. I also decided that if I could on the day of the first flight after I had established that aim point and if I were able to, I would let that aim point move back towards the end of the runway to give me a little bit more roll-out distance and with being a little bit late on the upper flaps, why that worked out great. I started out there at the dash lines and then let the aim point drop back probably to a quarter of a mile. Airspeed settled out on 290 knots and I was very happy with that. It flew nicely at 290. We aren't going to see a lot of steady-state stuff in here, because of the nature of that approach, part of it being flown on the uppers and then going to the lowers. So there was a lot of transitioning going on. I don't know whether that was good for data or not. I liked what I saw at 290, but I don't know if we'll get a true indication of what the real glide slope is at 290.

Handling qualities in pitch.
Here, again I just didn't have any problem with the airplane. OK, 2 1/2 in pitch and roll and I'll not rate the yaw. I guess when you don't rate the yaw that means that you haven't had any problems in it but I'm not controlling in yaw at that particular point.

What was maximum IAS?
With the upper flaps at 32°, it was 300 and with the upper flaps at 20°, about 290.

15. If turbulence was encountered, describe the vehicle's response and effect in piloting task.

I have already done that.

16. Did you note any PIO tendencies during the approach?

I did not notice any PIO tendencies during the approach. I didn't have any PIO tendencies at any time in the flight.

17. Did you note any limit cycle tendencies during the high speed approach?

I did not notice any limit cycle tendencies.

18. Describe the flare and rate the task.

Well, this will be a little bit different than our normal flares because the glide path angle had begun to change as soon as I retracted the flaps, why the glide path angle changed and it was probably one big continuous change from there on it. It was a very comfortable approach, when Gary called the 1,000 feet. Why there was no question that I had plenty to flare with, so I held it just a little bit longer and actually did the flare looking out of the airplane. I had looked at the altimeter going through a thousand and then just waited a little bit longer and did it just looking out the cockpit. (Did you make a conscious flare?) Yes, I did. Yes, I remember doing that now, just before I started I felt that we were nice and shallow and I said, gee, this should be no problem and I did make a distinct pull on the stick and I could actually feel the g there just a little bit and it felt good and the airplane responded nicely. I would rate the pitch 2 1/2 and the same with roll; it was no problem. I had a little heading change to make too. Just remember that I swung beyond the runway for energy management and then swung back in and lined it up with the runway and I touched down exactly where I wanted to between the lines. I wanted to touch down with the dotted line on my left and the right solid line on my right and probably closer to the dotted line than the other one and I was really pleased with where I touched down on the runway laterally. I had very good control of the airplane there.

19. Discuss trim change at gear deployment.

Trim change at gear deployment? I didn't notice any. Even the noise or the clang or the vibration

through the airplane seemed to be less on this one than I had experienced on the other airplanes. I don't know if that's good or bad but the clang and the bang feels good, normally like the feelum comes down good. This just wasn't that much of a sensation although Gary made a real quick call said they were 3 real good ones.

20. Did you note any handling qualities changes after gear deployment?

I did not notice any handling quality changes after gear deployment.

21. Did you note any PIO tendencies between gear down and touchdown?

I did not notice any PIO tendencies between gear down and touchdown and the only problem I had I guess was when Gary gave me the first altitude call. It seemed higher than I thought I was and that was a little bit of a surprise, but then once you remember that it's difficult for a chase pilot to call anything above 10 feet, it just becomes a real problem. He doesn't have any real good reference out there and he's busy with his airplane and I think his accuracy really comes from 10 feet on down but the first call lead me to believe that I was higher than I was and I was a little bit concerned then because I had almost leveled out at that point. Then just took me awhile to get the airplane down again but it sure handled beautifully and I was able to just ease it down slowly and I felt that when I touched down that I probably could tell at that point within one or two feet. I felt that I was probably within one or two feet when I did touch down so I think I had a pretty good idea of where it should be at touchdown.

22. Describe the vehicle's attitude and its effect on visibility during landing.

No, I didn't notice any visibility change between this and X-24A. Apparently, I'm landing the airplane out of the side and I don't even recall seeing the nose up on the horizon. You know we

did it in the hangar a few times and things like that, well the nose was probably up there, but I'm not looking up there so if you don't look there why it doesn't bother you. I'm looking right out over the side for depth perception and that's no problem.

23. Describe the vehicle's reaction at touchdown as it came to a three point attitude.

And it's just like we had mentioned once the main gear comes down, the nose falls through very rapidly, although I would guess that it didn't come through as fast as the X-15. I would guess that never having flown the X-15, Jack, I can't relate to that, but I was prepared for it to come through very rapidly and it probably didn't come quite as fast as I had prepared myself for but it still came through--no sweat. Yes, this is quicker than the M2. I would say, it came right on down and maybe the thing that gets you is the fact that it goes way down, not just down but way down and really the lakebed looks like it's just right underneath that pitot out there.

24. Describe the roll out after landing.

OK, the first thing that I noticed right after the nose gear came down was the rapid deceleration, apparently that negative lift on there and our rolling friction you can really feel it really start to decelerate. As soon as the nosewheel hit, it felt like I had had some braking action of some sort more so than the other airplanes. As soon as the nose gear touched down, I had no qualms about a long run out. I just knew there wasn't going to be a long run out.

Was nose gear steering used?

Nose gear steering was not used. I armed it; I had such good control of the airplane that coming through 15° I remembered we said we'd arm it at 100 and I couldn't see any point in waiting because the airplane was going so straight and no problems so I armed it probably at 120 or 130.

25. Discuss the overall energy management and profile control versus planned.

I have already discussed the overall energy management profile control versus the planned, any similarity is coincidental.

26. What changes would I like to consider before Flight 2?

Probably fewer clouds, I guess we have to look at the yaw trim thing more than anything else and I would guess that once we resolved that problem we can find that maybe we'll launch with just a little yaw trim in there or something like that.

FLIGHT 2

PRELIMINARY RESULTS OF X-24B

Flight B-2-4

17 August 1973

By

AF/NASA X-24B PROJECT TEAM

X-24B Flight Request
10 August 1973

Flight No: B-2-4

Scheduled Date: 17 August 1973

Pilot: John Manke

Purpose:
1. First Flight with 40° Upper Flaps
2. Longitudinal Trim Curve Verification
3. Lift and Drag Determination
4. Stability and Control Data
5. Fin and Rudder Pressure Survey
6. Landing Gear Dynamics

Launch: South Rogers Lakebed, Mag Heading 360° + Crosswind Correction Angle. 45,000 feet, 175 KIAS. Flap Bias "Manual", Upper Flaps = -40°, Lower Flaps = 20°, Rudder Bias Mode "AUTO", Rudder Bias = 0". Aileron Bias = 7°, Aileron Bias Circuit Breakers Pulled. SAS Gains 4,3,2. Mach Repeater "Manual" = 1.0, KRA "AUTO".

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #1

ITEM	TIME	ALT	A/S	α	Mn	Event
1	0	45	175	6	.66	Launch, Trim to 10°α, Check Yaw Trim Call α and β
2	26	40	190	10	.66	Perform Rudder and Aileron Doublets
3	38	37	210	10	.67	Perform Pitch Damper Off Pitch Pulse
4	48	34	220	10	.66	Perform Pushover-Pullup (2° to 16° to 12°α

ITEM	TIME	ALT	A/S	α	Mn	EVENT
5	63	30	215	12	.60	Change Configuration. 20° Upper Flap Bias (Hands Off)
6	73	28	215	9	.56	Pullup to 14°α, Perform Rudder and Aileron Doublets
7	85	27	190	14	.5	Pushover to 5°α, Perform Rudder and Aileron Doublets
8	99	26	195	5	.49	Pullup to 10°α, Perform Rudder and Aileron Doublets
9	138	22	200	10	.46	One Mile. Landing Rocket Check, LH Fin Camera On
10	153	21	195	10	.44	Low Key, Start Left Turn
11	214	10	270	9	.50	Pushover to ≈6°α to Accelerate to 300 Kts. Mach Repeater to .3.
12	250	3.3	300	6	.48	Start Flare α ≈ 10°
13	260	2.4	250	7	.42	Level, Gear Down Below 240 Kts
14	270	2.3	180	12	.3	Touchdown

NOTES:

1. Nose Ballast = 100 lb

	X-24B	Weight	cg
2.	Launch	8175 lb	65%
	Landing (with H_2O_2)	8175 lb	65%
	Landing (w/o H_2O_2)	7978 lb	64.6%
3.	Pylon Adapter	5020 lb	

GROUND RULES FOR NO LAUNCH

1. Angle of Attack Malfunction
2. Any Control System Malfunction
3. Any Landing Rocket Malfunction
4. Turbulence Below 10K in Excess of Light
5. Surface Winds 10 Kts Crosswinds/15 Kts Max

(In addition to standard ground rules published in Lifting Body Joint Operations Plan)

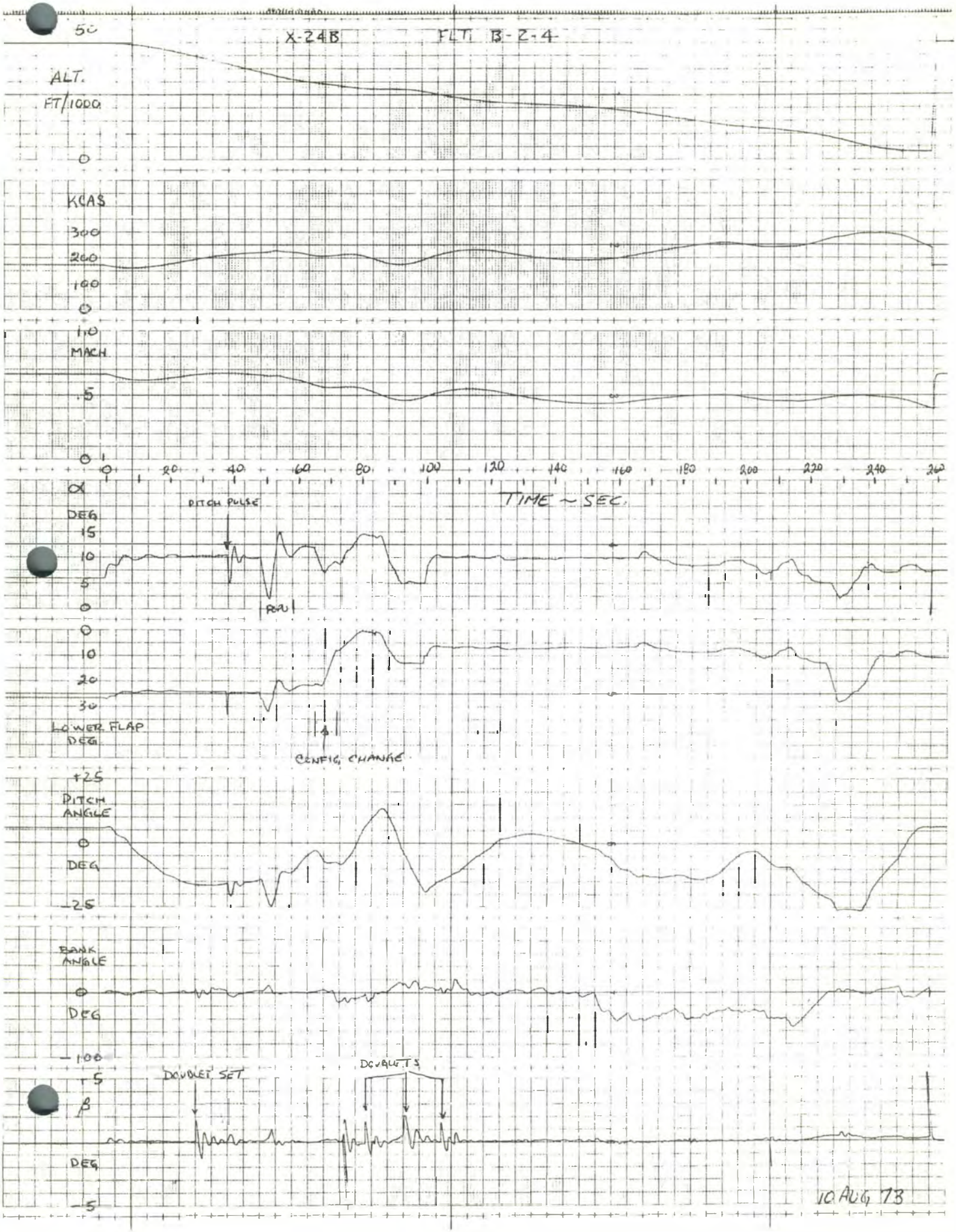
ALTERNATE SITUATIONS AFTER LAUNCH

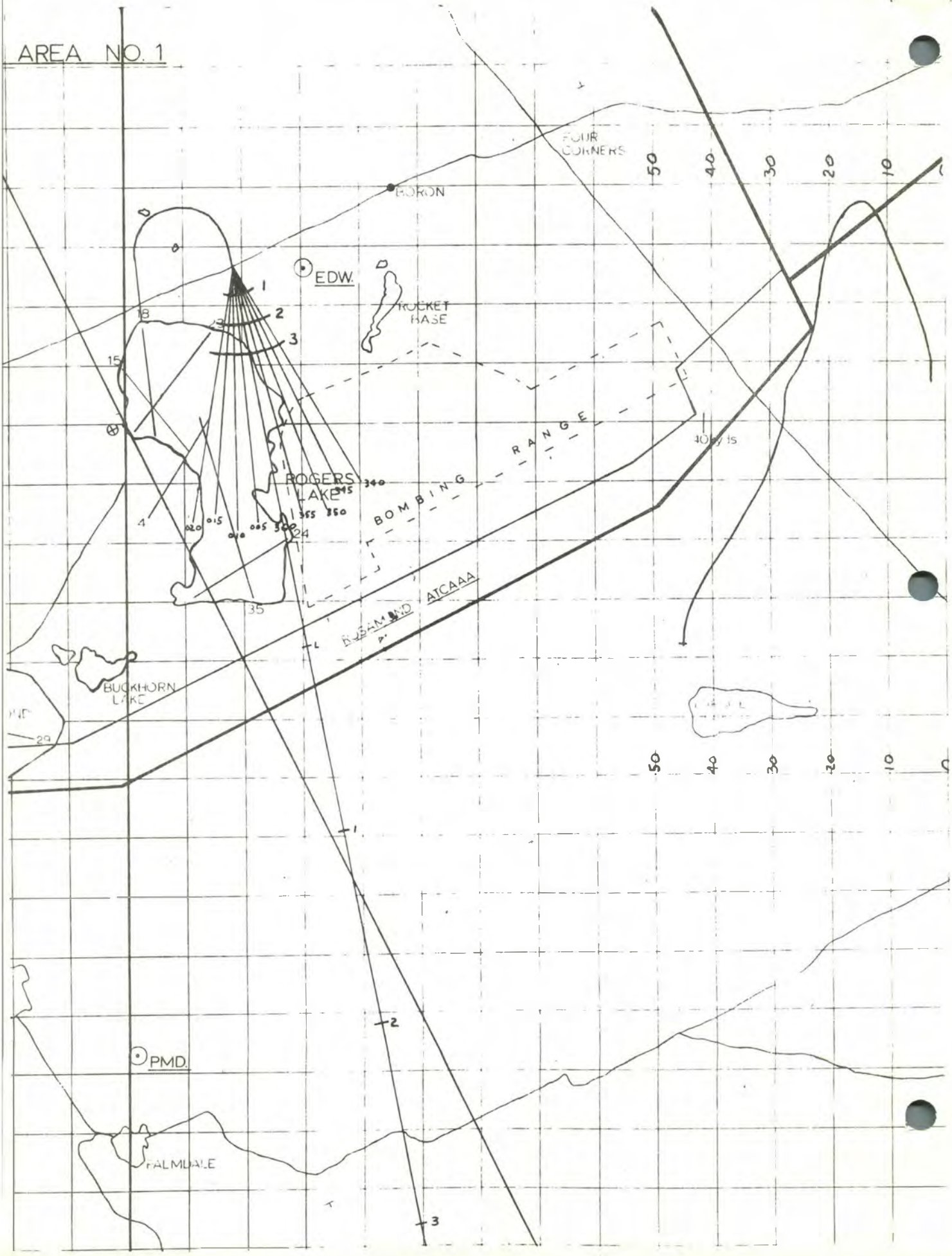
	Failure	Action
1.	Radio, Radar, PCM	Proceed as planned
2.	Airspeed, Altitude	Proceed as planned using α for primary control. Altitude calls from NASA 1. Airspeed and altitude calls from chase.
3.	Attitude System	Proceed as planned using backup attitude indicator and/or outside reference.
4.	Primary Angle of Attack Indicator Failure	KRA to "Manual" 10%, stick shaker "Off", proceed as planned using backup α indicator on ADI.

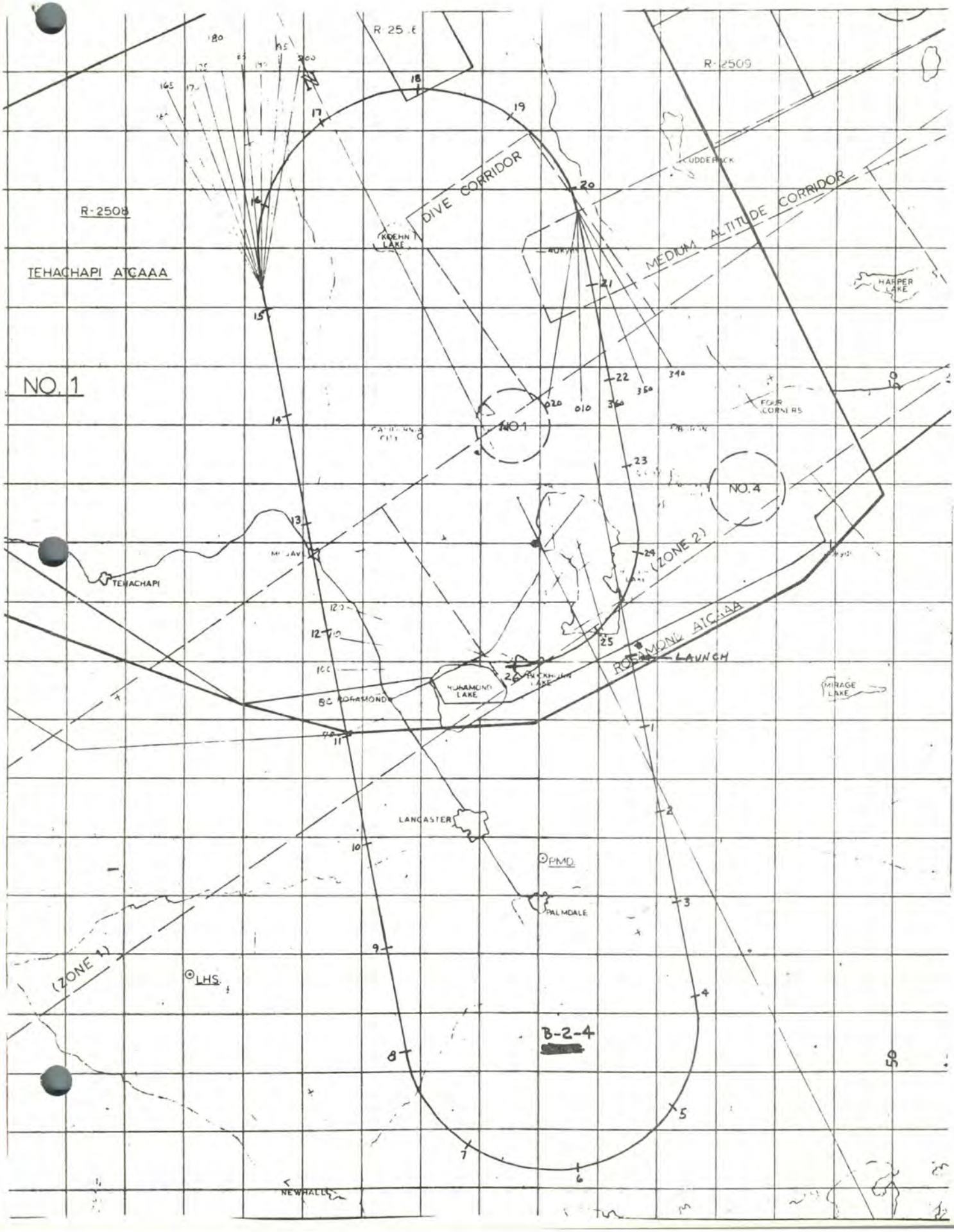
	Failure	Action
5.	Total Angle of Attack Failure	KRA to "Manual" 10%, stick shaker "Off". Fly 220 KIAS instead of α, do not perform pushover-pullup or post-configuration change doublets. Roll and yaw damper off evaluation at pilot's discretion.
6.	KRA "Auto" Failure	KRA to "Manual" 10%.
7.	Pitch Damper Failure	Proceed as planned limiting α to 12° during data maneuvers.
8.	Roll Damper Failure	Proceed as planned.
9.	Yaw Damper Failure	Proceed as planned setting Mach repeater to .3.
10.	All Axis Damper Failure	Mach repeater to .3, limit α to 12° during data maneuvers, pulses at pilot's discretion.
11.	Limit Cycle	Reduce gain setting in steps to 1, if limit cycle still excessive--turn damper off.
12.	Upper Flaps Fail to Close	Land Runway 23, start flare at 4,500 feet MSL and use landing rockets.

Robert G Hoey
ROBERT G. HOEY

Jack L Kolf
JACK L. KOLF


X-24B
FLT B-2-4
ALT.
FT/1000
KCAS
300
200
100
0
MACH
.5
0
20
40
60
80
100
120
140
160
180
200
220
240
260
TIME ~ SEC.
α
DEG
PITCH PULSE
RAD
LOWER FLAP
DEG
CONFIG. CHANGE
+25
PITCH
ANGLE
DEG
-25
BANK
ANGLE
DEG
-100
DOUBLET SET
DOUBLETS
β
DEG
-5
10 AUG 73


AREA NO. 1
FOUR CORNERS
BORON
EDW.
ROCKET BASE
ROGERS LAKE
BOMBING RANGE
BUCKHORN LAKE
PMD.
PALMDALE
ATCAAA
40 by 15
50
40
30
20
10
1
2
3
4
15
18
24
35
29
340
345
350
355
005
010
015
020


R-2508
TEHACHAPI ATCAAA
NO. 1
R-2509
DIVE CORRIDOR
MEDIUM ALTITUDE CORRIDOR
NO. 1
NO. 4
(ZONE 2)
(ZONE 1)
TEHACHAPI
EDWARDS AFB
ROSAMOND LAUNCH
ROSAMOND LAKE
BUDDERACK
KOEHN LAKE
HARPER LAKE
MIRAGE LAKE
LANCASTER
PMD
PALMDALE
LHS
NEWHALL
B-2-4

X-24B FLIGHT B-2-4 EVENTS

FLT. TIME = 04: 27.3 (267.3 sec)

TOD	ALT. i	KIAS	MACH i	EVENT	Δt
09: 19:34.4	—	—	—	LAUNCH	0.0
20:05.4	39027	189	.623	RUDDER DOUBLET α = 13° TO 11°	31.0
:09.3	37855	198	.634	AILERON DOUBLET α = 10°	34.9
:14.8	36208	210	.646	PITCH PULSE (DAMPER OFF)	40.4
:17.3	35490	214	.649	MAX MACH i	42.9
:22.2	34131	216	.635	START PUSHOVER-PULL UP α = 11°	47.8
:27.2	32761	222	.633	AT MIN α = 2°	52.8
:33.7	30872	222	.607	STICK SHAKER SIGNAL ON	59.3
:34.1	30783	220	.603	AT MAX. α = 17.2°	59.7
:34.2	—	—	—	STICK SHAKER SIGNAL OFF	59.8
:36.3	30364	217	.588	RETURN TO 10.5° α	61.9
:43.6	29328	200	.533	START CONFIG. CHANGE	69.2
:50.9	28425	202	.529	END CONFIG CHANGE	76.5
21 : 3.7	26763	206	.519	RUDDER DOUBLET α = 15°	89.3
:6.4	26697	195	.494	AILERON DOUBLET α = 15.8°	92.0
:20.8	26477	173	.438	RUDDER DOUBLET α = 5°	106.4
:25.0	25784	187	.464	AILERON DOUBLET α = 5°	110.6
:33.7	23605	223	.526	RUDDER DOUBLET α = 10.8°	119.3
:36.8	22868	231	.537	AILERON DOUBLET α = 10.8°	122.4
:41.5	21944	237	.539	PITCH PULSE (DAMPER OFF)	127.1
:57.3	20690	211	.471	LANDING ROCKET CHECK	142.9
:58.4	20668	209	.466	LARGE BANK ANGLE (START TURN OR POSITION CK)	144.0
22 :15.4	19447	209	.454	ANOTHER LEFT BANK (POSSIBLE TURN PT)	161.0
:43.8	13236	281	.539	SPEED BRAKES START OUT TO 30° δ_{SB}	189.4
:56.0	9895	286	.516	MACH REP. TO .3	201.6
:58.7	9225	281	.501	SPEED BRAKES START IN TO 20° δ_{SB}	204.3
23: 02.8	8313	281	.492	APPROX. LEVEL ON FINAL	208.4
:33.3	3218	283	.452	START FLARE	238.9
:50.5	2142	232	.364	GEAR DOWN	256.1
24 :01.7	2153	168	.264	MAIN GEAR TOUCHDOWN	267.3
:03.4	2153	163	.256	NOSE GEAR TOUCHDOWN	269.0

JGA

LAUNCH DYNAMICS

By

D. Richardson

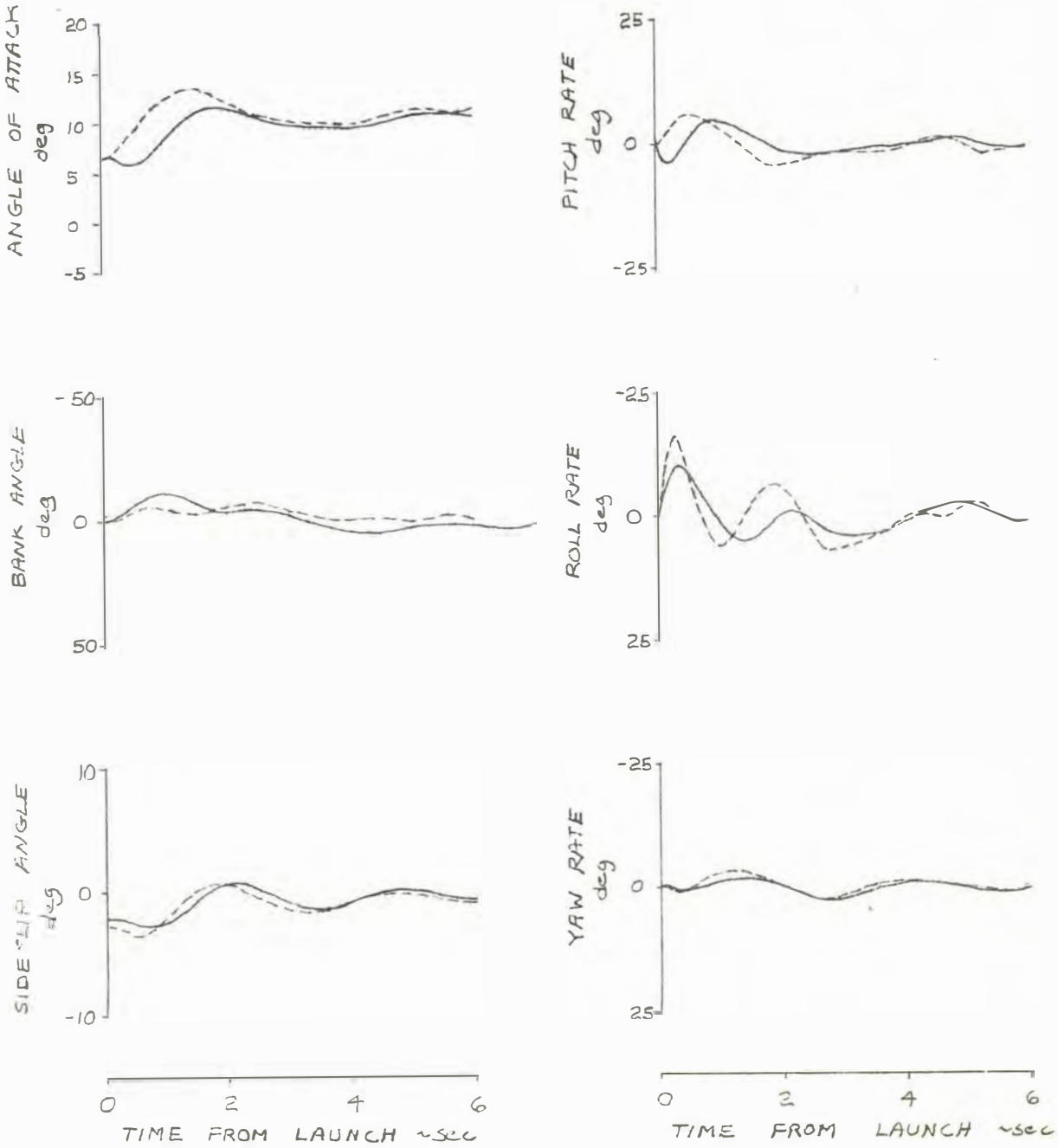
A comparison between the first launch and the second launch reveals the following differences: The second flight configuration at launch was with -40 degrees upper flaps as compared to the first flight launch configuration with -20 degrees upper flaps. The -40 degree upper flap configuration will be the standard launch configuration for all subsequent flights.

A only noticeable difference in the second flight launch transient was a slight pitch down at launch.

COMPARISON OF FIRST AND SECOND FLIGHT LAUNCHES
SAS-ON

– – – – – FIRST FLIGHT
$\delta_U = -20.5°$
$\delta e_L = 9.6°$
$\delta R_B = -10.0°$
$\delta A_B = 7.0°$
CG = 65.08 %
Wt = 8164.5 lbs

——— SECOND FLIGHT
$\delta_U = -40.3°$
$\delta e_L = 26.4°$
$\delta R_B = 0.0°$
$\delta A_B = 7.0°$
CG = 65.06%
Wt = 8154.0 lbs



X-24B DERIVATIVES

By

Alex G. Sim
and
Paul W. Kirsten

From Flight B-2-4, sets of derivatives were extracted from six maneuvers. Two of the maneuvers were performed in the longitudinal mode; while four were performed in the lateral-directional mode. Both the NASA FRC Newton-Raphson digital computer program and the AFFTC hybrid matching program were used to analyze the maneuver.

Lateral-directional derivatives were obtained at Mach numbers between 0.45 and 0.63 with an angle of attack range between 5.2° and 15.8°. Subsonic configuration data are shown in Figure 1 along with data obtained from the first flight. Generally, the second flight data verify the trends obtained from the first flight while at the same time expanding the envelope of data obtained. C_{ℓ_β}, C_{n_β}, C_{y_β}, $C_{\ell_{\delta a}}$ and $C_{n_{\delta r}}$ are at or slightly higher than the wind tunnel predictions. $C_{n_{\delta a}}$, $C_{\ell_{\delta r}}$ and $C_{y_{\delta r}}$ are slightly lower than wind tunnel predictions. $C_{y_{\delta a}}$ is about twice the magnitude of wind tunnel predictions although its effect on the airplane dynamics is still insignificant. The damping derivatives are all somewhat in the neighborhood of their pre-flight estimates. However, their normal scatter still precludes determining any trends.

The two sets of longitudinal derivatives were obtained at Mach numbers of 0.645 and 0.539 and at angles of attack of 10.2° and 10.3° respectively. The airplane was in the transonic configuration for the first maneuver and in the subsonic configuration for the second. Both maneuvers were performed without stability augmentation in the pitch axis. Data from the subsonic configuration maneuver are presented in Figure 2 with the results of the first flight. Longitudinal static stability is still lower than wind tunnel predictions. Likewise, longitudinal control effectiveness is still slightly higher than predicted. However, C_{m_q} is much higher than the first flight value although still lower than pre-flight estimates. Whether this is a result of the first flight maneuver being performed during the presence of tip fin separation or just "normal" scatter for this

derivative is unknown. The longitudinal pulses for Flight 2 were performed with the pitch damper off, however, which should give a better estimate of C_{m_q}.

Lateral-directional derivatives for the maneuver performed in the transonic configuration are shown in Figure 3. Trends in the derivatives are similar to those of the subsonic configuration data.

Longitudinal derivatives for the transonic configuration are shown in Figure 4. Longitudinal static stability is lower than wind tunnel predictions. Longitudinal control effectiveness is slightly higher than predictions. The longitudinal damping derivative for this case agreed well with predictions.

In conclusion, the trends in the lateral-directional derivatives indicate a superior flying airplane than previously predicted by wind tunnel data. The trends in the longitudinal subsonic configuration derivatives indicate a slightly less stable airplane than predicted, although the results of the second flight are more encouraging than those from the first flight.

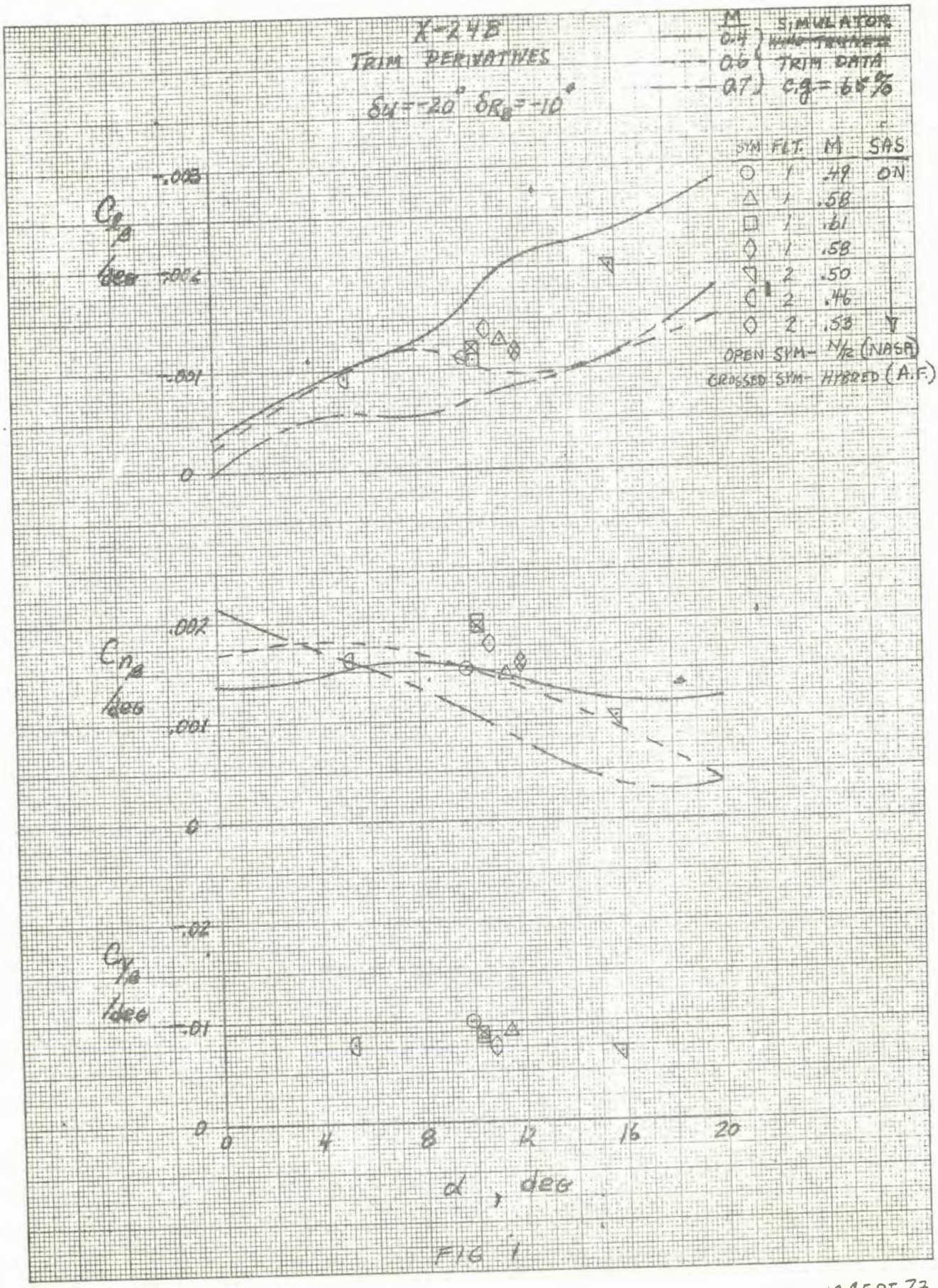


FIG 1

10 SEPT 73

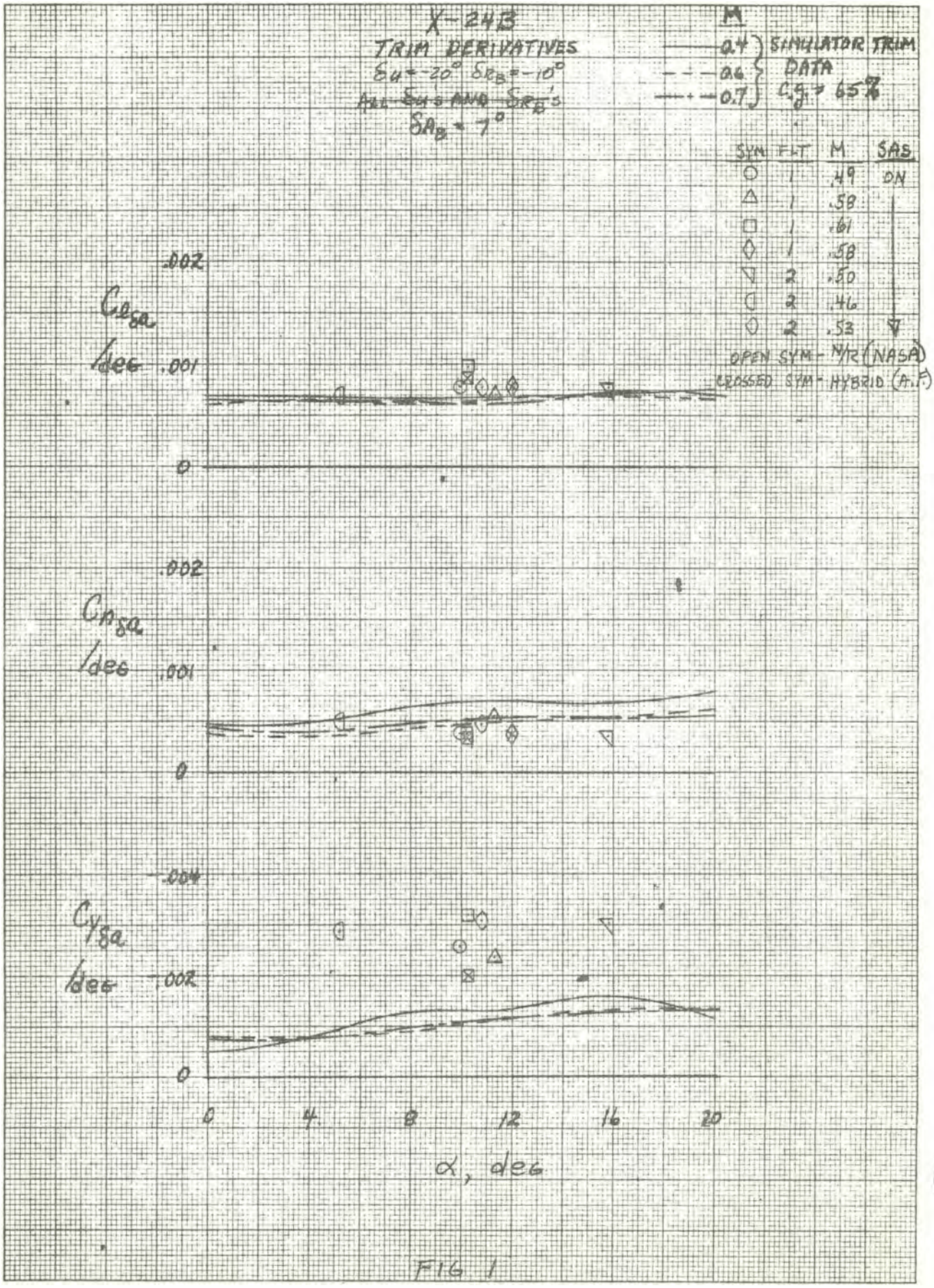


FIG 1

10 SEPT 73

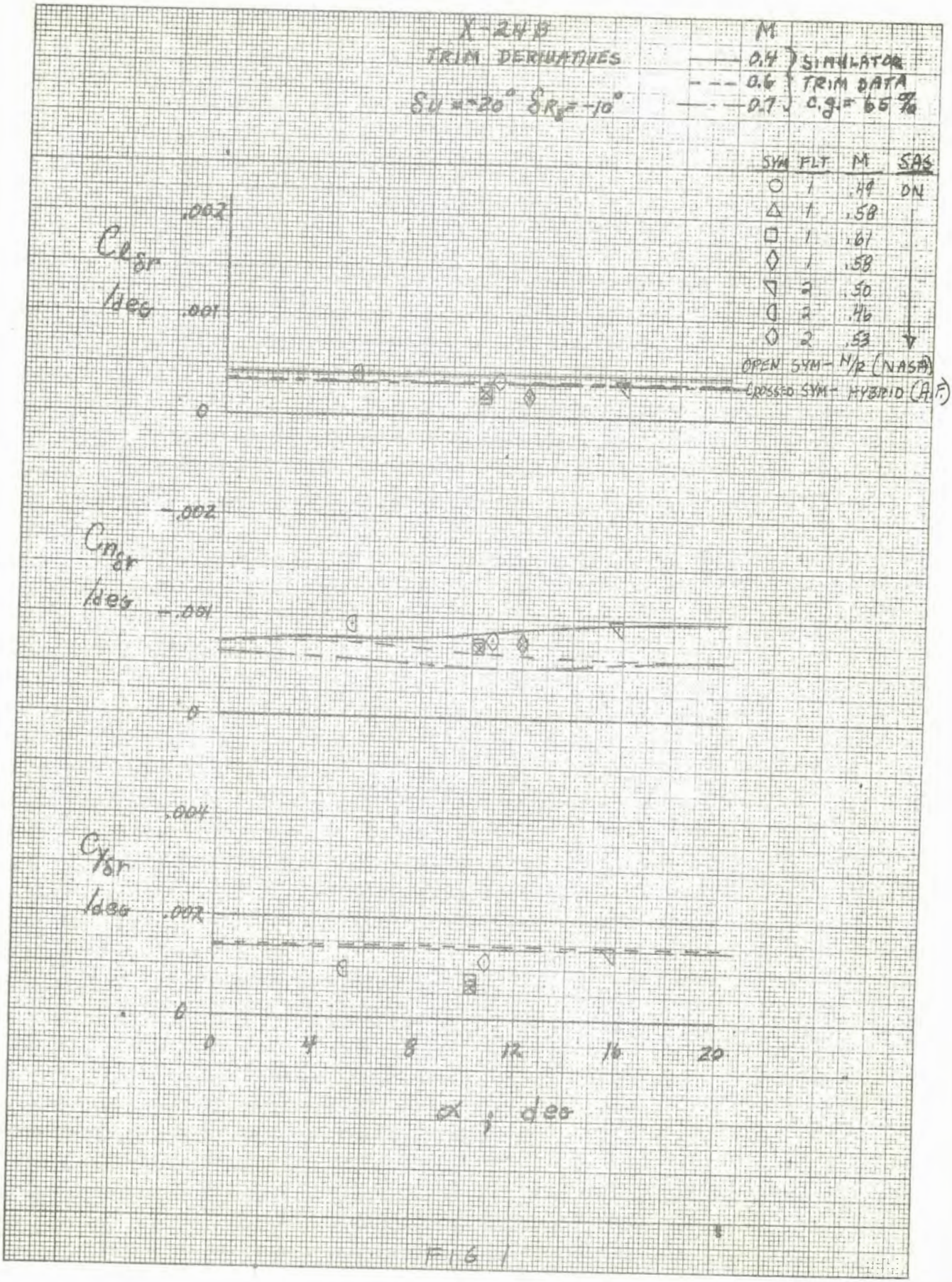


FIG 1

10 SEPT 73

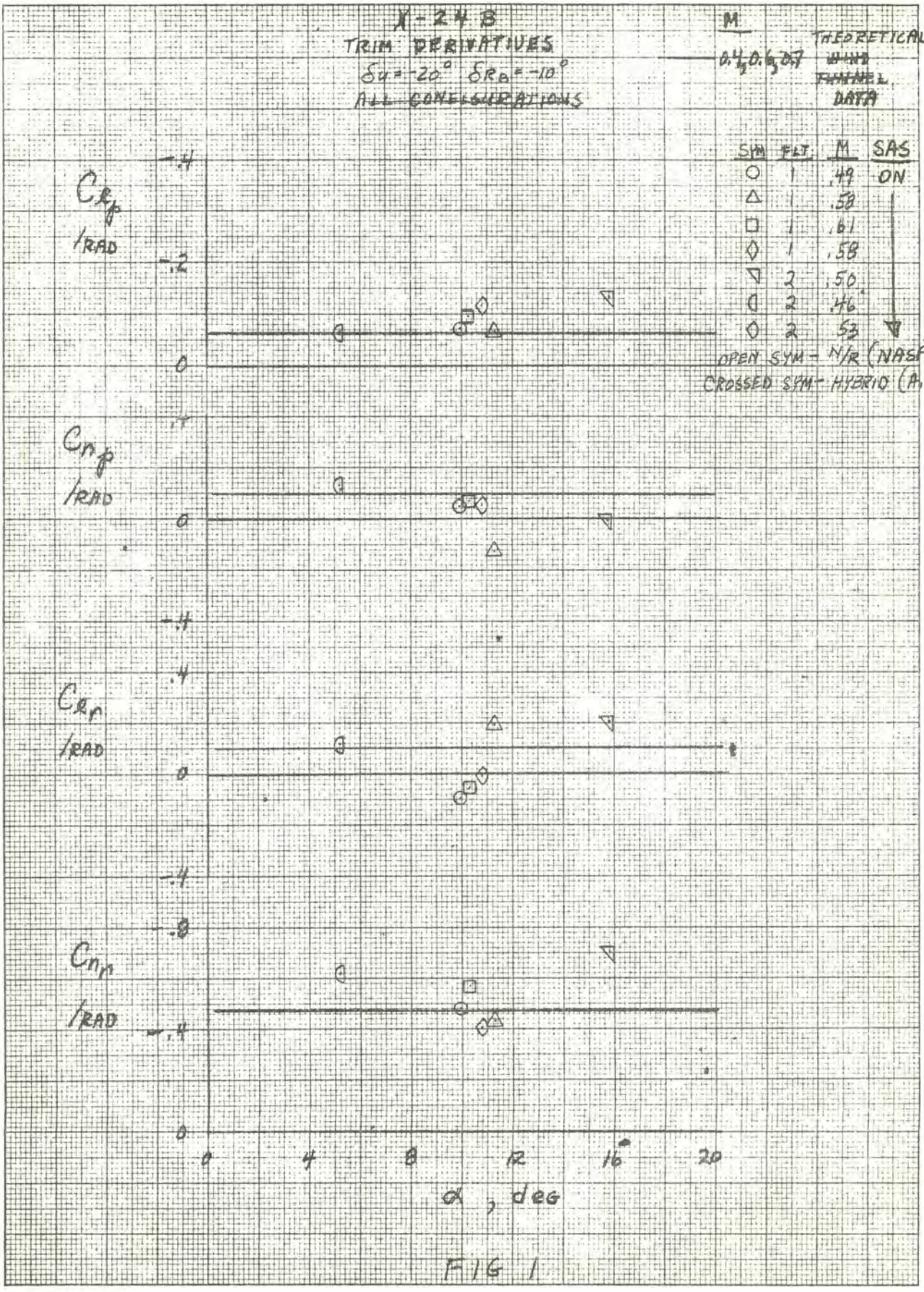


FIG 1

10 SEPT 73

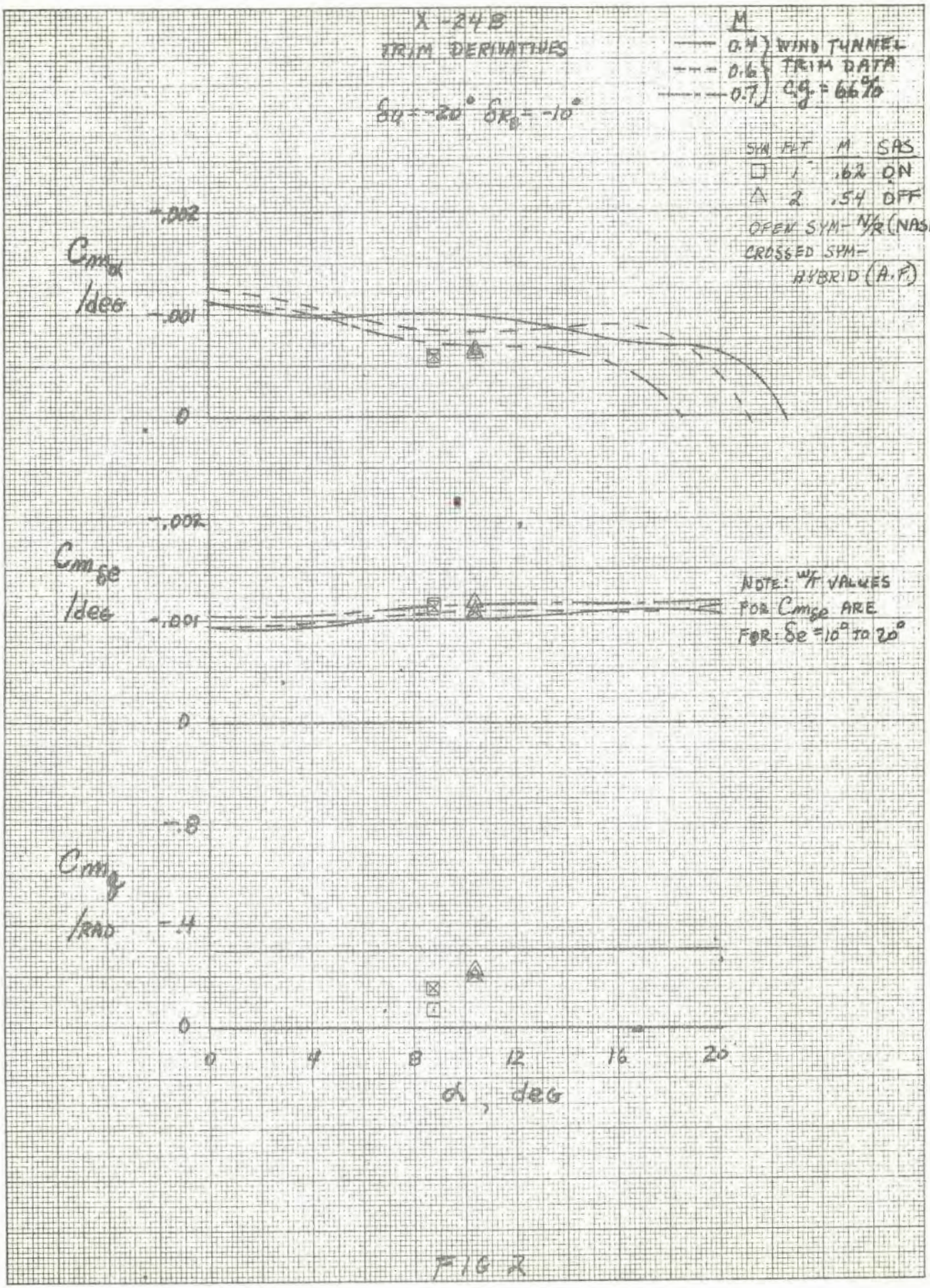


FIG 2

10 SEPT 73

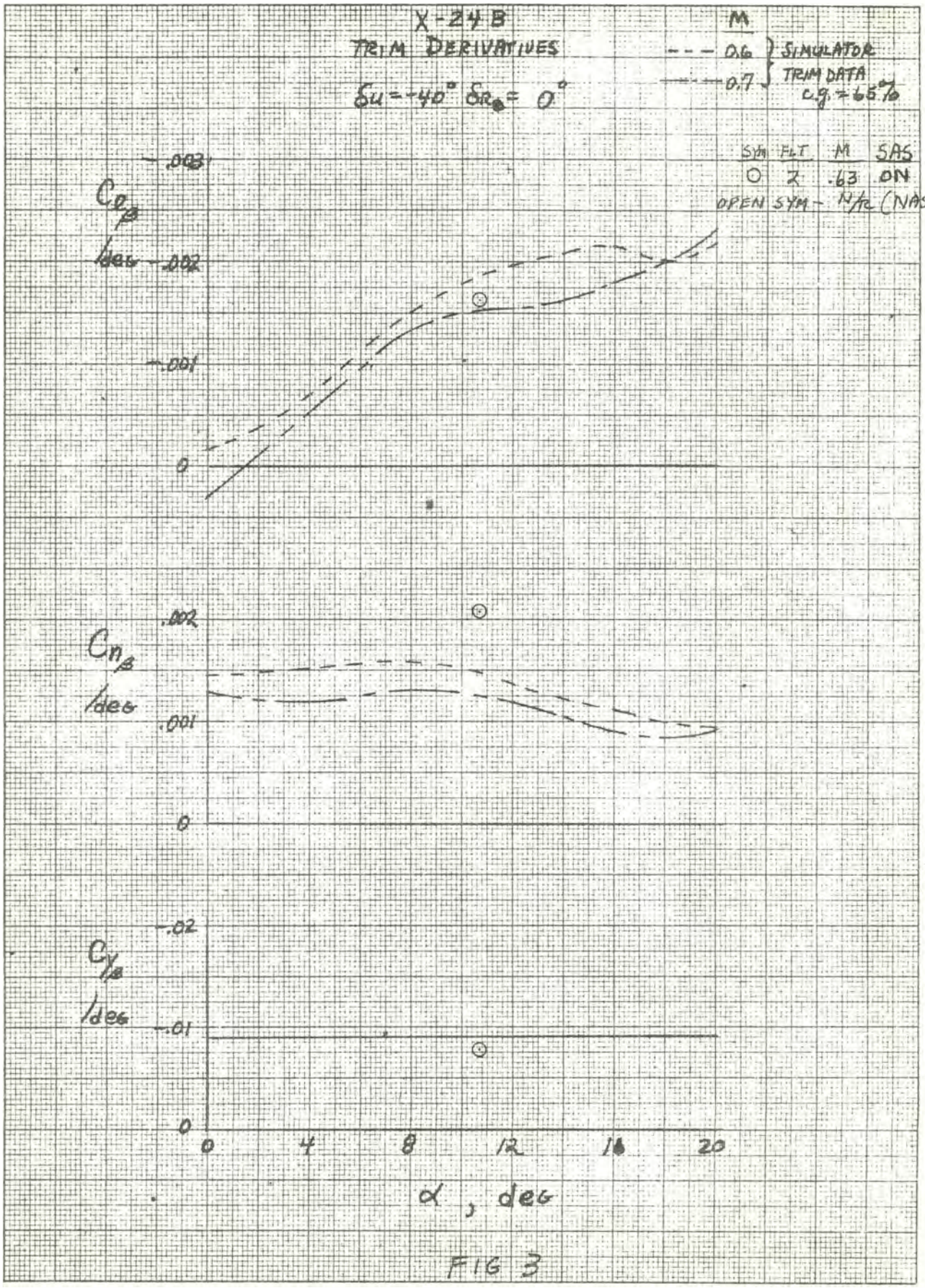


FIG 3

10 SEPT 73

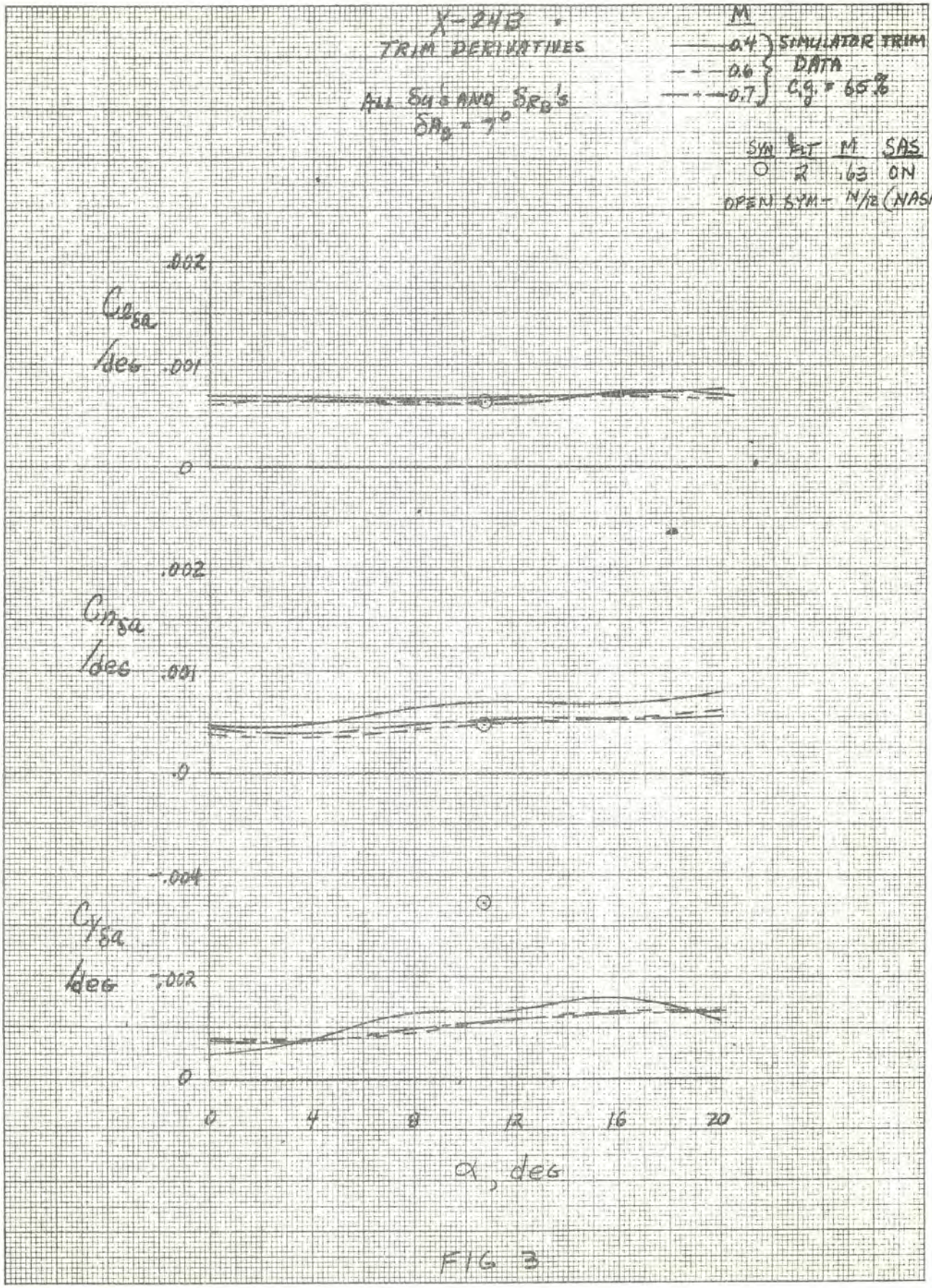


FIG 3

10 SEPT 73

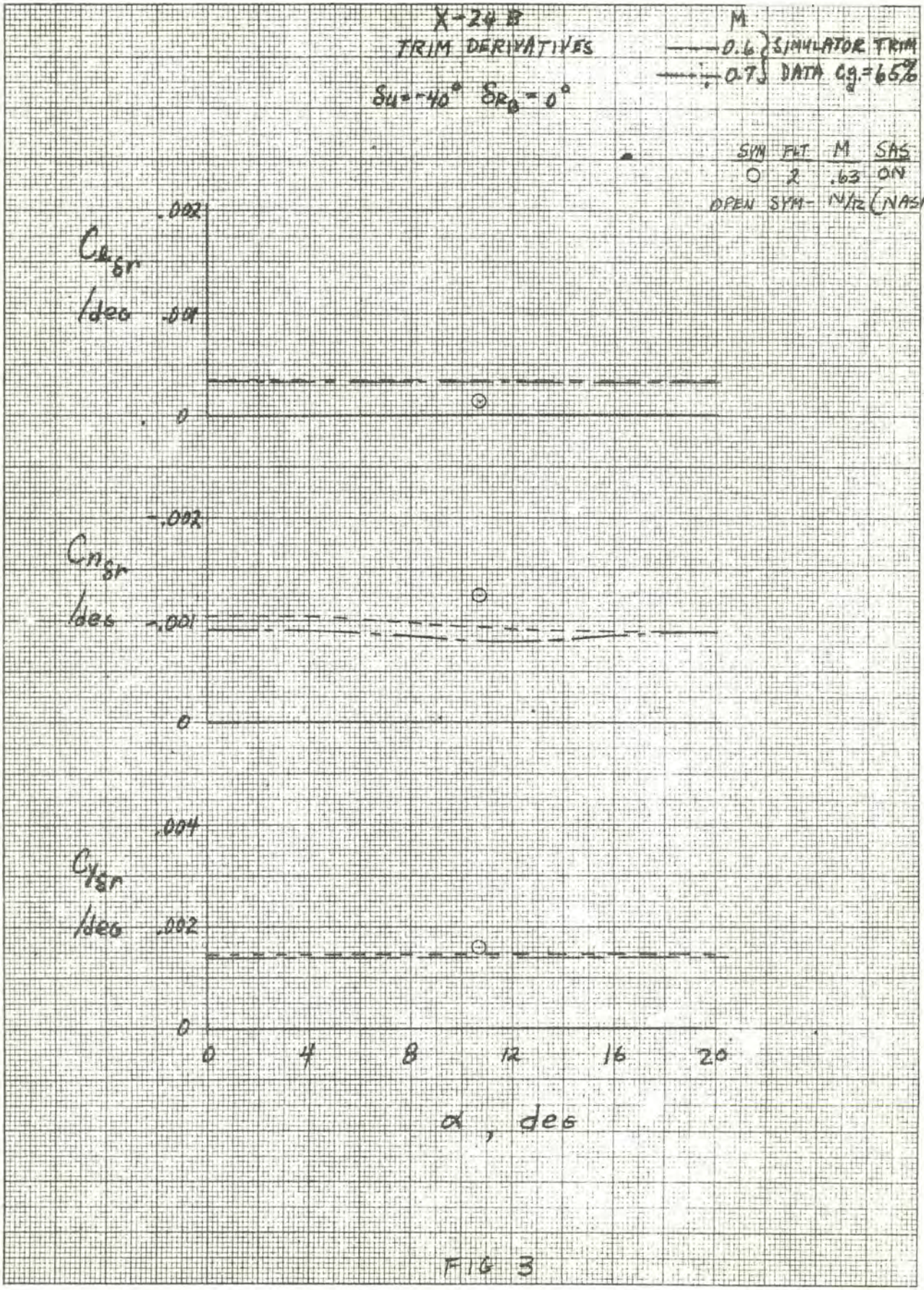


FIG 3

10 SEPT 73

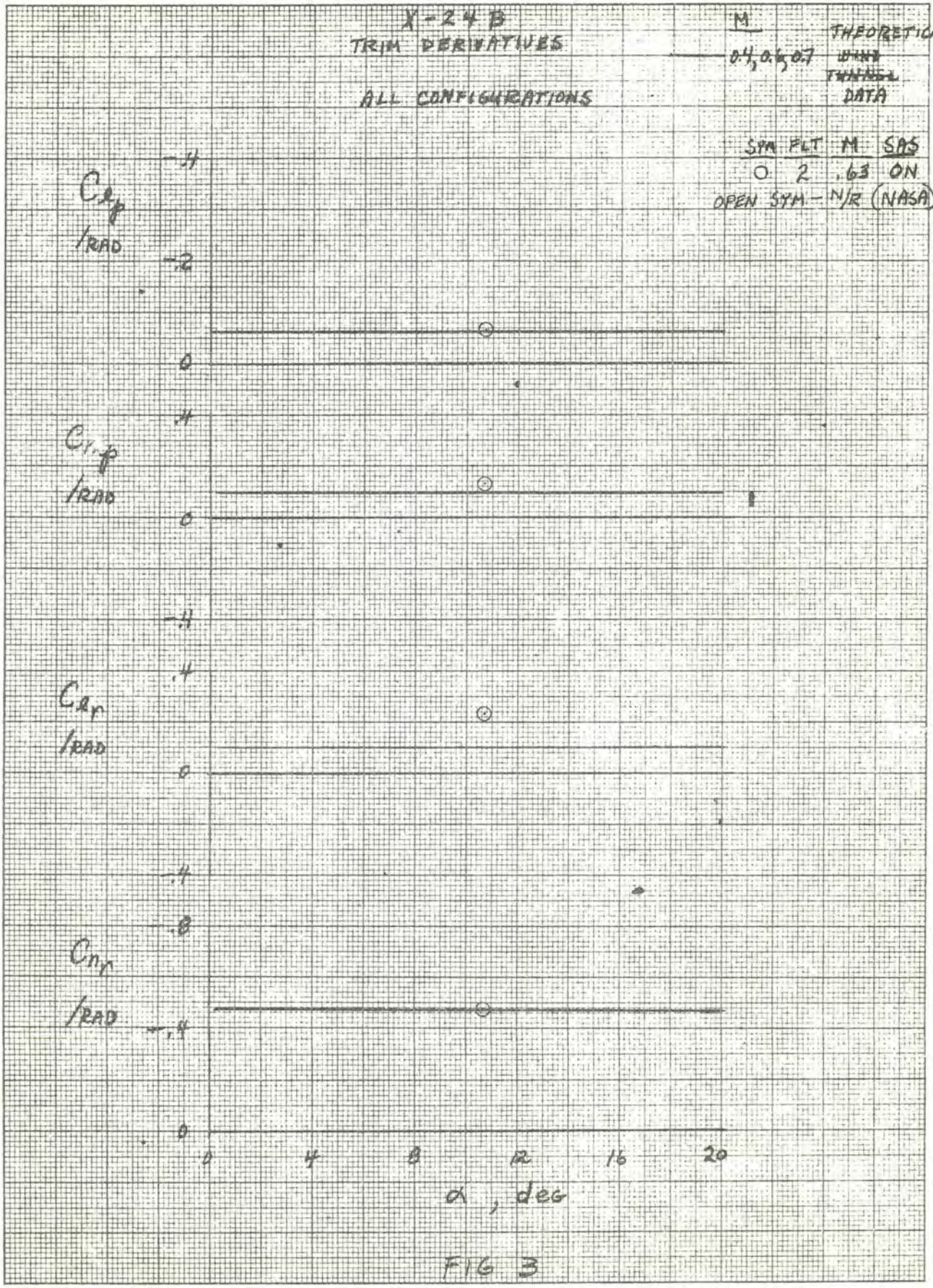
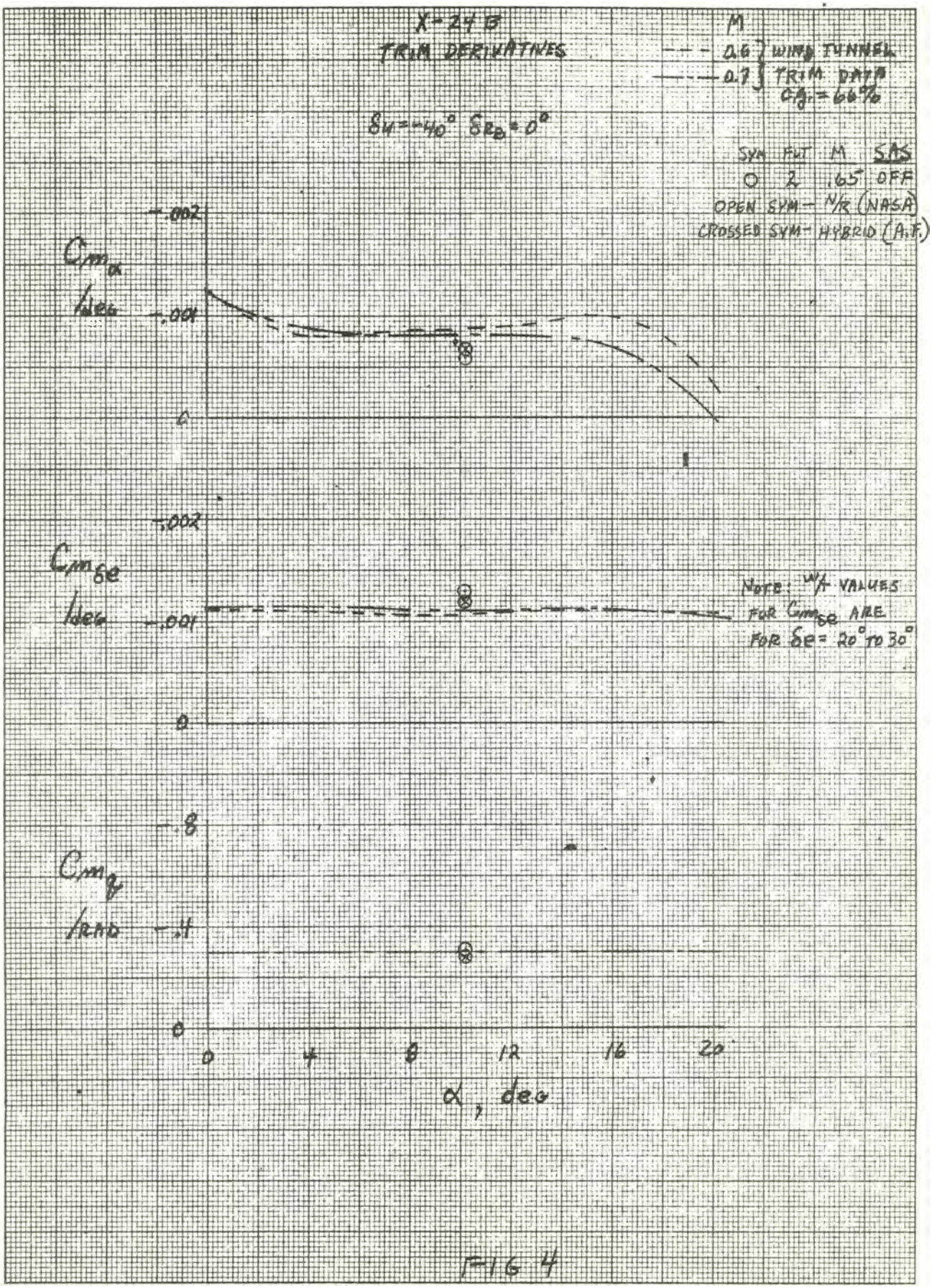


FIG 3

10 SEPT 73



F-16 4

10 SEPT 73

PERFORMANCE

By

D. Richardson

The data with the landing gear extended were worked up from the first flight. The lift-to-drag ratio is about .25 lower than predicted. However, the C_L at maximum L/D appears to be close to the predicted value which helps explain the pilot comment that his control over sink rate is perfect during the deceleration to the touchdown airspeed of 160 to 170 knots.

The incremental increase in chord force due to the landing gear is very close to the value predicted by the wind tunnel tests.

It was predicted that there would be no increment in normal force due to the landing gear, which the flight data confirms. However, there appears to be a ground effect which increases the slope C_{N_α} as the vehicle comes close to the ground.

There was no flow separation on the tip fin as indicated by the smooth rudder hinge moment traces during the flight. This was due to the fact that the upper flaps and rudders were set at -40 degrees and 0 degrees respectively for Mach numbers > 0.5 during this flight.

GEAR UP

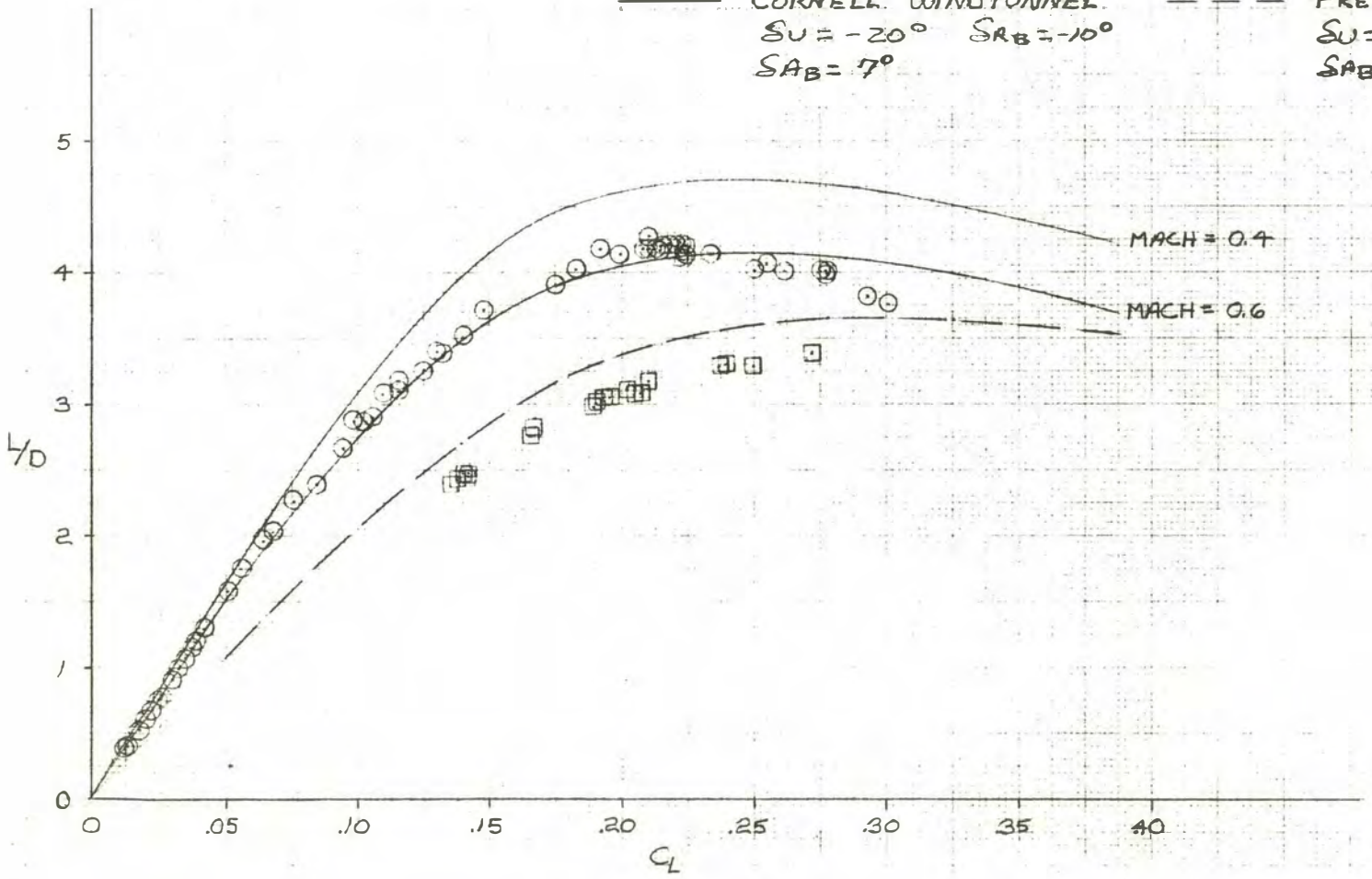
○ B-1-3 $\delta_U = -20.4$
$\delta_{R_B} = -10°$ $\delta_{A_B} = 6.7°$
MACH = 0.46

GEAR DOWN

□ B-1-3 $\delta_U = -20.5°$
$\delta_{R_B} = -10°$ $\delta_{A_B} = 6.4°$
MACH = .26-.36

——— CORNELL WINDTUNNEL
$\delta_U = -20°$ $\delta_{R_B} = -10°$
$\delta_{A_B} = 7°$

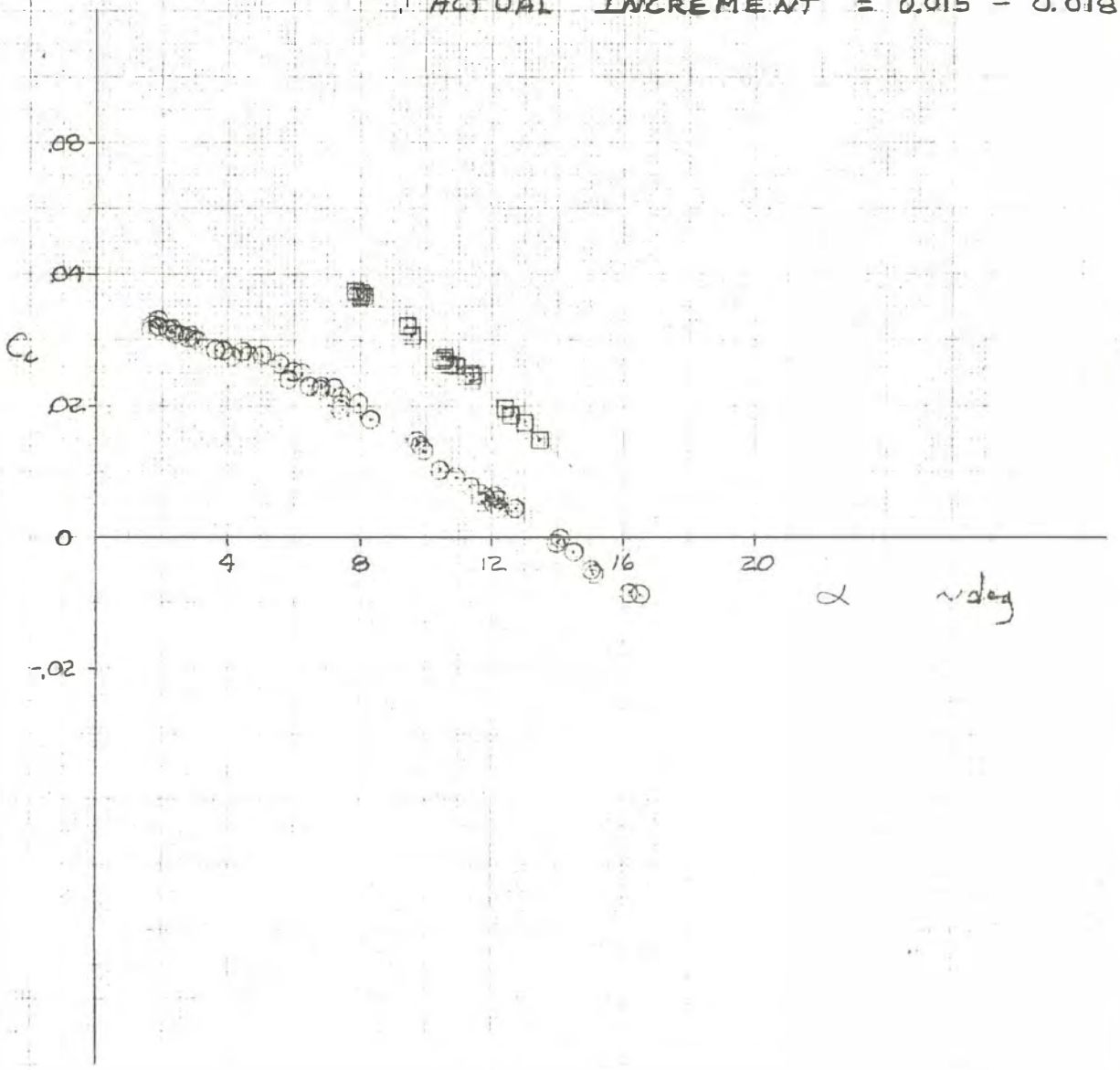
– – – PREDICTED
$\delta_U = -20°$ $\delta_{R_B} = -10°$
$\delta_{A_B} = 7°$



○ GEAR UP
B-1-3
$\delta_U = -20.4°$
$\delta_{R_B} = -10°$
$\delta_{A_B} = 6.7°$
MACH = 0.46

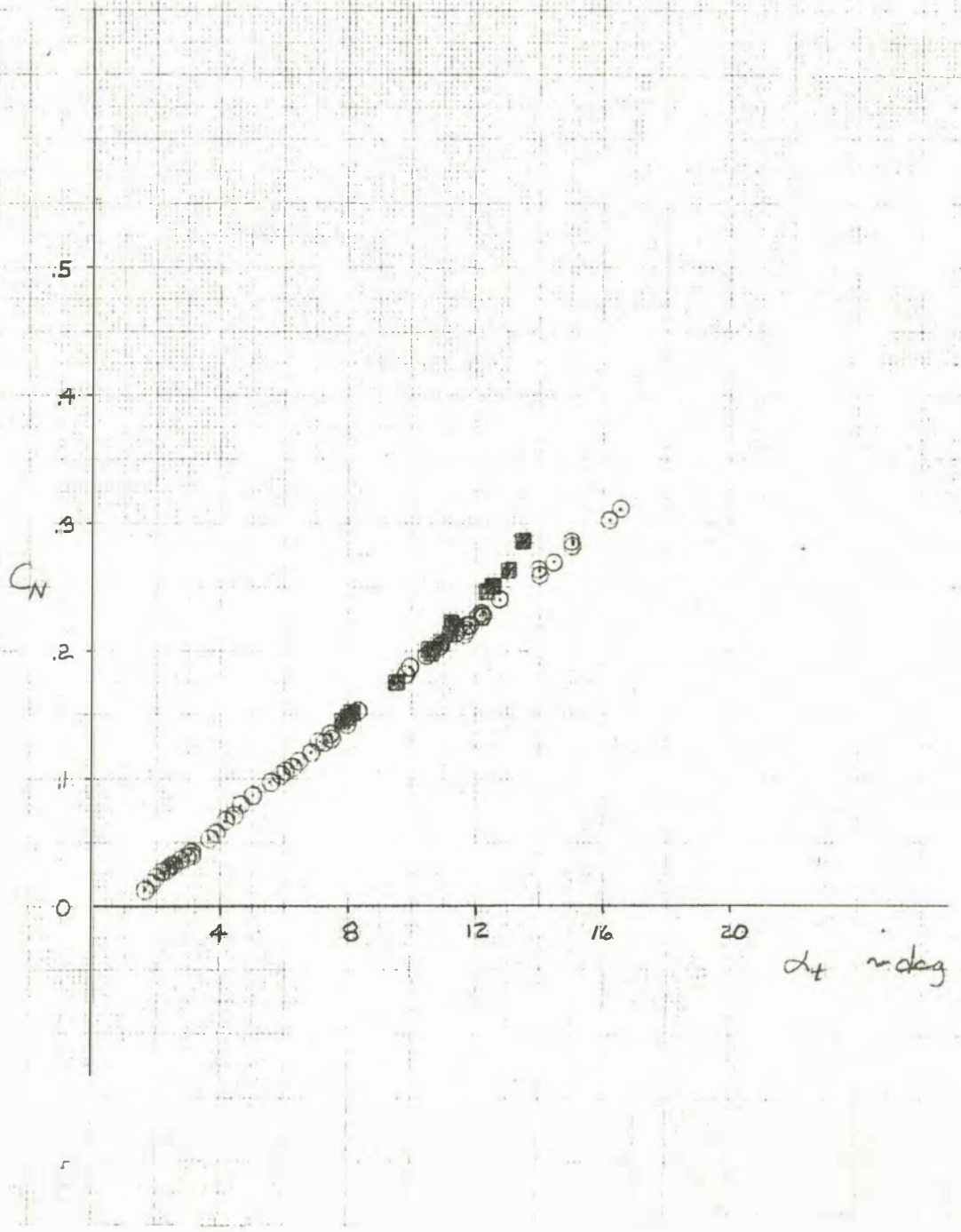
□ GEAR DOWN
B-1-3
$\delta_U = -20.5°$
$\delta_{R_B} = -10°$
$\delta_{A_B} = 6.4°$
MACH = .26-.36

PREDICTED INCREMENT IN CHORD FORCE DUE TO LANDING GEAR = 0.016
ACTUAL INCREMENT = 0.015 - 0.018



○ Gear Up
B-1-3
$\delta_U = -20.4$
$\delta R_B = -10$
$\delta A_B = 6.7$
MACH = 0.46

■ Gear Down
B-1-3
$\delta_U = -20.5°$
$\delta R_B = -10°$
$\delta A_B = 6.4°$
MACH = .26-.36



X-24B FLT. B-2-4
HANDLING QUALITIES SUMMARY

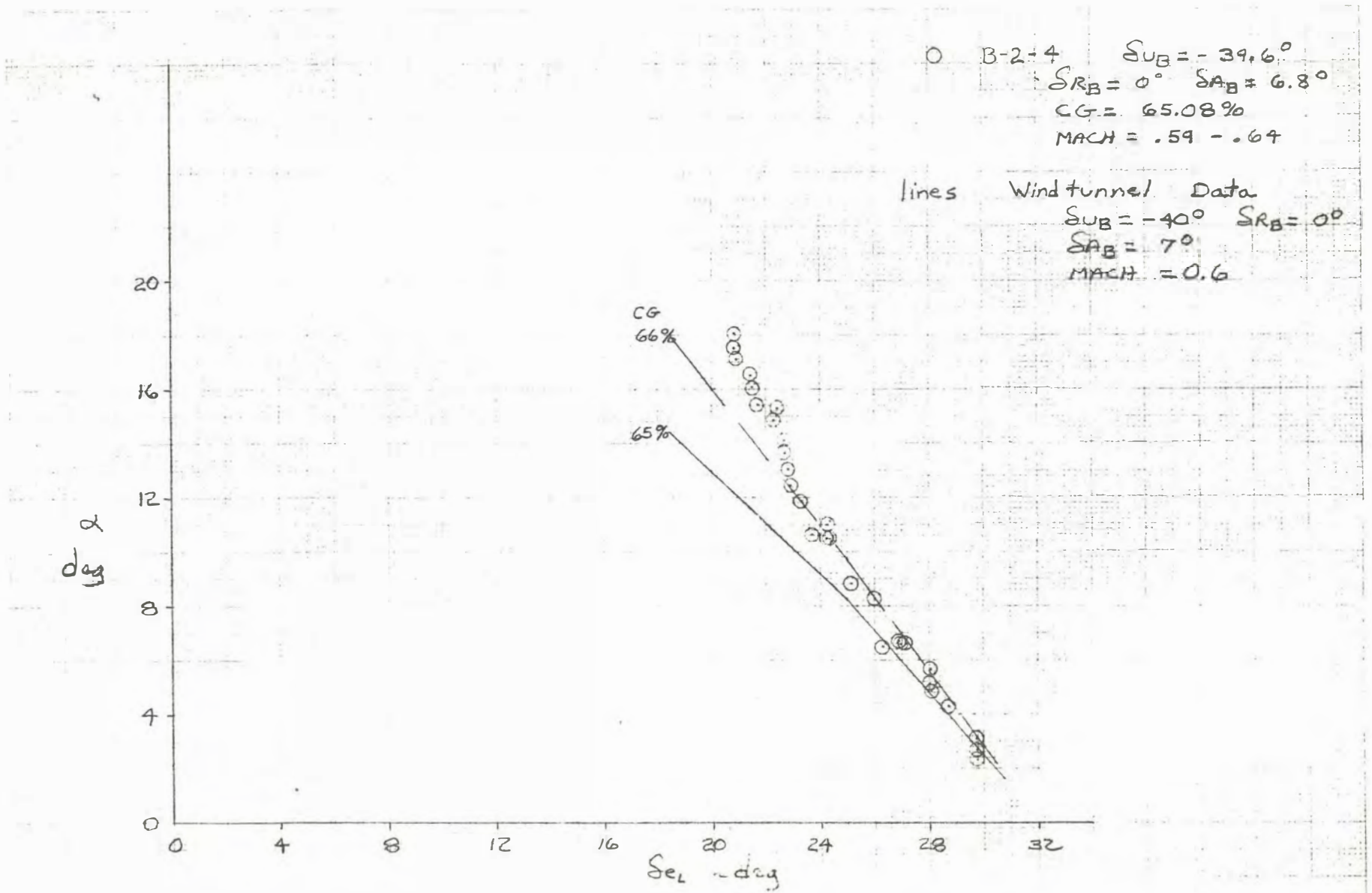
CONDITION	PILOT RATING
RECOVERY FROM LAUNCH	3
40° UPPER FLAPS (OVERALL)	2 1/2
TURN TO FINAL	2
FLARE	2 1/2
LANDING	2

LONGITUDINAL TRIM

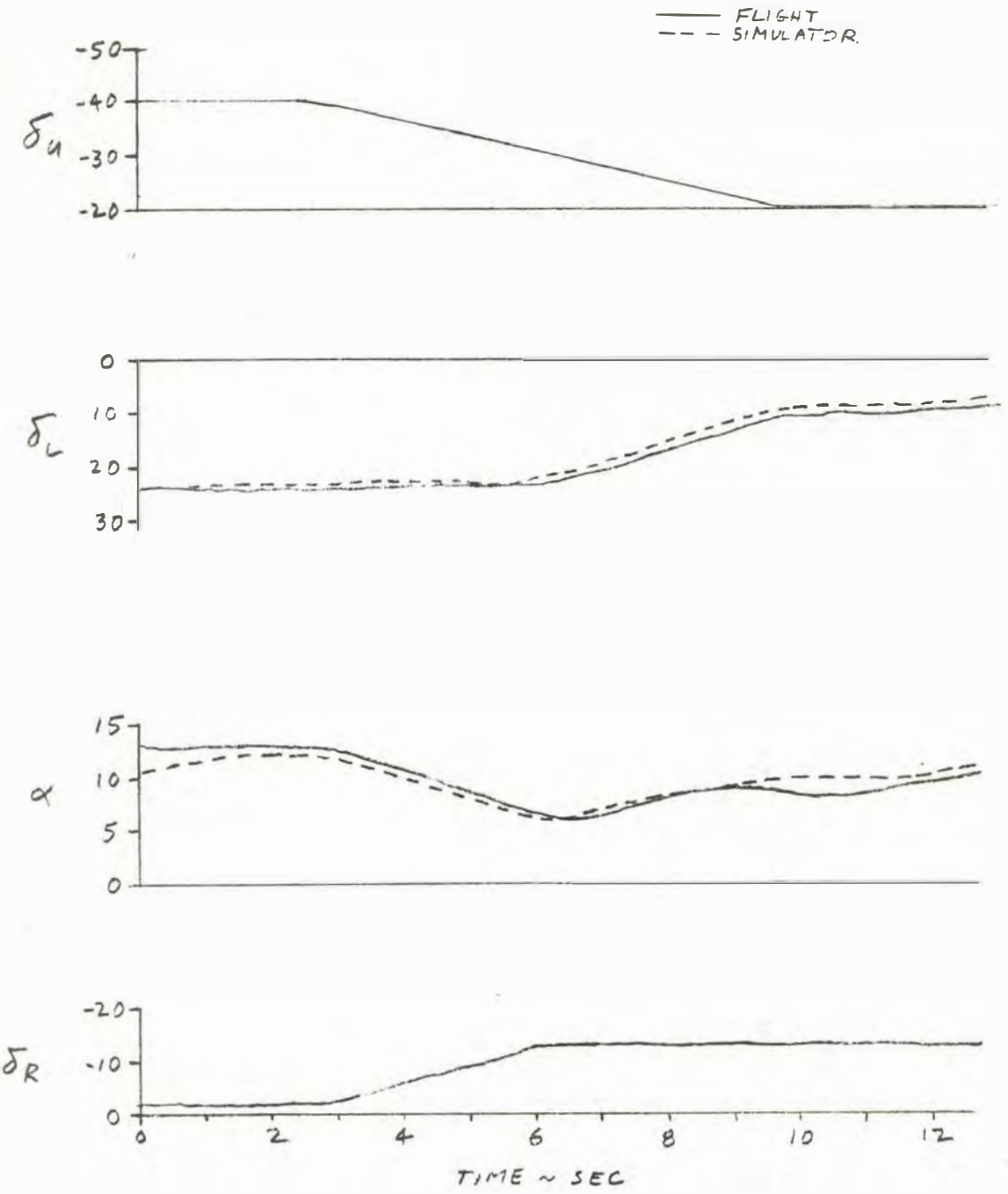
By
D. Richardson

The pushover-pullup maneuver with -40 degree upper flaps was plotted as angle of attack versus lower elevator deflection. As with the first flight data, the second flight data also shows that there is a one percent reduction in static margin between the flight vehicle and the predicted vehicle. The flight data was at -65 percent center of gravity position; however, it appears to match the predicted data at 66 percent center of gravity location.

The configuration change was performed as planned with the pilot's hand off the stick. The change in trim angle of attack as the flaps and rudders changed is shown in the time history as a solid line. The simulator time history is shown as a dashed line and is seen to compare quite well. (Note that the simulator run was performed just prior to Flight 2 using a 66 percent cg position to account for the one percent static margin discrepancy which had been observed on Flight 1.)


O B-2-4 $\delta_{U_B} = -39.6°$
$\delta_{R_B} = 0°$ $\delta_{A_B} = 6.8°$
CG = 65.08%
MACH = .59 - .64
lines Wind tunnel Data
$\delta_{U_B} = -40°$ $\delta_{R_B} = 0°$
$\delta_{A_B} = 7°$
MACH = 0.6
CG
66%
65%
α deg
δ_{e_L} - deg
0
4
8
12
16
20
24
28
32

CONFIGURATION CHANGE (HANDS OFF)
X-24B FLT. B-2-4



X-24B DIRECTIONAL MISTRIM

Paul W. Kirsten 24 August 1973

A discrepancy exists between the pilot's indication of β and the ground telemetered value of β. On the first two X-24B flights, the pilot used about 2 to 3 degrees of left rudder trim to zero out β according to his indicator. Ground data indicated that there was about 1 degree of nose left β under these conditions instead of zero degrees as shown on the cockpit indicator. The pilot qualitatively agreed that he did not have zero β since he had to apply right aileron to hold wings level. (The right aileron would counteract the left roll produced by the nose left sideslip shown in the ground data.) Ground data indicates there is a need for a small amount of left rudder trim to give a resultant zero β. Based on ground data from the first two flights, the amount of left rudder trim required to zero β is

	rudder trim required for zero β
From flight B-1-3 (shortly after launch	+0.75° (left)
From flight B-2-4 (shortly after launch	+0.75° (left)

On future flights, +0.75 degrees of left rudder trim will be preset before launch and the pilot will hopefully not need to do any further directional trimming during the flight.

ANGLE OF ATTACK AND SIDESLIP DISCREPANCIES
Flight B-2-4

Event	Time~Min (from launch)	Altitude~Ft	α Cockpit	α Instr.	β Cockpit	β Instr.
After T.O.	-38	10,800	2°	2.4°	-1.9°	-1.8°
26 Min	-26	31,000			-3.0°	-2.2°
22 Min	-22	35,000	2°	2.2°	-2.0°	-1.5°
9 Min	-9	41,700			-2.75°	-1.7°
1 Min	-1	44,600	5°	5.0°	-3.0°	-1.8°
After Launch	+.5	40,700			0°	+.9°
PO-PU	+1.0	30,800	16°	17.8°		
Low Key	+2.2	21,000	10°	10.4°	-.5	+.4

24 August 1973

X-24B CONTROL SYSTEM RESULTS FLIGHT B-2-4

Paul W. Kirsten

SAS

No SAS failures
No limit cycling
No structural resonance
SAS authority limits--
Not reached in yaw
Limits were reached in roll during doublets only
Limit in pitch was reached only at nose gear slap down at touchdown

Automatic Functions

KRA worked properly
Rudder bias worked properly
Stick shaker only engaged above 17°α (Sanborn) for 1/2 sec during pushover-pullup--should have engaged at 14.5°α

Surface Rate Limiting

Rudder, aileron, and lower flap surfaces were limited at pulse inputs only

Upper Rudders

Condition	Time	$\bar{q}$	V_c (Kts)	Rate Limit (Both)	δR_B
1st δr pulse	9:20:08	120	195	Left 32°/S Right 20°/S	0°
2nd " "	9:21:06	126	197	Left 33.5°/S Right 31°/S	-10°
3rd " "	9:21:25	115	188	Left 34°/S Right 30°/S	-10°
4th " "	9:21:36	171	229	Left 34°/S Right 30°/S	-10°

Lower Flaps

Condition	Time	$\bar{q}$	V_c (Kts)	Rate Limit (Both)	Range
1st δe pulse	9:20:17	143	214	Down 34°/S Up 47°/S	24-33° 33-24°
2nd " "	9:21:44			Down 41°S Up 48°/S	7-17° 17-7°

Ailerons

Condition	Time	$\bar{q}$	V_c (Kts)	Rate Limit (Both)	δA_B
1st δa pulse	9:20:08	120	195	Up 17.0°/S Down 16.3"/S	7°
2nd " "	9:21:06	126	197	Up 17.5°/S Down 16.5°/S	7°
4th " "	9:21:36	171	229	Up 17.3°/S Down 16.5°/S	7°

Upper Flap Bias Rate--From speed brake usage

2.5°/S increasing
2.9°/S decreasing

Yaw Trim Rate

0.8 in./sec going left

All of the above data compare well with ground test data

24 August 1973

X-24B CONTROL SYSTEM RESULTS FLIGHT B-2-4

Paul W. Kirsten

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No SAS failures
No limit cycling
No structural resonance
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Condition	Time	$\bar{q}$	V_c (Kts)	Rate Limit (Both)	δR_B
1st δr pulse	9:20:08	120	195	Left 32°/S Right 20°/S	0°
2nd " "	9:21:06	126	197	Left 33.5°/S Right 31°/S	-10°
3rd " "	9:21:25	115	188	Left 34°/S Right 30°/S	-10°
4th " "	9:21:36	171	229	Left 34°/S Right 30°/S	-10°

Lower Flaps

Condition	Time	$\bar{q}$	V_c (Kts)	Rate Limit (Both)	Range
1st δe pulse	9:20:17	143	214	Down 34°/S Up 47°/S	24-33° 33-24°
2nd " "	9:21:44			Down 41°S Up 48°/S	7-17° 17-7°

ANGLE OF ATTACK AND SIDESLIP DISCREPANCIES
Flight B-2-4

Event	Time-Min (from launch)	Altitude-Ft	α Cockpit	α Instr.	β Cockpit	β Instr.
After T.O.	-38	10,800	2°	2.4°	-1.9°	-1.8°
26 Min	-26	31,000			-3.0°	-2.2°
22 Min	-22	35,000	2°	2.2°	-2.0°	-1.5°
9 Min	-9	41,700			-2.75°	-1.7°
1 Min	-1	44,600	5°	5.0°	-3.0°	-1.8°
After Launch	+.5	40,700			0°	+.9°
PO-PU	+1.0	30,800	16°	17.8°		
Low Key	+2.2	21,000	10°	10.4°	-.5	+.4

FLIGHT LOADS AND HINGE MOMENTS

By

M. Tang

Delays in data reduction have caused delays in the analysis of the flight loads and hinge moments from Flight B-2-4. A review of the real-time strip recorder data does indicate that the forward hook load was somewhat higher with the upper flap at -40° (normal launch configuration) than with it at -20° (first flight configuration). The load also increased significantly (by approximately 5,000 lb) during the lower flap full throw checks. Although these loads were not critical for the light weight X-24B, they would have been critically close to design values for the heavy weight vehicle. An attempt to reduce these pre-launch loads will be made on the next flight by altering the control system procedures and B-52 airspeeds.

ANGLE OF ATTACK AND SIDESLIP DISCREPANCIES

By

R. Hoey

Analysis of data from Flight B-1-3 showed an apparent discrepancy between the β indicator in the cockpit and β values recorded by instrumentation. As a result several comparison checks were made on Flight B-2-4 to try to isolate the cause. Pre- and post-flight comparisons on Flight 2 showed less than .2° discrepancy between either the cockpit or telemetered values of α and β and the nose boom fixture readings. During the flight, a significant shift in the cockpit sideslip indication was observed. Notice that the discrepancy is apparently associated with altitude (or temperature). Analysis of the accelerometer and surface position data from both flights tends to support the theory that the instrumentation β is correct and the cockpit β is biased by approximately 1°.

Inconsistencies in the stick shaker actuation angle of attack have also been observed on ground tests as well as during one flight check on Flight B-1-3.

Component tests are being run both in the airplane and the laboratory to attempt to isolate these problems.

X-24B TECHNICAL DEBRIEFING

Flight Number: B-2-4 17 August 1973
Pilot: John Manke

1. Describe the launch transient with 40° upper flaps and compare to the first launch with 20° upper flaps.

   Okay, the only difference I guess that I noticed was the difference in pitch rate. The airplane today pitched down considerably more than it did on the first flight. The first flight, it looked like it was just a flat launch to the nose. Actually, it just rose up a little bit. Today, I could feel the pitch down just a little bit harder launch than the other one. From a roll standpoint, I didn't see a lot of difference.

2. Rate the task to recover from the launch transient and acquire 10°α. Compare pitch control and damping with the first flight.

   Okay, I would rate that a three and I would think that if we had the trim set where we thought it was going to trim at and be prepared for that, why that rating would probably go to two and a half. The pitch control and the ability to trim to the desired alpha with the 40 degrees flap is easier than with the 20 degrees flap. As I mentioned before with the 20 degrees flap, alpha seemed to wander just a little bit and didn't seem to want to settle down. Today, it was much more positive and it looked like it wasn't going to wander at all like it did before. So, it was better and I would think that we can very easily get this thing to a two and a half rating.

3. Discuss any out of trim conditions that existed after launch and describe your corrective inputs.

   Okay, this will be in the directional axis. The beta needle was somewhere around two to two and a half degrees needle left, right after launch. As we had planned to do, I trimmed left rudder until we got back to zero or very close to zero beta on my gage. Now, as we came through about one degree needle left on the beta gage, it required some right aileron to keep the wings level. So, at that time I was pretty

certain that we had passed through the zero beta point and I think if we played the tape back, why it would probably match pretty closely to where you saw the beta go zero. I went to the zero point, so that we could get a calibration so when I called the zero, I had a fairly good zero. After that, I took some of it out but I am sure that we didn't get all of it out and probably flew, I know we flew, in a little bit of a sideslip for the rest of the flight.

4. Compare the vehicle's response to the rudder and aileron pulse with the simulator.

I remember it being very much like the simulator. You don't get much response with aileron as you can see. You do the quick doublet and the airplane doesn't have time to respond. It's sort of a big let-down; you put this big aileron thing in there and the airplane doesn't do anything but the simulator doesn't either.

5. Discuss and compare the pitch damper off pitch pulse with the simulator.

Okay, as I mentioned before, I think the airplane was better damped than our latest simulation and the latest simulation includes a reduced C_{m_q} and a one percent rearward movement of the cg. So I would guess it's somewhere in between that and what we had before.

6. Discuss the pushover-pullup. If stick shaker actuated, describe.

Okay, the pushover-pullup started, I guess, from 10 degrees alpha. I hesitated somewhere after I got started, maybe down around 6 or 7. I was a little surprised at how far the nose looked to be going over and I mentioned that to you before that this always is a surprise every time you do one of these things and then I pressed on and pushed down to about two, back on up and I was expecting the stick shaker at 14 alpha and I think I eased up to 14 a little bit and nothing happened and I think I hesitated somewhere around 14 degrees and then from

there went on up to a little over 16. I think I saw about 16 and a half on the thing and I didn't feel the stick shaker actuate.

7. Give pilot ratings for the overall handling qualities with the 40° upper flap configuration.

I am just going to disregard the sideslip problem and try to rate the airplane as if that didn't exist and for the maneuvering that I did which included the pulses, the pushover-pullup; I did make a turn during this particular time or started to turn. I'd rate the airplane a two and half.

8. Discuss the "hands off" configuration change. Did you note any lateral-directional out of trim condition after the close up?

Okay, the "hands off" amounted to a hands off in pitch because of the sideslip thing. I had a little bit of lateral mistrim so I had to hold the stick with the palm of my hand so that meant I had to push the left aileron in and hold it that way. It went pretty much as the simulator except I think that we got a little bit larger alpha sweep in the airplane than we had in the simulator. Maybe two to three degrees more alpha change, but it's really a piece of cake. I don't think we'll have any trouble making either constant attitude or constant alpha configuration change. I just think it's going to work real well. Very predictable and it just follows down. The pitch damping is spectacular in this airplane and so it just looks like alpha is following the flap and it doesn't tend to overshoot or bauble or anything else. It goes down and it smoothly came right on back up again to 8 degrees. I guess I can't comment on the lateral-directional out of trim condition after the close up because I had a little out of trim condition before I started and I am sure it still existed afterwards. So, if there was a trim change associated with that, why I wasn't aware of it. If there was one, why it was small.

9. Discuss the planned rudder and aileron doublet sets at 14°, 5°, 10°α.

Okay, the doublet sets went just as planned. I guess the most impressive part was that the airplane looked

like the simulator at the 5 degree rudder pulse there. It's a pretty sloppy airplane down at 5 degrees. The nose will move out and just very slowly come back. The frequency is very low and the simulator shows that very nicely. And it's quite evident in an airplane like this with a long needle nose on it, because you just see the nose swing out and just gradually come on back again. It's damped, and I guess very well damped. It just takes its jolly ol time of getting back.

10. Discuss the vehicle's response to the pitch pulse with the damper off.

I really couldn't tell the difference between the damper off pitch pulse here with it closed up and the other one with it opened up. Damping looked just about the same and the same comments apply. It's a little bit better damped than our latest simulator configuration.

11. Can you give a set of pilot ratings for the overall handling qualities with 20° upper flaps between the configuration change and low key?

Because of the workload, I can't give a real qualitative answer to that one, but it would be in the top group--the one, two and three group, somewhere in that ballpark.

12. Comment on your low key conditions.

They were great. Lateral displacement was just about where I like it. It seemed like I may have been a thousand feet or so high but it was just about what we looked at this morning and really excellent low key conditions.

13. Discuss the turn to final. Rate handling qualities.

Okay, during the turn to final, I utilized the upper flaps. I ran them out to about 30 degrees to take care of a high energy situation. And I think I moved them out and brought them in while I was still in the turn. I may have just about rolled out on the final when we retracted them. Handling qualities, here again, are absolutely superb. The pilot isn't aware of any pitch change and I think the reason is

the airplane pitches in the direction you want to pitch to do the job. That's a real asset in this particular airplane. When you run the flaps out, why the nose goes down just a little bit. That's just where you would put it, if you were doing it yourself. So the pilot really doesn't even notice that. I'll rate the handling qualities in that area as a two.

14. Discuss the final approach. Rate handling qualities.

Okay, I left the brakes up a couple seconds too long and ended up just a little bit low on final approach. I settled for 290 to 295 knots then. As happened this morning with the F-104, the aim point would settle back because the winds would hit. So the aim point was moving with the F-104 a quarter to a half a mile back. Of course, that's a nifty situation if you're using the half mile point for an aim point. As you roll onto final, you've got it made. Your aim point moves back and that gives you that much more run-out. So I never objected to that particular situation. The handling qualities are again great.

15. If turbulence was encountered, describe the vehicle's response and effect on piloting task.

The turbulence level was actually the less than light, I guess, lighter or below, and I only remember one or two little baubles of turbulence and laterally, I don't think the airplane did anything. It was probably just a seats-of-the-pants type thing. Handling qualities, here, around two to two and a half and I have already covered question 15 on the turbulence. We'd have to call it just nil, I think, in turbulence.

16. Discuss and rate the flare.

I guess this airplane is easiest of any of them to flare. You feel like you could drive it down to six hundred feet and still not have any trouble with the flare. I guess the pilot is not even really aware of very much stick motion during the flare. You reach the point where you think you ought to start rounding it out and just think about it a little bit

and the airplane just seems to follow along. If we were to look at the airplane from the start of flare on through the touchdown, in the two flights that I've seen, this airplane is far superior to any of the other airplanes. Now, we are going to have to qualify that with some winds, cross-winds and turbulence, but in this no wind condition, it's a superior airplane. The flare, again, I would rate two and a half and the landing--we must have held one to two feet off the ground for probably 25 to 30 knots for the time interval of deceleration of 200 down to 170. The pitch control is just perfect. You can put the airplane anywhere you want it and just hold it there. You can control sink rate just beautifully and the other airplanes you always notice a sense of urgency. Once you get down close to the ground, you felt that you ought to get it on the ground pretty damn soon, because it just didn't feel right and the pitch rate on the other airplanes was pretty high once you let your speed get down and you got the impression that you ought to well be on the ground quickly. This airplane is different. I have a lot of confidence in the darn thing and it just feels like you could go forever.

17. Discuss and rate the landing.

A two on the landing.

18. Discuss the ground handling during roll-out.

Just like last flight, there wasn't any problem. I think one time required a little bit of right rudder. We got no nose, no lateral nose movement as the nose gear came down. It rolled straight. I didn't use any nose gear steering and I did use a little more braking this time than I used last time just to see the effect of it. Just like on the other airplane, these brakes are nothing to write home about.

19. Any improvements required before the next flight?

On the next flight, obviously, we want to do something with the beta and the alpha, resolve this thing. But to repeat what we've just said I suggest that we go ahead and launch a little bit of rudder

trim in and determine just to go ahead fly with it like it is unless NASA 1 decides that we have some trimming to do. I'd like to see us come up with a setting and launch and fly it that way.

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-2-4 DATE OF REPORT: August 21, 1973

PILOT: Manke DATE OF FLIGHT: August 17, 1973

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Roger's Dry Lake

PURPOSE OF FLIGHT: (1) First Flight with 40° upper flaps

(2) Longitudinal trim curve verification

(3) Lift and drag determination

(4) Stability and control data

(5) Fin and rudder pressure survey

(6) Landing gear dynamics

I. Discussion of Previous Operations

A. Flight B-1-3 was flown on 8/1/73 with no vehicle system problems except an apparent offset of approximately 1° between the cockpit presentation and telemetered side slip angle.

II. Vehicle Configuration Changes

A. The upper flap bias limit switches were reset to provide -20° to -40° flap travel.

III. Instrumentation System Changes

A. Re-aligned accelerometer at pilot's station to measure vertical acceleration.

B. Installed heater blanket on L/H Fin Camera.

C. Installed new "B" model sub-com (5 sample per second) for pressure tap measurement.

D. Installed power supply for band-pass filters being used on the semiconductor strain gages.

E. Angular accelerometer package removed for repair.

F. Removed center fin camera.

IV. Preflight Events

A. No problems could be found in the sideslip angle systems.

B. Preflight functionals were performed with no problems.

C. A new set of buffed main gear tires were installed. The present plan calls for new tires for each flight.

V. Flight Events

A. Flight servicing was accomplished with no problems.

B. The flight was made with no problems except that both sideslip and alpha systems appeared to have offsets between cockpit and T/M.

Approved by: _____
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: _____
Norman E. DeMar
X-24B Project Engineer
Operations Engineering
Branch

X-24B #551 POSTFLIGHT DATE: 8/17/73

PILOT: MANKE

Okay this was flight B-2-4, flown on the 17th of August. And it was really a dandy.

Prelaunch was just without flaw at all until I did the SAS check at 4 minutes, and that was me screwing that one up. I guess I got the second set of servos off too quick, George, and I got the red light in yaw. I'll talk to you about that, maybe we'll just go ahead and charge on. The second time through, I got the pitch one off too fast. Okay, well, anyway, it looked good from where I was, as long as you were happy with it.

A little bit more of a launch transient this time. I don't think there was any more in roll, but I noticed it more in pitch. The airplane felt like it pitched down a little bit, although when we came up on α, α was - looked like I was trimmed for just a little bit above 10°α. Still no bigger transient than we've had on the other ones, probably even a little bit lighter than most.

The response to trim inputs at 10 - trimming for 10 - were better this time than they were on the last flight, and I suppose that's because it's more stable in this configuration. Remember that I complained a little bit last time about it being a little bit sensitive in α, and I had to chase α just a little bit at the Mach number and configuration we were at. Today it was a lot more solid, and I had no problem at all going to 10α.

Okay, the first 5,000 feet we had set aside to look at this β trim problem that we had on the other flight. We've noticed that the sideslip I see in the airplane does not agree with what they're seeing on the ground. So, right after launch, I had 2 1/2° needle left sideslip. I started bringing in left rudder trim, and I took my feet off the rudder pedals to do this, and as I got about - as I got through about 1° left, I could feel the roll angle change. I got an indication there that my indicator is probably a degree off, and when it reads 1° needle left, why, we're probably pretty close to centered. At any rate, I went and trimmed to zero, so that we could get our calibration anyway, and I had to hold quite a bit of right aileron at that time, to keep the wings level. I gave you the call then at 10α and 0 sideslip. By that time, I had used up more than the allotted 5,000 feet, and I proceeded to get behind the flight, get behind the airplane just a little bit. I took some of that extra right rudder out at about this time, and I took a little bit more out later when I had a chance. So, I think we'll probably find that we flew in just a, maybe a half or 3/4 of a degree sideslip for the whole flight.

Okay, on the next maneuver was the rudder and aileron doublets, at 10° angle-of-attack. They looked very much like the simulator. It's always a surprise the little aileron response you have on a quick pulse. I think the guy's expecting to see the wings drop and all that sort of stuff, and with the doublet, why, its just a quick right and a quick left, and the airplane doesn't have all that much time to respond - I would say that the airplane looked very much like the simulator at that time.

The next maneuver was the pitch-damper-off-pitch-pulse, and it went real well. I think the airplane is better damped than our latest simulation. After looking at the data on our last flight, it looked like our Cmq was a little bit lower than predicted, and also it looked like we were flying at a little less static margin. We moved the simulator cg 1% aft and reduced the Cmq a bit, and it did decrease our pitch damping quite a bit. It looks now like the airplane is actually a little bit better than our latest simulation, somewhere in between what we had before.

Okay, the pitch damper came on, and we did the push-over pull-up. I got down, I think, to a little bit less than 2°. It's always surprising, the nose attitude, when you push over to these low α's. The airplane just looks like it's really going straight down, so it just takes a little longer to get to the 2 than you really planned on in simulation. The maneuver was supposed to be from 2 to 16°. I think it went a little less than 2 and one of the things I wanted to find out on this one was if the stick shaker was going to work. It should come in at about 14°α. It didn't come in at 14, so I went all the way up fairly close to 17° - we got 16 and a half or seventeen on the α. I didn't notice the stick shaker, I think I called it out. Bob said it looked like it did fire may be for a half a second. But, it's still not coming in where it should be and this is part of this α-β discrepancy we're seeing on the airplane in flight. Now we don't see this on the ground, that's the strange part. It should come on just a little bit before 14. It does in fact come on when we go down and do the check in the hangar. We'll run it up to 14 and an half and it'll come on like its supposed to.

Okay, I had convinced myself last night that I was going to see a lot of buffet at 14°α on this - well I'm getting ahead of myself - that would be after the cleanup. I'll talk about that later.

The next maneuver was to make a hands-off configuration change to see if our simulator trim data was correct. I did make it hands-off in pitch. I had to hold a little aileron in to keep the wings level, but it was hands-off in pitch. And the α went pretty much like we'd seen in the simulator. The simulator showed maybe trimming down from 12 to 7° or 7 and 1/2. The airplane looked like it went down to about 6 or 6 and 1/2° then back on up to 8 or 9. Very smooth configuration change and I would guess that it's going to be just much like the A - its a no-problem type deal, and I would think a guy could very easily make a constant α configuration change.

Okay, I trimmed up to 14°α then for the rudder and aileron doublets. This is the point that I had expected to see some buffet. We got quite a bit of buffet in the airplane right after launch at high α's in this configuration last time. The only difference was that the mach number was a little bit higher on the last flight. I guess it might have been .6 or .65. I didn't feel any buffet this time. I was a little slow getting to 14. I expected the buffet to come in and I wanted to look at it a bit, and it didn't and I would guess that's why we went high on profile - it just

took me a long time to get to 14. So, we spent quite a bit of time at high angles-of attack. The nose attitude was really high at this point - I don't know if chase noticed it or not - I happened to look up and saw the nose and it was very impressive how high it was. I don't know if we came level or not, I bet we came awful close huh? Yeah, we came awful close to level. Okay, also while doing this thing Mike asked for a heading correction, and he sounded like he meant it, so I gave him a little right wing down and could feel it turn pretty good.

Okay, the next pulse was the 5°α pulse and in the simulator this is a strange on too. Bob tells me this is because of very low C_{L_β} in this area. It's a, uh - the rudder pulse turns out that the nose just barely moves. It's very sluggish and very lightly damped. The airplane was just like that. Almost identical.

Okay, then we did a 10°α rudder aileron doublet and I don't remember what that looked like. I'm sure it was very much like the simulator.

Then the pitch damper came off for another pitch pulse and here again the airplane appeared to be a little bit better damped than I had seen in the simulator with our latest configuration.

And then about this time we were approaching the highway, and all our calls were coming at once but it turned out to be no problem. I got the rocket check, camera on, and to show you how much you depend on NASA-1 to get you someplace, the first time I ever got my head out of the cockpit was when Mike called "passing the highway". I looked out and sure enough the runway was back over here. On this kind of flight when you're that busy, why you really depend on the guy up at NASA-1 to get you where you want to go. It was the first time I'd really had a chance to look out of the airplane. It was a good call, and I don't know where we were but it sure looked good from my standpoint. I like that low-key position. Looks like we're just in a little bit. And I was maybe a 1,000 or 1500 feet high but no problem.

Okay, the pattern looked good, looked just like I'd seen in the 104 this morning. As I'd done this morning in the 104, I tended to fly a high pattern, and I wasn't quite sure why. I did the same here, came out with the speed brake, used about 30 to 35 degrees, and boy they're really effective, they're dandy speed brakes. The only thing we're going to have to be a little careful with - I was a little slow getting them in again today and I was very careful about it. You really get yourself a steep glide slope set up with the thing. So, for us that are going to fly it some more, we'll have to watch that and I think NASA-1 is going to have to pay particular attention to the speed brakes, cause it really starts down. And when I got them back in I was just a little bit lower than I would have liked to have been. It wasn't any problem. I used about 290 or 295 then for approach airspeed versus 300, which was great.

It's a piece of cake to flare this airplane. You feel like you could drive it down to 600 feet and start your flare. I started at about 800 to 1000 I guess. A lot of time then from flare initiation to gear down and to touchdown. Einar gave some real dandy calls on altitude and that really helps a lot. I held and waited for 240 knots to get the gear down and once again no gear transients. It's a very nice gear deployment. And then settled it down and I was level about two feet above the runway at about 200 knots. Jim McKay had asked me yesterday to touch it down 170 or below again until they get some more of their correlation at Wright field. So I just sat there and held the airplane off. This is where this airplane really differs from the other lifting bodies. You just got the feeling you could hold it off all day. The airplane flies nicely and you don't get that sense of urgency that we've had in the other airplanes that you ought to get it on the ground. You could tell with those things that once you got it down there and it started slowing up that you'd better damn well get it on the ground quickly. This airplane is different that way. We held it at 1 foot for I don't know how long. It seemed like a long time at 1 foot. As the airspeed came down to about 175, I concentrated on starting it back down and I guess we touched down at about 170 or a little bit less. The touchdown felt as smooth as the last flight. Once it's down, the nose seems to hesitate just a little while. Now that I think back on the other flight it did the same thing. It will hold off for just a little while and then once it starts, it goes like gangbusters. Right on down and always looks like that boom is going to go right into the ground. It hasn't so far. Okay, the control above the runway, and the altitude control and everything about it is superb, close to the runway. It's a dandy flying airplane.

Okay, I got the nose gear steering arm switch on and I didn't have to use nose gear steering. I did not use it again this time. The airplane rolled straight. I think I had to put a little right rudder in at one time to correct for starting left but it came right back and somewhere below 100 I got on the brakes a little bit and used some moderate braking. We'll see what a roll-out was.

We then made the β checks out there to find out if the problem still existed after we landed and I guess it turned out that you guys were reading about what I was reading. We'll have to resolve it someway.

I guess those are the only comments I have.

Q: You called fog twice during captive. Was there very much fog?

A: No, the fog wasn't much. It was pretty much like we saw one of those other wet days. We've still got a lot of moisture at altitude. I still think we got a little bit of easterly flow, or something like that. There were clouds around. Just a little bit up here - a little bit on this side.

Q: Was it fog or frost?

A: It was frost, no problem.

Q: Did you feel any turbulence?

A: Yeah, there was just a little bit of turbulence on final, but very mild. Just one or two little burbles. I didn't feel any at altitude. Just a little straight-forward bump in the seat. In fact it was so mild that I didn't even call it out.

Q: John, while you were floating there before touchdown, did you intentionally look at it laterally?

A: No, I did not.

X-24B #551

FLIGHT: B-2-4 DATE: 8/17/73

PILOT: J. Manke L/P: J. Russell

NASA 1: M. Love

NASA 1: 24 Minutes John

24 MINUTES TO LAUNCH

John: Good, 24. SAS Gains are 4, 3, 2; Ready for a calibrate?
NASA 1: Roger, go ahead.
John: Good, you got it.
NASA 1: Good calibrate.
John: Okay, my cabin altitude is 19,000; X-24 air is 3,000; Pylon air is steady at 600; here comes 2 & 4 pumps - okay, 2 & 4 pumps are on, and my lites just went out, and I got 3100.
NASA 1: Roger
John: Mode switches are on;
NASA 1: Roger
John: And all the circuit breakers are in except vehicle release and brake.
NASA 1: Roger.
B-52: 008 is 35,000.
NASA 1: Roger, 22 minutes John.

22 MINUTES TO LAUNCH

John: Okay Mike, 22 minutes, mach repeater coming to auto. Okay and it programs - α is 2°, β is 2° needle left, Airspeed - 232 about, altimeter 35,000, indicated mach is .67, Mach repeater reads about 72.
NASA 1: Roger.
John: My left mach meter reads about .7 and the other about .68.
NASA 1: Roger
John: Okay, let's go to page 6 and do the controls check. Rudder mode switch going to auto; mach repeater going to manual.
NASA 1: Start left turn Dale.
B-52: 008.
John: Mach repeater manual, 1.0. Here comes the KRA going manual; Cycle emergency flaps; and they go open and they go closed; now we'll open normal.
NASA 1: Roger, and Dale start your left turn.
B-52: Okay.
John: Okay, there's 40 and my rudders are zero; coming close; okay 20 and a -10, going back open.
NASA 1: Okay Dale can you give us your airspeed and fuel please.
B-52: Roger, airspeed right now is 230, fuel 53,500.
John: Okay I'm 40 and 0 ; the rudder mode switch is now manual; toe in; looks good, there's -10; going out; looks good; rudder mode is going to auto and rudder bias is zero.

NASA 1: Roger
Chase: Looks good John.
John: Okay the aileron mode switch is in backup and I'll cycle aileron.
NASA 1: Roger and 008 we'd like you to steepen the turn.
B-52: Okay.
John: About 9, 5, and normal.
RAPCON: Edwards approach to 008.
B-52: We're about 8 minutes departing the active now and we're in the blocks.
John: Okay I see 7 on the ailerons, how does it look from down there?
NASA 1: Looks good John.
John: Okay I'll pull my aileron bias circuit breakers.
NASA 1: Roger.
John: Okay, here comes full forward stick; full aft.
NASA 1: Roger John.
John: Trim, trim looks good; and I see 26.
NASA 1: Looks good down here John.
John: Okay, here comes some aileron trim, right, and left that should be about zero. Okay here comes some right rudder and left; and some yaw trim, right and left. And now back to zero.
Okay, it looks like about zero here.
Okay, KRA increase to 50; okay here comes some right stick and I get right rudder; left stick and I get left rudder.
NASA 1: That's good, John.
John: Here comes stick shaker test; good test, stick shaker on; KRA is zero, right, no rudder, left, and good - no rudder. Okay KRA going to emergency, and right, left, no rudder, KRA increase to 50.
NASA 1: 008 roll out 185.
John: Roger and KRA mode is going auto and I'm down to zero again.
Okay - mach repeater 1.0, flap mode switches manual, rudder mode switches auto.
NASA 1: Okay, it all looks good, John.
John: Okay, and how's the time Mike?
NASA 1: 008, roll out now.
B-52: Roger.
801: And John turbulence check same as before, possibly a little less turbulence.
John: Okay, thanks Fitz.
NASA 1: Copy.
John: Mike, what's our time now?
NASA 1: 17 and 10 seconds.

17 MINUTES TO LAUNCH

John: Okay, I'll get on with it here. SAS servos going to auto.
NASA 1: Roger.
John: SAS Gains are 5, 5, 5. Here comes the old SMRD. No lites.
NASA 1: Roger.

John: Here comes the torque. No lites.
NASA 1: Good torque.
John: Ones are off and a torque, 3 yellows. Twos are off and a torque, 3 reds; and 4,3,2; SAS servos are auto; lites are reset; good torque, no lites.
NASA 1: Good torque, John.
John: Okay, I guess we had about 3 transmissions at that time, I got the good call. Okay SAS mode switches are on. I'll wait here for 14 minutes, Mike.
NASA 1: Roger, we're at 16, John.

16 MINUTES TO LAUNCH

John: Was that 16, Mike?
NASA 1: Right.
John: Okay, thank you.
NASA 1: Okay John, we need a little more lower flap and a little bit of left aileron.
John: How's that?
NASA 1: Little more left aileron.
B-52: The ship 008 is flight level 40.
NASA 1: Okay, trim set John.
John: Okay, I read about 26 or 26 and a quarter probably, and aileron is right at zero now.
NASA 1: Roger. Okay 14 minutes, John.
John: Okay Mike, 14.

14 MINUTES TO LAUNCH

John: Okay, I've swapped hydraulics; number 1 and 3 are on and they're 2700.
NASA 1: Roger. Dale what's your heading?
B-52: Heading is 189.
NASA 1: Roger. Will you say that again?
B-52: Rog, 189.
NASA 1: Roger.
Chase: Mother ship 008, are you southbound on the track?
B-52: 008 affirmative and we're in the block.
John: Did you call 13, Mike?
NASA 1: 13 now John.

13 MINUTES TO LAUNCH

John: Okay and I'm ready for pitch and yaw pulse, Dale.
B-52: Roger.
NASA 1: Give me 3 left, 008.
B-52: Rog, 3 left. NASA 1, are you ready for the pitch and yaw pulse?
NASA 1: We're ready.
B-52: Okay.

NASA 1: Good pitch pulse.
B-52: Yaw pulse.
NASA 1: Good yaw pulse.
John: Okay, looked good here. I'll go to erect and fast erect on if we're fairly close to heading, Mike.
NASA 1: Roger. 12 minutes, John.

12 MINUTES TO LAUNCH

John: Okay, Mike, 12. Just a little fog just even with my right ear, no big problem.
NASA 1: We copied that. Chuck, when you check the trim, I'd like a good check on the upper rudders. 11 minutes, John.
John: Okay, Mike, 11 minutes.

11 MINUTES TO LAUNCH

John: My upper flaps are 40, lower flaps are 26, aileron is zero, aileron bias is 7, rudders zero, and rudder bias zero.
Chase: Everything looks good here, John.
John: Okay Chuck, thank you.
Okay Bill Dana, the coast is not clear.
NASA 1: Roger. 10 minutes John.

10 MINUTES TO LAUNCH

John: Okay, Mike, ten minutes. #1 Helium is 24, the #2 is 38. Control gas - about 480 and Governor balance oh, 435. Fuel tank is 33 and the LOX is 22 and a half. Landing gear 3,000.
NASA 1: Roger.
John: And if you like the heading here...well I'll just leave it since we're here. What do you have for heading, Dale?
B-52: 185.
John: Okay. Okay, Mike, on the sideslip, I'm reading a little bit less than 3. Probably 2 and 3/4.
NASA 1: Roger. We're showing a little under 2 John.
John: Okay there is a stranger there.
NASA 1: 9 minutes John.

9 MINUTES TO LAUNCH

John: Erect has been cutoff; fast erect is off; both attitudes look very good.
NASA 1: Roger.
John: Just a little fog at about 12 o'clock - just in front of the shade.
NASA 1: 8 minutes, start your turn.

8 MINUTES TO LAUNCH

John: Okay, got your 8 minute call. Chuck, you ready for a rocket check? How's that, Mike?

NASA 1: Did you see two, we only saw one here?
Chase: I saw two.
NASA 1: Roger. 7 minutes John.

7 MINUTES TO LAUNCH

John: Okay Mike. I'm on. X-24 radio already. Let's go secondary. Okay back to primary. Read okay, Mike?
NASA 1: Roger, you're 5-square.
John: Okay.
NASA 1: 6 minutes now.

6 MINUTES TO LAUNCH

John: Okay 6.
NASA 1: Chase aircraft check your windshield heat.
Chase: Chase 1. 2. α.
NASA 1: 5 minutes now.

5 MINUTES TO LAUNCH

John: Okay Mike 5. Going to batteries...I'm on battery power. I did not get the emergency lite so I'm in good shape.
NASA 1: Roll out 360.
John: ...and 3200 pounds. Bus loads: 110, 105, 100 and about 20.
NASA 1: Roger, roll out 360.
B-52: Okay.
John: SAS gains are 5-5-5, here comes the SMRD. No lites, and a torque. No lites. #1's off torque. All amber. #2's are off and the torque. Okay I gotta do it again on that yaw.
NASA 1: 4 minutes John.

4 MINUTES TO LAUNCH

John: Okay, torque - good. Okay, look good to you NASA?
NASA 1: Looked good John.
John: Okay, going to 4-3-2.
NASA 1: Roger.
John: And auto, lites are out and torque. No lites.
NASA 1: Good torque, John.
....., John.
John: Was that 3 minutes, Mike?
NASA 1: Affirmative.

3 MINUTES TO LAUNCH

John: Okay, going X-24 oxygen. The cylinder pressure is about 1750 and I've got good regulator pressure. Going to X-24 air. Okay, I'm on X-24 air and my air reads 2800, cabin altitude is about 24,000, canopy defog is on and the canopy defog is at heat. Suit vent is low. Helium is 23 and 13. Control gas looks good at 48 and governor balance is 440. Fast erect switch is on and the erect switch is erect. And my trim settings look good.

NASA 1: 2° left - trim's good down here.
John: Okay
NASA 1: 2 minutes.

2 MINUTES TO LAUNCH

John: Okay, 2 minutes. The release pressure low light is out. 1 and 3 hydraulics are on.
B-52: B-52 beacon is off; release pressure normal.
NASA 1: 3° left.
B-52: Roger.
NASA 1: Standby for 70 seconds.

70 SECONDS TO LAUNCH

John: Okay, Mike, press your key down a little bit before you start talking.
NASA 1: Okay, John, stand by for 1 minute. 1 minute now.

1 MINUTE TO LAUNCH

John: Okay, I got my clock started. #1 is 24, #2 is 38. SAS lites are out. Okay, α is exactly 5, β is exactly 3° needle left. Erect switch is cutoff, fast erect is off.
NASA 1: Systems are okay John.
John: Okay, Mike, thank you.
NASA 1: 30 seconds now.

30 SECONDS TO LAUNCH

John: Okay. Release circuit breaker's in. Camera and recorder is on.
NASA 1: Roger, 10 seconds.

10 SECONDS TO LAUNCH

John: Okay.
5 seconds.

5 SECONDS TO LAUNCH

LAUNCH

NASA 1: Check 10α and trim John. Okay trim, and I got about - almost 2°. Okay, stand by for doublets John.
John: Okay, there's 10α and 0β and I have a feeling that I have some right β in.
NASA 1: That's affirmative. Pitch damper off and pulse, John. Okay, get pitch damper on, and standby for popu and 2° right, John.
John: Okay.

NASA 1: Okay, John, 12α and close it up hands off. And 2° right.
John: Okay, no shaker.
NASA 1: You're on profile John. Paralleling, quarter mile left, stand by for doublets. Okay, John, give me 3° right. Inside about a half-mile, John.
Profile's good. Do your turn. Good heading correction, John. You're on profile. Okay going a little high on profile John, and holding half-mile inside. 3 miles John, check pitch damper off and pulse.
John: Still in my doublets, Mike.
NASA 1: Roger, you're 3,000 high and converging. 2 miles, John, check damper on and call α and β.
John: Here comes your pulse.
NASA 1: Good heading John, you're converging and a rocket check.
John: 10°α now, and I've got a half ° needle left β now.
NASA 1: Roger, check the rockets. You're on profile over the highway, John. Check fin camera on.
John: Fin cameras on, starting my turn.
NASA 1: We had two good chambers.
John: Okay.
Chase: 20,000 John.
John: Okay Einar, hang on.
NASA 1: 300 knots, and a little bump.
...John, and your flaps, close em.
John: Roger.
Chase: 290, passing 8,000. 1200 feet.
John: Okay Einar.
Chase: 1000 feet.
John: Okay.
Chase: 50 feet...three good gear, 20 feet. 10 feet... 5,2,2,1 holding 1, touch.
NASA 1: Check your nose gear switch, John.
John: Okay, good call Mike.
And I'll do a little braking here.
NASA 1: All stations, NASA 1, the post flight will be at 10:15. John, what was your last transmission on the roll-out?
John: Oh, I just thought I'd try some braking, Mike. I just used a little moderate braking just to see what it was like.
NASA 1: Okay, thank you.
John: You're welcome. Well, I've come to a stop, why don't we go to page 21?
NASA 1: Roger.
John: Well you did a nice job, Mike. Okay Mike, my throttle is off, cameras coming off, here comes the calibrate Mike.
NASA 1: We didn't see the calibrate, John.
John: Okay, you got one now. Now my stick shakers working. Okay, recorder coming off, 6 SAS servos are off, hydraulic pumps are off, defogs are off. Control gas 480, governor balance 440, #1 helium is 32, #2 is 23. Landing gear is 25, cylinder pressure is 650, cabin air is down to 9 1/2. I'll turn that off now. Radar switch is coming off, stick shaker is off. Okay, attitude systems are coming off, I'll get the oxygen system off and see you later.

NASA 1: Roger, all stations, NASA 1 again, Postflight at 2:50.
John: Mike, do you want to try these α-β things, I've got the throw boards down here. Are you still up there so you can read it?
NASA 1: Roger, We'll do that.
John: All right, we'll bring em out here, we'd like to take a look at that.
Mike, how did your α readings compare with mine?
NASA 1: The α's were good John, we saw you overtrim again in β.
John: Okay let's go ahead and get that throw board down and take a look.
NASA 1: Roger. They were calling you overtrim just when you said you felt like you were.
John: Yeah, well my needle had just barely gotten back to the center, and I could feel the overtrim because I had to hold some right aileron in there.
NASA 1: Roger, and at times when you were captive, you called 3, I wasn't seeing movement on the 8-ball up here. We're still on on 2.
John: Okay, that's real weird. Okay, Mike were showing 2° needle left.
NASA 1: Roger.
John: What do you got?
NASA 1: Have them move to 2.
John: Okay, we'll go to 2.
NASA 1: Roger, was it set at 3, then, John?
John: Yeah it was set right at 3. There's 2.
NASA 1: Roger.
John: Here comes 1. There's 1, now we'll give you zero.
NASA 1: Roger.
John: Okay, that's zero.
NASA 1: Roger, zero's good here. John, could we check to the right also?
NASA 9: NASA 1, standby, this is NASA 9. I think he's shut his radio down.
NASA 1: Okay.
NASA 9: Can I give him a message for you?
John: I'm on Mike, I can read you.
NASA 1: We'd like to go out to 3,2, and 1 on the right too, John.
John: Okay.
NASA 1: Are you able to be recording what you're indicating John?
John: No. Reading zero right now. static...
NASA 1: Rog, you were reading your indicator readings, right?
John: My indicator readings corresponded pretty well with what they were setting out there.
NASA 1: Okay.
John: Okay, we're at zero again,
NASA 1: Roger.
John: Now we'll go to three the other way...Okay, they're at three.
NASA 1: Roger.
John: And there's 2. Okay, there's 2.

NASA 1: Roger.
John: Okay, there's one.
NASA 1: Roger.
John: Okay, let's go 2 the other side again. There's 2 the other side.
NASA 1: Roger.
John: Now 3. That's three, Mike.
NASA 1: Okay, John.
John: Okay, shutting down.
NASA 1: Okay, thanks a lot.

missing

FLIGHT 3

FLIGHT 4

PRELIMINARY RESULTS OF X-24B

FLIGHT B-4-6

18 SEPTEMBER 1973

BY

AF/NASA X-24B PROJECT TEAM

X-24B Flight Request
7 September 1973

Flight No: B-4-6

Scheduled Date: 18 September 1973

Pilot: John Manke

Purpose:
1. Longitudinal Stability and Control Data at 64% with 40° and 20° Upper Flaps
2. Handling Qualities Evaluation with Pitch Damper Off
3. Handling Qualities Evaluation Using Upper Flaps for Pitch Control
4. Investigation of Aerodynamic Effect of WALC Jettison (Modified Exit Location)
5. Control System Evaluation with Two Hydraulic Pumps
6. Aileron and Upper Flap Pressure Survey
7. Boundary Layer Noise Experiment (RED PLUG)

Launch: South Rogers Lakebed, Mag Heading 360° + Crosswind Correction Angle. 45,000 feet, 185 KIAS. Flap Bias "Manual", Upper Flaps = -40°, Lower Flaps = 25°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = .75° LEFT. Aileron Bias = 7°, ~~Aileron Bias Circuit Breakers Pulled~~. SAS Gains 4,3,2. Mach Repeater "Manual" = 1.0, KRA "AUTO", #2 and #4 Hydraulic Pumps On.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #1 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	Mn	EVENT
1	0	45	185	5	.70	Launch, Trim to 10°α.
2	20	42	190	10	.66	Jettison WALC (Note Trim Change).
3	34	38	215	10	.69	Perform Pushover-Pullup (5° to 17° to 11°α).

ITEM	TIME	ALT	A/S	α	Mn	EVENT
4	53	33	200	11	.60	Disengage Pitch Damper, Evaluate Longitudinal Handling Qualities.
5	75	30	185	11	.50	Change Configuration to 20° Upper Flap Bias at 11°α.
6	86	28	200	11	.52	Engage Pitch Damper, Perform Pushover-Pullup (17° to 5° to 10°α).
7	108	25	205	10	.50	Retract Upper Flaps to 13°. Evaluate Longitudinal Handling Qualities with the Upper Flaps and in the Crossover (Lower to Upper Flaps).
8	136	22	220	10	.50	Extend Upper Flaps to 20° Vector to Low Key, #1 and #3 Hydraulic Pumps On, Landing Rocket Check.
9	156	20	200	10	.44	Low Key, Start Left Turn, Fin Camera On, Calibrate.
10	214	10	270	9	.50	Pushover to ≈6°α to Accelerate to 300 kts. Mach Repeater to .3.
11	255	3.3	300	6	.48	Start Flare $\alpha \approx$ 10°.

ITEM	TIME	ALT	A/S	α	Mn	EVENT
12	265	2.4	250	7	.42	Level, Gear Down Below 240 kts.
13	287	2.3	180	12	.3	Touchdown

NOTES:

1. Nose Ballast = 260 lb
2. WALC in Forward Compartment of Tank = 350 lb

	X-24B	Weight-Lb	cg-%
3.	Launch	8664	64
	Landing (with H_2O_2) Assume 350 lb WALC Jettisoned	8314	64
4.	Pylon Adapter	5020	

GROUND RULES FOR NO LAUNCH

1. Angle of Attack or Sideslip Malfunction
2. Any Control System Malfunction
3. Any Landing Rocket Malfunction
4. Turbulence Below 10K in Excess of Light
5. Surface Winds 10 kts Crosswinds/15 kts Max

(In addition to standard ground rules published in Lifting Body Joint Operations Plan)

ALTERNATE SITUATIONS AFTER LAUNCH

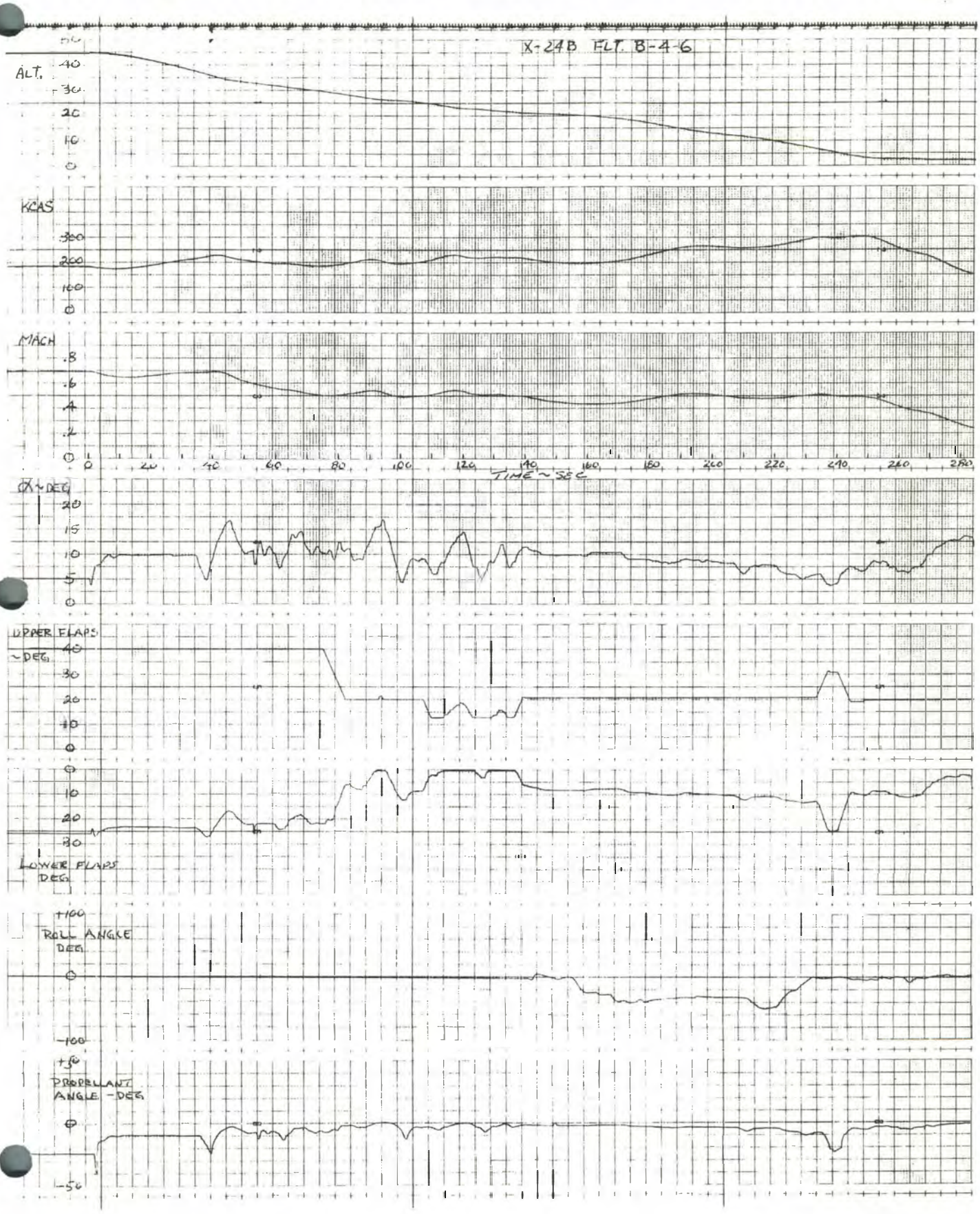
	Failure	Action
1.	Radio, Radar, PCM	Proceed as planned.
2.	Airspeed, Altitude	Proceed as planned using α for primary control.

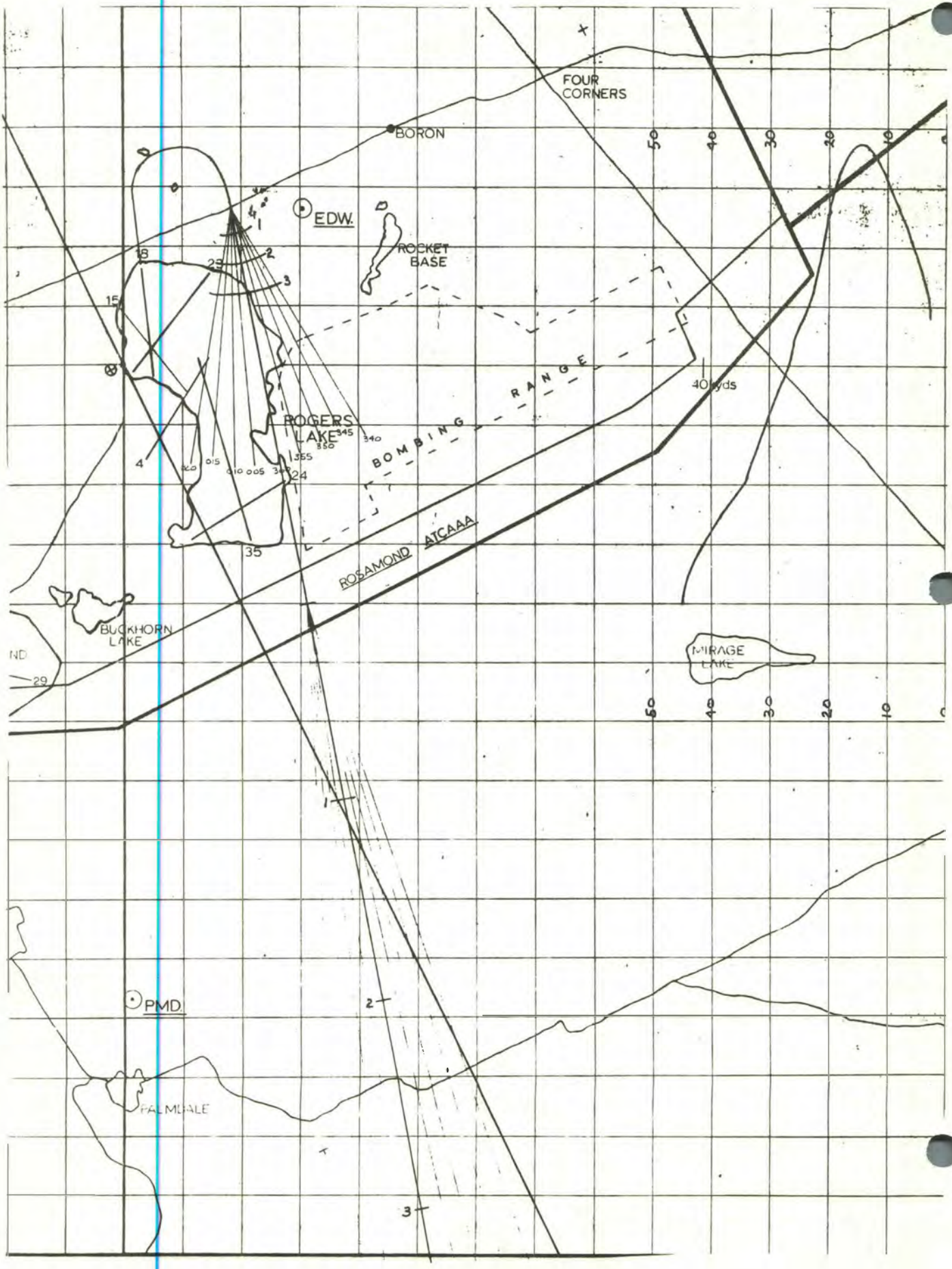
	Failure	Action
		Altitude calls from NASA 1. Airspeed and altitude calls from chase.
3.	Attitude System	Proceed as planned using backup attitude indicator and/or outside reference.
4.	Primary Angle of Attack Indicator Failure	KRA to "Manual" 10%, stick shaker "Off", proceed as planned using backup α indicator on ADI.
5.	Total Angle of Attack Failure	KRA to "Manual" 10%, stick shaker "Off". Fly 220 KIAS instead of α. Delete push-over-pullup, pitch damper off and 13° upper flap tests. Roll and yaw dampers off evaluation at pilot's discretion.
6.	KRA "AUTO" Failure	KRA to "Manual" 10%.
7.	Pitch Damper Failure	Proceed as planned limiting α to 12° during data maneuvers.
8.	Roll Damper Failure	Proceed as planned.
9.	Yaw Damper Failure	Proceed as planned, setting Mach repeater to .3.
10.	All Axis Damper Failure	Mach repeater to .3, limit α to 12° during data maneuvers.
11.	Limit Cycle	Reduce gain setting in steps to 1, if limit cycle still excessive--turn damper off.
12.	Upper Flaps Fail to Close	Land Runway 23, start flare at 4,500 feet MSL and use landing rockets.

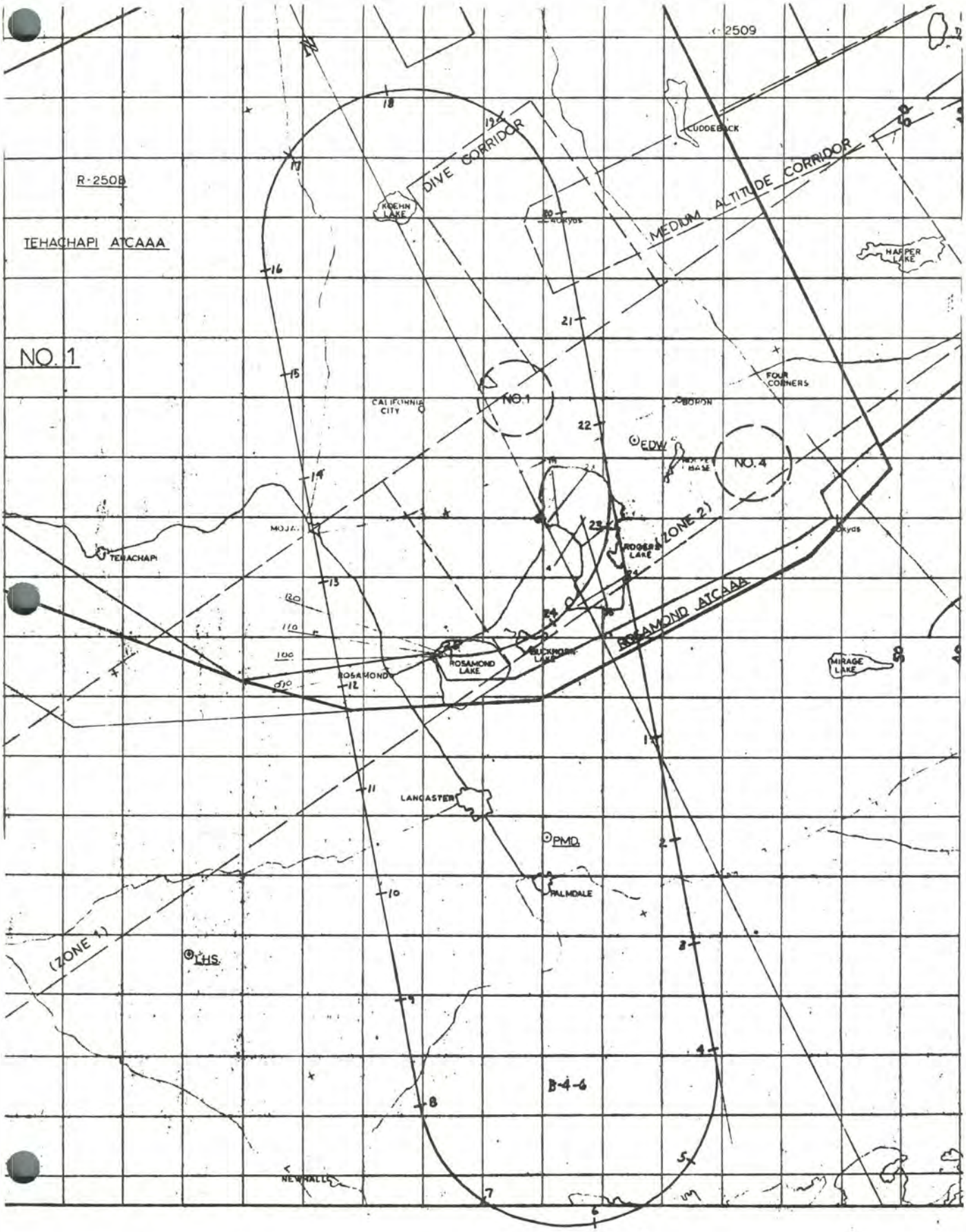
	Failure	Action
13.	Jettison Malfunction or Unsatisfactory Handling While Jettisoning	Stop jettison--proceed as planned.

Robert G. Hoey
ROBERT G. HOEY

Jack L. Kolf
JACK L. KOLF


X-24B FLT. B-4-6
ALT.
40
30
20
10
0
KCAS
300
200
100
0
MACH
.8
.6
.4
.2
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
TIME ~ SEC
DEG
20
15
10
5
0
UPPER FLAPS
~DEG
40
30
20
10
0
0
10
20
30
LOWER FLAPS
DEG
+100
ROLL ANGLE
DEG
0
-100
+50
PROPELLANT
ANGLE - DEG
0
-50


FOUR CORNERS
BORON
EDW.
ROCKET BASE
ROGERS LAKE
BOMBING RANGE
40 yds
ROSAMOND
ATCAAA
BUCKHORN LAKE
MIRAGE LAKE
PMD.
PALMDALE


R-2508
TEHACHAPI ATCAAA
NO. 1
2509
DIVE CORRIDOR
MEDIUM ALTITUDE CORRIDOR
CUDDEBACK
KOEHN LAKE
HARPER LAKE
FOUR CORNERS
CALIFORNIA CITY
BORON
EDW
NO. 1
NO. 4
MOJA
TEHACHAPI
ROGERS LAKE
ZONE 2)
ROSAMOND ATCAAA
ROSAMOND
ROSAMOND LAKE
BUCKHORN LAKE
MIRAGE LAKE
LANCASTER
PMD
PALMDALE
(ZONE 1)
LHS
NEWHALL
B-4-6

FLT. B-4-6 EVENTS

TOD	MACH	KIAS	ALT.	EVENT	Δt
09:50:28.1	—	—	—	LAUNCH	0.0
:49.2	.635	182	41584	START JETTISON	21.1
:59.7	.644	190	40343	END LIQUID JETTISON	25.6
:59.2	.651	199	38750	STOP JETTISON	31.1
:59.0	.650	199	38817	START POPU $\alpha = 11°$	30.9
51:4.2	.678	216	37159	MAX MACH NO. (656 EDS TAS)	36.1
51:02.6	.669	210	37689	AT MIN α $\alpha = 5.5°$	34.5
8.3	.659	216	35855	STICK SHAKER ON	40.2
10.2	.641	212	35390	AT MAX α $\alpha = 17°$	42.1
10.8	.633	210	35258	STICK SHAKER OFF	42.7
:14.3	.616	207	34573	RETURN TO 11° α	46.2
:15.3	.615	208	34374	PITCH DAMPER OFF	47.2
:17.4	.610	208	33998	PITCH PULSE $\alpha = 12°$	49.3
:45.9	.505	187	29735	START CONFIG. CHANGE	77.8
:53.5	.5397	208	28106	END CONFIG. CHANGE $\delta u_B = -19°$	85.4
:56.3	.554	217	27512	PITCH DAMPER ON	88.2
:56.6	.555	217	27468	START PUPO $\alpha = 10.5°$	88.5
52:5.4	.539	217	26125	STICK SHAKER ON	97.3
7.3	.518	208	26059	STICK SHAKER OFF	99.2
7.4	—	—	—	STICK SHAKER ON	99.3
9.0	.494	198	26059	AT MAX α $\alpha = 17°$	100.9
9.4	.491	197	26081	STICK SHAKER OFF	101.3
14.0	.460	184	26169	AT MIN α $\alpha = 6°$	105.9
18.3	.456	183	25971	START CLOSEUP TO $\delta u_B = -13°$	110.2
20.9	.464	187	25707	AT $\delta u_B = -13°$	112.8

FLT. B-4-6

TOD	MACH$_L$	KIAS	ALT$_i$	EVENT	Δt
09:52:24.1	.478	195	25245	START PULLUP - PUSHOVER $\alpha = 7°$	116.0
:33.5	.492	208	23704	AT MAX α $\alpha = 15.5°$ (ON UPPER FLAPS)	125.4
:37.1	.489	208	23330	RETURN TO 6°α	129.0
:48.0	.523	231	21592	UPPER FLAPS EXTENDING TO 19°	139.9
:58.7	.526	241	19876	LANDING ROCKET CHECK	150.6
53:4.0	—	—	19129	CALIBRATE	155.9
5.1	—	—	18997	START TURN	157.0
28.0	.496	245	16028	UPPER FLAPS TO 20°	179.9
54:0.0	.510	283	9983	MACH REPEATER TO .3	211.9
7.5	.515	295.5	8137	SPEED BRAKES START OPEN ($\delta_{SB} = 27.5°$)	219.4
:23.6	.487	298	4623	ROLL OUT OF TURN	235.5
:23.8	.488	298	4579	UPPER FLAPS RETURN TO 20°	235.7
:35.7	.467	295	2647	FLARE	247.6
:50.5	.365	233	2054	GEAR DOWN	262.4
:58.9	.286	182	2076	MAIN GEAR TOUCHDOWN	270.8
09:55:01.3	.267	170	2076	NOSE GEAR TOUCHDOWN	273.2

FLT. TIME : 4 MIN 30.8 SEC.

JGA

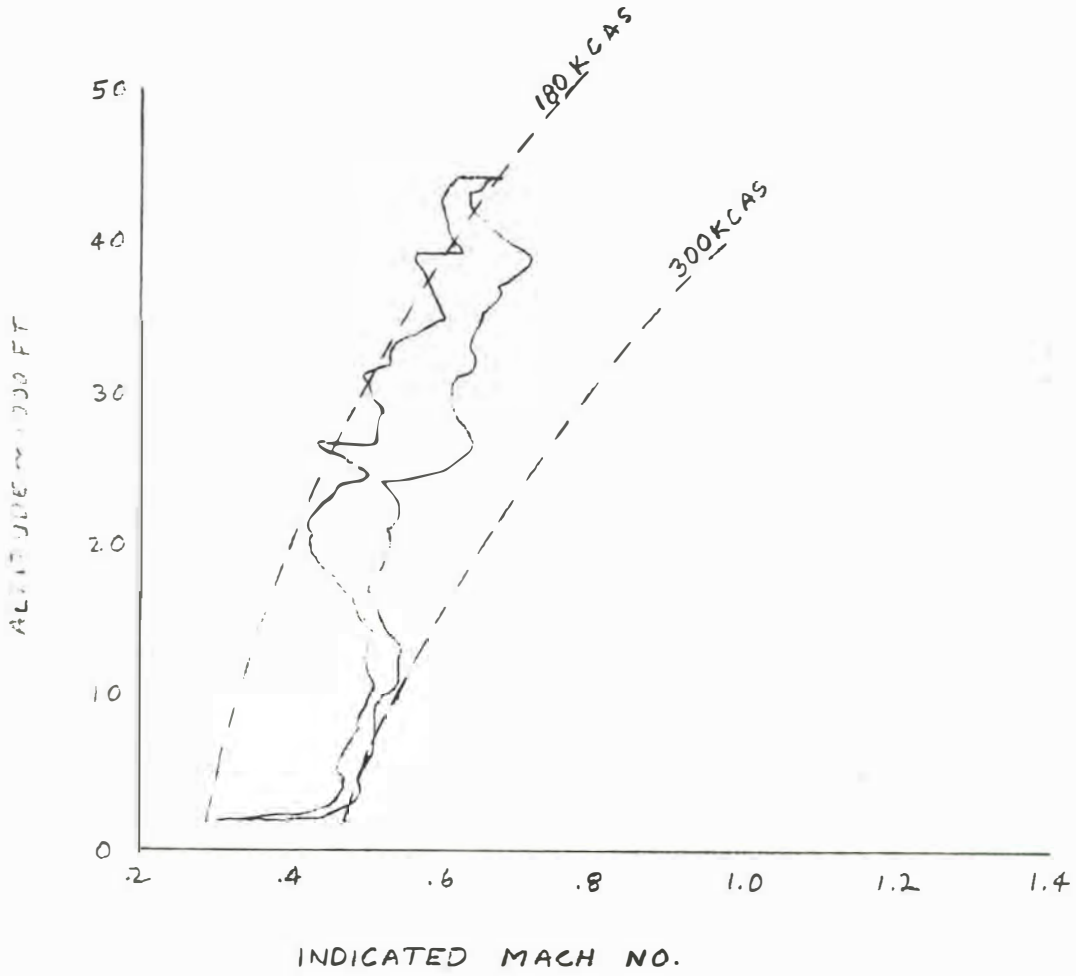
FLIGHT ENVELOPE

By

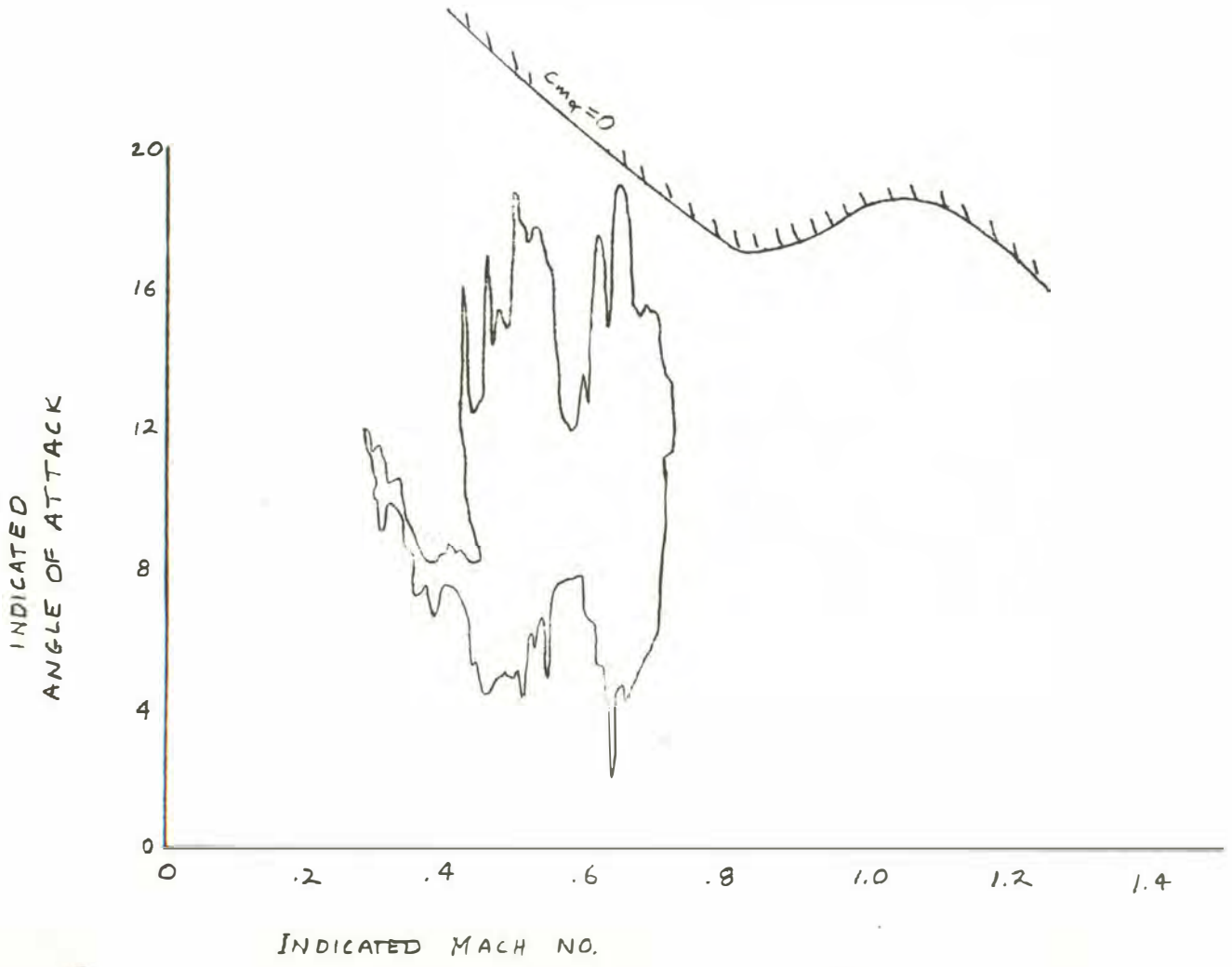
R. Hoey

The flight envelope which has been flown on the first four X-24B glide flights includes an angle of attack range of approximately 4° to 18° and an indicated Mach number range of .3 to .7. (Position error corrections have not yet been applied to these data) An airspeed range of from 165 to 305 KIAS has also been flown.

X-24B FLIGHT ENVELOPE
FLIGHTS 1 THRU 4



X-24B FLIGHT ENVELOPE
FLIGHTS 1 THRU 4



LAUNCH DYNAMICS

By

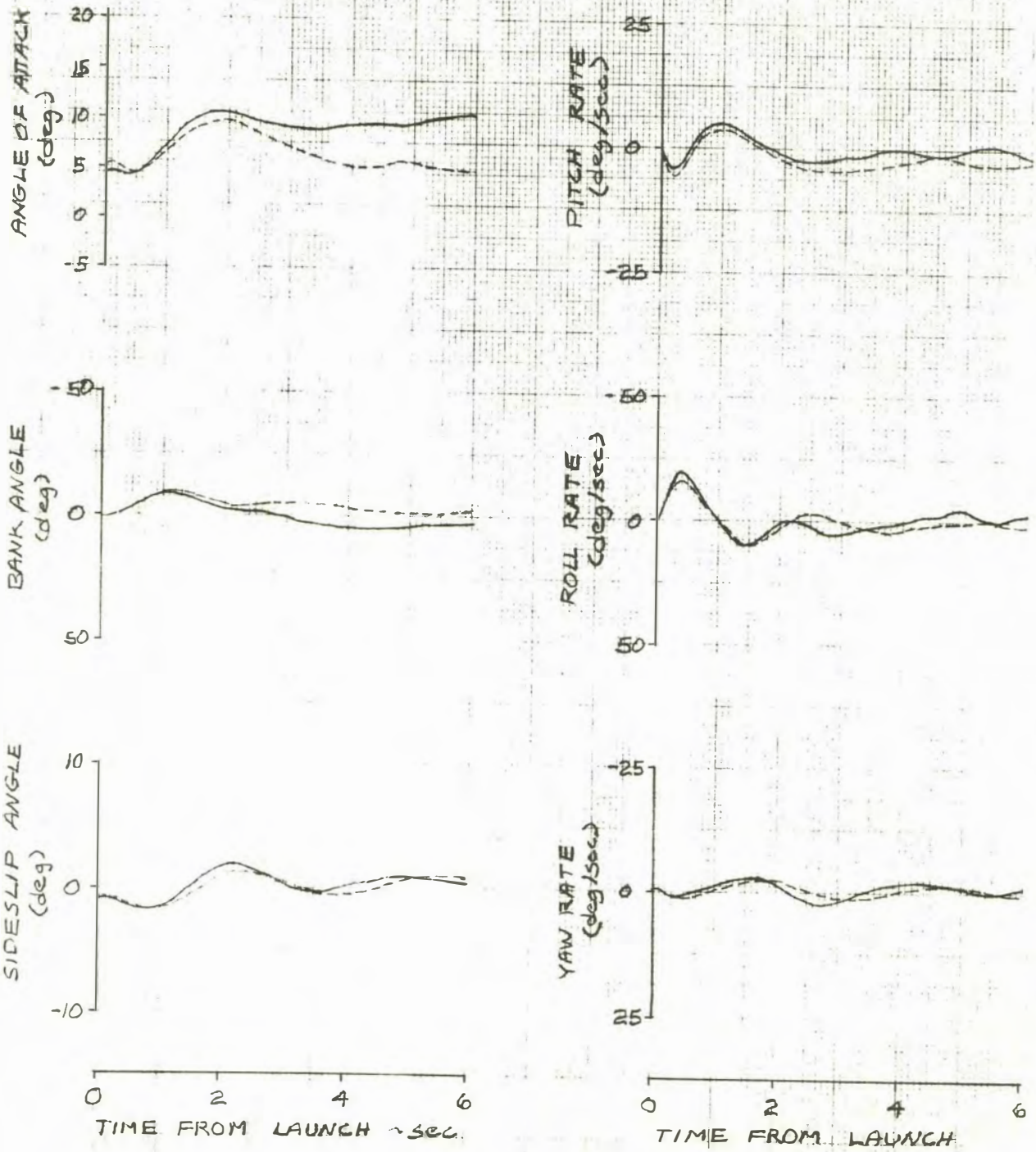
D. Richardson

The launch configuration for flights three and four was the same, however the launch airspeed for flight four was increased by 5 knots and the gross weight was increased by 160 pounds to move the center of gravity to 64 percent. The launch airspeed of 185 knots is the maximum expected at this point in the flight program. The small differences between the previous two launches were: The launch angle of attack for flight four was slightly less than that of the previous flight. Also the minimum normal acceleration at launch was a larger negative value for flight four (-.34 g's) than for the previous flight (-.29 g's).

LAUNCH DYNAMICS

THIRD FLIGHT
$\delta_U = 39.7°$
$\delta e_L = 26.5°$
$\delta R_B = 0°$
$\delta A_B = 7°$
CG = 65.05%
WT = 8508 lbs
V_i = 180 kts
$n_{z_{min}} = -.29$

FOURTH FLIGHT
$\delta_U = -39.5°$
$\delta e_L = 24.8°$
$\delta R_B = 0°$
$\delta A_B = 7°$
CG = 64.01%
WT = 8668 lbs.
V_i = 185 kts
$n_{z_{min}} = -.34$



PERFORMANCE

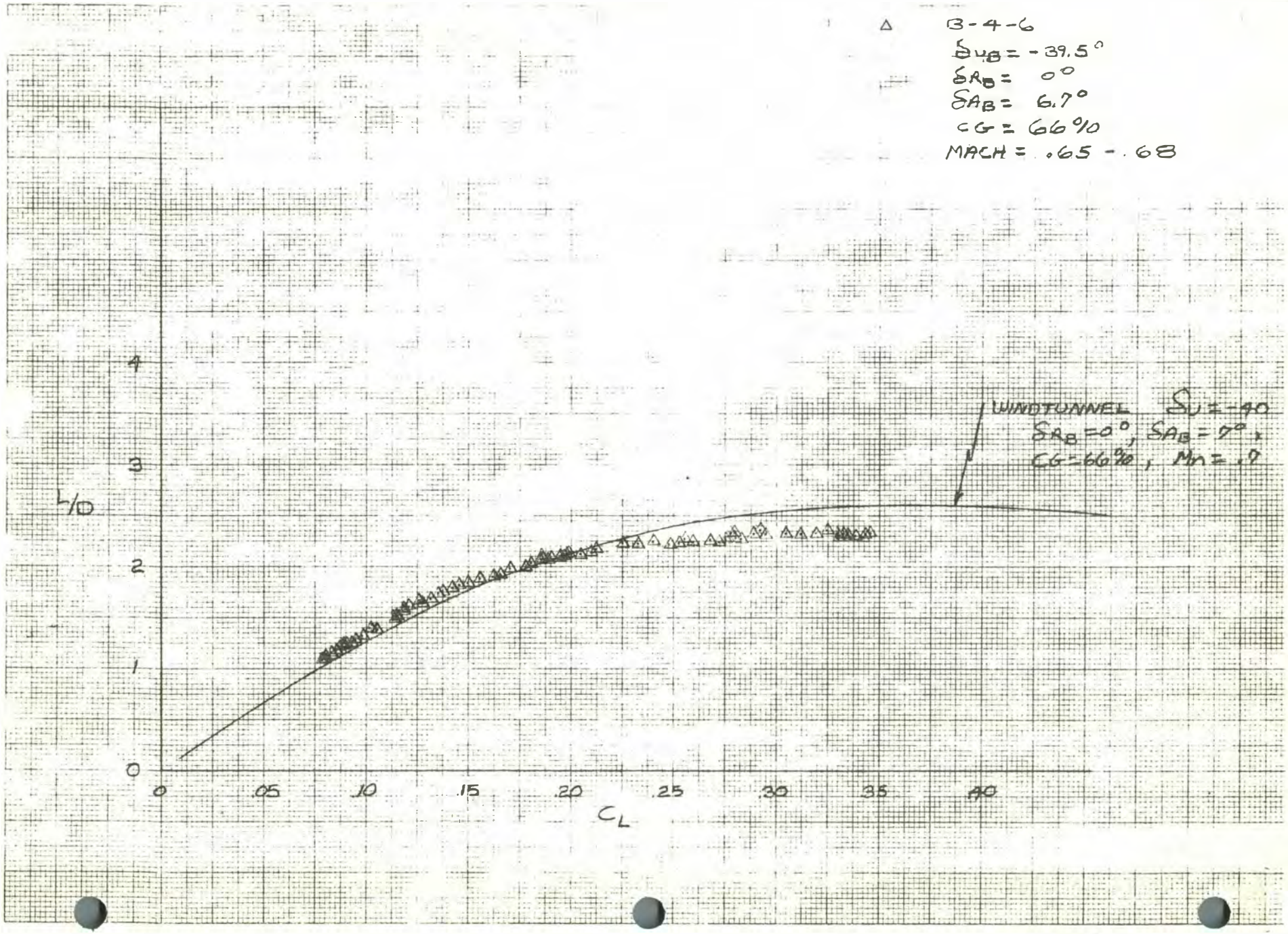
By

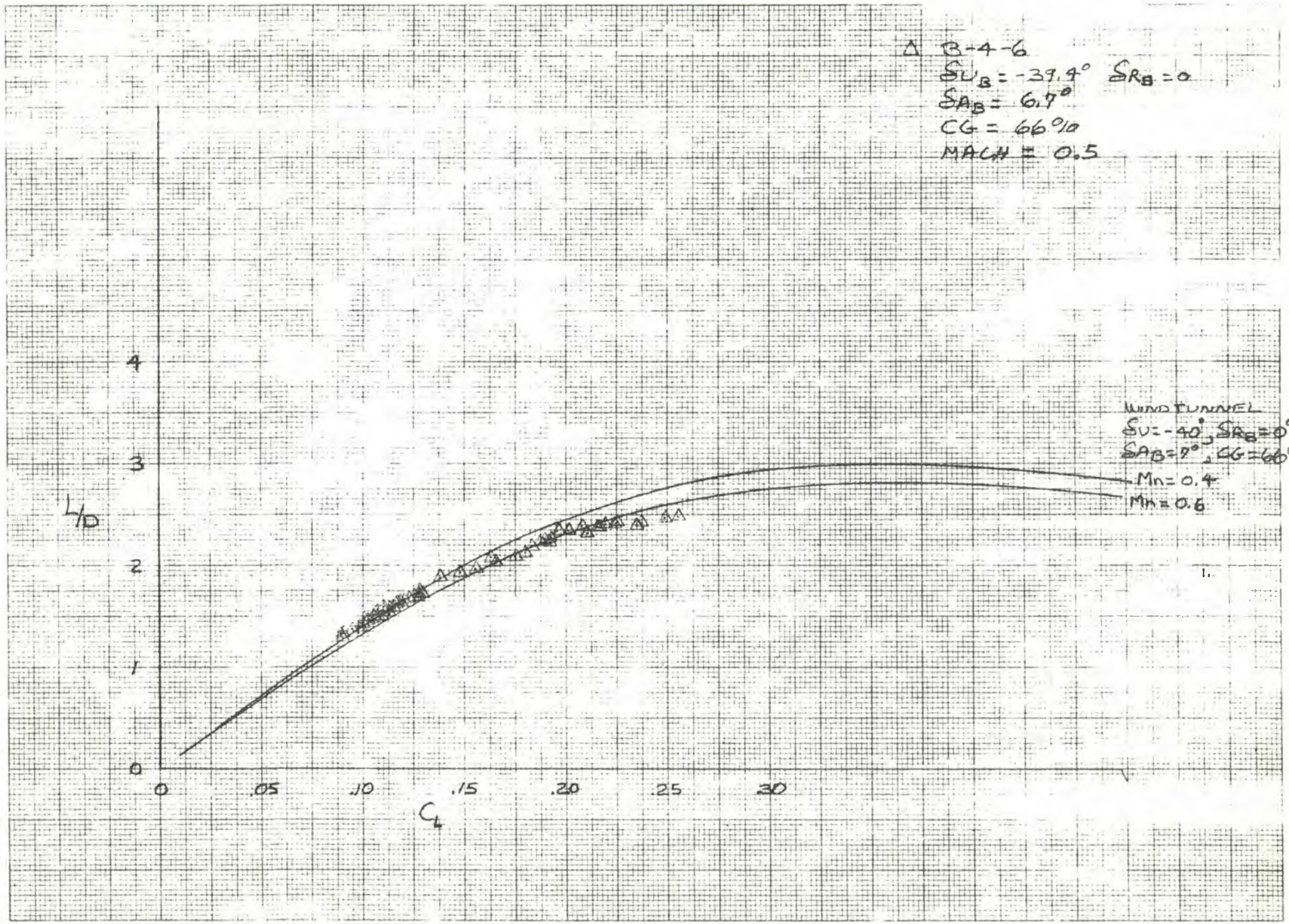
D. Richardson

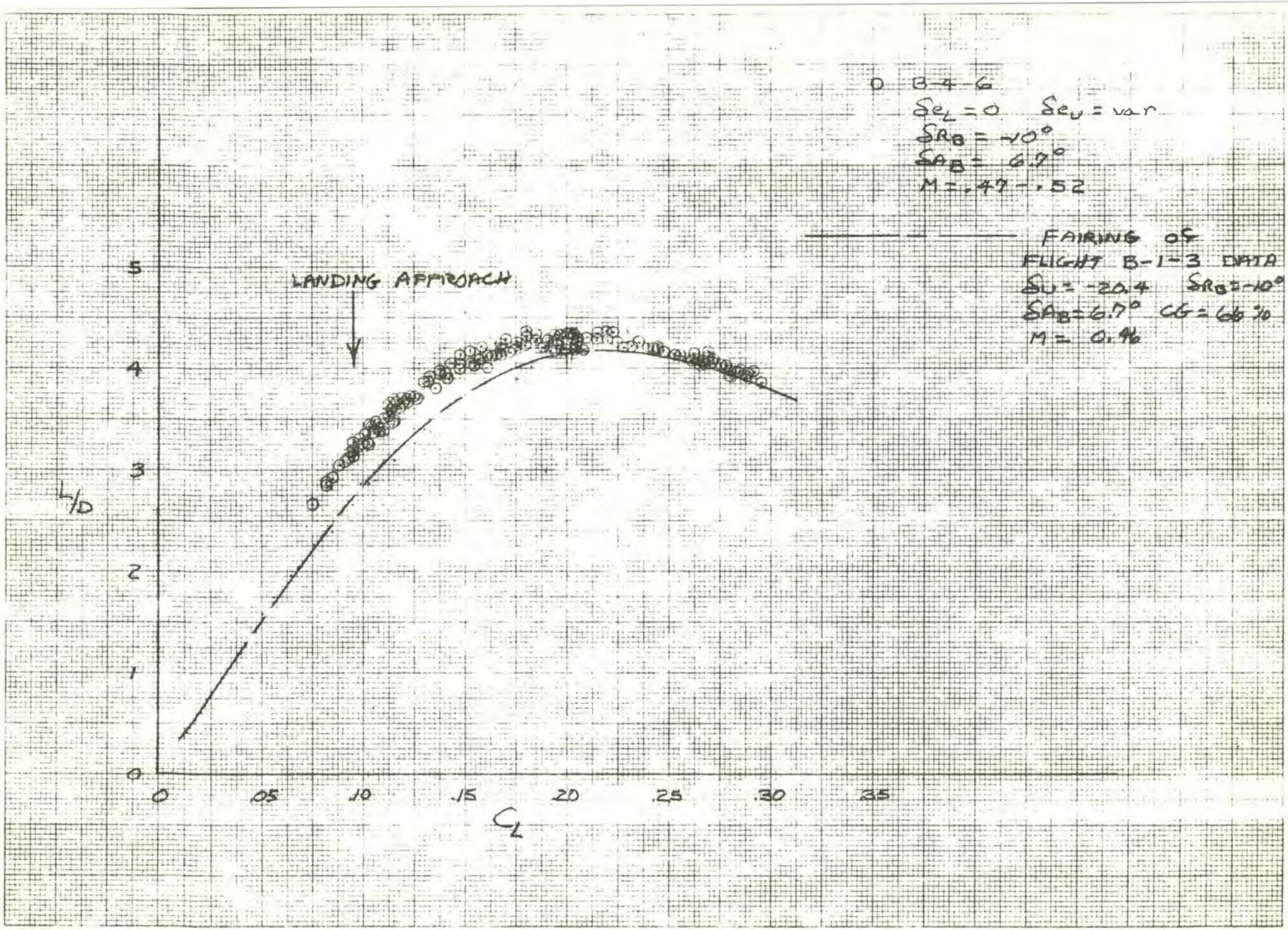
The performance data from flight four is similar to the previous flight data which indicates that there is a reduction in maximum L/D when compared with the predicted data. This reduction in L/D occurs above 11 degrees angle of attack.

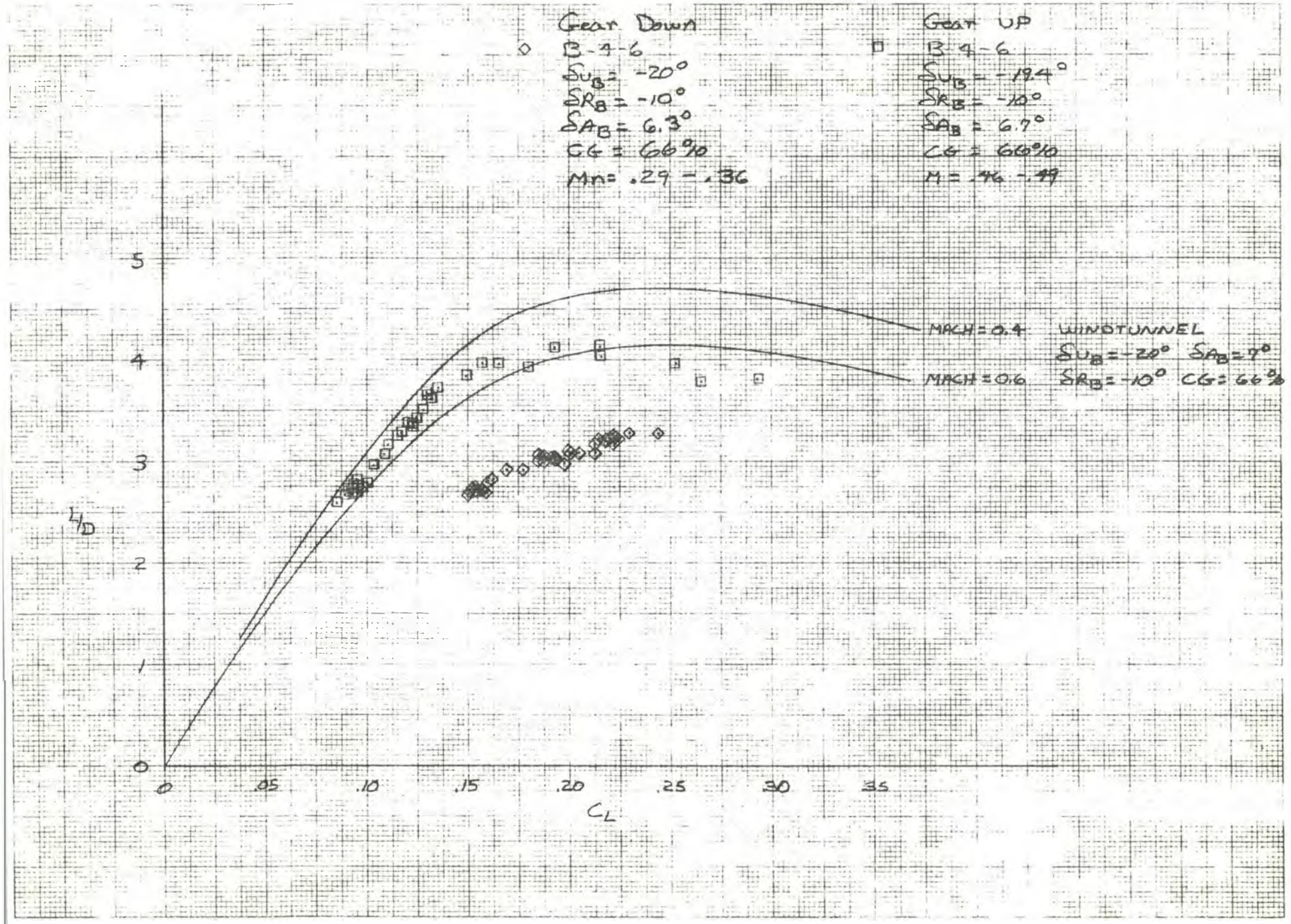
Extensive flight data was obtained in a configuration where the lower flap was at zero degrees and pitch control was with the upper flaps. This data shows an increase in L/D at the low angles of attack of 0.3 to 0.5 when compared with the L/D of the 20 degree fixed upper flap configuration. The maximum L/D increased slightly to a value of 4.3 which is the same maximum value obtained during the X-24A program.

The gear down performance data from this flight is similar to that extracted from the previous flights.


△ B-4-6
$\delta_{U_B} = -39.5°$
$\delta_{R_B} = 0°$
$\delta_{A_B} = 6.7°$
CG = 66%
MACH = .65 - .68
WINDTUNNEL $\delta_U = -40$
$\delta_{R_B} = 0°$, $\delta_{A_B} = 7°$,
CG = 66%, $M_n = .9$
L/D
0
1
2
3
4
0
.05
.10
.15
.20
.25
.30
.35
.40
C_L


Δ B-4-6
$\delta U_B = -39.4°$ $\delta R_B = 0$
$\delta A_B = 6.7°$
CG = 66%
MACH = 0.5
WIND TUNNEL
$\delta U = -40°$, $\delta R_B = 0°$
$\delta A_B = 7°$, CG = 66%
Mn = 0.4
Mn = 0.6
L/D
C_L
0
1
2
3
4
.05
.10
.15
.20
.25
.30


B-4-6
$\delta e_L = 0$ δe_U = var
$\delta R_B = -10°$
$\delta A_B = 6.7°$
M = .47 - .52
FAIRING OF FLIGHT B-1-3 DATA
$\delta_U = -20.4$ $\delta R_B = -10°$
$\delta A_B = 6.7°$ CG = 66 %
M = 0.46
LANDING APPROACH
L/D
C_L
0
1
2
3
4
5
.05
.10
.15
.20
.25
.30
.35


Gear Down
B-4-6
$\delta u_B = -20°$
$\delta R_B = -10°$
$\delta A_B = 6.3°$
CG = 66%
Mn = .29 - .36
Gear UP
B-4-6
$\delta u_B = -19.4°$
$\delta R_B = -10°$
$\delta A_B = 6.7°$
CG = 66%
M = .46 - .49
MACH = 0.4
MACH = 0.6
WINDTUNNEL
$\delta u_B = -20°$ $\delta A_B = 7°$
$\delta R_B = -10°$ CG = 66%
L/D
C_L
0
1
2
3
4
5
.05
.10
.15
.20
.25
.30
.35

LONGITUDINAL TRIM

By

D. Richardson

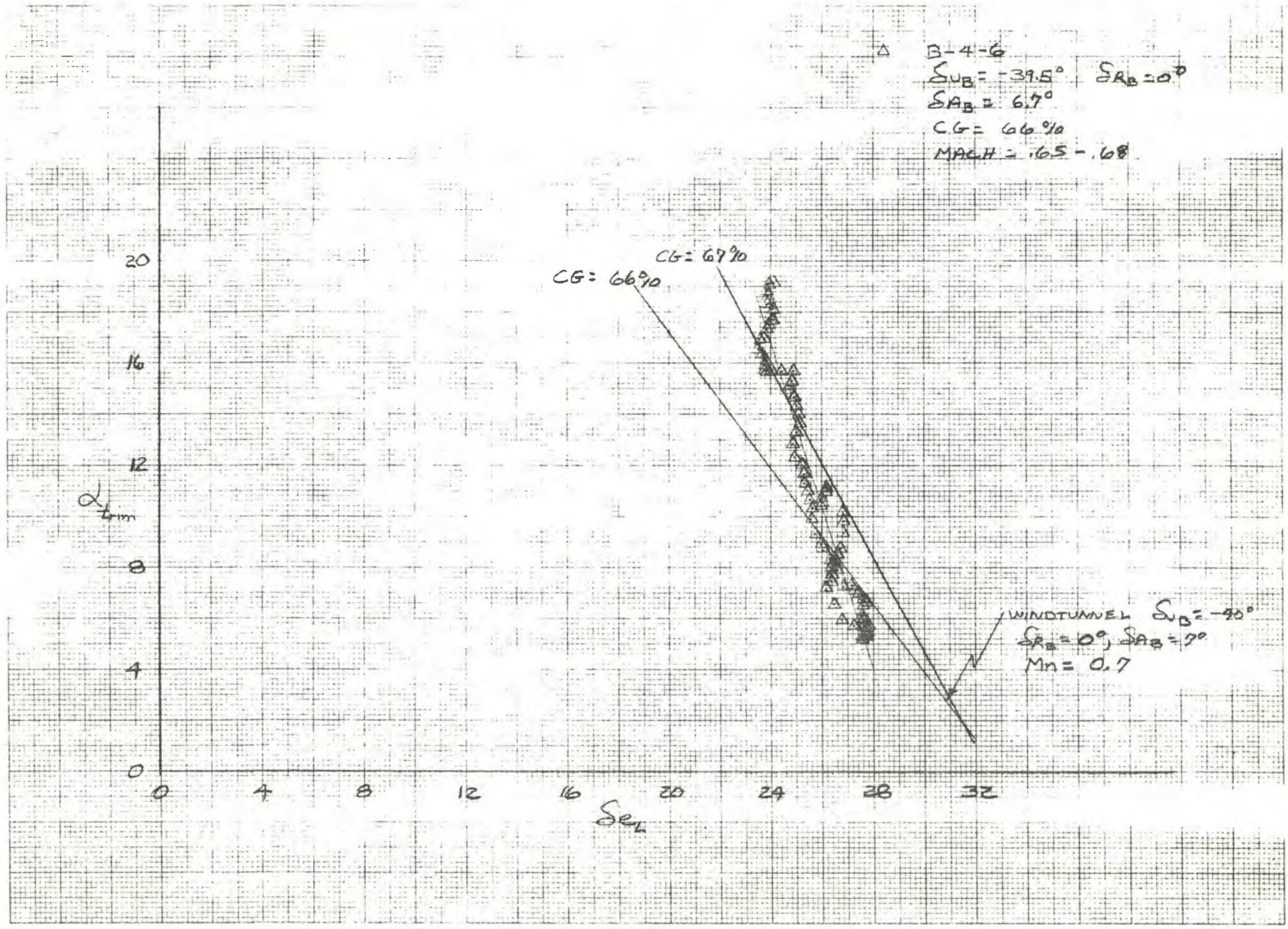
Pushover-pullup maneuvers were accomplished during the last flight for the purpose of extracting longitudinal trim data. All of the data indicates a reduction in static longitudinal stability. In particular, the 0.5 and 0.67 Mach number flight data for the transonic configuration (corrected to 66 percent cg) reveals a 1.0 to 1.5 percent reduction in static margin. This data is consistent with the data from the previous flights. None of the data contains an upwash correction to angle of attack; however, this would account for only a small part of the discrepancy between predicted and flight longitudinal trim data.

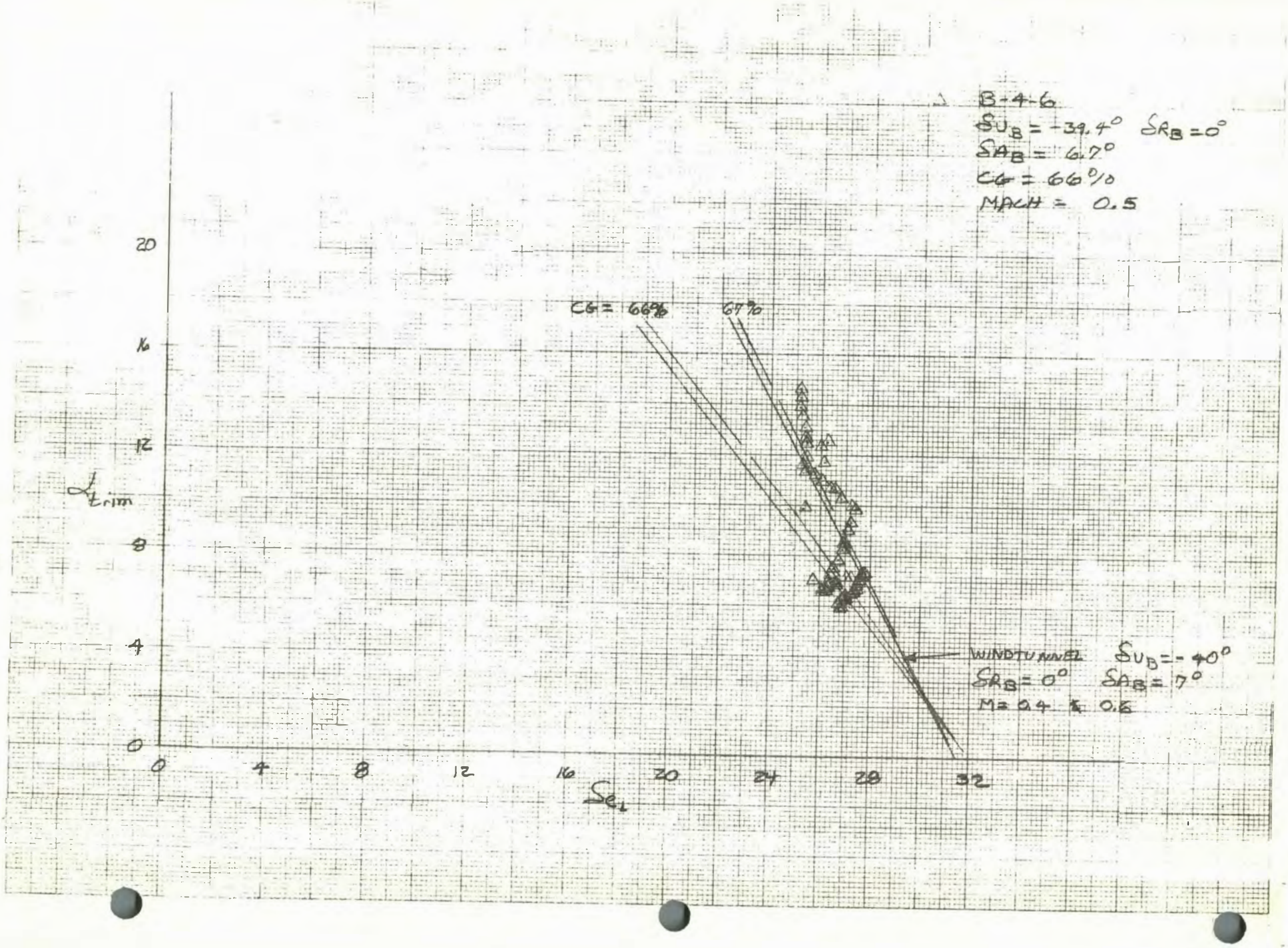
The reduction in static longitudinal stability is discussed further in the section entitled "Longitudinal Data Summary".

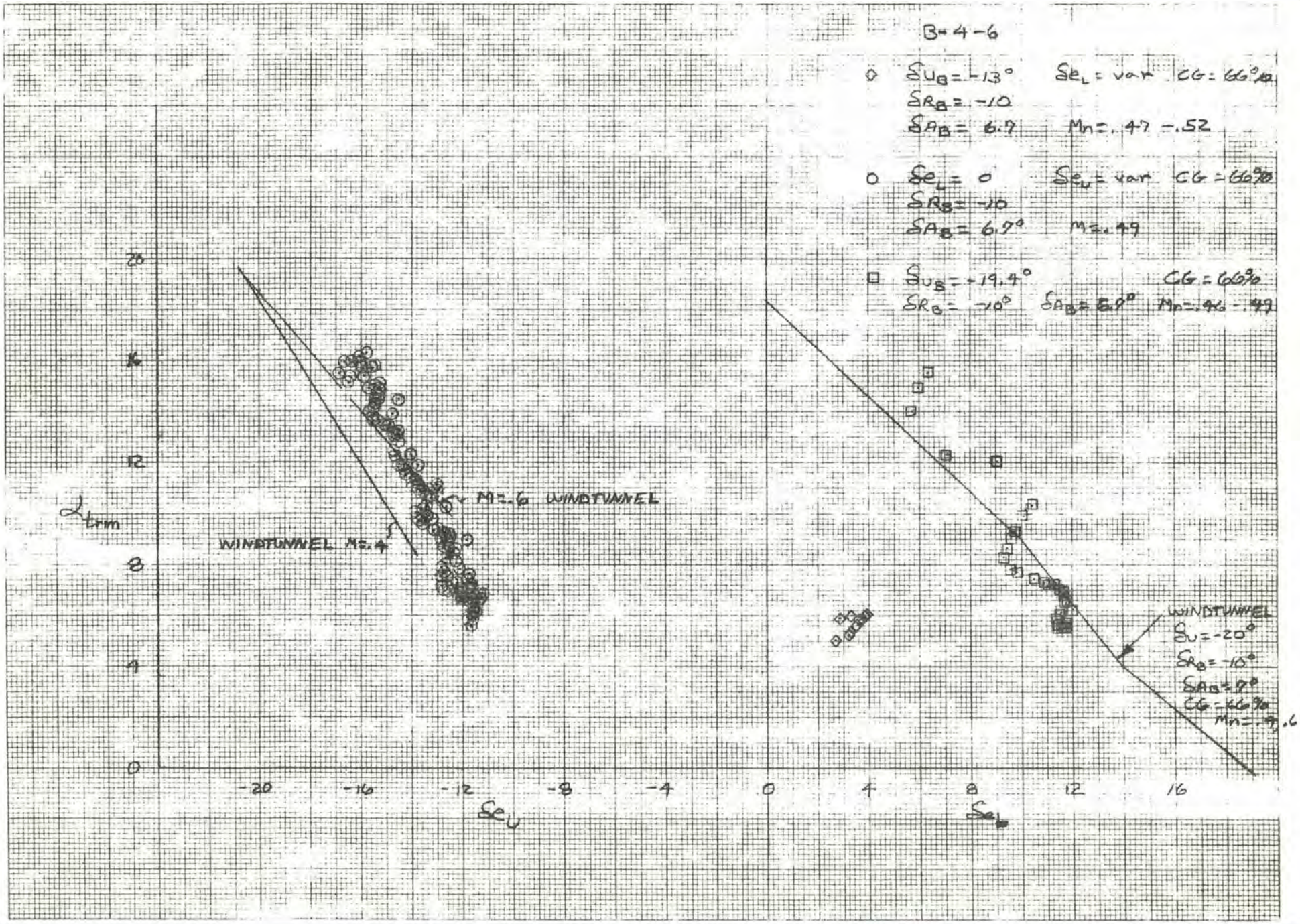
Data was also obtained in a configuration ($\delta U_B = -13°$) where pitch control crossed over from the lower flaps to the upper flaps as the angle of attack increased above six degrees. The upper flaps are slightly more effective than the lower flaps (ratio of $\alpha/\delta e_U$ to $\alpha/\delta e_L$ is 1.35).

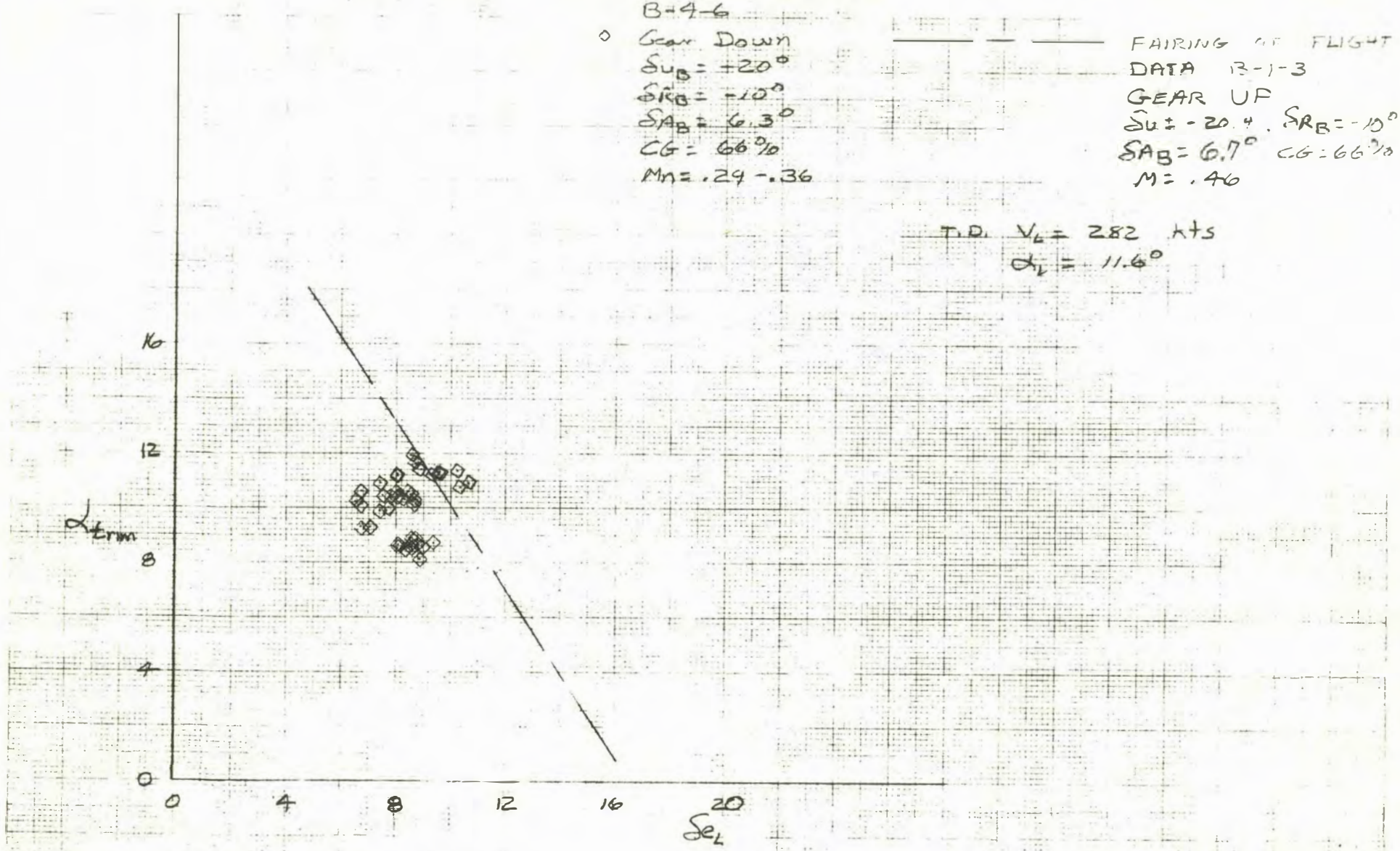
The deadband which exists in the crossover region amounts to one inch of longitudinal stick deflection. The deadband is evident to the pilot as a flat spot in the movement of angle of attack. At altitude this phenomenon is of no particular concern to the pilot. However, close to the ground he felt that it would be of concern which is why the landing configuration will remain as $\delta U_B = -20$ degrees.

Prior to touchdown on this flight as on the previous flight, the pilot had to relax the back pressure on the stick slightly just prior to landing in order to compensate for the ground effect.


B-4-6
δ_{LE_B} = -39.5° δ_{A_B} = 0°
δ_{A_B} = 6.7°
C.G = 66%
MACH = .65 - .68
C.G = 67%
C.G = 66%
WINDTUNNEL δ_{LE_B} = -40°
δ_{A_B} = 0°, δ_{A_B} = 7°
Mn = 0.7
α_{trim}
δ_{e_L}
0
4
8
12
16
20
24
28
32


B-4-6
$\delta U_B = -39.4°$ $\delta R_B = 0°$
$\delta A_B = 6.7°$
CG = 66%
MACH = 0.5
CG = 66%
67%
WINDTUNNEL $\delta U_B = -40°$
$\delta R_B = 0°$ $\delta A_B = 7°$
M = 0.4 & 0.6
α_{trim}
δe_1
0
4
8
12
16
20
24
28
32


B=4-6
◇ δu_B = -13° δe_L = var CG = 66%
δR_B = -10
δA_B = 6.7 Mn = .47 -.52
○ δe_L = 0 δe_u = var CG = 66%
δR_B = -10
δA_B = 6.7° M = .49
□ δu_B = +19.4° CG = 66%
δR_B = -10° δA_B = 6.7° Mn = .46 - .49
M=.6 WINDTUNNEL
WINDTUNNEL M=.4
WINDTUNNEL
δu = -20°
δR_B = -10°
δA_B = 7°
CG = 66%
Mn = .49.6
C_Ltrim
δe_u
δe_L
20
16
12
8
4
0
-20
-16
-12
-8
-4
0
4
8
12
16


B-4-6
Gear Down
$\delta u_B = +20°$
$\delta R_B = -10°$
$\delta A_B = 6.3°$
CG = 66%
M = .29 -.36
FAIRING OF FLIGHT DATA B-1-3
GEAR UP
$\delta u = -20.4$. $\delta R_B = -10°$
$\delta A_B = 6.7°$ CG = 66%
M = .46
T.D. V_L = 282 kts
α_L = 11.6°
16
12
8
4
0
α_{trim}
0
4
8
12
16
20
δe_L

FLT B-4-6 HANDLING QUALITIES SUMMARY

EVENT	PILOT RATING
ACQUIRING 10°α AFTER LAUNCH	3½
HQ WITH PITCH DAMPER OFF (40°S_{u_B}, 15°α)	4
CONFIG. CHANGE (PITCH DAMPER OFF)	4
PITCH CONTROL WITH UPPER FLAPS	2
TURN TO FINAL	2 TO 2½
FINAL (USE OF SPEED BRAKES)	2
FLAKE	2 TO 2½
LANDING	3½

JGA

LATERAL-DIRECTIONAL DATA SUMMARY

By

P. Kirsten

A summary of the lateral-directional data obtained thus far is in order. Sufficient data has been obtained in the subsonic configuration (-20° upper flap bias) to establish derivative values and compare these values with wind tunnel data. Lateral-directional data obtained from both analysis programs (Newton-Raphson/NASA and Hybrid/AFFTC) are shown for the subsonic configuration in figure 1. C_{ℓ_β} and C_{y_β} agree very well with wind tunnel data. C_{n_β} is higher than wind tunnel data for many points investigated in the mid angle of attack range and agrees with wind tunnel at the other conditions. For the aileron control derivatives, $C_{\ell_{\delta a}}$ is slightly higher than wind tunnel and $C_{n_{\delta a}}$ is slightly lower. Off--cg corrections were not applied to the values of $C_{y_{\delta a}}$ obtained from the Newton-Raphson program (open symbols). These corrections will make a significant difference in the value of $C_{y_{\delta a}}$. The corrections were applied to the hybrid matching results, and these results agree fairly well with wind tunnel data. In any case, $C_{y_{\delta a}}$ is an insignificant and unimportant derivative. The rudder derivatives $C_{\ell_{\delta r}}$ and $C_{y_{\delta r}}$ both seem to be slightly lower than wind tunnel data. $C_{n_{\delta r}}$ agrees well with tunnel data. Damping derivatives are more difficult to obtain from flight data. The most significant lateral-directional damping derivative, C_{ℓ_p}, is the one most accurately obtained, and conclusions can be drawn from the flight data. It appears that C_{ℓ_p} is about double the theoretically predicted value. This difference, combined with

the smaller differences found in the other derivatives (particularly C_{n_β}, $C_{\ell_{\delta a}}$, $C_{n_{\delta a}}$, and $C_{\ell_{\delta r}}$), combine to produce a better flying vehicle in the lateral-directional mode than predicted by the simulator. This fact has been verified through pilot comments and pilot ratings. In particular, a factor of two increase in C_{ℓ_p} would significantly improve the SAS-off lateral-directional handling qualities. This improvement was very obvious to the pilot during his SAS-off evaluation on flight B-3-5.

Lateral-directional derivatives for the transonic configuration (-40° upper flap bias) are shown in figure 2. Although only two maneuvers have been analyzed thus far, the results show identical trends as those of the subsonic configuration. Of particular interest is the maneuver analyzed at 15° angle of attack, which will be the rotation angle of attack during the powered portion of the flight profile. Derivatives obtained again indicate a better flying vehicle than predicted by the simulator at this angle of attack (and at subsonic Mach numbers).

LONGITUDINAL DATA SUMMARY

By

R. Hoey

Pitch pulse maneuvers have been obtained in the mid angle of attack range with the pitch damper both on and off for the purpose of extracting the individual stability and control derivatives. Pushover-pullup maneuvers have also been used to establish the performance and longitudinal trim characteristics over a wide angle of attack range. Data from both of these sources indicate that the static longitudinal stability is significantly lower than predicted. The correlation between the $\delta e/\alpha$ slopes obtained during the pushover-pullups, and the local $\delta e/\alpha$ slopes computed from the derivatives obtained during pulses is exceptionally good. Correlation of the trimmed lift curve slopes from the two sources is only fair. Analysis of the individual derivatives indicates that C_{m_α} is significantly lower than predicted (by approximately .0002). C_{N_α} is also somewhat lower than predicted and the lower flap control effectiveness, $C_{m_{\delta e}}$ is the same as, or slightly above predictions.

The overall effect is a reduction in the trim $\delta e/\alpha$ slope of approximately .35 and a neutral point location of approximately 67.4 percent rather than 69 percent as predicted. (Transonic configuration, .6 to .7 Mach number) The glide and landing cg for powered flights will be at 64 percent and no problems are expected in these phases of flight. The initial powered phase, however, is flown at 66 percent cg. The longitudinal stability trends with Mach number and angle of attack will have to be watched closely during the initial powered flights. Simulator revisions are being initiated to reflect both the reduced pitch stability and slightly lower lift/drag ratios. An average value for the pitch damping (C_{m_q}) for the maneuvers analyzed thus far is -.25/rad as compared to a theoretically predicted value of -.30/rad.

FIGURE 1

X-24B
SUBSONIC CONF.
$\delta_u = -20°$, $\delta_{r_B} = -10°$
CG = .65 $\bar{c}$

— M=0.4
– – M=0.6
—·— M=0.7
} WIND TUNNEL

○ $M_\infty \approx 0.45$
□ $M_\infty \approx 0.50$
◇ $M_\infty \approx 0.55$
△ $M_\infty \approx 0.60$
⬡ $M_\infty \approx 0.65$
} FLIGHT

OPEN ~ DIGITAL
SOLID ~ HYBRID

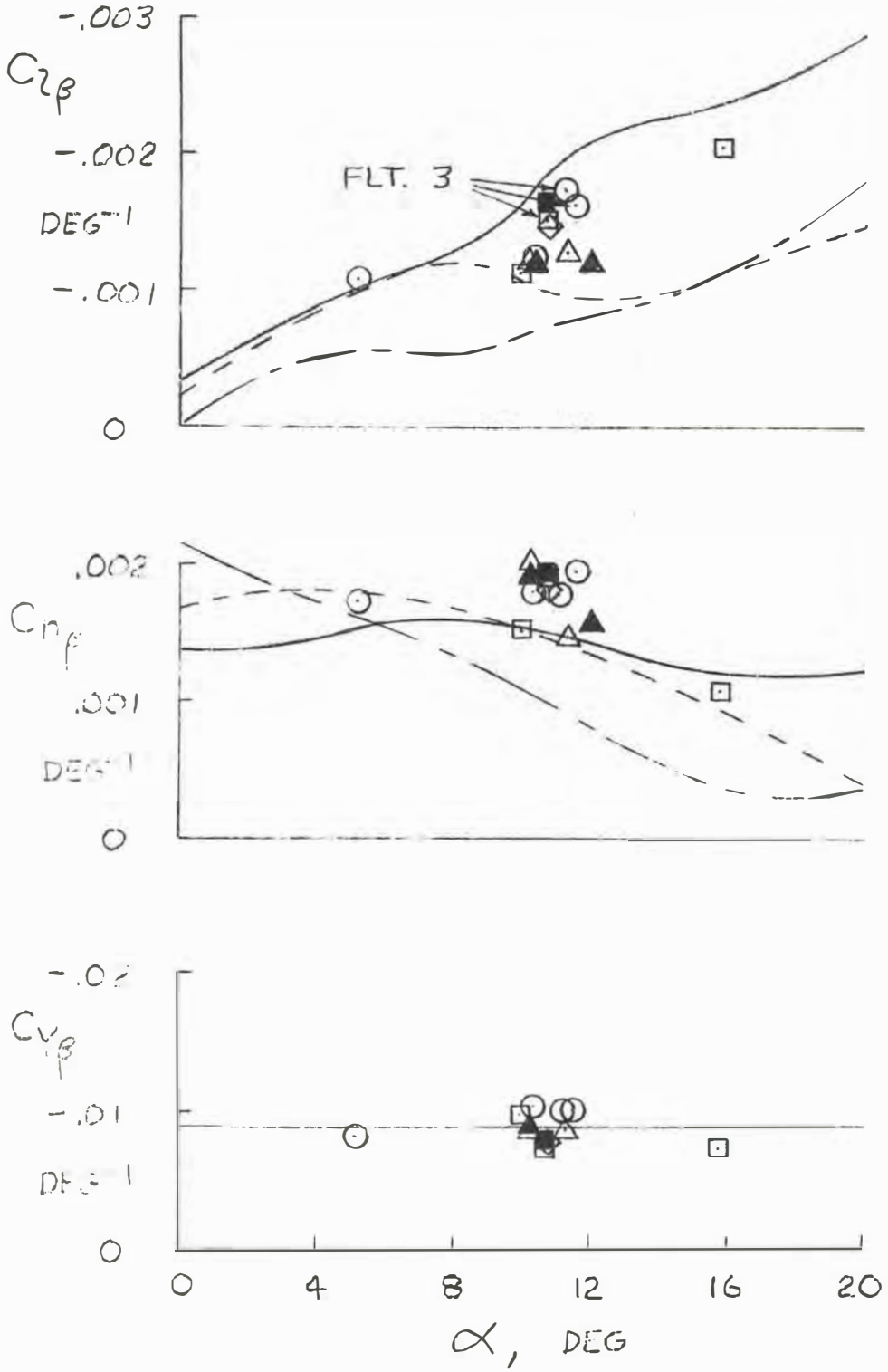


FIGURE 1, CONT.

X-24B
SUBSONIC CONF.

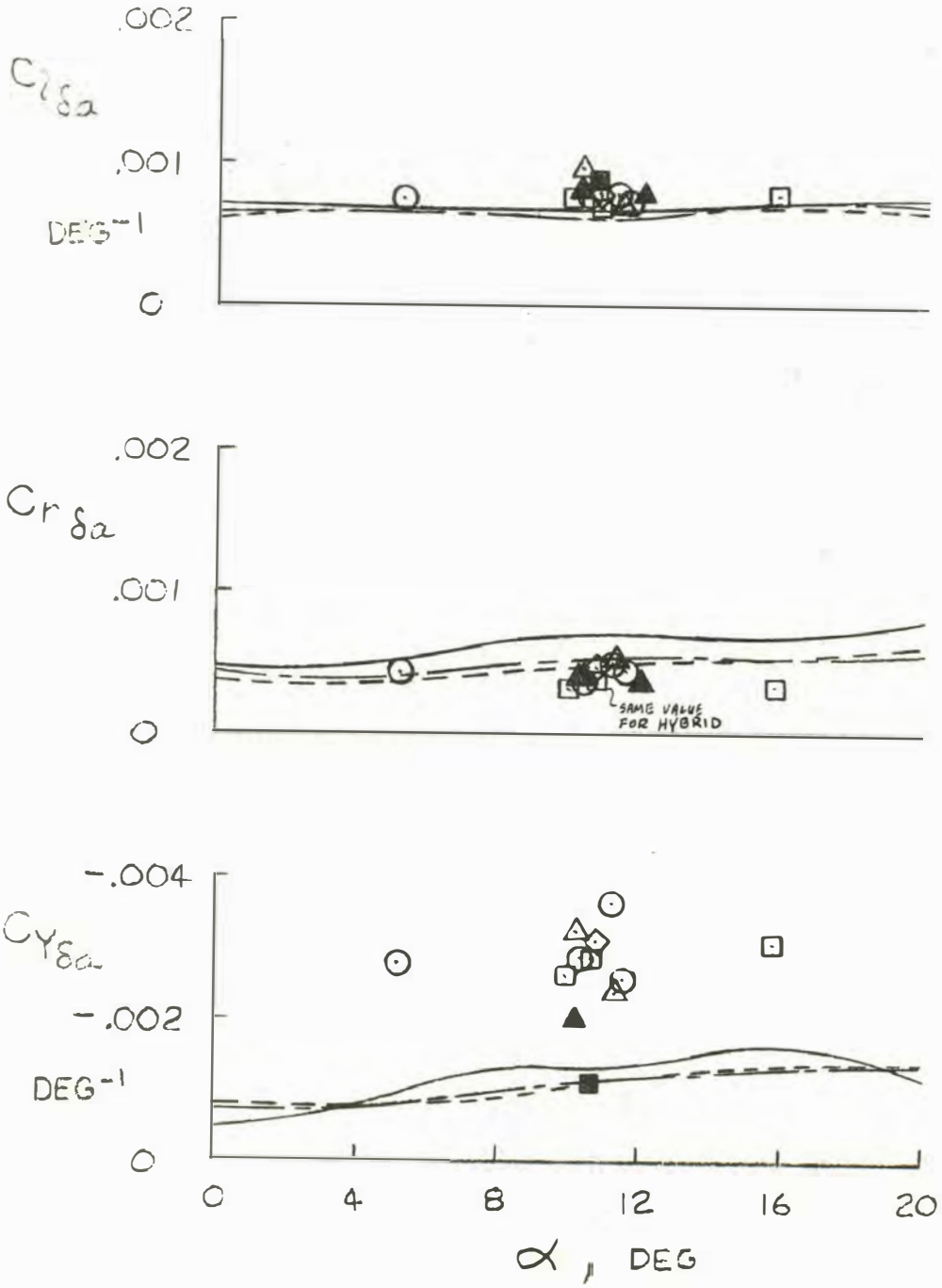


FIGURE 1, CONT.

X-24B
SUBSONIC CONF.

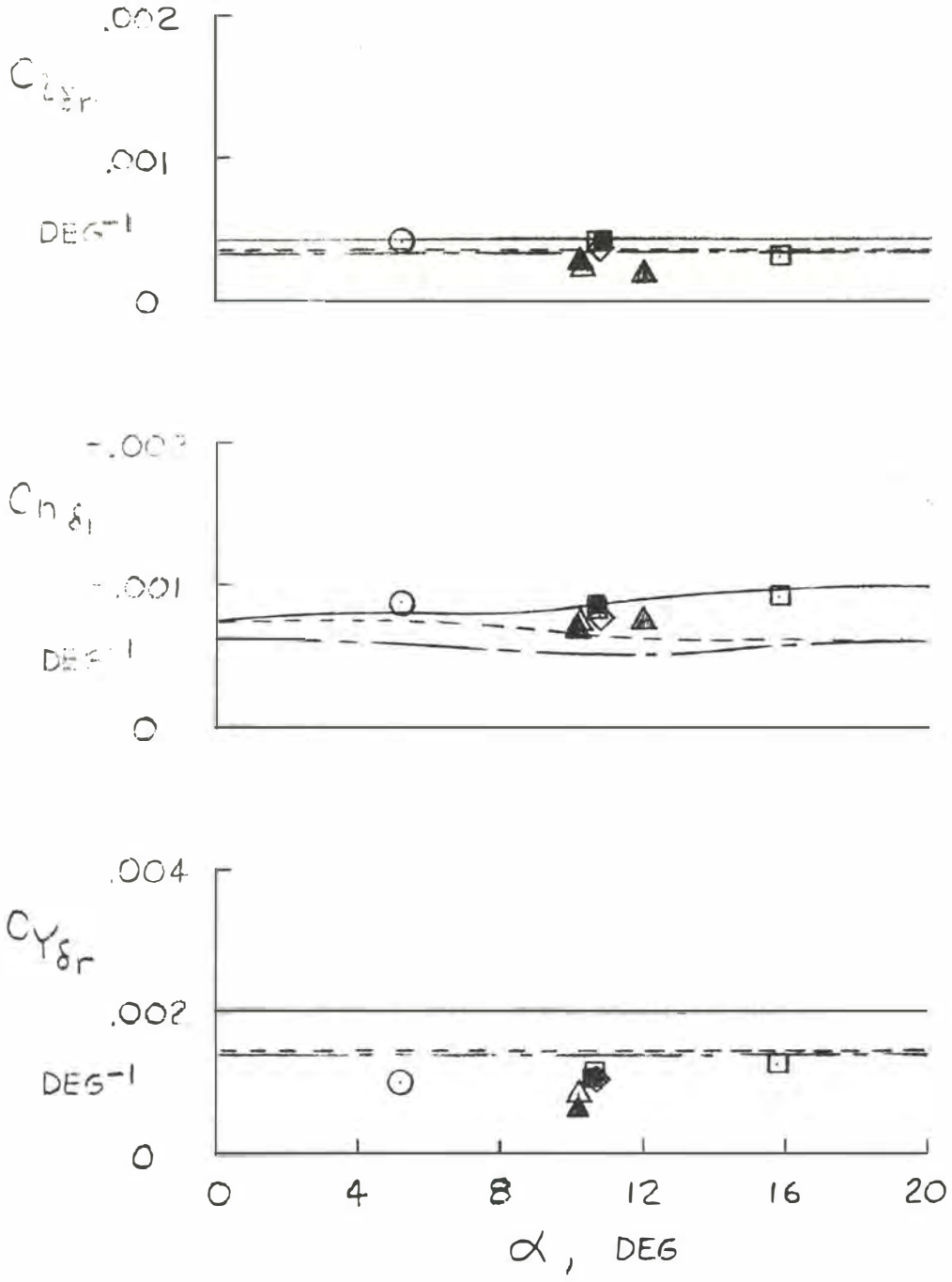


FIGURE 1, CONCLUDED —— ESTIMATE

X-24B
SUBSONIC CONF

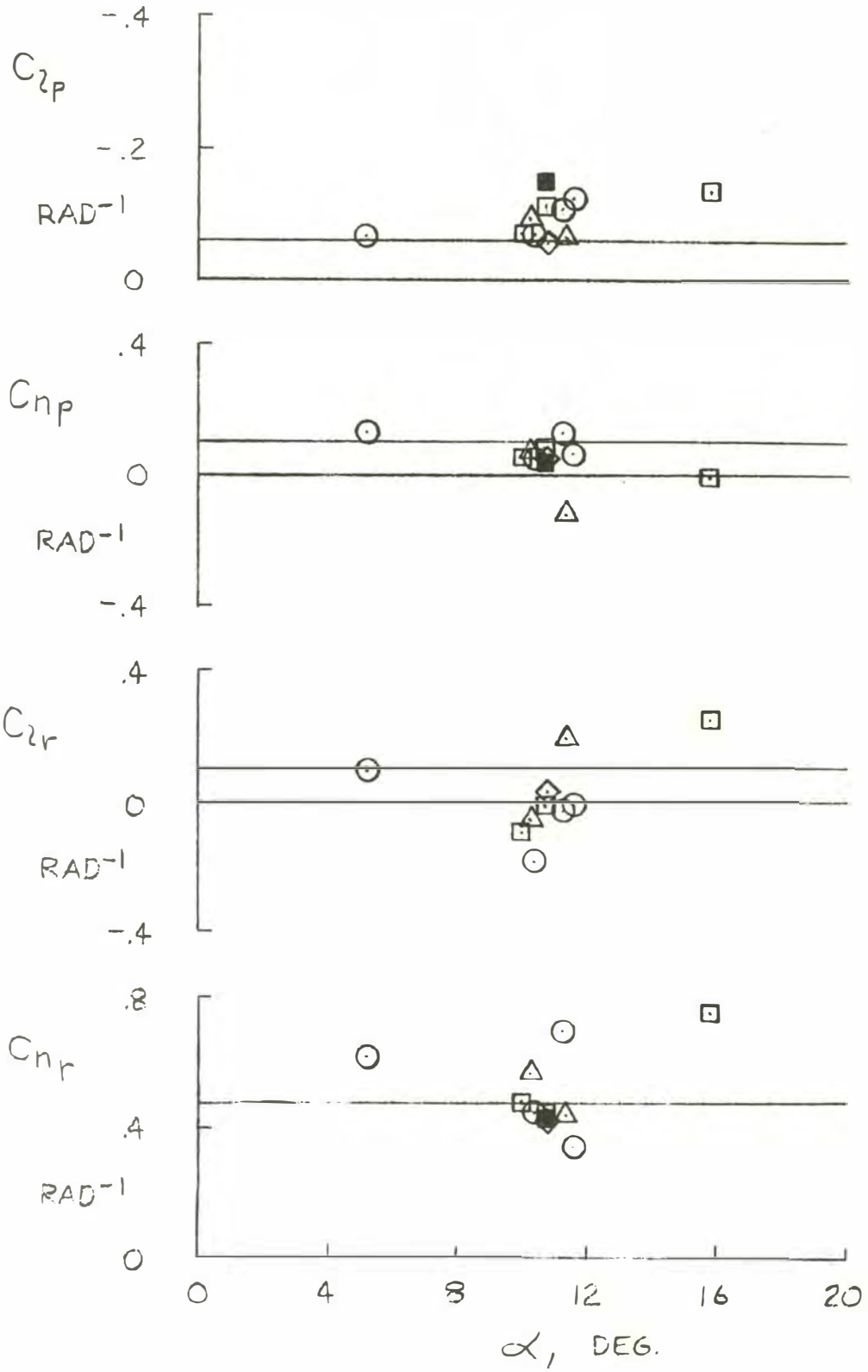


FIGURE 2

X-24B
TRANSONIC CONF.
$\delta_U = -40$, $\delta r_B = 0°$
CG = .45 $\bar{c}$

---- M=0.6 } WIND TUNNEL
—·— M=0.7 }

FLIGHT:

SYM	FLT	M_∞	COMMENT
○	3	.675	FAIR MATCH
□	2	.63	POOR MATCH
●	3	.675	GOOD MATCH

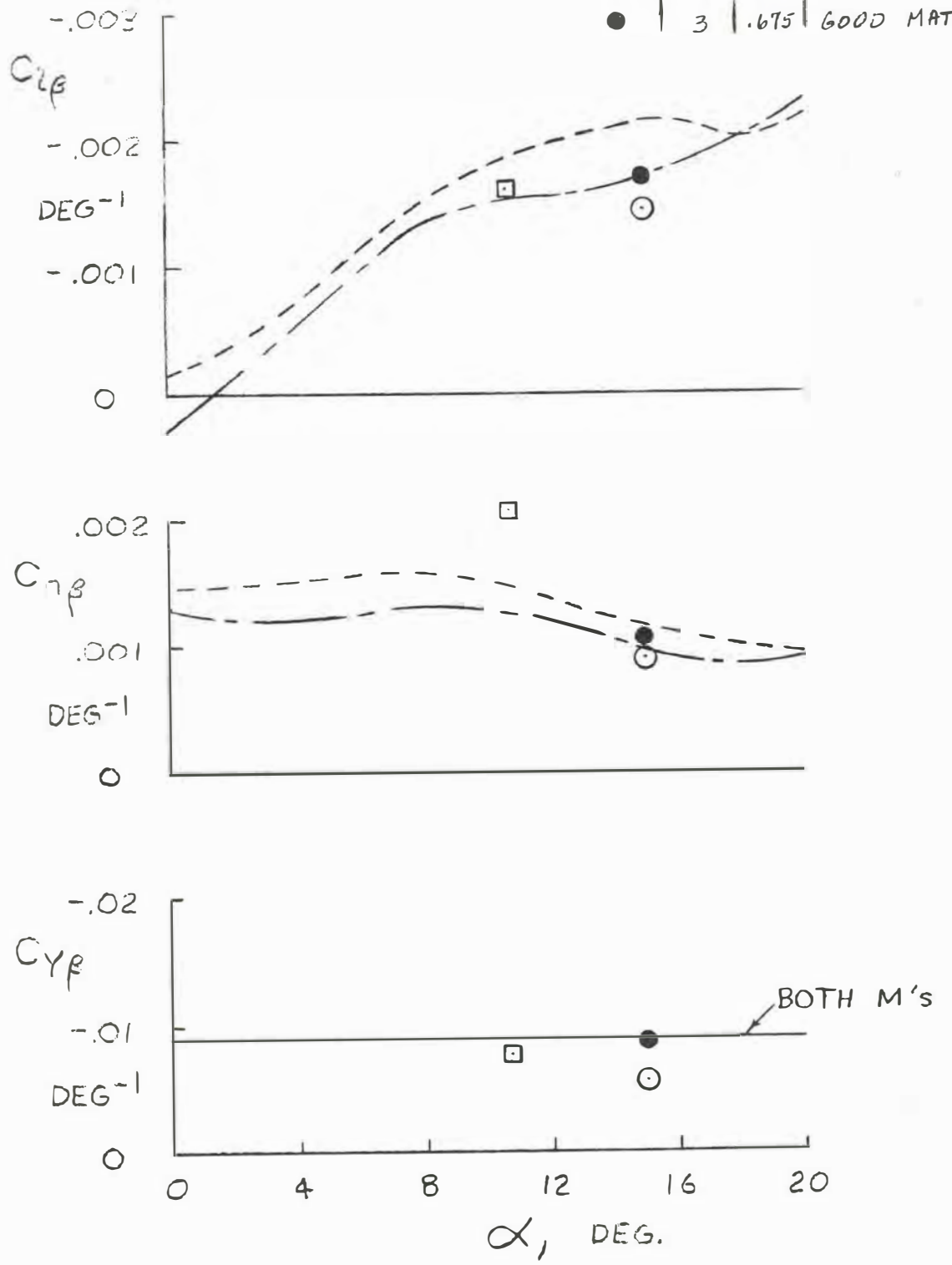


FIGURE 2, CONT

X-24E
TRANSONIC CONF.

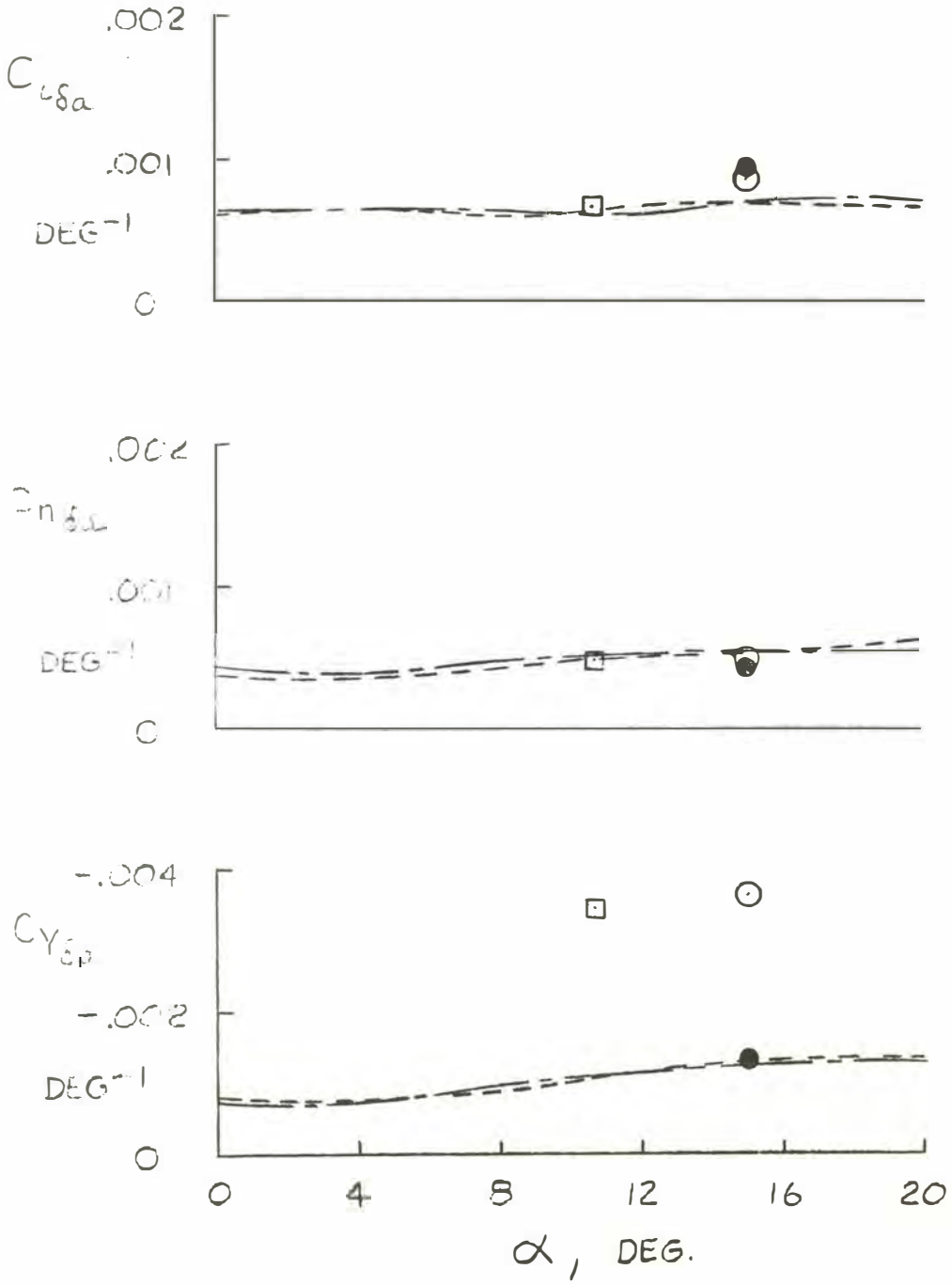


FIGURE 2, CONT.

X-24B
TRANSONIC CONF.

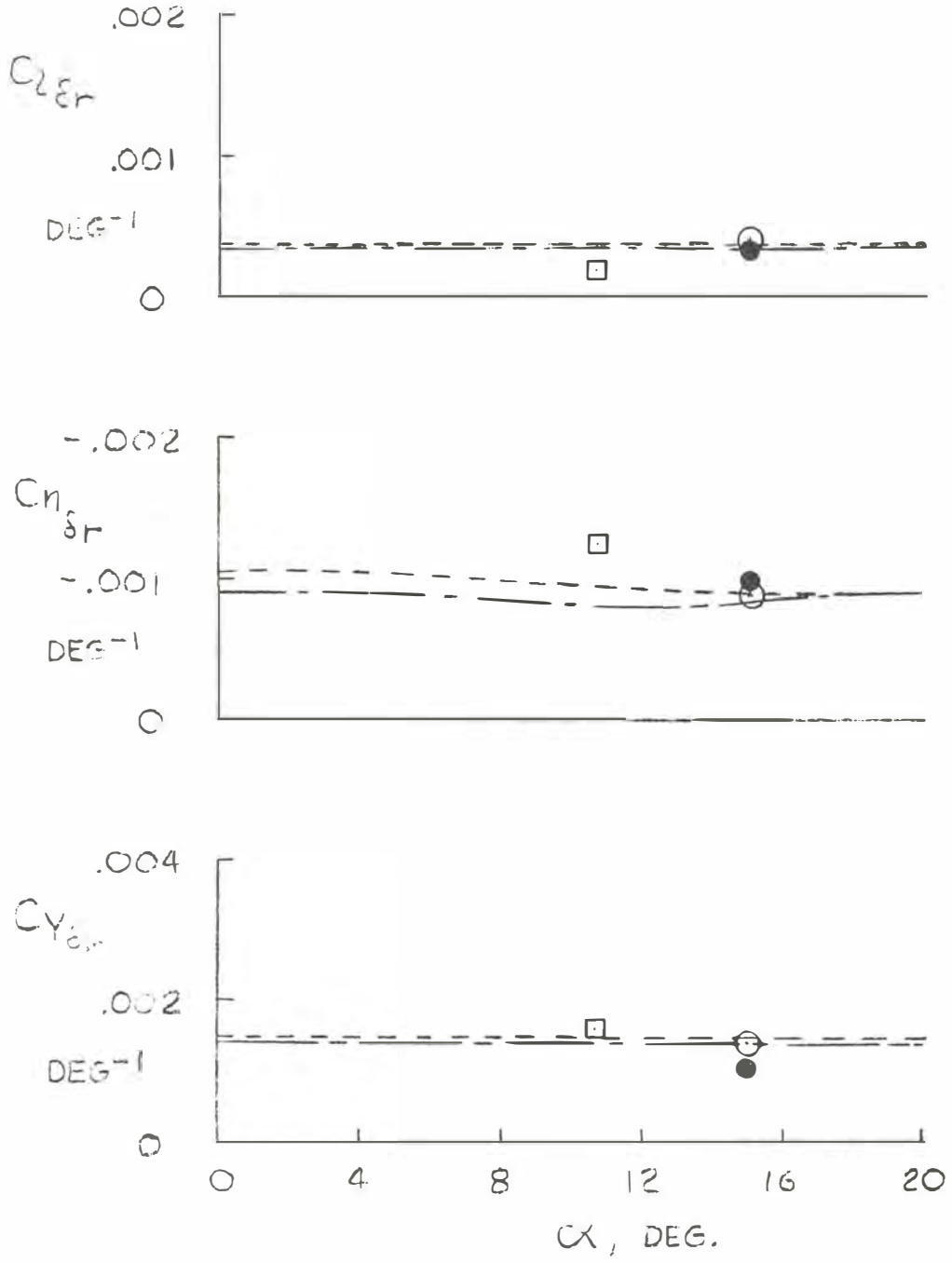
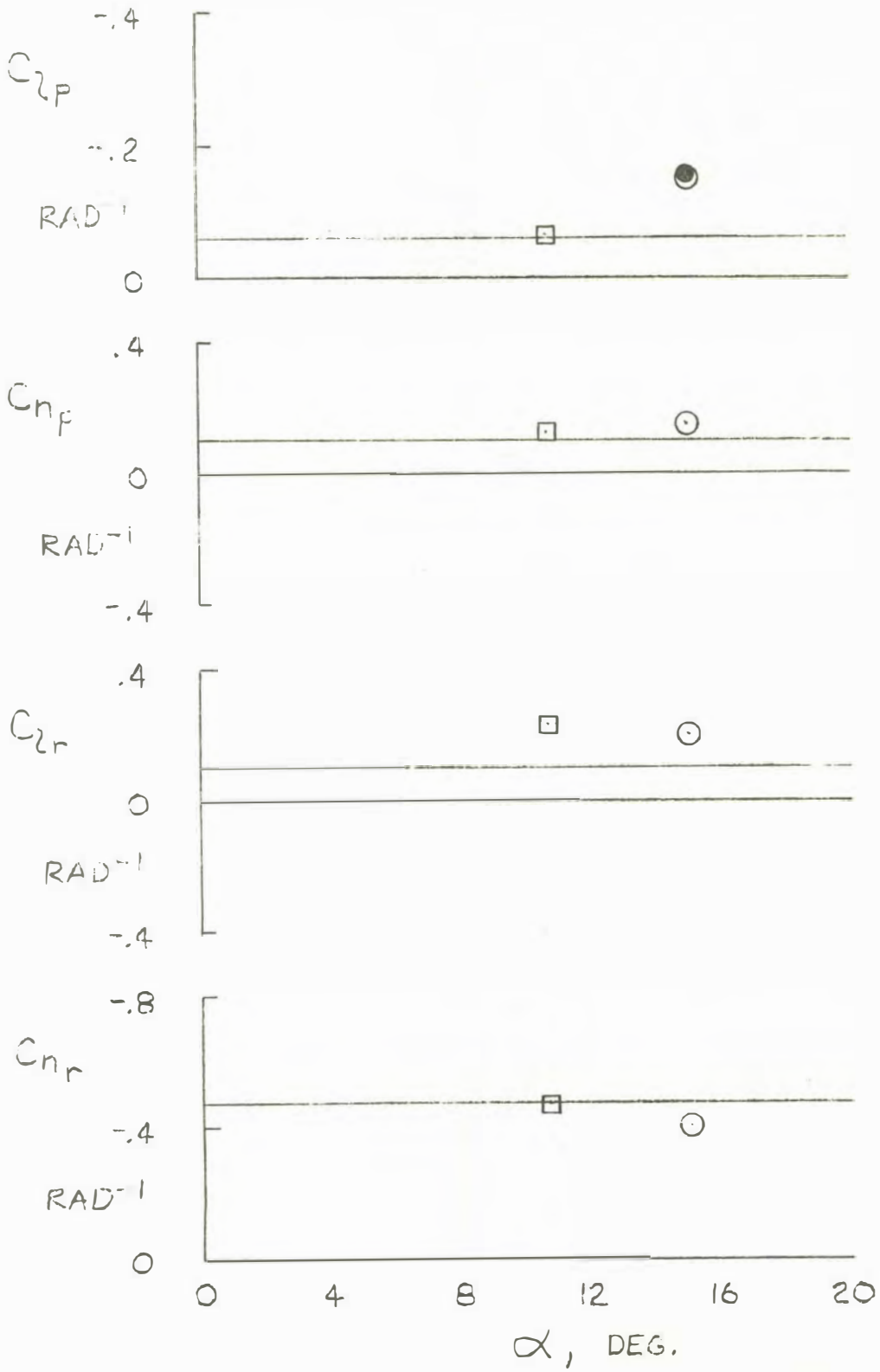
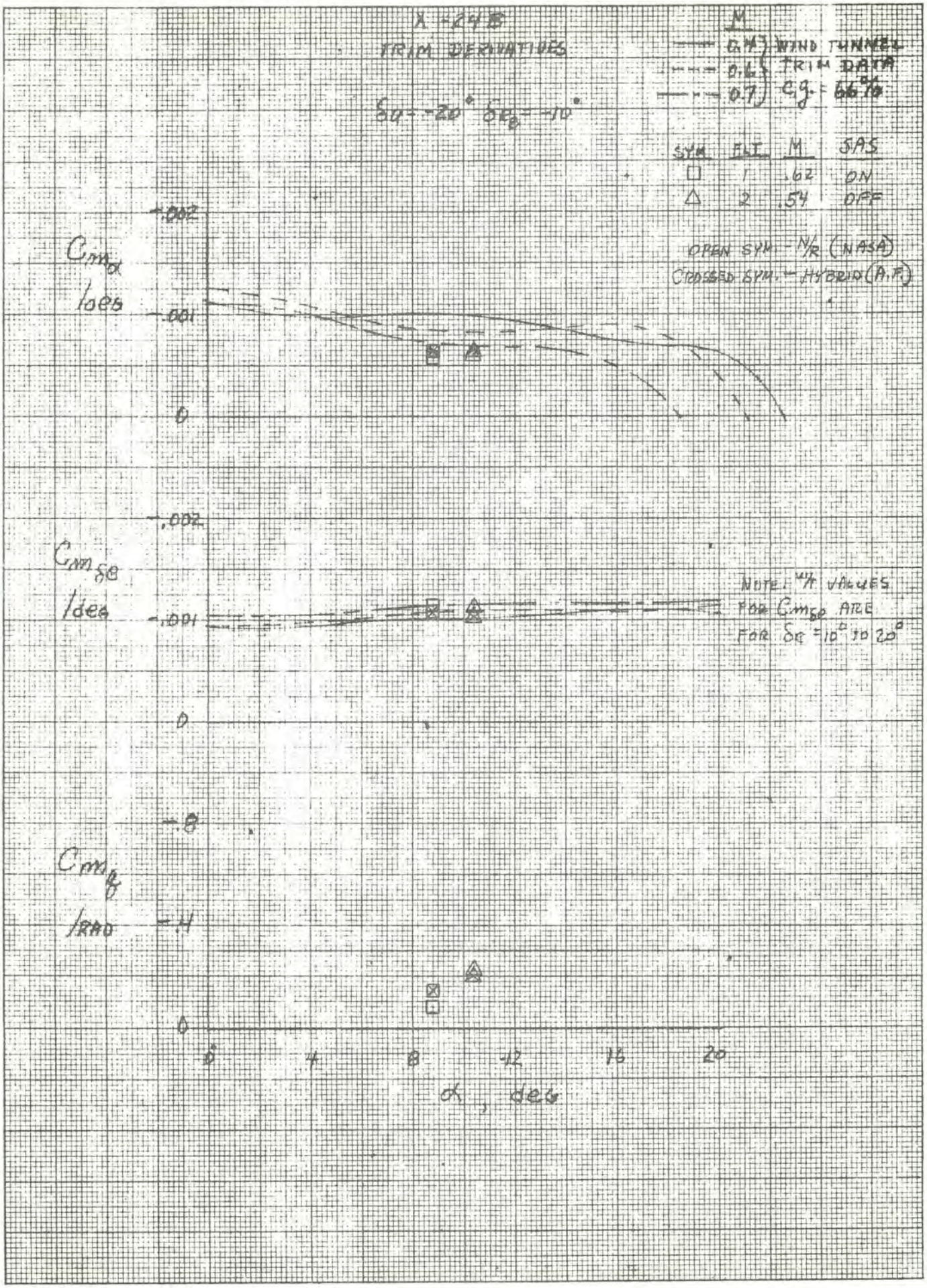
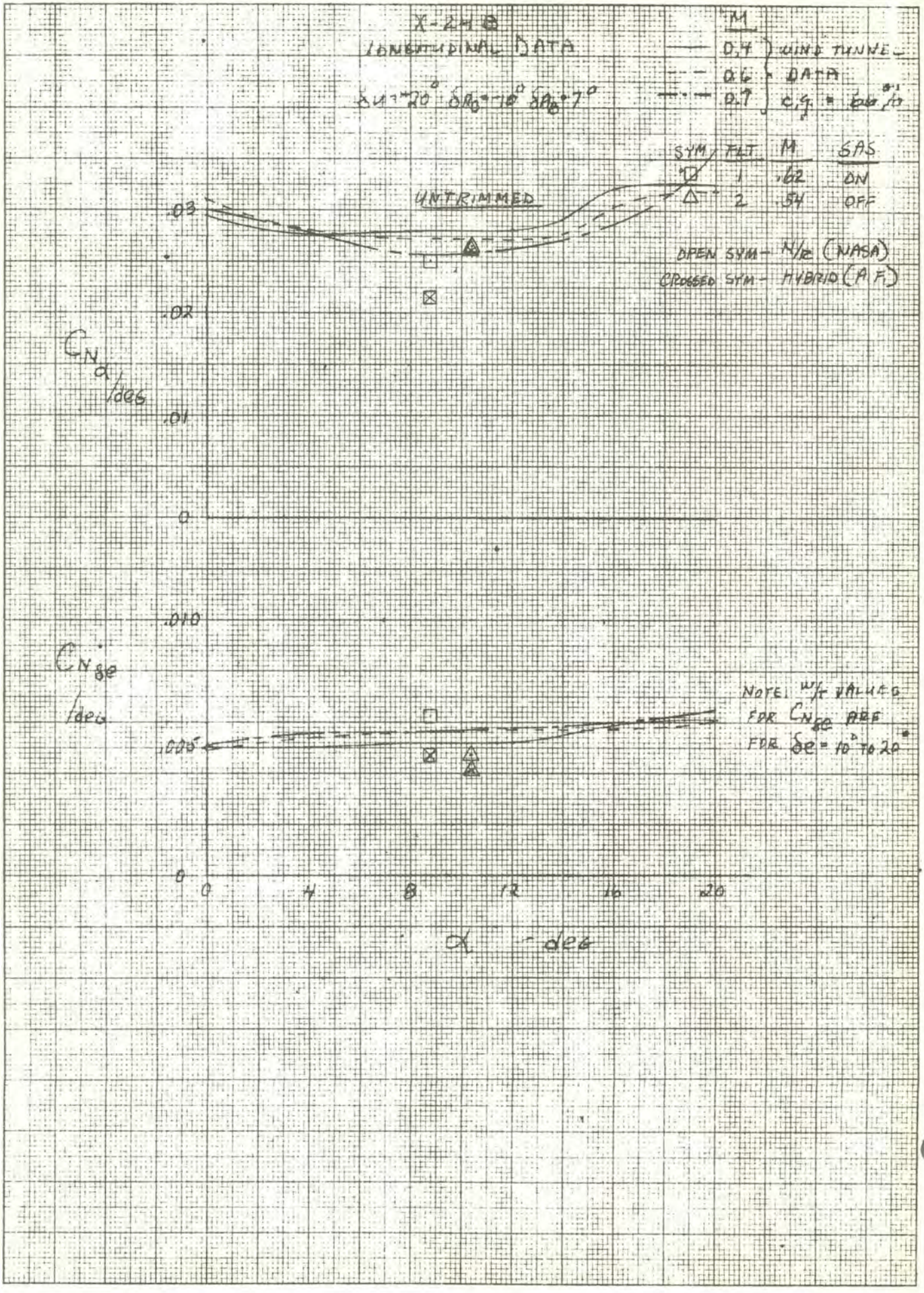


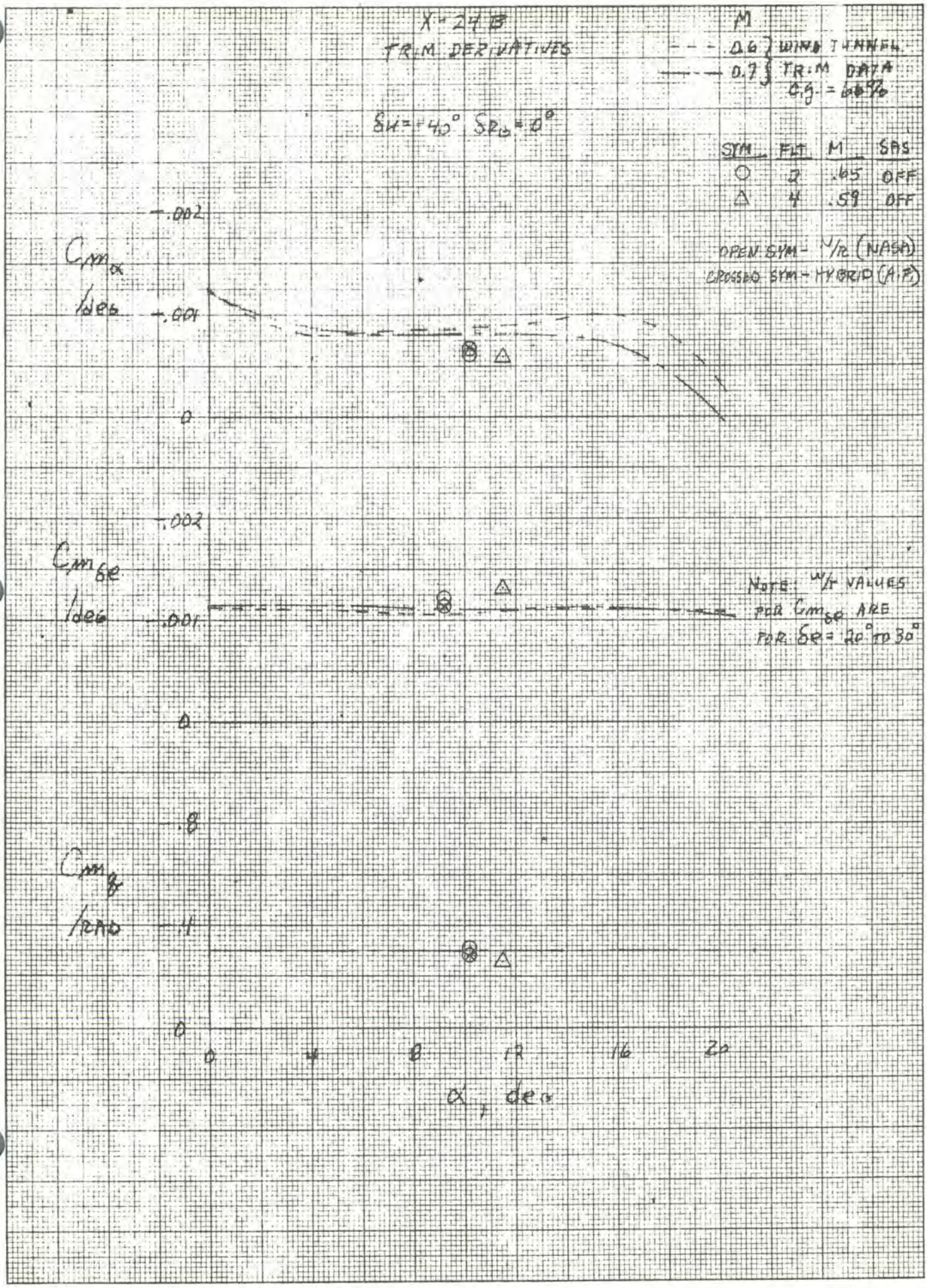
FIGURE 2, CONCLUDED

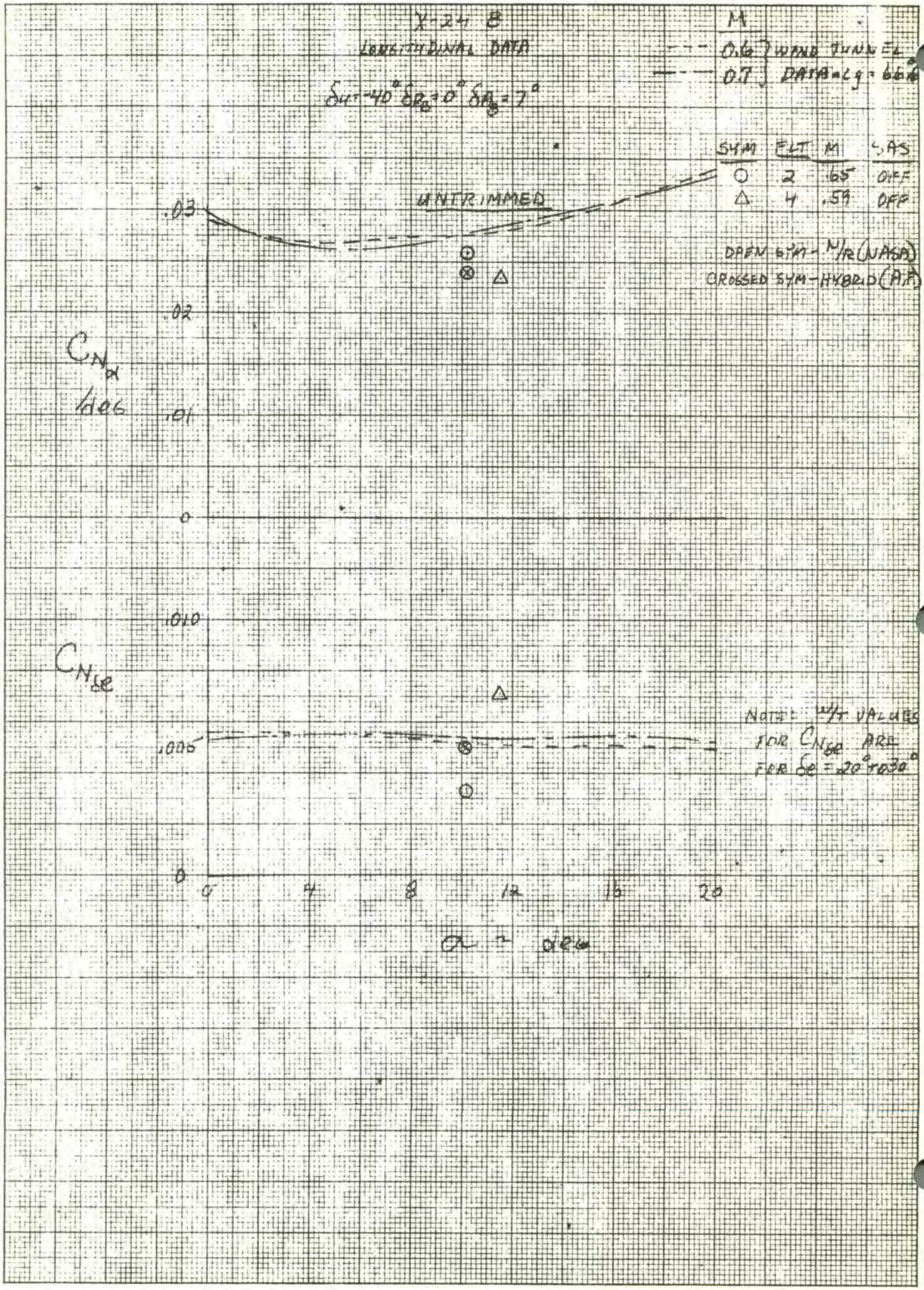
X-24B
TRANSONIC CONF.




X -24 B
TRIM DERIVATIVES
$\delta_H = -20°$ $\delta_{E_B} = -10°$
M
0.6 WIND TUNNEL
0.65 TRIM DATA
0.7 $c.g. = 66\%$
SYM FLT M SAS
□ 1 .62 ON
△ 2 .54 OFF
OPEN SYM. - N/R (NASA)
CROSSED SYM. - HYBRID (A.F.)
C_{m_α} /DEG
.002
.001
0
$C_{m_{\delta E}}$ /DEG
-.002
-.001
0
NOTE: W/T VALUES FOR $C_{m_{\delta E}}$ ARE FOR $\delta_E = 10°$ TO $20°$
C_{m_q} /RAD
-.8
-1.4
0
0°
4
8
12
16
20
α, DEG


X-24 B
LONGITUDINAL DATA
M
0.4
0.6
0.7
WIND TUNNEL DATA
C.G. = 20.1%
SYM FLT M SAS
1 .62 ON
2 .54 OFF
UNTRIMMED
OPEN SYM - N/E (NASA)
CROSSED SYM - HYBRID (A.F.)
.03
.02
.01
0
C_{N_α} /deg
.010
.005
0
$C_{N_{\delta e}}$ /deg
NOTE: W/T VALUES FOR $C_{N_{\delta e}}$ ARE FOR $\delta e = 10^\circ$ TO 20°
0
4
8
12
16
20
α - deg


X-24B
TRIM DERIVATIVES
M
0.6 } WIND TUNNEL
0.7 } TRIM DATA
C.G. = 44%
δH = +40° δRU = 0°
SYM FLT M SAS
○ 2 .65 OFF
△ 4 .59 OFF
OPEN SYM - W/T (NASA)
CROSSED SYM - HYBRID (AFFDL)
Cmα /deg
Cmδe /deg
Cmq /RAD
.002
.001
0
-.001
-.002
-.4
-.8
4
8
12
16
20
α, deg
NOTE: W/T VALUES FOR Cmδe ARE FOR δe = 20° TO 30°


X-24 B
LONGITUDINAL DATA
δ_{LE} = -40° δ_{R_0} = 0° δ_{R_B} = 7°
M
0.6 WIND TUNNEL
0.7 DATA
SYM FLT M SAS
○ 2 .65 OFF
△ 4 .59 OFF
OPEN SYM - N/R (NASA)
CROSSED SYM - HYBRID (AFFDL)
UNTRIMMED
C_{N_α}
/deg
.03
.02
.01
0
$C_{N_{\delta E}}$
.010
.005
0
NOTE: W/T VALUES FOR $C_{N_{\delta E}}$ ARE FOR δ_E = -20° TO 20°
0
4
8
12
16
20
α, deg

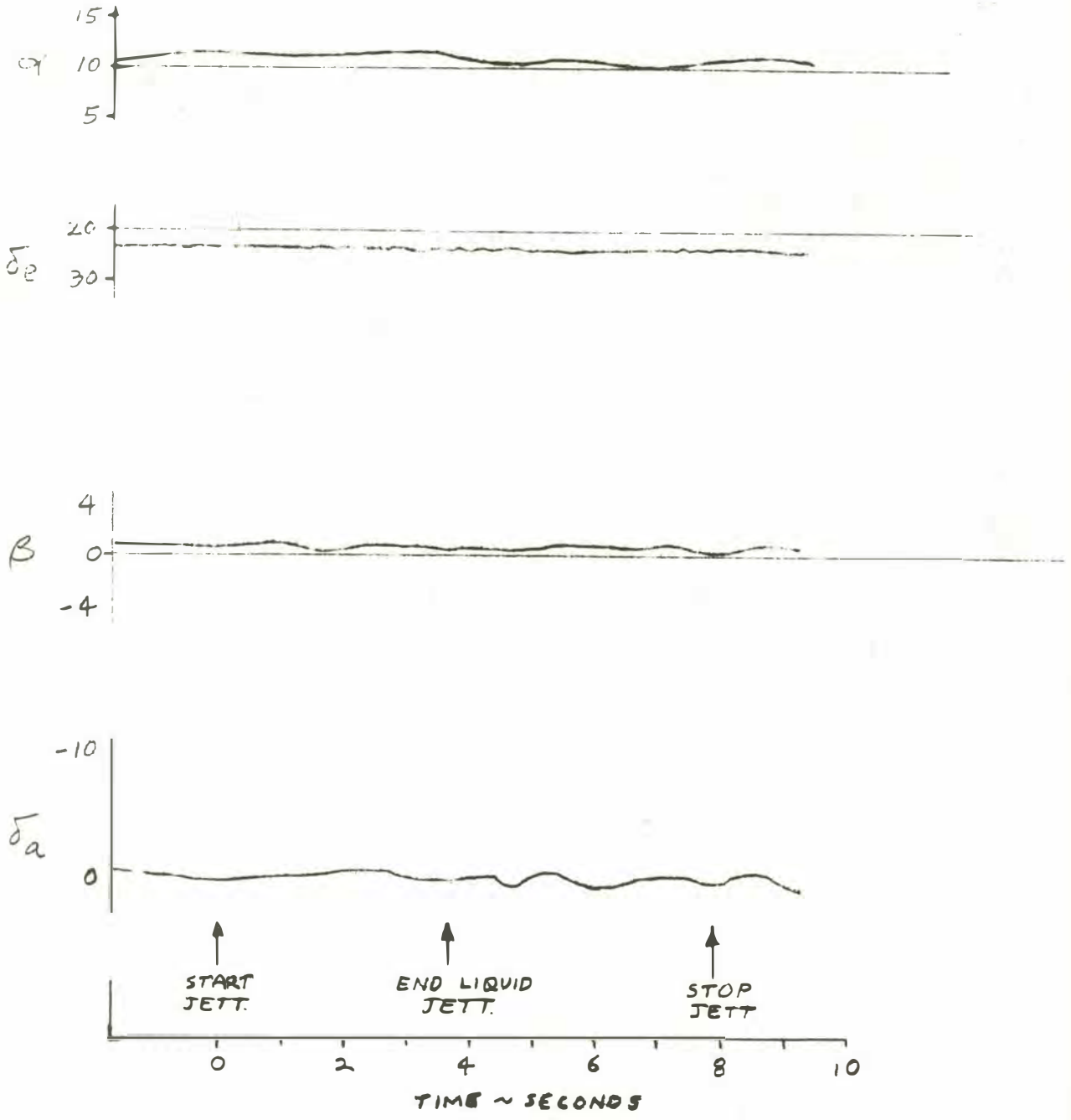
FUEL JETTISON TEST

By

R. Hoey

The fuel jettison line was modified to carry the fuel directly aft and parallel to the aileron upper surface (at 0° δa_B), exiting at the aft edge of the vehicle. There was no noticeable trim change during the fuel jettison test on flight 4. Chase photos showed that there was no recirculation of the fuel into the vehicle base area. This jettison line configuration will therefore be retained for future flights.

X-24B WATER/ALCOHOL JETTISON TEST
MODIFIED JETTISON LINE
FLT. B-4-6

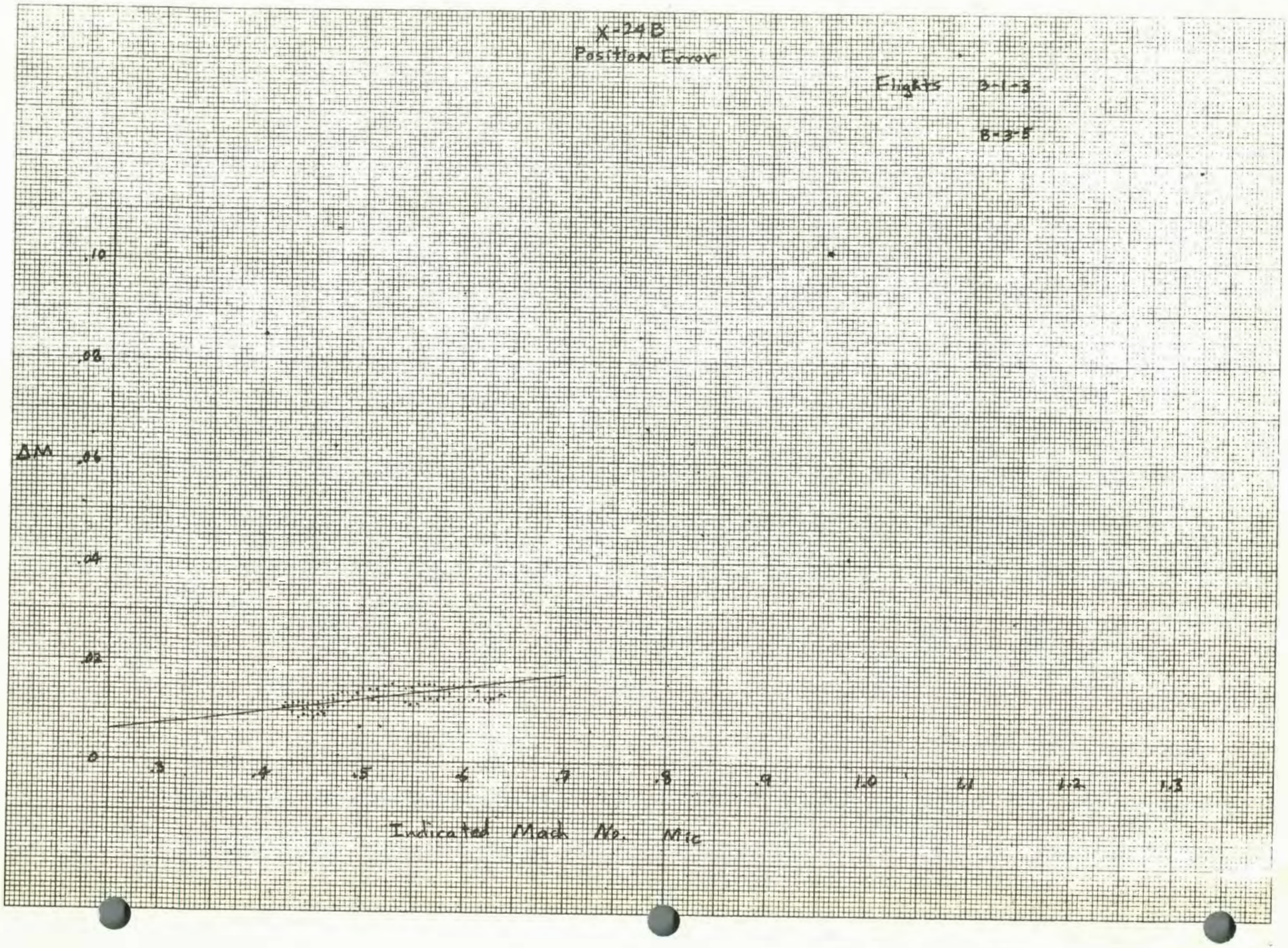


AIRSPEED SYSTEM POSITION ERROR

By

C. Nagy

Position error data were obtained from each of the first four flights. The methods and techniques were essentially the same as those developed in the X-24A program. Analysis of data has been limited to those regions of flight where the sink rate was less than 150 ft/sec to minimize lag effects. Flights B-1-3 and B-3-5 produced the data points shown and these data were used to fair the curve shown. Flights B-2-4 and B-4-6 produced data that were shifted down and in most cases negative. The reasons for these shifts are not known at this time but are being investigated.


X-24B
Position Error
Flights 3-1-3
3-3-5
.10
.08
ΔM
.06
.04
.02
0
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
Indicated Mach No. M_{ic}

X-24B TECHNICAL DEBRIEFING

Flight B-4-6

JOHN MANKE

18 September 1973

1. Discuss the Launch Transient:

I'm getting to the point now where I'm tuning the launch transient out and I'm into the next maneuver before launch so I'm not really paying any attention to it anymore; I will on the next flight because it's going to be a heavyweight launch. I don't guess there was any sufficient difference between this and my last one, the only thing that might be a little bit different is when we trimmed down to about 8° alpha, this is the lowest we've trimmed to I think on launch.

2. Rate the Task to Recover From the Launch Transient and Acquire 10° Alpha:

I had a little bit more difficulty getting to 10 alpha then I had thought I would, it seemed like I bobbled around a little shooting for the 10 alpha and I don't know if I ever got really stabilized and I kind of thought that I would try pretty hard to get the thing right up to 10 and see if I could stabilize it there so it locked in on 10 and I never did get to point where I thought I was really locked on 10 well and I guess the problem was that even though we had been setting the simulator to trim at about 8 or 9 I just hadn't figured it would go down that far after launch and try and stabilize there so it required probably a little bit more elevator trim than I had anticipated and so I was just slow getting up on the 10 alpha. I will have to rate it as the task it was today, if it were a task on a future day why it would be rated differently. Because I would have learned something about the airplane, but as a task for today, I'd rate a that at 3.5.

3. Discuss the Pushover - Pullup With 40° Upper Flaps. If Stick Shaker Actuated, Describe:

Ok, this was pretty much as I had seen on the simulator and pretty much a mechanical maneuver. I don't know whether I got all the way down to 5, if I didn't I got pretty close, this is the type

thing when you pushover you set up a rate with the stick and you have to anticipate about where it's going to go before you start back up so you can come within a degree or half a degree and call it good. The pullup to 17 was no problem, I did get the stick shaker just about where we thought and I may have held it just about at the stick shaker threshold for a little bit before I brought it on up to 17, I did glance down and look at the stick and I got the impression as I felt the shaker come on that it wasn't nearly enough to serve as a warning device during a powered rotation, so that we're going to have to change. It was uneventful, the airplane flew just about like the simulator, no problems.

4. Discuss and Rate the Pitch Damper Off Handling Qualities With 40° Upper Flaps:

Ok, the airplane flies superbly with the pitch damper off. In our simulation we have changed damping some, I guess all we've primarily done, Johnny, is changed cg and changing the c_{m_q} and we've tried a value that was 1/3 of the normal c_{m_q}, the airplane flies much more like the high value of c_{m_q} the pitch pulse was so well damped that I had wished that I had put a little bit more forward stick into it as I pulsed the thing it probably didn't take more than a cycle or two cycles, somewhere between that, to damp the thing out and then the pullup to 15° was really gratifying because the airplane followed just beautifully with the stick as I came back on the stick the angle of attack came up very smoothly no oscillation and I didn't even get any overshoot that I could remember as I hit 15. Then I attempted to hold 15 as precisely as I could and I got a little bleed-off on the alpha, it dropped down to 14 or so and I felt that I could hold it very accurately within a degree at the _____.

I wanted to hold, if I wanted to hold 15° alpha, it looks like the alpha needle was going to hang somewhere between 14 and 15 and probably oscillate back and forth there a little bit. Pitch damper off rating would be a 4.

5. Discuss and Rate the Configuration Change With the Pitch Damper Off:

The airplane was trimmed for 11° angle of attack. The task, from my standpoint, was to hold alpha as close to that 11° as I could during that whole configuration change. I was able to do it in the airplane much better then I could do it in the simulator. I feel that I could very easily change the configuration holding alpha within ±1° of my trim value and I believe we did it on the flight. This also would be rated a 4-desired performance required moderate pilot compensation.

6. Discuss the Pushover - Pullup With 20° Upper Flaps. Did You Note Crossover or Deadband? If Stick Shaker Actuated, Describe:

This was a pullup - pushover. We did get the crossover. The deadband occurred between 13 and 14° whereas on the simulator it occurred somewhere between 15 and 16°. Other than that it compared very much like the simulator pullup - pushover. I frankly couldn't tell any difference in sensitivity on the upper flaps. That is something I would really like to run out and check. I don't see it on the simulator either maybe it is just me I don't know. I don't see any difference and the airplane was just like the simulator. I don't see any difference there and it may be because stick force - wise why you got a lot of stick force in it at that point and maybe guys are hedging against the sensitivity I don't know. Ok, we did note the crossover and the deadband and the deadband is very much like the simulator. Maybe just a little bit less on total stick motion or stick movement. Stick shaker did actuate and it actuated at about 16° alpha. I take that back. I don't, I didn't on this particular pullup - pushover I don't remember the stick shaker. Ok, so if it actuated, well I had decided on the first one that it was not adequate. Ok the first one was my time for evaluating the stick shaker I had no intention of evaluating the stick shaker on the second one. Now on the simulator we alway got it. I noticed it on this one. If we got it I don't remember it.

7. Discuss Evaluation at 13° Upper Flap Bias With Respect to Trim Change, Deadband Crossover, Upper Flap Tightness Rate the Pitch Test:

Ok, the trim change looked very much like the simulator. The only thing is that the attitude change was a bit of a surprise and that is only because I was riding in the vehicle instead of in the simulator. I guess I hadn't expected that much attitude change with it and we got it angle of attack dipped down to 5° to 6° as it did in the simulator. No, but I let the trim, I let the airplane trim. I let the alpha go down. It wasn't hands-off but it was not pull back on it. The idea was to let it trim down so that I didn't have to do any trimming to bring it back up to the deadband. I wanted to use some force through the crossover. So it did trim down. I resisted it a bit. I remember doing that, pulling back on the stick because I thought it was going further than I wanted it to go. But it wouldn't have, it would have trimmed about what a simulator did. Maybe a degree further nose down. Ok, then I did pull up into the crossover again and it occurred about 1° lower than it had in the simulator. But I had expected this from Dave Richardson's curves he - Johnny showed me some data just the other day that Dave showed would crossover between 6° and 7° and it did. That's about where I got it. Ok, then we did the-we threw a po-pu in for the good guys here. I brought it up to 15° alpha and then back down to 5 again and then back up into the crossover one more time. Here again I couldn't change, I couldn't see any difference in sensitivity. It looked pretty much the same as I brought it up to 15. But you have to bear in mind I didn't have much area to evaluate it in before the crossover. Ok about a 1 or 2° alpha is all. So maybe that is not a fair evaluation there. Well, the pitch task certainly wasn't any problem on the 13° upper, it's no different than any other. I would have to rate the pitch task here other than in the crossover as a 2.

2. (I Think That is What We Want to Talk About):

At the higher alphas when you were on the upper flap) yeah I brought it up to 15° off and no problem I held it there and pushed right on back down. It was a no sweat deal.

8. Low Key Conditions:

Low key conditions were just about optimum for weather conditions today. Maybe slightly outside of where we normally are and just about at a good optimum low key altitude 19 and a half or 20,000 feet.

The turn to final was pretty much a picture book type turn. I had noticed this morning on the 104 flights that we were back to our normal Edwards winds so was able to fly the pattern just about the way I like to. I like to turn at 250 knots or so at the 90° position and then gradually pick on up to 280 or 300 knots. So I would have to rate that turn to final to 2 to 2 1/2. Now the final approach (question 10) was a very interesting one because I was able to get my 300 knots with the airplane at 20° on the uppers and then it appeared that I might be just a little bit high or just a little bit fast if I held the conditions so I was able to run the flaps out to 25° or 27° and use them as pure speedbrakes and this was probably one of the most gratifying parts of the whole flight. I could actually just as I touched the speedbrake switch I could feel the deceleration and I could feel it increasing the more I put the flaps out. It was just like a reverse throttle with real good response. And it enables you then to hold your aim airspeed and run the L/D down a little bit to decrease glidepath angle and I was able to put it right back where I wanted it.

Pull the brakes back into 20 and held my aim point to within just a very few feet of where I had been shooting for. So I am going to give you speedbrake readings on the final approach here because that was the most important part and the probably the speed brakes' effectiveness and the ability to rise them and maintain glide-

path control are better than any fighter I have flown so I would rate this at 2.

11. If Turbulence Was Encountered, Describe the Vehicle's Response and Effect on Piloting Task:

The turbulence was very mild today once or twice in the pattern I hit turbulence I just didn't do anything to counter it. I couldn't even tell you how the vehicle responded. All I could remember was a little burble here or there so let us just let it go at that.

12. Discuss and Rate the Flare:

Ok, I had an extra 5 knots or so before the flare this time I guess. The flare was very mild you don't even have to think about it hardly. I heard Tom's 1200-foot call and it was apparent that I didn't want to pull on the stick much at that time and went just a little bit further and just gradually eased it over. It is a very mild flare on this airplane and we ended up at the completion of the flare with a lot of airspeed. Rate the flare on this flight 2 to 2 1/2.

13. Discuss and Rate the Landing:

Now in rating the landing I'll skip the gear down which was very much like it has been before and down to where I was within a foot or two of the runway holding the airplane off. It seems there must have been a little turbulence down there or something. Something there has got to have been a little bit of chop or something down there. It seems like I was working a little harder down there today just holding it a foot off the ground than I had before. And then I got a bit of a sink rate and started to compensate for it and touchdown. Touched down a little earlier than I expected it to - I just apparently didn't stop the sink rate. I am going to rate this landing at 3 1/2 just from that standpoint and I am convinced that it was some outside influences, turbulence, a little wind sheer

or something out there on the lakebed.

14. Discuss the Ground Handling During Roll-Out:

Ground handling during roll-out seemed like I got just a little bit of swerve as the nosegear came dowm. The roll out wasn't as straight as the first two flights. The first two flights were just like arrows. Here again this kind a reflects there must have been something going on on the lakebed windwise or some other wise. Ground handling wasn't any problem. I did all my controlling with the rudders and the ailerons, primarily rudders. I used rudders just about exclusively for that. I am landing in the center of the right half of that runway. That runway is two lines 300 feet apart with a dotted line down the middle. I am landing between the dotted line and the right-hand line and I am able to keep it probably within 10 or 20 feet of going right down the center. Use a little braking at the tail end.

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-4-6 DATE OF REPORT: 10/3/73

PILOT: Manke DATE OF FLIGHT: 9/18/73

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Roger's Lakebed

PURPOSE OF FLIGHT: (1) Longitudinal stability and control data at 64% with 40° and 20° upper flaps.

(2) Handling qualities evaluation with pitch damper off.

(3) Handling qualities evaluation using upper flaps for pitch control.

(4) Investigation of Aerodynamic effect of WALC jettison (Modified Exit Location)

(5) Control system evaluation with two hydraulic pumps.

(6) Aileron and upper flap pressure survey.

(7) Boundary layer noise experiment (RED PLUG)

I. Discussion of Previous Operations

A. Flight B-3-5 was flown on 8/31/73 with no vehicle problems except that the stick shaker trigger point shifted and the backup α pointer on the ADI failed during flight.

B. The main gear tires from flight 2 were reused on flight 3 without incident.

C. Forty-eight gallons of water alcohol were jettisoned during flight to check on the new jettison tube location. The system worked satisfactorily but a large amount of aileron was required to correct the roll encountered with jettison.

D. Neither the center fin or left hand tip fin cameras worked during the flight.

II. Vehicle Configuration Changes

A. The water alcohol jettison tube was reworked to direct the exiting fluid parallel to the boattail surface.

B. The ballast load was increased to 260# to provide most forward c.g.

C. The installation of the backup aileron bias limit switches was completed.

D. The backup α system was repaired by adding support to a printed circuit board in the ADI coupler box.

E. The stick shaker system was reworked to correct for temperature sensitivity.

F. The upper flap bias limit switches were adjusted to -13 and -40 for crossover operation.

III. Instrumentation System Changes

A. Installed a blanket on center fin camera to retain heat from internal camera heater.

B. Reworked left hand tip fin camera mounting & made new cover for camera.

C. Changed fin load strain gages from even to odds.

D. Installed external heater on forward pylon camera.

E. Changed hookup on 6 pressure taps.

F. Changed to 'Red' plug for boundary layer noise monitoring on dynamics instrumentation.

IV. Preflight Events

A. The upper flap actuators were removed for seal changes to relieve chronic leakage.

B. The pressure sensing lines from the L/D rockets were purged to remove moisture.

C. Calibrated fin pressure taps.

D. Calibrated mics & accelerometers for dynamics system.

E. Main gear tires were changed.

F. Preflight functionals were performed with no problems.

V. Flight Events

A. The vehicle was agained serviced with 48 gallons of water alcohol.

B. Flight was made with no vehicle system problems.

C. None of the onboard cameras functioned properly.

D. The water alcohol jettison worked as planned with no adverse vehicle motions.

E. The vehicle was in good shape after flight.

Approved by: _____
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: _____
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

X-24B #551 POSTFLIGHT DATE: 9/18/73

PILOT: MANKE

Ok, this is flight B-4-6, the fourth X-24B flight. And, again, it was another real beautiful flight. Weatherwise and windwise it didn't get what the guys forecast. We had 10 knots this morning but it looks like that left us before launch. I had seen some turbulence this morning. Don saw the same stuff later with the Goon and later we saw it again on the approach. That was the only significant weather.

This was our first pressure suit flight with this airplane. I was very impressed with everything to do with the pressure suit. It was comfortable as much as a pressure suit can be comfortable. Good vent flow and it was reasonably cool. The only one comment, Norm, on the vent knob increase and decrease thing there. When you go to full decrease and then increase it is just a little bit then the flow decreases off. So the minimum flow is actually all the way closed and then opened just a little bit. It is no big deal. I could feel just a little difference in the suit. There are a couple of things that we should make sure will get in our new checklist, in the powered flight check list, that deal with the pressure suit and I will not cover them all here. Face plate heat is not in the checklist, and one or two other things that I want to talk to Mike about. I can't reach everything with the shoulder harness locked, so I would caution you to have the thing unlocked.

Ok, I launched 10 seconds after you guys told me it was 10 seconds to launch. That came three seconds after the one minute. Ok, understand all that? It looked like the airplane was trimmed to about 8° α, somewhere in that ball park, just about where I had hoped it would be. I trimmed it back up to 10. I had a chance to look at beta and I had about 1/4 - 1/2° needle right. I guess you saw about the same thing there. Had we seen the same thing on the last flight? (Yes, prior to jettison).

Ok, 42,000 went to jettison. I could hear the valve open. I could hear the jettison or feel it or something, but I did not feel any significant trim change. I could feel the airplane move a little bit but I could not tell you what axis it was in. It was a very small amount. Maybe it was me stirring the stick to find out whether it was moving at all. Very much difference between this one and the last one as far as what it takes to fly the airplane. The last jettison on the last flight took 3/4 of our aileron throw to keep the wings level. So we modified the jettison exist by putting a tube in it and exiting right straight out the back. This apparently has solved that problem. We will talk to Chase later and find out whether we had any recirculation. Ok, I went tanks off or stopped jettison and tanks off as we were going through 40,000. I don't know whether that was before your call or not. I could not feel any more or hear any more so I shut it off them.

I did the push over pull up. That went pretty much as billed on the simulator. No particular problem. I did get the stick shaker coming

through about 16 or somewhere in that ball park. The stick shaker isn't noticeable enough. We are going to have to increase the throw of that little cam in there. If I wasn't paying particular attention to it, almost watching the stick, I probably would not have noticed it. We will have to up that some. I will work with the crew on that. I did come on just about where I expected it to come on. We will get a good verification on the data here.

Ok, then back down to 11° α. I turned the pitch damper off and did a pitch pulse. I did not get as much input as I wished I had after I pulsed it. We have tried different values of cmq in the simulator and the lowest cmq indicated that I did not want to push it too hard. The higher one indicated a lot better damping. I did something in between and it turned out that the airplane is much better than our 1/3 cmq and not quite as good as the other one. Just about where we thought it might be. Very nicely damped with the damper off. After the pitch pulse the task was to fly it up to a high angle of attack and see how well I could hold the high angle of attack with the pressure in, with the pitch damper off. I brought it right up to 15° and it followed very nicely. It came right up to 15 and I thought, boy this thing is really going to hand in at 15 and then, there wasn't any overshoot like I had seen in the simulator, but as I relaxed a little bit, why then I bobbled a little bit and found I could fly it between 14 and 15°. So there is about a 1° α range that you can fly it in with the pitch damper off holding that much pressure on the stick. That's just about what a guy would be holding if you were landing with pitch damper off. Just about that much. Maybe just a bit more back stick. I was having such a good time flying it at high α that I ran out of time to go down to the low α. I did go down to about 6° α but we were approaching the configuration change so I did not spend much time there. I was a little surprised at how much force I had to hold to get 6° α. I will have to look at that again sometime. This also would be where you would be flying if you were flying the pattern and hadn't trim and it down to 300 knot approach speed with a little forward stick on it. It still looks like I could fly it within a band of 1 or 1 1/2° α.

Ok, I made the configuration change then around 11 α with the pitch damper off and the airplane flies much nicer than the simulator does in this regime. I think I could hold it within ±1° angle of attack through out the trim change that you get in the configuration change. I don't know that I did that. I suspect it got down to 10 and maybe up to 12 again. But, with allittle more attention why there is no question that I could fly it within ±1° which says a heck of a lot for the airplane with damper off.

Ok, after that the damper came back on again and we were to get a pull up push over at 20° on the uppers. I expected to get into the cross-over at about between 15 and 16 α. I got the cross over earlier. At least I think I did. Things seemed to stop somewhere between 13 and 14° α I think.

Somewhere between 13 and 15 I got the cross over and the dead band may not be quite as much as we have got in the simulator, but damn close to it. I had to go quite a bit back on the stick once it got to that cross over point before I could get any more noseup. I probably spent a little more time here than would be normally necessary on a popu but as you pull back through that area and you come through may 3/4" without anything happening it takes a little bit of time to readjust to it again once you get some authority back again. Now, I cannot tell any difference between the sensitivity on the lowers or on the uppers. This is one of the things I wanted to look at. We kind of felt that the uppers would be more sensitive than the lowers but for that extra 2 α that I went I could not tell any difference in the sensitivity. But I guess the data will have to show whether or not that is ture.

Ok, back down to 10 α, close it up to 13° and it trimmed forward just like the simulator. I guess I was a little surprised at how much it trimmed forward. It went almost identical to the simulator but the nose came down. It was more noticeable in the airplane than in the simulator when the nose comes below the horizon. Then we tried to fly it again in the cross over. That was the reason for this maneuver, to actually fly it through the crossover again, and here again, the crossover occurred e earlier in the airplane than it had in the simulator. In the simulator it occurred between 7 and 8 α, here I think it occurred between 6 and 7 α. Once again, I could not tell any difference between sensitivity. I pulled the think up to 15 α on the upper flaps then, pretty close to 15, but I could not tell any difference in sensitivity. Back down to 5 α and then I flew into the cross over again and then it was time to go back to 20 and clean it up and come to land. So we got all the maneuvers that we could plan on getting. It was pretty much a carbon copy of the simulator flight.

I guess you did not see my rocket check right off. I guess one of the chase called that they had seen it. I did not look out of the airplane until I got all these things done, the rocket check, the fin camera on and the calibrate, and Mike's calls were really great all the way through. I just followed him all the way to the highway and when I did look out we had just crossed the highway at about 19,000' or something like that. The pattern winds are back to normal Edward's type winds again. The pattern looked like an Edwards pattern for the first time since we have flown this airplane. Out of the west, very nice comfortable pattern to fly. This was the first time that I used the speed brakes once I got settled down on final. On all the other times I was always high and I recognized it early on, so I used the speed brakes during the turn and wasn't really able to determine the effectiveness of them because you are doing a lot of things here. You are diving and turning and using brakes. Today the pattern was really good so that I could leave everything alone until I rolled out on final. As I got up to 300 knots I ran the brakes out. I don't know 25 or 26° and it was just like working a throttle on an airplane. It was really something. There's absolutely no trim

change associated with it. I could feel the deceleration in my shoulder straps. It is really pretty and you can feel the deceleration increase as you come out with the brakes. You could almost control the thing by the way it feels in the cockpit. It's just a nifty situation. I could see my glidepath coming down to where I wanted it, brakes back in again. There were one or two bits or turbulence on final. Nothing to write home about. I think I called them out. Again, I guess I picked up a little over 300 knots this time, 310, 305. I guess I saw 305 maximum. Tom called 1200'. This airplane is so easy to flare. You really don't have to worry too much about altitude. You just kind of do it whenever you are ready to round it out. We rounded out and leveled out and I still had about 280 knots I guess, 275/280 when we came level, so we just sat there and waited for 240. I like to drop the gear at 240. I was probably 25 or 50 ft. off the ground. I went through 240 and the gear came out, and this was nice because there was no gear transient. I settled down and held it off the runway for a while. I don't know what my touchdown speed was. I did not look but it was a pretty smooth touchdown. Maybe just slightly one gear early. The right gear was just a little bit before the left gear this time. Got a little bit of swerve at touchdown. Nothing very gross, just enough to get your attention and then it straightened out. Rollout was pretty uneventful. I did not use nose gear steering. Just used the rudder and aileron and I used some brakes from about 60 on down.

X-24B #551

FLIGHT: B-4-6 DATE: 9/18/73

PILOT: J. Manke L/P: R. Young

NASA 1: M. Love

16 MINUTES TO LAUNCH

NASA 1: A little right aileron trim John.
John: OK.
NASA 1: That is good.
John: I will get on with it now. The SAS servos coming to AUTO. Ok, all servos are auto. Ok, I am 5, 5, 5 on the gains. Here comes the old SMRD. No lites. Here comes the torque. No lites. There's #1's and a torque. Got 3 ambers. #2 servos are off and a torque. 3 red. SAS gains are 4, 3, 2. Servos are auto. All lites are reset. Torque. No lites. Ok, my SAS mode switches are on. I'll wait for the 14 minute call for the hydraulic switch.
NASA 1: Roger, 15 minues now, John.

15 MINUTES TO LAUNCH

John: Ok.
Looks like you are going to make 50 today Dale.
B-52: Right, whatever you want.
John: No, 45's good today. Maybe another day.
NASA 1: 14 minutes, John.

14 MINUTES TO LAUNCH

John: Ok, Mike.
Ok, #2 and #4 hydraulics are off. #1 and #3 are on. Hydraulic pressures are 2700 each.
NASA 1: Roger.
John: And we can go ahead and do the pitch and yaw pulses Dale, like the ones we did last time.
B-52: Ok, are you ready for a pitch pulse?
NASA 1: Ready Mike? All set.
B-52: Here comes a pitch pulse.
NASA 1: Good pitch pulse.
B-52: Here comes a rudder pulse.
NASA 1: Good rudder pulse.
John: That's a good one.
Ok Mike if we are going to be on this heading a while I will go ahead and erect the gyros.
NASA 1: Roger.
Just past 13.

13 MINUTES TO LAUNCH

John: Ok got the 13 minute call and erect and fast erect is ON. And Dale what is your heading now.
B-52: Right now it is about 188 sneaking back to 190.
John: Ok.
NASA 1: Keep 188, Dale.
B-52: Ok.
Chase 1: Chase 1 is showing 190.
NASA 1: 11 minutes, John.

11 MINUTES TO LAUNCH

John: Ok, how many was that Mike, 11?
NASA 1: 11, Roger.
John: Ok, I am 40 on the uppers, 10 on the lower, ailerons are zero, aileron bias 7, rudder is 3/4° left, rudder bias zero.
Chase 1: Looks good here John.
NASA 1: Ok, 10 minutes.

10 MINUTES TO LAUNCH

John: Ok, Mike, 10.
#1 38, #2 36, Control gas 475, governor balance 435, fuel tank 40, lox tank 25, landing gear about 30.
NASA 1: Roger. 9 minutes, John.

9 MINUTES TO LAUNCH

John: Ok, Mike 9.
Erect switch is shutoff, fast erect is off, both attitudes are Ok.
NASA 1: Roger and Bob Hoey would like a beta reading.
John: Ok, β is 1° needle left, alpha is 3.
NASA 1: Roger, thank you. We agree.
8 minutes, start turn.

8 MINUTES TO LAUNCH

B-52: Turning
John: Ok, are you ready for a rocket check?
NASA 1: We are ready down here.
John: Ok, here it comes.
Chase 1: Good
NASA 1: You have two good chambers.
Ok John, turbulence check showed a very light nibble at 6500 and even lighter from there on to the ground. Should be no problem.
7 minutes.

7 MINUTES TO LAUNCH

John: Read you now on Primary.
NASA 1: Roger.
Read you 5 square on Primary.
6 minutes now, John

6 MINUTES TO LAUNCH

NASA 1: Chase aircraft check windshield heat.
Chase 1: 1, 1α, 2, 2α.
John: Ok, how's that for 25°, Mike?
NASA 1: That's 24 John.
John: Ok.
NASA 1: Your trims look good.
John: Very good.
NASA 1: 5 minutes John.

5 MINUTES TO LAUNCH

John: Ok, going pretty good Mike, here comes battery. I am on battery. Emergency battery lites did not come on. Swapping hydraulics. Ok #2 and 4 are on, pressures read 31. Electrics are 110, 105, 95 and about 20.
NASA 1: Roll out 360.
B-52: Roger.
John: SAS gains are 5, 5, 5.
SMRD, no lites. Here comes a torque, no lites. Ok #1 servos are off, torque, 3 ambers. #2 servos are off and a torque, got 3 reds. Gains are 4, 3, 2.
NASA 1: 4 minutes John.

4 MINUTES TO LAUNCH

John: Roger, 4. My servos, 6 of them are auto. Reset my lites and a torque. No lites.
NASA 1: Come right to heading 355 Dale.
B-52: Come left 355?
NASA 1: 3 right, Dale.
B-52: Rolled out 360, I'll come over to 030.
NASA 1: Ok, thank you.
3 minutes, now.

3 MINUTES TO LAUNCH

John: Ok, Mike, 3 minutes. I am on X-24 oxygen. My cylinder pressure is 17, regulator is 85. Ok, I am on X-24 air now, cabin altitude is 24 1/2. Ok, my canopy defog switch is heat, forward canopy is on. Suit vent is low. #1 helium is 38, #2 is 36, control gas is 480 and governor balance is 435. Erect going and fast erect is on. Trim settings look OK and here comes a calibrate.

Chase 1: Ok.
NASA 1: Say again please.
John: Here is another calibrate.
Chase 1: Everything looks good here, John.
John: Ok, release low pressure lite out. Going pressurize.
NASA 1: 3° left.
B-52: Ok.
John: Fuel tank about 41 and lox is coming up. Ok, fuel is about 44 LOX is 44.
NASA 1: We are approaching 70 seconds, John.
John: Ok, Mike.
NASA 1: 70 seconds, now.
John: Ok. You were cutoff Mike, say again.
NASA 1: Ok, 1 minute now.

1 MINUTE TO LAUNCH

John: Got your 1 minute call.
NASA 1: 2 degrees left and hold it, Dale.
John: #1 is 37 1/2, #2 is about 31. α is 3 3/4°.
Erect switch is cutoff, fast erect is off.
NASA 1: System checks are good, John.
John: Ok, release circuit breaker going in.
NASA 1: 30 seconds now.
John: Release circuit breaker is in. Camera and recorders coming on. They are on.
NASA 1: 10 seconds now.
John: Roger, got it.

LAUNCH

NASA 1: Ok, John check 10 α.
Standby for jettison.
John: Roger.
NASA 1: Ok, stop jettison and tanks off and standby for a popu. Ok, check 11° α and standby for pitch damper off. Ok, John, 31,000 now and standby to close it up to 20. Going high, John.
John: Closing up.
NASA 1: Ok, John standby for damper on and up and down. Heading is good. Got 19° on the uppers. Ok, standby to close it up to 13.
John: Roger.
NASA 1: Heading is good and you are 2 thousand high, John.
John: Ok.
NASA 1: Ok, you are high and outside. Past 3 miles John, standby to open up to 20 on the uppers.
John: Ok.
NASA 1: Holding 3,000 high at 2 miles. 1/2 miles off track.
John: Ok.

NASA 1: Ok, John lets go back to 20 and check 1 and 3 hydraulics on. You are at a mile.
John: Ok, they are on.
NASA 1: Ok, we got you at 19, check 1 and 3 hydraulics, fin camera on. You are over the highway John, start your turn and you can get a rocket landing check.
John: Yes, I got one. Did you see it?
NASA 1: We got 2 good chambers.
Chase 1: 87%.
NASA 1: You got 19 on the uppers, John. 20 now.
Chase 1: 270, 88%.
John: A little turbulence.
NASA 1: Ok, John, we got you at 6°. Set mach repeater to .3.
John: Okay.
Chase 1: 295
John: Beautiful, speed brakes.
Chase 1: 86%. 305
John: A little turbulence.
NASA 1: That's a good 20, John.
John: Roger.
Chase 1: 3500
John: Ok, Tom, thanks.
Chase 1: Three good gear. 10 ft., 5, 2, on.
NASA 1: Ok, John, check nose gear steering armed.
John, we haven't heard a thing from you since about launch, I don't think. I hope you read us.
John: Read every word you said.
Chase 1: All chase aircraft lets go tower.
John: Ok, I've come to a halt.
NASA 1: It's good to hear from you again.
John: Yes, well I said a few things in there, I mumbled a little bit.
Ok, let's see we are on page 21 here.
NASA 1: All stations, we'll debrief at 1045.
John: Ok, I want to give you a cabin source reading.
I got 1150 on instruments.
Got 1250 on my oxygen tank.
NASA 1: Roger John, we got, Mike is changing stations.
John: Ok, throttle is off, camera is coming off. Here comes another calibrate. Ok, now the recorder is coming off. 6 SAS servos are off. All hydraulics are off. Canopy defogs are off. Control gas is 490, governor balance 440. #1 Helium is #2
NASA 1: Got it.
John: Landing gear is 25, oxygen is , cabin air is now down to . Radar switch is off. Attitude system is off.
NASA 1: Yes, we got a call.

FLIGHT 5

PRELIMINARY RESULTS OF X-24B

Flight B-5-9

4 October 1973

By

AF/NASA X-24B Project Team

X-24B Captive Flight Request
21 September 1973

Flight No: B-2C-7

Scheduled Date: 3 October 1973

Pilot: Major Love

Purpose: Pilot Checkout

Simulated Launch: South Rogers Lakebed, Mag Heading 360° + Crosswind Correction Angle. 45,000 feet, 185 KIAS. Flap Bias "Manual", Upper Flaps = -40°, Lower Flaps = 27°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = ½° Left. Aileron Bias = 7°, SAS Gains 4,3,2. Mach Repeater "Manual" = 1.0, KRA "AUTO", ~~All-Hydraulic Pumps-On~~.

Landing: Main Base Runway

B-52 Track: X-24B Track #1 (R2515, Work Area I)

ITEM	EVENT
1	Takeoff and climb to 35,000 feet at 240 KIAS to initial point at Buckhorn Lake.
2	NASA I will vector B-52 along X-24B Track #1 as X-24B pilot performs pre-launch checklist functions.
3	After the simulated launch point, the B-52 will commence a descent for landing on Main Base Runway. X-24B pilot will perform abort checklist functions.

NOTES:

1. Nose Ballast = 100 lb

	Weight-lb	cg-%
2. X-24B	8154	65.06
Pylon Adapter	5020	---

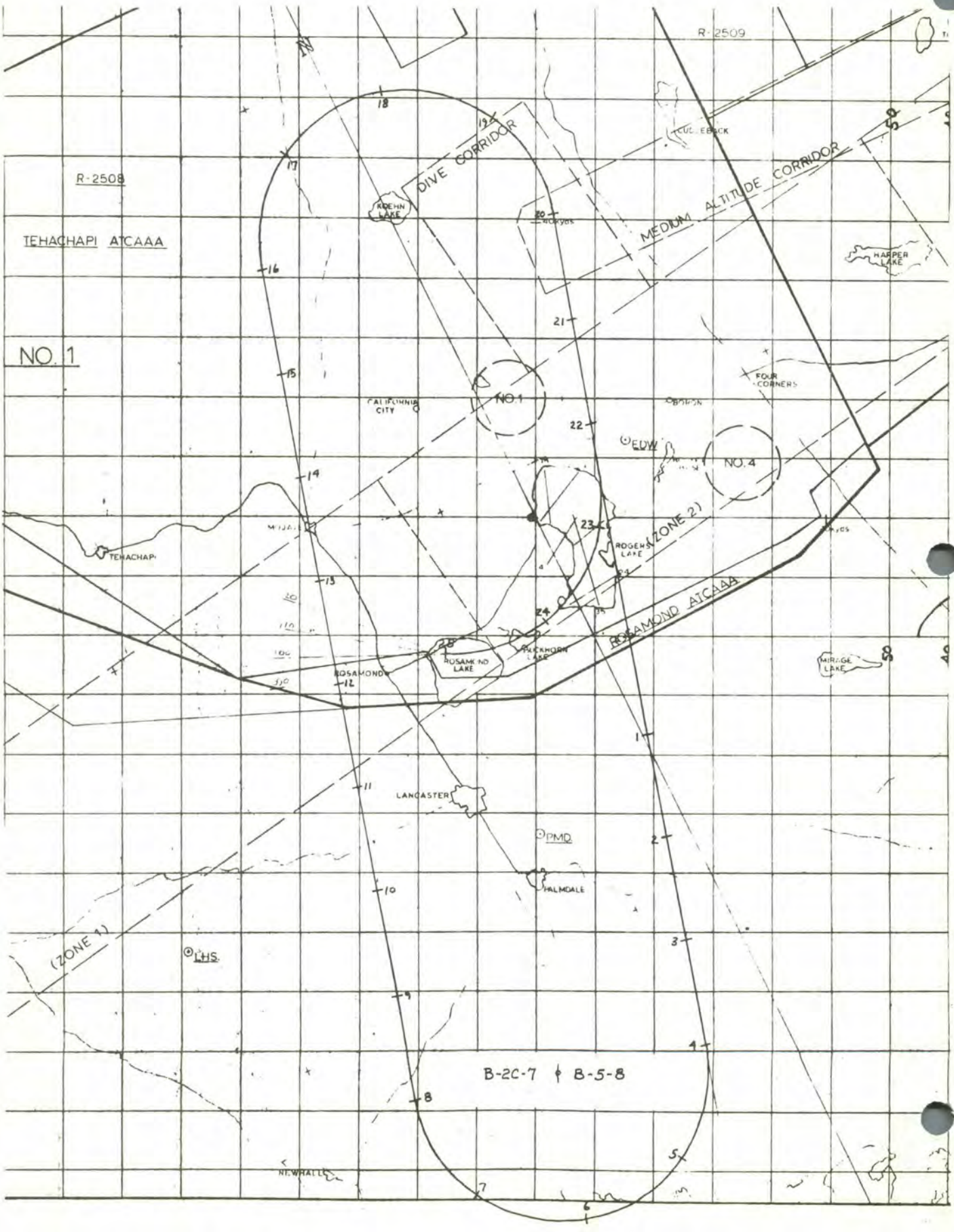
ALTERNATE SITUATIONS

1. If systems check reveal X-24B to be in unflyable condition--abort mission

2. Surface wind limit, 10 kts crosswind/15 kts maximum

Robert G. Hoey
ROBERT G. HOEY

W. O. Thompson for
JACK L. KOLF


R-2509
R-2508
TEHACHAPI ATCAAA
NO. 1
DIVE CORRIDOR
MEDIUM ALTITUDE CORRIDOR
ROSAMOND ATCAAA
(ZONE 2)
(ZONE 1)
NO. 1
NO. 4
EDW
LHS
PMD
TEHACHAPI
CALIFORNIA CITY
ROSAMOND
LANCASTER
PALMDALE
EDWARDS
FOUR CORNERS
HARPER LAKE
MIRAGE LAKE
ROGERS LAKE
ROSAMOND LAKE
BUCKHORN LAKE
KOEHN LAKE
B-2C-7 & B-5-8

X-24B Flight Request
21 September 1973

Flight No: B-5-89

Scheduled Date: 4 October 1973

Pilot: Major Love

Purpose:
1. Pilot Checkout
2. Handling Qualities Evaluation
3. Forward and Aft Fuselage Pressure Survey
4. Acoustic Noise and Vibration Experiment (WHITE PLUG)
5. TUFT STUDY

Launch: South Rogers Lakebed, Mag Heading 360° + Crosswind Correction Angle. 45,000 feet, 185 KIAS. Flap Bias "Manual", Upper Flaps = -40°, Lower Flaps = 27°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = ½° Left. Aileron Bias = 7°, SAS Gains 4,3,2. Mach Repeater "Manual" = 1.0, KRA "AUTO", All Hydraulic Pumps On.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #1 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	Mn	EVENT
1	0	45	185	5	.70	Launch, Trim to 10°α.
2	20	42	190	10	.68	Trim to 12°α.
3	27	40	200	12	.67	Perform Rudder and Aileron Doublets and Roll Evaluation.
4	50	35	195	12	.60	Heading Correction As Per NASA I, If Required.
5	82	30	185	12	.51	Change Configuration to 20°. Upper Flap Bias at 12°α. Mach Repeater to .3.

ITEM	TIME	ALT	A/S	α	Mn	EVENT
6	93	28	200	12	.52	Perform Slow Pullup-Pushover 15° to 5° to 12° Evaluating Handling Qualities. Retrim to 10°α. Mach Repeater to 1.0.
7	125	25	235	10	.55	Heading Correction As Per NASA I, If Required. Landing Rocket Check.
8	162	21	220	10	.48	Low Key, Start Left Turn, Fin Camera On.
9	224	10	270	9	.50	Pushover to ≈6°α to Accelerate to 300 kts. Mach Repeater to .3.
10	260	3.3	300	6	.48	Start Flare α ≈ 10°.
11	270	2.4	250	7	.42	Level, Gear Down Below 240 kts.
12	280	2.3	180	12	.3	Touchdown

NOTES:

1. Nose Ballast = 100 lb

	X-24B	Weight-lb	cg-%
2.	Launch & Landing	8154	65.06%
3.	Pylon Adapter	5020	---

GROUND RULES FOR NO LAUNCH

1. Angle of Attack or Sideslip Malfunction
2. Any Control System Malfunction
3. Any Landing Rocket Malfunction
4. Turbulence Below 10K in Excess of Light
5. Surface Winds ~~10~~ 5 kts Crosswinds/15 kts Max

(In addition to standard ground rules published in Lifting Body Joint Operations Plan)

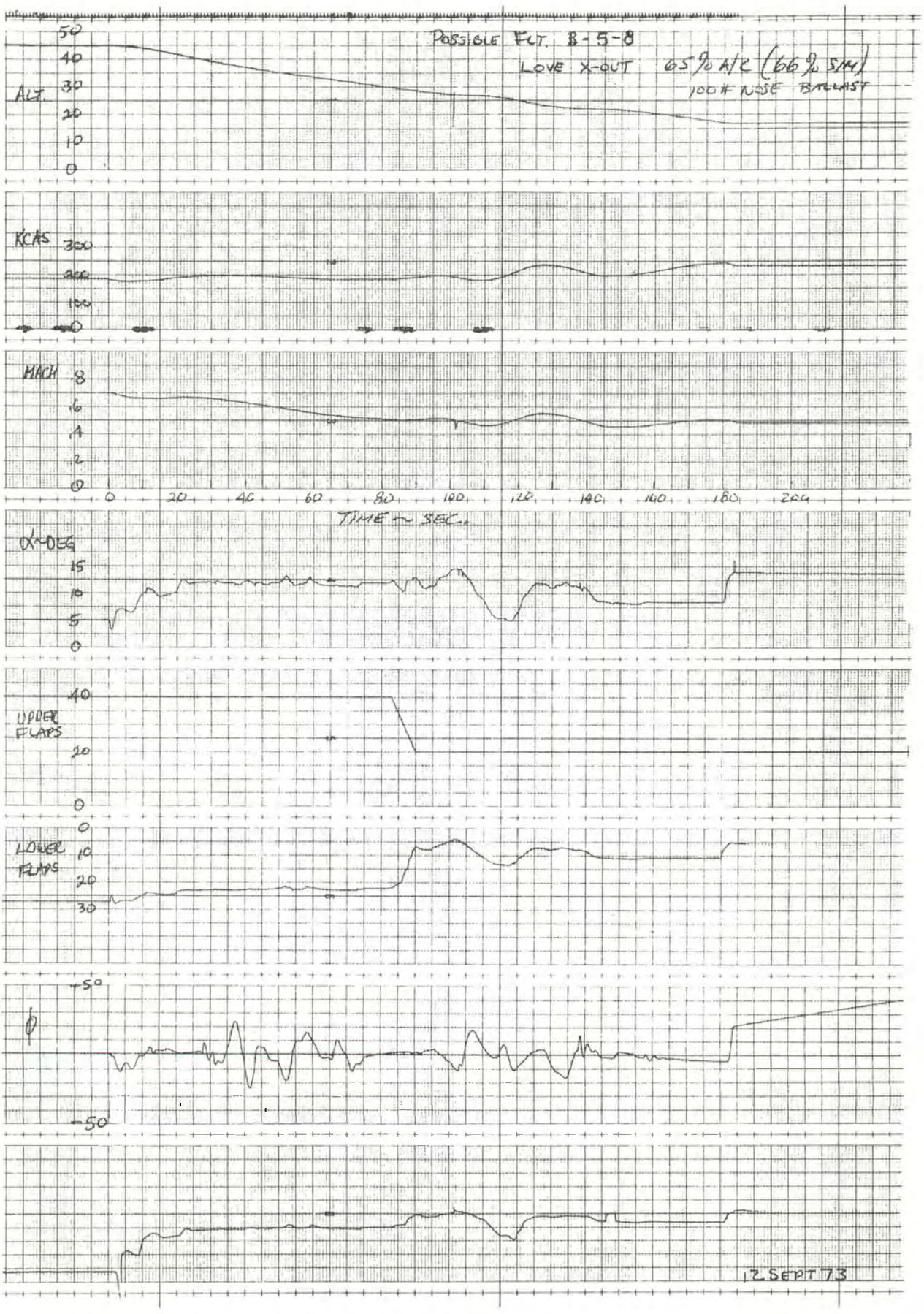
ALTERNATE SITUATIONS AFTER LAUNCH

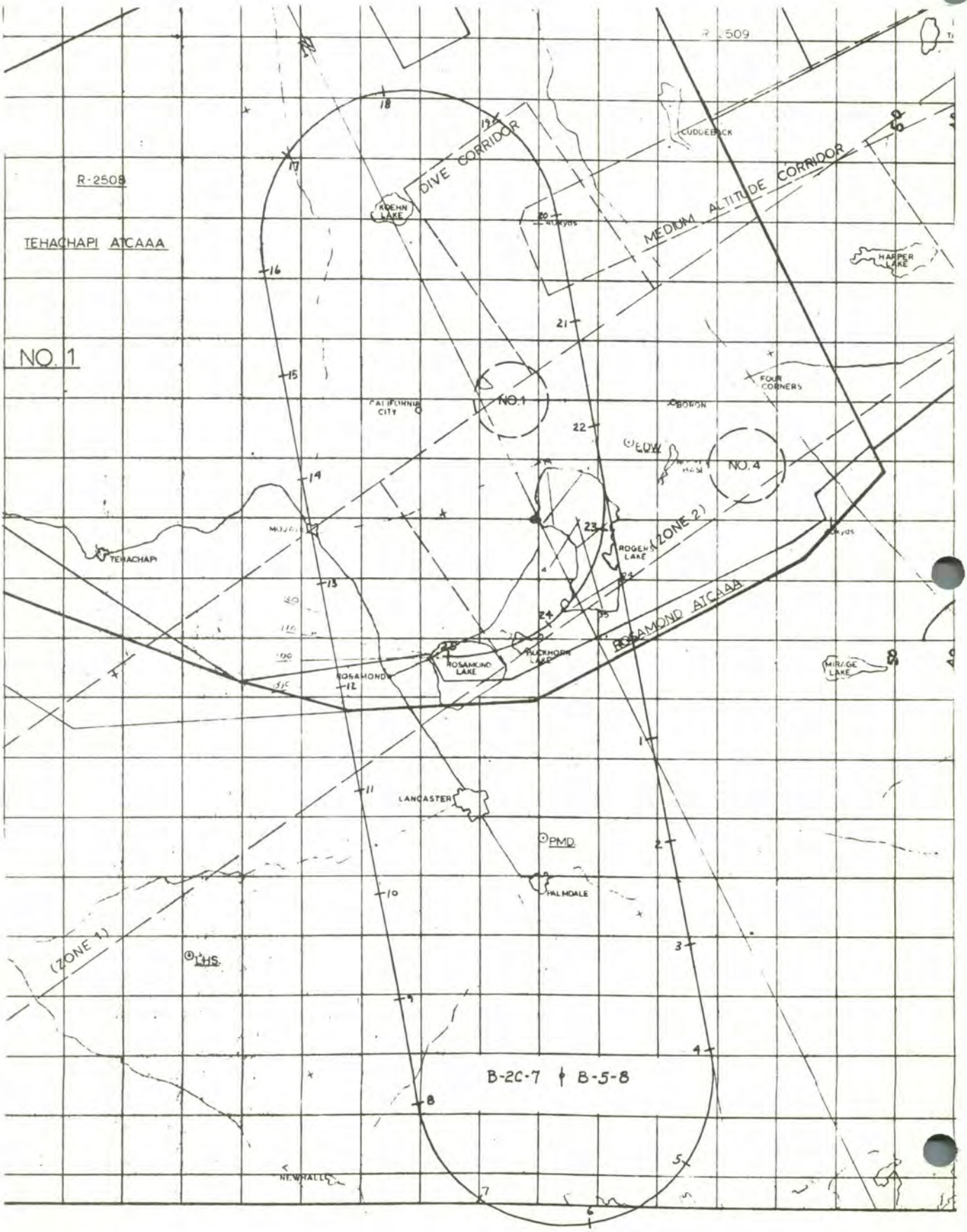
	Failure	Action
1.	Radio, Radar, PCM	Proceed as planned.
2.	Airspeed, Altitude	Proceed as planned using α for primary control. Altitude calls from NASA I. Airspeed and altitude calls from chase.
3.	Attitude System	Proceed as planned using backup attitude indicator and/or outside reference.
4.	Primary Angle of Attack Indicator Failure	KRA to "Manual" 10%, stick shaker "Off", proceed as planned using backup α indicator on ADI.
5.	Total Angle of Attack Failure	KRA to "Manual" 10%, stick shaker "Off". Fly 200 KIAS instead of α.
6.	KRA "AUTO" Failure	KRA to "Manual" 10%.
7.	Pitch Damper Failure	Proceed as planned limiting α to 12° during data maneuvers.
8.	Roll Damper Failure	Proceed as planned.

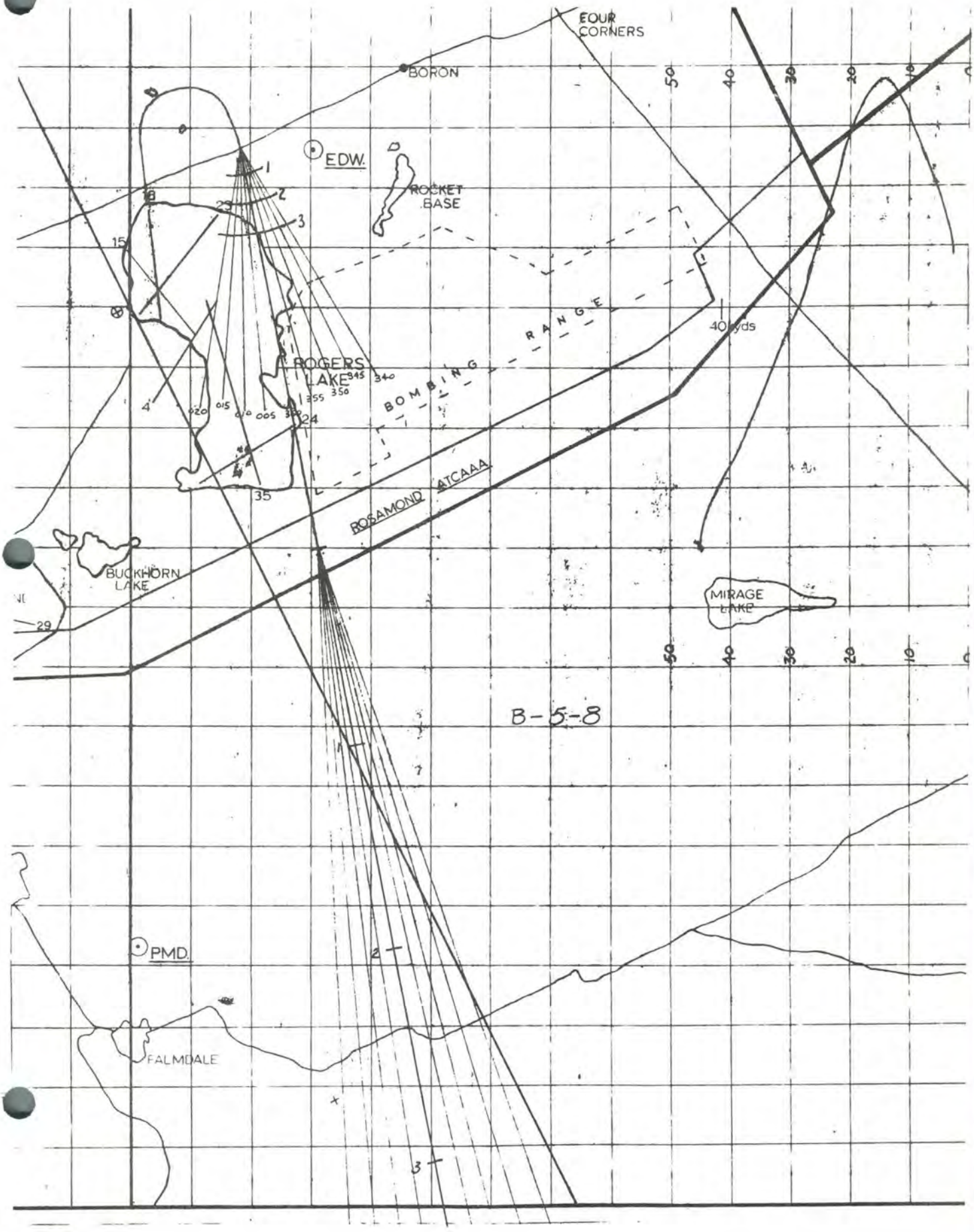
	Failure	Action
9.	Yaw Damper Failure	Proceed as planned, setting Mach repeater to .3.
10.	All Axis Damper Failure	Mach repeater to .3, limit α to 12°. Maneuvers and pulses at pilot's discretion.
11.	Limit Cycle	Reduce gain setting in steps to 1, if limit cycle still excessive--turn damper off.
12.	Upper Flaps Fail to Close	Land Runway 23, start flare at 4,500 feet MSL and use landing rockets.

Robert G. Hoey
ROBERT G. HOEY

W. L. Thompson for
JACK L. ROLF


POSSIBLE FLT. B-5-8
LOVE X-OUT 65% A/C (66⅔ S/M)
100# NOSE BALLAST
ALT.
50
40
30
20
10
0
KCAS
300
200
100
0
MACH
.8
.6
.4
.2
0
0
20
40
60
80
100
120
140
160
180
200
TIME — SEC.
α-DEG
15
10
5
0
UPPER FLAPS
40
20
0
LOWER FLAPS
0
10
20
30
θ
+5°
-50
12 SEPT 73


R-2508
TEHACHAPI ATCAAA
NO. 1
DIVE CORRIDOR
MEDIUM ALTITUDE CORRIDOR
R-2509
CUDDEBACK
KOEHN LAKE
HARPER LAKE
FOUR CORNERS
BORON
EDW
NO. 4
NO. 1
TEHACHAPI
ROGERS LAKE
(ZONE 2)
ROSAMOND ATCAAA
ROSAMOND LAKE
BUCKHORN LAKE
ROSAMOND
MIRAGE LAKE
LANCASTER
PMD
PALMDALE
(ZONE 1)
LHS
NEWHALL
B-2C-7 & B-5-8


FOUR CORNERS
BORON
EDW.
ROCKET BASE
ROGERS LAKE
BOMBING RANGE
40 yds
ROSAMOND
ATCAAA
BUCKHORN LAKE
MIRAGE LAKE
B-5-8
PMD.
PALMDALE

X-24B FLT. B-5-9 EVENTS

T.O.D.	MACH	ALT.	KCAS	EVENT	Δt
10:27:56.8	–	–	–	LAUNCH	0.0
57.2	.700	45286	185	MAX MACH TAS = 678 FPS	0.4
28: 3.1	.667	44926	177	FIRST PILOT INPUT AFTER LAUNCH	6.3
3.9	.668	44839	178	START PULL UP TO 10°α (11°α_{AUG})	7.1
12.3	.657	43389	180	START PULLUP TO 12°α (13°α_{AUG})	15.5
27.9	.612	40208	180	RUDDER DOUBLET α_{AVG} = 13°	31.1
32.2	.611	39323	184	AILERON DOUBLET α_{AVG} = 13°	35.4
34.4	.611	38881	185	START AILERON ROLL EVAL α_{AVG} = 13°	37.6
49.0	.576	36070	186	START AILERON + RUDDER ROLL EVAL α_{AVG} = 13°	52.2
53.7	.573	35208	189	START RUDDER ONLY ROLL EVAL α_{AVG}=13°	56.[illegible]
29: 7.0	.536	32800	186	END RUDDER ROLL EVALUATION	70.2
22.4	.508	30223	187	START CONFIG CHANGE α = 12° ± .5°	85.6
29.9	.508	29080	191	END CONFIG. CHANGE δ_{SB} = -20°	93.1
33.7	.513	28534	196	MACH REPEATER TO .3	96.9
34.0	.514	28490	196	START PULLUP PUSHOVER	97.2
43.0	.493	27553	191	AT MAX α (α = 15°+)	106.2
53.0	.461	27071	181	AT MIN α α = 6°	116.2
30: 1.7	.501	25603	203	MACH REPEATER TO 1.0	124.9
2.0	.502	25559	204	RETURN TO 12°α	125.2
20.3	.501	23252	214	ROCKET CHECK	143.5
27.3	.505	22419	219	ROLL FOR POSITION CHECK	150.5

TOD	MACH	ALT.	KCAS	EVENT	Δt
10:30:37.2	.490	21398	217	START TURN	160.4
:31:25.6	.548	12025	293	SPEED BRAKES START OUT ($\delta_{SB_{MAX}}$ = 29°)	208.8
:34.7	.532	9730	297	δ_{SB} BACK TO 26°	217.9
:37.3	.525	9088	296	RUDDER DOUBLET α = 6°	220.5
:39.4	.518	8599	294	PITCH PULSE α = 6°	222.6
:46.9	.500	6896	293	δ_{SB} BACK TO 20°	230.1
:50.0	.492	6192	295	MACH REPEATER TO .3	233.2
:52.2	.492	5727	294	≈ LEVEL ON FINAL	235.4
32:3.0	.485	3595	301	FLARE	246.2
:24.0	.379	2159	242	GEAR DOWN	267.2
:35.8	.272	2098	173	MAIN GEAR TOUCH DOWN α = 12°	279.0
:37.9	.256	2112	163	NOSE GEAR TOUCHDOWN	281.1
:45.1	.198	2111	126	"BUMP"	288.3

FLIGHT TIME = 279.0 SEC (:04:39.0)

LAUNCH DYNAMICS

By

D. Richardson

The launch on flight five was a "hands-off" launch. There were no pilot inputs until 6.3 seconds after launch. This allowed for a comparison between the actual and the predicted launch dynamics without any pilot control inputs. In the longitudinal axis the comparison is good. In the lateral axis the initial magnitudes of the predicted rates and angles are not correct; however, a comparison between the actual and predicted maximum values of bank angle and roll rate are good.

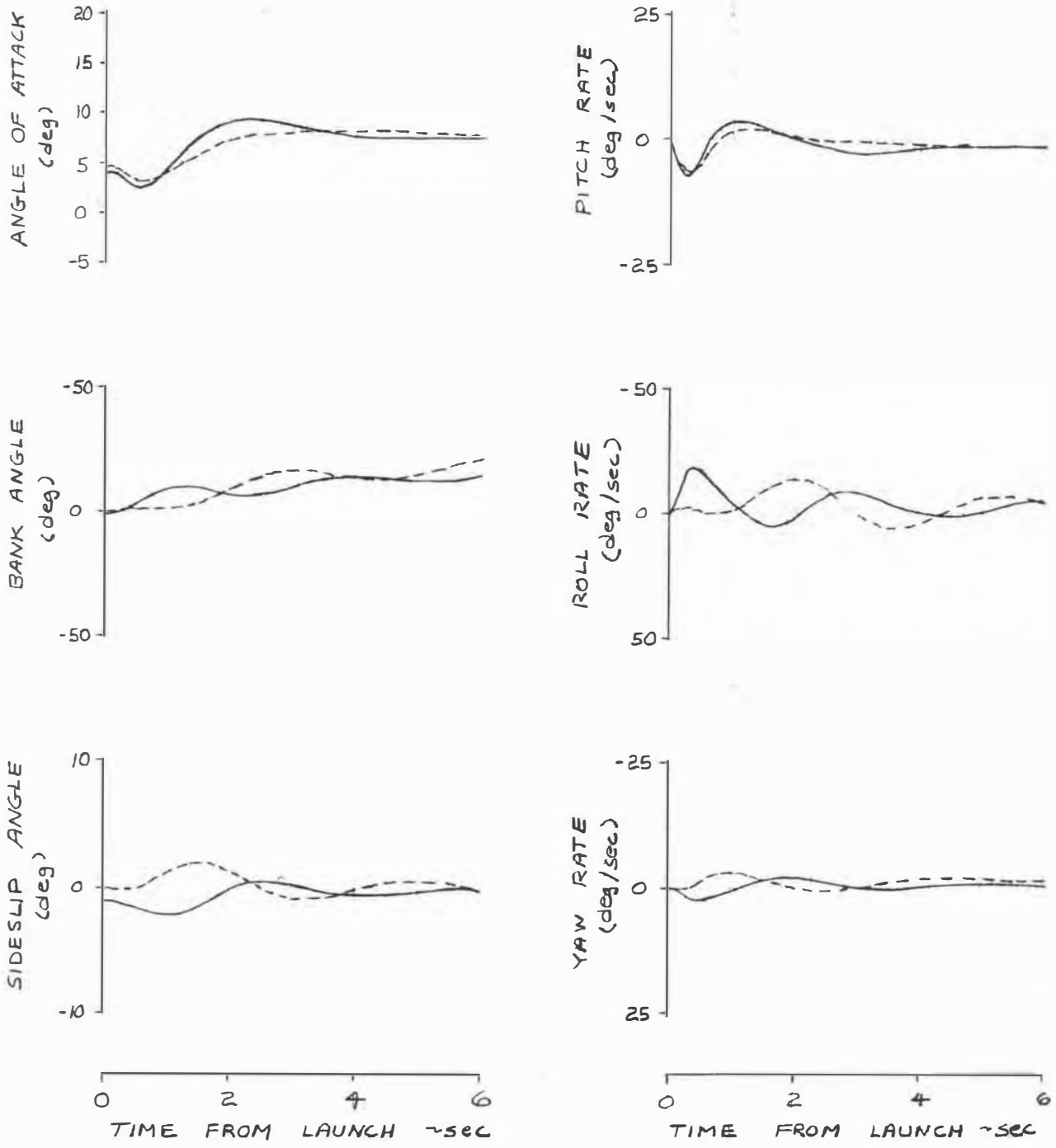
LAUNCH DYNAMICS

——— Flight B-5-9

- - - - - Simulator

$\delta u_B = -40$ $\delta e_L = 26.7$
$\delta R_B = 0°$ $\delta A_B = 7°$
$\delta r_{trim} = +.5$

WT = 8154 lbs CG = 65.06%
SAS "ON"
NO PILOT INPUTS



PERFORMANCE

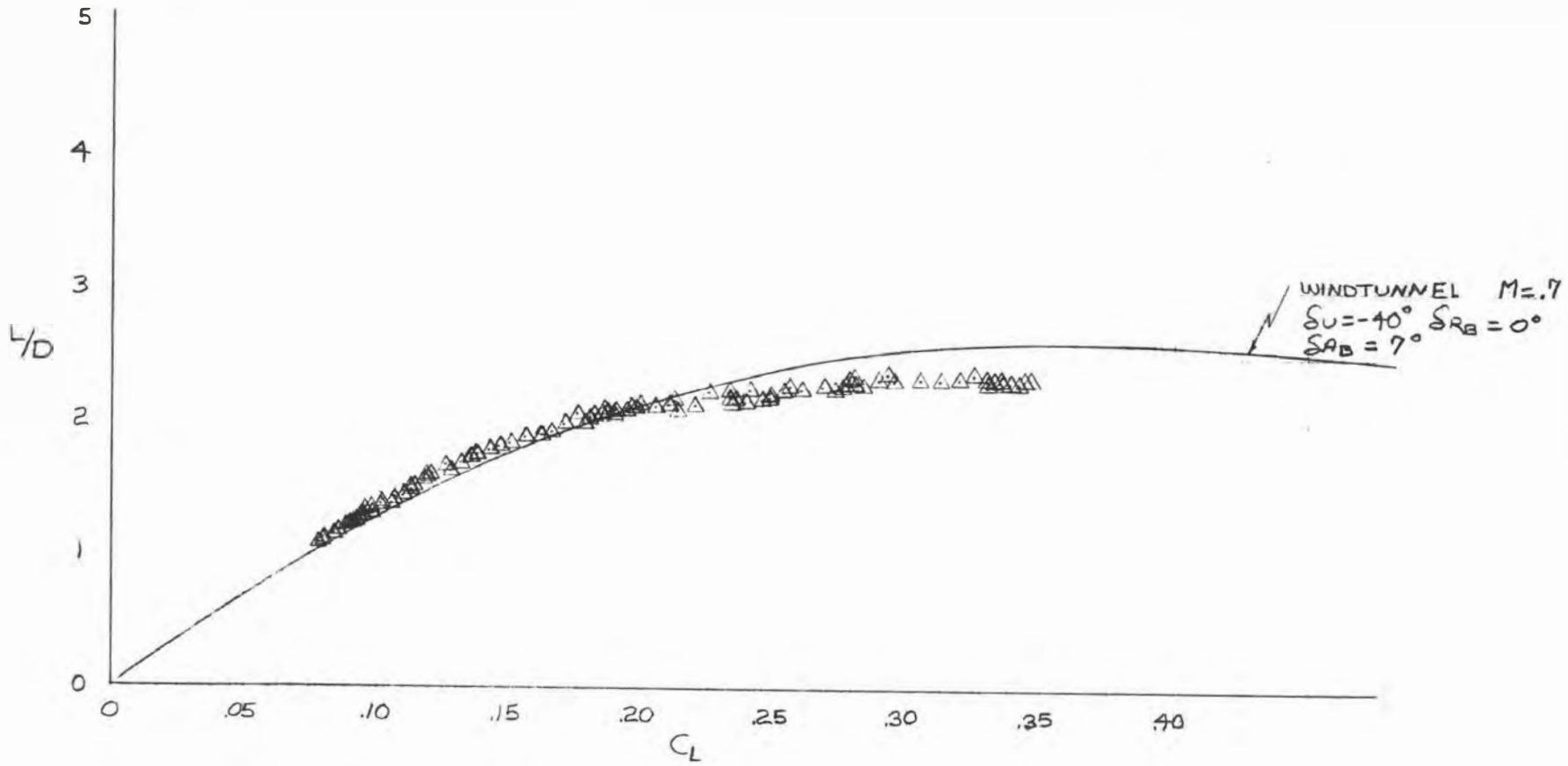
By

D. Richardson

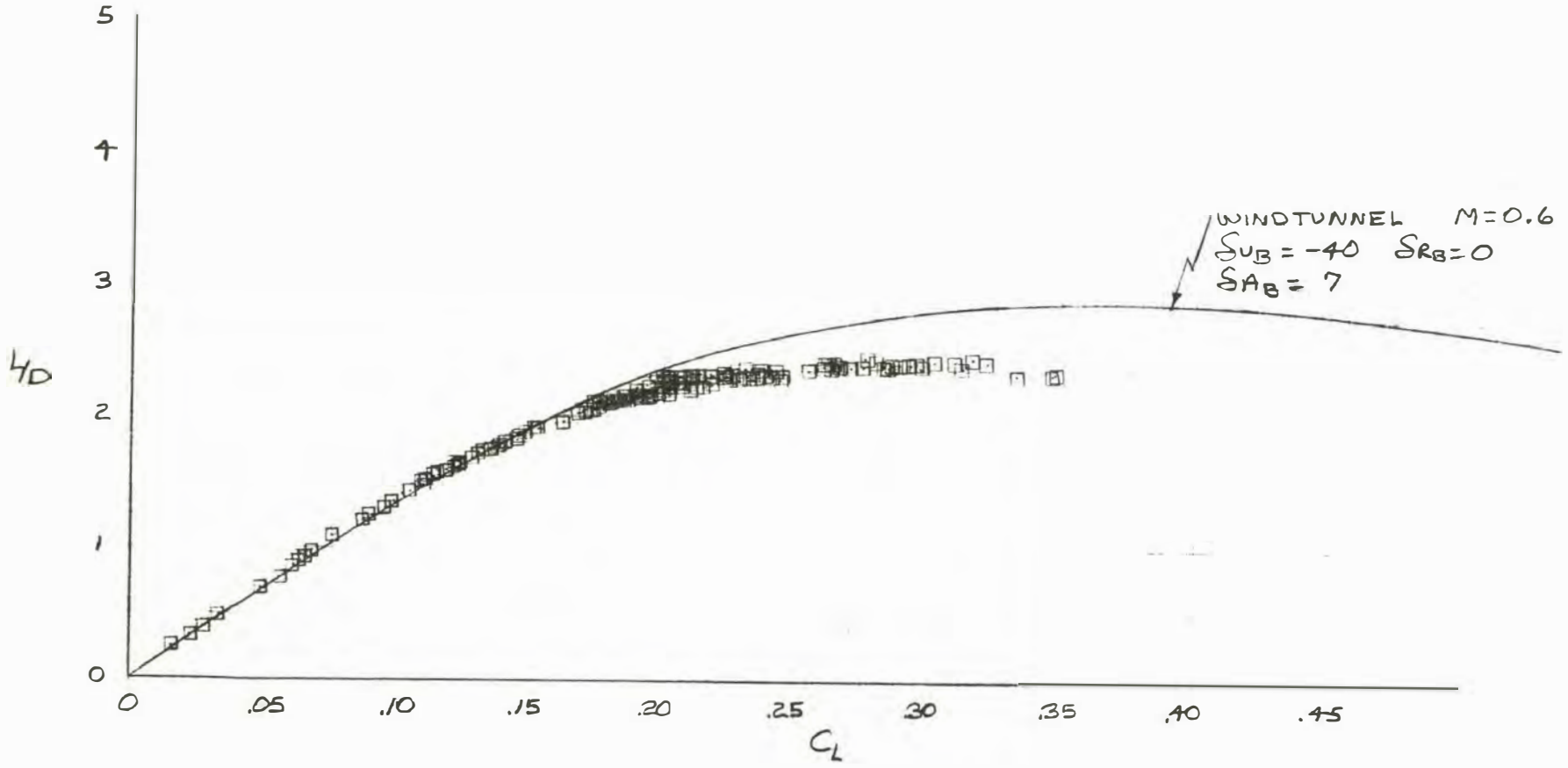
A summary of the L/D data obtained during the first five glide flights is summarized as background information for the first powered flight. The reduction in L/D above $C_L = 0.2$ ($\alpha = 12°$) is apparent; however, this data is considered preliminary until the discrepancies in the angle of attack calibration are resolved (refer to section entitled Simulator Update). The maximum L/D in the transonic configuration ($\delta U_B = -40°$, $\delta R_B = 0°$) is approximately 2.5. The maximum L/D in the subsonic configuration ($\delta U_B = -20°$, $\delta R_B = -10°$) with the landing gear retracted and extended is 4.2 and 3.4 respectively, noting that the gear down value is with ground effect. The L/D during the landing approach (gear up) is 2.6 and 2.9 depending on the approach airspeed. The flightpath angle during approach is -21 to -19 degrees.

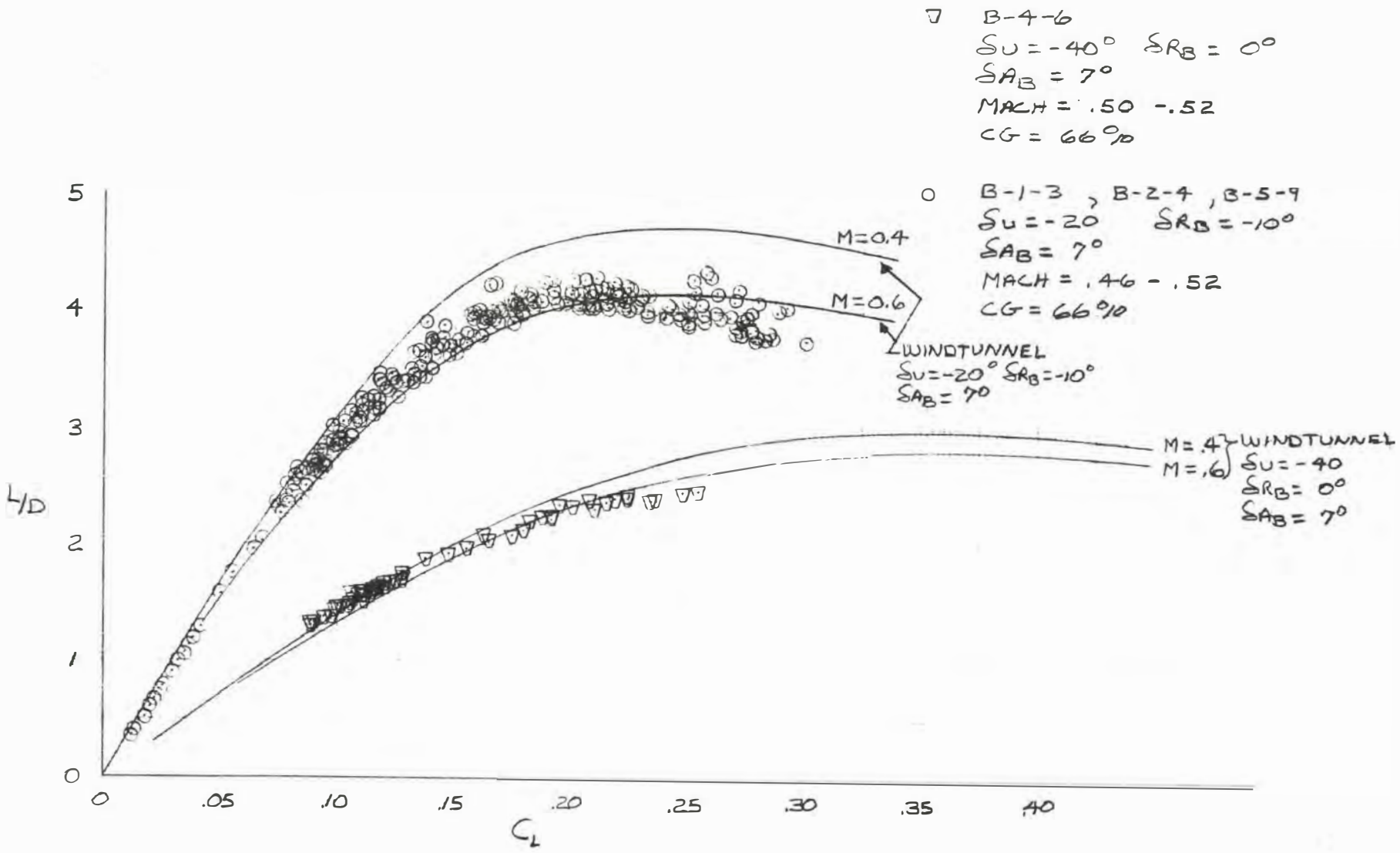
When the configuration is changed such that the lower flaps are closed completely and pitch control is maintained by using the upper flaps ($\delta e_L = 0°$, $\delta U_B = -13°$), the approach L/D is increased by 0.3. However, this configuration would necessitate that the landing approach be flown in or near the deadband which exists in the region where pitch control crosses over from the upper flaps to the lower flaps or vice versa. Precise flightpath control while flying in the crossover region would be difficult. This fact outweighs any benefits gained by the increased approach L/D, therefore the standard approach configuration will be with the upper flaps fixed at -20 degrees so that pitch control will be maintained by the lower flaps during the entire approach and landing.

△ B-3-5 , B-4-6
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = .67 - .73
CG = 66%



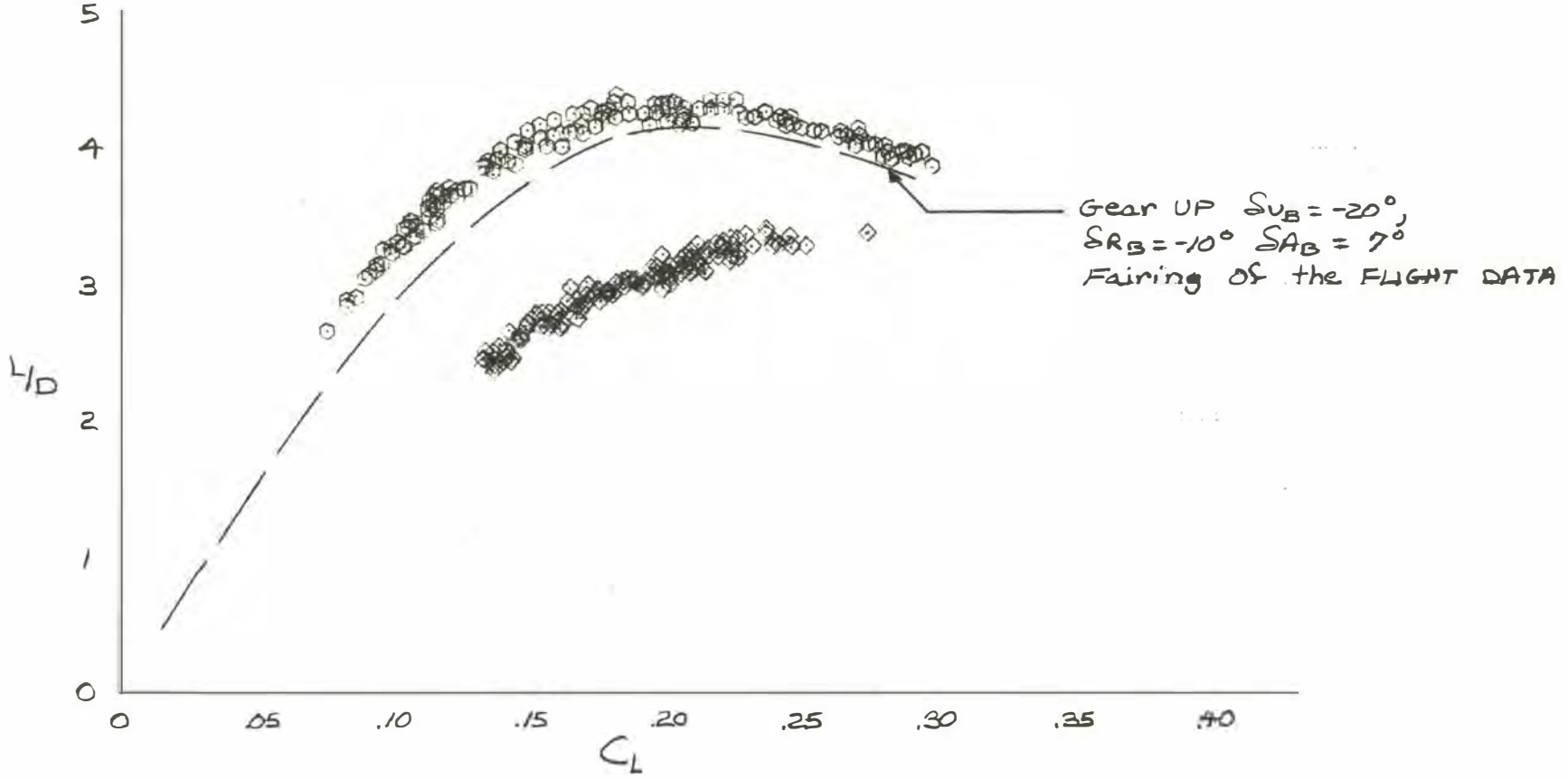
□ B-2-4, B-4-6, B-5-9
$\delta_{UB} = -40°$ $\delta_{RB} = 0°$
$\delta_{AB} = 7°$
MACH = .59 - .66
CG = 66%




▽ B-4-6
$\delta_U = -40°$ $\delta_{R_B} = 0°$
$\delta A_B = 7°$
MACH = .50 -.52
CG = 66%
○ B-1-3 , B-2-4 , B-5-9
$\delta_U = -20$ $\delta_{R_B} = -10°$
$\delta A_B = 7°$
MACH = .46 - .52
CG = 66%
M=0.4
M=0.6
WINDTUNNEL
$\delta_U = -20°$ $\delta_{R_B} = -10°$
$\delta A_B = 7°$
M=.4
M=.6
WINDTUNNEL
$\delta_U = -40$
$\delta_{R_B} = 0°$
$\delta A_B = 7°$
L/D
C_L
0
1
2
3
4
5
0
.05
.10
.15
.20
.25
.30
.35
.40

○ Gear UP
$\delta e_L = 0$ δe_U = var.
$\delta R_B = -10°$ $\delta A_B = 7°$
MACH = .48 - .53
CG = 66%

◇ Gear Down
B-1-3, B-2-4, B-3-5, B-4-6, B-5-9
$\delta U = -20°$ $\delta R_B = -10°$
$\delta A_B = 7°$
MACH = .27 - .37
CG = 66%



SIMULATOR UPDATE

By

D. Richardson

Based on the flight data the six-degree-of-freedom hybrid simulator was updated to reflect changes between the actual and the predicted data. Update to certain aileron, rudder and damping derivatives was based on data obtained from analog matching and Newton-Raphson matching of flight longitudinal and lateral-directional pulses.

Updates to the performance and longitudinal trim were based on the flight data obtained from pushover-pullup maneuvers. The longitudinal data was updated by adding an incremental change in C_{m_α} to the "old" simulator values of C_m to give the correct trim α as a function of lower flap.

A discrepancy has been noted on all flights between the pilot's indicated angle of attack and the telemetry angle of attack which is used in all aerodynamic calculations. Both values of α come from the same α-vane; however, the pilot's α indicator has consistently shown lower values of α whenever $\alpha > 12$ degrees. The calibration of the telemetered α is nonlinear above $\alpha = 12$ degrees and it has since been shown that this nonlinear region is sensitive to temperature however, it was not of sufficient magnitude to account fully for the errors seen in flight. The pilot's indicator is within the environment of the cockpit and therefore not subject to extreme temperature changes. The cockpit indicator was subject to a "g" test which revealed that it is not sensitive to "g" load. Therefore at this point in time the pilot's indicator is assumed to be giving correct values of α. Based on pilot call out of α at several points during the flights, a calibration of pilot's $\alpha_{cockpit}$ versus telemetry α was obtained. This data was supplemented by the fact that the stick shaker is activated at $\alpha = 16$ degrees by a signal from the cockpit α indicator. The resulting α calibration was included in the simulator update since all of the simulator aerodynamic data was based on the telemetry α .

SIMULATOR UPDATE

$C_{l_{\delta a}}$ - INCREASED BY .0001/deg ($\simeq$ 15%)

$C_{n_{\delta a}}$ - DECREASED BY .0001/deg ($\simeq$ 20%)

$C_{l_{\delta r}}$ - DECREASED BY .0001/deg ($\simeq$ 25%)

C_{l_p} - DOUBLED

C_{m_q} - DECREASED BY 25%

C_N - Increment of C_N as a function of α is added to the "old" simulator value of $C_{N_{trim}}$.

C_c - Increment of C_c as a function of α is added to the "old" simulator calculation of $C_{c_{trim}}$.

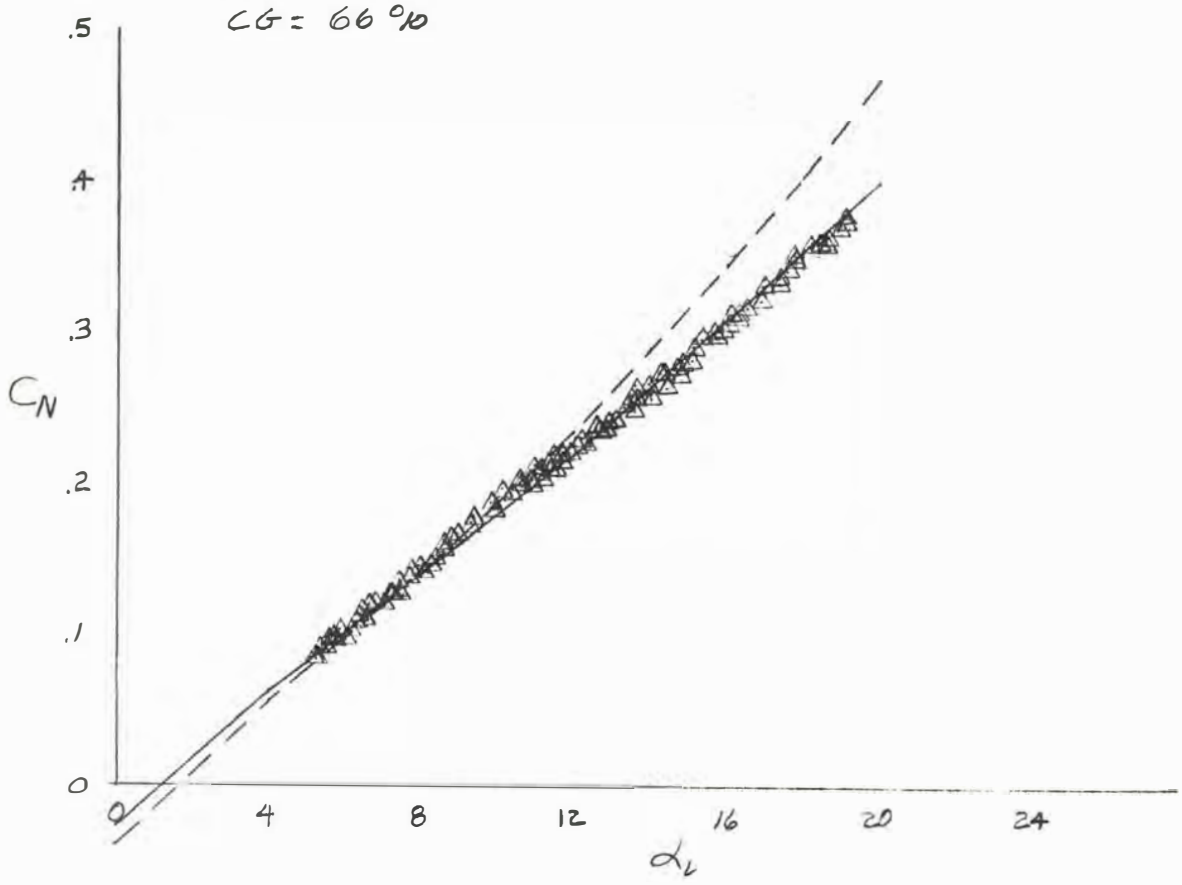
C_m - Increment of $C_m = .0004\ (\alpha-7)$ is added to C_m to give the correct trim α as function of lower flap.

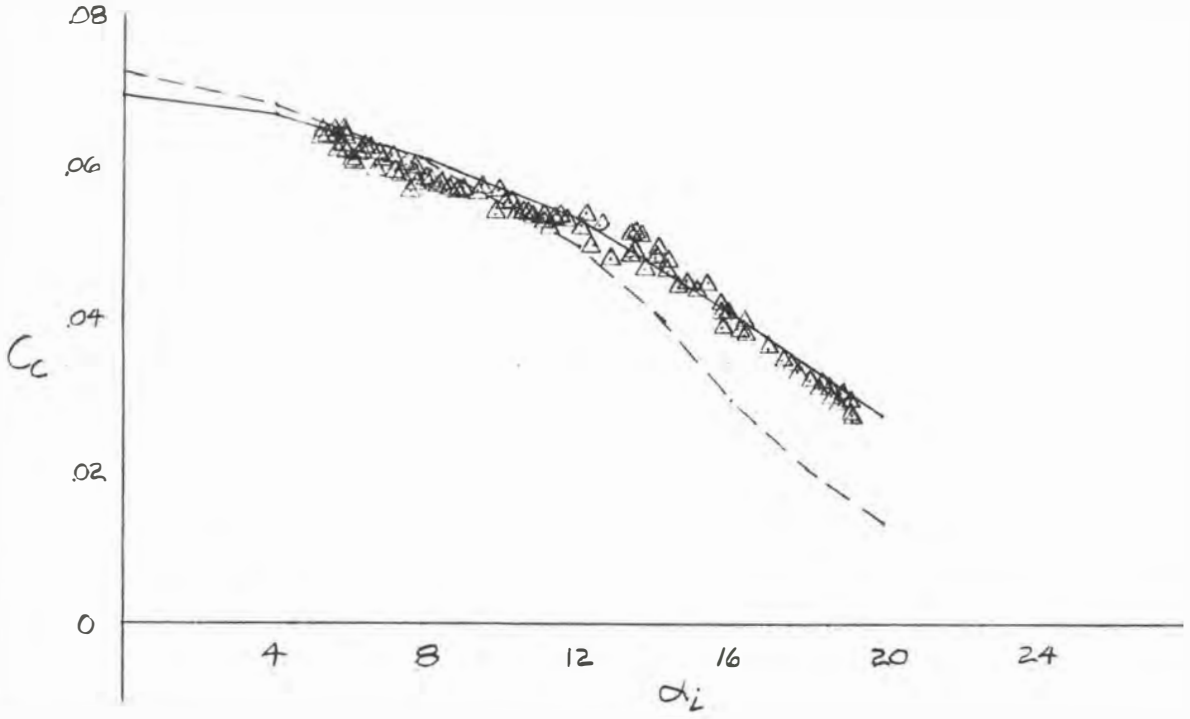
α - An α calibration to reflect the differences between the indicated α as read by the pilot and the telemetry α which is used in all aerodynamic calculations.

Simulator Update

△ B-3-5, B-4-6
$\delta_U = -40°$ $\delta_{R_B} = 0°$
$\delta_{A_B} = 7°$
MACH = .67 - .73
CG = 66 %

——— New Simulator
– – – – OLD Simulator



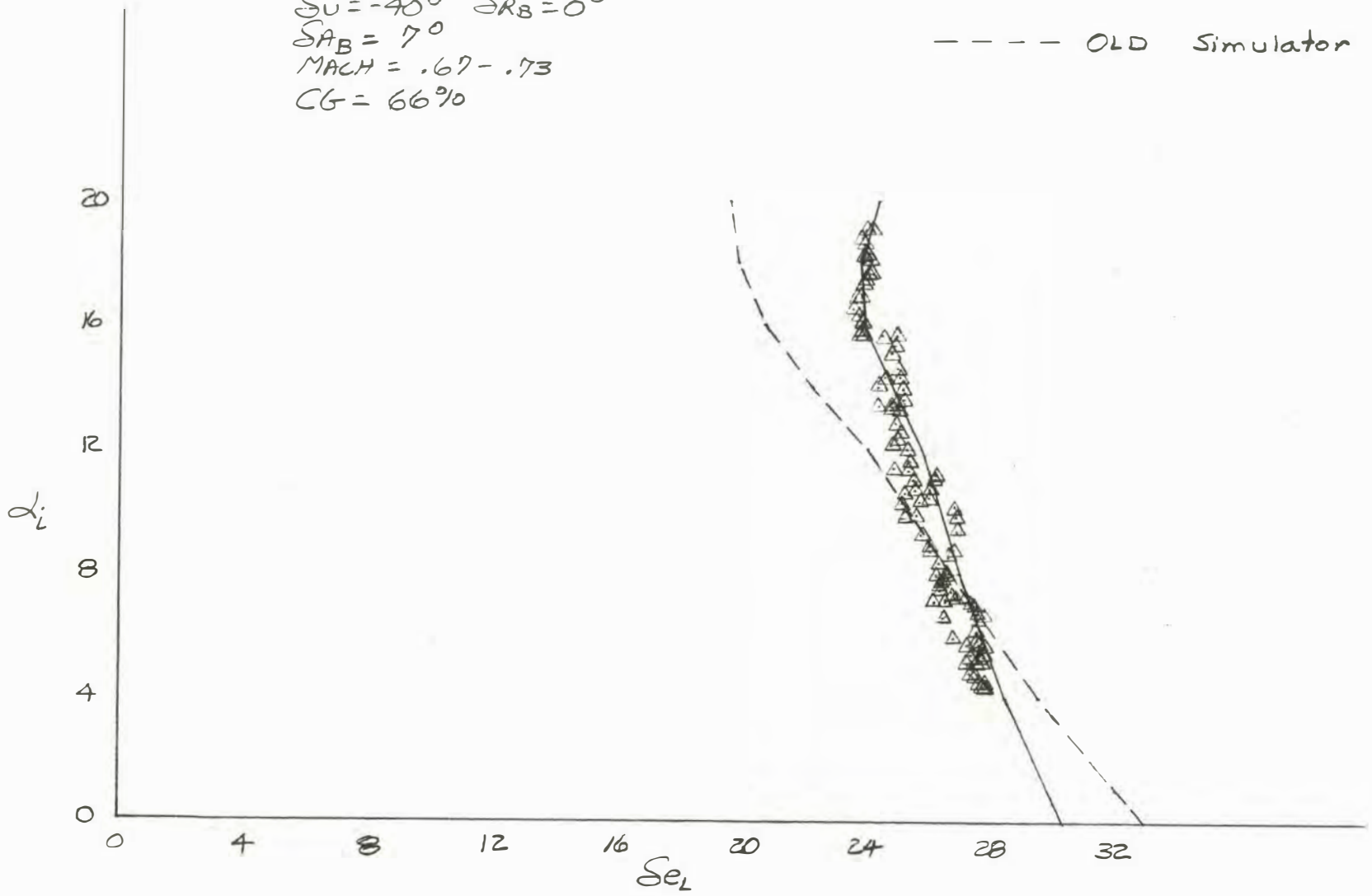


Simulator Update

△ B-3-5, B-4-6
$\delta_U = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = .67 - .73
CG = 66%

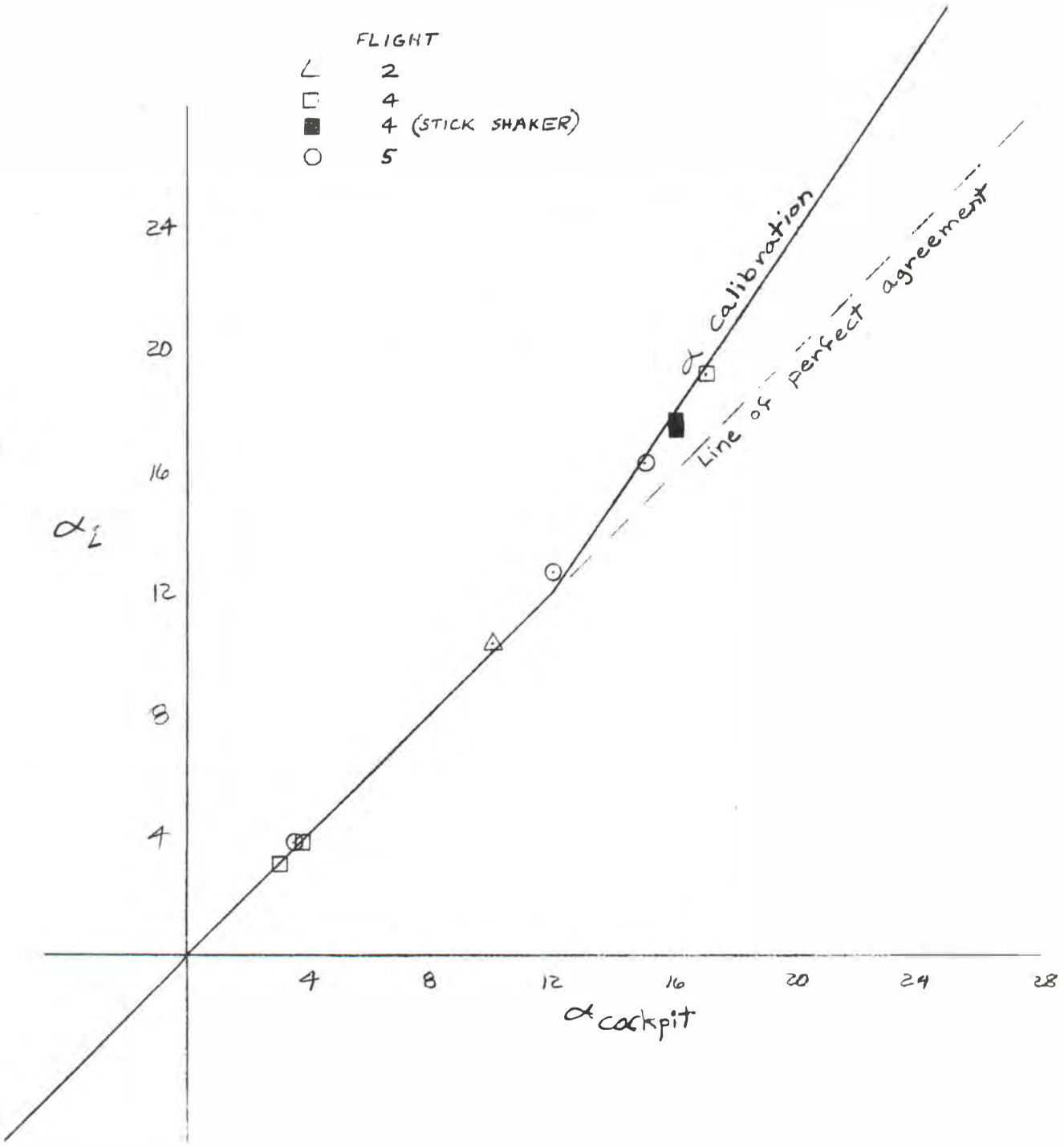
——— NEW Simulator

– – – – OLD Simulator



Simulator Update

α calibration



FLIGHT B-5-9 HANDLING QUALITIES SUMMARY
PILOT: MAJ LOVE

EVENT	PILOT RATING
ACQUIRING 10°α AFTER LAUNCH (±.5°)	3
HQ WITH 40° UPPER FLAPS	
OVERALL (INCLUDING PITCH)	3
ROLL TASK WITH AILERON	2
ROLL TASK WITH RUDDER ONLY	2
ROLL TASK WITH TOO MUCH RUDDER	2½
CONFIGURATION CHANGE	2
HQ WITH 20° UPPER FLAPS TO LOW KEY	2
TURNING FINAL	2½
FINAL	2
FLARE	2
LANDING	2

STABILITY DERIVATIVES

By

P. Kirsten

A summary of the flight-derived stability derivatives obtained through flight B-4-6 was presented in "Preliminary Results of X-24B--Flight B-4-6". Derivatives presented in that report are shown again in this report along with derivatives obtained from three lateral-directional maneuvers analyzed on flight B-5-9. Results obtained from flight B-5-9 are very consistent with previous results. In particular, data obtained from a small rudder pulse in the final approach (δ_U = -20°, $\bar{q}$ = 290, α = 6°) agree well with previous flight results and wind tunnel data. Two maneuvers in the transonic configuration (δ_U = -40°) were analyzed. The planned rudder and aileron doublet maneuver at α = 13.3° was analyzed by both the AFFTC hybrid matching program and the NASA Newton-Raphson program. For the first time, results of the two programs differed significantly. The differences occurred in the sideslip and aileron derivatives; rudder derivatives were very similar. A roll maneuver which was performed shortly after the rudder-aileron doublet and at similar flight conditions (Mach and α) was also analyzed through the Newton-Raphson program. The results obtained from this maneuver agreed well with the hybrid matching results of the doublet maneuver.

FIGURE 1

X-24B
SUBSONIC CONF.
$\delta_u = -20°$, $\delta_{r_B} = -10°$
CG = .65 $\bar{c}$

— M = 0.4
– – – M = 0.6 } WIND TUNNEL
—·— M = 0.7
○ $M_\infty \approx 0.45$
□ $M_\infty \approx 0.50$
◇ $M_\infty \approx 0.55$ } FLIGHT
△ $M_\infty \approx 0.60$
⬡ $M_\infty \approx 0.65$

OPEN ~ DIGITAL
SOLID ~ HYBRID

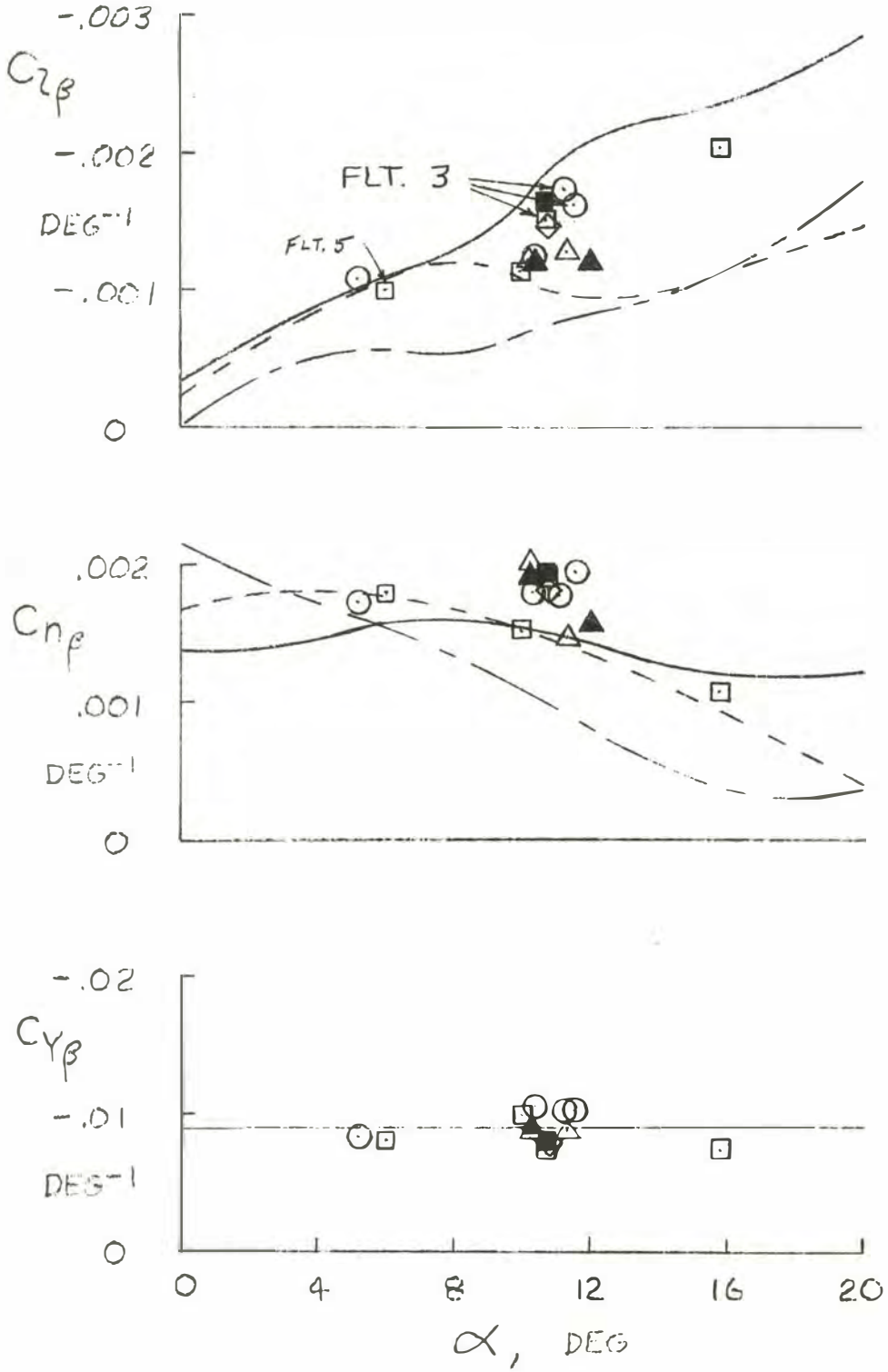


FIGURE 1, CONT.

X-24B
SUBSONIC CONF.

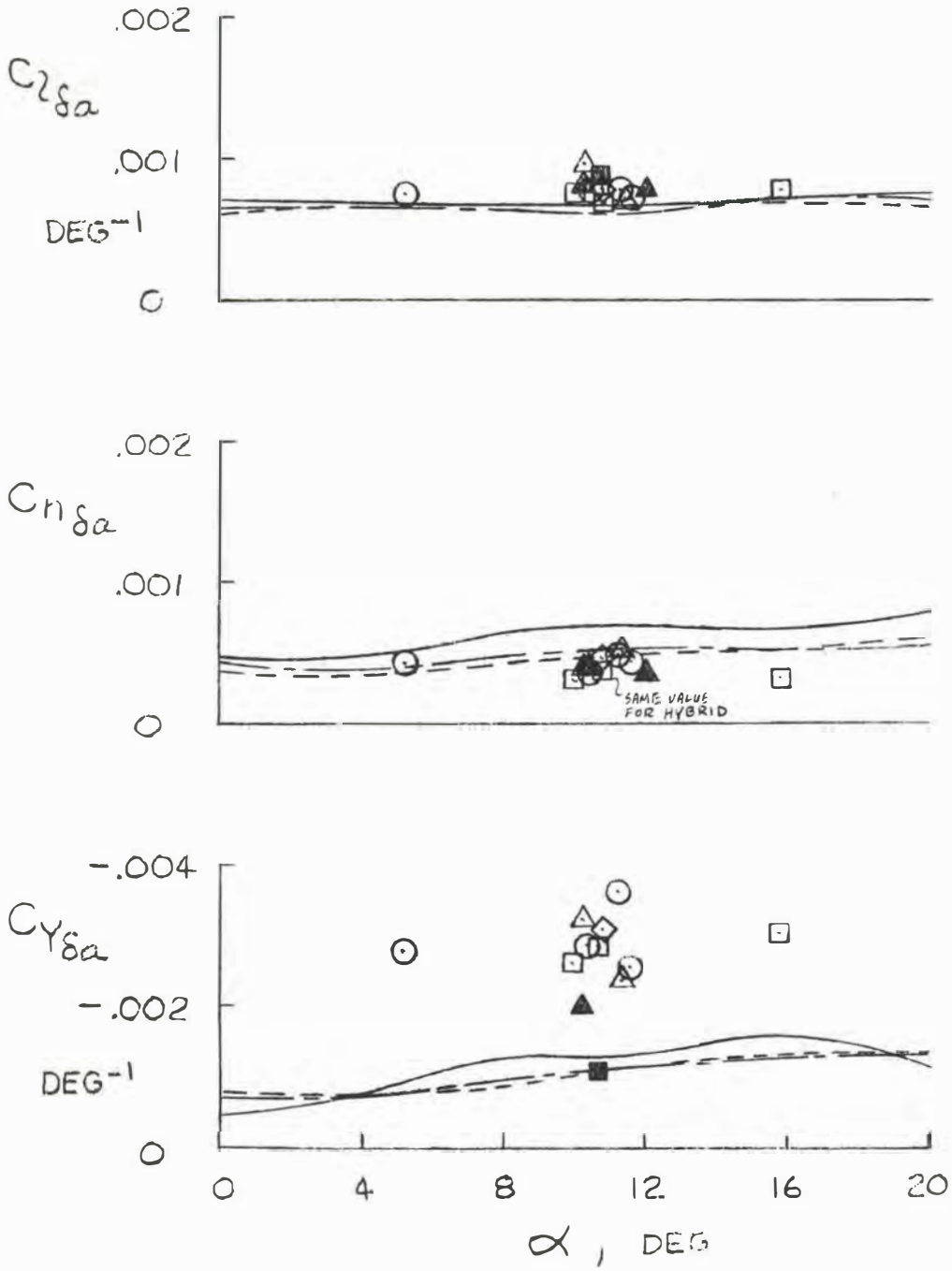


FIGURE 1, CONT.

X-24B
SUBSONIC CONF.

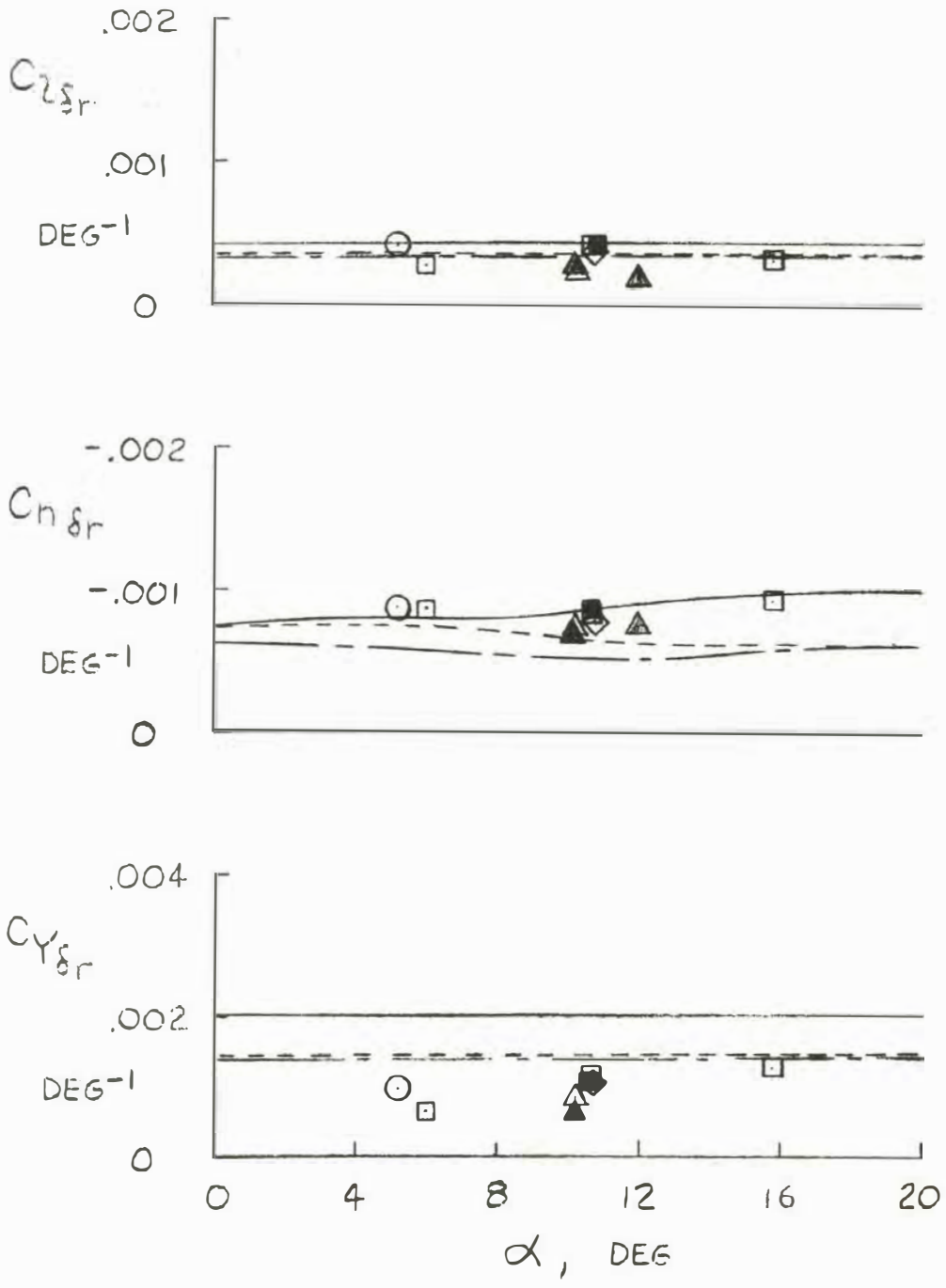


FIGURE 1, CONCLUDED —— ESTIMATE

X-24B
SUBSONIC CONF

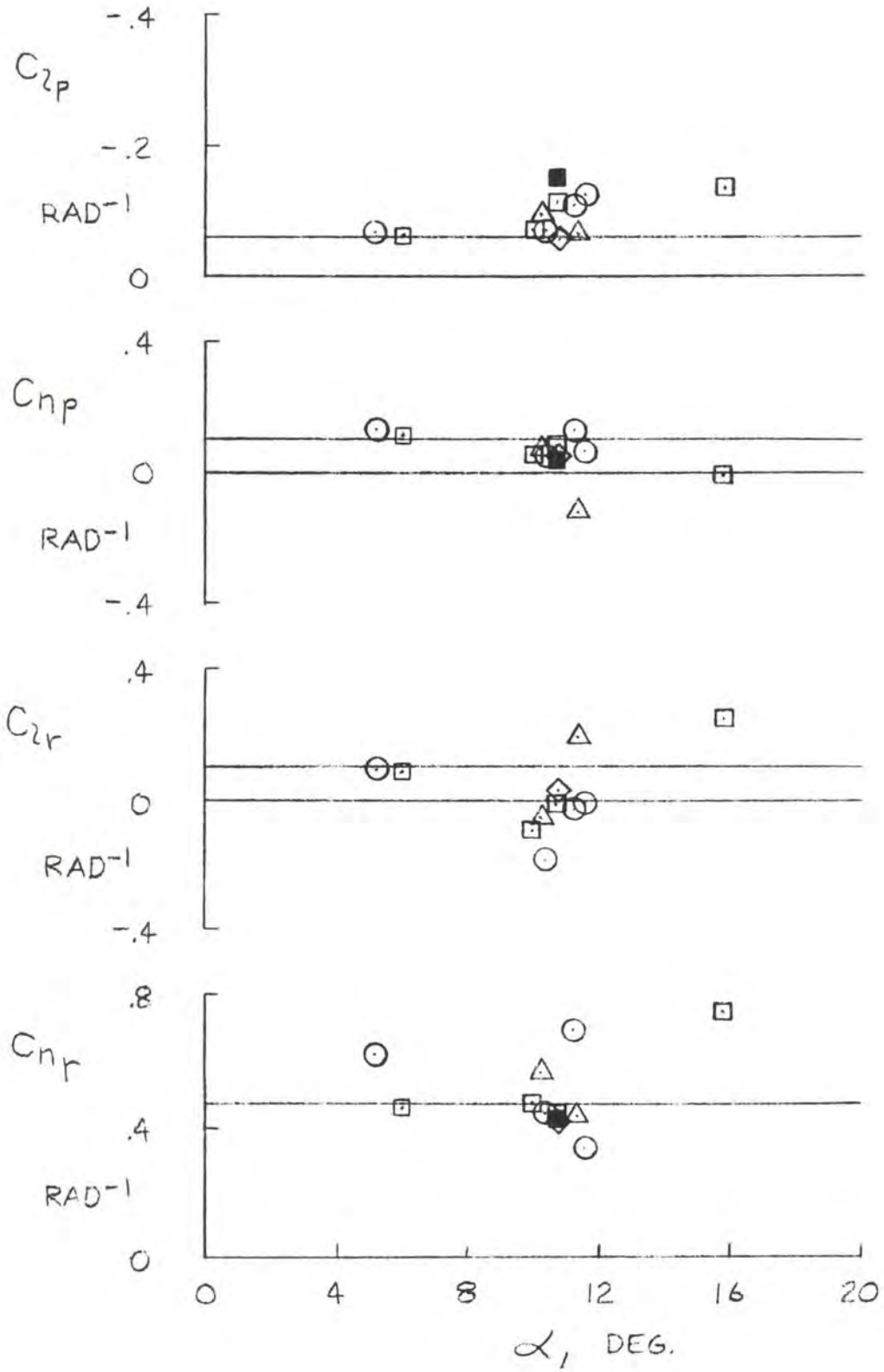


FIGURE 2

X-24B
TRANSONIC CONF.
$\delta_U = -40$, $\delta r_B = 0°$
CG = .65 $\bar{c}$

---- M=0.6 } WIND TUNNEL
—·— M=0.7 }

FLIGHT:

SYM	FLT	M_∞	COMMENT
○	3	.675	FAIR MATCH
□	2	.63	POOR MATCH
●	3	.675	GOOD MATCH
△	5	.61	δr, δa
◇	5	.58	ROLL MANUEVER

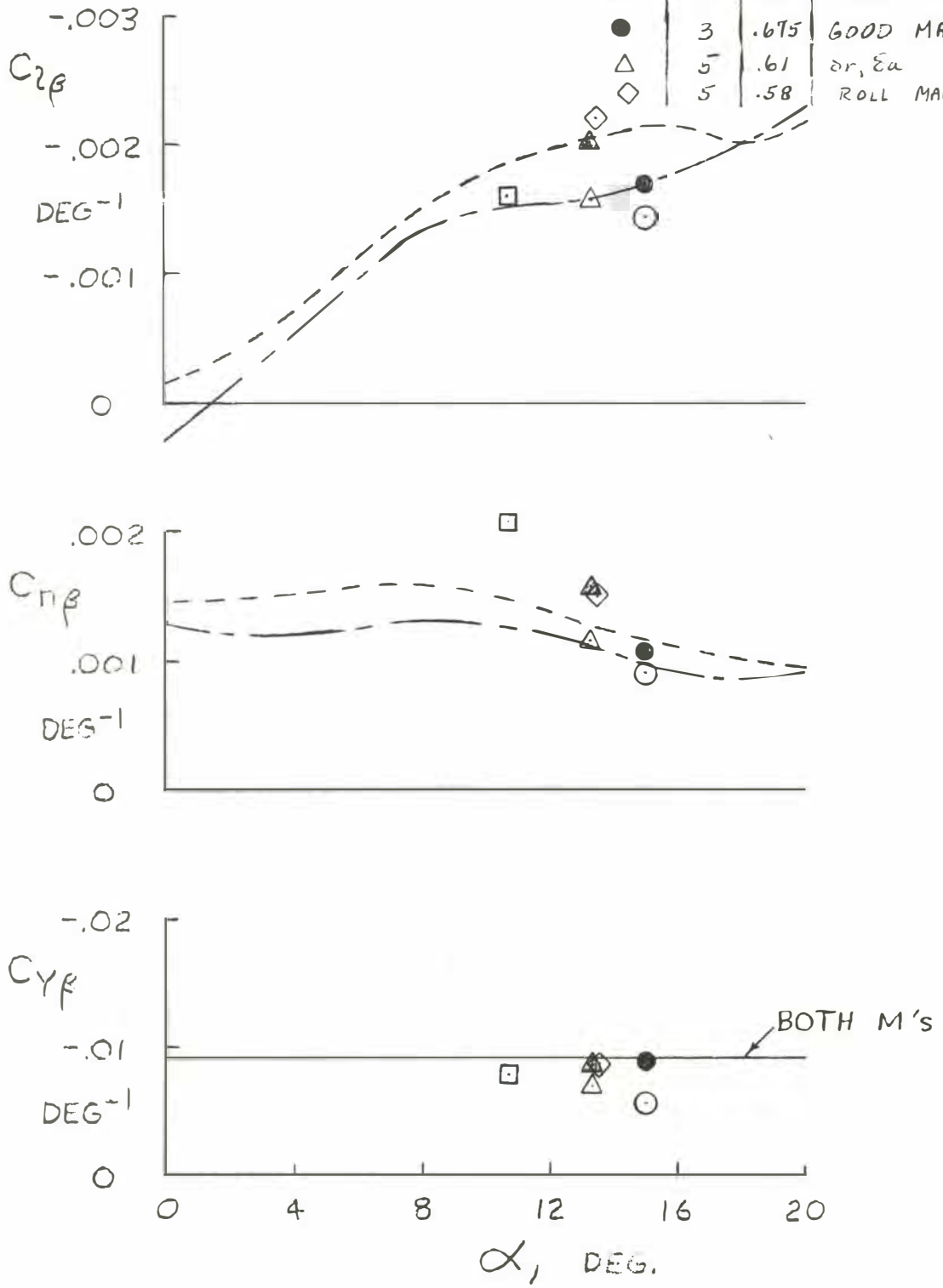


FIGURE 2, CONT

X-24B
TRANSONIC CONF.

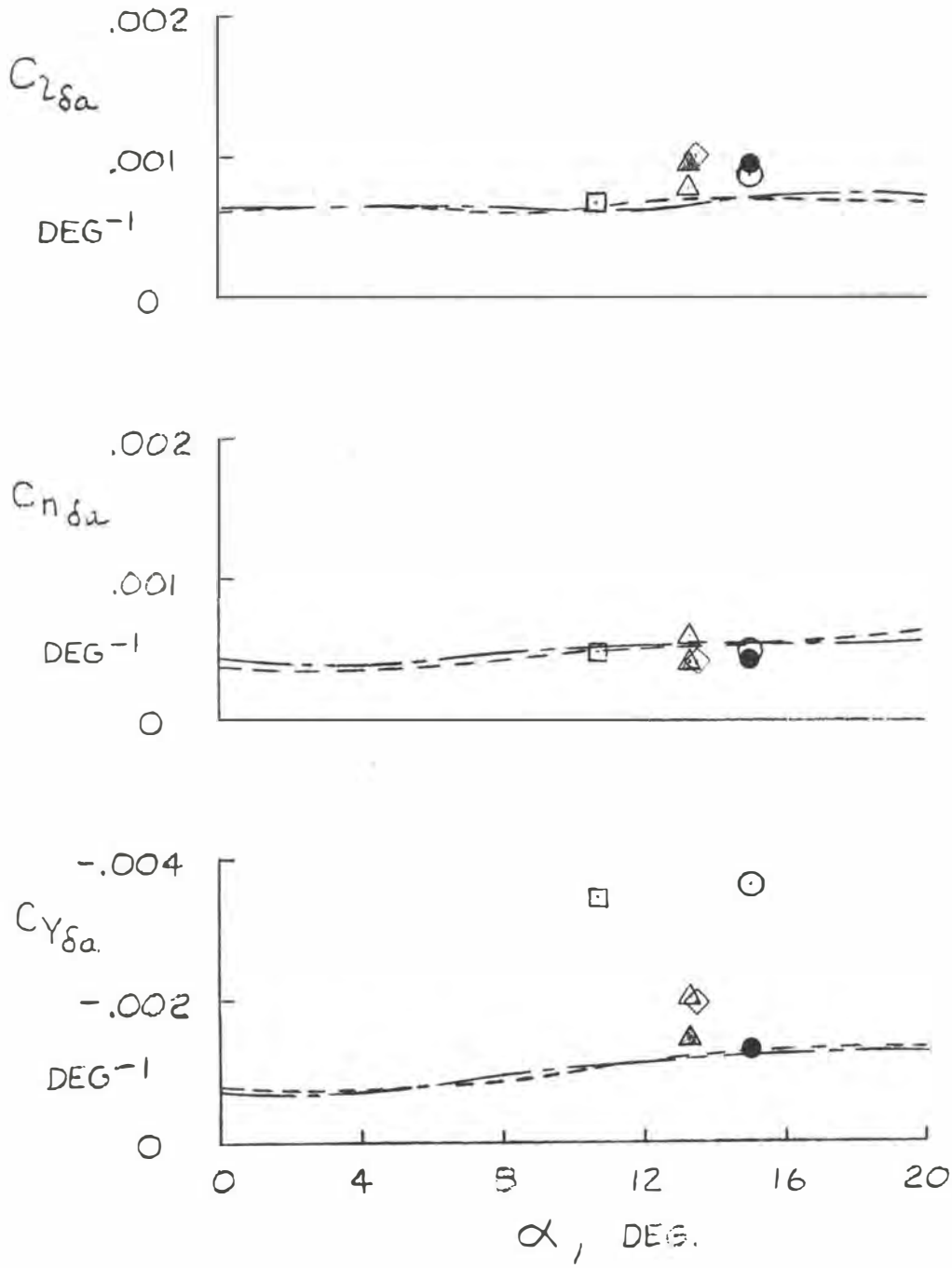


FIGURE 2, CONT.

X-24B
TRANSONIC CONF.

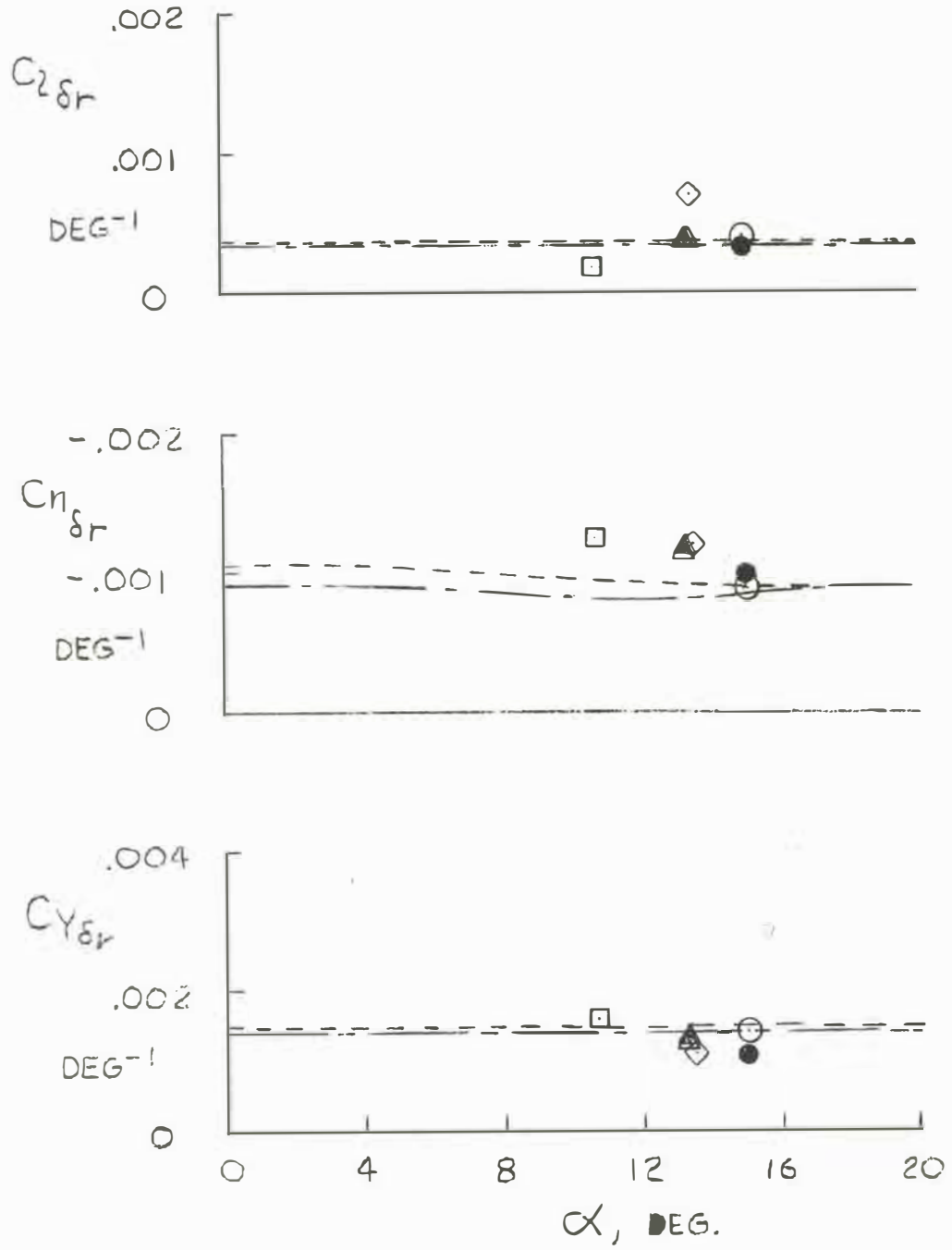
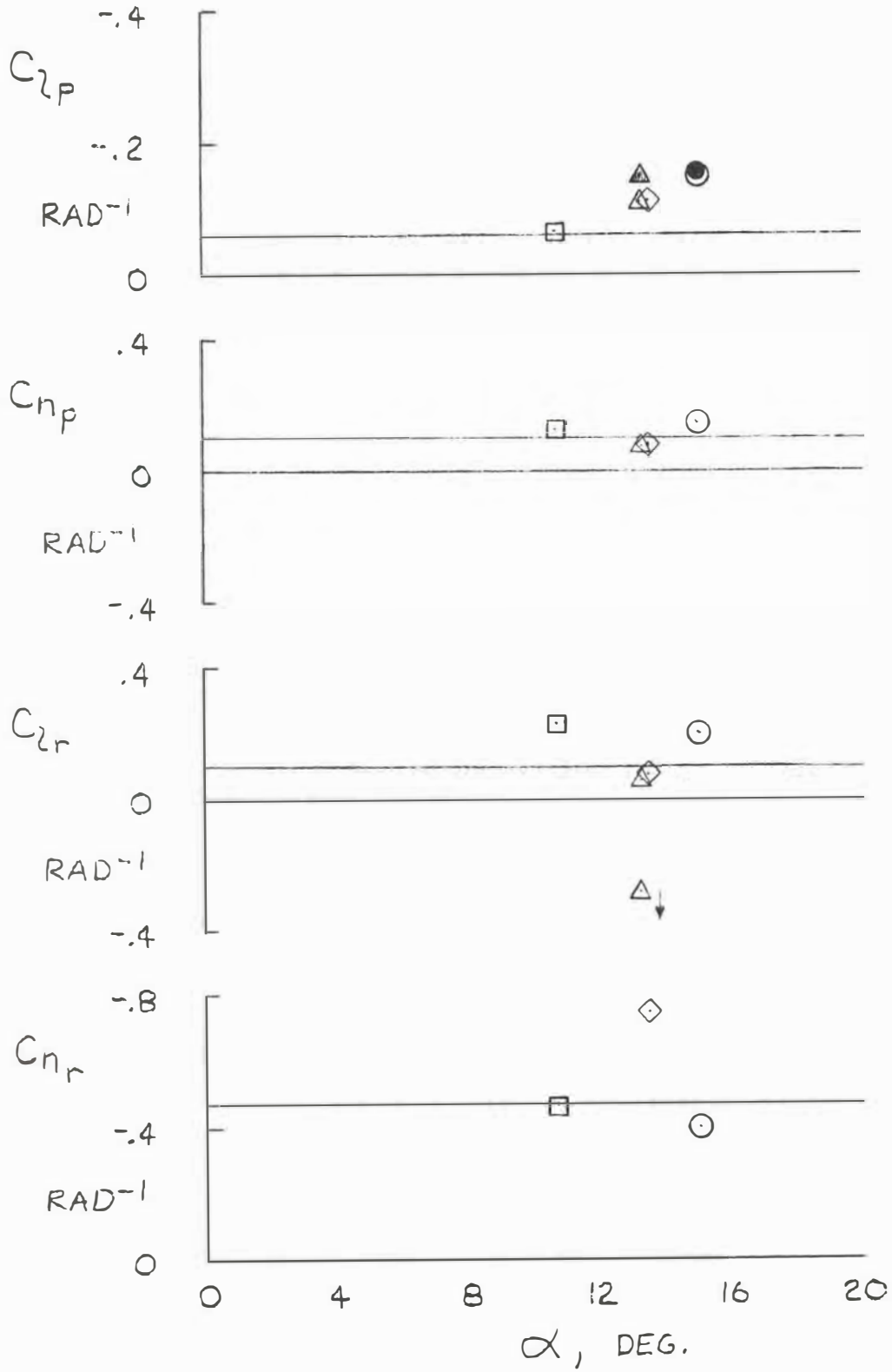


FIGURE 2, CONCLUDED

X-24B
TRANSONIC CONF.



X-24B

TRIM DERIVATIVES

$\delta_H = -20°$ $\delta_{RB} = -10°$

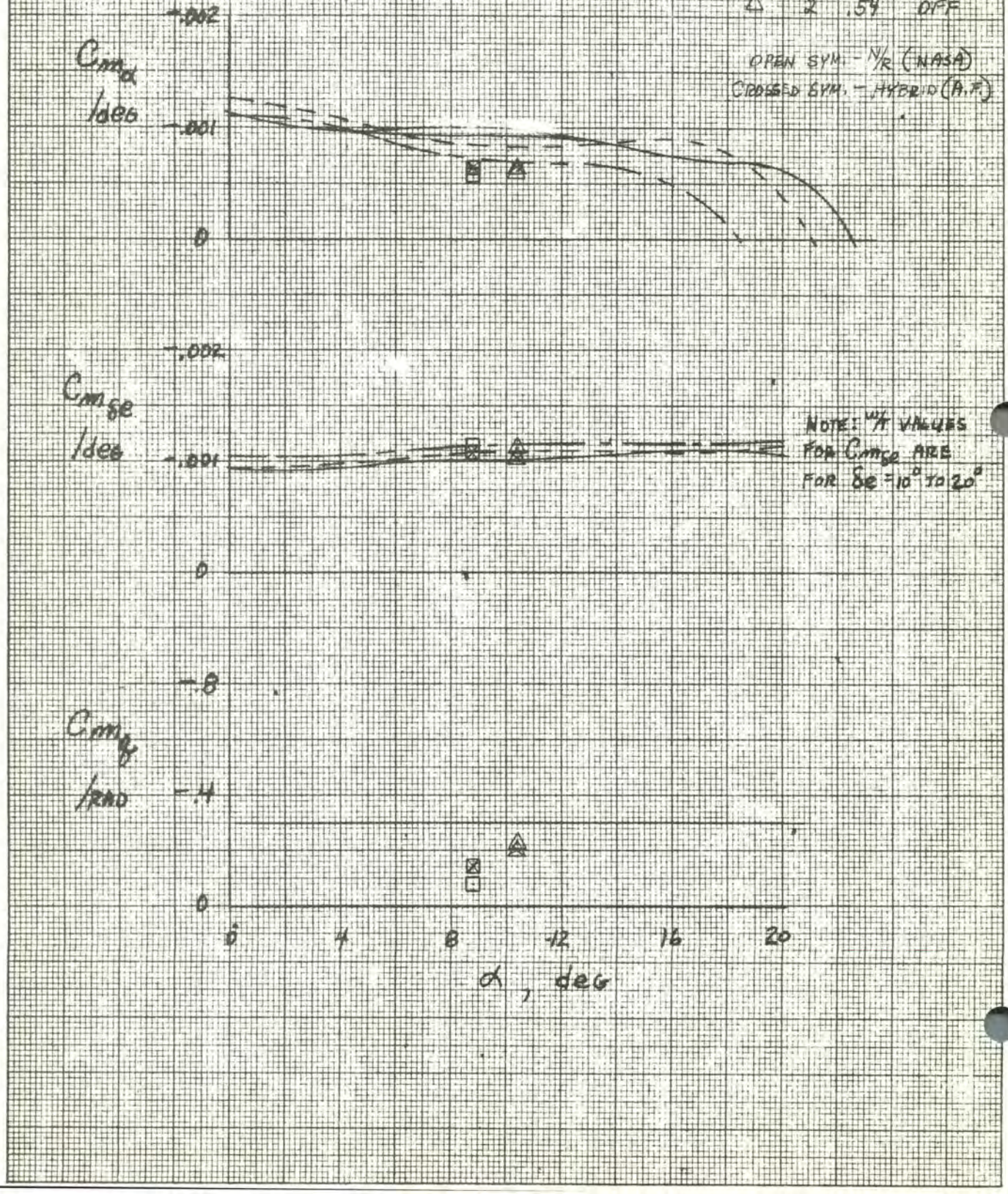
M	
0.4	WIND TUNNEL TRIM DATA
0.6	
0.7	

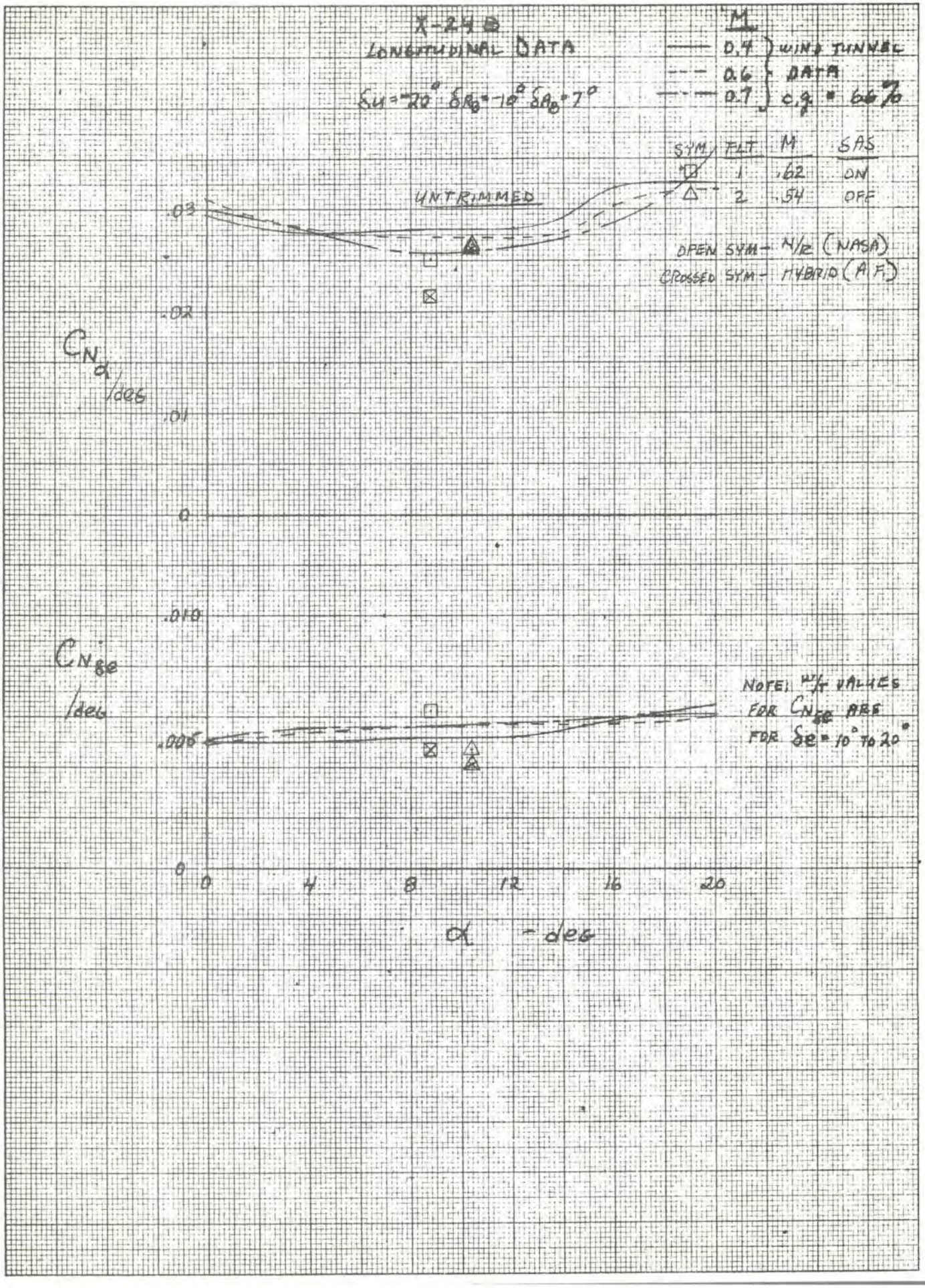
$C_G = 66\%$

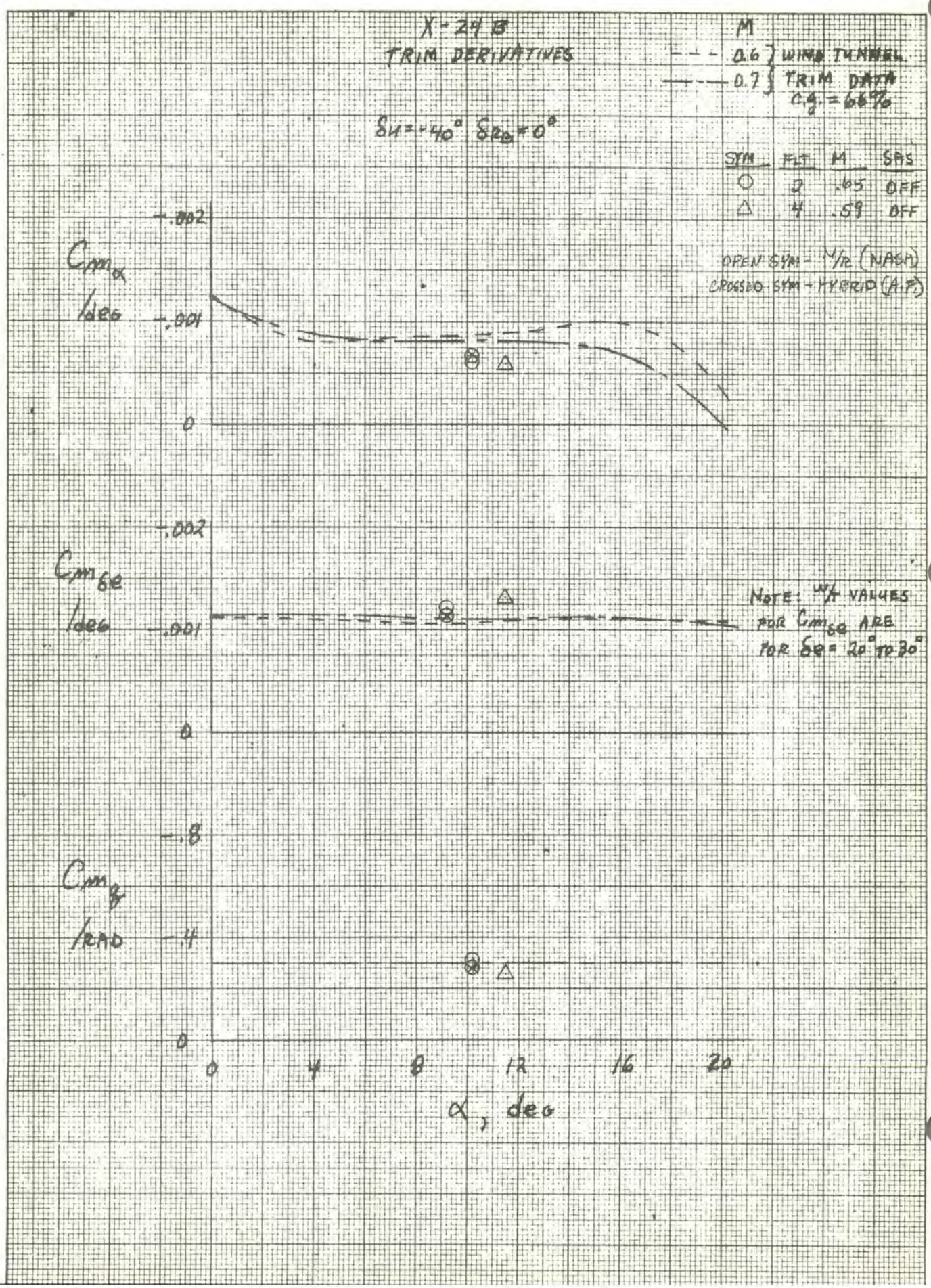
SYM	FLT	M	SAS
□	1	.62	ON
△	2	.54	OFF

OPEN SYM. - N/R (NASA)

CROSSED SYM. - HYBRID (A.F.)




X-24 ⊕
LONGITUDINAL DATA
$\delta_H = -20^\circ$ $\delta_{R_B} = -10^\circ$ $\delta_{A_B} = 7^\circ$
M
0.4 } WIND TUNNEL
0.6 } DATA
0.7 } C_g = 66 %
SYM FLT M SAS
1 .62 ON
2 .54 OFF
OPEN SYM - N/L (NASA)
CROSSED SYM - HYBRID (A.F.)
UNTRIMMED
C_{N_α} /deg
.03
.02
.01
0
$C_{N_{\delta_E}}$ /deg
.010
.005
0
NOTE: W/T VALUES FOR $C_{N_{\delta_E}}$ ARE FOR δ_E = 10° TO 20°
0
4
8
12
16
20
α - deg


X-24B
TRIM DERIVATIVES
M
0.6 } WIND TUNNEL
0.7 } TRIM DATA
c.g. = 66%
δH = -40° δRB = 0°
SYM FLT M SAS
○ 3 .65 OFF
△ 4 .59 OFF
OPEN SYM - N/R (NASA)
CROSSED SYM - HYBRID (A.F.)
Cmα /deg
.002
.001
0
Cmδe /deg
.002
.001
0
NOTE: W/T VALUES FOR Cmδe ARE FOR δe = 20° TO 30°
Cmq /RAD
-.8
-1.4
0
0
4
8
12
16
20
α, deg

X-24 B

LONGITUDINAL DATA

$\delta_H = -40° \quad \delta_{R_E} = 0° \quad \delta_{R_B} = 7°$

M

--- 0.6 } WIND TUNNEL

—·— 0.7 } DATA - $C_g = .662$

SYM	FLT	M	SAS
○	2	.65	OFF
△	4	.59	OFF

OPEN SYM - M/R (NASA)

CROSSED SYM - HYBRID (AIF)

UNTRIMMED

.03

.02

C_{N_α} /deg

.01

0

.010

$C_{N_{\delta E}}$

.005

0

NOTE: W/T VALUES FOR $C_{N_{\delta E}}$ ARE FOR $\delta e = -20°$ TO $30°$

0° 4 8 12 16 20

α ~ deg

KEUFFEL & ESSER CO.

X24B LATERAL-DIRECTIONAL DYNAMICS

By Alex G. Sim

The abundance of subsonic configuration lateral-directional flight data has made possible a comparison of airplane dynamics between present estimates of aerodynamic and inertial parameters with those prior to the first flight.

Open loop dynamic characteristics were computed at Mach number 0.54 and angles of attack of 5°, 10° and 15° using a linear three-degree of freedom model. The characteristic roots obtained are shown in figures 1 through 3 along with the time to half-amplitude and damping ratio in tabular form. From these figures, it is evident that the dutch roll damping and damping ratio are significantly better than predicted prior to the first flight. It is also significant that the flight data yielded conventional (uncoupled) roll and spiral mode characteristics. In addition, roll mode damping based on flight data is considerably improved.

FIGURE 1,

X-24B SAS OFF

$\alpha = 5°$, M = .54, $\bar{q}$ = 183 psf

X FLIGHT

WIND TUNNEL

	$t_{1/2}$	ζ
FLIGHT	1.35	.2
W.T.	2.30	.13

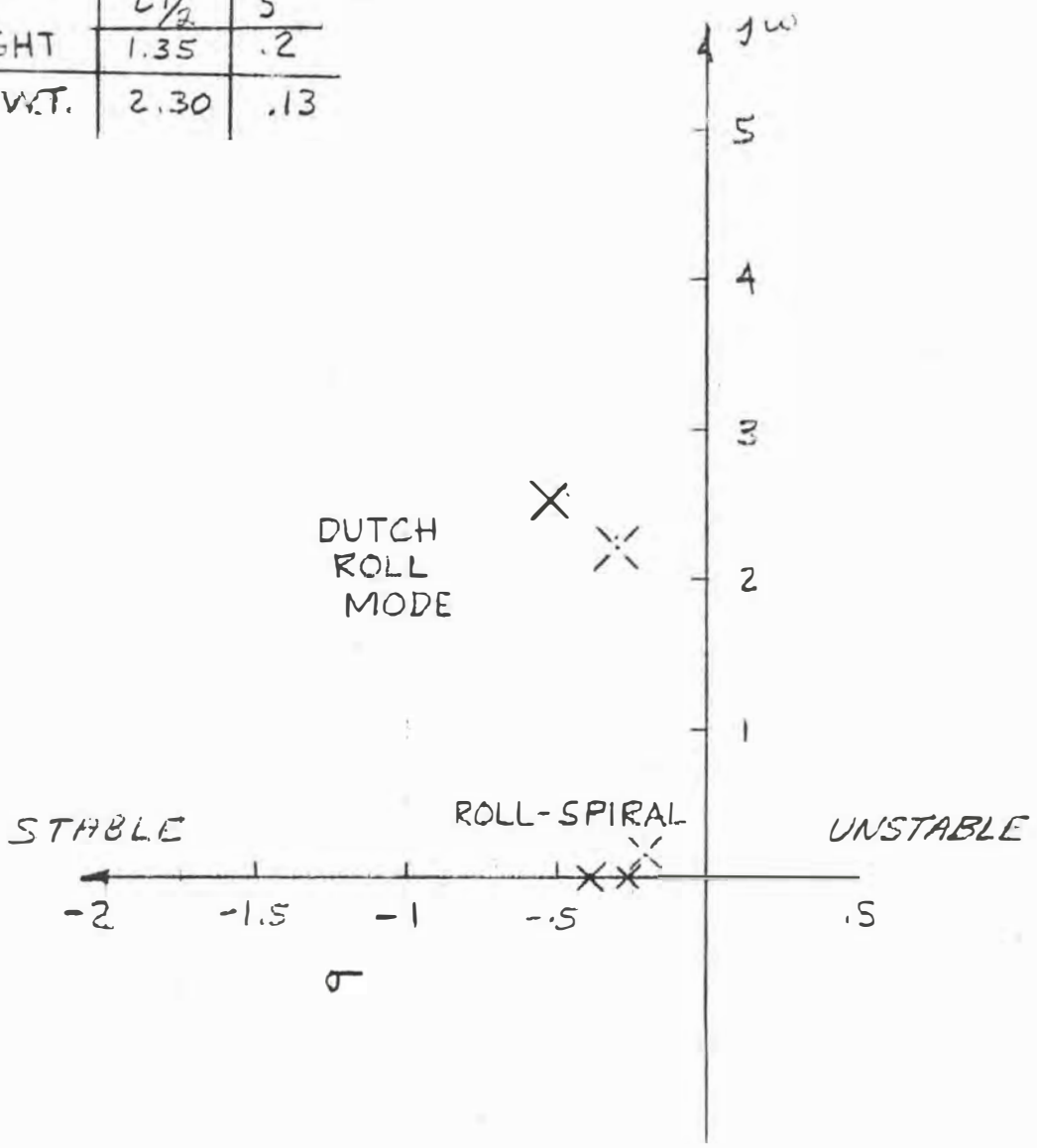


FIGURE 2,

X-24B SAS OFF

$\alpha = 10°$, $M = .54$, $\bar{q} = 183.$

X FLIGHT

WIND TUNNEL

	$t_{1/2}$	ζ
FLIGHT	1.21	.17
W.T.	2.24	.12

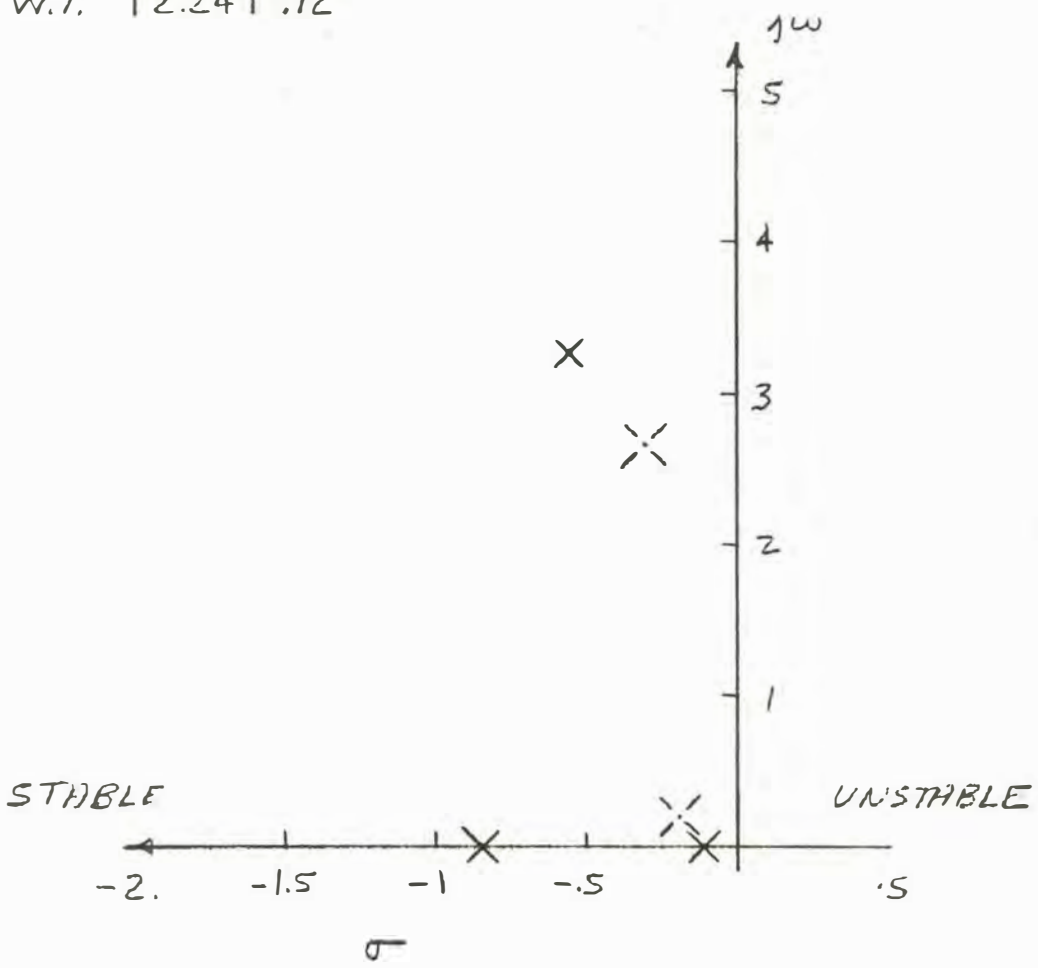


FIGURE 3,

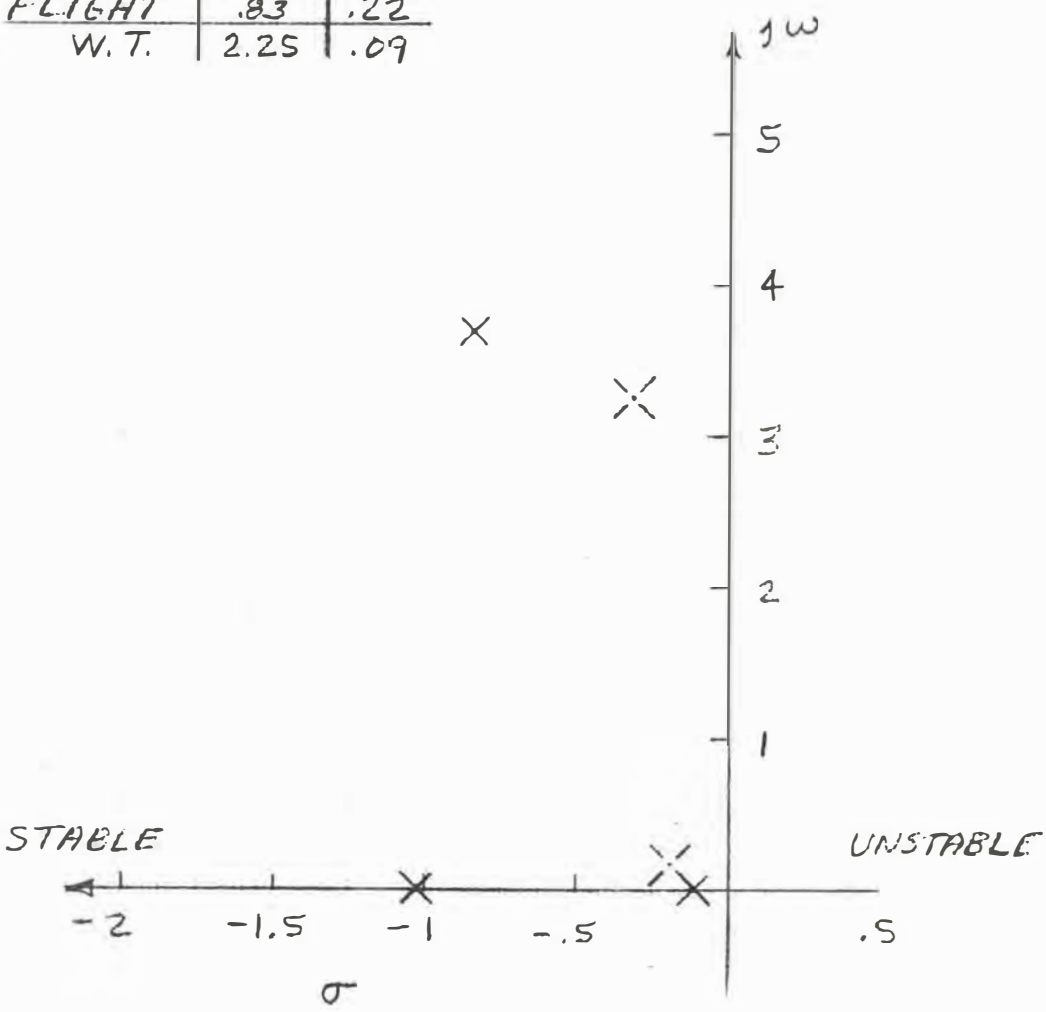
X-24B SAS OFF

$\alpha = 15°$, $M = .54$, $\gamma = 183.$

X FLIGHT

WIND TUNNEL

	$t_{1/2}$	ζ
FLIGHT	.83	.22
W.T.	2.25	.09



X-24B TECHNICAL DEBRIEFING

Flight Number: B-5-9 4 October 1973
Pilot: Mike Love

1. Discuss the launch transient.

   I guess the thing I noticed most was the pitch down. Pitch down was, I thought, surprising, not violent, but very rapid and heard the noise, also which I had already been well briefed on. The launch transient was surprising enough to me that I didn't get to see anything until it was over. John Manke was talking about the fact that I didn't have much roll off. I didn't see the transient roll nor did I see the alpha gage go down and come up, I just knew it was at eight and it was laying over in a 15° left bank. I think the launch transient was probably not unpleasant, but it was a big surprise that's all, I wouldn't complain about it at all.

2. Rate the task to recover from the launch transient and acquire 10°α.

   We have just had a discussion on what would be the desired performance in acquiring 10α and they've agreed for this task, in this flight regime, plus or minus a half of a degree would be desired performance. Therefore, the airplane is easily a three in my opinion in acquiring 10α. In rolling the wings level and trimming out the roll mistrim, I would also put it at a three and I would include that in recovering from the launch transient and starting down the track at the right heading. In discussing what I mean by pilot rating of three, I wouldn't consider a two for it and I was hesitating between three and a half and four so complimenting the airplane with a three on that. Also discussing the ease of recovering in the simulator versus the airplane I think that I can be more accurate in the simulator than I can in the airplane.

3. Discuss and rate the handling qualities with 40° upper flaps and compare with the simulator and other aircraft.

Well, the handling qualities are very nice with 40° upper flaps, I have had some complaint about capturing an α, but when I consider desired performance to be plus or minus a half of a degree then that isn't bad. I was pleased with the fact that I could trim it out and it didn't seem to want to roll off like the simulator, now that may be because I have a better cue from outside. When I fly the simulator I find that it tends to lay over on one wing or the other and I didn't find that a problem at least down to where I started the roll maneuvers today. During the rudder doublets and aileron doublets I was surprised with the way the thing rolls when you put in a rudder doublet. Roll acceration was higher than I expected and I was dissatisfied with fact that I came out of the rudder doublet with 30° right bank, I don't think it's the airplane's fault and I don't think it's objectionable, in fact, it's nice to have an airplane that will respond that rapidly. The roll maneuvers with normal rudder and aileron techniques to 30° to 30° of bank both looking inside and outside both were very pleasant. Compared to the simulator it was more pleasant, I get a little upset with the simulator and I think that the roll response as it comes up to its steady state roll rate, I think the time constant is a little slow in the simulator and I didn't like it very well. In the airplane I put in the stick and it would roll right over and this hesitation that I feel I see in the simulator wasn't apparent. I guess I should discuss here why I developed the roll task that I did today. I decided that I had time to do a bank-to-bank roll with strictly normal pilot technique, but because I didn't like the simulator, I decided to lead with rudder and see if I couldn't get a better roll response out of it, meaning that cut down the time constant a little bit to reaching desired roll rate. So I decided that after I did the normal technique I would lead with rudder and when I did that with the airplane I got more roll rate than I wanted for capturing 30°, probably went to 45° and stopped easily but this goes back to what I was saying I didn't see the hesitation. It was easier to hit 30° in the airplane than in the simulator using normal pilot technique and when I used my extra rudder it went past 30° faster then

I thought it would. Finally, I used simply rudder to roll the airplane and in the simulator I saw I thought a lot of effect of $C_{\ell_{\delta r}}$, in other words it would roll opposite or hesitate before it would pick up the roll in the desired direction. This was not nearly as apparent to me in the airplane and probably one reason was that I wasn't looking at the beta needle, all I was doing was putting in a little rudder and see if I could control it to a bank angle and I thought it was very pleasant. You could use the rudders easily to maintain wings level while you were doing other tasks, something you'd do in another airplane, write on your knee board, change a radio channel, look out and you could just walk on the rudders and keep wings level very easily like other airplanes. Summarize a little more with respect to other airplanes. It's hard to compare this task to another airplane but I like the roll response in this task at the airspeeds better than any other airplane I've flown. For one thing I don't feel I'm having an argument with the roll SAS about who's got control of the airplane. In an F-4 for example, the thing is moving the airplane around as you ask for roll response and then you stop your stick input. This airplane approaches, in my opinion, the T-38 in its smoothness and ease in performing the roll task, but it doesn't respond as rapidly, which may be better. As compared to the simulator, to summarize that, it responds I think faster than the simulator and I don't think the effect of $C_{\ell_{\delta r}}$ is as marked. In fact, last night when I was thinking about what I would do to the airplane I was thinking that if you had a task like flying down this glide profile and you wanted better response I'd put in opposite rudder and wash it out in a control system if it acted like the simulator, certainly after flying the airplane, wouldn't do that now. Overall Harper-Copper rating for the group of tasks to the close up would be a three. If I were asked to rate simply the roll task I would rate it a two and a half if I'm using too much rudder, if I was rating the roll task with normal control I'd rate it at two and I'd rate the rudder roll at two. The reason I come up with an overall three is because of my problems in capturing an alpha and holding it.

4. Discuss and rate the configuration change.

The configuration change was very easy. It was accomplished at 12°α as planned and I found that it was just very simple to hold 12 while I knew that α would be trying to drop and when I knew that it would be coming back up, I just anticipate a little bit and relaxed and it didn't seem to move very much. I'll be interested in looking at the cockpit film on that, because I think that holding it within a degree was no problem at all and I think I might have held it a little closer than that. Comparing that to the simulator, it's much easier than the simulator. In the simulator I have to anticipate that I'm closing up and really get with it as they start to move to hold the α and then I have to anticipate when it's going to reverse. Another thing is that I feel that the feedback from my hand in the airplane, one of the things was the softest of the forces, the very light force that I was applying to hold the α up and then just simply relaixing. My impression in the simulator is that I am really getting with it, into that force gradient when I'm trying to hold the α during the close up. I'm relaxing more to track it as the α comes up again, but the airplane force gradient seemed lower. Very easy task rated at a two.

5. Discuss the pullup-pushover with 20° upper flaps. Rate the pitch handling qualities.

I started the pullup from 12°, reached about 14 1/2 and then had trouble getting it to 15. About the time I had what I would interpret as 14.7° John called me and said I was at 15 and I thought well I wanted to get right at 15 and tell him I'm there. So I made another attempt and went to 15.2 or just over it. I wasn't able to go right up to 15 and hold it. As far as the stick gradient I wasn't aware of it, I was a lot stronger than I am in the simulator I guess. I didn't feel that I was pulling hard. Pushing over to 5° was about the same as the simulator. In that task, that's the hardest thing I have to do and I very seldom hit a good solid 5° in the simulator and I tended to hit about a six in the airplane. Bobbed down to 5° and barely got it trimmed to 5. In fact I

doubt that I had trimmed all the way to 5 when I started back to 12°. Coming from 5 to 12 was I think the easiest part of the whole thing. I again hit 12 plus or minus a half with not too much problem. Maybe because its a familiar area. I didn't feel that the stick gradient again was as steep to do this. It felt I had an easier time pulling the airplane up to 12°. Now one of the things I didn't do, I was supposed to roll the airplane there. In fact I reached down and went back to 1.0 on the Mach repeater a little prematurely I think. OK in rating the task for the pullup-pushover, I rate it the same rating as recovering to 10° then trimming to 12 and that would be a 3. With the desired performance being reaching ±1/2 degree; I could do that.

6. Discuss and rate the handling qualities with 20° upper flaps between configuration change and low key.

During the pullup-pushover I rated it as a 3. All I did then was drive straight ahead to low key. So I didn't really accomplish much of a task. Just sat there and looked at the airspeed and looked outside and it was very nice to do that so I would rate that a 2. I really wasn't doing a tight piloting task at the time. One thing I feel that is worth saying is that you feel the landing rocket. There is no doubt in your mind that you got landing rocket. Another thing that is worth talking about is getting the fin camera is easy. It doesn't distract you to have to get down to that switch. A lot of people say if you are going to have a switch you are going to flip every flight that you ought to put it on the glare shield but I don't think that was a problem.

7. Comment on your low key conditions.

They were exactly as we'd been planning. I rolled into a bank and looked out and just as John said it looked close but it was perfect. Couldn't ask for better. A nominal low key condition.

8. Discuss the turn to final. Rate handling qualities.

I consider that the portion from starting at the highway and lowering the nose and accelerating around Peterson Lake and rolling out on final at 300 kts. That's very pleasant. I wanted there to look at the spiral and see if it tends to roll out of the turn like it does in the simulator. I got so busy just flying it around that I didn't see that, I forgot to look at it. It was easy to let the airspeed build as we simulated, it was easy to see the aim point. The only thing I would say is there's a little bit of distortion out the top of the canopy at one place. I moved my head around a little bit and could see that. The handling qualities in that is a 2 1/2.

9. Discuss the final approach. Rate handling qualities.

Before I got on final I put out the speed brakes. I would say I was 20 to 30° from final. I hardly noticed the pitch down, or any unpleasant things about it. I just knew they came out; I could feel the drag. I felt I had a little too much, and looked down and I did have 30° which I thought was more than I wanted to get out. Then I brought them in a little bit. I'm not sure I like the fact that you tend to bring them in and leave them out some. The speed brakes are very pleasant. Just warn NASA that I will have to make sure that we get them back in. I did another unbriefed thing as I was rolling out on final. I went ahead and tickled the rudders and the stick just to see what it looked like. It looks to me as you predict, the dutch roll is a lot faster, I would describe it as a tighter airplane. Didn't see much tendency for it roll around and bank; seemed to snake back and forth kinda F-104 like. Also the pitch was a little tighter than I had seen up at low key; which was another thing I had snuck in. Just prior to turning I went ahead and bumped the stick a couple of times in pitch; not to rate it or anything but the needle went up and down just about like the simulator so it looked close to me. Overall handling qualities turning final I would rate

as a 2. The final approach - I consider from when you really roll out on final and just staring at the aim point just prior to the flare. In my particular final approach, I noticed the aim point going back just about the time I got a call from John that the boards were out. I brought the boards in and the aim point stabilized very nicely. Also no tendency to have a problem with PIO in any axis, just a very solid airplane. I'd rate it a 2.

10. If turbulence was encountered, describe the vehicle's response and the effect on piloting task.

I don't remember any turbulence.

11. Discuss and rate the flare.

The flare is very easy. Manke's discussions of the flare are the same as mine. You just think about flaring it, happy to be down where you are going to flare and look out the window and watch the runway rotate. No appreciable stick forces and this is probably the easiest task in the airplane I think that I saw this morning. I agree that pilot compensation is not a factor and I rate it as a 2. One thing I'd like to mention about the flare, however, from building the airplane stand point is that for me that cross bow on the canopy during that portion of the flight was right where I wanted to look so I was aware of the fact that I was looking down underneath it, then looking up over it and just kinda looking around it. I was aware that it was in my line of vision.

12. Discuss and rate the landing.

Landing would be from coming level after the flare maneuver where the rate of sink is essentially stopped and gear down speed is there and you drop the gear out. The airplane was again very easy to fly, when I dropped the gear out I noted a little bit of pitch over, the yaps head dropped a little bit and a slight aft stick took care of it. I think it would have come up by itself. The biggest problem I had was finding out how

high I was. I don't think that has anything to do with the airplane; it's just me looking in the wrong place. One thing, the nose comes up; rotates more than the T-38 but doesn't get in the way. The rate of rotation of the nose is no factor, it's just that you are aware of it. Stick gradient and the ability to hold wings level, I was aware of that and I thought, "now let's see, am I able to hold wings level," and I didn't move the wings around I just thought in my mind, "can I hold wings level and touch down with two wheels". I don't know whether I did or not but I felt that it was no problem. Flare to touchdown was very nice. At touchdown - the feel of the gear was pretty nice, softer gear than some airplanes; say something like a F-104. I rate the landing a 2.

13. Discuss the ground handling during roll-out.

Ground handling during roll-out surprised me. I'd expected a more responsive airplane. Let me first tell you what I did. First when I touched down I got the stick full back even though I didn't intend too, just a reflex reaction. Then the nose came through and I relaxed the pitch on the stick, and started with the ailerons. Used ailerons down to about 120 to 130 kts and started with the rudder; aimed the nose gear steering around 100 kts. Actually started with the steering around 90 which was higher than briefed and braked from about 30 to 40. I did not try differential braking. I felt the ailerons were most effective in turning the airplane and rightly so since I did that at the fastest speed, I was surprised that the rudders weren't more effective, however, it was still very controlable. I don't know if I went through ruts or what but I could feel just a little tendency to swerve out there and I could control it with rudders alone. Engaging the nose gear steering, I was surprised at the low turn radius available from them, but certainly good enough in fact fine for our task. And the brakes were OK; brake felt just like a T-38.

14. Compare the pattern with the T-38 practice.

It looked very similar. From a noise stand point it's more pleasant because you don't have all that noise from the gear. I think that the feel of the stick is closer to the T-38 than it is to the F-104. That would be especially down in the flare portion. I feel that the delta stick in the F-104 is a lot higher than in the T-38 and definitely higher than this airplane. That's during the flare and touchdown. The T-38 comes close to this airplane. The T-38, however, as John Manke points out doesn't rotate when you flare where as the X-24 does and the F-104 gives you a very nice feel, I think, for how the nose comes up.

15. Discuss visibility during approach and landing.

I already covered that a little bit. In the turn from base I felt we had a little distortion in the canopy, that's no factor. On final the cross bow on the canopy, during certain portion of the pattern, gets in you way and you have to look around it. But the visibility is excellent. The visibility is very good if you bank at altitude and I would imagine comparing it to other lifting bodies - it's excellent. Comparing it to T-38, it's just as good.

16. Give an evaluation of the simulator and simulator training for this flight.

I think the simulator training made it possible for me to fly a nominal profile. The simulator is easier to fly in some respects and harder in others. It's easier in pitch, I can be more accurate in acquiring α, but the simulator is not as pleasant to fly in roll. The simulator is terrible from low key to final. I hate to try to fly around that little line on that map. The simulator, I think, if you pull to the right, it can give a fairly good feel for flare time except it's impossible to always hit 2300 feet. Overall I just have a lot of good things to say about the simulator training though, it was just excellent.

17. What was your biggest surprise during the flight?

I guess the first thing that happened in the flight would be the biggest thing would be the launch transient, got my attention more than anything else. The rest of the flight - there weren't many surprises. Next to the launch transient if I was going to talk about surprises in handling qualities was the roll acceleration during the rudder doublet. John had told me about that but I guess I just didn't have a feel for it.

18. Are there any changes to training procedures that you would recommend for checking out a new pilot?

I have no changes that I would recommend. I think that as I said before the training program has been beautifully paced especially during the last two weeks. I had some question in my mind about flying a captive but I know darn well that we got a better glide flight today than we would have yesterday by taking the extra expense and time to fly the planned captive.

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-2C-7 DATE OF REPORT: 10/30/73

PILOT: Major Love DATE OF FLIGHT: 10/3/73

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Pilot Checkout

I. Discussion of Previous Operations

A. Flight B-4-6 was flown on 9/18/73 with a realigned water alcohol jettison line which eliminated the adverse vehicle motions during jettison encountered with the original line configuration.

II. Vehicle Configuration Changes

A. The emergency KRA circuit breaker was relocated from the left hand aft side vertical panel to the SAS control panel in place of the stick shaker breaker and both KRA breakers were painted red for fast identification. The stick shaker breaker was relocated adjacent to the KRA "beeper" switch.

B. The power voltage to the stick shaker actuator was increased from 16 volts to 28 volts to provide high level shake. The pilot had reported that the energy level was inadequate. The system was activated with SAS engaged throughout the available gains levels with no problem.

C. The UFB stops were readjusted to 20° to prevent control system operation in the crossover region.

D. The nose ballast was reduced to 100# to move the c.g. aft.

III. Instrumentation System Changes

A. The velocimeter was replaced with the X-24A radar altimeter.

B. The pressure orifices were repatched to the 3A program hookup.

C. Thermostats were installed on the forward pylon camera and the center fin camera magazine heaters.

D. The dynamics system was set up for "white" plug operation.

E. The drag on the center fin film feed spool was increased to prevent film jamming.

F. The film loading procedure for the L.H. fin camera was modified.

IV. Preflight Events

A. The 120 day inspection was completed on the ejection system. The system was set up for Mike Love (new seat spacer and headrest).

B. The lox feed and water alcohol jettison valves were changed.

C. Environmental tests were made on the center fin and L.H. fin cameras.

D. A complete dry run with Mike Love in the cockpit was made prior to the captive flight. Various failures of electrical busses, hydraulic pumps and SAS were simulated.

V. Flight Events

A. The vehicle was serviced for flight with no problems and the captive flight made with no vehicle problems.

B. All cameras worked during the flight.

Approved by: _____
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: _____
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-5-9 DATE OF REPORT: 10/30/73

PILOT: Major Love DATE OF FLIGHT: 10/4/73

CARRIER AIRCRAFT: B-53 #008 LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Pilot Checkout

(2) Handling Qualities Evaluation

(3) Forward and Aft Fuselage Pressure Survey

(4) Acoustic Noise and Vibration Experiment (WHITE PLUG)

(5) Tufts Fin and Strake

I. Discussion of Previous

The captive flight B-2C-7 was flown with no problems on 3 October 73.

II. Vehicle Configuration Changes

A. Tufts were added to the L.H. fin/strake for flow visualization studies during flight.

III. Instrumentation Changes

None

IV. Preflight Events

Preflight servicing of the vehicle went smoothly except for a failed breathing O_2 regulator in the B-52 supply to the X-24B. A new regulator was installed and the system worked satisfactorily.

V. Flight Events

Shortly after B-52 takeoff the chase pilot reported that something had fallen off of the X-24B. A close visual check by the chase pilots revealed that a rudder throwboard was still in place. The B-52 landed and both aircraft were visually inspected for possible damage, none was found and after the remaining throwboard was removed the B-52 tookoff and flight B-5-9 was flown with no vehicle problems.

The L.H. fin and nose camera did not operate during the flight.

Approved by: _____
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: _____
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

X-24B #551 POSTFLIGHT DATE: 10/4/73

PILOT: MANKE

This is flight B-5-9. Pilot checkout for Mike Love. I'll start with the crew entry procedures and I will read over things that I would like to have seen and things that I did not see that I wish had been apparent. It just happens too fast. I guess I should start by quoting a famous NASA test pilot in saying that we had another dandy flight. It really was an easy airplane to fly.

On the crew entry procedures, finally on the second time we got airborne I found the 26th light. Glen Ford signed off the lite check after 40 seconds when I could not count them. Haven't any thing on taxi and takeoff and the checklist went better today than it did yesterday. I was a lot more ready today to launch.

Ok, at the launch John said that there would be a loud noise and it was a loud noise. But he did not tell me that I'd hit my head on the canopy. Which I did. I had guaranteed Johnny Armstrong that I was going to see the altimeter jump up but I did not see anything at all during the launch really, except that I heard the noise and hig my head on the canopy. The airplane took very good care of itself at the launch as John said it would. It came right back to 8 α and it was laying over at 15° of left bank. I wanted to leave it there just a little longer but I knew I'd better correct the heading so I picked it up and then went to 10 α. I did see the angle of attack indicator pretty quick and the angle of bank, but all the other things that I wanted to look at I missed. So, I have got to have a lot more flights, John. (You've got to have a better reason than that Sounds like another quote, doesn't it?)

Ok, as far as recovering to 10 α, I don't think it is quite as easy to do in the airplane as it was in the simulator. I got to 10 pretty well and wanted to say, Ok, I'm at 10 α, Bob Hoey, and then it was immediately off 10. Then it was time to go to 12. So I went to 12 α and was iterating 1/2° either way and I just wasn't able to nail the angle of attack the way I can in the simulator. The only thing I can conclude is that it is not as easy to do in the airplane. I wanted to know if I would feel the break out, if I'd find the stick force gradient objectionable and all I can say is that the stick is very nice. And I don't feel the gradient, which is high if you pull the stick through a long travel. I also wanted to see what the trim rate was in pitch. I haven't always been happy with the simulator and there are a lot of airplanes that I don't like the trim rate in. I felt the trim rate was good. It is that I just can't seem to stop it - can't stop the airplane where I want it. I don't think it is the trims fault. I wanted to know, and John told me that the horizon would be no help and it certainly wasn't any. All you can do is look at the angle of attack gauge and try to chase it which is not a normal control technique for me. I like to look at the horizon and then stop things where they

are and you can't do that in the airplane. For on thing the nose is below the horizon most of the time. I was also interested in the trim rate in roll. The simulator is a little objectionable to me in the trim rate in roll and the airplane was much easier. I think maybe it is the horizon that makes it easier for me to go ahead and get that 15° bank out and get wings level. Generally in the simulator when I try that I end up rolling off again one way or the other. I thought airspeed was a good clue for me. It had developed to be a good one for me in the simulator. I didn't know whether it would in the airplane but I was happy to see that the airspeed and the altitude stayed as predicted by the simulator except that the airspeed at close-up was still 195 and I'd been on 12 all the time. So, the airplane didn't seem to slow down. I didn't lower the angle of attack to 11.

Ok, the rudder doublet. I'd be happy to see the actual data on that. This was a training doublet to see if I could do one that will give you data and the same for the aileron doublet. I was disappointed with my rudder doublet because I ended up laying over 30° of right bank, when it was over with. I would like it to iterate right back to zero. I wanted to know about the overshoots and didn't see them, and I wanted to watch the bank angle excursions, and I didn't see them. However, I do know that a lot of my rudder doublets in the simulator I end up in the same condition, so I don't know what I am going to do about that. One thing that surprised me is the yaw. In other words, the simulator is not an airplane, so it really does take the rudder doublet and I could feel the yawing motion more. In any other airplane I'd put a doublet in at that airspeed, pretty sluggish, so its a lot more responsive, I think, at that airspeed than most other airplanes. Aileron doublet, as John said, I wouldn't see anything and I didn't. I just hope it was sharp enough. I wanted to hear the pumps. I was hoping I could hear the pumps whine when I did that but I couldn't hear them. Maybe I am not familiar enough yet. I had kind of given up listening to the air because I did not think, I was convinced that you wouldn't hear it, but it sounds just like a glider. That doesn't tell you anything about the airplane, but it is really pleasant. (Those are the pumps, Mike.)

I may have rushed the aileron doublet because I finished the doublets at 39,000, had 190, and started roll maneuvers. Very nice to do a roll maneuver at the KRA schedule that John picked. You just roll over and look outside, roll back the other way, acceleration is nice and the stick feels good. Thats very nice. Then I had this trick I developed of leading with rudder. It does hesitate a little bit as you bring in that extra rudder and then it really wraps up and I did not mess with that very much because you can roll the thing over on its back quite rapidly with that sort of extra beta in it. I commented on that, then left it, I think in a 30° right bank, and I picked it up with the rudder. And I used the rudder, I think, a couple of times to roll it and it does a very nice rudder roll. So as far as the other lifting bodies, which I don't have any experience in, or excuse me research aircraft of this type, it is not as sensitive

to beta I guess because the rudder roll is a very nice thing. Now in the simulator I felt that, you know you put in rudder and it is the barn door effect from the rudder, CLDR makes it roll opposite and then pick that up. I haven't liked that in the simulator. In fact, I hadn't really liked the way it rolled with our KRA schedule, but the airplane is much nicer. I think that has to do with the fact that I can see outside. So, I really liked it in the roll axis much better than the pitch.

That closeup, I'll have to agree with John. I was close to 12 instead of 11 and I did not even have to think about maintaining that alpha. That was just real easy to do, much better than the simulator. I could put it at any α I wanted, I think, while it was closing up. At least where the stick forces were not too high. Can't remember the airspeed at the end. At the popu, again, I wanted to make sure I wouldn't get 16 and get graded down for getting a stickshake. I also wanted to hit 15 and say, there is 15, Bob Hoey, and when you said there is 15 α I had about 14.7. So I said dog-gone I'll get 15 and then it went to 15.2 and then I gave up and went down to 5. And 5 is just as hard to hit. I have trouble in the simulator with 5. I still did not like that as far as ease in flying. I just could not stop it where I wanted to.

I wanted to look at the spiral in the base turn and I forgot to do that. I was too excited hoping I'd get it on the runway. Came down final and decided, well, looks like some good speed brakes and I put the speed brakes out, looked down and I saw 30 and the aim point was moving back where I wanted. So, I brought them back in and about the time John called, you still got boards out, I was beginning to get concerned about the way the aim point was continuing to move back off the runway. So, that was a very good call. It was easy to bring the boards in part way and not really know they were still stuck out a little bit. So, its a good thing to keep watching. But the boards are very nice. You don't get any transients from them. And, they do, as John said, bring the nose down and you bring them in and the nose comes back up. They are excellent.

The flare was better than any airplane I've flown in these kind of maneuvers. Better than the T-38 which is better than the 104. Thats a very easy maneuver. I wish I'd looked at the angle of attack but I forgot to. However, I did not have a good feel for my height above the ground and having Bill out there telling me my height was excellent. It became pretty critical, you know, I got down to 35 or so and pulled the gear and John had wanted me to pull it higher. It just felt good where I was. From then on down I didn't have much depth perception. So, your altitude calls were excellent. I saw the airspeed at touchdown and it was about 176. So, we got down where we wanted to be. As soon as the nose touched, the stick came full back. The stick actuator had a hard-over. It just went like that. It did not slow it down, I am sure, but it felt better. Nose comes down right smartly as predicted. During the rollout, John, it is a very controllable airplane but I thought it would be a lot more responsive. Ailerons were OK and then I started pushing the rudders around.

I didn't think they moved me around very much. Engaged the steering, I didn't think it moved me around very much and then I braked. The brakes were like the T-38. I guess the responsiveness on the ground, I was ready for something a whole lot more hard to handle. I would say it is no where near like the Tiger Moth. (You had to get that in there, didn't you) Ok, I guess I ought to comment on two things. Again in aviation, you know, you see something and you say, you ought to say something or do something that, and later on you wish you had. I looked right at those rudders this morning and I've done enough control checks to know that they had no business being on there. I looked over at the rest of the airplane and the panels that were open and I thought, well they will get them. I just wished I'd walked over to Charlie and said are you going to do anything more on the rudders or you know you've still got those on there. I could have stopped that so I apologize to Charlie and Norm for not doing that.

The other thing, I'd like to make a general comment about, the training program. It has been what, 4 or 5 months long. There is no way I could have flown the airplane three or 4 months ago. Actually, 2 weeks ago I wasn't ready either. So things just came along beautifully and peaked wht right intensity and in the last 2wweeks I haven't done anything but think, eat, drink, sleep, flying this airplane, and that been lovely. Norm and the crew, they just gradually fed me the information about the airplane so that I am really at home with it and know the system. And of course the Operations Shop, Bill and John Manke, just super, I couldn't, I just really enjoyed it. I think the best way to summarize it, is that about 4 or 5 days agao I thought dammit, that sounds like a scary thing to do, and by yesterday when we went ahead with that planned captive I felt like I could have launched. By this morning I was ready to eat it alive. I just felt aggressive and it was just good. I was talking to Chuck Walls about it yesterday and having second thoughts about that captive yesterday. Obviously, John thought it was a good idea because he even launched me on another one this morning.

X-24B #551 DATE: 10/4/73

FLIGHT: B-5-9 L/P: V. Horton

PILOT: Maj. Mike Love

NASA 1: J. Manke

20 MINUTES TO LAUNCH

Mike: Rudder switch going to auto.
Mach repeater is manual.
Set 1.0.
NASA 1: Roger, Mike.
Mike: KRA mode switch is manual.
Chase: 40,000.
Mike: Got the lowers on 1.
NASA 1: Ok Mike, good.
Mike: Emergency flap switch open to 30. Back to 25.
Flap bias going open to 40. Here comes the rudders at 30, open to 40, rudders are at zero. Rudders moved to -10 and closing to 20 on the uppers. 20 and minus 10.
NASA 1: Ok Mike, concur.
Mike: Ok, coming back open to 40. Rudders moved again. I've got 40 and zero.
NASA 1: Roger.
Mike: Rudder mode switch going manual. Toeing in minus 10, back out to zero, back to auto. Rudders stayed at zero.
NASA 1: Ok Mike, good show.
Mike: Aileron bias switch to backup. Cycle to 5 and down to 9.
NASA 1: Roger, Mike.
Mike: Going normal, back to 5 and back to 7.
How's that for 7?
NASA 1: Ok, they like that at 7, Mike.
Mike: Stick coming full aft. Trimming forward, and aft, it works in the right direction. Trim set at 10.
NASA 1: Ok, Mike.
Mike: Aileron trim right, left, back to zero. Full right rudder, full left rudder.
NASA 1: Roger, Mike.
Mike: Rudder trim right, left, back to 1/2. KRA up to 50.
NASA 1: Roger, Mike.
Mike: Going right and I have 6. Going left and I have 6. Shaker test is good and is on.
NASA 1: Roger, Mike.
Mike: KRA to zero, full right and left and no rudder. KRA to emergency, full right and left and no rudder.
NASA 1: Roger, Mike.
Mike: KRA to 50, right and left and we have 6 right and 7 left.
Chase: Looks good.

Mike: KRA to auto and it programmed back down.
NASA 1: Ok, good.
Mike: Mach repeater is set 1.0, flap mode switch manual, and rudder mode switch is auto.
NASA 1: Good show, Mike.
Chase: It all looks good.
Mike: Ok, John, we will slow down a little here. SAS servos to auto.
NASA 1: Ok, we are in real good shape. We are about 17.5 minutes. You can go ahead if you like.
Mike: Roger. SAS gains are 5, 5, 5, and here comes the old SMRD.
NASA 1: That a boy.
Mike: No lites, torque, no lites.
NASA 1: Good torque, Mike.
Mike: #1 servos are off, torque, and 3 yellows. 2's are off and a torque, 3 reds.
NASA 1: Very good, Mike, and 008 rollout 185 please.
008: 185.
Mike: SAS gains are 4, 3, 2. Servos in auto, SAS lites reset.
NASA 1: Roger, Mike.
Mike: Toruqe, no lites. 3 SAS mode switches are on.
NASA 1: Ok, mighty fine. That takes care of the SAS check. It was a beauty. We can wait until 14 minutes now for the hydraulic pumps.
Mike: Roger.
NASA 1: And we are about 16 minutes now so you have a couple of minutes.

16 MINUTES TO LAUNCH

Mike: Ok.
NASA 1: Ok, we want to set our trims now, Mike. Give us a little bit of left roll and a little bit of left yaw.
A little more on the roll. Looks good on the roll. Ok, good on the yaw.
Mike: John, you might note that the standard mach meter jumps back and forth all the time, about .05 mach. It would be pretty unuseable if it keeps that up at high speed.
NASA 1: Yes, I noticed that on the 52, Mike. I don't think it will be quite like that once you get away from the 52.
Mike: Ok.
Chase: John, 2A departing.
NASA 1: Ok, Einar. You didn't burn out of fuel, did you?
Chase: Not yet.
NASA 1: Ok, lets call this 14 minutes Mike, 14.

14 MINUTES TO LAUNCH

Mike: I got your 14. Hydraulics are swapped and pressures are down to 2700.

NASA 1: Mighty fine.
008, NASA 1, we could do the pitch and the yaw pulses now, please.
008: Roger, here comes the pitch.
NASA 1: Ok, that was a good pitch.
008: Yaw.
NASA 1: Ok, good yaw pulse. Those were dandy.
Mike, you did say 27 on the hydraulics, didn't you?
Mike: Thats affirm, both of them.
NASA 1: Ok, great.
We will be pretty close to level here for a bit, why don't you go erect switch to erect and fast erect on. And, we just passed 13 minutes and that finishes page 11.

13 MINUTES TO LAUNCH

Mike: Roger.
Chase: Hey, John, who's in the lifting body this morning. Is it War?
NASA 1: No. "Mike Love, not War!"
12 minutes now, 12 minutes.

12 MINUTES TO LAUNCH

Mike: Getting another message from the General here.
John, have you heard how happy Bill Dana is that he's not going to be the permanent controller?
NASA 1: No, how happy is he?
Mike: He is very excited about it, but the F-15's got him anyway.
008: Level at 45 now.
NASA 1: Ok, great. Ok, we got 11 minutes.
We can go through the trim settings, Mike.

11 MINUTES TO LAUNCH

Mike: Roger. 40 on the uppers, 10 on the lowers, ailerons zero, aileron bias at 7. Rudders are 1/2 left, rudder bias is zero.
Chase: Looks good here.
NASA 1: Ok, we like the trims down here, Mike.
Mike: Ok.
NASA 1: Ok, Mike there is 10 minutes, 10 minutes.

10 MINUTES TO LAUNCH

Mike: #1 is down at 3700, #2 is 4000. Control gas is 480, Governor Balance is 430. Fuel Pressure 3700, LOX 2500, gear 3200.
NASA 1: Roger Mike, understand.
Mike: George, what's our heading?
008: 187, right now.

Chase: Chase has 184.
Mike: Ok, I'll set 184. No offense, George.
NASA 1: Ok, Mike, we just passed 9 minutes.

9 MINUTES TO LAUNCH

Mike: Roger. Erect switch cutoff and fast erect off.
NASA 1: Roger.
Chopper: Save 93 is in orbit.
Mike: John, both attitude indicators are in fine shape.
NASA 1: Good show, Mike.
Ok, 8 minutes now and you can start your turn, 008.

8 MINUTES TO LAUNCH

008: Ok.
Mike: Ok, standby for a rocket check, Chuck.
Chase: Ok. There it is.
NASA 1: Ok, chamber pressures look good down here, Mike.
Mike: Roger.
NASA 1: Ok, Mike, 7 minutes, 7 minutes.

7 MINUTES TO LAUNCH

Mike: Roger, I am on X-24. Primary is good.
Lets go secondary.
NASA 1: Roger.
Mike: 5, 5, 1.
NASA 1: We got a little modulation at the tail end so we are in good shape.
Mike: Ok, you were really booming on guard.
NASA 1: Ok. Ok, 6 minutes to launch, 6 minutes.

6 MINUTES TO LAUNCH

NASA 1: Chase airplanes, check your windshield heat.
Mike, if you're down to 200, you can trim to 27.
Mike: We got 205 right now, John.
NASA 1: That's good. A little more Mike, we've got 26.
Ok that looks good, 27 is there.
008, can you steepen your turn just a little bit please?
008: Roger.
NASA 1: Ok, 5 minutes, Mike, 5.

5 MINUTES TO LAUNCH

Mike: Roger. DC power switch to battery. Emergency battery light is off. Hydraulics are swapped, pressures are back up to 3200.

NASA 1: Good show, Mike.
Mike: #1 is 125, #2 is 110, #3 is 90, and #4 is 35.
NASA 1: Very good.
008, 360 for a heading.
008: Roger.
Mike: Coming 5, 5, 5 on the SAS gains and another old SMRD.
NASA 1: Looks great, Mike.
Mike: A torque, no lite. #1 servos off, a torque, 3 ambers.
NASA 1: Very good.
008: Electrical power is off and the ammeters are zero, John.
NASA 1: Roger.
Mike: #2 servos are off and a torque, 3 reds.
NASA 1: Thats good. You've passed 4 minutes and are doing great.

4 MINUTES TO LAUNCH

Mike: SAS 4, 3, 2 and servos coming to auto.
SAS lights are reset. Torque and no lites.
NASA 1: Ok, that was a dandy check, Mike. You are doing real great. We have got a 1/2 minute to go here to 3.
Mike: Roger, I'll standby.
NASA 1: Roger. Ok, Mike, lets call that 3 minutes, 3.

3 MINUTES TO LAUNCH

Mike: Ok, I am on X-24B oxygen. I have 85 regulated pressure, and 1750 oxygen cylinder.
NASA 1: Ok, Mike.
Mike: X-24 air is on and I am reading 3000, dropping a little. Cabin altitude is 25,000.
NASA 1: Real good.
Mike: Canopy heat and forward canopy defog is on. Suit vent going to low.
NASA 1: Roger, Mike.
Mike: #1 is 3650, #2 is 4000. Control Gas is 480, Governor balance is 440.
NASA 1: Ok, read you, Mike.
Mike: Erect switch erect, fast erect on and I am rechecking my trims.
40, 27, zero, 7, and zero.
NASA 1: Ok, and we like all your trims. They are good and we are in good shape. Ok, 008, 2° left please.
Ok, Mike, there is 2 minutes, 2 minutes.

2 MINUTES TO LAUNCH

Mike: Release pressure low light is out, 1 & 3 hydraulics are on.
NASA 1: Ok, very good.
008: B-52 air is off, beacon is off, and the pressures are good, John.

NASA 1: Ok, Victor, thanks.
008, we would like 2 more degrees left, 2 left.
008: Roger.
NASA 1: Ok, Mike Love, we are coming up on 70 seconds, now!
Mike: Got you, 70 seconds.
NASA 1: Ok, Mike, there is one minute, now.

1 MINUTE TO LAUNCH

Mike: Clocks running, John.
#1 is 3650, #2 is 4000. No SAS lites and heading 359.
α is 3.5 on both, β is a little bit to the left, about a degree. Erect switch is cutoff, fast erect is off.
NASA 1: Real good here, Mike.
Ok, Mike, systems OK.
There is 30 seconds now, and I'll give you a 10 second call.
Mike: Roger, got your 30 second call.
There's my view of 20.
NASA 1: Get your release circuit and recorder on.
Mike: Roger, camera and recorder on.
NASA 1: Ok, Mike.
Ok, coming up on 10 seconds, now.
Mike: Roger, got your 10.
5

LAUNCH

NASA 1: Ok, Mike, you are on your way. It looks mighty fine.
Very little roll off. $10°\alpha$.
Mike: Roger, coming up 10, John.
NASA 1: Ok, real good. A real nice heading going for you. You can start thinking about coming to 12.
Mike: Up to 12 now.
NASA 1: Ok, Mike, looks great. You can standby for your doublets and your roll maneuvers.
Mike: Roger.
NASA 1: Your heading still looks very good. You can shade it left if you do anything at all once you get your rolls.
Mike: Ok, starting to roll.
NASA 1: And we are plenty high; maybe 1000' high is all, on the profile. Looking great.
Mike: Roger, I am looking out, John.
NASA 1: Ok, and you might shade it just a tad to the left. We are doing great.
Mike: Roger.
It really whips up when you put some more rudder in there.
NASA 1: Yes. A pretty nice flying airplane, right?
Mike: Yes, and sounds like a glider. Tell Bob Hoey.
NASA 1: Ok.
Mike: Coming left a little bit, John.

NASA 1: Yes, it looks great, Mike. Mighty fine.
Mike: And the α did not sag.
NASA 1: Ok, standby to close up there, Mike.
And we got you coming up on 30 thousand now.
Mike: Yes, I am closing it, John. Real easy to hold that α.
NASA 1: Looks good.
Ok, mach repeater to 3/10th and standby for your pull-up, push-over.
Mike: Roger, John, 3/10th and pulling up at 200.
NASA 1: We show a nice 15 here.
Mike: 15 now, over to 5.
NASA 1: Ok, your track is real good. Coming up on 3 miles right about now. Get your mach repeater to 1.0 and your heading is great. You might shade just a little right, you are converging on the line now.
Mike: Ok, coming back right and I'm pulling at 12.
NASA 1: Ok, 850 to 1000' high. Looks good.
We're just past the 2 mile point.
Give us a rocket check and get your camera on.
Chase: Rocket looks good there, Mike.
Mike: There is the rocket and fin camera.
NASA 1: Understand, you got the camera. We saw the rockets down here. Looked good, and you are 1/2 mile from the highway. Just a little bit outside. Your energy is perfect.
Mike: Roger.
NASA 1: Take a look out now, Mike. You are coming across the highway now.
Mike: Roger, it looks close like you said it would.
NASA 1: Ok.
Chase: 21.5 Mike, when you crossed the highway.
Mike: Roger.
NASA 1: It is just like flying that T-38 now, Mike.
Mike: Roger.
I've got about 250 and 17.5.
Chase: I've got 260 and sameo.
Mike: Ok, and I see the gear handle, John.
NASA 1: I missed that, Mike.
Mike: Tell Stan, I know where the gear handle is.
NASA 1: Roger.
We see your brakes. You still got your brakes out and get your mach repeater.
Mike: Excellent call on the brakes.
Chase: Ok, there is 100' Mike. 35, 20, 3 good ones, 10, 5, 3, 1.

TOUCHDOWN

Chase: How about that!
NASA 1: Very pretty. Good job, Willie. Mike, it looked great.
Mike: Thanks, John.

Mike: Nose gear steering, John.

NASA 1: Ok, good call. For you guys, it'll be 11:15 debrief. You just keep a doing what you are doing, Mike. You might try the various things. I guess you are probably out of rudder and aileron so if you feel like a little brake, help yourself.

Mike: Just looked at the steering, getting on the brakes now.

NASA 1: Ok, Mike.
Ok, Mike, that was a real beauty. We see you coming to a halt here. Go to page 21.

Mike: Roger. Ok, throttle off, camera is coming off.

NASA 1: Roger.

Mike: And I will give you a calibrate when you are ready.

NASA 1: Roger, we are ready for a calibrate now. Ok, that was a good calibrate.

Mike: Ok, recorder's coming off.

NASA 1: Very good.

Mike: KRA back to manual.

NASA 1: Roger.

Mike: SAS servos coming off.

NASA 1: Ok.

Mike: Ok, all hydraulic pumps coming off.

NASA 1: Ok, Mike.

Mike: Canopy defog coming off. Ok, lets see, I got #1 is 36, #2 is 3750, control gas is 495, governor balance is440, fuel pressure is 25, lox pressure is 11. Cabin air, the amount remaining is 900.

NASA 1: Ok, 900 and tell me your oxygen again please. On the breathing oxygen.

Mike: Oxygen is 1100.

NASA 1: Ok, Mike.

Mike: Radar is off.

NASA 1: Roger.

Mike: Stick shaker is coming off.

NASA 1: Ok, Mike.

Mike: Attitude system is off, back-up off and the inverter is off and we are ready to open the canopy.

NASA 1: Ok, Mike, I will leave you alone and that was a dandy.

FLIGHT 6

Preliminary Results of X-24B

Flight B-6-13
15 November 1973

by

AF/NASA X-24B Project Team

X-24B Flight Request
19 October 1973

Flight No: B-6-~~11~~ 13

Scheduled Date: 31 October 1973

Pilot: John Manke

Purpose:
1. Powered Flight Checkout
2. Stability and Control at .8 Mach Number
3. Aft Fuselage, Upper Flap and Fin Pressure Survey
4. Boundary Layer Noise and Vibration Experiment (RED PLUG)

Launch: West of Rosamond, Mag Heading 060° + Cross-wind Correction Angle. 40,000 feet, 185 KIAS. Flap Bias "Manual", Upper Flaps = -40°, Lower Flaps = 26°, Rudder Bias Mode "AUTO", Rudder Bias = 0°. Rudder Trim = 1/2° Left. Aileron Bias = 7°, SAS Gains 7, 3, 3. Mach Repeater "Manual" = 1.0, KRA "AUTO", Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #2 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	Mn	EVENT
1	0	40	185	5	.62	Launch, Lite Chambers #2 and #4 Then #1, Trim to and Maintain 14°α Until θ = 20°.
2	25	37	250	14	.77	Max Mach During Rotation.
3	38	37	235	14	.74	θ = 20°, Maintain θ = 20° (Not to Exceed 14°α).
4	141	46	210	12	.80	Trim to 12°α, Perform Rudder and Aileron Doublet.

ITEM	TIME	ALT	A/S	α	Mn	EVENT
5	164	48	215	12	.85	At .85 Mach (True) or Call From NASA I Based on Ground Position, Shutdown Engine with Engine Master. Pushover to 5°α.
6	194	43	230	5	.80	At .80 Mach (True) or 43,000 feet Pullup to 15°α, Then Return to 12°α.
7	208	37	245	12	.77	Perform Rudder and Aileron Doublets. Jettison Propellants (360 lbs LOX--5 seconds; 400 lbs WALC--6.4 seconds).
8	224	33	220	12	.64	Intersection, Turn to Low Key Heading. Set SAS Gains 4,3,2.
9	231	27	210	11	.54	Change Configuration to -20° Upper Flaps.
10	268	24	240	10	.48	Perform Pushover-Pullup 5° to 17° to 10°α. #1 and #3 Hydraulic Pumps on.
11	305	21	220	10	.48	Low Key, Rocket Check, Fin Camera on, Set Mach Repeater to .3 During Final.

NOTES:

1. Nose Ballast = 260 lbs

2.

	Weight~lbs	cg~%	
Launch	13,495	65.9	
Shutdown	9,026	64.1	
Landing	~8,394	64.0	(gear down)

3. Engine S/N 8, Pump S/N 8A

   Thrust = 2,200 lbs/chamber
   LOX Flow Rate = 4.73 lb/sec/chamber
   WALC Flow Rate = 4.24 lb/sec/chamber

4. Pitch Attitude Null at 20°

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure
2. Electrical or SAS malfunction
3. A/S, altitude, Machmeter failure
4. Angle of attack or sideslip malfunction
5. Any control system malfunction
6. Loss of cabin pressure
7. Turbulence below 10K in excess of ~~light~~ MODERATE
8. Surface winds greater than ~~15~~ 20 kts or crosswind greater than 10 kts
9. Failure of engine control box heater
10. Failure ~~of landing rocket~~ OF STICK SHAKER

(In addition to standard ground rules published in Lifting Body Joint Operations Plan)

Alternate Situations After Launch:

	Failure	Action
1.	Radio, radar, PCM	Proceed as planned.
2.	Total pitch damper failure	Proceed as planned limit Mach number to .8 by shutting down chamber #1. Do not perform 15°α pullup after shutdown.
3.	Total roll or yaw damper failure	Proceed as planned.
4.	A/S, altitude, Mach	Proceed as planned using α, θ and time for profile control.
5.	Attitude System	Proceed as planned using backup attitude indicator.
6.	Delayed Engine Light	Proceed as planned. Use 2.5°θ
7.	Only One Chamber Operates	Vector for RW 02 Rosamond shutdown chamber, jettison, change configuration.
8.	Only Two Chambers Operate	Maintain 14°α, retract upper flaps to 35°. Change configuration to 30° upper flap at .7 Mach No. Shutdown on NASA I call (≈ 205 sec). Perform pulses at pilot's discretion.
9.	KRA "AUTO" Failure	Set to manual 10% and proceed as planned. If "MANUAL" mode inoperative - switch to "EMER" position and set to above value.
10.	Angle of Attack (Indicator Only)	Proceed as planned using backup angle of attack gage. KRA "MANUAL" 10% stick shaker off.

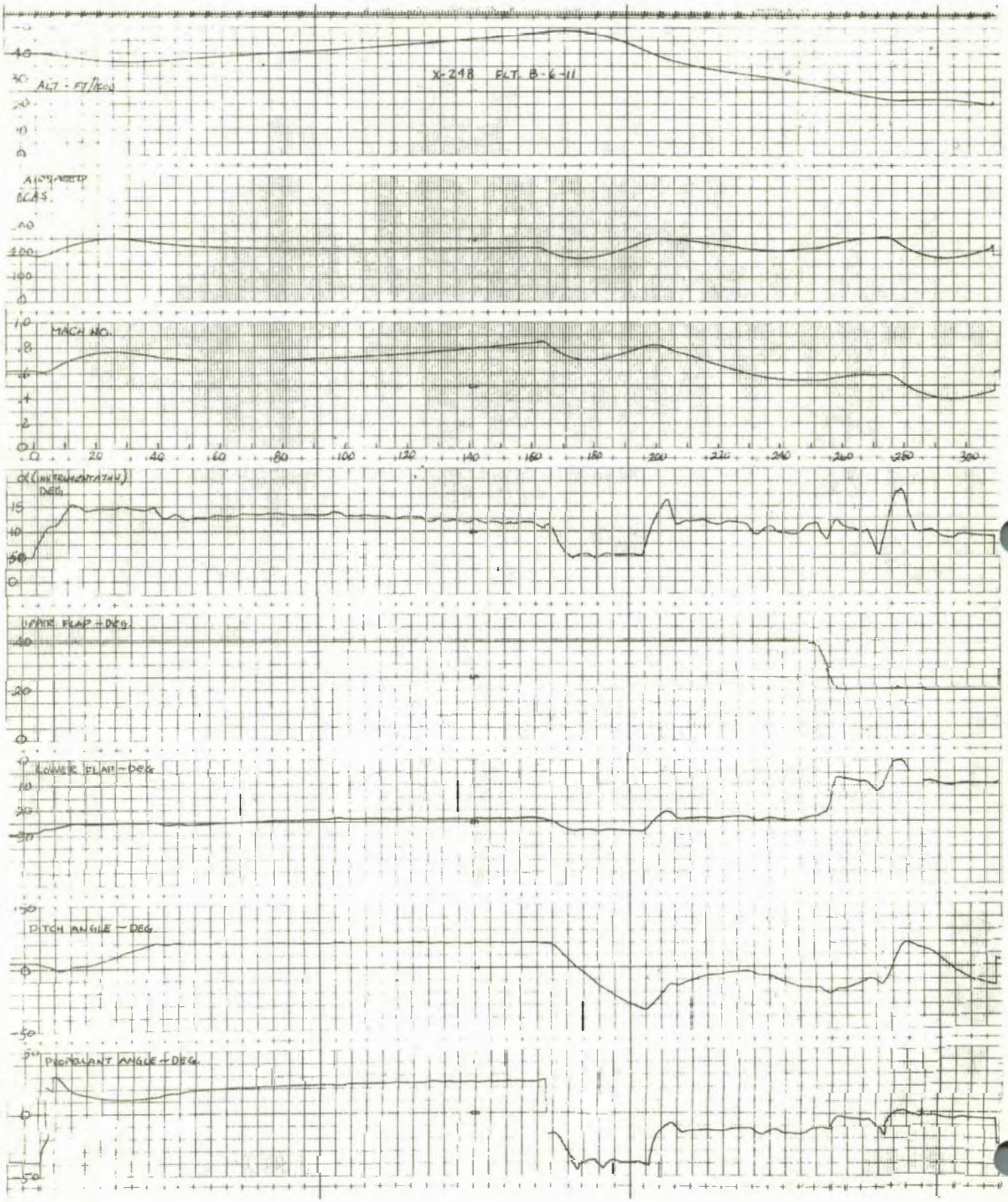
Failure	Action
11. Total Angle of Attack	Maintain θ = 0° to 250 KIAS. Maintain 250 KIAS to 20°θ. Maintain 20°θ. Limit Mach number to .8 by shutting down #1 chamber. Shutdown on NASA I call. Fly airspeed after shutdown. (KRA Manual 10%, stick shaker off)

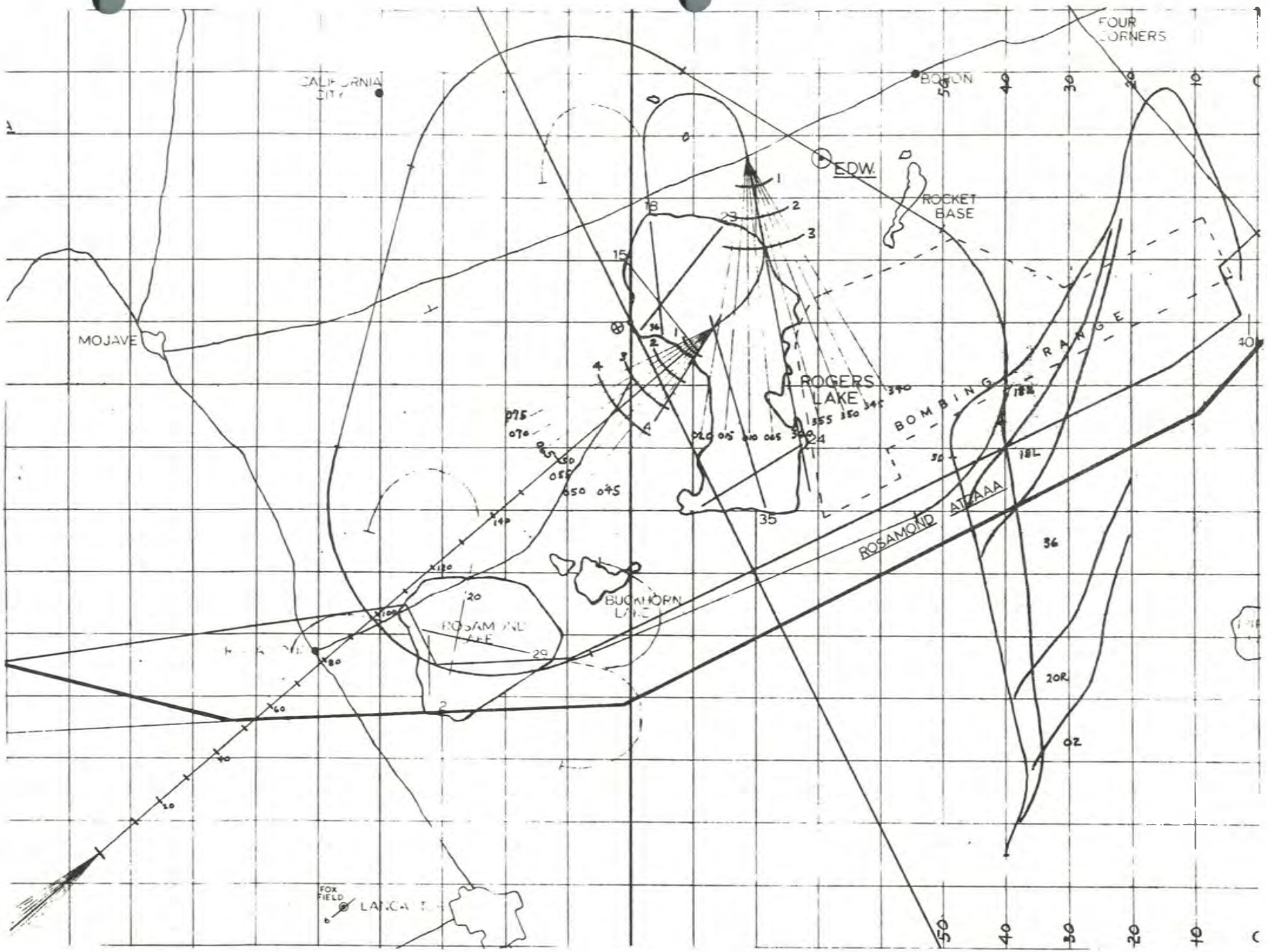
12. Premature Engine Shutdown

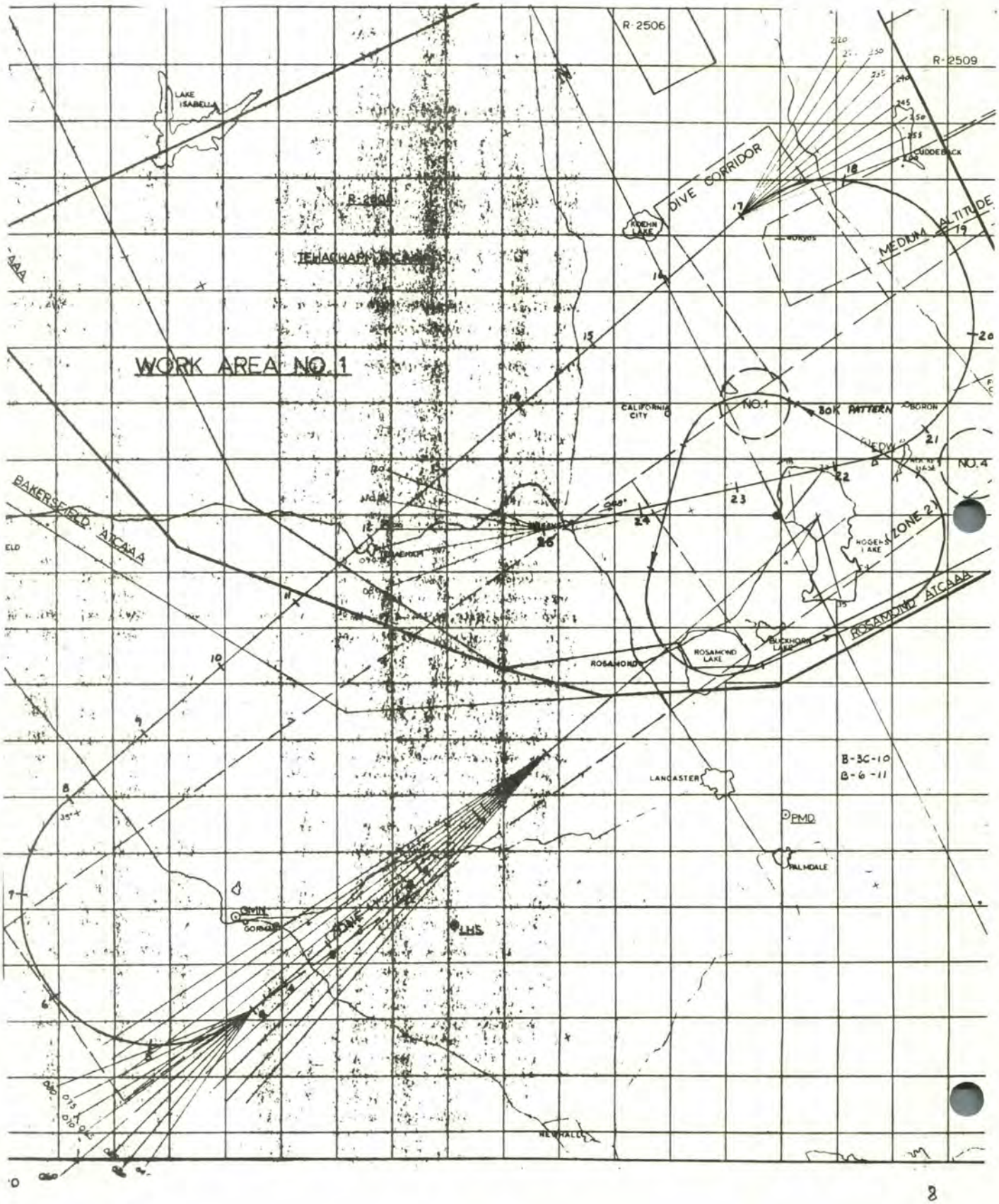
0 - 20 sec RW 2L Rosamond
20 - ~~55~~ 55 sec RW 20R Rosamond
~~50~~ 55 - ~~120~~ 115 sec RW 36L Rogers
~~115~~ ~~120~~ - 135 sec RW 18R Rogers
135 - up sec RW 18L Rogers

Robert G. Hoey
ROBERT G. HOEY

Jack L Kolf
JACK L. KOLF


X-248 FLT. B-6-11
ALT. - FT/SEC
ALTITUDE
BCAS.
MACH NO.
α (INSTRUMENTATION)
DEG.
UPPER FLAP - DEG.
LOWER FLAP - DEG.
PITCH ANGLE - DEG.
PROPULSANT ANGLE - DEG.


FOUR CORNERS
CALIFORNIA CITY
BORON
EDW.
ROCKET BASE
MOJAVE
ROGERS LAKE
BOMBING RANGE
ROSAMOND
ATTAAA
BUCKHORN LAKE
ROSAMOND LAKE
FOX FIELD
LANCASTER
18L
20R
36
35
40
50
30
20
10


R-2506
R-2509
LAKE ISABELLA
DIVE CORRIDOR
MEDIUM ALTITUDE
WORK AREA NO. 1
CALIFORNIA CITY
NO.1
30K PATTERN
BORON
NO.4
BAKERSFIELD ATCAAA
ZONE 2
ROSAMOND ATCAAA
ROSAMOND
ROSAMOND LAKE
BUCKHORN LAKE
LANCASTER
PMD
PALMDALE
LHS
B-36-10
B-6-11

X-24B FIT. B-6-13 Events

T.O.D.	MACH	ALT.	KCAS	Event	ΔT
[illegible]				Engine master on	
41.0				Good LOX Prime	
[illegible]				Igniter Test	
:26.5	.615	39713	183	Launch	0.0
:29.5	601	39603	179	Chambers 2 & 4 [illegible] pressure start up	3.0
:32.4	.604	39418	181	#2 Chamber at 100%	5.9
:35.0	.610	39366	183	#1 Chamber pressure start up	8.5
:33.5	.613	39313	184	#4 Chamber pressure at 100%	7.0
:35.1	.630	39138	191	#1 Chamber at 100%	8.6
:57.0	.756	37028	244	Max. A/S during rotation (Mach Sensor .77)	30.5
43:8.0	.[illegible]	37622	232	On 20° θ	41.5
+4:48.8	.844	50838	200	rudder doublet } $\alpha = 11°$ Power on	142.3
:52.1	.871	51343	205	aileron doublet }	145.6
45:2.2	.930	52880	214	Shutdown with engine master	155.7
:2.2	.930	52880	214	Max. A/S at S.D.	155.7
:8.6	546	53150	190	Max. ALT.	162.1
:33.4	.875	46567	231	Start pullup To 15°α	186.9
:37.8	.848	44365	234	at 15.8° α	191.3
:42.2	.847	42489	244	rudder doublet } $\alpha = 12°$	195.7
:45.1	.833	41358	245	aileron doublet } Power off	198.6
:52.4	.778	38900	241	Start LOX Jettison	205.9
:53.2	.773	38668	241	Start WALC Jettison	206.7
46:0.2	.737	36603	240	End LOX Jettison	213.7
:1.0	.733	36366	240	Start Turn at intersection	214.5
:1.2	.73[illegible]	36309	240	End WALC Jettison	214.7
:21.1	.642	30575	237	Pitch Gain To 4, Yaw Gain To 2	234.6
:32.8	.590	27551	231	Start Config. Change, 40°→20° δ_{UB}	246.3
:38.1	.581	26421	234	Start POPU	251.6
:44.2	.586	25259	241	at min. α, α = 2.1°	257.7

T.O.D.	MACH	ALT.	KCAS	Event	Δt
				Stick Shaker on	
:49.8	.577	24176	243	at max. α, $\alpha = 18°$	263.3
				Stick Shaker off	
:51.7	.558	24007	235	return to Trim α	265.2
:55.2	.547	23757	232	#1 & #3 hyd pumps on	268.7
:58.6	.545	23404	232	rocket check	272.1
47:11.2	.549	21420	244	Start Turn	284.7
:49.7	.557	13502	270	Speed brake out To 29° δ_{SB}	323.2
48:12.6	.483	8353	276	Mach Repeater To .3	346.1
:19.3	.478	6934	280	Speed brake in	352.8
:42.7	.448	3150	280	Flare	376.2
49:0.5	.363	2093	231	Gear Down	394.0
:9.3	.281	2036	179	Main Gear Touchdown	402.8
:11.2	.260	2037	166	Nose Gear Touchdown	404.7

Flight Time = 404.7 sec (:06:44.7)

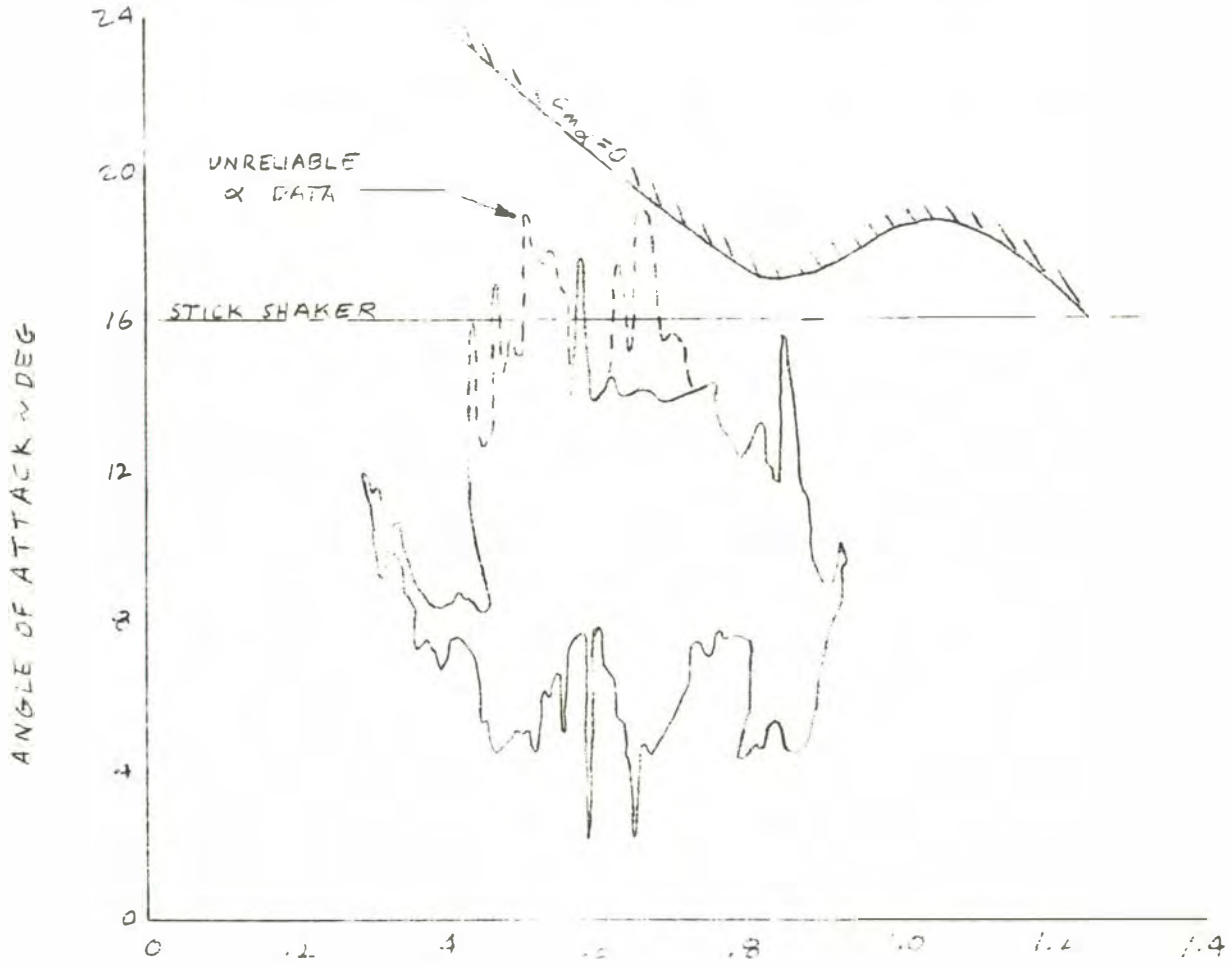
FLIGHT ENVELOPE

R. HOEY

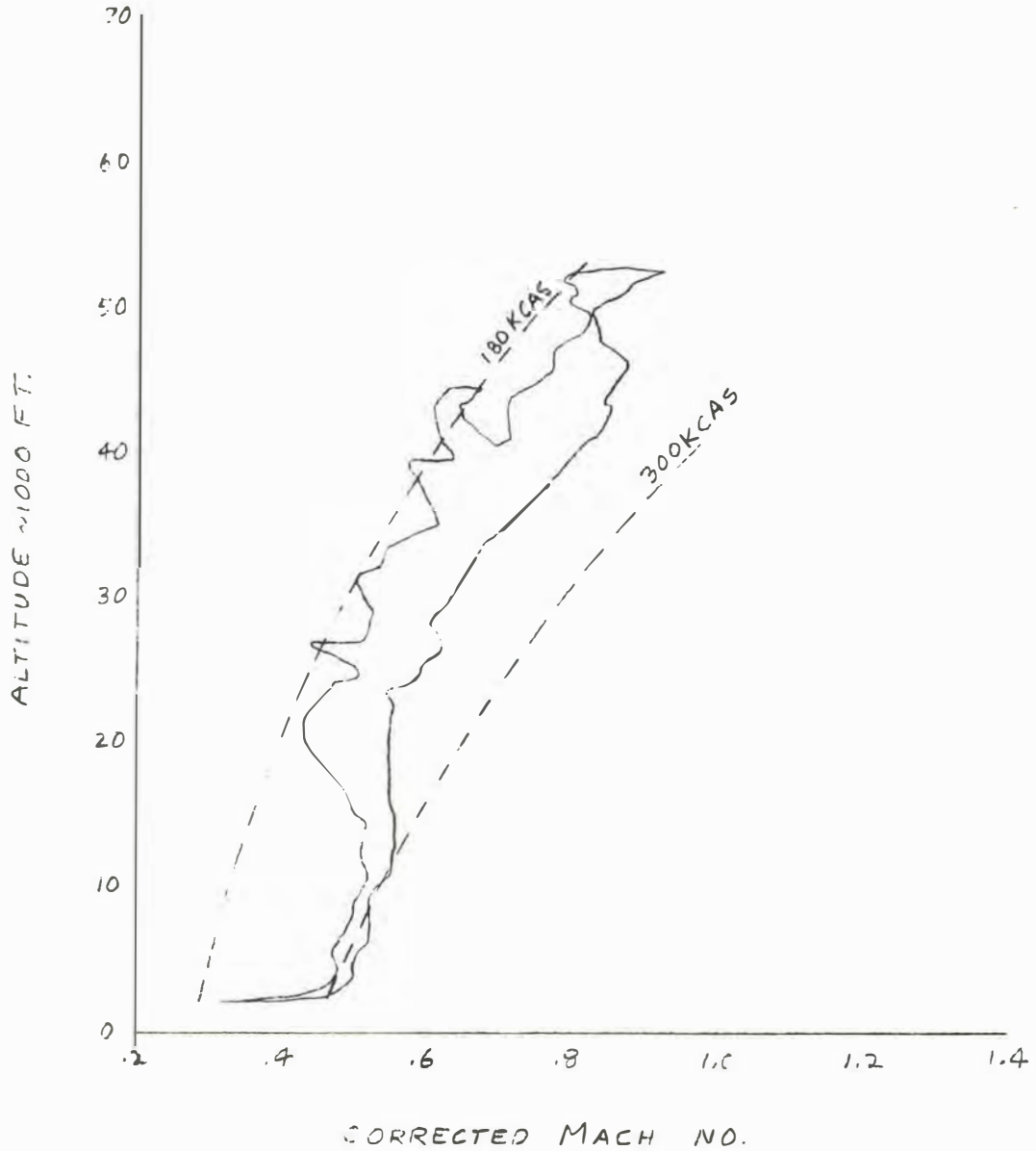
The flight envelope which has been flown on the first 6 flights includes an angle of attack range of approximately 4^{o} to 18^{o} and a true Mach number range of .3 to .92. An airspeed range of from 165 to 305 KIAS has also been flown. The dashed portion of the angle of attach envelope represents data which was obtained on the first 5 guide flights. Discrepancies between the recorded angle of attack and the pilots angle of attack indicator were observed on these flights and all evidence points to an error in the recorded values for angles of attack above 12^{o}. Indicated and recorded values of angle of attack from flight 6 were in good agreement over the entire α range.

X-24B FLIGHT ENVELOPE

FLIGHT 1 THRU 6



X-24B Flight Envelope
Flights 1 thru 6



FLT B-6-13 FLIGHT PROFILE

JOHNNY ARMSTRONG

The actual flight profile of flight B-6-13 was higher than planned and the time required to reach target Mach number was shorter. Figure one is a trace of the real time radar plot of altitude vs downrange and the deviation from the planned profile is readily apparent. This plot also indicates that the vehicle climbed steeper than planned although the pilot maintained the planned pitch angle on his display accurately. This is an indication that the pilots pitch angle was in error.

Figure 2 compares the flight path angle computed from two separate sources. One is that obtained from digital radar data corrected for winds and the other is obtained from pitch angle minus angle of attack from internal data. This also tends to confirm a suspected pitch angle error of 2 to 3 degrees.

A plot of Mach number versus altitude is presented in figure 3 for the planned profile and for the actual, both from internal data and radar. In addition to the actual being higher than planned note that the time to reach comparable Mach numbers was shorter than planned.

A post-flight simulator study was performed to determine the parameter variations that would allow a match of the observed performance. A simulator up date was accomplished prior to planning flight 6 and was based on data obtained when the angle of attack, calibration was suspect (see prel. Flt report Flt 5). A closer match could be obtained when the wind tunnel values of C_c and C_N were used rather than the updated values. The wind effect produced an increase in Mach No.

A reduction of C_c of .005 with the power on was required to match the acceleration observed. This base drag correction factor was half the magnitude that was found necessary in matching X-24A flight profiles. Figure 4 presents a simulator match obtained when using the factors presented on the figure. Note that a 2 degree higher pitch angle was required. Figure 5 summarizes the parameters considered during the simulator matching study as well as the data base used in flight planning the next flight (B-7-14).

B-6-13 PROFILE

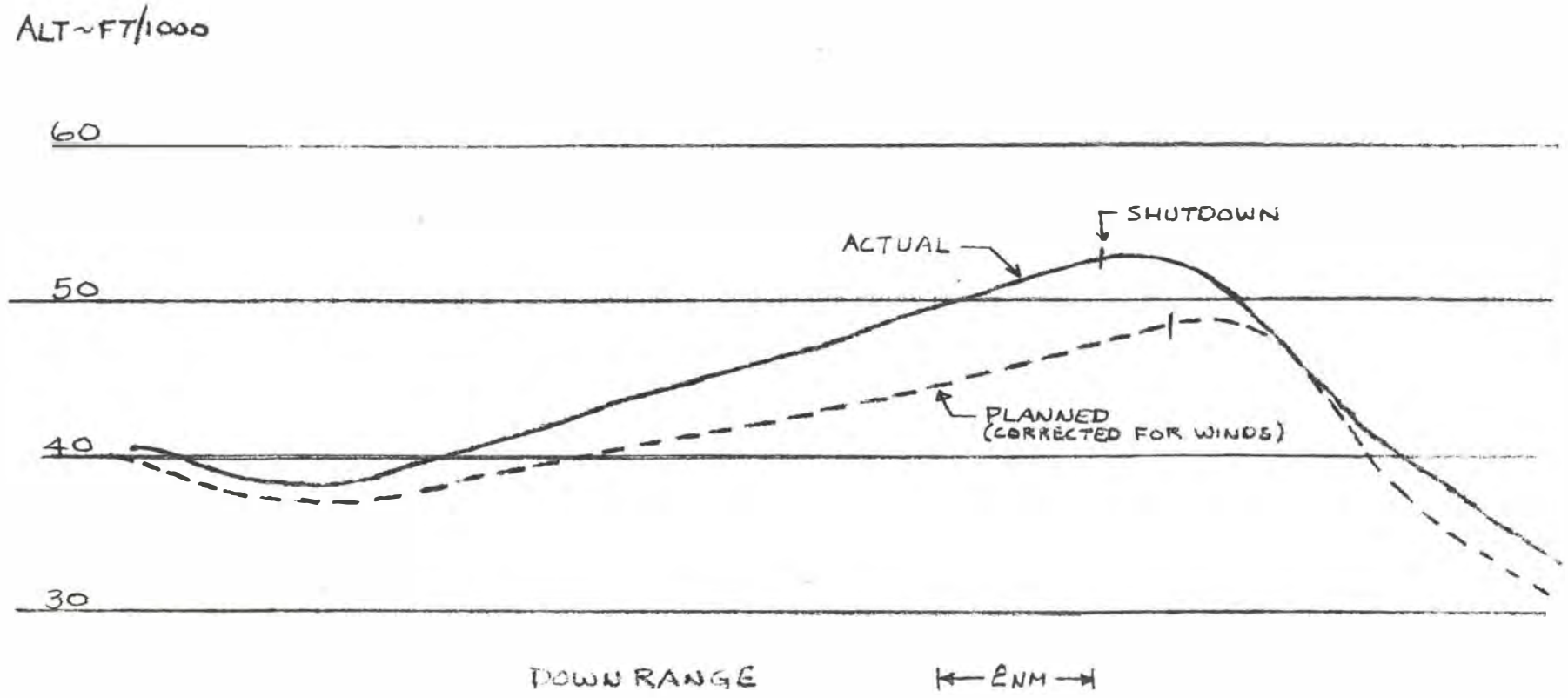


FIG. 1

JGA

B-6-13 FLIGHT PATH ANGLE

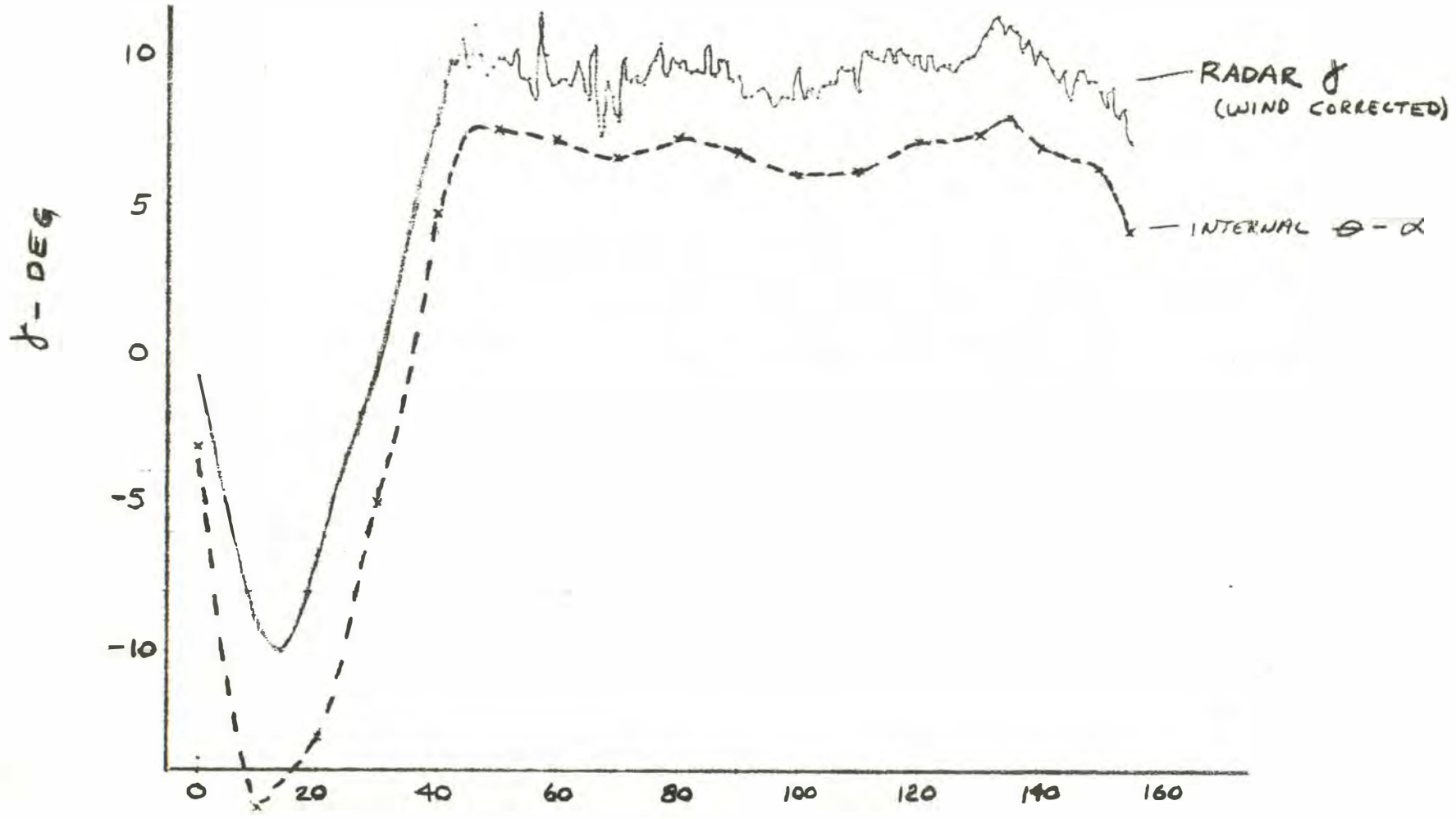


FIG. 2

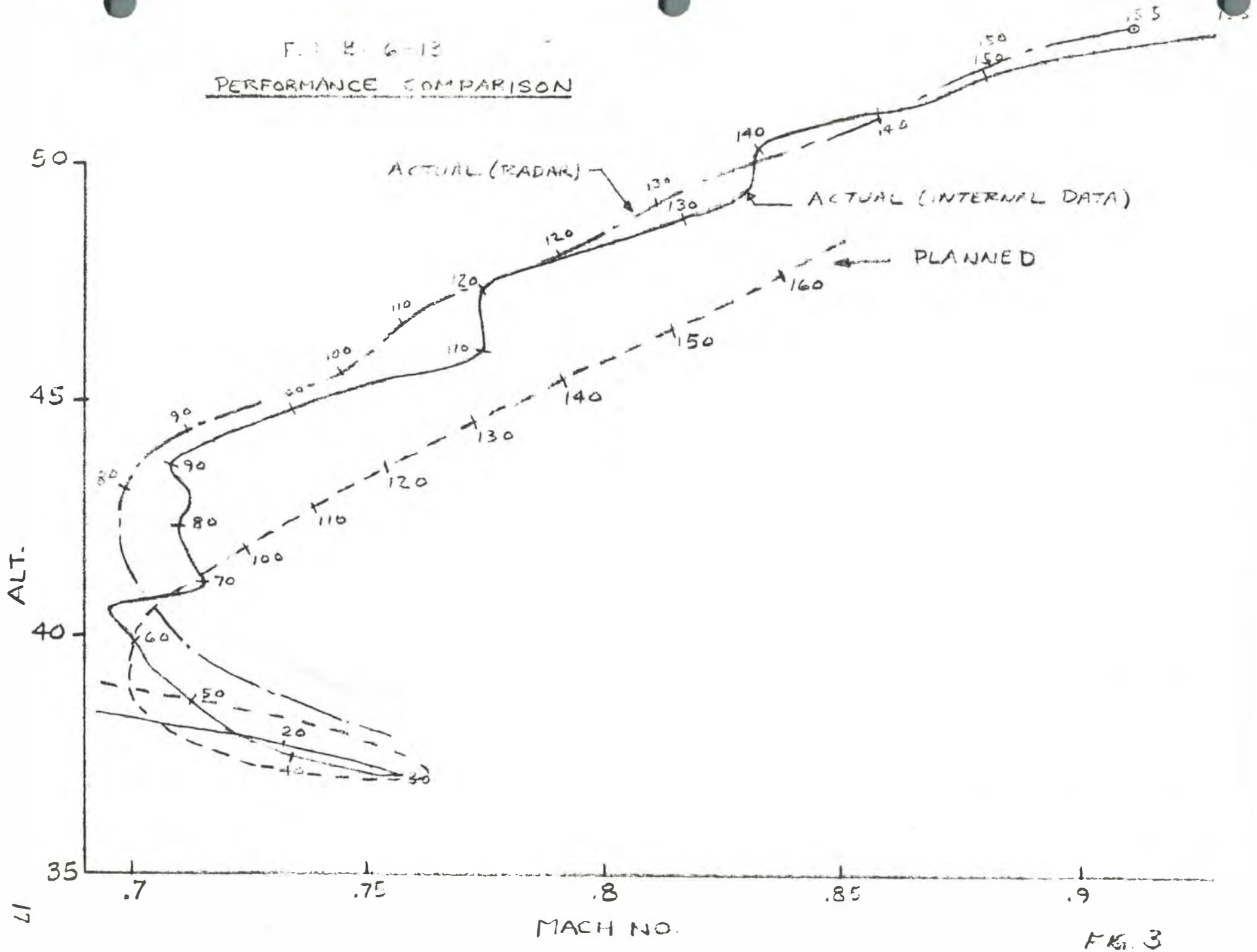
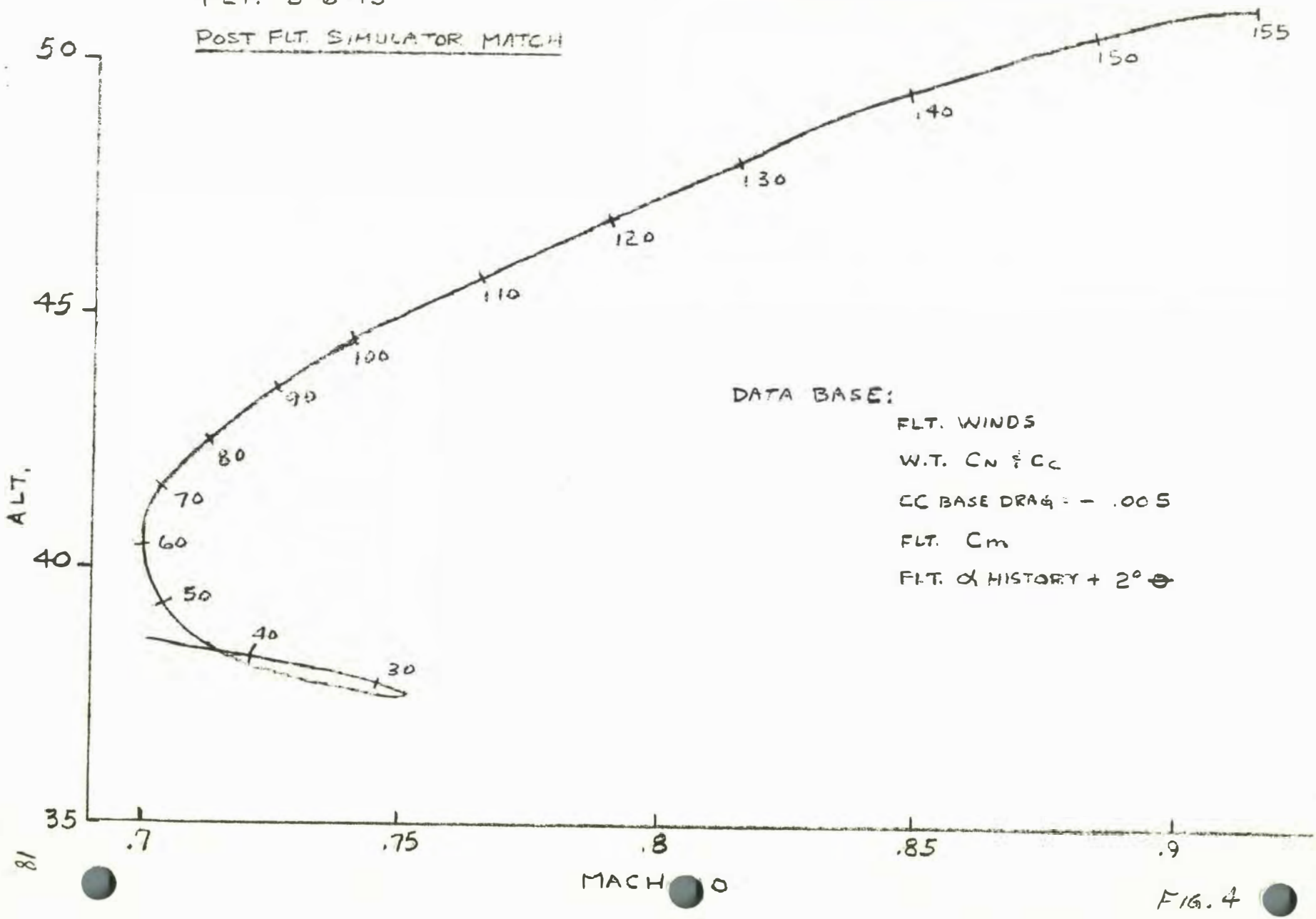

PERFORMANCE COMPARISON
ACTUAL (RADAR)
ACTUAL (INTERNAL DATA)
PLANNED
ALT.
MACH NO.
50
45
40
35
.7
.75
.8
.85
.9

FIG. 3

FLT. B-6-13

POST FLT. SIMULATOR MATCH



DATA BASE:

FLT. WINDS

W.T. C_N & C_C

CC BASE DRAG = − .005

FLT. C_m

FLT. α HISTORY + 2° Θ

81

FIG. 4

B-6-13 PROFILE MATCH

FACTORS CONSIDERED:

WINDS
THRUST
BASE DRAG
LIFT
WEIGHT
WIND TUNNEL DATA
PITCH ANGLE

B-7-14 SIMULATOR BASE

WIND TUNNEL LIFT & DRAG
FLT. TEST PITCHING MOMENT
POWER ON BASE DRAG REDUCTION

FIG. 5

PERFORMANCE AND LONGITUDINAL TRIM

D. RICHARDSON

Performance data obtained during the pullup (Mach = .85) after engine shutdown compared very well with the wind tunnel data.

During previous flights there was doubt about the validity of angle of attack (α) above 12 degrees. As mentioned in previous flight reports the calibration was nonlinear above α = 12 degrees and this nonlinear region was apparently sensitive to excitation voltage and temperature. As a result, the linear region of the calibration was shifted to be between 5 and 20 degrees angle of attack. Pilot callout of α during the flight confirmed the new α calibration. During flight 6 a pushover pullup maneuver was planned at Mach 0.5 in the subsonic configuration for comparison with previous flight data. The actual data maneuver was accomplished at a Mach number slightly greater than 0.5; however, the data did reveal that the normal force compared well with the windtunnel data above α = 12 degrees which was not the case with the previous flight data which used the old α calibration. The chord force data is still slightly greater than the windtunnel data above α = 10 degrees with the results that the maximum L/D is less than predicted by the windtunnel.

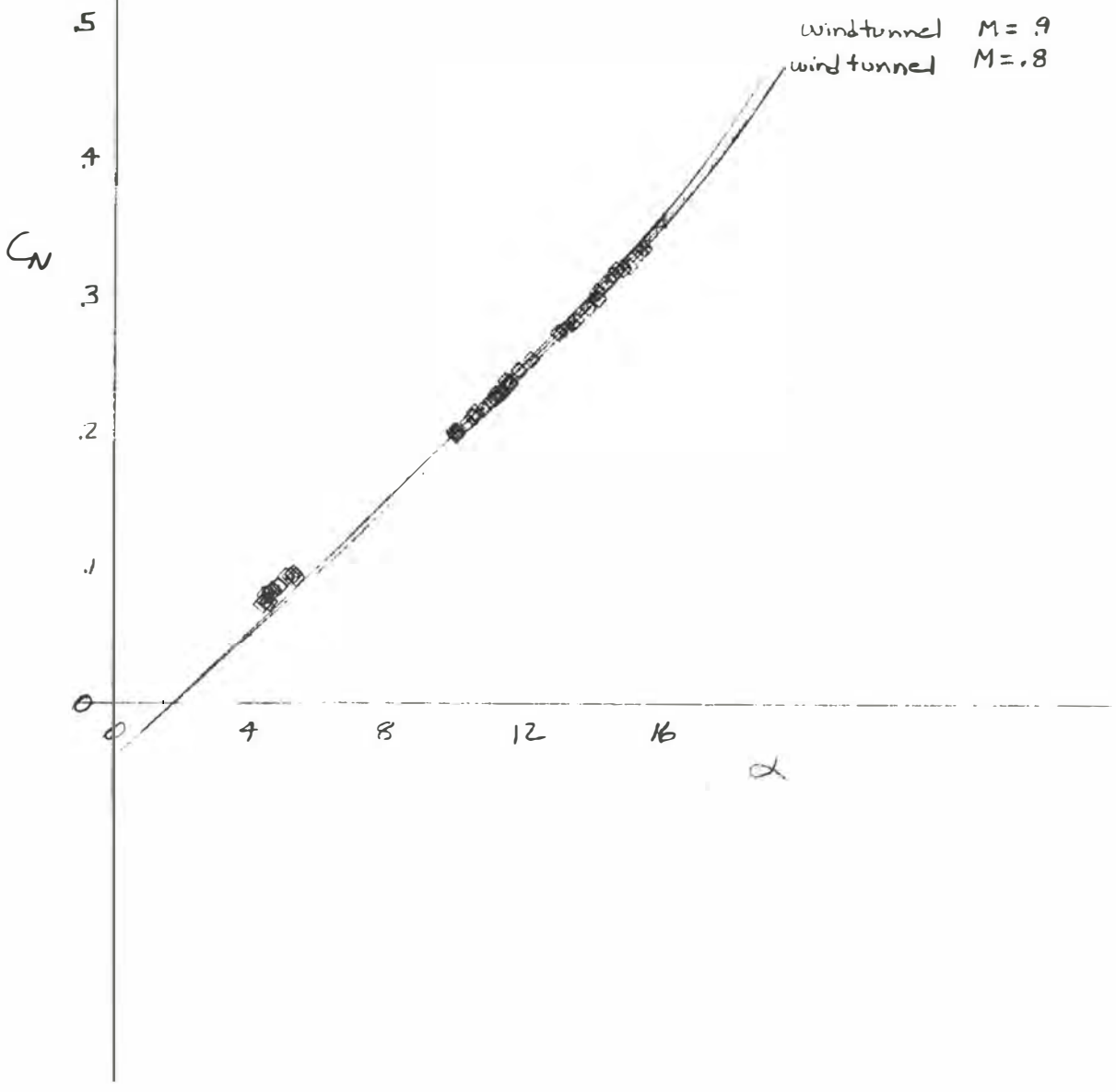
Longitudinal trim data revealed that the trim change with thrust (combination of engine misalignment and aerodynamic effects) was nonexistent.

The trim flight data (power off) in both the transonic and the subsonic configuration still indicate that there is a reduction in the static margin. This data used the new α calibration.

B-6-13 Power OFF

◇ $\delta_U = -37.2°$ $\delta_{RB} = 0°$
$\delta_{AB} = 7°$

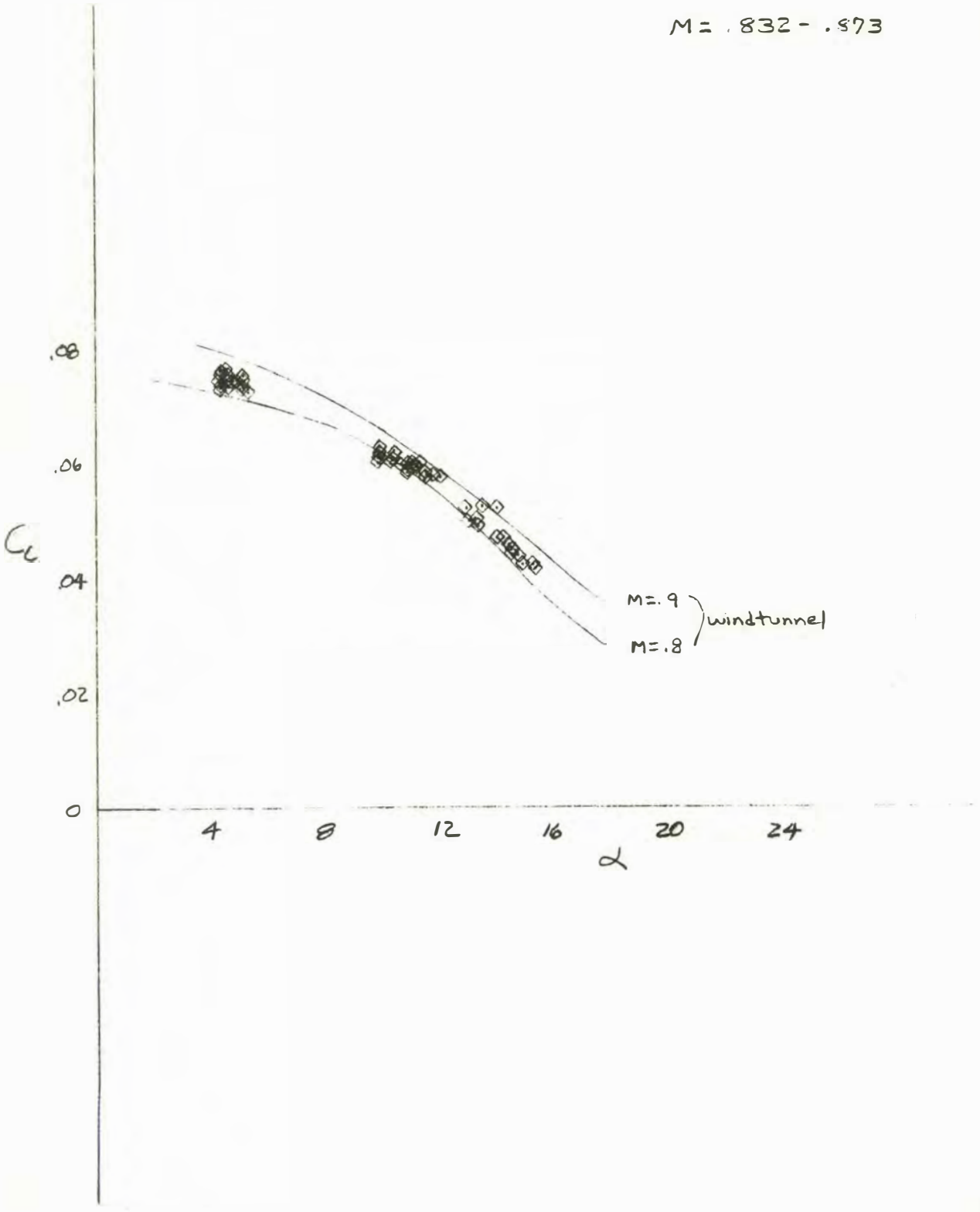
M = .832 - .873



B-6-13 Power OFF

◇ $\delta_{U_B} = -39.2°$ $\delta_{R_B} = 0°$
$\delta_{A_B} = 7°$

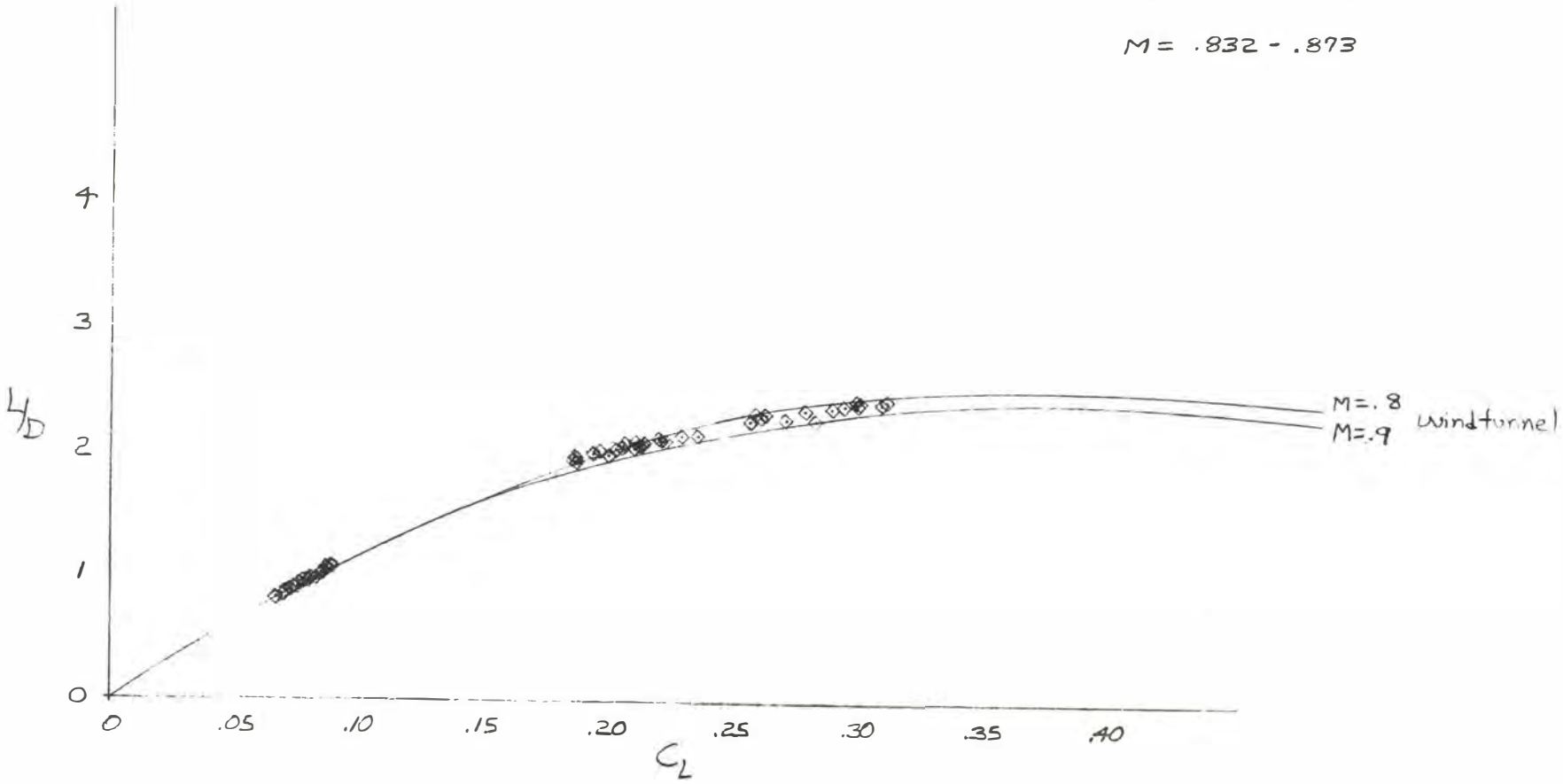
M = .832 - .873



B-6-13 Power OFF

◇ $\delta U_B = -39.2°$ $\delta R_B = 0°$
$\delta A_B = 7°$ CG = 66 3/4

M = .832 - .873

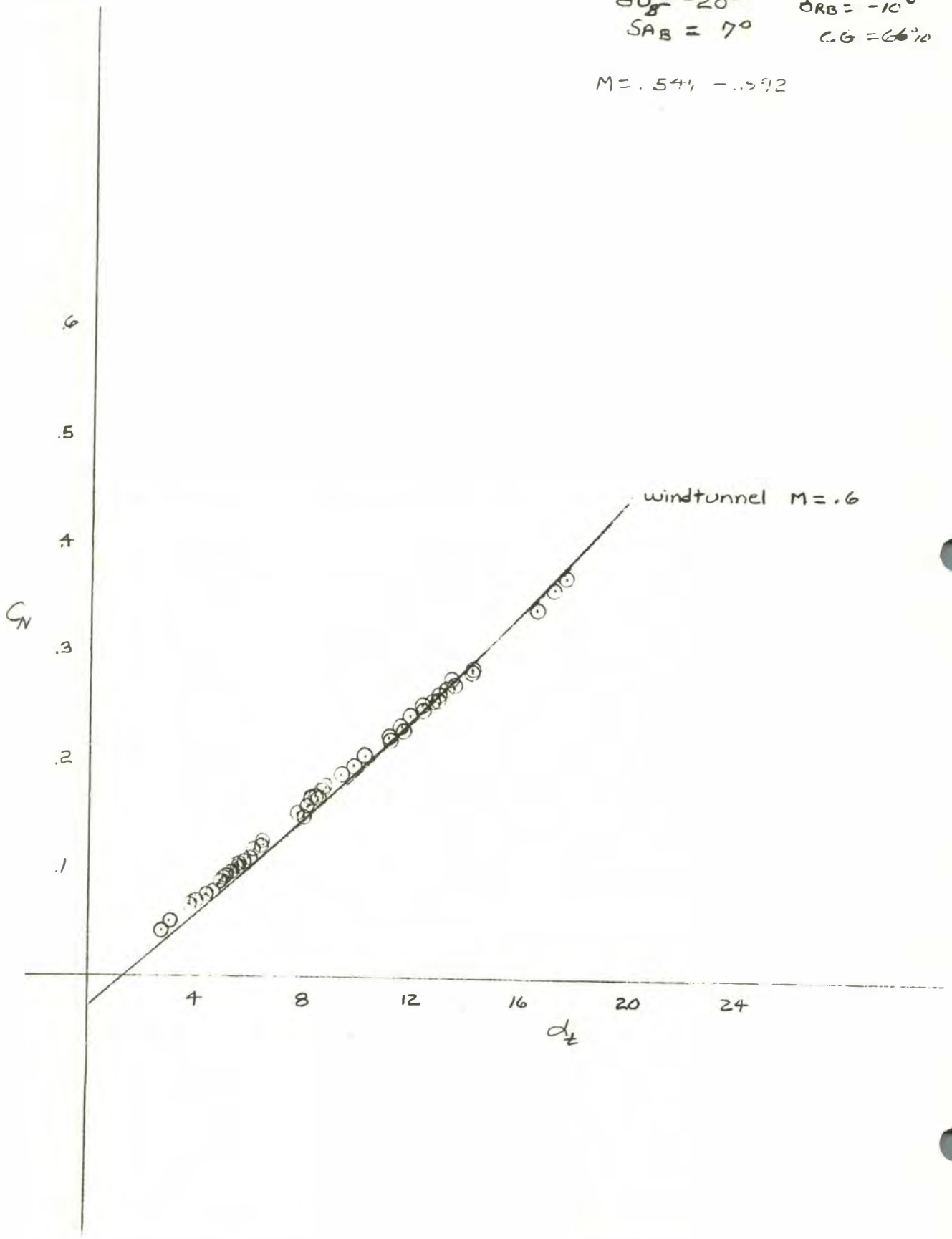


B-6-13 power off

$\delta U_B = -20°$ $\delta_{RB} = -10°$

$\delta A_B = 7°$ C.G = 66%

M = .54 - .592

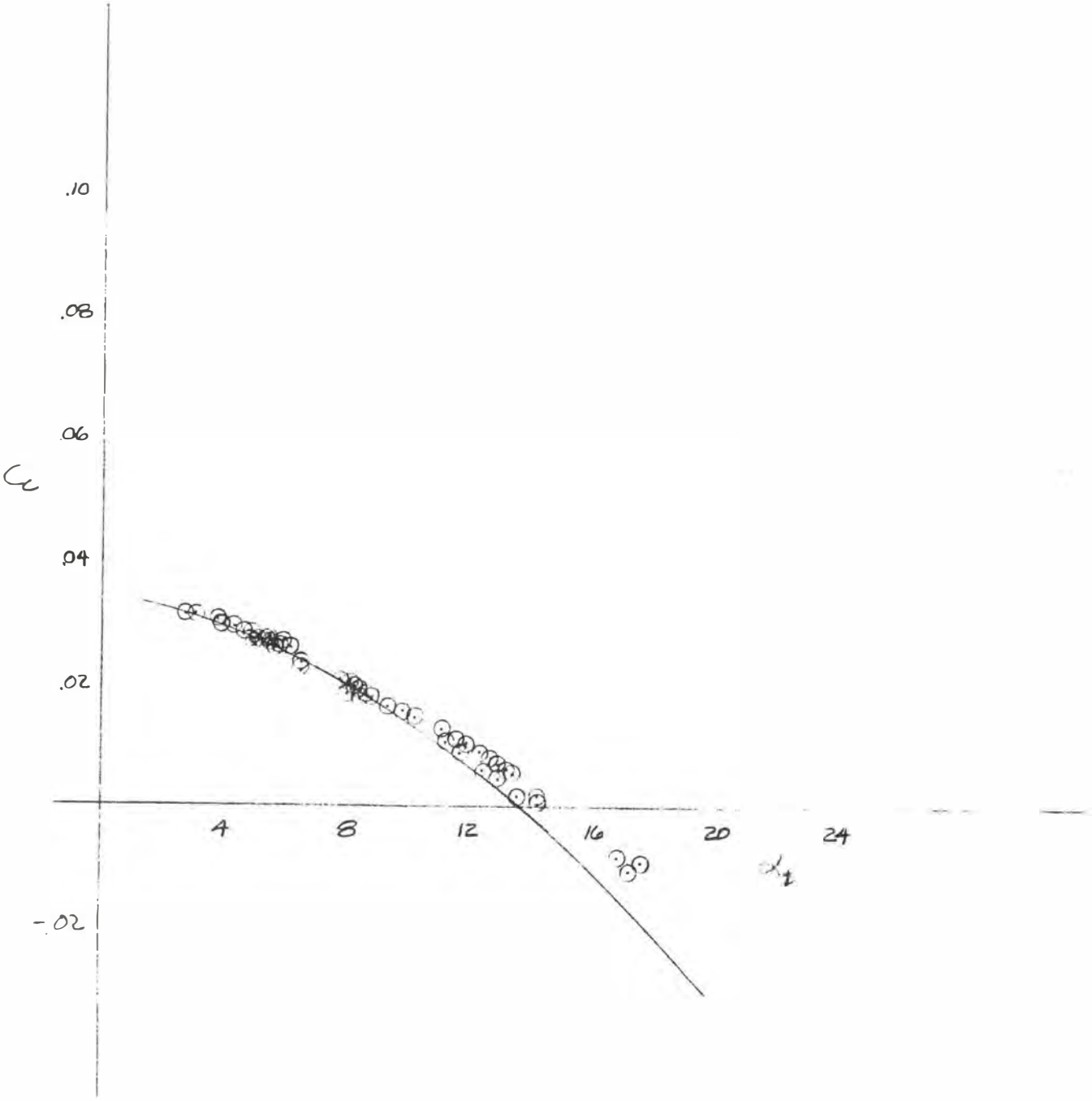


B-6-13 power off

δ_{LE} = -20° δ_{RB} = -10.

δ_{TB} = 7° CG = .65

M = .547 - .592

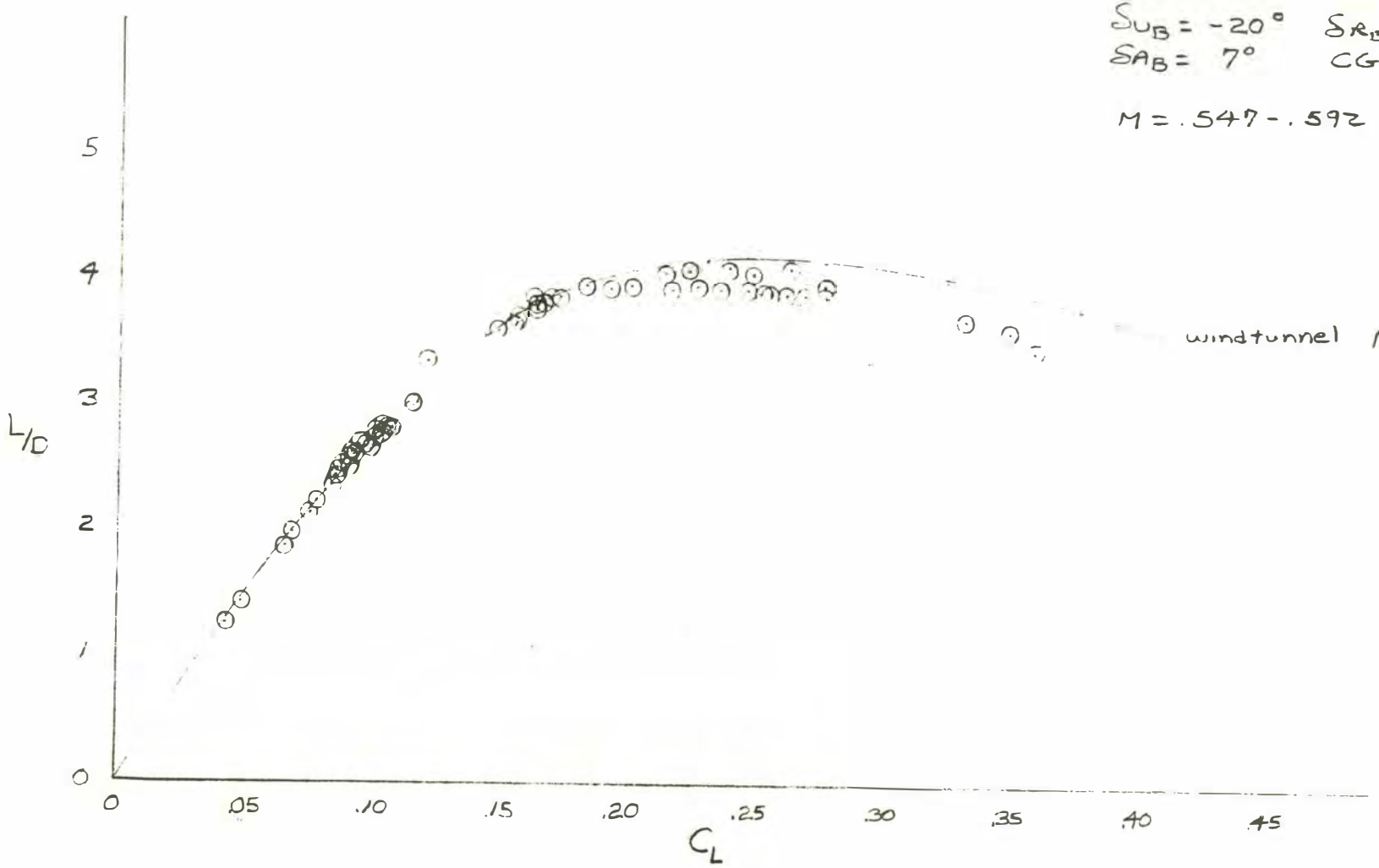


B-6-13 power off

$\delta_{U_B} = -20°$ $\delta_{R_B} = -10$

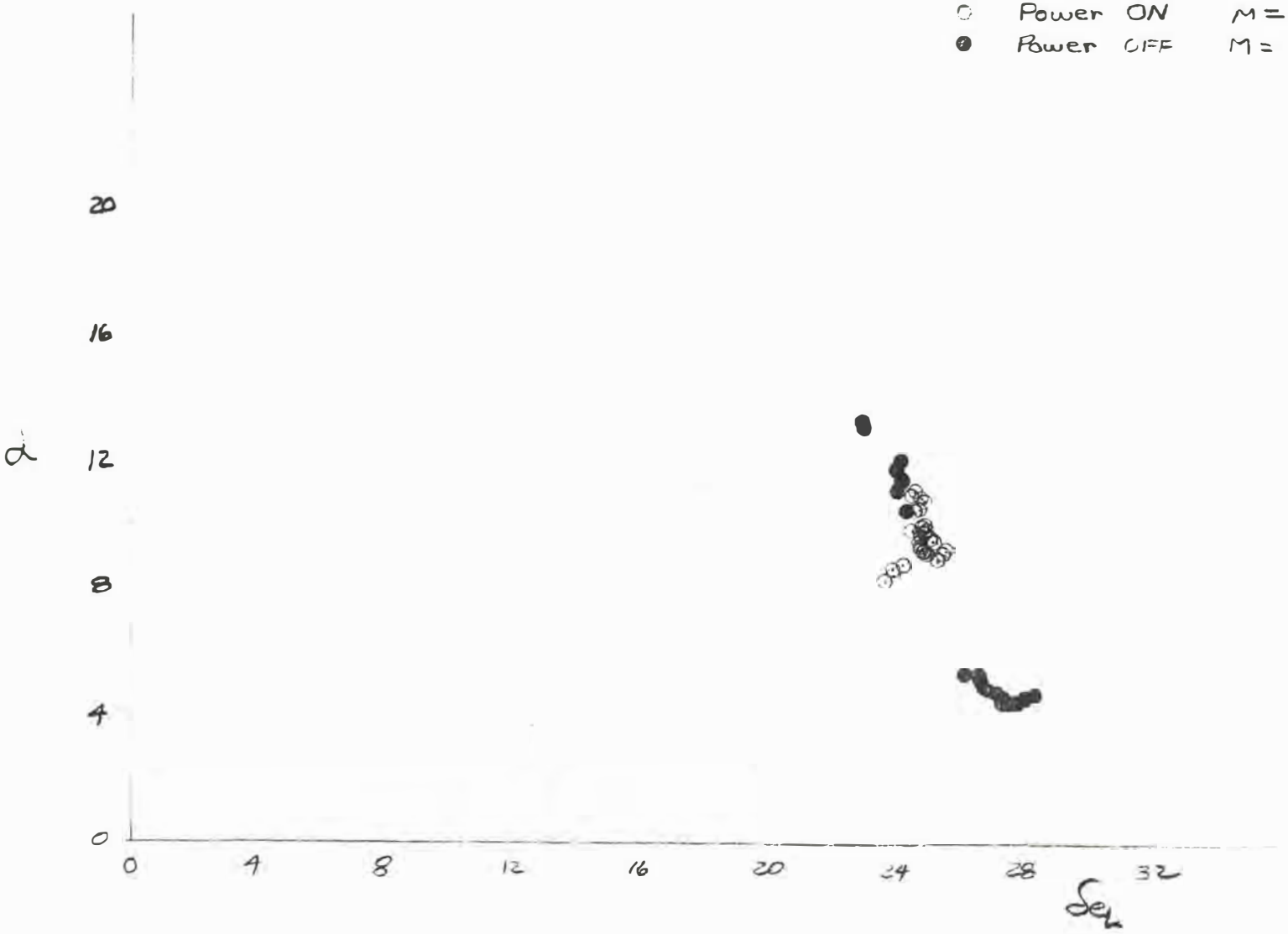
$\delta_{A_B} = 7°$ CG = 66%

M = .547 - .592



B-6-13 $\delta_{u_B} = -3.92°$ $\delta_{SB} = 0°$
$\delta A_B = 7°$ CG = 66%

○ Power ON M = .879 - .929
● Power OFF M = .865 - .873

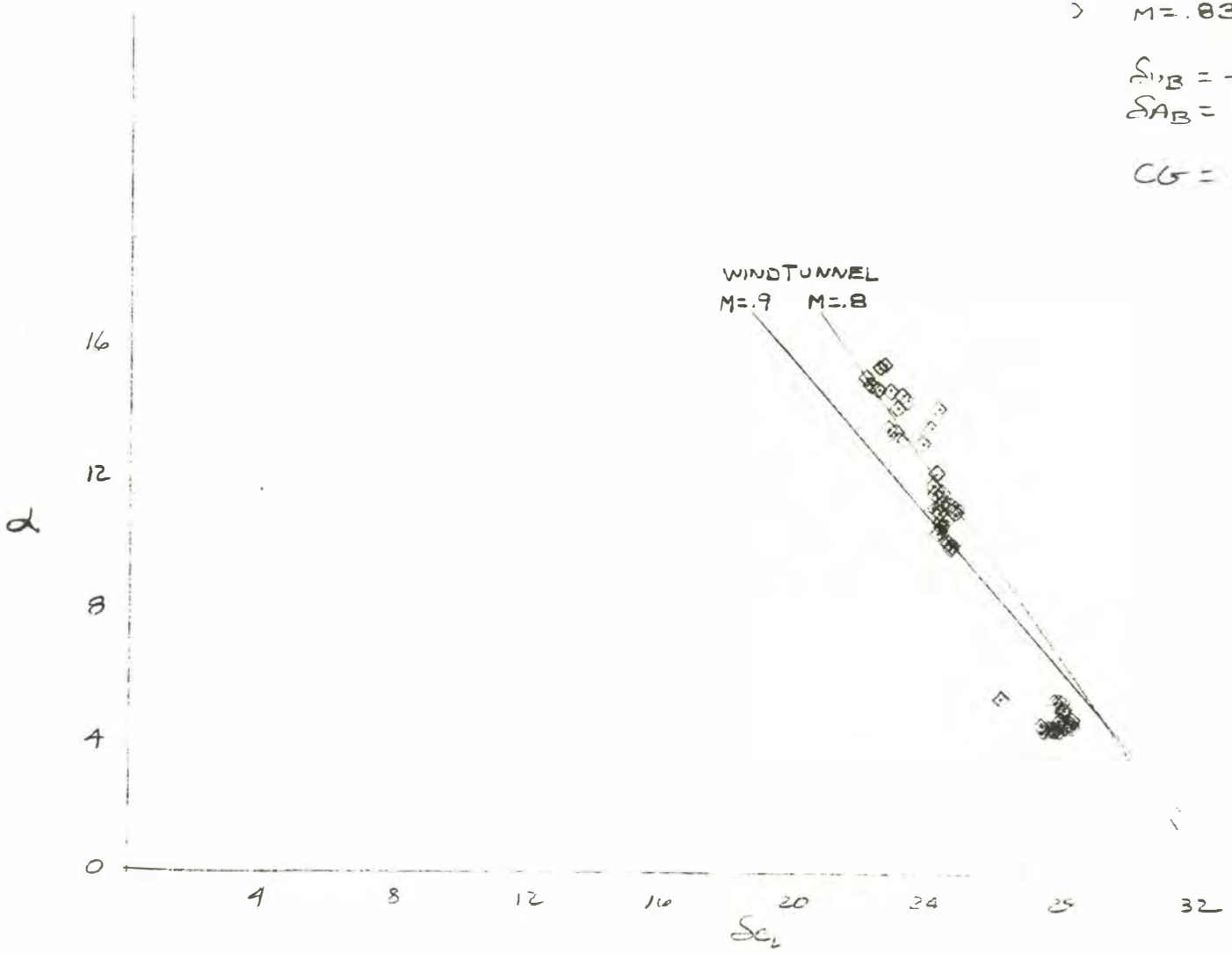


P-c-13 minor aff

> M=.832 -.872

$\delta_{H_B} = -2.7^\circ$ $\delta_{R_B} = 0^\circ$
$\delta_{A_B} = 7^\circ$

CG = 66%



28

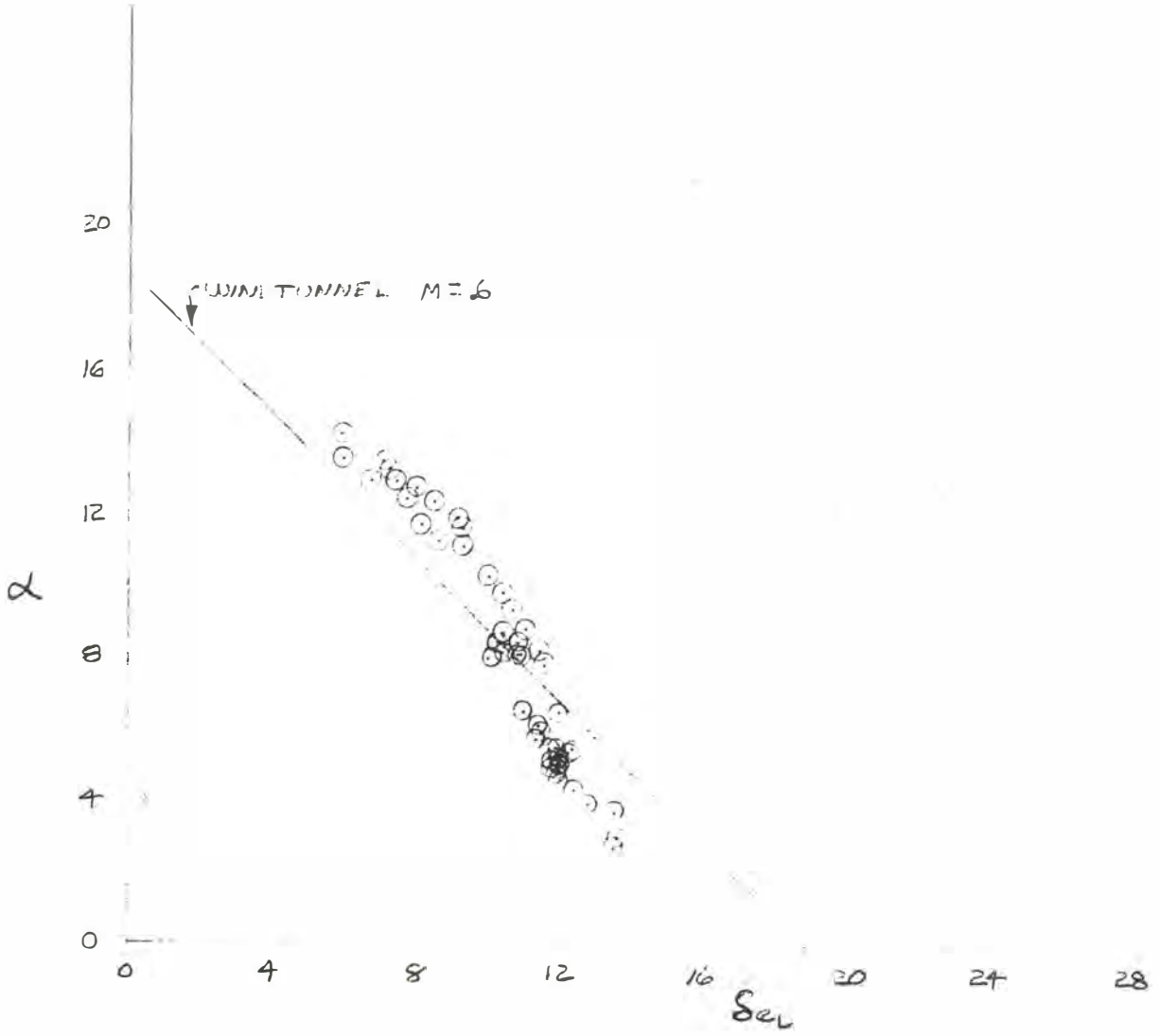
B-6-13 power off

$\delta_U = -20°$ $\delta_{R_2} = -$

$\delta_{AB} = 7°$

CG = 66%

M = .547 - .592

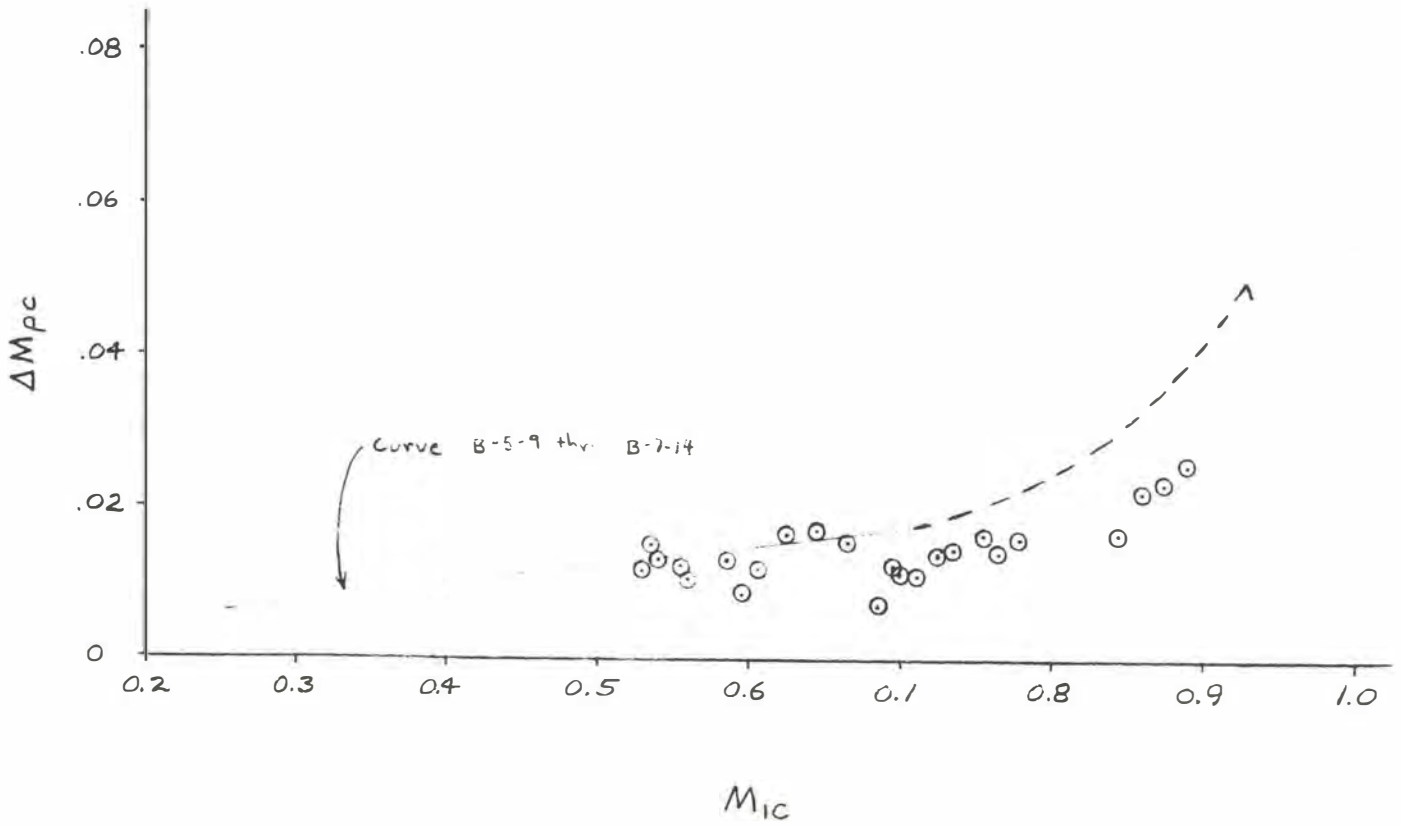


POSITION ERROR

C. NAGY

Position error data worked up for flight B-6-13 show lower values of ΔM in the transonic region than predicted. This trend is confirmed by other flights where data had been thought to be in error. A new curve will be forthcoming after data from B-7-14 is received.

X-24B
POSITION ERROR
FLIGHT B-6-13



X-24B FLT B-6-13

DERIVATIVE EXTRACTION

Paul W. Kirsten

Three maneuvers are presented in figure 1 for flight B-6-13; two lateral-directional and one longitudinal. All flight results were obtained using the NASA-FRC Newton-Raphson program. The two lateral-directional maneuvers were planned rudder and aileron doublet test maneuvers with SAS on. Both lateral-directional maneuvers were performed at similiar flight conditions (Mach and δ), nowever one maneuver was performed power on and the other power off. The longitudinal maneuver analyzed was a small, dampers on pitch transient which occurred at engine shutdown.

Power off wind tunnel data (simulator trim data) for .8 and .9 Mach numbers is shown in the figure as solid and short/long dashed lines. The short dashed line shown in the figure represents power on wind tunnel data for M = 0.9. This data was obtained by applying incremental power effects from the July 73 Langley Jet Plume tunnel data to the M = 0.9 power off data. Power effects obtained from flight data for $C_{l\beta}$, $C_{n\beta}$, and $C_{y\beta}$ (Difference between circle and triangle) agree remarkable well with wind tunnel results. Both the power on and power off flight values of $C_{n\beta}$ were slightly higher than wind tunnel predictions. This agrees with previous results which consistantly showed higher values of $C_{n\beta}$ in the 8^{o} to 12^{o} angle of attack range. Other lateral-directional derivatives obtained from these two maneuvers agree reasonable well with wind tunnel data and are consistant with previous flight results ($C_{n_{\delta a}}$ slightly lower than wind tunnel, $C_{l\beta}$ slightly higher, etc.). The only exception would be $C_{n_{\delta r}}$ which was significantly higher than tunnel data for the power off maneuver.

Results obtained from the M = 0.9 longitudinal maneuver are also shown in figure 1. Consistant with results obtained previously at lower Mach numbers, $C_{m\alpha}$ is again significantly lower than wind tunnel data. Other longitudinal derivatives compared well with tunnel data with the exception of C_{m_q}. However C_{m_q} cannot be extracted accurately from flight data for this type of maneuver (low amplitude, SAS on).

X-24B
TRIM DERIVATIVES
FLT B-6-13
$\delta_{H_B} = -40^\circ$ $\delta_{R_B} = 0^\circ$ $\delta_{A_B} = 7^\circ$

M		
0.8	——	SIMULATOR TRIM DATA 65%
0.9	— — —	
0.9	- - - -	INCREMENTAL W/T JET EXHAUST DATA
0.9	△	POWER ON FLT. DATA
0.84	○	OFF NEWT-RAPH. 65% c_g

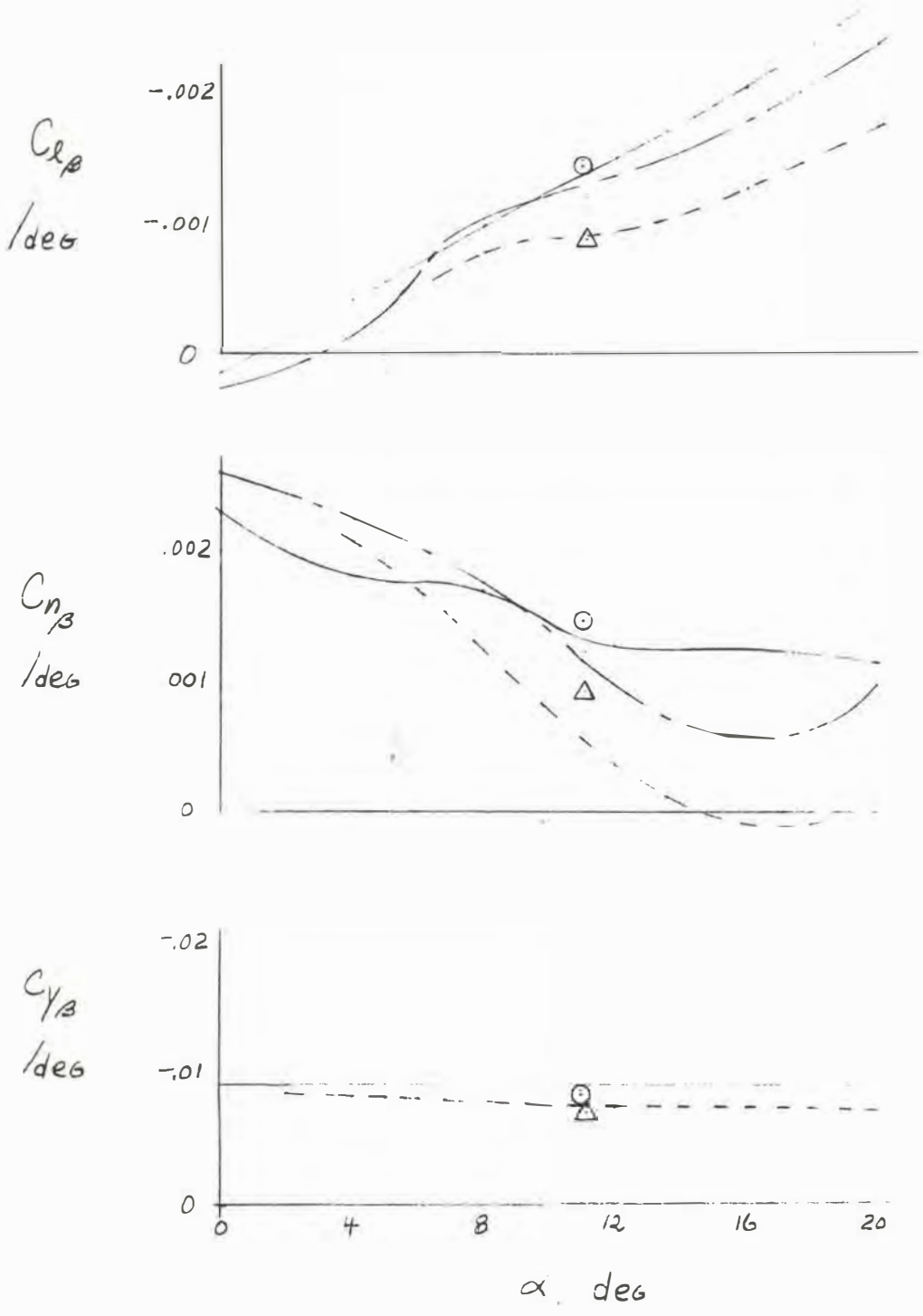


FIG 1

X-24 B
TRIM DERIVATIVES
FLT B-6-13
ALL δ_{H_B}'s AND δ_{R_B}'s

$\delta_{A_B} = 7°$

M	
— 0.8	} SIMULATOR
- - - 0.9	} DATA c.g. = 65%
△ 0.87 POWER ON	} FLT. DATA
C 0.84 ' OFF	} WEWT. RAPH. 65% C.g.

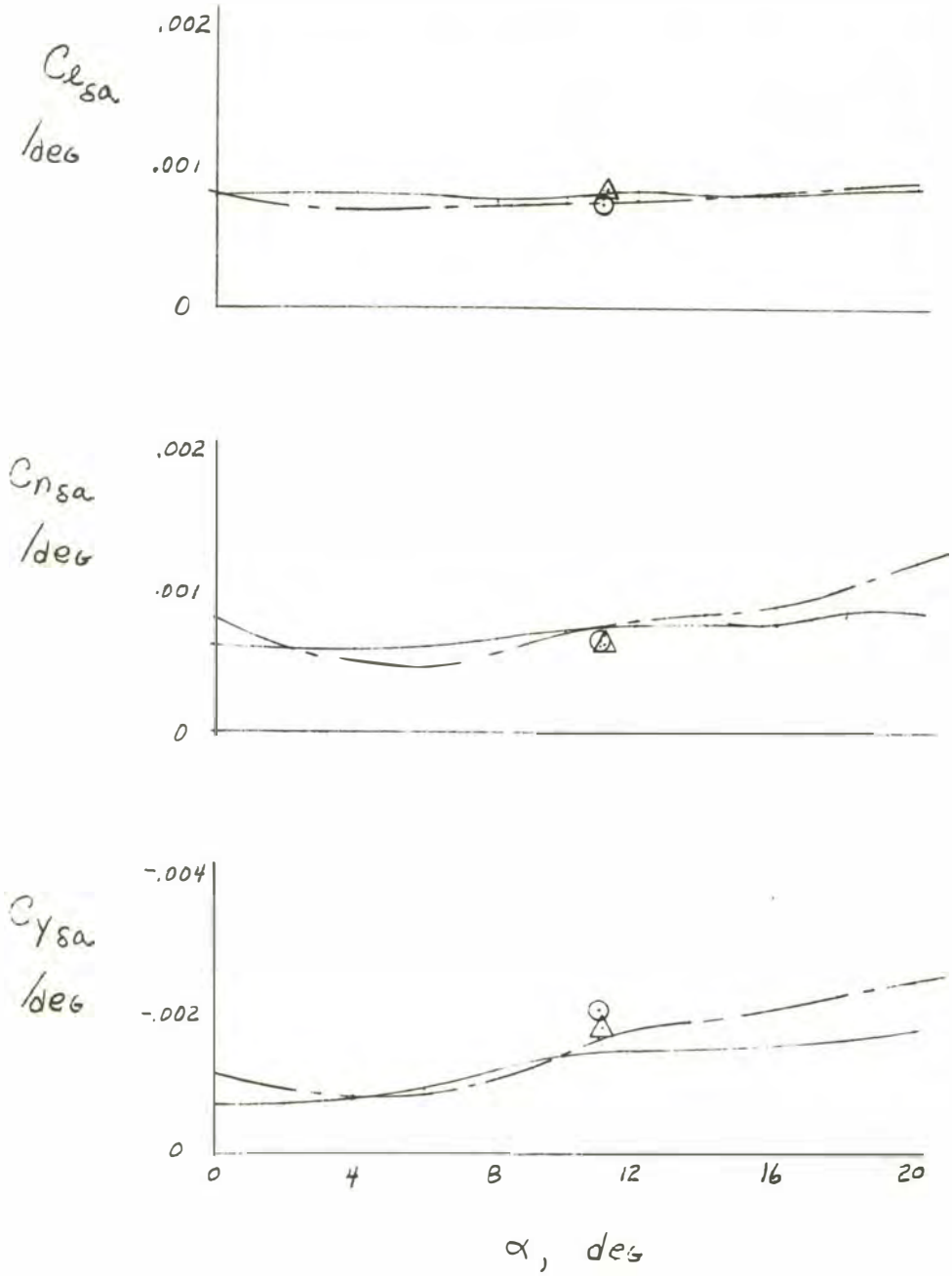


FIG 1

7DEC 73

X-24B
TRIM DERIVATIVES
$\delta_{H_B} = -40°$ $\delta_{T_B} = 0°$
FLT B-6-13

M_1
— 0.9 } SIMULATION
– – 0.7 } DATA $c.g. = .65\bar{c}$

△ 0.87 POWER ON } FLT. DATA
○ 0.84 POWER OFF } NEWT RAPH
65% c.g.

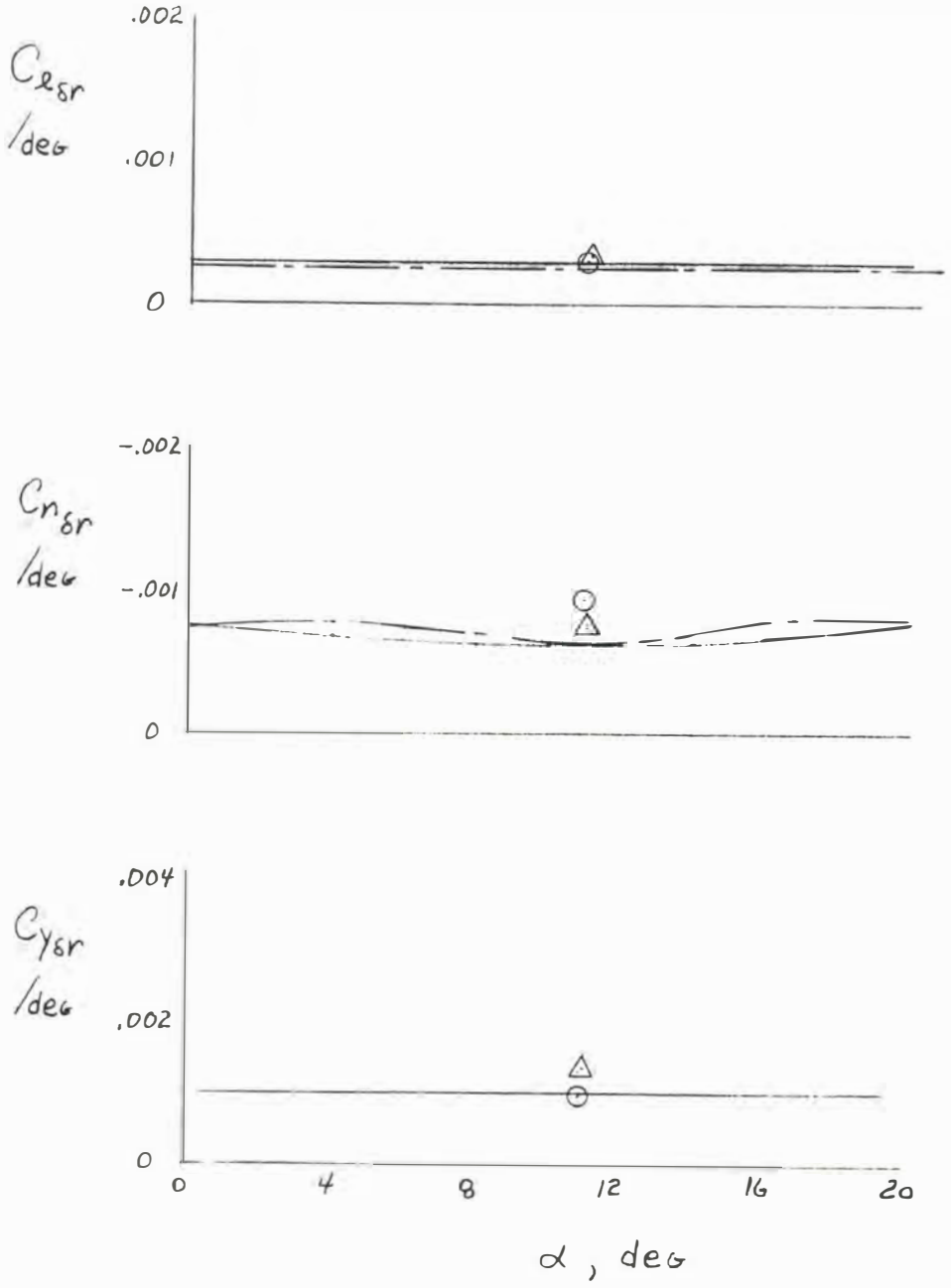


FIG 1

7 DEC 72

X-24B
DAMPING DERIVATIVES
FLT B-6-13
ALL CONFIGURATIONS

M
—— 0.8, 0.9 SIMULATOR DATA

△ 0.87 POWER ON } FLT. DATA
○ 0.84 OFF }
NEWT. RAPH 65% C_{D_0}

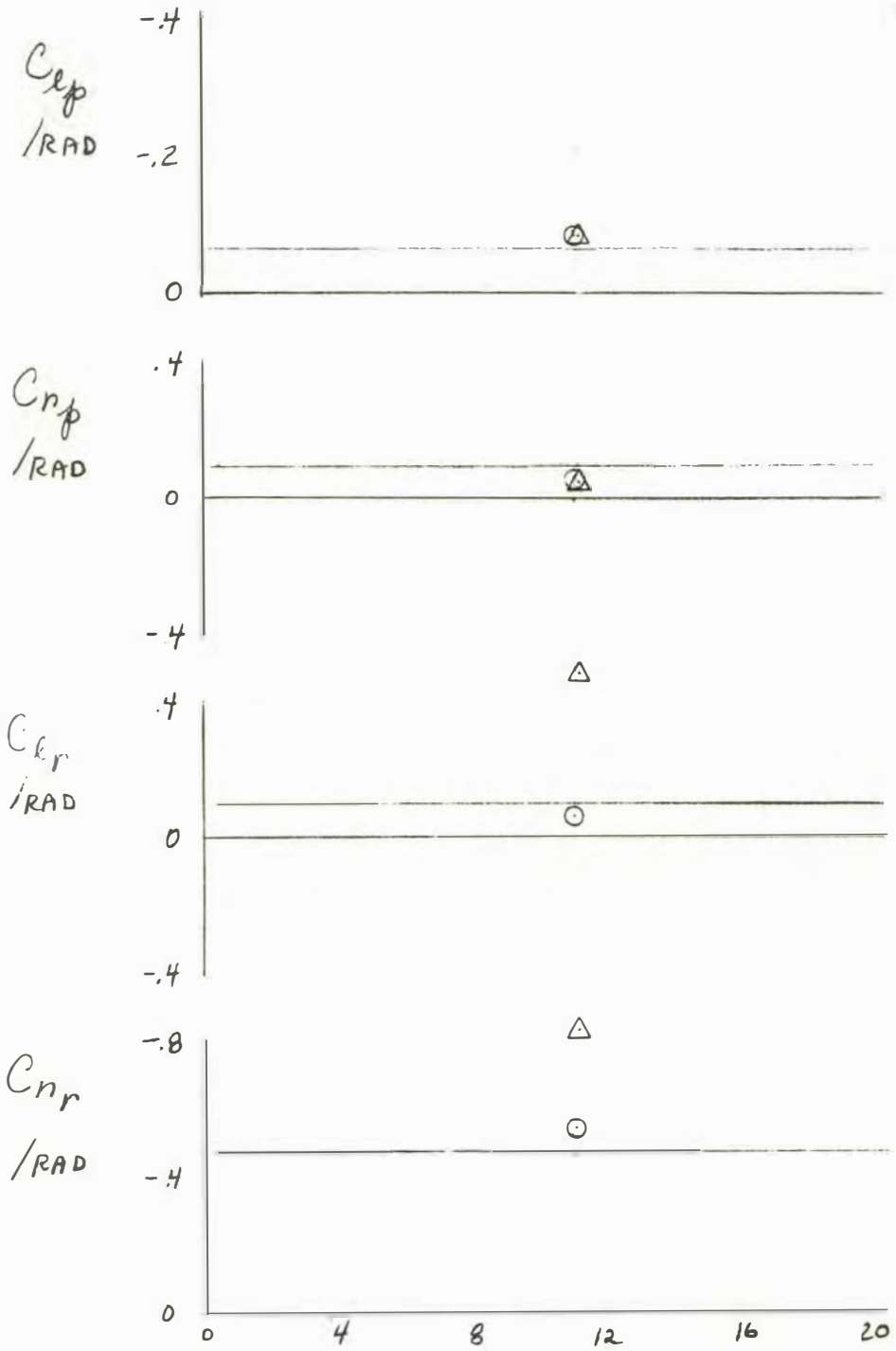


FIG 1

7 DEC 73

X-24 B
TRIM DERIVATIVES
FLT B-6-13
$\delta_H = -40^\circ \; \delta_{R_B} = 0^\circ \; \delta_{A_B} = 7^\circ$

M
—— 0.8 } WIND TUNNEL
– – – 0.9 } TRIM DATA
C.g. = 66%
○ 0.9 PWR. OFF FLT. DATA C.g. = 66%

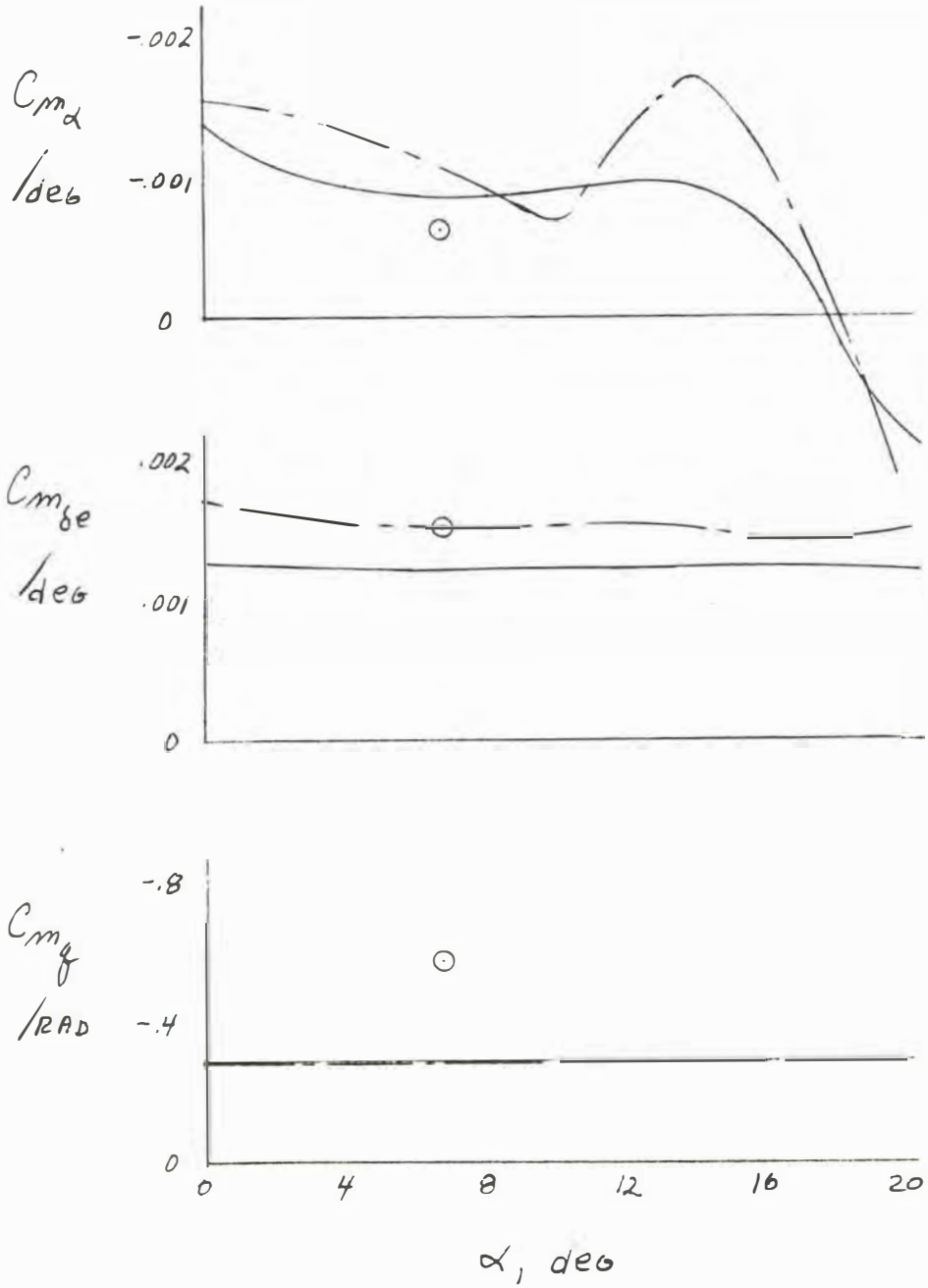


FIG 1

7 DEC 73

X-24B

LONGITUDINAL DERIVATIVES

FLT B-L-13

$\delta_{4_B} = -40^\circ \quad \delta_{R_B} = 0^\circ \quad \delta_{A_B} = 7^\circ$

M	
0.8	WIND TUNNEL
0.9	DATA $C_g = 66\%$
O 0.9	POWER OFF FLIGHT DATA

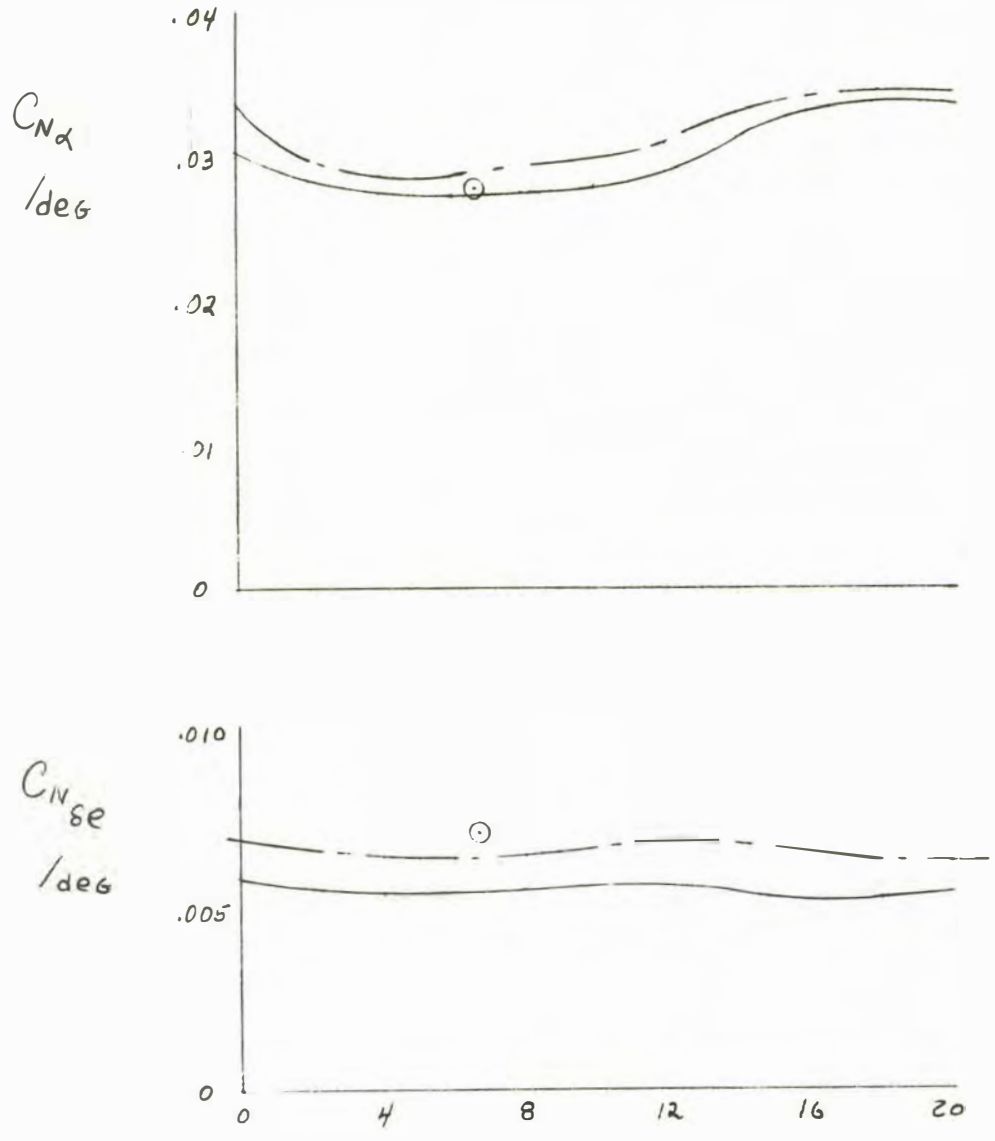


FIG 1

DEC 73

AILERON DEADBAND AND LATERAL OSCILLATIONS

Paul W. Kirsten

The pilot experienced a small amplitude, lightly damped PIO type oscillation in the lateral-directional axes shortly after launch at a Mach number of 0.65 and angle of attack of 14^{o} (Figure 1). The PIO tendencies gradually decreased as the angle of attack gradually decreased during the profile. Note from the figure that the pilot was flying proportional to bank angle at the beginning of the PIO. As he increased the frequency of his inputs and flew more proportional to roll rate, the PIO damped out. This characteristic of possibly incurring mild PIO tendencies if the pilot flew bank angle, but damping the PIO if he flew roll rate was predicted through simulator studies and root locus analysis before the first flight of the X-24B.

It is felt that one cause of the PIO was a small deadband in the left hand aileron control system linkage which occurred on flight B-6-13 (Figure 2). The magnitude of this deadband was approximately 0.6^{o} peak-to-peak of left hand aileron motion. Figure 2 shows that the two aileron surfaces tracked perfectly, even for very small deflections, on flight B-5-9 indicating that the deadband somehow occurred between flights B-5-9 and B-6-13. The left hand aileron control linkage has been inspected thoroughly by NASA personnel. The system has been tightened as much as possible. The deadband has not been completely eliminated, but has been reduced considerably to a value of 0.2^{o} peak-to-peak.

For flight conditions where peak-to-peak values of roll rate of 10^{o}/sec or less occurred (which includes the time during the PIO), a deadband of $.6^{o}$ p-p on one surface would result in no SAS input to that surface. Thus for most of flight B-6-13 the effective roll SAS gain was only one-half of the desired value.

Root-locus analytical results for bank angle pilot closures are shown in figure 3. The plot for the flight conditions of $M=0.65$ and $\alpha=14^{o}$ represents the PIO conditions experienced on flight B-6-13. The circles shown in the plot represent the effective SAS gains and interconnect (KRA) values for the PIO PIO condition. (A value of $K_p=.06^{o}/^{o}/s$ is the effective roll SAS gain which includes the deadband of the left hand aileron). As is shown in the figure, as the pilot increased his $\delta a/\phi$ gain

he drives the dutch roll mode toward zero damping. From the flight data, the pilot gain for the PIO was calculated to be p_a/ϕ=.56. The frequency was calculated as 3.3 rad/sec. These values compare well with the digital results shown in figure 3. The figure also shows that the yaw SAS gain and the aileron-to-rudder interconnect value have little effect upon the dutch roll frequency and damping at these flight conditions. However, roll SAS gain is shown to increase the dutch roll damping significantly. Thus roll SAS gain will be increased on the next flight in an effort to eliminate any PIO tendencies.

Figure 3 also shows projected frequency and damping characteristics for high angle of attack and Mach number conditions which will occur on future flights. Data used for these analyses was power on wind tunnel data (reduced C_{l_β}, C_{n_β}, and C_{y_β}). Results at all flight conditions show that yaw SAS gain and KRA have little effect on dutch roll characteristics, while roll SAS gain increases the dutch roll damping considerably.

X-24B
FLT B-6-13 FLIGHT DATA
$M = .65$ $\alpha \approx 14^\circ$ $\delta_H = -40^\circ$
POWER ON

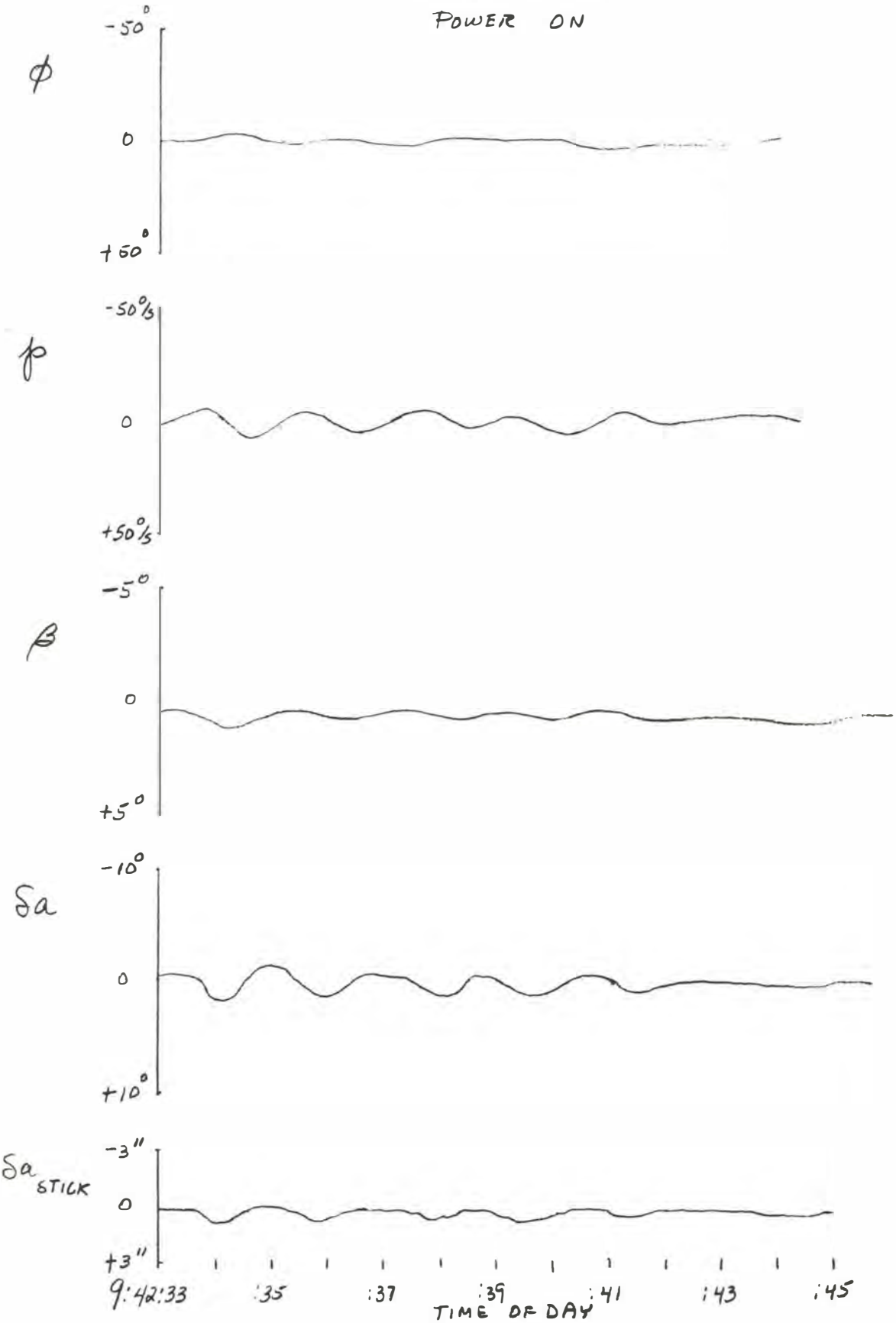
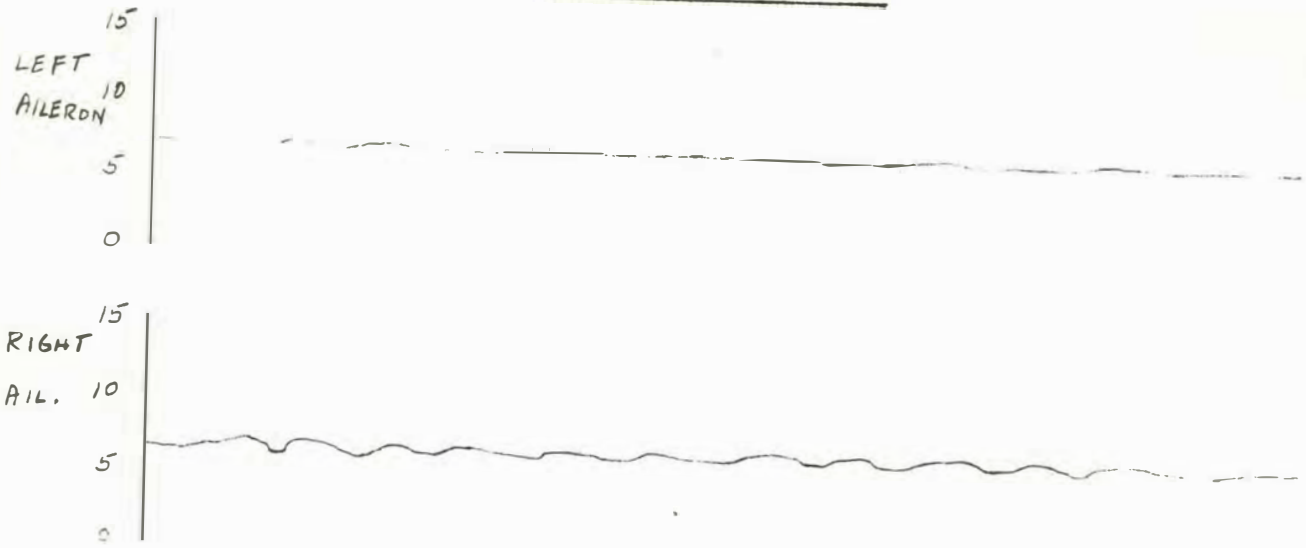


FIGURE 1

FLIGHT B-6-13



FLIGHT B-5-9



FIGURE 2

SASGAINS
(°/°/s)

	Kp	Kr	Krw
○	.06	.41	-.63
□	.19	.41	-.63
△	.06	.21	-.63
◇	.06	.41	-.28

X ROLL-YAW SAS OFF

CLOSED SYMBOLS REPRESENT OPEN LOOP CONDITIONS ($\delta a/\phi = 0$)

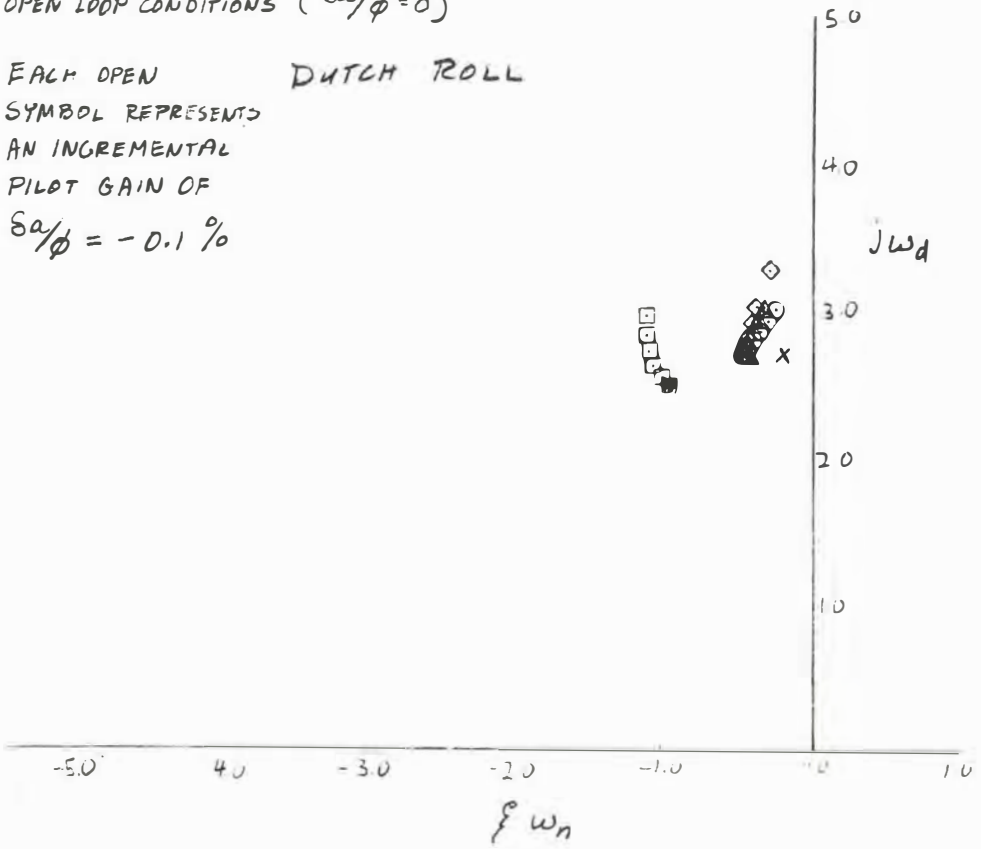
EACH OPEN SYMBOL REPRESENTS AN INCREMENTAL PILOT GAIN OF

$\delta a/\phi = -0.1$ %

X 245
M: .65
Q = 124
α: 14°
B-6-13 PIO

BANK ANGLE CLOSURES

DUTCH ROLL



PHUGOID

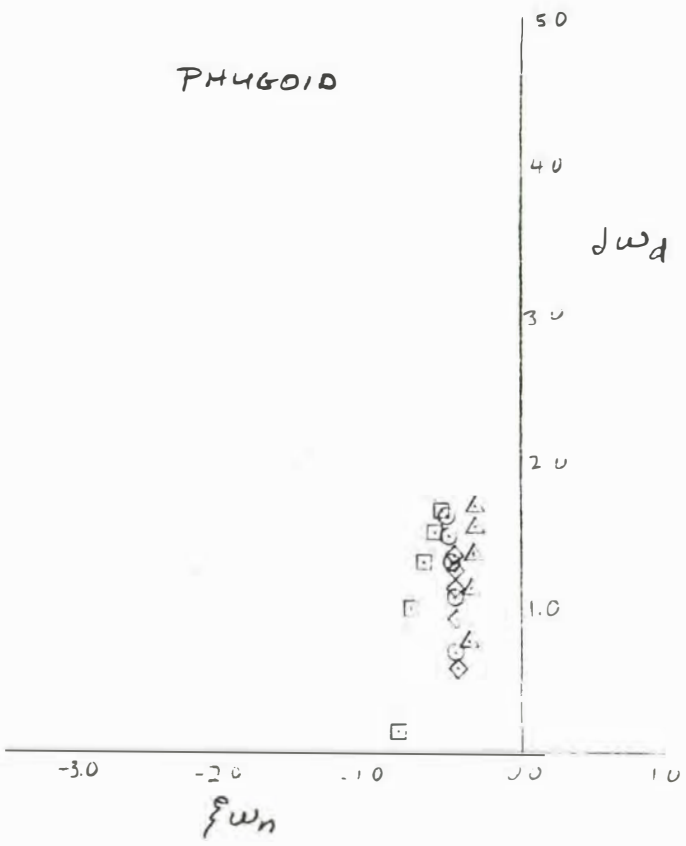


FIGURE 3

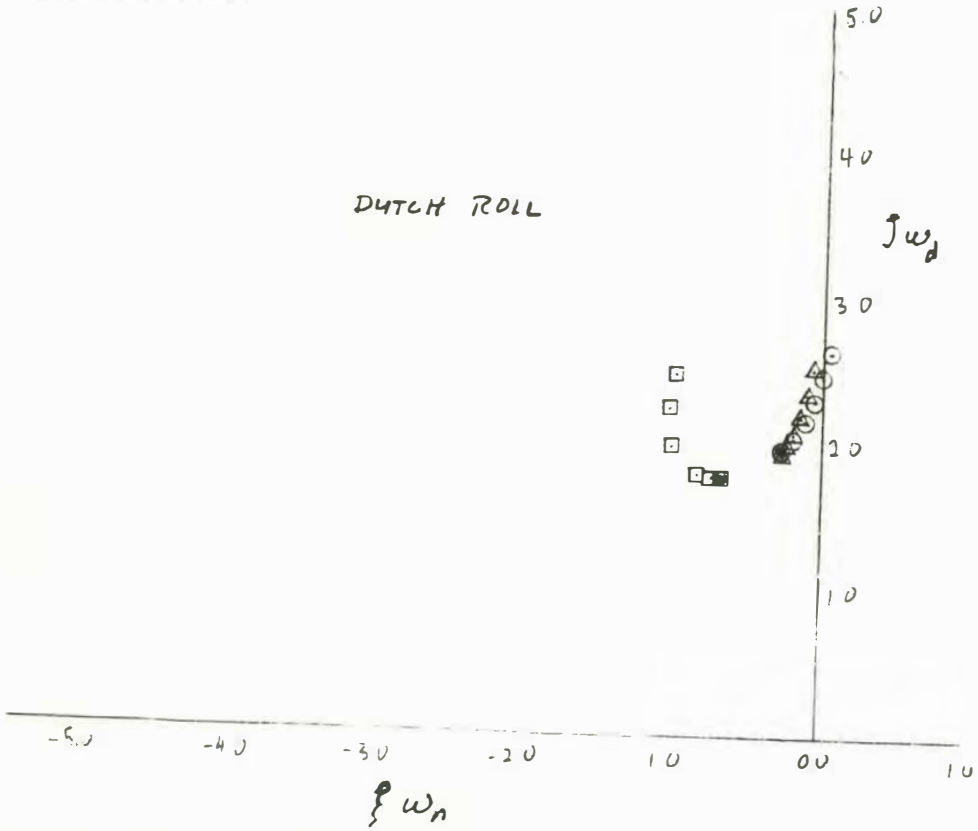
X-24B
M = 0.9
q = 125
α = 14°
B-7-14 Projected

BANK ANGLE CLOSURES

SAS GAINS (°/°/s)

	Kp	Kr	KRA
○	.06	.41	-.63
□	.19	41	
△	.06	.21	

Plot = (0.1)(ϕ)



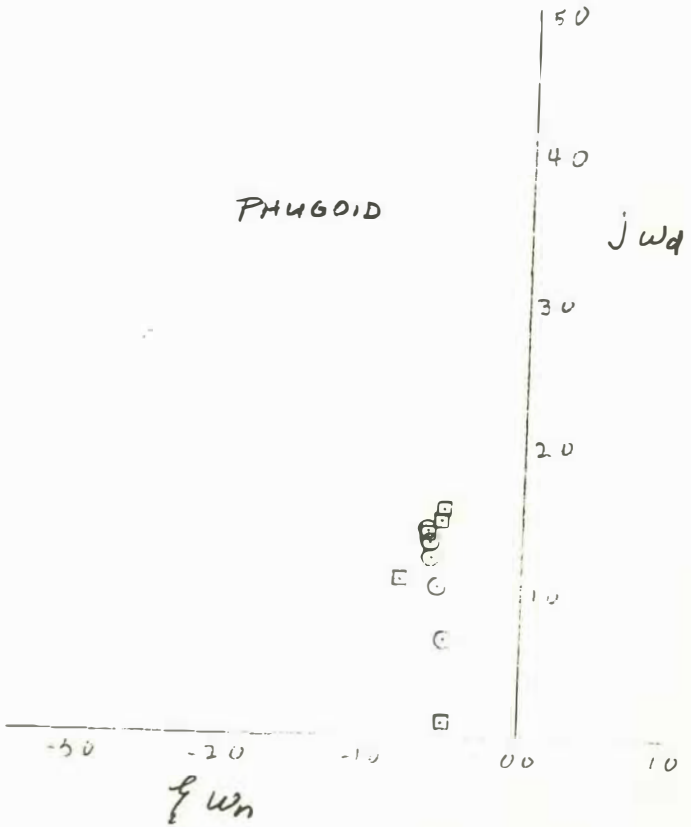


FIGURE 3

CJN 7 Dec 73

44

X-24B
M = 0.4
q = 125
α = 11°
B-7-14 Projected

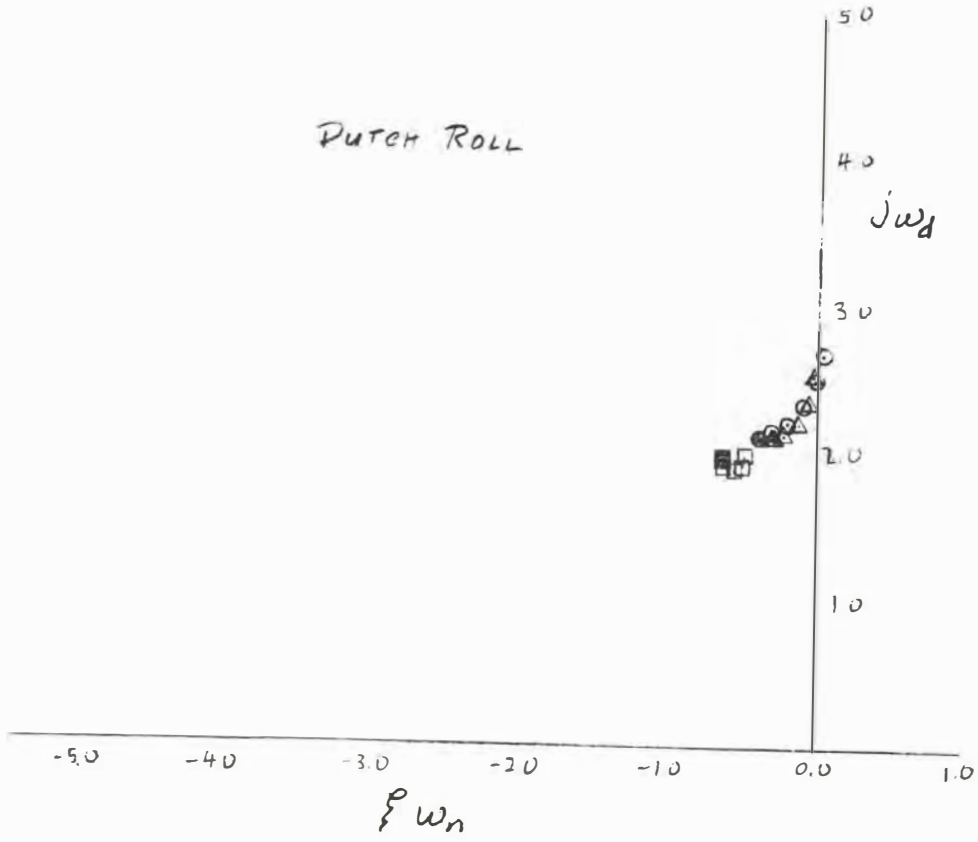
BANK ANGLE CLOSURES

SAS GAINS (°/s)

	K_P	K_R
○	06	41
□	.19	.41
△	06	.21

K_{TRA} = -.63

Plot = (-0.1)(ϕ)



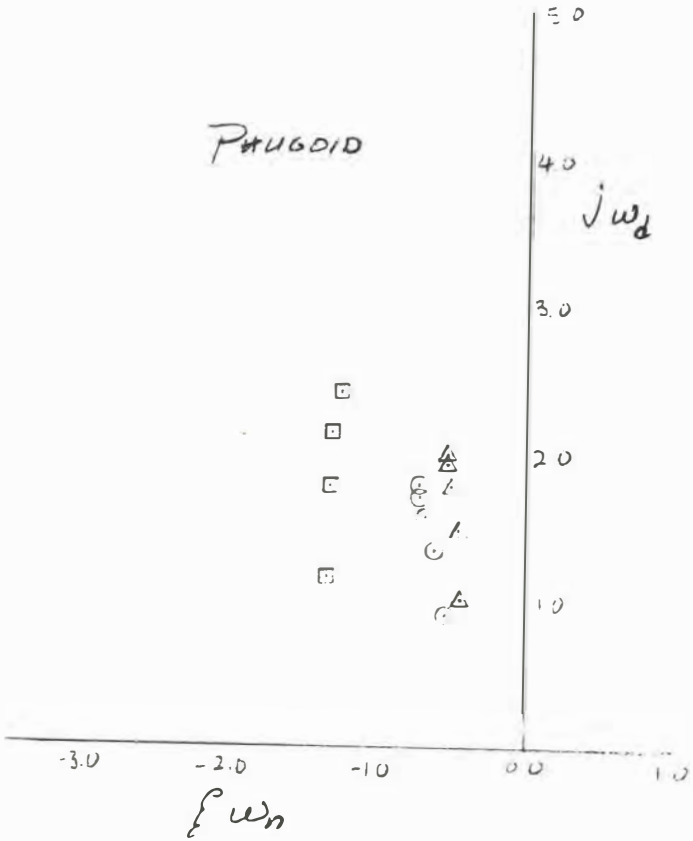


FIGURE 3

CTN 7 Dec 75

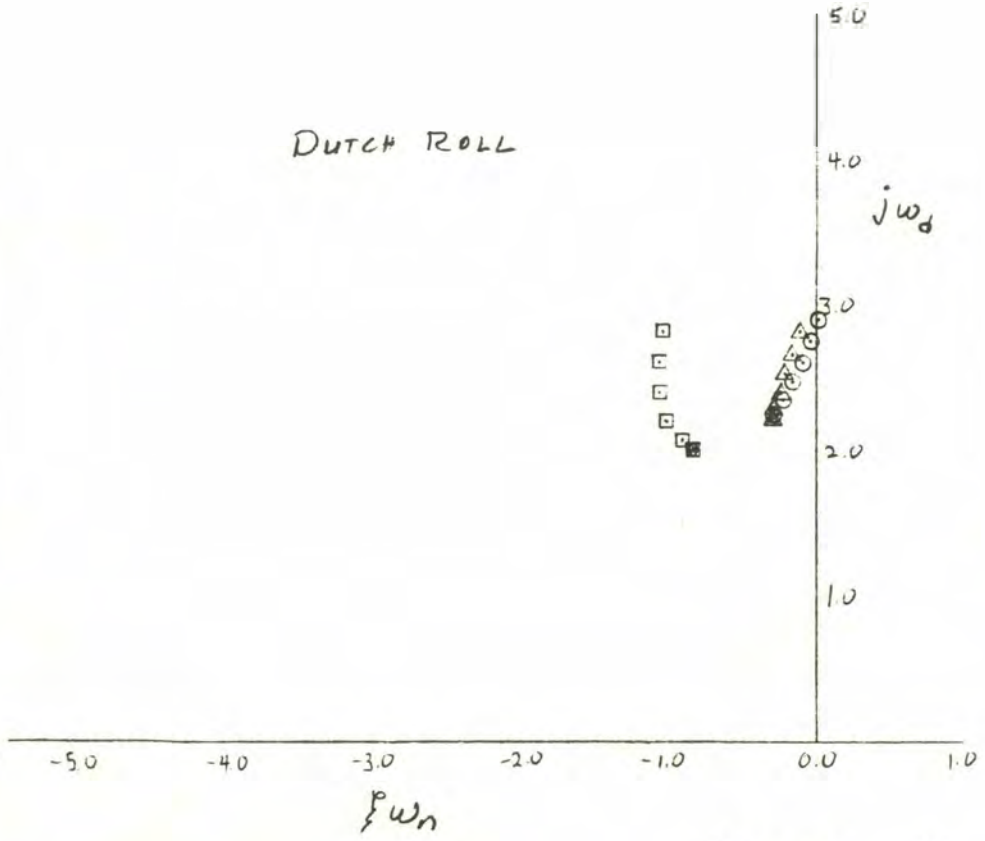
54

X-24B
M = 0.9
q = 12.5
α = 16°
B-7-14 Projected

BANK ANGLE CLOSURES

SAS GAINS (°/°/s)

	K_p	K_r	ISRA
○	.06	.41	-.63
□	.19	.41	
△	.06	.21	▽



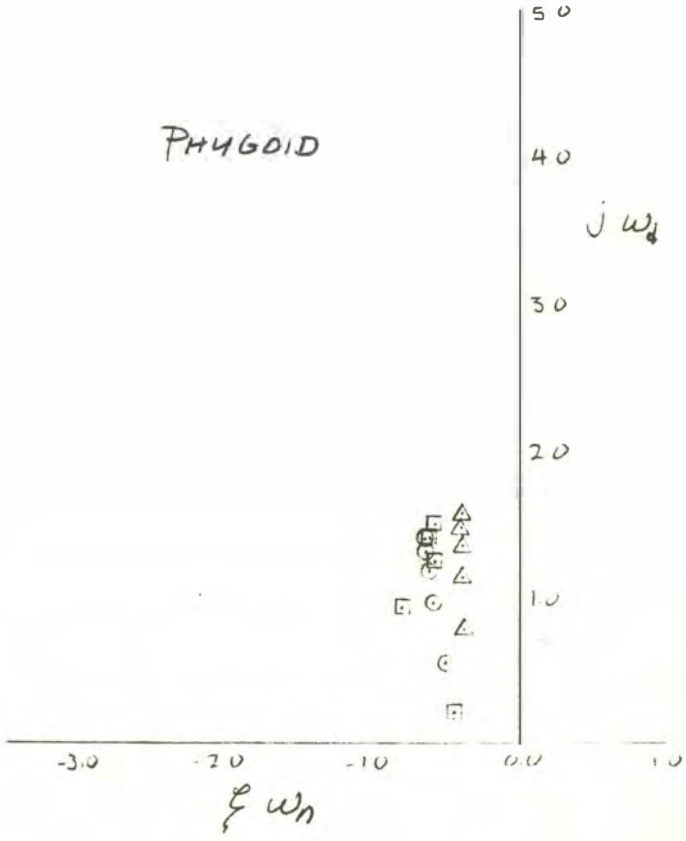


FIGURE 3

CIN 7 DEC 73

X-24B

LIMIT CYCLE CHARACTERISTICS

Paul W. Kirsten

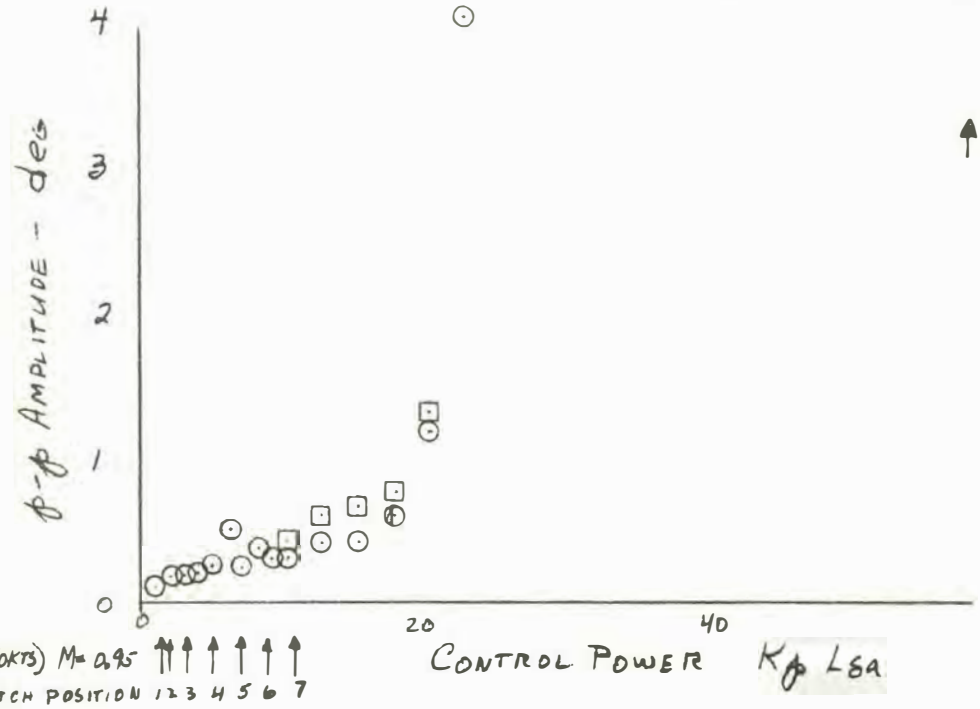
Ground test limit cycle data for the roll and pitch axes are shown in figures 1 and 2. Ground test data is shown as symbols and control power settings for the seven available cockpit switch positions are shown as arrows. The roll axis ground test data shows that the low amplitude limit cycle characteristics were improved somewhat after the left hand aileron linkage was tightened to remove the deadband found during flight B-6-13. A roll SAS cockpit switch position of 5 will be used on the next flight. This setting is far enough away from the divergent point ($K_{pL_{\delta_a}}$=22.5) so that no roll limit cycle problems should occur during flight. The small amplitude limit cycle shown in the ground test data should not be a problem if it occurs in flight. There is a good chance that this oscillation will be damped and not show up in flight.

Pitch limit cycle characteristics are shown in figure 2. Pitch control powers for the seven SAS switch positions are given for different airspeeds and Mach numbers. At Mach = .95, the elevator control effectiveness ($C_{M_{\delta e}}$) increases considerably. Thus the control power for a switch position of 7 at M = .95 and V = 300 KTS is close to the pitch limit cycle divergent point. Although the next flight is planned for V = 240 KTS at M = 0.95, overshoots in airspeed must be considered. Therefore a switch position of 6 will be used during the transonic portion of the next flight to lessen the tendency of a pitch limit cycle occurring. A pitch SAS switch position of 6 should give adequate pitch damping at transonic speeds.

X-24B
GROUND TEST LIMIT CYCLE DATA
ROLL $-7^\circ \delta a_B$

SYM	DATE
□	9-4-73
○	12-4-73 – AFTER TIGHTENING LEFT HAND AILERON LINKAGE

↑ LATERAL CONTROL POWERS FOR ROLL SAS SWITCH POSITIONS



q=212(250KTS) M=0.95
ROLL SWITCH POSITION 1 2 3 4 5 6 7

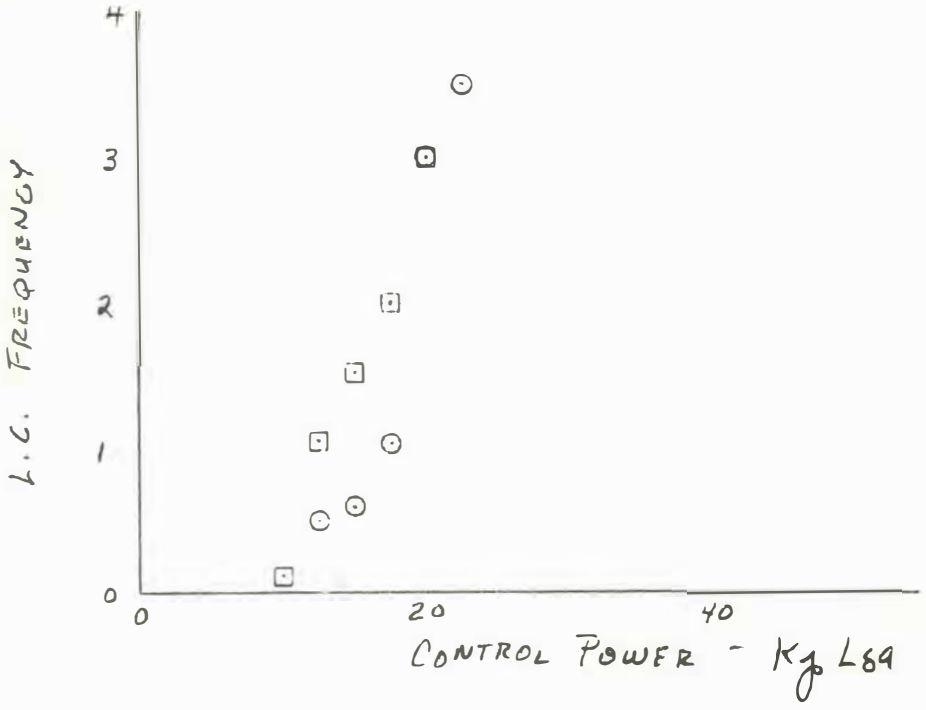


FIGURE 1

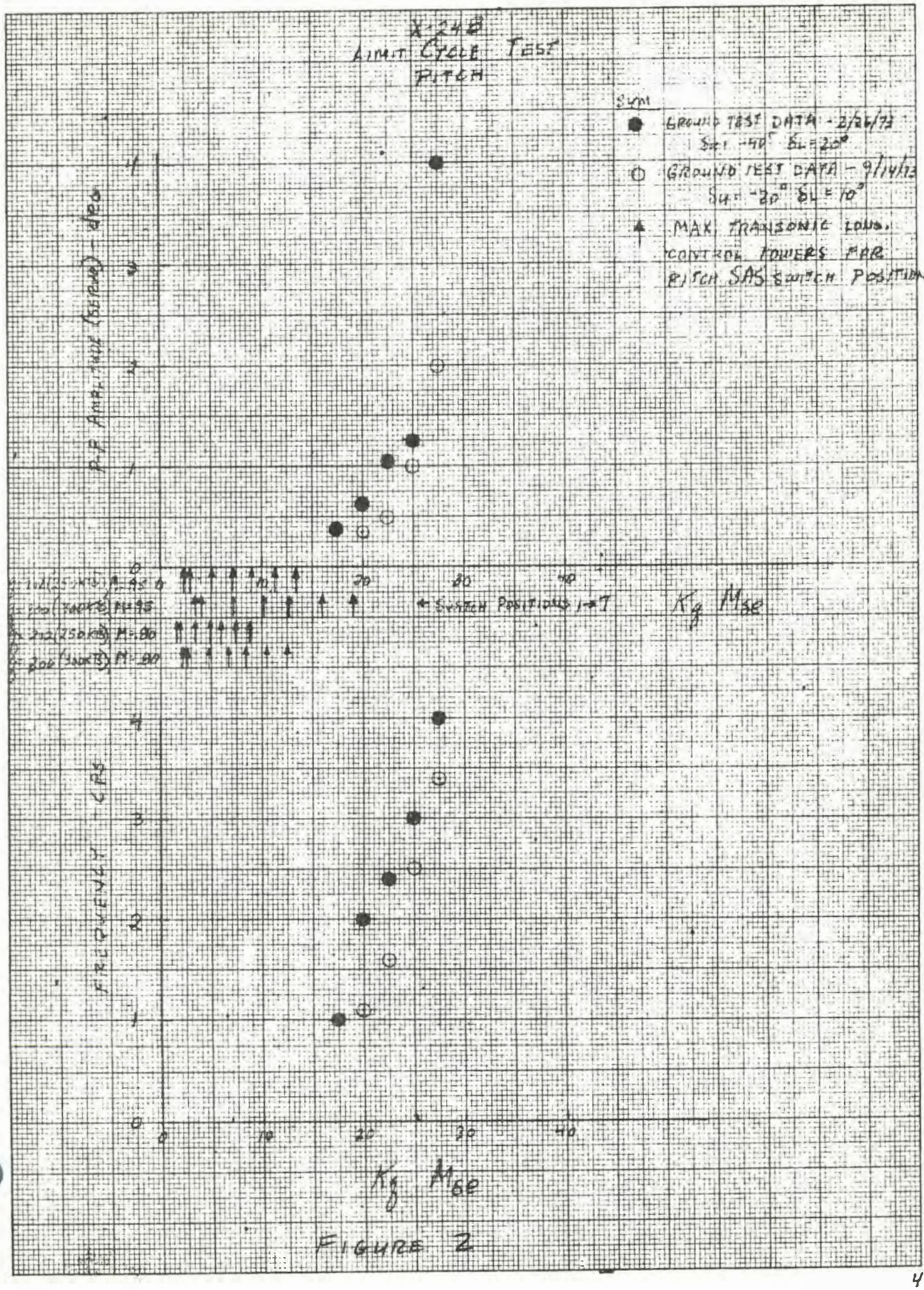

X-24B
LIMIT CYCLE TEST
PITCH
SYM
GROUND TEST DATA - 2/26/73
δH = -40° δL = 20°
GROUND TEST DATA - 9/14/73
δH = -20° δL = 10°
MAX TRANSONIC LONG. CONTROL POWERS MAR
PITCH SAS SWITCH POSITIONS
P-P AMPLITUDE (SURFACE) - deg
FREQUENCY - CPS
← SWITCH POSITIONS I→T
K_{δ} $M_{\delta E}$
K_{δ} $M_{\delta E}$

FIGURE 2

FLT. B-6-13

HANDLING QUALITIES SUMMARY

LAUNCH TRANSIENT	LITTLE ROLL OFF
TRIM CHANGE WITH POWER	VERY LITTLE
PITCH CONTROL DURING ROTATION	2.5
ROLL CONTROL DURING BOOST	4 (PIO)
OVERALL H.Q. AT 5°α AFTER SHUTDOWN	2.5 TO 3
TRIM CHANGE AT JETTISON	NONE

CHECK LIST OF FLT. B-6-13 RESULTS

\+ OVERALL HANDLING QUALITIES GOOD

\+ ENGINE ALIGNMENT GOOD

\+ LITTLE TRIM CHANGE WITH POWER

\+ NO JETTISON AFTERFIRE (BOTH TOGETHER)

\+ STICK SHAKER ACTUATED WHERE PLANNED

\+ α & β CALIBRATION IMPROVED

\+ ALL 6 AIRBORNE CAMERAS WORKED

\+ HEAVY WEIGHT PYLON LOADS ACCEPTABLE

\+ LAUNCH CHARACTERISTICS GOOD

$\pm$ HIGHER PERFORMANCE THAN PLANNED

$\pm$ THRUST EFFECT ON LAT DIR. DERIVATIVES

$\pm$ #3 CHAMBER DID NOT WORK (FOUND CAUSE)

\- PIO IN ROLL

\- PITCH ANGLE ERROR

\- DEADBAND OF LEFT HAND AILERON

X-24 Flight B-6-13 CG and Inertias

These c.g. locations and inertias represent "best guess" values at this time. These data have been worked up by hand, as the computer program to accomplish this task will not be completed until approximate the first of next year (that is, one month away). The process at this time is very tedious and is subject to several assumptions. These include:

1. LOX prime has not been taken into account.

2. LOX and WALC flow rates are subject to question as always.

3. Propellant inertias about their own c.g. have been calculated as follows:

   Roll - the fluid is assumed not to roll with the tank (i.e., Ix* = 0)

   Pitch, Yaw - the fluid is assumed to rotate with the tank (i.e., it acts like a solid)

4. Starting values for LOX and WALC are:

   LOX - 2800 lb.

   WALC - 2480 lb.

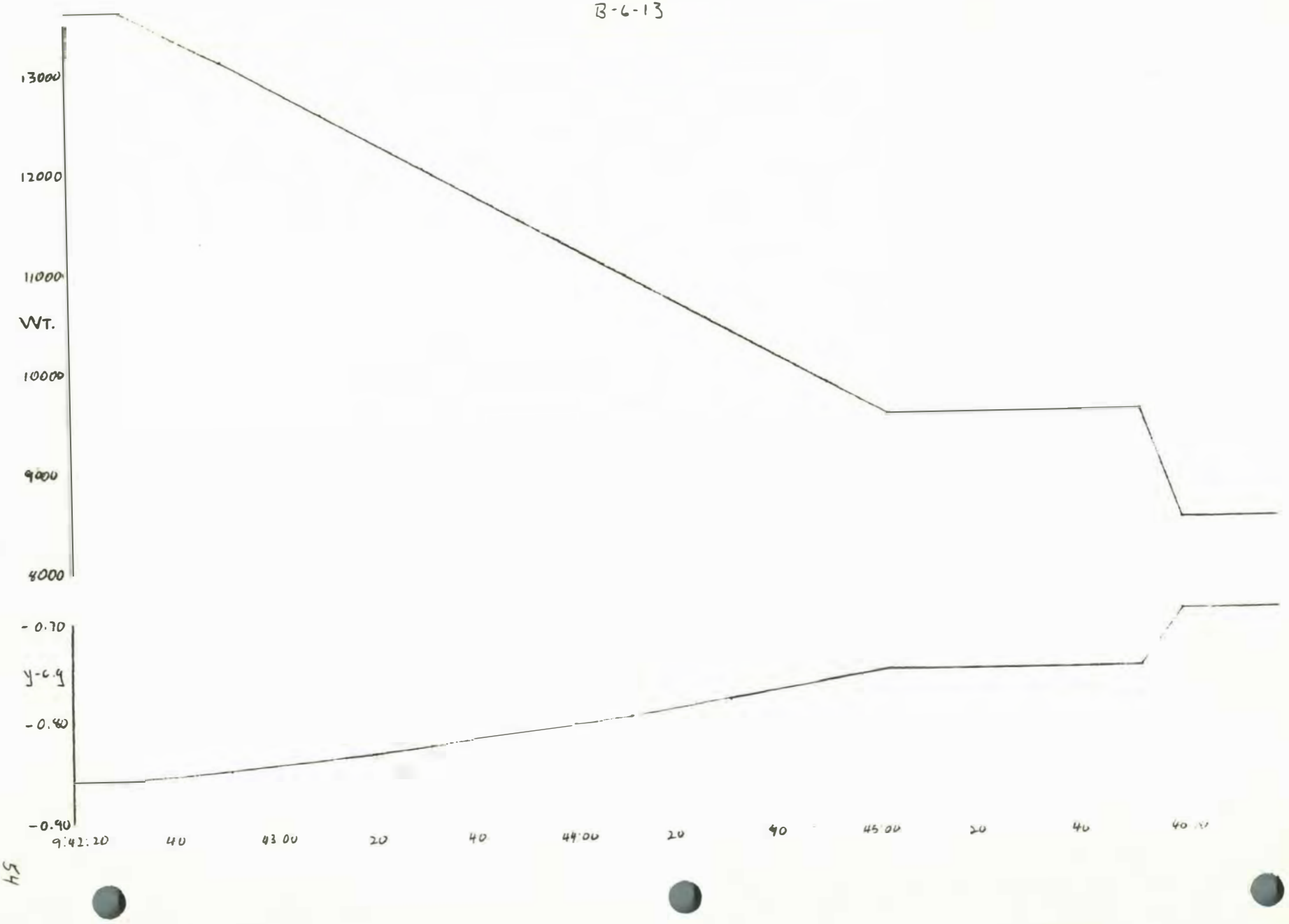
A comparison between empty weight, c.g. and inertias (before loading LOX and WALC and post jettison) shows two discrepancies. The first is a discrepancy in x-c.g. of a little over 3 inches. It would be expected that after jettison (with approximately 150 lb of remaining propellants) the x-c.g. would be approximately 126.5. Therefore the dashed line has been added. The author feels that this is probably more accurate than the solid line. The second discrepancy is in Ixz and amounts to about 100 slud-ff^2.

	Before loading LOX and WALC.	Post Jettison (150 lb. remaining propellants, 70 lb. used peroxide)
wt	8354	8435
x-c.g.	126.21	129.62
y-c.g.	-.66	-.70
z-c.g.	21.74	22.06

Ix	2694	2667
Iy	23804	23755
Iz	24150	24150
Ixz	1097	1209

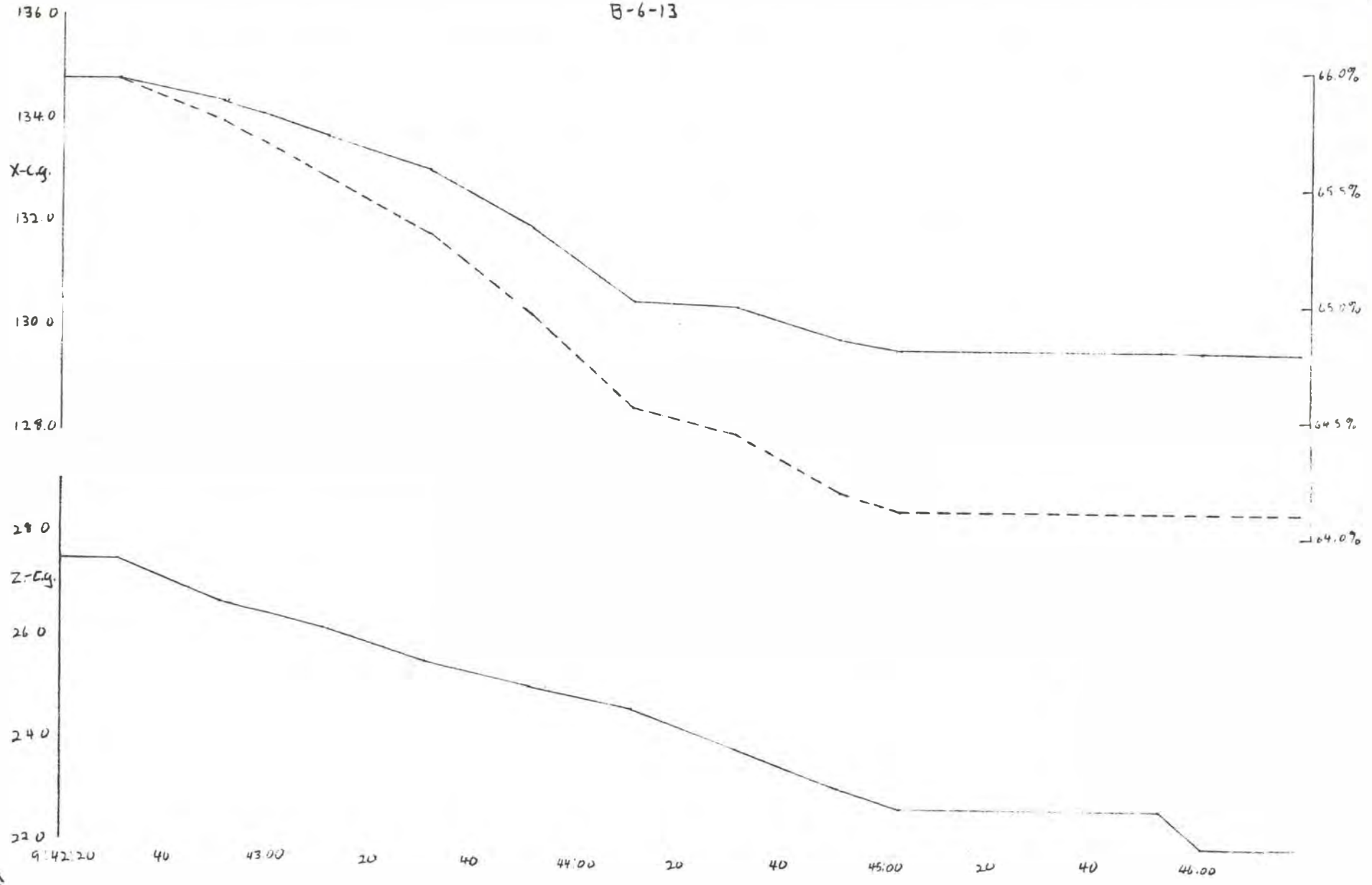
Note that the above numbers are in the "X-24A" axis system while the time history data is in the "X-23B" axis system.

X-24B
B-6-13


13000
12000
11000
Wt.
10000
9000
8000
-0.70
y-c.g
-0.80
-0.90
9:42:20
40
43:00
20
40
44:00
20
40
45:00
20
40
40

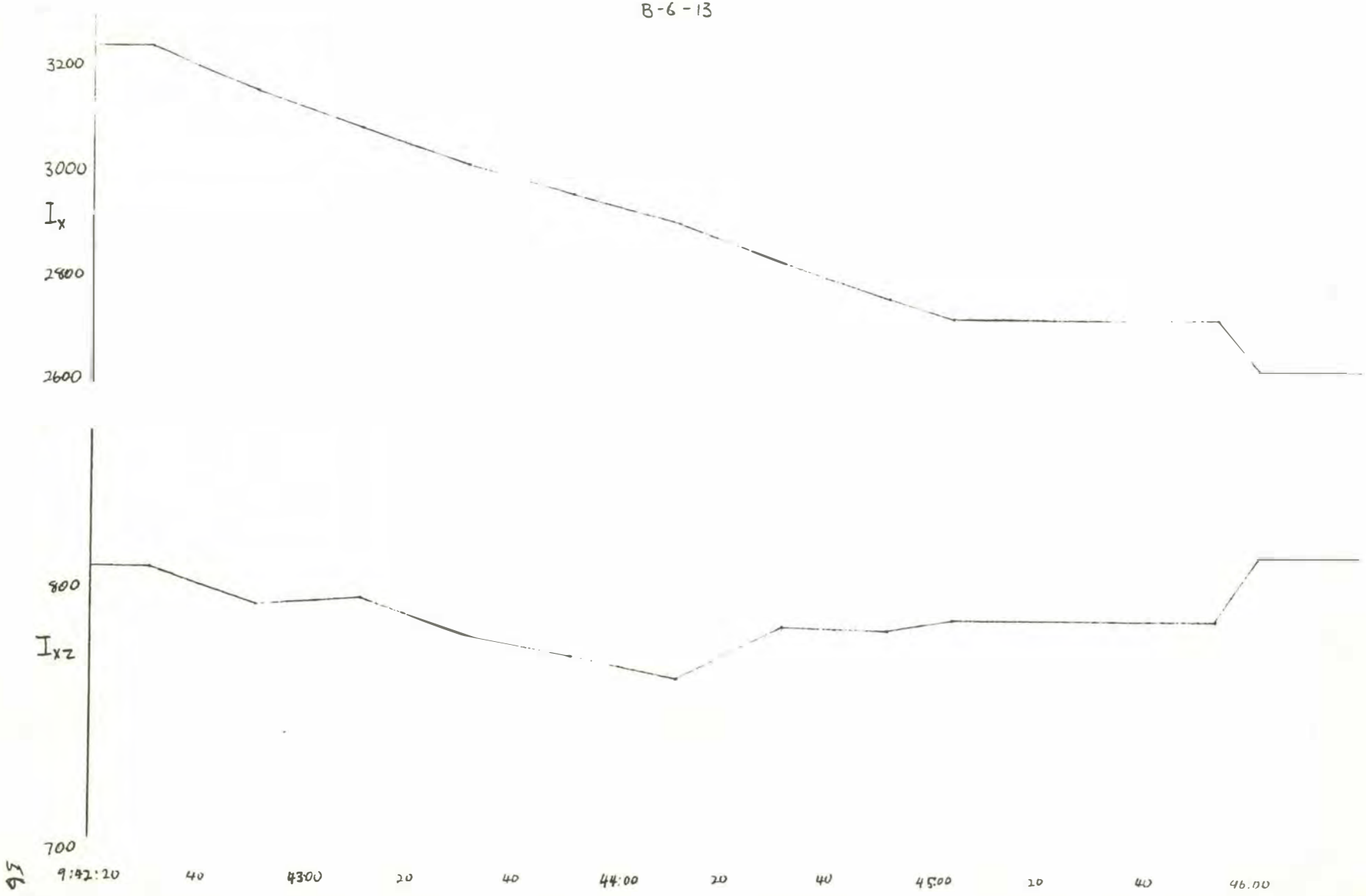
54

X-24B
B-6-13

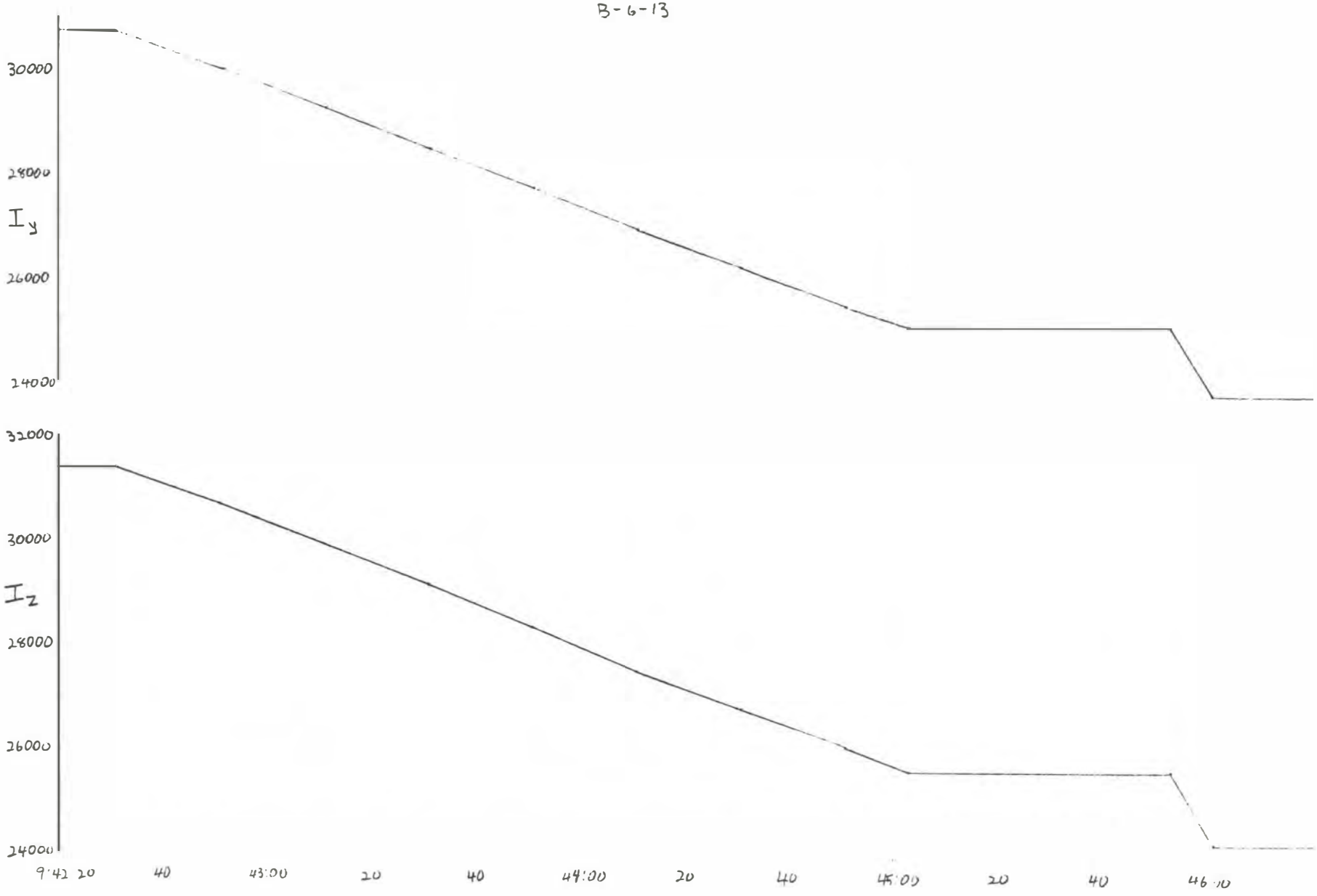

136.0
134.0
X-c.g.
132.0
130.0
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66.0%
65.5%
65.0%
64.5%
64.0%
28.0
Z-c.g.
26.0
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9:42:20
40
43:00
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44:00
20
40
45:00
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46:00

55

X-24B
B-6-13


3200
3000
I_x
2800
2600
800
I_{xz}
700
9:42:20
40
4300
20
40
44:00
20
40
45:00
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40
46:00

X-24B
B-6-13


30000
28000
I_y
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32000
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9:42 20
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46:00

X-24B TECHNICAL DEBRIEFING

Flight Number: B-6-13 15 November 1973
Pilot: John Manke

1. Describe the launch transient and compare to lightweight.

Ok, as I commented earlier I thought I got a little more negative or a little longer at 0 g or a little lower g than I had noticed before on the light weights. The rolloff was just minimal. Ok, looking at the data it was indeed a very small amount of rolloff, about 8° rolloff. It wasn't even worth commenting on, and I guess if someone would have asked me right afterwards, I would have commented that it wasn't even a rolloff at all.

2. Discuss the engine light sequence and any associated trim changes.

Ok, the plan was to launch and let alpha at least appear to stabilize. It looked as it came up that it was going to stabilize somewhere between 10 and 12 degrees. I then hit chambers two and four. I got the impression it was a little bit slower, maybe it was a half a second slower, than I expected it, but I think its the compressed time that probably made it appear that way. Bill Dana as controller said he thought it was a very good light when it came; just like it should. I could hear it come up all the way and it sounded real good, the pump started out smoothly and it came up. It was actually a rather smooth start. Some of them are hard and really give you a boot. This was a nice smooth start and it felt like these chambers were excellent. I waited till I got the lights on chambers two and four and then lit chamber one.

The trim change associated with the light was minimal, I had been expecting upwards of four or five degrees trim change and had been prepared to push forward on the stick as it came up. It wasn't required though. It increased slightly, I detected about a two degree trim change or estimated about a two degree trim change with the engine. It wasn't anything very rapid, the nose just came up slowly and I was able to control it and stop it at 14 degrees alpha which was my main alpha point.

3. (a) Describe the task to maintain 14° alpha during the rotation and rate the pitch task.

Ok, it was surprisingly easy to maintain 14° alpha. I was really pleased with it, the simulation had showed that with the seven pitch gain the task was quite easy, and the airplane turns out to be almost as easy as the simulator, maybe not quite. Without spending too much time doing the pitch task a guy could hold it I am sure within plus or minus a half a degree on alpha. I'd rate the pitch task a 2.5.

(b) Comment on lateral-directional handling qualities. Rate.

I had no problem controlling heading and the basic bank angle but I did have this wing rock problem that I had called out to you. I kind of got the impression that it would be initiated from a slight out of trim condition and then once I got it going it seemed like the pilot was sustaining the thing for awhile. And I guess I felt there was something that initiated it each time whether it was the "clerd" (a disturbance due to wind shear) or the trim thing but I got the feeling that once it started going that I sustained the thing or PIO'd it just a little bit. I never felt that it was going to diverge. It never felt like a hazardous or dangerous situation. It just was there and got my attention a few times. I really think that if we up the rollgain just a little bit its going to help that situation and that would be what I would propose for the next time. I'd have to look at it in the simulator but I would guess just off hand, that we might shoot for a rollgain of 5. Bob also suggested looking at the KRA and I think thats a good idea. Because of this little problem here, I would rate that a 4.

4. (a) Describe the task to maintain 20° alpha during the climb.

The task to maintain 20 theta was very similar to that to maintain 14 alpha. It was very straight forward. I overshot theta just a little bit and it was my fault, I was looking at the clock and trying to get a good hack on our rotation time. As I looked up at the clock to get a time hack I looked back down and I had just overshot the theta a little bit so I pushed back to 20. I think the records show that we held 20 real real good. In fact I

spent less time holding theta in the airplane probably than I did in the simulator, because this is when I started looking at these Mach things so I spent a lot of time off the 3 axis ball looking at other things in the cockpit, more than I had done in the simulator. And still theta was super easy to hold.

(b) How did the alpha to maintain theta compare with the simulator?

Ok, it looked like it was running at least a half of a degree less than I had seen in the simulator--half to one degree. Seldom did I ever see 12 alpha in the simulator to hold 20 theta except when Johnny would change my thrust or lower the base drag. So, about that range, half to one degree.

5. How did the powered performance compare with the simulator?

Ok, in light of the descrepancy I had in Mach readings its difficult to say. The one thing that was very apparent was that my altitude was better in the airplane than in the simulator. My rate of climb was higher in the airplane. For a given theta and everything else remaining the same, my altitude checks were higher; 60 seconds we were probably a 1000 feet higher or 1500 and at 100 seconds we were 2500 to 3000 feet higher. Bill's calls also indicated a better performing airplane. So, here again I tend to agree with that left hand Mach meter. The left hand Mach meter was showing a higher Mach number than I would have seen in the simulator, at 60 seconds and 100 seconds and 130 seconds.

6. Discuss trim changes associated with engine shutdown.

Ok, I didn't notice any. The data shows maybe a slight nose up, 1/2 degree to a degree alpha. I didn't detect it; it didn't come out and say the airplane pitched up there, I just didn't notice any. Very smooth, I could feel the going forward in the straps a little bit but the airplane just behaved beautifully, at that point and it was no problem getting the engine master, prop supply and push over.

7. Discuss the handling qualities at 5° alpha after shutdown. Rate.

This was a pleasant surprise, the other airplanes, have always been very sensitive down at low angles of attack coming over the top. I think if you look back at the pilots

comments on them they are always commented on how sensitive they were, getting down near 0 lift. Its a rather uncomfortable feeling to start with, the nose is coming down and you are sitting in a very nose down attitude and you get the impression that you are sitting on top of a ball-bearing about ready to roll off. Didn't get that feeling today. The airplane flew very nicely at 5 alpha. I was really impressed with it. I had made up my mind that I was going to really look at the airplane here. I had talked to both of you guys about the psychological thing about coming over the top and looking down. The airplane was just as solid as could be in this area, and I really enjoyed flying it there. I would rate it in this area about a 2 and 1/2 to 3.

8. Discuss the pullup to 15° alpha after shutdown. Rate.

Ok, at this point again I had this same dilema over Mach number, trying to check both numbers. The first time I looked at the right hand Mach meter as we came over the top it read lower than I expected it to. I can't even tell you what it was but it was reading low and I thought I'll never get the thing back up to .8. I glanced at the other Mach meter, and it was about where I expected Mach to be with that sort of condition. So I held the 5 alpha and then all at once the Mach started coming up good.

I did go back to the right hand gage again and it went by .8 before I started the pull-up. It was probably .81 as I started pulling up to 15 and the pull-up was just like in the simulator. I was straight forward and went up to about 15. I didn't trim on the way up. I normally had in the simulator trimmed just a beep of it in to help hold the thing steady afterwards. I didn't do it and I got up there and I thought "oh damn!" I forgot to trim it in and I gave it a quick beep there and relaxed pressure and came down and got your pulse at about 11° alpha instead of 12°.

I wasn't going to attempt to trim in to this point because the Mach was bleeding off so rapidly. I was going to come down, get an alpha and hold it as solid as I could with my hands and just give you the pulse and thats what happened. It turned out that I stopped at 11° and I took the 11° and gave you the pulse there. Mach; of course was more constant than it had been in the simulator on a normal profile because we'd gone high and we knew if we went high that the Mach holds better. It should be a real good .8, on the right hand gage which was about .85 on the left hand gage or .86. The doublets were very remeniscent of

the simulator. No big deal with the aileron. You don't see much motion when you hit the ailerons. Its like on a glide flight, you bang it and nothing happens.

The rudder damping was good or better than in the simulator. Gave a little pulse and it damped right out. I haven't even looked at it on the data but I would guess that it damped out in a cycle and a half to two cycles probably.

9. Were there any trim changes at jettison?

No. In fact thats why I asked afterwards if anybody saw a jettison, cause I didn't feel anything, didn't feel a cotton picken thing, no push, no nothin; didn't even hear the valves open or anything.

10. Discuss the energy management from the "intersection" to low key.

Well, this was just ideal. Its exactly like we practiced in the simulator. I guess I must have come by the intersection at 35 or 36 thousand feet and just like we had seen a hundred times before in the simulator. No problem. Oh, I could see the field really good too, as I started to turn off the intersection I looked out and just looked like you were home free, at that point.

11. Any comments on the configuration change?

No comment on the configuration change. I did it very mechanically just like in the simulator. I watched for 28,000 feet and I keyed on that because we were on energy. Its just so easy to change configuration your not even aware of changing stick position or trimming. My only thought during the configuration change was to hurry up so that I could do the pushover-pullup.

12. Discuss the pushover-pullup.

It occured at a fairly high air speed for these things, much like we simulated. I guess I was 250 knots somewhere in the ballpark. Pushover to just a little less than five and pulled up. I got the cross over and it looks like the cross over occurs just a little bit earlier in the airplane than in the simulator. Its the same problem, you've got a little dead band in there and it requires a real conscious effort to pull up through that and get it on up to the 17 alpha. It is particularly interesting here because of the high g on the airplane. That airplane's rotating like gangbusters and at that time, you start back on the stick and the airplane is really coming up and you can see that in the simulator. You really get the feeling, boy, you better

get that thing up there so that I can get my nose back down there again, because it is really rotating. And the airplane is just like the simulator. I could see my nose come up and I could see the horizon. So you can see that last 3 or 4 degrees comes rather quickly. You have got to pull through this area and the problem is (as you get in this dead band) knowing just how much you need to get it on up to 17 and its sort of a guess. You come on back through that and you got a pretty good rate going so your just guessing a little bit and you get what you get at the 17.

Thats why you probably see an overshoot. There is just not enough time to be precise there and thats the problem and if you've flown the thing over there (simulator) you've seen the problem. Its a case of having to get up there and getting it in a hurry and not knowing just how much to put in during this dead band. No big problem. Got the stick shaker, felt the stick shaker, stick shaker is good, right now the way we've got it set up in the airplane. It'll get your attention when you need it and its not too much, its just perfect. I can't tell you what alpha it came on at, but it sure did look like it came on when it was supposed to. Somewhere between 15 and 16 degrees.

13. Discuss the pattern.

Ok, the pattern was just great. Just like flying the F-104's this morning. We hit low key just about where we have been consistently in the simulator, we've hit it consistently at 23,000 feet in the simulator. I think thats just about where we hit it today, if I'm not mistaken. Ok, it was a picture book pattern, he had me set up perfectly at low key. I knew that we had to start to turn fairly early from our F-104 practice, we had some pretty good winds in the pattern, we had 50 knot winds till we got down lower. I did in the airplane just like I did in the F-104, this morning I got a little bit slow on the final. When I say slow I am saying about 10 knots. Its not slow for this airplane. I felt a little bit of turbulence about twice--one time about the 90 degree position so that would have been about 16,000 feet and one time maybe around 11 or 12,000 feet. Very light turbulence and this airplane rides it out so darn nice. I used speed brakes in the pattern, I think I got them out almost at 30 degrees and I was just a little late in getting them back in. I was consistently doing that this morning in the F-104. So it wasn't any surprise and my aim point dropped on back. In fact I let it

drop back and I think I will let it drop back now that I have got some confidence in the airplane. And I'll drop it back a little bit below that 1/2 mile marker. I dropped it back today. Let it fall back to almost to the end of the runway.

14. Discuss the landing.

The airplane is so comfortable as you come down on your final towards the flare that I didn't pay any attention to the altimeter today. I felt I could judge my flare altitude without it. It was an easy flare we leveled and chase 2 called 75 feet that looked pretty good. We'd just about leveled there and waited for the airspeed to go down. Here again I leveled out and here I had about 265 knots somewhere in that ballpark and you just sit there and wait for it to go down to 240 and drop the gear. About the time I dropped it I just punched a little forward on the stick to start it back down again. Got down about 6 feet or so and I ballooned the airplane a little bit. I felt it happen. I guess I just put a little bit too much or something it was very easy to stop. Its not a balloon that gets out of control. I could feel it. I had leveled or just a slight rate of climb. I could push it back over again; was able to settle it down to a foot or two and just pick my touchdown time. And I was able to pick my touchdown time today. It felt like a very smooth touchdown.

I would estimate the rate of sink as 1.2 to 1.3 fps. Then the nose comes slamming down like it always comes down much further than its supposed to. I didn't notice any cross wind today. I was hoping to fly in a cross wind. Next time I get a cross wind I'm going to crab it, down there just before touchdown and then I am going to take it out and I have been doing it in the F-104 and it looks pretty nice. Get it about a foot or two off the ground and then just kick it out and touch her down. I think that will be better than just slicing through. It didn't slice today and came down and, nice rollout. You've got instant rudder response when you need it after touchdown. So nice to control on the rollout, it just tracks straight. I engaged nose steering at about 100 knots today. Pushed the button in and I didn't have any rudder input at all, had my feet off the rudder to see if there would be any transient. I pushed the button and nothing happened and then I could ease a little bit of the rudder in and I could feel the nose gear steering working. Its really a nice situation that we have now. I don't notice any dead band. Its positive when you need it and yet the gearing is perfect for our type operation. I wouldn't be hesitant to engage my nose steering 120to 125 knots for this airplane.

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-6-13 DATE OF REPORT: 12/13/73

PILOT: John Manke DATE OF FLIGHT: 11/15/73

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Powered Flight Checkout

(2) Stability and Control at .8 Mach Number

(3) Aft Fuselage, Upper Flap and Fin Pressure Survey

(4) Boundary Layer Noise and Vibration Experiment (RED PLUG)

I. Discussion of Previous Operations

Flight B-5-9 was flown on 10-4-73 with no vehicle problems.

II. Vehicle Configuration Changes

A. The propulsion system was reactivated in preparation for the first powered flight S/N 8 engine and S/N 8A pump with all the latest changes were installed.

The new engine mount was installed and the engine aligned to aim the thrust vector through the vehicle heavyweight center of gravity. In order to accomplish this change the liquid oxygen lines, between the turbopump and engine were modified.

A new "overdrive" system was installed to provide increased thrust during flight. This is accomplished by starting the engine at approximately 270 PSIA chamber pressure where the start transient pressures in the manifolds are acceptable and after stable operation is achieved increasing the governor balance pressure to increase chamber pressure to 300 PSIA. The system was developed and tested on the PSTS prior to installation in the X-24B.

B. The nose ballast was increased to 260#.

III. Instrumentation Changes

A. Re-patched both pressure transducer boxes.

B. Replaced 680 pfd capacitor with 91 pfd in each input leg of Dynamic Instrumentation System amplifiers per request of AFFDL.

C. Installed "Red" plug in Dynamic Instrumentation System.

D. Re-worked L/H Fin camera mount to allow heater blanket placed around entire camera.

E. Added external heater to the nose camera cover.

F. Added "Instrumentation Compartment Temperature", "LOX Prime Line Temperature", and "Engine Control Box Temperature" to line-up.

G. Calibrated all CG accelerometers.

H. Re-nulled alpha to 12° and calibrated.

I. Replaced alpha indicator when original found to be sticking.

J. Installed and calibrated transducer for "LOX Pump Inlet Pressure".

K. Changed hook-up of radar altimeter to 5000 ft. range.

IV. Preflight Events

A. LOX and alcohol servicing for the captive flight on 10/30/73 was accomplished with no problems.

The cabin pressure system failed to pressurize the cockpit following B-52 takeoff and the captive flight was limited to a max altitude of 25,000 feet.

All the test objectives of the captive flight were achieved except engine igniter operation at 40,000 feet.

Following B-52 landing inspection of the X-24B revealed that the canopy seal was cut. The old seal was removed and a new one installed in time for a reschedule for flight B-6 on 10/31/73.

B. Flight B-6-11 was attempted on 10/31/73. Again following B-52 takeoff the X-24B cockpit failed to pressurize; however, when the pilot cycled the ram air door handle the system functional properly. This problem was a result of a limit switch on the ram air door handle which controls the cabin dump valve. The rigging of the system was such that it was possible to have the handle apparently locked but the switch would not be actuated.

The flight progressed up to the igniter test and was aborted when only the #1 and 2 igniters fired. The igniter test was repeated during the return of the B-52 and #4 igniter fired but the #3 still did not operate.

Telemetered data indicated no oxygen flow to the #3 igniter so the igniter oxygen valve was replaced prior to the next flight attempt. The original valve was environmentally checked at flight pressure and temperature conditions and would not fail.

The 28 volt power supply to the engine was revised to reduce the voltage drop between the equipment bus and the engine by installing a relay near the engine.

During checkout of the installation of the above relay the K-1 relay in the engine control box failed. This relay is used to control the 28 volt supply to the igniter power supply and had been changed during the recent control box modification to handle increased current flow.

The vendor who supplied the igniter power supply was contacted and provided us with new test data which showed that the current drain could be as high as 35 amps instead of the 17 amps originally specified. With this new information the relay in the control box is used to control a 50 amp rated relay which is aircraft mounted.

The flight was rescheduled for 11/13/73 and progressed normally until cloud cover caused the mission to be aborted. An igniter test was made following the abort and again the #3 igniter failed to light.

The electrical leads to the igniter oxygen valve and spark plugs were changed along with all three of the spark plugs and the flight was rescheduled for 11/15/73 with a new ground rule that only three igniters were required during the igniter test. This rule was adopted because only three chambers were needed for the flight.

V. Flight Events

Preflight servicing was normal except that LOX leakage at the interface between the B-52 pylon and the X-24B adapter became excessive. The adapter and pylon will be modified prior to the next LOX servicing.

The flight progressed per plan until the igniter test when the #3 igniter again failed to fire; however, the flight plan required only three chambers so the launch was made on schedule. Near the end of the powered portion of the flight the pitot attempted to start the #3 chamber but it did not lite.

The vehicle was in good shape following the flight.

Approved by: _____ Written by: _____

William P. Albrecht
Chief, Operations
Engineering Branch

Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

X-24B #551 POSTFLIGHT DATE: 11/15/73

PILOT: MANKE

This was flight B-6-13, November 15, 1973. It was our first powered flight and it was a real dandy.

Ok, the preflight, prelaunch all went beautifully. We got off early and climbout and everything was great. I can't think of any hang ups, can you Bill. (The only hang up came at 0620 this morning.) Yes, I heard something about that. I'll talk about the flight and you can talk about that one.

Ok, the ignitor test, I saw the same as Bill did, 1, 2 and 4 and nothing on 3. I didn't see anything on the #3 needle, not even a budge at engine bleed or anything, but I didn't see it on the other ones either. But absolutely nothing on 3. The others came up pretty normally. It looked like, let's see, it would be the #4 came up a little slower than the other 2 came up. I was worried for a second, it came up and hung for just a little bit and I don't know if you saw that or not. It hung a little bit and then it suddenly flopped on up there. That may have been what happened on the last ignitor test on the first attempt, it may have done that, maybe I just held the ignitor on a little bit longer this time. I don't know. This was more than I had seen the other day. Anyway it came up good and our ground rules that we had three, then we wouldn't make anymore and we would go.

Launch is very smooth in this airplane. I think I got a little more negative or closer to zero g than I'd had before. But, as far as rolloff, I didn't notice any particular rolloff, but I had my head right down in the cockpit looking for chamber switches. Launches, checked alpha and it was coming up nicely between 10 and 12 and looked back down and got the 2 and 4 chamber switches on and it seemed to me that it took a little longer for the things to light up than I had expected. But, it's been a long time and time has a funny way of playing tricks on you. I could hear it starting and the sequence sounded good all the way up. Bill actually called the 2 good ones slightly before I even saw the lights come on so you must have seen them..... No, the first 2 I'm talking about, the first 2. I got the first 2 and just when he called it my lights went on. I got the 2 and then came on with #3. Then, if I remember correctly, I had to come up a little bit to 14 alpha. We were worried about possible pitch up with the engine coming on. If there was any, there wasn't any problem. I would guess there wasn't anymore than 2 degrees alpha pitch up if there was that much with the onset of thrust. The task was 14 alpha and it was very easy to hold 14 alpha. I think if a guy really worked at it hard and wanted to hold alpha he could hold it easily in this area within ½ of a degree.

I looked at a few other things. It felt like we had a little mistrim that wanted me to roll right a little bit. If we get in and talk about

this wing rock I'll mention that again, I think that's part of the problem. I didn't take it out because I couldn't tell frankly whether it was an aileron mistrim or maybe rudder. It wasn't much, a very small amount of mistrim. I think we did go right a little bit after launch and I got the heading change from Bill to come back to the left.

I got to theta about 36 seconds which is very good. Our simulator has been showing about 35-36 seconds and we hit it at 36 seconds. We held the 20 degree theta then from there on up until the pulses. Now somewhere in this area I called a little wing rock. It wasn't anything that was alarming at all and maybe I got some people wondering about it. It's just that I had a lot of time at this particular point in the flight to look at things. This is something that you wouldn't even worry about if you had a lot of other things to do but since it was a pretty stabilized time in the flight I was able to sit there and look at it. It probably wasn't anymore than ± 4 or 5 degrees. I got the impression that I fed it a little bit a couple of times and I also got the impression that what started it was this little bit of mistrim, the wing would drop a little bit and then I would pick it up and then cycle a little bit. Also, there were 2 or 3 times that I felt we may have gotten one of our "klerds", our areas where we hit a little shear turbulence.

We may be just a little bit high on the roll sensitivity in this area and we can do here what we have done in pitch, we can run roll gain up a little bit. I've got the roll gain set down pretty darn low. I've got it flying like a fighter, in fact even a little bit quicker than some fighters so I would guess in this area we would probably run that roll gain up maybe to 5 or something like that. We'll take a look at it. Don't get me wrong, it wasn't any real problem, it's just something that was there and I did I few cycles with it and thought I would comment on it.

The thing that started getting my attention in this area, we had some checks. I had some performance checks, one at 60 seconds and one at 100 seconds and at that 60 second one it became obvious that we were going to go a little high. My check was high and Bill called that I was a little bit high, but I had a sort of a dilemma. The mach meter on the right which is suppose to be a very sensitive mach meter was reading .4 to .6 different than the other mach meter and the faster we got the bigger the difference became. So I expected to see about .69 in that area at 68 seconds and I saw .66 on the right and a little over 7/10 on the left one. This pattern went from there on up so I had a problem trying to decide which one was right and which one I should be flying on so I sort of split the difference on the way up. I spent more of my time looking at these mach meters and trying to decide than I really would have liked to. We'll have to resolve that problem.

At 100 seconds I again was 2000-2500 feet high and just a little bit low on the mach number. Then as we got down the pike a little bit, Bill called 2 miles from early shutdown line which had come earlier than I had expected it to. We seemed to be making fairly good headway down the track and then I got to thinking that maybe the higher mach meter was more correct then the other mach meter.

Got to .8 and I don't remember what the time was, I didn't look at the time. I went to .8 or .79 on the right hand meter before I did the pulses. The pulses were between 11 and 12 degrees and I got the rudder doublet and the aileron and they were very mild pulses. I didn't pulse it hard at this point because the fuel was down, I didn't want to shut it down. Got those pulses and by this time we had passed the early shutdown line and were coming up on the normal shutdown which turned out to be almost a must shutdown line. I was seeing about .83 on the right hand gage. I had just got off the left hand gage. Then I went to the right hand gage and saw about .83, reached over and tried the #3 chamber and nothing happened. By that time we had passed the shutdown line so I just reached over and hit the engine master switch. I didn't look at the peak mach number, didn't have time to get back up there. I didn't notice any pitch transient at shutdown.

Pushed over to 5 degrees alpha and boy the airplane flys awfully nice at 5 degrees alpha. It sure flys a lot better than the X-24A did at 5. The X-24A at 5 alpha was a very sensitive airplane. It felt like you were sitting on top of a ball bearing and about to roll off. I didn't get that impression today. The pitch attitude is very noticeable at 5 alpha coming over the top. It looks like you're coming just straight down.

The mach number seemed to be a little slow coming up as we pushed over on the right gage but it was higher on the left gage. It was a hell of a dilemma because you're keying on mach number and you've got two of them in there and you don't know which one is right. There is a considerable amount of difference in the two. So anyway, I got off the left one and went back to the right and started my 15 degree alpha pull up at .81, .82 on the right hand gage. Went right on to 15 alpha and back down to 11 and did the pulses at 11 degrees instead of 12. The mach held very nicely in this area, this is a result of the high profile. We've found in the simulator if we went high the mach number in the dive would hold very nicely and it did. I think the pulses were a good solid .8 on that one gage during the aileron and rudder pulses. They were very much like the simulator, very straight forward.

Ok, from there on it was just a jettison cycle, I don't know did Chase see any jettison? Ok. By the number, Bill's calls were excellent in this area. There was never a time in the flight that I didn't know where to put my angle of attack to get the airplane down to the energy that I wanted, so those were just perfect calls.

The turn went real good and once I got into the turn I could see the lakebed real well and put my head back into the cockpit then. I got the gains and watched my altitude and about 28,000, like in the simulator, I started to close up. I got the gains in the turn, did the popu after we got it closed up, and it was very much like the simulator too. I went down to 5 alpha, maybe down to 4, pulled up to 17, may have gotten just a little overshoot, got the crossover and I could feel the crossover. Our simulation of that is very good. It seems like we get it just a little bit earlier in the airplane but not more than a degree alpha.

The pattern was very nice. It was smooth air and just as I've said a hundred times before, this is a beautiful airplane in the pattern. It really flys nicely and it looked just like our 104 approach this morning. I was ending up a little bit slow on my final approach with the 104's this morning because of the winds that we have and I did the same with the X-24. Left my brakes out a little bit too long, got them back in, and flew final approach about 290 vs 300. Very comfortable approach and plenty of lift to flare the airplane.

The airplane is so nice that you don't even worry about altitude too much in the flare. You can really make a very nice eyeball type flare and the flare today was done by just looking out the window and deciding that now's the time to round the airplane out. You sit there and wait for 240 and I popped the gear out at 240 and set her down. I guess I ballooned a little bit one time, got down within 6 feet of the ground and I put in a little too much back stick and I felt it balloon. It was easy to catch, I put it back down where I wanted and set it down. We probably set down somewhere around 190 somewhere in that ball park. The nose came through like gang busters and rollout was straight. I used some nose gear steering on the rollout and probably changed heading 5 to 10 degrees either way. Moderate braking down below 80 knots. That's all there was to it. It was really a great flight.

(Where did you engage the steering?) I engaged the nose gear a little bit higher than that. I armed it about 140 or so and engaged it a little above 80, probably somewhere around 90. I just hit the button and then set in a little bit to see if I could get some. It's really a super nice system. The gearing is really great for this kind of thing. It's not something you go out and make pirouettes with or something like that but it's sure great in controlling on the runway.

(You were in the crossover after gear out. Did you notice it?) Maybe that's why I ballooned it. I don't know. Something didn't strike me and say I'm in the crossover. Well, I may have just over controlled it a little bit when I came down. I'm almost level about the time sitting there waiting for the gear to come out. You sit there at 75 down to 50 or so and then the gear comes out and I've got to ease it back down a little bit and I possibly over controlled it a little bit and maybe it did get into that crossover at that time.....No, I really can't. Let me think about it some more and it might turn out that that is part of the thing. But boy, all in all it was sure a nice flight. It was really a nice flying airplane. You just felt comfortable as the dickens all the way through.

(The General wanted to know if it was necessary?) Yea, I think so. We really needed this one today and boy the way the damn thing flew I think everything we did was necessary. That even goes for the chase practice. Anyone that has chased one of these damn things knows that that's a lot harder job than it is to fly the airplane. Chase has got the biggest flying job out there everyday and he needs to get out and look at some of these things and you can tell they did well because they're there. 22 or 23,000 feet Chase is there and with us all the way down. It pays off.

X-24B #551 DATE: 11/15/73

FLIGHT: B-6-13 L/P: V. Horton

PILOT: J. Manke

NASA 1: W. Dana

NASA 1: 25 minutes to launch.

(FROM THE 25 MINUTE POINT TO THE 7 MINUTE POINT WAS UNAUDIBLE.)

7 MINUTES TO LAUNCH

NASA 1: I'll call this 7 minutes John. 7 minutes.
JOHN: Ok. I heard Joe Reif.
NASA 1: Ok, John, we're reading you weak and a little garbled. You want to try secondary.
JOHN: Yes, let's go. Ok, Willie, I heard you 5by on all of them.
NASA 1: You're getting a lot better now John and I'm sure guard will pick up.
008 shallow your bank.
008: Roger.
NASA 1: We'll call this 6 minutes to launch, John.

6 MINUTES TO LAUNCH

JOHN: Ok, Bill. Coming back. Ok, there's 26.
NASA 1: Ok. And Chase aircraft check your windshield heat.
Chase: Chase 2. Roger.
NASA 1: Ok Chase.
Trim looks good John.
JOHN: Ok, Bill. Thank you.
NASA 1: And John we'll call this 5 minutes.

5 MINUTES TO LAUNCH

JOHN: Ok, going to battery. Ok, reset Emergency Battery.
I'm on 3 and 4 pumps, my pressures are 3200 and lites are out. Bus Loads 110, 105, 100, and about 30.
NASA 1: Ok, we copied all of that, John.
JOHN: SAS Gains 5, 5, 5. Here comes the old SMRD.
NASA 1: 008. Roll out 065 degrees.
008: 065.
JOHN: Here comes a torque. No lights. #1's are off, torque, 3 ambers. 2's are off and torque, 3 red ones.
NASA 1: Ok, we'll call this 4 minutes, John.

4 MINUTES TO LAUNCH

JOHN: Ok, I'm 7, 3, 3, SAS servos are auto, reset my lites and a torque. Looks good.

NASA 1: Looks good here, John.
L/P: B52 powers off and the ammeters are 0, Bill.
NASA 1: And John we're calling this 3 minutes.

3 MINUTES TO LAUNCH

JOHN: Ok, got your call. I'm on X-24B oxygen and I have about 1700 pounds here and regulated looks good at 85. I'm on X-24 air and I'm reading 3000 pounds there and my cabin altitude is 22.
NASA 1: Roger.
JOHN: Forward Canopy Defog is ON and the Canopy Defog is HEAT. Suit Vent is LOW. #1 Helium is 4000, #2 is 41. Cont. Gas is 490, Gov Bal 450. Switch is ERECT, fast erect is ON. My trim settings look good here.
NASA 1: Look good here, John. Everything looks good.
2 minutes, John.

2 MINUTES TO LAUNCH

JOHN: Ok, Bill, precool has been OFF. Eng Bleed coming ON, prop on, pressurize. Tanks coming up. You can get your top off, Vic.
L/P: Top off's complete, beacon's off and launch pressure's good.
NASA 1: Roger, Vic.
JOHN: LOX 50 and fuels about 49.
NASA 1: Roger, John.
JOHN: Release Pressure Low Lite OUT.
NASA 1: Roger. And John Manke we're driving into the launch point on a heading of 065 so there will probably be a 5 degree heading change to the left after launch.
JOHN: Ok.
NASA 1: 70 seconds, John.

70 SECONDS TO LAUNCH

JOHN: Ok, Bill.
NASA 1: NASA 1 calling 1 minute now.

1 MINUTE TO LAUNCH

JOHN: Ok, I've started the clock, 1 and 2 sources are good, SAS lites are OUT. Engine Master coming ON, heading is 064 and my alpha is 4 3/4, beta 3/4, needle left.
CUTOFF and OFF.
NASA 1: Everything looks good here, John.
JOHN: Ok, great. Release circuit breaker's IN, camera/recorders coming ON. Igniter test.
NASA 1: We see all but number 3, John.

JOHN: Ok, so do I. We'll have to go with that. I hit the reset and I'm ready to go. 5 seconds, Bill.

LAUNCH

NASA 1: Ok, John check your alpha. See 2 good ones. See 3 good ones, John. Check your alpha. Heading is good. Your heading is good.
JOHN: Ok. Nice solid 14 alpha.
NASA 1: Good heading, good profile, John.
JOHN: A little wing rock here for some reason or another.
NASA 1: Standby for theta.
JOHN: Good call.
NASA 1: When you have time, bring her 2 degrees left.
JOHN: Ok. Theta is pretty close.
NASA 1: Good profile John. Good track.
JOHN: Ok. 12 degrees alpha now.
NASA 1: Ok, we got your 12 alpha check, John. You are coming up on 60 seconds now.
JOHN: .66 on one and .7 on the other.
NASA 1: Roger. Your track is excellent, we show you going a little high on the nominal.
JOHN: Ok, maybe just a little. I think I'm getting a few of those "clurds."
NASA 1: Ok, John.
JOHN: 13 alpha mark.
NASA 1: Ok, we got your 13.
JOHN: I guess we want to try that chamber, Bill.
NASA 1: We will want to try that chamber, John, but that will be later in the profile.
JOHN: Rog.
NASA 1: Radar has got you through 44,000, John.
JOHN: Ok.
NASA 1: Coming up on 100 seconds now.
JOHN: Ok. A couple thousand high and I'm reading about .7, a little low and .76 on the other one.
NASA 1: Roger. You're about 2 miles to your early shutdown line, John. Track is good.
JOHN: Ok.
NASA 1: Coming up on 130 seconds now.
JOHN: Ok.
NASA 1: Standby for .8, 12 alpha and you're at your early shutdown line. Standby for doublets.
JOHN: Got them.
NASA 1: And we have you coming up on your normal shutdown line now. Want to try #3 chamber. Ok, John, let's go 5 alpha and prop supply off.
JOHN: Ok.

NASA 1: You're coming over the top at about 52,000, John. You'll be a little high on energy but you're ok.
JOHN: Ok.
NASA 1: Your track is excellent, John.
JOHN: Ok. Boy, that nose is coming down.
NASA 1: That's fine, John. Your energy looks superb. You're right on the old line, John. You're 4 miles to the intersection.
JOHN: Ok.
NASA 1: Standby for .8 and 15 alpha, John. Ok, we see you at 15 alpha, we have you through 43,000, John. You're right on the nominal energy, you're 2 miles to the intersection, your heading is good. Now we have you going a little high on the nominal. Standby for 12 alpha and doublets, John.
JOHN: I've got them already, Bill and I'm jettisoning.
NASA 1: Ok, start your turn, John. You're at the intersection. Let's start a pretty good left turn, heading 350.
JOHN: Ok.
NASA 1: Let's stop jettison, tanks and bleed off and keep the turn coming.
JOHN: Ok. Good shape.
NASA 1: You've got a nice turn going, John. That's just the right amount of bank, you're 2,000 high on your nominal energy. Nice turn going, John. 350 is your rollout heading.
JOHN: Ok.
NASA 1: We see 4,3,2 on the SAS and you can standby to close it up.
JOHN: Ok, coming clean.
NASA 1: You're 3 miles to the intersection, radar has you at 28,000, John. You're coming right down your north bound track. You're going high, you're about 3,000 high, you can standby for the popu, John. 2 miles to the intersection. See you closed up John. We see your popu. When you get done with it let's get 1 and 3 hydraulics on, you're at 1 mile to the highway, John. We're standing by for a rocket check. You're 3,000 high on your nominal profile right on track.
CHASE: Nice rocket check.
NASA 1: Good rocket, John. You're at the highway, you might want to get your turn started. Get your chambers switches off and your camera on.
JOHN: Ok, got all that.
NASA 1: Ok, John.
CHASE: About 21,000, John.
JOHN: Ok, Gar thanks. Little brakes Gary.
CHASE: Ok. 305 knots.
JOHN: 290.
CHASE: Ok, 295 now. Closing very slowly.
NASA 1: Ok, John, when you get rolled out let's go mach repeater to 3/10.
JOHN: Got it.
NASA 1: Thank you sir.

CHASE: 280.
JOHN: Brakes coming in. Ok, I'm reading about 285, I think I'll leave that. 290, nice flying.
CHASE: 287.
JOHN: Nice show.
CHASE: About 75 feet, John.
JOHN: Yes.
CHASE: Three good gear. Ok, 6, 4, 3, 2, floating about 1 foot. Beautiful.
NASA 1: Ok, when you get to 100 knots John, you can arm your nose wheel steering.
JOHN: Ok.
NASA 1: All stations. Debrief will be at 1030.
John Manke, we would like you to go KRA manual when you have the time.
JOHN: Ok, hang in there. Manual. Good airplane.
NASA 1: Your pony called and said nice flight.
JOHN: Looks like 150.
NASA 1: Roger on the burn time, John.
JOHN: Let's see. I guess we change pages here.
NASA 1: John Armstrong's interested in what kind of mach number you saw, John.
JOHN: It depends on which mach number thing I look at. I saw about .83 on this right one and .87 on the other one. Of course, I didn't look at it right at the last and I went down for that other chamber switch.
NASA 1: Roger, John. We're ready to pickup page 21 whenever you are.
JOHN: Throttles OFF, cameras are coming OFF, calibrate?
NASA 1: We're ready for the calibrate. That was a good one.
JOHN: Ok, now the recorder is coming OFF. The SAS Servos are OFF.
NASA 1: Roger.
JOHN: Hydraulic pumps are OFF.
NASA 1: Roger.
JOHN: Defogs are OFF. Here are the readings: #1 is 12, #2 is 38, Cont. Gas is 490, Gov Bal is 460, Landing Gear is 2600, Cabin Air is 900, Engine Timer is 150 and a quarter.
NASA 1: Ok, we copied all of that, John.
JOHN: Radar is coming OFF and stick shaker coming OFF.
NASA 1: That takes care of page 21.
JOHN: I got a good stick shaker test on that popu.
NASA 1: Ok.
JOHN: Att. Systems are coming OFF.
NASA 1: OK.
JOHN: Ok, we've got some safety pins, I'll get the canopy up and I'll see you back there.
NASA 1: Ok, that was a beauty John. You'll really like your profile when you see it.

FLIGHT 7

Lot 7 Space 76/

PRELIMINARY RESULTS OF X-24B

Flight B-7-14

12 December 1973

By

AF/NASA X-24B PROJECT TEAM

X-24B Flight Request
5 December

Flight No: B-7-14

Scheduled Date: 11 December 1973 FLOWN 12 DEC.

Pilot: John Manke

Purpose:
1. Envelope Expansion to .95 Mach Number
2. Stability and Control at .9 Mach Number
3. Performance with aileron bias at -11^{o}
4. Fin and Rudder Pressure Survey
5. Accoustic Noise and Vibration Experiment (WHITE PLUG)

Launch: West of Rosamond, Mag Heading 060^{o} + Crosswind Correction Angle. 45,000 feet, 185 KIAS. Flap Bias "Manual", Upper Flaps = -40^{o}, Lower Flaps = 27^{o}, Rudder Bias Mode "AUTO", Rudder Bias = 0^{o}. Rudder Trim = $1/2^{o}$ Left. Aileron Bias = -7^{o}, SAS Gains 6, 5, 3. Mach Repeater "Manual" = 1.0, KRA "AUTO", Hydraulic Pumps 2 and 4 on.

Landing: Rogers Lakebed Runway 18

B-52 Track: X-24B Track #2 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
1	0	45	185	5	.70 (.68)	Launch, Lite Chambers #2 and #4 Then #1, Trim to and Maintain 14^{o} α
2	26	42.5	240	14	.84 (.81)	Max Mach During Rotation.
3	35	44	235	14	.83 (.80)	Lite Chamber #3, Maintain 14^{o} α
4	50	46	225	14	.82 (.79)	$\theta = 30^{o}$ Maintain 13^{o} α (cross check θ)

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
5	94	58	190	13	.90 (.87)	At M_T = .9 Pushover to 12° α and shutdown Chamber #1. Perform Rudder and and Aileron Doublets
6	115	62	180	12	.95 (.91)	At .95 $Mach_T$ Shutdown Engine with Engine Master. Pushover to 5° α. Perform Rudder and Aileron Doublets.
7	132	61	170	5	.87 (.84)	At .87 $Mach_T$ Pullup to 14° α, Perform Rudder and Aileron Doublets.
8	153	53	210	14	.90 (.87)	Pushover to 10° α, Perform Rudder and Aileron Doublets.
9	165	48	235	10	.90 (.87)	Disengage Pitch Damper Perform Pitch Pulse Reengage Damper Jettison Propellants
10	226	33	215	10	.60 (.59)	Intersection, Turn to Low Key Heading. Set SAS Gains 4,3,2.
11	250	28	205	12	.53 (.52)	Change Configuration to -20° Upper Flaps.

ITEM	TIME	ALT	A/S	α	M_T/M_i	EVENT
12	263	26	220	10	.54 (.53)	Aileron Bias to $+11^{o}$ Perform Pushover-Pullup 5^{o} to 15^{o} to 10^{o} α. Aileron Bias to $+7^{o}$.
13	295	21	220	10	.48 (.47)	Low Key, Rocket Check, #1 and #3 Hydraulic Pumps on.
14						LH Fin Camera on at 90^{o} position. Set Mach Repeater to .3 During Final. Rudder Doublet After Gear Down at Pilot's Discretion

NOTES:

1. Nose Ballast = 220 lbs (+ 100 AMP HR Equp Batt)

2.

	Weight~lbs	cg~%
Launch	13,495	65.9
Shutdown	9,026	64.1
Landing	~8,394	64.0 (gear down)

3. Engine S/N 8, Pump S/N 8A

   Thrust = 2,200 lbs/chamber
   LOX Flow Rate = 4.73 lb/sec/chamber
   WALC Flow Rate = 4.24 lb/sec/chamber

4. Power on Base Drag Reduction C_C = -.005

5. Pitch Attitude Null at 30^{o}

Ground Rules for NO LAUNCH:

1. Radio, radar, PCM failure

2. Electrical or SAS malfunction

3. A/S, altitude, Machmeter failure

4. Angle of attack or sideslip malfunction

5. Any control system malfunction

6. Loss of cabin pressure

7. Turbulence below 10K in excess of moderate

8. Surface winds greater than 20 kts or crosswind greater than 10 kts

9. Failure of engine control box heater

10. Failure of stick shaker

11. Must have 3 good igniters to launch

(In addition to standard ground rules published in Lift Body Joint Operations Plan)

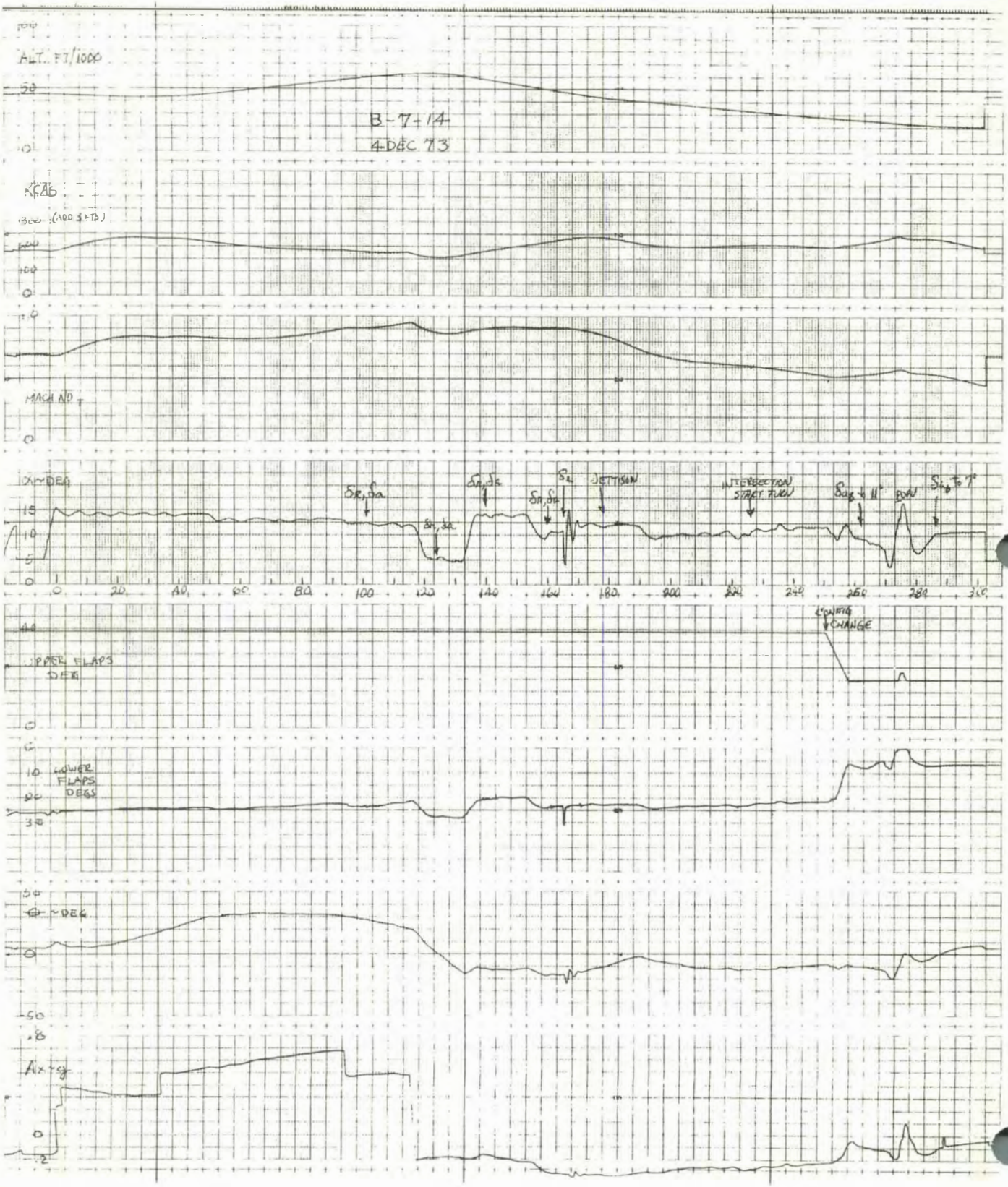
Alternate Situations After Launch:

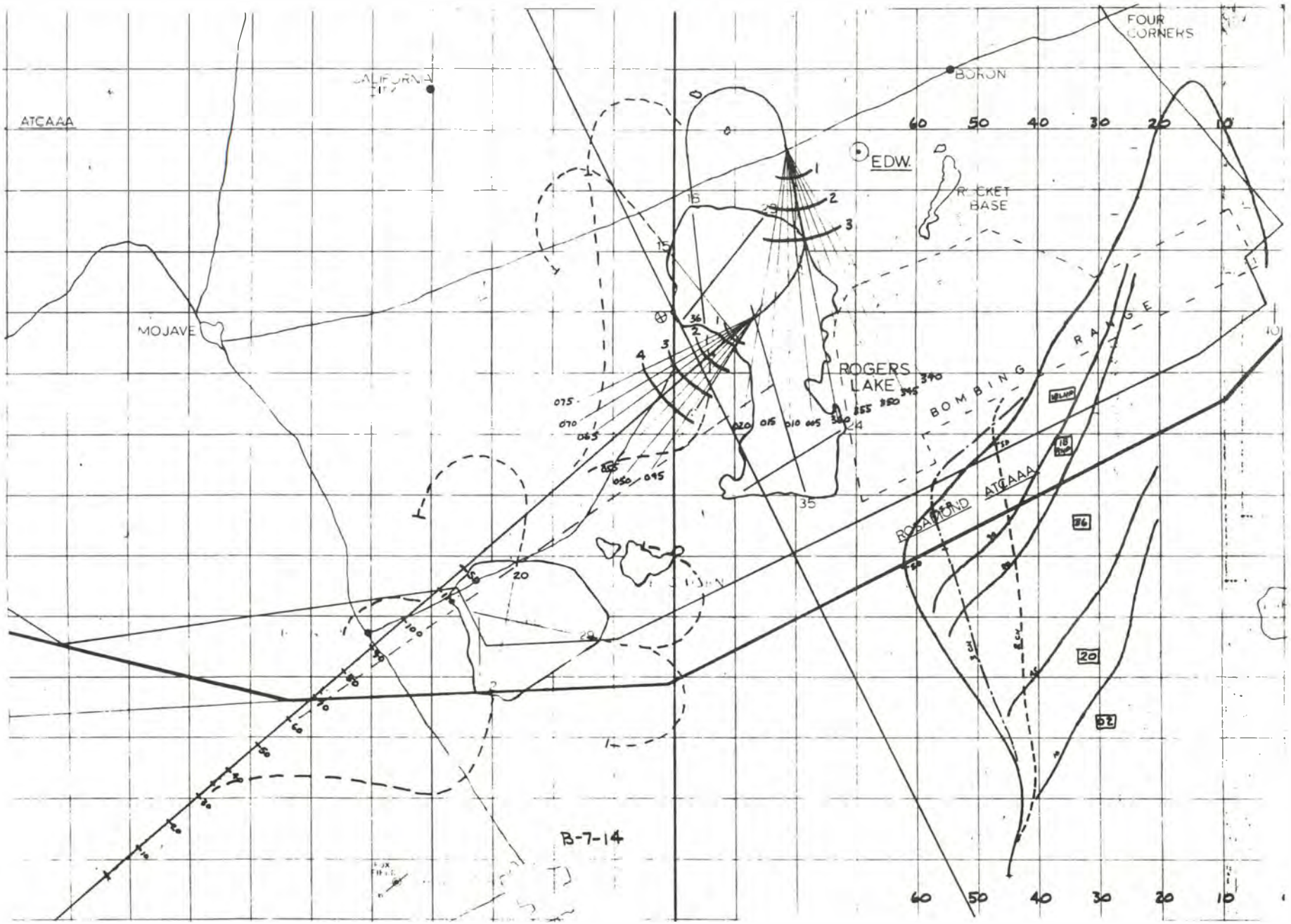
	Failure	Action
1.	Radio, radar, PCM	Proceed as planned.
2.	Only One Chambers Operates	Vector for RW 02 Rosamond shutdown chamber, jettison, change configuration.
3.	Only Two Chambers Operate	Maintain 14^{o} α, retract upper flaps to 35^{o} after rotation and M_T < .8. Change configuration to 30^{o} upper flap at .7 Mach No. Shutdown on NASA I call (≈ 183 sec). Evaluate dampers OFF handling qualities at pilot's discretion.
4.	Only Three Chambers Operate	Maintain 14^{o} α. Turn 5^{o} right at 50 sec. at .9 M_T/56K pushover to 12^{o} α, perform doublet set, shutdown at .95M_T (148 sec). Perform planned data maneuvers.

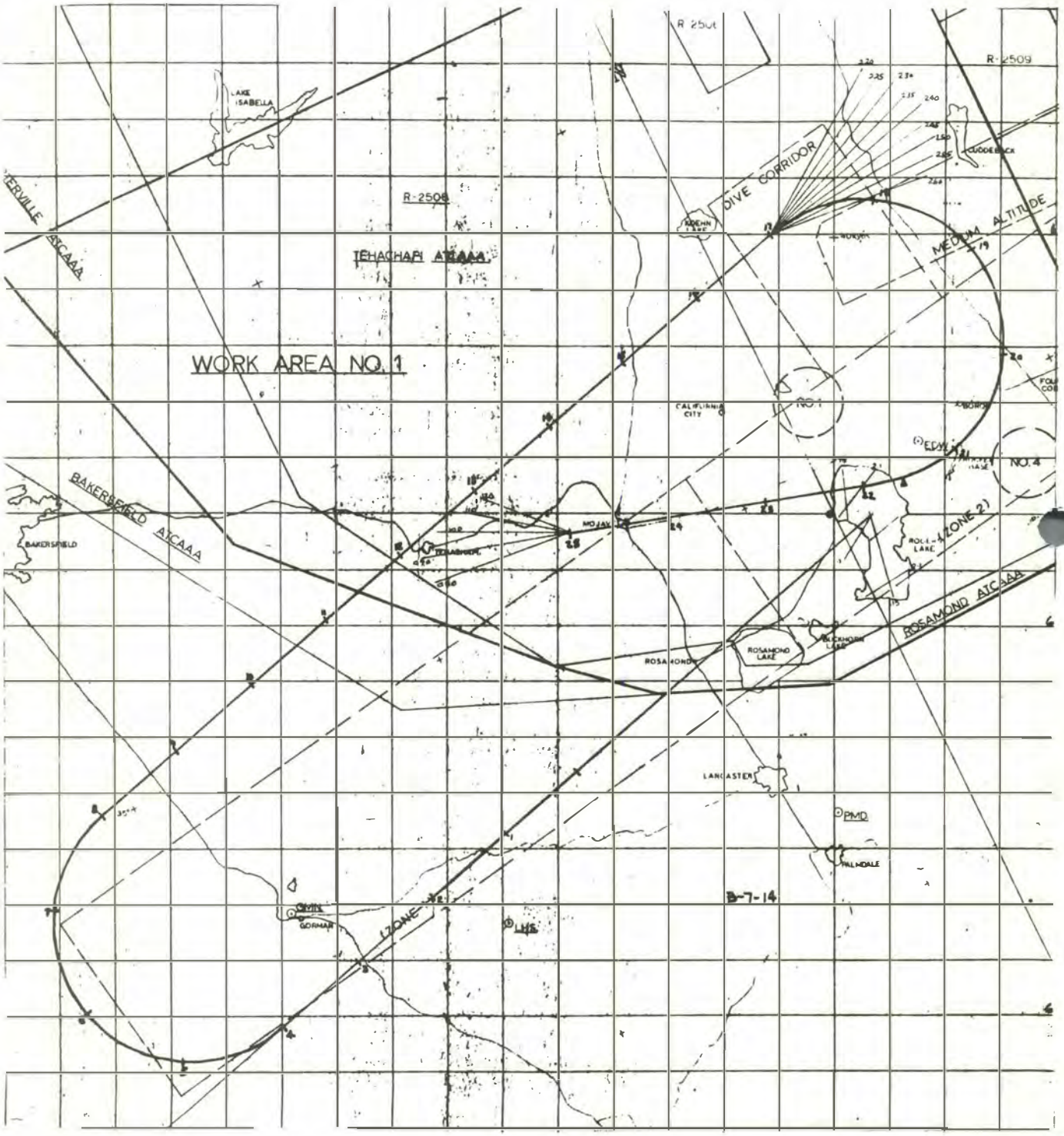
	Failure	Action
5.	Delayed Engine Light	Proceed as planned.
6.	Total pitch or roll damper failure	Fly 3 Chamber profile, limit M_T to .85 ~~.9~~. Data maneuvers at pilot's discretion. AT .8M SHUTDOWN ONE CHAMBER ETC
7.	Total yaw damper failure	Proceed as planned.
8.	KRA "AUTO" Failure	Set to manual 10% and proceed as planned. If "MANUAL" mode inoperative-switch to "EMMER" position and set to above value.
9.	Angle of Attack (Indicator Only)	Proceed as planned using back-up angle of attack gage. KRA "MANUAL" 10%, stick shaker off.
10.	Total Angle of Attack	Fly Two Chamber profile, use 200 KTS instead of 14^{o} α. (KRA Manual 10%, stick shaker off)
11.	A/S, altitude, Mach	Proceed as planned using α, θ and time for profile control.
12.	Attitude System	Proceed as planned using back-up attitude indicator.
13.	Premature Engine Shutdown 0 - 10 sec RW 02 Rosamond 10 - 45 sec RW 20 Rosamond 45 - 80 sec RW 36 Rogers 80 - 90 sec RW 18RHP Rogers 90 - up sec RW 18LHP Rogers	

Robert G. Hoey
ROBERT G. HOEY

W D Thompson
JACK L. KOLF


B-7-14
4-DEC 73
ALT. FT/1000
MACH NO
δR, δA
δR, δA
δR, δA
δR, δA
S2
JETTISON
INJECTION START TIME
δA = 11°
δA = 7°
LIFTING CHANGE
UPPER FLAPS DEG
LOWER FLAPS DEGS
Θ - DEG
Ax+g


FOUR CORNERS
BORON
ATCAAA
EDW.
ROCKET BASE
MOJAVE
ROGERS LAKE
BOMBING RANGE
ROSAMOND
ATCAAA
B-7-14


R 2506
R-2509
LAKE ISABELLA
R-2508
TEHACHAPI ATCAAA
DIVE CORRIDOR
MEDIUM ALTITUDE
WORK AREA NO. 1
NO. 1
NO. 4
EDW
BAKERSFIELD ATCAAA
BAKERSFIELD
MOJAVE
ROSAMOND ATCAAA
ROSAMOND LAKE
LANCASTER
PMD
PALMDALE
B-7-14
LZONE
LHS

X-24B FLT. B-7-14 EVENTS

DD	MACH	ALT.	KCAS	EVENT	Δt
11:14:18.0				LIQUID LOX PRIME	-44.0
14:46.0				IGNITER TEST	-16.0
15:02.0	.693	44792	185	LAUNCH	0.0
15:05.1	.683	44662	183	#2&4 CHAMBER PRESS. START UP	3.1
15:06.5	681	44572	183	Ax INCREASING (2&4)	4.5
15:07.8	.683	44441	184	#2 AT 100%	5.8
15:08.3	684	44386	184	STICK SHAKER ON	6.3
15:08.8	.688	44333	186	SUDDEN NOSE DOWN PULSE α=17°	6.8
15:09.0	688	44312	186	#4 AT 100%	7.0
15:09.5	691	44247	187	STICK SHAKER OFF	7.5
15:09.6	.691	44236	187	#1 CHAMBER PRESS. START UP	7.6
15:11.0	.699	44054	190	AX INCREASE (#1)	9.0
15:12.3	.709	43863	194	#1 AT 100%	10.3
36.3	823	41074	244	LEFT RUDDER TRIM INPUT	34.3
:41.8	.824	40989	245	#3 CHAMBER PRESS. STARTS UP	39.8
:43.1	.825	41003	246	AX INCREASE (#3)	41.1
:45.2	.829	41048	247	#3 AT 100%	43.2
:47.8	.833	41182	247	MAX ROTATION MACH NO.	45.8
:51.9	.831	41585	244	LEFT RUDDER TRIM INPUT	49.9
11:16:31.6	.747	52681	169	RIGHT RUDDER TRIM INPUT	89.6
:44.8	.861	56926	178	PUSHOVER FROM 14 TO 12° α	104.8
:48.9	.859	57474	175	#1 CHAMBER PRESSURE DECREASES	106.9
:49.1	.858	57525	175	Ax DECREASE (#1)	107.1
:52.3	.874	58393	175	RUDDER DOUBLET α=12°	110.3
:57.1	.881	59508	171	AILERON DOUBLET α=12°	115.1
17:18.3	.987	62536	183	SHUTDOWN (CHAMBER PRESS)	136.3
18.5	.9874	62531	183	MAXIMUM MACH NUMBER, PUSHOVER TO 5°α	(955.9 fps)
22.1	.966	63081	176	PEAK ALTITUDE	
28.3	.919	62547	168	RUDDER DOUBLET α=5°	146.3
32.1	.928	61940	172	AILERON DOUBLET α=5°	150.1
34.2	.925	61388	174	START PULLUP TO 14° α	152.2
43.0	.930	58550	187	RUDDER DOUBLET 14° α	161.0
47.7	.955	56900	200.	AILERON DOUBLET 14° α	165.7
11:17:52.3	.908	55149	197	RUDDER DOUBLET 15° α	170.3

2-7-4 CON'T

TOD	MACH	ALT.	KCAS	EVENT	Δt
11:17 54.8	.872	54224	192	START PUSHOVER TO 10°α	172.8
18:01.3	.881	51949	205	RUDDER DOUBLET 10°α	179.3
:04.9	.861	50537	206	AILERON DOUBLET 10°α	182.9
:09.4	.890	48799	223	PITCH DAMPER OFF	187.4
:09.9	.893	48603	225	PITCH PULSE 10°α	187.9
:15.8	.888	46228	236	PITCH DAMPER ON	193.8
:19.0	.880	44978	241	START LOX JETTISON	197.0
:20.3	.874	44593	241	START WALC JETTISON	198.0
:26.6	814	42308	234	END LIQUID LOX JETT (7.6 SEC)	204.6
:28.5	.791	41771	230	END LIQUID WALC JETT. (8.5 SEC.)	206.5
:41.0	.695	38758	214	START LEFT TURN AT INTERSECTION	219.0
:41.8	.691	38589	213	PITCH GAIN TO 4	219.8
:42.6	.686	38408	212	ROLL GAIN TO 3	220.6
:43.4	.682	38239	212	YAW GAIN TO 2	221.4
11:19:19.5	.586	29861	219	START CONFIG. CHANGE	257.5
27.0	.585	28190	226	END CONFIG. CHANGE	265.0
:29.5	.586	27707	229	AILERON BIAS MOVE FROM 7°	267.5
:35.0	.587	26720	234	AILERON BIAS AT 11°	273.0
:37.0	.590	26316	237	START PUPO AT MIN α=4.5°	275.0
:38.2	.593	26066	240	LOWER FLAPS BOTTOM α=9°	276.2
:38.9	.594	25923	241	UPPER FLAPS START UP α=10°	276.9
:43.6	.560	25217	230	AT MAX α = 16.5° (δ_H = 26.5°)	281.6
:47.0	.539	25014	222	AT MIN α = 4.5°	285.0
:48.8	.535	24879	221	AILERON BIAS LEAVE 11°	286.8
:53.6	.534	24373	223	AILERON BIAS AT 7°	291.6
:54.2	.534	24297	223	LOW KEY START TURN	292.2
:55.1	.534	24189	225	ROCKET CHECK	293.1
:58.4	.545	23765	231	#1 PUMP ON	296.4
11:19:58.7	.545	23690	231	#3 PUMP ON	297.1

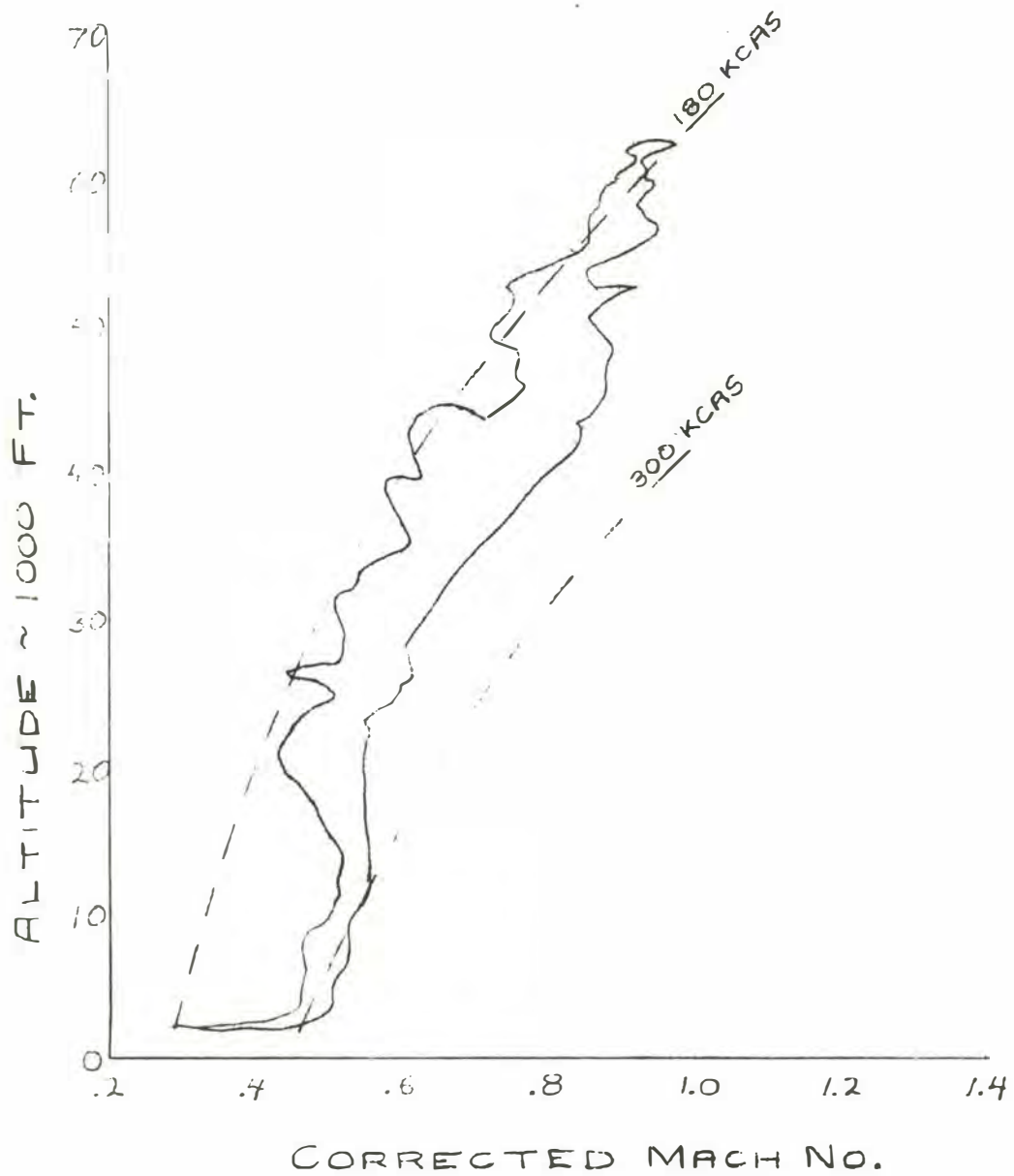
B-7-14 CON'T

TOD	MACH	ALT	KCAS	EVENT	Δt
11:20 55.4	.538	13980	277	MACH REP. TO .3	353.4
:58.8	.540	13257	282	UPPER FLAPS START UP TO 31° (SPEED BRAKE)	356.8
21:23.3	.470	7739	271	UPPER FLAPS START IN	381 3
:27.9	.468	6860	274	UPPER FLAPS AT 20°	385.9
:31.0	.468	6334	277	LEVEL ON FINAL	389.0
:53.2	.450	2910	283	FLARE	411.2
22:04.9	.380	2148	242	GEAR DOWN	422.9
:07.2	.359	2102	228	RUDDER DOUBLET	425.2
:16.8	.274	2033	175	MAIN GEAR TOUCHDOWN	434.8
11:22:18.6	.260	2037	166	NOSE GEAR TOUCHDOWN	436.6

FLT. TIME = 7 MIN 14.8 SEC

X-24B

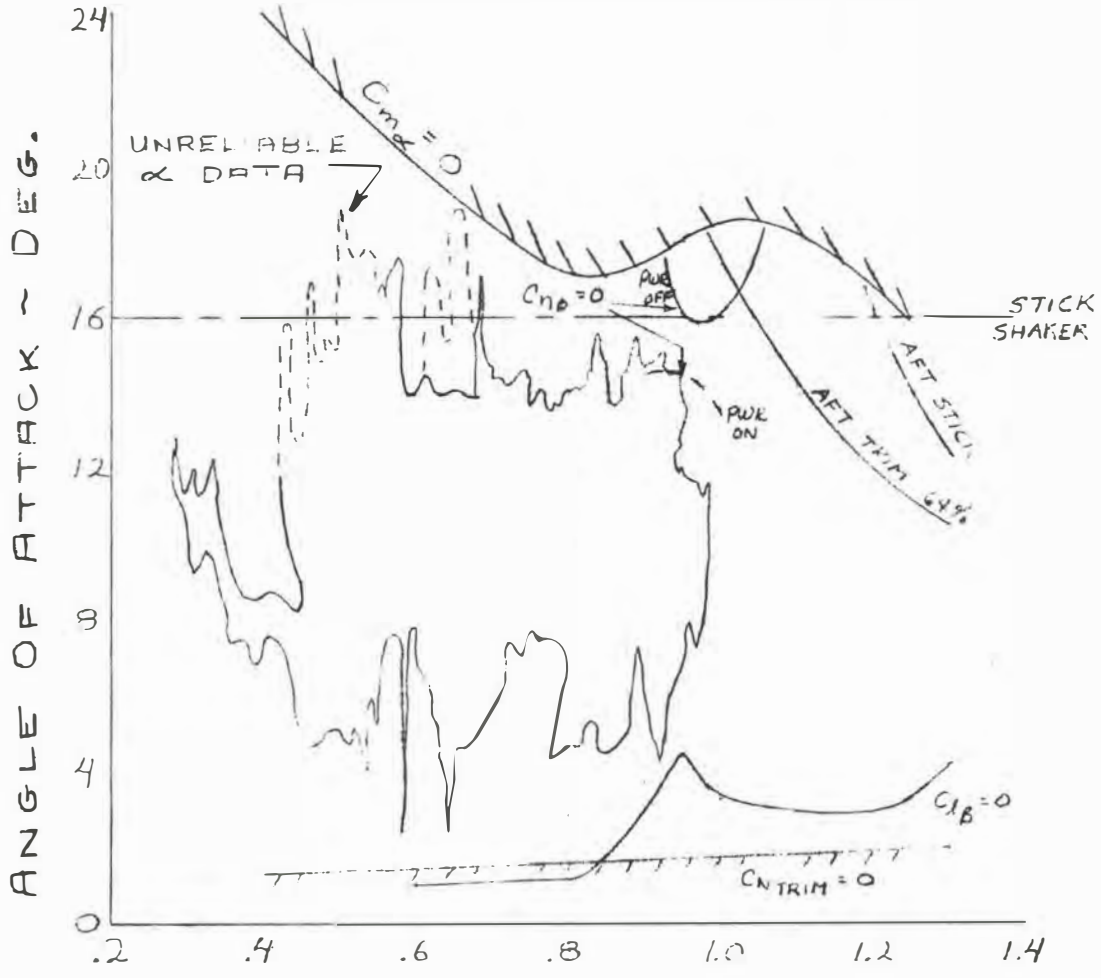
MACH NO. VS ALTITUDE ENVELOPE FLIGHTS 1 THRU 7



X-24B

MACH NO. VS ANGLE OF ATTACK ENVELOPE

FLIGHTS 1 THRU 7



Performance & Longitudinal Trim

by
D. Richardson

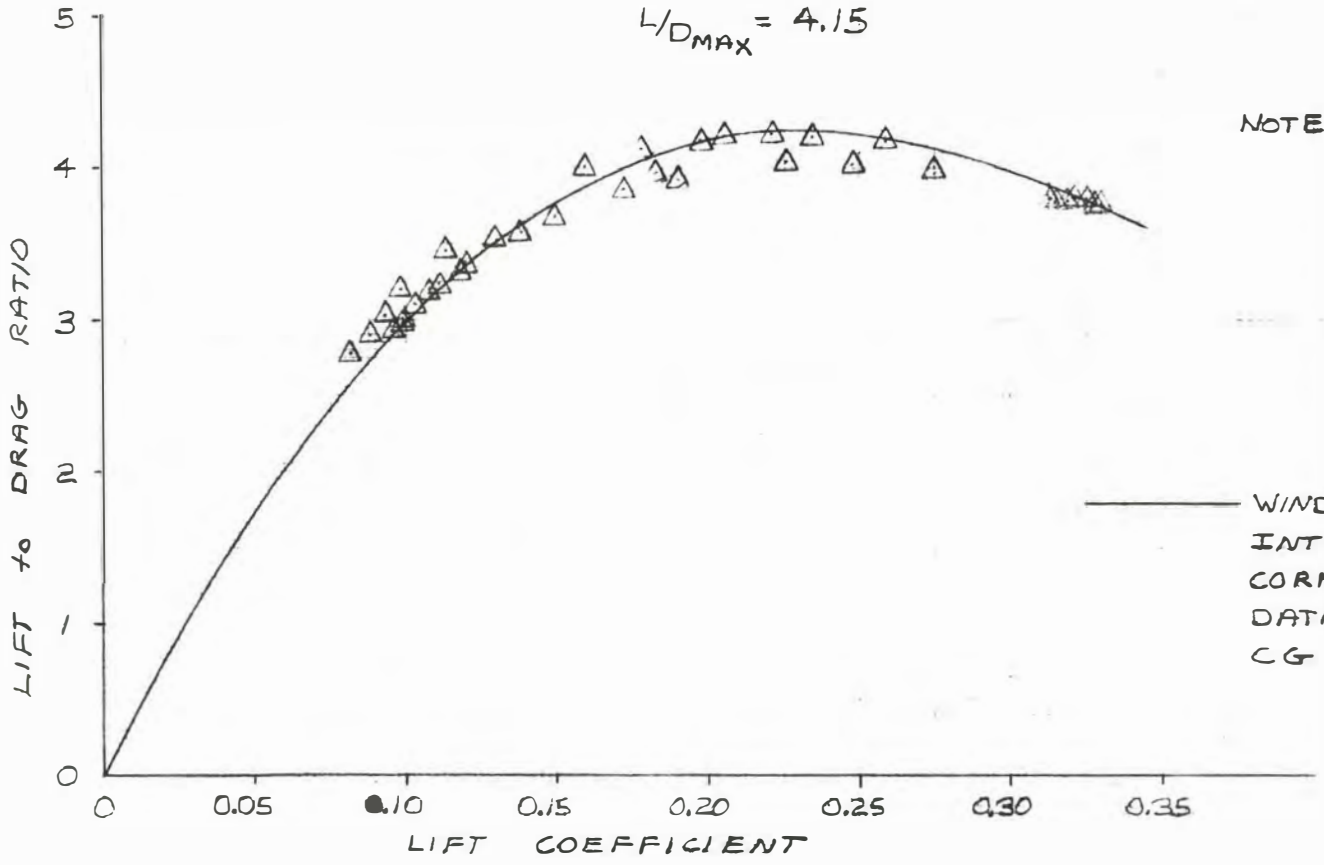
During flight seven the aileron bias deflection was moved from 7 degrees down to 11 degrees in order to show the effects of aileron bias deflection on performance (figures 1 to 3) and longitudinal trim (Fig 10) in the subsonic configuration. The maximum L/D ratio increased by 0.2 at Mach 0.6 when the aileron bias was moved down to 11 degrees. This was due to the fact that the lower flap deflection required for trim was less with 11 degrees aileron bias than with 7 degrees aileron bias with the results that the drag was less. The slope $C_{N\alpha}$ in this configuration was slightly less than predicted by the wind tunnel data. The chord force was slightly greater than the wind tunnel data at the higher angles of attack.

After engine shutdown on flight seven the pilot pushed over to 5 degrees angle of attack at .95 Mach number and then pulled up to 15 degrees angle of attack at .85 Mach number. Both of these maneuvers were performed in the transonic configuration. The performance data obtained form the pullup matched the wind tunnel data very closely (figures 4 to 6). Although the maximum L/D was not reached during this maneuver, the data appeared to be leveling out at an L/D of 1.9 to 2.0. The performance data extracted from the pushover also closely matched the wind tunnel data (figures 7 to 9). The drag rise is very noticeable in the chord force data (figure 8) as the Mach number increases from 0.93 to 0.94.

The longitudinal trim with 11^{o} aileron bias (figure 10) still shows a reduction in static margin when compared with the wind tunnel data as is also the case with the transonic data in figures 11 and 12. In neither of these cases was there any indication of pitchup; this was expected because the pilot deliberately stayed below the predicted pitchup boundary.

The effect of the rocket engine on the longitudinal trim is negligible (figure 13). The engine "ON" data in this figure was corrected for the known thrust misalignment. This means that the only effect unaccounted for was the aerodynamic effect of the thrust and, as can be seen, this aerodynamic effect is very small. In the X-24A the aerodynamic effect of the engine thrust was quite large.

△ FLIGHT B-7-14
$\delta U_B = -20°$ $\delta R_B = -10°$
$\delta A_B = 11°$
MACH = 0.54 - 0.59
CG = 66%



NOTE: THERE IS A USEFUL SPEEDBRAKE CAPABILITY IN THIS CONFIGURATION HOWEVER THE VEHICLE WILL BE FLYING IN THE CROSSOVER REGION AT TOUCHDOWN

——— WINDTUNNEL DATA INTERPOLATION USING CORNELL DATA & AEDC DATA @ MACH = 0.6
CG = 66%

FIG 1

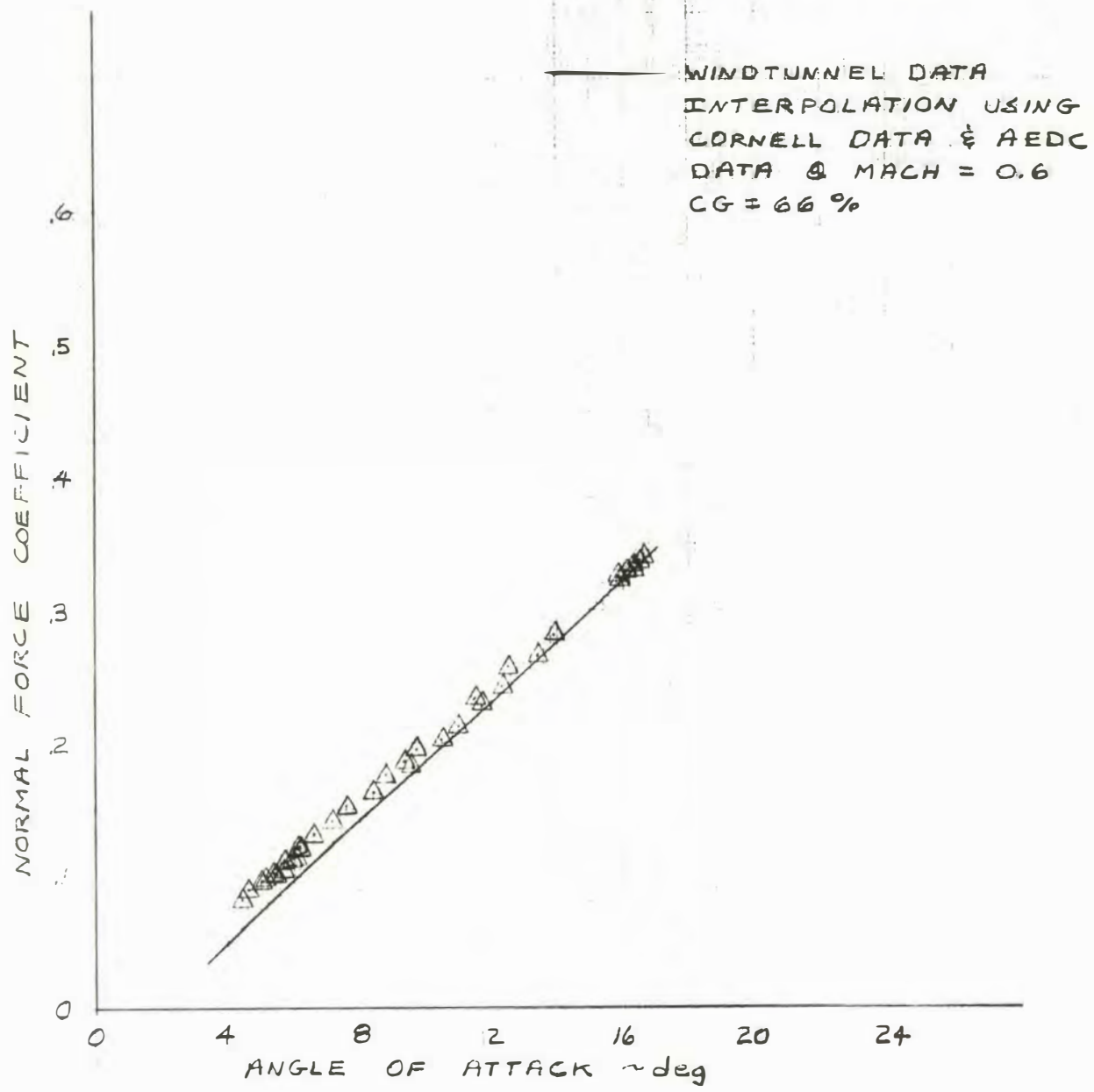

Δ FLIGHT B-7-14
$\delta U_B = -20°$ $\delta R_B = -10°$
$\delta A_B = 11°$
MACH = 0.54 - 0.59
CG = 66%
WINDTUNNEL DATA
INTERPOLATION USING
CORNELL DATA & AEDC
DATA @ MACH = 0.6
CG = 66 %
NORMAL FORCE COEFFICIENT
.6
.5
.4
.3
.2
.1
0
0
4
8
12
16
20
24
ANGLE OF ATTACK ~deg

FIG. 2

FLIGHT B-7-14
$\delta U_B = -20°$ $\delta R_B = -10°$
$\delta A_B = 11°$
MACH = 0.5+ 0.5?
CG = 66 %

——— WINDTUNNEL DATA
INTERPOLATION USING
CORNELL DATA & AEDC
DATA @ MACH = 0.6
CG = 66 %

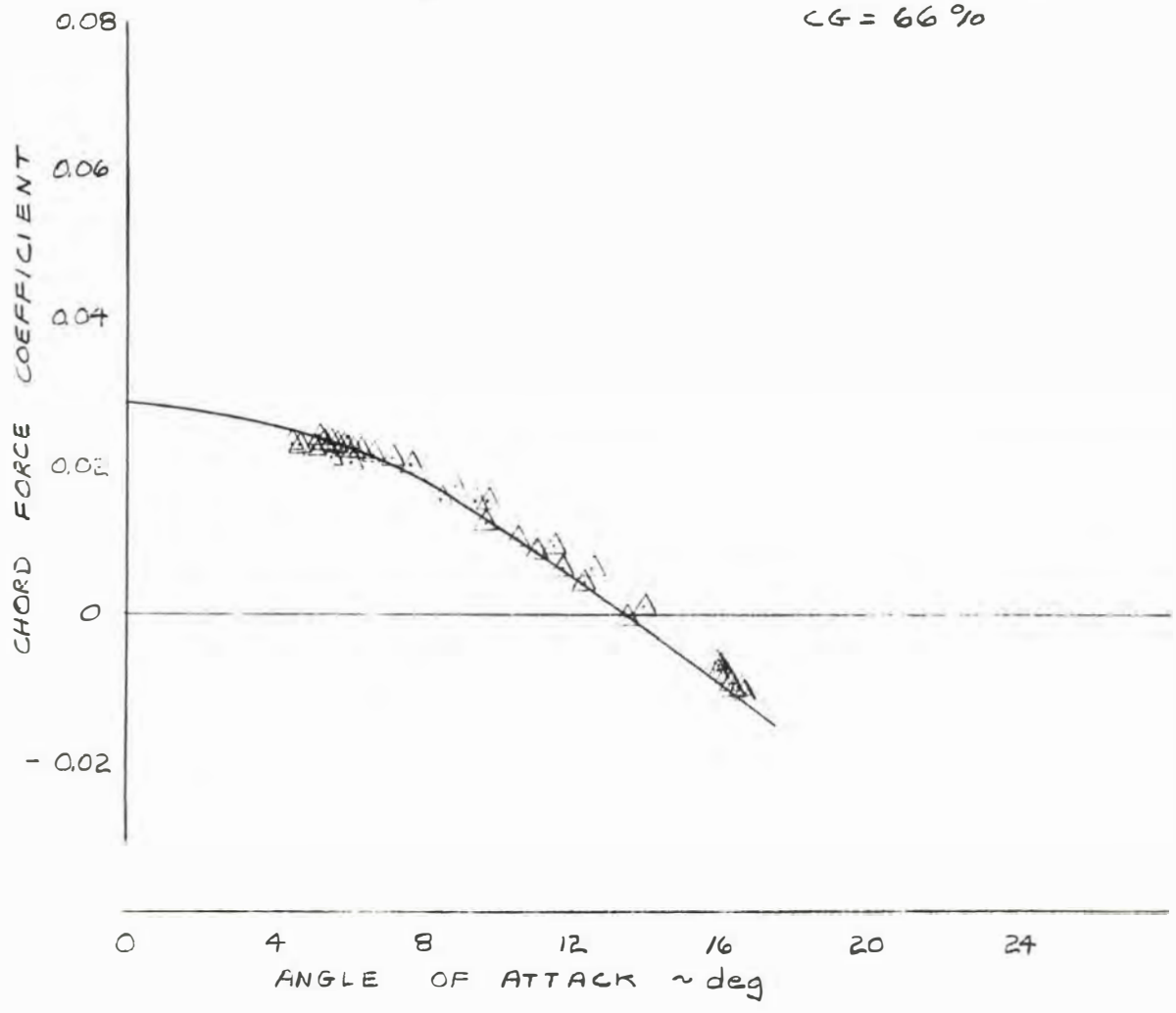


FIG 3

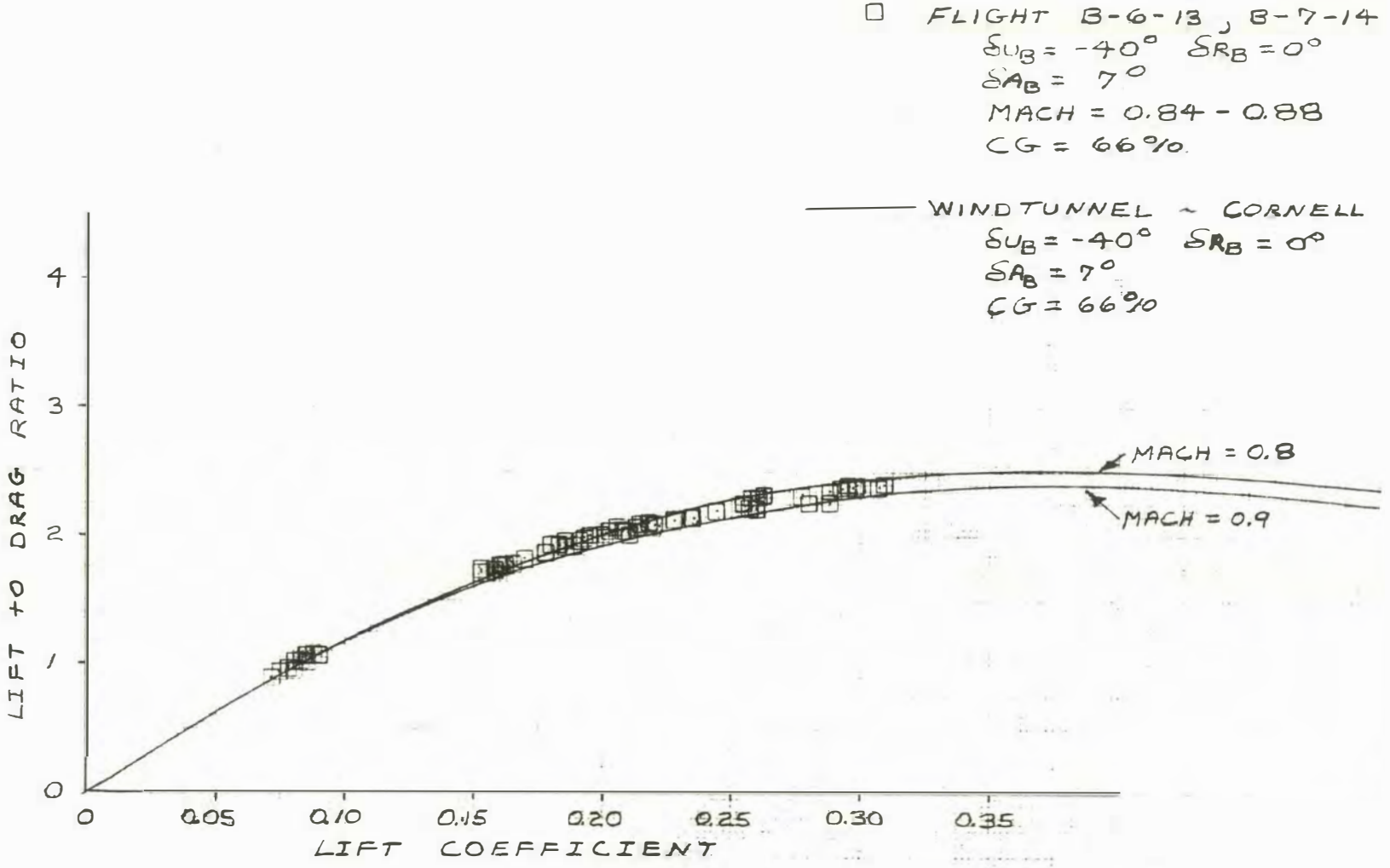

□ FLIGHT B-6-13, B-7-14
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = 0.84 - 0.88
CG = 66%
WINDTUNNEL ~ CORNELL
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
CG = 66%
MACH = 0.8
MACH = 0.9
LIFT TO DRAG RATIO
0
1
2
3
4
0
0.05
0.10
0.15
0.20
0.25
0.30
0.35
LIFT COEFFICIENT

FIG. 4

□ FLIGHT B-6-13, B-7-14
$\delta U_B = -4.0°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = 0.84 - 0.88
CG = 66%

——— WINDTUNNEL ~ CORNELL
$\delta U_B = -4.0°$ $\delta R_B = 0°$
$\delta A_B = 7°$
CG = 66%

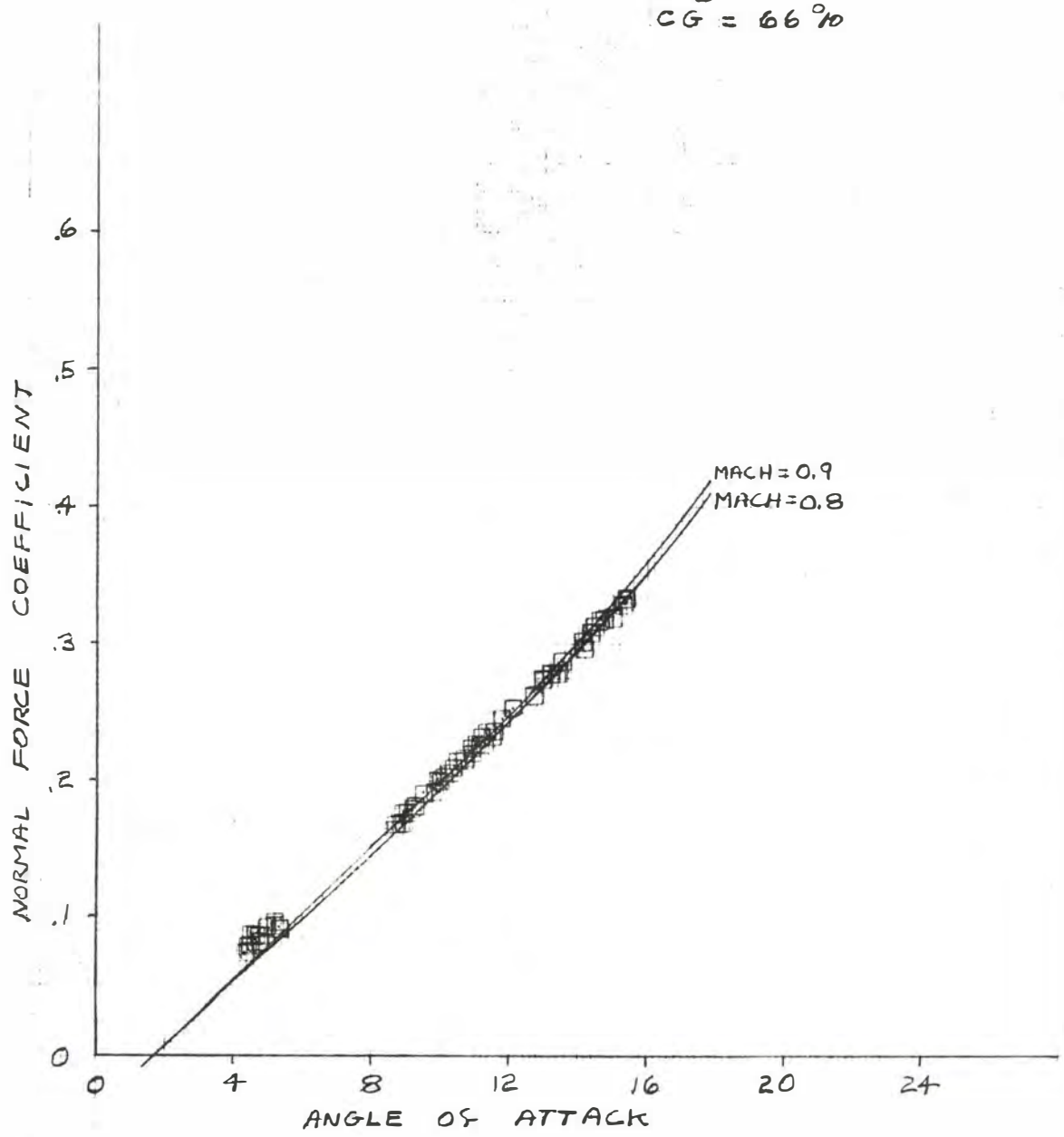


FIG 5

□ FLIGHT B-6-13, B-7-14
$\delta E_B = -4.0°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = 0.84 - 0.88
CG = 66%

——— WINDTUNNEL - CORNELL
$\delta E_B = -4.0°$ $\delta R_B = 0°$
$\delta A_B = 7°$
CG = 66.%

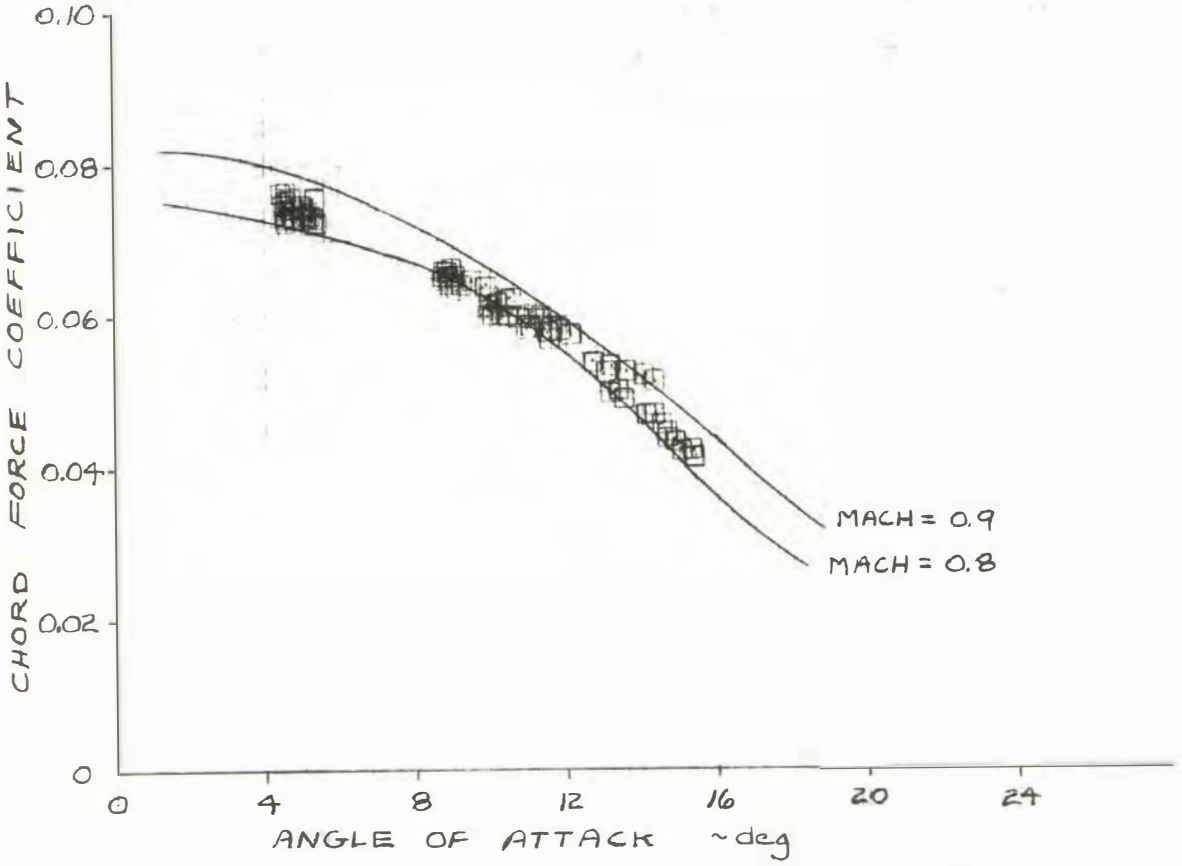


FIG. 6

◇ FLIGHT B-7-14
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = 0.93 - 0.95
CG = 66%

——— WIND TUNNEL ~ CORNELL
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
CG = 66%

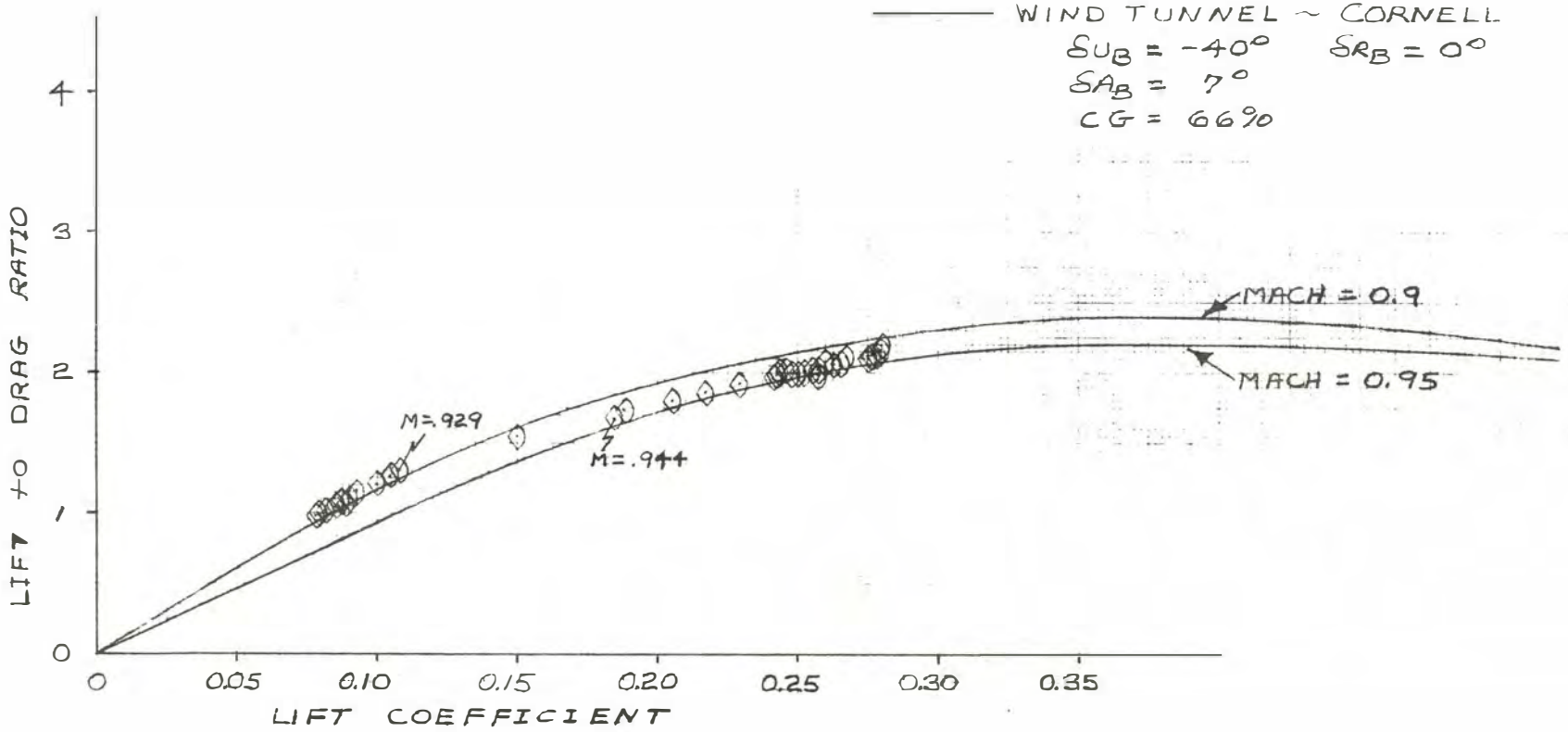


FIG. 7

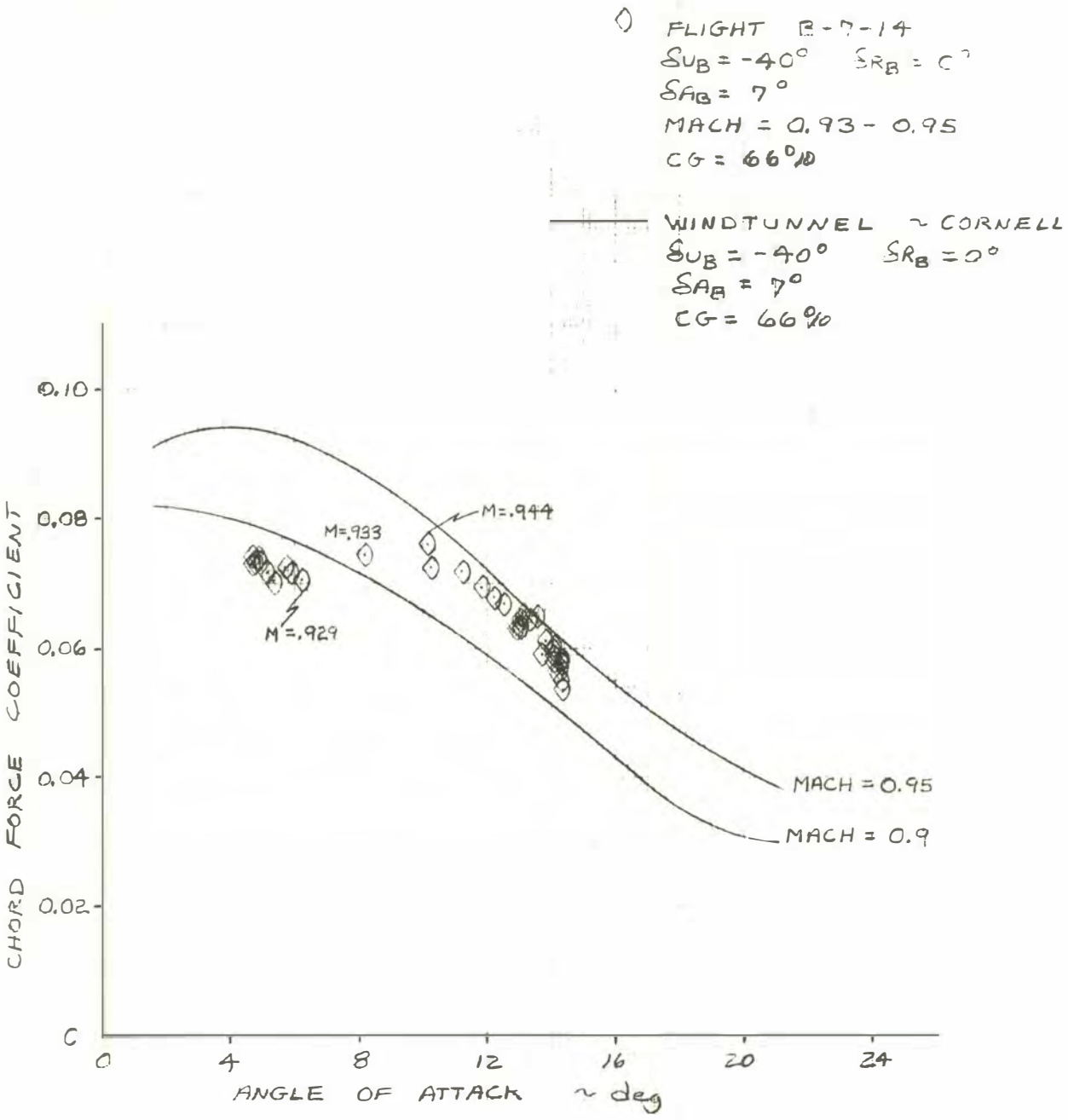

FLIGHT B-7-14
$\delta_{U_B} = -40°$ $\delta_{R_B} = 0°$
$\delta_{A_B} = 7°$
MACH = 0.93 - 0.95
CG = 66%
WINDTUNNEL ~ CORNELL
$\delta_{U_B} = -40°$ $\delta_{R_B} = 0°$
$\delta_{A_B} = 7°$
CG = 66%
0.10
0.08
0.06
0.04
0.02
0
CHORD FORCE COEFFICIENT
M=.944
M=.933
M=.929
MACH = 0.95
MACH = 0.9
0
4
8
12
16
20
24
ANGLE OF ATTACK ~ deg

FIG. 8

◇ FLIGHT B-7-14
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = 0.93 - 0.95
CG = 66%

——— WINDTUNNEL ~ CORNELL
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
CG = 66%

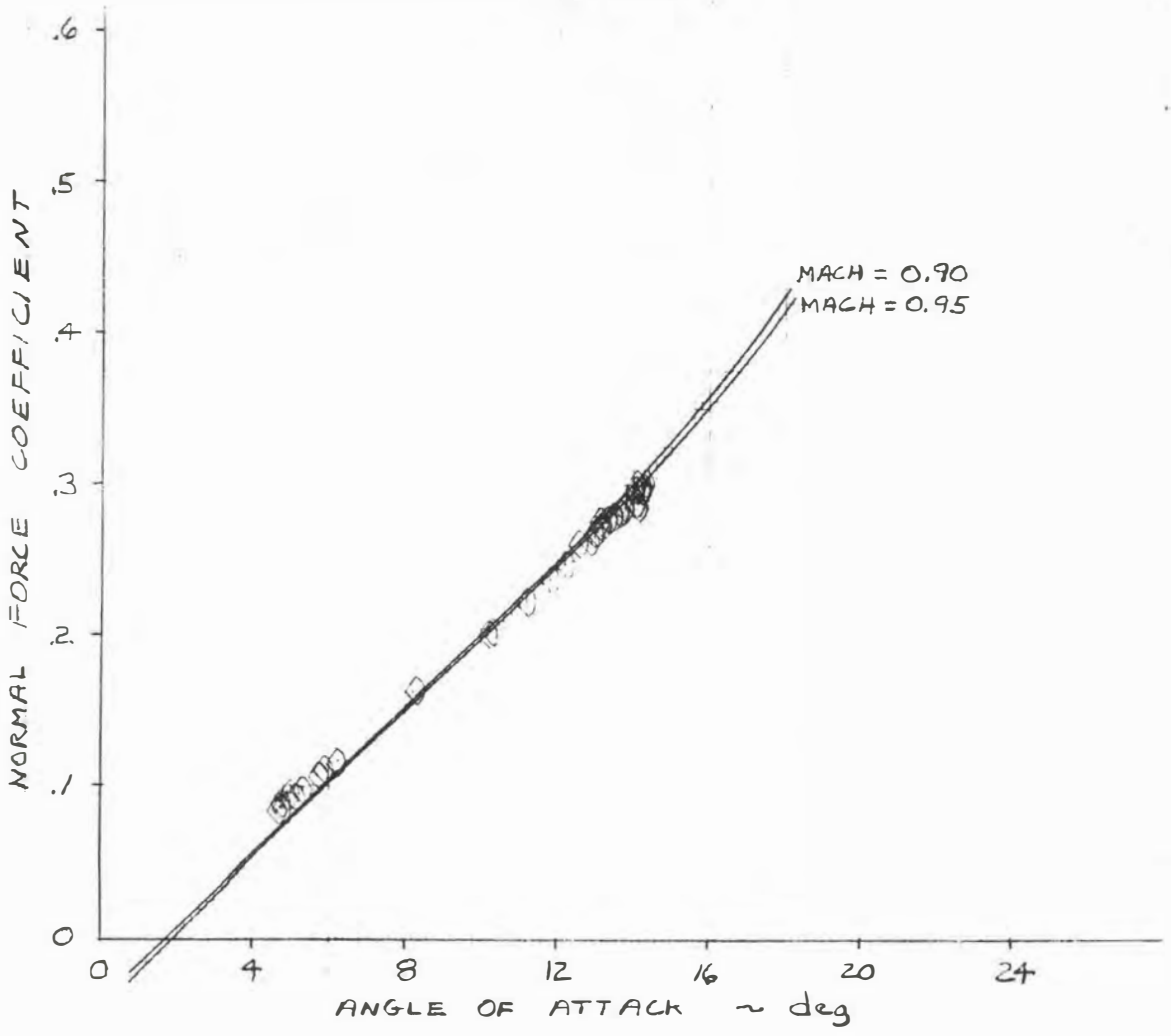


FIG. 9

△ FLIGHT B-7-14
$\delta U_B = -20°$ $\delta R_B = -10°$
$\delta A_B = 11°$
MACH = 0.54 - 0.59
CG = 66%

——— WINDTUNNEL DATA INTERPOLATION USING CORNELL DATA & AEDC DATA @ MACH = 0.6
CG = 66%

— — — FAIRING OF FLIGHT B-6-13
$\delta U_B = -20°$ $\delta R_B = -10°$
$\delta A_B = 7°$
MACH = 0.55 - 0.59
CG = 66%

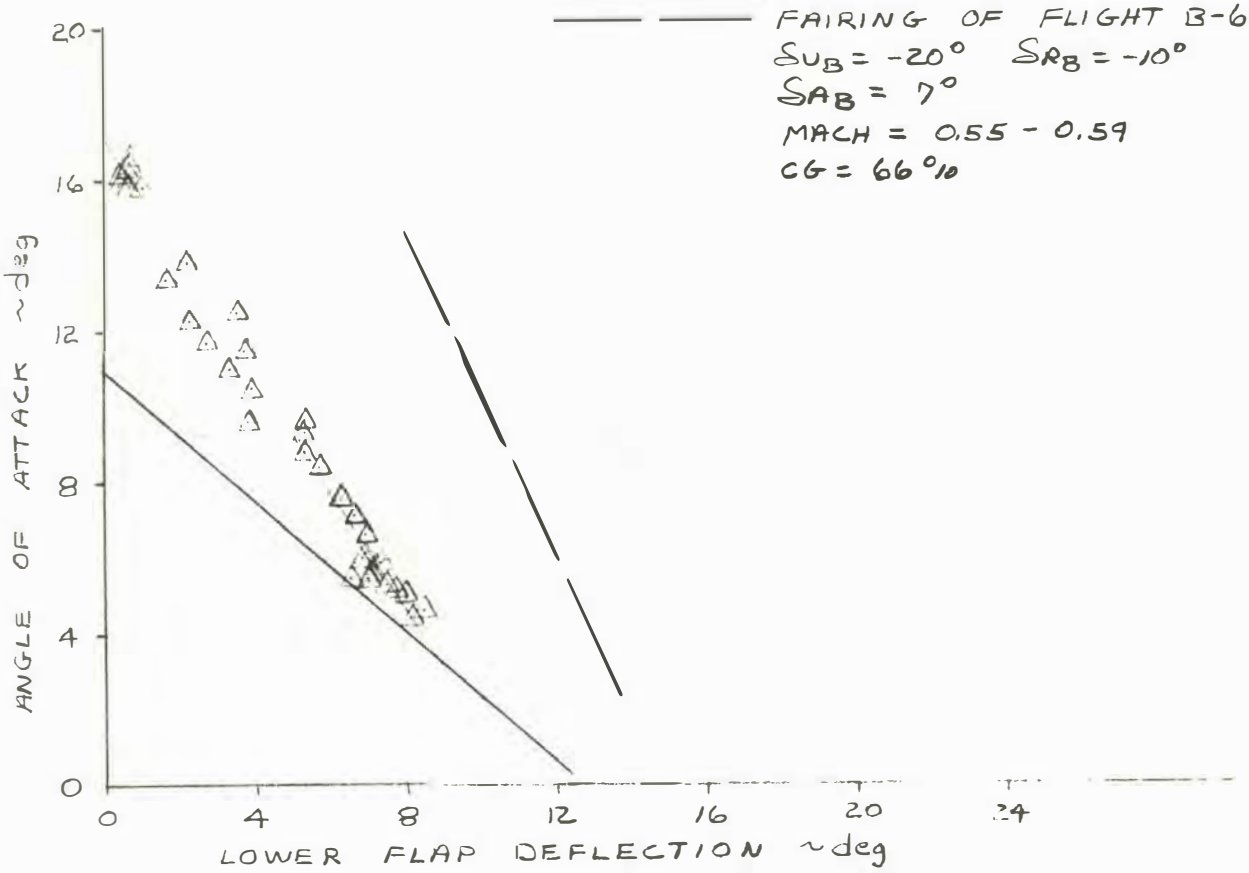


FIG 10

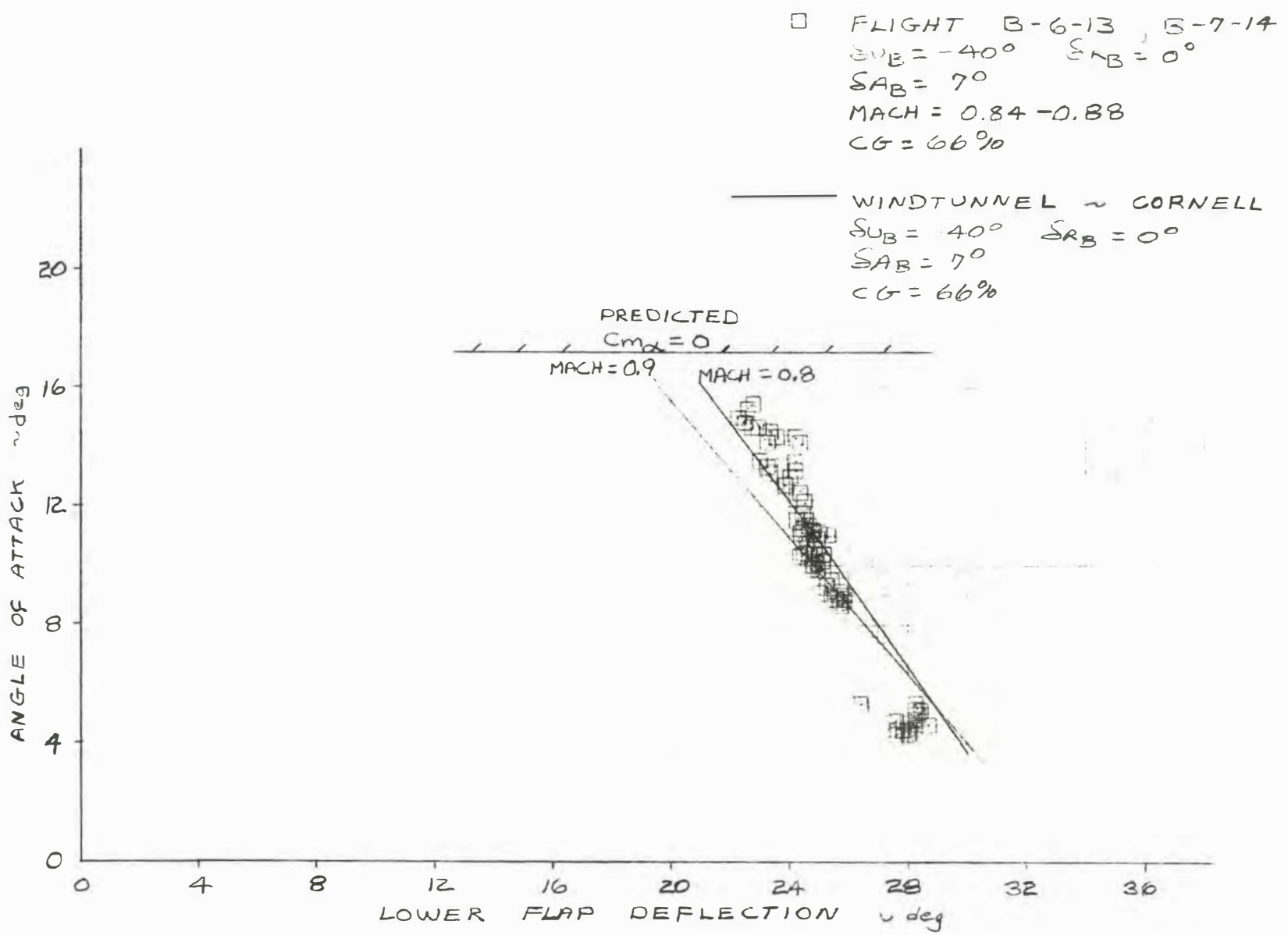

□ FLIGHT B-6-13, 5-7-14
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = 0.84 - 0.88
CG = 66%
WINDTUNNEL ~ CORNELL
$\delta U_B = 40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
CG = 66%
PREDICTED
$C_{m_\alpha} = 0$
MACH = 0.9
MACH = 0.8
ANGLE OF ATTACK ~deg
0
4
8
12
16
20
0
4
8
12
16
20
24
28
32
36
LOWER FLAP DEFLECTION ~ deg

FIG. 11

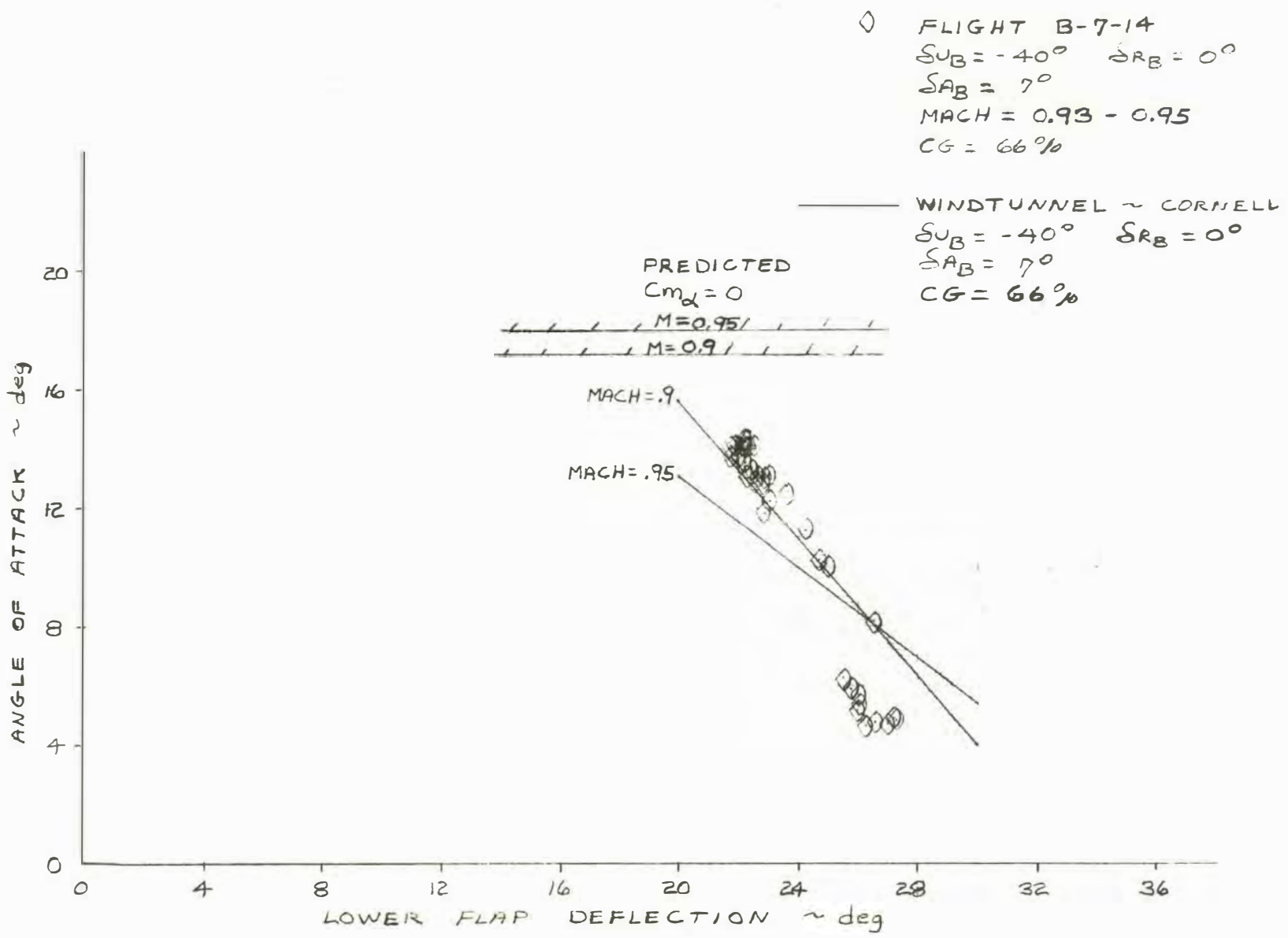

◊ FLIGHT B-7-14
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = 0.93 - 0.95
CG = 66%
WINDTUNNEL ~ CORNELL
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
CG = 66%
PREDICTED
$Cm_\alpha = 0$
M=0.95
M=0.9
MACH=.9
MACH=.95
ANGLE OF ATTACK ~ deg
0
4
8
12
16
20
LOWER FLAP DEFLECTION ~ deg
0
4
8
12
16
20
24
28
32
36

FIG. 12

$\delta U_B = -40^\circ$
$\delta R_B = 0^\circ$
$\delta A_B = 7^\circ$
$CG = 66\%$

● ROCKET ENGINE ON
CORRECTED FOR KNOWN
THRUST MISALIGNMENT
FLIGHT B-6-13
CHAMBERS 1, 2 & 4
MACH = .88 - .89
FLIGHT B-7-14
CHAMBERS 2, 3 & 4
MACH = .86 - .88

○ ROCKET ENGINE OFF
FLIGHT B-7-14
MACH = 0.86 - 0.88

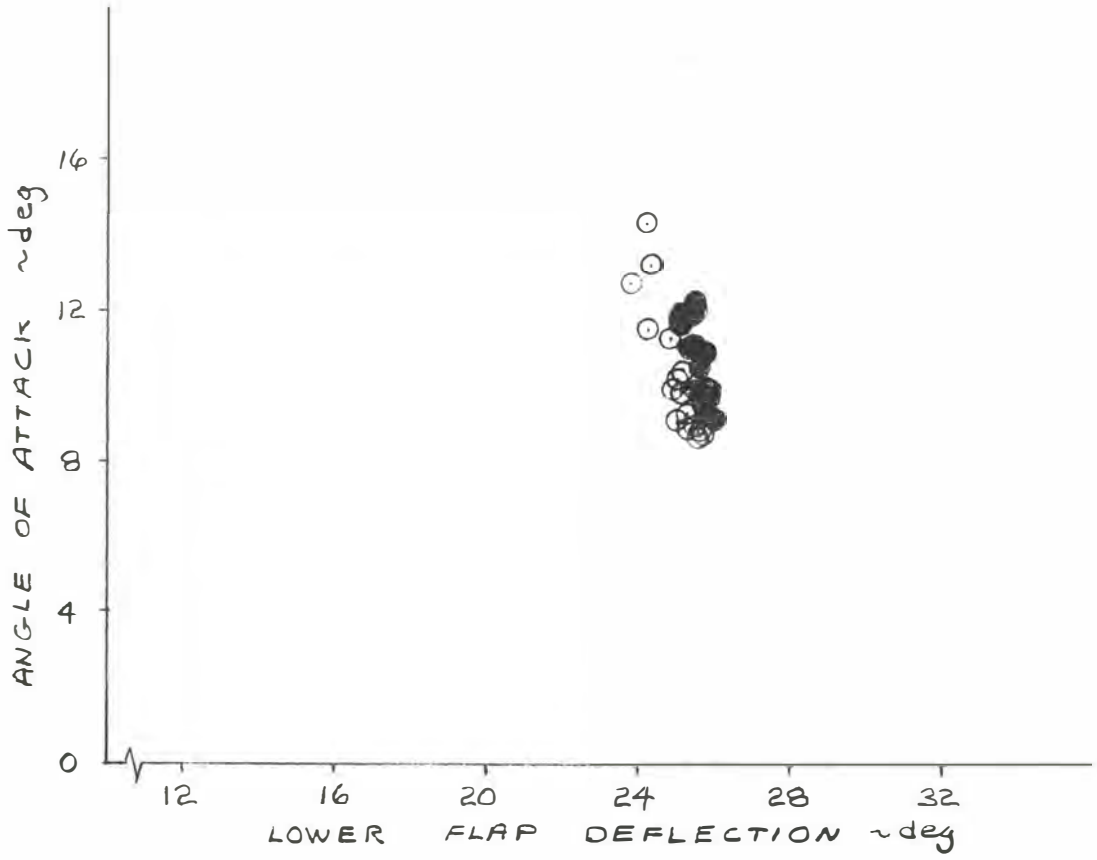


FIG. 13

PRELIMINARY

Derivative Extraction

Paul W. Kirsten

A total of nine lateral-directional maneuvers and four longitudinal maneuvers were analyzed for flight B-7-14. Four of the lateral-directional and three of the longitudinal maneuvers were with power on. Most of the lateral-directional maneuvers were analyzed by both the AFFTC hybrid matching program and the NASA Newton-Raphson program. The longitudinal maneuvers were analyzed by the Newton-Raphson program only. One of the lateral-directional maneuvers was a gear-down rudder pulse performed just before touchdown.

Results of the planned gear-down rudder pulse are shown in figure 1. All derivatives compared well with wind tunnel data and the results of the two programs compared well with each other. Of particular interest is the value of C_{n_β} with the gear down. Wind tunnel data from Cornell at M=.4 for gear up is shown in the figure along with data obtained from the AFIT tunnel for both gear up and gear down at M=.17. The AFIT data was obtained at a very low Reynold's number of 1.1×10^6, and for this reason was felt to be questionable. Shown in the figure is the average gear up value of C_{n_β} obtained from previous flight data (which has been higher than wind tunnel prediction in the region of 10^o angle of attack). Thus although the absolute flight value of C_{n_β} for the gear down configuration is much higher than the AFIT data, the increment in flight data is similiar to the increment in the AFIT data between the gear up and gear down values.

The remaining lateral-directional maneuvers analyzed for flight B-7-14 are shown in figure 2. Both power-on and power-off wind tunnel data are shown at each Mach number for C_{l_β} and C_{n_β}. Power-on wind tunnel data is not available for the other derivatives. Most power-off values of C_{l_β} agree well with tunnel data. The exceptions being the maneuver at M=.9, $\alpha=14.5^o$ and the maneuver at M=.95, $\alpha=4.8^o$. The maneuver at M=.9, $\alpha=14.5^o$ was not a planned pulse maneuver and for this reason the accuracy of the derivative is questionable. Both the hybrid and Newton-Raphson values of C_{l_β} for the planned pulse maneuver at M=.95, $\alpha=4.8^o$ were significantly higher than tunnel data. This is important since the tunnel shows a value of zero for C_{l_β} at this angle of attack. Power-on values of C_{l_β} were generally lower than power-off values and usally somewhat lower than wind tunnel power on values. The two power-on maneuvers at M=.8 and the one at M=.95 were obtained by analyzing conditions in which sideslip angle diverged to a steady state value of 1 to 2 degrees. The reason for the divergence is at this time assumed to be wind shear disturbances which cause a change in the flight value of β.

Flight values of C_{n_β} at M=.95 and high angles of attack were significantly lower than wind tunnel predictions. This attributes to rather poor lateral-directional stability in this flight regime. The high andle-of-attack, transonic Mach regime was an area of concern on the X-24A vehicle and needs to be investigated carefully on the X-24B.

Flight values of C_{y_β} were slightly lower than wind tunnel predictions for most maneuvers analyzed.

Flight values of $C_{l_{\delta r}}$ and $C_{y_{\delta r}}$ were close to wind tunnel predictions for all cases. Flight values of $C_{n_{\delta r}}$ were somewhat higher than wind tunnel values for most maneuvers.

Wind tunnel and flight values of $C_{l_{\delta a}}$ agreed well, while flight values of $C_{n_{\delta a}}$ were lower than wind tunnel values. This trend in $C_{n_{\delta a}}$ has shown up in almost all of the data which has been analyzed on previous flights.

Longitudinal results of flight B-7-14 are shown in figure 3. Three of the maneuvers analyzed were power-on transients caused by engine chamber shutdown. The resulting motions associated with these maneuvers were small and the accuracy of the derivatives may be deteriorated somewhat.

All longitudinal derivatives agree well with wind tunnel data except for C_{m_α} and C_{N_α}. As has been experienced in previous flight data, C_{m_α} was lower than tunnel predictions for three of the four maneuvers analyzed. However, the value of C_{m_α} obtained from the planned, SAS-off pitch pulse (which should give an accurate value for C_{m_α}) agreed well with tunnel prediction.

X-24B DERIVATIVES
FLT B-7-14
$\delta_{H_B} = -20°$ $\delta_{R_B} = -10°$ $\delta_{A_B} = 7°$

O M=0.35 FLIGHT - GEAR DOWN

—— M=0.4 GEAR UP - CORNELL W.T.
– – – GEAR UP } M=0.17 AFIT W.T.
— — — GEAR DOWN }

FLAGGED SYM - HYBRID
UN " " - NEWTON-RAPHSON

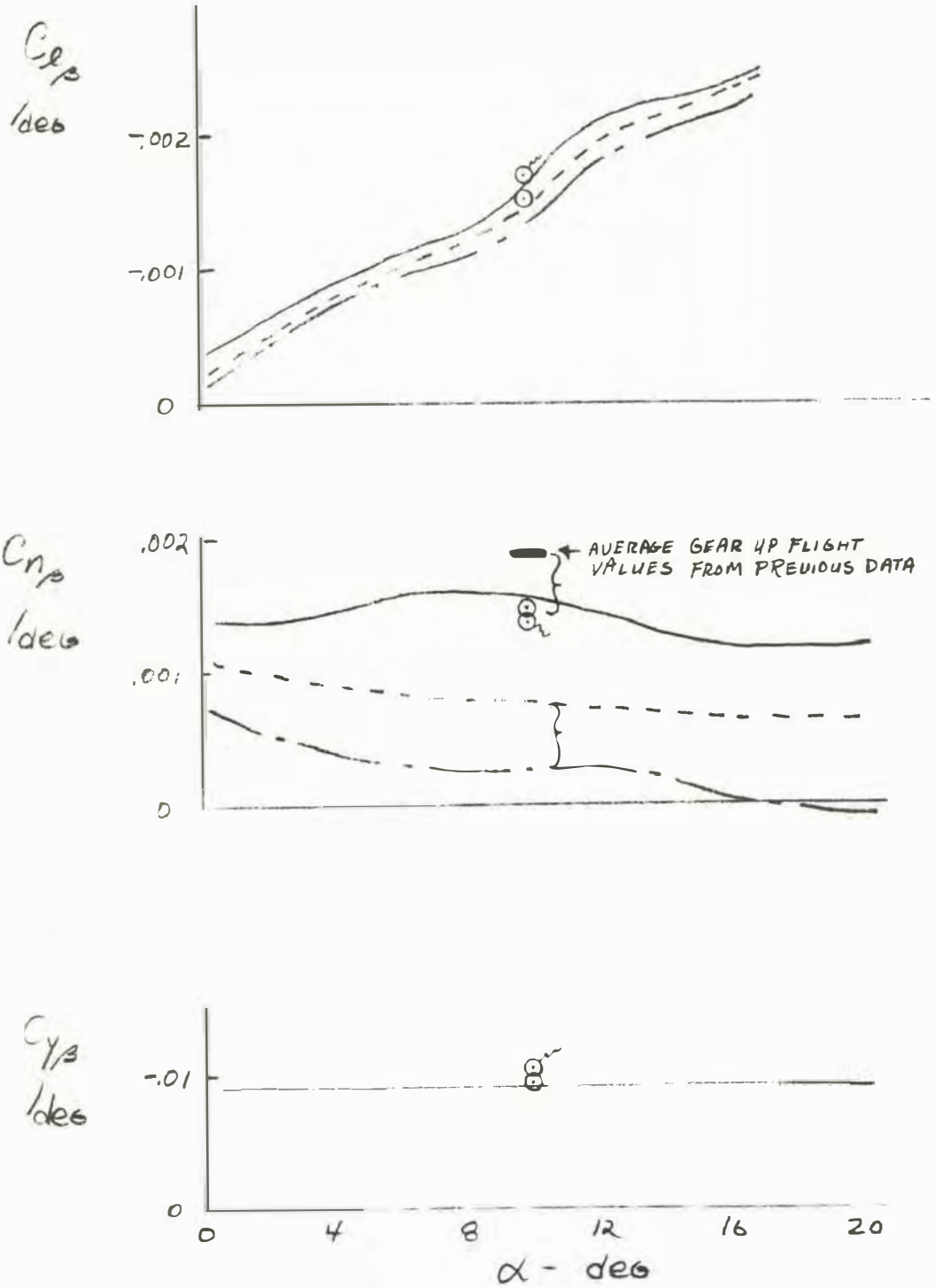


FIGURE 1

X-24B DERIVATIVES
FLT #-7-14
$\delta_{H_B} = -4.9°$ $\delta_{R_B} = 0°$ $\delta_{A_B} = 7°$

M = 0.8

—— POWER OFF } SIMULATOR TRIM
- - - " ON } DATA - CG = 65%

● POWER ON - FLIGHT DATA
FLAG - HYBRID

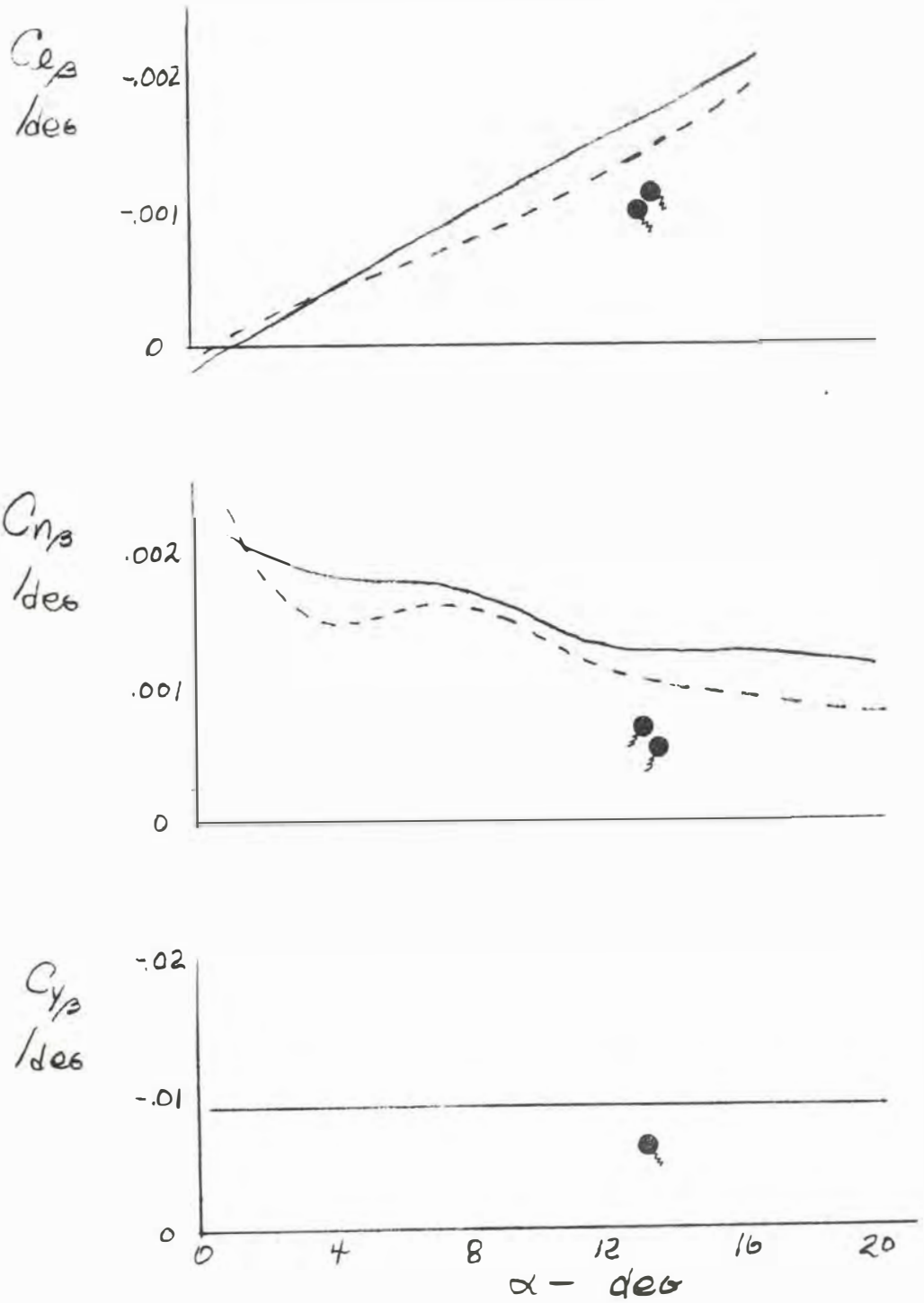


FIGURE 2

X-24B DERIVATIVES
FLT B-7-14
$\delta_{4_B} = -40°$ $\delta_{R_B} = 0°$ $\delta_{A_B} = 7°$

M = 0.9

— POWER OFF } SIMULATOR TRIM
--- ON } DATA - Cg = 65%

□ POWER OFF } FLIGHT DATA
■ " ON }

FLAG - HYBRID MATCHING
NO FLAG - NEWTON-RAPHSON

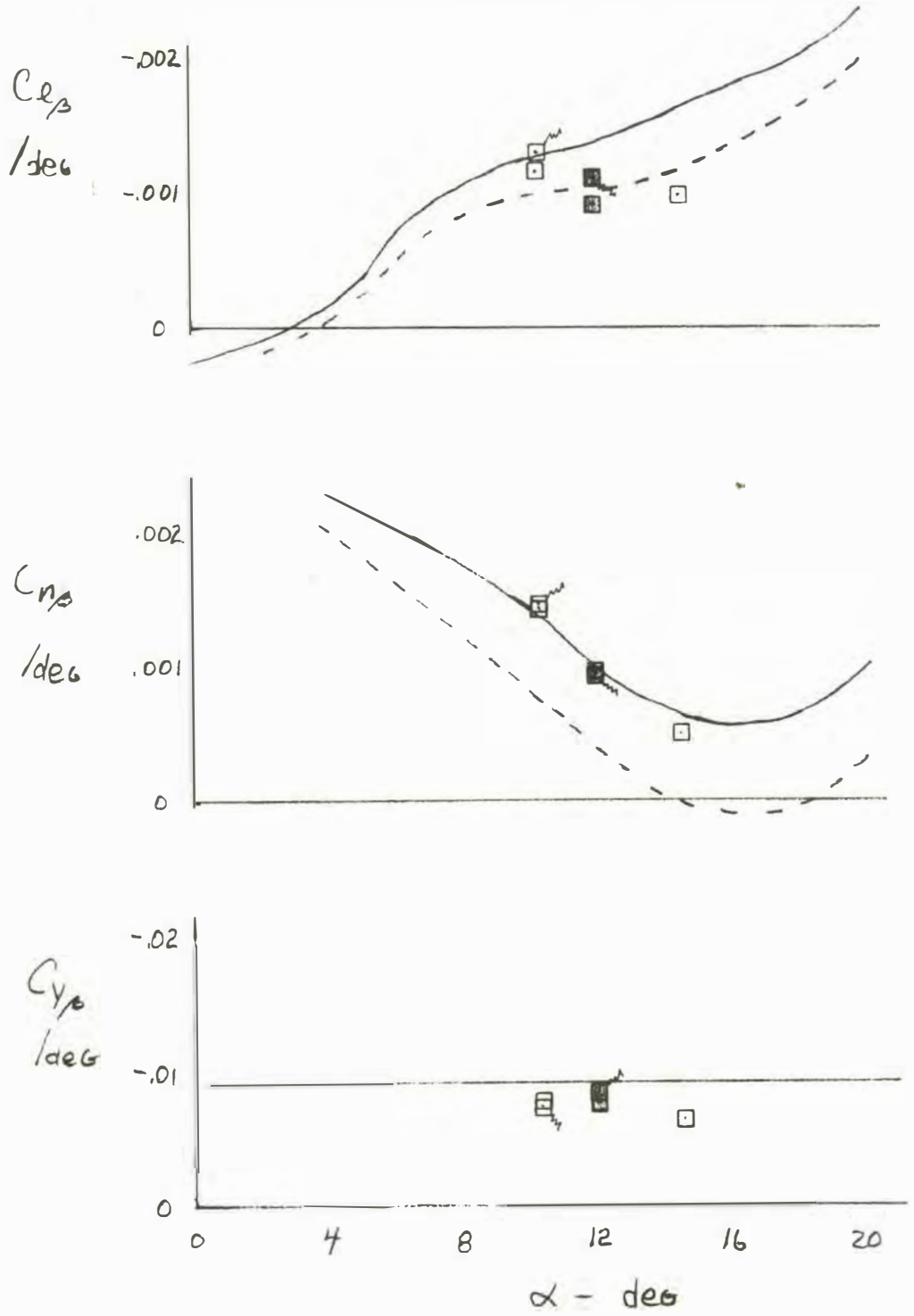


FIGURE 2 CONT.

X-24B DERIVATIVES
FLT B-7 4
$\delta_{H_B} = -40°$ $\delta_{R_B} = 0°$ $\delta_{A_B} = 7°$

M = 0.95

—— POWER OFF } SIMULATOR TRIM
- - - ON } DATA - CG = 65%

△ POWER OFF
▲ ON } FLIGHT DATA

FLAG - HYBRID MATCHING
NO FLAG - NEWTON-RAPHSON

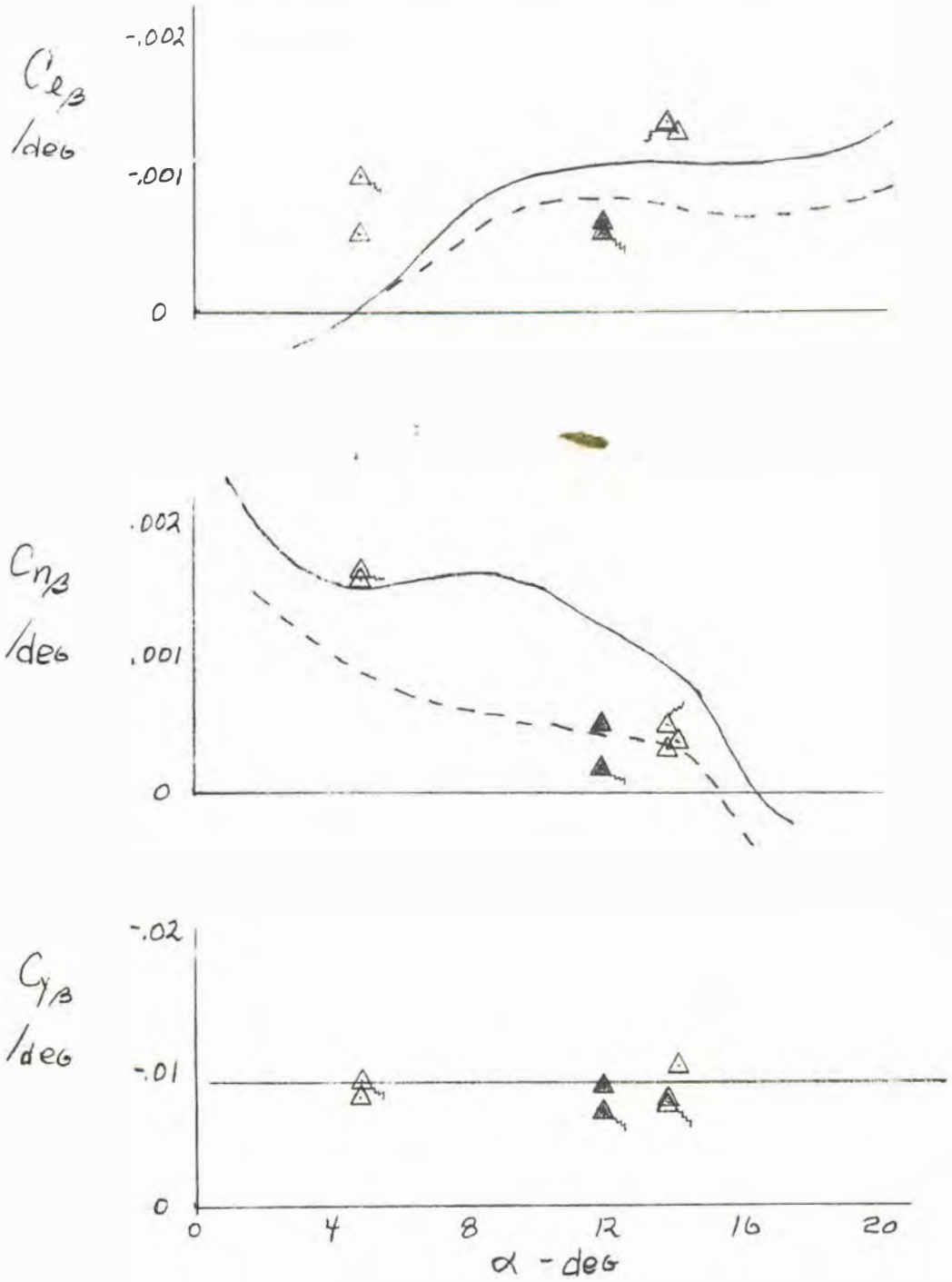


FIGURE 2 CONT.

X-24B DERIVATIVES
FLT 8-7-14
$\delta A_B = -40°$ $\delta R_R = 0°$ $\delta A_B = 7°$

—— M = 0.8
—·— M = 0.9
– – – M = 0.95
SIMULATOR DATA $c_g = 65\%$

○ M = 0.8
□ M = 0.9
△ M = 0.95
F-SMT DATA

SOLID - POWER ON
FLAG - HYBRID MATCHING
NO FLAG - NEWTON-RAPHSON

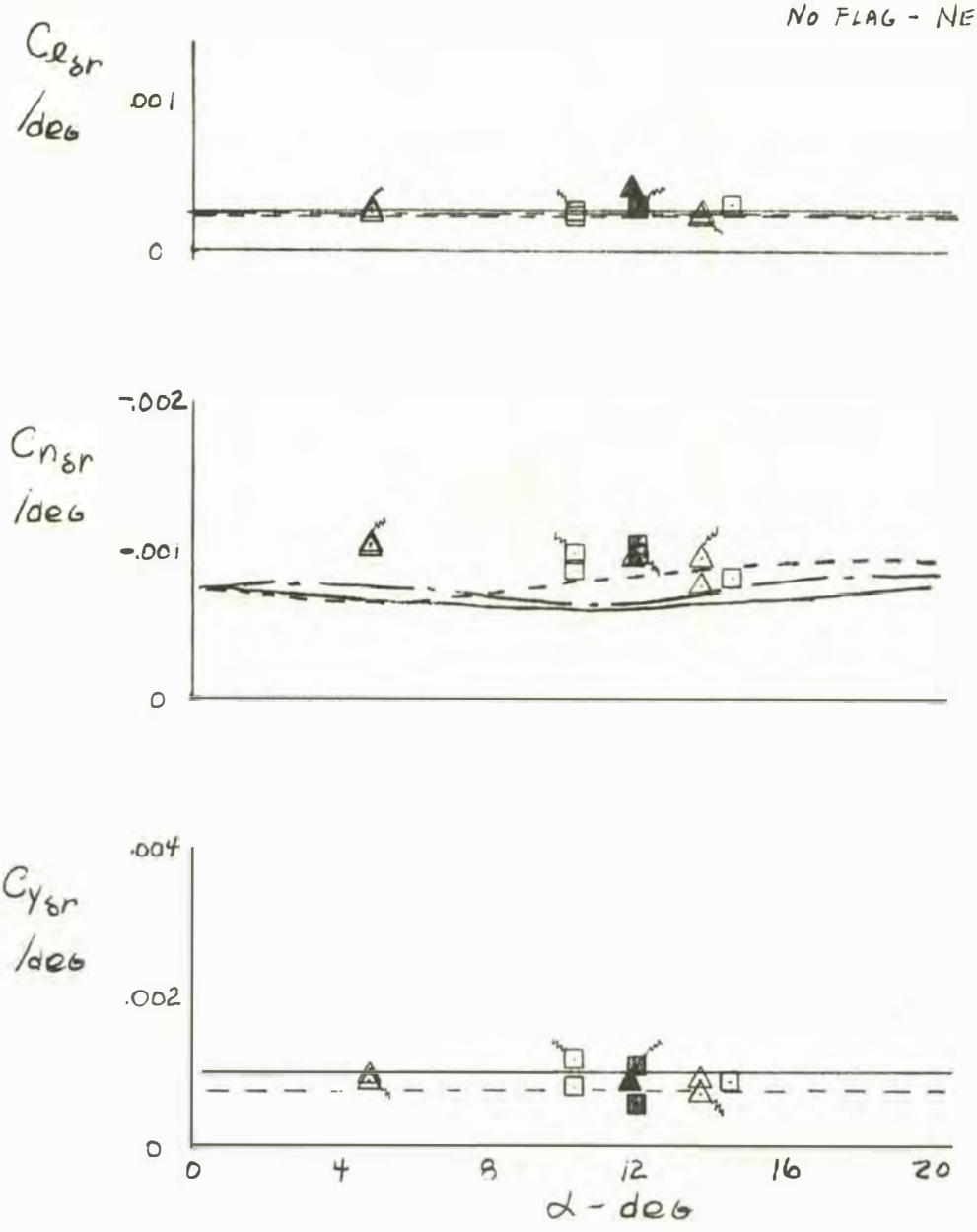


FIGURE 2 CONT.

X-24B DERIVATIVES
FLT B-7-14
$\delta_{U_B} = -40°$ $\delta_{R_B} = 0°$ $\delta_{A_B} = 7°$

—— M = 0.8 } SIMULATOR
—·— M = 0.9 } DATA cg = 65%
--- M = 0.95 }
○ M = 0.8 }
□ M = 0.9 } FLIGHT
△ M = 0.95 } DATA

SOLID - POWER ON
FLAG - HYBRID MATCHING
NO FLAG - NEWTON-RAPHSON

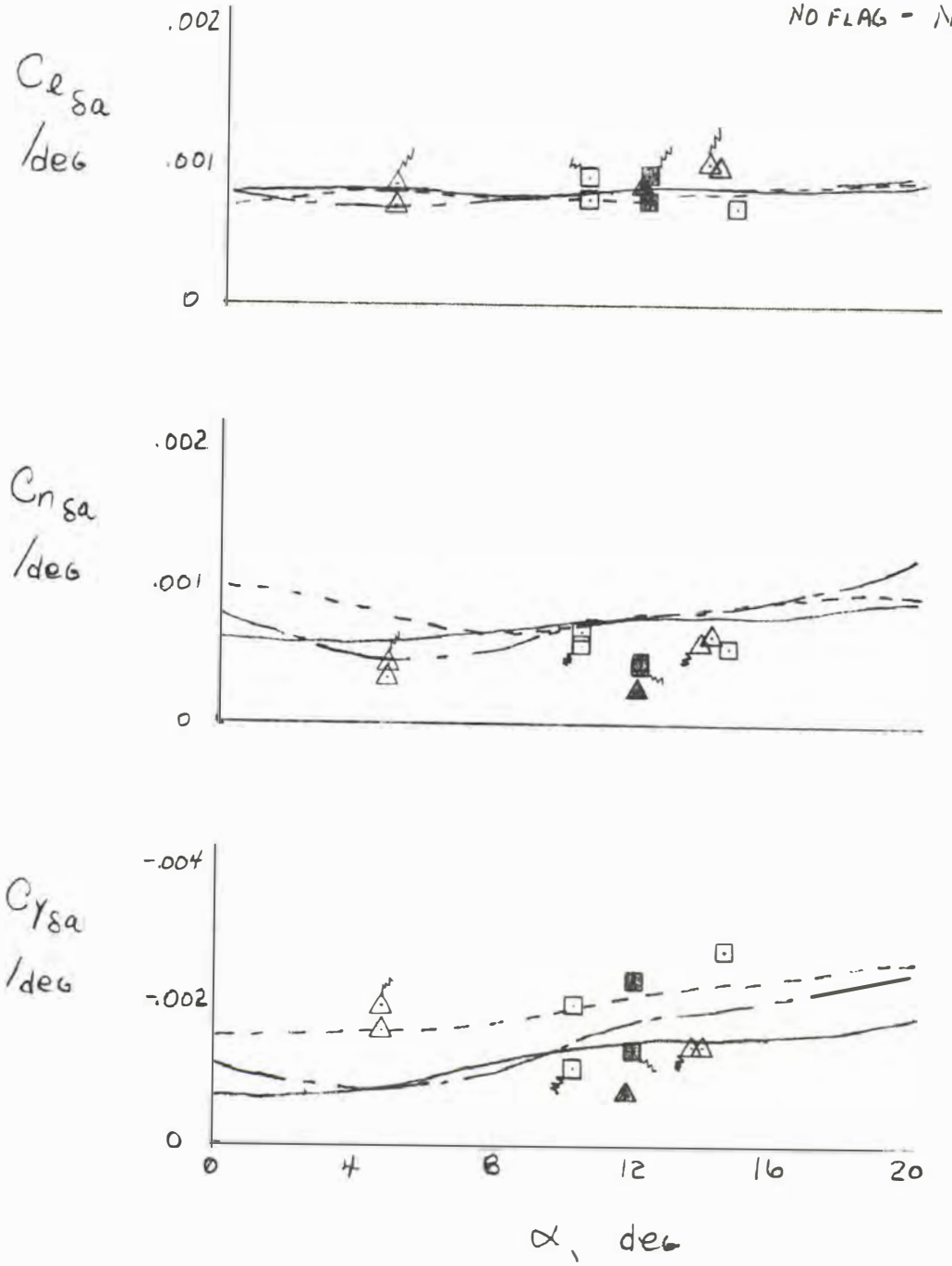


FIGURE 2 CONT

X-24B DERIVATIVES
FLT B-7-14
$\delta_{H_B} = -40°$ $\delta_{R_B} = 0°$ $\delta_{A_B} = 7°$

— M=0.8
– – M=0.9
– – – M=0.95
} SIMULATOR DATA

○ M=0.8
□ M=0.9
△ M=0.95
} FLIGHT DATA - NEWTON-RAPHSON

SOLID - POWER ON

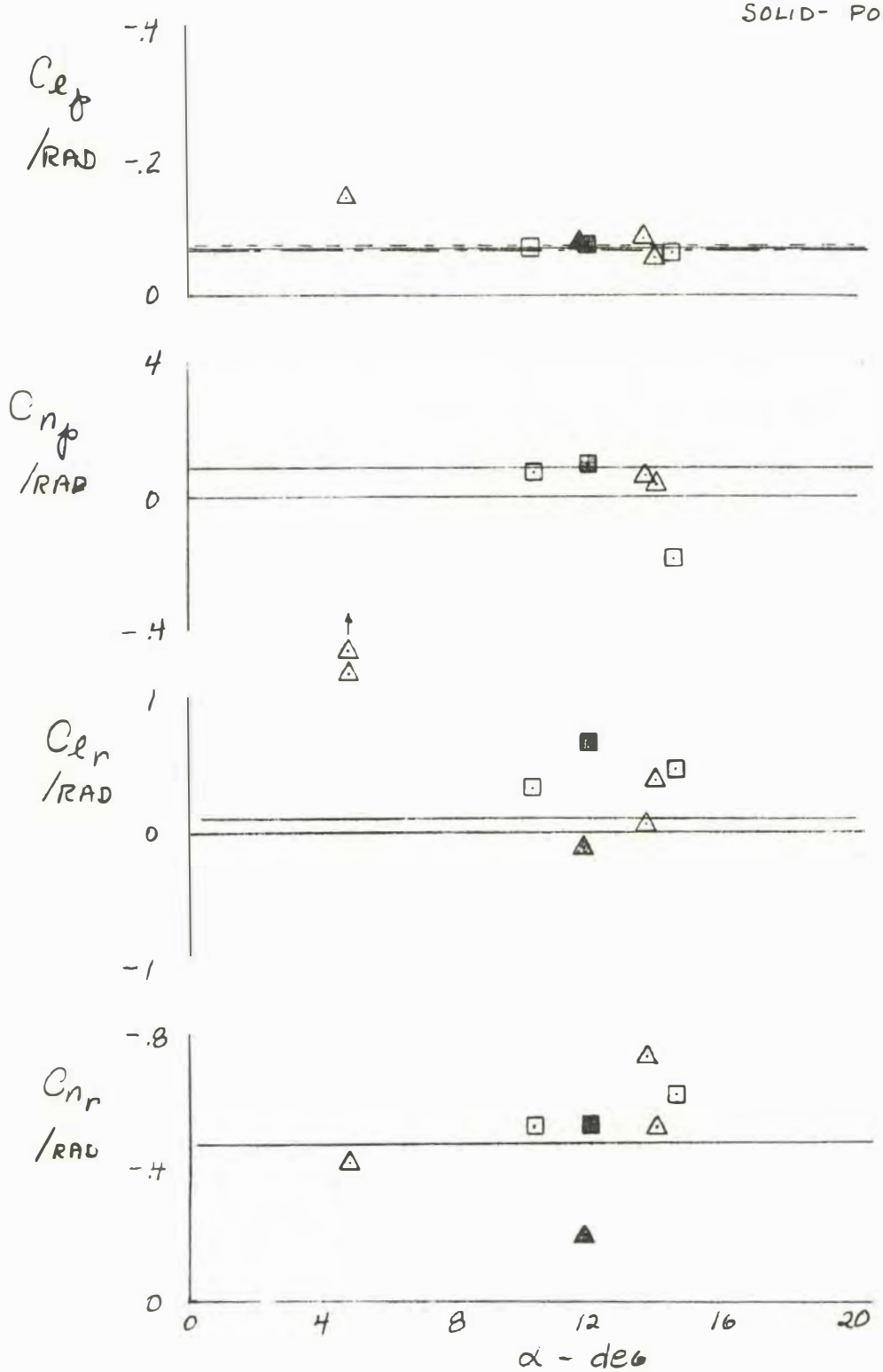


FIGURE 2 CONT.

X-24B DERIVATIVES
FLT B-7-14
$\delta_{U_B} = -40°$ $\delta_{R_B} = 0°$ $\delta_{A_B} = 7°$

--- M=0.7
—— M=0.8
—·— M=0.9
} SIMULATOR DATA cg=66%

△ M=0.7
○ M=0.8
□ M=0.9
} FLIGHT DATA

SOLID — POWER ON
FLAG — HYBRID MATCHING
NO FLAG — NEWTON-RAPHSON

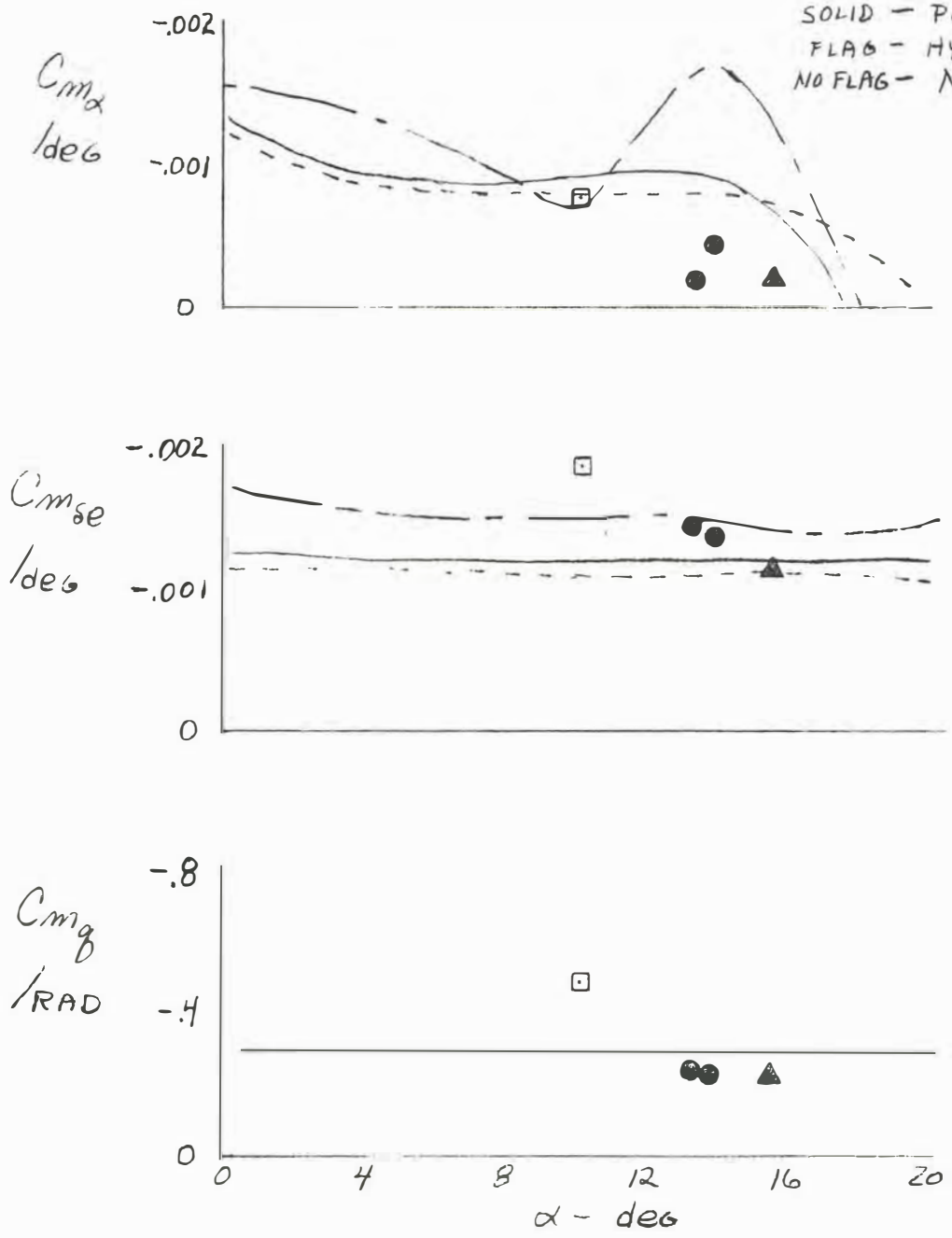


FIGURE 3

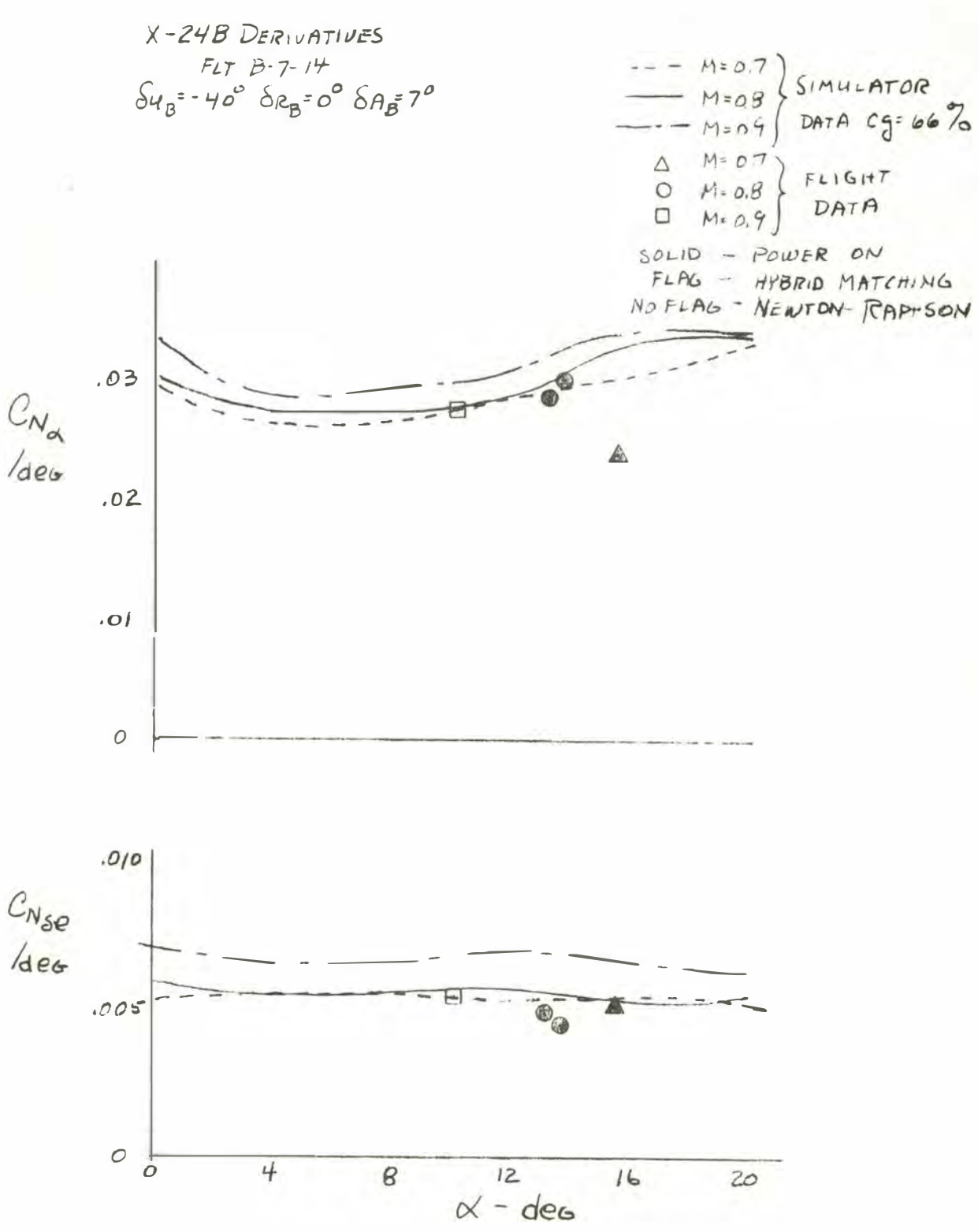


FIGURE 3 CONT.

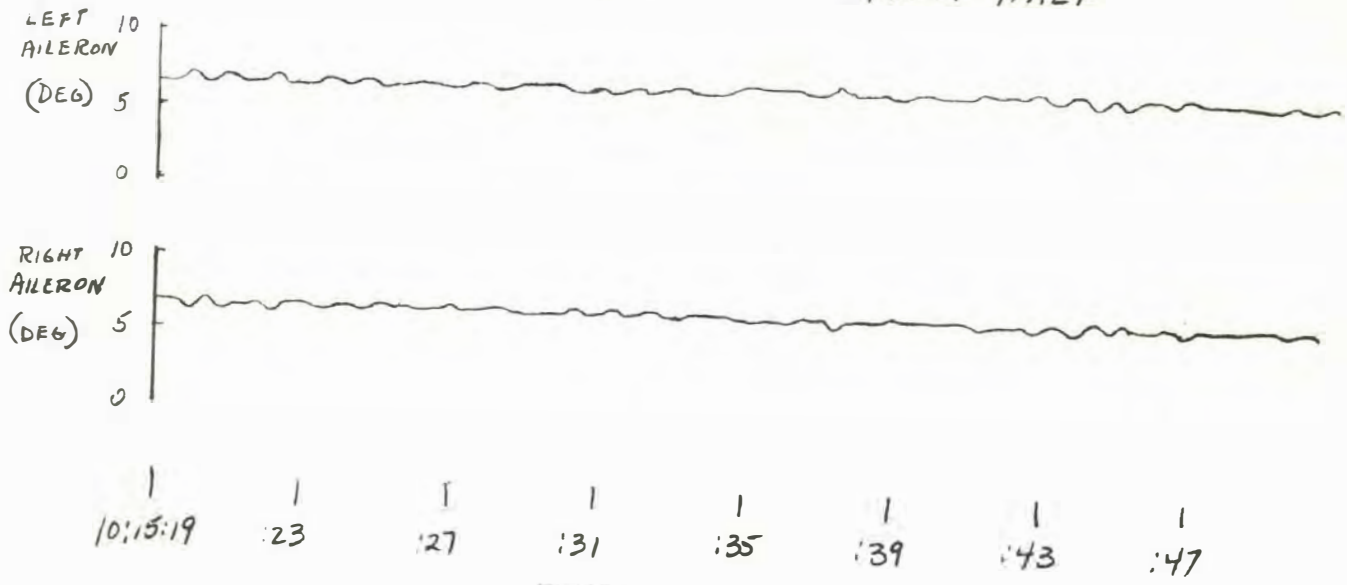
Aileron Deadband and Crossover Deadband

Paul W. Kirsten
George Sitterly

The deadband in the left hand aileron control system which was observed on flight B-6-13 appeared again on flight B-7-14 about half way through the flight. The deadband was not present during the first portion of the flight (figure 1), but was measured from telemetry data to be approximately 0.6 degrees peak-to-peak during the latter portion of the flight. The amount of deadband measured on the ground after the flight was 0.25 degrees peak-to-peak. This aileron deadband has been eliminated on the ground by lubricating the preload spring cartridges and replacing over tolerance bushings throughout the left hand aileron mechanical system with bushings that are intolerance.

The pitch crossover region between the upper and lower flaps has previously had approximately 3.5 degrees of surface motion loss. The surface motion loss has been reduced to 0.5 degrees by stiffening the pitch system splitter bell crank area.

FLIGHT B-7-14 - FIRST HALF



FLIGHT B-7-14 - SECOND HALF



FIGURE 1 AILERON DEADBAND

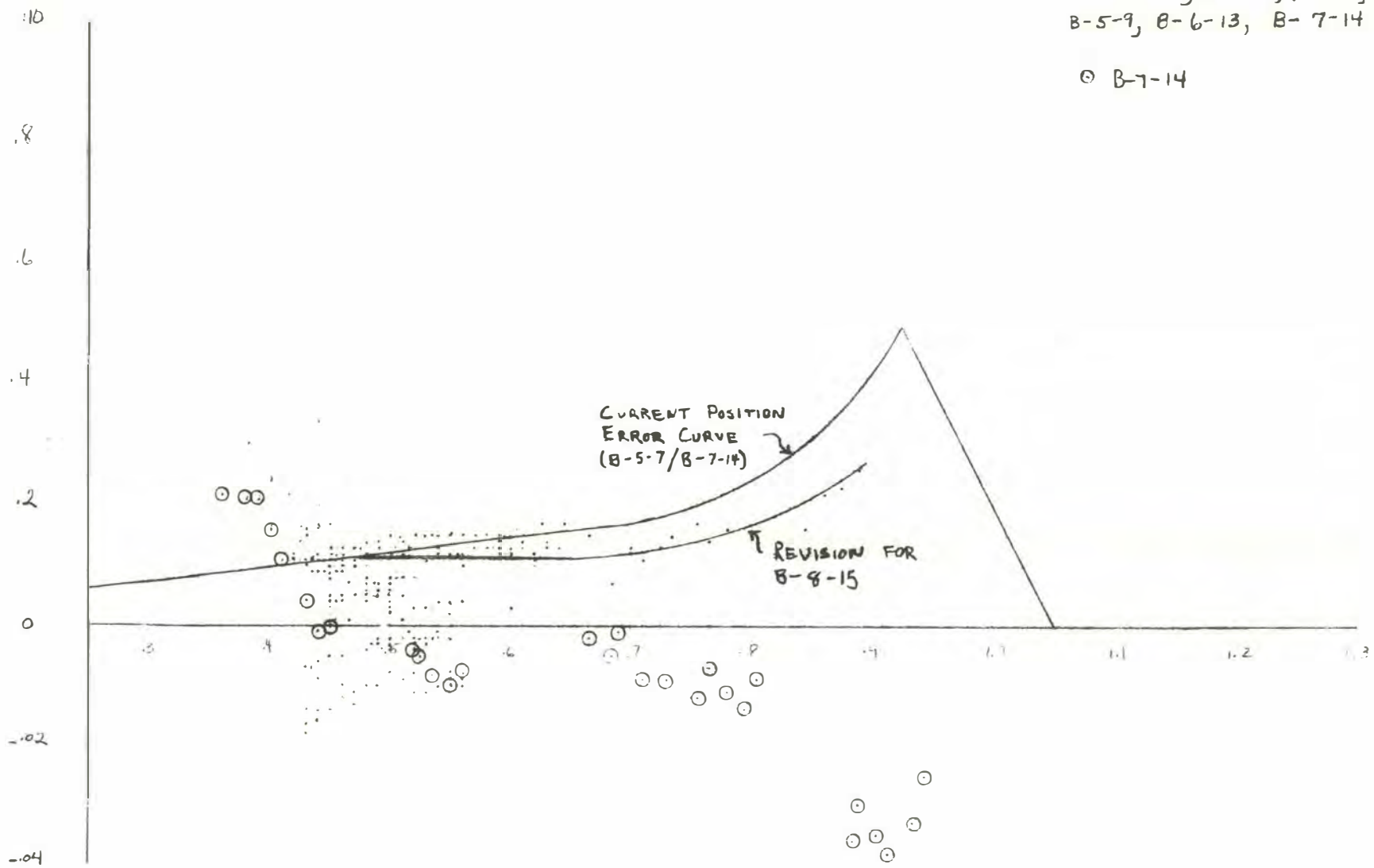
B-7-14 Position Error

Position error data from B-7-14 showed virtually no agreement with data from previous flights. Data are presented in the following figure along with points from previous flights and the new position error curve based on flight B-6-13. Data from this flight were worked up from NASA-FRC radar since AFFTC radar was not available at the time of the flight. Tests during the X-24A program showed some discrepancies between the two radar systems and the change of radar data may account for the poor agreement with previous data. The new position error curve should be incorporated by flight B-8-15.

X-24B
POSITION ERROR

FLIGHTS B-1-3, B-2-4, B-3-5, B-4-6, B-5-9, B-6-13, B-7-14

⊙ B-7-14



FLT. B-7-14

HANDLING QUALITIES SUMMARY

LAUNCH TRANSIENT	LITTLE ROLL OFF 2.5
PITCH CONTROL DURING ROTATION	4.5
LATERAL-DIRECTIONAL CONTROL DURING BOOST	4.5 (BECAUSE OF PITCH CONTROL DIFFICULTY)
PITCH CONTROL DURING CLIMB AT 13°α	3.0
PITCH CONTROL AT .9 MACH	3.0
YAW CONTROL AT .9 MACH	6.0
TRIM CHANGE AT SHUTDOWN	NONE
PITCH CONTROL FOR DOUBLET SET AT 5°α AND 14°α	3.0 (BOTH αS)
LATERAL-DIRECTIONAL CONTROL AT 5°α AND 14°α	4.0 (BOTH αS)
ROLL RESPONSE AT INTERSECTION (10° TO 14°α)	2.5
ROLL CONTROL AFTER RUDDER DOUBLET WITH GEAR DOWN	3.0
PITCH CONTROL AFTER RUDDER DOUBLET WITH GEAR DOWN	4.5

Flight B-7-14 Technical Debriefing

Pilot: John Manke

1. Describe the launch transient.

The launch transient on this flight was just like the other one. Hardly any roll off, and maybe a little bit more negative "g" than a light weight launch, but really a very mild launch. Recovery from launch transient PR 2.5.

2. Discuss the engine lignt sequence and any associated trim changes.

The engine light sequence was chambers 2 & 4 and then chamber #1. I didn't notice any particular trim changes although I did let the α get high on me. Since we had no apparent problem on the last flight I had decided to go ahead and let α increase and light the chambers at the same time. I think maybe we have to be a little bit more cautious like we were on the first flight when we light the engine and go ahead and light the engine at 10^{o} to 12^{o} α. Once it's lit, then get back up and perform the rotation. I just diverted my attention away from the α gage going for the engine switched and it just got away from me. So back to the technique I used on the first flight.

3. Describe the task to maintain 14^{o} α during the rotation and rate the pitch task.

OK, I initially rated that at a 4.5

b. Comment on lateral-directional handling qualities. Rate.

I'll just talk about both parts. I rated both axes at a 4.5. Now, that is a considerable worse rating than I had rated on the last flight and I guess we ought to talk about why. If one has one of the tasks that he doesn't have to worry about at all you can spend most of your time on the other one. Of course as you know the pitch task is the primary task during the boost on any of these airplanes. Now if something causes you to divert your attention from that task then it becomes more difficult because I guess the pitch isn't as good as one would like to have it. You take your attention away from it and it tends to drift a little bit. The thing that I was concerned about here was the apparent yaw mistrim right after I lit the engine. Had it been a previous flight I may not have worried about it but since we had put the reduced derivatives in the simulation, the simulator indicated that if I started out with a misstrim it could get to be a very serious problem when I got to the .9 to .95 Mach area and the area of low dynamic pressure. So I was concerned about that

and attempted to do something about it with my yaw trim and with rudders. So the time I could spend on the pitch task was decreased considerably and that's why I've rated them like this. It was a busy airplane trying to get that yaw mistrim squared away.

4. Describe the task to maintain 13^{o} α during the climb. Rate.

How did the θ to maintain α compare with the simulatro?

OK, I rated this at a 3.0 and I guess one of the reasons this is rated better here is because I could spend more time on the α. I had sorta put away the B problem at this point. I guess I convinced myself that I couldn't do anything any better with the yaw trim so I decided just to leave it alone. I had satisfied myself that it was close enough to zero. So I could spend more time on the pitch task. It was probably no more difficult or less difficult here that it was at 14 α but I could spend more time on it and consequently it didn't drift as much. Didn't require as many control inputs as the 14^{o} α did.

I was a little late coming up on θ. I attributed that to the fact that my α control during the initial rotation wasn't too good. It was probably 3 seconds later than I had seen in the simulator. Now the maximum θ that I remember seeing during the boost was 35. Normally in the simulator we saw 33 or so on a normal profile.

5. (a) Discuss the Handling Qualities at .9 Mach No. power on after chanber #1 was shutdown. Rate.

I rated that 3.0 in pitch and 5.5 in yaw. I guess I would rate it - after looking at the data - I would rate it at least that bad and maybe even slightly worse than that. I remember now, between the .9 to .95 Mach area flying primary a β task. I had considered shutting down because of the low directional stability but I found that I could control the yaw axis very nicely with the rudders. So I decided to continue out to .95 Mach No. I think I'd rate that instead of the 5.5, I run the rating to 6.0.

(b) Compare the response to the doublet set with the simulator.

The response to the doublet set I thought was quite good - the comparison of the two. I cued on the β needle for the rudder pulse because it was interesting in the simulator because it would move very slowly. The period was long. I was impressed at the time that the airplane looked pretty much like that. I did the rudder pulse and the aileron pulse but it was after that point when the β started moving out to the side that it looked just a little bit different than the simulator. The simulator didn't indicate that it would do that without a fairly sizeable roll input. The simulator showed that if I did put a fairly sizeable roll input I could get β to drift out to the side. Now I'm not so sure that I would be as concerned in the simulator with one degree or two degrees of sideslip as I was in the

airplane, so maybe I'm not giving a fair evaluation there. I became quite concerned with the one to two degrees that I was noticing in the airplane or the fact that it was going out into that area. I think it was just a little bit worse in the airplane than it was in the simulator because of this sideslip between .9 and .95. OK, now when we talk about simulation at this point we are talking about the reduced derivatives that we put in two or three days before the flight. The reduced derivatives ($C_{n\beta}$ $C_{l\beta}$) due to the power effects.

6. Discuss trim changes associated with engine shutdown.

I didn't really notice any. I had geared myself to go to 5° α right after I hit the engine master off. So it was all one big motion, I hit the engine master and pushed over to 5. I didn't notice any trim changes.

7. Discuss the doublet set at 5° α after shutdown.

8. Discuss the pullup to 14° α and the doublet set.

Question 7 and 8 will kind of run together. This whole area I rated these before we looked at the data. I rated pitcj as 3 and lateral directional I rated together as 4 in this general area. Now this is essentially the same area we flew before but this time with power off. The doublet set at 5 α after shutdown - the pitch control was no problem. It took me just a little long to trim to 5 α but probably if we compared it with simulator records it would be about the same time. This speeded up time thing got me to thinking I was a little slow trimming to 5. Pitch control was good here, the doublet set looked very much like the simulator. And I felt better about directional stability at this point too, I could just tell the difference in directional stability. Was of no concern anymore from a hazard standpoint even though the stability is a little bit low here, I could feel that the airplane was directionally stable.

The pullup to 14° α was very straight forward. It was a relatively simple pitch task. The doublet set there again looked very much like the simulator. I held 14° α a little bit longer than I had in the practice sessions because it looked like Mach had gone a little bit higher and it was a little bit slow coming back down again. Handling qualities were reasonably good in this area.

9. Comment on the doublet set at 10° α.

Here again there was no particular problem in any of the axes. I had held 14° α a little too long and Mach started down a little more rapidly than I wanted it to so I went down to about 7° to 8° α to let the Mach build back up again. And it did, it came back up and I went to 10 α and got the rudder and aileron doublet. They again looked very much like the simulator. You're never impressed with quick damping; you do the rudder pulse and β is rather slow coming back but here again it felt like the airplane was well enough damped.

10. Compare the response to the pitch pulse with the simulator.

I thought the response and the damping was very comparable to what we had in the simulator.

11. Discuss the roll evaluation at 10^{o} to 12^{o} α approaching the "intersection". Rate.

I had rated this at a 2.5 and I wouldn't change that rating. I was impressed with the roll response at this high roll gain (switch position 5). I had expected to see a lot more sluggest airplane. This rating is based on the task to be flown in this area and here it's just rolling the airplane up to a 30^{o} to 40^{o} bank and commencing a turn to down wind leg. I did rock it around a bit in this area and I was very pleased with the roll response. A factor of two better than I had seen in the simulator.

12. Comment on the configuration change.

I guess the only comment I can make is that all I remember is running the switch and flying the pattern. I don't remember any usual aircraft responses or anything. It's just a piece of cake in this airplane, it's a very pleasant thing to fly.

13. (a) Discuss the trim change during the aileron bias change.
(b) Discuss the pushover pullup
(c) Comment on handling qualities in this configuration.

This aileron bias change happened really at the tail end of the flight and it was something we did in a hurry. We were pretty high on energy and I was debating whether or not to go thru with it. The trim change during the flight looked just about like it did in the simulator. Normally in the simulator I started at 10^{o} α and let the nose trim down, hands off, and it would trim down to about 5 α. It did about the same in the airplane. Today I went and looked at the data and sure enough it trimmed just about identical to what we saw in the simulator. About $5^{o}\alpha$ trim change for this 7^{o} to 11^{o} on the aileron bias - almost - degree per degree in that area.

The pushover pullup (POPU) was done very quickly. It was actually a PUPO. Since I had already trimmed down to 5 α there wasn't any point to push forward at that time. So it was a pullup and then back down to somewhat less than 5 α. So it was a pullup to about 17^{o} α. I got the stick shaker again in this area - as we were supposed to. You hit the cross over here, angle of attack wise than you do with the aileron bias at 7^{o}. We saw that in the simulator. I don't remember what the angle of attack was when I hit the corss over. The simulator was hitting it around 13^{o} α. We hit it womewhere between 10 and 13. Don't have any more to say about the POPU, it was very straight forward but the fact that we were really rushed for time it was more of a mechanical maneuver than a qualitative look at it. I can't even make any comment on the handling qualities in that configuration.

Everything flew just the way I wanted it to in that area so that speaks rather well for it. Nothing bad happened and the airplane did what I asked it to.

14. Discuss the energy management from the "intersection" to low key.

All I can say is we practiced this time and again in the simulator and in the F-104 so we do just exactly what's required. The call you get from NASA I are just absolutely invaluable when it comes to managing energy. The pitch task that the pilot flies at this point is based on the calls he gets from NASA I. As I mentioned at the degriefing yesterday, I looked out one time from the intersection to low key and everything else is based on what NASA I is telling me. We had enough things to do on the down wind leg to get rid of energy and get the aileron test in that I didn't even bother to look out of the airplane. This is pretty straight forward thing and the reason it's rather a simple problem is because we plan it that way from the start. We shoot for an optimum energy over the intersection and we are able to handle very large deviations from that just because we practice it and we know what to do with it.

15. Discuss the pattern.

I was high at the low key so the pattern from my standpoint I flew a little bit wider pattern and then as we passed the 90 degree position I ran some speed brakes out. And as I do occasionally I left them out too long; realized that as I was pulling them in. My aim point dropped (back) about a half a mile. Flew about a 290 - 295 knot pattern from that point. It is no real problem but I'm going to have to work on it just to improve my touchdown dispersion.

16. Discuss the rudder doublet with the gear down.

There weren't any surprises. I had been practicing the doublet with an F-104. Occasionally in the F-104 I'd get a fairly good upset and dump the lift and have to work pretty hard at the pitch task to catch it again before touchdown. The same thing happened with the X-24. Nothing unusual and I think the response was almost like I had seen in the simulator in the lateral directional axes. But I did let the pitch get away from me during the pulse and I got a good rate of descent going and had to work a little bit in stopping it and getting it leveled out and resuming the final approach to touchdown. I was asked to rate this thing and the roll response to the rudder upset was absolutely great. We may have had a cycle, hardly anymore than a cycle of roll and the roll took care of itself. My biggest task then was recovering from the rate of descent that set up during the pulse itself. (Ratings were distinguished between the task induced by the rudder doublet and the normal airplane as follows:)

	TASK	AIRCRAFT
Roll	3.0	2.5
Pitch	4.5	2.5

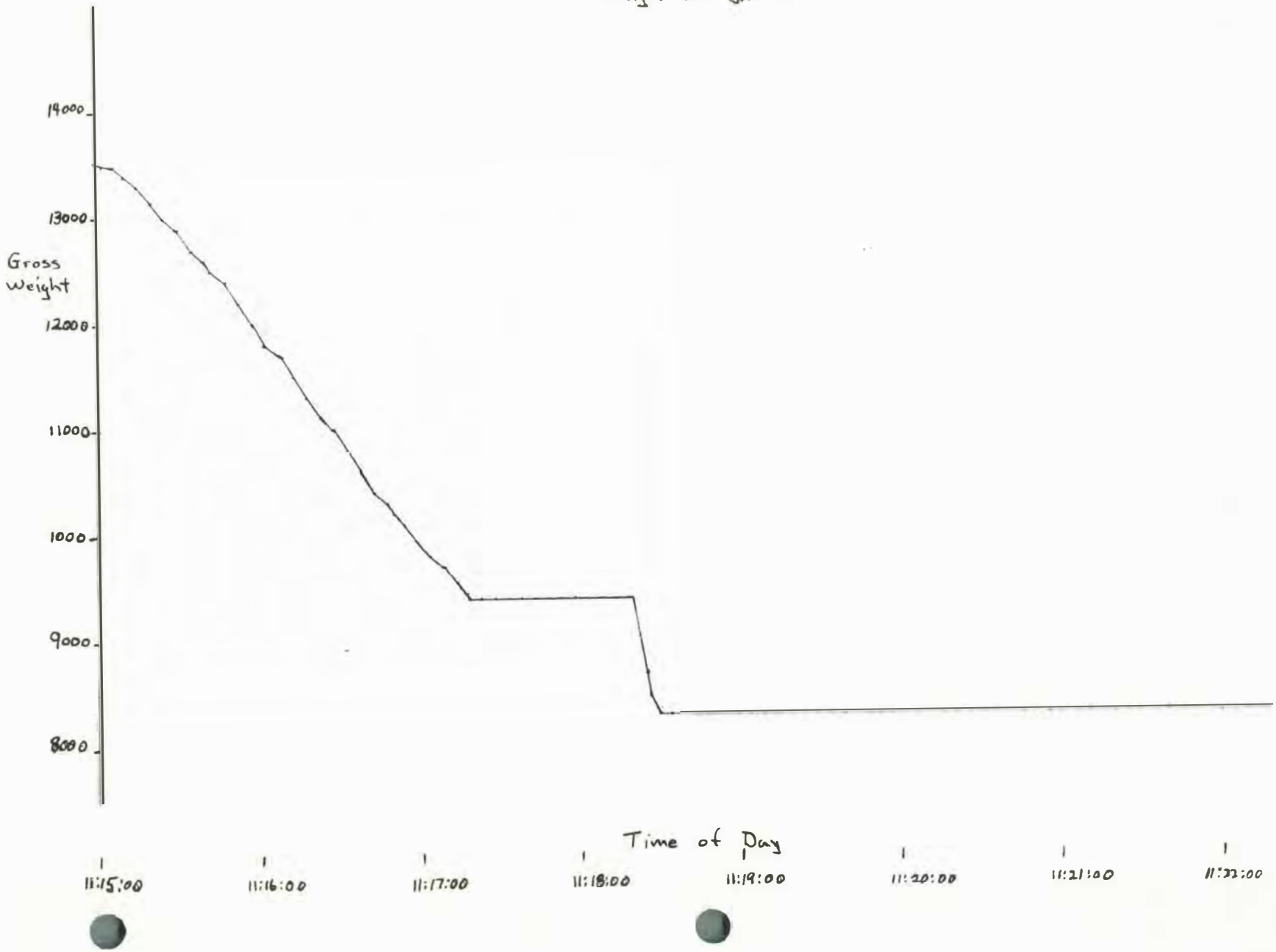
17. Were you aware of flying in the crossover during the landing?

No I was not. The airplane responded well enough to the things I was asking it to do that I wasn't of any change in pitch sensitivity or anything that's associated with crossover.

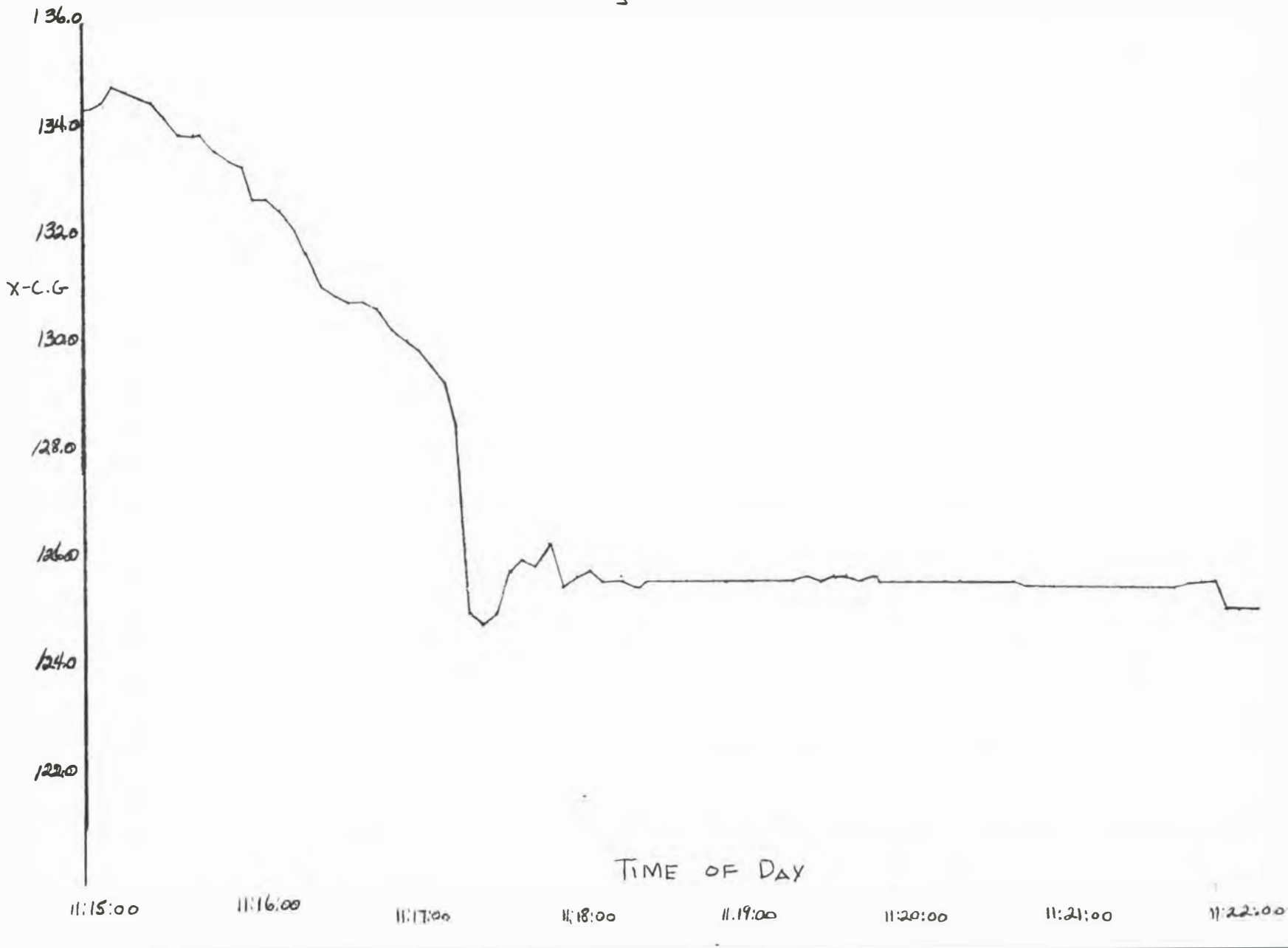
18. Additional pilot comment.

I had forgotten to discuss the roll control during the boost. During the last powered flight we had a roll PIO (pilot induced oscillation). I didn't notice that at all this time. Whether or not it was there in the records I don't know, but it wasn't apparent to me. It didn't manifest itself as a roll PIO at any time during the boost. I'll comment here that our roll (SAS) gain setting on this flight was 5 and on the last slight it was 3. So that change from the pilots standpoint solved that particular problem.

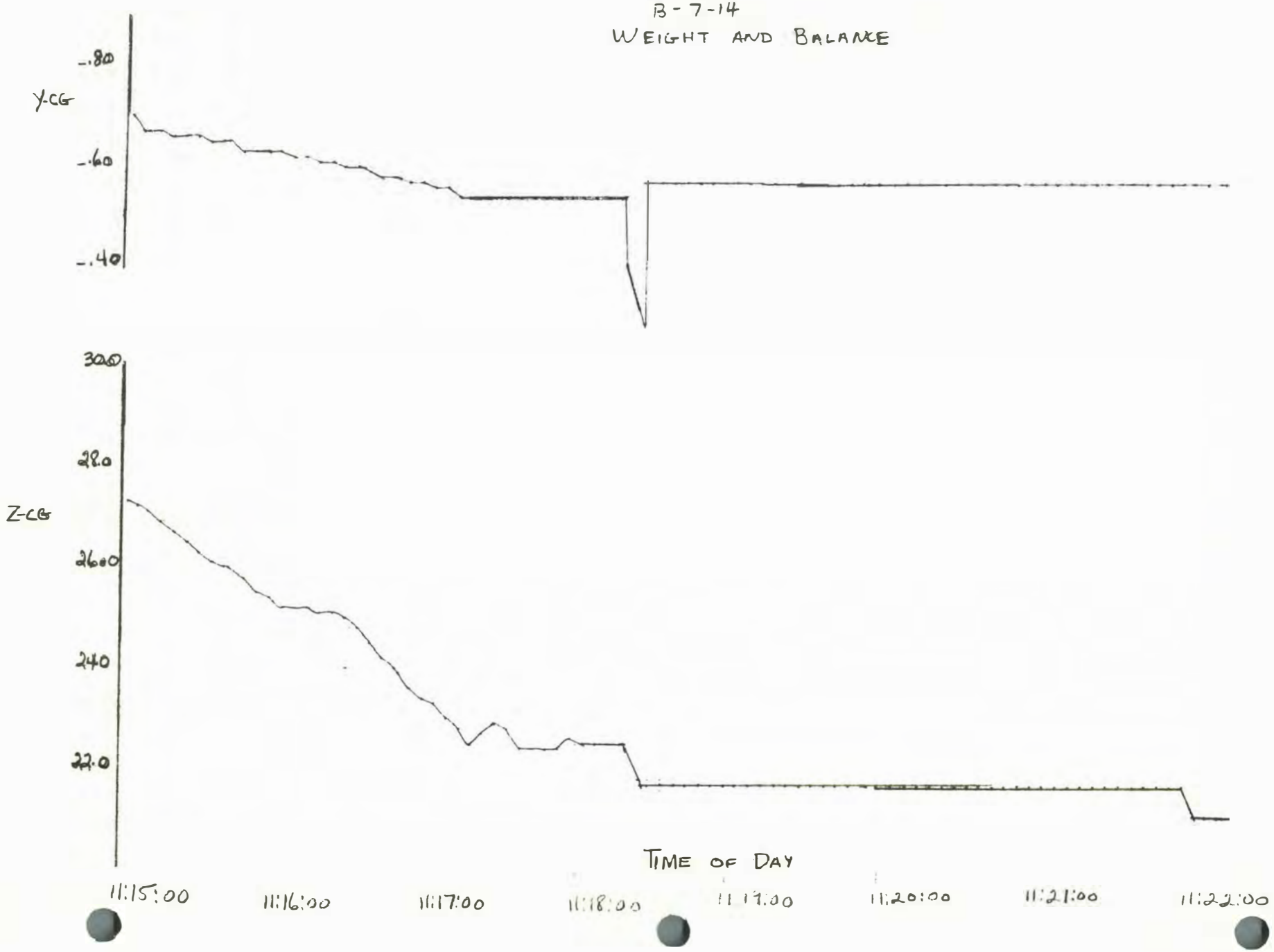
X-24B
B-7-14
Weight and Balance



X-248
8-7-14
Weight and Balance



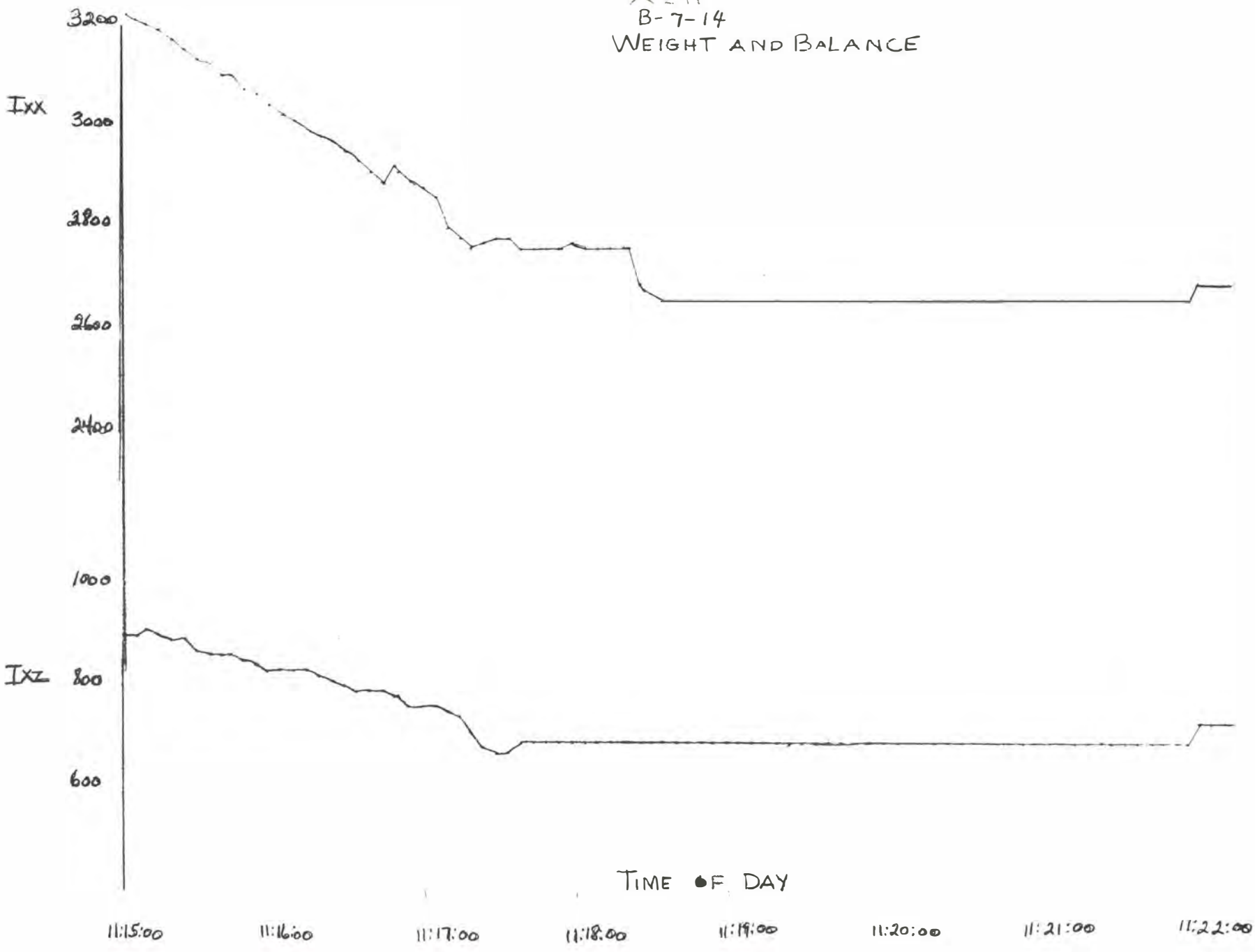
X-24B
B-7-14
WEIGHT AND BALANCE



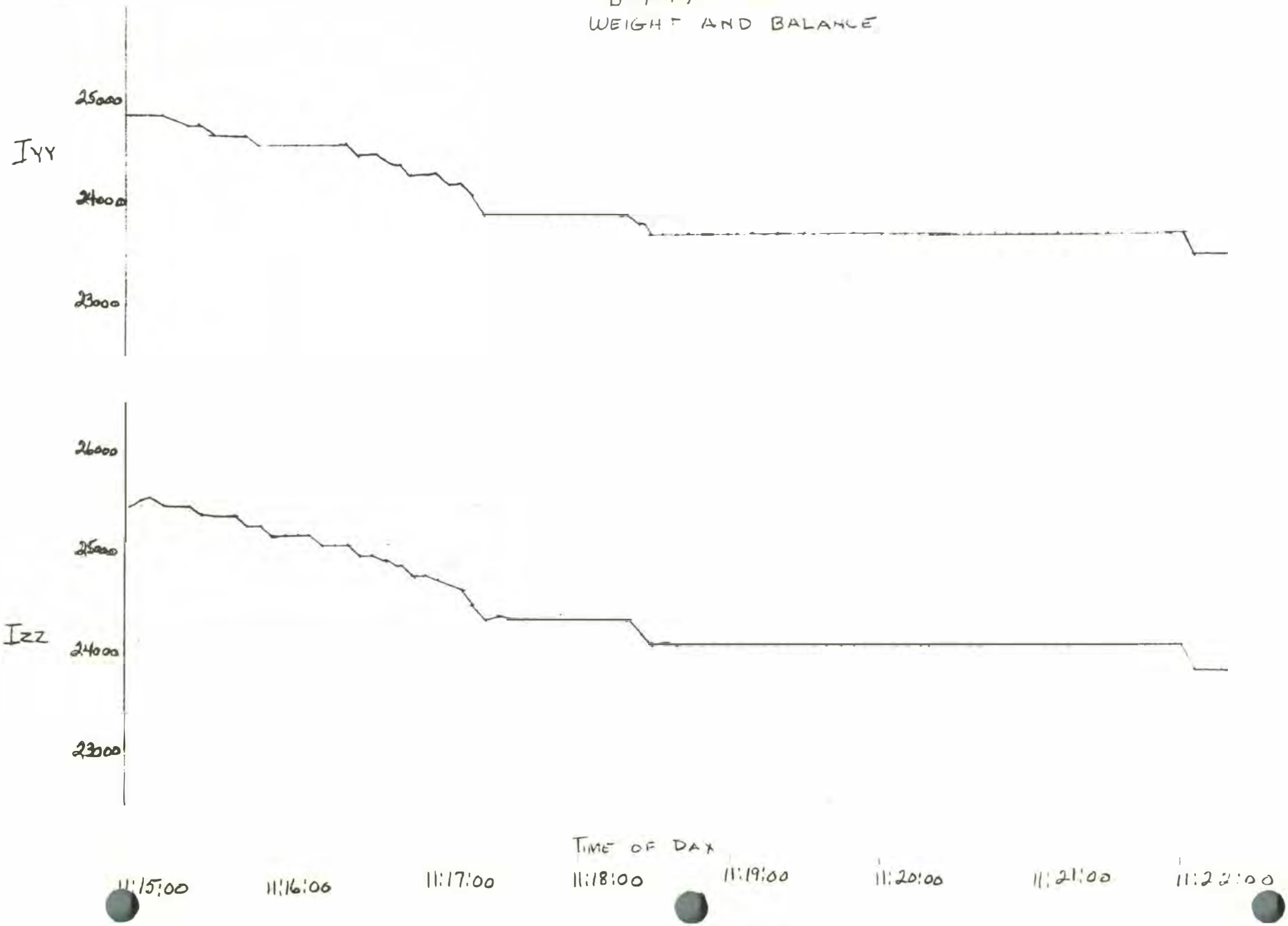
X-24F

B-7-14

WEIGHT AND BALANCE

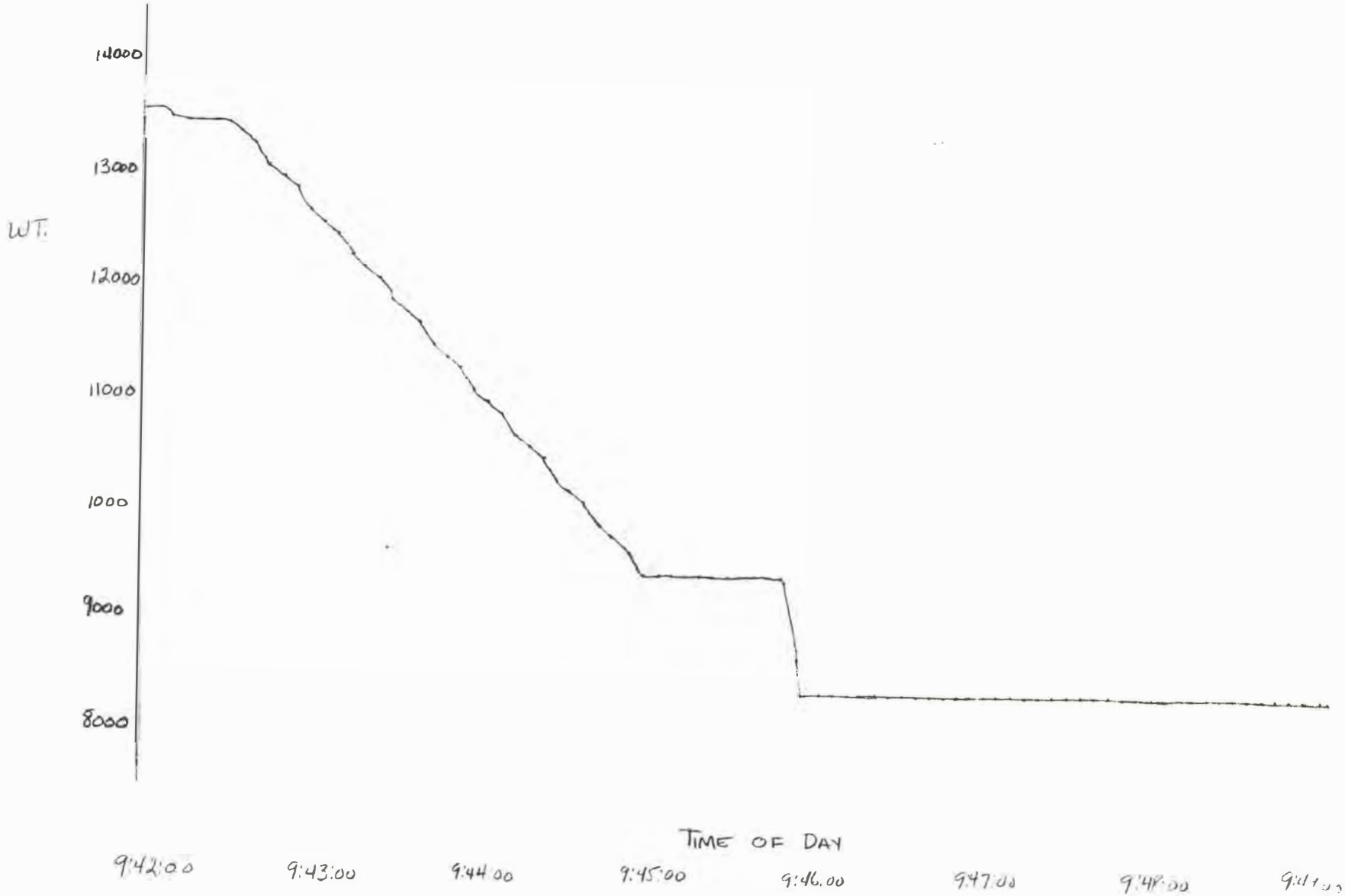


X-24E
B-7-14
WEIGHT AND BALANCE



X-24B
B-6-13
WEIGHT AND BALANCE

FINAL



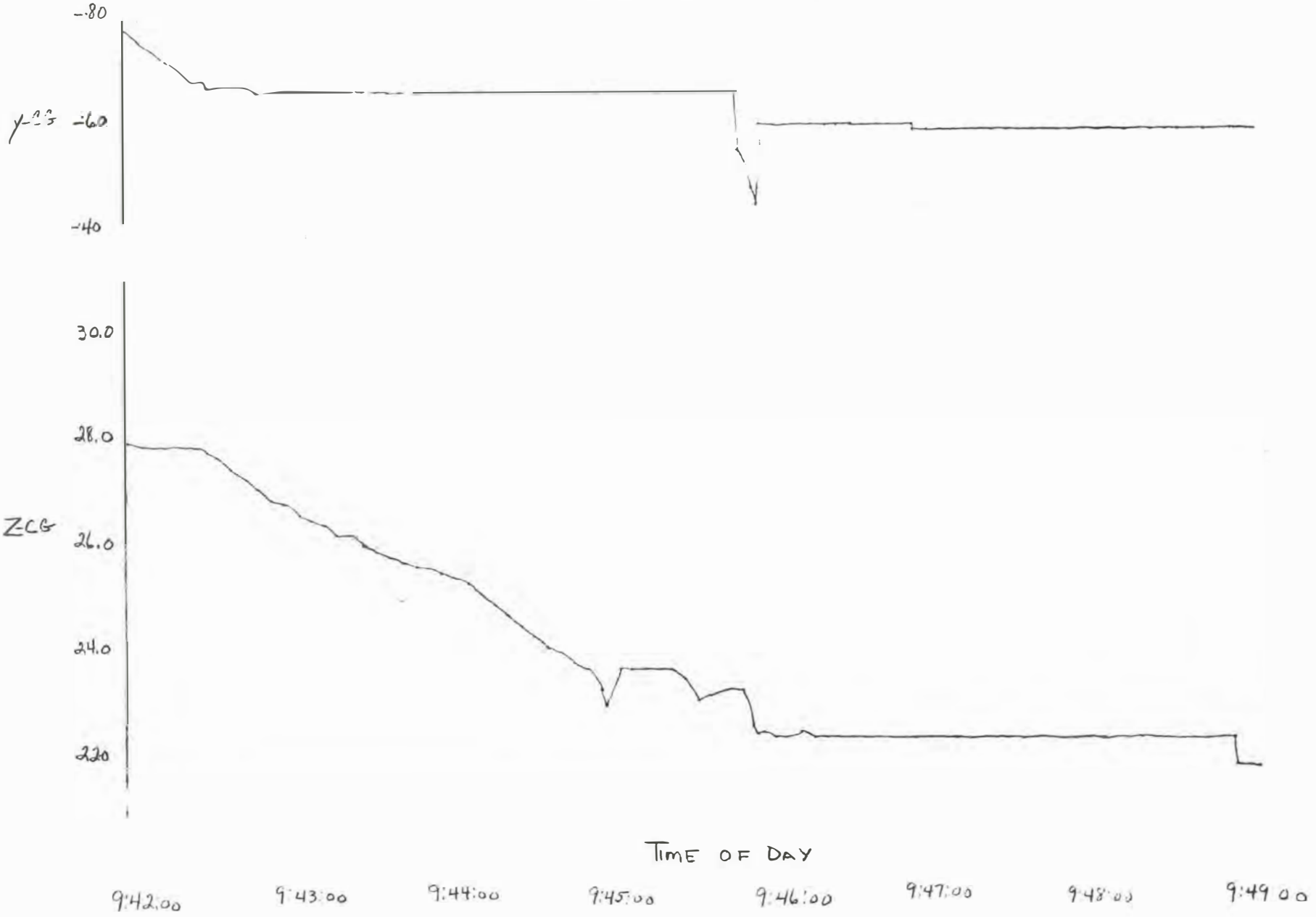
X-24B
B-6-13
WEIGHT AND BALACE

FINAL



X-24B
B-6-13
WEIGHT AND BALANCE

FINAL



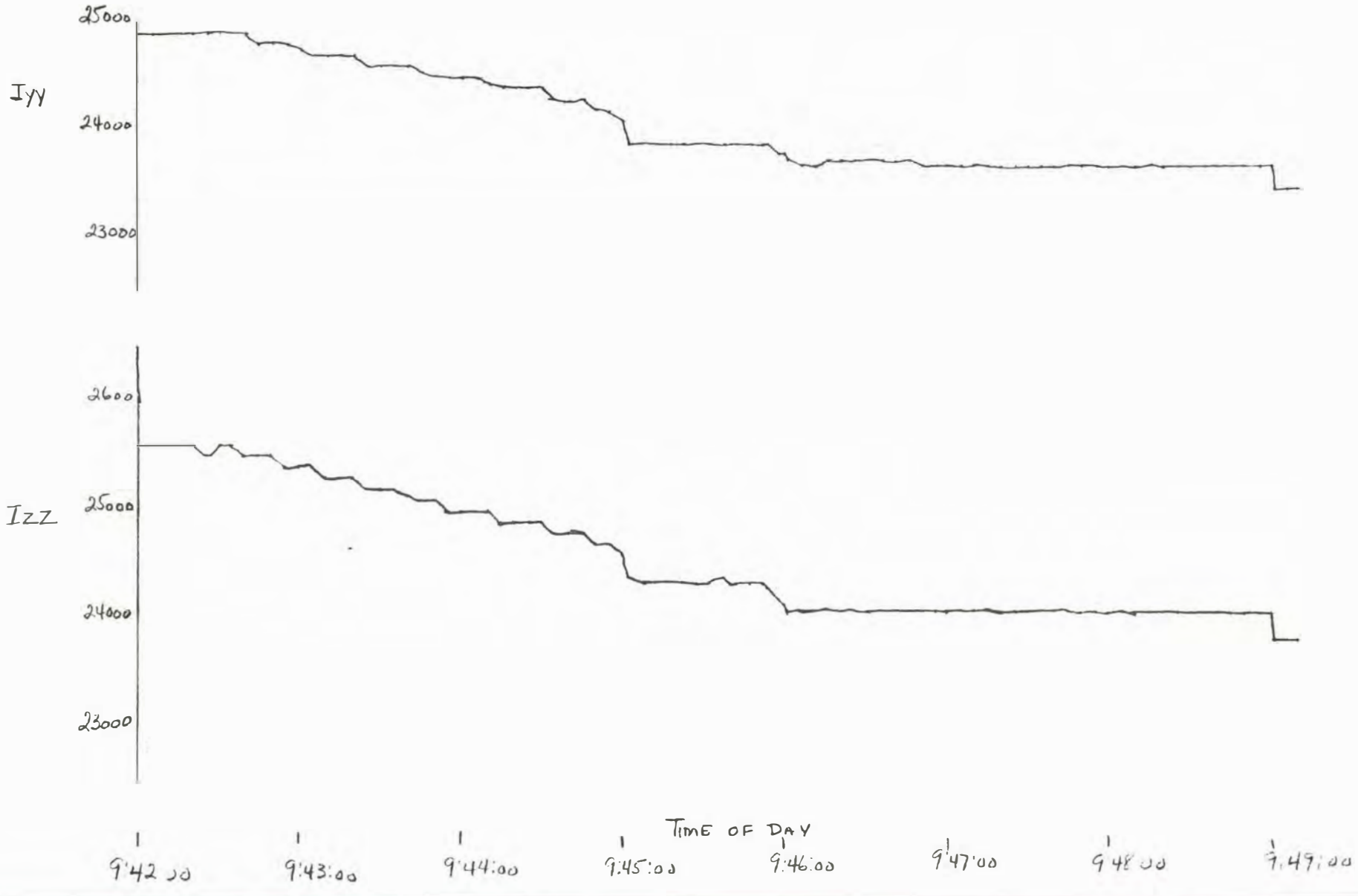
X-24 B
B-6-13
WEIGHT AND BALANCE

FINAL



X-24B
B-6-13
WEIGHT AND BALANCE

FINAL



X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-7-14 DATE OF REPORT: 12/21/73

PILOT: John Manke DATE OF FLIGHT: 12/12/73

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Envelope Expansion to .95 Mach Number.

(2) Stability and Control at .9 Mach Number

(3) Performance with aileron bias at -11°

(4) Fin and Rudder Pressure Survey

(5) Accoustic Noise and Vibration Experiment (WHITE PLUG)

I. Discussion of Previous Operations

Flight B-6-13 was flown on 11-15-73 with no vehicle problems.

II. Vehicle Configuration Changes

A. The 'o' ring seals in the LR11 rocket engine ingiter oxygen valves were changed to the type used in the igniter chamber pressure switches to improve low temperature operation.

B. The R.H. single turn Kollsman machmeter was deleted. This meter is designed such that above 50,000 feet the mechanism bottoms out causing erroneous readings both at aititudes above and as the vehicle decends.

The L.H. Bendix mach/airspeed meter is good through 80,000 feet and will be used for the remaining flights.

C. The B-52 lox topoff system was modified to eliminate the slip joint between the pylon and X-24B adapter to eliminate the lox leak reported after flight 6.

III. Instrumentation Changes

A. Replaced transformer that supplies 26 VAC to alpha-beta system.

B. Replaced demodulator for "SAS Inverter Voltage".

C. Added new power wires from bus to power distribution box in order to increase current capacity to instrumentation system and reduce voltage drop from bus to instrumentation system.

D. Re-patched pressure survey orifices.

E. Replace attitude system gyro and re-calibrated attitude system parameters.

F. Calibrated alpha, beta, SAS Inverter Voltage.

IV. Preflight Events

A. The LR11 rocket engine was removed from the vehicle following flight 6 and setup in the environmental chamber for temperature tests to determine what was happening to the #3 igniter oxygen valve.

The test setup consisted of applying gas pressure to the oxygen manifold and control gas system and cold soaking the engine to launch conditions, -65°F for approximately 15 minutes. After the cold soak the igniter oxygen valve pilot valve was electrically energized. Gas leakage was found on all four igniter oxygen valves with the #3 valve leaking so much that it would not actuate.

All four valves were removed from the engine and reworked with new E.P. "o" rings and retested as above before reinstallation on the engine.

B. Preflight functionals and an engine run were made with no problems.

V. Flight Events

A. The vehicle was partially serviced on 12-11-73 but the flight was cancelled prior to B-52 takeoff because of cloud cover.

B. The takeoff was delayed approximately 30 minutes on 12-12-73 for cloud cover. The clouds moved through the area and the flight was made as planned.

The vehicle was in good condition after the flight.

Approved: _____
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: _____
Norman E. DeMar
X-24B Project Engineer,
Operations Engineering Branch

X-24B #551 POSTFLIGHT DATE: 12/12/73

PILOT: J. MANKE

Ok, this is flight B-7-14, today is the 12th of December. It was a real busy one. Postlaunch I can't think of anything other than a few smart remarks from Dana that stick in my mind. Everything else went good. I think it was an excellent call on the weather. And all kidding aside the backup chase thing really paid off. I guess when fuel's at a premium like it is with the 52 that really was pretty nifty having Tom fall in there to fly it. (We'll never convince Dave it wasn't planned.) Another rose for Tom there. Tom got up at 4:30 this morning to come in and fly with us, just to fly in the back seat of the 2 seater to get a little look at the profile. I think that's a rose for Tom and I sure appreciate all that good stuff.

Ok, the launch was just like the last one was. The heavy weight launch on the airplane is pretty straight forward. Very little rolloff and maybe a little bit lower on the normal acceleration but nothing bad at all. The chambers came up very nicely this time. It seemed the 2 + 4 came up quicker this time than they did on the last flight, maybe it was my imagination but I could hear the pump starting and it really came up well. On the last flight I had made it a point to stop at 10° alpha and light the engine and then come up to 14 and this time I didn't think that was necessary and smartly pulled back on the pole and immediately got the stick shaker. So, I went up to about 17° alpha, the shaker helped a bunch. It got my attention and I looked at alpha and pushed it back down to 14. Just a little bit loose in pitch but not nearly as loose as the M2 was. At any rate, as we all know when you light the engine you've got your head down in the cockpit and it's pretty easy to let alpha get up on you. It was a good lesson for me again.

Ok, after that I dropped alpha a little bit for some reason or other. I got it down to 10 I guess on that push fwd when I got the shaker and then back up to 14. Then I noticed this 1° sideslip again to the left. We have been practicing with some reduced directional stability derivatives in the simulator and it shows that if we had any sideslip mistrim early on in the flight it could get to be a pain in the neck later on. So, I tried to trim that out and I put in some left rudder and was satisfied that I had trimmed most of it out, got back up and put alpha where it was supposed to be again. The boost part of these things is basically a pitch task, it's alpha and theta. On this flight it's strictly an alpha control. When other things come along like this sideslip thing it takes your attention away from the pitch control and the pitch stability isn't that good so that it will hang in and hold whatever you had before. My pitch performance wasn't as good from my standpoint today as it was on the last flight because these other little things were going on and my attention would get diverted from it and I would go back and my alpha wasn't quite where I wanted it. So I felt a little bit busier here today than before. Although, one big plus for us - I didn't notice any of the PIO tendency in roll that we had in the

last flight. And to get rid of that we cranked our roll gain up 2, we went from a roll gain of 3 to a roll gain of 5. From the pilot's standpoint, at least on this one, it looks like we solved that problem. That's pretty encouraging because I don't think we ever solved it on the other airplanes, we always had a little looseness and roll.

Ok, fooling with the sideslip I didn't see the max mach during the boost or during the roundout. I lit my chamber on time at 35 seconds, it came up very nicely. Just like it was suppose to. Held 14 alpha and we were supposed to get our 30 theta about 50 seconds and I was a little slow getting there. I attributed it to the fact that I had dropped alpha earlier, just a little bit. It was about 3 seconds late. At that time I went over to 13 alpha and somewhere in here we got a few, what we call "klurds" which we attribute to changes in wind gradient or something of that nature, some form of turbulence on the climb. They manifest themselves in just a little dutch roll. Rather sharp input and then it goes away.

Ok, we had a 70 second point for a performance check. The performance appeared to be a little low at 70 seconds, about 1500 or 2000 feet in altitude and I read .75 which converts to about .77 and we were looking for about .8 in the series. So, performance at that time appeared to me to be just a little low. Somewhere in this area I looked back down at the sideslip and it was out to the right so I took some of that trim out that I had put in originally. I don't know where we ended up trim wise, but I took enough out to be satisfied with it.

The next thing we were supposed to do was get .9 mach number and that was supposed to occur at about 93 seconds. It seemed slow as the dickens coming up. I went beyond 100 seconds and we still hadn't gotten the .9 so I pushed over to 12 and shut that chamber down away. I would guess we were .02 of a mach below .9. Did the 12 degree alpha pulse and the airplane seemed loose as the dickens in yaw at this particular point. I did the pulse and watched beta and beta didn't seem to be going anyplace in particular but just drifting around quite a bit. So, it did worry me a little bit. I fooled with the rudders to make sure I had good control. There's good rudder response at this point, it's just that beta is just directionally kind of loose. I could drive beta around with the rudders very easily but what that does to you, it takes some of the time away from the other tasks, the pitch tasks. It was just a little bit disconcerting but I think we can learn to fly this thing in this area without any real problem as long as we find out we do have definite directional stability. I think I got you two pulses in here because of the slowness with which I was coming up to .95.

Now, somewhere in here I felt some buffet again. It was very reminiscent of the buffet I got on the first flight at 20 degrees on the uppers. I don't remember exactly where it was. Sitting waiting for .95 I also got the feeling that we were pushing the mach. Whether or not we were, I don't know. I remember on the X-24A a guy could feel just about the time

you got to mach, and I could never tell whether it was a change in control sensitivity or just what it was. I just always had a feeling and it was always right, I could tell that we were getting to the mach and I got the impression today that we were close to that. Whether it's an increase in drag or what it is I don't know. The mach was coming up rather slowly at this time toward the .95 area and then all at once it became a little more rapid it seemed like. Whether or not we were approaching a mach jump or not I don't know. I shutdown at about .93 or .94 indicated.

Ok, pushed over to 5 alpha at that point and the stability is definitely better with the engine off. It takes some of the pressure off, you can feel that the directional stability is better. I did the 5 degree alpha pulse, rudder and aileron, and it was very much like the simulator.

Coming back down hill the mach came back up to .92 or .93 indicated, probably around 92. Went to 14 alpha, did the pulse there and looked down and checked mach and it hadn't decreased a bit so I held 14 alpha just a little bit longer to keep it from getting any higher. I held it a little bit too long and the mach started back down again so I went down to 10 and just a little bit below 10 and held it for a while and let the mach come back up and it sure enough did. So as it came up back toward .9 area, I went to 10 alpha got the rudder, aileron pulses and they looked about like the simulator. Then pitch damper off, got a pitch damper off pulse and my first impression is just a little bit better damped than the simulator.

Ok, damper came back on, jettison, jettison went ok. Somewhere during the jettison cycle, I guess it was about the time we finished up jettison, I felt something in the airplane. A vibration or something. I immediately thought of the torching off we did on the M2 but I couldn't feel any thing in the longitudinal, it was just sort of a shudder in the airplane. Maybe it was when we went, just as we completed jettison, maybe we had a couple of burbles going out the back. Whatever it was it got my attention and I thought of fire but I didn't feel any acceleration so I forgot it and shortly thereafter came the stop jettison call.

Ok, we did a little bit of a roll evaluation there. We were higher than, about 4,000 feet high on energy, I still got a chance to look at it in roll. We had run our roll gain up to 5 to get rid of this PIO in the boost and in the simulator it appeared to be a little sluggish. It was not a real fine maneuvering airplane for pattern work at 5. But, the airplane itself seemed to have a lot better response at a gain setting of 5 than the simulator does. That's always the case and I've never been able to figure out why, the simulator always appears to be more sluggish. I think a guy's a lot more powerful when he's flying the airplane. Anyway, it's a nice flying airplane in the roll gain of 5. We took the gains down at that point to the landing gains, roll gain down to 3 and here again it's a hell of a nice flying airplane down here.

Ok, we were a bit high, so we held the configuration change well into the downwind leg. I guess I pulled them in about 29,000 feet. One thing, the

visibility coming across the intersection wasn't as good as the 104. I had to work a little bit harder at finding the runway and seeing where I was. It was no big deal, it's just a little surprise, I looked out and I couldn't see the, about all I could see was north base and a little bit this side of it. I had to roll it up pretty good to take a look. No real problem. Nothing at all like we had with the HL-10.

Ok, I looked out at that point, it looked like Mike had the situation well in hand, he was vectoring me to where it looked like I wanted to go so I went back in the cockpit. As soon as we got cleaned up we went the nose down aileron bias change. I didn't get a very good qualitative look at the thing here. We were terribly rushed at this point and I had almost considered forgetting that maneuver because we were getting so close to the low key point. But, then it looked like we had half a mile to spare so I did run it down. It was more of a mechanical thing so we'll have to get the quantitative stuff more than the qualitative. Trim change looked just like I had seen in the simulator, 4 to 5 degrees trim change. The popu was a quicky. Hardly any pushover because I was at 5 alpha, anyway. Pulled up and I pulled up to about 17 and got the shaker again, back on down to 10 and brought the aileron bias back to where it was. So I can't give you any good handling quality stuff except the airplane appeared to fly very nicely in that area.

Ok, we were beyond the highway by the time we got all that done and that was the second time I looked out. I only looked out twice in the whole flight before we got to the landing pattern. One was coming across the high key intersection and here again as we crossed the highway. Tom's call was real good. You called crossing the highway and the pilot always sees it earlier than the controller does. I think we misjudge it a little bit from the air but that was really a good call. That gave me a good indication that we were getting awfully close to there. We were a little bit high on energy at that point, so I just flew a little bit wider pattern. The pattern itself was real good, got the camera on at the 90 degree position. Then it appeared that we were pretty high so I ran the brakes out to 30 degrees and as I've done countless times before, I left them out too long. When I pulled them in I ended up a little bit low. My aim point dropped back about 1/2 a mile.

But the final approach was very straight forward, we hit one or two bits of turbulence. The airplane responds nicely to turbulence like we've noted before. It was a good flare, Tom called it 1200 feet, I probably started 300 feet later. Easy airplane to flare. Brought the geat down maybe 5 knots higher in airspeed than I had before to try to get this doublet in and I was probably a little bit higher when I dropped the gear than I had done before. We'd been requested to do a rudder doublet after I got the gear down. I've been practicing it in the 104 and it found that very frequently in the 104 if I don't do it quite right I dump my lift and get a pretty good rate of decent and I did the same thing with the 24 today. Gave it a pretty good rudder boot and it dumped. This airplane

is kind of nifty though because you've got a lot of lift available so after it started down I was able to honk back on the stick and stop it. I don't even think we ballooned. Stopped it about there and I guess we flew level for a little bit and Tom's calls were great. We just eased it back down again and it was a pretty normal touchdown. I touched down a little beyond the 1 mile marker. I did not look at my touchdown airspeed. Nose came through like it always does. Real spooky. And, rollout was pretty straight. I didn't use any brakes on rollout. I didn't use nose gear steering. I used a little rudder control and that was all I needed to hold it down the runway.

It was a darn good flight.

X-24B #551 DATE: 12/12/73

FLIGHT: B-7-14 L/P: R. Young

PILOT: J. Manke

NASA 1: Maj. Love

NASA 1: Ok, 24 minutes John.

24 MINUTES TO LAUNCH

JOHN: Ok, Mike. 24. SAS Gains are 6, 5, 3 and here comes the calibrate.
NASA 1: Got a good one John.
JOHN: Cabin pressure altitude is about 18,000, X-24 Air is 3,000, pylon is down around 550. 2 and 4 hydraulics coming on. Low pressure lites OUT. I've got 3100 pounds, a pair. SAS Mode switches are on. Ok, all my circuit breakers are IN except Veh Release and Brake.
NASA 1: Roger, thank you.
Eddy Twr: Mothership 008, say altitude.
008: Passing 51033 sir.
Eddy Twr: Mothership thank you.
NASA 1: 008 come left to 240.
008: 008, Roger.
Eddy Twr: Mothership 008, Supersonic Corridor active flight level 350 to 450.
008: Roger.
NASA 1: Eddy Tower, NASA 1.
We'll be launching in 22 minutes to 10 after the hour. It's 22 minutes now John.

22 MINUTES TO LAUNCH

JOHN: Ok, Mike. 22. Going to Auto on the Mach Repeater. Ok, alpha is reading, right now 3 1/2, airspeed reads about 215, altitude 34.2, indicated mach is .64, mach repeater says about .65.
NASA 1: Roger.
JOHN: Mach repeater going manual. It's set at 1.0. Lowers trim to about 1. Here comes the emergency flap switch. There's 30, works the other direction too. Flap bias is coming open. There's 40 and rudders are 0. Coming closed, 20 and -10. Coming back open.
NASA 1: Will you rollout this heading of 1,008.
JOHN: Rud Mode going to manual. Toe IN.
NASA 1: 008, rollout this heading for 1 please.
008: Roger.
JOHN: Toe out to 7 looks good. Rud Mode going to auto. It works. Aileron bias mode going to backup. Run it down to 11 now. Ok, it won't do that in the backup mode. Going back up and I'll run it back to 11 when I get to the normal mode. It works both ways in that mode, going to normal. And it stops at 11. Looks real good. I read 11.

NASA 1: We agree John.
JOHN: And that should be about 7 there. Does that look reasonable?
NASA 1: That's good 7, John.
JOHN: Ok, stick coming full aft. Stick Trim forward. Stick trim aft. And I've got it set at 10. Aileron trim right, aileron trim left.
NASA 1: Ok, 008, resume your turn please.
008: Roger.
JOHN: Trim Set 0. Rudder pedal is right and left. Looks good and yaw trim right, yaw trim left and it's set about 1/2° left. You'll have to verify that. KRA increased to 50. Right and left stick, rudder moved. Back to 0. Right, left, no rudder.
CHASE: Roger, looks great.
JOHN: Going Emergency mode. Increase to 50. Right and left and 1 get rudders. To auto. It programs. Ok, stick shaker test. Looks good.
NASA 1: Rollout 255, 008.
JOHN: Mach repeater is 1.0. Flap Mode is manual. Rdr Mode is auto.
NASA 1: Ok, go ahead 008.
CHASE: I think your heading was cut out Mike.
NASA 1: Hold that heading 008.
008: Roger, 257.
L/P: Starting to top off.
JOHN: 6 SAS Servos are auto. Get the top off call, Ray?
L/P: Rog, starting top off.
JOHN: Very good.
NASA 1: Roger, we copy.
JOHN: SAS Gains are 5, 5, 5. Here comes the old SMRD. No lites.
NASA 1: Roger, John. Could you get precool off, please?
JOHN: Precool is off. Ok, here comes torque. No lites. #1's are off and a torque. Three ambers. #2's are off and a torque and three reddies. SAS Gains are 6, 5, 3, SAS servos are all auto, SAS lites are reset and a torque. No lites. SAS Mode switches are ON. And I'll wait here for 14.
NASA 1: Roger. I need a little left roll, John, and a beep of left yaw trim.
JOHN: Ok. Here comes left roll.
008: 40,000 feet now.
NASA 1: Roger.
JOHN: Left yaw.
NASA 1: A little more left roll. 17 minutes, John.

17 MINUTES TO LAUNCH

JOHN: Got 17. Good shape. How's that aileron, Mike?
NASA 1: Aileron's good, rudder's good.
JOHN: Ok. And I guess you're happy with that aileron bias too, right?
NASA 1: Roger. That was very good. Mr. Scherer just walked back in, John. He's got another flash message from Washington.

JOHN: Let's ave it till after the flight, Mike.
NASA 1: Ok.
JOHN: Oh. That's all right. Go ahead. What's the message.
NASA 1: Well, the President has been noticing your good work again and he's directed that William Simon award you 10 gallons 100 octane av-gas to burn anyway you want to.
JOHN: That's beautiful, Mike.
CHASE: Why don't you sprinkle it on yourself and then light it?
NASA 1: 16 minutes John. 008 come 5 left.

16 MINUTES TO LAUNCH

008: 5 left.
NASA 1: There's one hitch though John. He's directed that you maintain two-way radio contact with Fox Tower at all times when you're burning it.
JOHN: Ok, I'm prepared to do that. I've noticed one thing, there's a lot of hot gas in one of the chase planes here.
NASA 1: That's 10 seconds, Bill.
CHASE: Roger. We're ready here.
NASA 1: Ok, 008, give me two more left.
008: 2 left, 250.
NASA 1: Ok, 008, come two more left.
008: Roger.
NASA 1: 14 minutes, John. 14 minutes.

14 MINUTES TO LAUNCH

JOHN: Ok, Mike 14. I've swapped the hydraulic pumps. #1 and 3 are on. Low pressure lites are out and I've got 2700 on each.
NASA 1: Roger.
JOHN: And I'm ready for pitch and yaw pulse.
008: Roger. Pitch pulse now.
NASA 1: Good pitch pulse.
008: Yaw pulse now.
NASA 1: Good yaw pulse.
JOHN: They both looked good from here too. Ok, Mike if you're established on a reasonable heading I can go to erect.
NASA 1: That's a good idea, John.
JOHN: Ok, I'm in erect and fast erect is on.
NASA 1: Roger. 13 minutes, John. 13.

13 MINUTES TO LAUNCH

JOHN: Ok, Mike, 13.
CHASE: 2 alpha was just over by the launch point and the weather's clear and there's a little bit of light turbulence between about 30 and 35,000.
NASA 1: Roger. Thank you very much, Tom.

JOHN: Thanks, Tom.
CHASE: Do you think the surface winds are within his limits, Tom?
CHASE: I'm not worried about him, Bill. I'm worried about you.
NASA 1: 12 minutes, John. 12 minutes.

12 MINUTES TO LAUNCH

JOHN: Ok, Mike let's call it 12.
NASA 1: 11 minutes, John. 11 minutes.

11 MINUTES TO LAUNCH

JOHN: Ok, Mike, 11. I've got 40 on the uppers, 10 on the lowers, aileron trim looks 0, ail bias 7, rudder's 1/2 left and rdr bias at 0.
NASA 1: Roger.
JOHN: What do you read for mach number?
008: I read about .6.
JOHN: Ok.
NASA 1: 008, we'd like you to come 3 left.
008: 3 left, Roger.
NASA 1: 10 minutes, John. 10 minutes.

10 MINUTES TO LAUNCH

JOHN: Ok, Mike. 10. #1 Helium is about 38, #2 is 41, cont gas is 40 to 45, gov bal is about 450, fuel tank reads about 6, LOX tank 15, landing gear about 32. Pump heater is OFF and ON. OFF now, back ON.
NASA 1: Roger. We got a good read ing.
JOHN: Ok.
NASA 1: Ray Young, do you see good top off yet?
L/P: Negative on the top off. No visual on the plume. Chase 1, will you give a call when you see a plume out the lower left.
CHASE: Roger.
NASA 1: 9 minutes John. 9 minutes.

9 MINUTES TO LAUNCH

JOHN: Ok, Mike. 9. Erect switch cutoff. Fast erect off. Give me a heading here 008.
008: 245.
L/P: Launch panel stopping feed until 3 minutes.
008: Mothership, 354 in position.
JOHN: 345 called and my attitude looks good.
NASA 1: Roger.
JOHN: Ray, are we still using a lot of LOX like we did before?
L/P: Negative. LOX is good shape, over 220.
JOHN: Are we sure we're topped off then?

NASA 1: 8 minutes. 8 minutes. 008 start your turn.

8 MINUTES TO LAUNCH

008: 008.
JOHN: Did you stop top off, Ray?
L/P: Affirmative. Outside of about 5 minutes right here.
JOHN: If you're not low on LOX why don't we just keep it going?
L/P: Ok, going back to feed.
JOHN: Here comes the landing rocket check.
NASA 1: Ok, that was good John.
JOHN: Ok, Mike. I'm just afraid if that rate falls down like it used to be, we might not get a top off.
L/P: Rog, it's going.
NASA 1: Ok, 7 minutes, John.

7 MINUTES TO LAUNCH

JOHN: Ok, Mike. I am on X-24 radio and on primary. How do you read?
NASA 1: You're good now.
JOHN: Ok, going secondary. Ok, Mike, I'm back to primary. I read you real good all three.
NASA 1: All right. Shallow the turn 008. Shallow the turn.
L/P: John, launch panel. I can verify LOX plume on the monitor.
JOHN: Ok, Ray, thanks a lot.
008: 008, level 450.
NASA 1: Rollout this heading for 1 and we'd like you to stop lox top off for a couple of minutes.
L/P: Ok, stopping top off.
NASA 1: 6 minutes, John.

6 MINUTES TO LAUNCH

JOHN: Ok, Mike, 6 minutes.
NASA 1: Roger. Chase aircraft check you windshielf heat.
CHASE: 1. 2. 2A.
JOHN: Ok, there's what I call 27.
NASA 1: Ok, we've got 26, John. That's good.
JOHN: Ok.
NASA 1: Resume the turn 008. Resume the turn.
008: Roger.
NASA 1: 5 minutes, John.

5 MINUTES TO LAUNCH

JOHN: Roger, 5. 2 and 4 hydraulics ON, lites are out. Buses are 110, 100, 60 and about 30. SAS is 5, 5, 5. The old SMRD again.
NASA 1: 008, Rollout 060.
JOHN: Torque. No lites. #1's are off - torque. 3 amber. #2's are off - torque. 3 reds. Ok, 653.

NASA 1: 4 minutes, John.

4 MINUTES TO LAUNCH

JOHN: Ok, Mike. SAS Servos are auto.
NASA 1: Start your top off again please.
L/P: Starting top off.
JOHN: SAS lite reset and a torque. No lites. Ok, I'll sit here till 3 minutes.
NASA 1: Ok. 3 minutes, John. 3 minutes.

3 MINUTES TO LAUNCH

JOHN: Ok, I'm on X-24 oxygen and reading about 85 pounds. Low pressure in the cylinder about 1850.
NASA 1: 2° left 008.
008: Roger.
JOHN: Cabin air is X-24, X-24 air is 28, cabin altitude is about 24.5. Defog is heat. Fwd Canopy is ON. Suit vent is low. #1 is 37 1/2 and #2 is 41. Cont gas is about 480 and gov bal 450. Going to erect. Fast erect is ON. And my trims look good.
CHASE: Look good out here.
NASA 1: Good down here, John.
JOHN: Ok.
NASA 1: 2 minutes, John.

2 MINUTES TO LAUNCH

JOHN: Ok, precool is OFF, engine bleed is ON, prop supply-ON, tanks pressurized. Ok, they came up nice. I got about 48 on the fuel and 46 on the LOX.
L/P: Ok, stopped topoff and beacon coming OFF.
JOHN: Release press low lite is OUT.
NASA 1: Roger.
CHASE: Release pressure is good.
NASA 1: Roger. 2° right 008.
008: 2 right.
CHASE: 2A this is Chase 2.
CHASE: Roger. Go Bill.
CHASE: I just lost the hydraulic system, you've got the flight.
NASA 1: Standby for 70 seconds. Mark.

70 SECONDS TO LAUNCH

JOHN: Ok. Got it.
NASA 1: Standby for 1 minute. 1 minute, Mark.

1 MINUTE TO LAUNCH

JOHN: I've started my clock. Sources both look good. SAS lites are OUT. Engine master coming ON, now. Heading is 060, alpha 3 1/2 to 4, beta is 1/2° needle left. Erect switch cutoff, fast erect is OFF.

NASA 1: Systems are good John. Standby for 30 seconds, mark.

30 SECONDS TO LAUNCH

JOHN: Release circuit breaker's IN.
L/P: .....
JOHN: Cameras/recorders are ON. Ok, here comes my igniter test.
NASA 1: Got 4, John.
JOHN: Ok, saw 4. Did you see 4?
NASA 1: Roger, we got 4 good ones.
JOHN: Ok, I've hit the reset. Here we go.

LAUNCH

NASA 1: Check 14 alpha. Got 3 good ones here, John.
JOHN: Ok, I got 3. I rotated a little bit much and got stick shaker.
NASA 1: Ok, you've got good heading and you're on profile.
JOHN: Good 14 alpha. Got a little needle left side slip.
NASA 1: Roger. Ok, check your mach and standby to light one chamber. Ok, we got 4 good ones, John. And you can come 2° left.
JOHN: Roger.
NASA 1: Standby for theta and 13 alpha. Good heading change and you're about 1000 low on profile.
JOHN: Roger. That was my fault.
NASA 1: Good heading, Check your theta.
JOHN: Got 34.
NASA 1: Roger. Standby for 70 seconds. 70 seconds, Mark.
JOHN: Ok, little low both on mach and ....
NASA 1: Good heading and you're coming back to profile here. You're about 1/4 of a mile south of track and on profile. Ok, standby for 12 alpha and one chamber off.
JOHN: Roger.
NASA 1: Ok, standby for doublets. Check your beta. Ok, you're in the green John, you've crossed the early shutdown. Standby for shutdown and 5 alpha. You're at the normal shutdown line, good heading, on track.
JOHN: 12 alpha here.
NASA 1: Ok, John, let's get the prop supply and standby for doublets. Ok, good heading, you're about 63,000, got your doublets, standby for 14 alpha and doublets. We see 14, good heading, got your doublets. Standby for 10 alpha and doublets and you're about 4,000 high. Ok, John get your pitch damper off and pulse. Good pulse, you're inside 3 miles, 4,000 high. Ok, let's go jettison. We see your damper on, check 12 alpha.
JOHN: Roger.
CHASE: Jettison.
NASA 1: Please lower your alpha John and we'll get rid of some of that energy.
JOHN: Ok.

NASA 1: Check your airspeed and get a roll eval. You've got good heading, about 3,000 high. You're at the intersection. Let's come left to 360, stop jettison, tanks and bleed OFF. See your 4, 3, 2.

JOHN: Roger.

NASA 1: Ok, you're still 4,000 high and you can come left to 360.

JOHN: Roger. We're going to have a little trouble getting that aileron thing done.

NASA 1: You're going a little outside, John. Approaching 3 miles.

JOHN: Ok.

NASA 1: We see your 40° on the uppers.

JOHN: Ok, I'm going to clean it up now.

NASA 1: Ok, you're inside about 2 1/2 miles.

JOHN: Roger.

NASA 1: See you coming closed.

JOHN: Got a stick.

NASA 1: You're 2 miles. 360 is a good heading. You're 3,000 high. We see your 11. Standby for the popu. Ok, you're still 3,000 high, let's go back to 7. Ok, you're over the highway, John. Come on back to 7 and get your 1 and 3 hydraulics. You can start your turn now, John.

JOHN: Ok, Mike.

NASA 1: Got your hydraulics and rocket checks.

JOHN: Yea, I got that, did you get it?

NASA 1: Got a rocket check. You can get your chamber switches if you want to.

JOHN: Got them.

CHASE: 245.

JOHN: Ok, good call, Tom. I got 240.

CHASE: 88 1/2%.

JOHN: Ok. Probably going to use a little brake here.

CHASE: Ok.

JOHN: Ok.

CHASE: 85%.

JOHN: Ok, I've got about 270 now.

NASA 1: Ok, John we've got you at the 90° point. Get the fin camera.

JOHN: Good call.

NASA 1: Your energy is starting to look real nice in here. And we've got your mach repeater. Ok, we see your uppers at 30.

JOHN: Roger.

NASA 1: Remember you've got a doublet after the gear. And we see you coming closed.

JOHN: Little turbulence.

CHASE: 285.

JOHN: We've only got about 290, Tom.

CHASE: Roger.

JOHN: We'll let that be good.

CHASE: 3500

JOHN: Roger.

CHASE: Three good gear. 20 feet, 10 feet, 1 foot, beautiful.
NASA 1: Ok, John nose gear steering on.
JOHN: Ok, Mike.
NASA 1: Ok, all stations NASA 1, we'll have debrief at 1230.
CHASE: NASA 1, Chase 2.
NASA 1: John, when you have a chance we'll go manual on the KRA.
CHASE: Bill, this is 2A, do you need anything.
CHASE: No, just tell them I'm on the ground.
CHASE: Ok.
CHASE: Chase 1, I'll join on with you 2A.
CHASE: Ok, let's go tower now.
CHASE: Roger.
JOHN: Ok, we're on the ground.
NASA 1: Real nice, John.
JOHN: Thank you, Mike. Good calls.
NASA 1: I knew you'd sneak in the aileron bias.
JOHN: Ok, I guess we go to page 21. Throttle is OFF, camera coming OFF, here's the calibrate.
NASA 1: Good calibrate, John.
JOHN: Ok, now the recorder is coming OFF.
NASA 1: Roger. Remember the instrument switch is suppose to stay on.

FLIGHT 8

PRELIMINARY RESULTS OF X-24B

Flight B-8-15

15 February 1974

By

USAF/NASA X-24B PROJECT TEAM

X-24B Flight Request

6 February 1974

Flight No: B-8-15

Scheduled Date: 12 February 1974 FLOWN 15 FEB 74

Pilot: Major Love

Purpose:
1. Longitudinal Stability with 40° Upper Flaps
2. Lateral-Directional Stability and Control with 30° Upper Flap with Both 0° and -10 Rudder Bias
3. Longitudinal Stability with 30° Upper Flaps and -10° Rudder Bias
4. Fin and Rudder Pressure Survey
5. ~~Acoustic Noise~~ BOUNDARY LAYER NOISE and Vibration Experiment RED (~~WHITE~~ PLUG)

Launch: South Rogers Lakebed, Mag Heading 360° + Cross-wind Correction Angle. 45,000 feet, 185 KIAS. Flap Bias "Manual", Upper Flaps = 40°, Lower Flaps = 24°, Rudder Bias Mode "Manual", Rudder Bias = 0°. Rudder Trim = 1/2° Left. Aileron Bias = 7°, SAS Gains 4,3,2. Mach Repeater "Manual" = 1.0, KRA "AUTO", #2 and #4 Pumps On.

Landing: Rogers Lakebed Runway 15

B-52 Track: X-24B Track #1 (R2515, Work Area I)

ITEM	TIME	ALT	A/S	α	Mn	EVENT
1	0	45	185	5	.70	Launch, Trim to 12°α.
2	19	43	180	12	.64	Perform Pushover-Pullup (5° to 17° to 12°α).
3	30	40	195	12	.66	Change Configuration to 30° Upper Flap Bias (Rudder Bias Remains at 0°). Retrim to 12°α.
4	41	37	215	12	.67	Perform Rudder and Aileron Doublets.

ITEM	TIME	ALT	A/S	α	Mn	EVENT
5	49	35	215	12	.64	Perform Pushover-Pullup (5^{o} to 15^{o} to $12^{o}\alpha$)
6	59	33	215	12	.62	Rudder Bias "AUTO" (Rudders Move to -10^{o}), Retrim to $12^{o}\alpha$.
7	65	32	210	12	.59	Perform Rudder and Aileron Doublets.
8	82	30	190	12	.52	Perform Pushover-Pullup (5^{o} to 15^{o} to $10^{o}\alpha$). Maintain $10^{o}\alpha$. Turn left to 330^{o}.
9	98	28	200	10	.52	Change Configuration to 20^{o} Upper Flaps. Maintain $10^{o}\alpha$.
10	104	27	200	10	.51	Perform Pushover-Pullup (5^{o} to 17^{o} to $10^{o}\alpha$).
11	123	25	180	10	.44	Vector to Low Key. If Energy Management Permits, Disengage Pitch Damper, Evaluate Handling Qualities, Reengage Damper.
12	164	21	210	10	.48	Low Key, #1 and #3 Hydraulic Pumps On, Landing Rocket Check, Start Left Turn.
13	226	10	270	9	.50	Pushover to $\simeq 6^{o}\alpha$ to Accelerate to 300 kts. Mach Repeater to .3.
14	266	3.3	300	6	.48	Start Flare $\alpha \simeq 10^{o}$.
15	276	2.4	250	7	.42	Level, Gear Down Below 240 kts.
16	286	2.3	180	12	.3	Touchdown

NOTES:

1. Nose Ballast = 220 lb

	Weight-lb	cg-%
2. Launch & Landing	8274	64

GROUND RULES FOR NO LAUNCH

1. Angle of Attack or Sideslip Malfunction
2. Any Control System Malfunction (STICK SHAKER NOT REQUIRED)
3. Turbulence Below 10K in Excess of Moderate
4. Surface Winds ~~Below~~ ABOVE 10 kts Crosswinds/20 kts Max

(In addition to standard ground rules published in Lifting Body Joint Operations Plan)

5. UNACCEPTABLE AILERON DEAD BAND

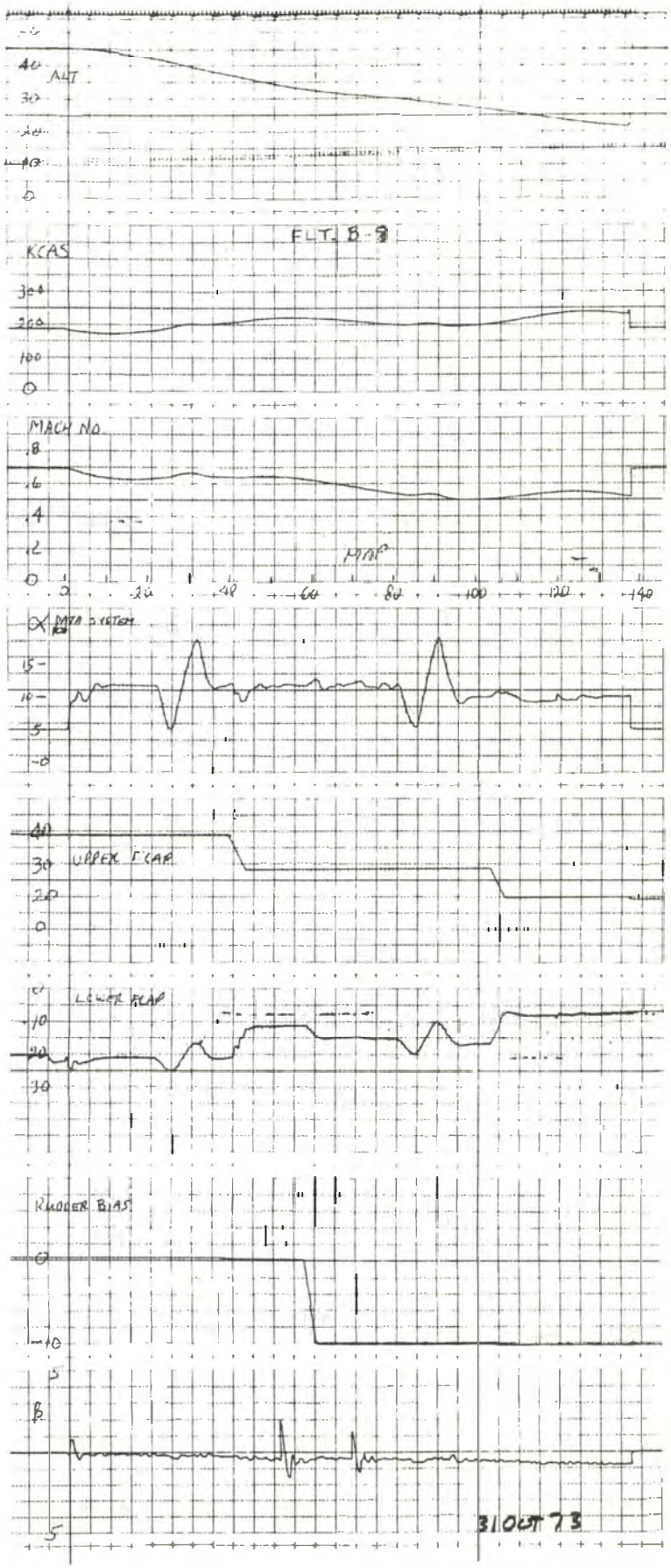
ALTERNATE SITUATIONS AFTER LAUNCH

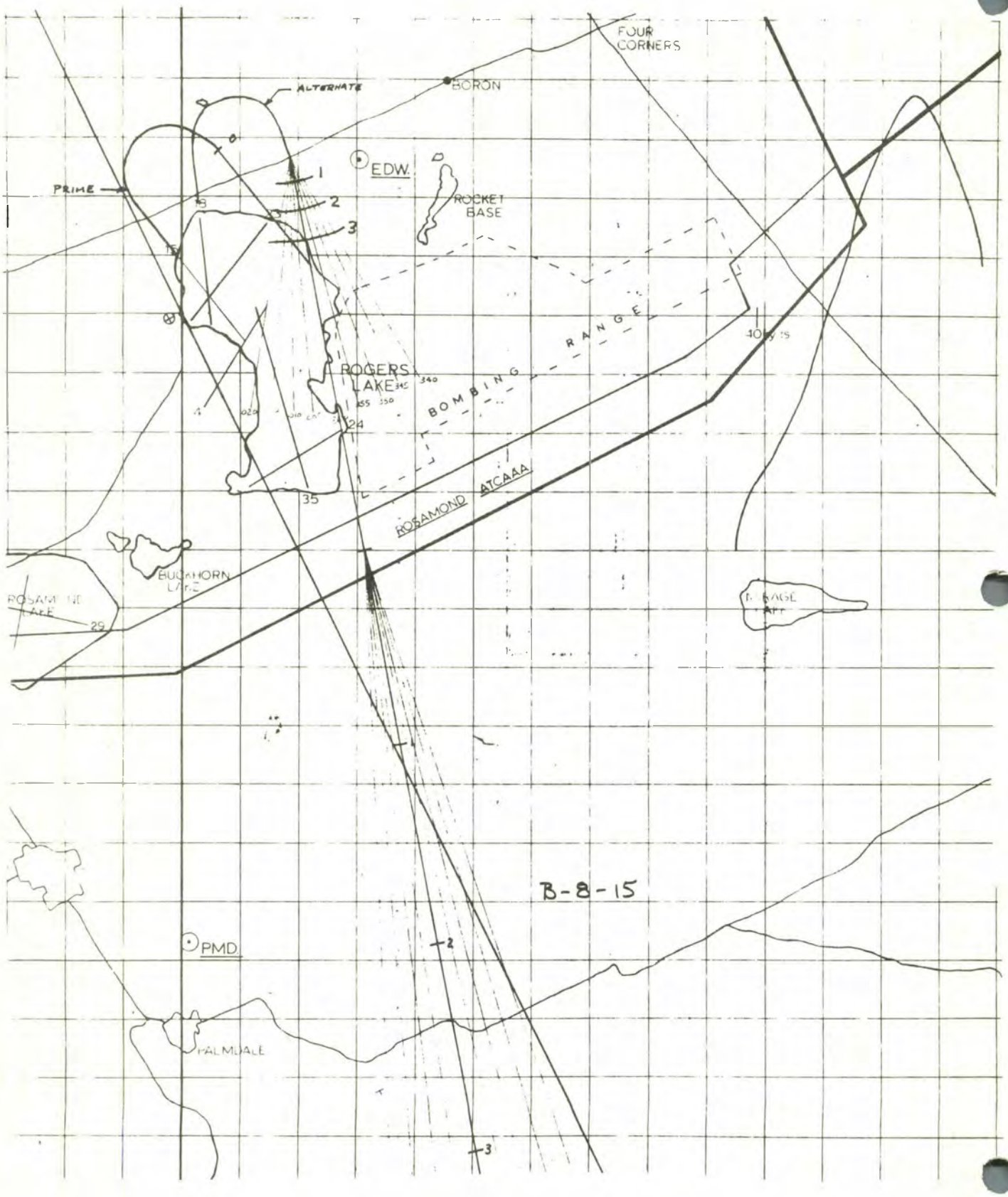
Failure	Action
1. Radio, Radar, PCM	Proceed as planned.
2. Airspeed, Altitude	Proceed as planned using α for primary control. Altitude calls from NASA I. Airspeed and altitude calls from chase.
3. Attitude System	Proceed as planned using backup attitude indicator and/or outside reference.

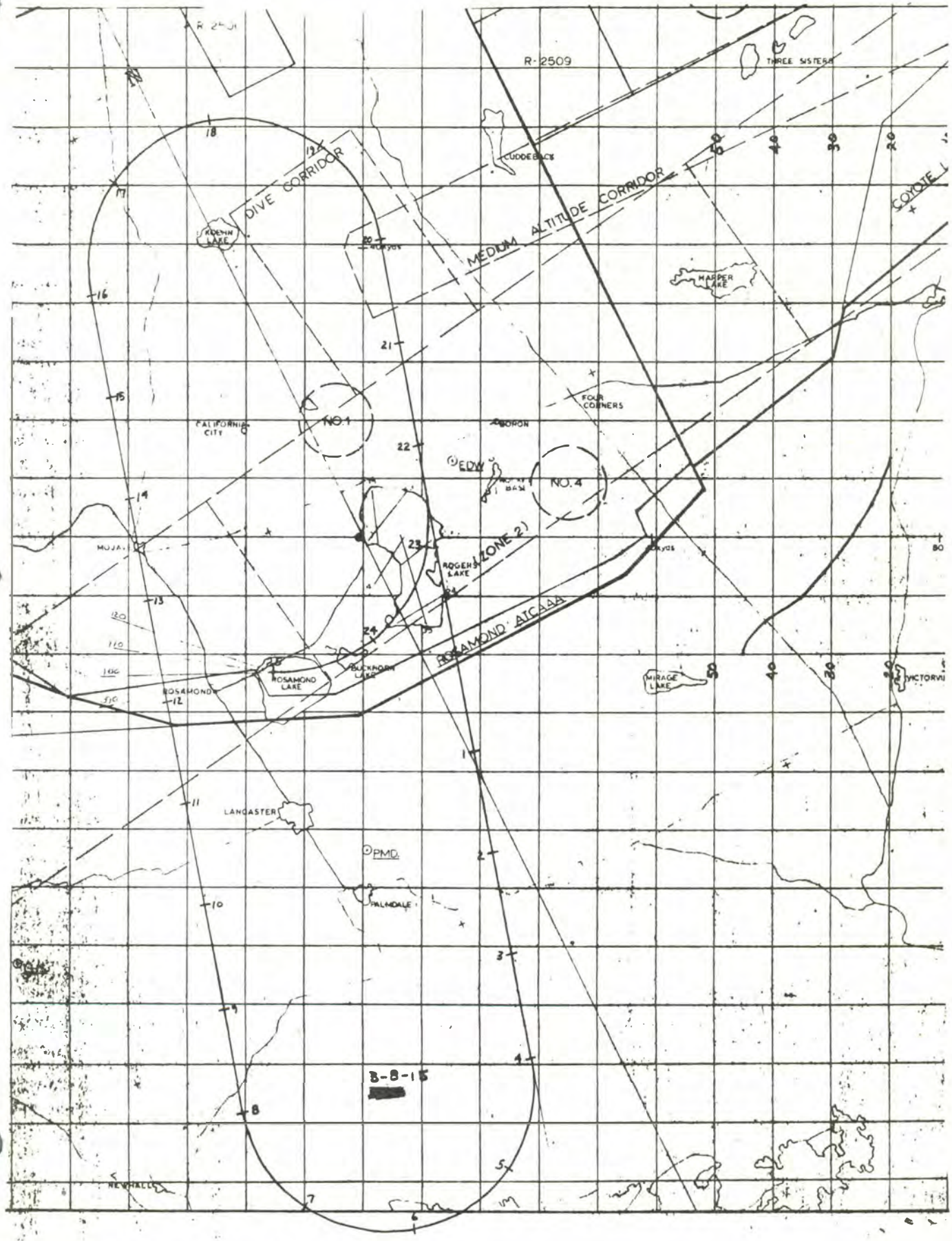
	Failure	Action
4.	Primary Angle of Attack Indicator Failure	KRA to "Manual" 10%, stick shaker "Off", proceed as planned using backup α Indicator on ADI.
5.	Total Angle of Attack Failure	KRA to "Manual" 10%, stick shaker "Off", rudder bias to "AUTO". Fly 200 KIAS instead of α. Do not perform 30^{o} upper flap tests or pushover-pullup maneuvers. Change configuration at 30K.
6.	KRA "AUTO" Failure	KRA to "Manual" 10%.
7.	Pitch Damper Failure	Rudder bias to "AUTO", eliminate 30^{o} upper flaps/0^{o} rudder bias test (items 3 and 4) proceed limiting α to 14^{o} during data maneuvers.
8.	Roll Damper Failure	Proceed as planned. [redacted]
9.	Yaw Damper Failure	Proceed as planned, setting Mach repeater to .3.
10.	All Axis Damper Failure	Mach repeater to .3, rudder bias to "AUTO", limit α to 14^{o}. Do not perform 30^{o} upper flap test or pushover-pullup. Change configuration at 30K.
11.	Limit Cycle	Reduce gain setting in steps to 1, if limit cycle still excessive--turn damper off.

Robert G. Hoey
ROBERT G. HOEY

Jack L. Kolf
JACK L. KOLF


ALT
FLT B 9
KCAS
MACH NO
MAP
DATA SYSTEM
UPPER FLAP
LOWER FLAP
RUDDER BIAS
31 OCT 73


FOUR CORNERS
ALTERNATE
BORON
PRIME
EDW.
1
2
3
ROCKET BASE
ROGERS LAKE
BOMBING RANGE
ROSAMOND
ATCAAA
BUCKHORN LAKE
PMD
PALMDALE
B-8-15


R-2509
THREE SISTERS
CUDDEBACK
DIVE CORRIDOR
MEDIUM ALTITUDE CORRIDOR
COYOTE
KOEHN LAKE
HARPER LAKE
FOUR CORNERS
BORON
CALIFORNIA CITY
NO. 1
NO. 4
EDW
ROGERS LAKE
ZONE 2
ROSAMOND ATCAAA
ROSAMOND
ROSAMOND LAKE
BUCKHORN LAKE
MIRAGE LAKE
VICTORVI
LANCASTER
PMD
PALMDALE
NEWHALL
MOJA
8-8-15

X-24B Flt. B-8-15 Events

TOD	MACH	ALT.	KCAS	EVENTS
11:14:57.5				LAUNCH
11:15:05.2	.607	42352.	170.	START POPU $\alpha = 12°$
:08.0	.606	42327.	170.	AT MIN $\alpha = 5°$
:13.2	.606	42307.	170.	AT MAX $\alpha = 18°$
:15.2	.605	42285.	170.	RETURN TO 13° α
:20.6	.601	42263.	170.	START CLOSEUP TO 30°
:25.8	.631	41128.	182.	UPPERFLAP AT 29.8° (RUDDER BAS AT 0°)
:33.0	.656	39474.	198.	RUDDER DOUBLET $\alpha = 12°$
:37.7	.682	38480.	211.	AILERON DOUBLET $\alpha = 12°$
:39.7	676	38090.	211.	START POPU $\alpha = 13°$
:44.2	.663	37288.	210.	AT MIN $\alpha = 5°$
:50.0	.664	36139.	202.	AT MAX $\alpha = 16°$ [START TURBULENCE]
:51.4	.618	35928.	201.	RETURN TO 12° α
:53.5	.602	35615.	197.	RUDDER BIAS TO "AUTO" RUDDERS START MOVING FROM 0° TO −10°
:55.5	.597	35305.	197.	RUDDER DOUBLET 14° TO 15° α
11:16:05.8	.567	34237.	191.	RUDDER DOUBLET $\alpha = 12°$
:08.8	.551	33459.	189.	AILERON DOUBLET $\alpha = 12°$
:10.5	.558	33816.	190.	START POPU $\alpha = 12°$
:13.7	.557	33473.	191.	AT MIN $\alpha = 5°$
:17.1	.564	33001.	196.	START LEFT TURN TO LOW KEY
:18.3	.570	32837.	198.	AT MAX $\alpha = 15°$
:20.6	.563	32559.	197.	RETURN TO 10° α
:34.1	.560	30960.	203.	START CONFIG CHANGE 30°–20° UPPERFLAPS
:37.7	.557	30341.	205.	END CONFIG CHANGE (20° UPPERFLAPS)
:56.8	.542	27522.	212.	START POPU $\alpha = 10.5°$
:59.9	.546	27062.	216.	AT MIN $\alpha = 5°$
11:17:07.7	.525	26023.	212.	AT MAX $\alpha = 17°$
:12.7	.489	25891.	197.	END POPU $\alpha = 8°$
:13.1	.487	25880.	196.	PITCH DAMPER OFF
:13.9	.485	25857.	195.	PITCH PULSE

B-8-15 Cont.

TOD	MACH	ALT.	KCAS	EVENTS
11:17:47.8	.482	22274.	209.	PITCH DAMPER ON
50.0	.478	22075.	208.	LANDING ROCKET CHECK
:53.8	.471	21721.	207.	HYDS 1 AND 3 ON
:18:03.3	.474	20591.	213.	START TURN
:27.6	.519	16411.	255.	UPPER FLAPS TO 21°
:53.5	.514	11579.	277.	UPPER FLAPS START OPEN (SPEED BRAKER)
:56.4	.506	11206.	275.	UPPER FLAPS AT 28.5
:19:10.5	.480	8364.	274.	UPPER FLAPS RETURN TO 20°
:16.6	491	7084.	287.	MACH REPEATER TO .3
:31.7	495	3840.	307.	LEVEL ON FINAL
:33.3	494	3543.	307.	START FLARE
:54.9	.370	2042.	236.	GEAR DOWN
:20:05.2	.376	1979.	176.	MAIN GEAR TOUCHDOWN α = 13°
:07.1	251	1970.	164.	NOSE GEAR TOUCHDOWN

FLT. TIME 5MIN 07.7 SEC.

X-24B DERIVATIVES

A primary objective of flight 8 was to determine the subsonic lateral-directional stability and control with 30° Upper Flap with both 0° and -10° Rudder Bias. In addition to flying the airplane in these configurations, three dynamic maneuvers were performed to extract derivatives. The resultant derivatives are presented in figure 1 along with wind tunnel curves. On figure 1, it can be seen that the derivatives fall either within the bounds of the wind tunnel predictions or at about the same level as derivatives shown in previous flight reports.

In addition to the lateral-directional results, one subsonic configuration longitudinal maneuver was obtained. Results from this maneuver agree well with previously obtained flight data.

FIGURE 1

X-24B

DERIVATIVES

——— M=.6, δ_{U_B}=-30°, δ_{r_B}=-10° } WIND TUNNEL TRIM DATA

- - - - M=.7, δ_{U_B}=-30°, δ_{r_B}=-10°

○ M=.669, δ_{U_B}=-30, δ_{r_B}=0 }

□ M=.593, δ_{U_B}=-30, δ_{r_B}=-6.7 } FLIGHT

△ M=.560, δ_{U_B}=-30, δ_{r_B}=-10 }

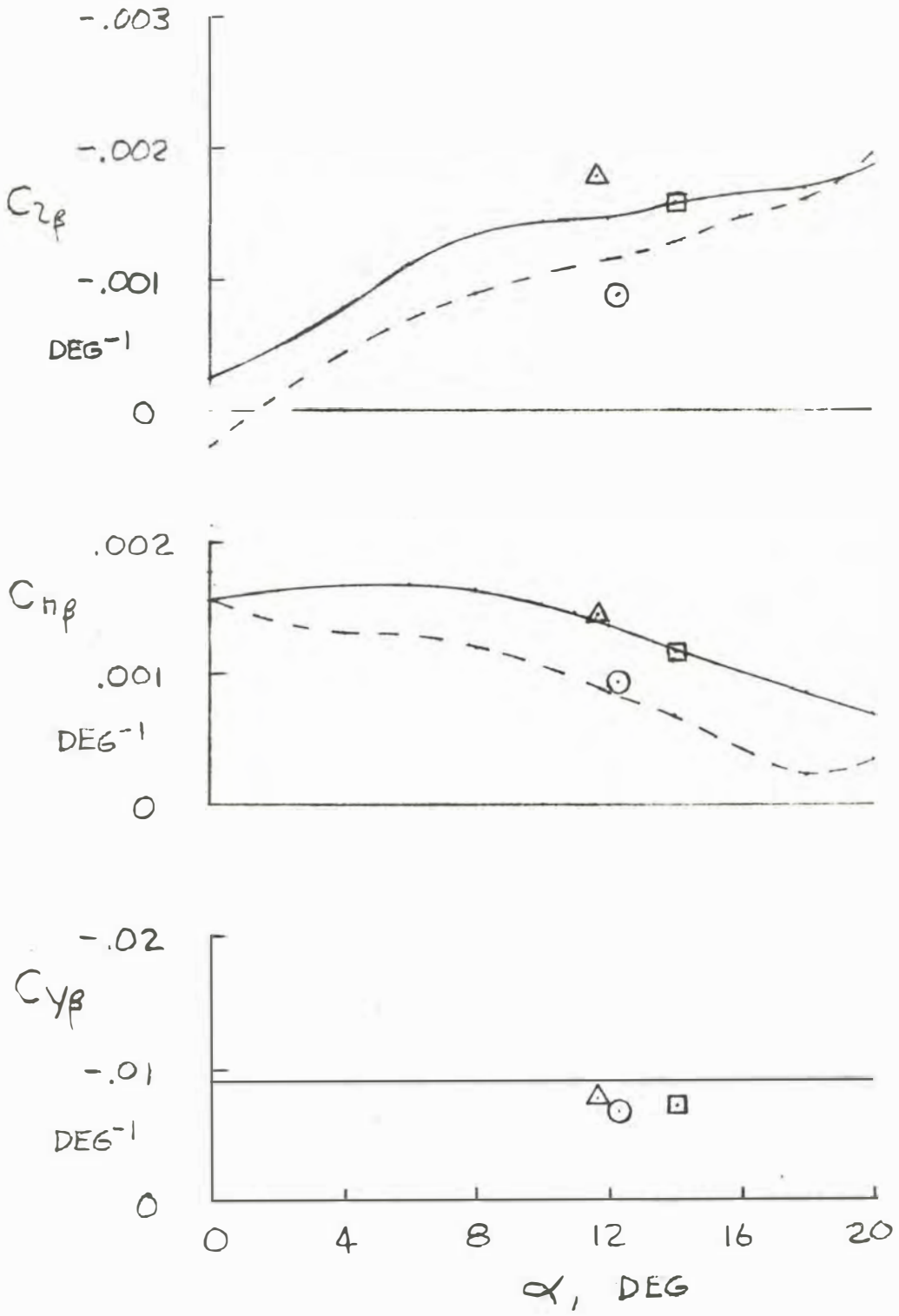


FIGURE 1, CONT.

——— M=0.6 } WIND TUNNEL
- - - - M=0.7 } ALL δ_{u_B}'s & δ_{r_B}'s

X-24B DERIVATIVES

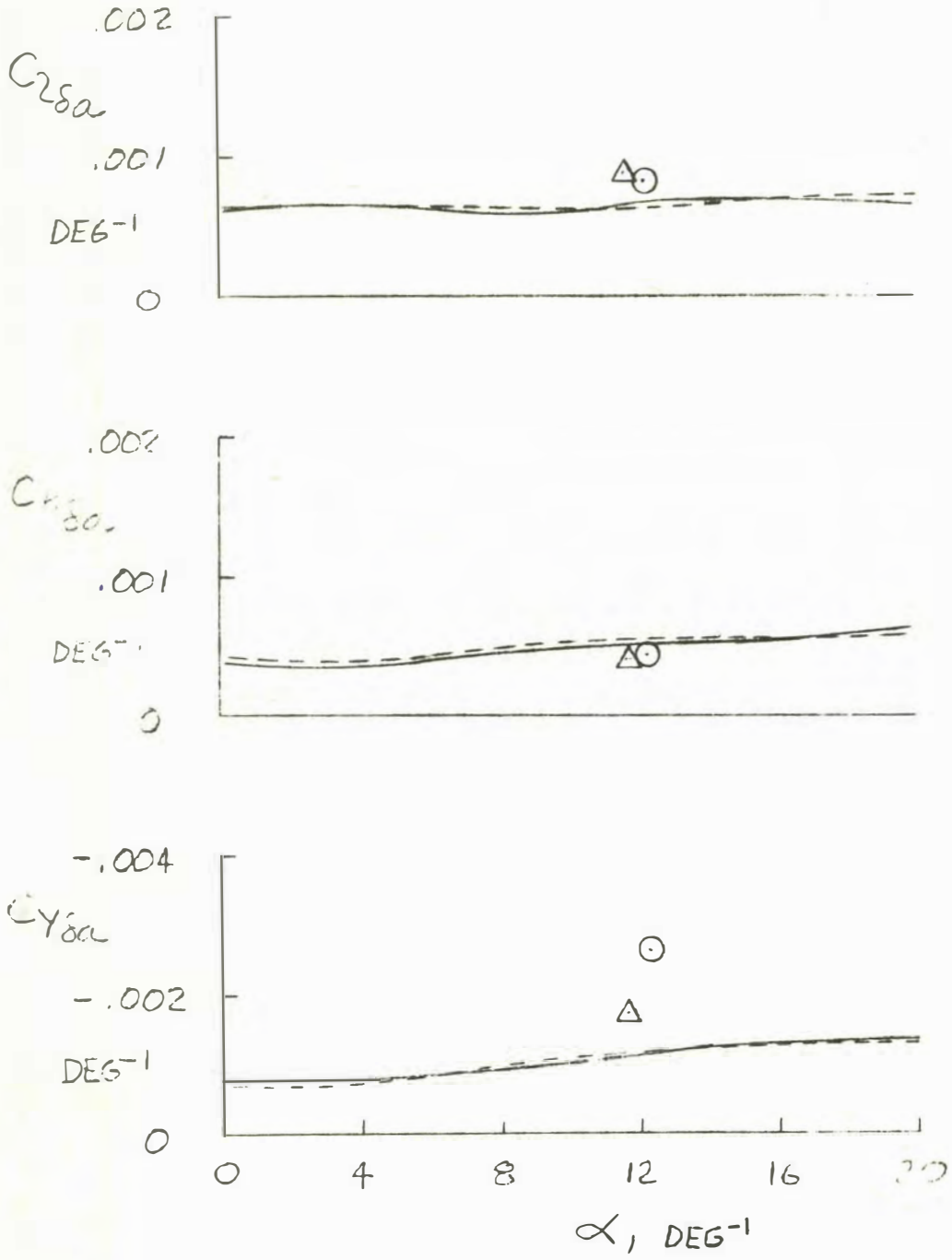
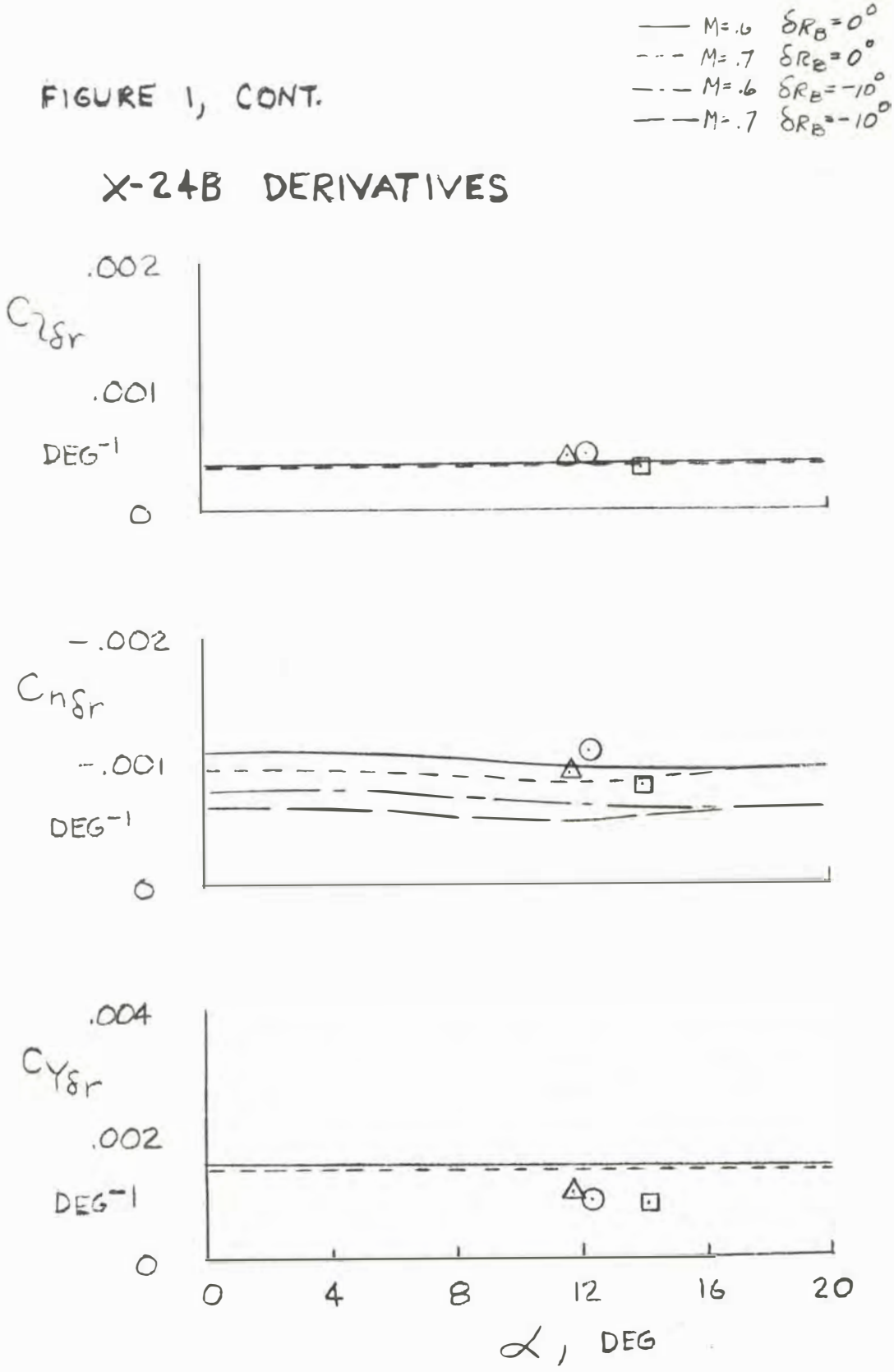


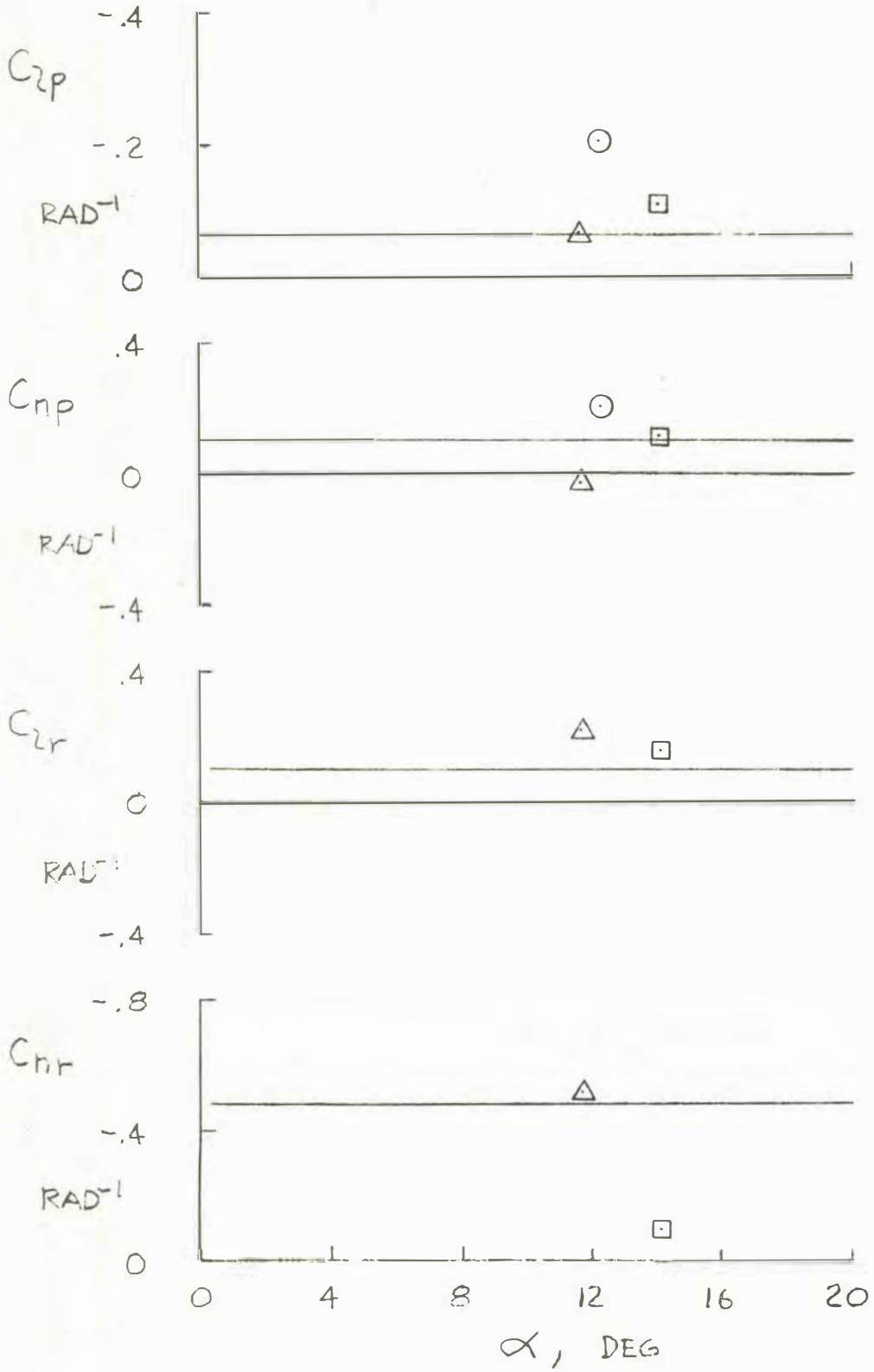
FIGURE 1, CONT.



—— PRE-FLIGHT ESTIMATE

FIGURE 1, CONCLUDED

X-24B DERIVATIVES



PERFORMANCE AND LONGITUDINAL TRIM

BY

D. Richardson

During flight 8 the pilot performed four pushover-pullup maneuvers: one each in the transonic and subsonic configurations at 0.61 and 0.52 Mach number; another with -30 degrees upper flap and 0 degree rudder bias at 0.65 Mach number; and the final maneuver was with -30 degrees upper flap and -10 degrees rudder bias at .56 Mach number. The first two maneuvers were performed for comparison with earlier data which contained errors in the angle of attack due to calibration difficulties (reference Flight Report B-5-9). Whereas in the earlier data the normal force dropped below the wind tunnel data for angles of attack greater than 10 to 12 degrees, it is now shown that the new normal force data (figures 2 and 5) compares well with the wind tunnel data. The chord force data is still higher than the wind tunnel data (figures 3 and 6) however, the difference is not as large as it was in the earlier data. The net result of these changes is that the lift-to-drag ratio has increased slightly at the higher lift coefficients (figures 1 and 4).

Figures 7 through 12 is the performance data from the two maneuvers with an upper flap setting of -30 degrees. A valid comparison can not be made between the two sets of data to show the effect of rudder bias because of the difference in Mach number. A comparison between figures 1 and 7 and figures 4 and 10 shows that when the upper flap is changed by ten degrees the increment in lift-to-drag ratio changes by 0.5 to 0.75. A comparison of the trim normal force coefficient plots reveals that the trimmed C_N curve is unaffected by changes in the upper flap bias setting or the rudder bias setting. This was expected since the centers of pressure of the upper flaps, lower flaps and rudders are essentially the same distance from the center of gravity.

Figures 13 through 16 are the longitudinal trim curves for the four longitudinal data maneuvers of flight eight. There were no surprises in the data, their is still the indication that there is a reduction in static margin when the flight data is compared with the wind tunnel data.

△ FLIGHT B-8-15
$\delta_{LE} = -40°$ $\delta_{RB} = 0$
$\delta_{AB} = 7°$
MACH = .60 - .63
C.G = 66%

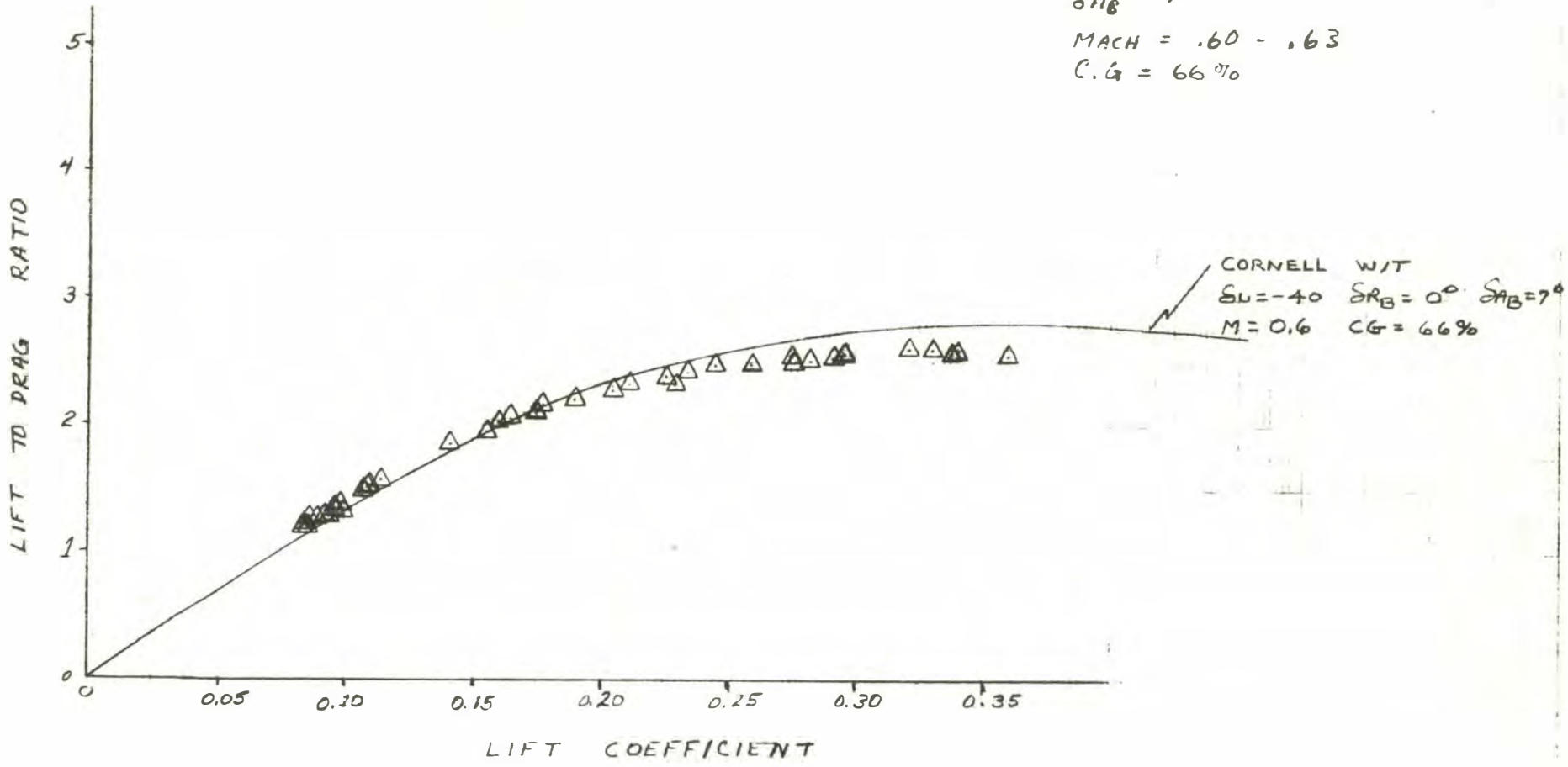


FIG 1

△ FLIGHT B-8-15
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = .60 - .63
C.G. = 66%

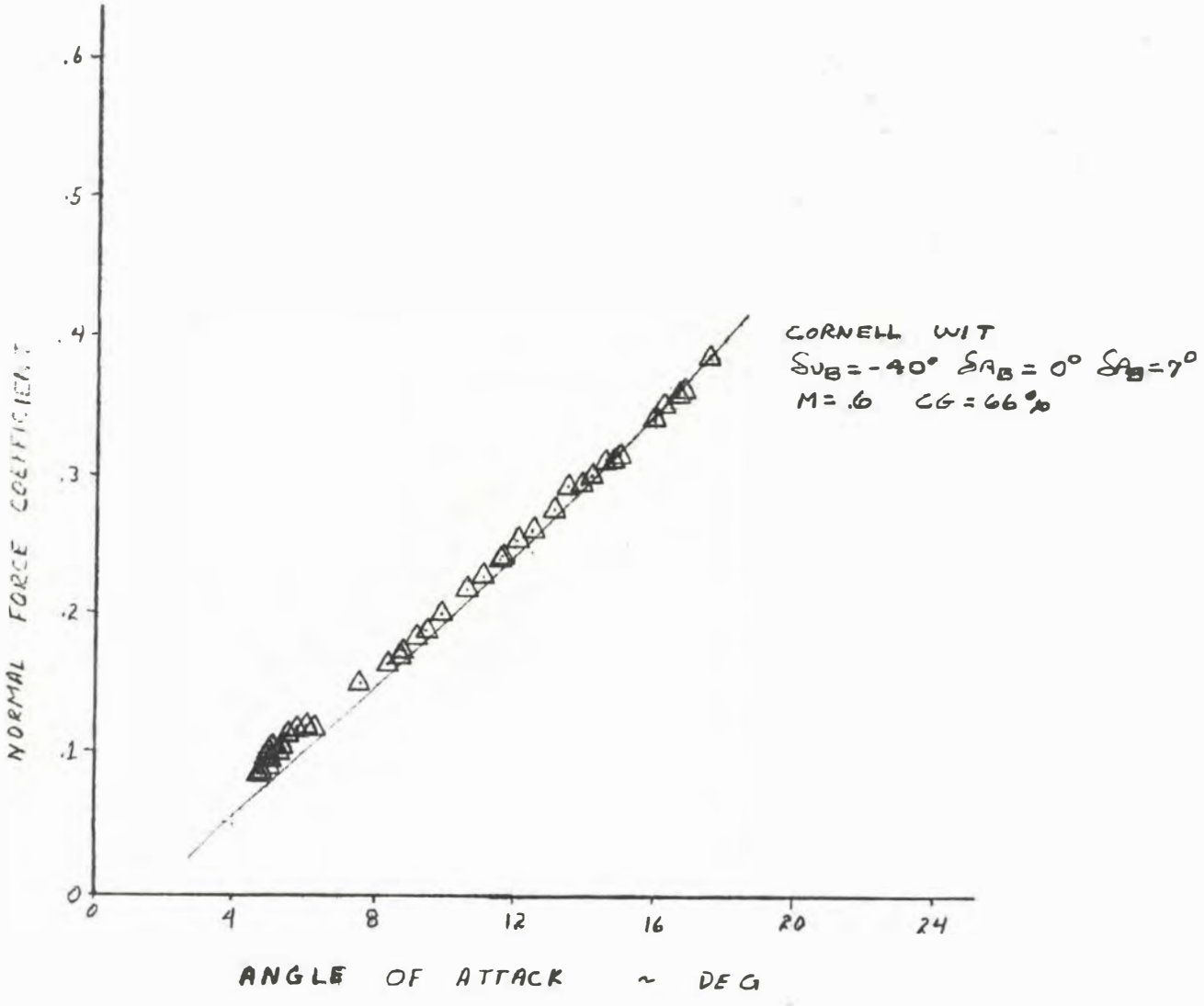


FIG 2

△ FLIGHT B-6-15
$\delta u_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = .60 - .63
C. G. = 66 %

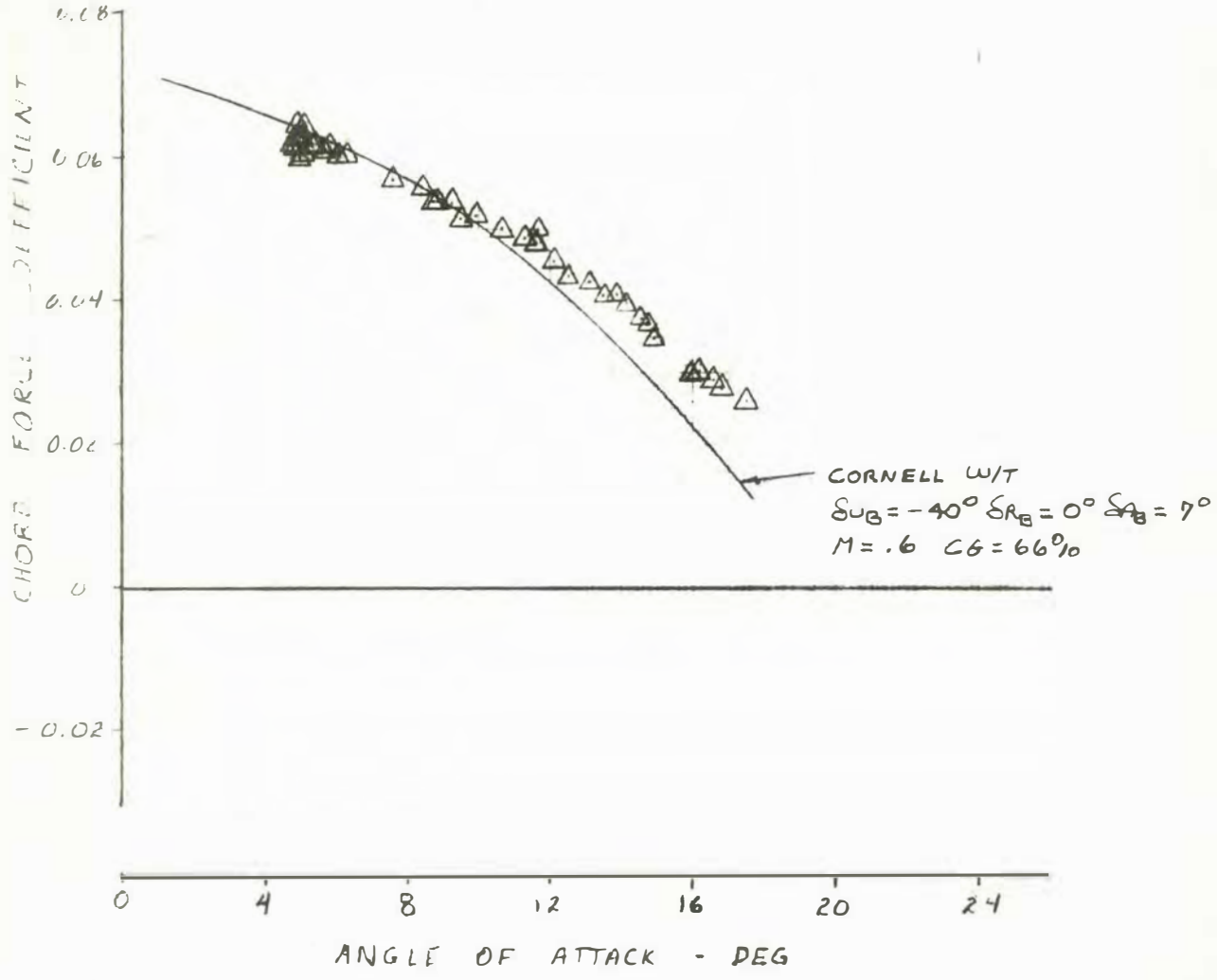


FIG 3

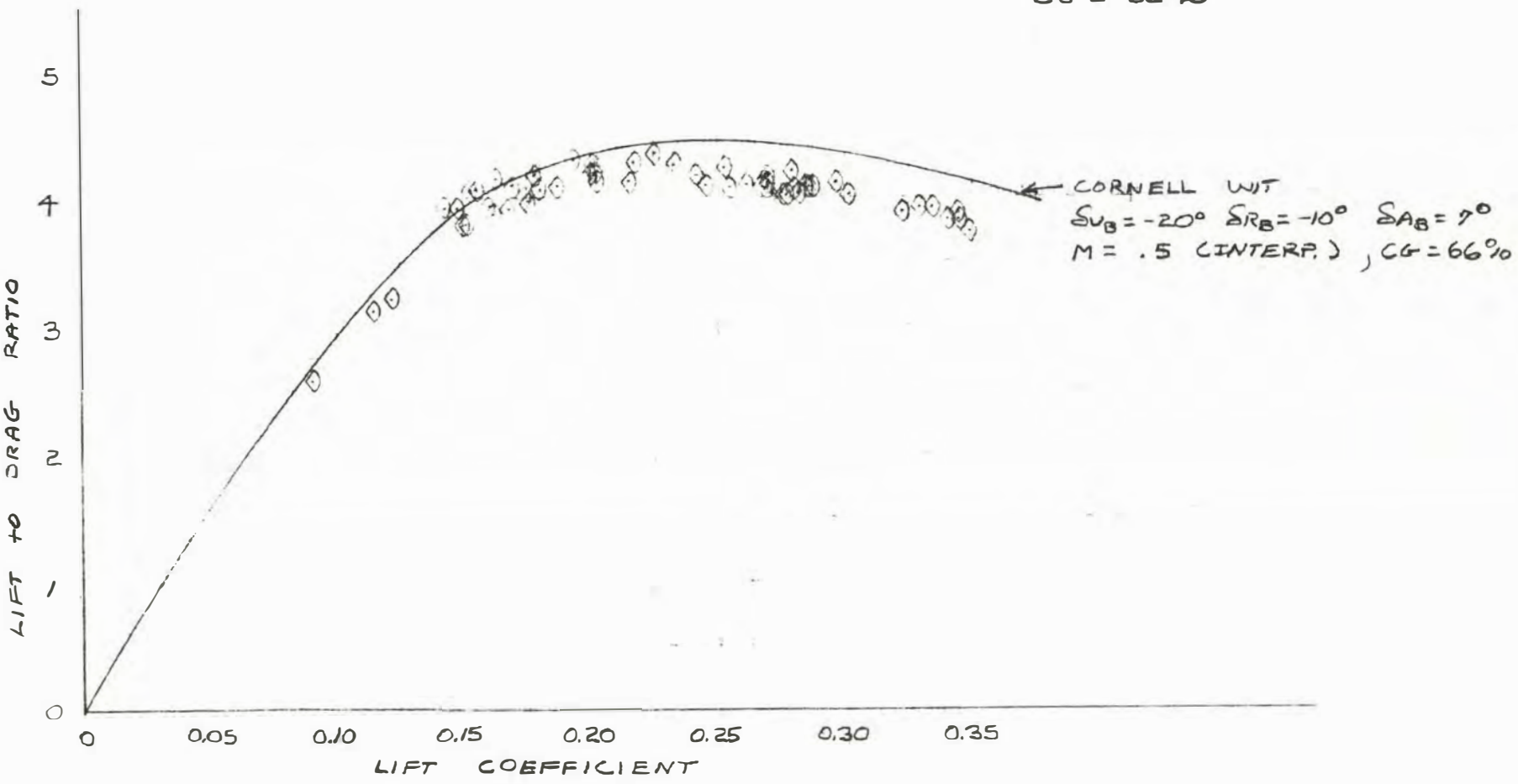

FLIGHT B-8-15
$\delta_{U_B} = -20°$ $\delta_{R_B} = -10$
$\delta_{A_B} = 7°$
MACH = .488 - .551
CG = 66%
CORNELL WIT
$\delta_{U_B} = -20°$ $\delta_{R_B} = -10°$ $\delta_{A_B} = 7°$
M = .5 (INTERP.), CG = 66%
LIFT TO DRAG RATIO
0
1
2
3
4
5
0
0.05
0.10
0.15
0.20
0.25
0.30
0.35
LIFT COEFFICIENT

FIG 4

○ FLIGHT B-8-15
$\delta U_B = -20°$ $\delta R_B = -10°$
$\delta A_B = 7°$
MACH = 488 - .561
CG = 66 %

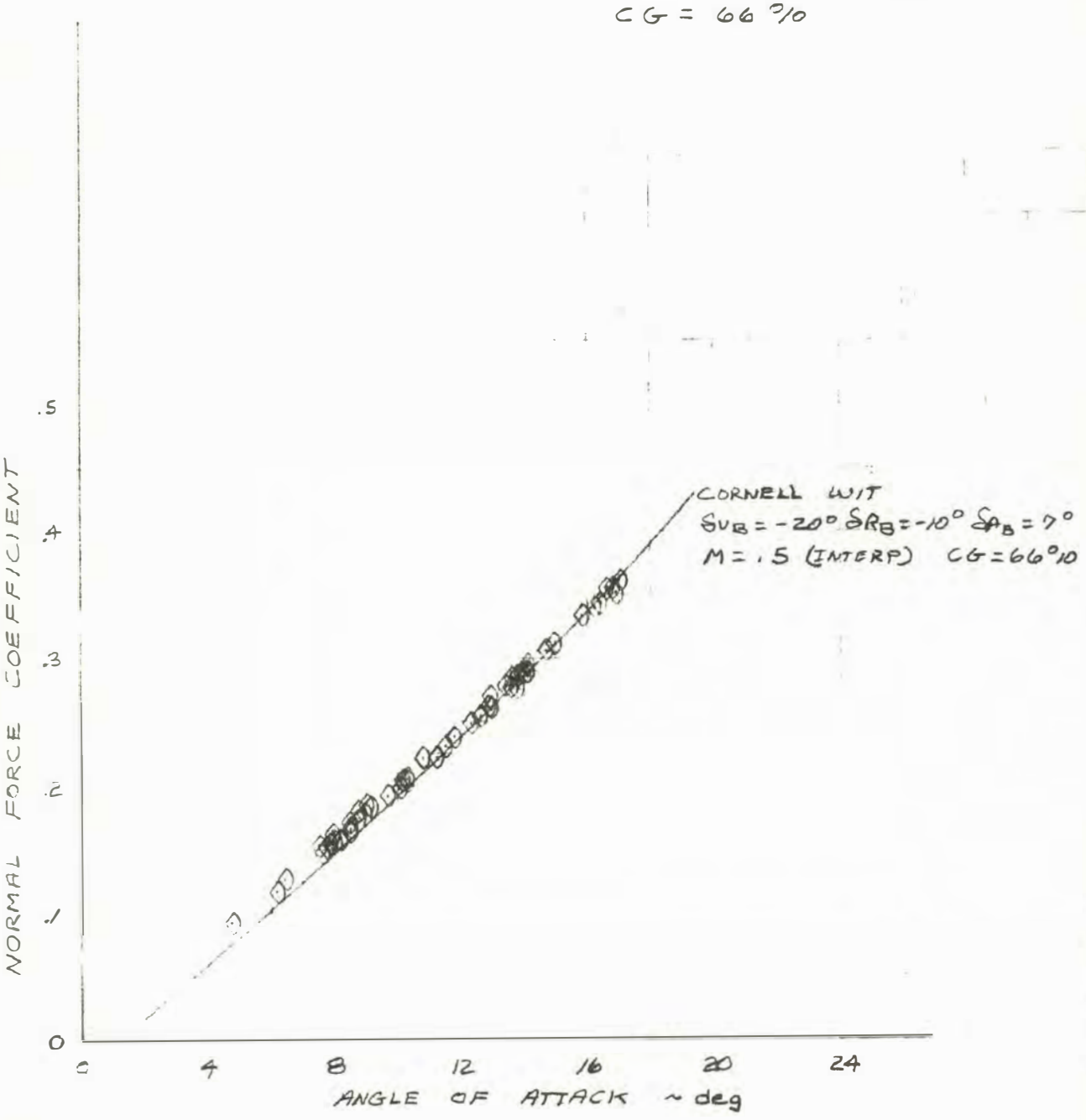


FIG 5

FLIGHT B-8-15
$\delta U_B = -20°$ $\delta R_B = -10°$
$\delta A_B = 7°$
MACH = .488 - .551
CG = 66%

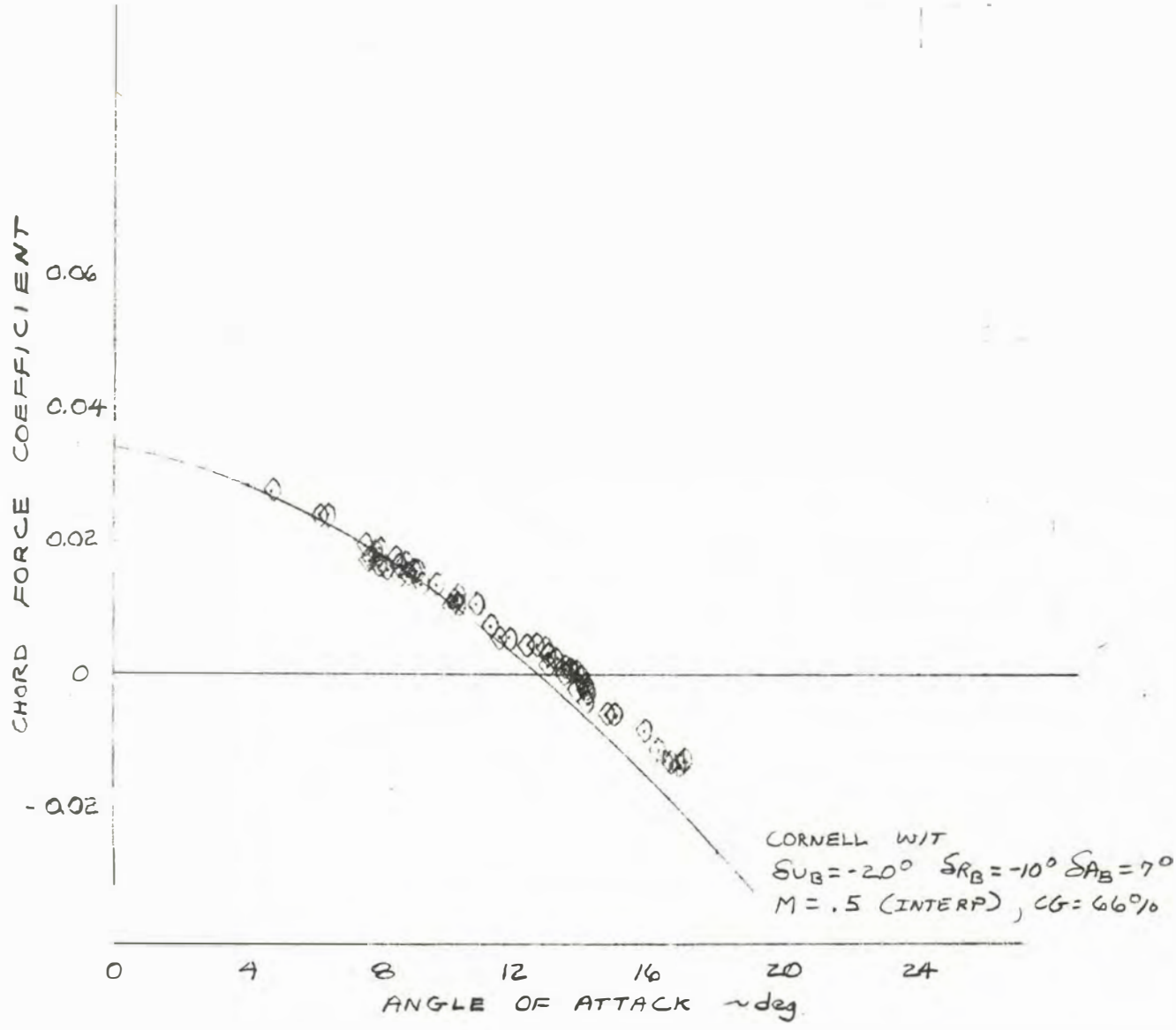


FIG 6

□ FLIGHT 8-8-15
$\delta u_B = -30°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = .61-.67
C.G. = 66%

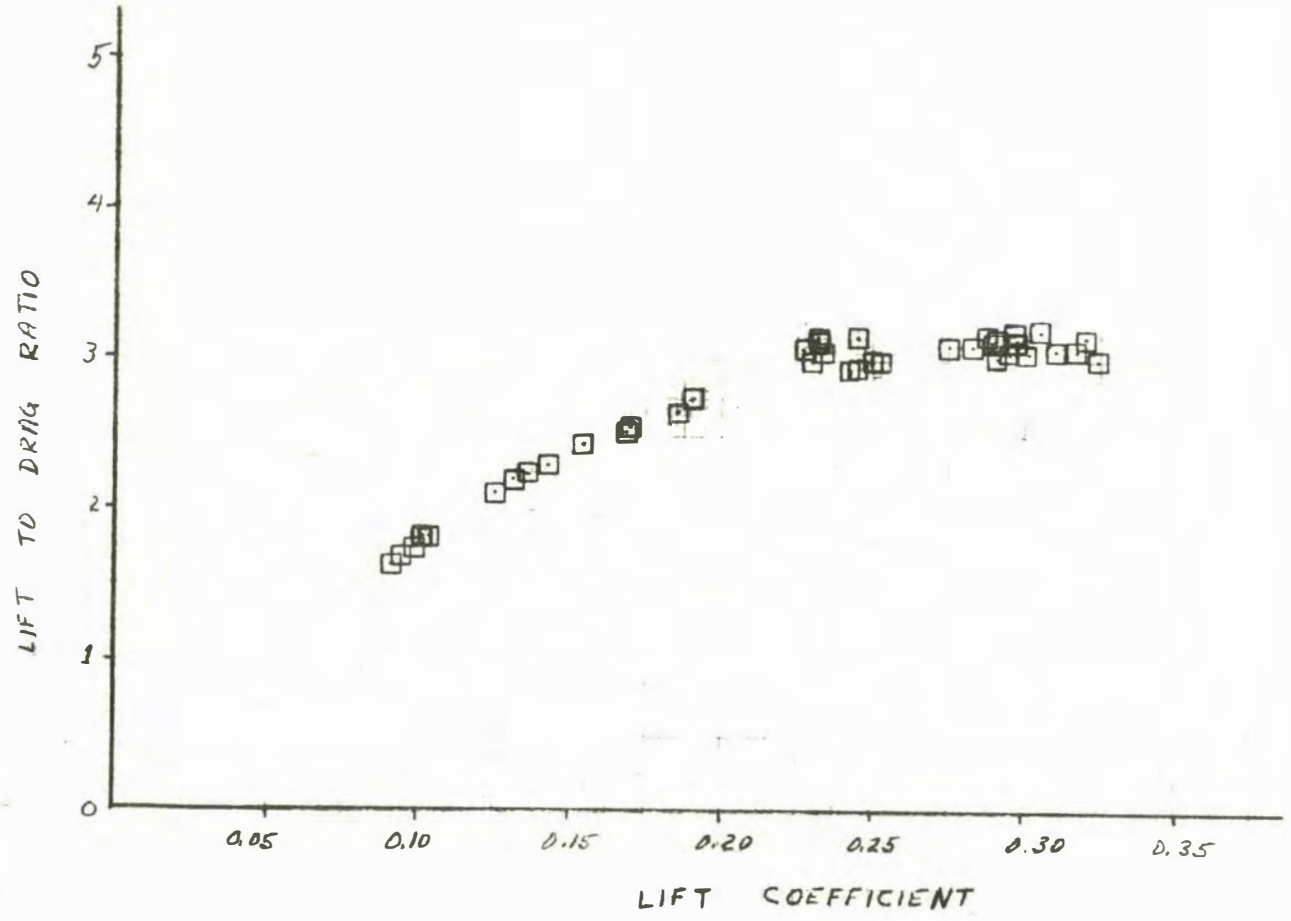


FIG 7

□ FLIGHT B-8-15
$\delta U_B = -30°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = .61-.67
C. G. = 66%

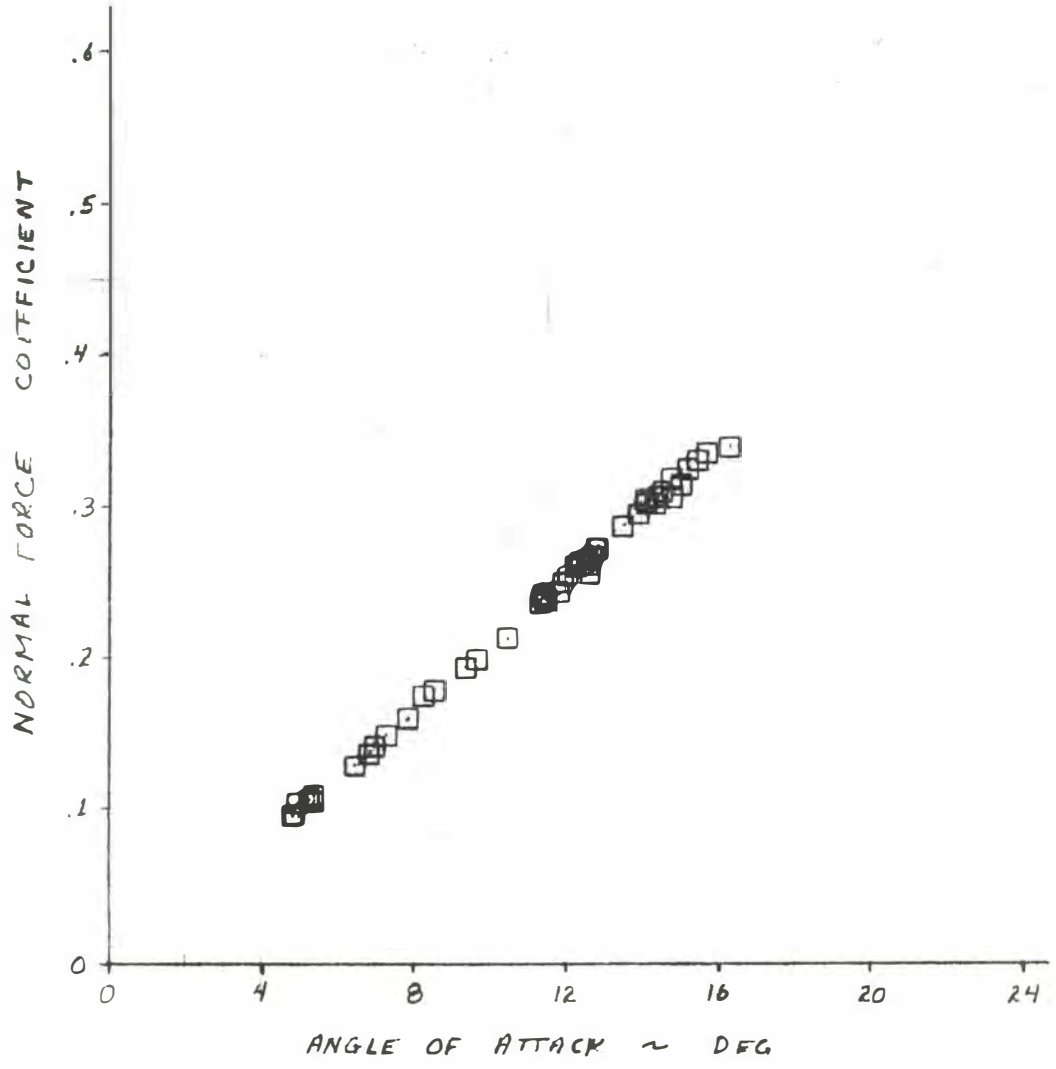


FIG 8

□ FLIGHT 3-2-15
$\delta U_B = -30°$ δR_B 0°
$\delta A_B = 7°$
MACH = .61 - .67
C.G = 66%

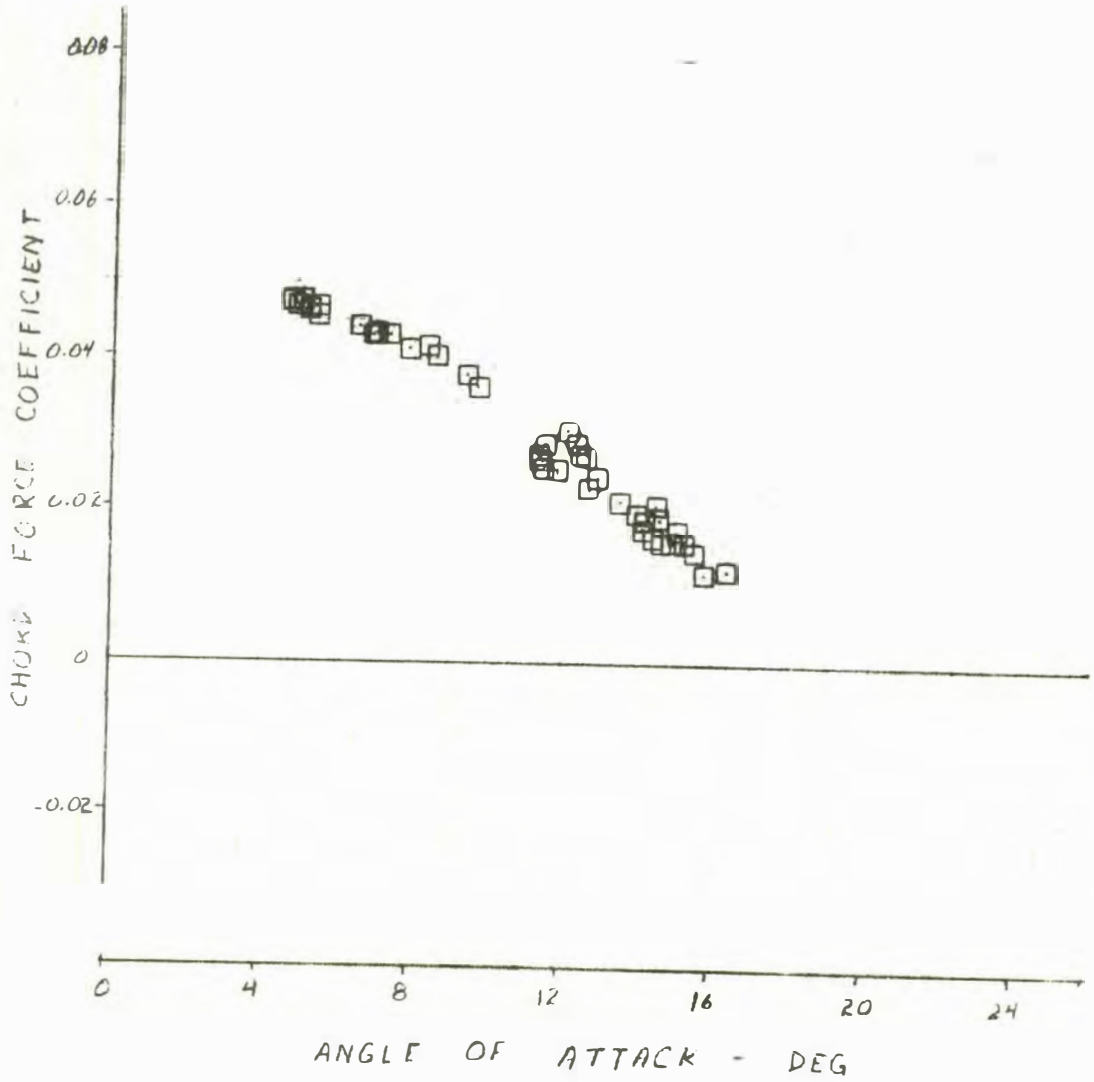


FIG 9

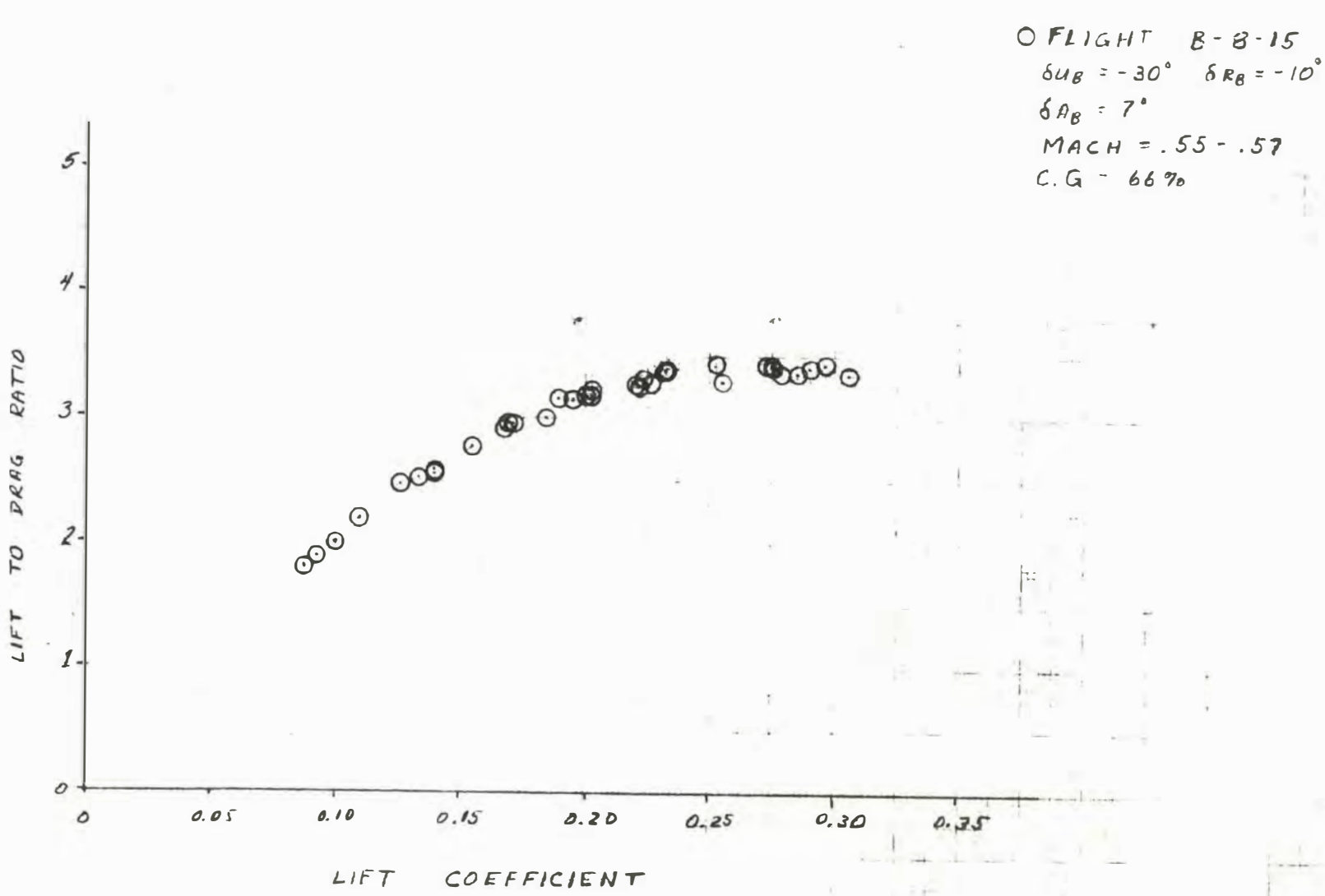

O FLIGHT B-8-15
$\delta_{U_B} = -30°$ $\delta_{R_B} = -10°$
$\delta_{A_B} = 7°$
MACH = .55 - .57
C.G - 66%
LIFT TO DRAG RATIO
0
1
2
3
4
5
0
0.05
0.10
0.15
0.20
0.25
0.30
0.35
LIFT COEFFICIENT

FIG 10

○ FLIGHT B-8-15
$\delta_{U_B} = -30°$ $\delta_{R_B} = -10°$
$\delta_{A_B} = 7°$
MACH = .55 - .57
C.G. = 66 %

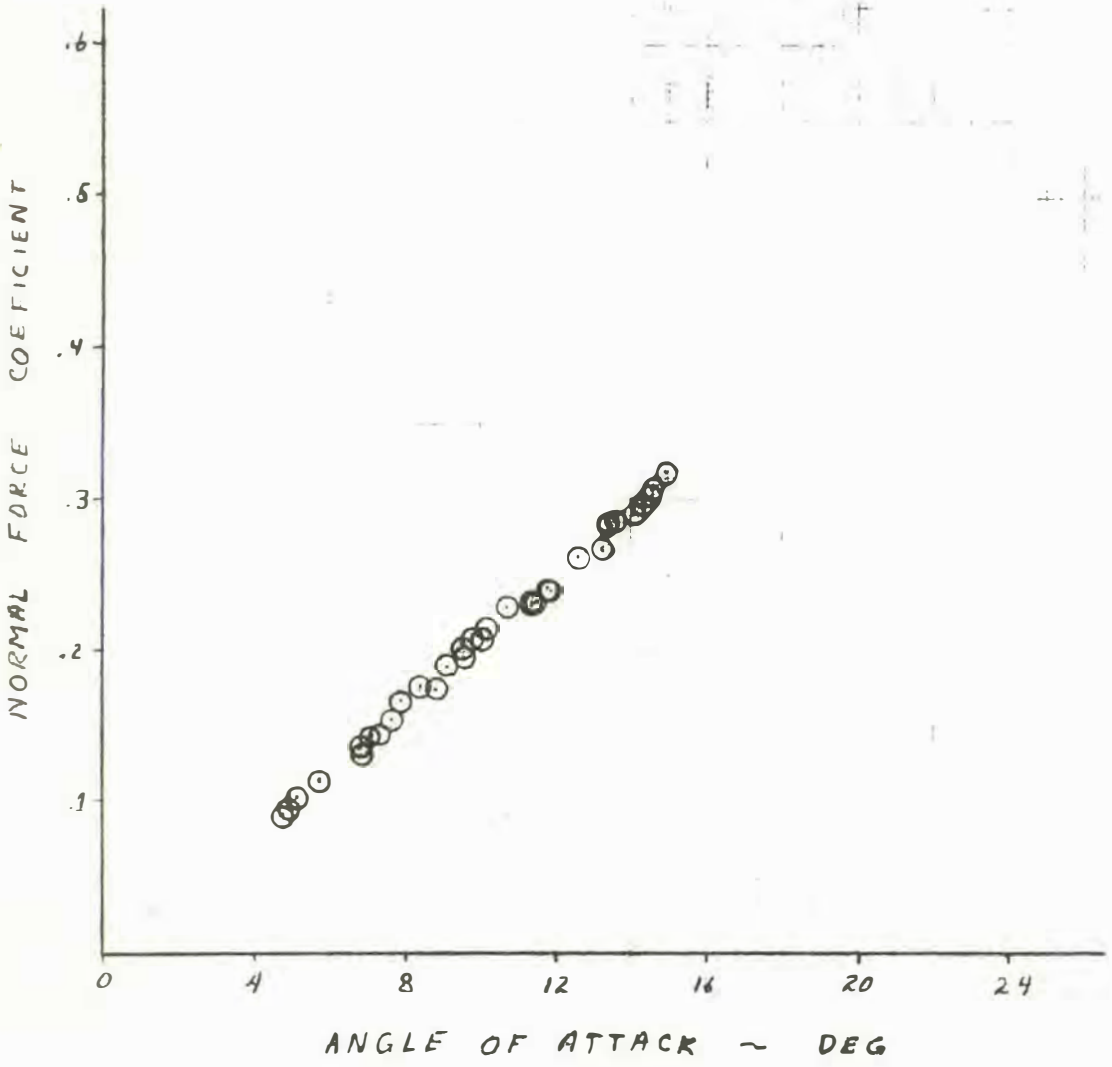


FIG 11

○ FLIGHT B-8-15
$\delta U_B = -30°$ $\delta R_B = -10°$
$\delta A_B = 7°$
MACH = .55 - .57
C.G. = 66%

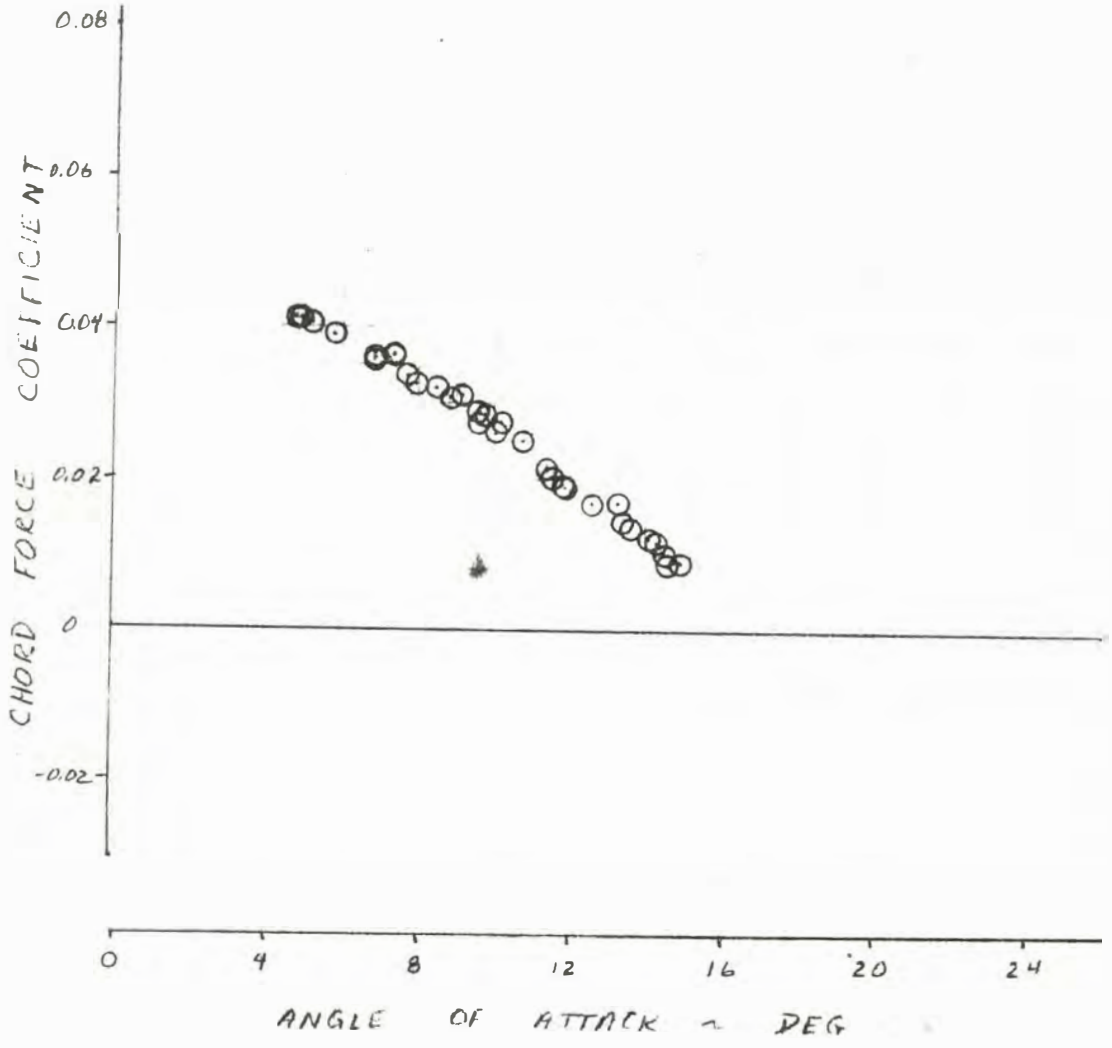


FIG 12

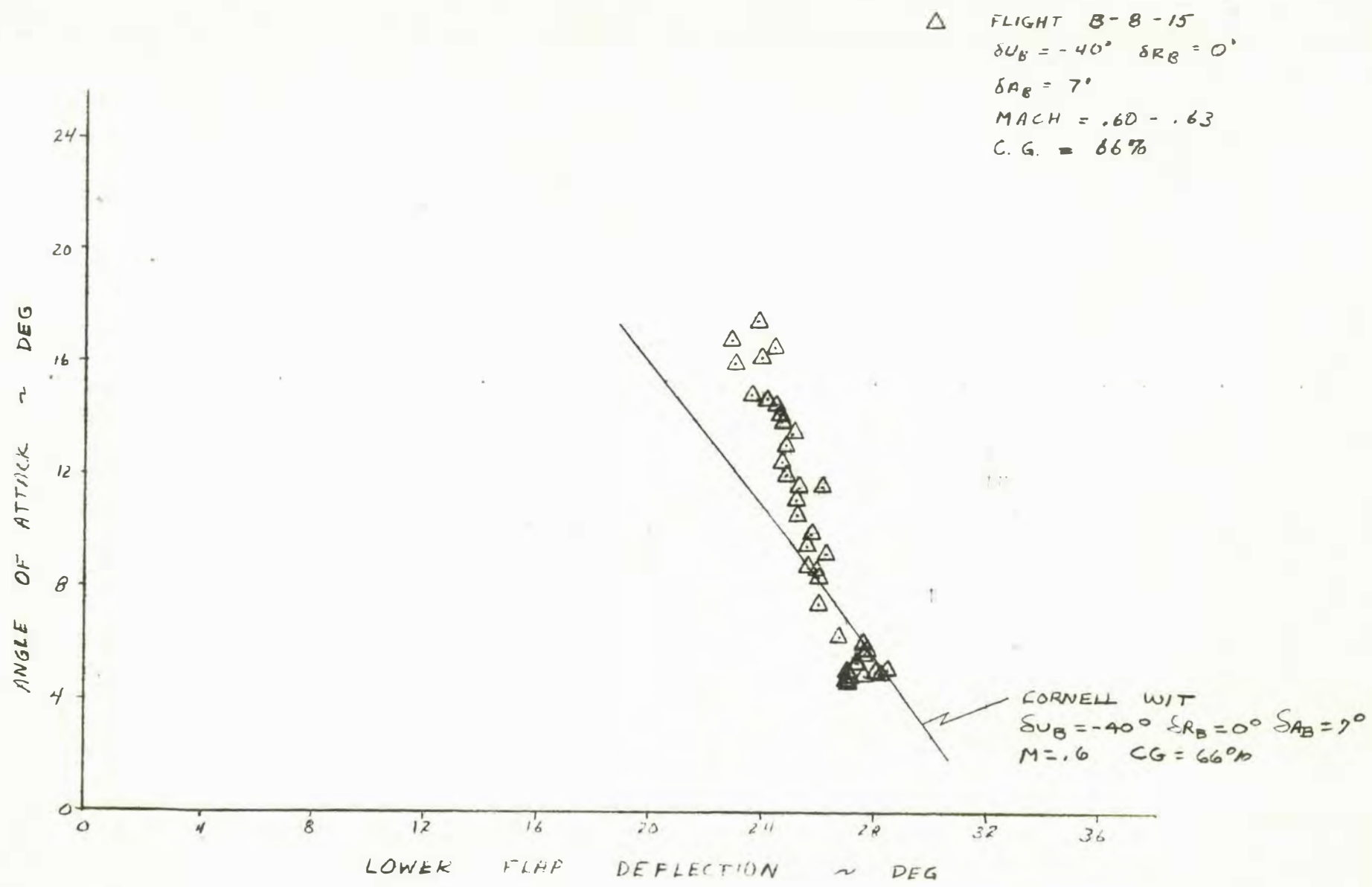

△ FLIGHT B-8-15
$\delta U_B = -40°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = .60 - .63
C. G. = 66%
ANGLE OF ATTACK ~ DEG
0
4
8
12
16
20
24
0
4
8
12
16
20
24
28
32
36
LOWER FLAP DEFLECTION ~ DEG
CORNELL WIT
$\delta U_B = -40°$ $\delta R_B = 0°$ $\delta A_B = 7°$
M = .6 CG = 66%

FIG 13

FLIGHT B-8-15
$\delta U_B = -20°$ $\delta R_B = 0°$
$\delta A_B = 7°$
MACH = .488 - .551
CG = 66%

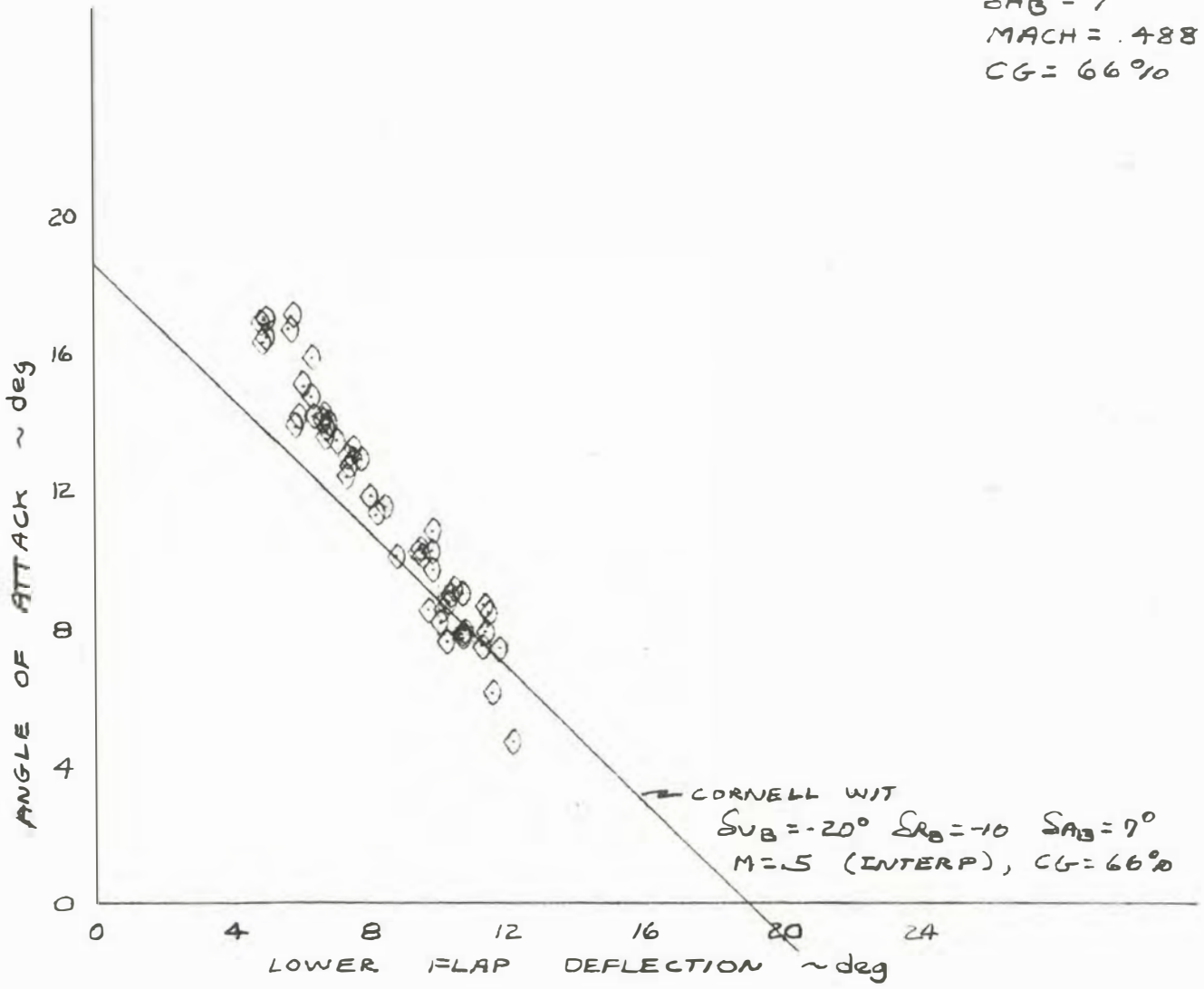


FIG 14

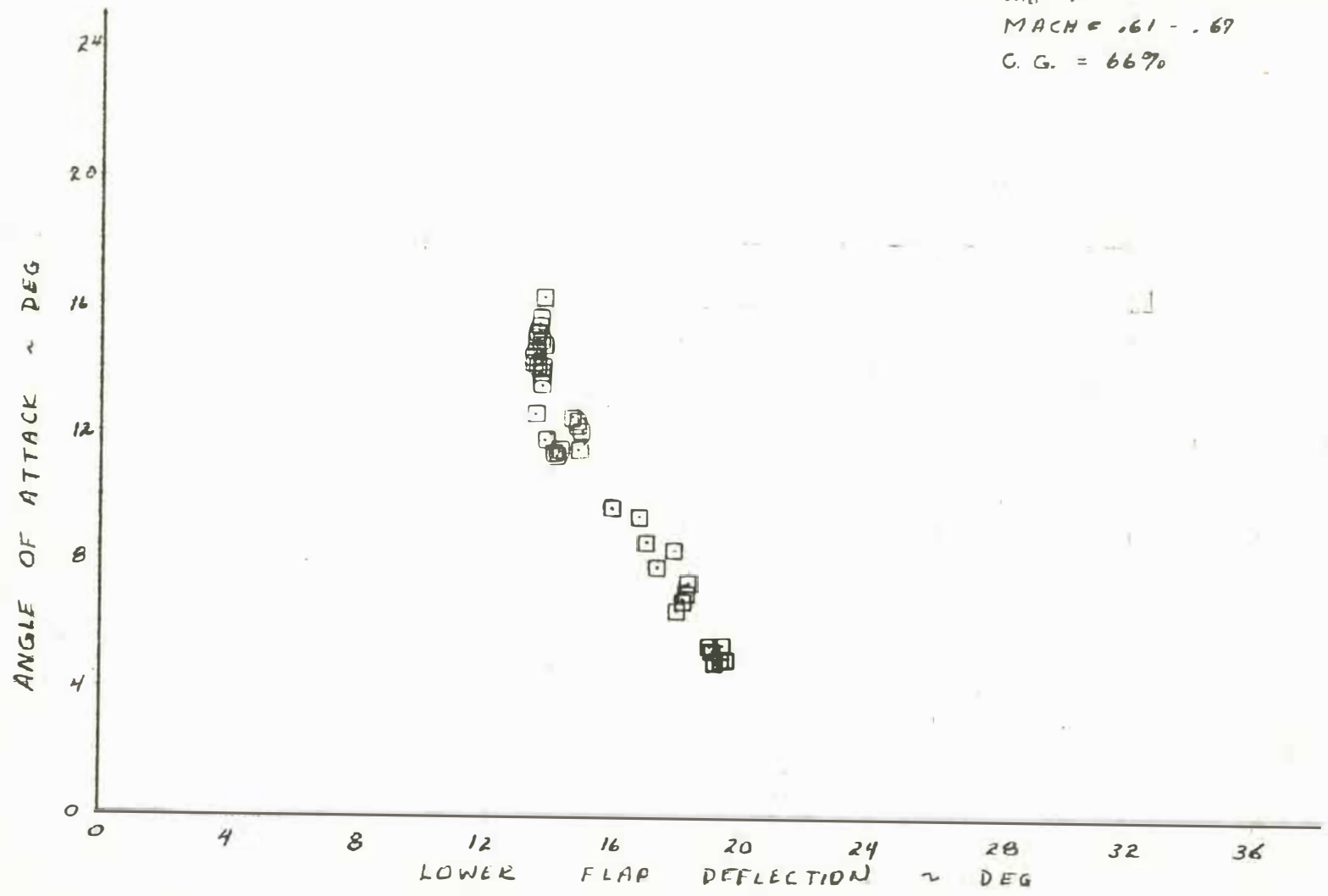

□ FLIGHT 8-8-15
δU_B = -30° δR_B = 0°
δA_B = 7°
MACH = .61 - .69
C. G. = 66%
ANGLE OF ATTACK ~ DEG
0
4
8
12
16
20
24
0
4
8
12
16
20
24
28
32
36
LOWER FLAP DEFLECTION ~ DEG

FIG 15

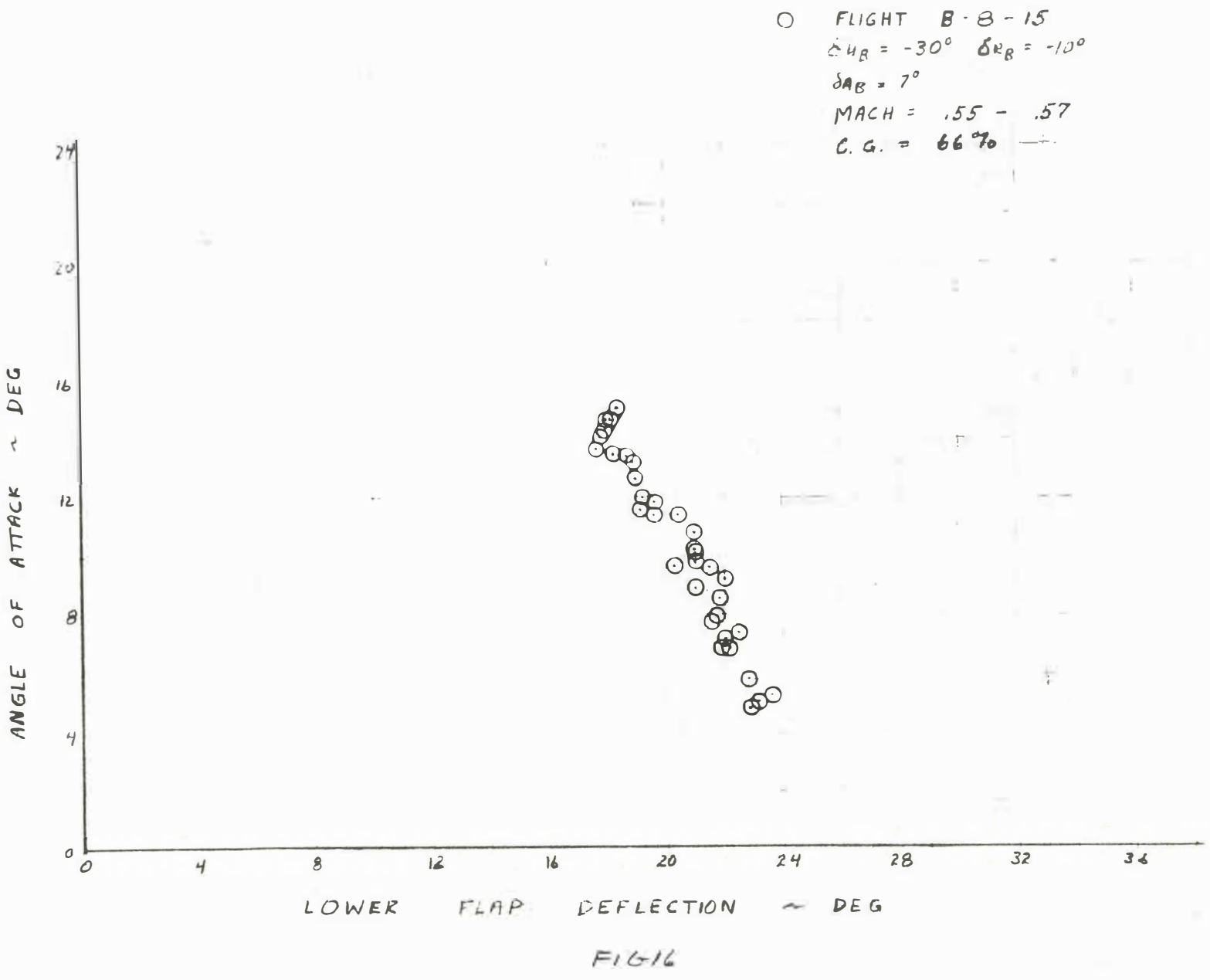

○ FLIGHT B-8-15
$\delta H_B = -30°$ $\delta R_B = -10°$
$\delta A_B = 7°$
MACH = .55 - .57
C. G. = 66%
ANGLE OF ATTACK ~ DEG
0
4
8
12
16
20
24
0
4
8
12
16
20
24
28
32
36
LOWER FLAP DEFLECTION ~ DEG

FIG 16

FLT B-8-15

HANDLING QUALITIES SUMMARY

TRIM TO 12° α AFTER LAUNCH	2.0
CHANGE CONFIGURATION FROM 40° TO 30° UPPER FLAP W/ 0° RUDDER BIAS	2,0
PUSHOVER PULLUP WITH 30° UPPER FLAP / -10° RUDDER BIAS	2.0
PITCH CONTROL WITH PITCH DAMPER OFF AT 20° UPPER FLAP / -10° RUDDER BIAS	3.0
LANDING PATTERN	2.0
LANDING	3.0 (BALLOON)
OVERALL RATING FOR 40° UPPER FLAP / 0° RUDDER BIAS	2.0
OVERALL RATING FOR 30° UPPER FLAP / 0° RUDDER BIAS	2.0
OVERALL RATING FOR 30° UPPER FLAP / -10° RUDDER BIAS	2.0
OVERALL RATING FOR 20° UPPER FLAP / -10° RUDDER BIAS (PITCH DAMPER ON)	2.0

PILOT QUESTIONAIRE
FLIGHT B-8-15

Flight B-8-15
Technical Debriefing

Pilot: Major Mike Love

1. Discuss the Launch transient and rate the task to recover and acquire 12° d.
(Answer)
This is my second flight in the airplane. On the first flight the launch transient was a big surprise to me. I hit my head on the canopy in that launch transient and I really thought it was something. Today I was strapped in better. The launch transient was mild, I noted a little roll-off and the alpha came right up. Prior to the launch there was a lot of vibration on the B-52 and I was looking forward to getting off the bomber and getting the smooth sense of flight that you get in the X-24. That's exactly what I got just after launch, it felt very nice. Another item, I was concerned during the past couple of weeks preparing for the flight in just how fast I could get to 12 alpha and be ready to do the pop. I was very pleasantly surprised that I was almost immediately satisfied with my 12 alpha. Part of this, I think, came from our trim setting at launch. Using the criteria of plus or minus a half degree to be satisfied with my trim, I'd have to rate it as a 2.

2. Comment on the pushover and pullup maneuver with 40° upper flaps.
(Answer)
One thing I like to see in being able to do the pushover is to make a nice smooth rate, stop within half a degree of the aim alpha, and then turn around say from 5, and get a nice smooth rate back up to 18. This means that I'm pushing forward, then just relaxing, going through a deadband and pulling back and on up with aft stick, then back down by relaxing. The control system is very nice. I think you can do that very smoothly without any rough spots. At least on this one with 40° upper flaps, that's what I felt. I felt that I hit 17 and the shaker came on just as I expected. I may have overshot, I think Bob Hoey said that I went to 18.

3. Discuss the configuration change from 40° to 30° upper flap bias with rudder bias in manual mode.
(Answer)
My method for doing this was to concentrate on the upper flap indicator while mechanically trimming in a couple of long beeps of back stick trim to correct for the trim transient. I didn't intend to pay much attention to alpha except to note that it stayed somewhere around 9 or 10. The upper flap moved exactly right, it was easy to stop at 30. I wasn't even quite as aware of trimming the airplane as I have been in the simulator. I think the alpha stayed around 9 or 10. Whereas that might have been a maneuver that occupied a lot of altitude, and be aggravating to hit 30, it was easy to do. I think it's worth rating as a pilot task. The airplane handled very nicely there, I couldn't complain about it at all. I'd have to give it a 2 just to close up also. The pitch change was very easy to control.

4. Comment on the rudder and aileron doublets at 30° upper flap bias/0° rudder bias.
(Answer)
My game plan for the rudder and aileron doublets was to make big ones and make very fast ones. My first flight, on the rudder doublets, I had a feeling, especially after discussing it with several people, that they were done too slow and it caused a surprising amount of roll-off. So today I did very fast rudder doublets and I got very little roll-off. In looking at the data, it looked like they could have been slowed down a little bit in order to allow the airplane to respond because the airplane didn't get a chance to really respond like we probably wanted to see it. Aileron doublets...as a matter of fact, I got just about as much roll with the aileron doublets, I felt, as I did with the rudder doublets. No problem doing them.

5. Discuss the pushover pullup with 30° upper flaps. Did you note any buffet?
(Answer)
I didn't notice any buffet during the pushover pullup, but as I moved the flap switch and came in to 30° upper flaps I felt a vibration in the airplane that I initially thought, in my mind, I said, "that's buffet", and that was about 12 degrees, or 9 to 12 degrees, during the time that I was moving the flap and then retrimming. I thought for sure then, when I go through about 12 on the pop-up, I'll feel some buffet, but I didn't feel any buffet. This is one pop-up that I didn't feel that I moved the alpha needle quite as smoothly as I wanted to. I don't know why that is, it just wasn't quite as smooth as the one at 40° upper. Other than that I don't have any outstanding comments on it, I felt that the pop-up was similar to the one I discussed in question 2.

6. Comment on the longitudinal-trim change when rudder bias "auto" was selected.
(Answer)
I selected rudder bias "auto," evidently thought I was trimmed, and then got a trim change later on. I think in this case, that I was just moving so fast that I didn't wait for the rudders to move. It takes them a few seconds to move so I got ahead of them and started a rudder doublet before they had really caused a trim change. So as advertized in the simulator the nose went up, I saw 15 and I felt the shaker, so I at least got 16 degrees alpha during that time. The data should show some rudder applications during that trim change. It was no problem to recover from this pitch-up. I just pushed the nose forward and retrimmed, trimming to 12 was as easy as it was following the launch. I guess maybe there's a learning curve in the airplane. It seemed easier to trim at all times in pitch today than on my first flight. The magnitude of the trim change in the airplane going from rudder zero to rudder 10 in, looked to be exactly the same as the simulator.

7. Comment on rudder and aileron doublet set in the 30° upper flap/-10° rudder bias configuration.
(Answer)
I have no additional comments on this rudder and aileron doublet set over the one at 30° upper flap and zero rudder bias. The airplane responded the same as it did; I made the inputs the same.

8. Discuss the pushover pullup in the 30° upper flap/-10° rudder bias configuration.
(Answer)
Again, nothing remarkable to say about it. It was very easy to push to 5, back to 15. I will be interested in seeing, I think I hit 15 within a half degree on that, then back to 12. I believe I pushed over to 10 as the end of that one because I was high on the profile. It was easy to do...again; I'd have to rate it at a 2. I was very happy with what I saw in pitch. I guess I was anticipating having a harder time with it.

9. COMMENT ON THE CONFIGURATION CHANGE TO 20° UPPER FLAPS.
(Answer)
On my first flight I looked at the alpha gauge and tracked alpha. I believe the pilot task on this was to close up to 20 and maintain 10 alpha; however, I don't know what I maintained because when I closed up I looked at the upper flap gauge. I came out of it at 10 so it must be easy to do. The airplane doesn't pitch up or down. I looked down at the upper flap guage and flew right on, fat, dumb and happy, without really thinking about the alpha, so I'd have to say it's very easy to close to 20° upper flaps and not even worry about it. We've seen that before in the airplane.

10. Discuss the pushover pullup with 20° upper flaps.
(Answer)
The only additional comments that I have on this one is that I saw crossover start at 14 alpha. In the simulator, crossover starts at 15 alpha. In fact I commented on that on the radio. The stick shaker fired again at 16 and I think I went to 17 again, it'll be interesting to see where I got with the alpha. I guess that will be interesting for me to look at the data and see where I went on the popus because I came down and landed thinking that I hit my aim and if I didn't hit my aim I guess we'll have to look at the delta's and see what we really think about them.

11. Discuss and rate the handling qualities with the pitch damper off.
(Answer)
I got the damper off and just made a forward pitch pulse. The response in the backup alpha gauge, interestingly enough that's what I look at when I make a pitch pulse, and it responded just like the simulator. It came right back up. I thought to myself I must try to fly 10 degrees alpha so I tried that a little bit and there wasn't much to it. So I decided I'd start looking out at the runway. It was so easy to fly with the pitch damper off I kind of lost interest in it. If you go to track an alpha that low, where it's in the nice area for the airplane, all you notice is that you tend to overshoot a little bit and it comes back. It's no problem at all. I would have to - well let's see, the airplane doesn't need the pitch damper to be flown pretty accurately in this regime or this part of the envelope. I'd have to give it a 3.

12. Discuss and rate the pattern.
(Answer)
The pattern, I think, went just like we've seen on all previous seven flights including my flight; very easy to fly. I was super aware, from in the simulator, of starting to use the boards. In simulating coming around the pattern it seemed to make me more aware of using them in the pattern. I saw no trim changes at all from them because I was just concentrating on flying to that glide path.

12. (Answer continued)
The airplane is rated at a 2 for flying the pattern. One thing I have mentioned twice now, this will be the last time I mention it, It might be worth thinking about if you're going to build an X-24C or any other airplane that you're going to fly a pattern like this; you want to look at the canopy and not put something in front of where a guy is going to look in the pattern. The cross bow in this canopy is right in front of where I look as I roll around on final and I have to move my head to see where I want to see. It's not that big a thing but if anybody looks at this data in the future it might be something to think about.

13. Discuss and rate the landing.
(Answer)
I tried to modify my flare to not level off when I get the gear, but to get the gear somewhere close to 50 feet and then let on down. Using the chase report that I was in that area, I was satisfied that I got the gear about that height. I had to wait a while for 240. The flare from then on was easy, again, waiting for the airspeed to bleed off. I was down where I could have touched down, looked down and I saw 190, and didn't want to touch down. So I waited a little bit and then got a balloon. I don't know what it was that caused that, I guess I just pulled back on the stick too much. I had nice response, then concentrated on re-rounding out without getting a big sink rate or any problem. Then I touched down at some unknown airspeed, I don't know what. The touchdown felt smooth and, because I had a little pitch rate, or we think because I had a little pitch rate, to re-arrest my rate of sink, the nose didn't seem to crash down like it has in the past. It went down very nicely, at least through the first portion and then, say through the last 25 %, it moved fairly rapidly. I'd have to rate the landing as a 3 because of the tendency to balloon a little bit, but once you've ballooned, there's still no problem to re-track. It's almost like strafing, you know. I don't know if I'm tracking or what I'm doing when I'm flaring, but you probably have an ability to track one or two seconds and then you loose your ability to track, keep your pipper on target or something. When it moves off you have to re-track and it's very easy to re-track the landing altitude and make a nice touchdown.

14. If possible give an overall pilot rating for the configurations flown
a. 40^{o} upper flap bias/0^{o} rudder bias
(Answer)
a. For what I did today, rate it a 2.

b. 30^{o} upper flap bias/0^{o} rudder bias
(Answer)
b. Again for the tasks performed, I can't help but say it's a 2.

c. 30^{o} upper flap bias/-10^{o} rudder bias
(Answer)
c. Once I got it set and trimmed, I couldn't tell any difference and I couldn't change the rating, It's a 2.

d. 20^{o} upper flap bias/-10^{o} rudder bias
(Answer)
d. Rate it a 2 with the damper on and not lower than a 3 with the pitch damper off and put it at a 3 in the flare because of the tendency to balloon.

ADDITIONAL COMMENTS

I have additional comments regarding roll response. I had enough time in the 30^{o} upper flap/-10^{o} rudder and in the 20^{o} upper flap/-10^{o} rudder with and without the damper, the pitch damper, on to roll the airplane up and look down at the runways and get a feeling for whether it responds nicely when you ask for 30 to 45 degrees of roll, and whether it rolls back out without the nose going all over, it does respond very nicely when you consider the indicated airspeed is low. It doesn't respond as rapidly as, say, a T-38 at 300 knots, but it rolls better than a T-38 does at 220 knots or whatever it was. So the time to roll 45 degrees for this class of airplane would certainly meet MIL-F-8785B, and when you do the roll I just don't have to even worry about the nose moving around or a lot of objectionable adverse yaw or any proverse yaw or anything that is bad. I would rate it a 3 for roll after all those good things I said. The reason is that it isn't a T-38, it's an X-24, and if I want anything out of it, I'd have to agree with John Manke, that you want it to roll just a little faster, like a fighter. But for a mission of coming down and landing from where we launched today, it was certainly adequate. No improvement is necessary.

Additional comments on ground handling after the nose came down. At the higher speeds, above 100 knots or so, I made no test-type inputs. All I did was run it straight down the runway and you'd have to look at the data to see what I did 'cause I don't know what I did. I just went straight down the runway, watched Bill Dana go around, and I was quite at home and comfortable, no problem controlling the airplane. At about 100 k, I thought to myself"I wonder if the ailerons will still turn it." So I put in right aileron and tried to turn right. I didn't get any response. So I think that I tried rudders then and I'd be going through about 80 then. I didn't get very fast response if I got any at all. I don't recall any, then I engaged the nosewheel steering, I'd already armed it. I would say I'm 70 knots or so and I tried to move the nose back and forth, with the small rudder inputs I got very small response, if any, and thought to myself, "I wonder if the nosegear steering is working". I then put in quite a lot of right rudder and was able to get the nose to track to the right. I was doing it just to see how it would steer. When it started to track to the right I said "ok, well it works but it doesn't give you much response." Then I got on the brakes and just braked straight ahead. I didn't try to steer it with the brakes, I know I can. I would call it normal braking for stopping a T-38 below 50. I just did it to try the brakes and feel their control. They feel just like T-38 brakes, kind of ineffective.

We have been discussing landing the airplane and keeping it straight or, say, landing on a runway, a concrete runway. We know from past tests that we have rudder and aileron control at least to 100 knots on the lakebed and some below. We know that, that would be somewhat increased on a concrete runway. My feeling is that for no problems, and certainly with no crosswind, the airplane is very controlable, but I question controlling a blown tire with the demanding task of staying on a concrete runway with the nosegear steering, not from the standpoint of a PIO or overcontrolling, but the standpoint of the lack of response and a lack of authority.

X-24B FLIGHT B-8-15 WEIGHT AND BALANCE

TOD	EVENT	WEIGHT	$\bar{x}$	$\bar{y}$	$\bar{z}$	I_{xx}	I_{yy}	I_{zz}	I_{xz}
11:17:57.5	LAUNCH	8358.9	126.25	-.65	21.79	2693.2	23686.6	24031.4	1090.7
			126.66	-.65	22.56	2660.4	23686.6	24064.2	699.0
11:17:52.0	LNDG ROCKET CHECK	8344.7	126.13	-.65	21.78	2693.0	23672.4	24017.3	1087.6
			126.54	-.65	22.54	2660.3	23672.4	24050.0	696.1
11:19:54.9	GEAR DWN	8344.7	125.61	-.65	21.24	2720.1	23425.8	23743.7	1123.2
			126.01	-.65	22.02	2686.0	23425.8	23777.2	737.2

NOTE: FIRST ROW - VALUES IN X-24A AXES

SECOND ROW - VALUES IN X-24B AXES

DJP 21 DEC 74

LEFT-HAND FIN PRESSURE ANOMALIES

BY

D. Richardson

During the boost portion of flight 7 at .9 Mach number the vehicle sideslip angle drifted out to -2 degrees without the aid of any control surface inputs. In an effort to explain this phenomenon the left-hand fin surface pressures were studied. Figure 1 shows that at the time when β started to drift, several pressure orifices on the inboard surface of the fin experienced an instantaneous change in pressure. Figure 2 is a plot of the fin pressure coefficients before and after the β started to drift. Figure 3 illustrates that the fin side force coefficient (C_Y), which is obtained by integrating the pressures over the area of the fin and rudders, is very nearly the same before and during the β glitch. The conclusion is that the pressure changes on the left-hand fin were not sufficient to account for the change in sideslip angle. At present, two other theories are being explored: One theory is that there is an assymetric flow change occurring over the two outboard fins(note that there were no pressure measurement on the right hand fin); and the second theory is that the vehicle went through a significant change in wind gradient(see wind analysis in this report).

While studying the β glitch problem it was observed that there were step changes in the inboard surface fin pressures at steady state α and β conditions when only the Mach number was changing (Figure 4, 5 and 6). These step changes in pressure also occurred during pushover-pullup maneuvers and they appeared to be a function of Mach number and angle of attack. A summary of the Mach and α conditions at which the step changes in pressure occurred on flights 6, 7 and 8 are presented in figure 7. It is interesting to note that this data is following a pattern rather than being random. It is thought that this phenomenon is a result of the change in vortex impingment on the inboard side of fin.

B-7-14

POWER ON

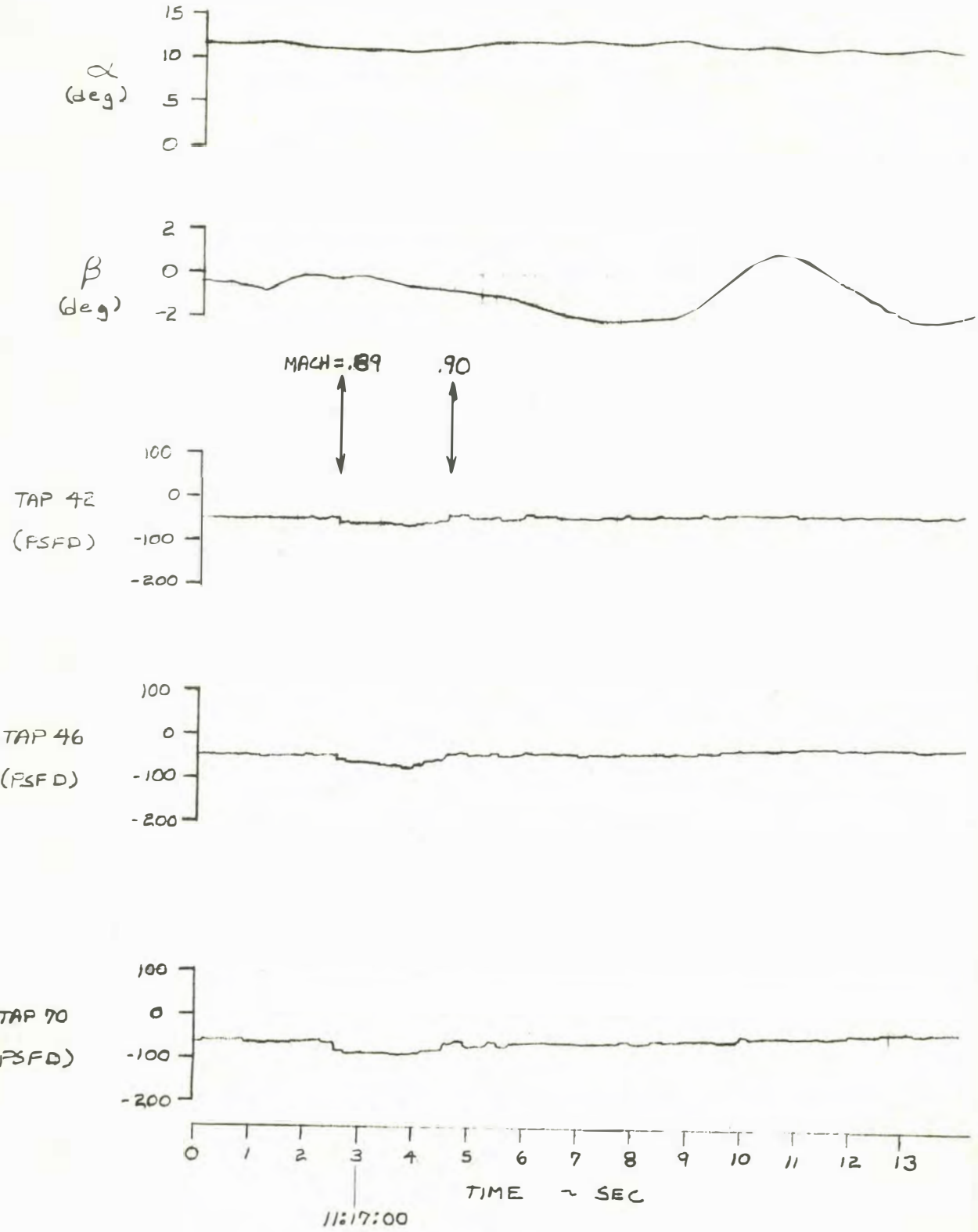


FIG 1

FLIGHT B-7-14 TIME 11-16-58-520

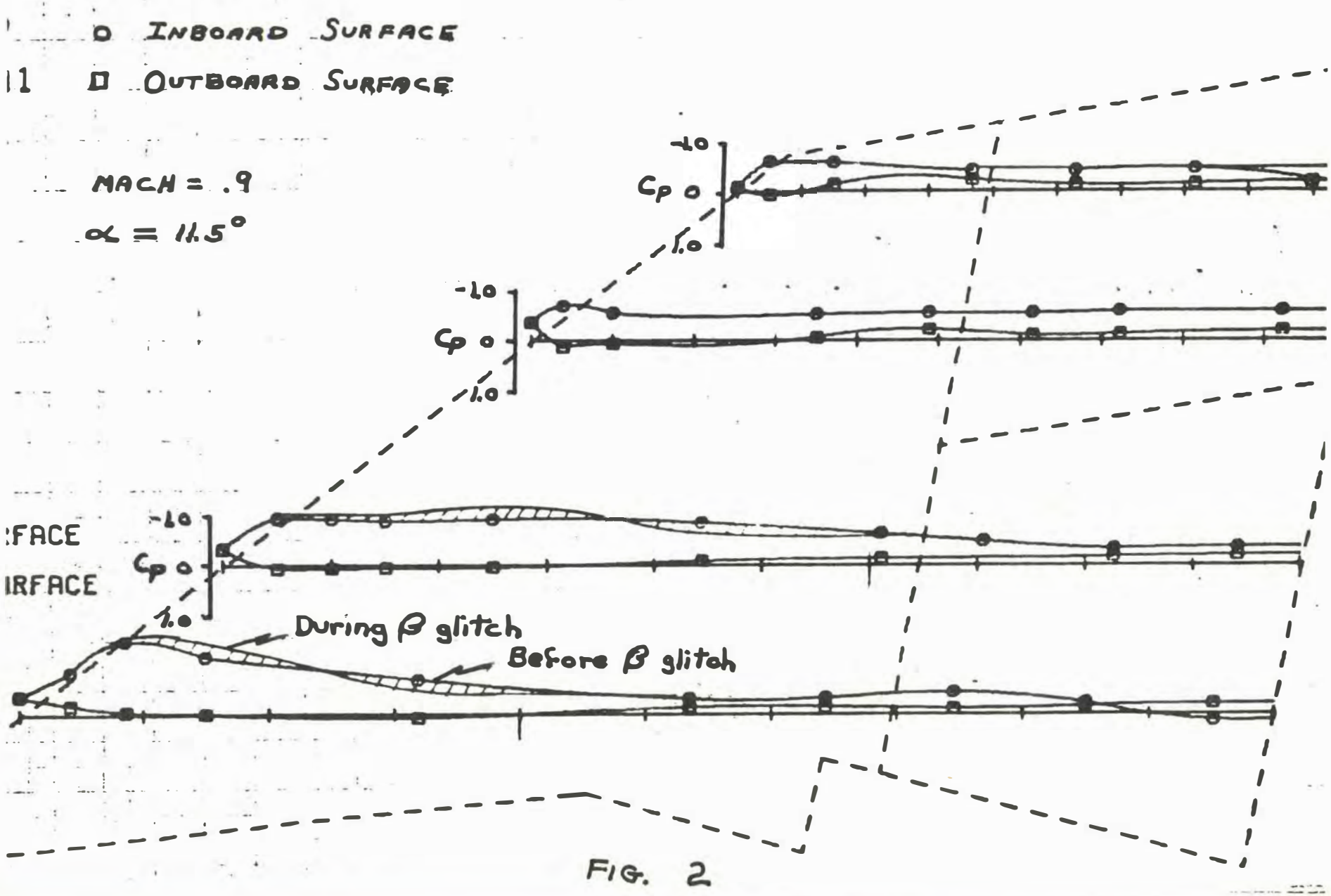
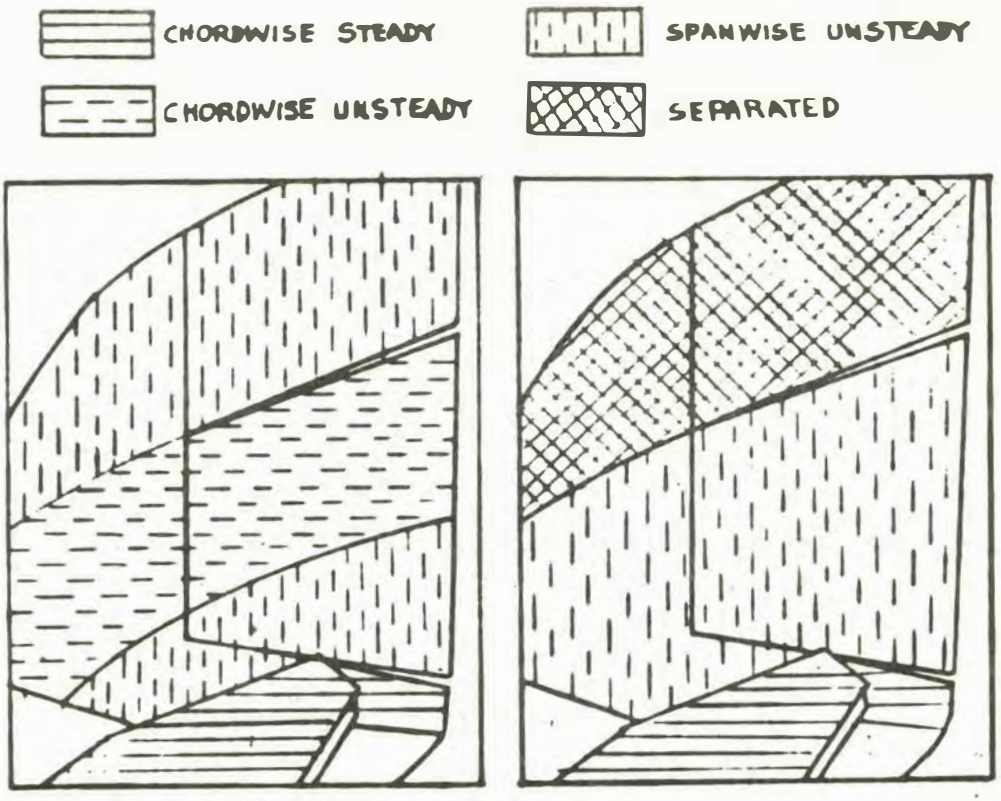
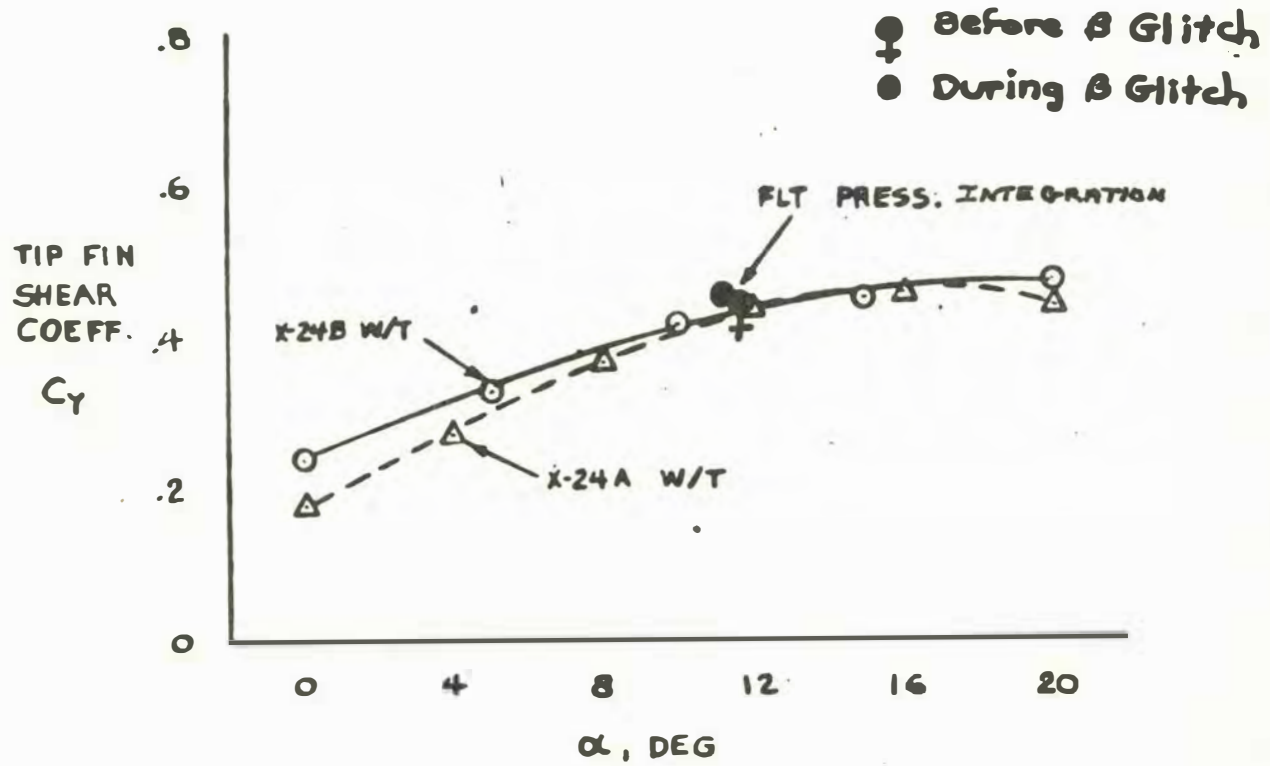


FIG. 2



X-24A TUFT STUDY (M Σ.9)



$M = 0.9$, $\delta_{ul} = -40°$, $\delta_{rb} = 0°$, $\delta_r = 0°$

FIG. 3

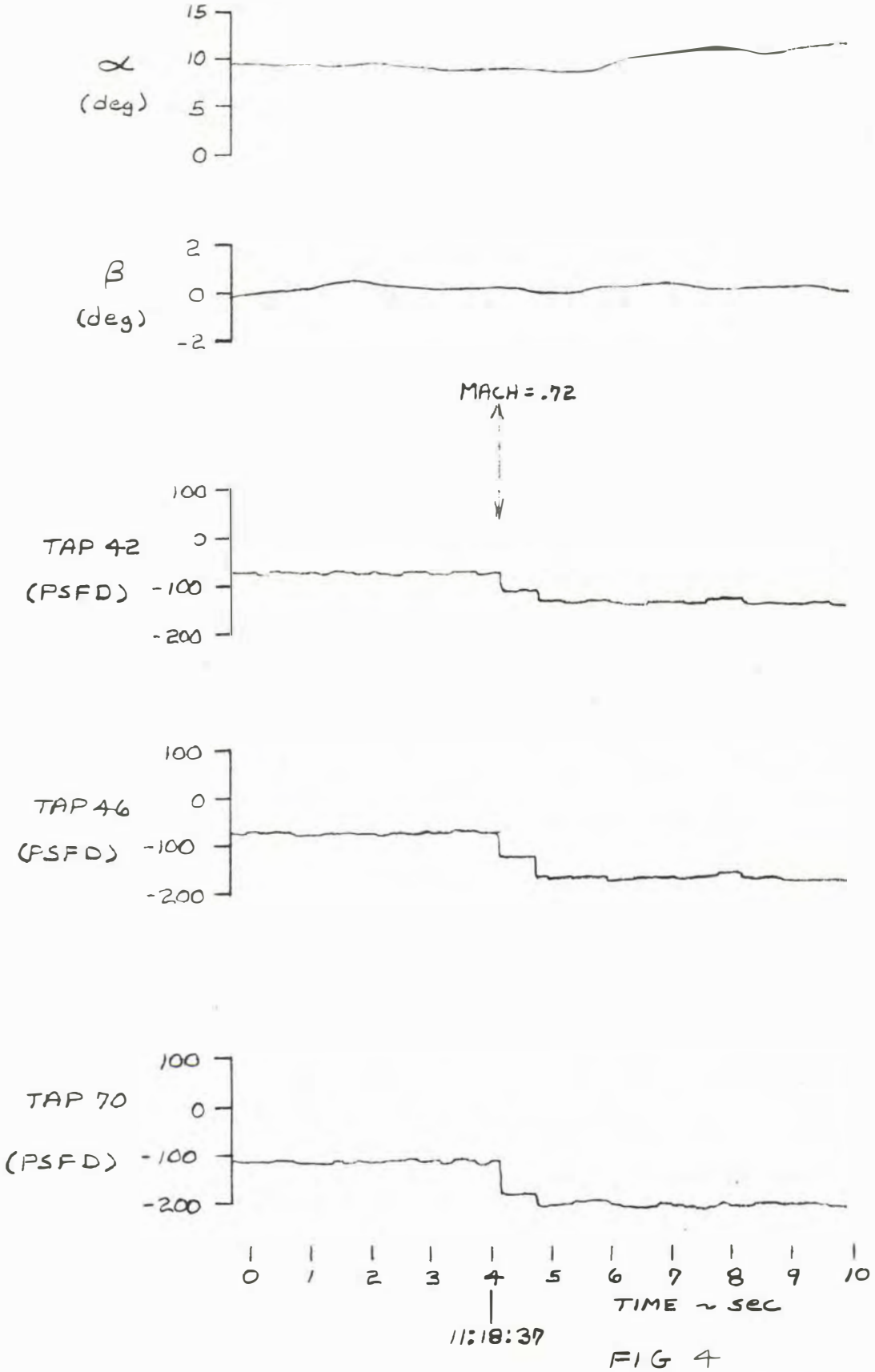

15
10
5
0
α
(deg)
2
0
-2
β
(deg)
MACH = .72
100
0
-100
-200
TAP 42
(PSFD)
100
0
-100
-200
TAP 46
(PSFD)
100
0
-100
-200
TAP 70
(PSFD)
0
1
2
3
4
5
6
7
8
9
10
TIME ~ SEC
11:18:39

FIG 4

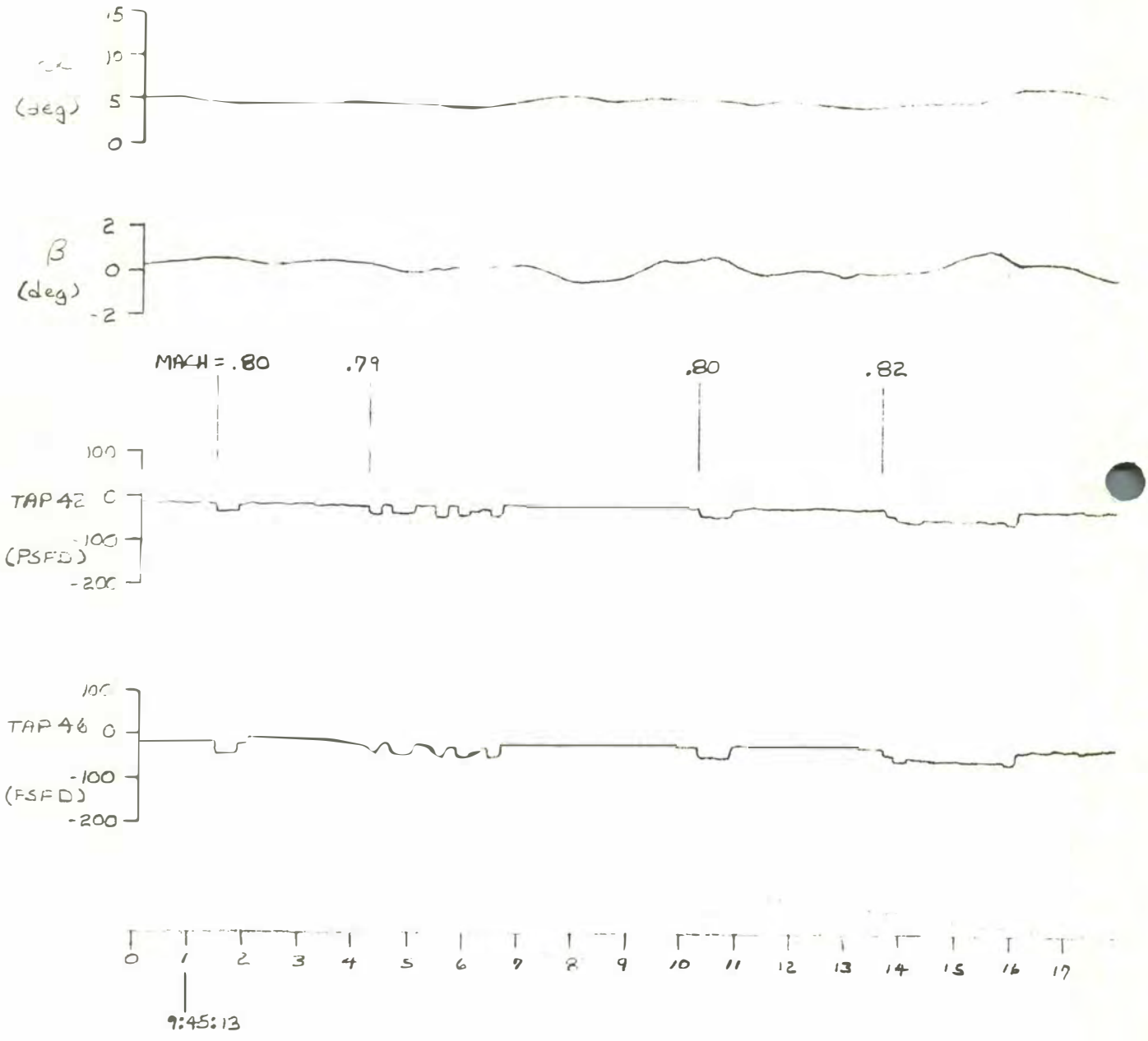

15
10
5
0
(deg)
2
0
-2
β
(deg)
MACH = .80
.79
.80
.82
100
TAP 42 C
-100
(PSFD)
-200
100
TAP 46 0
-100
(PSFD)
-200
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
9:45:13

FIG 5

E-6-12

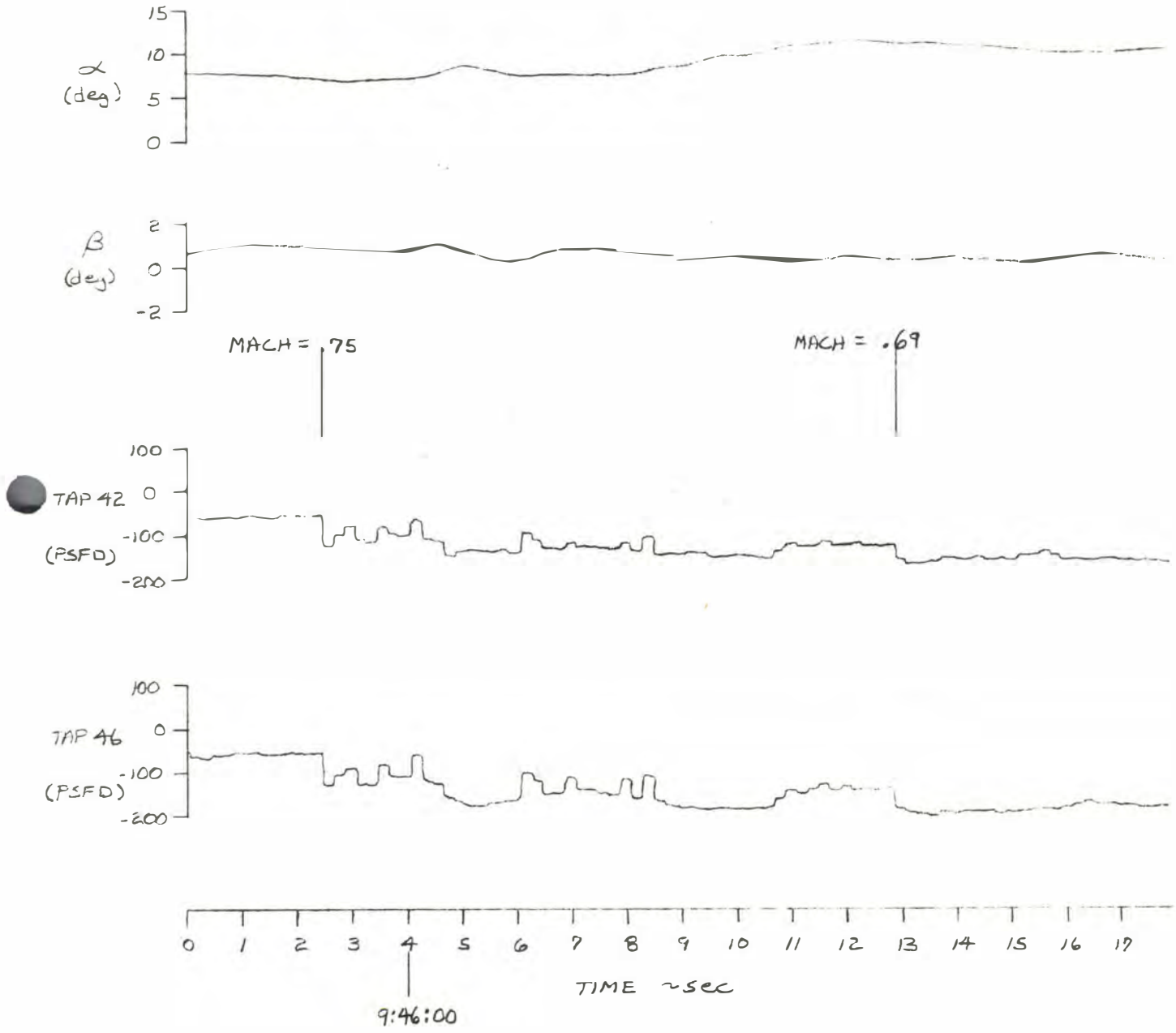

15
10
5
0
α
(deg)
2
0
-2
β
(deg)
MACH = .75
MACH = .69
100
0
-100
-200
TAP 42
(PSFD)
100
0
-100
-200
TAP 46
(PSFD)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
TIME ~sec
9:46:00

FIG 6

These are the conditions at which an instantaneous change in pressure occured at several orifices on the inboard side of the left fin.

SYM	FLT		
△	B-6-13	$\delta_U = -40°$	$\alpha_B = 0°$
□	B-7-14	$\delta_U = -40°$	↓
○	B-8-15	$\delta_U = -30° \& -40°$	

DARK SYM — POWER ON

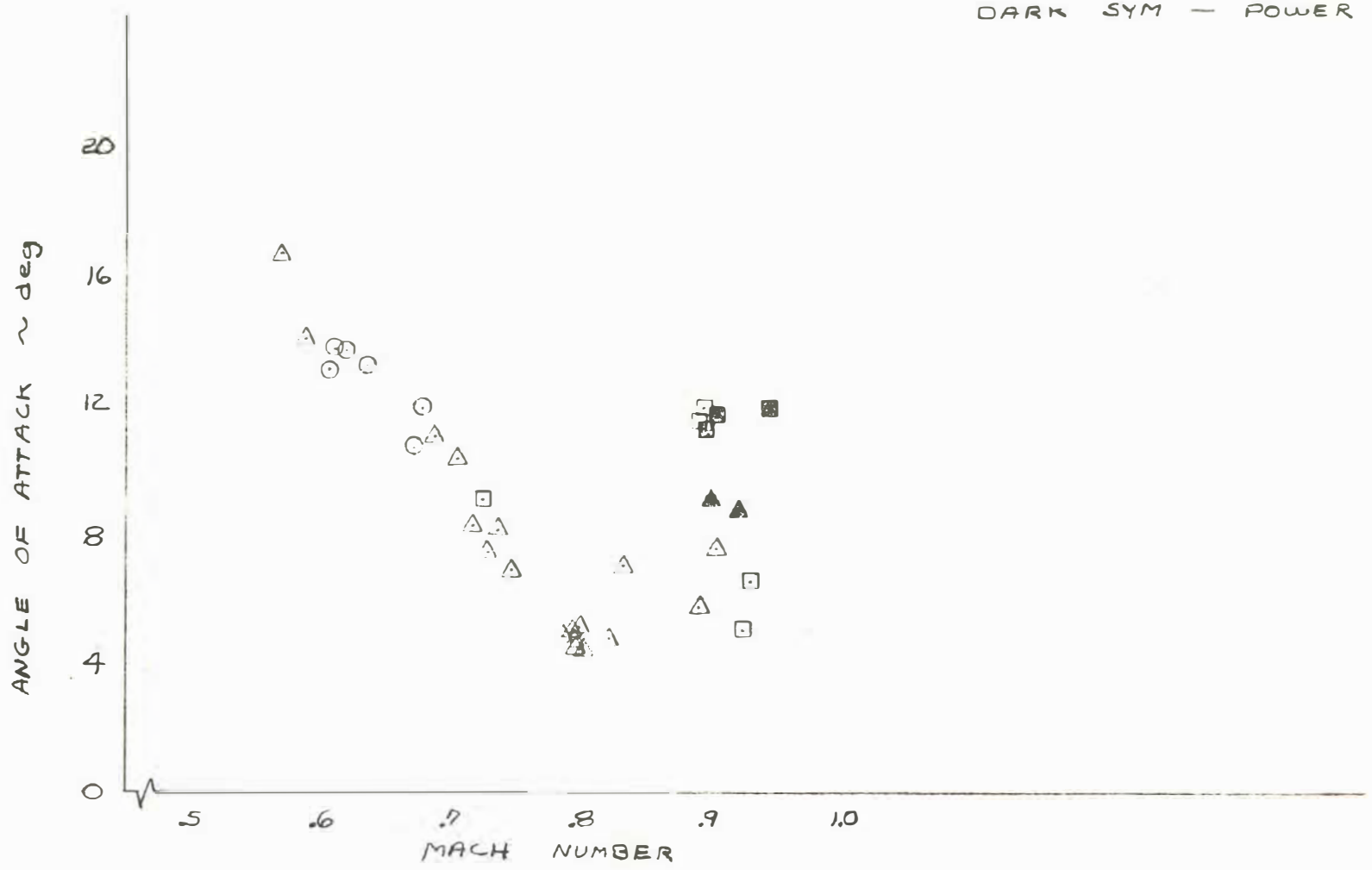


FIG 7

FLIGHT B-7-14 SIDESLIP/WIND INVESTIGATION

BY

Dennis J. Penka, Capt

Several apparently uncommanded sideslip excursions were noted during the powered boost portion of flight B-7-14. One cause postulated to explain these β drifts was that the vehicle encountered abrupt wind changes which induced the observed sideslip. In order to investigate this, a Digital Computer Program was written to calculate the side wind profile vs altitude required to account for the difference between the measured flight β and β as computed from the $\dot{\beta}$ equation of motion using flight measured rates, angles and control surface inputs. In addition, the program computes a side wind component from the weather station wind profile obtained by balloon. It was hoped that some correlation between the sideslip excursions and abrupt wind changes (i.e. A match between the calculated and weather station wind profiles) would be found.

The wind profile computed for flight B-7-14 showed abrupt changes in the wind gradient with altitude at points of observed β excursions, as was expected. Correlation between the computed wind profile and weather station winds, however, was poor (figure 1) with the weather station winds showing none of the abrupt wind gradient shifts required. When a wind profile was computed based on recorded descent data for the same flight, however, a good match was obtained with the computed ascent profile. (Figure 2) The vertical offset between the curves is attributed to pressure lag in the aircraft instruments during the descent. This analysis was repeated for flight B-6-13 with similar results. (Figures 3 and 4) Based on this, we believe that the computed wind profile may be providing a better picture of abrupt wind changes with altitude than the weather balloon. Work is continuing to attempt to resolve the difference in profiles.

Three particular regions of β drift were identified during flight B-7-14 at 11:16:16, 11:16:28 and 11:17:00, respectively. Out of the three, sharp wind gradient shifts were computed at altitudes corresponding to the first two. These shifts were repeated in the descent profile, strongly indicating that they did exist although they were not shown on the balloon data, and that these two vehicle upsets were, in fact, caused by wind gradients. For the third case, however, the computed β and measured β were very close and no significant wind changes were calculated indicating that this excursion was probably not attributable to wind shifts.

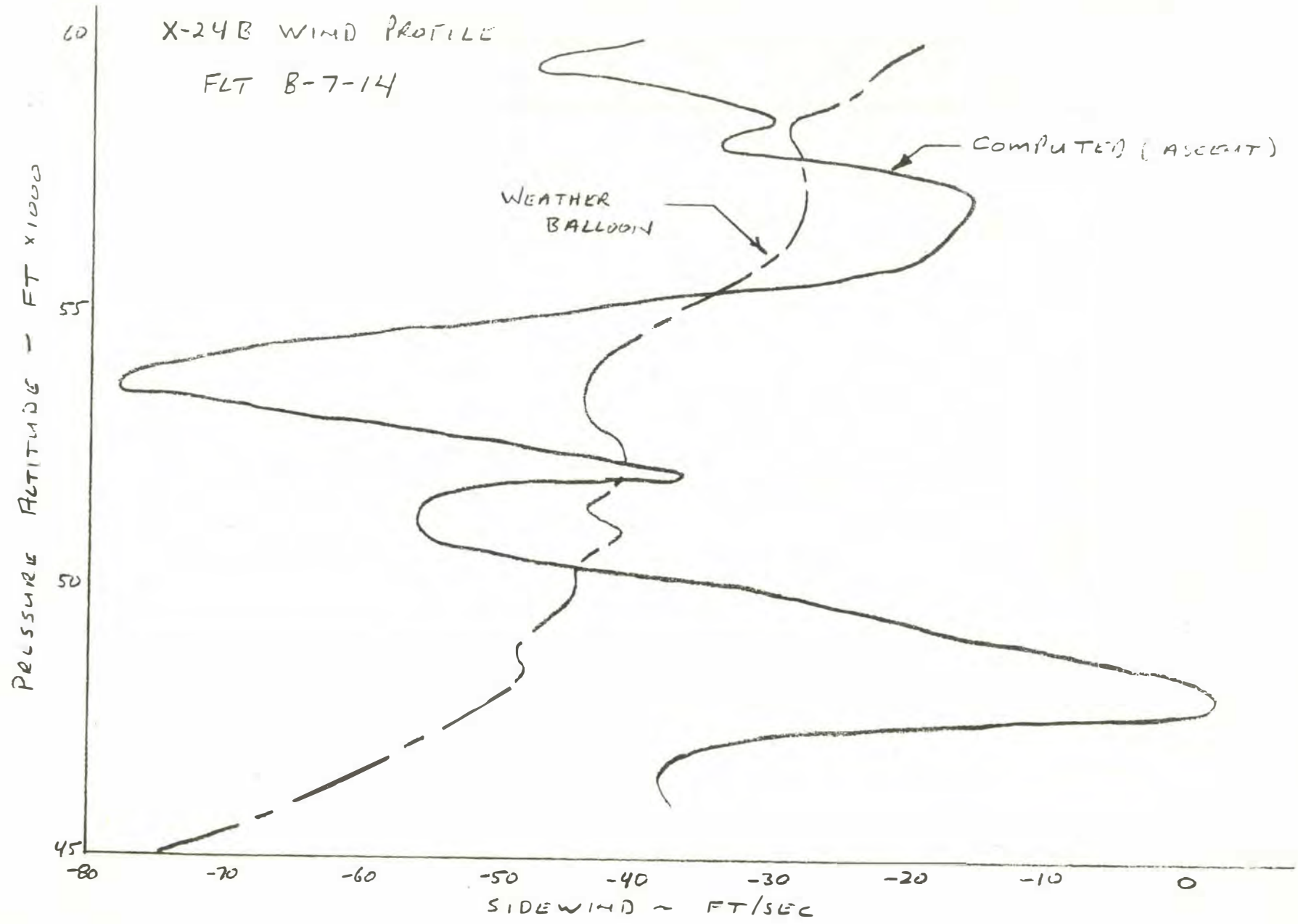

X-24B WIND PROFILE
FLT B-7-14
COMPUTED (ASCENT)
WEATHER BALLOON
PRESSURE ALTITUDE - FT X 1000
60
55
50
45
-80
-70
-60
-50
-40
-30
-20
-10
0
SIDEWIND - FT/SEC

FIG 1

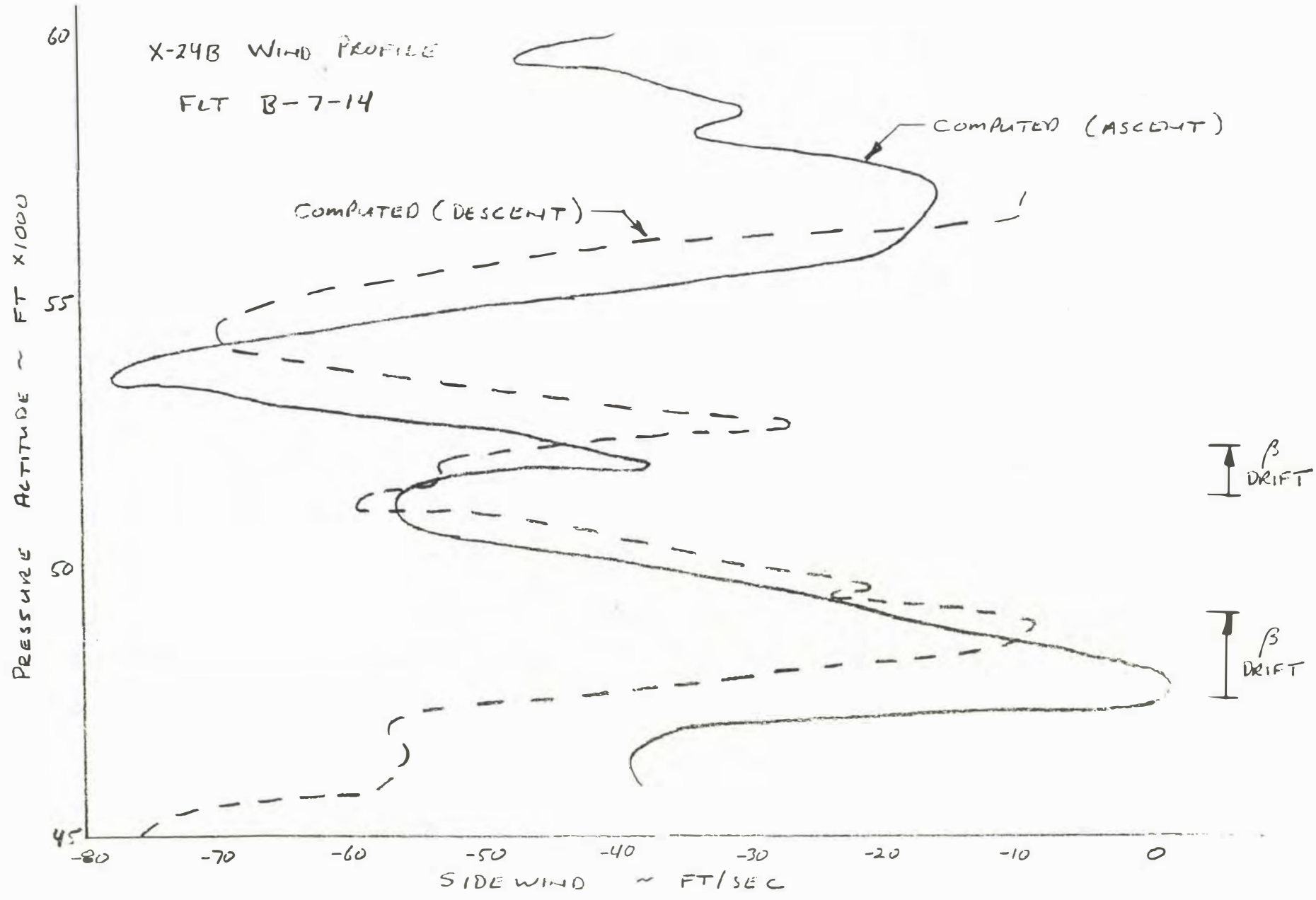

X-24B WIND PROFILE
FLT B-7-14
COMPUTED (ASCENT)
COMPUTED (DESCENT)
β DRIFT
β DRIFT
PRESSURE ALTITUDE ~ FT X1000
60
55
50
45
-80
-70
-60
-50
-40
-30
-20
-10
0
SIDE WIND ~ FT/SEC

FIG 2

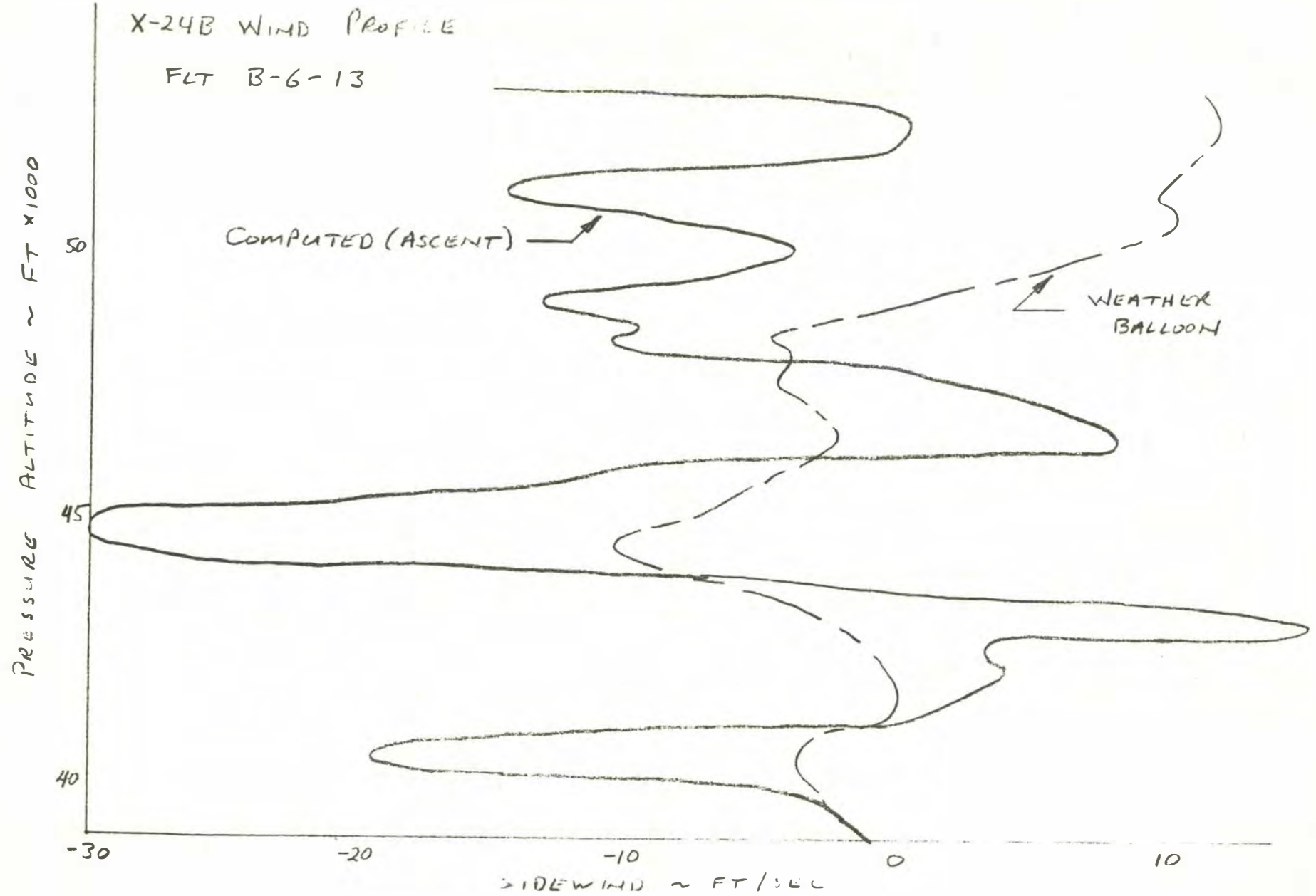

X-24B WIND PROFILE
FLT B-6-13
COMPUTED (ASCENT)
WEATHER BALLOON
PRESSURE ALTITUDE ~ FT x1000
50
45
40
-30
-20
-10
0
10
SIDEWIND ~ FT/SEC

FIG 3

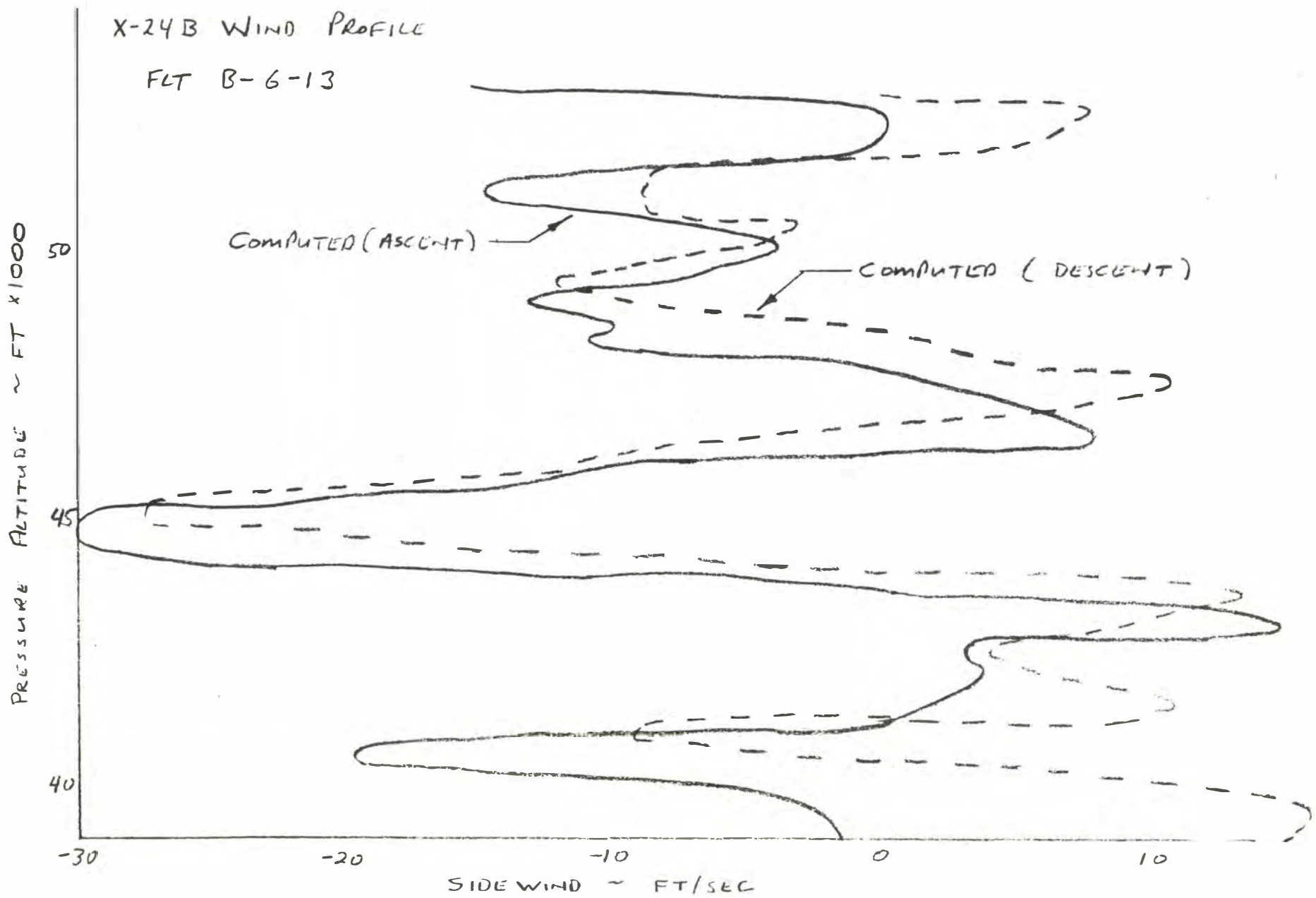

X-24B WIND PROFILE
FLT B-6-13
COMPUTED (ASCENT)
COMPUTED (DESCENT)
PRESSURE ALTITUDE ~ FT X1000
50
45
40
-30
-20
-10
0
10
SIDEWIND ~ FT/SEC

FIG 4

X-24B #551 POSTFLIGHT DATE: 2/15/74

PILOT: LOVE

This is X-24B flight B-8-15, Major Love on February 15, 1974. I'll cover prelaunch, climb out, systems checks, the flight and touchdown. I didn't notice anything up to where we were finishing the cockpit checks with Glenn Ford and then the Bombers guys started running those power units. I think we ought to talk to Tom and them and see....Has that happened to you anytime, John? Run a power unit on the Bomber when you're doing the checks? Ok, well there's not much we can do about that I guess. It made it awful difficult for Glenn do the cockpit check with me. There's nothing we can do about that. Ok, I got a roll SAS lite and master caution when the B-52 went to internal power, that's pretty normal, I guess. This is the first time I had seen a roll SAS lite. That's all that happened prior to takeoff. It was very smooth as far as everything else went.

We climbed out and nothing after we once got the B-52 gear up and until we got the aileron bias check. I thought I might get a comment on that from the control room. Evidently you were satisfied with it. Going to battery, I don't recall getting the emergency battery lite on the first flight that I flew and we got it today and it reset ok. When I went from B-52 to battery, the emergency battery lite came on which is ok for it to do and it reset fine. I had an interesting thought before I launch. It had been kind of turbulent climbing out and a lot of vibrations and I was kind of anxious to get off the B-52. I could remember how smooth the X-24 felt the first time I flew it and sure enough after I launch it really did feel nice to get off the Bomber. I think that's a significant point.

One of the things I was concerned about in the flight, I wanted to know how fast I could trim to 12 alpha. I got there a lot faster than I ever thought I could so I got way ahead of the profile and I went ahead anyway which I said I would. I looked down and I think I saw the altimeter going through 447 and I was already satisfied with 12 so I started the popu. I should have been at 43 when I started that so I feel that it is as easy to trim the airplane to 12 as the simulator. The last few days I was saying I wished the airplane would be that easy. I felt that it was. I did the popu from down to 5 and up to 17 and the kicker fired at 16, just the way it should. Tracking the alpha and hitting 17 I think was easy within what we have said is the criteria of a half a degree.

Started the configuration change and concentrated on the upper flap indicator as I had planned and just trimmed back stick. It was very easy and I think I probably drooped to 9 or 10 alpha, I don't know, but it was easy to recapture 12. I wondered what I got for upper flaps. About that time I got what felt a little bit like buffet and I thought well, good, I get to talk about buffet when I go to 15 for sure, but it must have been turbulence. I did the rudder and aileron doublets and then went from 5 to 15 and that

was nice and smooth then so I must have passed thru a little turbulence about the time I got to 30°. I used more rapid rudder application today than I did on the first flight and the airplane didn't roll like it did on the first flight. The doublet was more comfortable for me than on the first flight. I think I probably tried to get full rudder, I don't know if I did, and it doesn't repond to aileron doublets either. An interesting thing, that I still hadn't seen the beta needle, still have no idea where it was. The airplane didn't require a lot of trimming for rolloff so it must have been good. I wish I could tell you where it had been.

Then came time to go rudder bias auto and your calls were coming just exactly right even though I was way ahead. That was a nice adjustment. You beat me to that and I then got the switch in. I had been, I kind of feel, a little too mechanical. In fact, that is my complaint about my performance on the whole flight. I moved the rudder bias switch to auto and didn't really retrim. I guess I thought I was retrimmed so I started the rudder doublet and about that time the angle of attack when thru 15 and the shaker came on and John called that I was in some turbulence. Some of the turbulence there was caused by a rudder doublet that I did a little early. The airplane I guess, we got a look at it there, it doesn't do anything bad. It was really nice to push it back over and set it at 12 and say come on and get started again, then I did the doublet. I didn't see any difference in them and didn't see any difference in the popu after that doublet.

I was done early there, probably 33 - 34,000. I rolled over and looked at the intersection of 18-15 and I've got to say at that indicated airspeed it sure rolls nice. 38 or 104 don't roll that nicely at that altitude at that indicated airspeed. I kind of feel that if you did a 360 roll it would be pretty sloppy but it's just going back and forth that is remarkable for the low airspeed. Then I went ahead and closed up when you said to close up, John. Since I had been looking at the upper flap indicator for the last couple of weeks, I looked right at the upper flap indicator and I don't know what the alpha did. That's all I saw. It went to 20 and the alpha was no problem. It just stayed right where it was. I kind of used the stick automatically as I've done in the simulator. One thing on the pushover-pullup we did after that inthe 20 degree configuration is that the crossover came at 14, I thought. I'll have to look at the data. In the simulator it comes at 15.

Ok, I got the pitch damper off probably around 25 or 26 as the flight plan said and did a pulse and flew a little bit and that wasn't much to see. I rolled over and looked at the runway a couple of times. In other words, the short period is nice and fast compared to the F4 where it's hard to see the short period. It just kind of wanders up and down. The X-24 oscillates a little bit and if you have a task like going to 10 or something, the only thing I notice is it tends to overshot a little bit and then track back and forth. I don't think it appreciably degrades the aircraft when you turn the pitch damper off and come around making a pitch damper off landing would be no problem.

Rocket check, feel the thrust, and 1 & 3 hydraulics and turn. There's not much to say about the pattern that hasn't been said about 7 times before or same as on my flight. I noticed the canopy bow again right in the way. It's interesting that I had seen a canopy bow just like that earlier in the week. The F5 canopy bows in the same place. I guess when we redesign that canopy we could move that.

Flared and tried to get my gear a little earlier, don't know where I got it exactly. Had to wait for the airspeed so I could get the gear and then went down and rounded out nicely and looked down and had 190 so I decided to wait for 180 and ballooned and then on back down. I don't know what I touched down at. No problem at all with touching down. This time I wasn't looking at the nose boom when I pulled the gear handle. I was looking down the runway so I couldn't see any pitch changes this time. I could just feel the gear come out and not aware of any requirements to make a stick input. Talked with John a little earlier, I evidently; since I had ballooned and then I was rotating again, perhaps I had a little pitch rate at touchdown and the nose didn't seem to come through very fast like it did the first time. The nose went down a lot more reasonably until it was almost down and then it slammed down.

Ok, so much for the flight as far as the training for the flight, being up to speed. I would like to thank Johnny and John Manke. I was really up to speed and ready for the flight. Thank NASA for that suit van. I had been a little uncomfortable in suits prior to this but the suit van and energy in going over to the simulator and flying the simulator in the suit, the suit didn't degrade my performance at all.

Oh, yes, turbulence feels like vibration to me. The airplane didn't roll around at all. It was hard to detect it. The only way I could detect it is I would feel the airplane vibrating. I didn't get any rocking. Let's compare that to the 38 this morning. Of course it's much higher airspeed but the 38 dutch roll was excited pretty good. I didn't see that, I wasn't aware of the turbulence as much except every now and then I could feel some vibrations. I just couldn't comment very much, I just couldn't feel it very much. Let's compare the launch transient to last time. The last time it was a real attention getter. This time I was strapped in much tighter so I didn't hit my head and I could see everything that went on and really get off to the alpha. It rolled off a little but no problem at all. I will have to agree with John now, it's a real mild launch.

X-24B #551 DATE: 2/15/74

FLIGHT: B-8-15 L/P: R. Young

PILOT: Maj. Love

NASA 1: J. Manke

NASA 1: Ok, Tom, you can come left to 180 now. This is 20 minutes now.

20 MINUTES TO LAUNCH

008: Roger.
MIKE: And coming back to 7. Stick Full Aft. Fwd and Aft trim set. There's trim. Ok, aileron trim check right and left and set back at 0°. Full right and left rudder.
NASA 1: Roger.
CHASE: Looks Good.
MIKE: Ok, yaw trim set, check and set at half left.
NASA 1: A little left yaw and little left aileron.
MIKE: How does that look?
NASA 1: That's good.
MIKE: KRA going to 50.
NASA 1: Ok, and Tom shallow your turn please.
008: Roger. And I'm coming up on 40,000 right now.
NASA 1: Ok.
MIKE: KRA 0. Stick right and left, no rudder.
CHASE: Looks good.
MIKE: KRA - Emergency. Increase to 50. Moved stick right and left, it got rudder.
NASA 1: Roger.
MIKE: Stick shaker test works. The Mach Rep is 1.0, Flap Mode is manual, rudder mode is manual.
NASA 1: Roger, Mike.
MIKE: Ok. SAS servos coming to AUTO.
NASA 1: Roger.
MIKE: Gains are 5, 5, 5 and the old SMRD. No lites.
NASA 1: Ok.
MIKE: Torque, no lites. Number 1 servos coming off. Torque and 3 ambers, #2's are off, torque, and 3 reds. 4, 3, 2 set.
NASA 1: Roger.
MIKE: Going back to auto. SAS lites are out, torque-no lites. SAS mode switches are on.
NASA 1: Ok, good check Mike. We can wait here for 14 minutes. We're about 16 and a half now I guess.
MIKE: Roger.
NASA 1: Would you verify stick shaker switch on.
MIKE: Yes, it's on. How about a look at 30°, John?

NASA 1: Ok, lets do it. Roll out 185, Tom.
008: Roger.
NASA 1: Ok, we'd like a look at 30.
MIKE: Ok.

16 MINUTES TO LAUNCH

NASA 1: We just passed 16 minutes.
MIKE: Roger.
NASA 1: Ok, Tom 4° left please.
008: Roger.
NASA 1: Ok, Mike. There's 14 minutes now. 14 minutes.

14 MINUTES TO LAUNCH

MIKE: Ok. Switch hydraulic systems and I've got 2700.
NASA 1: Roger, Mike. Ok, we can go ahead and do those other good things, the pitch and yaw pulses whenever you are ready.
008: Ok, are you ready Mike?
MIKE: All set.
008: Ok, here comes the pitch.
NASA 1: Good pitch pulse.
008: And here comes the yaw.
NASA 1: Good yaw pulse.
MIKE: I can see the surfaces in here.
NASA 1: Ok, good.
MIKE: Erect switch-erect, fast erect-on.
NASA 1: Roger, Mike. We just passed 13 minutes, Mike.

13 MINUTES TO LAUNCH

MIKE: Roger.
NASA 1: We can look at these trims now if you want.
MIKE: Ok. I'm showing 40 on Uppers, 10 on Lowers, 0 aileron, 7 aileron bias, half left on the rudders. Rudder bias is 0.
NASA 1: Ok, they look good Mike. Ok, Tom, 2° right.
008: 2° right.
MIKE: What's the heading now?
008: Mothership has 183.
CHASE: Chase 2 has 181.
MIKE: Roger.
NASA 1: Ok, 12 minutes Mike. 12 minutes.

12 MINUTES TO LAUNCH

MIKE: Roger.
NASA 1: And 2 more degrees right Tom.
008: Roger.
NASA 1: We just passed 11 minutes Mike. 11 minutes.

11 MINUTES TO LAUNCH

MIKE: Ok.
NASA 1: Ok, Mike, 10 minutes. 10.

10 MINUTES TO LAUNCH

MIKE: Ok, 10 minutes. #1 is holding at 36, #2 is down to 39, Cont Gas is 500, Gov Bal is 450, Fuel Tank at 32, LOX Tank at 15, Landing Gear is down to 3000.
NASA 1: Ok, Mike, those look good. Ok, Mike, that's 9 minutes, 9 minutes now.

9 MINUTES TO LAUNCH

MIKE: Ok, Erect switch is cutoff, fast erect off.
NASA 1: Roger.
MIKE: Both attitude indicators are looking good. I've got 183 on heading.
NASA 1: Ok, Mike. And Tom Higgins we'll start out turn at 8 minutes.
008: Roger.
NASA 1: Ok, this is NASA 1, 8 minutes now and Tom you can start your turn.

8 MINUTES TO LAUNCH

008: Turning.
MIKE: Ok, I'm ready to test the landing rockets.
CHASE: Looks good, Mike.
NASA 1: Ok, they look good down here Mike.
MIKE: Ok.
NASA 1: Now we can get in a radio check if you'd like.
MIKE: Ok, that looks good so let's go.
NASA 1: Ok.
MIKE: 551 back on primary.
NASA 1: Ok, Mike. Good show. Good check all the way through. We've just passed 7 minutes.

7 MINUTES TO LAUNCH

MIKE: Roger.
NASA 1: Ok, all stations. 6 minutes, 6 minutes to launch.

6 MINUTES TO LAUNCH

NASA 1: Chase airplane check your windshield heat.
CHASE: 1, 1 alpha, 2, 2 alpha.
MIKE: Ok, that looks like 24 up here.
NASA 1: Ok, we like that Mike. Looks good. What do you have for LOX tank pressure Mike?

MIKE: Holding at 50.
NASA 1: Roger, 50.
MIKE: 15.
NASA 1: Roger, 15 and Tom steepen your turn, please.
008: Roger.
NASA 1: Ok, Mike, 5 minutes, 5.

5 MINUTES TO LAUNCH

MIKE: Roger. Ok, I went to battery and the emergency battery lite is on and I'll reset.
NASA 1: Roger.
MIKE: Reset and it's out.
008: And John, the rollout heading about 360?
NASA 1: 004, Tom.
008: Ok.
MIKE: Ok, cycled the hydraulics and I've got 3200 on both systems and #1 battery 125, #2 is 110, #3 is 100, #4 is 25.
NASA 1: Ok, we'll keep her going.
L/P: Launch Panel, adapter power is off.
MIKE: Reset SAS gains are 5, 5, 5. The old SMRD, no lite.
NASA 1: Good.
MIKE: Torque. No lite. #1 servos are off, torque, 3 ambers. #2 servos are off, torque, and 3 red. 4, 3, 2 set, 6 servos coming on. SAS lites are punched out, torque and no lites.
NASA 1: Ok, Mike, good. We're about 3 1/2, we can hold to the 3 minute call.
MIKE: Roger.
NASA 1: Ok, Tom Higgins, you can give us 2 left please.
008: Roger, 2 left.
NASA 1: Ok, Mike, 3 minutes, 3.

3 MINUTES TO LAUNCH

MIKE: Roger, 3 minutes. Ok, X24 oxygen, Reg Oxygen is 85, Cyl is 17.
NASA 1: Roger.
MIKE: Cabin air is on X24, X24 Air is 3000, Cab Altitude is 245.
NASA 1: Roger, Mike and 2 left, Tom.
008: Roger.
MIKE: Canopy Defog is in heat, fwd canopy defog is on, suit vent is on low.
NASA 1: Ok, Mike.
MIKE: #1 is 3600, #2 is 3900, cont gas is 500, gov bal is 450.
NASA 1: Ok, great Mike.
MIKE: Erect switch is erect, fast erect is on and I've got 40-24, 0 aileron, aileron bias 7, rudder half left at 0 bias.
NASA 1: Roger, and 2 minutes now.

2 MINUTES TO LAUNCH

CHASE: Looks good Mike.
MIKE: 2 minutes. Release pressure low lite's out.
NASA 1: Ok, we like your trim settings. It looks good.
L/P: Beacon is off, alternate release pressure good.
NASA 1: Thank you, Ray. Ok, Mike, everything looks great. Surface winds look good.
MIKE: Ok.
NASA 1: Tom Higgins, 1 degree left.
008: Roger.
NASA 1: 70 seconds, Mike.

70 SECONDS TO LAUNCH

MIKE: Roger.
NASA 1: 1 minute, mark.

1 MINUTE TO LAUNCH

MIKE: Clock's running. #1 is 36, #2 is 39, SAS lites are out, heading is 358, alpha is 4, beta is 1 and 1/4 left. Erect switch cutoff, fast erect off, Camera/recorder on.
NASA 1: Ok, Mike, we're coming up on 30 seconds now. Systems are ok.
MIKE: Roger. Circuit breaker's in.
NASA 1: Roger.
MIKE: Tip camera's on.
NASA 1: Roger, got it.
Mike: 5...

LAUNCH

NASA 1: Ok, Mike, looks good. Coming to 12 degrees alpha. I've got you down to about 6, there she comes back up. Watch your alpha. We saw your popu. Ok, standby to close it up to 30, Mike. You're right on the profile and give me just a shade left. You've got 30 on the uppers, standby for your doublet set. Ok, standby popu. I've got you going just a little bit high, if you could shade your alpha a little bit low. Get your rudder bias and watch your alpha. A little bit more shade left, Mike. Standby for doublets. Ok, we see a little turbulence there. Standby for your popu, Mike. We see the doublet. I gave you an early call on the popu. You're doing great. Running about 4000 feet high on energy.
MIKE: Roger. I'm coming left John and I'm going down to 10 for a second.
NASA 1: Ok, you don't need to come left too much, Mike. I've got you running about half a mile outside. You're in good shape for that energy.
MIKE: Ok.

NASA 1: You can standby to close it up whenever you want. I've got you about a mile and a quarter from the intersection.
MIKE: Roger. I'm closing it up, reading 315.
NASA 1: Ok. 330 looks like a good heading here. You can look out and see where you are going.
MIKE: Ok, turn left 330.
NASA 1: Standby for your popu and 10° alpha. That heading is going to take you in too far left, you might want to look out and come right a little.
MIKE: Ok, I'm in the popu and coming right.
NASA 1: Ok, bring her on around right a little bit.
MIKE: Here's the cross-over.
NASA 1: Ok, it looks like a heading about 335 ought to do it. Get your pitch damper off and you're coming back on energy. You're looking real good. I've got you 3 miles now, Mike.
MIKE: Ok, 3 miles.
NASA 1: I've got you converging nicely right on your track line and you're converging on energy. Got you 2 miles now, right on track and right on profile.
MIKE: Roger.
NASA 1: And if you'd like to take a peek out, we've got you right on.
MIKE: Ok.
NASA 1: I've got you swinging a little bit to the right now, no sweat. You can put your pitch damper back on now.
MIKE: Pitch coming on.
NASA 1: Rocket check. Good rocket checks, get your hydraulics on. You're about half a mile.
MIKE: Ok, got 1 and 3.
NASA 1: Ok. You're at your turn point now.
MIKE: Loos good, John. I'm starting to turn.
NASA 1: Ok, Mike, looks great here. Right on energy.
CHASE: 262 knots, 15,000, my rpm's 89, Mike.
NASA 1: Ok, Bill.
MIKE: Little flap, John.
NASA 1: Ok, Mike. I see a little brake going out. Don't leave them out too long.
MIKE: Roger. 25 Bill.
NASA 1: Ok, get your mach repeater to 3/10th.
MIKE: Got it at 3.
CHASE: 300 knots, 6200 feet, rpm is 88.
NASA 1: Good call.
CHASE: 1000 feet. Call that 100 Mike. 50. Three good gear. You're 20 feet. 15, 10, 5, 3, 2, 3, 2, 1. How about that?
NASA 1: Okay, good. Nice chase calls.
CHASE: Ok, we're coming down the fly-by line.
NASA 1: We'll debrief at 1215, Chase.
CHASE: Bill, are you going to break from here?
CHASE: Negative Gary, I'm going to re-enter and we got a bogey at 11 high.
CHASE: Roger.

CHASE: Tower, NASA 819 would like to break from this mission for a down wind.

NASA 1: Ok, Mike, you're at a stand still. That was a beauty. Page 21, Mike.

MIKE: Cameras are off, standby for the calibrate.

NASA 1: Ok, let's have it. Are you still with me Mike?

MIKE: Yes. It was a good calibrate.

NASA 1: Ok, got it.

MIKE: Ok, Recorder off.

NASA 1: Roger.

MIKE: Sas servos coming off. Hydraulic pumps coming off.

NASA 1: Roger.

MIKE: Canopy defog coming off.

NASA 1: Ok, Mike, on that recorder, was the switch in the on position?

MIKE: Roger.

NASA 1: Ok, we wanted to, the tape dropped out down here. We'll work that out later.

MIKE: Ok, erect switch is erect, fast erect on, #1 is 35 and #2 is 36, cont. gas is 500, gov. bal is back to 460, landing gear is holding 2700, oxygen is at 1200, cabin air is 1000, pylon of course is 0. Engine Timer is not applicable. Radar is going off, stick shaker is off and I guess I'll go ahead and turn the fast erect off, erect switch to cutoff.

NASA 1: That's affirmative, Mike.

MIKE: Attitude systems coming off, back up off, att. inverter off. And I'm going to open the canopy and I'll see you up stairs.

NASA 1: Ok, get the KRA manual, Mike.

MIKE: KRA manual.

NASA 1: That was really a good flight, Mike.

MIKE: Thank you John. I did mess something up that I'll talk to you about.

NASA 1: Ok, no sweat.

X-24B OPERATIONS FLIGHT REPORT

FLIGHT: B-8-15 DATE OF REPORT: 3/27/74

PILOT: Maj. Love DATE OF FLIGHT: 2/15/74

CARRIER AIRCRAFT: B-52 #008 LAUNCH LAKE: Rogers Lakebed

PURPOSE OF FLIGHT: (1) Longitudinal Stability with 40° Upper Flaps.

(2) Lateral-Directional Stability and Control with 30° Upper Flap with Both 0° and -10 Rudder Bias.

(3) Longitudinal Stability with 30° Upper Flaps and -10° Rudder Bias

(4) Fin and Rudder Pressure Survey.

(5) Acoustic Noise and Vibration Experiment (RED PLUG)

I. Discussion of Previous Operations

Flight B-7-14 was flown on 12/12/73 with no vehicle problems.

II. Vehicle Configuration Changes

A. Installed temperature sensor on lox tank overboard vent line to aid in determining when lox topoff was complete.

B. Relocated landing gear service fittings to improve flight morning operations.

C. Installed plexiglass window in hydraulic accumulator access panel to improve flight morning operations.

III. Instrumentation Changes

A. Added "Lox Vent Line Temp".

B. Replaced vertical accelerometer with lateral accelerometer.

C. AFFDL calibrated all Dynamic Inst. System sensors.

D. Calibrated all parameters on PCM.

E. Changed tape recorder control circuit.

F. Re-positioned "wheel speed" magnetic pickup.

IV. Preflight Events

A. Postflight data analysis of flight 6 & 7 revealed lost motion in the L.H. aileron system of approximately .6 of a degree peak to peak in flight where there had been no greater than .2 degree peak to peak during ground tests.

After flight 6 several bearings were replaced in an attempt to reduce the deadband but the lost motion again appeared on flight 7.

After flight 7 the aileron system preload spring cartridges were readjusted and relubed to better balance the system.

B. An attempt was made to reduce the deadband in the pitch system in the crossover from lower to upper flap operation of approximately 1 inch of stick travel. The new pitch bellcrank at sta 125 was stiffened by the addition of several struts.

The deadband was reduced significantly but the structural resonance problem was amplified. The struts were removed because of the flight schedule and the fact that no operation in the crossover was planned for the upcoming flights.

A coordinated effort involving NASA-FRC, AFFTC and Martin personnel is underway to develop a method of solving the problem. Possible solutions being considered are: relocation of the pitch gyros and/or a notch filter in the pitch SAS system.

C. Preflight system functionals were performed without incident.

V. Flight Events

A. Flight servicing for glide flight was on schedule until the noise level from the YF-16 engine run became unbearable. The operation was slipped 30 minutes and then proceeded with no further problems.

B. The flight was made as planned with no vehicle problems.

Approved by: _____
William P. Albrecht
Chief, Operations
Engineering Branch

Written by: _____ for
Norman E. DeMar
X-24B Project Engineer
Operations Engineering Branch

REPORT DOCUMENTATION PAGE

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