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Weight Reduction Study
for the
Gemini Launch Vehicle Instrumentation System

28 DECEMBER 1962

Prepared by
GEMINI LAUNCH VEHICLE PROGRAM OFFICE
Prepared for COMMANDER SPACE SYSTEMS DIVISION
UNITED STATES AIR FORCE
Inglewood, California

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WEIGHT REDUCTION STUDY
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GEMINI LAUNCH VEHICLE INSTRUMENTATION SYSTEM

Prepared by
Gemini Launch Vehicle Program Office

AEROSPACE CORPORATION
El Segundo, California

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GEMINI LAUNCH VEHICLE INSTRUMENTATION SYSTEM

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ABSTRACT

This document presents the study of a feasible plan for weight reduction of the Instrumentation System of the Gemini Launch Vehicle.

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1.1 INTRODUCTION

In this investigation, several methods for obtaining a reduction of weight in the Gemini Launch Vehicle were considered, using the following ground rules.

- a. No re-design of the basic vehicle structure
- b. No re-design of the Flight Control system
- c. Reduction of weight in the instrumentation subsystem by:
 - (1) Replacement or deletion of components
 - (2) Re-design of components.

The major effort was directed toward weight reduction studies associated with Stage II because more immediate improvements in performance are indicated. However, a long range plan is also presented outlining possible areas of weight reduction in both stages. Figure 1 gives a summary of the most promising weight reduction possibilities with related cost and time estimates.

2.1 PLAN A - STAGE II

a. Program Board

An estimated 30 pounds of weight can be saved by removing the program board. However, removal will not allow last minute changes in telemetry requirements without rewiring the vehicle.

b. Circulator and Load Telemetry System

During periods of high reflected power (staging), a directional coupler and dummy load were originally installed to protect the transmitter against excessive voltage build-up. But this was deleted as a Gemini requirement, since the transmitter system is identical to Titan II and the weapon system does not use this type of protection. (Reference M-M/B, LV-90-5 dated November 15, 1962.)

c. Remove Two Telemetry Antenna Cables and Hardware

This would yield a weight saving of 37 pounds but would have to be weighed against the possibility of data loss in the event of vehicle dynamic

malfunition if holes occurred in the antenna patterns. If this risk can be accepted, then removing the two antennas seems feasible because of the reduced roll program. Of course, new antenna patterns would have to be run and the 5 port junction would have to be replaced with a 3 port. A proper choice here would save another 2 pounds (Microlab). Requalification would be required.

d. Replace Avco Command Control Receivers with Leach AlW1-4C

The Avco receivers weigh 12 pounds whereas the proposed receivers (Leach AlW1-4C) weigh 1 1/2 pounds. They have been qualified by White Sands for use in Hound Dog and Mauler. However, a qualification program before use on Gemini is required.

e. Replace Martin Telemetry Transmitter

A survey of the transmitters available showed American Bosch Arma as a possible source. There is a completely enclosed unit using standard components putting out 10 watts and weighing between 4 to 6 pounds including power supply. A similar unit is qualified for Scout. Another possibility is a transmitter by United Electroynamics TRD-16. This unit is similar to American Bosch Arma. Qualification would be required.

f. Re-design Junction Box

This box was originally designed with room for expansion. For its present application, the box is over-designed; when it was last displayed (at a TD meeting), the contents did not fill half of it nor were active elements present. Requalification would be required.

g. Re-design 5 Volt Power Supply

This power supply was also designed with an expanding requirement in mind, and seems to be over-designed. The total load on the power supply is 115 ma. for M-M/B and Aerojet requirements, and its capacity

is 1 amp. A 5 pound saving is possible with redesign if telemetry requirements do not exceed 150 ma. Requalification would be required.

h. Re-design Signal Conditioner

By using present modular techniques and sandwich boards and re-packaging, a 15 pound weight saving is projected. Requalification would be required.

i. Re-design PCM Multiplexer

To effect a worthwhile weight reduction, it would be necessary to review the instrumentation list and scale down the sampling rates wherever possible. At the present time, temperature and on/off functions are sampled at a rate of 20 per sec which is higher than necessary. However, the response and real time monitoring requirements must be kept in mind and sampling rates assigned accordingly. This would still be a major re-design effort and would require requalification with an estimated saving of 15 pounds.

3.1 PLAN B - STAGES I AND II

a. Re-design the Telemetry and Command Antennas

(1) Telemetry Antenna

The telemetry antenna for GLV consists of four cavity-backed slot antennas. The frequency bandwidth is 230 to 252 megacycles at a VSWR of 2.0 to 1. The polarization is linear and the antenna can handle 100 watts.

If the telemetry frequency can be considered fixed then there would not be a requirement for the bandwidth and a consequent reduction in antenna dimensions and weight.

The 100 watt power rating of the GLV antenna is unrealistic. A reduction in the requirements for power handling capability should contribute to a weight reduction.

There is also the possibility that four antennas are not necessary. Three or possibly two of the proper design may give the required coverage. A change in the antenna configuration however could involve a change in the vehicle structure.

(2) Command Antennas

The Command Control antennas are cavity-backed spirals with frequency range of 405 to 455 mc. and VSWR of 2.0:1. Polarization is circular and each antenna weighs 5 pounds.

The Atlas uses two antennas (dual probe fed cavity) located 180° apart to satisfy range illumination requirements. Weight of these antennas is not known at present. A study would be required to determine whether two re-designed antennas would provide adequate coverage as required by range regulation and functional requirements.

b. Re-design Multiplexer for 10 Pound Maximum Target Weight

A quick survey of the Multiplexer market brought up two likely candidates:

(1) Towson Laboratories, Baltimore Maryland

The company representatives stated they could have a multiplexer suitable for GLV telemetry application (capacity and environment) that would weigh about 5 pounds. This does not include the case. This is all the information that is available on this unit at present. More information has been requested.

(2) 5 D, Princeton, N. J.

5 D, Princeton, N. J. was referred to by American Bosch Arma as a knowledgeable manufacturer of multiplexer equipment. Time did not allow further inquiring.

c. Re-evaluate Instrumentation Sensors and Wiring Weights

This effort would require a study to determine if the sensors utilized in GLV were up to the present state of the art and to find properly qualified units to make appropriate substitutions. Even a quick look points out that the gain probably would not be worth the cost and effort.

d. Re-evaluate Instrumentation Land Lines

Since some of the more important GLV functions will be real time monitored it would seem logical to extend this concept to other functions as well.

There are 120 pounds of land line instrumentation in Stage II consisting of 77 pounds for wiring, 11 pounds for end instruments, 24 pounds for umbilicals and 8 pounds for supports. Just how much of this could be saved by real time telemetry monitoring would have to be determined by a study of AGE functions and checkout requirements.

e. Re-design Power Supplies

The 40-volt power supply is designed for output voltages of 32.8 volts \pm 5% and 7.2 volts \pm 5%. Ripple is 35 mv max (rms) and output regulation of \pm 1/2% with load variation of 110 ma. to 330 ma. The supply weights 4 1/2 pounds.

A possible weight reduction of 1 1/2 pounds can be estimated on this supply. Not recommended.

The 25-volt dc power supply is a rectifier type with A. C. supplied by a 400 static inverter. It provides a 25 volt d. c. output \pm 1 1/4% with load variation of .15 to 2 amps and supplies the TARS and Adapter packages.

The supply weighs 7 pounds and could possibly be reduced to 6 pounds (estimated). Not recommended.

f. Instrumentation Truss Weight

No attempt was made to consider weight reduction of structural members on the premise that this may alter the dynamic characteristics of the vehicle and modify all the structural studies up to this time.

Figure 1

Item	Weight		Engineering Cost Estimate	Time Estimate
	Original lbs.	Save lbs.		
1. Remove Program Board and Associated Wiring	20 10 est.	30	10K	1 Month
2. Remove Circulator and Load on Telemetry System	-	7	-	Accomplished
3. Remove 2 Telemetry Ant. (13.5 lbs ea.)	54	27	10K	1 Month
4. Remove R. F. Cables and Connectors to Ant.		10	-	-
5. Replace 5 Port TLM Jcnctn with 3 Port	3	2	29K	3 Months
6. Replace Avco Command Control Revers with (2) (Leach A1W1-4C)	12 ea. 24	21	174K	6 Months
7. Replace TLM Xmtr with American Bosch Arma	29	23	150K	6 Months
8. Redesign Junction Box	13	6	25.4K	3 Months
9. Redesign 5 Volt Instrmntn Power Supply	6.5	5	80K	6 Months
10. Redesign Signal Conditioner	35	15	101K	4 Months
11. Redesign PCM Multiplexer	35	15	120K	6 Months
TOTAL		161	699.4K	

4.1 SUMMARY

A quick weight reduction can be accomplished by implementing items (a) (b) and (c) of Plan A. These are readily removable items and will reduce the weight by 69 pounds not including the circulator and load on the telemetry transmitter. The circulator and load removal has already been implemented and adds 7 pounds to the above mentioned saving. The engineering cost will be an estimated 49 K. Implementation time estimate is about one month.

Items (d) and (e) are items that can save some weight by replacement. The units are off-the-shelf items and will save 44 pounds. The estimated cost is 324K. The time estimate on these items is about 6 months since they will require repackaging and qualification.

Items (f) to (i) are items requiring re-design effort with resultant weight saving of approximately 44 pounds. The re-design will essentially consist of modification of the present units to take advantage of newer techniques. The cost estimate is an approximate 326.4K and the time estimate is approximately 6 months including the repackaging and qualifications effort.