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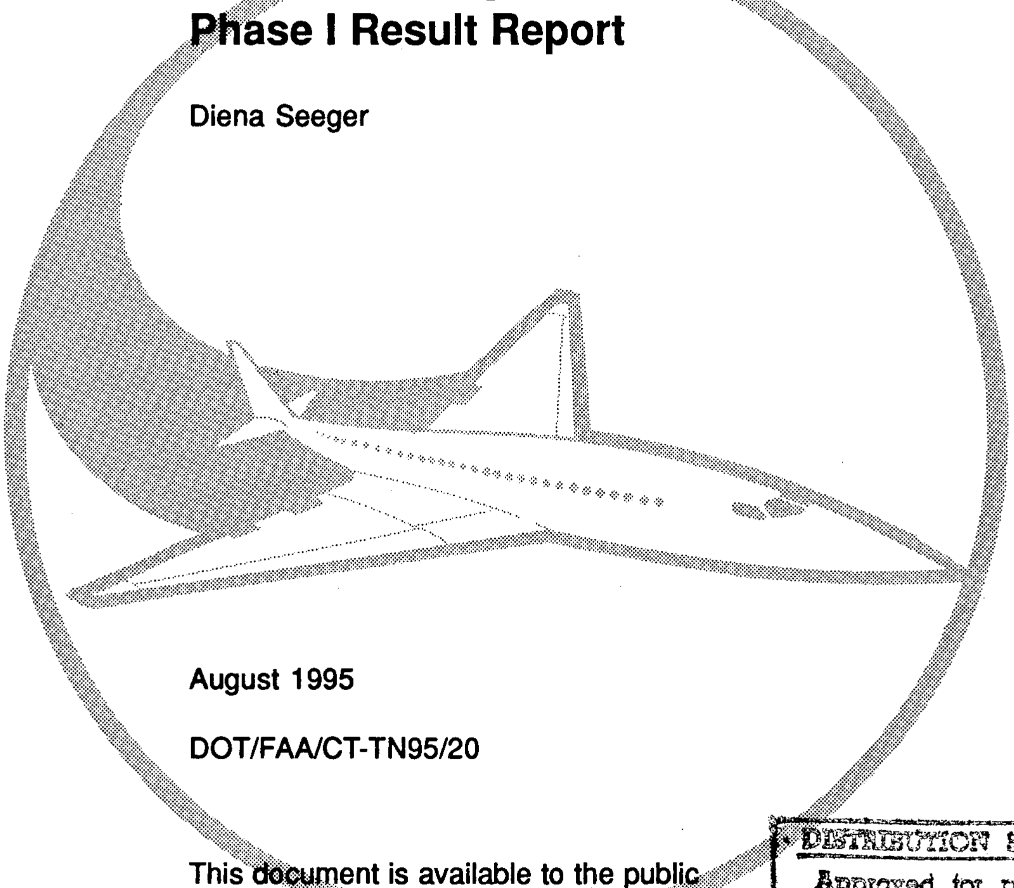
National Simulation Capability Reduced Vertical Separation Minima

Phase I Result Report

Diena Seeger



August 1995

DOT/FAA/CT-TN95/20

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U.S. Department of Transportation
Federal Aviation Administration
Technical Center
Atlantic City Airport, NJ 08405

NOTICE

Technical Report Documentation Page

1. Report No. DOT/FAA/CT-TN95/20	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle National Simulation Capability Reduced Vertical Separation Minima, Phase I Result Report		5. Report Date August 1995 6. Performing Organization Code ACD-350
7. Author(s) Diena Seeger, ACD-350 and R. Roske-Hofstrand, Ph.D., CTA		8. Performing Organization Report No. DOT/FAA/CT-TN95/20
9. Performing Organization Name and Address Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS) 11. Contract or Grant No. F1911A
12. Sponsoring Agency Name and Address Federal Aviation Administration Operations Research Service 800 Independence Avenue, SW Washington, DC 20590		13. Type of Report and Period Covered Technical Note December 1993-January 1994 14. Sponsoring Agency Code AOR-20

15. Supplementary Notes

16. Abstract

The Reduced Vertical Separation Minima (RVSM) experiment resulted from the North Atlantic (NAT) System Planning Group's conclusion to carry out studies aimed at achieving early implementation of RVSM in the NAT Region. RVSM is an approved International Civil Aviation Organization concept to reduce aircraft vertical separation from the Conventional Vertical Separation Minima (CVSM) of 2,000 feet to 1,000 feet. This reduction occurs between flight level 290 to 410, within a designated portion of the NAT Region.

Phase I investigated workload changes resulting from the transition of westbound aircraft from RVSM to CVSM before leaving defined nonradar RVSM airspace. The simulated New York Air Route Traffic Control Center Oceanic Sectors D71 and D72 were configured with an Oceanic Display and Planning System position to replicate controller operations, including simulated high frequency and inter- and intra-facility communications.

The RVSM procedure increased the amount of available altitudes, thus providing the controller with greater flexibility for managing traffic. However, simulation results indicated that controllers operating under RVSM conditions experienced increased coordination requirements, longer display scanning times, and needed additional information from aircraft as compared to CVSM.

17. Key Words CVSM RVSM Minimum Navigation Performance Specifications (MNPS) When Able Higher (WAH)	18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 81	22. Price

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TABLE OF CONTENTS

APPENDIXES

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

The Reduced Vertical Separation Minima (RVSM) experiment resulted from conclusions drawn during the 26th Meeting of the North Atlantic System Planning Group to conduct studies aimed at achieving early implementation of RVSM in the North Atlantic (NAT) Region. RVSM is an approved International Civil Aviation Organization concept to reduce aircraft vertical separation from the Conventional Vertical Separation Minima (CVSM) of 2000 feet to 1000 feet, between flight levels 290 to 410, within a designated portion of the NAT Region. In the United States, RVSM simulation studies are being conducted by the Federal Aviation Administration (FAA) Technical Center's National Simulation Capability (NSC) RVSM Experimentation Working Group.

Experimental procedures, findings, and conclusions from Phase I of the NSC RVSM simulations are provided to assist the FAA's Air Traffic organizations in defining geographical areas for RVSM transitioning and establishing procedures to effect that transition. Phase I investigated workload changes resulting from the transition of westbound aircraft from RVSM to CVSM before leaving defined nonradar RVSM airspace. A second phase is planned to investigate controller workload effects and the feasibility of radar sector transitions with mixed traffic flows.

Real-time simulations were conducted in December 1993 and January 1994 at the FAA Technical Center's Oceanic Development Facility. The simulation investigated nine different scenarios exploring four traffic conditions. The New York Air Route Traffic Control Center (ZNY) Oceanic Sectors D71 and D72 were configured with an Oceanic Display and Planning System position to replicate controller operations, including simulated high frequency (HF) and inter- and intra-facility communications. Flight strip posting and Aeronautical Radio Incorporated (ARINC) printer capabilities were also replicated to produce a high fidelity, functional control environment. Westbound oceanic traffic scenarios were developed based on actual traffic flows recorded by the ZNY. Simulated traffic was controlled by currently certified and active ZNY oceanic controllers. Simulated HF communication lines were staffed by ARINC operators.

Extensive audio and video recordings were made to provide objective data of all simulation runs. Guided post-simulation discussions and questionnaires were used to gather subjective data. A dynamic workload probe was used at 15-minute intervals to assess levels of workload throughout the 4 to 6 hours of each run.

The simulation results indicated that, while interval increases in controller workload occurred under RVSM traffic conditions when compared to CVSM conditions, the overall controller workload did not increase. High interval workload did not interfere with a controller's ability to provide service to the aircraft. Interval increases can be attributed to the following causes:

a. Additional coordination activities with adjacent sectors and facilities; and
b. Increased traffic scanning due to more altitudes being available and occupied.

When controllers experienced extremely high workload conditions during the simulation trials, the nature of their difficulties with RVSM under complex, high-volume traffic loads can be summarized as follows:

a. Keeping abreast of aircraft position reports (updates) and other flight strip management activities;

b. Identifying the location of an aircraft reporting turbulence; and

c. Extreme time pressure for traffic scanning and coordination resulting in overload-induced operational errors.

The simulation results showed that the following major traffic flow situations should be avoided under RVSM:

a. Vertically-stacked aircraft with all available altitudes occupied; and
b. A traffic mixture with a high percentage of aircraft not flying track routes.

Based upon the Phase I RVSM simulation results, the introduction of RVSM in the ZNY Oceanic Airspace is feasible provided that certain procedures are well defined and agreed upon prior to implementation.

1. INTRODUCTION.

This report details procedures and findings from Phase I Reduced Vertical Separation Minima (RVSM) simulations conducted by the Federal Aviation Administration (FAA) Technical Center's National Simulation Capability (NSC) RVSM Experimentation Working Group. Due to time constraints, Phase I was conducted in two parts, Part 1 and Part 2.

RVSM is an approved International Civil Aviation Organization concept to reduce aircraft vertical separation from the Conventional Vertical Separation Minima[1] (CVSM) of 2000 feet to 1000 feet, between flight levels (FL) 290 to 410, within a designated portion of the North Atlantic (NAT) Region.

1.1 BACKGROUND.

The RVSM experiment stems from a decision made during the 26th Meeting of the North Atlantic System Planning Group to conduct studies leading to early implementation of RVSM in the NAT Region.

The NSC RVSM simulations were scheduled in phases. Phase I was designed to study the transition of westbound aircraft from RVSM to CVSM before leaving RVSM/Minimum Navigation Performance Specification (MNPS) airspace.[2] Aircraft that enter radar coverage adjacent to RVSM/MNPS airspace or Canadian airspace, which is either MNPS or radar coverage, are an exception (see figure 1).

1.2 PURPOSE.

The simulation conditions were designed to provide baseline data for a comparison between current oceanic operations under CVSM and planned air traffic (AT) operations under RVSM. These data will be used to provide the agency's AT service organizations, especially the International Procedures Branch (ATP-140), with vital human performance information needed to define issues in the RVSM implementation process.

1.3 APPROACH.

Data collection efforts were designed to measure changes in controller workload across various conditions and focused on procedural issues that arose from the controllers' simulation experiences with RVSM operations.

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[1] CVSM - 2,000 ft. VSM above FL 290 up to FL 600, inclusive.

[2] MNPS airspace - A portion of the NAT airspace between FL275 and FL400 extending between latitude 27N and the North Pole, bounded in the east by eastern boundaries of control areas (CTAs) Santa Maria oceanic, Shanwick oceanic, Reykjavik, and in the west by the western boundaries of CTA Gander oceanic and the western boundary of CTA New York oceanic, excluding the area west of 60W and south of 38.4N. To ensure safe separation, aircraft operating in this airspace must meet a specified minimum navigation performance standard.

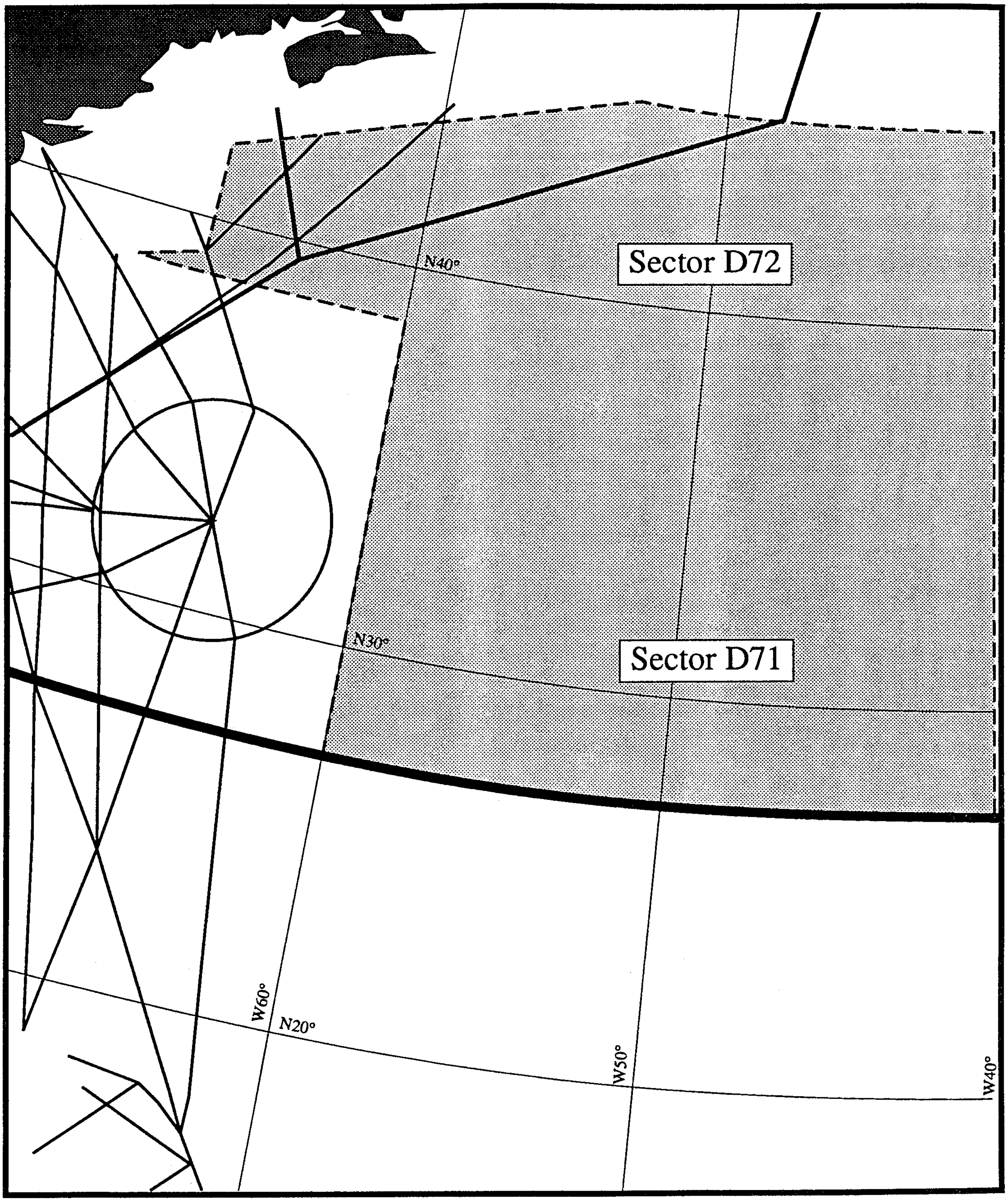

FIGURE 1. PHASE I TRANSITION AREA

2. SUBJECTS.

Simulation participants included four Full Performance Level (FPL) controllers (referred to hereafter as controllers A, B, C, and D) from the New York Air Route Traffic Control Center (ZNY), and two technical observers (T/Os), also from the ZNY, (referred to as observers X and Y) with air traffic control (ATC) training experience. Participation in all simulation exercises was voluntary. Data records were managed by assigning four-digit numbers to each individual to avoid disclosure of participant identity.

The average age of the controllers was 31 years and their average years of experience as FPL controllers was 3.3. Almost all of that experience was accumulated in a NAT oceanic control position. The four controllers had their entire ATC experience at ZNY. The average age of the T/Os was 34. Both observers were current as air traffic controllers (see appendix A for more controller background information).

2.1 BACKGROUND SURVEY.

A background survey was conducted to collect basic demographic data and some information regarding the controllers' and observers' opinions (and biases) regarding high workload situations. Data from the background survey were used as a baseline for comparison with survey responses collected throughout the simulation.

2.1.1 Background Survey Results.

Each controller was asked to indicate three aspects of ATC in the current oceanic environment that they would like to see changed (see appendix A). Their answers reflected the following three primary concerns: having an accurate visual display of aircraft position, having more reliable air-to-ground and ground-to-ground communications, and having additional personnel available at the sectors during periods of heavy traffic.

The controllers were also asked about their experiences with high workload conditions. They identified the following factors as contributing to high workload: adverse weather conditions, flight strip printing speed, low flight progress strip board space, and communication line outages. Although they did not agree on which of these factors occurred most frequently, all indicated that slow strip generation causes a "domino effect" on workload.

Controllers and observers were presented with 10 factors that experimenters believed contributed to high workload in the current ATC environment (see appendix A for a complete listing of questions and results). Participants were asked to check any items they felt contributed significantly to high levels of workload. In addition, they were asked to add any factors not listed. The following summarizes the responses of the controllers and observers:

a. 100% checked Flight Information Regions (FIRs);

b. 83% marked Oceanic Display and Planning System (ODAPS) printer speed;

c. 50% of the participants selected "Coordination with Fellow Controllers"; and

d. 17% commented, "Sometimes coordination can take several minutes because of inexperienced/weak control personnel."

3. SIMULATION DESIGN.

Phase I simulations were conducted in the Oceanic Development Facility (ODF) located at the FAA Technical Center. Due to time constraints, Phase I was scheduled in two parts. Part 1 was conducted December 6-10, 1993, and Part 2 followed on January 10-14, 1994. As a result of controller comments during Part 1, Part 2 employed different scenario characteristics and controller rotation. For both parts, the physical environment of the ODF realistically simulated the ZNY, including the available equipment and communication interfaces (see figure 2). The ODF, together with the ODAPS, which is also located at the Technical Center, provided a complete simulated oceanic ATC environment.

3.1 EQUIPMENT/CONFIGURATION.

The ODF was configured to include two complete oceanic control positions, each containing an M-1 console. The console included: strip bays, integrated Flight Data Input/Output (FDIO) equipment, voice communication equipment, flight strip printers, Aeronautical Radio Incorporated (ARINC) printers (emulated by dot matrix printers), and overhead sector charts. During the Phase I simulations, only one ODAPS Plan View Display (PVD) was used.

A Target Generator (TG) resident in the ODF utilized flight plan and adaptation data to generate aircraft targets. The TG allowed aircraft to react dynamically to controller-issued clearances. Position reports that represented the trajectory of simulated aircraft were also provided by the TG.

Two Digital Equipment Corporation work stations were configured as Remote Operator (RO) positions. Both were used to simulate voice communications between ARINC, adjacent sectors, FIRs, and the controllers. One RO position had the additional capabilities of modifying flight plan data resident in the TG and of generating and directing ARINC messages to the appropriate sector positions.

ODAPS performed flight data processing for the simulated ZNY Oceanic Sectors D71 and D72. It processed flight plan data and related messages, in conjunction with stored adaptation data, to produce outputs that were transmitted via an FDIO control unit to FDIO equipment located at the oceanic sector positions in the ODF. The FDIO equipment used the data output by ODAPS to print flight strips and other essential messages at the appropriate sector position. ODAPS also provided controllers with a graphical representation of flight plan-extrapolated positions of all aircraft under their control.

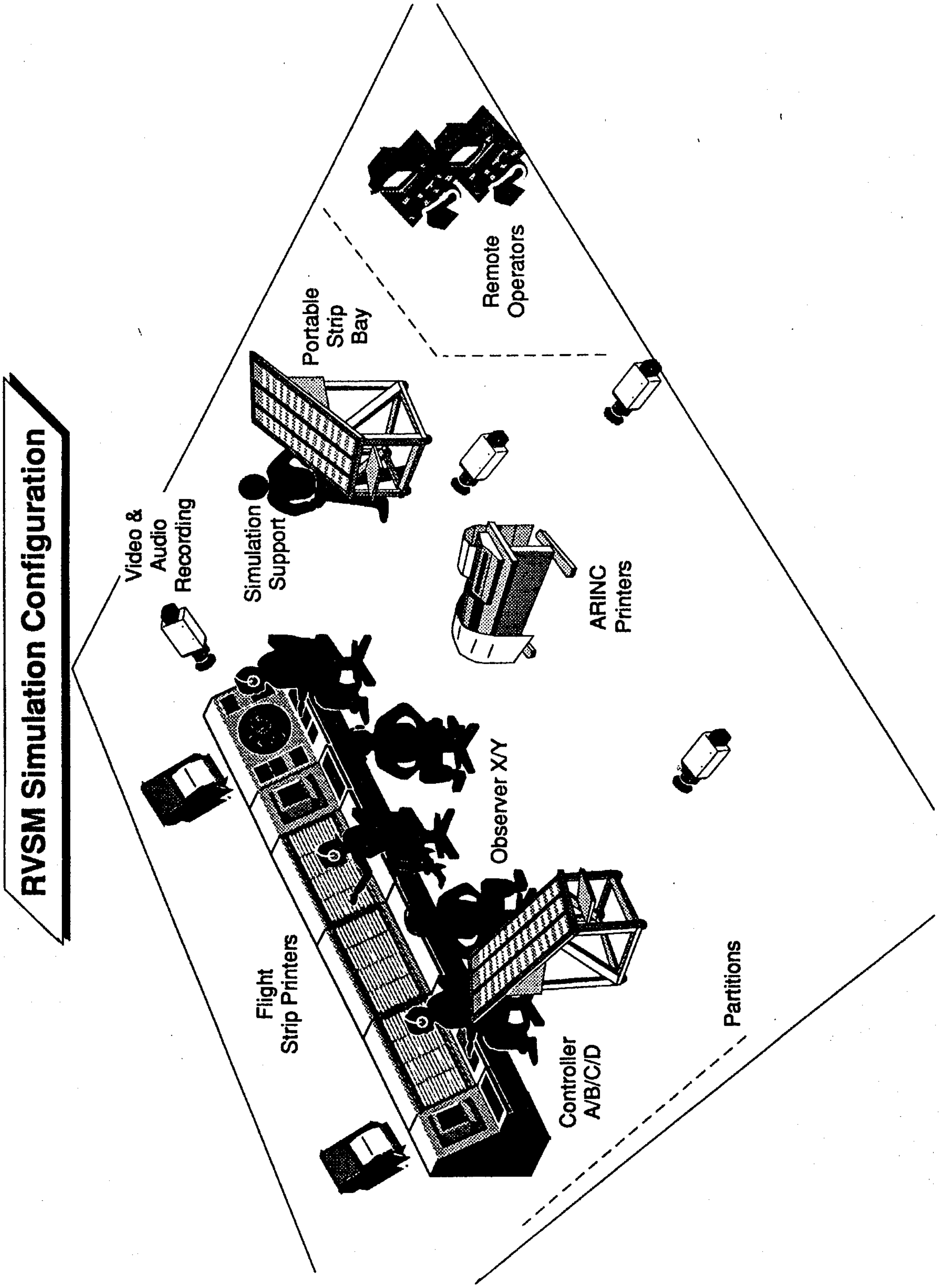

FIGURE 2. SIMULATION CONFIGURATION FOR NSC PHASE 1

A Combine Sector message was entered into ODAPS to combine sector D71's FDIO, PVD, and flight strip information with D72's at the D72 position. A system-build restore tape was generated from ZNY's Adaptation Controlled Environment Subsystem tapes which were current at the time of the simulation. The reference number for the restore tape is TC0284. The software loaded on the Series 1 was National Airspace Data Interchange Network for the ODAPS Communication System and SA2000 for the ODAPS Display Channel.

3.2 SCENARIOS.

All scenarios were developed in cooperation with a ZNY ATC specialist referred to in this report as the scenario developer. Phase I scenarios were developed from Data Analysis and Reduction Tool (DART) runs of System Analysis and Recording (SAR) tapes from ZNY. The DART was run against the SAR tapes to extract flight plans, amendment messages, ARINC messages, and upper winds information. Actual flight plans were loaded onto a personal computer for manual editing to create simulated flight plans. After simulated flight plans were generated, they were entered into the scenario generation tool resident in the ODF. The tool put the flight plan information in a format suitable for simulation.

3.2.1 SAR Tape Information.

Part 1 scenarios were developed based on flight plan data extracted from a ZNY ODAPS SAR tape dated March 18, 1993, between 1400 Greenwich Mean Time (GMT) and 1800 GMT. Part 2 scenarios used existing Part 1 information and additional flight plan data from a ZNY ODAPS SAR tape dated December 15, 1993, between 1000 GMT and 2000 GMT. The SAR tapes provided flight information which was used to recreate primarily westbound traffic patterns for ZNY Oceanic Sectors D71 and D72 in a simulated environment.

3.2.2 Traffic Type.

To allow for valid comparisons, each traffic scenario consisted of 97 aircraft traversing sectors D71 and D72.[3] Days 2, 3, 4, 5, 7, and 9 were developed from the 4 hours of recorded ZNY traffic during March. Due to the traffic density of this day, ZNY recommended this traffic flow be expanded to a 6-hour period (expanded traffic conditions) to better replicate a moderate flow.

For days 6, 8, and 10, flight plan information was extracted from 10 hours of December SAR tape traffic and condensed to create a 4.5-hour scenario (condensed traffic conditions). There were two reasons for condensing the traffic and using a different SAR tape for portions of the Part 2 simulations. First, controllers commented that March scenarios were not an accurate reflection of traffic that was current at the time of the simulation because the flow patterns were no longer accurate and traffic was not heavy enough. Second, the scenario developer followed the assumption that fewer delays would be placed on aircraft departing European airports

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[3] Training scenario not included.

because, under RVSM rules, there would be more altitudes available resulting in a more condensed traffic flow; therefore, traffic would be heavier.

3.2.3 Scenario Conditions.

The first day of simulation was a training day. Subsequent days consisted of simulations under CVSM and RVSM rules, respectively. There were a total of 9 experimental conditions that varied by traffic scenario (March 93 or December 93), traffic flow (expanded or condensed), separation rules in effect (CVSM or RVSM), and by pilot reports of clear air turbulence (CAT). Table 1 shows the sequence of experimental conditions followed throughout the 2-week simulation.

TABLE 1. SEQUENCE OF EXPERIMENTAL CONDITIONS
FOR PHASE I SIMULATIONS

Day	Condition[†]	Part	Run Date	Description
2	CVSM-1	1	12/7/93	Expanded Scenario, CVSM Rules, March 93 traffic
3	CVSM-2	1	12/8/93	Expanded Scenario, CVSM Rules, March 93 traffic
4	RVSM-1	1	12/9/93	Expanded Scenario, RVSM Rules, March 93 traffic
5	RVSM-2	1	12/10/93	Expanded Scenario, RVSM Rules, March 93 traffic
6	RVSM-3	2	1/10/94	Condensed Scenario, RVSM Rules, December 93 traffic
7	MTT-1	2	1/11/94	Minimum Time Track, Expanded Scenario, RVSM Rules, March 93 traffic
8	MTT-2	2	1/12/94	Minimum Time Track, Condensed Scenario, RVSM Rules, December 93 traffic
9	CAT-1	2	1/13/94	Clear Air Turbulence Reports, Expanded Scenario, RVSM Rules, March 93 traffic
10	CAT-2	2	1/14/94	Clear Air Turbulence Reports, Condensed Scenario, RVSM Rules, December 93 traffic

[†] See following sections for detailed description of conditions.

3.2.3.1 Training Scenario.

On the first day of simulation, a training scenario was used to introduce participants to the ODF. It consisted of a 20-aircraft scenario with a minimal amount of estimates and ARINC communications. CVSM rules were in effect and March traffic was used.

3.2.3.2 CVSM Scenarios.

On simulation days 2 and 3, scenarios were conducted using CVSM-1 and CVSM-2 conditions (respectively) to provide a baseline for comparison to RVSM conditions. The expanded March traffic was used. These 2 days utilized ZNY operating procedures current at the time of the simulation.

3.2.3.3 RVSM Scenarios.

On simulation days 4 and 5, RVSM-1 and RVSM-2 conditions utilized expanded March traffic scenarios and applied operating procedures current at the ZNY at the time of the simulation, with the exception of reduced vertical separation. On Day 6, RVSM-3 was conducted with the same procedures as in the previous RVSM runs, but a condensed traffic scenario was used.

3.2.3.4 Minimum Time Track (MTT) Scenarios.

Operationally, the ZNY makes use of MTTs to accommodate heavy traffic flows. "Because of the constraints of large horizontal separation criteria and a limited economical height band (FL310-390) the airspace [NAT Region] is very congested at peak hours. In order to provide the best service to the bulk of the traffic, a system of organized tracks is constructed every 12 hours to accommodate as many aircraft as possible, on or close to, their minimum time paths."[4]

Since MTTs are an important part of the ZNY operations, scenarios were developed to simulate MTT traffic flows. The tracks used for MTT-1 and MTT-2 conditions were the published westbound tracks used in the NAT region on March 18, 1993, and December 15, 1993, respectively. These tracks were established to accommodate as many westbound aircraft leaving Europe on, or close to, their minimum time paths.

MTT-1 and MTT-2 conditions, which were used on simulation days 7 and 8, are modifications of RVSM-1 and RVSM-3 conditions, respectively. As table 2 illustrates, the MTT scenarios had a larger percentage of aircraft moved onto tracks. All vertical separation rules that were applied to RVSM were applied to MTT (see section 3.2.5 and appendix B for track descriptions).

3.2.3.5 CAT Scenarios.

The last experimental condition, CAT, was conducted on the final 2 days of simulations. This consisted of simulation runs similar to RVSM until two pilot reports of greater than moderate CAT were received by controllers. When this situation occurred, the controller was required to comply with the ATC in-flight contingency procedures for RVSM airspace defined in the NAT Vertical Separation Implementation Group Meetings One[5] and Two.[6]

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[4] Reference "North Atlantic MNPS Airspace Operations Manual Sixth Edition", January 1994.

[5] November 4-8, 1991, FAA, Washington, DC.

[6] March 2-6, 1992, FAA, Washington, DC.

TABLE 2. AIRCRAFT ON TRACKS

	Track Identification								
Condition†	G	H	J	K	L	M	N	No Track	% on Tracks
RVSM-1	24	5	8	5	9	N/A	N/A	46	53%
MTT-1	31	0	13	5	6	N/A	N/A	42	57%
RVSM-3	N/A	N/A	N/A	N/A	13	0	1	83	14%
MTT-2	N/A	N/A	N/A	N/A	13	14	14	56	42%

† Refer to section 3.2.3.3 for description of RVSM conditions.

During the CAT-1 pre-simulation briefing, controllers were informed of the in-flight contingency procedures that applied to RVSM airspace. If more than one aircraft reported greater than moderate CAT, the controllers were instructed to take the following actions:

a. If the reporting aircraft has reduced vertical separation with, and is within 5 minutes of, another aircraft, then the controller should establish a conventional separation by climbing/descending either aircraft.

b. Any aircraft not yet cleared on the affected track/level should be conventionally separated for the remainder of the active period of the Oceanic Track System time parameter.

The purpose of these simulation runs was to examine the controller's ability to safely and effectively handle a CAT situation.

The CAT-1 condition used on simulation day 9 was primarily the RVSM-1 scenario with pilot reports of greater than moderate CAT. The final day (CAT-2 condition) was a slight modification of the condensed MTT-2 scenario with CAT reports.

3.2.4 Sector Boundaries.

To emulate an actual operational environment and to allow for an equitable distribution of workload, the boundary between sectors D71 and D72 changed on a daily basis (see table 3 and appendix B). Controllers were informed each day of the sector boundary in effect.

3.2.5 Tracks.

In the NAT region, an organized track structure exists to provide the best service to the bulk of the traffic. When high traffic levels are expected, EUR/CAR[7] tracks are established in addition

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[7] Track established to cater to the European/Carribean (EUR/CAR) axis.

TABLE 3. ASSIGNED SECTOR BOUNDARIES PER CONDITION

Day	Condition†	D71/72 Sector Boundary Latitude/Longitude in degrees			
2	CVSM-1	38/40	37/50	37/60	BDA††
3	CVSM-2	38/40	37/50	37/60	BDA
4	RVSM-1	38/40	37/50	37/60	BDA
5	RVSM-2	38/40	37/50	37/60	BDA
6	RVSM-3	37/40	37/50	37/60	BDA
7	MTT-1	38/40	37/50	33/60	BDA
8	MTT-2	40/40	38/50	37/60	BDA
9	CAT-1	40/40	38/50	37/60	BDA
10	CAT-2	27/40	37/50	37/60	BDA

† Refer to section 3.2.3 for a description of conditions.
†† Bermuda Control Area

to NAT tracks. These routes differ from " 'core' tracks in that they may cross, and in some cases may not extend from coast out to coast in."[8]

The westbound NAT and EUR/CAR tracks published on March 18, 1993 and December 15, 1993 were included in each scenario. These tracks are shown in table 4 and appendix B.

3.2.6 ARINC Messages.

Different but equal numbers of ARINC messages were scripted for each simulation day except Day 5, RVSM-2. The scenario developer expected the increase in available altitudes under RVSM to increase pilot requests for higher altitudes. RVSM-2 was used to test controllers under this situation and thus was scripted with a higher number of ARINC messages.

The send time and sector designation for each message were determined from flight plan data and sector boundary information. ARINC messages consisted mostly of pilot requests for higher altitudes. Messages were delivered via the RO position to the proper simulated ARINC printer. A monitor was assigned to track aircraft altitudes and positions to ensure scripted ARINC messages were appropriate throughout each scenario.

Because of controller comments during initial debriefings, the scenario developer decided to incorporate additional “requests for higher” for aircraft flying at or below FL310. The additional requests for low altitude aircraft and the monitors' omissions of some messages caused a daily fluctuation in the number of ARINC messages (see table 5).

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[8] Reference "North Atlantic MNPS Airspace Operations Manual Sixth Edition", January 1994.

TABLE 4. TRACK POSITIONS BY SIMULATION DAY

Day	Condition	Track	Type	Track Coordinates
1	Training	G	NAT	49/15 49/2 47/30 46/40 44/50 42/60 POGGO
		H	NAT	48/08 48/15 48/20 46/30 45/40 43/50 41/60 JOBOC
		K	EUR/CAR	46/28 46/15 45/20 43/30 38/40 34/45 30/50 25/55 20/60 8/60
		J	EUR/CAR	47/08 47/15 47/20 45/30 43/40 40/50 35/60 PRISS
		L	NAT	DETNA 42/20 43/30 44/40 42/50 40/60 SLATN
2	CVSM -1	SAME AS ABOVE		
3	CVSM -2	SAME AS ABOVE		
4	RVSM -1	SAME AS ABOVE		
5	RVSM-2	SAME AS ABOVE		
6	RVSM-3	L	NAT	4130/15 42/20 43/30 44/40 44/50 43/60 POGGO
		M	NAT	40/15 40/20 41/30 42/40 43/50 42/60 JOBOC
		N	EUR/CAR	41/40 39/50 34/60 BDA
7	MTT-1	G	NAT	49/15 49/20 47/30 46/40 44/50 42/60 POGGO
		H	NAT	48/08 48/15 48/20 46/30 45/40 43/50 41/60 JOBOC
		N	EUR/CAR	41/40 39/50 34/60 BDA
8	MTT -2	L	NAT	4130/15 42/20 43/30 44/40 44/50 43/60 POGGO
		M	NAT	43/15 42/20 42/30 41/40 39/50 34/60 BDA
		N	EUR/CAR	FS 35/40 27/50 18/57
9	CAT-1	G	NAT	49/15 49/20 47/30 44/40 44/50 42/60 POGGO
		H	NAT	48/08 48/15 48/20 48/30 43/40 43/50 41/60 JOBOC
		J	EUR/CAR	47/08 47/15 47/20 45/30 39/40 37/50 35/60 PRISS
		K	EUR/CAR	46/28 46/15 45/20 43/30 38/40 34/45 30/50 25/55
		L	NAT	DETNA 42/20 43/30 42/40 42/50 40/60 SLATN
10	CAT-2	L	NAT	4130/15 42/20 43/30 44/40 44/50 43/60 POGGO

TABLE 5. NUMBER OF SCRIPTED ARINC MESSAGES SENT PER CONDITION

Condition	Total Messages Sent	% Messages Sent to D71	% Messages Sent to D72
CVSM-1	34	56	44
CVSM-2	54	37	63
RVSM-1	54	44	56
RVSM-2	78	37	63
RVSM-3	52	60	40
MTT-1	45	31	69
MTT-2	52	56	44
CAT-1	53	43	57
CAT-2	57	58	42

3.2.7 Planned Events.

Planned events were also scripted for each day. These consisted of any estimates, altitude revisions, or time revisions issued by adjacent sectors or FIRs. Planned events were sent by the RO position via phone communications. While the total number of aircraft in each scenario remained constant, the number of handoff estimates given per phone call was varied to emulate realistic intrafacility communications. This resulted in a different number of phone calls per scenario. Table 6 presents the frequency of phone calls made to both sectors.

3.3 SIMULATION SUPPORT PERSONNEL.

Flight strips were posted by support personnel on movable strip bays. Strips were posted at controller sectors by either a T/O or other ZNY personnel. The RO positions were staffed by two ARINC radio operators and by NSC support personnel.

3.4 FIDELITY ISSUES.

There were several differences between the simulated and actual oceanic environment, including the physical properties of the ODAPS position and phone lines, communication response times, and variation in traffic patterns. A detailed list of differences and their magnitude are shown in table 7.

Efforts were made to correct any reported scenario and communication differences. Because of time constraints, the hardware and lab configuration remained unchanged.

TABLE 6. FREQUENCY OF PHONE CALLS MADE TO SECTORS D71 AND D72[†]

Condition	Total Calls	% Calls to D71	% Calls to D72
CVSM-1	24	29	71
CVSM-2	33	21	79
RVSM-1	35	29	71
RVSM-2	43	28	72
RVSM-3	29	52	48
MTT-1	28	21	79
MTT-2	29	41	59
CAT-1	24	33	67
CAT-2	27	33	67

[†] Does not include inter-sector communication.

TABLE 7. SIMULATION FIDELITY: BASED ON CONTROLLER/OBSERVER COMMENTS

Magnitude of Reported Difference	Category	Description Comparison between ZNY and the ODF simulated environment
SLIGHT	Equipment	Different Phones
SLIGHT	Equipment	Faster ARINC printer speed in the ODF lab
SLIGHT	Scenario/Event	Longer delays in RO phone answering at ZNY
MODERATE	Scenario/Event	More estimates received at one time at ZNY
SLIGHT	Traffic Realism	More Aircraft reports of "unable" at ZNY
MODERATE	Traffic Realism	More requests by Aircraft for "higher" at ZNY
MODERATE	Traffic Realism	Aircraft accept fewer climbs at ZNY
MODERATE	Physical Layout	Position of ODAPS to the right of "D" at ZNY
MODERATE	Physical Layout	Strip bay configuration (space) insufficient in the ODF lab

3.4.1 Physical and Functional Realism.

Controllers and observers were asked to rate the physical (equipment) and functional (operations) realism of the ODF using their current ZNY environment for comparison. Realism was rated on a scale from 1 (Very Low) to 10 (Very High). Table 8 shows the means and standard deviations of the ratings given by controllers and observers for each simulation day and the simulation as a whole.

TABLE 8. PHYSICAL AND FUNCTIONAL REALISM OF THE SIMULATION

	Physical Realism		Functional Realism	
Condition	Mean	Std. Dev.	Mean	Std. Dev.
Training	7.00	1.00	6.40	1.14
CVSM-1	7.50	1.38	7.30	1.03
CVSM-2	7.67	1.37	7.17	0.98
RVSM-1	7.83	0.75	8.20	0.84
RVSM-2	6.67	1.51	6.67	1.51
RVSM-3	7.80	0.84	8.20	1.10
MTT-1	7.30	1.11	7.67	1.51
MTT-2	7.50	1.38	7.83	1.60
CAT-1	7.17	1.57	7.50	1.98
CAT-2	7.50	1.22	8.00	1.26
TOTAL	7.40	1.23	7.49	1.36

Controllers gave a high rating for the 2 weeks of simulation. Physical and functional realism both had an overall mean of at least 7.4. In the post simulation discussions, controllers commented that the following list of items were different from ZNY, but they did not think the items made any significant difference in the results of the simulation experiments:

a. The number of available strip bays were fewer [the ODF uses roll-aways].
b. The ODAPS position would be located between D71 and D72 at ZNY.
c. The ARINC printers in the ODF were quieter.

4. EXPERIMENTAL PROCEDURES.

The following sections detail the simulation procedures, data types, and collection methods used for Phase 1.

4.1 TRAINING.

During the training day, controllers were familiarized with the various functions in the ODF, questionnaires, and procedures for dynamic workload probes. Controllers also completed a brief background information questionnaire which queried their experiences with high traffic loads and high workload.

4.2 CONTROLLER ASSIGNMENT.

Controller position assignments varied between Parts 1 and 2. All controllers were rotated through all three control positions (D71, D72, and ODAPS) to minimize scenario familiarity and to maximize the number of samples per position. For Part 1, the same individual was denoted as controller A, B, C, or D or as observer X or Y. Controller C could not participate in the Part 2 simulation runs due to schedule conflicts. Part 1 Observer Y was assigned to work Controller C's vacant position. No additional observers or controllers participated in Part 2.

4.2.1 Part 1 Assignment.

During the four experimental days of Part 1, CVSM-1, and 2, and RVSM-1 and 2, each controller was assigned to a rotating schedule consisting of a continuous 90-minute work session followed by a 30-minute break. The controllers followed the same rotation scheme through the 3 control positions (D71, D72, and ODAPS) for each of the 4 days. The rotation assignment is shown in table 9.

TABLE 9. PART 1 CONTROLLER POSITION ASSIGNMENTS
BY HALF-HOUR PERIODS

Period	Sector D71 (Observer X)	Sector D72 (Observer Y)	ODAPS (X and Y)	On Break
1	A	C	B	D
2	D	C	B	A
3	D	C	A	B
4	D	B	A	C
5	C	B	A	D
6	C	B	D	A
7	C	A	D	B
8	B	A	D	C
9	B	A	C	D
10	B	D	C	A
11	A	D	C	B

Since controller assignment remained constant over the four experimental days of Part 1, the same individual worked the same control position during the same interval for each day. For example, controller C always worked position D72 during the third interval. The schedule allowed a comparison of the various conditions based on an individual's data because the amount of traffic and communication load was roughly comparable. The rotation assignment was used to maximize the power of the analysis because there were only four subjects.

4.2.2 Part 2 Assignment.

To maximize controller exposure to control positions, balance task load, and minimize controller scenario familiarity, controllers were randomly assigned to a given position for each day of Part 2. The rotation assignment for Part 2 is shown in table 10.

TABLE 10. PART 2 CONTROLLER POSITION ASSIGNMENTS
BY HALF-HOUR PERIODS

	RVSM-3			MTT-1			MTT-2			CAT-1			CAT-2		
Period	D71	D72	ODAPS	D71	D72	ODAPS	D71	D72	ODAPS	D71	D72	ODAPS	D71	D72	ODAPS
1	A	B	C	A	C	B	C	A	B	B	A	C	B	C	A
2	A	B	C	A	C	B	C	A	B	B	A	C	B	C	A
3	X	B	C	A	C	X	C	X	B	B	A	X	B	X	A
4	X	A	C	B	C	X	A	X	B	B	C	X	C	X	A
5	X	A	B	B	A	X	A	X	C	A	C	X	C	X	B
6	C	A	B	B	A	C	A	B	C	A	C	B	C	A	B
7	C	A	B	B	A	C	A	B	C	A	C	B	C	A	B
8	C	X	B	X	A	C	X	B	C	A	X	B	X	A	B
9	C	X	A	X	B	C	X	B	A	C	X	B	X	A	C
10	B	X	A	X	B	A	X	C	A	C	X	A	X	B	C
11	B	C	A	C	B	A	B	C	A	C	B	A	A	B	C

During Part 2 simulations, controllers generally worked continuously for 2 hours at an assigned position. All other procedures were identical to those executed in Part 1.

4.3 RATING FORMS.

The following section describes the controller and observer pre- and post-simulation questionnaires and data recording forms used during each simulation run. The questionnaires, data recording forms, and instructions are included in appendix C.

4.3.1 Dynamic Quick Observer Assessments.

The following measures were taken at 15-minute intervals throughout the simulation runs:

a. Workload ratings given verbally by the controllers to the observers. The rating scale ranged from 1 (very low) to 10 (very high) perceived workload;

b. Workload ratings by the observers using the same 10-point scale;

c. Observer ratings of controller coordination and communication. A rating of 1 indicated remarkably good and 5 indicated unusually poor;

d. Observer ratings of traffic management and control judgment, using the same 5-point scale; and

e. Observer ratings of controller flight strip management using the 5-point scale.[9]

All the ratings were obtained from the two sector control positions. In addition, workload ratings were obtained from the ODAPS position. Observer X sat or stood behind the D71 control position and observed the controller, while tallying various activities. At 15-minute intervals, the observer probed the controller for his or her workload rating. The observer then made a rating judgment for the same 15-minute time interval. Observer Y performed these tasks for both the D72 sector and the ODAPS positions. When an observer was not available (i.e., on break), experimental support staff assumed the responsibility of collecting controller ratings; however, they did not make any other judgment assessments.

4.3.2 Post-Simulation Questionnaires.

Following each simulation day, the controllers and observers met to complete post-simulation questionnaires and to discuss issues surrounding that day's simulation. The discussions were audio taped. Post-simulation questionnaires consisted of three types of questions. The first type addressed the fidelity and realism of the simulation environment. The second question group dealt with overall ratings of workload and operational performance. The third was concerned with anticipated or experienced differences between CVSM and RVSM operations. The questionnaires served to focus the topics of the discussions.

4.4 AUDIO AND VIDEO DATA RECORDING.

An extensive audio and video system was used for data collection during each simulation run. Four separate camera views were recorded, consisting of sectors D71 and D72, the ODAPS control area, and an overall view of the ODF. The video was recorded in Super VHS format on 2-hour tapes and was stamped with National Television System Committee time code for synchronous playback.

Eleven separate audio channels were recorded on a 1/2-inch audio tape. The audio signals recorded were obtained from three wireless microphones worn by the controllers, two ambient microphones, and six channels of controller headsets and speakers used in the ODF voice communication system. Several audio channels were also mixed and recorded on the Super VHS recorders' audio tracks to match the appropriate camera view.

Three separate camera views, along with the associated audio, were sent from the ODF to the Human Factors Laboratory (HFL) on fiber optic lines and displayed on three large screens. The HFL briefing room is a remote location at the FAA Technical Center. This display allowed observers to view the experiment in real time without intrusion, thereby maintaining a sterile and non-obtrusive simulation environment in the ODF.

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[9] The observer forms were changed slightly from Part 1 to Part 2 simulations to accommodate recorder preferences.

5. RESULTS.

The reported findings were based on controller concerns that arose during debriefings and from questionnaires. Statistical data analysis were performed to support or disclaim subjective comments when appropriate. All statistical tests were performed with a significance level $\alpha = 0.05$.

5.1 OPERATIONAL ERRORS.

Table 11 lists the operational errors observed and recorded by the technical observers (T/Os) during the simulation runs. No errors were recorded during both Conventional Vertical Separation Minima (CVSM) runs, both Minimum Time Track (MTT) runs, and the Clear Air Turbulence (CAT)-2 run. Several errors were recorded during the Reduced Vertical Separation Minima (RVSM) runs and the CAT-1 run.

TABLE 11. OPERATIONAL ERRORS NOTED BY THE T/OS

Day	Interval	Explanation
CVSM-1	-	None noted.
CVSM-2	-	None noted.
RVSM-1	9	Plane progressed at FL300. Strip was marked FL330.
	10	Strip not marked at FL290.
	13	Aircraft reported FL300 at 38/40. Strip marked as FL320. Position report written on 45W strip not 40W strip.
RVSM-2	11	ODAPS missed an incorrect altitude on the 40W position report for AOM433. Approved at FL300, activated at original strip altitude, FL350.
	8	30/60 aircraft coordinated at FL370, actual altitude was FL360 - strip flat in bay - indicating complete (MPH633).
RVSM-3	7	CFG600 given clearance "maintain FL360 until 61W climb to cross 62W at FL370." This did not allow aircraft to be level in MNPS airspace.
	14	AAL69 coordinated at 31/60 time 17:19 FL350. Aircraft was only 7 minutes from boundary. AAL69 strip laid flat and was not coordinated with BDA.
	15	IBE6101 at 30/60. Did not coordinate with D89 until 1 minute prior to progressing 60W.
MTT-1	-	None noted.
MTT-2	-	None noted.
CAT-1	15	Loss of Separation, 9 minutes at 60W.
	17	Aircraft climbing to FL370. When that aircraft reported out of FL360 another aircraft was cleared to climb. This violated Air Traffic Procedures (ATP) report leaving procedures.
CAT-2	-	None Noted. Note: Controllers reported that the traffic was so dense that they often were uncertain about lateral separation between aircraft.

5.2 EFFECTS OF RVSM ON SERVICE TO AIRCRAFT.

Controllers claimed there was a decrease in aircraft service under RVSM conditions. They reported a greater ability to approve altitude requests under CVSM conditions compared to RVSM. Under RVSM conditions, controllers felt they were more likely to issue pilot advisories of unable to climb/descend, or to simply ignore pilot requests. This was due to traffic and their own heavy workload.

During each simulation run, the frequency and transmission times of pilot requests for higher altitudes were recorded. Aircraft position reports, providing time and altitude information for each aircraft, were extracted from SAR tapes created during the simulation. Position reports, pilot requests, and the number of aircraft descents were the available data utilized to assess the service supplied to the airlines.

Aircraft that climbed directly to a requested altitude soon after a request was made were assumed to have moved in response to that request (referred to as "direct move"). If no movement was reported by a requesting aircraft, it was assumed that the request was ignored or denied (referred to as "no move"). Since there were no scripted pilot requests for descents, aircraft descents were assumed to be issued by controllers as a result of traffic conditions. Finally, if a requesting aircraft climbed to a level other than what was requested, it was assumed to be either a result of traffic or the only clearance a controller could issue in response to that request. This type of climb was not analyzed because the reason for the movement was indeterminate.

The following analyses exclude both CAT runs. Although RVSM was employed during the CAT testing, service to the aircraft was not measured because contingency procedures were in effect. Aircraft could have been descended or had clearances denied due to weather conditions.

The 5 days of RVSM runs were combined and compared to the 2 CVSM baseline runs. The purpose was to determine if RVSM was a significant factor in granting or denying an aircraft's request for a higher altitude, and to see if a controller was more likely to issue an unrequested descend clearance under RVSM.

Request and movement frequencies for CVSM and RVSM are presented in table 12. A test of proportions, using arc sine transformation, was performed on CVSM and RVSM for no movement and direct movement, $n' = 121.3$, $h_c = .212$. For No Moves, $h_s = .062 < h_c$ showed no statistically significant difference between separation minima. The same held for Direct Moves, $h_s = .106 < h_c$. This indicated that a controller was not more likely to deny or grant a request for higher altitudes under CVSM conditions than RVSM conditions.

Because no significant difference was found for separation minima, traffic type was explored in an attempt to explain controller comments. Table 13 reorganized the data in table 12 by traffic type.

TABLE 12. PROPORTION OF REQUESTS RESULTING IN DIRECT AND NO MOVEMENT BY SEPARATION MINIMA

Separation Minima	Direct Moves	No Moves
CVSM	.35	.50
RVSM	.30	.47

TABLE 13. PROPORTION OF REQUESTS RESULTING IN DIRECT AND NO MOVEMENT BY TRAFFIC TYPE

Traffic Type†	Direct Moves	No Moves
Expanded	.34	.44
Condensed	.23	.55

† See section 3.2.2 for more information on traffic types.

A test of proportions, using arc sine transformation, was performed on expanded and condensed traffic for no movement and direct movement, n' = 145.5, $h_c = .194$. For No Moves, $h_s = .220 > h_c$ showed a statistically significant difference between traffic types. A significant difference was also found for Direct Moves, $h_s = .220 > h_c$. Unlike the test of proportions done on data grouped by separation minima, a test by traffic type showed statistical significance. This indicated that a controller was more likely to deny or grant a request for higher altitudes under condensed traffic conditions than expanded traffic conditions, regardless of separation.

Examination of table 14 further supported the above findings. The highest number of descend clearances, 7, was issued under condensed traffic. All other runs had between 0 and 2 descend clearances.

TABLE 14. DESCEND CLEARANCES ISSUED PER RUN

Traffic Type	Average Descend	Range
Expanded	1.2	0.2
Condensed	7	7

5.3 INCREASED USE OF WHEN ABLE HIGHER (WAH) INFORMATION.

Controllers expressed a need for information about an aircraft's ability to climb to a higher altitude in order to develop an effective strategy for handling traffic, especially under high workload conditions. This was claimed to be particularly true when issuing clearances to aircraft operating at relatively higher RVSM altitudes in comparison to a CVSM altitude. Controllers preferred to obtain this information before a high workload situation occurred. This would allow time for other necessary tasks rather than obtaining WAH information with time consuming telephone conversations.

The bar chart in figure 3 illustrates the average number of all requests made by controllers compared to the average number that were for WAH only. Averages depicted in the figure were tabulated from manually recorded phone conversations between the controllers and Remote Operator (RO) positions. Inspection of figure 3 revealed a notable increase in the average percentage of WAH requests under all scenarios run with RVSM compared to CVSM. Twelve percent of all requests made during CVSM-2 were for WAH, as compared to an average of 41 percent under RVSM conditions. Even higher averages were observed under MTT and CAT conditions.

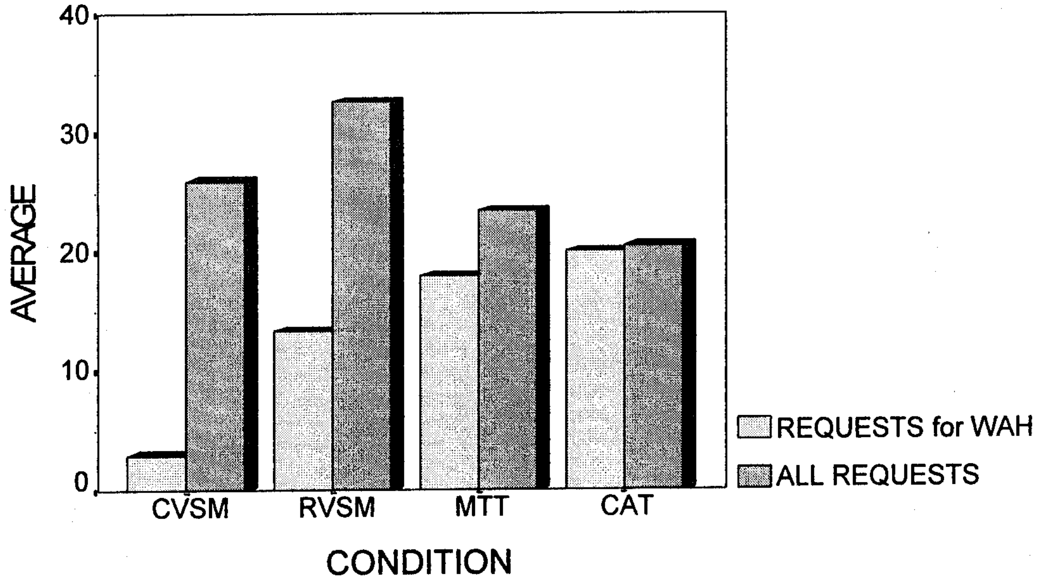
5.4 WORKLOAD ASSESSMENT.

Throughout the simulation, interval workload was assessed by the controllers and the T/Os. A non-parametric statistical correlation (Spearman's Rank) was calculated to evaluate the relationship between the controllers' and observers' ratings. A very high, statistically significant positive correlation was observed, $r_s = .75, p < .001$.

Figure 4 shows the 95 percent confidence interval (CI) of the average controller interval workload ratings as recorded on the Quick Forms each day (see section 4.3.1 and appendix C). It can be seen from figure 4 that the highest average interval workload ratings were observed under CVSM. All scenario parameters remained constant (i.e., traffic type, percent of traffic on tracks) for the RVSM-1/-2 and CVSM-1/-2 runs. Each day the average interval workload ratings decreased under RVSM, showing that the introduction of RVSM did not increase controller workload. For RVSM-3, scenario parameters were modified and the average interval ratings increased, but still did not exceed the CVSM ratings. Also, it should be noted that for all conditions, the day employing condensed traffic had a slightly higher average interval workload rating than for the day with expanded traffic, (i.e., MTT-2, μ =3.8 > MTT-1 μ = 3.5).

A non parametric test (Mann-Whitney Test) on the average interval workload ratings showed a statistically significant decrease under RVSM (μ = 3.77) compared to CVSM (μ = 4.25), Z = -2.47, p = .014. However, the highest interval workload rating (10) was reported under RVSM. Controllers explained that the increase in available altitudes under RVSM created longer flight strip scanning times and unfamiliarity of altitude patterns, which resulted in high interval workload ratings.

An overall rating at the end of each run was recorded. Controller and observer overall average ratings ranged from 6.5 to 6.9 for all conditions.



Note: Due to technical complications, an accurate account of requests made during CVSM-1 was not calculated, thus CVSM-1 results were not reported.

FIGURE 3. ALL REQUESTS AND WAH REQUESTS

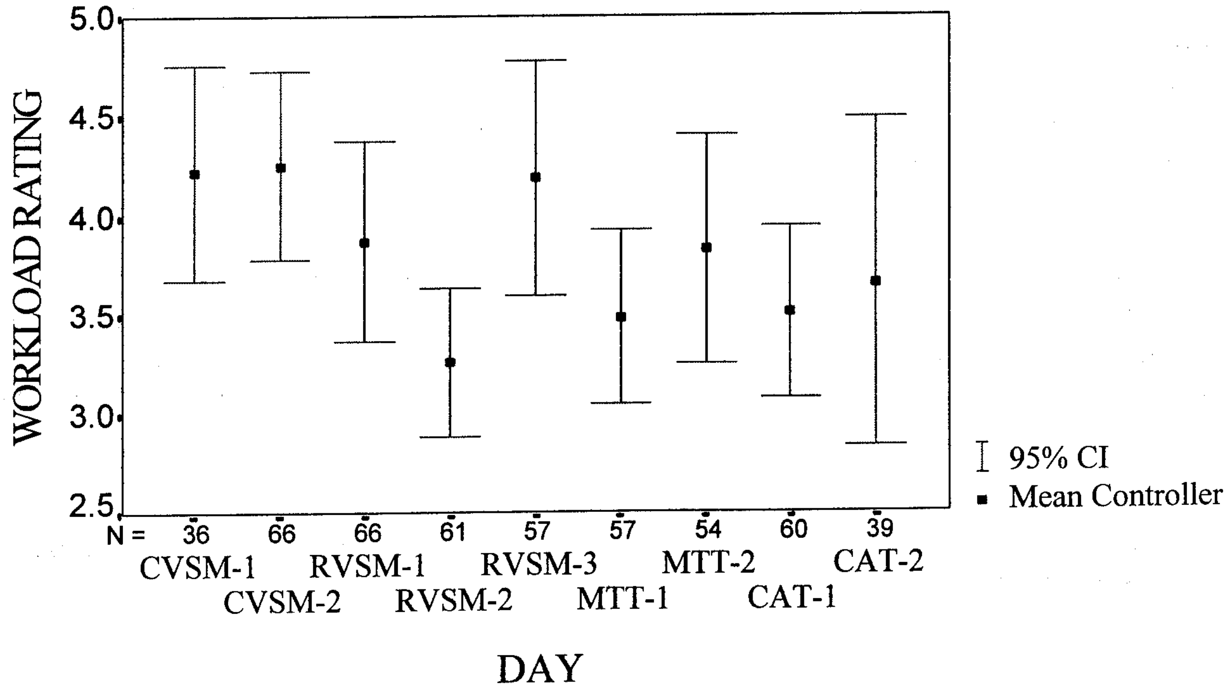


FIGURE 4. 95 PERCENT CI OF CONTROLLER ASSESSED WORKLOAD RATINGS

5.4.1 Workload Based on ARINC Printer Paper.

Experienced Air Traffic Control (ATC) personnel claimed that the length of paper rolled out from an Aeronautical Radio Incorporated (ARINC) printer on the control room floor is an informal metric used to instantly gauge the relative level of controller workload. The total length of an ARINC printer page is determined by the number of messages sent to the printer before a controller tears the paper. The total number of messages that appeared on each sheet of ARINC paper torn during the simulation was recorded. Since each ARINC message had to be read and possibly required flight strip updates or ATC action, paper scraps gave observers access to a readily available and intuitive measure of the amount of task loading on the controllers.

The length (i.e., number of messages) of a piece of torn ARINC paper was assumed to be partially dependent on how busy a controller was with other control activities and the relative level of workload experienced at the time messages were sent. The correlation coefficient for reported controller workload and the maximum number of messages on a piece of paper, $r_s = .3508$, $p < .01$, revealed a very high positive correlation. This indicated that higher workload ratings were associated with a larger number of messages per piece of paper. Accordingly, ARINC printer paper length constituted an objective measure of workload.

When expanded traffic was run with CVSM, the average number of messages was 3.7. When the same traffic was run with RVSM, the average rose slightly to 4.0. However, when traffic was condensed and run with RVSM, the average rose to 5.3. A t-test performed on messages by traffic type resulted in statistical significance, $t = -2.32$, $p = .021$. The same traffic run with RVSM or CVSM had similar average workloads. Tests with complex traffic resulted in a higher controller workload.

5.4.2 Effects of Traffic on Workload.

During pre-simulation discussions, controllers speculated that having a greater percentage of traffic flying track routes would reduce their workload, presumably because they could incorporate the advanced track knowledge into their control plan. The controllers stated that they preferred a traffic flow that consisted of approximately 60 to 75 percent of aircraft on track routes. During debriefing sessions, they revealed that the advanced marking of flight strips with the track-identifying letter and having the tracks shown as a background feature on the Oceanic Display and Planning System (ODAPS) display mitigated high workload conditions. The percentage of aircraft flying track routes and the average workload ratings tabulated from the Quick Form (see section 4.3.1) are displayed in table 15.

The correlation between the amount of aircraft flying track routes and the average D71 workload ratings, $r_s = -.41$, $p < .001$, showed a highly significant negative correlation. This strong inverse relationship revealed that the D71 controller reported being less busy when a higher percentage of the total aircraft were flying track routes and more busy when a high percentage were flying random routes. This trend was apparent when conditions were examined separately within the sector. For example, D71's workload increased from an average of 3.33 for RVSM-2 to 6.53 for

TABLE 15. AVERAGE WORKLOAD RATINGS AND PERCENTAGE OF AIRCRAFT FLYING TRACK ROUTES PER DAY

Day	Aircraft on Tracks	Sector D71 Workload Rating	Sector D72 Workload Rating
CVSM-1	53 %	5.08	4.58
CVSM-2	53 %	4.36	5.72
RVSM-1	53 %	4.32	5.09
RVSM-2	53 %	3.33	4.35
RVSM-3	14 %	6.53	3.05
MTT-1	57 %	3.11	5.21
MTT-2	42 %	5.67	3.72
CAT-1	54 %	3.65	4.80
CAT-2	12 %	5.31	4.15

RVSM-3. RVSM-3 and CAT-2 had the lowest percentages of aircraft flying track routes, 14 percent and 12 percent respectively, and the highest average workload values reported for D71 were during these days.

In contrast, the correlation for the average workload ratings for the D72 controllers and the number of aircraft flying track routes was significantly positive, $r_s = .35$, $p < .001$. This relationship revealed that the D72 controller reported being busier when a high percentage of the total aircraft were flying track routes. Again, this trend was apparent when conditions were examined. It should be noted, however, that the magnitude of the decreased average workload within conditions for D72 was smaller than the magnitude of increased average workload for D71.

These opposite trends can be explained by the track structures used for Phase I. For all days, a larger number of tracks were routed through sector D72 than D71. Therefore, an increase in track traffic increased the traffic through sector D72 and decreased the traffic flow through D71, resulting in the observed changes in average workload ratings for each sector.

An assessment of track percentage versus average workload without regard to sector was performed. CVSM-1 and CVSM-2 were excluded from this analysis since the track percentage was identical for both. Also, RVSM-1 was excluded because it had the same track percentage as RVSM-2. Figure 5 illustrates that the overall effect of increased track traffic was decreased workload.

In each condition, it appeared that workload was highly related to the relative distribution of aircraft flying track routes and random routes. When fewer aircraft were flying on tracks, the track pre-planning knowledge was less effective, and the overall workload increased.

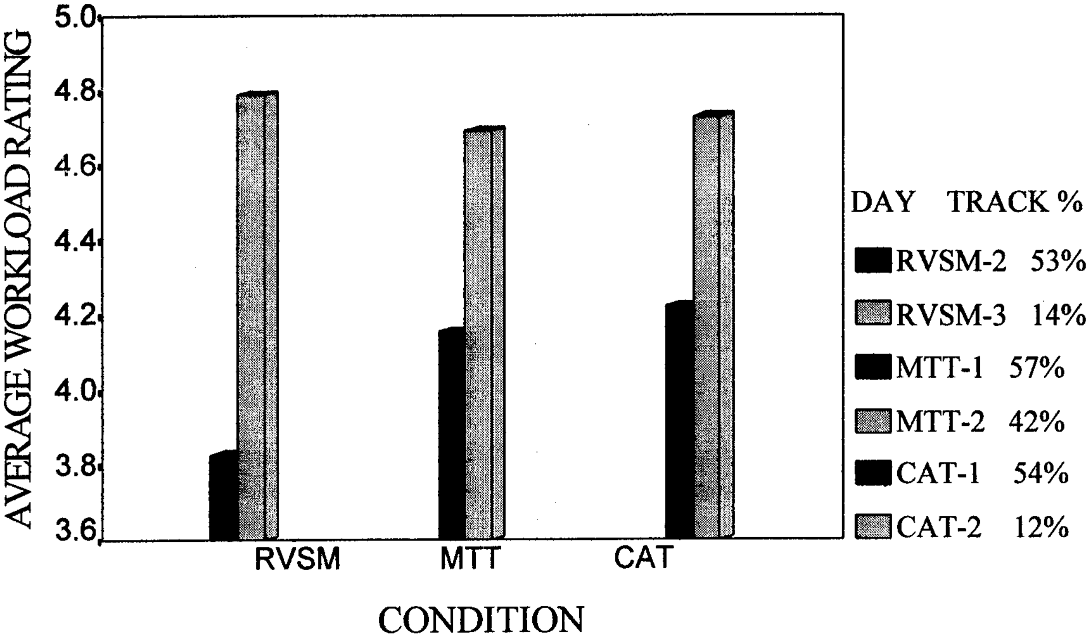


FIGURE 5. AVERAGE WORKLOAD BY CONDITION

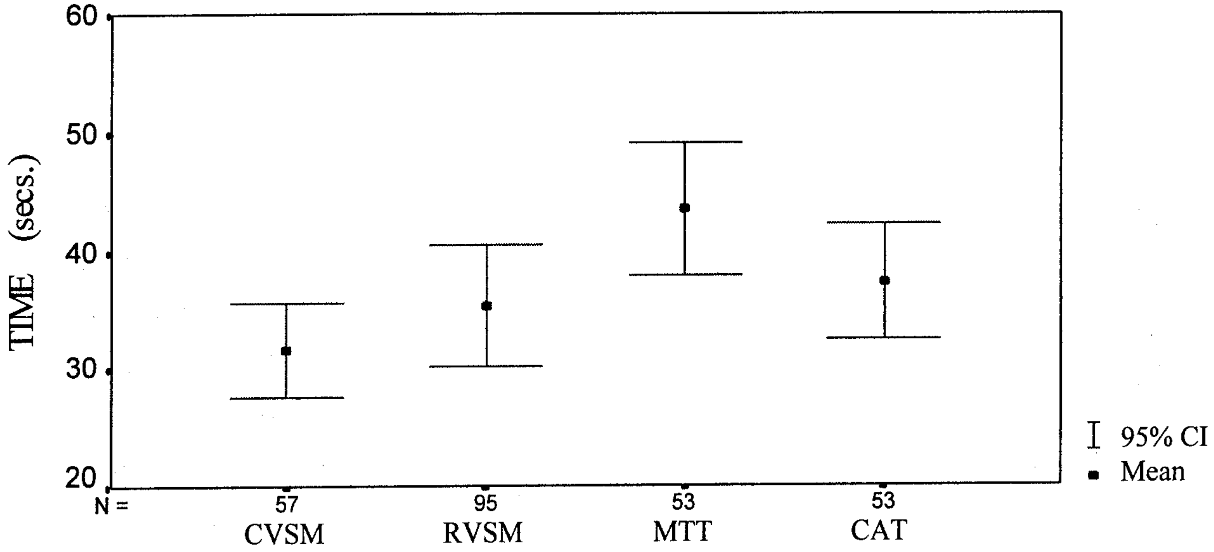
5.5 COMMUNICATIONS.

Controllers reported that RVSM runs required more coordination between sectors D72 and D71 to work out climb clearances. Also under RVSM, especially MTT and CAT, controllers reported having a difficult time coordinating with each other because one or another was on the phone. The amount of time spent on the phone receiving handoff estimates and a random sample of time controllers spent on the phone in general were extracted from audio/video recordings of the simulation.

Figure 6 illustrates the 95 percent CI for the average time it took for a controller to receive one handoff estimate given by an adjacent sector or FIR.

A non-parametric test (Kruskal-Wallis) showed a significant difference in average times across conditions, $\chi^2= 18.13$, $p = .000$. The smallest average time, 31.67 seconds, was observed under CVSM, and the numbers increased to as high as 43.62 under MTT. Controllers stated that the increased number of altitudes under RVSM resulted in longer flight strip scanning times. This possibly accounted for the increase in time to receive a handoff estimate.

A non-parametric test (Mann-Whitney) of the same data grouped by traffic type showed a significant difference in average times between traffic types, $Z = -3.28$, $p = .001$. An average time of 34.78 seconds was observed when traffic was expanded. The average rose to 40.88



CONDITION

FIGURE 6. MEAN TIME FOR A HANDOFF ESTIMATE TO BE RECEIVED BY CONTROLLERS

seconds when traffic was condensed, indicating increased time to receive a handoff estimate when traffic was condensed. This trend was observed within each condition. For example, MTT-2 (condensed) had a higher average time than MTT-1 (expanded).

Figure 7 illustrates the 95 percent CI for the average elapsed time for a random sample of controller phone conversations.

A Kruskal-Wallis Test revealed a significant difference in the length of a phone conversation between conditions, $\chi^2 = 17.56$, $p = .001$. Examination of figure 7 showed virtually no difference between CVSM ($\mu = 37.3$) and RVSM ($\mu = 37.2$). Average times greatly increased under the MTT ($\mu = 49.3$) and CAT ($\mu = 51.1$) conditions, supporting controller claims.

The average number of calls controllers made per hour to adjacent sectors and FIRs was calculated. The smallest average was observed under MTT, 43 calls per hour. RVSM had the largest average, 56 calls per hour. Controllers commented that less coordination was necessary when more aircraft were flying track routes, (i.e., MTT). Also, aircraft exiting sector D72 to the north did not need to be transitioned back to a CVSM altitude. A majority of the published tracks during the MTT runs were in the northern part of D72. The RVSM runs had more random routing.

During debriefing sessions, controllers also mentioned that when operating under RVSM, more information needed to be relayed to the relieving controller which resulted in longer position relief briefings. This information included conveying information about which aircraft needed to

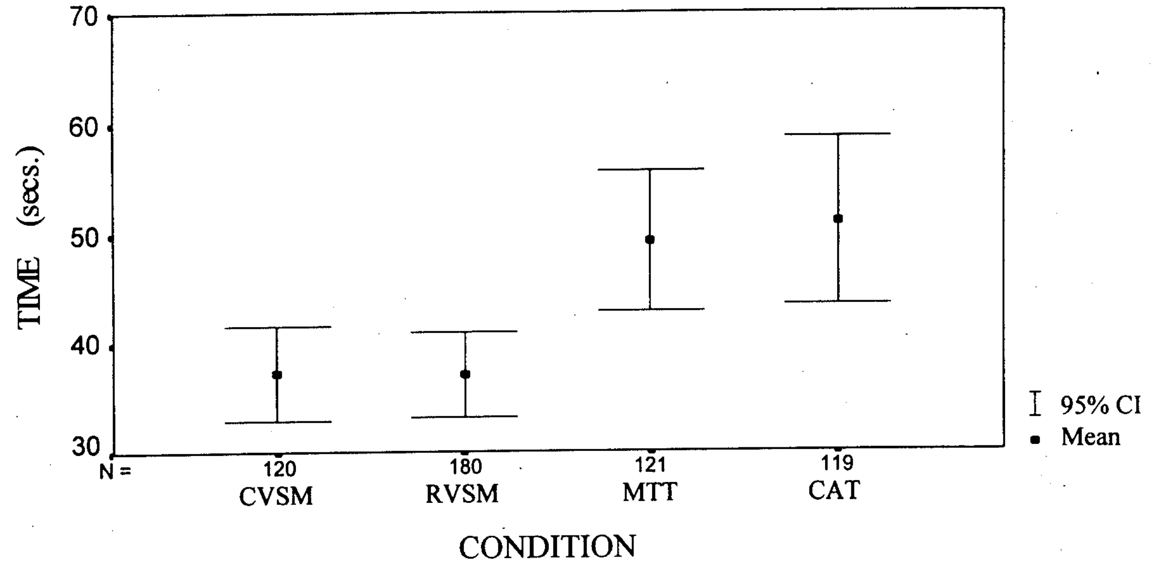


FIGURE 7. MEAN TIME OF A CONTROLLER PHONE COMMUNICATION

be moved out of their altitudes. Lengths of the position relief briefings were not recorded, therefore, data is reported.

6. DISCUSSION.

Controllers were instructed to transition aircraft from RVSM to CVSM before leaving the RVSM/ Minimum Navigation Performance Specification (MNPS) airspace, with the exception of aircraft that entered radar coverage adjacent to RVSM/MNPS airspace or Canadian airspace. The following findings and recommendations are based on controllers' simulation experience with RVSM transitioning in nonradar airspace.

Controllers' unfamiliarity with new altitudes and traffic patterns attributed to the operational errors observed during the RVSM runs. After limited exposure to RVSM through simulation, controllers felt RVSM could be effectively implemented with minimal errors. However, in order for controllers to safely and effectively operate under RVSM, clearly defined procedures are required. The following issues should be addressed:

a. When reverting back to CVSM from RVSM, is legal separation defined by 2000 feet between aircraft regardless of altitude (odd or even) or only by 2000 feet using conventional altitudes?

b. Since there is no instantaneous reversion to CVSM, what is legal and how should this be accomplished (i.e., can controllers climb several aircraft at once)?

c. During a CAT situation, do all aircraft in the airspace need to be reverted back to conventional altitudes, or should only the reporting aircraft be removed from the turbulent altitude?

In addition to ensuring safe control of traffic, the controllers' abilities to effectively service aircraft were examined. The introduction of RVSM did not reduce the quality of service to the airlines. When either separation (RVSM or CVSM) was applied to the same traffic situation, controllers were just as likely to deny or approve pilot requests. In fact, the availability of more altitudes allowed more aircraft to fly at or near their optimum altitudes. It was mentioned, however, that better altitude assignment would be possible if all aircraft operating in the MNPS airspace were RVSM-certified and equipped. This would allow controllers to apply minimum separation to all aircraft, thus providing more availability for optimum altitudes.

When trying to devise an effective traffic plan under RVSM, controllers found a greater need for WAH information than they did under CVSM. Due to the increase in communications necessary to receive such information, WAH information should be available without a controller request. Some concerns about the possible impact of having to request WAH were raised during debriefing sessions. They included a greater occurrence of confusion among foreign pilots between requests for altitude information and actual clearances, and the unavailability and inaccuracy of remarks about WAH in the International Civil Aviation Organization flight plans. Controllers suggested ways to make WAH available to controllers without request. These included: creating a coordinator position at all ATC centers to alleviate controllers of some of their less critical duties; having Santa Maria Air Route Traffic Control Center (ARTCC) include WAH information when they pass estimates to New York ARTCC (ZNY); and having pilots report WAH information.

Controller workload was a primary concern of this simulation. Analyses indicated that although interval increases in workload were observed, the overall impact of RVSM resulted in no increase in controller workload compared to CVSM. Controllers mitigated high interval workload by allowing the ODAPS controller to be more active in traffic coordination and climbs.

When faced with the potential for high workload conditions, controllers stated that having sufficient time for pre-planning and having advanced, detailed knowledge of the track structure for that day was important for managing the traffic load. The amount of pre-planning a controller could accomplish, based on track knowledge, effected his/her ability to manage high traffic loads. Discerning from this, aircraft flying random non-track routes seemed to demand more of the controllers' resources than aircraft flying track routes. As a result, controllers suggested minimizing random routing to help alleviate high interval workload levels.

During simulation, controllers experienced additional differences between RVSM and CVSM. Under RVSM, controllers experienced longer position relief briefings, longer flight strip scanning times due to unfamiliarity of altitude patterns, and in some cases, increased communications. As a result, controllers made some suggestions: assign the ODAPS controller more responsibility to help coordinate traffic and to assist with climbs; create a planner position at the Centers to start an off-loader track and to relieve controllers of less critical duties during busy periods; allow transitions to occur in radar sectors; split sectors on a daily basis considering track positions; and minimize random routing.

The increased available altitudes under RVSM provided greater flexibility for managing traffic. These altitudes are most effective if all aircraft operating in RVSM airspace are certified and equipped. Based upon the Phase I RVSM simulation results, the introduction of RVSM in New York ARTCC's Oceanic Airspace is feasible provided that certain procedures are well defined and agreed upon prior to implementation.

APPENDIX A
CONTROLLER AND OBSERVER BACKGROUND INFORMATION

Observers:

Observer # 5720 = Observer Y [Observer X for Part II]
Observer # 2793 = Observer X [Observer Y for Part II]

Controllers:

Controller #3009 = Controller A [for both Part I and Part II]
Controller #5116 = Controller B [for both Part I and Part II]
Controller #2145 = Controller C [Not present for Part II]
Controller #8231 = Controller D [Controller C for Part II]

TABLE A-1. CONTROLLER BACKGROUND INFORMATION SUMMARY[1]

	Controllers:				Observers:		Controller:	
	A	B	C	D	X	Y	Mean	Mode
Ages	25	29	29	41	34	34	31	29
Years FPL	0	3	3	7	6	1	3.25	3
Years Oceanic	0	3	3	7	6	1	3.25	3
Years as NAT FPL Oceanic Controller	0	3	3	7	4	1	3.25	3
Months since controlling oceanic	0	0	0	0	0	0	0	0
Years as a trainer in ATC	0	4	-	10	5	3.5	4.67	-
Facilities worked	ZNY	ZNY	ZNY	ZNY	ZNY	ZNY		

Q1. If you had the opportunity to change three current elements in the oceanic area (practices, procedures, equipment, etc.) what would they be?

---

[1] Controller and Observer Designations refer to Part I Assignment Scheme.

A1.

X	Equipment - Some type of radar or global positioning system. Communications - direct contact with aircraft. Telephone Systems - more reliable links with other facilities.
Y	Increase strip printing speed. Increase ODAPS update rate. Consider a coordinator position to call QX & PAZ on heavy eastbound flows.
A	Eliminate grease pencils and Plexiglas maps, and provide fully automated map displays.
B	Would like to be on-line with foreign facilities. This would help to reduce the time it takes for coordination.
C	Reliable visual automation for separation use. Reliable communications to aircraft. Two controllers per sector during heavy periods for safety.
D	Equipment. Accurate visual presentation by two-way satellite link with aircraft navigation equipment. Procedures. A separate coordination position would increase sector efficiency during high density traffic.

Q2. Based on your experience with high traffic and high workload in oceanic operations - a. What are some of the things that can occur that could cause a controller to have significant difficulties in maintaining an orderly and expeditious traffic flow ?

A2a.

X	Weather is an important factor, as are equipment problems (phone line outages), and inexperience of control personnel.
Y	Strip generation backlogged. Increasing pressure on approving altitudes on eastbound flights. Falling behind on ARINC progresses during saturation traffic, especially when time revisions are routinely occurring.
A	Board space is limited, overflowing bays of flight strips allows for mismarking altitudes, times, etc. Random crossing traffic presents problems. Following successive strips on random routes where flight paths of aircraft cross and re-cross sometimes presents problems.
B	Not having flight strips on aircraft entering my sector. Coordination difficulties (not answering the line).
C	Poor staffing during heavy traffic periods, slow flight strip generation.
D	Inordinately long time spent on the phone to accomplish manual coordination. Lack of board space. Strip printing.

Q2b. Which of these events tend to occur most frequently ?

A2b.

X	Weather.
Y	No response.
A	No response.
B	Not having strips.
C	Both.
D	Lack of board space.

Q2c. Which of these events would most likely cause additional problems?

A2c.

X	Telephone problems. Inexperienced controllers.
Y	Backlogged strip generation- allows less time to plan traffic flow.
A	As air traffic increases and more aircraft are thrown into the picture, it becomes increasingly difficult to follow complex random flight paths and to provide all aircraft "good" fuel efficient altitudes without any real automation to assist ATC.
B	Not having strips causes a domino effect. Aircraft are spinning and the flow (regulation) of traffic deteriorates.
C	Both.
D	Coordination phone time.

Q3. Which items below do you feel contribute significantly to high levels of workload in the current oceanic ATC system ?

A3.

	A	B	C	D	X	Y	Response Frequency
Printer Speed ODAPS	✓	✓	✓	✓		✓	5
Printer Speed ARINC							0
ODAPS Update Rate						✓	1
ARINC Com Delays					✓		1
Phone System			✓		✓		2
Special Pilot Requests	✓			✓			2
Coordination with Foreign Facilities	✓	✓	✓	✓	✓	✓	6
Coordination with Fellow Controllers		✓	✓		✓		3
Oceanic Track System							0
Random Routes	✓		✓				2
Aircraft Performance Characteristics/Mix			✓				1
OTHER			Speed of flight-strip printer				-

Additional Comments

X	Much time is spent and lost because of the items in Q1. Sometimes coordination can take several minutes because of inexperienced/weak control personnel.
A	Pilots often request higher altitudes and in many cases, ATC must step climb other aircraft to comply with pilot requests. To climb aircraft and get all necessary read backs from ARINC takes up a great deal of time. Coordination with foreign facilities, for example, taking estimates (numerous) from Santa Maria, can take as much as 10-15 minutes. Problems with random routes are mentioned previously.
B	The speed of the ODAPS printer affects everything. All traffic hinges on the strips which controllers can't get in time. This also affects coordination with other controllers and facilities.
C	Strip generation lags during heavy traffic periods. Coordination becomes very time consuming for both sides. Incorrect information from pilots (bad estimate, wrong altitude report, etc.) has a snowballing effect at the sector. All of these factors increase workload sharply.
D	Foreign coordinations take the longest because other facilities use separate coordinators who don't have the feeling of urgency a controller has.

APPENDIX B
MAPS, AIRSPACE, AND TRACK STRUCTURE

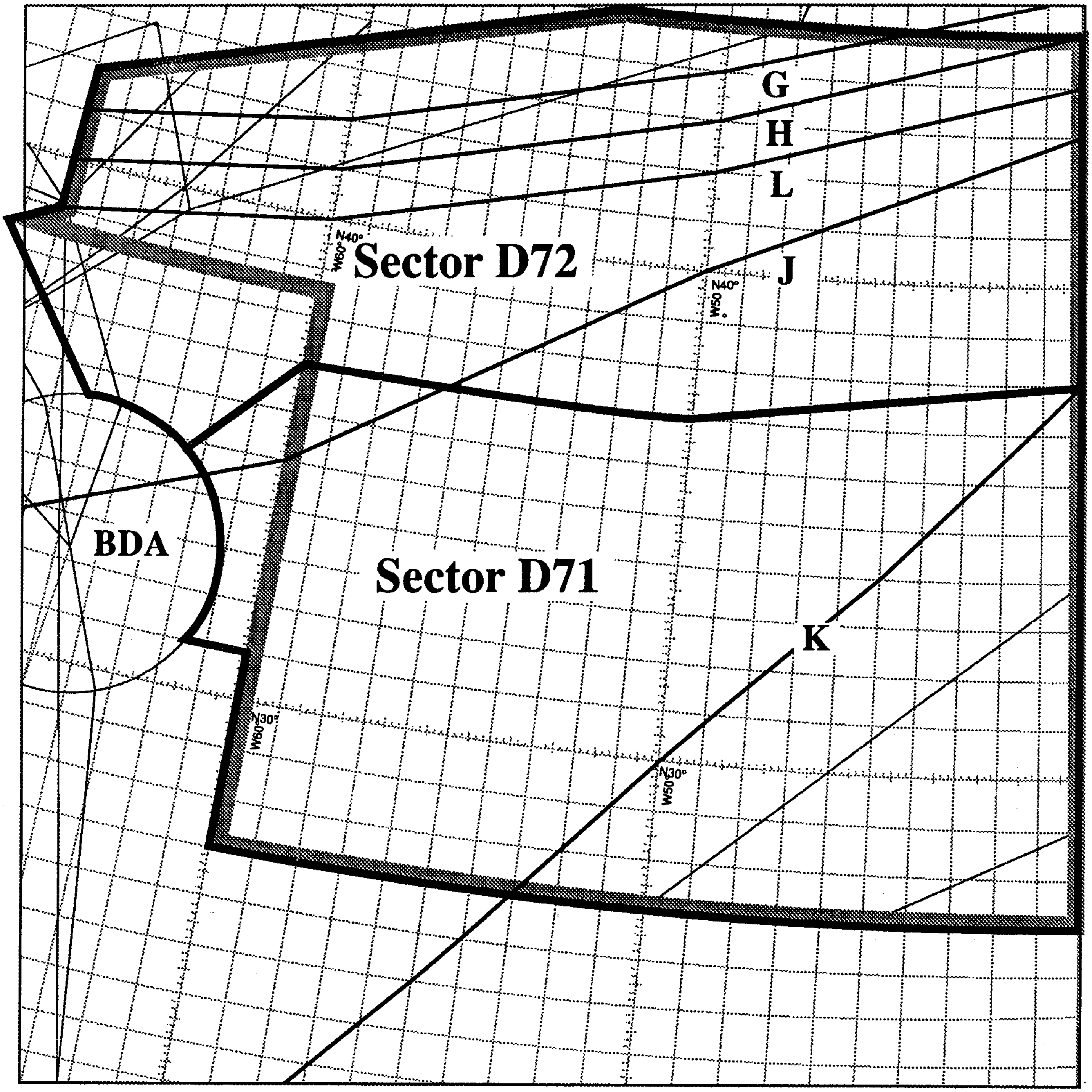


FIGURE B-1. PHASE 1 - PART 1 CVSM 1-2, RVSM 1-2

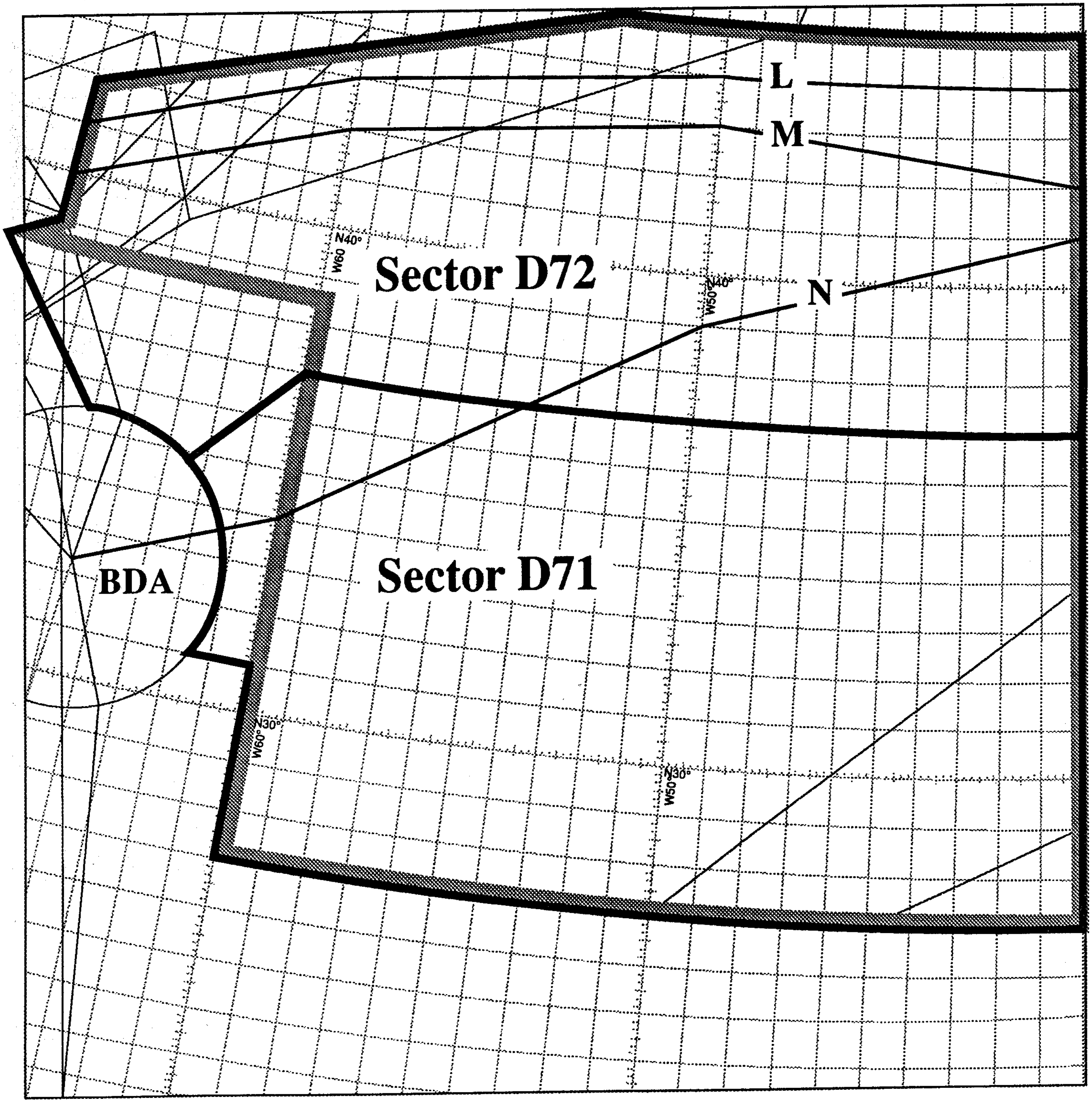


FIGURE B-2. PHASE 1 - PART 2, RVSM

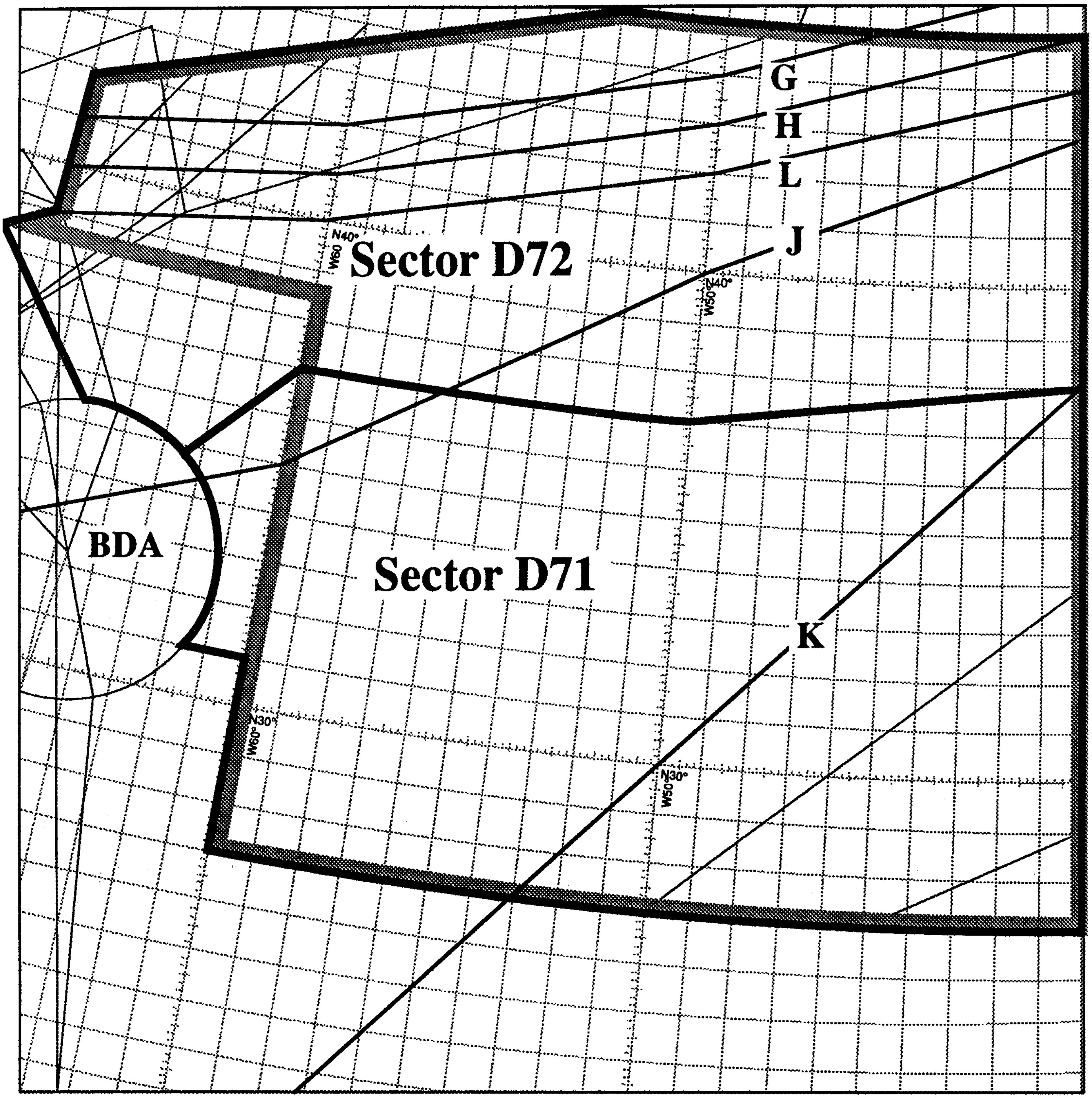


FIGURE B-3. PHASE 1 - PART 2, MTT-1

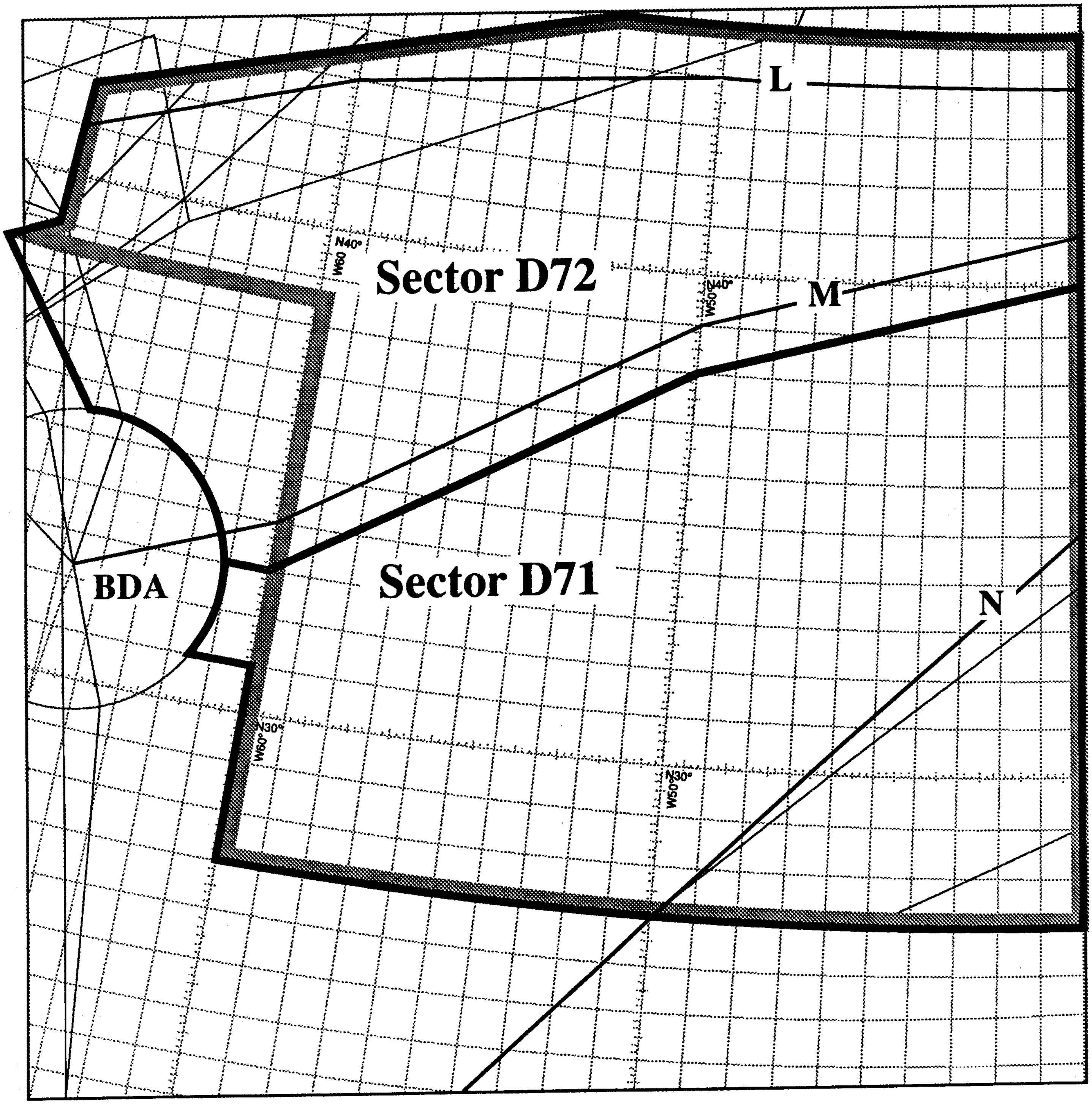


FIGURE B-4. PHASE 1 - PART 2, MTT-2

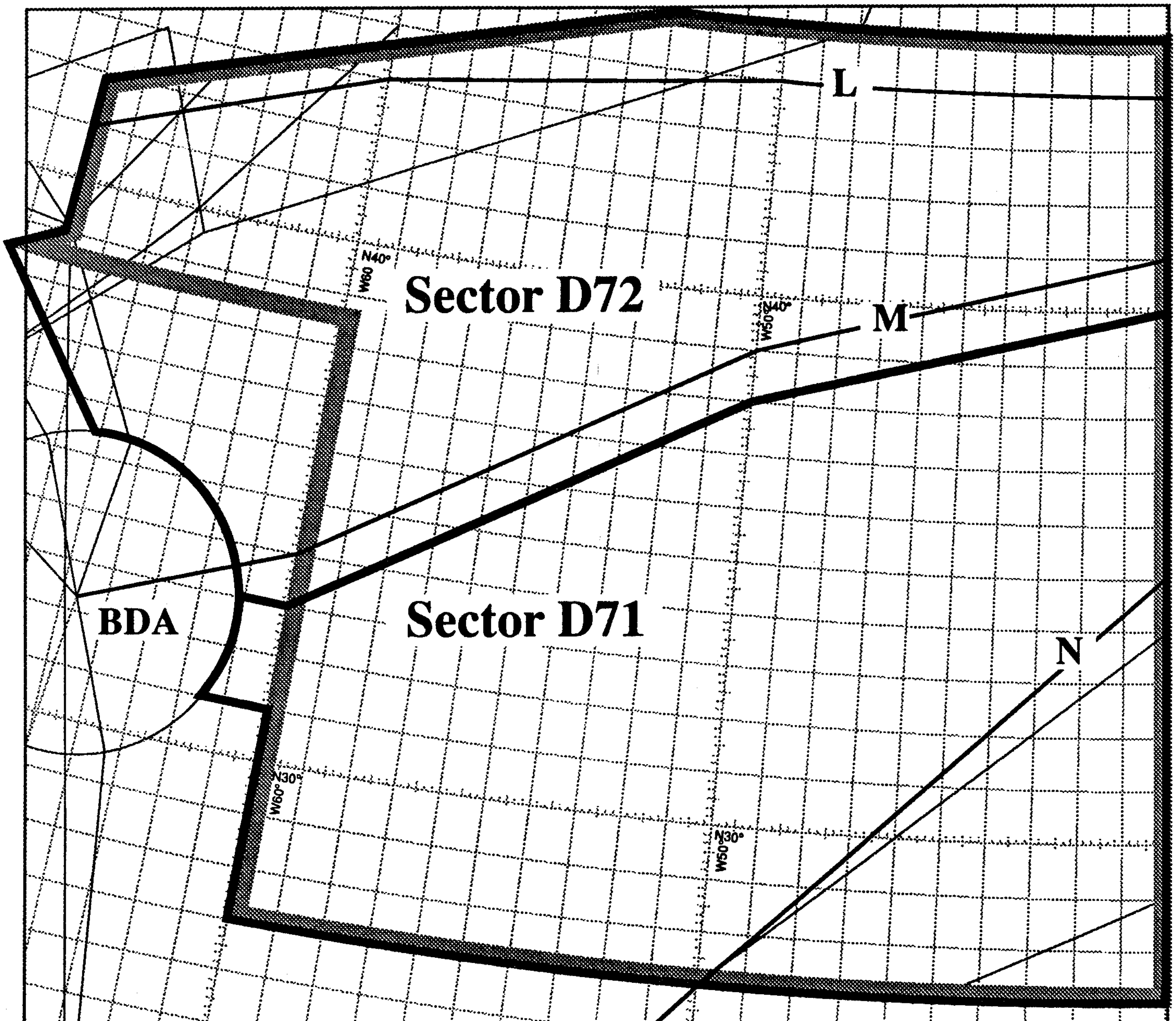


FIGURE B-5. PHASE 1 - PART 2, CAT-1

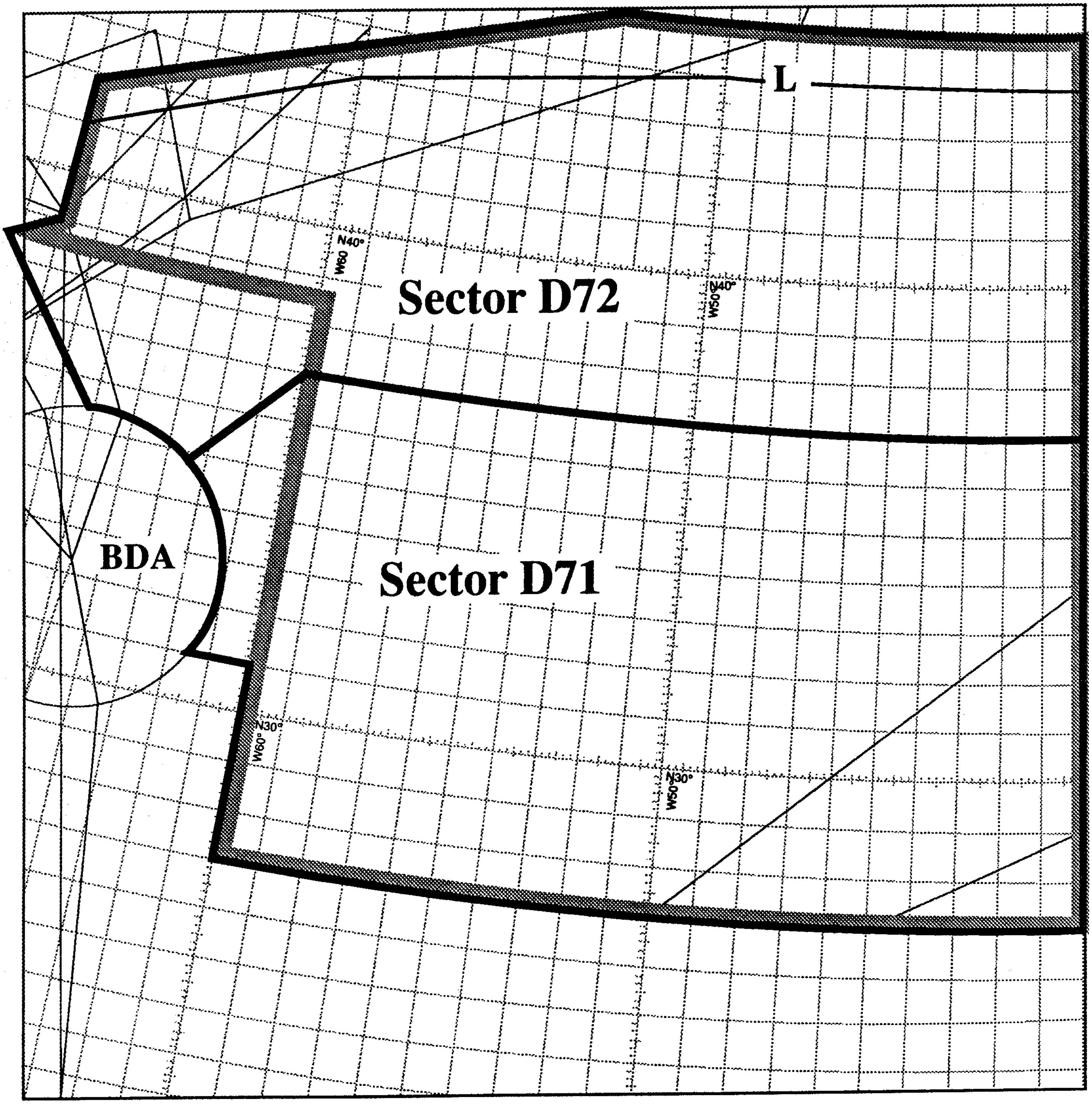


FIGURE B-6. PHASE 1 - PART 2, CAT-2

APPENDIX C.
FORMS and QUESTIONNAIRES

1. This form is to be completed by all controllers prior to participation in the NSC Phase I Simulation activities. The form consists of requests for general background information and an initial (baseline) judgment regarding oceanic control practices.

2. Controllers should be advised that their names will not be listed or appear in any of the NSC's data records to insure anonymity and to encourage unbiased reporting. Findings will be reported as group data and generically, as Controller A, B, C, etc. In order to facilitate data analysis, the experimenters will use the last four digits of a controller's social security number to collate various data records belonging to a particular simulation subject.

NSC SIMULATION: CONTROLLER FORM I.

GENERAL BACKGROUND INFORMATION

Date: ____________
Last four digits of your Social Security Number: _________
Age: _______
How many years of experience as a (FPL) controller? _______years_______months
How many years of experience as an Oceanic FPL? ___years ____ months
How much time as an oceanic controller in the North Atlantic Region? _______
Name the last three facilities at which you have worked starting with your current assignment:
(1)____________________ (2)______________________ (3)__________________

GENERAL PROCEDURES & PRACTICES INFORMATION

1. If you had an opportunity to change three current elements in the oceanic area (practices, procedures, equipment, etc.), what would they be?

2. Based on your experience with high traffic and high workload in oceanic operations

a) What are some of the things that can occur that could cause you to have significant difficulties in maintaining an orderly and expeditious traffic flow ?

b) Which of these events tend to occur most frequently?

c) Which of these events tend to most likely cause additional problems?

3. Please check all items below that you feel contribute significantly to high levels of workload in the current oceanic ATC system:

- ☐ Printer Speed ODAPS__ ARINC__
- ☐ ODAPS Update Rate
- ☐ ARINC Communication Delays
- ☐ Phone System
- ☐ Special Pilot Requests
- ☐ Other ____________________
- ☐ Coordination with Foreign Facilities
- ☐ Coordination with Fellow Controllers
- ☐ Oceanic Track System
- ☐ Random Routes
- ☐ Aircraft Performance Characteristics/Mix
- ☐ Other ____________________

Please include comments (explanations) on any of the above checked items:

NSC SIMULATION: OBSERVER FORM I.
INSTRUCTIONS:

1. This form is to be completed by all technical observers prior to participation in the NSC Phase I Simulation activities. The form consists of requests for general background information and an initial (baseline) judgment regarding oceanic control practices.

2. Observers should be advised that their names will not be listed or appear in any of the NSC's data records to insure anonymity and to encourage unbiased reporting. Findings will be reported as group data and generically, as Observer X, and Y. In order to facilitate data analysis, the experimenters will use the last four digits of a controller's social security number to collate various data records belonging to a particular simulation subject.

NSC SIMULATION: OBSERVER FORM I.

GENERAL BACKGROUND INFORMATION

Date: ______________
Last four digits of your Social Security Number: __________
Age: _______
How many years of experience as a (FPL) controller? _______years________months
How many years of experience as an Oceanic FPL? ___years ____ months
How much time as an oceanic controller in the North Atlantic Region? _______
How many years/months since you have controlled oceanic traffic?
How many years/months as a trainer/developer in an ATC facility?

GENERAL PROCEDURES & PRACTICES INFORMATION

1. If you had an opportunity to change three current elements in the oceanic area (practices, procedures, equipment, etc.), what would they be?

____
____
____
____

2. Based on your experience with high traffic and high workload in oceanic operations;
a) What are some of the things that can occur that could cause you to have significant difficulties in maintaining an orderly and expeditious traffic flow ?

____
____

b) Which of these events tend to occur most frequently?

____
____

c) Which of these events tend to most likely cause additional problems?

____
____

3. Please check all items below that you feel contribute significantly to high levels of workload in the current oceanic ATC system:

☐ Printer Speed ODAPS__ ARINC__
☐ ODAPS Update Rate
☐ ARINC Communication Delays
☐ Phone System
☐ Special Pilot Requests
☐ Other ____________________

☐ Coordination with Foreign Facilities
☐ Coordination with Fellow Controllers
☐ Oceanic Track System
☐ Random Routes
☐ Aircraft Performance Characteristics/Mix
☐ Other ____________________

Comments on any of the above checked items:

____
____
____

NSC SIMULATION: CONTROLLER FORM II.
INSTRUCTIONS:

1. This form is to be completed by all controllers after each completed simulation run in the NSC Phase I Simulation activities. The form consists of requests for information regarding overall experiences and judgments about the just completed simulation run.

2. The RATING NUMBERS to be used for item #4 are:
   1 = Remarkably good
   2 = Moderately good
   3 = So-so
   4 = Not very good
   5 = Unusually poor

3. Page 2 of the Form consists of two different versions: Version 1 is to be filled out after CVSM (baseline) simulation runs, Version 2 is to be filled out after simulations with RVSM conditions. The difference between these two versions is that Version 2 elicits additional, RVSM-specific information.

NSC SIMULATION: CONTROLLER FORM II.
POST SIMULATION RUN QUESTIONNAIRE

Simulation Condition: ______________________________

Your SS#-(4 last digits) ________Date:__________Simulation Run No:________

1. Please estimate your overall WORKLOAD during the last simulation (circle one)?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
VERY LOW				**MODERATE**					**VERY HIGH**

2. In terms of REALISM, how real was the PHYSICAL SIMULATION ENVIRONMENT for you (circle one)?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
VERY LOW				**MODERATE**					**VERY HIGH**

3. In terms of FUNCTIONAL REALISM, how real was the SIMULATED TRAFFIC for you (circle one)?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
VERY LOW				**MODERATE**					**VERY HIGH**

4. Please judge your OWN PERFORMANCE over the most recent simulation run. Using the RATING NUMBERS from the instruction sheet, for each position worked, insert the appropriate rating into each box next to the following factors:

H-POSITION	RADAR-POSITION
☐ Proper Coordination	☐ Proper Coordination
☐ Promptness of Actions	☐ Promptness of Actions
☐ Situation Awareness Maintenance	☐ Situation Awareness Maintenance
☐ Communication Management	☐ Communication Management
☐ Proper Message Construction	☐ Proper Clearances Issued
☐ Computer Entry Management	☐ Flight Strip Management
☐ Other________________	☐ Maintenance of Separation

5. What was most difficult for you to accomplish during the simulation ?

a) (at the) ODAPS Position   b) (at the) "D" Position

____

____

____

NSC SIMULATION: CONTROLLER FORM II (continued)
CVSM (Baseline) CONDITIONS

6. If you could change something about the last simulation run (anything at all about the traffic scenario, aircraft, procedures, etc.) , what would it be ?

7. Did you change your usual control and work strategies in any way in order to work the traffic in the last simulation? If so, how? What did you do differently?

8. Based upon your experience with the traffic load during the last simulation run, what procedures would have to be changed and/or implemented in order for you to continue to be comfortable about working this same traffic but under reduced vertical separation minima (RVSM)?

9. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

NSC SIMULATION: CONTROLLER FORM II (continued)
RVSM CONDITIONS

6. If you could change something about the last simulation run (anything at all about the traffic scenario, aircraft, procedures, etc.) , what would it be ?

7. Did you change your usual control and work strategies in any way in order to work the traffic with RVSM? If so, how? What did you do differently?

8. Based upon your experience with RVSM in the last simulation run, what procedures (equipment) would have to be changed and/or implemented in order for you to continue to be comfortable about transitioning this traffic ?

9. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

Supplementary Background Information

(to be completed by all simulation participants)

Controller # ______________________

(Last four digits of your Social Security Number)

1. Please indicate the total time you have worked as a full performance level controller (in any control position, not only oceanic):

YEARS _______ MONTHS_________

2. Please indicate the total time you have worked as a full performance level *oceanic radar* controller (only oceanic experience):

YEARS _______ MONTHS_________

3. Please indicate the total time you have worked as a full performance level oceanic radar controller with North Atlantic traffic (as opposed to Pacific traffic):

YEARS _______ MONTHS_________

4. Please indicate how long it has been *since* you last controlled oceanic radar traffic (i.e., indicate 0 if currently active):

YEARS _______ MONTHS_________

5. Please indicate the total experience you have as a trainer of controllers (for any control position):

YEARS _______ MONTHS_________

6. Starting with your current facility, please list all FAA facilities which you have worked in throughout your career as a controller:

(1)_______ (2)_______ (3)_______ (4)_________

NSC SIMULATION: OBSERVER FORM II.
INSTRUCTIONS:

1. This form is to be completed by all observers after each completed simulation run in the NSC Phase One Simulation activities. The form consists of requests for information regarding overall experiences and judgments about the just completed simulation run.

2. The RATING NUMBERS to be used for item #4 are:
   1 = Remarkably good
   2 = Moderately good
   3 = So-so
   4 = Not very good
   5 = Unusually poor

3. Page 6 of the Form consists of two different versions: Version 1 is to be filled out after CVSM baseline simulation runs, Version 2 is to be filled out after simulations with RVSM. The difference between these two versions is that version 2 elicits additional, RVSM-specific information.

NSC SIMULATION: OBSERVER FORM II.
POST SIMULATION RUN QUESTIONNAIRE

Simulation Condition: ☐ CVSM ☐ RVSM ☐ RVSM-MTT ☐ RVSM-CAT

Observer ID# ____________ Date: ____________ Simulation Run No.: ____________

1a. For each controller please estimate the overall "D" position WORKLOAD during the last simulation (circle one):

Controller SS# (four digits)__________

1	2	3	4	5	6	7	8	9	10
VERY LOW				**MODERATE**					**VERY HIGH**

Controller SS# (four digits)__________

1	2	3	4	5	6	7	8	9	10
VERY LOW				**MODERATE**					**VERY HIGH**

1b. For each controller please estimate the overall ODAPS position WORKLOAD during the last simulation (circle one):

Controller SS# (four digits)__________

1	2	3	4	5	6	7	8	9	10
VERY LOW				**MODERATE**					**VERY HIGH**

Controller SS# (four digits)__________

1	2	3	4	5	6	7	8	9	10
VERY LOW				**MODERATE**					**VERY HIGH**

NSC SIMULATION: OBSERVER FORM II. (continued)

2. In your opinion, in terms of REALISM, how real was the PHYSICAL SIMULATION ENVIRONMENT for the controllers (circle one)?

1	2	3	4	5	6	7	8	9	10
VERY LOW				**MODERATE**					**VERY HIGH**

3. In your opinion, in terms of FUNCTIONAL REALISM, how real was the SIMULATED TRAFFIC for the controllers (circle one)?

1	2	3	4	5	6	7	8	9	10
VERY LOW				**MODERATE**					**VERY HIGH**

4. Please judge OVERALL CONTROLLER PERFORMANCE during the most recent simulation run. Using the RATING NUMBERS from the instruction sheet, insert the appropriate rating number for each of the positions observed into the box next to each of the following factors:

Controller SS# (4 digits)______________

ODAPS POSITION	D POSITION
☐ Proper Coordination	☐ Proper Coordination
☐ Promptness of Actions	☐ Promptness of Actions
☐ Situation Awareness Maintenance	☐ Situation Awareness Maintenance
☐ Communication Management	☐ Communication Management
☐ Proper Message Construction	☐ Proper Clearances Issued
☐ Computer Entry Management	☐ Flight Strip Management
☐ Other__________________	☐ Maintenance of Separation

NSC SIMULATION: OBSERVER FORM II. (continued)

Controller SS# (4 digits)_____________

ODAPS POSITION	D POSITION
☐ Proper Coordination	☐ Proper Coordination
☐ Promptness of Actions	☐ Promptness of Actions
☐ Situation Awareness Maintenance	☐ Situation Awareness Maintenance
☐ Communication Management	☐ Communication Management
☐ Proper Message Construction	☐ Proper Clearances Issued
☐ Computer Entry Management	☐ Flight Strip Management

☐ Other____________________ ☐ Maintenance of Separation

5. What was most difficult for controllers to accomplish during this simulation ?

a) (at the) ODAPS Position b) (at the) D Position

6. If you could change something about the last simulation run (anything at all about the traffic scenario, aircraft, procedures etc.), what would it be ?

NSC SIMULATION: OBSERVER FORM II (continued)
CVSM (Baseline) CONDITIONS

7. Did the controllers change their usual control and work strategies in any way in order to work the traffic in the last simulation? If so, how? What did they do differently?

8. Based upon your observations with the traffic load during the last simulation run, what procedures (equipment) would have to be changed and/or implemented in order for the controllers to be comfortable about working this same traffic but under reduced vertical separation minima (RVSM)?

9. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

NSC SIMULATION: OBSERVER FORM II (continued)
RVSM CONDITIONS

7. Did the controllers change their usual control and work strategies in any way in order to work the traffic with RVSM? If so, how? What did they do differently?

8. Based upon your observations with RVSM in the last simulation run, what procedures would have be changed and/or implemented in order for the controllers to continue to be comfortable about working this traffic?

9. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

NSC SIMULATION: <u>TECHNICAL OBSERVER "QUICK" FORM.</u>
INSTRUCTIONS:

1. This form is to be completed by trained technical observers during each simulation run.

2. Observations and responses will be recorded in 15 minute intervals. A new (identical) form should be used for each 15 minute time period.

3. Observations will be made on this form primarily for the "Radar-Position" controller. However, both controllers (Radar and Hand-off) will be prompted for their workload rating at 15 minute intervals and the observer will make "quick evaluations" about performance on both positions.

4. The rating numbers for <u>WORKLOAD</u> are on a scale from 1 to 10 with
   1 = very low workload
   5 = moderate workload
   10 = very high workload

5. The rating numbers for the rest of the QUICK EVALUATIONS are
   1 = Remarkably good
   2 = Moderately good
   3 = So-so
   4 = Not very good
   5 = Unusually poor

TECHNICAL OBSERVER "QUICK" FORM.

INTERVAL: _______ TIME:_____:____:____ Simulation Run No.______________

Date:________ Sector Number:________ Observer ID (SS#)__________________

Prompt for workload rating from the controllers every 15 minutes!

WORKLOAD RATING - "D" Controller :	1 2 3 4 5 6 7 8 9 10
WORKLOAD RATING - "ODAPS" Controller :	1 2 3 4 5 6 7 8 9 10

RESTRICTIONS ISSUED (hash marks):

SPEED

TIME

ALTITUDE

ROUTING

ARINC COMMUNICATIONS GROUPINGS (hash marks):

ONE CLEARANCE

TWO AT A TIME

THREE AT A TIME

FOUR OR MORE AT A TIME

OPERATIONAL ERROR(s) OBSERVED:

TIME:_____:_______:_____ ☐ Loss of Separation

☐ Other____________________

Briefly describe what happened:

QUICK OBSERVER EVALUATIONS (circle one)

ODAPS CONTROLLER	D CONTROLLER
WORKLOAD RATING	
1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
COORDINATION & COMMUNICATION	
1 2 3 4 5	1 2 3 4 5
TRAFFIC MANAGEMENT & CONTROL JUDGMENT	
1 2 3 4 5	1 2 3 4 5
FLIGHT STRIP MANAGEMENT	
1 2 3 4 5	1 2 3 4 5

APPENDIX D.
SUMMARY OF POST-SIMULATION RESPONSES

TABLE D-1. POST-SIMULATION RESPONSES

QUESTION: What was the most difficult for controllers (you) to accomplish during this simulation?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
Training	Working around the equipment people.	No response.	Manually inputting all altitude level reports.	Getting altitude reports for climbing.	No response.	No response.
CVSM-1	No response.	No response.	(1) Separation of data blocks. (2) Marking "NAR" amendments to routes of flight.	Keeping data blocks apart. At times you were unable.	No response.	Keeping up with the updates after numerous start-overs.
CVSM-2	No response.	Keep data blocks from overlapping.	Separation of data blocks was somewhat difficult yet easier than yesterdays simulation (CVSM Day 1). Perhaps today I just had more time to keep up with things.	Enter progress reports on reject messages.	Separating data blocks.	Figuring out why some progresses rejected when there didn't seem to be anything wrong with them.
RVSM-1	No response.	No response.	Separation of data blocks.	ODAPS temporarily failed.	Separate data blocks.	No response.
RVSM-2	No response.	Data block overlap, ODAPS communication with D71 due to physical positioning (D72 in between).	Keeping up with altitude changes, separating data blocks.	Separating data blocks.	Separate data blocks.	It was easier than yesterday (RVSM-1).
RVSM-3	There appeared to be no difficulty at the ODAPS position.	No response.	No difficulties noted.	Progress on certain flights; Separating data blocks and aircraft for the D-position.	No response.	ODAPS was easy despite having to manually progress several flights.
MTT-1	No difficulties noted.	Keep data blocks from overlapping.	Did not work O-position tonight. N/A	Nothing.	Keep the data blocks from overlapping.	Just making sure the entries were correct.
MTT-2	No response.	No change.	N/A	Progressing aircraft in D71 in beginning of problem.	N/A	Keeping data block separate.
CAT-1	No problems noted at ODAPS position.	Data block overlap.	N/A	Progress for 40 W Separating data blocks.	See Observer Y comment.	No problems noted.
CAT-2	No difficulties noted.	Data block overlap.	No difficulties noted.	Try to look for separation errors. -All data blocks were together. It was hard to see if the clearance was good.	N/A	It was easy.

TABLE D-2. POST-SIMULATION RESPONSES

QUESTION: What was the most difficult for controllers to accomplish during this simulation?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
Training	Getting used to the communications system and the physical location of the ARINC printers.		Familiarization with the communication lines.	Nothing.	Communications while other sector was on line.	The telephones were erratic at first, but were fine after the initial calls.
CVSM-1	Board Management. Due to space limitation board management became a problem.		I started the problem on D71. It was initially difficult to catch up on strip-marking, since I sat down after the problem started.	Not enough room for strips. Board management. Strips were taking too long to print.	Traffic searching. Track traffic without normal track data.	
CVSM-2	There was nothing really difficult for the controllers to accomplish. They adapted well to the slight differences from NY Center.	After peak traffic period, communications became less "by the book". Fatigue increased workload (or perception).	Since it was busy it was a little difficult to check progress reports and maintain a current sector. (ARINC scrolls were long.)	Issue routings Domestic.	Planning altitude and routing during initial coordination with Santa Maria.	Getting aircraft to climb as per their clearances.
RVSM-1	Maintaining awareness of FL 300, 320, 340, 360, etc.	Use of the "odd" RVSM altitudes slowed traffic sectors due to both the "oddness" and there being more altitude strata to consider.	Had to make many requests for aircraft at RVSM altitudes (transitioning) when they were able to reach higher CVSM altitudes.	Traffic search.	Traffic searches using RVSM altitudes.	Marking all the strips.
RVSM-2	Since the problem was the same, I think it was difficult for controllers to maintain a sense of objectivity.	Traffic scans due to more altitude strata. Coordination with D71 on RVSM altitude aircraft that needed to be transitioned to CVSM.	Formulating climb clearances for transitioning RVSM aircraft.	Nothing.	Separation using non-standard altitudes.	It was easier than yesterday.
RVSM-3	The most difficult thing appeared to be moving all aircraft to conventional altitudes prior to 27 N or 60 W.	No response.	As it got busier it became increasingly difficult to transition aircraft from RVSM to CVSM.	Nothing.	Try to plan the transitions from RVSM to standard separation while running the sector.	Keeping up with progresses, coordinations. Just finding the flights was difficult at times.

TABLE D-2. POST-SIMULATION RESPONSES (continued)

QUESTION: What was the most difficult for controllers to accomplish during this simulation?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
MTT-1	There appeared to be no difficulties for the controller today.	Developing a plan for RVSM to CVSM transitions. Due to aircraft altitude limitations (as in when able higher) modify the plan during implementation.	Keeping up with ARINC progresses, answering aircraft requests for higher altitudes	Nothing.	Nothing was overly difficult.	Managing telephone time and function. Next, getting the aircraft to standard altitudes prior to D71.
MTT-2	Due to the complexity of the traffic, coordination seemed to be the most difficult to accomplish. This was due in part to an unusual split in the sectors.	Devise and implement RVSM to CVSM transition plans once a lot of the traffic hit the sector. This adds ARINC progresses to the workload.	Transitioning aircraft from RVSM to CVSM was very difficult at times.	No response.	Implementing a plan for traffic to D89 involving reroutes at 60W and climbs.	Pre-planning and staying ahead of the traffic flow.
CAT-1	The most difficult thing observed was the application of the RVSM CAT rules: 2 operational errors occurred.	Having to react quickly and revising and implementing a plan to move aircraft effected by severe turbulence.	By Coordinating well in advance I found it necessary to pester Santa Maria, continually asking when aircraft could make higher altitudes.	No response.	See Observer Y comment.	Staying ahead and maintaining separation west of 60W when everybody converged.
CAT-2	Due to CAT (3) workload became extreme. This resulted in an operational error. Separation was difficult to accomplish.	72. None. 71. Remaining truly aware during peak traffic and keeping caught up.	D71 was busy so coordination from D72 to D71 was slow.	No response.	Getting a hold of D-71 for coordination.	Keeping up or catching up with the sector. I was "tubing".

TABLE D-3. POST-SIMULATION RESPONSES

QUESTION: If you could change something about the last simulation run, what would it be?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
Training	Increase the amount of phone calls so that everyone can get used to the system.	Some simulation runs should incorporate a varying degree of time revisions on aircraft progresses. In a live traffic environment, depending on how accurate the forecast winds are, there can be a significant difference in workloads.	After adjusting to the communication lines, there is nothing that requires change.	Aircraft types could be more realistic. Example, MPH B727 ETOPS. He may not be able to fly that route. Also, it is usually B767 high altitude FL370 or FL390.	Basically a good simulation for training purposes.	If a clearance is issued involving a route change and an altitude change, the "read back" should come back in one ARINC message.
CVSM-1	Board space, more bays would help. Also, there were too many people helping and running around.	No response.	Due to changes in the upper winds some aircraft progress points very early or very late. Larger time revisions would make the simulation more realistic and much more difficult.	Open up ODAPS 71. This would allow for faster strip generation and easier separation of data blocks. Move the observers back further. The O-person needs easy access to D71 & D72 for strip posting.	Allow time to pre-plan proposals and mark track routings on them.	I might try to reorient myself to bay placement.
CVSM-2	I would not make the problem so long. After the initial push of traffic was received, you could see the controllers easing back. The conversations began to stray from air traffic.	Add time revisions and make land line communications less speedy.	Once again, more time revisions would be more realistic and more difficult. Carrying through revised times on the strips takes up time and increases chance of error.	More aircraft would have their domestic routing. It is time consuming to be issued during peak traffic. The times for progress should be more realistic; i.e., all times were good, there were no revisions.	Nothing, very realistic.	No response.

TABLE D-3. POST-SIMULATION RESPONSES (continued)

QUESTION: If you could change something about the last simulation run, what would it be?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
RVSM-1	I would like to see the controllers take the scenario more serious. There were two situations were altitudes were incorrect and the controller involved seemed to not care.	No response.	No response.	Establish procedures for coordination with D71. They were requesting the aircraft at CVSM altitudes. This additional workload defeats the purpose of splitting the sector.	Adding more random route aircraft would make problem worse. Traffic searches would be much more difficult.	For total realism the estimates wouldn't stay.
RVSM-2	Change the traffic. Four days of the same traffic do not give a realistic view of the actual.	Observers should keep separate totals for "restrictions" such as : requests (through ARINC), requests (through other), clearances (through ARINC); clearances (through other). This will help indicate how much work is done through another sector/facility on original altitude approval and/or before entry into the sector versus workload on the controller when the flight is in the sector. A possible indication of impact of increased workload on the sending sector/facility. Example, for RVSM day 1 72 coordinating with 71. 72 issuing (altitude/time/routing clearances/altitude requests) to PAZ.	We need to see more southwest bound D71 traffic (transitioning RVSM aircraft) to make the situation as complex as it will get and then come up with solutions.	Different problems should be run. Once you know the traffic flow, you could run it anyway.	More random traffic...some communication problems time revisions and bad reports...an emergency ?	For increased realism 72 and 71 should still be getting estimates at the end of the problem just at a greatly reduced rate. Why does 72 get all those ARINC progresses outside of the airspace toward the end?
RVSM-3	I would not change anything. The traffic appeared to be realistic as did the working conditions.	No response.	No changes necessary; Traffic was heavy and constant, yet manageable using RVSM.	Change the ARINC paper.	No response.	I would either meter traffic to reduce the amount of aircraft per hour or would NOT permit RVSM on NON-North American Landfall Tracks and random routings.

TABLE D-3. POST-SIMULATION RESPONSES (continued)

<u>QUESTION</u>: "f you could change something about the last simulation run, what would it be?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
MTT-1	I would make the problem more condensed and increase the number of aircraft. This would really test the maximum capacity of the ODAPS and D-controllers.	Same as controller C comment.	No simulation changes necessary.	Aircraft that needed to be changed to CVSM altitudes were canted out as a reminder that an action needed to be taken	Traffic proceeding 40/50, 35/60. No 50 W progress report with 60W estimate was sent by ARINC to D71. In "real life" D-71 would receive this.	Possibly reroute a few more aircraft onto the tracks.
MTT-2	I would change the sector split. There was too much confusion. Also the split was not depicted on the maps or ODAPS.	Same as controller C comment.	More time revisions would make the simulation even more difficult and more realistic.	Nothing.	Straighten out the ARINC message sending- addressing problem	Only approve non-RVSM altitudes on flights transitioning to D70 within 10 degrees of entering D71 airspace.
CAT-1	I think a more comprehensive explanation of the separation standards for CAT was in order.	Pilot estimates and progress times this close to strip time is not realistic.	Both severe turbulence reports I had were easy to resolve because neither aircraft had any traffic in its way. If an aircraft was "boxed in" and reported severe turbulence it would make the problem much more difficult.	Have D89 and D70 say unable on a few aircraft for coordination.	See Observer Y comment.	I would have advised the BAW with moderate turbulence higher not available, though FL340 and 360 were. He slowed down without clearance but I'm not sure my clearance to him was proper. RVSM may actually have been a help not a hindrance in this situation.
CAT-2	The sectors should have been split differently to even out the flow of traffic. D-71 was much busier than D72.	No response.	When taking estimates from Santa Maria have aircraft advise when able maximum altitudes.	I would not require the controller to take a break. Sometimes it is not good to take a break depending on traffic. Also allow the O-person to help with coordination just like on the floor. This is usually needed for about 30 minutes.	See Observer Y comment.	Fix it so I wouldn't be at D71 during that time period.

TABLE D-4. POST-SIMULATION RESPONSES

QUESTION: Did the controllers [you] change their usual control and work strategies in any way in order to work the traffic in the last simulation ? If so how? What did they do differently?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
Training	No. Controllers appeared to have the same work habits/procedures as on the control room floor.	No response.	No.	No.	None.	No.
CVSM-1	No. I noticed controllers were the same as when traffic is live.	Not noticeably.	No.	The pace was increased. Each situation for climb was checked further and a more detailed traffic search was done.	The pace was increased. Each situation for climb was checked further and a more detailed traffic search was done.	No.
CVSM-2	No. Controllers acted the same and used the same work techniques.	Since less time was spent on coordinating with other sectors and facilities it was easier to keep up with the traffic and board management. No time revisions made it easier too.	No.	Yes. Took aircraft closer with minimum separation (only 10 minutes). In reality this would not be done because you are too busy to watch it. Here you know it is going to be good. No restrictions necessary.	No significant change, work habits basically the same.	No, just paid more attention to detail compared to yesterday.
RVSM-1	I noticed controller "C" seemed to take this scenario less serious than the other scenarios.	Coordination D72 with D71 was lengthier due to having to work out climb clearances for the RVSM altitude aircraft between the two controllers to miss both of their traffic.	I did not have to change any of my usual working habits to control using RVSM. Although unusual at first, RVSM made many altitudes available and worked very well.	Yes. Most aircraft were taken vertically separated. More altitudes available so there is no need to force aircraft at altitudes.	Had to adapt to using one thousand for separation. Seeing those non-standard altitudes written on the strips was distracting.	No.

TABLE D-4. POST-SIMULATION RESPONSES (continued)

QUESTION: Did the controllers [you] change their usual control and work strategies in any way in order to work the traffic in the last simulation ? If so how? What did they do differently?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
RVSM-2	Today, yes. Since the problem was the same, the decisions made by the controller mirrored yesterday's decisions with corrections for mistakes made.	Traffic from 72 to 71/87 was transitioned from RVSM to CVSM sooner, unlike day 1 RVSM. More requests for "when able higher" altitudes to allow for pre-planning RVSM to CVSM transitions.	No.	Yes. Planned an aircraft necessary to transition to CVSM. I took care of any clearances required for D71 before coordination. I didn't try to coordinate aircraft at RVSM altitudes.	Due to computer limitations, if I gave a clearance to maintain an altitude to a fix then climb, the plane never reports level. However if I give a clearance to maintain to a fix then climb to cross a fix, I received level reports.	Beyond answering conventional altitudes at MNPS boundaries, no.
RVSM-3	No. Usual work strategies appeared the same.	As D-71 fell behind, the D-72 controller tried to send traffic at CVSM altitudes. As traffic peaked, the D-71 controller ignored incoming calls and progresses, refused to take estimates from PAZ "I'll call you back" in order to plan RVSM to CVSM transitions.	The only change I made to my usual control actions was to coordinate very early so that if transitions from RVSM to CVSM were difficult, I would have plenty of time to accomplish these transitions.	Yes. I planned on moving RVSM a/c to CVSM before leaving my airspace. Always had in mind that I would have to move them.	Occasionally ignore incoming calls, ARINC progresses, etc. just to allow time to plan climb/descend clearances for RVSM aircraft.	No, I just tried to keep up with the sector but fell behind.
MTT-1	There appeared to be no change in the controllers' work strategies.	Same as controller C comment.	I tried to coordinate early in order to have adequate time to transition from RVSM to CVSM altitudes.	More information was gathered regarding when an aircraft could climb for D71 and changing RVSM to CVSM.	Tried to pre-plan and make requests for when able higher much earlier.	No, but I did coordinate very early.
MTT-2	The controllers changed slightly : (1) due to the area manager being present and (2) because of the unusual sector split.	Same as controller C comment.	In order to successfully transition from RVSM to CVSM, there were times I had to change altitudes of aircraft still in Santa Maria's airspace.	Not compared to yesterday.	Had PAZ find out when aircraft were able higher. Start working on my transition plan much earlier.	I pre-planned, coordinated, and reached out for information much sooner than normal.

TABLE D-4. POST-SIMULATION RESPONSES (continued)

QUESTION: Did the controllers [you] change their usual control and work strategies in any way in order to work the traffic in the last simulation ? If so how? What did they do differently?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
CAT-1	Controllers began to pre-plan for anticipated CAT. This soon changed because CAT did not occur until late in the problem.	Put some of the workload on PAZ. Finding out when aircraft were able higher and sometimes requesting PAZ to issue clearances.	I called Santa Maria well in advance, asking when many aircraft could make higher altitudes. Although sometimes necessary, I should have limited my number of requests so as to not increase Santa Maria's workload.	When working D-71 a plan was formulated with many outs to transition aircraft to CVSM altitudes. There were a few alternate plans. This way when it got busy it was already figured out. Not scrambling.	See Observer Y comment.	No.
CAT-2	No. Controllers worked with usual procedures.	Shift some of the load to PAZ to allow earlier plan formulation and implementation.	I completed coordination well in advance.	Just pre-planning more. Instead of only having one plan, I would have 3.	See Observer Y comment.	No. I just tried to speed and to get the rest of the guys to speed up.

TABLE D-5. POST-SIMULATION RESPONSES

QUESTION: Based upon your observations with the traffic load (RVSM) during the last simulation run, what procedures would have to be changed and/or implemented in order for the controllers to be comfortable about working this same traffic but under reduced vertical separation minima (RVSM)?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
Training	I think that running a few familiarization problems using RVSM (unusual altitudes) would benefit the controllers.	No response.	A way needs to be determined to successfully transition RVSM to CVSM; specifically; how do we take an influx of traffic separated vertically by 1000 ft in sector 71 and move aircraft into CVSM in sector 70 ? With large traffic flows, hopefully, we can come up with a number of solutions.	Some transition airspace back to CVSM.	Reliable and certified visual reference.	None if the traffic is spaced as it was today.
CVSM-1	None.	Some restrictions on assignment of standard vs. non-standard altitudes should be considered. Reference crossing traffic or what sectors the traffic is going to.	After resolving computer problems, it will be important to have accurate, current airline progress reports in order to transition from CVSM to RVSM.	RVSM could only be used when the flight transitions to radar. You are too busy to worry about changing the altitude. When you get this busy you don't have time to look at every aircraft to climb.	Mark strips to show track routing. Also, implement a reliable visual aid to see more traffic easier. A visual aid being a display of traffic real-time at the sector.	More bay space. Eight per sector is inadequate, ten may be enough. We can function with roll-away strip bays.
CVSM-2	I know of no change necessary.	Transition to CVSM would be occurring at either peak traffic or at post peak, with a possibly fatigued controller. Possibility of human error may be increased.	I am interested to see what solutions are proposed for the RVSM to CVSM transition.	The aircraft need to be spaced more time wise. With RVSM, you are going to have to transition the aircraft to CVSM before they leave your airspace. Your slow time after the push will no longer be slow; you will be transitioning.	Automated visual reference absolutely needed. Scanning strips alone is very time consuming during heavier periods.	Initially it would be easier, but when conventional altitudes have to be reverted to, geographical (Lateral) separation may have to be established creating a much higher workload.

TABLE D-5. POST-SIMULATION RESPONSES (continued)

<u>QUESTION:</u> Based upon your observations with the traffic load (RVSM) during the last simulation run, what procedures would have to be changes and/or implemented in order for the controllers to be comfortable about working this same traffic but under reduced vertical separation minima (RVSM)?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
RVSM-1	The ODAPS position would have to take a more serious role.	The first transitions from RVSM to CVSM happened near the peak workload. Possibly limit use for days of forecast heavier traffic to R65 or BDA landfalls.	Transitioning aircraft at RVSM needed to be asked if they could make higher CVSM altitudes. It would be less time consuming if aircraft automatically supplied this information rather than controllers making all the requests. Also, if transitioning became increasingly difficult, have the O-person come up with options.	More tracks put in and the aircraft must be on them. In this situation RVSM would be beneficial.	Allow transition areas to be <u>solely</u> radar sectors and allow easier transitioning.	None.
RVSM-2	The problem is the controllers were too comfortable running this problem. I think there was a false sense of security.	No change.	Let the O-person become more involved with RVSM transitioning aircraft (i.e. make requests for higher altitudes, provide lateral and longitudinal solutions which will allow for conventional vertical separation.	Buffer areas need to be adjusted for transitioning. BDA should be able to accept aircraft at RVSM. Then, you only need to transition D89 and D70 aircraft.	D72 separated traffic bound for BDA. D72 should own this airspace.	I'm comfortable now, but it would be nice to have an accurate certified display to monitor traffic.
RVSM-3	The splitting of the sectors would have to change. D-71 has significantly more work to do just because of RVSM.	Limit the use of RVSM in D71 where transitions to CVSM had to be done by the controller.	Although the simulation worked well it would be even more beneficial if Bermuda could accept aircraft at RVSM altitudes and if transitions could be accomplished by ZNY boundary (18 North).	Transition airspace for BDA.	Limit the use of RVSM in D71, especially when aircraft transition to D70 before 50 W to allow time to move the aircraft.	See previous statement: I would either meter traffic to reduce the amount of aircraft per hour or would NOT permit RVSM on NON-North American Landfall Tracks and random routings.

TABLE D-5. POST-SIMULATION RESPONSES (continued)

QUESTION: Based upon your observations with the traffic load (RVSM) during the last simulation run, what procedures would have to be changes and/or implemented in order for the controllers to be comfortable about working this same traffic but under reduced vertical separation minima (RVSM)?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
MTT-1	I would not change any of the procedures. The controllers appeared to be comfortable and confident about their control decisions.	Same as controller C comment.	Using RVSM makes climbing aircraft to higher altitudes difficult due to the congestion of many altitudes (many aircraft) in a short period of time. I would like to comply with aircraft requests for higher altitudes rather than ignore them, but such an influx of traffic made it too difficult.	Other facilities or sectors should be required to forward the information when an aircraft can climb when they are coordinating an aircraft at a RVSM altitude. This would give you more time for the actual working of traffic.	The traffic volume during this simulation was about peak to still feel comfortable with and have sufficient time to plan and execute transitions from RVSM to CVSM.	More vertical board space to manage more traffic without having such a wide sector.
MTT-2	The sector split would be changed to accommodate the flow of traffic.	Same as controller C comment.	Aircraft on the same route of flight (i.e. a track) cannot come in a wave from Santa Maria separated by 1000 ft within 10 minutes of each other. When busy, step climbing five aircraft at a shot is too difficult.	Since more aircraft are on tracks for a shorter period of time less aircraft are being able to be climbed.	Possibility of putting restrictions on the use of RVSM in D71.	Move sectors or an altitude sector split.
CAT-1	More defined procedures for CAT need to be in place before application of the rules can be tested.	Limit the use of RVSM when the D-controller is responsible for transition to CVSM. When turbulence is reported, to be able to advise PAZ and possibly "shut down" that altitude.	No changes noted.	Confidence in the next sector controller's ability to accept the traffic at RVSM altitudes and not expect me to separate them.	See Observer Y comment.	Attempt to meter traffic so no two aircraft are exactly on top of each other.
CAT-2	I would not have changed any procedure other than sector split.	Limit the use in D71 Allow BDA to transition Have PAZ find out when some key aircraft are able higher before initial coordination call.	Aircraft must advise early when they are higher and maximum altitudes.	Transition area outside MNPS airspace.	See Observer Y comment.	In times of bad weather, it may behoove us to space out the flights more.

TABLE D-6. POST-SIMULATION RESPONSES

QUESTION: What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
Training	I don't think the simulation was realistic and therefore the controllers did not even consider safety an issue.	No response.	Separation of traffic.	None.	Separation.	Just to familiarize myself with the lab and the few unique equipment provisions.
CVSM-1	Due to the board space limitation, it became more difficult to follow through on strip-marking. I noted one case of an altitude not being carried through because of where the 60 West Bay Area was located. This could cause a safety problem.	Loss of computer. Simulated loss of communications between ARINC and aircraft or delay in communications due to heavy ARINC frequency congestion. . Lack of board space.	Separation of Air Traffic.	Not taking close aircraft together (including crossing).	Keeping aircraft separated and working high volume with random routings.	Making sure all the strips were present.
CVSM-2	I had no doubt of safety in jeopardy. Safety was not a concern, never a problem!	None.	Separation of aircraft.	None. They were all separated.	Separation and maintaining separation, climbing aircraft to requested altitudes.	None. It ran smoothly.
RVSM-1	The use of FL 300, 320, etc. required a much more intense traffic search prior to issuing clearance. The chance for error increases greatly.	Possibility of error at peak traffic.	Separation of aircraft.	Traffic search;. Aircraft at FL300 requesting FL360. It takes much longer to do a traffic search.	Seeing the traffic with an additional 5 to 6 altitudes.	Just making sure aircraft were at conventional altitudes prior to leaving MNPS airspace.
RVSM-2	There was no real concern for safety. It was never jeopardized.	Increased possibility of ARINC "typos" on position reports. Controller error on reading altitudes until used to seeing the new altitudes.	Separation of aircraft.	None.	Seeing traffic using RVSM altitudes. Traffic searches were more time consuming.	Separation, what else?

TABLE D-6. POST-SIMULATION RESPONSES (continued)

QUESTION: What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
RVSM-3	My primary concern was that by using RVSM altitudes, in an emergency situation the controller had no emergency altitudes available if necessary.	Having to climb and descend aircraft when the traffic scan is made under pressure.	Separation of traffic.	None.	Falling behind on coordination with 89 & 70. Negatively impacting PAZ by not answering calls to approve altitudes. Most important of all, lack of time to fully analyze traffic situations and having to climb or descend aircraft with this pressure.	Just maintaining separation and attempting timely coordination on D-71 was overwhelming. Re: RVSM, I seriously question the validity of RVSM when, on January 6, I witnessed a L1011 tumble from FL290 to FL278 and then back up to FL308 all within 30 seconds in an area where there was supposedly only light to moderate turbulence.

TABLE D-6. POST-SIMULATION RESPONSES (continued)

QUESTION: What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

Condition	Observer X	Observer Y	Controller A	Controller B	Controller C	Controller D
MTT-1	My primary safety concern today was to see if all aircraft were being coordinated timely so as to not compromise safety.	The inability to "stop traffic" when the sector becomes overloaded and aircraft have to be transitioned from RVSM to CVSM. The possibility of not getting to it before the aircraft leaves RVSM airspace or getting behind on coordination with receiving sectors.	Separation of traffic.	Nothing.	None.	The traffic was spaced evenly and wasn't overwhelming.
MTT-2	The primary safety concern was traffic converging on the BDA boundary that were not separated and because of the sector spilt one sector did not know about the traffic.	Same as controller C comment.	Separation of traffic.	The sector split was unacceptable. Numerous aircraft needed to be given as information to the other sector. The sector controllers were unaware of this and a loss of separation could have occurred. More thought needs to be given to sector splits.	Implementing my transition plans and coordination early in case traffic volume later might cause time constraints.	Staying ahead and only moving traffic that had to be transitioned to CVSM.
CAT-1	The CAT was obviously the major safety issue. Two operational errors occurred because of misapplication of separation standards due to CAT.	Making a mistake when under time pressure.	Separation of traffic.	None.	See Observer Y comment.	Trying to get the BAW in turbulence a better altitude.
CAT-2	Separation became a problem. D-71 controller had separation problem compounded by 2 CAT reports.	Time pressure making traffic scans & traffic planning too rushed when busiest.	Separation of traffic.	No response.	See Observer Y comment.	Determining lateral separation in the lower southeast corner.

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