Final Report
For
Domestic Reduced Vertical Separation Minima (DRVSM)
Second Simulation

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TABLE OF CONTENTS

1. Introduction 1
   - 1.1 Background 1
   - 1.2 Scope of the Report 1
   - 1.3 Document Organization 1
2. Simulation Overview 2
   - 2.1 Objectives 2
   - 2.2 Airspace 2
   - 2.3 Scenarios 2
   - 2.4 Scenario Conditions 3
   - 2.5 Participants 3
   - 2.6 Measures 5
   - 2.7 Simulation Environment 7
   - 2.8 Data Collection 7
3. Results for Objective 1: Gain Additional Understanding of the Operational Impact of DRVSM 9
   - 3.1 Overview of Impacts 9
   - 3.2 Separation Violations 10
4. Results for Objective 2: Gain Additional Understanding of the Operational Impact of Specific Conditions 11
   - 4.1 Impact of Non-DRVSM-Approved Aircraft in DRVSM Airspace 11
   - 4.2 Impact of the Loss of an Approved Aircraft's Equipment 20
5. Results for Objective 3: Identify Specific Procedural Issues 21
6. Results for Objective 4: Gain Operational Experience in Tactical Use of DRVSM in a CVS Environment 22
   - 6.1 Subjective Measures 22
   - 6.2 Objective Measures 23
7. Results for Objective 5: Assess Effort Entailed in Transitioning Aircraft from Reduced Vertical Separation Standards to Conventional Separation Standards 23
   - 7.1 Workload 24
   - 7.2 Complexity 26
   - 7.3 Potential for Error 27
8. Results for Objective 6: Assess Impact of Suspension of DRVSM on the NAS 28
   - 8.1 Subjective Measures 28
   - 8.2 Objective Measures 29
   - 8.3 Controller Comments 30
9. Conclusions 30
   - 9.1 Summary of Key Findings 30
   - 9.2 Next Steps 33

Appendix A Sample Post-Run Questionnaire 34
Appendix B Separation Violations 45

LIST OF FIGURES AND TABLES

Figure 2-1	Simulated ZID Airspace	3
Table 2.4-1	Description of Scenario Runs Derived from SAR Data	4
Table 2.6-1	Measures per Objective	6
Table 4.1-1	Numbers of Non-DRVSM-Approved Aircraft	11
Table 4.1-2	Average Workload Ratings Comparison for Runs 4a and 3a	12
Table 4.1-3	Average Workload Ratings Comparison for Runs 1a and 1b	13
Table 4.1-4	Verbal Communications Workload Data for Runs 1a and 1b	13
Table 4.1-5	Pointout Data for Runs 1a and 1b	14
Table 4.1-6	Verbal Communications Workload Data for Runs 3a and 4a	14
Table 4.1-7	Pointout Data for Runs 3a and 4a	15
Table 4.1-8	Complexity Ratings for Runs 1a/1b and Runs 4a/3a	16
Table 4.1-9	Number of Non-DRVSM-approved Aircraft for Runs 1a/1b and Runs 4a/3a	16
Table 4.1-10	Time (in Seconds) of Non-DRVSM-Approved Aircraft in DRVSM Airspace for Runs 1a/1b and Runs 4a/3a.	17
Table 4.1-11	Frequency of Conflict Alert Warnings for Runs 1a/1b and Runs 4a/3a	18
Table 4.1-12	Ratings of Potential for Error for Runs 1a/1b and Runs 4a/3a.	18
Table 4.1-13	Frequency of Operational Errors for Runs 1a/1b and Runs 4a/3a	19
Table 4.1-14	Ease of Adapting to Revised Altitudes	20
Table 4.2-1	Equipage Loss Impact Ratings	21
Table 6.1-1	Opportunity to Use DRVSM Altitudes Tactically	22
Table 6.1-2	Tactical Use Impact Ratings for Workload, Complexity, and Potential for Error	23
Table 6.2-1	Operational Errors for Run 2b	23
Table 7.1-1	Workload and Workload Impact Ratings for a Mixed Vertical Separation Environment	24
Table 7.1-2	Verbal Communication Workload Data for Runs 3a and 3c	25
Table 7.1-3	Pointout Data for Runs 3a and 3c	25
Table 7.2-1	Complexity and Complexity Impact Ratings for a Mixed Vertical Separation Environment	26
Table 7.2-2	Frequency of Conflict Alert Warnings	27
Table 7.3-1	PFE and PFE Impact Ratings for a Mixed Vertical Separation Environment	27
Table 7.3-2	Operational Errors for Runs 3a and 3c	28
Table 8.1-1	DRVSM Suspension Impact Ratings for Workload, Complexity, and Potential for Error	29
Table 8.2-1	Operational Errors for Runs 1c and 2a	29
Table 9-1	Summary of Average Subjective Ratings	30
Table B-1	Operational Error Data	45

1. INTRODUCTION

1.1 Background

Reduced Vertical Separation Minimum (RVSM) is an ICAO-approved concept that reduces the vertical separation standard from 2000 feet to 1000 feet between flight level (FL) 290 and FL410. RVSM adds six flight levels between FL290 and FL410, thereby increasing airspace throughput and allowing more flexibility for controllers to grant user preferred altitudes. RVSM has been implemented in the North Atlantic and Pacific oceanic airspace, and was implemented in domestic European airspace in January 2002. Domestic RVSM (DRVSM) is a high priority for the FAA's Operational Evolution Plan (OEP); however, the impact on en route controllers in high-density domestic U.S. airspace needs to be understood.

Under the auspices of ATP-110, a series of human-in-the-loop (HITL) simulations are being conducted to investigate the operational impacts on en route controllers and airspace users of implementing RVSM in domestic U.S. airspace. The first of the series of HITL simulations took place October 24 – 30, 2001, at the William J. Hughes Technical Center (WJHTC) Display System Facility (DSF). This first simulation focused primarily on identifying and understanding the impacts of different DRVSM altitude bands on en route controllers. The second DRVSM simulation, also conducted in the DSF, took place from June 3 - 7, 2002.

1.2 Scope of the Report

The purpose of this Final Report is to provide the results of the second DRVSM simulation. Different types of data were collected throughout the simulation, including subjective controller ratings (e.g., for workload, complexity, potential for error, and ease of conversion), as well as objective data captured via system analysis and recording (SAR) and voice switching and control system (VSCS) recordings. The previously published Quick Look Report provided results of the analysis of the subjective data collected during the simulation. This Final Report integrates the results of the analysis of the objective data.

1.3 Document Organization

This document is organized in nine sections and two appendices. Section 2 provides an overview of the simulation structure, environment, and conduct. The results of the simulation are provided in Sections 3 through 8, and Section 9 provides conclusions. Appendix A provides a sample of a typical post-run questionnaire used to obtain controller comments and subjective ratings. Appendix B provides summary data for the operational errors that occurred during the simulation.

2. SIMULATION OVERVIEW

2.1 Objectives

The primary objectives for the second DRVSM simulation were to:

1. Gain additional understanding of the operational impact of DRVSM for FL290-FL410. In particular, identify operational concerns and problems for subsequent resolution.
2. Investigate the impacts of specific conditions:
   - Non-DRVSM-approved Department of Defense (DOD) and lifeguard flights.
   - Non-DRVSM-approved transitioning flights.
   - Loss of DRVSM-approved aircraft equipment.
3. Identify specific procedural issues.
4. Assess the tactical use of DRVSM in a conventional vertical separation (CVS) environment.
5. Assess effort entailed in transitioning aircraft from reduced vertical separation standards to conventional separation standards.
6. Assess impact of suspension of DRVSM on the National Airspace System (NAS).

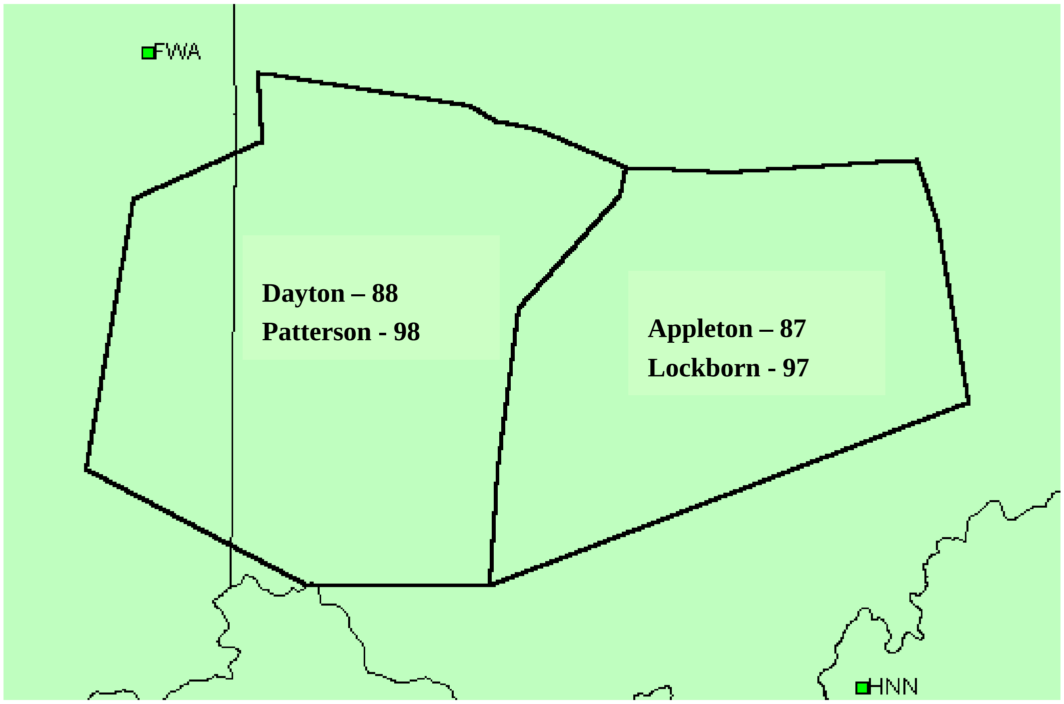
2.2 Airspace

This second DRVSM simulation was designed as a real-time, high fidelity, HITL, en route simulation. The simulated airspace was based on four adjacent sectors in Indianapolis Air Route Traffic Control Center (ZID). ZID sectors 87 (Appleton), 97 (Lockborn), 88 (Dayton), and 98 (Patterson) had the appropriate characteristics for this study. Sector 87 is a high-altitude sector (FL240 – FL310). Sector 97 is a super-high altitude sector (FL330 and above) that overlies sector 87. Sector 88 is a high-altitude sector that encompasses FL240 – FL310, and was assigned FL320 for purposes of the simulation. Sector 98 is a super-high altitude sector (FL330 and above) that overlies sector 88. For purposes of this study, sectors 87 and 97 were combined at sector 87 (FL240 and above). The simulated sectors are adjacent to Cleveland Air Route Control Center (ZOB) to the north. Figure 2-1 provides a depiction of the airspace used.

2.3 Scenarios

The traffic scenarios provided a peak demand and level of complexity that fully engaged both the Radar (R) and Radar Associate (RA) controllers. Three distinct traffic scenarios were developed from flight plans extracted from data analysis and reduction tool (DART) runs of ZID SAR tapes. The data allowed for the realistic representation of sector boundaries, jet routes, and fixes for the chosen and adjacent sectors. ZID personnel and air traffic control (ATC) subject matter experts assisted in developing and validating the scenarios, and in ensuring that the traffic levels represented peak conditions. A total of eight runs using the three distinct traffic scenarios were developed, tested, and used for this second DRVSM simulation. Since the three traffic scenarios (referred to as traffic samples 1, 2, and 3) were each used to create an additional one or two scenarios, aircraft identities were changed to give a different appearance to each scenario.

FIGURE 2-1. Simulated ZID Airspace



- Dayton: FL240 – FL320 (FL310 during CVS)
- Patterson: FL330 and above
- Appleton/Lockborn: FL240 and above

2.4 Scenario Conditions

Table 2.4-1 provides a definition of the eight different runs performed during the simulation, including (1) the traffic sample from which each run was developed, (2) the objective (or objectives) the run addresses, (3) the number of non-DRVSM-approved aircraft in each run, and (4) scripted events included in each run.

2.5 Participants

Six certified professional controllers (CPC) from ZID who work the simulated sectors (and who were not involved in the definition and validation of the scenarios) staffed the R and RA positions. The participating controllers interacted with individuals functioning as pilots (simulation pilots) and ghost controllers. The simulation pilots manipulated computer-generated targets in response to controller instructions. Ghost controllers performed the automation entries and voice communications associated with the airspace surrounding the sectors that were simulated.

TABLE 2.4-1. Description of Scenario Runs Derived from SAR Data[1]

Traffic Sample	Run	Objective Addressed	Number of Non-DRVSM-Approved Military or Lifeguard Aircraft to be Accommodated in DRVSM Airspace	Number of Non-DRVSM-Approved Aircraft Wanting to Transition Through DRVSM Airspace	Total Numbers of Non-DRVSM-Approved Aircraft	Scripted Events	Run Comparisons	
1	1a	1,2,3	Total of 5 aircraft selected to ensure some potential loss of separation. Per sector: • 2 in 87/97 • 2 in 88 • 3 in 98	Total of 11 aircraft. Per sector: • 6 in 87/97 • 7 in 88 • 6 in 98	Total of 16 aircraft. Per sector: • 8 in 87/97 • 9 in 88 • 9 in 98 Avg/sector: 8.7	Loss of approved aircraft's equipment	1b	Change in number of non-DRVSM-approved aircraft
	1b	1,2,3	Total of 9 aircraft selected to ensure some potential loss of separation. Per sector: • 5 in 87/97 • 4 in 88 • 5 in 98	Total of 13 aircraft. Per sector: • 6 in 87/97 • 6 in 88 • 7 in 98	Total of 22 aircraft. Per sector: • 11 in 87/97 • 10 in 88 • 12 in 98 Avg/sector: 11	Loss of approved aircraft's equipment	1a	Change in number of non-DRVSM-approved aircraft
	1c	1,2,6	Total of 3 aircraft selected to ensure some potential loss of separation. Per sector: • 2 in 87/97 • 1 in 88 • 2 in 98	Total of 6 aircraft. Per sector: • 3 in 87/97 • 2 in 88 • 2 in 98	Total of 9 aircraft. Per sector: • 5 in 87/97 • 3 in 88 • 4 in 98	After 30 minutes, suspend DRVSM and begin CVS.	None	
2	2a	6	Total of 6 aircraft. Per sector: • 3 in 87/97 • 2 in 88 • 2 in 98	Total of 12 aircraft. • 5 in 87/97 • 6 in 88 • 5 in 98		After 30 minutes, suspend DRVSM and begin CVS.	None	
	2b	4	N/A	50% DRVSM-approved 50% non-DRVSM-approved		None	None	

[1] The numbers of non-DRVSM approved aircraft have been updated to reflect the actual numbers per run as obtained from SAR data (vs. as designed into the scenarios). These numbers, particularly the per sector numbers, differ somewhat from previous versions of this table since they reflect differences in controller actions.

TABLE 2.4-1. Description of Scenario Runs Derived from SAR Data (Continued)

Traffic Sample	Run	Objective Addressed	Number of Non-DRVSM-Approved Military or Lifeguard Flights to be Accommodated in DRVSM Airspace	Number of Non-DRVSM-Approved Aircraft Wanting to Transition Through DRVSM Airspace	Total numbers of Non-DRVSM-approved Aircraft	Scripted Events	Run Comparisons	
3	3a	1,2,3	Total of 4 aircraft selected to ensure some potential loss of separation. Per sector: • 2 in 87/97 • 2 in 88 • 3 in 98	Total of 7 aircraft. Per sector: • 4 in 87/97 • 3 in 88 • 3 in 98	Total of 11 aircraft. Per sector: • 6 in 87/97 • 5 in 88 • 6 in 98 Avg/sector: 5.7	Loss of approved aircraft's equipment	4a	Change in number of non-DRVSM-approved aircraft
							3c	Impact of Transitioning to CVS airspace
	4a[2]	1,2,3	None	None	• None	None	3a	Change in number of non-DRVSM-approved aircraft
	3c	1, 5	Total of 4 aircraft. Per sector: • 2 in 87/97 • 1 in 88 • 3 in 98	Total of 7 aircraft. Per sector: • 5 in 87/97 • 1 in 88 • 4 in 98	Total of 11 aircraft. Per sector: • 7 in 87/97 • 2 in 88 • 7 in 98 Avg/sector: 5.3	• Loss of approved aircraft's equipment • Mixed vertical separation environment ZOB uses CVS while ZID uses DRVSM	3a	Impact of transitioning from DRVSM to CVS

2.6 Measures

Table 2.6-1 depicts the subjective and objective data that were collected during the simulation.

[2] The results of the first six of eight runs were such that the decision was made to modify the planned numbers of non-DRVSM-approved aircraft in this run. As a result, the run originally called 3b was renamed 4a and all aircraft were assumed to be DRVSM approved.

TABLE 2.6-1. Measures Per Objective

Objectives	Data to Be Collected	Source of Data	Measures
1. Gain additional understanding of the operational impact of DRVSM FL290-FL410. In particular, identify operational concerns and problems for subsequent resolution.	• Specific operational problems and concerns requiring resolution • Ideas for possible solutions	• Controller comments • Questionnaires • Subjective measures	• Workload • Complexity • Potential for Errors • Ease of Conversion
2. Investigate the impacts of each of the following events: • Increasing the numbers of non-DRVSM-approved DOD and lifeguard flights in DRVSM airspace • Increasing the numbers of non-DRVSM-approved transitioning flights • An outage of an aircraft's DRVSM equipment	• Impacts on: o Sector workload o Sector complexity o Potential for error o Coordination between sectors • Specific operational problems and concerns requiring resolution, per event • Ideas for possible solutions	• Controller comments • Questionnaires • Subjective and objective measures	• Workload • Complexity • Potential for Errors • Ease of Conversion
3. Identify specific procedural issues	• Specific procedural issues requiring resolution and/or further investigation • Specific existing procedures that will need to be revised • Specific issues that may require new procedures • Ideas for possible solutions	• Controller comments • Questionnaires	• Not applicable
4. Gain operational experience in tactical use of DRVSM in a CVS environment	• Specific operational problems and concerns requiring resolution • Specific procedural issues requiring resolution and/or further investigation • Ideas for possible solutions • Benefits of tactical use	• Controller comments • Questionnaires • Subjective measures	• Workload • Complexity • Potential for Errors
5. Assess effort entailed in transitioning aircraft from reduced vertical separation standards to conventional separation standards	• Specific operational problems and concerns requiring resolution • Specific procedural issues requiring resolution and/or further investigation • Ideas for possible solutions	• Controller comments • Questionnaires • Subjective and objective measures	• Workload • Complexity • Potential for Errors
6. Assess impact of suspension of DRVSM on the NAS	• Specific operational problems and concerns requiring resolution • Specific procedural issues requiring resolution and/or further investigation • Ideas for possible solutions	• Controller comments • Questionnaires • Subjective measures	• Workload • Complexity • Potential for Errors

2.7 Simulation Environment

The simulation was performed in the DSF-2 at the WJHTC. The display system replacement (DSR), the host computer system (HCS), the voice switching and control system (VSCS), and the user request evaluation tool (URET) were, with very few differences, configured identically to ZID's systems. Flight progress strips were not used, since ZID primarily employs the electronic flight data provided by URET. The target generation facility (TGF) provided high fidelity target generation and movement.

Two modifications were made to the DSR/HCS environment for the DRVSM simulation runs.

1. A symbol in the data block was used during the DRVSM scenario runs to indicate that an aircraft was not DRVSM-approved. Since it is expected that significantly more aircraft will be approved than not, coding the non-DRVSM-approved aircraft reduces clutter on the controller's situation display. The indicator was a coral box around the fourth character in the second line of the data block for non-DRVSM-approved aircraft. The Air Traffic DSR Evolution Team (ATDET), the team responsible for the final computer human interface (CHI) design, provided this design for the indicator.
2. The conflict alert (CA) logic used by the HCS was updated to accurately reflect the revised vertical separation standards for DRVSM.

The version of URET used during this simulation is the version known as core capability limited deployment (CCLD). It is the version that is currently in use at six ARTCC's, including ZID. URET provided electronic flight data. Because the conflict probe logic used by URET has not yet been updated, the conflict probe and trial planning feature had to be deactivated for the purposes of this simulation to avoid giving erroneous alerts for pairs of DRVSM-approved aircraft with at least 1000-foot vertical separation.

2.8 Data Collection

The same types of data were recorded and collected for each simulation run. This approach supports the comparison of the results of selected runs. Table 2-1 depicts the runs for which the collected data are directly comparable. The objective data collected included SAR data, VSCS recordings, and TGF recordings. Data were collected to measure controller workload, complexity, potential for error, and ease of conversion. The general data types collected for each measure are described in the following sections. Not every type of data collected relates to every objective of the simulation. Therefore, information is provided in each of the results sections to indicate which measures were used in the analysis of a given objective.

2.8.1 Workload

2.8.1.1 Subjective Workload Data

Participants were asked to subjectively rate workload in two distinct ways for every run. The controllers completed a questionnaire following each run in which they rated their overall workload, on a scale of 1 to 5. Additionally, the workload assessment keypad (WAK) was used during the conduct of each run. The WAK allows a workload rating to be entered electronically at regular intervals. The WAK was programmed to beep at 5-minute intervals, prompting each controller to enter their combined cognitive and physical “instantaneous” workload rating on a scale of 1 to 5. In both cases, a rating of 1 represented a very light workload, 3 a moderate workload, and 5 a very heavy workload. Depending on the scripted events or conditions applicable to a given run, additional questions about the impact on workload were asked. The questions can be viewed in the sample questionnaire included in Appendix A. Unless otherwise indicated, the workload ratings presented in this report are the average ratings for the R and RA controllers, per sector.

2.8.1.2 Objective Workload Data

The objective measures of controller workload collected were:

- Number of verbal communications between controllers and pilots. VSCS voice recordings were analyzed to determine the number of ground-to-air (G/A) and air-to-ground (A/G) calls made per sector.
- Number of VSCS ground-to-ground (G/G) calls between the participants. The data collection for this measure captured only those verbal communications made via VSCS. Since the controllers sometimes communicated with each other directly during the simulation without placing a G/G call (as they often do during live operations), this measure is not considered as accurate a reflection of communications workload as the frequency of A/G and G/A calls.
- Number of pointouts made from and received at the three simulated sectors. Only pointouts accomplished via HCS commands were recorded. Pointouts performed without the benefit of the automation system were not captured in this measure.

2.8.2 Complexity

2.8.2.1 Subjective Complexity Data

Participants were asked in the post-run questionnaire to rate the complexity of traffic flow and volume at their sector. Participants again used a 5-point scale, in which a rating of 1 indicated not complex at all, a rating of 3 indicated moderate complexity, and a rating of 5 indicated very complex. Depending on the scripted events or conditions applicable to a given run, additional questions on the impact of the scripted event or condition on complexity were asked. The questions can be viewed in the sample questionnaire included in Appendix A. Unless otherwise indicated, the complexity ratings presented in this report are the average ratings for the R and RA controllers, per sector.

2.8.2.2 Objective Complexity Data

The following objective measures of complexity were collected and analyzed:

- Number of non-DRVSM-approved aircraft per altitude
- Flying time of non-DRVSM-approved aircraft in sector
- CA frequency.

2.8.3 Potential for Error

2.8.3.1 Subjective Potential for Error Data

Participants were asked in the post-run questionnaire to rate the potential for error at their sector during the run. In this case a rating of 1 indicated a very low potential for error, 3 a moderate potential for error, and 5 a very high potential for error. Depending on the scripted events or conditions applicable to a given run, additional questions on the potential for error were asked. The questions can be viewed in the sample questionnaire included in Appendix A. Unless otherwise indicated, the potential for error ratings presented in this report are the average ratings for the R and RA controllers, per sector.

2.8.3.2 Objective Potential for Error Data

The number of operational errors was obtained from SAR tapes.

2.8.4 Ease of Conversion

Ease of conversion was assessed via subjective data only. Ease of conversion refers to the ease or difficulty the controller had using the DRVSM vertical separation standards, the additional six altitudes, and in using the revised correct altitude for the direction of flight associated with DRVSM. Participants were asked in the post-run questionnaire to rate the ease of using the correct altitude for the direction of flight, at their sector. Participants used a 5-point scale in which a rating of 1 indicate it was very easy, a 3 moderately easy, and a 5 very difficult. Depending on the scripted events or conditions applicable to a given run, additional questions on the ease of conversion were asked. The questions can be viewed in the sample questionnaire included in Appendix A. Unless otherwise indicated, the ease of conversion ratings presented in this report are the average ratings for the R and RA controllers, per sector.

3. RESULTS FOR OBJECTIVE 1: GAIN ADDITIONAL UNDERSTANDING OF THE OPERATIONAL IMPACT OF DRVSM

3.1 Overview of Impacts

The simulation was designed to understand the impact of DRVSM on high-density domestic U.S. airspace. The following items were identified as impacts, lessons learned and possible operational considerations that should be noted:

- Non-DRVSM-approved aircraft in DRVSM airspace have significant impact on controllers and on DRVSM-approved airspace users. One non-DRVSM-approved aircraft can require that multiple approved aircraft be given one or more vectors or altitude changes to maintain separation.
- It will take time for controllers to learn to use the additional altitudes. The ZID controllers felt that significant training and familiarization will be necessary to become comfortable with DRVSM operations in peak traffic conditions.
- Additional altitudes decrease workload, but non-DRVSM-approved aircraft increase workload.

- While the additional altitudes can be helpful, they have the effect of making descents (e.g., to descend an approved or non-DRVSM-approved aircraft for approach) more complex because there are more altitudes to clear.
- There is a need for coordination when a non-DRVSM-approved aircraft is at the base or ceiling altitude between the high and super-high altitude sectors.
- Controllers indicated they had to constantly reassess the separation for non-DRVSM-approved aircraft as they traversed through their sector, thereby increasing workload and potential for errors. In today's CVS environment, the controllers indicated they can essentially check an aircraft's separation at the point of hand-off, and know whether a separation action will or will not be needed. As experienced during this simulation, controllers believe this will no longer be true due to the complexity added by non-DRVSM-approved aircraft in DRVSM airspace.
- The participants expressed concern that a non-DRVSM-approved aircraft flying above FL410 may have to be descended below DRVSM altitudes well before it is desirable because the destination ARTCC or interim ARTCC's may not be able to descend the aircraft at the more optimal point.
- Participants found that there was an increase in vectoring aircraft (both approved and non-DRVSM-approved) in order to get non-DRVSM-approved transitioning aircraft above or below DRVSM airspace.

3.2 Separation Violations

A critical result of the first DRVSM simulation was the finding that the availability of the additional six DRVSM altitudes significantly reduced the potential for operational error when the number of non-DRVSM-approved aircraft per sector was in the 1 to 3 range. Since that finding was clear and unambiguous, the second simulation focused, not on DRVSM itself, but on the impact of a large number of non-DRVSM-approved aircraft in sectors with DRVSM airspace.

A total of eleven operational errors occurred during the conduct of the second DRVSM simulation. The rate of operational errors that occurred during this simulation was considerably higher than during the first DRVSM simulation. The likely reason for this is the combination of the following three factors:

1. The traffic volume and complexity of the problems were extremely high, even without the added complication of non-DRVSM-approved aircraft in DRVSM airspace. In fact, the participants indicated that under such traffic levels in their facility today, the sectors would have been staffed by three controllers.
2. During this simulation, the numbers of non-DRVSM-approved aircraft in the sectors far exceeded the number of such aircraft expected to be handled within a sector.
3. The ZID controllers placed a high priority during the simulation on accommodating all of the non-DRVSM aircraft's requests to fly in or through DRVSM airspace.

Appendix B provides a summary of operational error data for all eight runs. The sections that follow present an analysis of the operational errors for individual runs.

4. RESULTS FOR OBJECTIVE 2: GAIN ADDITIONAL UNDERSTANDING OF THE OPERATIONAL IMPACT OF SPECIFIC CONDITIONS

Understanding the operational impact of specific conditions was a key objective of the second DRVSM simulation. These conditions were:

1. Accommodating increased numbers of non-DRVSM-approved DOD and lifeguard flights in DRVSM airspace, as well as increased numbers of non-DRVSM-approved transitioning flights.
2. The loss of a DRVSM-approved aircraft's equipment, requiring the controller to provide conventional vertical separation for the aircraft and to expedite the aircraft's climb or descent out of DRVSM airspace.

4.1 Impact of Non-DRVSM-Approved Aircraft in DRVSM Airspace

One of the primary concerns raised during the first DRVSM simulation was the need for understanding the impact of non-DRVSM-approved aircraft in DRVSM airspace. Consequently, this was a primary objective of this second DRVSM simulation. Two pairs of simulation runs (Runs 1a/1b and Runs 4a/3a) were conducted to analyze the impact of different numbers of non-DRVSM-approved aircraft in DRVSM airspace, in terms of impacts on workload, complexity, potential for error, and ease of conversion.

Table 4.1-1 provides the numbers of non-DRVSM aircraft in each of the four runs designed to address the impact of non-DRVSM aircraft. The four runs are grouped into two pairs of runs. Within each pair, the traffic volume and flows were held constant, and only the number of non-DRVSM-approved aircraft was varied. This approach allowed a direct comparison of workload, complexity, potential for error, and ease of conversion.

TABLE 4.1-1. Numbers of Non-DRVSM-Approved Aircraft

Traffic Sample	Runs	Number of Non-DRVSM-Approved DOD/Lifeguard Aircraft to be Accommodated in DRVSM Airspace	Number of Non-DRVSM-Approved Aircraft Wanting to Transition Through DRVSM Airspace	Total Number of Non-DRVSM-Approved Aircraft
1	1a	5 aircraft selected to ensure potential loss of separation.	11 aircraft.	16
	1b	9 aircraft selected to ensure potential loss of separation.	13 aircraft.	22
3	4a	None	None	None
	3a	4 aircraft selected to ensure some potential loss of separation.	7 aircraft.	11

4.1.1 Workload

Workload was quantified using subjective workload ratings provided by the controllers, as well as objective measures.

4.1.1.1 Subjective Workload Ratings

Consistent with the verbal input provided during the debrief sessions, controllers' ratings of workload increased, on average, as the numbers of non-DRVSM-approved aircraft in DRVSM airspace increased. The best illustration of this can be seen in Table 4.1-2, which compares runs 4a and 3a, since this pairing of runs encompassed the largest spread in the numbers of non-DRVSM-approved aircraft. The average rating[3] increased by .71 on a 5-point scale, when the number of non-DRVSM-approved aircraft increased from 0 to 11 (an average of 5.7 per sector).[4]

TABLE 4.1-2. Average Workload Ratings Comparison for Runs 4a and 3a

Sector	Run	WAK Ratings	Questionnaire Ratings	Average Rating	
87/97	4a	1.65	2	1.825	
	3a	2.55	3	2.775	
88	4a	2.65	3.5	3.075	
	3a	2.8	3	2.9	
98	4a	2.2	2	2.1	
	3a	2.9	4	3.45	
Average	4a	2.17	2.5	2.335	.71
	3a	2.75	3.333	3.0415	

Even in the case in which the number of non-DRVSM-approved aircraft per sector increased from 8.7 (Run 1a) to 11 (Run 1b), a difference of only 2.3 non-DRVSM-approved aircraft per sector, the average workload rating increased by .36, as shown in Table 4.1-3.[5]

4.1.1.2 Objective Workload Measures

The objective measures for workload included the frequency of A/G and G/A communications, the frequency of VSCS G/G communications between controllers, and the number of pointouts. The data for each of these objective measures are provided in the Tables 4.1-4 and 4.1-5 for Runs 1a/1b and in Table 4.1-6 and 4.1-7 for Runs 4a/3a.

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[3] Averaged across the three sectors, R and RA controllers, and across the WAK and Questionnaire ratings.

[4] The number of non-DRVSM-approved aircraft has been updated from the Quick Look Report based on the objective data available from SAR tapes.

[5] The number of non-DRVSM-approved aircraft has been updated from the Quick Look Report based on the objective data available from SAR tapes.

TABLE 4.1-3. Average Workload Ratings Comparison for Runs 1a and 1b

Sector	Run	WAK Ratings	Questionnaire Ratings	Average Rating	
87/97	1a	3.75	4.5	4.125	
	1b	3.3	5	4.15	
88	1a	2.65	5	3.825	
	1b	2.9	4.5	3.7	
98	1a	2.9	3.5	3.2	
	1b	3.75	5	4.375	
Average	1a	3.1	4.333	3.7165	.36
	1b	3.32	4.833	4.0765	

The most significant result from the analysis of the objective data is the substantive increase in the A/G and G/A communication workload from Run 1a to Run 1b, shown in Table 4.1-4. The traffic volume, flow, and complexity in these two runs were equivalent in all respects except in the number of non-DRVSM-approved aircraft. When the number of non-DRVSM-approved aircraft increased from 16 in Run 1a to 22 in Run 1b, the A/G and G/A workload increased by 22.5 percent, from a total of 1,110 calls in Run 1a to 1,360 calls in Run 1b. This finding is consistent with controller feedback that there was an increase in vectoring aircraft (both approved and non-DRVSM-approved aircraft) in order to accommodate non-DRVSM-approved aircraft in or transitioning through DRVSM airspace.

TABLE 4.1-4. Verbal Communications Workload Data for Runs 1a and 1b

Sector	Run	A/G and G/A Communications Frequency		G/G Communications Frequency
87/97	1a	402		3
	1b	452		1
88	1a	389		6
	1b	490		8
98	1a	319		3
	1b	418		2
Total	1a	1110	+22.5%	12
	1b	1360		11
Average per Sector	1a	370.0		4
	1b	453.3		3.7

In contrast, G/G and pointout workload decreased slightly from Run 1a to Run 1b. (As previously mentioned, the data collection methodology for G/G and pointouts is capable of measuring only those actions made via VSCS and HCS, and thus these figures may not account for all actions taken.) The G/G communications workload data are provided in Table 4.1-4, and pointout data are in Table 4.1-5.

TABLE 4.1-5. Pointout Data for Runs 1a and 1b

Sector	**Run**	**Pointouts Initiated**	**Pointouts Received**	**Total Pointout Workload**
87/97	1a	2	3	5
	1b	3	1	4
88	1a	4	3	7
	1b	3	3	6
98	1a	5	2	7
	1b	2	3	5
Totals	1a	11	8	19
	1b	8	7	15
Average per Sector	1a	3.7	2.7	6.3
	1b	2.7	2.3	5

Tables 4.1-6 and 4.1-7 provide the objective workload data comparisons for Runs 4a and 3a. In these runs, even though the number of non-DRVSM-approved aircraft increased from 0 in Run 4a to 11 in Run 3a and the subjective rating for workload increased moderately from a 2.34 (on a 5-point scale) in Run 4a to a 3.04 in Run 3a, there was no meaningful difference in workload as measured in terms of verbal communications or pointouts.

TABLE 4.1-6. Verbal Communications Workload Data for Runs 3a and 4a

Sector	**Run**	**A/G and G/A Communications Frequency**	**G/G Communications Frequency**
87/97	4a	387	2
	3a	372	1
88	4a	407	1
	3a	399	3
98	4a	382	0
	3a	393	0
Total	4a	1176	3
	3a	1164	4
Average per Sector	4a	392	1
	3a	388	1.3

TABLE 4.1-7. Pointout Data for Runs 3a and 4a.

Sector	Run	Pointouts Initiated	Pointouts Received	Total Pointout Workload
87/97	4a	0	2	2
	3a	3	1	4
88	4a	4	3	7
	3a	4	2	6
98	4a	6	2	8
	3a	3	5	8
Total	4a	10	7	17
	3a	10	8	18
Average per Sector	4a	3.3	2.3	5.7
	3a	3.3	2.7	6

The reasons for the difference in objective findings between Runs 1a/1b and Runs 4a/3a cannot be known definitively. Since controllers did rotate to different positions during the various runs, some of the differences may be due to individual controller techniques. Traffic sample 1 was designed to be more complex with a heavier base traffic volume than traffic sample 3. It may be that the base traffic flow in traffic sample 3 did not require extensive vectoring for the comparatively smaller number of non-DRVSM aircraft included in Run 3a, and so the A/G and G/A verbal communications workload were unaffected. In any case, it must be stressed that only a subset of elements that make up sector workload were objectively measured in this study. In particular, the objective workload measures available here include selected indicators of *physical* workload only, and do not address *cognitive* workload. Yet, controllers stressed the impact of non-DRVSM-approved aircraft in DRVSM airspace on their cognitive workload during the post-run debrief sessions. In particular, participants stated that in today's CVS environment controllers can check an aircraft's separation once at hand-off and know whether a separation action will be required. However, the presence of non-DRVSM-approved aircraft required a constant reassessment of separation as non-DRVSM-approved aircraft traversed the sector. It is possible that it is the cognitive element of workload that drove the controllers' subjective ratings for Run 3a, and this workload could not be captured in the objective workload data available.

4.1.2 Complexity Ratings

4.1.2.1 Subjective Complexity Ratings

As depicted in Table 4.1-8, complexity ratings increased as the number of non-DRVSM-approved aircraft in DRVSM airspace increased. Although the traffic base in Runs 1a and 1b does not allow a direct comparison with Runs 4a and 3a, it can be seen that Run 4a had the lowest complexity rating with no non-DRVSM-approved aircraft and Run 1b had the highest with the most non-DRVSM-approved aircraft.

TABLE 4.1-8. Complexity Ratings for Runs 1a/1b and Runs 4a/3a

Run	Number of Non-DRVSM-approved Aircraft		Complexity Ratings			
	Total	Average/Sector[6]	Sector 87/97	Sector 88	Sector 98	Average
1a	16	8.7	4.5	5	4	4.5
1b	22	11	5	5	5	5
4a	0	0	2.5	3.5	2.5	2.833
3a	11	5.3	3	4	3	3.333

4.1.2.2 Objective Complexity Measures

Since controllers must provide non-DRVSM-approved aircraft flying in DRVSM airspace with a 2000-foot vertical separation from all other aircraft, the number of such aircraft in their sector is an indication of complexity, as is the duration of time the aircraft was in the sector. The number of non-DRVSM-approved aircraft in Runs 1a/1b and Runs 4a/3a are presented in Table 4.1-9. The total number of non-DRVSM-approved aircraft per run is provided, as well as the number of non-DRVSM-approved aircraft handled by each sector, and the average number per sector.

TABLE 4.1-9. Number of Non-DRVSM-approved Aircraft for Runs 1a/1b and Runs 4a/3a

Run	Non-DRVSM-approved Aircraft					Average Complexity Rating
	Sector 87/97	Sector 88	Sector 98	Total[7]	Average per Sector[8]	
1a	8	9	9	16	8.7	4.5
1b	11	10	12	22	11	5
4a	0	0	0	0	0	2.833
3a	6	5	6	11	5.7	3.333

As can be seen by comparing the total with the complexity rating per run, there is a strong correlation between the number of non-DRVSM-approved aircraft in a run and the participants' average subjective rating of complexity.

[6] The average number of non-DRVSM-approved aircraft per sector was calculated by adding the sector numbers and dividing by 3.

[7] The total of non-DRVSM-approved aircraft is less than the sum of the per sector numbers since an individual aircraft usually traversed more than one sector.

[8] The average number of non-DRVSM-approved aircraft per sector was calculated by adding the sector numbers and dividing by 3.

Table 4.1-10 (Note 1) shows there is a similar correlation between the subjective complexity ratings and the total amount of time non-DRVSM-approved aircraft spent in the simulated sectors. This is as expected, since the more non-DRVSM-approved aircraft are added, the more total flying time these aircraft accumulate. When the sector average flying time is normalized by dividing by the average number of non-DRVSM-approved aircraft per sector, as was done for Runs 1a and 1B (Note 2), the result is more meaningful. Notice that the average (per non-approved aircraft) flying time in each sector increased by 10 seconds from Run 1a to Run 1b. This is meaningful since the routing of aircraft in Runs 1a and 1b were held constant. This finding is also consistent with the increase in vectoring that the participants reported, as well as the associated increase in A/G and G/A communications. (See Section 4.1.1.2.)

TABLE 4.1-10. Time (in Seconds) of Non-DRVSM-Approved Aircraft in DRVSM Airspace for Runs 1a/1b and Runs 4a/3a

Traffic Sample	**Run**	**Non-DRVSM-approved Aircraft Time in Sector (Secs)**				**Average Complexity Rating**	**Normalized Flying Time for Non-DRVSM-Approved Aircraft**
		Sector 87/97	**Sector 88**	**Sector 98**	**Sector Average**		
1	1a	3337	5249	4057	4214	4.5	484
	1b	5420	4195	6704	5440	5	495
3	4a	0	0	0	0	2.833	N/A[9]
	3a	3539	2496	4209	3415	3.333	

Note 2

Note 1

The frequency of occurrence of CA warnings is presented in Table 4.1-11. The data do not correlate with the controllers' perception of complexity as represented by their subjective ratings, nor do they correlate with the preceding objective complexity measures. It is not clear why the frequency of CA warnings would decrease when the number of non-DRVSM-approved aircraft increased. This was true; however, for sectors 87 and 88 in both Runs 1a/1b and Runs 4a/3c. Sector 98's CA warnings increased very slightly in both Runs 1a/1b and Runs 4a/3c.

[9] Since the basic traffic flight plans and routings differ between the two traffic samples, Runs 4a/3a cannot be compared to Runs 1a/1b. And since Run 4a had no non-DRVSM-approved traffic, the amount of flying time cannot be normalized for Runs 4a and 3a.

TABLE 4.1-11. Frequency of Conflict Alert Warnings for Runs 1a/1b and Runs 4a/3a

Run	Number of CA Warnings[10]								Average Complexity Rating
	Sector 87	Sector 88	Sector 98	Sectors 87/88	Sectors 87/98	Sectors 88/98	Totals	Avg. Per Sector	
	FL 240 and Above	FL 240-320	FL 330 and Above						
1a	25	34	49	24	28	74	360	120	4.5
1b	18	21	50	23	14	59	281	94	5
4a	26	21	31	27	23	71	320	107	2.833
3a	18	19	35	16	9	83	288	96	3.333

4.1.3 Potential for Error

4.1.3.1 Subjective Potential for Error Ratings

Consistent with workload and complexity, Table 4.1-12 shows that controllers' subjective ratings of the potential for error increased with the number of non-DRVSM-approved aircraft. This can be seen in comparing Run 1a with Run 1b, as well as Run 4a with Run 3a. Although the traffic base varied from the Runs 1a/1b pairing to the Runs 4a/3a pairing, there is a high correlation between the number of non-DRVSM-approved aircraft and the average potential for error rating.

TABLE 4.1-12. Ratings of Potential for Error for Runs 1a/1b and Runs 4a/3a

Run	Number of Non-DRVSM-approved Aircraft	Sector 87/97	Sector 88	Sector 98	Average
1a	16	5	5	4.5	4.833
1b	22	5	5	5	5
4a	0	2.5	1.5	2	2
3a	11	3	4	3	3.333

4.1.3.2 Objective Potential for Error Measures

Table 4.1-13 provides the number of operational errors for the four runs that were designed to assess the impact of different numbers of non-DRVSM-approved aircraft. See Appendix B for a summary of all operational errors that occurred during the simulation.

[10] The numbers in the individual sector columns include CA warnings involving two aircraft that were both under that sector's control. The sector pairings columns (e.g., Sectors 88/98) provide the number of conflict alerts between two aircraft that were under the control of different sectors.

TABLE 4.1-13. Frequency of Operational Errors for Runs 1a/1b and Runs 4a/3a

Run	Number of Non-DRVSM-approved Aircraft	Sector 87/97	Sector 88	Sector 98	Total	Number of Operational Errors Involving Non-DRVSM-approved
1a	16	0	1	0	1	0
1b	22	0	0	1	1	1
4a	0	1	0	0	1	N/A[11]
3a	11	0	2	0	2	1

In Runs 1a/1b, the number of operational errors remained the same, although the number of non-DRVSM-approved aircraft increased by 6. In Runs 4a/3a, the number of non-DRVSM-approved aircraft increased by 11, and the operational errors increased by 1. Half of the errors in the three runs that had non-DRVSM equipped aircraft (i.e., Runs 1a, 1b, and 3a) involved a non-DRVSM-approved aircraft. In fact, when all of the runs with non-DRVSM-aircraft in DRVSM airspace were considered, 27 percent of the errors involved at least one non-DRVSM-approved aircraft, despite the fact that non-DRVSM-approved aircraft accounted for approximately only 6 to 14 percent of the total traffic in these runs. On the other hand, **none** of the four errors that occurred during Run 3c involved non-DRVSM-approved aircraft, again demonstrating that the presence of non-DRVSM-approved aircraft affects the sector as a whole.

While an increase in non-DRVSM-approved aircraft did not produce a directly proportional increase in operational errors, the objective operational error finding is nonetheless compatible with the other subjective and objective findings that indicate that the presence of too many non-DRVSM aircraft per sector may be problematic under heavy or complex traffic conditions. (Table 2-1 depicts the number of non-DRVSM-approved aircraft in each sector for each run of this simulation.)

4.1.4 Ease of Conversion

On a scale of 1 (very easy) to 5 (very difficult), controllers were asked to rate the ease of using the revised altitudes for direction of flight inherent in DRVSM. Even though the participants' experience with DRVSM grew during the week, using the revised altitudes did not necessarily become easier. In general, as seen in Table 4.1-14, the average rating increased proportionally as the number of non-DRVSM-approved aircraft increased. In Run 4a, however, the average rating was 1.8, indicating participants found the changes in appropriate altitudes for direction of flight moderately easy to adjust to in the absence of non-DRVSM-approved aircraft.

[11] Run 4A included no non-DRVSM-approved DOD, lifeguard or transitioning aircraft in DRVSM airspace.

TABLE 4.1-14. Ease of Adapting to Revised Altitudes

Run	Sector 87/97	Sector 88	Sector 98	Average	Number of Non-DRVSM-approved Aircraft	Run order
1a	3.5	4	5	4.166	16	1
1b	4.5	4.5	4.5	4.5	22	6
4a	1.5	1.5	2.5	1.833	0	7
3a	3	4.5	2	3.166	11	2

4.2 Impact of the Loss of an Approved Aircraft's Equipment

Participants were instructed at the beginning of the simulation that if a DRVSM-approved aircraft reported a loss of their equipment, the controllers at that sector were to provide the aircraft with conventional separation as quickly as possible, to change the equipage code so that the non-DRVSM-approved indicator would be visible, and to expedite the aircraft out of DRVSM airspace.

The impact of the loss of a DRVSM-approved aircraft's equipment was found to be wholly dependent upon the specific traffic conditions at the time of the loss. In some cases, the loss occurred in a situation in which the controller had to immediately vector or change the altitude of that aircraft and/or other aircraft to achieve conventional separation for the aircraft with the equipment loss and to transition the aircraft out of DRVSM airspace. In other cases, the situation was such that the aircraft already had 2000 feet separation from other aircraft at the time of the equipment loss, and there was no traffic to impede the descent of the affected aircraft out of DRVSM airspace.

Two types of subjective data were obtained from each run in which an equipment loss occurred. First is the WAK data for the 5-minute interval immediately prior to the outage and immediately following the outage. Second, the controllers whose sector was affected by the equipage loss were asked, after the completion of the run, to rate the impact of the equipage loss on their workload, complexity, and potential for error. In the 5-point scale used in the questionnaire, a response of 1 indicated the impact of the equipment loss was a significant decrease in workload, complexity, or potential for error, a response of 3 indicated there was no impact, and a response of 5 indicated a significant increase in workload, complexity, or potential for error. The following table provides the impact rating results.

TABLE 4.2-1. Equipage Loss Impact Ratings

Run	Sector Affected by Loss	Change in WAK Ratings[12]	Impact Ratings for Workload[13]	Impact Ratings for Complexity[14]	Impact Ratings for PFE[15]	Comments
1a	87/97	0	4	4	3	-
1b	98	+ .5	3.5	4	4	-
3a	87/97	- 1.0	2.5	2.5	3	No aircraft in path of descent
3c	87/97	- 1.0	3[16]	3.5	4.5	No potential loss of separation

5. RESULTS FOR OBJECTIVE 3: IDENTIFY SPECIFIC PROCEDURAL ISSUES

The need for procedures for DRVSM operations was identified during the debriefs. The list below includes considerations for possible national procedural development, as well as local procedures:

- Non-DRVSM-approved aircraft transitioning through DRVSM airspace.
- Required coordination when a non-DRVSM-approved aircraft is at the base or the ceiling altitude between a high and super-high altitude sector. Approval request (APREQ) and wrong altitude for direction of flight (WAFDOF) for hand-off of non-DRVSM-approved aircraft.
- Procedures for the suspension of DRVSM. Controller responsibilities and priorities, given that there will be aircraft with 1000-foot separation when suspension is called.
- Procedure to change the equipage suffix when a DRVSM-approved aircraft loses its equipment. This ensures that controllers will see the non-DRVSM indicator on their situation display.

[12] Averaged across the R and RA ratings. The change is the difference between the WAK rating in the 5-minute interval prior to and the 5-minute interval following the equipment loss. A positive value indicates an increase in workload; a negative value indicates a decrease in workload.
[13] Averaged over R and RA ratings, with the exception of run 3c.
[14] Averaged over R and RA ratings.
[15] Potential for Error (PFE).
[16] This entry represents the R-controller rating alone. The RA-controller appeared to misunderstand the question and gave a response of 5, which was inconsistent with the written and verbal comments, as well as that controller's WAK ratings.

6. RESULTS FOR OBJECTIVE 4: GAIN OPERATIONAL EXPERIENCE IN TACTICAL USE OF DRVSM IN A CVS ENVIRONMENT

One of the eight runs, Run 2b, was used to assess the tactical use of DRVSM altitudes in a CVS environment. Run 2b included peak traffic, with 50 percent of the aircraft DRVSM-approved and 50 percent non-DRVSM-approved. Although only subjective data were analyzed for Objective 4, objective data for operational errors are provided for completeness.

6.1 Subjective Measures

Controllers were asked to rate to what extent they had the opportunity to use the DRVSM altitudes tactically during this run. Table 6.1-1 provides their ratings, using a scale in which a rating of 1 indicated there was no opportunity to use the DRVSM altitudes tactically, a rating of 3 indicated moderate opportunity to use DRVSM tactically, and a rating of 5 indicated significant opportunities to use DRVSM altitudes tactically.

TABLE 6.1-1. Opportunity to Use DRVSM Altitudes Tactically

	Sector 87/97	Sector 88	Sector 98	Average
Ratings	2.5	1.5	1.5	1.833

An average rating of 1.8 indicates the participants saw little to moderate opportunity to use DRVSM altitudes tactically during this run. During the post-run debriefing only one sector indicated they actually used DRVSM tactically. During the debrief, the participants indicated there was almost no use of the additional altitudes because the mixture of DRVSM-approved and non-DRVSM-approved aircraft caused an increase in cognitive workload and complexity. For the most part, the controllers used CVS for controlling traffic and provided all aircraft with 2000-foot separation, because they considered this easier, with less potential for errors. Although there was no such opportunity during this run, the participants indicated one possible use would be to use 1000-foot separation for a short-duration descent of an approved aircraft that will shortly be returned to its prior altitude.

The controllers from ZID who participated in the pre-simulation shakedown period (to validate and refine the traffic scenarios) indicated that the peak traffic volume in Run 2b would probably provide little, if any, opportunity to use the additional altitudes. Possibly, there could be greater opportunity and benefit to using DRVSM altitudes tactically in a CVS environment during light to moderate traffic conditions. Additionally, the ZID controllers indicated that (at least for the areas of specialization used for this simulation) they tend to use vectoring much more frequently than altitude changes to maintain separation.

Table 6.1-2 provides the ratings for the impact of tactical use on workload, complexity, and potential for error. In the 5-point scale used in the questionnaire, a response of 1 indicated the impact of tactical use of DRVSM altitudes was a significant *decrease* in workload, complexity, or potential for error; a response of 3 indicated there was no impact; and a response of 5 indicated a significant *increase* in workload, complexity, or potential for error.

TABLE 6.1-2. Tactical Use Impact Ratings for Workload, Complexity, and Potential for Error

Sector	Impact Rating for Workload	Impact Rating for PFE	Impact Ratings for Complexity
87/97	3	3	3
88	3[17]	-[18]	3
98	3	2.5	3[19]
Average	3	2.75	3

All six of the controllers responded that tactical use of DRVSM altitudes had no impact - positive or negative - on their workload, or on the complexity of their sectors. One of the six controllers responded that there is a potential for a slight reduction in errors, while the remaining controllers felt having the DRVSM altitudes available for use tactically would have no impact on potential for error. This is consistent with (and perhaps due to) the extremely low tactical usage of DRVSM in this run.

6.2 Objective Measures

Table 6.2-1 provides the number of operational errors that occurred during Run 2b. These data are provided for completeness sake only. As depicted in Table 2-1, no comparisons to other runs are meaningful. See Appendix B for a summary of all operational errors that occurred during the simulation.

TABLE 6.2-1. Operational Errors for Run 2b

Run	Sector 87	Sector 88	Sector 98	Total	Number of Operational Errors Involving Non-DRVSM-approved
2b	0	1	0	1	0

7. RESULTS FOR OBJECTIVE 5: ASSESS EFFORT ENTAILED IN TRANSITIONING AIRCRAFT FROM REDUCED VERTICAL SEPARATION STANDARDS TO CONVENTIONAL SEPARATION STANDARDS

Runs 3a and 3c were designed to allow an assessment of the impact of a mixed DRVSM and CVS environment on controller workload, sector complexity, and potential for error. Runs 3a and 3c were equivalent in all respects *except* that in Run 3a both ZID and ZOB used DRVSM. During Run 3c, ZOB used CVS, while ZID used DRVSM. Since all three simulated ZID sectors are

[17] One controller did not provide a rating.

[18] Both controllers at this sector wrote comments that they did not use the DRVSM altitudes tactically, and therefore did not rate the impact on potential for error.

[19] One controller did not provide a rating.

adjacent to ZOB airspace, the ZID controllers were required to transfer control of aircraft to ZOB at CVS altitudes during Run 3c. Similarly, aircraft arriving from ZOB airspace were received at CVS altitudes during Run 3c.

7.1 Workload

7.1.1 Subjective Workload Ratings

The subjective workload data collected included WAK and questionnaire ratings. Two distinct questions were asked. After both runs, controllers were asked to rate their overall workload on a scale of 1 to 5, where a rating of 1 is very light, a 3 is moderate, and a 5 is very heavy. Additionally, after Run 3c controllers were asked to rate the impact of a mixed vertical separation environment on their workload. In this case, a 1 on the 5-point rating indicated a significantly reduced workload, a rating of 3 indicated no impact, and a rating of 5 indicated a significantly increased workload. Subjective workload results are provided in Table 7.1-1.

TABLE 7.1-1. Workload and Workload Impact Ratings for a Mixed Vertical Separation Environment

Sector	Run	WAK Ratings	Questionnaire Workload Ratings	Average Workload Ratings	Workload Impact Ratings
87/97	3a	2.55	3	2.775	-
	3c	3.6	4	3.8	4
88	3a	2.8	3	2.9	-
	3c	3.5	3.5	3.5	4
98	3a	2.9	4	3.45	-
	3c	3.5	4	3.75	4
Average	3a	2.75	3.333	3.0415	-
	3c	3.53	3.833	3.6815	4

On average, the six ZID controllers indicated some degree of workload impact from using DRVSM in airspace that is immediately adjacent to CVS airspace – rating this impact at 4 – between "no impact " (3) and "significantly increased workload" (5). These ratings are consistent with the increase in average workload ratings when Run 3a (an all DRVSM environment) is compared with Run 3c (a mixed DRVSM/CVS environment).

7.1.2 Objective Workload Measures

The objective measures for workload included numbers of verbal communications between controllers and pilots, numbers of VSCS communications between controllers, and numbers of pointouts. Table 7.1-2 provides the verbal communications workload numbers for Runs 3a and 3c. As can be seen by the total number of A/G and G/A communications, the communications workload between controllers and pilots did not significantly change with the introduction of the mixed vertical separation environment, however, the G/G communications workload jumped substantially, from 4 G/G calls made via VSCS to 19.

TABLE 7.1-2. Verbal Communication Workload Data for Runs 3a and 3c

Sector	Run	A/G and G/A Communications Frequency	G/G VSCS Communications Frequency
87/97	3a	372	1
	3c	398	2
88	3a	399	3
	3c	380	6
98	3a	393	0
	3c	391	11
Total	3a	1164	4
	3c	1169	19

The number of pointouts initiated and received by each sector is provided in Table 7.1-3. The data indicate the number of pointouts initiated or received at each of the three sectors increased substantially from a full DRVSM environment to a mixed vertical separation environment. This finding is consistent with the increase in G/G communications, since controllers must coordinate pointouts with the affected sector. Further, the increase in G/G communications and pointouts is consistent with the moderate increase in workload subjective ratings provided by the participants.

TABLE 7.1-3. Pointout Data for Runs 3a and 3c

Sector	Run	Pointouts Initiated	Pointouts Received[20]	Total PO Workload
87/97	3a	3	1	4
	3c	1	6	7
88	3a	4	2	6
	3c	9	4	13
98	3a	3	5	8
	3c	9	4	13
Total	3a	10	8	18
	3c	19	14	33

[20] Includes only pointouts received by one of the three simulated sectors. Pointouts to ghost sectors are not included in this column.

7.2 Complexity

7.2.1 Subjective Complexity Ratings

After each run controllers were asked to rate the complexity of the problem on a scale of 1 to 5, where a rating of 1 is not complex at all, a 3 is moderate, and a 5 is very complex. Additionally, after Run 3c, controllers were asked to rate the impact of a mixed vertical separation environment on sector complexity. In this case, a 1 on the 5-point rating indicated significantly reduced complexity, a rating of 3 indicated no impact, and a rating of 5 indicated significantly increased complexity.

The subjective results for the impact of a mixed vertical separation environment on sector complexity are very similar to, and entirely consistent with, those for workload. A mixed vertical separation environment represents a moderate increase in sector complexity, as can be seen in Table 7.2-1 shows.

TABLE 7.2-1. Complexity and Complexity Impact Ratings for a Mixed Vertical Separation Environment

Sector	Run	Overall Complexity Ratings	Complexity Impact Ratings
87/97	3a	3	-
	3c	4.5	3.5
88	3a	4	-
	3c	3.5	4
98	3a	3	-
	3c	4.5	4
Average	3a	3.333	-
	3c	4.166	3.833

7.2.2 Objective Complexity Measures

Table 7.2-2 provides the number of CA warnings for Runs 3a and 3c. Overall, the total number increased slightly when the mixed vertical separation environment was introduced. The picture is more complex, however, on a per sector basis. Considering the CA warnings involving aircraft within individual sectors, the number of CA warnings from Run 3a to Run 3c increased substantively for sector 87 (+10) and sector 88 (+7), but decreased significantly for 98 (-14). Similarly, when considering CA warnings involving aircraft in different sectors, CA warnings increased for sector pairs 87/88 (+7) and 87/98 (+16), but decreased by 20 for the 88/98 sector pairing. This result may indicate that the impact of a mixed vertical separation environment on sector complexity could differ based the altitude stratum of the sector.

TABLE 7.2-2. Frequency of Conflict Alert Warnings

Run	Number of CA Warnings						
	Sector 87	Sector 88	Sector 98	Sector 87/88	Sector 87/98	Sector 88/98	Total
	FL 240 and Above	FL 240-320	FL 330 and Above				
3a	18	19	35	16	9	83	288
3c	28	26	21	23	25	63	297

Since Runs 3a and 3c were designed to have the same traffic complexity, including the number of non-DRVSM-approved aircraft, neither the number of non-DRVSM-approved aircraft nor the time non-DRVSM aircraft spent in the sectors are valid measures for Objective 5.

7.3 Potential for Error

7.3.1 Subjective Potential for Error (PFE) Ratings

After each run, controllers were asked to rate the potential for error on a scale of 1 to 5, where a rating of 1 is very low, a 3 is moderate, and a 5 is very high. Additionally, after Run 3c, controllers were asked to rate the impact of a mixed vertical separation environment on potential for error. In this case, a 1 on the 5-point rating indicated a significantly reduced potential for error, a rating of 3 indicated no impact, and a rating of 5 indicated a significantly increased potential for error.

As with subjective ratings for workload and complexity, Table 7.3-1 shows that controllers rated the impact of a mixed vertical separation environment as moderately increasing the potential for error.

TABLE 7.3-1. PFE and PFE Impact Ratings for a Mixed Vertical Separation Environment

Sector	Run	Overall PFE Ratings	PFE Impact Ratings
87/97	3a	3	-
	3c	4.5	4
88	3a	4	-
	3c	4	4
98	3a	3	-
	3c	5	4.5
Average	3a	3.333	-
	3c	4.5	4.333

7.3.2 Objective Potential for Error Measures

Consistent with the increase in CA warnings in sectors 87 and 88, Table 7.3-2 shows that the number of operational errors in these sectors increased, while sector 98 had no errors in either run. Overall, the number of operational errors increased from 2 (Run 3a) to 4 (Run 3c) when the neighboring ARTCC (ZOB) was assumed to use CVS, while ZID used DRVSM. The number of operational errors in Run 3c was higher, in fact, double that of any other of the eight runs. While operational errors occur relatively infrequently and, therefore, the sample size is always comparatively smaller than other measures, this fact nevertheless seems to validate the subjective ratings of the impact of a mixed vertical separation environment. See Appendix B for a summary of all operational errors that occurred during the simulation.

TABLE 7.3-2. Operational Errors for Runs 3a and 3c

Run	Sector 87	Sector 88	Sector 98	Total	Number of Operational Errors Involving Non-DRVSM-approved
3a	0	2	0	2	1
3c	1	3	0	4	0

8. RESULTS FOR OBJECTIVE 6: ASSESS IMPACT OF SUSPENSION OF DRVSM ON THE NAS

Two of the eight runs, Runs 1c and 2a, were used to assess the impact of suspending DRVSM. Controllers were told there would be suspensions at some point during the week, but were not told which runs would be affected. The purpose was to understand the impact on workload, complexity, and potential for error, as well as obtain feedback on concerns and procedural issues. Although only subjective data were analyzed for Objective 6, objective data for operational errors are provided for completeness.

8.1 Subjective Measures

Two types of subjective data were obtained from each run in which DRVSM was suspended. First is the WAK data for the 5-minute interval immediately prior to the suspension and immediately following the outage. Second, the controllers were asked, after the completion of the run, to rate the impact of the suspension on their workload, complexity, and potential for error. In the 5-point scale used in the questionnaire, a response of 1 indicated the impact of suspension was a significant decrease in workload, complexity, or potential for error; a response of 3 indicated there was no impact; and a response of 5 indicated a significant increase in workload, complexity, or potential for error.

Table 8.1-1 provides the impact ratings for the two suspension runs. As can be seen from the averages, controllers felt that suspension had a moderately significant to significant impact on workload, complexity and potential for error. In all cases, controllers were able to convert all aircraft to CVS within a 2 to 4 minute period. The participants indicated that the ease or difficulty of converting aircraft to CVS will depend upon two factors: the specific traffic conditions in the sector at the time suspension was called, and the individual sector team's experience and skill level.

TABLE 8.1-1. DRVSM Suspension Impact Ratings for Workload, Complexity, and Potential for Error

Sector	Run	Change in WAK Ratings[21]	Impact Ratings for Workload	Impact Ratings for Complexity	Impact Ratings for PFE
87/97	1c	+ .5	5	5	5
	2a	+ .5	4.5	4.5	4
	Avg.	+ .5	4.75	4.75	4.5
88	1c	+ .5	5	5	5
	2a	+ 1.5	4.5	4	5
	Avg.	+ 1.0	4.75	4.5	5
98	1c	+ 2.5	4.5	4.5	5
	2a	- 1.0	3	3.5	3.5
	Avg.	.75	3.75	4	4.25
Averages	1c	1.167	4.833	4.833	5
	2a	.333	4	4	4.833
	Avg.	.75	4.416	4.416	4.917

8.2 Objective Measures

Table 8.2-1 presents the operational error data for Runs 1c and 2a. As depicted in Table 2-1, no comparison to any run (including 2a) is meaningful for Run 1c. Similarly, results for Run 2a cannot be compared to Run 1c or any other run. See Appendix B for a summary of all operational errors that occurred during the simulation.

TABLE 8.2-1. Operational Errors for Runs 1c and 2b

Run	Sector 87/97	Sector 88	Sector 98	Total	Number of Operational Errors Involving Non-DRVSM-approved
1c	0	0	0	0	0
2a	0	1	0	1	1

[21] Averaged across the R and RA ratings. The change is the difference between the WAK rating in the 5-minute interval prior to and the 5-minute interval following the equipment loss. A positive value indicates an increase in workload; a negative value indicates a decrease in workload.

8.3 Controller Comments

Several issues and concerns related to suspension of DRVSM operations were collected from the debriefings and the participant's written comments. These included the need for defined procedures that specify the rules for transitioning from DRVSM to CVS, as well as the definition of the controller's priorities when suspension is called. The need for definition of controller responsibilities and priorities when suspension is called was highlighted given that there will be aircraft with only 1000-foot separation. The participants indicated that their transition back to CVS during the simulation should not be viewed as representative since they were much more comfortable with CVS than with DRVSM.

9. CONCLUSIONS

9.1 Summary of Key Findings

9.1.1 Impact of Increased Numbers of Non-DRVSM-Approved Aircraft

It is known and documented from the first DRVSM simulation that the additional altitudes provided by DRVSM can reduce controller workload, complexity, and potential for error when the number of non-DRVSM-approved aircraft is small, i.e., between 1 to 3 such aircraft per sector. A primary objective of this second DRVSM simulation was to gain an understanding of the impact of larger numbers of non-DRVSM-approved aircraft in the DRVSM airspace. The four runs in Table 9-1 were designed to permit an assessment of the impact of different numbers of DRVSM-approved aircraft. As shown in Table 9-1, controllers' perceptions of their workload, sector complexity, and potential for error increased in direct proportion with an increase in the average number of non-DRVSM-approved aircraft per sector. Runs that are based on the same traffic sample are equivalent in all regards *except* the number of non-DRVSM-approved aircraft. While the base complexity of traffic samples 1 and 3 are not directly comparable, each subjective measure increased with each increase in the average number of non-approved aircraft per sector.

TABLE 9-1. Summary of Average Subjective Ratings[22]

Traffic Sample	Run	Average Number of Non-DRVSM-Approved Aircraft Per Sector	Average Workload Ratings	Average Complexity Ratings	Average PFE Ratings
3	4a	0	2.3	2.8	2
	3a	5.7	3.0	3.3	3.3
1	1a	8.7	3.7	4.5	4.5
	1b	11	4.1	5	5

[22] All ratings were based on a 5-point scale in which 1 is very light or low, 3 is moderate, and 5 is very heavy or high.

Based on the controller feedback received, *cognitive* workload resulting from non-DRVSM-approved aircraft in DRVSM airspace may be the largest single impact on workload. In today's CVS environment, they can check an aircraft's separation at the point of hand-off and know whether a separation action will or will not be needed. Controllers indicated they had to constantly reassess the separation for non-DRVSM-approved aircraft as they traversed through their sector, thereby increasing cognitive workload. Cognitive workload was assessed only via subjective ratings.

The objective measures for workload were numbers of verbal communications and pointouts. The most significant result was in A/G and G/A communications. Consistent with the subjective ratings, there was a 22.5 percent increase in the number of pilot and controller communications when the average number of non-approved aircraft increased from 8.7 per sector to 11 per sector from Run 1a to Run 1b. This indicates that substantially more clearances were needed in traffic sample 1 to maintain separation as the number of non-approved aircraft increased, even though the overall number of aircraft and their routings were held constant. Traffic sample 3, designed to be less heavy and complex than traffic sample 1, supported an increase in non-DRVSM-approved aircraft from 0 (in Run 4a) to 5.7 (in Run 3a), without an increase in A/G and G/A communications, although the number of G/G communications and pointouts increased very slightly.

For the objective measures for complexity and potential for error, the key finding was that 27 percent of operational errors that occurred in runs with non-DRVSM-approved aircraft involved at least one non-DRVSM-approved aircraft, even though the non-DRVSM-approved aircraft accounted for less than 15 percent of the traffic. When the per sector flying time of non-DRVSM-approved aircraft was normalized by dividing by the number of non-approved aircraft, the flying time per aircraft per sector increased by 11 seconds when the number of non-approved aircraft increased from 8.7 to 11 (Runs 1a and 1b). For reasons unknown, the total number of CA warnings decreased when the number of non-approved aircraft increased, and this result was consistent across both traffic samples 1 and 3.

Overall, there are some objective data that support the subjective assessment that workload, complexity, and potential for error do, in fact, increase for larger numbers of non-DRVSM-approved aircraft. The remaining objective data neither support nor contradict the subjective assessment.

9.1.2 Impact of Loss of DRVSM-Approved Equipment

The simulations demonstrated that the impact of the loss of a DRVSM-approved aircraft's equipment is wholly dependent upon the specific traffic conditions at the time of the loss. In some cases, the loss required vectoring or change of altitude of that aircraft and/or other aircraft to achieve conventional separation for the affected aircraft. In other cases, the aircraft already had 2000 feet of separation, and there was no traffic to impede the descent of the aircraft out of DRVSM airspace.

9.1.3 Ease of Conversion

As the controllers gained experience during the weeklong simulation, they stated that it became somewhat easier to use the revised altitudes for direction of flight inherent with DRVSM, however, the data from this simulation show that when controllers were extremely busy it was harder for them to remember the new directions of flight or to use the additional altitudes. While controlling traffic, controllers depend on such factors as memory, facility culture, and the techniques they habitually use to control traffic. Many of today's controllers have years of experience and habits that are deeply ingrained. It may take time to change these habits, to learn to use the additional altitudes, and to become comfortable using the revised altitudes for the direction of flight. The ZID controllers felt that significant training and familiarization will be necessary to become comfortable with DRVSM operations in peak traffic conditions. Due to operational differences among ARTCC's, the length of training may vary from ARTCC to ARTCC.

9.1.4 Specific Procedural Issues Identified

New or revised procedures to support DRVSM operations are a requirement for successful DRVSM implementation. Specific topics identified from this simulation include procedures for non-DRVSM-approved aircraft in DRVSM airspace, required coordination and approval requests for non-DRVSM-approved aircraft, suspension of DRVSM, and handling of aircraft equipment loss resulting in loss of DRVSM approval status.

9.1.5 Tactical Use of DRVSM

The simulation participants found little opportunity to use the DRVSM altitudes tactically in a CVS environment. It is likely that the peak traffic volume in the tactical use problem caused the controllers to use the same separation techniques they habitually use today, since it required less cognitive effort. Additionally, it may be because the simulation participants indicated they tend to use vectoring to a significantly greater degree than vertical separation. ARTCC's that rely more on altitudes for separation may find tactical use more beneficial.

9.1.6 Mixed Vertical Separation Environment

Transitioning aircraft from reduced vertical separation standards to conventional vertical separation standards (and vice versa) resulted in at least a moderate increase in controller ratings for workload, complexity, and potential for error. Average workload and complexity ratings increased by 20 and 25 percent, respectively, while the potential for error ratings increased by 35 percent. Objectively, workload associated with G/G communications and pointouts increased substantially, by 375 percent and 83 percent, respectively. However, A/G and G/A workload (which is perhaps the best overall objective measure of sector workload) remained essentially unchanged. In terms of potential for error, the run in which there was a mixed vertical separation environment (Run 3c) incurred the highest number of operational errors (4), twice that of any other run. Consequently, it appears that a mixed vertical separation environment would have a moderate impact on workload, complexity, and potential for error for those sectors adjacent to the CVS airspace.

9.1.7 Suspension of DRVSM

The controllers' impact ratings indicate that suspension of DRVSM results in a moderately significant increase in workload and complexity, and a significant increase in potential for error, despite the fact that the participants were much more comfortable with CVS than DRVSM.

9.2 Next Steps

Another DRVSM simulation is planned in 2003. The focus of this simulation is expected to be the assessment of DRVSM procedures and any remaining areas of concern to Air Traffic.

Appendix A
Sample Post-Run Questionnaire

The following questionnaire includes all of the questions the participants were asked to answer during the course of the simulation runs. Not every question was relevant to every run, so the actual questionnaires used were tailored for each run.

INSTRUCTIONS

This form requests information regarding your overall experiences and judgments about the DRVSM run that you just completed.

Your name will not be listed or appear in any reports in order to insure your anonymity and to encourage unbiased reporting. Findings will be reported generically, e.g., Controller A, B, C, etc.

You will be asked to rate various aspects of the run you have just completed on a rating scale from 1 to 5. Each question to be rated has its own scale, which is provided, in the shaded area below the question. The end points, 1 and 5, as well as the mid-point, 3, will always be defined for you, but you may also use the intermediate ratings of 2 and 4. To illustrate, here's a sample:

What was your overall workload (e.g., mental, physical, communications) level during this problem? Circle your response using the scale shown below.

1 – Very light
3 – Moderate
5 – Very heavy

1 2 3 4 5

When making your ratings, **please** consider all five levels of the rating scale, and not just the middle ratings of a 2, 3, or 4. For the sake of interpreting the rating scale, consider the full range of conditions you actually encounter on a regular basis at your specific sector when the sector is staffed with two controllers. For example, rate the above question a 5 if the workload was similar to the heaviest period for a two-person sector during a normal busy traffic day at this particular sector.

Please use the space for comments to jot yourself a reminder of any items that you want to discuss during the debriefings. Also, if something in the simulation environment influenced your rating, please describe.

Date: _______________ Controller ID: __________________ Sector: ___________

Run: _____________ Control Position: R ❒ D ❒

1. Rate each of the factors described below according to the prescribed scales:

A. What was your overall workload (e.g., mental, physical, communications) level during this problem? Circle your response using the scale shown below.

1 – Very light
3 – Moderate
5 – Very heavy

1 2 3 4 5

COMMENTS: ____

____

____

B. Complexity of traffic flows and volume

1 – Not complex at all
3 - Moderate
5 - Very complex

1 2 3 4 5

COMMENTS: ____

____

____

C. Potential for controller error

1 – Very low
3 - Moderate
5 – Very high

1 2 3 4 5

COMMENTS: ____

____

____

D. Ease of adapting to the revised altitudes for direction of flight

1 – Very easy
3 - Moderate
5 – Very difficult

1 2 3 4 5

COMMENTS: ____

____

____

2. For the following questions, please consider the impacts of the additional DRVSM altitudes in your ratings. Rate the impact of each of the following according to the prescribed scales:

A. Extent of the impact of the additional DRVSM altitudes on your workload? Circle your response using the scale shown below.

1 – Significantly reduced workload
3 – No impact
5 – Significantly increased workload

1	2	3	4	5

COMMENTS:

B. Extent of the impact of the additional DRVSM altitudes on the complexity of your sector? Circle your response using the scale shown below.

1 – Significantly reduced complexity
3 – No impact
5 – Significantly increased complexity

1	2	3	4	5

COMMENTS:

C. Extent of the impact of the additional DRVSM altitudes on the potential for error at your sector? Circle your response using the scale shown below.

1 - Significantly reduced potential for error
3 – No impact
5 – Significantly increased potential for error

1	2	3	4	5

COMMENTS:

3. For the following questions, please consider the impacts of the non-approved military and lifeguard flights to be accommodated in your sector in your ratings. Rate the impact of each of the following according to the prescribed scales:

A. Extent of the impact of the accommodated non-approved military and lifeguard flights on your workload? Circle your response using the scale shown below.

1 – Significantly reduced workload
3 – No impact
5 – Significantly increased workload

1	2	3	4	5

COMMENTS:

B. Extent of the impact of the accommodated non-approved military and lifeguard flights on the complexity of your sector? Circle your response using the scale shown below.

1 - Significantly reduced complexity
3 – No impact
5 – Significantly increased complexity

1	2	3	4	5

COMMENTS:

C. Extent of impact of the accommodated non-approved military and lifeguard flights on the potential for error at your sector? Circle your response using the scale shown below.

1 - Significantly reduced potential for error
3 – No impact
5 – Significantly increased potential for error

1	2	3	4	5

COMMENTS:

4. For the following questions, please consider the impacts of the non-approved transitioning aircraft on your ratings. By non-approved transitioning aircraft we mean non-approved aircraft that are transitioning or that would transition through DRVSM altitudes. Rate the impact of each of the following according to the prescribed scales:

A. Extent of the impact of non-approved transitioning aircraft on your workload? Circle your response using the scale shown below.

1 – Significantly reduced workload
3 – No impact
5 – Significantly increased workload

1	2	3	4	5

COMMENTS:

B. Extent of the impact of non-approved transitioning aircraft on the complexity of your sector? Circle your response using the scale shown below.

1 - Significantly reduced complexity
3 – No impact
5 – Significantly increased complexity

1	2	3	4	5

COMMENTS:

C. Extent of the impact of non-approved transitioning aircraft on the potential for error at your sector? Circle your response using the scale shown below.

1 - Significantly reduced potential for error
3 – No impact
5 – Significantly increased potential for error

1 2 3 4 5

COMMENTS:

5. For the following questions, please consider the **cumulative** impacts of DRVSM in your ratings. That is, consider the impacts of the additional DRVSM altitudes **and** the non-approved aircraft (military, lifeguard, and transitioning) in your ratings. Rate the impact of each of the following according to the prescribed scales:

A. Extent of the impact of DRVSM on your workload? Circle your response using the scale shown below.

1 – Significantly reduced workload
3 – No impact
5 – Significantly increased workload

1 2 3 4 5

COMMENTS:

B. Extent of the impact of DRVSM on the complexity of your sector? Circle your response using the scale shown below.

1 - Significantly reduced complexity
3 – No impact
5 – Significantly increased complexity

1 2 3 4 5

COMMENTS:

C. Extent of the impact of DRVSM on the potential for error at your sector? Circle your response using the scale shown below.

1 - Significantly reduced potential for error
3 – No impact
5 – Significantly increased potential for error

1 2 3 4 5

COMMENTS:

D. Roughly how many total aircraft in your sector would you say were non-RVSM-approved (military, lifeguard, and transitioning) in this run? That is, how many had the colored box indicator in the second line of the datablock?____

E. Roughly how many non-approved military and/or lifeguard flights were to be accommodated at a DRVSM altitude in your sector? ____

F. Roughly how many non-approved transitioning aircraft were you able to allow access to DRVSM altitudes in your sector? ____

G. Did you need to deny any non-approved aircraft from transitioning through DRVSM altitudes in your sector? (Check one) Yes ☐ No ☐

If yes, roughly how many were denied? ____

6. Please answer the following questions related to procedural issues. While you do not need to describe the situation in detail, please jot down sufficient information to jog your memory during subsequent group discussions.

A. What situations did you encounter in this run that may require changes to existing procedures for DRVSM operations?

____
____
____
____

B. What situations did you encounter in this run that may require some new procedures for DRVSM operations?

____
____
____
____

7. Please answer the following questions related to the loss of a DRVSM-approved aircraft's altimetry equipment, requiring the controller to provide conventional vertical separation for that aircraft. Rate the impact of each of the following according to the prescribed scales:

A. Was any aircraft in your sector affected by a loss of altimetry equipment that caused the controller to revert to conventional vertical separation standards for that aircraft? (Check one) Yes ☐ No ☐

<u>If you answered "no" to this question, skip Parts B through E.</u>

B. If you answered "Yes" to Part A, please describe the actions you took.

COMMENTS: ____
____
____

C. If you answered "Yes" to Part A, what was the impact of this on your workload? Circle your response using the scale shown below.

1 – Significantly reduced workload
3 – No impact
5 – Significantly increased workload

1	2	3	4	5

COMMENTS: ____
____
____

D. If you answered “Yes” to Part A, what was the impact of this altimetry equipment loss on the complexity of your sector? Circle your response using the scale shown below.

1 Significantly reduced complexity
3 – No impact
5 – Significantly increased complexity

1 2 3 4 5

COMMENTS:

E. If you answered “Yes” to Part A, what was the impact of the altimetry equipment loss on the potential for error at your sector? Circle your response using the scale shown below.

1 Significantly reduced potential for error
3 – No impact
5 – Significantly increased potential for error

1 2 3 4 5

COMMENTS:

8. Please answer the following questions related to tactical use of DRVSM altitudes. Rate the impact of each of the following according to the prescribed scales:

A. To what extent were you able to use the DRVSM altitudes tactically during this run? Circle your response using the scale shown below.

1 – No opportunity to use the DRVSM altitudes tactically
3 – Moderate opportunity to use of DRVSM altitudes tactically
5 – Significant opportunity to use the DRVSM altitudes tactically

1 2 3 4 5

COMMENTS:

B. Under what operational conditions would you be able to take greater advantage of tactical use?

COMMENTS:

C. To what extent did the tactical use of DRVSM altitudes during this run impact your workload? Circle your response using the scale shown below.

1 – Significantly reduced workload
3 – No impact
5 – Significantly increased workload

1 2 3 4 5

COMMENTS:

D. To what extent did the tactical use of DRVSM altitudes during this run impact the complexity of your sector? Circle your response using the scale shown below.

1 - Significantly reduced complexity
3 – No impact
5 – Significantly increased complexity

1 2 3 4 5

COMMENTS:

E. To what extent did the tactical use of DRVSM altitudes during this run impact the potential for error at your sector? Circle your response using the scale shown below.

1 - Significantly reduced potential for error
3 – No impact
5 – Significantly increased potential for error

1 2 3 4 5

COMMENTS:

F. During this run, what were the benefits to the sector team of tactical use of the DRVSM altitudes?

COMMENTS:

G. What operational concerns or issues do you have related to suspension of DRVSM operations?

9. Please answer the following questions related to transitioning aircraft from DRVSM separation standards to conventional vertical separation (CVS) standards. Rate the impact of each of the following according to the prescribed scales:

A. What was the impact of transitioning from DRVSM to conventional vertical separation standards minima (CVSM) airspace on your workload? Circle your response using the scale shown below.

1 – Significantly reduced workload
3 – No impact
5 – Significantly increased workload

1 2 3 4 5

COMMENTS:

B. What was the impact of transitioning from DRVSM to CVSM airspace on the complexity of your sector? Circle your response using the scale shown below.

1 – Significantly reduced complexity
3 – No impact
5 – Significantly increased complexity

1 2 3 4 5

COMMENTS:

C. What was the impact of transitioning from DRVSM to CVSM airspace on the potential for error at your sector? Circle your response using the scale shown below.

1 – Significantly reduced potential for error
3 – No impact
5 – Significantly increased potential for error

1 2 3 4 5

COMMENTS:

D. What operational concerns or issues do you have related to transitioning from DRVSM to CVSM airspace?

10. Please answer the following questions related to suspension of DRVSM operations. Rate the impact of each of the following according to the prescribed scales:

A. What was the impact of suspension of DRVSM on your workload? Circle your response using the scale shown below.

1 – Significantly reduced workload
3 – No impact
5 – Significantly increased workload

1 2 3 4 5

COMMENTS:

B. What was the impact of suspension of DRVSM on the complexity of your sector? Circle your response using the scale shown below.

1 - Significantly reduced complexity
3 – No impact
5 – Significantly increased complexity

1 2 3 4 5

COMMENTS:

C. What was the impact of suspension of DRVSM on the potential for error at your sector? Circle your response using the scale shown below.

1 - Significantly reduced potential for error
3 – No impact
5 – Significantly increased potential for error

1	2	3	4	5

COMMENTS: ____

D. What operational concerns or issues do you have related to suspension of DRVSM operations?

Appendix B
Separation Violations

Table B-1 provides summary data for the 11 operational errors that occurred during the second DRVSM simulation.

	Scenario Run	Sector	ACID[23]	ALT	Separation
1	1a	88	LN9326	320	V =0[24]
			NWA2767	320	L=1.6[25]
2	1b	98	ASA3	290	V=7
			+MISTY44	283	L=3.1
3	2a	88	N646AB	263	V=7
			+OPEC83	270	L=2.9
4	2b	88	NWA573	310	V=0
			UAL276	310	L=3.7
5	3a	88	NWA662	300	V=0
			SWA254	300	L=1.9
6	3a	88	+LN967VH	320	V=0
			SYX2247	310	L=4.7
7	3c	88	NWA872	300	V=0
			SWA932	300	L=1.1
8	3c	88	NWA113	300	V=0
			SWA932	300	L=3.9
9	3c	87	FLG3459	330	V=0
			LXJ876	330	L=.5
10	3c	88	N75YB	290	V=0
			NWA182	290	L=2.1
11	4a	87	N639N	320	V=6
			UAL496	326	L=3.5

[23] The "+" in front of the call sign indicates that aircraft was non-DRVSM-approved
[24] V=Vertical separation in 100's of feet.
[25] L=Lateral separation in miles.