Reduced Vertical Separation Minima in U.S. Airspace: Air Traffic Control Issues and Answers

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Introduction

Reduced Vertical Separation Minima (RVSM) is an International Civil Aviation Organization approved concept that permits the 1,000-foot vertical separation standard that is applied below Flight Level (FL) 290 to be applied between FL 290 and FL 410. RVSM has been implemented successfully in many areas of global operations, including the domestic airspace of Europe and Australia and over the oceans. RVSM has proved safe and beneficial in these areas and operators have found benefits greater and costs less than predicted. FAA plans to implement domestic RVSM (DRVSM) between FL 290 – FL 410 (inclusive) in the airspace of the United States, the San Juan Flight Information Region (FIR), and in the Gulf of Mexico where FAA provides air traffic services. The United States, Canada, and Mexico are planning a simultaneous transition to RVSM on January 20, 2005, at 0901 Coordinated Universal Time.

The U. S. DRVSM Program is a collaborative, parallel effort led by the FAA's Flight Standards Service (AFS), the William J. Hughes Technical Center (WJHTC) Separation Standards Group, and the Air Traffic Planning and Procedures Program (ATP). AFS has primary responsibility for promulgating the proposed rule to revise the flight levels listed in CFR 91.159 and 91.179, and for approving U.S. operators and aircraft to conduct RVSM operations. The Separation Standards Group monitors the altitude-keeping performance of aircraft to ensure that the RVSM standards are being met. ATP, in partnership with the National Air Traffic Controllers Association (NATCA), is responsible for evaluating the impact of DRVSM on controllers and for developing, validating, and implementing National air traffic control procedures and training. Participating organizations include the Department of Defense and NAVCANADA.

For users of the airspace, DRVSM will provide greater availability of more fuel-efficient altitudes. The FAA estimates that users will save $393 million in fuel costs in the first year of DRVSM operations, increasing by two percent each year thereafter. For air traffic controllers, DRVSM is expected to decrease workload, reduce conflict points, enhance sector throughput, and provide greater flexibility for controllers to grant user-preferred altitudes. In recognition of these potential benefits, DRVSM is a high priority project in the FAA's Operational Evolution Plan.

DRVSM Environment

The reduction of vertical separation from 2,000 feet to 1,000 feet between FL 290 and FL 410 will create six additional altitudes, thereby significantly increasing air traffic control flexibility. The airspace between these flight levels will be for the exclusive use of RVSM-approved aircraft, with the exception of Department of Defense aircraft, Lifeguard flights, and aircraft flown by manufacturers or airlines for certification, development, and maintenance, traffic permitting. Unapproved aircraft may also be allowed to transition through DRVSM airspace, traffic permitting. The six new altitudes with the revised directions of flight are illustrated in Figure 1.

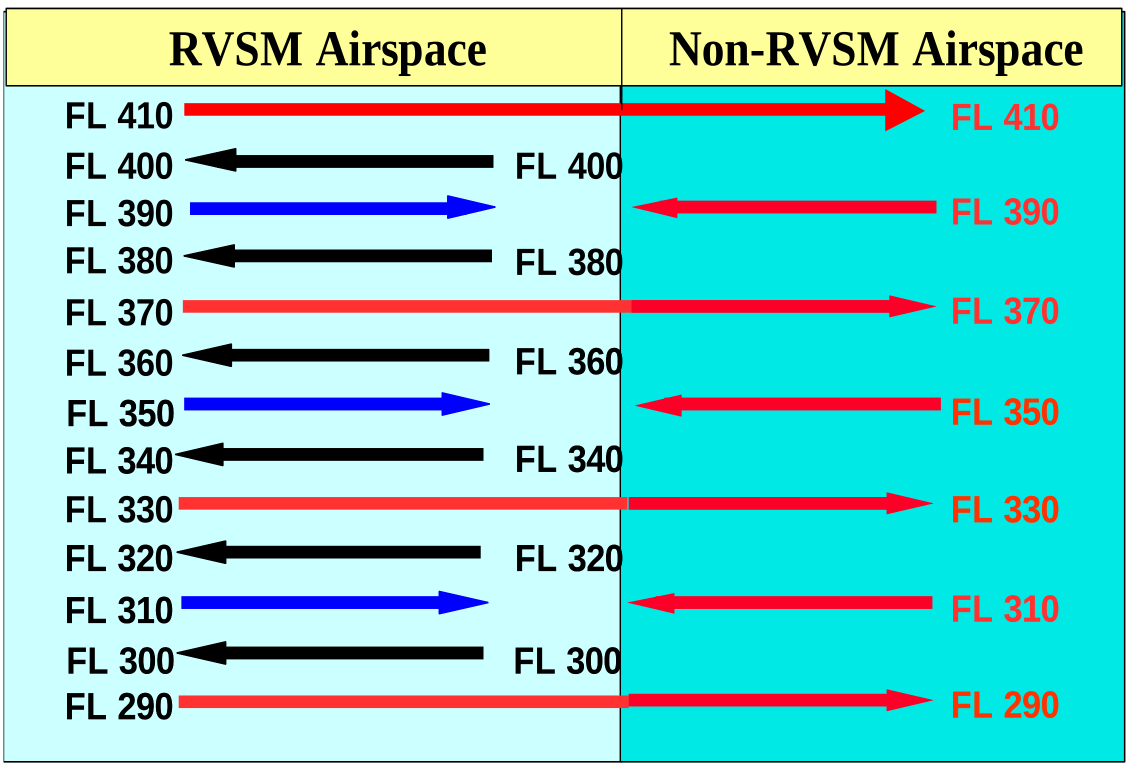

Figure 1. RVSM Altitudes

Impact on Controllers

DRVSM will replace the 2,000-foot vertical separation standard that has been in effect between FL 290 and FL 410 for the past 40 years. Revising the separation minima requires changing long-established air traffic control procedures and relearning the appropriate altitudes to use for various situations. Before DRVSM can be implemented, the impact on controllers must be fully understood. To address this and other questions, the Air Traffic Plans and Procedures Program Office sponsored three real-time, high fidelity human-in-the-loop (HITL) simulations. All three simulations were conducted at the WJHTC's Display System Facility (DSF). The Host Computer System, displays, and other equipment were configured virtually identical to those used by the controllers in their local facilities. Participating controllers interacted with individuals functioning as simulation pilots and ghost controllers. The simulation pilots manipulated computer-generated targets in response to controller instructions. The ghost controllers performed the automation entries and voice communications associated with airspace adjacent to the simulated sectors. Eight scenarios were developed and fully tested for each simulation. Each scenario provided a traffic demand and level of complexity that engaged both the radar (R) and Radar Associate (RA) controllers. Human Solutions, Incorporated, worked with the WJHTC's Simulation and Analysis Group to design, conduct, analyze, and document the three one-week simulations.

DRVSM Simulation 1

The first simulation, conducted October 24-30, 2001, was designed primarily to identify, understand, and compare the impacts of different DRVSM altitude bands on en route workload, complexity, and potential for error. Four distinct vertical separation conditions were studied: Conventional Vertical Separation (CVS) minima (baseline condition); DRVSM for FL 350 – FL 390; DRVSM for FL 330 – FL 390; and DRVSM for FL 290 – FL 410. The simulated airspace was based on four adjacent sectors in the Cleveland ARTCC (ZOB). Section 59 (Franklin) is a super-high altitude sector (FL 330 and above), Sector 57 (Brecksville) is directly below Sector 59 (FL240-FL310), Sector 68 (Allegheny) is a super-high altitude sector (FL350 and above), and Sector 67 (Imperial) is below half of Sector 68 (FL240-FL330). For this study, Sector 67 and half of Sector 68 were combined at Sector 67. Six certified professional controllers from ZOB who work the sectors that were simulated staffed the R and RA positions.

Major Findings. In general, the six controllers in this simulation found it easy to transition to the use of DRVSM standards. Of the three alternate DRVSM altitude bands, FL 290 – FL 410 produced the largest benefits in terms of reduced workload, complexity, potential for error, and the greatest ease of transition for both high and super-high altitude sectors. The primary sources of decreased workload are reduced vectoring for separation and associated communications, reduced frequency of inappropriate altitude for direction of flight and subsequent coordination efforts, and significantly reduced numbers of confliction points. DRVSM for FL 290 – FL 410 also eliminated the additional scanning and cognitive workload associated with applying multiple vertical separation standards within a sector, as well as the potential for applying an inappropriate separation standard, that were present with the other DRVSM bands. During very busy times, this additional cognitive workload caused some of the controllers to fall back on conventional separation standards.

The results of this simulation demonstrated that a full implementation from FL 290 through FL 410 was clearly superior and that a phased implementation would not be feasible.

DRVSM Simulation 2

The second simulation took place June 3-7, 2002. The primary objectives of this study were to investigate the impact of a mix of approved and non-approved aircraft operating under heavy traffic conditions in DRVSM airspace, and to gain additional understanding of the operational impact of DRVSM for FL 290 – 410. This simulation also explored allowing controllers to apply "tactical RVSM" in U.S. domestic airspace, prior to the proposed DRVSM implementation date. Under tactical use, controllers could, at their discretion, use 1,000-foot vertical separation between FL 290 – 410, if both aircraft were RVSM-approved. The simulated airspace was based on four adjacent sectors in the Indianapolis ARTCC (ZID) Sector 87 (Appleton) is a high-altitude sector (FL240-FL310). Sector 97 (Lockborn) is a super-high altitude sector (FL330 and above) that overlies Sector 87. Sector 88 (Dayton) is a high altitude sector (FL240-FL310) and was assigned FL320 for purposes of the simulation. Sector 98 (Patterson) 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. Six certified professional controllers from ZID who work the simulated sectors staffed the R and RA positions.

Major Findings. It was learned from the first DRVSM simulation that the additional altitudes provided by DRVSM reduce controller workload, complexity, and potential for error when the number of non-RVSM-approved aircraft is small, i.e., one or two such aircraft per sector. Consequently, the second simulation was designed to analyze the impact of increasingly greater numbers of non-RVSM-approved aircraft in DRVSM airspace. A key result was that controllers' perceptions of workload, complexity, and potential for error increased *in direct proportion* with an increase in the average number of non-RVSM-approved aircraft per sector. Based on the controller feedback, *cognitive workload* resulting from non-RVSM-approved aircraft in DRVSM airspace may be the largest single impact on workload. In today's conventional vertical separation environment, controllers 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-RVSM-approved aircraft as they traversed through their sector, thereby increasing cognitive workload. The findings of the simulation reinforced the need to develop procedures for non-approved aircraft operating in DRVSM airspace.

The results of the assessment of tactical use of RVSM during this simulation indicated it is difficult to use RVSM tactically during peak traffic conditions.

DRVSM Simulation 3

The third and final DRVSM simulation occurred June 9-12, 2003. The primary objectives of this simulation were to assess the air traffic procedures and controller training needed for DRVSM and to further examine the use of RVSM tactically, specifically under moderate traffic conditions. The simulated airspace was based on four adjacent sectors in Washington ARTCC (ZDC): Sectors 10 (Bay), 12 (Brooke) 16, Hopewell), and 38 (Tar River). Sector 10 was combined at Sector 12 for the purposes of the simulation. Six certified professional controllers from ZDC who work the simulated sectors staffed the R and RA positions.

The preliminary procedures assessed during the simulation were developed by the DRVSM Procedures Workgroup and covered the following topics:

- Accommodation of non-RVSM-approved military, lifeguard, or ferry flight aircraft
- Non-RVSM-approved aircraft transitioning through DRVSM airspace
- Base/ceiling coordination with abutting sectors
- Failure of aircraft equipment required for DRVSM operation
- Wake turbulence in DRVSM airspace

Special events were scripted into each DRVSM run to create the opportunity for each participant to use one or more of the procedures. The simulation design was created specifically to ensure that over the course of the DRVSM runs, each participant would have the opportunity to exercise all of the procedures at least once while staffing the R-side position and at least once while staffing the RA-side position.

The training-related objective for this simulation was to obtain as much field input as possible on training needs. Insights were gained on training approaches, areas to emphasize in controller and supervisory training, specific skills necessary for DRVSM, and the duration of DRVSM simulation training.

Major Findings. The preliminary findings of the third DRVSM simulation served to validate and refine the draft DRVSM procedures, support the development of an effective DRVSM training plan, and provide the FAA with information to support a decision on tactical use of RVSM altitudes prior to full DRVSM implementation.

With two exceptions, the preliminary procedures developed for the simulation were determined to be complete and effective. The participants noted that requests for military, lifeguard, certification, or maintenance flights to fly at a RVSM altitude may need to be coordinated in advance with traffic flow management. They recommended streamlining the procedure for controllers to notify supervisors of the presence of a non-RVSM-approved aircraft to take advantage of this advance notification. Secondly, participants suggested an additional procedure to help ensure continual situational awareness of a non-RVSM-approved aircraft operating in DRVSM airspace. Specifically, the controllers recommended adding a requirement for pilots of non-RVSM-approved aircraft to state that their flight is non-RVSM-approved on initial radio contact at each sector traversed while operating in DRVSM airspace. These changes are being incorporated into the proposed DRVSM revisions to FAA Handbook 7110.65, FAA Order 7210.3, and the Aeronautical Information Manual (AIM).

Based on the simulation findings, the individual skills most relevant to adapting to DRVSM operations are better understood, as is the amount of simulation training required to acquire each skill. From the subjective data collected, it appears that a total simulation time of three to four hours per controller will suffice. Based on suggestions from the field participants, the training development team will consider using six to eight simulation problems of 20 to 30 minutes duration each, instead of 45 to 60 minute problems, and each problem will have specific, well-defined training objectives.

A key finding of the simulation is that the plan to display the non-RVSM indicator in data blocks only for full DRVSM operations, and not for tactical use, is not viable. Lack of a visual indication in the data block effectively precludes the ability of the sector to apply reduced vertical separation tactically during single-person sector operations or during heavy traffic periods. The participants found the manual search and analysis of flight data to identify RVSM-approved aircraft was sufficiently workload intensive that it would be feasible only in two-person sector operations and only then with moderate traffic densities. Given these findings, the FAA has decided not to pursue tactical use of RVSM prior to full implementation in January 2005.

Conclusion

Based on the results of the initial simulation, FAA does not consider phased implementation of DRVSM to be feasible. Full implementation from FL 290 through FL 410 yielded superior benefits and minimized the impact on controllers. Simulation results also show that tactical use of RVSM prior to full implementation is not feasible and will not be pursued. The simulations provided a better understanding of the issues involved in implementing DRVSM, and have led to changes in both the training plan and proposed procedures. Work is ongoing to develop training plan templates, National Cadre training instruction, traffic management flow plans, and test and implementation plans and procedures for the seamless integration of DRVSM within the National Airspace System. A safety assessment is planned in July 2004 and an operational readiness assessment in September 2004. As these activities indicate, the FAA is fully committed to the successful implementation of DRVSM in January 2005.

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