Flight Safety
DIGEST

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Global Implementation Of RVSM Nears Completion

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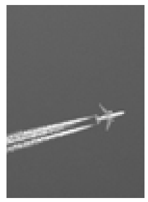

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Global Implementation of RVSM Nears Completion

Reduced vertical separation minimum (RVSM) for aircraft being flown at 29,000 feet through 41,000 feet has been applied in many regions; North America, South America and the Caribbean will follow in January 2005. Experience has shown that increased traffic congestion below RVSM airspace and wake-turbulence encounters in RVSM airspace have not been significant problems.

Swiss Large Airplanes Had No Fatal Accidents in 2003

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There were no fatal accidents in Swiss airspace in 2003 involving airplanes, Swiss-registered or non-Swiss-registered, in the two highest weight classes. The number of accidents and serious incidents involving Swiss-registered helicopters increased for the year, but the number of fatalities and serious injuries did not. The number and rate of air traffic incident (AIRPROX) reports increased.

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Keys to a Successful Audit Are Objectivity, Technical Competence And Knowledge of Audit Practices

Quality Audits for Improved Performance describes the stages of an audit and offers principles for conducting one effectively. After the facts have been gathered and findings developed, says the author, the report must be presented in a manner that clearly relates to each stakeholder's interests.

B-777 Crew Extinguishes Lavatory Fire During Trans-Atlantic Flight

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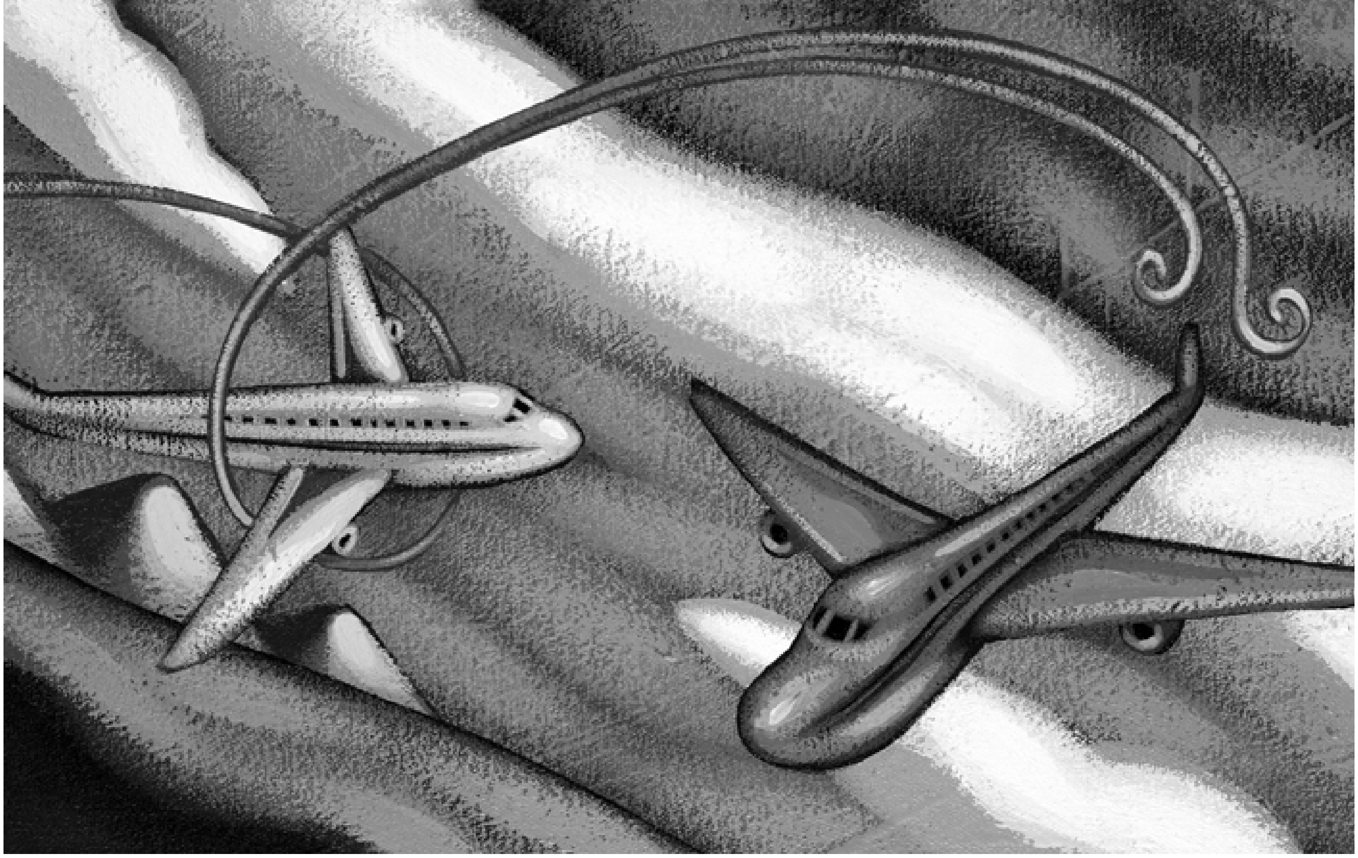

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— FSF EDITORIAL STAFF

Among the benefits cited by the International Civil Aviation Organization (ICAO) for the implementation of reduced vertical separation minimum (RVSM) is the increased availability to aircraft operators of efficient cruising levels and, thus, lower fuel costs.[1]

The reduction of standard vertical separation from 2,000 feet/600 meters to 1,000 feet/300 meters between aircraft being flown at Flight Level (FL) 290 (approximately 29,000 feet) through FL 410 adds six new flight levels: FL 300, FL 320, FL 340, FL 360, FL 380 and FL 400.

ICAO said that, in general, operators of aircraft flown in the North Atlantic Region, where RVSM first was implemented, are saving about US$8 million each year in fuel costs. Regional RVSM authorities also have cited fuel-cost savings. For example:

- The European Organization for the Safety of Air Navigation (Eurocontrol) said that RVSM has resulted in fuel savings of 2 percent to 3 percent in the European Region;[2]

- Airservices Australia said that RVSM will save the Australian aviation industry about $21 million annually;[3] and,

- The U.S. Federal Aviation Administration (FAA) said that increased access to more fuel-efficient cruising altitudes will result in $5.3 billion in fuel-cost savings during the first 10 years of RVSM operations in the United States.[4]

RVSM also benefits air traffic control (ATC) by increasing the capacity of the ATC system and reducing air traffic controller workload, ICAO said.

The International Federation of Air Line Pilots' Associations (IFALPA) said that it supports RVSM implementation in accordance with the requirements and guidelines published in ICAO Document 9574.[5]

"RVSM is just one element of ever-decreasing separation standards that are needed to provide the air traffic system with enough capacity," said Capt. Heinz Frühwirth, vice chairman of the IFALPA Air Traffic Services Committee and a pilot for Austrian Airlines.[6] "The back side of this coin is that pilots are faced with more stringent accuracy requirements with every step. Today's airspace leaves little room for departure from established procedures."

Altimetry Accuracy Improves

ICAO said that with the advent of jet airliners in the late 1950s, civil aviation authorities recognized that barometric altimeters, which become increasingly inaccurate as air density decreases, might not be sufficient to maintain the standard 1,000-foot/300-meter vertical separation minimum between aircraft at high altitudes.[7]

"Today's airspace leaves little room for departure from established procedures."

In 1960, the international standard for the vertical separation minimum (VSM) between aircraft cruising at and above FL 290 was doubled.

"At the same time, it was considered that the application of a reduced VSM above FL 290, on a regional basis and in carefully prescribed circumstances, was a distinct possibility in the not-too-distant future," ICAO said.

The selection of FL 290 as the vertical limit for 1,000-foot separation was not based on experience, "but rather [was] a function of the operational ceiling of the aircraft at the time," ICAO said.

Fuel shortages and increased fuel costs in the mid-1970s prompted ICAO to encourage member states (countries) to study the risks and benefits of RVSM. In the 1980s, studies were conducted under the auspices of ICAO by several states, including Canada, France, Germany, Japan, the Netherlands, the former Union of Soviet Socialist Republics, the United Kingdom and the United States.

The objectives of the studies included the following:

- Determine the accuracy of current altimeter systems;
- Determine the causes of height-keeping[8] errors;
- Determine whether global implementation of RVSM was technically feasible and cost-beneficial;
- Establish a minimum aircraft system performance specification (MASPS) for altimetry systems and associated height-keeping equipment (e.g., autopilots); and,
- Determine the required safety levels for RVSM implementation.

High-precision radar systems were used to measure the geometric height (vertical distance above mean sea level) of aircraft in straight-and-level flight at and above FL 290. The recorded geometric heights were compared with the flight levels that had been assigned to the aircraft to determine general height-keeping performance. The results then were used to estimate the risk of collision if vertical separation between the aircraft were reduced.

"These studies employed quantitative methods of risk assessment to support operational decisions concerning the feasibility of reducing the VSM," ICAO said. "The risk assessment consisted of two elements: first, risk estimation, which concerns the development and use of methods and techniques with which the actual level of risk of an activity can be estimated; and second, risk evaluation, which concerns the level of risk considered to be the maximum tolerable value for a safe system. The level of risk that is deemed acceptable was termed the target level of safety (TLS)."

Technical Risk Assessed

The TLS addresses *technical risk* — that is, the risk of collision associated with aircraft height-keeping performance. It does not address the risk of collisions associated with factors such as altitude deviations caused by turbulence, emergency descents, operational errors by air traffic controllers in the issuance of ATC instructions or operational errors by flight crews in compliance with ATC instructions.

The studies yielded TLS rates ranging from $1x10^{-8}$ to $1x10^{-9}$ fatal accidents (collisions) per aircraft flight hour. (A TLS rate of $1x10^{-8}$ equates with one fatal accident per 100 million flight hours.)

Based on the studies, ICAO concluded that RVSM was technically feasible.

"This technical feasibility refers to the fundamental capability of aircraft height-keeping systems, which could be built, maintained and operated in such a manner that the expected, or typical, performance is consistent with safe implementation and use of [RVSM]," ICAO said. "On the basis of these figures, it was agreed that an assessment TLS of $2.5x10^{-9}$ fatal accidents per aircraft flight hour would be used to assess the technical feasibility of [RVSM] and also to develop aircraft height-keeping-capability requirements for operating in [RVSM] airspace."

(A TLS rate of $2.5x10^{-9}$ equates with 2.5 fatal accidents per 1 billion flight hours and with 1.0 fatal accident per 400 million flight hours.)

Regional RVSM planning groups also were required to assess *overall risk*, which includes the technical risk of collision and the risk of collision associated with operational errors and in-flight contingencies (e.g., altitude deviations caused by turbulence or by emergency descents). The overall TLS of RVSM operations applied in the North Atlantic Region, for example, was $5x10^{-9}$ fatal accidents per aircraft flight hour.

Regional RVSM planning groups also were required to assess *overall risk*.

Costs of Implementation Considered

ICAO also recommended that regional RVSM planning groups consider the following factors before implementing RVSM:

- Costs that aircraft operators will incur to meet the RVSM MASPS;
- Mix of military aircraft and civil aircraft, and traffic density in RVSM airspace;
- RVSM implementation plans in adjacent regions;
- Airspace organization and constraints, and ATC procedures and equipment;
- Options to reduce the collision risk in areas with high traffic density (e.g., by applying parallel track offsets);
- Effects of regional meteorological conditions (e.g., mountain waves); and,
- Procedures to ensure that noncompliant aircraft are not operated in RVSM airspace.

A noncompliant aircraft is an aircraft that has been equipped/modified to comply with MASPS but has been shown by height-monitoring (a requirement of RVSM implementation) not to meet MASPS performance specifications.

"It is imperative that all aircraft continue, during their service life, to satisfy the requirements of the RVSM MASPS," ICAO said. "While height-monitoring data from independent sources … should help to detect any long-term deterioration in altimetry-system performance, it is nevertheless essential that certifying authorities ensure that, as part of the approval process, operator maintenance-and-inspection practices are reviewed

The cost for MASPS modifications almost matches the value of some older aircraft.

and updated to reflect the specific airworthiness requirements applicable to RVSM operations."

Guidance for aircraft operators about obtaining RVSM approval is provided in two ICAO-approved documents: European Joint Aviation Authorities (JAA) Leaflet No. 6[9] and in FAA document 91-RVSM.[10] The documents state that the following minimum equipment is required for RVSM operations:

- Two independent altitude-measurement systems;
- One secondary surveillance radar transponder with an altitude-reporting system that can be connected to the altitude-measurement system in use for altitude-keeping;
- An altitude-alerting system; and,
- An automatic altitude-control system.

MASPS requires that the altimetry systems have a maximum error of 80 feet/25 meters and that the automatic altitude-control systems be able to hold altitude within 65 feet/20 meters.

Some Operators Face High Costs

To obtain approval to operate in RVSM airspace, aircraft operators are required to:

- Show that their aircraft meet the MASPS;
- Establish a program to assure the continued airworthiness of the required equipment;
- Establish a program for participating in height-monitoring;
- Develop initial and recurrent training programs for flight crewmembers, maintenance technicians and dispatchers; and,
- Ensure that their operations manuals and airplane flight manuals include information and requirements for RVSM operations.

The costs to modify an aircraft for RVSM approval typically range from about $100 to $235,000. The higher costs are for older aircraft that must be equipped with dual air-data computers, digital flight-control systems and other equipment for RVSM approval.

Because the cost for MASPS modifications almost matches the value of some older aircraft, some operators have not pursued RVSM approval.

FAA said that initial costs and ongoing costs of RVSM approval for U.S. aircraft operators through 2016 will be about $869.2 million; operators of non-RVSM-approved aircraft that no longer will be allowed to operate above FL 290 will face added operating costs of about US$1,147 per aircraft per year.[11]

Once an aircraft operator has been approved by a civil aviation authority to conduct RVSM operations in that authority's domestic RVSM airspace, the operator can conduct RVSM operations elsewhere.

RVSM approval for each aircraft specifies permissible operating altitudes (e.g., from FL 290 to FL 410, or from FL 290 to the aircraft's maximum certified altitude), airspeeds (e.g., from the maximum authorized holding speed or maneuvering speed to the maximum operating limit speed [M_{MO}/V_{MO}]) and gross weights.

Maintenance Procedures Established

JAA Leaflet No. 6 includes the following recommendations about RVSM equipment maintenance (the recommendations in FAA document 91-RVSM are almost identical):

- "All RVSM equipment should be maintained in accordance with the component manufacturers' maintenance instructions and the performance criteria of the RVSM approval data package;
- "Any modification or design change which in any way affects the initial RVSM approval should be subject to a design review acceptable to the responsible authority;

- "Any repairs, not covered by approved maintenance documents that may affect the integrity of the continuing RVSM approval (e.g., those affecting the alignment of pitot/static probes, repairs to dents or deformation around static plates) should be subject to a design review acceptable to the responsible authority;

- "Built-in test equipment (BITE) testing should not be used for system calibration unless it is shown to be acceptable by the aircraft constructor or an approved design organization, and with the agreement of the responsible authority;

- "An appropriate system leak check (or visual inspection where permitted) should be accomplished following reconnection of a quick-disconnect static line;

- "Airframe and static systems should be maintained in accordance with the aircraft constructor's inspection standards and procedures;

- "To ensure the proper maintenance of airframe geometry for proper surface contours and the mitigation of altimetry-system error, surface measurements or skin waviness checks will need to be made [near static ports], as specified by the aircraft constructor, to ensure adherence to RVSM tolerances. These checks should be performed following repairs or [following] alterations having an effect on airframe surface and airflow;

- "The maintenance and inspection program for the autopilot will need to ensure continued accuracy and integrity of the automatic altitude-control system to meet the height-keeping standards for RVSM operations. This requirement will typically be satisfied with equipment inspections and serviceability checks; [and,]

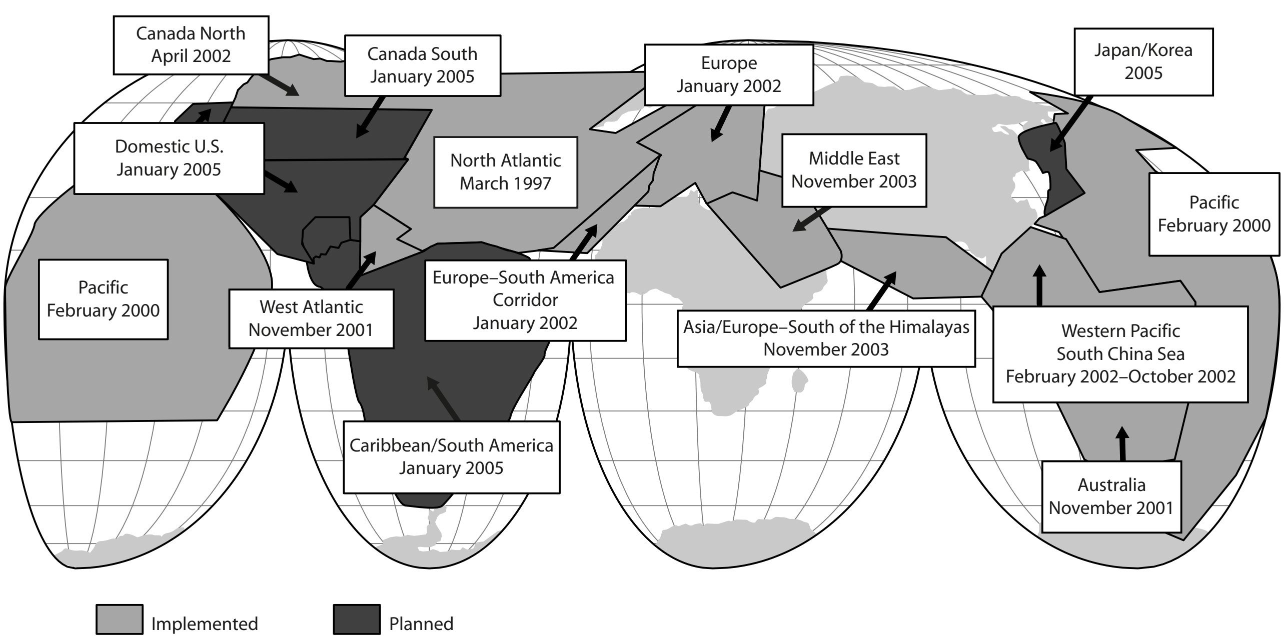
- "Whenever the performance of installed equipment has been demonstrated to be satisfactory for RVSM approval, the associated maintenance practices should be verified to be consistent with continued RVSM approval. Examples of equipment to be considered are:

  - "Altitude-alerting [system];
  - "Automatic altitude-control system;
  - "Secondary surveillance radar altitude-reporting equipment; [and,]
  - "Altimetry systems."

North Atlantic Selected as Pioneer

Figure 1 shows the status of global RVSM implementation as of October 2004. Although specific organizations headed regional pre-implementation planning and are serving as regional monitoring agencies (e.g., Eurocontrol in the European Region and FAA in the

Figure 1
Reduced Vertical Separation Minimum Implementation Status, October 2004



Source: Adapted from U.S. Federal Aviation Administration

North American Region), each ICAO member state is responsible for RVSM implementation in its domestic airspace.

The North Atlantic Region was selected for initial implementation because of the relatively uniform flow of traffic on basically an east-west route orientation with few altitude changes by aircraft being flown in the airspace.

Implementation of RVSM in the North Atlantic Region was conducted in three phases: from FL 330 to FL 370 in March 1997; from FL 310 to FL 390 in October 1998; and from FL 290 to FL 410 in January 2002, when RVSM was implemented in the Europe/South America corridor and completed in the West Atlantic route system.

RVSM implementation over most of the Pacific Region occurred in February 2000. Unlike other regions, non-RVSM-approved aircraft are permitted to be flown at FL 410 in the Pacific Region.

Australia implemented domestic RVSM (DRVSM) in November 2001. Implementation in the Western Pacific Region and over the South China Sea occurred in 2002.

Austria, Germany, Ireland and the United Kingdom began limited use of 1,000-foot vertical separation between RVSM-approved aircraft in April 2001; full RVSM implementation in the European Region occurred in January 2002.[12]

RVSM was implemented in the Middle East Region and over parts of Asia and Europe south of the Himalayan Mountains in November 2003.

Each ICAO member state is responsible for RVSM implementation in its domestic airspace.

Canada implemented RVSM initially in domestic airspace north of the 57th parallel in April 2002. On Jan. 20, 2005, Canada will implement RVSM in its southern domestic airspace, in conjunction with RVSM implementation by Mexico, the United States and states in the Caribbean, Central America and South America.

FAA will implement RVSM over the continental United States, Alaska, the San Juan (Puerto Rico) Flight Information Region (FIR) and the airspace between Florida and the San Juan FIR, and the portion of the airspace over the Gulf of Mexico where FAA provides air traffic services.[13]

RVSM will not be implemented over the Hawaiian Islands.

"Instead, 1,000-foot vertical separation [will be] applied between FL 290 and FL 410 when two passing aircraft are both RVSM-approved, and 2,000-foot vertical [separation] or horizontal separation [will be] applied if either of the passing aircraft is not RVSM-approved," FAA said.

RVSM will be implemented in the domestic airspace of Japan and Korea in 2005.

There currently is no schedule for RVSM implementation in the remainder of Africa (Morocco and Tunisia participated in RVSM implementation in the European Region), in China or in Russia. China and Russia are two countries in which height is measured in meters. Russia currently uses 300-meter separation from 900 meters to 8,100 meters, 500-meter separation from 8,100 meters to 12,100 meters, and 1,000-meter separation above 12,100 meters.

Specific Training Required

Operating procedures in RVSM airspace are very similar to operating procedures in other airspace. Because of the increased height-keeping-accuracy requirements in RVSM airspace, however, ICAO requires states to establish specific initial training programs and recurrent training programs for flight crews.

"Initial training is most important for pilots who have not yet been involved in RVSM operations," Frühwirth said. "Basically, it is no big deal, but players have to know the essential rules."

ICAO Document 9574 — which provides guidance for regional planning groups for the development of documents, procedures and programs to enable RVSM implementation in their regions — recommends that routine training of flight crews include a review of the following procedures:[14]

- "In level cruise, it is essential that the aircraft be flown at the cleared flight level (CFL). This requires that particular care be taken to ensure that ATC clearances are fully understood and complied with. Except in the event of an emergency, the aircraft should not intentionally depart from CFL without a clearance from ATC;

- "During cleared transition between [flight] levels, the aircraft should not be allowed to overshoot or undershoot the new flight level by more than [150 feet/45 meters]. The transition should be accomplished using the altitude-capture feature of the automatic altitude-keeping device, if installed;

- "The automatic-altitude-keeping device should be operative and engaged during level cruise, except when circumstances such as turbulence or the need to retrim the aircraft require its disengagement. In any event, adherence to cruise altitude should be done by reference to one of the two altimeters required by the RVSM MASPS;

- "The altitude-alerting device should be operating and engaged;

- "Regular (hourly) cross-checks between the altimeters should be made, and a minimum of two RVSM MASPS-compliant systems must agree within [200 feet/60 meters]. Failure to meet this condition will require that the system be reported as defective and notified to ATC;

- "The operative altitude-reporting transponder should be connected to the RVSM MASPS-compliant altimetry system being used to control the aircraft; [and,]

- "Before entering RVSM airspace, the pilot should review the status of equipment required. … Should any of this equipment fail prior to the aircraft entering RVSM airspace, the pilot should request a new clearance so as to avoid flight in this airspace."

Contingency Procedures Required

ICAO recommends that flight crew training stress the requirement for notifying ATC of any contingency (e.g., equipment failure, meteorological condition) that affects the ability of the crew to maintain the assigned flight level.

Examples of equipment failures cited in Document 9574 are the following:

- "Failure of all automatic altitude-keeping devices on board the aircraft;

- "Loss of redundancy of altimetry systems, or any part of these, on board the aircraft;

- "Failure of all altitude-reporting transponders;

- "Loss of thrust on an engine necessitating descent; and,

- "Any other equipment failure affecting the ability to maintain CFL."

ICAO recommends that aircraft operators revise their operating manuals to incorporate any procedural differences resulting from operations in RVSM airspace.

New ATC Procedures Developed

The addition of six flight levels in RVSM airspace and the concomitant changes in traffic-flow directions at FL 310, FL 350 and FL 390 (i.e., from westbound in VSM airspace to eastbound in RVSM airspace) require increased vigilance by controllers, ICAO said.

RVSM has required the development of new ATC procedures to accommodate situations such as the following:

- A flight plan requesting cruise in RVSM airspace is filed for a noncompliant aircraft;

- A flight crew reports the loss of ability to maintain their assigned flight level;

- A flight crew reports that the automatic altitude-keeping device has been disengaged; or,

RVSM has required the development of new ATC procedures.

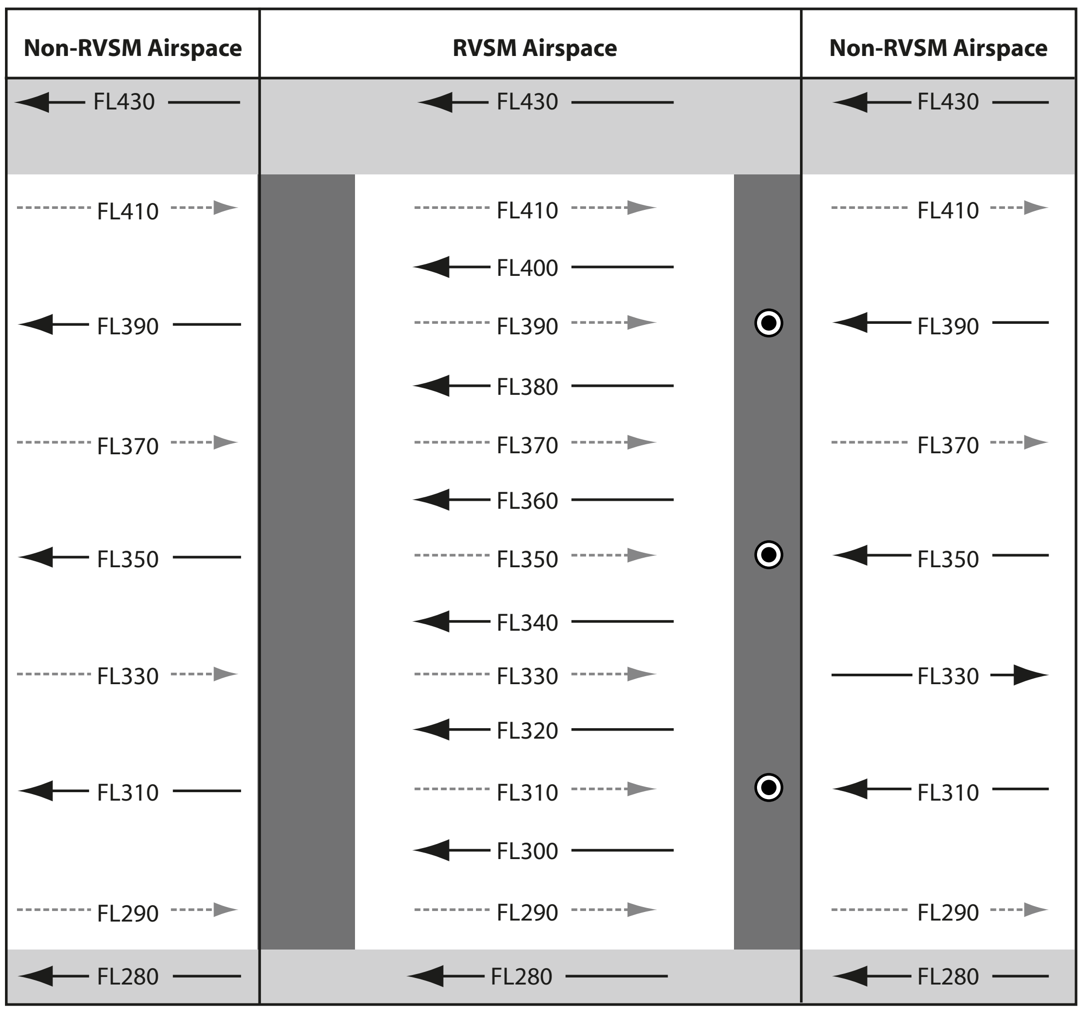
- The altitude displayed on the controller's radar screen differs from the assigned flight level by more than 300 feet/90 meters.

New ATC procedures also have been developed to accommodate contingencies such as a flight crew report of severe turbulence. ATC might suspend RVSM in the affected area and revert to 2,000-foot/600-meter vertical separation between aircraft. A forecast of severe turbulence could result in the issuance of notices to airmen (NOTAMs) about suspension of RVSM and reversion to 2,000-foot/600-meter vertical separation between aircraft from FL 290 to FL 410.

To safely accommodate the flow of traffic between regions using RVSM airspace and regions continuing to apply 2,000-foot/600 meter VSM, transition areas in the adjoining airspace and transition-coordination procedures in the transition areas have been established (Figure 2; Figure 3, page 9).

Letters of agreement between adjacent area control centers detail how transitioning aircraft will

Figure 2
Reduced Vertical Separation Minimum (RVSM)/Non-RVSM Transition Areas



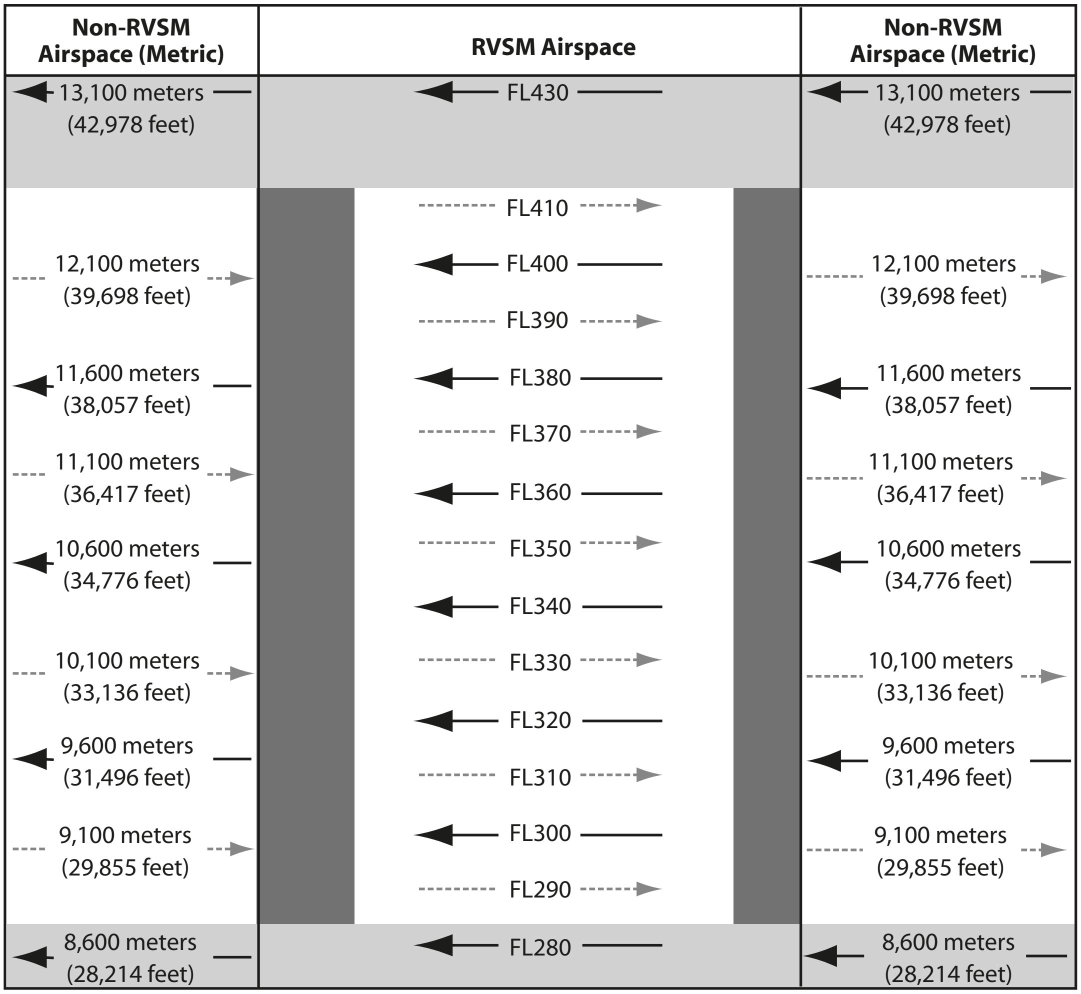
FL = Flight level

Cruise direction conflict will be resolved during transition.

Airspace where air traffic control transition tasks are carried out.

Source: Adapted from Eurocontrol

Figure 3
Reduced Vertical Separation Minimum (RVSM)/Non-RVSM (Metric) Transition Areas



FL = Flight level

Airspace where air traffic control transition tasks are carried out.

Source: Adapted from Eurocontrol

be handled to prevent hazardous situations such as two aircraft being flown in opposite directions at the same flight level. In transition areas, 2,000-foot/600-meter vertical separation is used.

Height-keeping Data Collected

Monitoring of aircraft height-keeping performance is a cornerstone of RVSM.

ICAO requires regional monitoring agencies to collect data on deviations of 300 feet/90 meters or more from the assigned flight level and altimetry-system errors of 245 feet/75 meters or more, and to take follow-up action to determine why the deviations/errors occurred and how to prevent them from reoccurring.

"Height deviations, as a consequence of operational errors and in-flight contingencies, occur in all airspace irrespective of the separation minimum," ICAO said.[15] "The purpose of this monitoring activity is to ensure that operations in RVSM airspace do not induce an increase in the risk of collision from these causes and that the total vertical risk does not exceed the agreed overall safety objectives."

Leaflet No. 6 and 91-RVSM state that RVSM approval could be suspended or revoked for aircraft operators that consistently experience height-keeping errors.

Aircraft worldwide are required to undergo height-monitoring.

Two systems are used to acquire height-keeping data: ground-based height-monitoring units (HMUs) or aircraft-geometric-height-monitoring elements (AGHMEs); and portable global positioning system (GPS) monitoring units (GMUs).

HMUs and AGHMEs typically comprise a master station and four slave stations that receive signals transmitted by an aircraft's transponder and, by measuring the time differences of signal reception at the various stations, record the aircraft's position in space to an accuracy of 50 feet (15 meters).

The position data then are processed — basically, compared with meteorological data on the geometric height of the assigned flight level — to obtain the *total vertical error* (TVE) of the aircraft. TVE is defined by ICAO as "the vertical geometric difference between the actual pressure altitude flown by an aircraft and its assigned pressure altitude (flight level)."

The major difference between the two ground-based monitoring systems is that the data processing is accomplished at the various HMU sites; data recorded by AGHMEs are sent to a separate facility for processing.[16]

Ground-based monitoring stations typically are located near navigational aids. For example, Eurocontrol has installed HMUs in Linz, Austria; Nattenheim, Germany; and Geneva, Switzerland.[17] In the North American Region, Nav Canada is installing AGHMEs near Lethbridge, Alberta, and near Ottawa, Ontario;[18] FAA is installing AGHMEs near Wichita, Kansas; Atlantic City, New Jersey; Cleveland, Ohio; Virginia Beach, Virginia; and at a location in the U.S. Southwest that had not been determined at press time.[19]

The data recorded by AGHMEs in the North American Region will be sent to the North American Approvals Registry and Monitoring Organization (NAARMO) for processing. NAARMO will be located at the FAA William J. Hughes Technical Center in Atlantic City.

Aircraft worldwide are required to undergo height-monitoring during initial RVSM certification and during periodic RVSM recertification (typically, every 24 months). An aircraft must be flown level for five minutes within about 45 nautical miles (83 kilometers) of a ground-based monitoring station to be height-monitored.

An alternative for operators that do not fly their aircraft in HMU/AGHME-monitored airspace is to arrange with the regional monitoring agency or a company contracted by the regional monitoring agency for GMU height-monitoring. (In the United States, for example, FAA has contracted with ARINC [formerly Aeronautical Radio Inc.] and CSSI for GMU height-monitoring services.)

A GMU is a battery-powered unit that typically comprises a GPS receiver, two antennas that are attached with suction pads to a flight deck window and a device for recording GPS data. The recorded data are used to determine the aircraft's geometric height.

IFALPA said that height-monitoring should be continued beyond initial implementation of RVSM to detect possible height-keeping performance degradations.

"Height-monitoring has been found to be very effective in assuring that the technical and operational assumptions are actually achieved," Frühwirth said. "Height-monitoring needs to continue and to be extended to all regions where RVSM is in operation or planned."

Monitoring Detects 'ASE Drift'

The U.K. Civil Aviation Authority (CAA) reported in June 2004 that height-monitoring revealed a phenomenon called *altimeter system error (ASE) drift*, which generally is causing aircraft to gradually fly lower than the displayed altitude.[20]

ICAO defines ASE as "the difference between the altitude indicated by the altimeter display, assuming a correct altimeter barometric setting, and the pressure altitude corresponding to the undisturbed ambient pressure."

In its report, the U.K. CAA said, "ASE is not unexpected; however, height-monitoring by [HMUs] has revealed that, for both individual aircraft and fleets of the same aircraft type, the ASE is drifting with time. In general, this ASE drift is negative. … Over time, most aircraft are flying gradually lower in relation to their displayed altitude."

As of Sept. 24, 2004, the investigation of ASE drift was continuing.[21] Likely causes of ASE drift include changes in the performance of air-data computers and erosion of pitot-static ports.

"The investigation into ASE has also reinforced the fact that poor operational practices by flight crews can lead to greater ASEs or make the interpretation of the height-monitoring data difficult," the report said.

The U.K. CAA recommended that all aircraft operators ensure that their operations manuals and training programs include the following information:

- "Flight crews are required to comply with any aircraft operating restrictions given in the RVSM airworthiness approval. In particular, if the approval was based on adherence to speed limits, the flight crew must be aware of those limits and ensure that the aircraft is operated within the cleared speed envelope. Details of any speed limits should be readily available to the flight crew. Operators should be aware that different restrictions can apply to different airframes of the same aircraft type if the RVSM modification is dissimilar. Information regarding any RVSM operating restrictions will be found in the aircraft flight manual (AFM) or in a supplement to the AFM. Failure to operate within the cleared RVSM flight envelope will lead to greater ASEs and will invalidate the RVSM approval; [and,]

- "During normal RVSM operations, the altimetry system being used to control the aircraft should be selected for the input to the altitude-reporting transponder transmitting information to ATC. In other words, both the active autopilot and the operating transponder should be selected to the same altimetry system (unless there is a systems limitation or functionality which makes the requirement unnecessary and is detailed in the AFM). Operators should ensure that there is a published standard operating procedure to ensure that this practice is carried out. Failure to adhere to the required practice will cause a fault in the process of calculating any ASE by an RVSM HMU which would, in turn, prolong the process of identifying the cause of ASE drift."

Smooth Transition Cited

The implementation of RVSM in the European Region was the "biggest change in Europe's airspace for 50 years," said Bernd Tiemeyer, safety manager for the Eurocontrol RVSM program.[22] "Nevertheless, the switch-over to RVSM was executed extremely smoothly; and since then, there have been no major problems (either safety or operational) related to RVSM."

Eurocontrol had identified 73 hazards during its pre-implementation work. After implementation, Eurocontrol found that most of the 73 hazards "could be considered as causes giving rise to higher-level hazards," Tiemeyer said.

Figure 4 (page 12) shows the higher-level hazards identified after RVSM implementation. They include the following:

- Aircraft entering RVSM airspace from non-RVSM airspace at incorrect flight levels or on incorrect routes;

- Flight plans indicating RVSM approval for aircraft not approved for operation in RVSM;

- Inability of flight crews to notify ATC about loss of RVSM capability (e.g., because of communication-equipment failure);

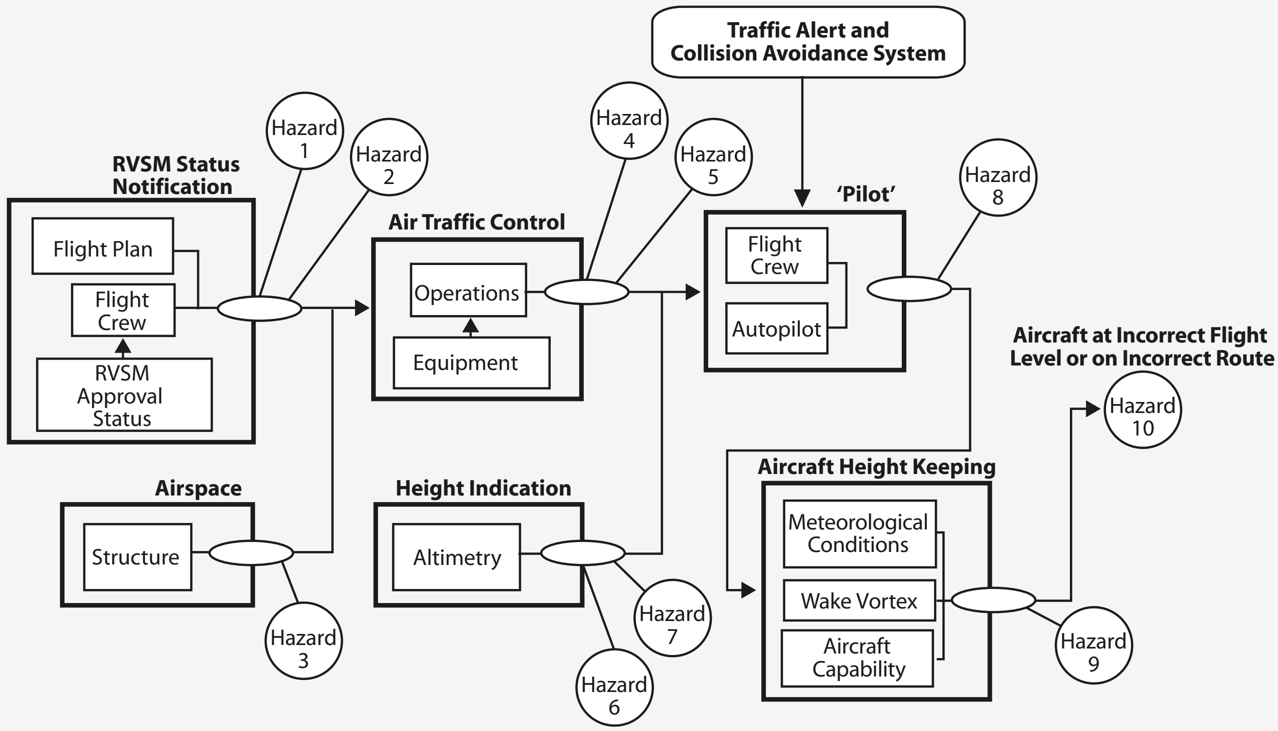
- ATC assignment of inappropriate flight levels to flight crews;

- Non-receipt by flight crews of ATC clearances/instructions;

- Undetectable altimetry-system errors;

"The switch-over to RVSM was executed extremely smoothly."

Figure 4
Reduced Vertical Separation Minimum (RVSM) Hazards Identified by Eurocontrol



Hazard 1: Flight plans indicating RVSM approval for aircraft not approved for operation in RVSM.

Hazard 2: Inability of flight crews to tell air traffic control (ATC) about loss of RVSM capability.

Hazard 3: Incorrect airspace structure.

Hazard 4: ATC assignment of inappropriate flight levels to flight crews.

Hazard 5: Non-receipt by flight crews of ATC clearances/instructions.

Hazard 6: Undetectable altimetry-system errors.

Hazard 7: Loss of altimetry information or detectable errors in altimetry information.

Hazard 8: Flight crew deviations from assigned flight levels.

Hazard 9: Inability of flight crews to maintain assigned flight levels.

Hazard 10: Aircraft entering RVSM airspace from non-RVSM airspace at incorrect flight levels or on incorrect routes.

Source: Adapted from Tiemeyer, Bernd. "Reduced Vertical Separation Minimum (RVSM): Pre-implementation and Post-implementation Safety Cases." In *Change — A Safety Challenge: Proceedings of the 15th annual European Aviation Safety Seminar*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2003.

- Loss of altimetry information or detectable errors in altimetry information;
- Flight crew deviations from assigned flight levels; and,
- Inability of flight crews to maintain assigned flight levels (e.g., because of turbulence or an autopilot malfunction).

Tiemeyer said that these lessons learned led to efforts by Eurocontrol to prevent the problems and to lessen the severity of the consequences.

He said that although Eurocontrol managed the RVSM program for the states involved, each state was responsible for implementing RVSM in its domestic airspace and for developing a safety plan.

"These safety plans show in detail how the respective state responsibility is discharged, what activities it is undertaking to assure the safety of the changes it is making in order to implement RVSM and how risks to aircraft are identified and managed," Tiemeyer said. "Eurocontrol's role was to provide guidance, coordination and support to the participating states."

Congestion Increases Below FL 290

Eurocontrol said that RVSM has caused about a 10 percent increase in traffic congestion below FL 290 in the European Region.

"There has been an increase in traffic at flight levels immediately below RVSM airspace," Eurocontrol said. "The increase is due in part to traffic that is non-RVSM-approved that is now obliged to fly below RVSM airspace. However, when RVSM was introduced, the numbers of flights already in the upper airspace by RVSM-approved aircraft had reached 90 percent.

"Thus, the maximum number of flights obliged to fly below FL 290 is around 10 percent (or less) of the former traffic. … The only portion of the market that probably is not showing overall savings in fuel as a result of RVSM implementation is the small element that made the commercial decision not to equip for RVSM operations and is now operating at less-efficient flight levels."

A study of flight plans filed during one week in the early summer of 2002 showed that 100 flight plans included the ICAO-specified "W" as the aircraft-equipment-suffix code to indicate RVSM approval, although the aircraft were not RVSM-approved.

"This constitutes 0.15 percent of the total numbers of flights in RVSM airspace [that week]," Eurocontrol said.

Stephen Creamer, FAA Air Traffic DRVSM Program manager, said that FAA expects that 88 percent to 93 percent of the flights currently conducted at FL 290 and above involve aircraft that will be approved for RVSM operations when RVSM is implemented in U.S. domestic airspace.

"We expect to be on the high end of that range," he said. "We did some airspace modeling and analysis, and knew we needed to get at least 85 percent. At the 90-plus percentage, there should be an acceptable burden on ATC from non-RVSM-approved airplanes pushed down to altitudes below FL 290.

"While there will be more traffic below FL 290, whether that causes congestion or not remains to be seen. We do have a traffic-flow-management process that we will use to mitigate congestion, but our impression is that it won't be an undue burden on the controllers working that airspace."

"There has been an increase in traffic at flight levels immediately below RVSM airspace."

FAA said that controllers will not refer to an RVSM-approvals database to determine whether an aircraft can be cleared into RVSM airspace; clearance generally will be based on whether a "W" has been filed in the "aircraft type/special equipment" block of the flight plan.[23]

"[Nevertheless,] RVSM program managers [will] regularly review the operators and aircraft that operate in RVSM airspace to identify and investigate those aircraft and operators flying in RVSM airspace but not listed on the RVSM approvals databases," FAA said.

Exceptions Are Made

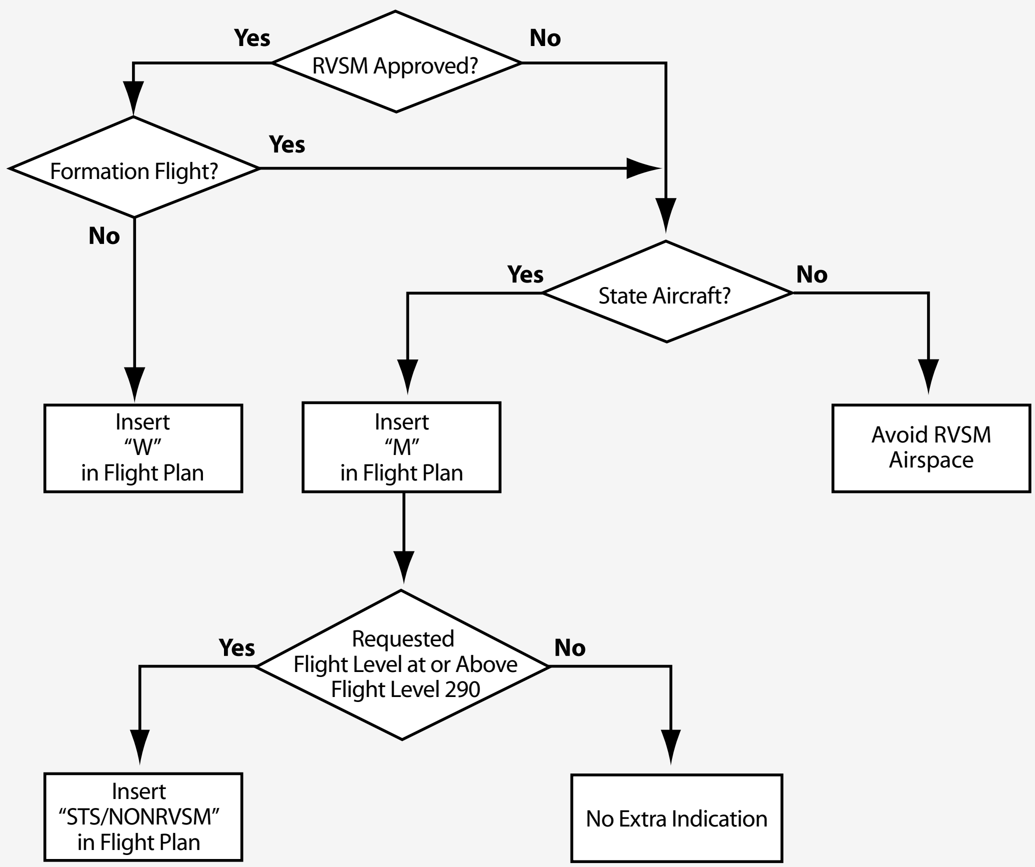
Specific non-RVSM-approved aircraft are permitted to be flown in RVSM airspace. Exceptions primarily are made for "state aircraft," including aircraft used in military service, customs service, police service and for the transport of heads of state.

The required flight plan notation for non-RVSM-approved state aircraft is "STS/NONRVSM" (Figure 5, page 14).

Civil aviation authorities also are granting exceptions for non-RVSM-approved aircraft conducting humanitarian flights, emergency medical services (EMS) flights and certification-and-development flights by aircraft manufacturers.

The Eurocontrol ATC manual said, "Operators are required to indicate their RVSM approval status regardless of the requested flight level (RFL), since ATC must have a clear indication of the non-RVSM-approval status of aircraft intending to operate within or in close vertical proximity to … RVSM airspace. In the absence of such an indication, the controller shall solicit such information."[24]

Figure 5
Reduced Vertical Separation Minimum (RVSM)
Flight Planning Requirements for Aircraft Operators



Source: Adapted from Eurocontrol

In compliance with new pilot-controller communication phraseology developed for RVSM operations (Table 1, page 15), the controller would say, "Confirm RVSM approved." The flight crew's reply would be "affirm RVSM," "negative RVSM" or "negative RVSM, state aircraft."

'Climb-throughs' Might be Allowed

Flight crews of non-RVSM-approved aircraft can request clearance to climb through RVSM airspace to cruise at FL 430 or higher. Approval of the request will depend on controller workload and the capability of the aircraft to be flown on an uninterrupted climb through RVSM airspace.

Creamer said that accommodation of "climb-throughs" in U.S. DRVSM airspace is "on the books, and we're training controllers to be able to do it; however, the success of that operation will depend on traffic." He said that in many parts of the United States, the possibility is remote that a non-RVSM-approved aircraft could be flown in a climb through RVSM airspace without creating a conflict with an RVSM-approved aircraft.

"I don't recommend that people plan their business around trying to do that on every flight," he said. "When we did a traffic survey, we looked across the country for airplanes that might be qualified to do this performance-wise but that might not be RVSM-qualified. We estimated that on any given day, between 75 and 125 operators

Table 1
Pilot-Controller Communication Phraseology for Reduced Vertical Separation Minimum (RVSM) Operations

Circumstance	Phraseology
Air traffic control (ATC) query about RVSM status of flight	"Confirm RVSM approved."
Pilot indication that flight is RVSM approved.	"Affirm RVSM."
Pilot indication that flight is not RVSM approved.	"Negative RVSM."
Pilot of state aircraft (e.g., military) indication that flight is not RVSM approved.	"Negative RVSM, state aircraft."
ATC denial of clearance into RVSM airspace.	"Unable clearance into RVSM airspace. Maintain (descend to or climb to) Flight Level __."
Pilot report of weather (e.g., severe turbulence) affecting ability to maintain RVSM height-keeping requirements.	"Unable RVSM due turbulence."
Pilot report of equipment degraded below RVSM requirements.	"Unable RVSM due equipment."
ATC request for report when flight is able to resume RVSM operations.	"Report able to resume RVSM."
Pilot report of ability to resume RVSM operations after weather and/or equipment contingency.	"Ready to resume RVSM."

Source: Adapted from Eurocontrol

of these aircraft would request approval to climb through RVSM airspace. So, with an average of 100 requests a day, I wouldn't expect to see more than about half getting approved."

Creamer said that FAA is establishing preflight procedures for operators of non-RVSM-approved aircraft to request exemptions to conduct flights in RVSM airspace.

"Valid exemptions are lifeguard flights [i.e., urgent EMS flights requiring expeditious handling] and some aircraft-certification test-flight activity," he said. "The process also will apply to non-RVSM climb-throughs that will operate at FL 430 or above.

"There is a pre-coordination process that will be implemented that will permit an operator to either use the telephone or a Web site to request a non-RVSM flight in RVSM airspace or to climb to FL 430. Actually, a climb to FL 430 does not need to be pre-coordinated. A traffic-management specialist will look at the traffic load and the weather, and give the operator an indication of whether the flight might be cleared into RVSM airspace. That will then be coordinated with the operating centers. When the flight comes into the airspace, if it has been pre-coordinated, the [request] has a better chance [of being approved] because everyone is aware and staffing should be adequate to accommodate the flight."

Pre-coordination, however, will be no guarantee that the operator will receive clearance into RVSM airspace.

"It is always dependent on the workload of the controller at the operating position," Creamer said. "A controller can clear a climb-through to FL 430 if no adjacent airspace will be affected; but, in most cases, airplanes cannot climb that far [i.e., from FL 280 to FL 430] in less than 100 miles. So, it's almost always going to require coordination with an adjacent sector."

No step-climbs will be allowed.

"The climb must be completed in one step," Creamer said. "If the aircraft needs to stop the climb somewhere to burn off fuel, then the controller's instructions are to take the aircraft back down, out of RVSM airspace. If the controller has to stop the climb because of traffic, that's not included."

Wake Turbulence Threat Analyzed

An issue that was identified early in RVSM implementation in the North Atlantic Region is wake turbulence.

"Wake turbulence in cruising levels has been encountered mainly in organized track systems," Frühwirth said. "There is little evidence that this would jeopardize height-keeping accuracy, but it could induce injuries of unsecured aircraft occupants. Standardized procedures for offset tracking have alleviated much of this concern."

Eurocontrol contracted for an independent study of wake turbulence before implementing RVSM in the European Region.

"Experience gained from the implementation of RVSM in the North Atlantic Region indicated that the turbulence created by the wake vortex of aircraft operating at the same flight level/track could present operating difficulties," Eurocontrol said.[25]

The pre-implementation study concluded that "RVSM is not expected to increase the probability of a hazardous encounter with wake vortices, but pilots and air traffic [controllers] should be informed that nuisance encounters would increase [and that] before the introduction of RVSM, an effective system should be established for reporting, collecting and analyzing reports from pilots and air traffic [controllers] of significant wake vortex encounters," Eurocontrol said.

The effects of mountain waves on aircraft can be very similar to the effects of wake turbulence. Eurocontrol said that mountain-wave activity that can affect the ability of flight crews to maintain their assigned flight levels occurs over the Alps in autumn, winter and spring.

Eight aircraft encountered wake turbulence from aircraft that were being flown on reciprocal tracks.

In the 10 months following RVSM implementation in the European Region, Eurocontrol received 26 reports of wake-turbulence encounters. Analysis of the reports by Woodfield Aviation Research showed that 10 of the reports involved actual wake-turbulence encounters in RVSM airspace; the other reports involved wake-turbulence encounters below RVSM airspace or encounters with clear air turbulence rather than wake turbulence.[26]

In its report on the analysis of the wake-turbulence encounters, Woodfield Aviation Research included the following description of wake-vortex characteristics: "A pair of contra-rotating vortices trail behind all aircraft in flight as a direct consequence of the lift generated by the wings. If a following aircraft encounters one of these vortices before they decay, then it will experience a significant roll disturbance. The size of [the] roll disturbance will be strongly related to the ratio of the wingspan of the aircraft generating the vortex to that of the following aircraft, and the amount that the vortex has decayed."

The rate at which wake vortices decay is dependent on time and natural air turbulence.

"Vortices generated [by an aircraft] in high-altitude cruise will typically decay completely at a range of around 20 nautical miles [37 kilometers] — 150 seconds behind or 75 seconds after crossing on reciprocal tracks," the report said. "Vortices descend slowly below the track of the generating aircraft and are affected by temperature gradients in the atmosphere and any local [updrafts] or [downdrafts]. In most atmospheric conditions and in the absence of any vertical [drafts], the vortices from a large aircraft will descend and decay progressively before decaying completely around 500 [feet to] 600 feet below the track.

"Vortices from aircraft with a large wingspan descend [farther] than those from smaller aircraft. A region of generally turbulent air will remain for a while after a vortex has decayed, but there will be no [discrete] vortex to cause a roll disturbance."

The report said that eight aircraft encountered wake turbulence from aircraft that were being flown on reciprocal tracks (i.e., in the opposite direction) 1,000 feet higher. In six encounters, the turbulence intensity was moderate and lasted about three seconds. The report said that these were nuisance encounters that likely occurred in residual turbulence after the wake vortices decayed.

"No control action [was] taken, and there [were] no significant disturbances in pitch, roll or heading," the report said. "The very small number of reports is some indication of how infrequently wake vortices and their residual turbulence descend far enough to interact with traffic nominally 1,000 feet below on a reciprocal path in RVSM operations.

"In most cases, it is likely that there is a combination of the aircraft being slightly closer than 1,000 feet and the vortices descending slightly farther than normal due to particular meteorological conditions and/or local [downdrafts]."

Significant Roll Disturbances Occurred

The report said that significant roll disturbances occurred when two aircraft encountered wake turbulence from aircraft being flown on reciprocal tracks 1,000 feet higher.

The pilot of a Boeing 777 said that a 15-degree roll disturbance was caused by the wake turbulence from a B-747-400. The encounter occurred about 60 seconds to 70 seconds after the aircraft passed each other. The pilot said that he had observed the other aircraft's contrails and should have illuminated the fasten-seat-belt signs in anticipation of the encounter.

"There were no injuries, but [the] pilot [was] concerned that there could have been injuries to passengers or cabin crew," the report said.

The pilot of an Embraer EMB-145 said that an initial roll disturbance of 30 degrees was caused by the wake turbulence from a B-747.

"The pilot requested permission to turn … to avoid a possible vortex encounter, but this request was rejected by [ATC]," the report said. "The aircraft subsequently rolled 45 degrees the other way before recovery.… No injuries were reported, but the passengers were [described as having been] very scared."

The report said that the 45-degree roll might have been induced by the EMB-145 flight crew.

"The size of the bank angle during recovery is mainly dependent on pilot [actions] and autopilot actions, and rarely [results from] a further encounter with a wake vortex," the report said. "It is possible that natural pilot overcompensation following the automatic disengagement of the autopilot may have contributed to this bank angle being larger than that during the encounter with the wake vortex."

The report said that an EMB-145 has a wingspan of 20 meters (66 feet) and a maximum takeoff weight (MTOW) of about 22,000 kilograms (48,501 pounds), and that a B-747 has a wingspan of about 60 meters (197 feet) and an MTOW of about 333,000 kilograms (734,132 pounds).

"This encounter is likely to be representative of a rare worst case, where vertical separation deviations, meteorological conditions and [downdrafts] result in an encounter with the wake of one of the large airliners by a small airliner at less than 15 nautical miles [28 kilometers]," the report said.

A B-737 rolled 45 degrees left and descended 300 feet when it encountered the wake of a B-747.

Two aircraft encountered wake turbulence from aircraft that had been flown through their flight levels:

- A B-737 at FL 320 rolled 20 degrees left when it encountered the wake of a B-757 that had descended through FL 320 10 nautical miles (19 kilometers) ahead; and,

- A B-737 rolled 45 degrees left and descended 300 feet when it encountered the wake of a B-747 that had been flown through the B-737's flight level six nautical miles (11 kilometers) ahead. "Several passengers and crew were scalded with hot water as in-flight service had already begun," the report said.

Eurocontrol said that the analysis of the 10 wake-turbulence encounters "concluded that the majority of wake vortex encounters occur with climbing [aircraft] or descending aircraft and that the implementation of RVSM does not appear to increase the probability of a hazardous encounter with a wake vortex. There is a continuing need, however, to keep up the momentum of reporting so that any significant trends can be identified."

Request a Vector

In preparation for U.S. RVSM implementation, FAA issued a NOTAM that said that flight crews should be alert for wake turbulence during the following operations:[27]

Most of the nuisance advisories were generated by ACAS equipment with version 6.04 software.

- "In the vicinity of aircraft climbing or descending through their altitude;
- "Approximately 12–15 [nautical] miles after passing 1,000 feet below opposite-direction traffic; [or,]
- "Approximately 12–15 [nautical] miles behind and 1,000 feet below same-direction traffic."

The NOTAM said that controllers might issue a radar vector for avoidance when the possibility exists that an aircraft could encounter wake turbulence from another aircraft.

Creamer said that a flight crew can request a vector, a parallel track offset or a flight level change from ATC to avoid wake turbulence.

"In the non-radar environments over the oceans, pilots are allowed to effect a parallel track offset of one [mile] or two miles on their own," he said. "You don't want that in a radar environment, so we ask pilots to give us a call if they encounter wake turbulence, and we'll provide a radar vector or approve a track offset.

"We also provide merging-target traffic advisories so that pilots are aware of the traffic and can assess where they need to be to avoid potential wake turbulence. The pilot just needs to request a vector to avoid that target, and the controller will provide it."

ACAS Nuisance Alerts Increased

Eurocontrol said that soon after RVSM was implemented in the North Atlantic Region, many pilots complained that their airborne collision avoidance systems (ACAS, also called the traffic alert and collision-avoidance system [TCAS II]) were generating traffic advisories (TAs) of long duration for aircraft being flown at adjacent flight levels. A few "nuisance" resolution advisories (RAs) also were triggered by wake turbulence, meteorological turbulence or "imperfect altitude-keeping."[28]

Most of the nuisance advisories were generated by ACAS equipment with version 6.04 software, which was designed for 2,000-foot/600-meter vertical separation of aircraft above FL 290. Eurocontrol said that among the modifications incorporated in current ACAS software, version 7.0, are a change from 1,200 feet to 850 feet in the altitude threshold at which TAs are generated, a change from 800 feet to 700 feet in the altitude threshold at which RAs are generated, and a reduction of the target vertical miss distance from 700 feet to 600 feet.

Eurocontrol said that ACAS with version 7.0 software performs well in RVSM airspace. Nevertheless, aircraft that are flown with high climb rates or high descent rates before level-off at the assigned flight level will trigger nuisance RAs.

Avoid Level Busts

ICAO recommends that flight crews reduce vertical speed to less than 1,500 feet per minute in the last 1,000 feet before level-off to avoid triggering ACAS advisories and to avoid altitude deviations (also called "level busts").

Eurocontrol defines a level bust as "any unauthorized vertical deviation of more than 300 feet from an ATC flight clearance."

Many civil aviation authorities, including FAA, require aircraft operators to report altitude deviations in RVSM airspace of 300 feet/90 meters or more.[29]

Moreover, when a controller observes an altitude display that differs from the assigned flight level by 300 feet or more, the controller notifies the flight crew of the discrepancy and instructs them to check their altimeter setting and confirm the aircraft's altitude. If the discrepancy continues, the controller handles the flight as having a transponder Mode C (altitude-reporting) failure and, thus, as non-RVSM-approved.

"An aircraft rendered non-RVSM-approved shall normally be cleared out of RVSM airspace by air traffic control," Eurocontrol said.

Eurocontrol formed a Level Bust Task Force and conducted two workshops in 2002.[30] The task force is developing a level bust tool kit, which will include material from the Flight Safety Foundation (FSF) *Approach-and-landing (ALAR) Tool Kit*.[31]

A demonstration copy of the level bust tool kit distributed to participants at the FSF European Aviation Safety Seminar in Barcelona, Spain, in March 2004 said that a level bust is a serious hazard that can result in a midair collision, controlled flight into terrain (CFIT) or "a rapid avoidance maneuver, which may result in injuries to passengers, flight crewmembers and, particularly, to cabin crewmembers."[32]

The FSF *ALAR Briefing Notes*, which are one of the elements of the FSF *ALAR Tool Kit*, said that altitude deviations usually occur as the result of one or more of the following conditions:[33]

- "The controller assigns an incorrect altitude or reassigns a *flight level* after the pilot was cleared to an *altitude*;
- "Pilot-controller communication breakdown — mainly readback/hearback errors such as the following:
  - "Controller transmits an incorrect altitude, the pilot does not read back the altitude and the controller does not challenge the absence of a readback;
  - "Pilot reads back an incorrect altitude, but the controller does not hear the erroneous readback and does not correct the pilot's readback; or,
  - "Pilot accepts an altitude clearance intended for another aircraft (confusion of call signs);
- "Pilot receives, understands and reads back the correct altitude or flight level but selects an incorrect altitude or flight level because of:
  - "Confusion of numbers with another element of the message (e.g., airspeed, heading or flight number);
  - "Expectation of another altitude/flight level;
  - "Interruption/distraction; or,
  - "Breakdown in crew cross-checking;
- "Autopilot fails to capture the selected altitude;
- "The crew does not respond to altitude-alert aural warnings and visual warnings when hand-flying; or,
- "The crew conducts an incorrect go-around procedure."

Miscue Cited in Level Bust

Miscommunication of an ATC clearance was involved in a level bust and a loss of required separation between two Boeing 737s in Australian RVSM airspace on Nov. 21, 2001.[34]

In its report on the incident, the Australian Transport Safety Bureau said that one aircraft, registered as VH-TAW, was en route from Sydney, New South Wales, to Ayers Rock, Northwest Territories, at FL 320. The other aircraft, VH-TJY, had departed from Ayers Rock for a flight to Sydney and was climbing. The flight plan for VH-TJY requested FL 350 for cruise.

The controller estimated that the aircraft would pass each other at 1328 local time and planned to have VH-TJY maintain FL 310 until it passed the other aircraft and then climb to FL 350. Nevertheless, the controller inadvertently told the flight crew of VH-TJY to climb to FL 330.

A level bust is a serious hazard that can result in a midair collision.

At 1321, the controller told the crew of VH-TAW to "report sighting and passing [VH-TJY] on climb to FL 310."

"The crew of [VH-]TJY heard the controller's transmission and queried their assigned level of FL 330," the report said. "The controller advised the crew that they had been assigned FL 310.

The crew of [VH-]TJY, having passed FL 320, elected to continue the climb and, at 1322, reported maintaining FL 330."

The report said that required ATC separation standards were not complied with because the aircraft were not established 1,000 feet apart (vertically) at least 10 minutes before the estimated time of passing.

The report said that distraction and fatigue likely were involved in the controller's miscommunication.

"The situational awareness of the crew of [VH-]TJY and their query regarding the assigned flight level ensured that the situation was clarified and [that] safety was maintained," the report said.

North America 'Ready to Go'

Civil aviation authorities and air-navigation-service providers in Canada, Mexico and the United States in December 2003 formed the North American RVSM Implementation Group to "monitor their individual RVSM programs related to a concurrent trilateral implementation and to harmonize ATC, airspace and flight crew procedures so that the interface at common airspace boundaries will be a seamless environment," said Don MacKeigan, Southern Domestic RVSM project manager for Nav Canada.[35]

"Together with the United States and Mexico, we have reaffirmed our 'go' decision for Jan. 20, 2005, implementation," MacKeigan said. "We have a lot of work to do, but we are ready to go ahead with our part of the program."

MacKeigan's "go" was confirmed by Robert Swain, FAA RVSM Program manager.

"It is going to happen on the 20th of January," Swain said.[36] "There's no chance of a delay."

Creamer said, "From an air traffic control perspective, I think that for pilots of aircraft that are RVSM-approved, the change in the operation will be remarkably small. They won't see that air traffic control has any new complications for them — that it works the same as it worked before.

"RVSM has been proven safe by millions of flight hours around the world, and it has proven to dramatically increase the efficiency and the effectiveness of the airspace. We're going to see airplanes operating much closer to where they want to operate on virtually every flight, effective on the day we implement."[37] ■

Notes

1. International Civil Aviation Organization (ICAO). "RVSM Now in Effect on Major Air Traffic Routes Between Asia, the Middle East and Europe." *ICAO Journal* Number 9 (2003).
2. The European Organization for the Safety of Air Navigation (Eurocontrol) said that its primary objective is "the development of a seamless, pan-European air traffic management (ATM) system." Eurocontrol has 34 member states: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Former Yugoslav Republic of Macedonia, Malta, Moldova, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom.
3. Airservices Australia. *Airservices Australia Annual Report 2001–02.*
4. U.S. Federal Aviation Administration (FAA). "Reduced Vertical Separation Minimum in Domestic United States Airspace; Final Rule." *Federal Register* Volume 68 (Oct. 27, 2003).
5. ICAO. *Manual on Implementation of a 300 m (1,000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive.* Document 9574. Second edition — 2002.
6. Frühwirth, Heinz. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 4, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.
7. ICAO. Document 9574.
8. ICAO, in Document 9574, defines *height-keeping performance* as "the observed performance of an aircraft with respect to adherence to [the] cleared flight level." ICAO defines *height-keeping capability* as "the aircraft height-keeping performance that can be expected under nominal environmental operating conditions with proper aircraft operating practices and maintenance."
9. Joint Aviation Authorities. *Guidance Material on the Approval of Aircraft and Operators for Flight in Airspace Above Flight Level 290 Where a 300-meter (1,000-foot) Vertical Separation Minimum Is Applied.* Leaflet No. 6, Revision 1. Jan. 10, 1999.

10. FAA. *Guidance Material on the Approval of Operations/Aircraft for RVSM Operations*. Document no. 91-RVSM. Feb. 20, 2004.

11. FAA. Oct. 27, 2003.

12. The following 40 countries are participating in the European RVSM program: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Former Yugoslav Republic of Macedonia, Malta, Moldova, Monaco, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Tunisia, Turkey, Ukraine and the United Kingdom.

13. FAA. Oct. 27, 2003.

14. ICAO. Document 9574.

15. Ibid.

16. Swain, Robert. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 4, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S. Swain is the RVSM Program manager for FAA.

17. Eurocontrol. *EUR RVSM: The Official Website for the European Reduced Vertical Separation Minimum Programme*. <www.ecacnav.com/rvsm/library.htm>.

18. MacKeigan, Don. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Sept. 28, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S. MacKeigan is Southern Domestic RVSM Project manager for Nav Canada.

19. Creamer, Stephen. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 1, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S. Creamer is Air Traffic DRVSM Program manager for FAA.

20. U.K. Civil Aviation Authority (CAA) Safety Regulation Group. *Flight Operations Department Communication 7/2004*. April 28, 2004.

21. Sanders, David. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. Sept. 24, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S. Sanders is a U.K. CAA press officer.

22. Tiemeyer, Bernd. "Reduced Vertical Separation Minimum (RVSM): Pre-implementation and Post-implementation Safety Cases." In *Change — A Safety Challenge: Proceedings of the 15th annual European Aviation Safety Seminar*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2003.

23. FAA. "FAA Notice: Domestic U.S. Reduced Vertical Separation Minimum (RVSM) Operational Policy Procedures." *Domestic/International NOTAM Book*. July 8, 2004.

24. Eurocontrol. *ATC Manual for a Reduced Vertical Separation Minimum (RVSM) in Europe*. ASM.ET1.ST13.5000. Jan. 2, 2001.

25. Eurocontrol. *The EUR RVSM Pre-implementation Safety Case*. RVSM 691. August 2001.

26. Woodfield, Alan A. *Review of Pilot Reports of Wake Vortex Encounters Following Implementation of RVSM in European Airspace*. Woodfield Aviation Research Report No. 200301. February 2003.

27. FAA. July 8, 2004.

28. Eurocontrol. *ACAS II Operation in the European RVSM Environment*.

29. FAA. Federal Aviation Regulations (FARs) Part 91, *General Operating and Flight Rules*. Appendix G, *Operations in Reduced Vertical Separation Minimum (RVSM) Airspace*. Section 6, "Reporting Altitude-keeping Errors."

30. Blajev, Tzvetomire; Barrass, John. "The Eurocontrol Level Bust Initiative." In *Safety Without Borders: Proceedings of the 16th annual European Aviation Safety Seminar*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2004.

31. The Flight Safety Foundation (FSF) *Approach-and-landing Accident Reduction (ALAR) Tool Kit* provides on compact disc (CD) a unique set of briefing notes, videos, presentations, risk-awareness checklists and other tools designed to help prevent approach-and-landing accidents (ALAs) and controlled flight into terrain (CFIT). The tool kit is the culmination of the Foundation-led efforts of more than 300 safety specialists worldwide to identify the causes of ALAs and CFIT, and to develop practical recommendations for prevention of these accidents. The tool kit is a compilation of work that was begun in 1996 by an international group of aviation industry volunteers who comprised the FSF ALAR Task Force, which launched the second phase of work begun in 1992 by the FSF CFIT Task Force.

32. CFIT, as defined by the FSF CFIT Task Force, occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport.

33. FSF ALAR Task Force; FSF Editorial Staff. "ALAR Briefing Notes." *Flight Safety Digest* Volume 19 (August–November 2000).

34. Australian Transport Safety Bureau. Occurrence Brief No. 200105559. Aug. 7, 2002.

35. MacKeigan.

36. Swain.

37. Creamer.

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FSF Editorial Staff. "Faulty Shift Handoff Cited in Failure to Close B-747 Static Lines." *Aviation Mechanics Bulletin* Volume 52 (January–February 2004).

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Swiss Large Airplanes Had No Fatal Accidents in 2003

There were no fatal accidents in Swiss airspace in 2003 involving airplanes, Swiss-registered or non-Swiss-registered, in the two highest weight classes. The number of accidents and serious incidents involving Swiss-registered helicopters increased for the year, but the number of fatalities and serious injuries did not. The number and rate of air traffic incident (AIRPROX) reports increased.

— FSF EDITORIAL STAFF

For the second consecutive year, no fatalities or serious injuries[1] resulted from accidents/serious incidents[2] in 2003 to Swiss-registered large-class airplanes (greater than 5,700 kilograms/12,500 pounds maximum takeoff weight [MTOW]). Nine accidents/serious incidents occurred in the category, compared with six in 2002 (Table 1, page 23). There were also no fatalities or serious injuries in accidents/serious incidents in 2003 to Swiss-registered medium-class airplanes (2,250 kilograms [4,960 pounds] to 5,700 kilograms MTOW), compared with four fatalities in 2002. There were two accidents/serious incidents involving medium-class airplanes in 2003, and an equal number in 2002.

The 11 accidents/serious incidents to Swiss-registered helicopters in 2003 resulted in two fatalities and three serious injuries. That compared with seven accidents/serious incidents, resulting in two fatalities and four serious injuries, in 2002.

The figures were reported in a statistical survey issued by the Swiss Aircraft Accident Investigation Bureau.[3]

Accidents/serious incidents that occurred in Switzerland to non-Swiss-registered large-class airplanes in 2003 totaled four, with no fatalities or serious injuries. There had been two accidents/serious incidents in the class in 2002, with no resulting fatalities or serious injuries.

For non-Swiss-registered medium-class airplanes, there were four accidents/serious incidents in Switzerland in 2003, resulting in no fatalities and no serious

The 11 accidents/serious incidents to Swiss-registered helicopters in 2003 resulted in two fatalities and three serious injuries.

Table 1
Accidents and Serious Incidents Involving Swiss-registered Aircraft and Non-Swiss-registered Aircraft in Switzerland, 2002–2003

	Accidents and Serious Incidents Involving Swiss-registered Aircraft in Switzerland						Accidents and Serious Incidents Involving Swiss-registered Aircraft Abroad						Accidents and Serious Incidents Involving Non-Swiss-registered Aircraft in Switzerland					
	Medium-class Airplanes*		Large-class Airplanes**		Helicopters		Medium-class Airplanes*		Large-class Airplanes**		Helicopters		Medium-class Airplanes*		Large-class Airplanes**		Helicopters	
	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002
Accidents/serious incidents	0	0	7	4	11	6	2	2	2	2	0	1	4	1	4	2	0	0
Fatalities	0	0	0	0	2	0	0	4	0	0	0	2	0	2	0	0	0	0
Crew	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0
Passengers	0	0	0	0	1	0	0	3	0	0	0	1	0	1	0	0	0	0
Third persons	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Persons seriously injured	0	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0
Crew	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Passengers	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Third persons	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0

MTOW = Maximum takeoff weight

*Medium-class airplanes have MTOWs between 2,250 kilograms (4,960 pounds) and 5,700 kilograms/12,500 pounds.

** Large-class airplanes have MTOWs greater than 5,700 kilograms/12,500 pounds.

Source: Swiss Aircraft Accident Investigation Bureau

injuries. The equivalent figure for 2002 was one accident/serious incident, with two fatalities and no serious injuries. There were no accidents/serious incidents in Switzerland to non-Swiss-registered helicopters in either year.

The annual numbers of accidents/serious incidents involving all Swiss-registered aircraft have declined from 1980 through 2003 (Figure 1, page 24), although the numbers of fatalities have varied with no discernible trend. The sharp increase in fatalities for 1998 reflects the fatal accident involving Swissair Flight 111 on Sept. 2, 1998, near Peggy's Cove, Nova Scotia, Canada. [The airplane was destroyed and its 229 occupants were killed after a fire began above the cockpit ceiling and spread rapidly, leading to loss of control, and the airplane struck water.]

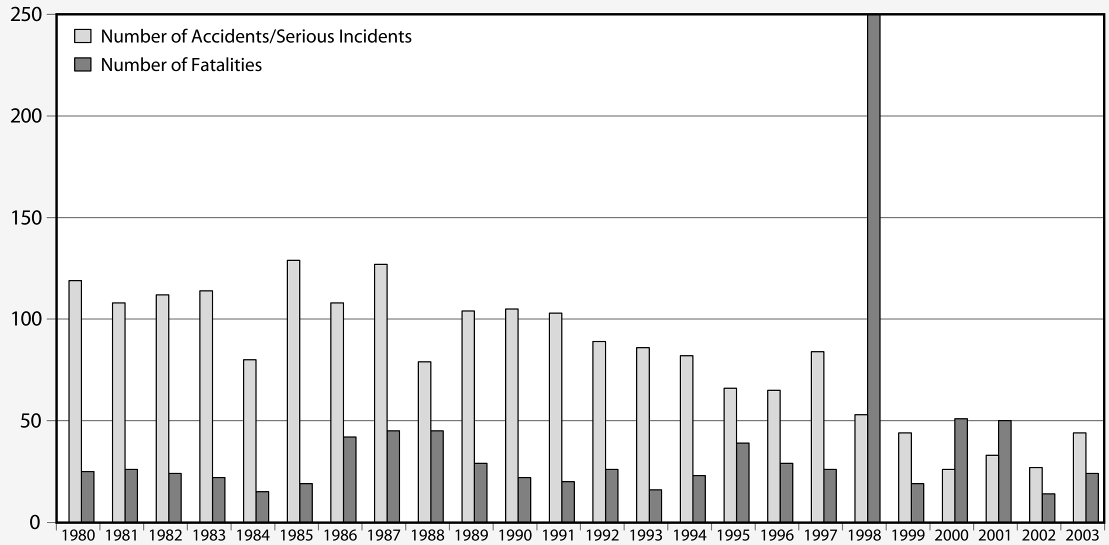
In 2003, among accidents involving Swiss-registered aircraft and non-Swiss-registered aircraft in Switzerland, the "starting and climb" phase of flight involved the largest number of accidents/serious incidents to airplanes in the two weight categories (Table 2, page 24), with nine (47 percent) of the total 19 in these categories. The landing phase accounted for the next highest number, five (26 percent). Combining the "descending flight/approach" phase with the landing phase brought the number to seven (37 percent). Corresponding figures for 2002 were one accident/serious incident in the starting and climb phase (9 percent) out of a total of 11, two in the landing phase (18 percent) and five in the combined descending flight and approach/landing phases (45 percent).

In 2003, there were 65 air traffic incident reports (ATIRs, or AIRPROX[4] reports), and 18 more ATIRs in airspace E,[5] an increase from 49 in 2002 (Table 3, page 25). Of the 2003 ATIRs, 25, plus three in ATIR airspace E, were in the Risk A category (involving a high risk of collision), compared with 15 in the Risk A category in 2002. The ATIR rate was 5.0 per 100,000 instrument flight rules

Continued on page 25

Figure 1

Accidents/Serious Incidents and Fatalities Involving Swiss-registered Aircraft, 1980–2003

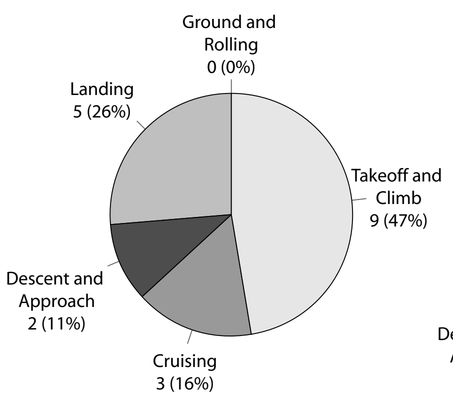


Source: Swiss Aircraft Accident Investigation Bureau

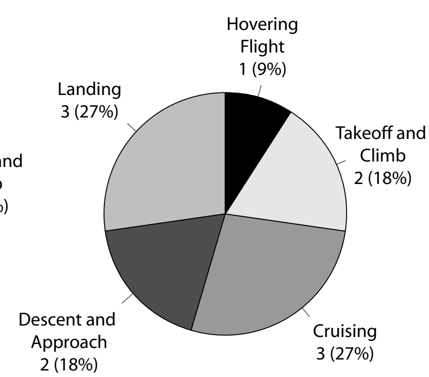
Table 2

Flight Phase, Accidents/Serious Incidents Involving Swiss-registered Aircraft and Non-Swiss-registered Aircraft in Switzerland, 2002–2003

	Ground and Rolling/ Hovering Flight		Takeoff and Climb		Cruising		Descending Flight and Approach		Landing		Total	
	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002
Airplanes with MTOW 2,250 kilograms (4,960 pounds)–5,700 kilograms/12,500 pounds	0	0	1	0	1	1	1	1	3	1	6	3
Airplanes with MTOW > 5,700 kilograms/12,500 pounds	0	1	8	3	2	1	1	2	2	1	13	8
Helicopters	1	1	2	1	3	4	2	0	3	1	11	7



Airplanes (2003)



Helicopters (2003)

MTOW = Maximum takeoff weight

Source: Swiss Aircraft Accident Investigation Bureau

Table 3
Air Traffic Incident Reports (ATIRs) in Swiss Airspace, 1993–2003

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total of ATIRs announced	**17**	**11**	**20**	**14**	**22**	**20**	**29**	**45**	**47**	**49**	**65 (+18)***
Risk A (high risk of collision)	4	6	2	2	2	4	12	22	13	15	25 (+3)*
Risk B (possible risk of collision)	11	4	12	6	9	8	6	14	10	6	10 (+6)*
Risk C (no risk of collision)	—	—	4	6	5	6	11	7	24	28	30 (+9)*
Risk D (risk not determined)	2	1	2	—	6	2	—	2	—	—	—
Total IFR flights	935,000	976,680	1,024,919	1,069,424	1,119,826	1,224,425	1,266,204	1,352,319	1,324,578	1,287,826	1,287,665
Number of ATIRs announced per 100,000 IFR flights	1.8	1.1	2.0	1.3	2.0	1.6	2.3	3.8	3.5	3.9	5.0 (6.4)*

IFR = Instrument flight rules

* Number of ATIRs in Airspace E (ARFA sector). ARFA is an air traffic control (ATC) sector that includes the region of Friedrichshafen. In this region, airspace is classified as E, where aircraft flown under visual flight rules may enter without the pilot contacting ATC.

Source: Swiss Aircraft Accident Investigation Bureau

(IFR) flights (6.4 including those in airspace E), an increase from 3.9 in 2002.

Because AIRPROX reporting involves a degree of subjectivity, and the "reporting climate" can vary over time, changes in ATIR/AIRPROX numbers and rates may not precisely reflect actual trends.■

Notes

1. A *serious injury* is defined as "an injury which is sustained by a person in an accident and which: (a) within seven days requires hospitalization for more than 48 hours; (b) involves a fracture of any bone except simple fractures of fingers, toes or the nose; (c) involves lacerations which cause severe hemorrhage, nerve, muscle or tendon damage; (d) results in damage to any internal organ; (e) involves second-[degree] or third-degree burns or any burns affecting more than 5 percent of the body surface; [or] (f) is the result of verified exposure to infectious substances or injurious radiation."

2. An *aircraft accident* is defined as "an occurrence associated with the operation of an aircraft, as long as a person is aboard the aircraft with the intention of flight: (a) in which a person in or outside the aircraft is seriously or fatally injured, or (b) in which the aircraft sustains damage which substantially affects structural strength, performance or flight characteristics and which normally requires major repair or the replacement of the affected component; or (c) in which the aircraft is missing or the wreckage is inaccessible." A *serious incident* is defined as an "occurrence associated with the operation of an aircraft under circumstances which nearly led to an accident."

   Accidents and serious incidents were combined into a single category by the report.

3. Swiss Aircraft Accident Investigation Bureau. "Statistics Concerning Accidents and Serious Incidents Involving Swiss-registered Aircraft in Switzerland and Abroad and Foreign-registered Aircraft in Switzerland, 2003." Berne, Switzerland, May 2004. Available on the Internet at <http://www.bfu.admin.ch/en/html/statistiken_tabellen.html>.

4. Switzerland follows the International Civil Aviation Organization (ICAO) in defining an AIRPROX incident as "a situation in which, in the opinion of a pilot or of the air traffic control personnel, the distance between aircraft moving under their own power as well as their relative positions are such that the safety of the aircraft involved could be endangered in flight or on the ground in the aircraft-maneuvering area." In Switzerland, ATIRs are required to be reported by air traffic controllers and flight crews in accordance with ICAO Annex 13, *Aircraft Accident and Incident Investigation*.

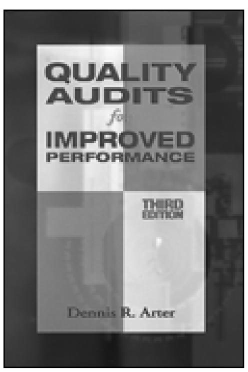
5. ARFA is the name of an air traffic control (ATC) sector that includes the region of Friedrichshafen. In this region, the airspace is classified as E, which means that aircraft flown under visual flight rules may enter without the pilot contacting ATC. ATIRs in this sector were not investigated prior to 2003, so they are shown separately to enable valid ATIR comparisons with previous years.

STATS

Keys to a Successful Audit Are Objectivity, Technical Competence And Knowledge of Audit Practices

***Quality Audits for Improved Performance* describes the stages of an audit and offers principles for conducting one effectively. After the facts have been gathered and findings developed, says the author, the report must be presented in a manner that clearly relates to each stakeholder's interests.**

— FSF LIBRARY STAFF



Books

Quality Audits for Improved Performance. Arter, Dennis R. Third edition. Milwaukee, Wisconsin, U.S.: ASQ Quality Press, 2003. 142 pp. Tables, figures, glossary, index.

An audit, says the author, is more than an inspection. Describing the general model of auditing, he says, "We must first have requirements for the item, activity or organization. This is called the *basis* of the audit. We must also have facts relating to the implementation of those requirements. These are called *evidence*. When you compare the facts to the requirements, you get an *observation*, which can be either good or bad. So far, this is very much like an inspection. Auditors push on. They analyze these observations for patterns, which are called *findings*. Often, auditors are also requested to take all the observations, findings, sights and smells, and draw *conclusions*. Their product, the *report*, is presented to interested parties for use."

The book, written largely from the auditor's point of view, is not specifically about aviation audits but is relevant to them. It provides a step-by-step guide through the stages of an audit, from preparation through the report and follow-up.

Members of an audit team should have three qualifications, the author says:

- Objectivity. "The audit team must be free of a vested interest in the area to be audited, so they can perform their duties in an objective and unbiased manner. They must not own the very thing to be audited."

- Technical competence. "Auditors must know the technical processes they are examining. They should understand common industry practices. They need to know what approaches are successful and where danger lies."

- Knowledge of audit practices and processes. "Just as welders must know welding, auditors must know auditing. They should know about work papers, opening meetings, data collection and problem identification."

Among the data-collection processes is interviewing employees of the company whose operations are being audited. Whereas much of the information gathering is purely observational and impersonal, interviews raise human factors issues. A good interviewer, says the author, follows six steps:

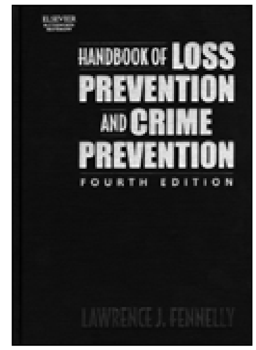
- Put the person at ease;
- Explain your purpose;
- Find out what the person does;
- Analyze what the person does;
- Make a tentative conclusion; [and,]
- Explain your next step.

In connection with the second step, the author says, "The natural first reaction to your presence might be, 'Why me?' You must address that concern immediately. What information do you want? Why are you asking all these questions? Most people will express a desire to share information once they know why you want it. In this way, it makes them feel important. A useful technique here is to show the other person a copy of your blank checklist. Right away, they can see the questions, understand the data you need and make a decision as to whether they have that information."

When the time for reporting arrives, the author says, the auditor must present findings so that their significance can be readily understood, rather than as isolated facts. "In order to change practices for the better, audit results must be in business terms and appeal to the interests of the various stakeholders," says the author. "Do they really care if six 5391 forms are missing the shift supervisor's signature? So what? If, however, … a projection of the continued practice of not recording reviews shows that the quality of the maintenance program is or could be adversely affected, then the responsible managers can take steps to correct the situation."

The report, says the author, should be accurate, concise, clear, timely and be written in the right tone: "The report must be completely factual, in that every statement and reference must be based on one of the five forms of data discussed [physical properties, sense perceptions, documents and records, interviews, and patterns]. It must be concise so that superfluous words do not block reception of the message. A clear report puts your thoughts into the mind of the reader. Timely reports examine topics while they are of interest. Reports are published before they are forgotten. Finally, the tone of the report must be courteous and professional."

Handbook of Loss Prevention and Crime Prevention. Fennelly, Lawrence J. (ed.). Fourth edition. Oxford, England: Butterworth-Heinemann, 2004. 525 pp. Figures, tables, references, glossaries, appendixes, index.



"Risk cannot be eliminated, but it can be managed. Risk can be reduced to a manageable level through the proper risk-analysis research and assimilation of data — then, [by] a thorough implementation of measures designed to avoid, reduce or eliminate the remaining factors associated with that risk," says contributing author Murray Neal.

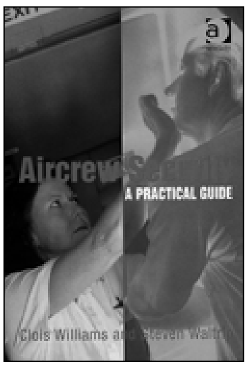
This single-volume handbook is a collection of articles and other materials written by specialists in crime prevention, loss prevention and workplace security. Its intended audience is security professionals and managers working in any type of industry, including aviation.

Risks are broadly described in terms of threats and consequences. Risk assessment begins with answers to the following four basic questions:

- What is to be protected?
- From whom is it being protected?
- How might the resources be harmed? and,
- What is the full range of consequences if the protection fails?

The authors discuss four major aspects of crime prevention and loss prevention: security methods (vulnerability to threats of terrorism or bombs), security applications (protecting facilities and human resources), security operations and security equipment (locks, lighting and surveillance). Security checklists, reporting forms, guidelines for assessing risks, guidelines for developing security plans and examples of security applications used in different environments accompany discussions.

Use of security professionals should not be limited to crime prevention or loss prevention, say the authors. They should be included when an organization designs its emergency management plans or reviews its emergency management procedures. Regardless of the type of crisis an organization faces, the authors say, security personnel can be vital participants on emergency management teams and recovery teams.



Aircrew Security: A Practical Guide. Williams, Clois and Waltrip, Steven. Aldershot, England: Ashgate Publishing, 2004. 506 pp. Tables, illustrations, appendixes.

"Any assumption by the traveling public that aviation travel is now safer because of all the attention and the many announced 'new security procedures' being implemented at the airports is a big mistake," say the authors. "*Activity and attention should not be mistaken for effective solutions to airport security.*" [Emphasis in original]

The authors — a former Airbus A320 pilot and president of a security-training company, and a current A320 pilot and vice president of the company, respectively — believe that regardless of government-sponsored programs, "security and protection of the passengers on a commercial flight will always ultimately fall onto the shoulders of the captain and the flight crew. For these reasons, we believe crew security training should be comprehensive and should empower the crews with the tools to protect themselves, passengers and the aircraft."

The book discusses the threats to commercial-aviation security, including the "air rage" of disruptive passengers as well as the terrorist repertoire of hijacking and sabotage.

Passengers who lose self-control do more than threaten physical harm to crewmembers; the authors cite a study by the U.S. National Aeronautics and Space Administration (NASA) of 152 disruptive-passenger situations that revealed 15 instances of pilot error attributed to the disturbances. "Errors included flying too fast, at wrong altitudes, and incursions of taxiways or active runways," the authors say. "Pilots elected to leave the cockpit to quell a disturbance, or were interrupted from their duties by flight attendants seeking help, in 40 of 152 events."

In connection with aviation-related terrorism, the authors say that "no government can protect its citizens all the time. Nor can your airline. It is an impossible task." Their conclusion is that flight crewmembers must compensate for the aviation-security system's inability to prevent every possible hostile action.

Chapters discuss at length the nature of disruptive passenger behavior and of terrorist tactics. The use of explosive devices and of chemical, biological and radiological weapons is explained. The authors then describe methods by which flight crews can prevent and counter on-board security threats.

In responding to disruptive passengers, the authors say, flight crewmembers need to understand the psychological and emotional background of the situation. They frankly acknowledge that for today's passengers, air travel can be stressful and unwelcoming — "a crazy environment" — in ways that earlier generations rarely had to encounter.

"Some crewmembers are able to handle uncomfortable situations professionally and in their stride, while others continually escalate the situation into a full-blown confrontation with passengers or other crewmembers," the authors say. "What makes the difference? The difference lies in the training and experience of the person willing to adjust their personal approach to conflict management." Although they recognize that some passenger disruptions must be dealt with by force, they offer specific techniques designed to resolve conflict before it reaches that stage.

Psychological preparation, or what the authors call "developing a survival mindset," is also important for responding to a terrorist threat. The authors stress the value of anticipation, constant vigilance, developing bonds of trust with other flight crewmembers, and cultivating the will and ability to act.

The authors then go on to discuss "flight crew survival tactics and techniques," including means of physically restraining or disabling terrorist passengers.

"We are in a new reality of air transportation and must develop strategies to counteract current and future threats," say the authors. "Security, survival techniques and tactics must become a way of life for pilots and flight attendants."

Reports

Cabin Air Quality. U.K. Civil Aviation Authority (CAA). CAA Paper 2004/04.
February 2004. 52 pp. Figures, tables, appendixes, references. Available on the Internet at <http://www.caa.co.uk> or from Documedia Solutions.*

A variety of symptoms experienced by flight crewmembers and cabin crewmembers on commercial airlines has stimulated the investigation of the quality of cabin air. This research report addresses the effects of cabin-air contamination on a pilot's ability to safely fly and safely land aircraft.

"The CAA initiated its research program into cabin-air quality in 2001, after a small number of events, including two on U.K.-registered aircraft, where flight crew were partially incapacitated," says the report. "Evidence from these incidents indicated that contamination of the ventilation systems by engine-oil fumes was the most likely cause. This was also supported by the determinations of 'likely cause' from previous investigations made in Sweden and Australia and discussion with the U.K. AAIB [Air Accidents Investigation Branch]. Although the CAA research was targeted in this direction, it was also necessary to keep an open mind on other potential causes. However, subsequent CAA investigations found no weight of evidence indicating that other causes were involved."

Incidents have been reported in several aircraft types, including a British Aerospace BAe 146, the report said. All have a common method of supplying air to the passenger cabin. Air is bled off the engines and supplied to the environmental conditioning system for air conditioning before entering the cabin. A portion of this air is recirculated. The report says that "in the event of oil leakage there is the opportunity, therefore, for the pyrolysis [chemical decomposition or other chemical change caused by heat] products of engine lubricant/fuel to enter the cabin-air supply and exert toxic effects on both passengers and crew."

Research was conducted in two phases to investigate the existence of noxious or toxic products generated at the engine level and to investigate the existence of noxious or toxic products generated at the aircraft level. Supporting toxicological data on reported symptoms appear in the document.

In phase 1, symptoms that had been reported in cabin-air quality incidents were reviewed and separated into two categories — acute and chronic. Acute symptoms included irritation (e.g., sore eyes, a burning sensation in the throat and in the nose) and symptoms related to the central nervous system (e.g., nausea, dizziness and inability to concentrate). Chronic symptoms were more diverse and affected the intestines and peripheral nerves. No common pattern of symptoms could be identified as being characteristic of cabin-air-quality incidents, and the occurrence of an odor in passenger cabins or cockpits is not always associated with symptoms. Likewise, the occurrence of symptoms is not necessarily related to the presence of an odor.

In phase 2 of the research, contaminated cabin-air-supply ducts from two different BAe 146 aircraft were examined to determine if specific symptoms could be linked to leakage of oil into the engine-bleed air of certain aircraft.

The report says that a general assessment of the toxic potential of the components and thermal degradation products of aviation lubricating fluid, as related to cabin-air quality incidents, determined that no single component or set of components could be identified at concentrations to have been definite causes of symptoms reported in cabin-air quality incidents. It was noted that symptoms of irritation could be induced by short-chain organic acids formed during pyrolysis of aircraft lubricants.

The report recommends further studies to determine contaminants in the cabin, to investigate other sources of chemical contamination and to define the long-term cumulative toxicity of certain materials.

Regulatory Materials

Fire Safety Manual. Civil Aviation Authority of Singapore (CAAS). September 2004. 108 pp. Figures, illustrations, appendixes, glossary. Available on the Internet at <http://www.caas.gov.sg/caas> or from CAAS.**

Considering the nature of airport operations, the high number of passengers passing through an airport and the atrium-like design (large and spacious) of many airport terminal buildings, "fire safety at the airports need[s] to be at a high level," says this manual. The document contains fire safety procedures that are based on existing regulations and other codes in Singapore. "These procedures spell out the fire safety measures to be observed by airport operators and tenants so that a high standard of fire safety can be maintained at key buildings of Singapore Changi [Airport] and Seletar Airport," says the manual.

The manual identifies required procedures and guidelines for compliance, fire safety precautions, implementation of safety codes, fire safety tests, and general procedures to follow in the event of a fire. The manual recommends supplementing requirements with those of other authoritative bodies, such as the (U.K.) Fire Prevention Association and the (U.S.) National Fire Protection Association.

Chapters include "General Fire Safety — Duties and Responsibilities," "General Fire Prevention Measures," "Maintenance of Fire Detection and Protection Systems," "Provision and Usage of Portable Fire Extinguishers," and "Requirements for Renovations, Alterations and Additions to CAAS Owned/Managed Properties."

Powerplant Guide for Certification of Part 23 Airplanes and Airships. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 23-16A. Feb. 23, 2004. Figures, references. 194 pp. Available from FAA via the Internet at <http://www.airweb.faa.gov/Regulatory_and_Guidance_Library> or from GPO.***

This AC provides information and guidance for acceptable means of compliance with U.S. Federal Aviation Regulations (FARs) Part 23, subpart E, which applies to the powerplant installation in normal, utility, acrobatic and commuter airplanes. Guidance is directed to airplane manufacturers, modifiers, non-U.S. regulatory authorities and FAA small-airplane type certification engineers and their designees.

FARs Part 23, subpart E, addresses powerplant, fuel system, fuel-system components, oil system, cooling, liquid cooling, induction system, exhaust system, powerplant controls and accessories, and powerplant fire protection.

The AC spans nearly 38 years of FAA aviation history and consolidates, into one document, pertinent policy documents and pertinent ACs. Documents and ACs that have been superseded are listed, as are other related regulations and publications.

Joint Aviation Requirements (JARs) Part 23 has been harmonized with FARs Part 23 to the extent that the powerplant installation requirements are essentially the same. The numbering scheme is the same between JARs Part 23 and FARs Part 23 so that documents may be cross-referenced easily. "With the coming of the European Aviation Safety Authority (EASA), the rules will be embodied as certification specifications (CS), which, in the beginning, are created directly from the JARs with the same numbering scheme," says the AC. ■

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B-777 Crew Extinguishes Lavatory Fire During Trans-Atlantic Flight

An investigation found that paper products stored on a shelf behind the lavatory mirror had come in contact with a ballast assembly that was hot to the touch.

— FSF EDITORIAL STAFF

The following information provides an awareness of problems through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

AIR CARRIER

Incident Prompts New Guidelines for Storing Paper Products

Boeing 777. No damage. No injuries.

The airplane was being flown in cruise flight over the Atlantic Ocean en route from Barbados to London, England, when a crewmember smelled an "unusual odor." Two minutes later, a toilet smoke warning sounded and smoke was observed emanating from beneath a lavatory door.

When the lavatory door was opened, flames and smoke were observed; a fire extinguisher was discharged into the lavatory, and the lavatory door was closed. After the fire was extinguished, crewmembers inspected the area and found that the fire had originated in a storage area behind the lavatory's vanity mirror. Three shelves held paper towels, boxes of tissues and other items used in the lavatory.

The incident report said, "In the roof of the stowage area is a ballast assembly that was hot to the touch. In contact with this were some of the flammable materials, including a charred pack of paper napkins."

Crewmembers declared the lavatory unserviceable for the remainder of the flight. The captain asked an off-duty B-777 captain who was traveling as a passenger to pull the "LAV LIGHTS RIGHT" circuit breaker, which the crew believed was responsible for controlling electrical supply to the lavatory, which was on the right side of the airplane; the lights did not extinguish.

An investigation revealed that the words "Do not overstock, only 1 each item" had been written in black felt-tip pen next to the storage unit on the incident airplane and in all other B-777 airplanes in the operator's fleet. The investigation also found that the circuit breaker that controlled electrical power for the lavatory ballast assembly was labeled "LAV LIGHTS LEFT," the report said.

After the incident, the operator issued a notice to require cabin crewmembers to ensure that no flammable material is stored on the upper shelves behind lavatory mirrors in B-777s. Because cabin crewmembers have found flammable material on the shelves since the incident, the operator is modifying the shelf space to prevent items from contacting the ballast assembly.

Flight Attendant Breaks Leg During Turbulence

Airbus A319. No damage. One serious injury.

Visual meteorological conditions prevailed for the evening passenger flight in the United States, and the airplane was being flown in level flight at 17,000 feet. The captain told the lead flight attendant that the airplane was nearing cumulus clouds and that all flight attendants should be seated after they completed their immediate duties.

The lead flight attendant completed her duties and sat down, "unaware of the status of the remaining flight attendants, who were stationed at the rear of the airplane," a preliminary report said.

The airplane then encountered a "horrendous bump," the lead flight attendant said, and the other two flight attendants were thrown to the floor of the airplane. One flight attendant received a broken leg.

The injured flight attendant said that, when the lead flight attendant had warned him about impending turbulence, he heard "no urgency in the lead flight attendant's voice." He was completing his duties and sealing a food-and-beverage cart when the incident occurred.

Airplane Encounters Wind Shear on Takeoff

McDonnell Douglas DC-9. Substantial damage. One serious injury.

Instrument meteorological conditions prevailed for the domestic flight in Mexico. A preliminary report said that, immediately after rotation, the airplane encountered wind shear.

The flight crew was unable to maintain control of the airplane, which was forced back onto the ground. All three landing gear collapsed, and the right wing was destroyed.

Airplane Strikes Fence During Familiarization Flight

Piper PA-32R-301 Saratoga SP. Substantial damage. No injuries.

Visual meteorological conditions prevailed for the return charter flight in Australia, which was intended to familiarize the pilot-in-command with the route and the facilities at the destination airport. The five other people in the airplane included the airplane's owner, who also was a pilot.

At takeoff, the airplane weighed about 67 kilograms (148 pounds) more than the maximum allowable takeoff weight. The pilot said that preflight checks and engine indications were normal and that the elevator trim was aft of the neutral position, as specified by the aircraft operating manual. The accident report said that the pilot selected one stage of flaps.

After rotation, the airplane "veered to the left of the runway centerline," the report said. "The pilot lowered the nose of the aircraft slightly in an attempt to gain airspeed and increase aircraft control, but it veered right and traveled beyond the edge of the runway towards the aerodrome boundary fence."

The airplane remained airborne in ground effect, and, in an attempt to increase speed, the pilot retracted the landing gear. The airplane struck the boundary fence.

The day before the accident, the pilot had conducted three takeoffs and landings to refamiliarize himself with the aircraft type. The airplane owner, who accompanied the pilot, suggested that he set the elevator trim nearly full-forward before takeoff, and the pilot handled the airplane satisfactorily.

"It is likely that a combination of the different trim setting, the rear center of gravity position and the higher aircraft weight for the accident takeoff, compared with the flight the previous day, resulted in the aircraft assuming a high nose-up attitude after becoming airborne," the report said.

Engine Failure Prompts Ditching in Caribbean

Convair 440. Destroyed. One fatality, one serious injury.

Visual meteorological conditions prevailed for the cargo flight over the Caribbean Sea. The copilot said that the preflight inspection and the ground checks before takeoff indicated no anomalies but that, after leveling the airplane at 5,500 feet, the cylinder-head temperature and oil temperature for the right radial piston engine were about 10 degrees higher than normal for that engine. The report said that the crew observed a significant decrease in the right engine brake mean effective pressure (a measurement used in comparing engine performance) and felt the right engine vibrating.

A preliminary report said that the copilot then told the captain that the front lower cylinders of the right engine were on fire, and the right-engine fire-warning light illuminated and the fire bell sounded. The captain feathered the right engine propeller and discharged two fire-extinguishing bottles, but the fire spread to the entire front of the engine cylinders.

The captain ditched the airplane, which sank into 1,000-foot-deep water. The captain was killed in the accident; the copilot, who was the only other person in the airplane, was rescued by the U.S. Coast Guard.

Escape Hatch Separates From Airplane During Flight

Short Brothers SD3-60. Minor damage. No injuries.

The crew of the cargo airplane was beginning a descent from 4,000 feet in preparation for landing at an airport in England, when the cockpit noise level increased and they observed that the overhead emergency escape hatch had separated from the airplane.

Flight controls felt normal, and there were no abnormal engine indications. The crew reduced airspeed and declared pan-pan, an urgent condition. They received radar vectors and conducted an instrument landing system approach. They said later that their only difficulty was the increased ambient noise level in the cockpit, which complicated their communications with air traffic control.

The incident report said that the airplane was used for cabin crew training the previous day and that the training included a demonstration of the airplane's escape hatches.

"The flight deck hatch operating handle was operated to demonstrate its function," the report said. "When the instructor attempted to re-engage the lock pins subsequently, she found that she did not have sufficient strength to move the handle through the last part of its movement. Upon leaving the aircraft, she informed a member of ground staff on the ramp that she had been unable to fully lock the escape hatch and assumed that he would take the necessary action. However, the person whom she informed was not a member of the engineering staff. His attention was subsequently taken up with other activities, and he did not follow the matter up."

The report said that the escape hatch lock pins "progressively migrated back" during the five flights before the incident flight, and that during the incident flight, the hatch moved into the airstream and separated. The company said that the flight crew would not have detected a difference between the fully locked position of the escape hatch handle and the unsafe position unless their attention was specifically directed to the handle.

After the incident, the company eliminated flight deck escape hatch demonstrations from cabin crew training sessions and introduced a requirement for the cabin crew instructor to make an entry in the technical log if exits or flight deck oxygen masks are removed during training.

Airplane Strikes Trees During Low-visibility Mountain Flight

De Havilland DHC-3 Otter. Destroyed. One fatality, one serious injury, one minor injury.

The airplane was the second in a flight of two airplanes that were delivering supplies to a hunting camp in a remote, mountainous area of the United States. The airplanes were being operated as visual flight rules cross-country business flights.

After the second airplane did not arrive at the destination, search and rescue personnel were notified. Because of low visibility along the route of flight, a search was delayed for two days.

The rear-seat passenger said that the pilot flew the airplane about 500 feet to 1,000 feet above ground level because of smoke and fog. He said that visibility at takeoff was about 1.0 statute mile (1.6 kilometers) and that about 30 minutes later, visibility decreased because of fog.

The airplane's throw-over control yoke had been positioned in front of the right-seat passenger, who also was a pilot (the report did not say what type of pilot certificate the passenger had). The report said that the yoke was quickly repositioned in front of the pilot-in-command in the left seat after "a mountain ridge appeared in front of the airplane."

The rear-seat passenger said that the pilot banked the airplane left and increased engine power. The airplane then struck trees and descended to the ground.

Airplane Strikes Wall After Takeoff

Piper PA-60-601P Aerostar. Destroyed. Six fatalities.

Visual meteorological conditions prevailed and a visual flight rules flight plan had been filed for the midday business flight in the United States. Witnesses said that before departure, they observed one of the passengers fueling the airplane and placing "a lot" of items, including two children's car seats and four pieces of luggage, in the back of the airplane. The pilot and five passengers, including two small children, then boarded the airplane.

A preliminary report said that one witness observing the takeoff roll was concerned that "it seemed to take too long to take off."

"As the airplane approached the end of the runway, it became airborne," the report said. "However, it did not climb and appeared to be floating. It then veered to the left and dove quickly toward the ground."

Another witness said that the airplane sounded "awful quiet" as it neared the departure end of the runway and that "it did not seem to have enough power to lift into the air. It just seemed to skim the trees and make a left bank turn … and nose-dive to the ground."

Another pilot monitoring the airport's UNICOM frequency (a communication facility providing airport information) said that he heard the pilot broadcast his intentions to depart and soon afterward, heard the pilot say, "Oh, God! I'm in trouble."

The airplane struck a concrete retaining wall behind a house about 1.1 nautical miles (2.0 kilometers) from the airport.

Weather conditions at another airport 16 nautical miles (30 kilometers) from the accident site included a temperature of 90 degrees Fahrenheit (32 degrees Celsius) and a density altitude of about 3,000 feet.

Glider-tow Pilot Dies After Takeoff

Piper PA-25-235 Pawnee. Destroyed. One fatality.

Visual meteorological conditions prevailed for the flight from a gliding club in England, where the airplane was being used to tow gliders. The pilot conducted three aero tows before the accident flight.

On the fourth flight, the takeoff and the initial climb appeared normal, and the pilot began to turn the airplane left, according to gliding club procedures.

The accident report said, "At approximately 200 feet above aerodrome level, the glider crew [an instructor and a student on a pre-solo check flight] noticed the aircraft ahead return to a wings-level attitude and fly in an unanticipated direction. They then saw the aircraft start to turn gently to the right and descend. The aircraft's engine was still at full power."

The glider instructor pulled the glider's cable-release handle and conducted a downwind landing at the departure site. The airplane descended, rolled right and struck trees and the ground. Witnesses said that the airplane "appeared to go gently out of control."

The report said that the 71-year-old pilot probably died of heart failure in flight. The pilot had received a Class 2 medical certificate following a physical examination (including an electrocardiogram) eight months before the accident flight. The report said that heart abnormalities observed during the autopsy probably had developed after the physical examination.

Airplane Strikes Tree, Ground During Flight Test

Raytheon Beech Duchess 76. Destroyed. One fatality, one serious injury.

Night visual meteorological conditions prevailed for the flight in Australia, which was being conducted as a multi-engine instrument-rating flight test. After departure, the flight-test candidate demonstrated a number of maneuvers, including simulated engine failures, at two airports. The flight-test candidate said that he and the testing officer had agreed before the flight that simulated engine failures would be conducted above 500 feet above ground level.

The flight-test candidate said later that, as he began to retract the landing gear after a touch-and-go landing at the second airport, the testing officer simulated a right-engine failure.

"The candidate said that he continued to retract the landing gear and maneuvered the aircraft to maximize its climb performance but did not handle the engine controls," the final accident report said. "He reported that because the aircraft was not achieving satisfactory performance, he called for the [testing officer] to apply full power. He said that soon after this call, there was a loud impact noise. Moments later, the aircraft collided with the ground."

An examination of the accident site showed that the airplane's right wing had struck a tree 296 meters (971 feet) beyond the departure end of the runway, about 133 meters (436 feet) right of the extended runway centerline.

"Asymmetric flight with one engine failed degrades this aircraft type's ability to climb to a negligible quantity under optimal conditions," the report said. "It is also normal to expect a minor change in direction as a change to an asymmetric condition is managed. … Planned low-level asymmetric flight at night is considered to be an unacceptable risk because … the pilot may neither know about, nor be able to see, any obstacles in the aircraft's changed flight path in order to take avoiding action."

The report said that the testing officer had begun the simulated engine-failure exercise "from a position where a subsequent safe flight path could not be assured."

The report said that several changes have been proposed to Australia's *Civil Aviation Safety Regulations*, including a prohibition against the initiation of planned asymmetric operations at night below traffic-pattern altitude or below 1,000 feet above ground level.

Airplane Strikes Terrain During Approach in IMC

Beech Bonanza 36. Destroyed. No injuries.

Instrument meteorological conditions prevailed and a visual flight rules flight plan was filed for the flight in Chile. The pilot was on final approach at the destination airport and was navigating with global positioning system information and the airport's localizer.

The pilot became disoriented, and the airplane struck the ground. The pilot and two passengers exited the airplane, which then was destroyed by fire. One of the airplane's occupants used a cellular telephone to notify rescue authorities.

Engine Fails After Takeoff

Cessna 150F. Substantial damage. Two minor injuries.

After takeoff from an airport in Australia, at about 200 feet above ground level, engine power began to decrease. The pilot conducted an emergency landing on a nearby road.

Later, the pilot said that about two hours before the flight, the airplane had been washed and that there were about 35 liters (nine gallons) of fuel in the fuel tanks at departure. The report said that induction system icing and/or water in the fuel system were possible, but neither could be substantiated. The reason for the engine failure was not determined.

Pilots Shut Down Wrong Engine, Forget to Extend Landing Gear

Bell 430. Substantial damage. Two serious injuries.

Soon after takeoff from an airport in India, the flight crew observed a full authority digital electronic control (FADEC) failure indication for the no. 1 engine and decided to return to the departure airport. As they turned the helicopter toward the airport, the captain told the copilot to return the no. 1 engine to manual control.

The accident report said, "[The] copilot changed over the engine no. 2 to manual control, which was a healthy engine. By the time the pilot[s] could realize their mistake, engine no. 1 was out, and there was no power available from engine no. 2."

The flight crew then conducted an autorotative landing, but "forgot to lower the undercarriage," the report said.

The report said that the probable cause of the accident was "improper handling of engine emergency, leading to complete power loss." Contributing factors were "poor crew coordination and following non-standard procedures of emergencies," the report said.

Emergency Landing on Glacier Follows Unexpected Power Reduction

Hughes 369HS. Substantial damage. No injuries.

Visual meteorological conditions prevailed for the scenic flight in New Zealand. The helicopter was being flown at 9,500 feet near a glacier when the pilot observed a sudden decrease in instrument indications for engine power turbine speed (N_2) and main-rotor speed (N_R). The pilot flew the helicopter to 6,500 feet, and both indications returned to normal.

Because of the problem, the pilot decided to end the flight, and he told his company that he was returning to the departure area. Several minutes later, at 6,500 feet over a glacier, the problem recurred. The pilot exercised the collective control lever governor switch (beep switch; an electric switch on the collective lever that sets the power turbine governor [PTG] to maintain N_2 at a specific speed) but was unable to increase N_2. When he raised the collective lever, N_2 decreased further.

He conducted an emergency landing at the base of the glacier. The right-rear skid struck a rock and broke during the landing, and the helicopter rolled onto its right side.

An investigation found that the beep switch was loose and that the looseness had caused two beep-switch wire terminals to break. When beep-switch electrical continuity was lost, N_2 and N_R decreased. The report said that the pilot responded appropriately to the unexpected power reduction but, because of his inexperience with turbine-engine helicopters, did not recognize that the power reduction was a result of a PTG underspeed. The pilot had 40 flight hours in turbine-engine helicopters, including 35 flight hours in Hughes 369s.

Bolt Failure Prompts Emergency Landing

Schweizer 269C-1. Substantial damage. No injuries.

The helicopter was being flown on an instructional flight in England, when during climbout, at about 1,500 feet above ground level, there was a sudden, severe vibration. The flight instructor conducted an autorotative landing in a field.

An investigation revealed that the vibration was caused by the fatigue failure of the tail-rotor teeter pivot bolt (fork bolt). After the accident, the procedure for installing the bolt was changed, and a new requirement was implemented for a torque check of the nut 25 hours after installation of the fork bolt. ■

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