

# **A BRIEF HISTORY OF THE REDUCED VERTICAL SEPARATION MINIMUM (RVSM)**

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# OVERVIEW

## Early Vertical Separation Practices

- The Vertical Separation Panel
- Early Regional Air Navigation (RAN) Meetings
  - The 1958 RAC/SAR Divisional Meeting
  - The 1960 NAT RAN Meeting
  - The 1963 RAC/SAR Divisional Meeting
  - Special NAT RAN (1965) Meeting

# OVERVIEW (continued)

- Review of the General Concept of Separation Panel (RGCSP)
- Implementation History in the North Atlantic Region
- Implementation History in the Asia Pacific Region
- European RVSM

# EARLY VERTICAL SEPARATION PRACTICES

- ➔ Vertical spacing of aircraft in 1940s was 1,000 feet in all cases except 500 feet when:
  - ➔ Aircraft flown with 1 to 3-mile visibility
  - ➔ Aircraft holding above well defined top of cloud during darkness if pilot reports indicate forward visibility at least 1 mile
  - ➔ Aircraft on paths crossing at/near reporting point, provided that aircraft use same altimeter setting
- ➔ No separation for enroute traffic above well defined top of cloud if frequent weather reports indicate unlimited ceiling and flight visibility of at least 3 miles. During daylight, holding aircraft under these conditions requires no separation.

# THE INTERNATIONAL CIVIL AVIATION ORGANIZATION'S VERTICAL SEPARATION PANEL

- Advent of commercial turbojet aircraft operating at high levels necessitated reevaluation of the vertical separation minimum
- International Civil Aviation Organization (ICAO) formed Vertical Separation Panel in June 1954
- Panel identified those factors likely to contribute most to loss of vertical separation and proposed steps that should be taken to reduce or eliminate their influence

# BASIS FOR THE CHANGE IN THE VERTICAL SEPARATION MINIMUM AT FL290

- ★ **The 1958 ICAO RAC/SAR Divisional Meeting:**  
Based on work of Vertical Separation Panel “vertical separation minimum between IFR traffic shall be a nominal 1000 ft below an altitude of 29000 ft or flight level 290 and a nominal 2000 ft at or above this level, except where, on the basis of regional air navigation agreements, a lower level is prescribed for the change to a nominal 2000 ft vertical separation minimum.

# FURTHER DEVELOPMENTS

- Fourth ICAO North Atlantic Regional Air Navigation Meeting (RAN) and 1963 ICAO Rules of the Air/Air Traffic Services - Operations (RAC/OPS) meetings encouraged pursuit of developments necessary to extend 1000-ft standard upward from FL290
- Special NAT RAN (1965) encouraged operators to take steps to bring altimetry systems and maintenance practices up to high enough standard to allow implementation of 1000-ft vertical separation standard above FL 290

# DEVELOPMENT OF THE REDUCED VERTICAL SEPARATION MINIMUM (RVSM) - WHY SO MUCH INTEREST?

- ➔ Aircraft fuel-burn penalty of about 1 percent for each 1000-ft below optimum cruise altitude
- ➔ Oceanic Area System Improvement Study (OASIS) (late 1970s): major study of oceanic system improvement options, chiefly separation-standard reductions, concluded that RVSM was single best thing to do: fuel-burn reduction far outweighed that attributable to any horizontal plane separation reductions, for example, 30-nm lateral/30-nm longitudinal
- ➔ RVSM provides (theoretical) doubling of capacity in same airspace
- ➔ RVSM thought achievable without major change to aircraft or ATC system

# REVIEW OF THE GENERAL CONCEPT OF SEPARATION PANEL I

- ICAO Review of the General Concept of Separation Panel (RGCSP) (1982): agreed to begin task (put in work program in 1974) to determine RVSM technical feasibility
- Several States represented on Panel began individual programs, coordinating efforts within Panel: Canada, Eurocontrol (France, Germany, Netherlands, United Kingdom), Japan, the former USSR and the United States

# REVIEW OF THE GENERAL CONCEPT OF SEPARATION PANEL II

- RGCSP/6 (1988): concluded that the RVSM was technically feasible without placing undue burden on equipment
- RGCSP/7 (1990): produced draft RVSM guidance material - Doc 9574
- ICAO Air Navigation Commission (1990): approved draft guidance material and draft Standards and Recommended Practices (SARPS) - Amendment 31 to Annex 2

# WHY DID IT TAKE SO LONG FOR RGCSP TO FINALIZE GUIDANCE MATERIAL?

- Aircraft maintain assigned flight level by sensing and measuring pressure and converting pressure to feet via ICAO Standard Atmosphere
- Errors in the sensing and conversion process not easily estimated
  - observed errors in pressure altitude on flight deck or in SSR Mode C reflect only differences between cleared (or commanded) pressure altitude and pressure altitude actually flown
  - difference between aircraft-measured pressure and constant-pressure surface defining flight level is what is needed
- Difference called altimetry system error (ASE)

# WHY SO LONG?

- Flight levels (constant pressure) defined by constant-pressure surfaces in atmosphere
- Constant-pressure surface over a geographic region is not at constant geometric (tape measure) height
  - in general: constant-pressure surfaces increase in geometric height from pole to equator
  - in general: in temperate climates, constant-pressure surface geometric heights are higher in summer than winter
- To determine errors in altimetry system, need information about geometric height of flight level and geometric height of aircraft - neither of which is available readily

# DEVELOPMENT OF THE RVSM - THE MAJOR PROBLEM



***FL 350 = Constant Pressure Altitude***

***FL 350 Geometric Height***



# HEIGHT KEEPING PERFORMANCE ERRORS

***FL 350 Geometric Height***



***Aircraft geometric height***

***Total Vertical Error (TVE)  
= Altimetry System Error +  
Assigned Altitude Deviation  
= ASE + AAD***

# IMPLEMENTATION HISTORY IN THE NORTH ATLANTIC REGION

- North Atlantic Systems Planning Group (NAT SPG) is ICAO regional planning group for North Atlantic Region: international airspace between Europe and North America
- NAT SPG formed RVSM study group in 1990
- Study group (June 1992): reported to annual NAT SPG meeting that RVSM was feasible in NAT
- Limited North Atlantic Regional Air Navigation Meeting (October 1992): agreed on an implementation plan for RVSM in NAT MNPS airspace - operational trial 1 January 1997

# IMPLEMENTATION HISTORY IN THE NORTH ATLANTIC REGION - II

- December 1996: Phased implementation plan adopted due to delays in availability of State-approved aircraft RVSM engineering programs; RVSM introduction delayed to 27 March 1997
- 27 March 1997: RVSM implemented from FL 330 to FL 370
- 8 October 1998: NAT RVSM airspace expanded down to FL 310 and up to FL 390
- January 2002: NAT RVSM airspace further expanded down to FL 290 and up to FL 410 to coincide with in European RVSM implementation

# IMPLEMENTATION HISTORY IN THE NORTH ATLANTIC REGION - III

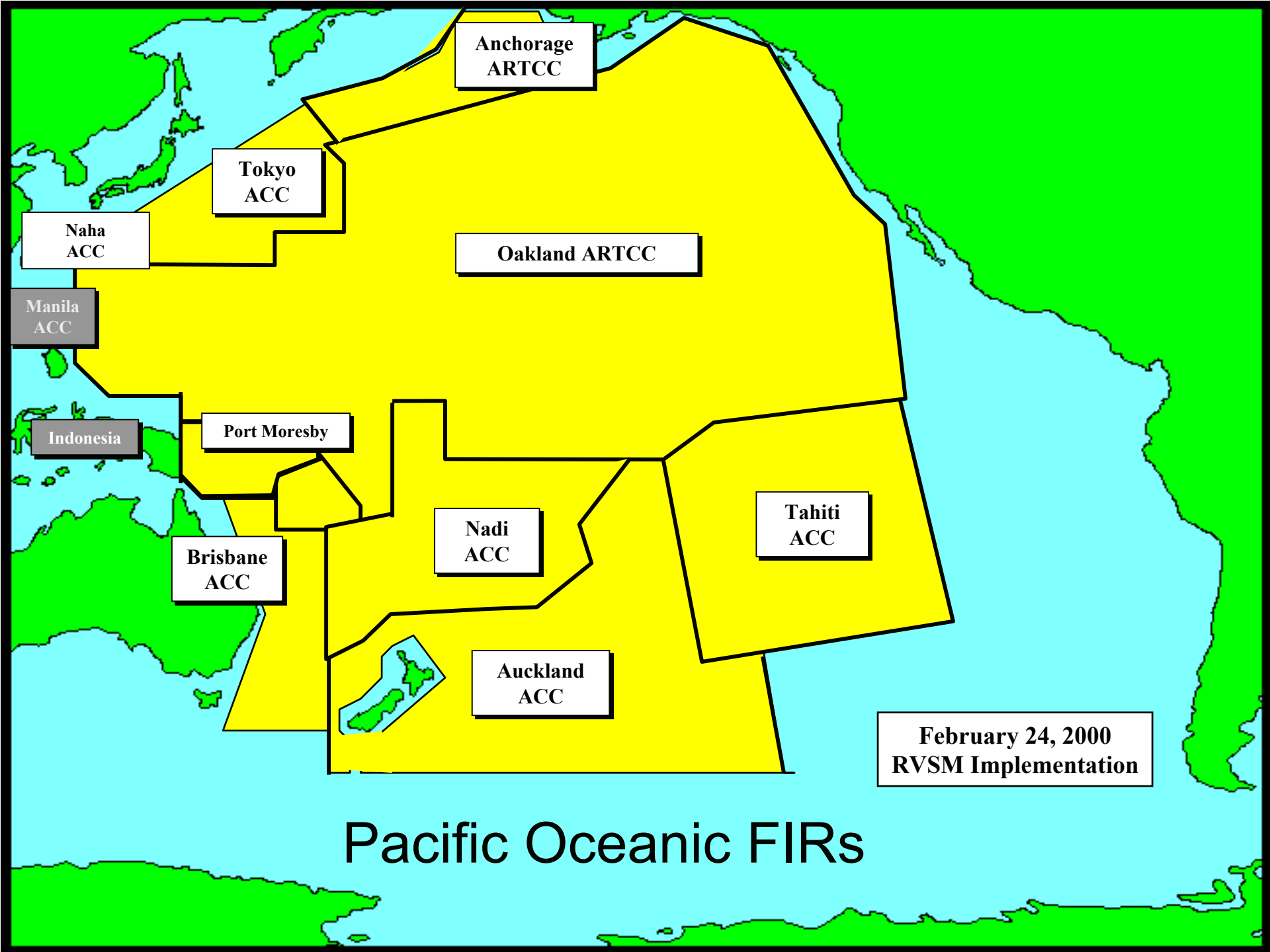
- New York Oceanic Capacity Enhancement Task Force progressed two-phase introduction of the RVSM into West Atlantic Route System (WATRS) airspace:
  - Phase I: September 30, 2000: expanded FAA designated transition areas to U.S. facilities adjacent to New York FIR
  - Phase II: November 1, 2001: created an exclusive equipage environment in the New York FIR portion of WATRS where only RVSM approved aircraft were allowed to operate in the RVSM altitude stratum

# IMPLEMENTATION HISTORY IN THE ASIA PACIFIC REGION

- June 1997 meeting of Informal Pacific ATC Coordinating Group (IPACG) RVSM Task Force established work program for North Pacific RVSM
- January 1998 meeting of Informal South Pacific ATS Coordinating Group (ISPACG) agreed to joint introduction of RVSM into all Pacific FIRs in 2000
- August 1998 meeting Asia Pacific Air Navigation Planning and Implementation Group combined IPACG/ISPACG RVSM efforts into single Asia Pacific Regional ICAO Implementation Task Force

# IMPLEMENTATION HISTORY IN THE ASIA PACIFIC REGION II

- RVSM introduced into all Pacific flight information regions (FIRs) in February 2000
- RVSM introduced into majority of FIRs in Western Pacific/South China Sea in February 2002
- RVSM introduced into remaining Western Pacific/South China Sea FIRs in October 2002 and plans call for introduction in airspace south of the Himalayas in November 2003, contemporaneous with ICAO Middle East Region RVSM implementation



Anchorage  
ARTCC

Tokyo  
ACC

Naha  
ACC

Oakland ARTCC

Manila  
ACC

Indonesia

Port Moresby

Brisbane  
ACC

Nadi  
ACC

Tahiti  
ACC



Auckland  
ACC

February 24, 2000  
RVSM Implementation

# Pacific Oceanic FIRs

# OCEANIC EXPERIENCE

- One-way track problems:
  - Wake Turbulence - generally moderate or less
  - Repetitive TCAS II Version 6.04a Traffic Alerts
  - Tactical offset procedure mitigated both problems
- Aircraft population performance significantly better than minimum requirements
- Human errors most significant contributor to risk estimation

# EUROPEAN RVSM

- Eurocontrol led RVSM introduction into airspace of 41 States in Continental Europe and surrounding airspace in January 2002
- RVSM introduction covered FL 290 through FL 410, inclusive
- Largest program of its kind ever undertaken by Eurocontrol

# WAS IT WORTH IT?

- Operators have found benefits greater and costs less than predicted
- Most major oceanic operators have recovered equipment costs within first year of RVSM implementation based on fuel savings alone
- ATC units report little difficulty with RVSM procedures or RVSM/conventional VSM transitions
- ATC units able to offer more desirable routings
- ATC units report RVSM provides more operational flexibility