R V S M

Reduced
Vertical
Separation
Minimum

Version 3.0 2005-08-01

The purpose of this module is to provide a basic introduction to operations in RVSM airspace.

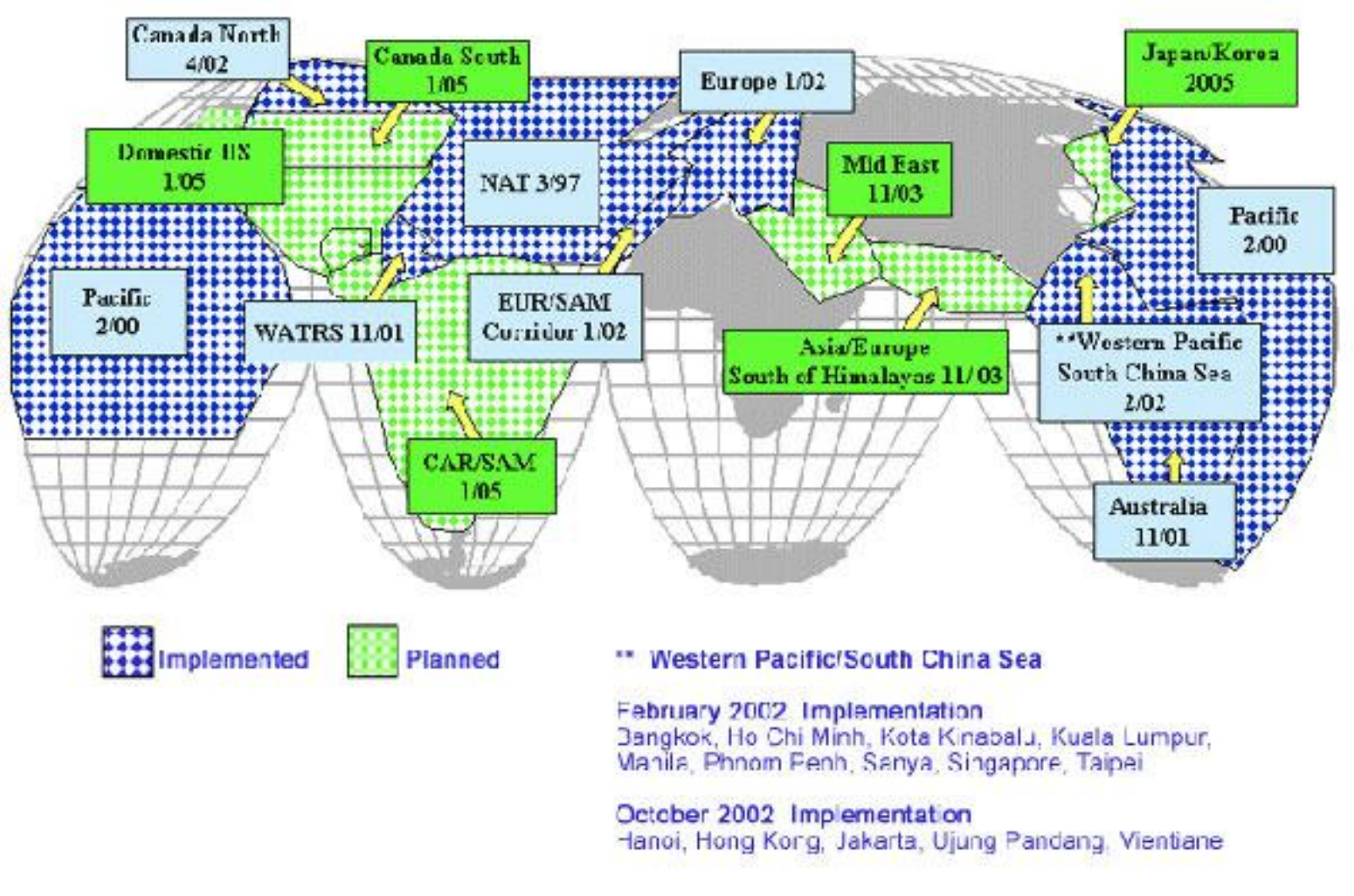
Region Abbreviations :

NAT	:	**N**orth **A**tlan**T**ic
EUR	:	**Eur**ope
ASIA/PAC	:	**Asia** & **Pac**ific
CAR/SAM	:	**Car**ibbean/South **Am**erica
WATRS	:	**W**est **AT**lantic **R**oute **S**ystem

RVSM airspace is defined as any airspace where aircraft are separated vertically by 1000 ft instead of the usual 2000 ft. between FL290 and 410 inclusively.

RVSM operations require special aircraft and flight crew certification and training.

Global RVSM Program



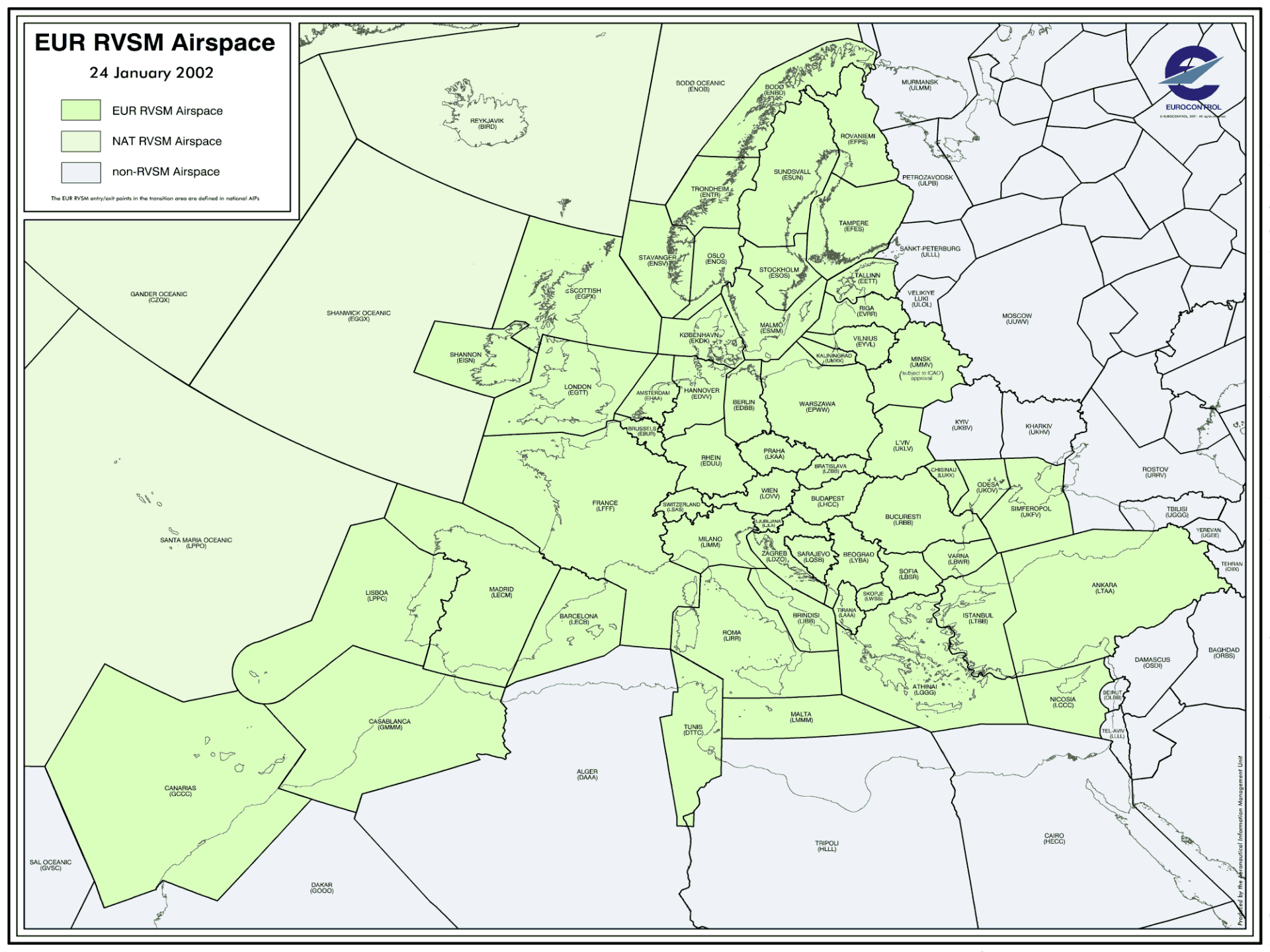
The diagram shows the effective dates of RVSM implementation

RVSM Status Americas - Europe

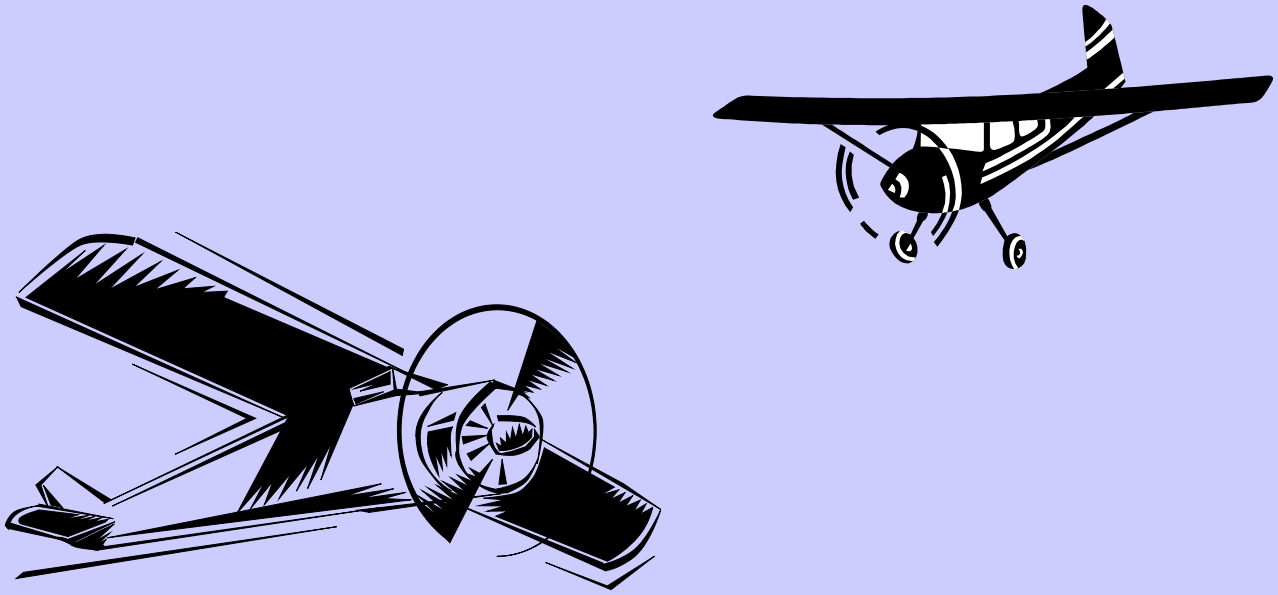
North Atlantic:	March 1997	FL 330-370
	October 1998	FL 310-390
	Jan 24, 2002	FL 290-410
West Atltanic Rt Syst (WATRS):	Nov 1, 2001	FL 310-390
	Jan 24, 2002	FL 290-410
Europe Tactical (UK, Ireland,Germany, Austria)	April 2001	FL 290-410
Europe-wide	Jan 24, 2002	FL 290-410
South Atlantic:	Jan 24 2002	FL 290-410
Canada Northern Domestic	April 2002	FL 290-410
Canada Southern Domestic	Coordinate with US domestic	
Domestic US - *Proposed Implementation*	January 20, 2005	FL 290-410
Caribbean/South America	January 20, 2005	Consult AIPs

RVSM Status Asia/Pacific

Pacific:	February 2000	FL 290-390
*FL 410 is available for non-RVSM approved flights	Tactical Use	FL 400-410
Australia:	November 2001	FL 290-410
Western Pacific/South China Sea	Feb 21, 2002	Consult AIPs
Mid East:	11/2003	Consult AIPs
Asia-Europe/South of Himalayas:	11/2003	Consult AIPs


EUR RVSM Airspace
24 January 2002
EUR RVSM Airspace
NAT RVSM Airspace
non-RVSM Airspace
The EUR RVSM entry/exit points in the transition area are defined in national AIPs
EUROCONTROL
BODØ OCEANIC (ENOB)
REYKJAVIK (BIRD)
GANDER OCEANIC (CZQX)
SHANWICK OCEANIC (EGGX)
SANTA MARIA OCEANIC (LPPO)
SAL OCEANIC (GVSC)
DAKAR (GOOO)
ALGER (DAAA)
TRIPOLI (HLLL)
CAIRO (HECC)
BODØ (ENBD)
MURMANSK (ULMM)
ROVANIEMI (EFPS)
SUNDSVALL (ESUN)
PETROZAVODSK (ULPB)
TRONDHEIM (ENTR)
TAMPERE (EFES)
STAVANGER (ENSV)
OSLO (ENOS)
STOCKHOLM (ESOS)
SANKT-PETERBURG (ULLL)
TALLINN (EETT)
SCOTTISH (EGPX)
VELIKIYE LUKI (ULOL)
RIGA (EVRR)
MOSCOW (UUWV)
KØBENHAVN (EKDK)
MALMO (ESMM)
VILNIUS (EYVL)
SHANNON (EISN)
KALININGRAD (UMKK)
MINSK (UMMV) (subject to ICAO approval)
LONDON (EGTT)
AMSTERDAM (EHAA)
HANNOVER (EDVV)
BERLIN (EDBB)
WARSZAWA (EPWW)
KYIV (UKBV)
KHARKIV (UKHV)
BRUSSELS (EBUR)
L'VIV (UKLV)
RHEIN (EDUU)
PRAHA (LKAA)
BRATISLAVA (LZIB)
CHISINAU (LUKK)
ROSTOV (URRV)
WIEN (LOVV)
ODESA (UKOV)
FRANCE (LFFF)
BUDAPEST (LHCC)
SIMFEROPOL (UKFV)
SWITZERLAND (LSAS)
TBILISI (UGGG)
LJUBLJANA (LJLA)
BUCURESTI (LRBB)
YEREVAN (UGIE)
MILANO (LIMM)
ZAGREB (LDZO)
SARAJEVO (LQSB)
BEOGRAD (LYBA)
VARNA (LBWR)
TEHRAN (OIIX)
SOFIA (LBSR)
LISBOA (LPPC)
MADRID (LECM)
SKOPJE (LWSS)
ANKARA (LTAA)
BARCELONA (LECB)
TIRANA (LAAA)
ISTANBUL (LTBB)
BRINDISI (LIBB)
ROMA (LIRR)
BAGHDAD (ORBB)
DAMASCUS (OSDI)
ATHINAI (LGGG)
BEIRUT (OLBB)
NICOSIA (LCCC)
MALTA (LMMM)
TEL-AVIV (LLLL)
TUNIS (DTTC)
CASABLANCA (GMMM)
CANARIAS (GCCC)
Produced by the Aeronautical Information Management Unit

Early generation altimeter errors



The consideration for vertical separation of 2000 feet was based on the error of early generation altimeters.

Barometric Errors

@33,000 ft  =87 ft

(1hPa error)

@Sea level  =27 ft

At sea level the vertical error associated with 1 Hecto Pascal error is only 27ft.
However, at FL330 the vertical error increases to 87ft.
This drastically increases the risk of collision with old equipment tolerances.

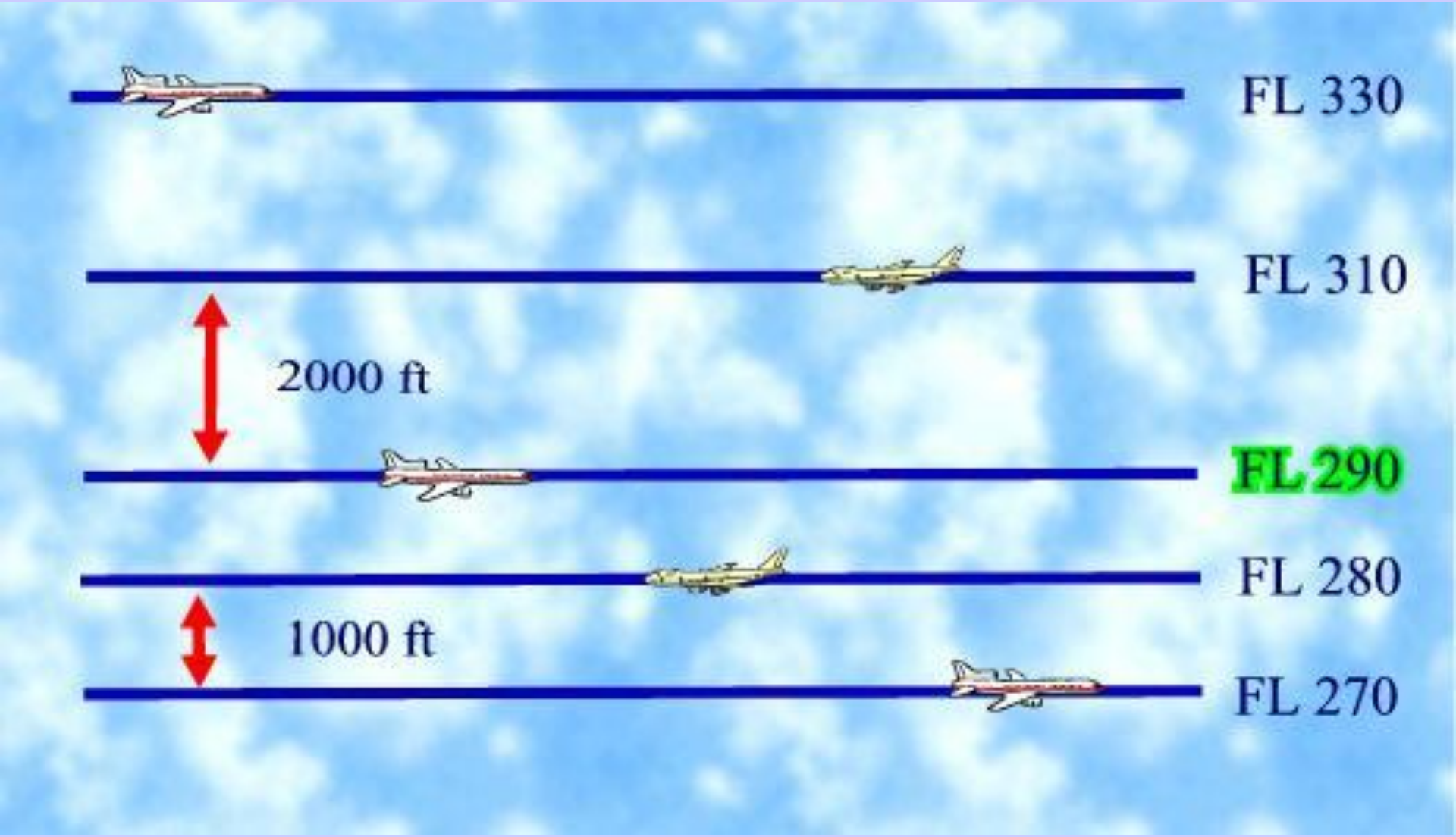
To avoid this: (at high altitude)

2000ft VSM introduced in1966

To safeguard against collision, in 1966, ICAO agreed that above FL290, a 2000 ft vertical separation minimum would be applied on a global basis.

However, ICAO agreed that 1000 ft separation could be implemented at a later date as long as safety conditions were specified and on the basis of regional air navigation agreements.

Above FL290



Conventional Vertical Separation of 2000 feet above FL290 remained for some years.

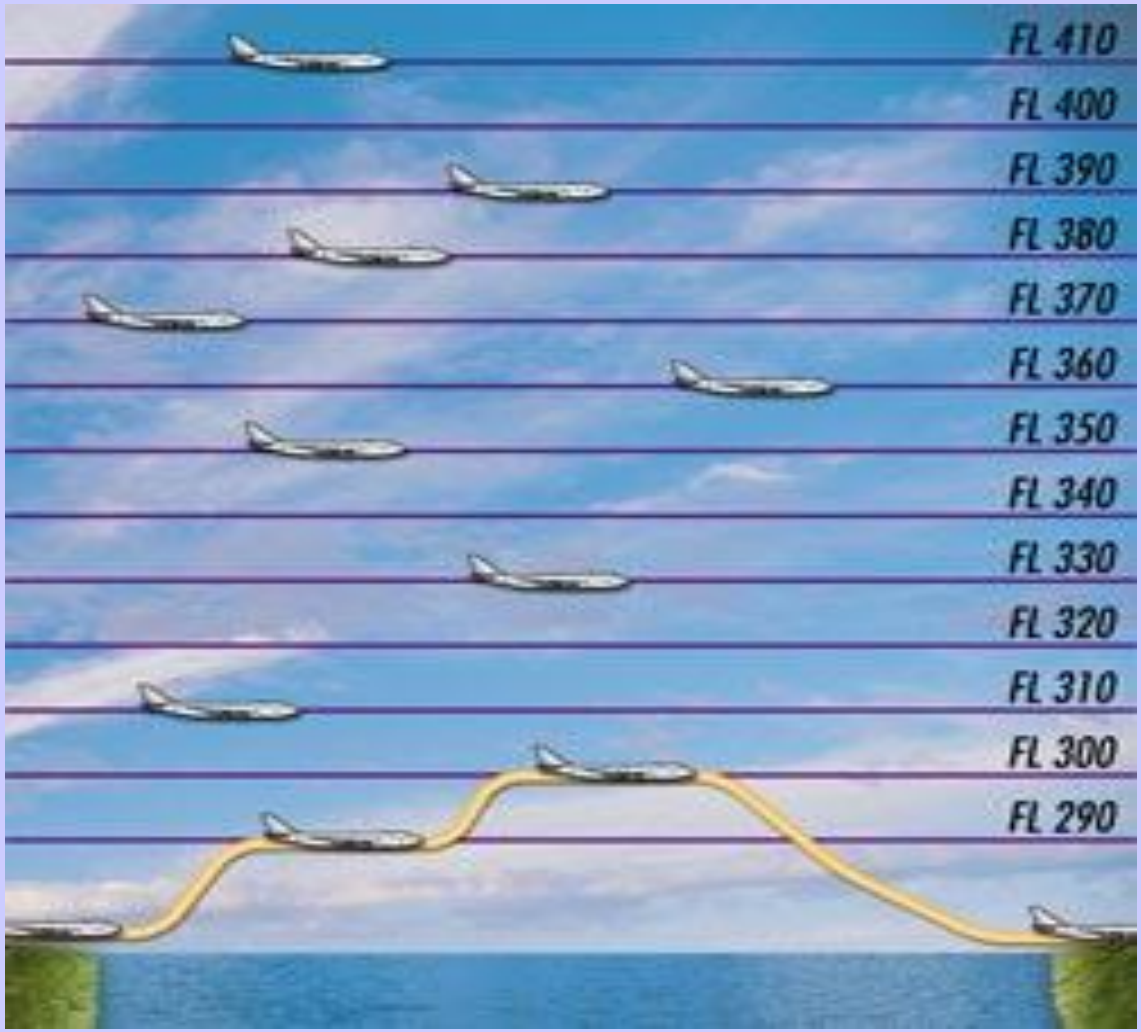
Conventional VSM FL's

	450
430	
	410
390	
	370
350	
	330
310	
280	290

RVSM FL's in Opposite Directions

Westbound	Eastbound
400	410
380	**390**
360	370
340	**350**
320	330
300	**310**
	290

The North Atlantic Organized Track System

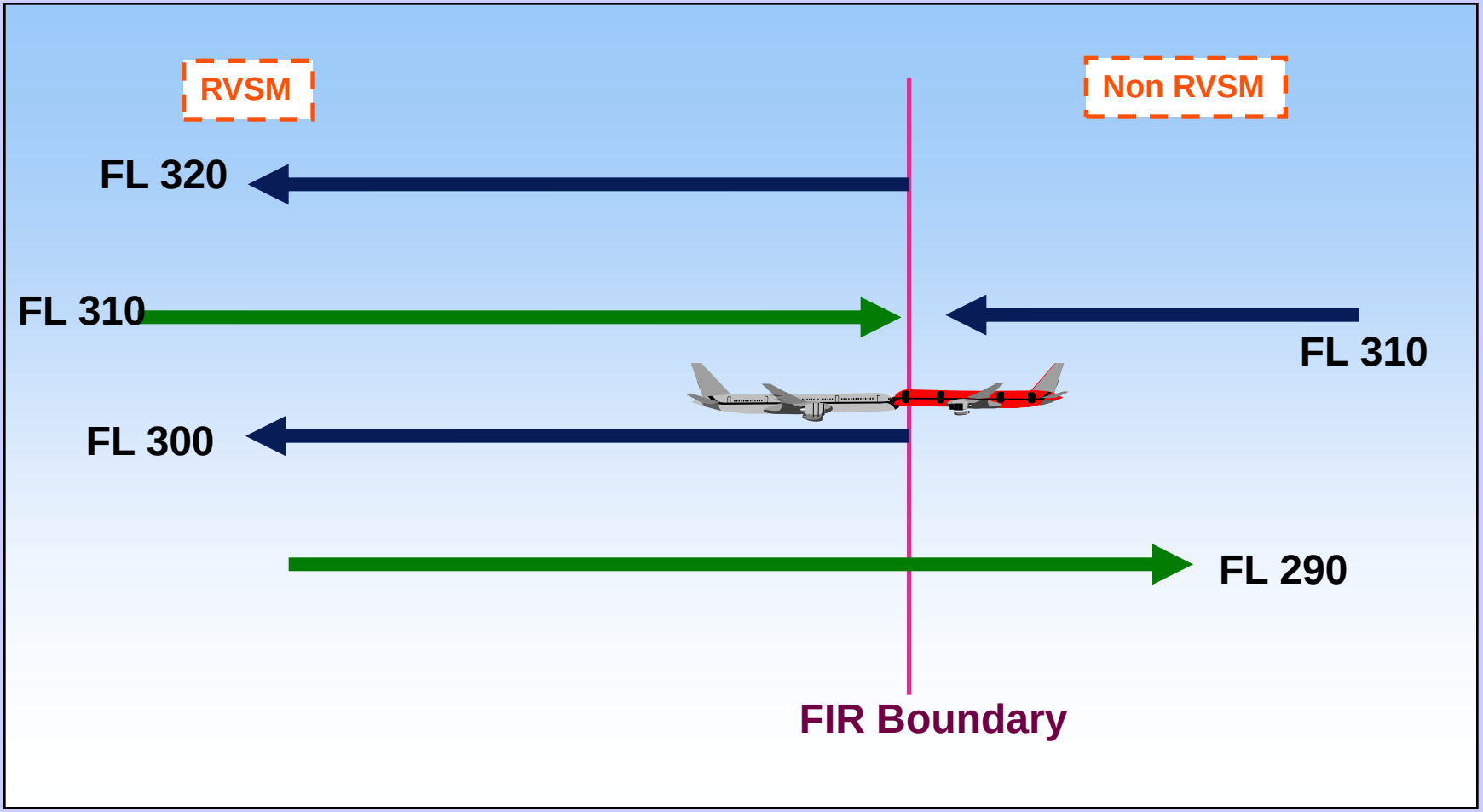


On the North Atlantic Organised Track System (NAT OTS) traffic flows in the same direction and aircraft are separated by 1000 feet.

The same flight levels are used in either direction during the OTS validity period.

The North Atlantic Planning Chart and NAT MNPSA Manual should be consulted for flight levels to be used outside the OTS validity period.

Boundaries



To ensure conflicts do not exist between aircraft transiting from RVSM to Non-RVSM airspace, Transition Areas have been established.

Solution : Transition area

Transition Areas have been implemented where separation standards exist between adjacent airspace.

Crews should be aware of the risks associated with transitioning between RVSM Airspace and Non-RVSM Airspace

Precautions should include ensuring that ATC cleared levels are rigidly adhered to, as well as making any necessary requests to ATC in a timely manner in order to co-ordinate with adjacent ATC units.

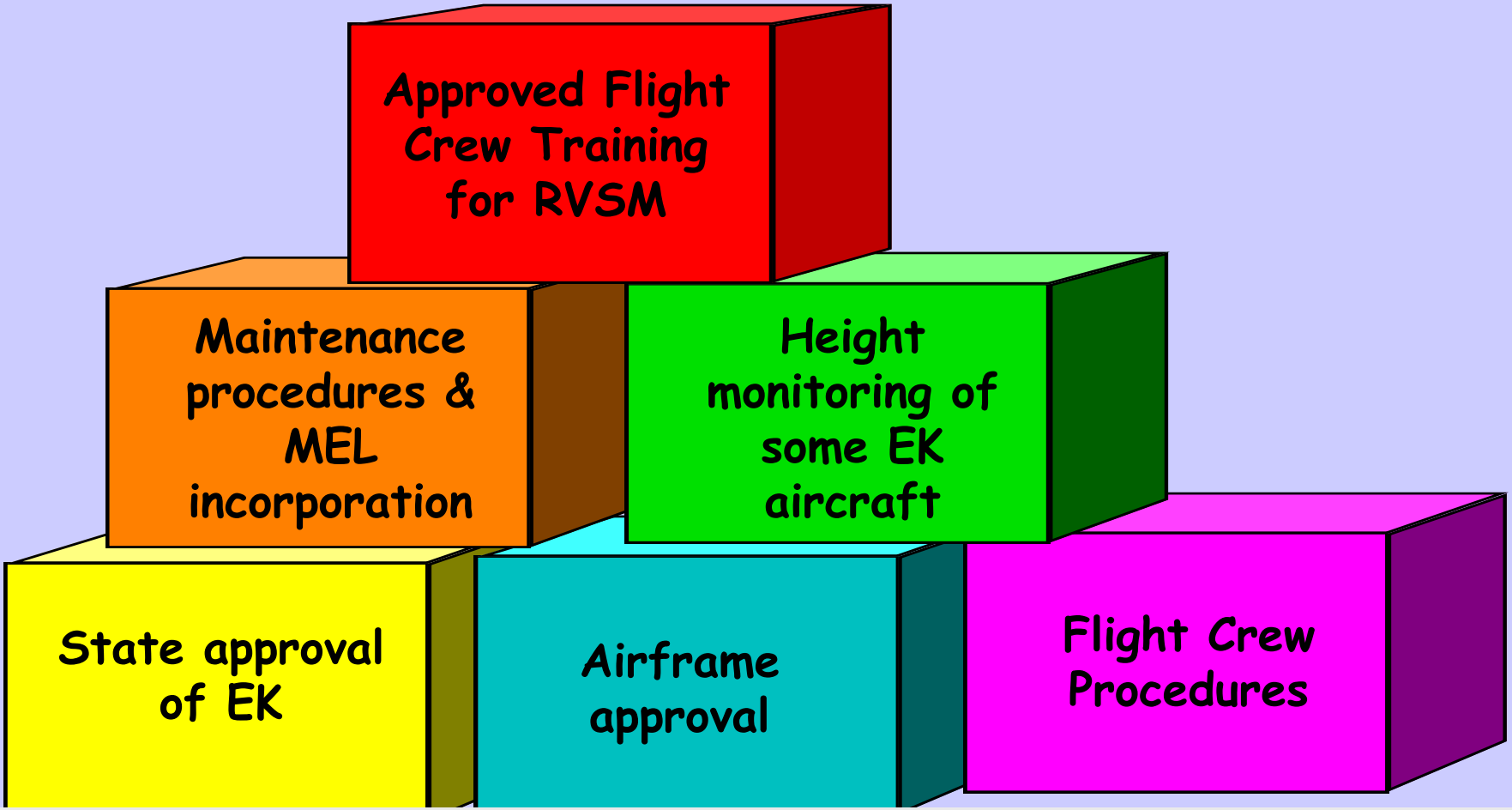
More flights on fuel efficient routes

More flights will cruise at/near optimum level

The objective of RVSM airspace is to increase the capacity of saturated airspace while keeping at least the same level of safety.

This is achieved by imposing stringent requirements on equipment, along with training flight crews and ATC controllers.

The RVSM Approval Requirements



Each aircraft type that an operator intends to use in RVSM airspace must receive specific approval. Special flight crew RVSM procedures are required.

There are specific requirements to be met relating to continuous airworthiness (maintenance) programs and MEL considerations for RVSM operations.

Aircraft must meet the Height Monitoring requirements.Special flight crew training for RVSM is required.Aircraft approved for operation in one area of RVSM will be approved to operate in other RVSM areas.

Basis for Airworthiness approval

Aircraft:

- Group - Mean System Error (MSE) ≤ 80ft
- Individual - Altimetry System Error (ASE) ≤ 200ft
- Autopilot – Altitude Error (ALT) +/- 50 ft

Vertical Error Abbreviations

- **TVE** Total Vertical Error
- **AAD** Assigned Altitude Deviation
- **ASE** Altimetry System Error

The height-keeping errors which will contribute to collision risk in RVSM airspace can be divided into two categories; Technical Errors and Operational Errors.

Technical Errors, i.e. Altimetry System Error, are caused by inaccuracies in the height-keeping equipment of aircraft.

Operational Errors, i.e. Assigned Altitude Deviation, are caused by mistakes by ATC or Flight Crew which result in aircraft being flown at incorrect flight levels.

ASE and AAD are the main constituents of Total Vertical Error.

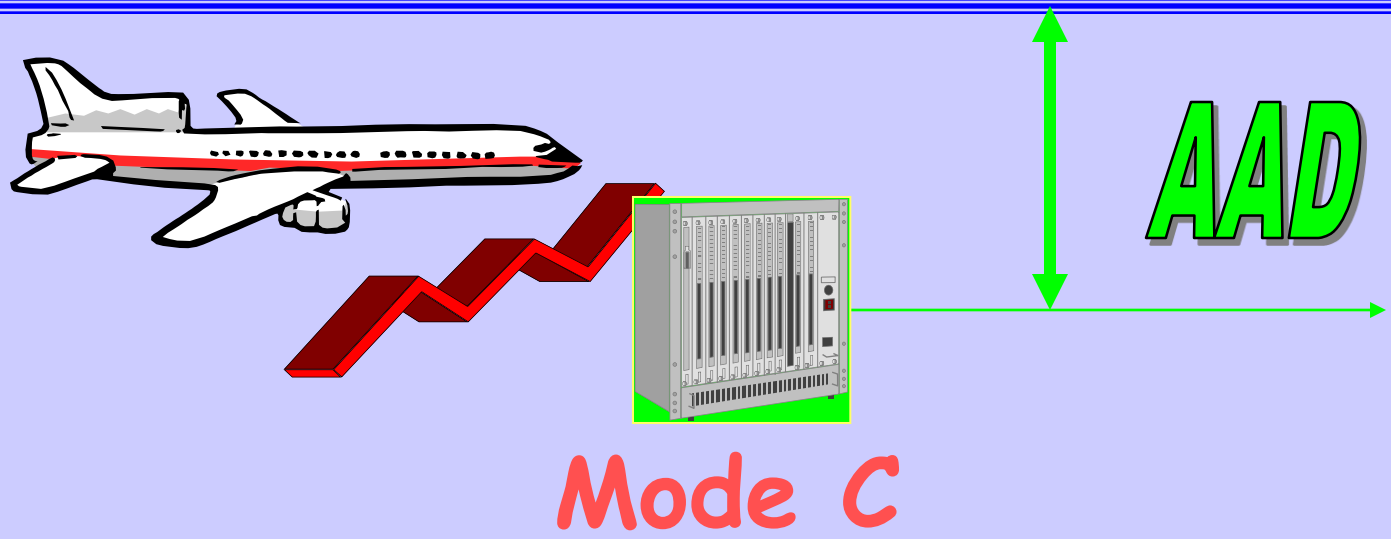
Assigned flight level

TVE

Actual altitude
(as determined by HMU)

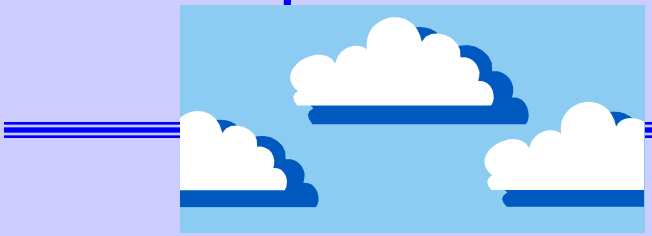
TOTAL VERTICAL ERROR (TVE) is the vertical geometric difference between assigned pressure altitude (flight level) and actual aircraft pressure altitude (determined by Height Monitoring Unit - HMU).

Assigned flight level



ASSIGNED ALTITUDE DEVIATION (AAD): The difference between the transponder Mode C altitude and the assigned altitude/flight level.

Freestream pressure altitude



ASE

Altitude displayed to crew
(1013.2)

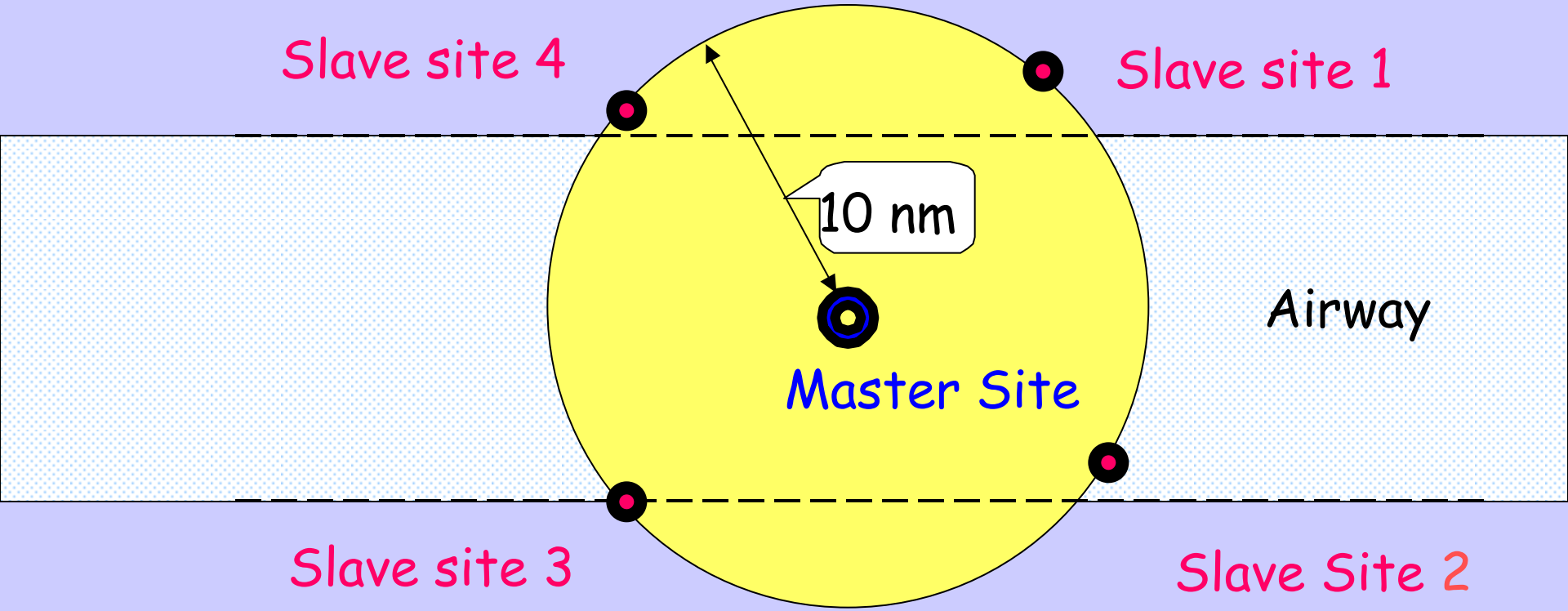
ALTIMETER SYSTEM ERROR (ASE): The difference between the altitude displayed to the flight crew when referenced to ISA standard ground pressure setting (29.92 in Hg/1013.25 hPa) and the free stream pressure altitude.

Height Monitoring

- ATC will continue to monitor
- Verification is done by height measuring equipment:
  - SSR-based called HMU's

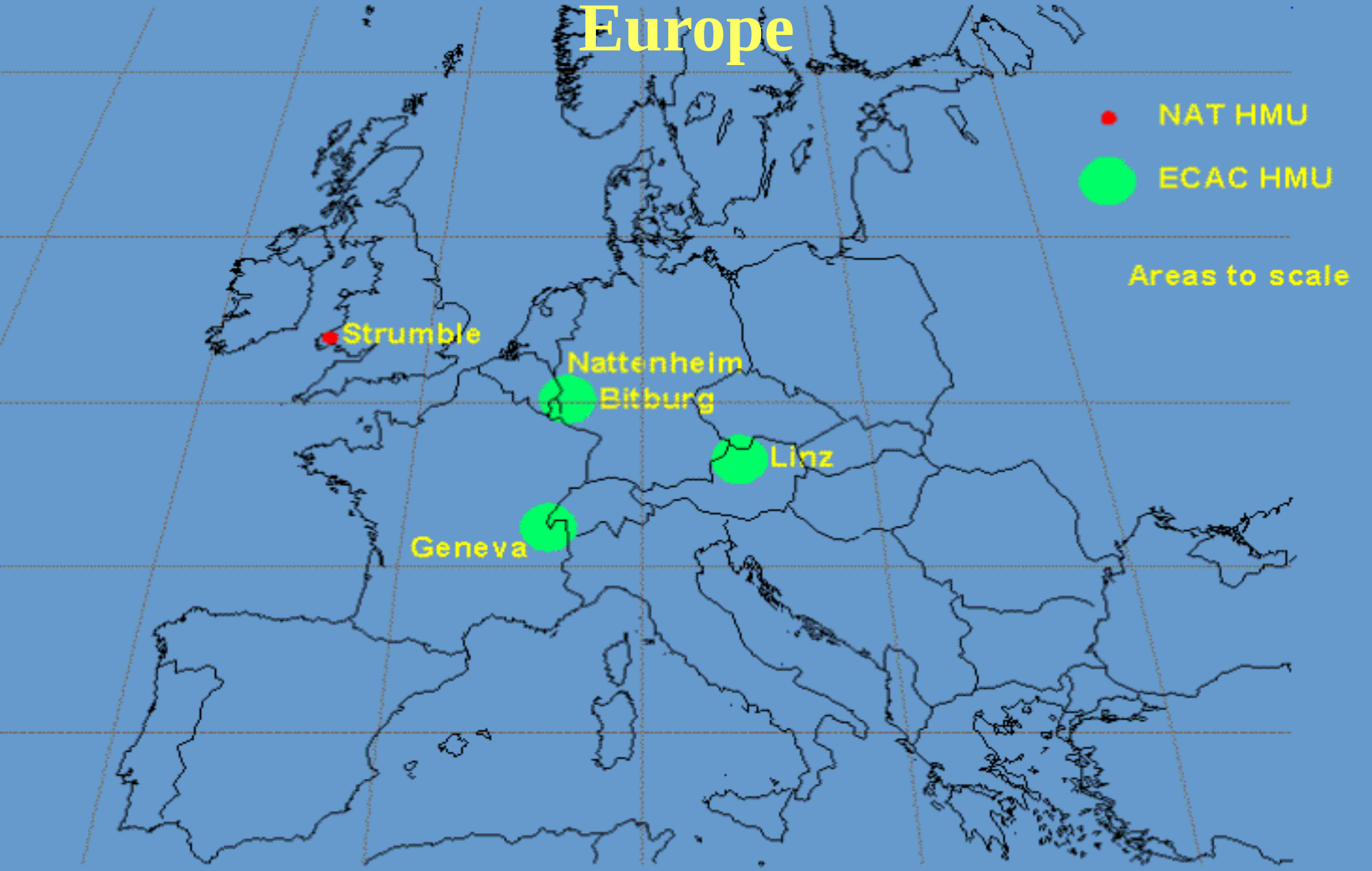
The Height Monitoring Unit (HMU) is a passive ground based system that measures aircraft height-keeping within its area of coverage.

Deployment Geometry of HMU



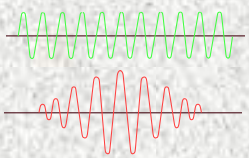
HMU Locations

Europe

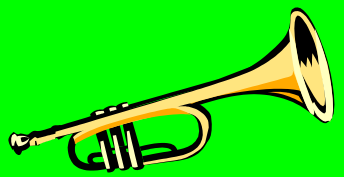


Minimum Equipment required

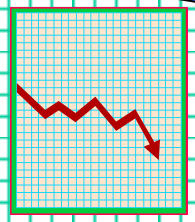
1 SSR Transponder



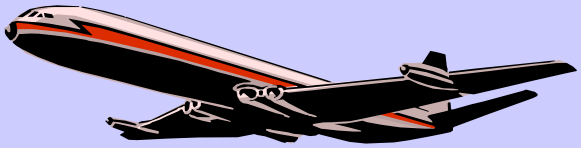
1 altitude alert system

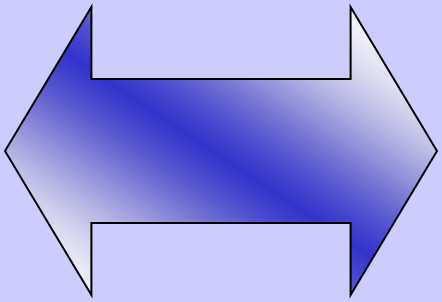


1 auto altitude control system



2 independent altitude measurement systems





Only Standard R/T

To avoid any confusion between the flight crew and ATC, only approved/standard R/T phraseology should be used.

Standard Controller/Flight Crew phraseology can be found in the FOM, Chapter 28.

CLEARANCES

PROMPT

X-CHECKED

CORRECT

ATC clearances should be cross-checked and verified to be correct. Prompt action by the flight crew is expected by ATC in executing the clearance.
The flight crew shall immediately inform ATC of any problem that has a direct impact on the ability of the aircraft
to operate in accordance with the RVSM performance requirements.
Whenever possible, a revised ATC clearance should be obtained prior to initiating any deviation from the last clearance.
When a revised ATC clearance is not possible prior to a deviation, the flight crew shall obtain an ATC clearance as soon as possible thereafter.

Standby Altimeter

Standby altimeter should be recorded and available for use in contingency situations.

Note the standby altimeter deviation when level in case of loss of one primary altimeter.

Because of its location, in the event that the Standby altimeter is required to be used as the only means of maintaining altitude, perhaps the CM1 should fly the airplane.

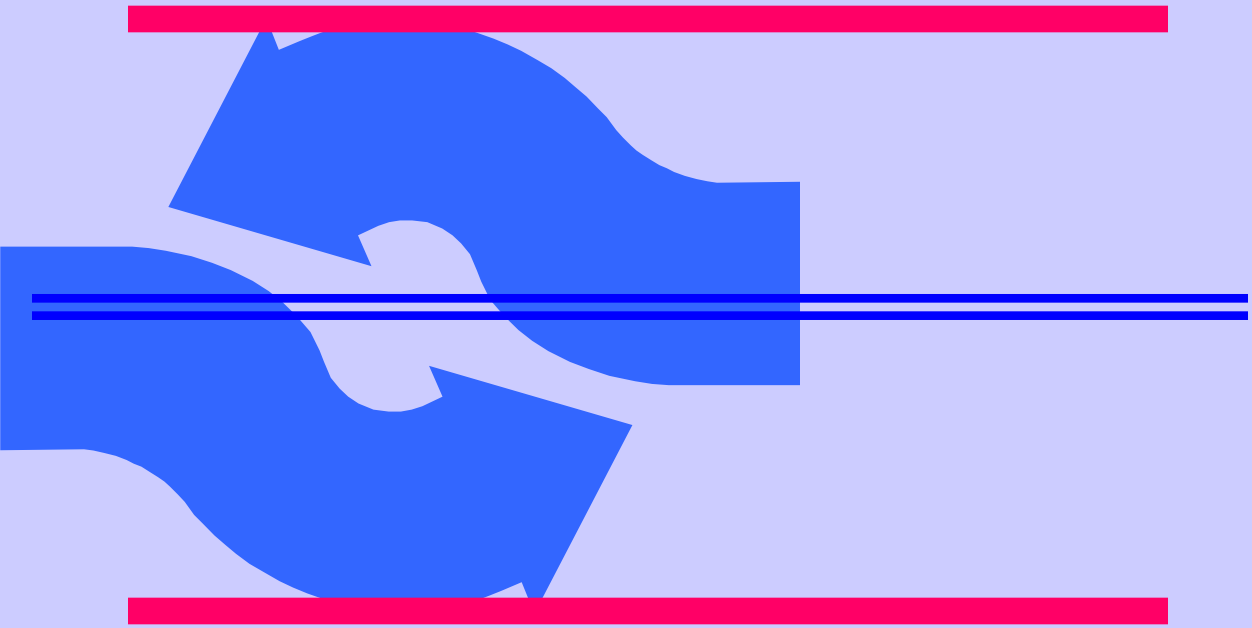
Visual Perception (1000ft separation)

- Northern lights
- Opposite direction traffic
- Same direction traffic
- During turns

It is important to realise that the visual perspective when crossing 1000 ft above or below opposite traffic at high speed and high altitude requires some adjustment.

This is particularity so when either climbing,r descending or turning, the problem is made worse at night.

under/overshoots

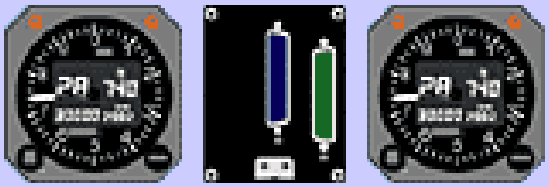


Max
150 ft

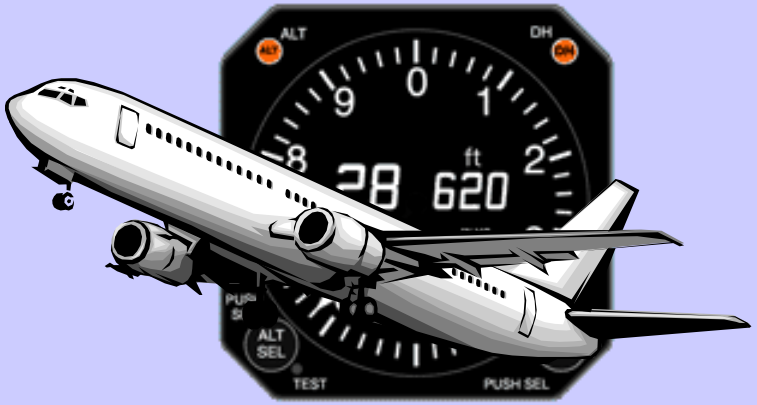
When approaching the first cleared flight level, and/or when changing flight levels in RVSM airspace, keep vertical speed within 500 to 1000 fpm. Do not exceed 100 fpm.

Ensure that the airplane neither undershoots nor overshoots the cleared flight level by more than 150 feet.

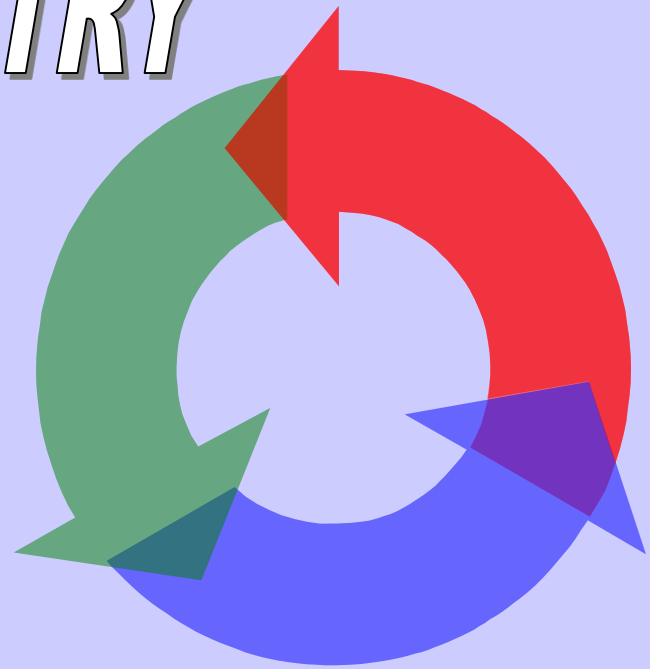
RVSM Air Data Systems



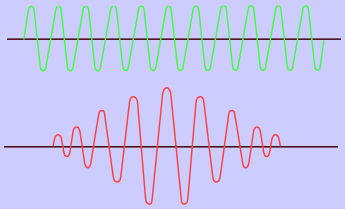
ALTIMETRY



ALTITUDE CONTROL



TRANSPONDER



Continuous monitoring of aircraft altitude, cross-checking altimeters and correct transponder operation is essential to safe RVSM operations.

Airframe Operating Restrictions

- Airspeed
- Altitude
- Weight
- A/C specific

Ensure that all Airframe Operating Restrictions are complied with and the aircraft is operated within all limitations, i.e. airspeed, altitude and weight.

There are no restrictions placed on EK aircraft from operating in RVSM airspace.

Flight Planning

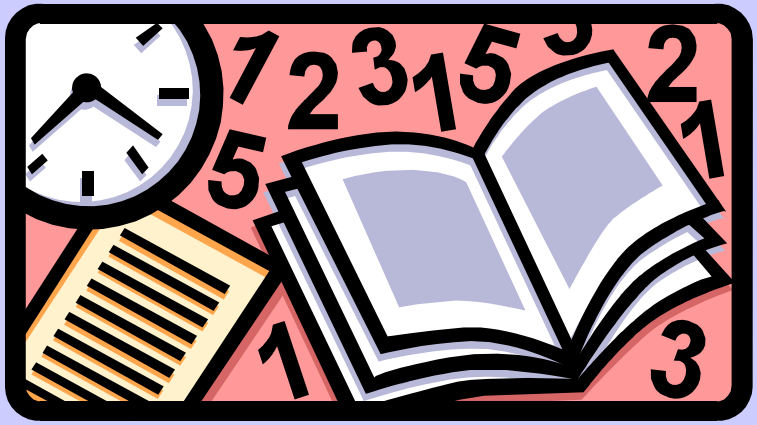
Particular attention should be paid to flight planning for RVSM flights.

Operators of aircraft that are approved by their state authority for operations in RVSM airspace shall indicate the RVSM approval status by inserting the letter **W** in item 10 of the ICAO flight plan form.

Review the weather forecast with particular attention to sever turbulence which may affect the aircraft altitude keeping performance required for RVSM.

Ensure aircraft restrictions are accounted for, Mach or Altitude.

Pre-flight at aircraft



- Tech log
- Maintenance action
- Walk around

Check the Aircraft Technical Log for RVSM Status MEL items.

During exterior inspection, particular attention should be taken to inspect static ports and adjacent areas, which have an effect on altitude readings.

At those airfields where the parking bay has significantly different elevation compared with the ARP, the altimeters indicated elevation can be checked during the Flight Instrument check at an appropriate time during the taxi.

Pre take-off

- Altimeter check
- RVSM equip faults

Prior to takeoff check that all altimeters are within limits and ensure that all required RVSM equipment is operating normally.

In Flight Procedures

Consult the FOM and FCTM for In-flight - Entering, Flying At and Leaving RVSM Levels for specific aircraft type procedures.

ALTITUDE TOLERANCES :

- PFD 1 or PFD 2 at ground check : ± 25 ft
- STBY ALTI at ground check : ± 300 ft

Note : On ground, the vibrator of stand-by altimeter is off ; this is why the STBY ALTI tolerance value is high. In flight, the vibrator is on and the value is reduced.

MAXIMUM DIFFERENCES BETWEEN ALTITUDE INDICATIONS.

	ALTITUDE (ft) COMPARISON BETWEEN		
	ADR 1 and ADR 2 (on PFD)	ADR 3 and ADR 1 or ADR 3 and ADR 2 (on PFD)	STBY ALTI and any ADR 1 or 2 or 3
GND CHECK	20	20	*
FL 50/250 kt	55	55	90
FL 100/250 kt	60	60	130
FL 200/300 kt	95	100	220
FL 300/0.82	120	130	320
FL 410/0.82	145	150	380

* on ground, the check is meaningless as the stand-by altimeter vibrator is off

MAXIMUM DIFFERENCES BETWEEN SPEED/MACH INDICATIONS.

	SPEED (kt) MACH COMPARISON BETWEEN					
	ADR 1 and ADR 2 (on PFD)		ADR 3 and ADR 1 or ADR 3 and ADR 2 (on PFD)		STBY ASI and any ADR 1 or 2 or 3	
	SPEED	MACH	SPEED	MACH	SPEED	MACH
GND CHECK	6	0.008	6	0.008	6	–
FL 50/250 kt	4	0.010	4	0.010	7	–
FL 100/250 kt	4	0.009	4	0.009	7	–
FL 200/300 kt	3	0.008	3	0.009	8	–
FL 300/0.82	3	0.009	3	0.009	8	–
FL 410/0.82	4	0.009	4	0.009	7	–

MAXIMUM DIFFERENCE BETWEEN ND MAGNETIC HEADING INDICATIONS :

R Maximum difference between magnetic heading indications on the NDs : 4 degrees.

TCAS

For system description refer to FCOM volume 1 chapter 34.
For operational procedures, refer to the ABN and EMER procedures of the FCOM Vol 3.

For Boeing: An altimeter cross check should be carried out prior to entering RVSM airspace.

The Primary altimeters must agree within ±200ft.

The chart refers to A330 altimeter cross checking procedures.

POST FLIGHT

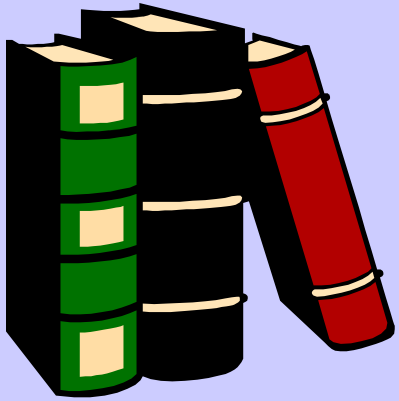
Log in detail any altimetry system fault

Fully cover defect
& action taken to
isolate/rectify

TCAS 7 Alert thresholds

		Altitude Threshold
		TCAS7
Traffic Advisory	<FL300	850ft
	FL300-FL420	**850ft**
Corrective RA	<FL300	600ft
	FL300-FL420	**600ft**
Preventative RA	<FL300	700ft
	FL300-FL420	**700ft**

For **additional** RVSM information and R/T phrases specifically for RVSM areas please consult the



FOM & FCTM

To Summarize

RVSM will increase world wide airspace capacity by providing six additional useable flight levels between FL 290 and FL 410.

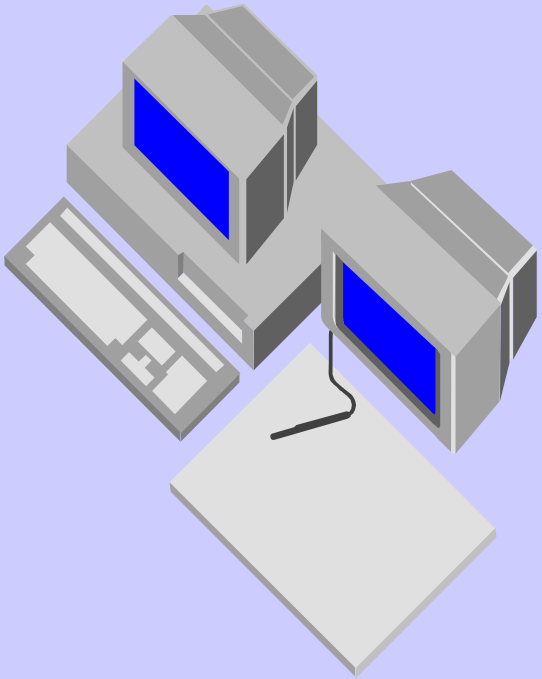
This will be achieved by reducing the separation minima from 2000ft to 1000ft through the application of strict safety requirements and aircraft certification processes.

A cost benefit analysis that the introduction of the six extra flight levels has the potential to offer huge benefits to all operators at minimal cost.

RVSM is considered to be the best and most cost effective means of increasing en-route airspace capacity to cope with the continuing traffic growth.

Everyone involved in the RVSM Programme must play their part to ensure that this important program succeeds.

www.eur-rvsm.com
www.faa.gov



You should now have a good basic understanding of the concept and procedures when operating in RVSM airspace.

Further information can also be obtained from the web-site above.