A BRIEF HISTORY OF RVSM

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Objective

To present a brief history related to the development and implementation of RVSM.



Outline

- >The Beginning
- ➤ The Vertical Separation Panel
- ➤ Early Regional Air Navigation (RAN)
 Meetings
- **≻**RGCSP
- >Time for development
- > Results



THE BEGINNING

- ➤ 1940s: 1,000 feet (300 meters) in all cases except 500 feet (150 meters) when:
 - □ Aircraft are being flown in conditions of flight visibility of less than 3 miles (5km) but not less than 1 mile (1.5 km).
 - □ Aircraft are holding above a well defined top of cloud or other formation during the hours of darkness if the pilot reports indicate the forward visibility is not less than 1 mile (1.5 km).



VERTICAL SEPARATION IN THE 1940s

- ☐ Aircraft are on flight paths which will cross at or near a reporting point, provided that the aircraft concerned are using the same altimeter setting.
- □No separation is required for enroute traffic above a well defined top of cloud or other formation if frequent in-flight weather reports indicate a generally unlimited ceiling on top and flight visibility of at least 3 miles (5km). During the hours of daylight, holding aircraft operation under these conditions will require no separation.



THE VERTICAL SEPARATION PANEL

- The advent of commercial turbo jet aircraft operating at high levels necessitated a reevaluation of the vertical separation minimum.
- ➤ A Vertical Separation Panel was therefore formed in June 1954.
- The Panel identified those factors which were likely to contribute towards the greatest loss of separation and proposed steps that should be taken to reduce or eliminate their influence.



The 1958 RAC/SAR Divisional Meeting

"The vertical separation minimum shall be 305 meters (1000 ft) except that, above a level to be determined on the basis of Regional Air Navigation Agreements, 610 meters (2000 ft) shall be established as the vertical separation minimum. This level should not be higher than an altitude of 8850 meters (29000 ft) or flight level 8850 metric (290)".



The 1958 RAC/SAR Divisional Meeting

> The vertical separation minimum between IFR traffic shall be a nominal 300 meters (1000 ft) below an altitude of 8850 meters (29000 ft) or flight level 290 and a nominal 600 meters (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 600 meters (2000 ft) vertical separation minimum.



THE FOURTH NAT REGIONAL AIR NAVIGATION (RAN) MEETING - 1960

That, in view of the importance of vertical separation criteria in the planning of Air Traffic Services for NAT Region, as well as for other regions of high traffic density, the work of the Organization in the field of vertical separation be pursued vigorously to an early conclusion and be presented in a form suitable for early application in regional ATS.



THE 1963 RULES OF THE AIR AND AIR TRAFFIC SERVICES - OPERATIONS (RAC/OPS) DIVISIONAL MEETING

That in view of the importance of vertical separation in the planning of air traffic services particularly in regions of higher traffic density and the desirability of reducing vertical separation intervals above Flight Level 290, work in the field of vertical separation be vigorously pursued by all concerned to an early conclusion and presented to ICAO in a form suitable for early application in ATS planning on a world-wide basis, or, if this is not attainable, at least on a regional basis.



SPECIAL NAT RAN 1965 MEETING

Recommendation - Technical Measures by States and Operators of aircraft intended to be used for operation in that part of the NAT Region where 1000 feet vertical separation is to be applied above FL290:



SPECIAL NAT RAN 1965 MEETING

- ➤ Ensure as soon as possible that operators are taking all necessary measures for installation, calibration and maintenance of altimeter systems and autopilots in accordance with the latest available methods; and
- Assure themselves as soon as possible by means of flight tests, as appropriate, that calibration, maintenance and operating techniques used by the operators are such as to achieve the necessary degree of reliability and accuracy of altimeters and autopilots.



1966

- The changeover level was established at FL 290 on a global basis
- 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
- Accordingly, ICAO provisions stated that such a reduced VSM could be applied under specified conditions within designated portions of airspace on the basis of regional air navigation agreement.



1970

- World fuel shortages and the resultant rapid escalation of fuel costs
- Growing demand for a more efficient utilization of the available airspace, emphasized the necessity for a detailed appraisal of the proposal to reduce the VSM above FL 290.



DEVELOPMENT OF THE RVSM - WHY SO MUCH INTEREST?

- ➤ fuel-burn penalty of about 1 percent for each 1000 ft below optimum cruise altitude
- ➤ RVSM was single best thing to do fuel-burn reduction far outweighed any horizontal plane separation reductions, for example, 30 NM lateral/30 NM longitudinal
- RVSM provides (theoretical) doubling of capacity in same airspace
- > achievable without major change to aircraft or ATC system
- ➤ 1971 RGCSP/1



REVIEW OF THE GENERAL CONCEPT OF SEPARATION PANEL

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



REVIEW OF THE GENERAL CONCEPT OF SEPARATION PANEL

- ➤ RGCSP/6 (1988): "Recommended that RVSM was technically feasible"
- ➤ RGCSP/7 (1990): draft RVSM guidance material was produced Doc 9574
- ➤ICAO ANC (1990): approved draft guidance material and draft Standards and Recommended Practices (SARPS) to Annex 2
- > 1997 27 March, First RVSM Implementation



WHY SO LONG?

- ➤ 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 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 levels 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 + FTE(AAD)

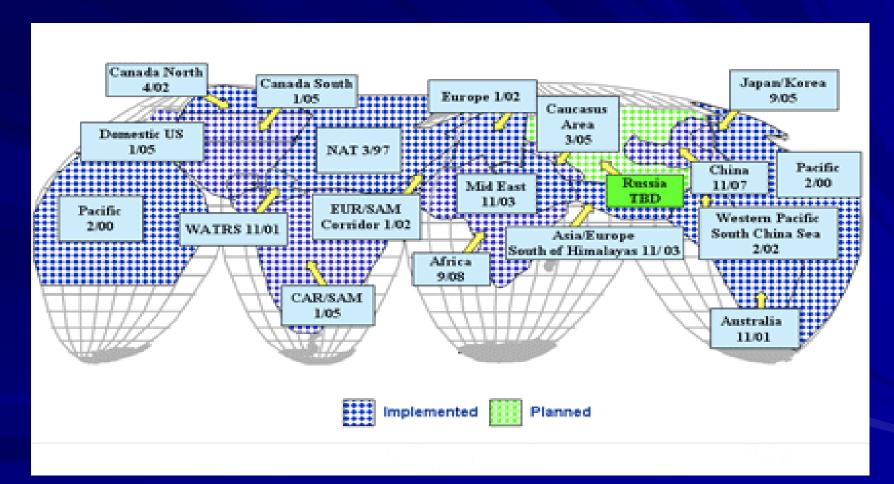


WAS IT WORTH IT?

- Operators have found benefits greater and costs less than predicted
- > ATC units report little difficulty with RVSM procedures
- > ATC units able to offer more desirable routings
- ➤ ATC units report RVSM provides more operational flexibility.



WAS IT WORTH IT?





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 Meetings
- **≻**RGCSP
- >Time for development
- > Results

A BRIEF HISTORY OF RVSM

THANK YOU

QUESTIONS?

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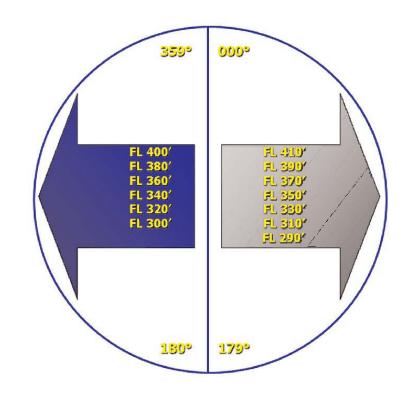


ICAO RVSM Implementation Safety Assessment Seminar

Nairobi, 19-22 April 2010

AFI RVSM Cost Benefit Analysis Forecast

Presented by Prosper ZO'O MINTO'O Assistant Regional Director, IATA AFI Safety, Operations and Infrastructure





to represent, lead and serve the airline industry





Plan

- I. Introduction
- II. AFI Traffic Forecast
- III. AFI RVSM Cost Benefit Analysis (CBA)



I - Introduction



Chicago Convention (1944)

- Preamble: "...Therefore the undersigned governments, having agreed on certain principles and arrangements in order that international civil aviation may be developed in a <u>safe</u> and <u>orderly</u> manner and that international air transport services may be established on the basis of <u>equality of opportunity</u> and <u>operated soundly</u> and <u>economically...</u>"
- Annex 11: Air traffic control service. A service provided for the purpose of preventing collisions ...and expediting and maintaining an orderly flow of air traffic.



Air Traffic Management [ATM]

(Source: ICAO ATM Operational Concept)

Definition. Air Traffic Management [ATM] is defined as "the dynamic, integrated management of air traffic and airspace - <u>safely</u>, <u>economically</u>, <u>and efficiently</u> - through the provision of facilities and seamless services in collaboration with all parties".



II - AFI Traffic Forecast



AFI Traffic Forecasts for 2004 – 2020

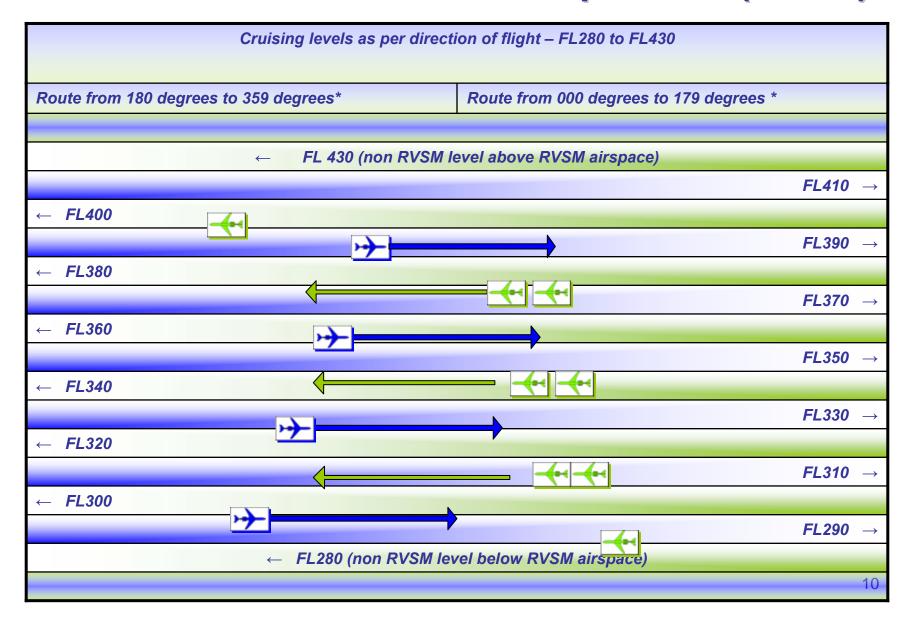
(Source: ICAO Doc 9879)

									Average Annual Growth (%)		
	2004	2005	2006	2007	2008	2009	2010	2020	2004- 2010	2010- 2020	2004- 2020
NAM-AFI	3990	4248	4524	4817	5130	5463	5818	10311	6.5	5.9	6.1
EUR-AFI	131319	137623	144229	151152	158407	166010	173979	265057	4.8	4.3	4.5
MEA-AFI	43719	46413	49274	52310	55534	58956	62589	119118	6.2	6.6	6.5
ASP-AFI	10953	11468	12007	12571	13162	13780	14428	21563	4.7	4.1	4.3
INTRA AFI	77988	84937	92506	100749	109727	119505	130154	296998	8.9	0.0	87
TOTAL	267969	284689	302538	321599	341959	363714	386967	713048	6.3	6.3	6.3



III – AFI RVSM CBA

Reduced Vertical Minimum Separation (RVSM)



Flights and Hours of operation

	Year 1	Year 2	Year 3	Year 4	Year 5
	245,000	257,250	270,113	283,618	297,799
Average International flight duration (hours)	6	6	6	6	6
对Total hours	1,470,000	1,543,500	1,620,675	1,701,709	1,786,794
⊅Domestic flights 2006 (South Africa) (flights)	200,000	210,000	220,500	231,525	243,101
Average domestic flight duration (hours)	1.3	1.3	1.3	1.3	1.3
对Total hours	260,000	273,000	286,650	300,983	316,032
对Total RVSM flights	445,000	467,250	490,613	515,143	540,900
对Total RVSM hours	1,730,000	1,816,500	1,907,325	2,002,691	2,102,826

Fuel

	Year 1	Year 2	Year 3	Year 4	Year 5
⊿ Ave fuel consumption (kg/h)	4,000	4,000	4,000	4,000	4,000
	5,880,000,000	6,174,000,000	6,482,700,000	6,806,835,000	7,147,176,750
⊘Percentage reduction in fuel consumption (%)	1.5	1.5	1.5	1.5	1.5
对Total fuel saved	88,200,000	92,610,000	97,240,500	102,102,525	107,207,651
⊘ Ave fuel reduction (kg)	60	60	60	60	60
	800,000,000	840,000,000	882,000,000	926,100,000	972,405,000
⊘Percentage reduction in fuel consumption (%)	1	1	1	1	1
对Total fuel saved	8,000,000	8,400,000	8,820,000	9,261,000	9,724,050
⊘ Ave fuel reduction (kg)	31	31	31	31	31
	96,200,000	101,010,000	106,060,500	111,363,525	116,931,701
⊅Fuel cost in USD per USG Aug 2005 (USD)	3.23	3.71	4.27	4.91	5.65
⊼Total savings due to reduced fuel consumption	102,617,569	123,910,715	149,622,188	180,668,792	218,157,567

Delays

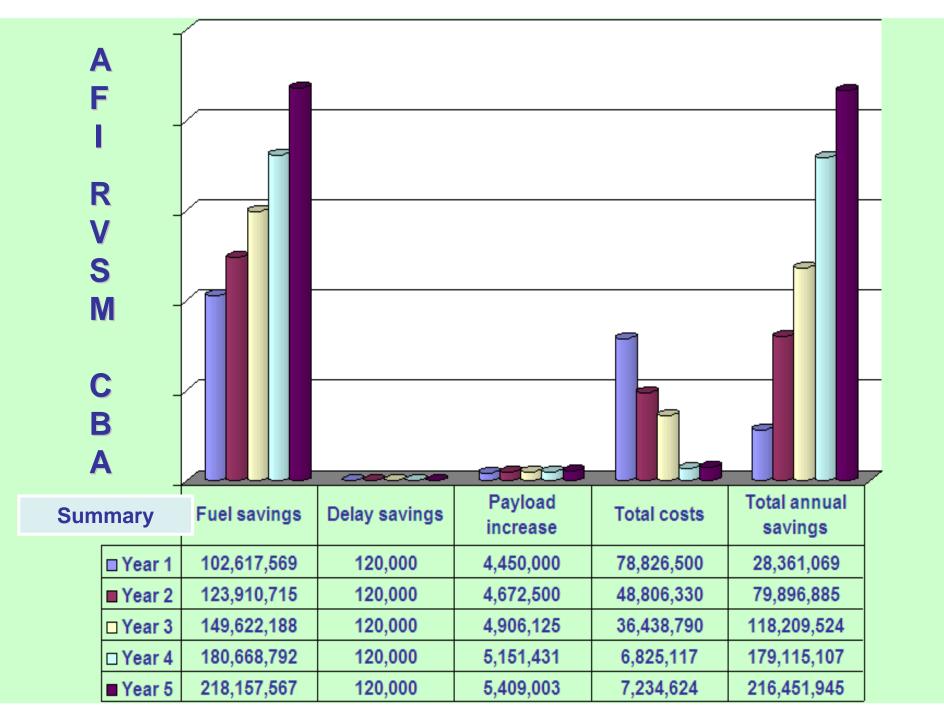
		Year 1	Year 2	Year 3	Year 4	Year 5
7	Average block hour cost	6,000	7,200	8,640	10,368	12,442
7	Average delay reduction due RVSM (SA flight levels - 150 flights)	8	8	8	8	8
7	Total hours saved	20	20	20	20	20
71	Total savings	120,000	120,000	120,000	120,000	120,000

Payload

		Year 1	Year 2	Year 3	Year 4	Year 5
7	Estimate Revenue per flight due increased payload (USD)	10	10	10	10	10
7	Total revenue (USD)	4,450,000	4,672,500	4,906,125	5,151,431	5,409,003

Costs

		Year 1	Year 2	Year 3	Year 4	Year 5
	ARMA					
7	Operations	5,200,000	5,512,000	5,842,720	6,193,283	6,564,880
7	Height Monitoring	4,900,000	0	0	0	0
	Aircraft operators					
7	Altimetry MASPS	530,500	562,330	596,070	631,834	669,744
7	Inspections / upgrades	38,196,000	12,732,000	0	0	0
	ANSPs					
7	ATM Upgrades	30,000,000	30,000,000	30,000,000	0	0
7	Total (USD)	78,826,500	48,806,330	36,438,790	6,825,117	7,234,624





Thank You!



International Civil Aviation Organization



AFI RVSM Implementation Safety Seminar

AFI RVSM Backdrop

Six Eighty Hotel, Nairobi, Kenya 19-23 April 2010

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Sharing the Limited Jet Levels





₹Early views

APIRG & SP AFI RAN

Safety Management

Tactical Action Group (TAG)

*****Conclusion

EARLY VIEWS APIRG 12, Tunis, 1999

- **№ Decision 12/66: Implementation of RVSM**
 - That the planning and evolutionary implementation of RVSM in the AFI region be carried out and the problems associated with the implementation of RVSM in Europe and other AFI interface areas be considered within the framework of the implementation co-ordination groups (ICGs) or APIRG sub-groups as appropriate.

EARLY VIEWS APIRG 13 2001

- **№ Decision 13/58: Establishment of a Task Force on RVSM and RNAV/RNP Implementation**
- Conclusion 13/85: Initial Implementation of RVSM in the AFI Region
 - That RVSM be implemented in the AFI Region concurrently with or soon after its implementation in the EUR Region, and initially between fl 350 and fl 390
- **► Conclusion 13/86: Seminars/Workshops on RVSM and RNAV/RNP**

EARLY VIEWS What do we remember?

What has changed, 11 Years on?

- Resistance to change
- Limited understanding about the concept
- Uncertain about safety implications
- More pressing priorities
- Unaware/lack of concern about the user benefits
- **∄** etc., ...
- Skeptical and pessimistic
- Everything is just fine; if ain't broke don't fix it
- Under prioritized RVSM safety resource (e.g. no NPM)
- **∄** etc., ...

SP-ARI RAN 2008

- 2 months after successful RVSM Implementation on September 25
- Recommendation 6/6 Operational safety assessment methodology
 - That APIRG adopt the ATM Performance Objective: Operational Safety Assessment Methodology as contained in the performance framework form in Appendix B to the Report on Agenda Item 6
- Recommendation 6/7 Establishment of a Tactical Action Group (TAG)

SP-ARI RAN 2008

- Rec. 6/8 –RVSM monitoring & follow-up activities
 - That AFI States support:
 - **■** Long term
 - Submission of State RVSM operationally approved aircraft ARMA;
 - support to the AFI height monitoring programme;
 - collection of safety assessment data;
 - personnel to fulfil the role of RVSM NPM;
 - establishment of the scrutiny group in 2009;
 - measures to reduce the large number of horizontal incidents in the AFI Region.

What flexibility is there?

- RVSM Airspace is a thin layer under increasing demand
- As aircraft navigation precision increases, missing each other gets harder, risk of collision increases
- As opposed to a low level CFIT, an RVSM Mishap involves at least two aircraft, lots of lives!
- We share our airspace with non AFI aircraft; consequences are not just AFI...

What flexibility is there?

Eurocontrol expecting 4,000 flights on Sunday compared to 24,000

Kenya losing Sh300m daily over cancelled flights

(Sunday Nation)

Financial pressure pushes some airlines to test the skies



Safety Management

■ What is safety?

- Zero accidents or serious incidents
 - a view widely held by the travelling public
 - some managers still refer to lack of incidents as being safe
- Freedom from hazards (i.e. those factors which cause or are likely to cause harm)
- Attitudes towards unsafe acts and conditions by employees of aviation organizations
- Error avoidance
- Regulatory compliance (if rules are not broken, we are safe)
- **!**

Sebo

11

Safety Management



Safety Management

The need to be predictive is imperative

- Considering the forces and magnitudes of energy involved in flying, it's known level of safety is NOT by chance
- A lot conscious effort is needed, continuously
- We nap on the wheel, we take a hit
- A good part of our senior management is not from technical or safety backgrounds (moreover, they migrate more); we need to educate them, continually
- Safety management is conscious pre-planned process that is executed according to plan



TACTICAL ACTION GROUP (Lessons and observations)

- There are much more unsatisfactory condition reports than we readily estimate
- There is reluctance to report particularly from:
 - CAAs
 - ANSPs
- There is reluctance to investigate airspace incidents
- There is reluctance to accommodate TAG missions in States
- There's work to be done!

SSP and SMS components

SSP components



SMS components

- State safety policy and objectives
- 2 State safety risk management
- 3 State safety assurance
- 4 State safety promotion

- Safety policy and objectives
- Safety risk management
- **3** Safety assurance
- 4 Safety promotion

RVSM Post Launch Imperatives

- SP AFI RAN Rec. 6/7
- Implement SSP & SMS
 - This is not the SMS of 2005)
- SSP framework guidance in Attachment to Annexes
- SMS Standard framework in Appendix to Annexes
- More guidance in Doc 9859
- Safety Management Training is imperative
- (ACIP Website: http://www2.icao.int/en/acip/)
- **▼** etc.;...

CONCLUSION

- We have come a long way in views and understanding. Great, but we cannot relax
- So long as we fly, some obligations will just never go away
- At the least/minimum, we should implement ICAO provisions
- We have an obligation keep our senior managers on board



THANK YOU

questions...

ICAO ESAF OFFICE RVSM IMPLENTATION SAFETY SEMINAR (Nairobi, 19 - 22 April 2010) **Air Traffic Controllers** Perspective (Presented by IFATCA)

SUMMARY

 One and a half years after the implementation of the AFI RVSM between FL 290 to FL410 the Controllers in the region have had various experiences; this paper thus highlights these experiences.

Introduction

- •On 25th September 2008 the AFI region implemented RVSM in the airspace between FL290 and FL410.
- This airspace became restricted to RVSM approved aircraft only except for those aircraft which would climb or descend unrestricted to/from levels above FL410.

This implementation was as a result of close monitoring and consultations by a team of experts that included ARMA, ICAO, IATA, ATNS, Kenya CAA, ASECNA, IFALPA and IFATCA. This AFI RVSM working group with the blessings from APIRG (Conc. 16/38) had approved the date of 25th September 2008 for the implementation of the RVSM in the AFI region with approval from APIRG 16th meeting held in Rwanda on 19-23 November 2007.

- At the AFI RVSM TF 14th meeting the States had indicated that:
 - the National Safety Plans (NSP),
 - the CNS infrastructure to support the implementation of RVSM,
 - The Letters of Agreement/ Letters of Procedures (LOA/LOP) between States and adjacent FIRs,
 - had all been completed and the Pre-Implementation Safety Case (PISC) for the region had been completed and would be sent to the ICAO ANC for approval by June of 2008.

As the days drew closer to the implementation date, the AFI RVSM TF co-opted IFATCA into the Project Management Team (PMT). It was the mandate of this team to ensure that all the Tasks agreed on for the safe implementation was completed by the target date, and any difficulties resolved or contingencies put in place to deal with them.

Discussion

• At the time of implementation IFATCA had expressed concern that although the States had reported that all the necessary safety targets were met some ATC centers were not ready for the implementation, some controllers were not very conversant with the requirements and new ATM systems were yet to be validated. Some States had raised concern that their Communication infrastructure would not be ready by 25th September 2008 among them Angola and DRC.

- These concerns the PMT believed would be overcome in the following few weeks before implementation and therefore the target date of 25th September 2008 was accepted at the RVSM TF 14th meeting in Nairobi on 26th-28th May 2008.
- Due to the concerns expressed on individual unit readiness, IFATCA embarked on intense monitoring of the States preparation through the Member Associations.

 Following the implementation, IFATCA member associations have provide the necessary feedback. In general the air traffic controllers in the region have been happy with the extra six flight levels created by the implementation of RVSM in the region. These extra levels have eased the congestion that were initially experienced on optimum levels like FL310-FL370 and created less workload for the controllers in the area of coordination.

- A number of ATC units reports difficulties with handling **State aircraft**. While a number of state aircraft are RVSM approved some are not. The AFI region handles a large volume of state aircraft and the requirement to provide 2000 feet separation between them and other traffic over stretch the airspace.
- In a region where large areas are not covered by surveillance equipment it is essential that information is received concerning the status of all flight; this is not happening as required.

• Cases are sometimes not reported of **Non RVSM** approved flights entering RVSM airspace without authority; this happened a lot in the early part of implementation. Flight plans sometimes indicated that aircraft were RVSM approved and yet later it would be realized that this was not the case; the assumption that certain types of aircraft have the required capability have led to most of these breaches.

 Although Communication was improved in the region before implementation, today communication failures have been in the increase in the region. Whereas this is a widespread problem in the region, Controllers mainly in the west and central African region are more affected; they continue to work with very limited communication facilities. Coordination between units is sometime very difficult, resulting into a number of ATC incidents in the region.

 Due to the nature of provision of Air traffic services, certain types of incidents go unreported because they are considered as normal operations; a good example is large altitude deviations due to turbulence. For this reason it is important to note that Safety case analysis may not reflect the true picture. It is important that all incidents irrespective of how small it is be reported.

 Also reported is that in TCAS RA cases and Turbulence conditions, flight levels are changed with more than 500 feet; often a full flight level is changed e.g. from FL330 to FL350 or from FL330 to FL340 etc this sometimes without controllers being aware of the magnitude of change in flight level.

Conclusion

 The deficiencies that are still being realized in the AFI region are of great concern to the controllers. There is urgent need to address Communication deficiencies, especially between ground units for both RVSM and general safety of operations.

 The number of non-RVSM aircraft that operate in RVSM airspace (whether State aircraft or incorrect action or emergency traffic of non-RVSM non-State aircraft) must be monitored keenly and on-going assessment made on whether the safety of exclusive RVSM airspace continues to be valid.

- Pilot and controller education must continue on procedures in RVSM for dealing with turbulence (including the suspension of 1000 foot separation), and how to respond to TCAS RAs.
- The reporting of events (what to report, and reporting procedures, etc), especially reporting of Large Height Deviations must be encouraged.
- IFATCA would like to stress that the TAG should continue to address on-going issues.

Recommendation

• IFATCA recommends that this presentation be accepted as information paper.

ARMA APPROVAL PROCESS OVERVIEW

- How come the poster doesn't have training
- This is just an overview all info is in TGL6.
- Madagascar is happy with process.
- Sudan is not happy with approval process.
 Kevin explained the process to Sudan
 Kevin explained ARMA Form 2 and Form 3
 Kevin explained AFI RVSM monthly returns F1, F2, F3, F4

POSC

- Conclusion 3 editorial problem to look at.
- Grey area to be addressed remedial action route network to be re-looked.
- Concept of RVSM was not properly grasped.

RECOMMENDATION

- State approvals how do we assist States ICAO is an umbrella and States approve acft.
- Train avionics in approving RVSM aircraft. ICAO must Audit States with their RVSM approvals. Re-training re-familiarization some delegates might have moved on ARMA to put a package together to dispatch to all AFI CAA. States need to assist each other.
- Comply AFI minimum requirements most States comply and others don't What is ICAO input to CAAs in AFI. CAA's are responsible for HM ARMA and HM program to engage with CAAs and Operators.
- Ops error reporting improved why don't we get incidents from GND how do mangers and Ops operate if they don't know what errors are there.
- Victimization, fear and voluntary incidents reporting non-punitive policy, education to pilots and controllers in reporting open safety culture.

OPS Error Reporting and Assessment should be consistent:

- IATA and ARMA to work together.

Reporting processes must be improved:

- IATA and ARMA teamed up for incidents freedom of reporting from ACC to ARMA.

TFC Flow data submission:

First submission was by hand then States dep was created then ARMA is able to get data. Extra data analysis function billing VSAT IATA data or billing avenue.

Proportion acft GNSS

- ARMA to look at GNSS and aircraft manufacturers.

Updated all documents:

- Doc.7030 to be updated. ATC Manual to be updated State letters to CAAs to be fully aware.

RVSM docs relating to PISC:

- Will be revisited.

SLOP implemented ICAO provisions:

- Realized and satisfied at SG/11.

SLOP Harmonized:

ESAF and WACAF to decide.

Surveillance Review:

- State should ensure surveillance offering.

CPDLC re-inforced:

- State should provide as required – SG/11.

Unidirectional and/or parallel Routes:

- TF implemented to review AFI route network States must be encouraged NAVAIDS.
- GNSS airspace in RVSM airspace.
- TF to be implemented when all requirements are met.

Management of non-RVSM civil acft in RVSM airspace to be reviewed. Descend acft out of RVSM band. How did it get there. CAA to support ATC who report these Ops, address courses.

Op, acft, RVSM approvals be in-force

AIS dep must sift this fplns. Databases should be available to States to cross-check RVSM approvals.

Pilots must be also educated – How do I know if pilot is lying – IFALPA to assist ARMA reports non-IFALPA pilots to CAAs pilots from abroad think this is bush airspace and even AFI pilots CAAs to educate operators.

Wrong LVL

- FLAS must be emphasized.
- Deviation acft need urgent attention. Flight deck discipline TCAS parameters.
- Any other comments.
- Hefty penalties, RVSM vigilance for our TLS.
- Transponder requirement on MEL procedures.
- Querry transition airspace.
- Weather deviation frequency 121.5 mhz/123.45 mhz used is emergency not just weather. Contingency plan by IFALPA in AFI.
- SLOP radar or surveillance LD Pilots and ATC procedures Pilot does not have to inform ATC to be revisited.
- State acft.
- Post flight slide 300ft and more.
- Degradation of acft equip slide
- Pilots to notify ATC.
- Discrepancy weather encounter IATA and ICAO frequencies
- Severe turbulence only as a title.

 Mountain wave activity slide 2nd bullet if pilot ATC procedures ICAO, ASECNA website.

OUTCOME OF THE AFI RVSM IMPLEMENTATION SAFETY SEMINAR (RISS) 19-23 APRIL 2010

➤ National Programme Manager (NPM) as the National RVSM implementation focal points should sensitize their civil aviation authorities (CAA) with regard to adherence to the RVSM Approval processes.

- AFI CAA's are to ensure that the State Approval processes are clearly understood by the staff responsible for applying such processes and are adhered to by operators in order to reduce incidents of violations.
- ➤ AFI CAA's to ensure enough qualified CAA inspectors and adequate oversight of RVSM approvals and to ensure effective enforcement where necessary.
- ➤ AFI CAA's to ensure that the ARMA is supported in the AFI Height Monitoring Program.
- ➤ NPMs continue following up RVSM implementation issues as stipulated in the RVSM Implementation plan to ensure compliance
- ➤ To ensure optimal use of RVSM flight levels and efficiency in the upper airspace in general, LOP's should be re-addressed between Seychelles/Mumbai & Mogadishu/Mumbai in order to address current costly level restrictions being experienced.
- ➤ AFI ANSP's to ensure that ATS service providers are properly trained in RVSM and that proficiency checks are conducted periodically to ensure appropriate use levels in RVSM airspace.
- Following discussion and review of contingency procedures relating to RVSM operations within the AFI Region, the seminar wishes to request ICAO to review the contents of both Chapter 15 (*Procedures related to emergencies*, communication failure and contingencies) and Chapter 16 (*Miscellaneous procedures*), PANS ATM (DOC 4444) with a view of converting contingency procedures which relate specifically to Oceanic operation to general contingency procedures, for use both Continentally as well in Oceanic airspace as appropriate.
- ➤ CAA's to communicate to all stakeholders information about the existence and function of <u>TAG</u>.
- > States to amend the LOA/LOP's to include the requirement to exchange information on individual aircraft/flight RVSM Status.
- ➤ CAA's to ensure specifically appointed personnel for the collection of data. This function could be assigned to existing staff but should be clearly, expressly assigned and supported.

- > CAA's to ensure that NPM are supported to communicate with the ARMA_and to provide necessary data.
- ➤ CAA's to apply immediate enforcement actions on Non-RVSM operators who operate in RVSM airspace where shear negligence and/or willful misconducts are confirmed. The same applies to RVSM Approved operators who commit such violence.
- ➤ AFI State that have not already done so to ensure that RVSM approvals certificates are included in the list of docs to be carried onboard.
- ➤ AFI CAA's should ensure that reporting procedures are in place in order to facilitate timely processing of RVSM related incidents or violations.

AFI Reduced Vertical Separation Minimum (RVSM) Implementation Safety Seminar (RISS) (Nairobi, Kenya 19 – 23 April 2010)

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Global ATM Operational Concept

SAULO SILVA
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Air Navigation Bureau, ICAO HQ
April 2010



Objective

To present the concept and the steps towards the implementation of the future ATM system.



Presentation Outline

- History and Background
- ATM Community
- Concept components
- Guiding principles
- Expectations / KPA's
- Key Conceptual Changes
- Information Management
- Expected benefits
- Summary



History and Background

- FANS
- Tenth Air Navigation Conference
- CNS/ATM Systems
- Global Coordinated Plan for Transition to ICAO CNS/ATM Systems
- Planning and Implementation Regional Groups embarked on an extensive effort
- SARPs, PANS, Guidance material
- Global Air Navigation Plan for CNS/ATM Systems (Doc 9750)
- Eleventh Air Navigation Conference
- ICAO's commitment to adopt a business process approach.



Vision statement

To achieve an interoperable global air traffic management system for all users during all phases of flight, that

- meets agreed levels of safety
- provides for optimum economic operations
- · is environmentally sustainable and
- meets national security requirements.



Global ATM Operational Concept

- → The global ATM operational concept is a vision that;
 - describes how an integrated global ATM system should operate
 - ✓ describes what is envisaged on the basis of services
 - ✓ describes how the services form an integrated system
 - utilizes an information rich environment, that solves most problems strategically, through a collaborative process
 - ✓ provides States and industry with clearer objectives for the design and implementation of ATM and supporting CNS systems



Transition to a Performance Based Air Navigation System

- Technology is not an end in itself
- Requires a comprehensive concept for an integrated, global air navigation system, based on clearlyestablished operational requirements
- Concept endorsed by the 11th Air Navigation Conference
- Strategic Guidance Established
 - ATM system requirements
 - Transition strategy
 - Performance framework

Next steps

 Global Performance Objectives to achieve measurable progress towards achievement of the vision of the concept

Performance Objectives

Global Performance Objective:

Improvements to the Air Navigation System that are on the critical path towards the Global Operational Concept.

Regional Performance Objective:

Considers operating environments and priorities specific to a regional level.



ATM Community

The aggregate of organizations, agencies or entities that may participate, collaborate and cooperate in the planning, development, use, regulation, operation and maintenance of the air navigation system.



Members of the ATM Community

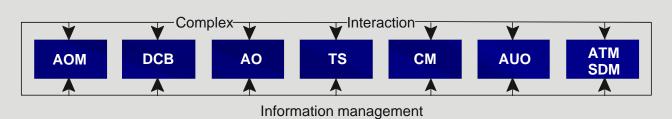
- Aerodrome community
- Airspace providers
- Airspace users
- ATM service providers
- ATM support industry
- ICAO
- Regulatory authorities
- States

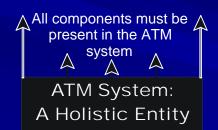


The seven ATM concept components

The ATM system needs to be disaggregated to understand the sometimes complex interrelationship between its components.







The ATM system cannot, however, function without all of its components. The components must be integrated.

AOM — Airspace organization and management

DCB — Demand/capacity balancing

AO — Aerodrome operations

TS — Traffic synchronization

CM — Conflict management

AUO — Airspace user operations

ATM SDM — ATM service delivery management



Seven Concept Components

- Airspace organization and management (AOM)
- Aerodrome operations (AO)
- Demand and capacity balancing (DCB)
- Traffic synchronization (TS)
- Airspace user operations (AUO)
- Conflict management (CM)
- ATM service delivery management (SDM)



Airspace Organization and Management (AOM)

- All airspace will be the concern of ATM and will be a useable resource
- Any restriction on the use of any particular volume of airspace will be considered transitory
- Airspace management will be dynamic and flexible.



Aerodrome Operations (AO)

- Runway occupancy time will be reduced
- The ability to safely manoeuvre in all weather conditions
- Precise surface guidance to and from a runway
- The position and intent of all vehicles and aircraft operating on the manoeuvring and movement areas will be known.

<u>Return</u>



Demand and Capacity Balancing (DCB)

- Through CDM at the strategic stage, assets will be optimized
- Through CDM at the pre-tactical stage, adjustments will be made to assets, resource allocations, projected trajectories, airspace organization, and allocation of entry/exit times
- At the tactical stage, dynamic adjustments to the organization of airspace to balance capacity; dynamic changes to the entry/exit times.



Traffic Synchronization (TS)

- Dynamic 4-D trajectory control and negotiated conflict-free trajectories
- Choke points will be eliminated
- Optimisation of traffic sequencing will achieve maximization of runway throughput.



Airspace User Operations (AUO)

- ATM data will be fused for an airspace user's situational awareness and conflict management
- Airspace user operational information will be made available to the ATM system
- Individual aircraft performance, flight conditions, and available ATM resources will allow dynamically-optimised 4-D trajectory planning.



Conflict Management (CM)

- Collaborative decision making
- Aircraft should be designed with the ATM system as a key consideration.



ATM Service Delivery Management (SDM)

- Principles include:
- Trajectory, profile, and aircraft or flight intent
- Management by trajectory
- Clearance

<u>Returุก</u>



Guiding Principles in six main areas:

- Safety
- Humans
- Technology
- Information
- Collaboration
- Continuity



Guiding Principles: Safety

- A safe system is the highest priority in air navigation system
- A comprehensive process for safety management will be implemented, enabling the ATM community to achieve efficient and effective outcomes



Guiding Principles: Humans

- Humans will play an essential and, where necessary, central role in the global air navigation system
- Humans are responsible for managing the system, monitoring its performance and intervening, when necessary, to ensure the desired system outcome
- Due consideration to human factors must be given in all aspects of the system



Guiding Principles: Technology

- No reference to any specific technology
- Openness to new technologies
- CNS systems and advanced information management technology will functionally combine the ground-based and airborne system elements into a fully integrated interoperable and robust air navigation system
- Flexibility across regions, homogeneous areas and major traffic flows
 Return



Guiding Principles: Information

The ATM community will depend extensively on the provision of timely, relevant, accurate, accredited and quality-assured information to collaborate and make informed decisions.

Sharing information on a system-wide basis will allow the ATM community to conduct its business and operations in a safe and efficient manner.



Guiding Principles: Collaboration

 Strategic and tactical collaboration in which the appropriate members of the ATM community will participate in the definition of the types and levels of service.



Guiding Principles: Continuity

The realization of the concept requires contingency measures to provide maximum continuity of service in the face of major outages, natural disasters, civil unrest, security threats or other unusual circumstances.



Eleven Expectations / KPA's (in alphabetical order)

- Access and Equity
- Capacity
- Cost-effectiveness
- Efficiency
- Environment
- Flexibility
- Global interoperability
- Participation by the ATM community
- Predictability
- Safety
- Security



Access and Equity

- A global air navigation system should provide an operating environment that ensures that all airspace users have right of access to the air navigation system resources needed to meet their specific operational requirements and that the shared use of airspace by different users can be achieved safely.
- The global air navigation system should ensure equity for all users that have access to a given airspace or service.



Capacity

- The global air navigation system should exploit the inherent capacity to meet airspace user demands at peak times and locations while minimizing restrictions on traffic flow.
- To enable future growth, capacity must increase, while ensuring that there are no adverse impacts on safety, and giving due consideration to the environment.



Cost-effectiveness

- The air navigation system should be costeffective, while balancing the varied interests of the ATM community
- The cost of service to airspace users should always be considered when evaluating any proposal to improve ATM service quality or performance.
- ICAO policies and principles regarding user charges should be followed.



Efficiency

- Addresses the operational and economic costeffectiveness of gate-to-gate flight operations from a single-flight perspective.
- In all phases of flight, airspace users want to depart and arrive at the times they select and fly the trajectory they determine to be optimum.



Environment

The air navigation system should contribute to the protection of the environment by considering noise and emissions in the implementation and operation of the global air navigation system.



Flexibility

Addresses the ability of all airspace users to modify flight trajectories dynamically and adjust departure and arrival times, thereby permitting them to exploit operational opportunities as they occur.



Global interoperability

■ The air navigation system should be based on global standards and uniform principles to ensure the technical and operational interoperability of ATM systems and facilitate homogeneous and non-discriminatory global and regional traffic flows.



Participation by the ATM community

■ The ATM community should have a continuous involvement in the planning, implementation and operation of the system to ensure that the evolution of the global ATM system meets the expectations of the community.



Predictability

- Refers to the ability of airspace users and ATM service providers to provide consistent and dependable levels of performance.
- Predictability is essential to airspace users as they develop and operate their schedules.



Safety

- Safety is the highest priority in aviation
- ATM plays an important part in ensuring overall aviation safety
- Uniform safety standards and risk and safety management practices should be applied systematically to the air navigation system.



Security

Adequate security is a major expectation of the ATM community and of citizens. The air navigation system should therefore contribute to security, and ATM as well as ATM-related information should be protected against security threats.



Key Conceptual Changes

Three Conflict Management Layers

- Strategic conflict management
- Separation provision
- Collision avoidance



Key Conceptual Change

Strategic Conflict Management

- Achieved through airspace organization and management, demand and capacity balancing and traffic synchronization
- "Strategic" is used here to mean "in advance of tactical"
- Strategic conflict management measures aim to reduce the need to apply the second layer — separation provision



Key Conceptual Change

Separation Provision

- The tactical process of keeping aircraft away from hazards by at least the appropriate separation minima
- Only used when strategic conflict management (i.e. airspace organization and management, demand and capacity balancing and traffic synchronization) cannot be used efficiently
- The separator is the agent responsible for separation provision for a conflict and can be either the airspace user or a separation provision service provider.



Key Conceptual Change

Collision avoidance

- The third layer of conflict management
- Must activate when the separation mode has been compromised
- Collision avoidance is not part of separation provision
- Collision avoidance systems are not included in determining the calculated level of safety required for separation provision
- Collision avoidance systems will, however, be considered as part of ATM safety management.



Aeronautical Information Management (AIM)

- AIM will ensure the cohesion and linkage between the seven concept components
 - Provides quality-assured and timely information to support ATM operations
 - An information-rich environment will be key to the concept.



- Will be tailored to meet ATM requirements in terms of content, format and timeliness
- The main benefits of meteorological information, for the ATM system, will be related to the following:
 - 1. to optimize real time flight trajectory planning and prediction, thus improving the safety and efficiency of the ATM system;
 - 2. increased availability of meteorological information (air-reports) from on-board meteorological sensors will contribute to improving forecast meteorological information and the display of real-time information; and
 - 3. meteorological information will contribute to minimizing the aviation impact on environment.



Other essential services

- ATM system will provide information to, or may receive information from other essential activities as:
 - Air defence systems and military control systems will need timely and accurate information on flights and ATM system intents. They will be involved in airspace reservations and notification of air activities and in enforcing measures related to security.
 - Search and rescue organizations will need timely and accurate search and rescue information on aircraft in distress and accidents because such information plays an important role in the quality of the search function.
 - Aviation accident/incident investigation authorities will need to exploit recordings of flight trajectory data and ATM actions.
 - Law enforcement (including customs and police authorities)
 will need flight identification and flight trajectory data, as well as
 information about traffic at aerodromes.
 - Regulatory authorities will need to implement the regulatory framework within the legal powers given to them and to monitor the safety status of the ATM system.



Expected Benefits in General

- Improved safety management processes will ensure that safety performance remains the highest priority
- Business cases will ensure efficient and costeffective air navigation system developments and operations
- Collaborative decision making and system-wide ATM information will enable airspace user participation in balancing the demands on the air navigation system, thereby providing flexibility and predictability



All airspace will be available as a usable resource, resulting in improved access, increased opportunity for user-preferred trajectories and, through community cooperation, increased capacity



Improved surface management of the aerodrome will provide predictable departure and gate-arrival times, thereby improving overall air navigation system predictability and subsequent capacity



- Improved information exchange and cooperation within the ATM community will maximize system capacity
- Improved all-weather operations will maintain maximum capacity
- Improved information concerning demand and system capabilities will prevent system overloads, ensuring manageable workloads



- Provision of accredited, quality-assured and timely information will allow an informed decision-making process
- The ATM community will contribute to the protection of the environment by taking into consideration the consequences of airspace activities



- CNS/ATM systems was a first step
- We needed a vision: the operational concept
- Concept consists of 7 integrated components
- The future system will be an information rich environment, that solves most problems strategically, through a collaborative process
- Ongoing work consists of developing
 - Flight and Flow Information far a Collaborative Environment (FF-ICE)
 - Detailed concept components for SARPS development
- Global Performance Objectives will achieve measurable progress towards achievement of the vision of the ATM Operational Concept



Global ATM Operational Concept

SAULO SILVA
ATM Section
Air Navigation Bureau, ICAO HQ
April 2010



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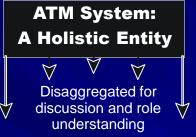
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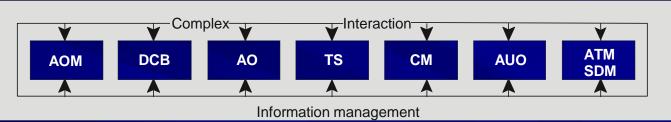
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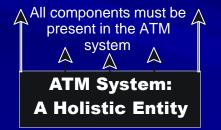


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- Environment
- Flexibility
- Global interoperability
- Participation by the ATM community
- Predictability
- Safety
- Security



Key Conceptual Changes

Three Conflict Management Layers

- Strategic conflict management
- Separation provision
- Collision avoidance



Key Conceptual Change

Strategic Conflict Management

- Achieved through airspace organization and management, demand and capacity balancing and traffic synchronization
- "Strategic" is used here to mean "in advance of tactical"
- Strategic conflict management measures aim to reduce the need to apply the second layer — separation provision



Key Conceptual Change

Separation Provision

- The tactical process of keeping aircraft away from hazards by at least the appropriate separation minima
- Only used when strategic conflict management (i.e. airspace organization and management, demand and capacity balancing and traffic synchronization) cannot be used efficiently
- The separator is the agent responsible for separation provision for a conflict and can be either the airspace user or a separation provision service provider.



Key Conceptual Change

Collision avoidance

- The third layer of conflict management
- Must activate when the separation mode has been compromised
- Collision avoidance is not part of separation provision
- Collision avoidance systems are not included in determining the calculated level of safety required for separation provision
- Collision avoidance systems will, however, be considered as part of ATM safety management.



Aeronautical Information Management (AIM)

- AIM will ensure the cohesion and linkage between the seven concept components
 - Provides quality-assured and timely information to support ATM operations
 - An information-rich environment will be key to the concept.



Meteorological information

- Will be tailored to meet ATM requirements in terms of content, format and timeliness
- The main benefits of meteorological information, for the ATM system, will be related to the following:
 - 1. to optimize real time flight trajectory planning and prediction, thus improving the safety and efficiency of the ATM system;
 - 2. increased availability of meteorological information (air-reports) from on-board meteorological sensors will contribute to improving forecast meteorological information and the display of real-time information; and
 - 3. meteorological information will contribute to minimizing the aviation impact on environment.



Other essential services

- ATM system will provide information to, or may receive information from other essential activities as:
 - Air defence systems and military control systems will need timely and accurate information on flights and ATM system intents. They will be involved in airspace reservations and notification of air activities and in enforcing measures related to security.
 - Search and rescue organizations will need timely and accurate search and rescue information on aircraft in distress and accidents because such information plays an important role in the quality of the search function.
 - Aviation accident/incident investigation authorities will need to exploit recordings of flight trajectory data and ATM actions.
 - Law enforcement (including customs and police authorities)
 will need flight identification and flight trajectory data, as well as
 information about traffic at aerodromes.
 - Regulatory authorities will need to implement the regulatory framework within the legal powers given to them and to monitor the safety status of the ATM system.



Expected Benefits in General

- Improved safety management processes will ensure that safety performance remains the highest priority
- Business cases will ensure efficient and costeffective air navigation system developments and operations
- Collaborative decision making and system-wide ATM information will enable airspace user participation in balancing the demands on the air navigation system, thereby providing flexibility and predictability



All airspace will be available as a usable resource, resulting in improved access, increased opportunity for user-preferred trajectories and, through community cooperation, increased capacity



Improved surface management of the aerodrome will provide predictable departure and gate-arrival times, thereby improving overall air navigation system predictability and subsequent capacity



- Improved information exchange and cooperation within the ATM community will maximize system capacity
- Improved all-weather operations will maintain maximum capacity
- Improved information concerning demand and system capabilities will prevent system overloads, ensuring manageable workloads



- Provision of accredited, quality-assured and timely information will allow an informed decision-making process
- The ATM community will contribute to the protection of the environment by taking into consideration the consequences of airspace activities

Summary

- CNS/ATM systems was a first step
- We needed a vision: the operational concept
- Concept consists of 7 integrated components
- The future system will be an information rich environment, that solves most problems strategically, through a collaborative process
- Ongoing work consists of developing
 - Flight and Flow Information far a Collaborative Environment (FF-ICE)
 - Detailed concept components for SARPS development
- Global Performance Objectives will achieve measurable progress towards achievement of the vision of the ATM Operational Concept



INTERNATIONAL CIVIL AVIATION ORGANIZATION EASTERN AND SOUTHERN AFRICAN OFFICE

RVSM IMPLENTATION SAFETY SEMINAR

(Nairobi, 19 - 22 April 2010)

Air Traffic Controllers Perspective

(Presented by IFATCA)

SUMMARY

One and a half years after the implementation of the AFI RVSM between FL 290 to FL410 the Controllers in the region have had various experiences; this paper thus highlights these experiences.

1. Introduction

- 1.1 On 25th September 2008 the AFI region implemented RVSM in the airspace between FL290 and FL410. This airspace became restricted to RVSM approved aircraft only except for those aircraft which would climb or descend unrestricted to/from levels above FL410.
- 1.2 This implementation was as a result of close monitoring and consultations by a team of experts that included ARMA, ICAO, IATA, ATNS, Kenya CAA, ASECNA, IFALPA and IFATCA. This AFI RVSM working group with the blessings from APIRG (Conc 16/38) had approved the date of 25th September 2008 for the implementation of the RVSM in the AFI region with approval from APIRG 16th meeting held in Rwanda on 19-23 November 2007. At the AFI RVSM TF 14th meeting the States had indicated that the National Safety Plans (NSP), the CNS infrastructure to support the implementation of RVSM, The Letters of Agreement/ Letters of Procedures (LOA/LOP) between States and adjacent FIRs, had all been completed and the Pre-Implementation Safety Case (PISC) for the region had been completed and would be sent to the ICAO ANC for approval by June of 2008.
- 1.3 As the days drew closer to the implementation date, the AFI RVSM TF co-opted IFATCA into the Project Management Team (PMT). It was the mandate of this team to ensure that all the Tasks agreed on for the safe implementation was completed by the target date, and any difficulties resolved or contingencies put in place to deal with them.

2. Discussion

- 2.1 At the time of implementation IFATCA had expressed concern that although the States had reported that all the necessary safety targets were met some ATC centers were not ready for the implementation, some controllers were not very conversant with the requirements and new ATM systems were yet to be validated. Some States had raised concern that their Communication infrastructure would not be ready by 25th September 2008 among them Angola and DRC. These concerns the PMT believed would be overcome in the following few weeks before implementation and therefore the target date of 25th September 2008 was accepted at the RVSM TF 14th meeting in Nairobi on 26th-28th May 2008. Due to the concerns expressed on individual unit readiness, IFATCA embarked on intense monitoring of the States preparation through the Member Associations.
- 2.2 Following the implementation, IFATCA member associations have provide the necessary feedback. In general the air traffic controllers in the region have been happy with the extra six flight levels created by the implementation of RVSM in the region. These extra levels have eased the congestion that were initially experienced on optimum levels like FL310-FL370 and created less workload for the controllers in the area of coordination.
- 2.3 A number of ATC units reports difficulties with handling **State aircraft.** While a number of state aircraft are RVSM approved some are not. The AFI region handles a large volume of state aircraft and the requirement to provide 2000 feet separation between them and other traffic over stretch the airspace. In a region where large areas are not covered by surveillance equipment it is essential that information is received concerning the status of all flight; this is not happening as required.
- 2.4 Cases are sometimes not reported of **Non RVSM approved flight**s entering RVSM airspace without authority; this happened a lot in the early part of implementation. Flight plans sometimes indicated that aircraft were RVSM approved and yet later it would be realized that this was not the case; the assumption that certain types of aircraft have the required capability have led to most of these breaches.
- 2.5 Although **Communication** was improved in the region before implementation, today communication failures have been in the increase in the region. Whereas this is a widespread problem in the region, Controllers mainly in the west and central African region are more affected; they continue to work with very limited communication facilities. Coordination between units is sometime very difficult, resulting into a number of ATC incidents in the region.
- 2.6 Due to the nature of provision of Air traffic services, certain types of incidents go un-reported because they are considered as normal operations; a good example is large altitude deviations due to turbulence. For this reason it is important to note that Safety case analysis may not reflect the true picture. It is important that all incidents irrespective of how small it is be reported.

2.7 Also reported is that in **TCAS RA cases and Turbulence conditions**, flight levels are changed with more than 500 feet; often a full flight level is changed e.g. from FL330 to FL350 or from FL330 to FL340 e.t.c; this sometimes without controllers being aware of the magnitude of change in flight level.

3. Conclusion

- 3.1 The deficiencies that are still being realized in the AFI region are of great concern to the controllers. There is urgent need to address Communication deficiencies, especially between ground units for both RVSM and general safety of operations.
- 3.2 The number of non-RVSM aircraft that operate in RVSM airspace (whether State aircraft or incorrect action or emergency traffic of non-RVSM non-State aircraft) must be monitored keenly and on-going assessment made on whether the safety of exclusive RVSM airspace continues to be valid.
- 3.3 Pilot and controller education must continue on procedures in RVSM for dealing with turbulence (including the suspension of 1000 foot separation), and how to respond to TCAS RAs.
- 3.4 The reporting of events (what to report, and reporting procedures, etc), especially reporting of Large Height Deviations must be encouraged.
- 3.5 IFATCA would like to stress that the TAG should continue to address on-going issues.

4. Recommendation

4.1 IFATCA recommends that this presentation be accepted as information paper.

Threat and Error Management (TEM) & Normal Operations Safety Survey (NOSS) – Essential SMS Tools

Chris Henry, Ph.D.
NOSS Collaborative
henry@nosscollaborative.org





Overview

- Normal Operations Safety Survey (NOSS)
 - History and background
 - Success Factors the 10 characteristics
 - Threat and Error Management (TEM)
 - Case studies: Applications of NOSS data



What is NOSS?

- Proactive (Predictive) safety data collection tool
- Over-the-shoulder observations during normal shifts
- An evaluation of the larger ATC system, not the controller
- Focuses on daily challenges & how they impact controllers and & the ATC system
- Based on objective data, not opinions
- Provides data on <u>strengths</u> and <u>weaknesses</u>
- Is a period/cyclic program, rather than continuous (NOSS is envisioned to be conducted every 3-4 years)



TEM, LOSA & NOSS Background & Development



LOSA Airlines

Aeromexico

Alaska Airlines

Air Canada

Air Nelson (New Zealand)

Air Freight New Zealand

Air New Zealand

Air Transat (Canada)

ANA

Asiana (South Korea)

Braathens (Norway)

Cathay Pacific

China Airlines

COPA (Panama)

Continental

Continental Express

Continental Micronesia

Delta

DHL

EVA Air (Taiwan)

Emirates

Frontier Airlines (United States)

Horizon Air (United States)

Japan Airlines

JetBlue (United States)

QANTAS

Malaysian Airlines

Mexicana

Mount Cook Airlines (New Zealand)

Regional Express (Australia)

Saudi Arabian Airlines

Singapore Airlines

Singapore Airlines Cargo

Silk Air (Singapore)

TACA (El Salvador)

TACA Peru

TAP Portugal

Thomas Cook (United Kingdom)

UNI Air (Taiwan)

US Airways

Westjest (Canada)



TEM & NOSS Development

The ICAO NOSS Study Group

- Airservices Australia
- Airways New Zealand
- > EUROCONTROL
- Federal Aviation Administration
- International Civil Aviation Organization
- International Federation of Air Traffic Controllers' Associations'
- NAV CANADA
- United Kingdom Civil Aviation Authority
- DFS (Germany)
- University of Texas (Dr. Henry was the University representative to the study group)

ICAO Publications

- Circular 314 Threat and Error Management (TEM) in Air Traffic Control
- Document 9910 The Normal Operations Safety Survey (NOSS)



NOSS Deployments

Where has NOSS been deployed

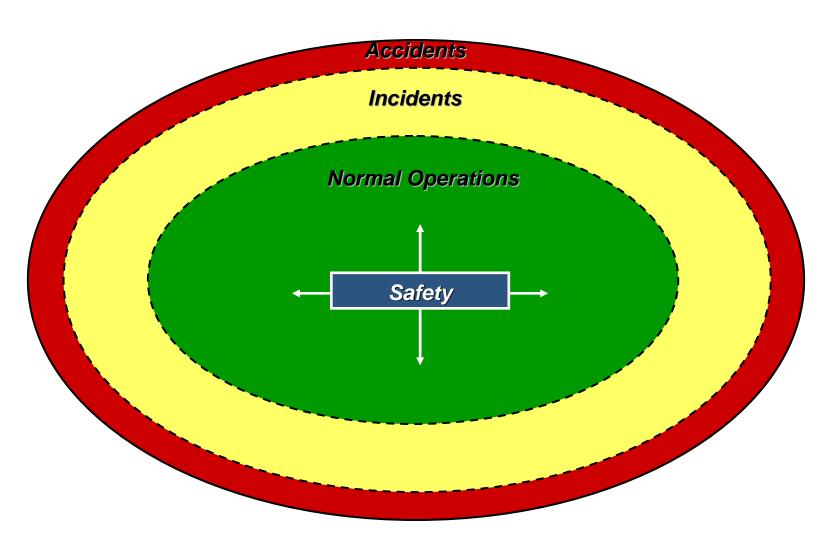
- Australia
- Canada
- New Zealand
- United States
- > Finland
- ➤ NOSS Archive 1,400+ observations
- > Future/Additional deployments
- South Korea
- United States
- Canada
- New Zealand
- Australia
- Middle East
- Latin America
- Europe



Contributions to Safety Management

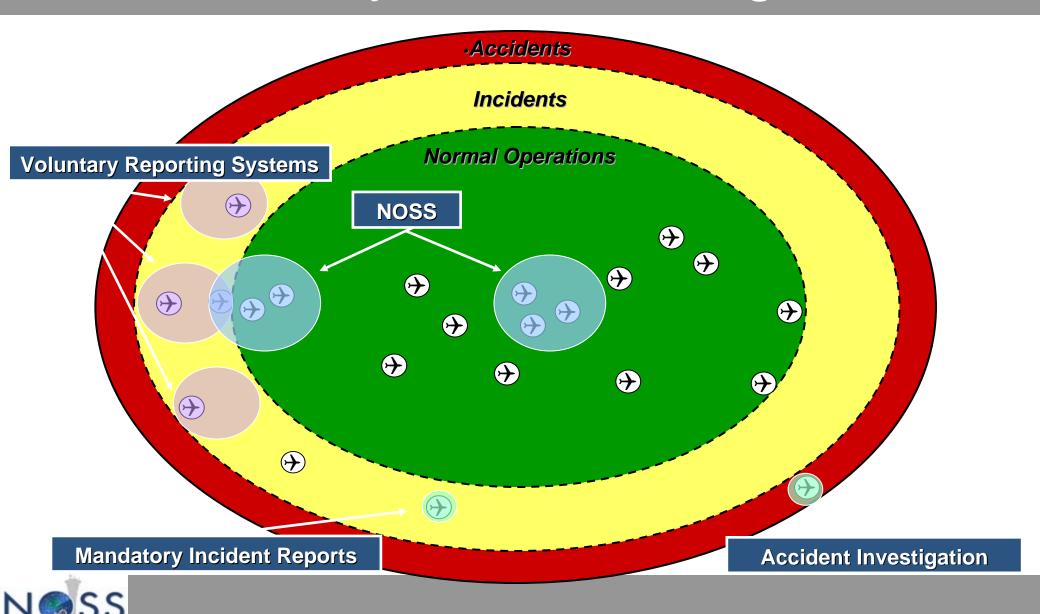


Aviation Safety Envelope





Safety Data Coverage

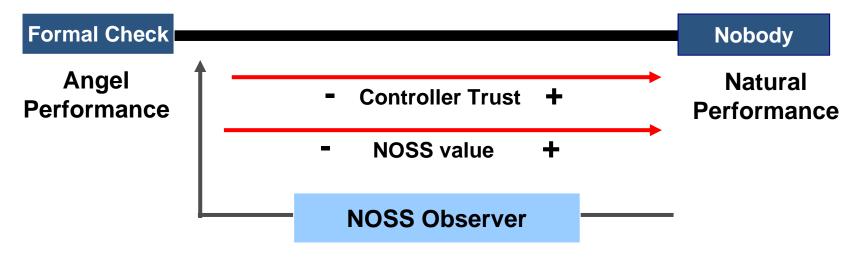


NOSS Success Factors



NOSS Success Factors

NOSS success is dependent upon <u>methodology</u> and <u>execution</u>



Low controller trust = Low quality data because there will be no differentiation between NOSS and proficiency checks



NOSS: The Ten Characteristics

- Over-the-shoulder observations during normal shifts
- 6. Trusted and secure data collection site

- Anonymous, confidential, and non-punitive data collection
- 7. Systematic data collection instrument
- Joint management / association sponsorship
- 8. Data verification process

4. Voluntary Participation

Data-derived targets for safety enhancement

- 5. Trusted and trained observers
- 10. Feedback results to controllers



Over-the-shoulder observations during normal shifts

- No observations of controllers who are undergoing training / checks
- No direct feedback to the controller after the observation
- "Fly on the Wall" principle

2. Anonymous, confidential, and non-punitive data collection

- No names, operating initials, employee numbers, dates, years experience, or other identifying information
- Data used for safety purposes only no punitive actions
- > Observers identity is known only by the third party facilitator



3. Voluntary Participation

Controllers have the right to refuse observation

4. Joint management / controller association support

Letter signed by senior management and association representatives

5. Trusted and Trained Observers

- Trust and Credibility
 - Selection process management / association comfort with observers
 - Diversity of observers increases buy-in
- Training
 - Theoretical background, observation protocols
 - Practice, feedback and calibration



6. Systematic data collection instrument

No judgments – observers record data based on TEM events

7. Trusted and secure data collection site

- > Third party or controller association gatekeeper
- Controllers, observers and management must all be comfortable with the data collection site

B. Data verification process

- TEM data checked to ensure coding accuracy and consistency with procedures
- Data analysis does not begin until verification has been completed



Data-derived targets for safety enhancement

- Serve as benchmarks for safety change
- Initial NOSS, safety change process, follow-up NOSS

10. Feedback results to controllers

- Results summarized for controllers
- Information on how organization intends to respond to the data



NOSS Defined

- The 10 characteristics that differentiate NOSS (LOSA) from other methodologies have been endorsed by the:
 - International Civil Aviation Organization
 - International Air Transport Association
 - International Federation of Airline Pilots' Associations'
 - International Federation of Air Traffic Controllers' Associations'
 - Federal Aviation Administration
 - The NOSS Collaborative
 - The LOSA Collaborative
 - US Airline Pilots Association
 - University of Texas
- NOSS must have all ten characteristics, otherwise it is not NOSS!



What do we look for? Threat and Error Management

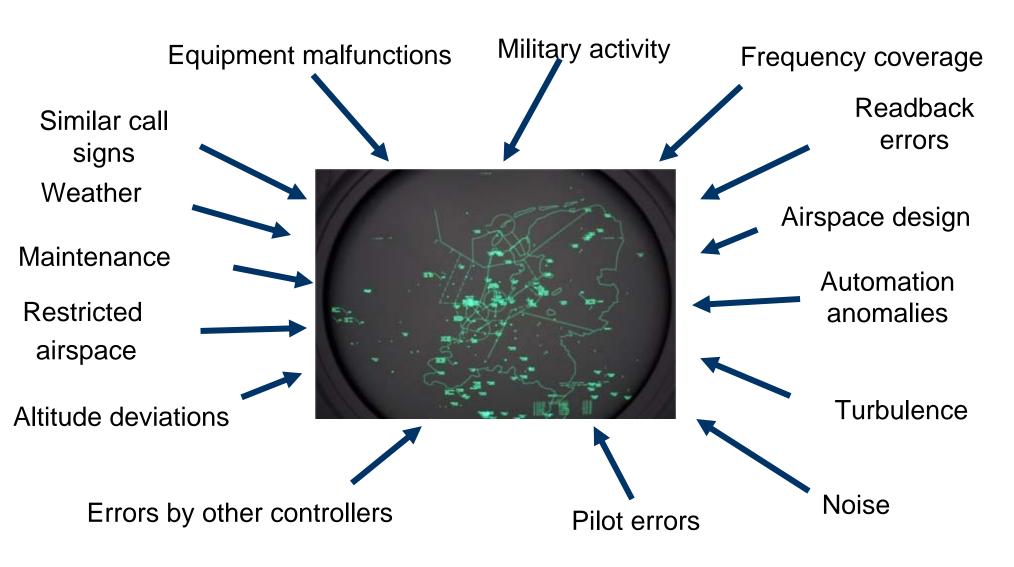


Threats

Threats: Events or errors that occur beyond the influence of the observed air traffic controller, that increase operational complexity, and which must be managed to maintain safety margins.



Threats – Radar Environment



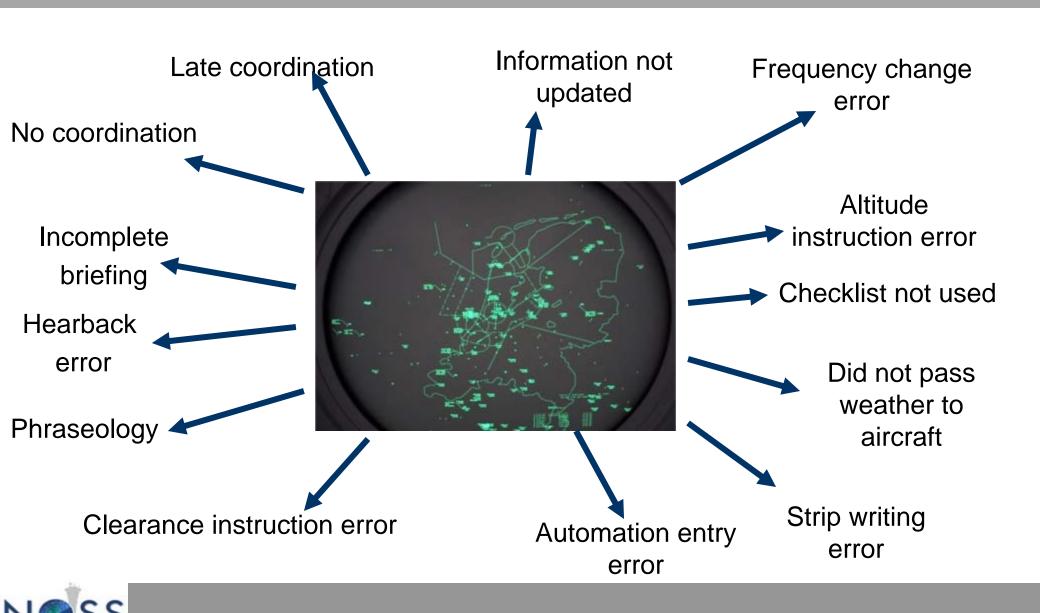


Errors

 Errors: Actions or inactions by the air traffic controller that lead to deviations from organisational or controller intentions or expectations



Errors – Radar Environment

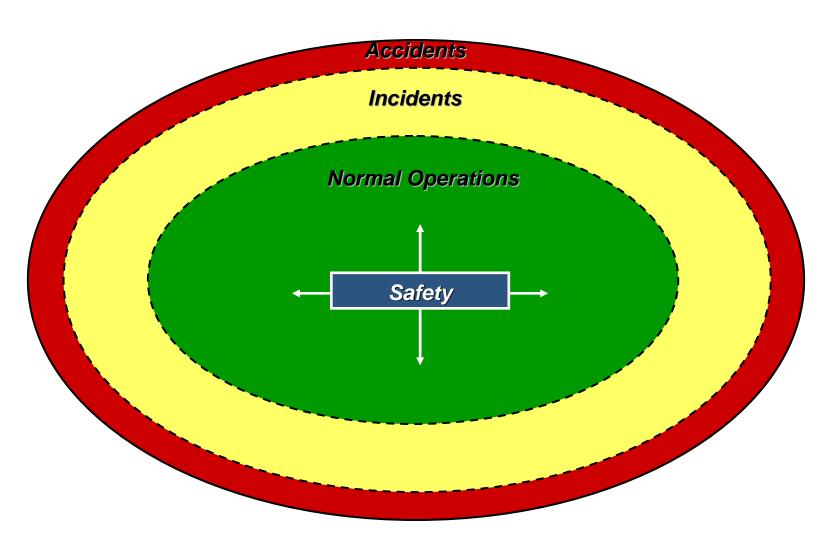


Undesired States

 Undesired States: Operational conditions where an unintended traffic situation results in a reduction in margins of safety

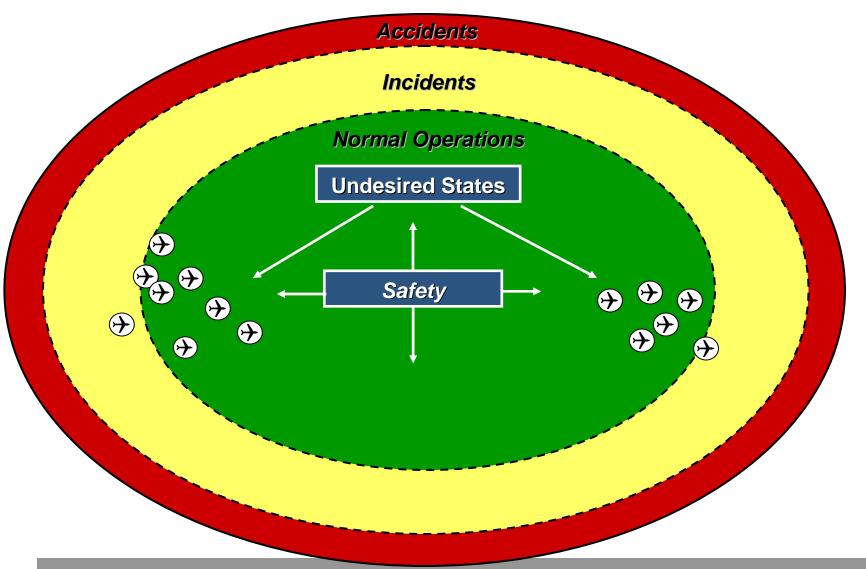


Aviation Safety Envelope





Safety Data Coverage





Case Study 1 – Enhancing Training (& a RVSM finding)



Enhancing Training

NOSS Finding

There were numerous instances of non-RVSM aircraft being cleared into the RVSM stratum (in contravention of procedures). Additionally, there was an instance in which coordination was poorly effected in relation to a non-RVSM aircraft

Response to finding

- Ensuing discussions came to the conclusion that controllers may not fully appreciate the implications of non-RVSM aircraft in the RVSM stratum.
- A component on RVSM operations was included in fresher training



Case Study 2 – Relation to Incident Data



NOSS and Incident Data

- Problem: An elevated number of incidents were attributable to "Hillside" controllers
 - > Incidents
 - Aircraft handed off at altitudes other than what was coordinated
 - TCAS RA aircraft were not vertically separated
 - Incident investigations
 - Events were occurring because of differences between the cleared Flight Level of aircraft and what the controller had entered into the electronic strip.
 - The number of these incidents varied greatly from month to month



NOSS and Incident Data

- Did NOSS data show similar findings?
 - Yes, an elevated number of Undesired States were observed in Hillside Airspace compared to other sectors.
 - These Undesired States were an "inaccurate representation of traffic", which was the same factor noted in the incident investigations
- What additional information did NOSS provide?
 - The underlying practices/behaviors that led to the incidents were identified
 - Errors Controllers were updating (pre-loading) the electronic strip before aircraft where being issued altitude instructions.



Case Study 2 – Runway Safety & Identifying Threats



Vulnerable Runways

- Problem: Monitoring runway activity is critical to preventing runway incursions and maintaining safety
- NOSS Findings:
 - Controllers were not scanning runways prior to issuing takeoff and landing clearances
 - Controllers were not spending enough time monitoring aerodrome movements.



Why were controllers not monitoring aerodrome movements?

- Were the controllers being irresponsible? NO!
- Threats: controllers were encountering threats that led to "heads down" time instead of monitoring aerodrome movements
 - Unnecessary automated messages
 - Flight Data Progress Strip (FDPS) distribution procedures
- Safety Improvements
 - Create a software filter to eliminate unnecessary messages
 - Change the procedure so the assistant sorts the FDPS instead of the aerodrome controller



Case Study 2 – The Predictive/Unexpected Finding!



The Unexpected Finding

- NOSS Findings: The ACC had a lot of frequency change issues in comparison to other NOSS Archive ACCs
 - Aircraft were not being given frequency changes by the prescribed locations
 - Controllers accepting the handoffs often did not realize that communication had not been established
 - In some instances, these aircraft were conflicting with other aircraft.
- The extent of this issue was a surprise!
- A highly publicized incident (at another ACC) brought this incident to attention towards the end of the NOSS data collection period



The Unexpected Finding

- Solutions discussed by NOSS team
 - Observers identified "best practices" utilized by controllers to ensure they knew which aircraft were on frequency. Controllers should have to used one of the identified best practices to indicate which aircraft were on frequency.
- Solutions implemented as a result of the incident
 - Controllers must use a strategy to indicate which aircraft were on frequency.



Case Study 5 – Informing Airspace Design



Identifying Threats – The BAY Sector

- Problem: The "BAY" sector had a reputation of being an unstructured and challenging piece of airspace, but there was little data from the SMS to support this reputation
- NOSS data supported the reputation and provided some details
 - More threats, mismanaged threats, errors, and undesired states in Bay than other sectors
 - Traffic conflictions, parachute activity, training aircraft, little airspace for vectoring or solving problems
 - Impartial observers agree, the sector is a mess!



Response to Findings

One sector in particular that was previously recognized as being unstructured, and containing a high number of threats was confirmed by the NOSS data to the point that a formal review was initiated. I would have to say it was not NOSS alone that lead to the review, but the factual information it provided gave considerable weight that lead to the final decision. Since the review the sector has undergone some wide ranging changes including improved procedures for controllers working the sector.

-- Provided by the BAY Manager



Fixing the shortcomings in BAY sector

- Solutions suggested (and adopted) by staff:
 - An area was dedicated for parachute activity that reduced demands on controllers
 - A circular flow structure was introduced that minimized conflictions and complexity
 - Confines of controlled airspace expanded to give more options/flexibility to controller
- A follow-up NOSS in 2008 (1st NOSS was in 2005) indicated that the airspace changes were largely successful in reducing complexity



Other Examples of Informing Airspace Design

- NOSS findings have been used to:
 - Reduce complexity in Vancouver area airspace during a major re-design of the airspace surrounding the city
 - Prioritize the development of STARs for airports that did not yet have STARS
 - Airports with more movements were to receive STARs first.
 - NOSS data showed the impact of not having STARs was greater at some of the airports with fewer movements – so these airports received STARs first.



Position Handovers - Improvements

- How can briefings be improved?
- The typical way of doing briefings
 - > Both controllers are responsible for the briefing.....
 - BUT, in practice the outgoing controller tells the incoming controller what they need to know
 - > The incoming controller often has a passive role
- The Challenge and Response Method
 - Incoming controller asks questions and the outgoing controller responds
 - More interactive
 - Best practice identified at Minneapolis ACC



Case Study 6 – Exchanging Information with Airlines



Exchanging Information with Airlines

- Issue: Controllers are usually the largest sources of threats to pilots
- Issue Part II: Pilots are usually the largest source of threat to controllers
- There could be great benefit in airlines and ATC providers exchanging LOSA/NOSS information regarding the impact they are having on one another



Exchanging Information with Airlines - Examples

- Pilots were having difficulty complying with a SID at a major airport
 - NOSS Data Pilots were not always able to comply with a particular SID
 - LOSA Data Pilots were having difficulty making SID restrictions; aircraft type and weight were a factor
 - The SID was re-designed to enhance flight crew ability to comply
- Similar call signs



Case Study 7 – The Value of Objective Data



The Value of Objective Data

"The greatest benefit of the project was getting documented, analyzed data on most of the "small" things many controllers were already aware of. The main threat in our NOSS was primarily noise and bad acoustics in the operations room. This has been the topic of coffee-table discussions for as long as I remember; now it's on paper as a real problem. Also, by taking a step back and looking at operations, we noticed a few things that nobody had really thought of before. Like the layout of the operations room, causing "traffic flows" and mingling of controllers on their break, in close vicinity to those working." -- Provided by a NOSS observer and project manager



The Value of Objective Data

"As a direct, tangible result of the noise findings, a specialist acoustics planning company was brought in to fix it. Noise damper paneling has been installed in the ceiling and the walls, this work will continue as we switch over to the new controller operating positions and the old ones are removed. This would certainly never have been done without the NOSS findings." -- Provided by a NOSS project manager



Case Study 8 – Position Relief Briefings



Position Handovers

- Problem: FAA research shows that incidents are more likely to occur shortly after a position handover
- NOSS Findings:
 - In multiple NOSSs, there have been vulnerabilities identified surrounding the handover of positions
 - Position relief checklists not being used
 - Incomplete information given during briefings
- This has been the most consistent finding across all NOSSs!



Position Handovers - Improvements

How can briefings be improved?

- Improving Checklists
 - In many places, controllers did not use checklists because they did not see them as relevant
 - Make checklists specific to each sector and focus on what is different in today's operations



Intangible Benefits of NOSS



Intangible Benefits

Observer Level

- Observers report that they learn a lot from their experience – in some cases, they have changed their own practices
- Greater understanding of how their work impacts other controllers
- Observed best practices are incorporated into their own work/sectors.
- Training instructors have new tools to use with their trainees



Intangible Benefits

- Organizational Level
 - New processes are developed to deal with predictive safety information
 - Previously, organizations were more accustomed to dealing with "crisis" information from failures
 - Enhanced trust from controllers and management working together on a safety project

"NOSS created the <u>trust</u> to pursue other projects such as the Just Culture Initiative at NAV CANADA."

Greg Myles, CATCA President IFATCA Regional Meeting (Aruba) November 2007



Avenues of Improvement - Summary

Airspace Re-design

- Served as a catalyst to change a piece of highly unstructured and complex piece of airspace that had long been a concern amongst controllers
- Used to reduce complexity in a major re-design of Vancouver area airspace
- Prioritize the development of STARs for airports where a lack of STARS had a high observed degree of impact.

Procedures

- Provisions for splitting sectors or adding a data position
- Releasing equipment for maintenance
- Position relief protocols
- Strip writing procedures
- > Equipment/Workspace
 - Shortcuts taken by controllers identified
 - Noise dampening panels
 - > Special lighting added to sectors with glare problems



Avenues of Improvement - Summary

> Training

- > Findings used to enhance refresher or recurrent training
- Special training modules developed discussing NOSS and Incident data from a TEM perspective

Information Exchange

- Problematic SID re-designed after consultation with airline
- Similar call signs one airline changed the manner in which they numbered their fights
- Aircraft operating without proper equipment have been identified and paths to remedy this situation have been implemented
- ATC providers are exchanging 'best practices'
- Intangibles perhaps the most impressive benefit of all!
 - > Observers gain a different perspective
 - ATC organizations have developed new methods of dealing with predictive safety data
 - Enhanced trust between controllers and managers





PISC Overview Presented by Harry Roberts

Nairobi Kenya

(20th April 2010)







- **→**Summary
- → AFI Safety Policy
- > PISC
- **→** Aim and Purpose
- → AFI RVSM Programme
- → Actions Proposed





SUMMARY

- → Implementation of RVSM
 - Compliance with international activity relating to RVSM
 - Improvement to Safety in the AFI Region environment
- → Traffic Forecasts
- **→** Cost Effective
 - Operator efficiency
 - Reducing fuel costs by operating closer to optimum trajectory
- → Additional Flight Levels
- → Environmentally beneficial.





DISCUSSION AFI SAFETTY POLICY

- Established guidelines for implementation activities
- → The policy elements as reflected in that document were:
 - RVSM Functional Hazard Analysis
 - Collision Risk Assessment
 - National Safety Plans
 - AFI RVSM Pre-Implementation Safety Case(PISC)
 - AFI RVSM Post-Implementation Safety Case(POSC)



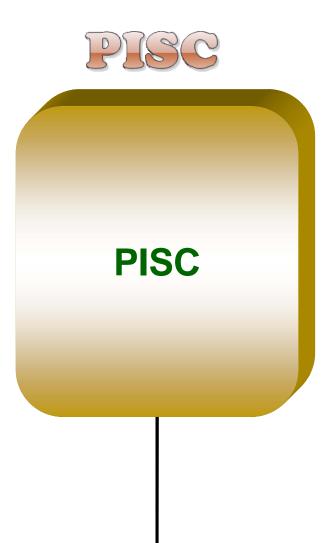




- → Project Management team resolved to model implementation on Eurocontrol Model.
- →Three legs:
- → FHA, CRM, National Safety Plans











AIM AND PURPOSE

→ RVSM implementation not to contribute to an increase in risk, or incidents within the airspace more than what was currently being experienced, while improving on efficiency, contributing to economic benefit and reducing impact on the environment.





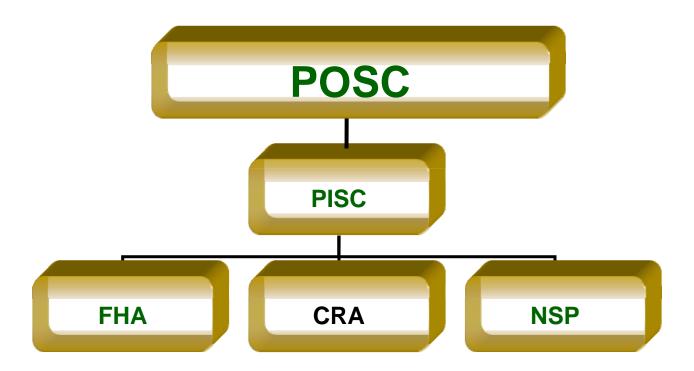
AFI RVSM PROGRAMME

- → Consists of 5 Sub-programmes to ensure and provide evidence on the Compliance of the AFI RVSM Programme which are
 - Functional Hazard Assessment (FHA) report
 - Collision Risk Assessment (CRA) report
 - National Safety Plans (NSPs)
 - Pre Implementation Safety Case (PISC)
 - Post Implementation Safety Case (POSC)













AFI STATES

Algeria	Angola	Benin	Botswana	Burkina Faso	Burundi
Cameroon	Cabo Verde	Central African Republic	T'chad	Comores	Congo
Côte d' Ivorie	Djibouti	Democratic Republic of Congo	Egypt	Equatorial Guniea	Eritrea
Ethiopia	Gabon	Ghana	Guinea Bissau	Guinea	Kenya
Lesotho	Liberia	Libyan Arab Jamahiriya	Madagascar	Malawi	Mali
Mauritania	Mauritius	Mozambique	Namibia	Niger	Nigeria
Reunion	Rwanda	Sao Tome	Senegal	Seychelles	Sierra Leone
Somalia	South Africa	Sudan	Swaziland	Tanzania	The Gambia
Togo	Uganda	Zambia	Zimbabwe		





ACTIONS PROPOSED

Seminar:

→ While the format of the FHA originally conducted, may not compliment the current ICAO hazard assessment, the hazards which were identified during the implementation process are as valid today as they were then and sight should not be lost of the fact that reviews of hazards present in the airspace are as important now as when they were first identified.





END OF PRESENTATION

Thank you

Asante

Merci

RVSM Implementation Safety System Seminar

KENYA RVSM EXPERIENCE INCLUDING OPERATIONS OF STATE AIRCRAFT



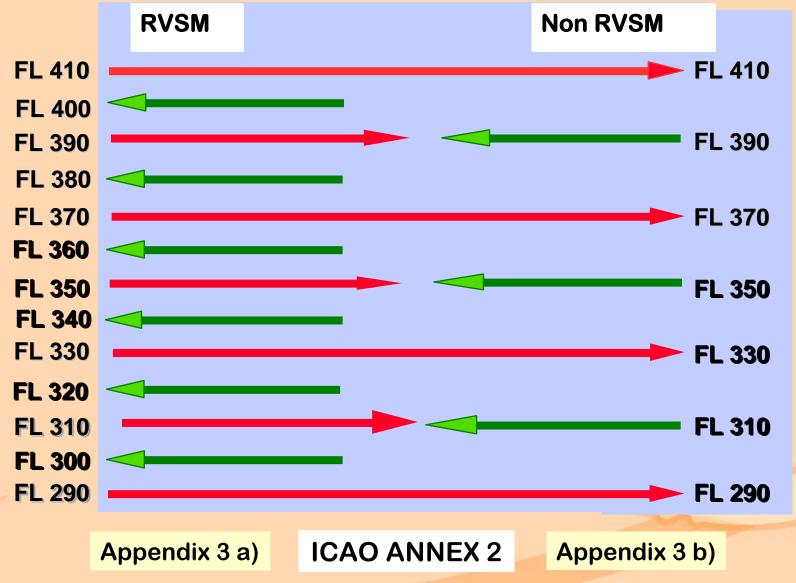
Kenya joined the rest of AFI
Region in implementing the RVSM
on 25 September 2008. This paper
presents Kenya's experience on
RVSM experience including State
aircraft operation.



- RVSM is an aviation term used to describe the reduction of standard ICAO Conventional Vertical Separation Minima (CVSM) required between aircraft operating between FL290 and FL410 inclusive from 2000FT to 1000FT.
- This has effectively increased the number of aircraft that can operate between the above mentioned levels by an additional six flight levels being introduced.



ICAO Tables of Cruising Levels





 Kenya's experience is that before the implementation of RVSM we used to experience a lot traffic delays especially for aircraft that used to operate between Nairobi and Europe. The applicable Flight levels were 310; 350 and 390 for west bound traffic whereas for Eastbound traffic 290, 330 and 370.



- The optimum level used to be 310. It was common for flights to experience 30 or more minutes waiting for availability of optimum level. Alternately the flights would opt for lower levels which would at times even be FL260.
- With the introduction of six additional levels became available and this effectively increased the number of aircraft that can operate between the above mentioned levels by an additional six flight levels. Today ATC delays because of nonavailability of levels are minimal.



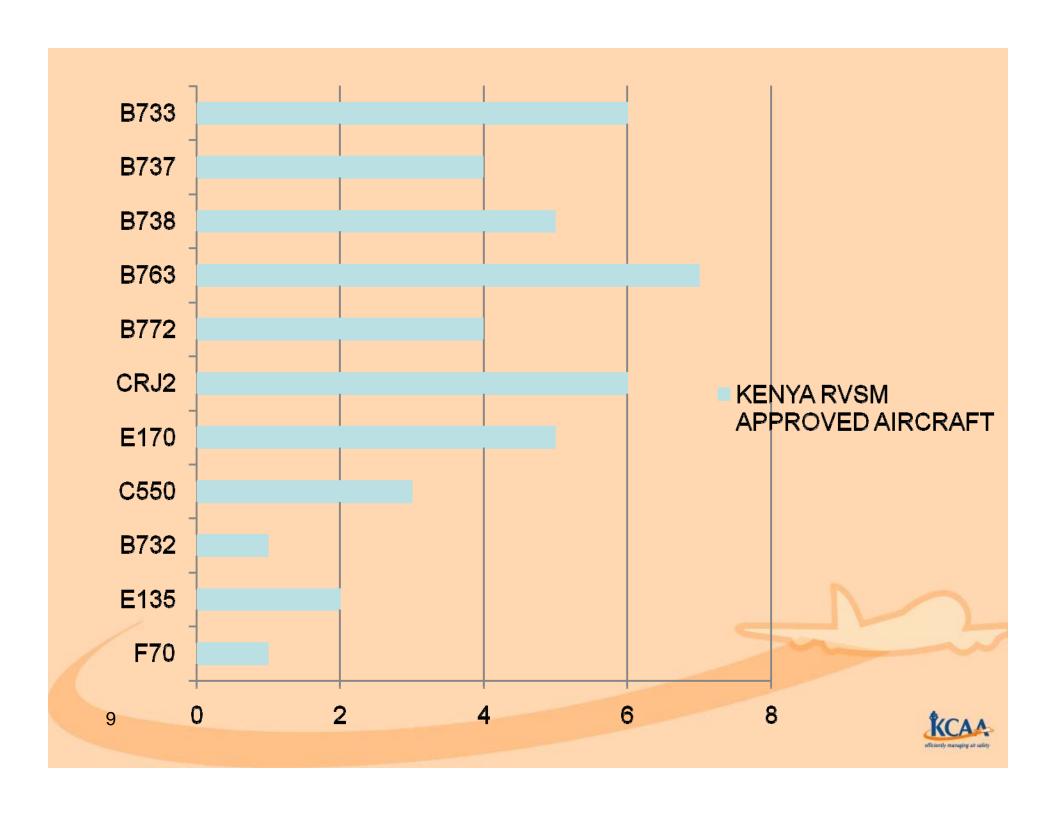
AIRCRAFT AND OPERATIONS APPROVAL

- In order to sustain the gains and benefits associate with RVSM operation, only aircraft with the required Minimum Aircraft System Performance Specification (MASPS) and approved by their respective States for RVSM operations are permitted to fly in RVSM airspace.
- Non compliant aircraft, excluding State aircraft, are required to operate at or below FL280.



- Our experience is that most aircraft operating in the RVSM airspace do have aircraft operations approval. However occasionally we might have operators who obtain operations approval without getting aircraft RVSM approval.
- We also find the operator who obtain aircraft RVSM aircraft approval and would like to utilize the Aircraft before the information is distributed to respective units including ARMA (Friday evening syndrome).





Large Height Deviation monitoring

- As air Navigation Providers we are required to ensure aircraft do operate at assigned flight levels. Any large height deviation (LHD) by an aircraft is required to be reported to ARMA.
- Our experience is that most flights are operating on assigned levels and LHD deviations has occurred if the ATC Units are not informed of level change by transferring unit.



LHD (cont)

- Our experience is that there are frequent level changes associated with aircraft performance and availability of optimum cruising levels.
- Frequent level changes require effective coordination with adjacent units.
- This has been achieved through rapid and reliable communication links thanks to NAFISAT.



Aircraft operation data

- Kenya recognizes her obligation in collecting and disseminating data to ARMA for analysis and reporting on monthly basis. This requires dedicated staff and also systems that are capable of extracting automatically the required data.
- Kenya has endeavored to do so however we have experienced some challenges as our data is collected and processed manually before transmission to ARMA.
- Kenya expects to overcome this challenge by commission new ATC systems at JKIA within the next one month.



Incidents due RVSM Operations

- Kenya has not experienced any ATC incidents due RVSM operations. However we have had a few ATC incidents /AIRPROX that are associated with:
- Lack of ATC anticipation/ATC situational awareness/ATC proficiency
- Lack of coordination between ATS units and cockpit discipline



Abnormal operations that would affect the safe operations in RVSM airspace

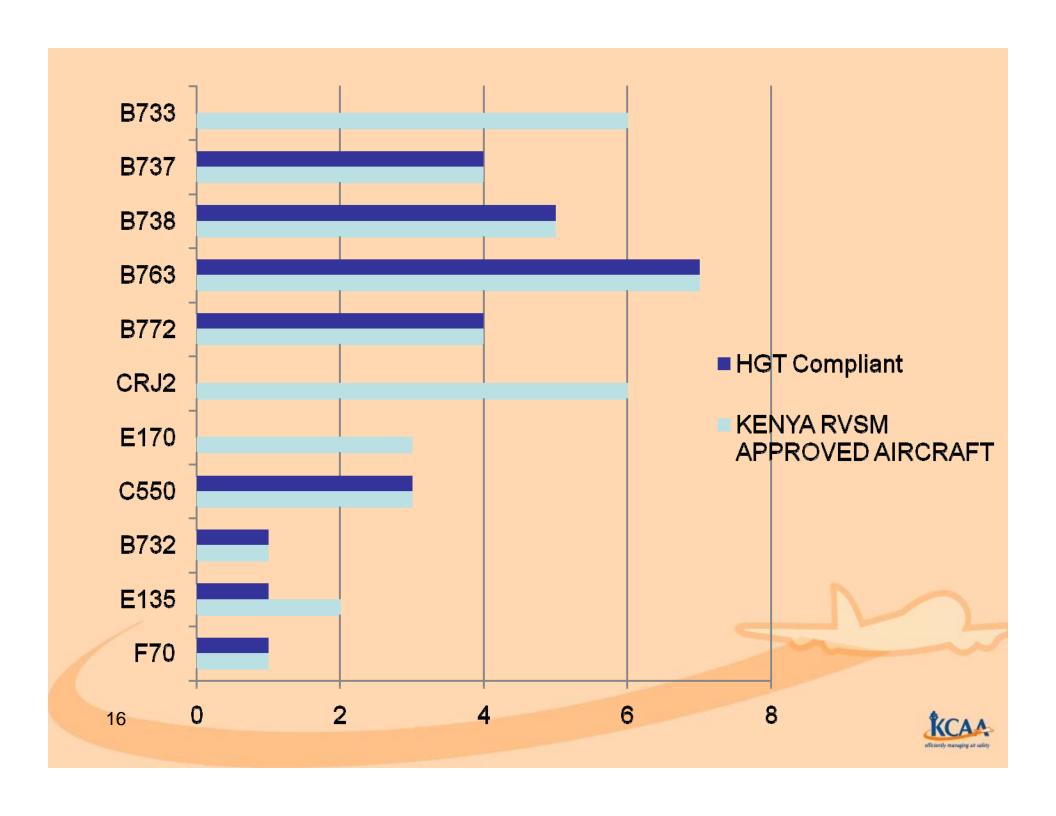
- Kenya has not experienced abnormal occurrences that would have direct impact on safety assessment in Kenyan airspace except occasional request by flights to operate at different levels due moderate turbulence.
- We have not had the necessity to suspend RVSM operations.



Aircraft Height Monitoring

- In order to ensure continued safe operation of aircraft in RVSM airspace; aircraft are required to undergo routine height keeping monitoring.
- To date we have 42 Kenyan RVSM approved aircraft. Sixteen (16) of these aircraft especially those that operate regionally have not participated in height monitoring exercise.
- This requires to be addressed. Aircraft operators are required to make arrangements





A BRIEF HISTORY OF RVSM

SAULO SILVA
ATM Section
Air Navigation Bureau, ICAO HQ
April 2010



Objective

To present a brief history related to the development and implementation of RVSM.



Outline

- >The Beginning
- ► The Vertical Separation Panel
- ➤ Early Regional Air Navigation (RAN)
 Meetings
- **≻**RGCSP
- >Time for development
- Results



THE BEGINNING

- ➤ 1940s: 1,000 feet (300 meters) in all cases except 500 feet (150 meters) when:
 - □ Aircraft are being flown in conditions of flight visibility of less than 3 miles (5km) but not less than 1 mile (1.5 km).
 - □ Aircraft are holding above a well defined top of cloud or other formation during the hours of darkness if the pilot reports indicate the forward visibility is not less than 1 mile (1.5 km).



VERTICAL SEPARATION IN THE 1940s

- Aircraft are on flight paths which will cross at or near a reporting point, provided that the aircraft concerned are using the same altimeter setting.
- □ No separation is required for enroute traffic above a well defined top of cloud or other formation if frequent in-flight weather reports indicate a generally unlimited ceiling on top and flight visibility of at least 3 miles (5km). During the hours of daylight, holding aircraft operation under these conditions will require no separation.



THE VERTICAL SEPARATION PANEL

- The advent of commercial turbo jet aircraft operating at high levels necessitated a reevaluation of the vertical separation minimum.
- ➤ A Vertical Separation Panel was therefore formed in June 1954.
- The Panel identified those factors which were likely to contribute towards the greatest loss of separation and proposed steps that should be taken to reduce or eliminate their influence.



The 1958 RAC/SAR Divisional Meeting

"The vertical separation minimum shall be 305 meters (1000 ft) except that, above a level to be determined on the basis of Regional Air Navigation Agreements, 610 meters (2000 ft) shall be established as the vertical separation minimum. This level should not be higher than an altitude of 8850 meters (29000 ft) or flight level 8850 metric (290)".



The 1958 RAC/SAR Divisional Meeting

The vertical separation minimum between IFR traffic shall be a nominal 300 meters (1000 ft) below an altitude of 8850 meters (29000 ft) or flight level 290 and a nominal 600 meters (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 600 meters (2000 ft) vertical separation minimum.



THE FOURTH NAT REGIONAL AIR NAVIGATION (RAN) MEETING - 1960

That, in view of the importance of vertical separation criteria in the planning of Air Traffic Services for NAT Region, as well as for other regions of high traffic density, the work of the Organization in the field of vertical separation be pursued vigorously to an early conclusion and be presented in a form suitable for early application in regional ATS.



THE 1963 RULES OF THE AIR AND AIR TRAFFIC SERVICES - OPERATIONS (RAC/OPS) DIVISIONAL MEETING

That in view of the importance of vertical separation in the planning of air traffic services particularly in regions of higher traffic density and the desirability of reducing vertical separation intervals above Flight Level 290, work in the field of vertical separation be vigorously pursued by all concerned to an early conclusion and presented to ICAO in a form suitable for early application in ATS planning on a world-wide basis, or, if this is not attainable, at least on a regional basis.



SPECIAL NAT RAN 1965 MEETING

➤ Recommendation - Technical Measures by States and Operators of aircraft intended to be used for operation in that part of the NAT Region where 1000 feet vertical separation is to be applied above FL290:



SPECIAL NAT RAN 1965 MEETING

- Ensure as soon as possible that operators are taking all necessary measures for installation, calibration and maintenance of altimeter systems and autopilots in accordance with the latest available methods; and
- Assure themselves as soon as possible by means of flight tests, as appropriate, that calibration, maintenance and operating techniques used by the operators are such as to achieve the necessary degree of reliability and accuracy of altimeters and autopilots.



1966

- The changeover level was established at FL 290 on a global basis
- 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
- Accordingly, ICAO provisions stated that such a reduced VSM could be applied under specified conditions within designated portions of airspace on the basis of regional air navigation agreement.



1970

World fuel shortages and the resultant rapid escalation of fuel costs

Growing demand for a more efficient utilization of the available airspace, emphasized the necessity for a detailed appraisal of the proposal to reduce the VSM above FL 290.



DEVELOPMENT OF THE RVSM - WHY SO MUCH INTEREST?

- ➤ fuel-burn penalty of about 1 percent for each 1000 ft below optimum cruise altitude
- ➤ RVSM was single best thing to do fuel-burn reduction far outweighed any horizontal plane separation reductions, for example, 30 NM lateral/30 NM longitudinal
- RVSM provides (theoretical) doubling of capacity in same airspace
- achievable without major change to aircraft or ATC system
- ➤ 1971 RGCSP/1



REVIEW OF THE GENERAL CONCEPT OF SEPARATION PANEL

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



REVIEW OF THE GENERAL CONCEPT OF SEPARATION PANEL

- ➤RGCSP/6 (1988): "Recommended that RVSM was technically feasible"
- ➤RGCSP/7 (1990): draft RVSM guidance material was produced Doc 9574
- ➤ICAO ANC (1990): approved draft guidance material and draft Standards and Recommended Practices (SARPS) to Annex 2

> 1997 – 27 March, First RVSM Implementation



WHY SO LONG?

- ➤ 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 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 levels 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 + FTE(AAD)

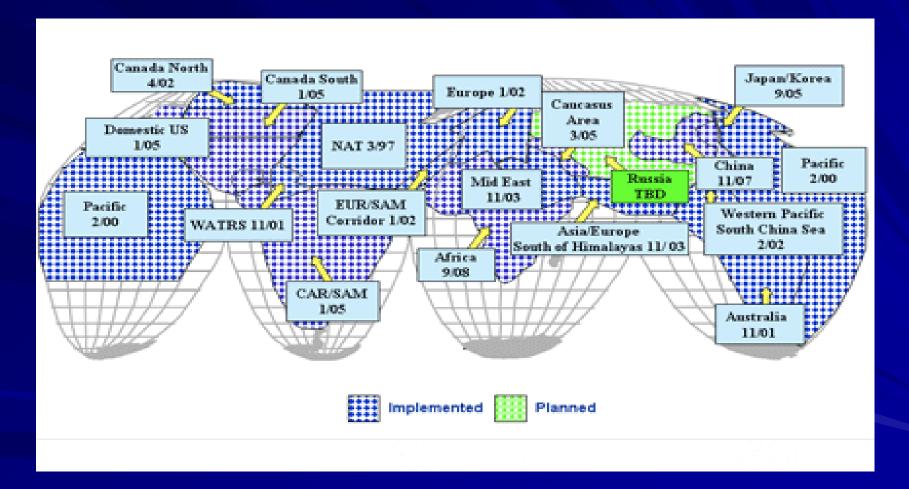


WAS IT WORTH IT?

- Operators have found benefits greater and costs less than predicted
- > ATC units report little difficulty with RVSM procedures
- > ATC units able to offer more desirable routings
- ➤ ATC units report RVSM provides more operational flexibility.



WAS IT WORTH IT?





Outline

- The Beginning
- ► The Vertical Separation Panel
- ➤ Early Regional Air Navigation (RAN)
 Meetings
- **≻**RGCSP
- >Time for development
- Results

A BRIEF HISTORY OF RVSM

THANK YOU

QUESTIONS?

SAULO JOSÉ DA SILVA SDASILVA@ICAO.INT

TECHNICAL REVIEW OF RVSM

SAULO SILVA
ATM Section
Air Navigation Bureau, ICAO HQ
April 2010



Objective

To present some technical aspects related to the implementation and safe use of RVSM.



Outline

- ➤ General requirements
- >Implementation planning
- > Aircraft requirements
- System performance monitoring
- ▶ Responsibilities
- Challenges
- **≻**Example



GENERAL REQUIREMENTS

>SAFETY OBJECTIVES

The implementation and use of RVSM is based on the satisfaction of safety objectives

Technical risk – 2.5 10E-9

Overall risk - set by regional agreement

Overall risk – 5.0 10E-9



GENERAL RQUIREMENTS

- ➤ Reduction in the level of risk of collision resulting from operational errors and in-flight contingencies in RVSM airspace
- ➤ To institute measures to ensure that the risk due to operational errors and in-flight contingencies does not increase following the reduction of vertical separation
- ➤ To guarantee that the implementation of RVSM will not adversely affect overall airspace safety



GENERAL REQUIREMENTS

GLOBAL SYSTEM PERFORMANCE SPECIFICATION

- Defines the height-keeping performance necessary to meet the safety goal for RVSM technical risk
- a) a **passing frequency equal to 2.5** opposite-direction passings per aircraft flight hour;
- b) a standard deviation of lateral path-keeping error equal to 550 m (0.3 NM); and
- c) a probability that two aircraft will lose procedural vertical separation of RVSM value, **Pz(1 000)**, equal to 1.7 × 10-8



GENERAL REQUIREMENTS

- GLOBAL HEIGHT-KEEPING PERFORMANCE SPECIFICATION
- Required Pz(1 000) value of the global system performance specification be met
- a) the proportion of height-keeping errors beyond 90 m (300 ft) in magnitude is less than 2.0 × 10-3;
- b) the proportion of height-keeping errors beyond 150 m (500 ft) in magnitude is less than 3.5 × 10-6;
- c) the proportion of height-keeping errors beyond 200 m (650 ft) in magnitude is less than 1.6 × 10-7;

and

■ d) the proportion of height-keeping errors between 290 m and 320 m (950 ft and 1050 ft) in magnitude is less than 1.7 × 10-8



GENERAL REQUIREMENTS

The mentioned requirements have been the basis for the development of the RVSM minimum aircraft system performance specification (MASPS).



The implementation planning

- CONSIDERATIONS
- The introduction of RVSM is based on a regional air navigation agreement
- All aircraft operating within the designated airspace must meet the height-keeping performance



The implementation planning

Factors considered

- Ability of the ATS infrastructure to fully support RVSM, including examination of the equipment and procedures necessary to achieve the goal of the elimination of operational errors;
- State procedures for ensuring that aircraft on their registry, or for which they have a responsibility because they are the State of the Operator, do not operate in RVSM airspace unless approved to do so.



OPERATING CONDITIONS

- Transition procedures
- IFR
- Contingency plans
- Strategic ATC procedures when system performance monitoring indicates that established tolerances are exceeded



IMPLEMENTATION STRATEGY

- > Identified the need for RVSM
- > Preliminary assessment of system safety
- > Plan and preparation
- ➤ Verification phase
- ➤ Operational use of RVSM



OPERATIONAL USE OF RVSM

- It will be necessary to ensure continued system safety
- Particular attention will be required to ensure that:



OPERATIONAL USE OF RVSM

- 1) all aircraft operating in RVSM airspace are RVSM approved
- 2) the RVSM approval process remains effective
- 3) the TLS continues to be met
- 4) additional safety measures, introduced to reduce the risk as a result of operational errors
- 5) evidence of altimetry system error (ASE) stability exists
- 6) ATC procedures remain effective.



AIRCRAFT REQUIREMENTS AND APPROVAL

- □ RVSM HEIGHT-KEEPING PERFORMANCE
- performance level that aircraft need to be capable of achieving in service (RVSM MASPS)
- □ AIRWORTHINESS APPROVAL
- group or non-group
- **□** CONTINUED AIRWORTHINESS
- operator maintenance and inspection practices



AIRCRAFT REQUIREMENTS AND APPROVAL

□ STATE RVSM APPROVAL

Will encompass:

- Airworthiness approval (including continued Airworthiness)
- Operational approval procedures that an operator may need to adopt for the airspace where RVSM is applied.



VALIDITY OF APPROVAL

RVSM approval issued for one region will always be valid for RVSM operations in another region provided that specific operational approval is not required.

■ The State of the Operator/State of Registry should formulate policies and courses of action with respect to aircraft/operators that are found to be operating in RVSM airspace without approval, which could jeopardize the safety of other users of the airspace.



SYSTEM PERFORMANCE MONITORING

- The objective is to ensure that the operation of RVSM meets the safety objectives
- the monitoring of aircraft technical height keeping performance aims to achieve the following:
- a) confidence that the technical TLS of 2.5 × 10-9 fatal accidents per aircraft flight hour will be met;
- b) provide guidance on the efficacy of the RVSM MASPS and on the effectiveness of altimetry system modifications; and
- c) provide evidence of ASE stability.



MONITORING THE TECHNICAL PERFORMANCE

CRM parameters for monitoring

First group

- a) vertical overlap probability, P_z (1 000)
- b) airspace parameter (exposure to vertical collision risk):

For opposite and same direction:

- 1) passing frequency
- 2) lateral overlap probability, $P_v(0)$.

For crossing and direct routings:

"Frequency of passing events involving horizontal overlap"

Second group

- c) aircraft relative speeds
- d) aircraft dimensions



ASSESSMENT AND EVALUATION OF OPERATIONAL ERRORS

- The frequency of occurrence of these errors is not considered to be a function of the separation minima applied
- The monitoring process will involve the collection of operational data, and appropriate methodologies to process this data to enable comparison with the agreed overall safety objectives
- The data may come from different sources



ASSESSMENT AND EVALUATION OF OPERATIONAL ERRORS

- People reviewing and acting on these data should be prepared to take action as necessary
- In the case of an unacceptable risk increase, a thorough assessment of the cause of the risk increase must be done, with increased monitoring vigilance to ascertain that the follow-up actions have the required riskcompensation and/or risk-reducing effect.



- The evaluation of system performance encompass specific tasks of the various bodies which form a typical regional organization:
- a) regional planning group;
- b) regional monitoring agency; and
- c) air traffic control.



- Responsibilities of the regional planning group (RPG)
- ➤ Has the overall responsibility for deciding that RVSM should be implemented and continued.



Responsibilities of a regional monitoring agency (RMA)

➤ Has the overall responsibility for monitoring the different data associated with RVSM operations and report to the RPG.



Role of the appropriate ATC authority

➤ To gather information on and report any deviation equal to or greater than 90 m (300 ft), for any reason, from cleared levels whether the deviation causes an incident or not.

This information will contribute to the assessment of the level of overall risk in the system by the RMA.





BACKGROUND

- First implementation of the RVSM was 1997; ICAO promulgated 2000-ft standard in 1958
- So.....Why did it take so long to make the change?
- Answer: Developing sufficient, reliable information on aircraft height-keeping performance is a challenging task
- Aircraft height-keeping performance is the result of the performance of two aircraft systems: altitudekeeping system and altimetry system



Aircraft Height-Keeping Systems

- Altitude-keeping system
 - Feedback control system designed to keep pressure altitude flown by aircraft at a commanded value
 - Performance of system can be observed by both flight crew (altimeter reading) and air traffic control (secondary surveillance radar Mode C)
 - Common practice in RVSM work to refer to error in altitude keeping system as Assigned Altitude Deviation (AAD), similar to flight technical error



Aircraft Height-Keeping Systems

Altimetry system

- Barometric pressure sensor/transducer which translates ambient static pressure measured at an orifice on aircraft to geopotential feet (pressure altitude) by means of ICAO Standard Atmosphere
- Performance of system cannot be observed by either flight crew or air traffic control
- Error in this system referred to as altimetry system error (ASE)



Technical Challenge: Obtaining Empirical Evidence Concerning Aircraft Height-Keeping Performance

- Empirical evidence of height-keeping performance informs requirements-development process
 - Must know limits on feasible height-keeping performance in order to develop meaningful standards
- Empirical evidence of height-keeping performance permits assessment of individual-aircraft compliance with requirements
 - Assessment process is termed "monitoring height-keeping performance"
- Empirical evidence of height-keeping performance supports overall assessment of airspace system with RVSM safety goals



Technical Challenge: Obtaining Empirical Evidence Concerning Aircraft Height-Keeping Performance

- Aircraft assigned to fly a constant pressure altitude are attempting to adhere to an isobaric surface
 - A constant-pressure surface, but not a constantgeometric-height surface
- Obtaining empirical evidence concerning height-keeping performance requires estimation of geometric height of aircraft and estimation of geometric height of isobaric surface defining the constant pressure altitude to which the aircraft is assigned by air traffic control



Technical Challenge: Obtaining Empirical Evidence Concerning Aircraft Height-Keeping Performance

- Overall error in adhering to flight level is termed "total vertical error" (TVE)
- Because of the statistically independent and additive nature of the two height-keeping system error sources:
 - **TVE = ASE + AAD**
 - or
 - ASE = TVE AAD
- Figure illustrating difficulties of obtaining empirical evidence of aircraft height-keeping performance for aircraft assigned to 35,000-ft pressure altitude (FL350)



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 + FTE(AAD)



MEETING THE TECHNICAL CHALLENGE

- Develop process to estimate TVE, ASE and AAD to support RVSM
- Need to estimate:
 - Geometric height of aircraft
 - Geometric height of flight level
 - AAD



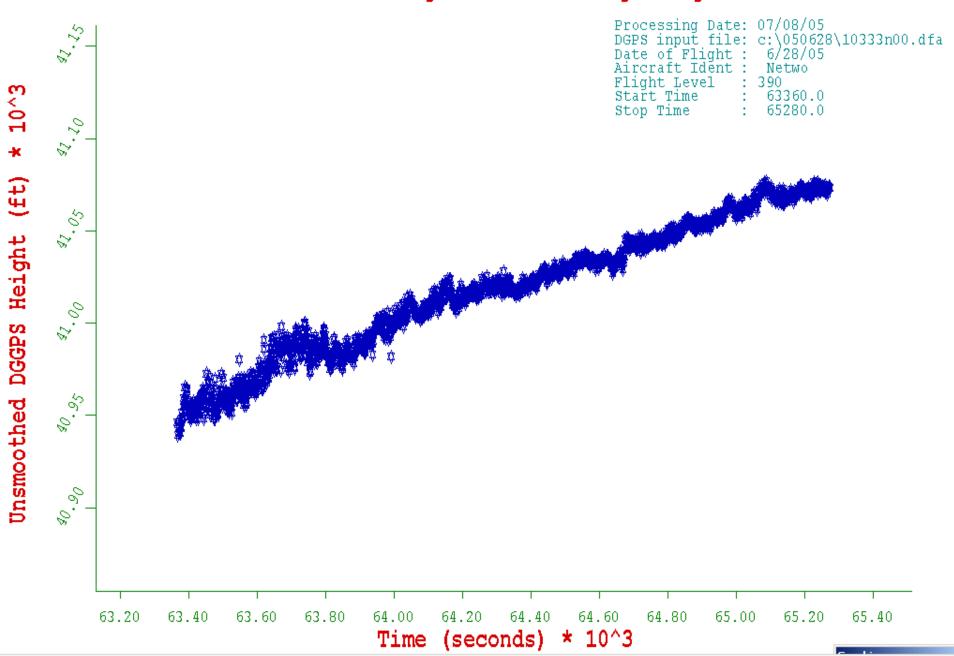
Example Of Estimation of Height-Keeping Performance

Varig Flight 8923 – VRG8923

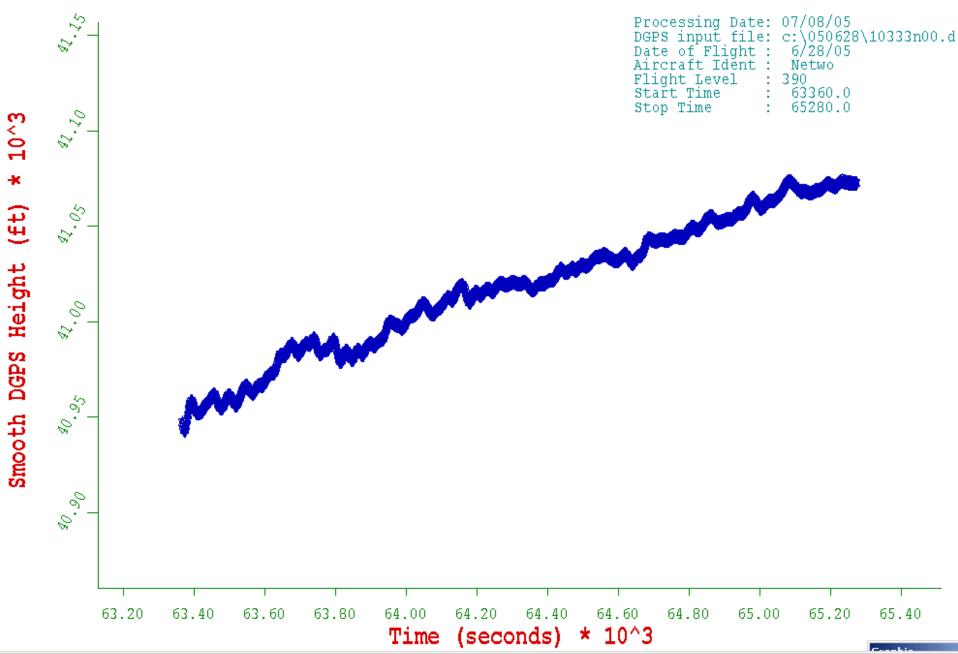
■Boeing 737-800

Monitored in flight over Brazil while in revenue service

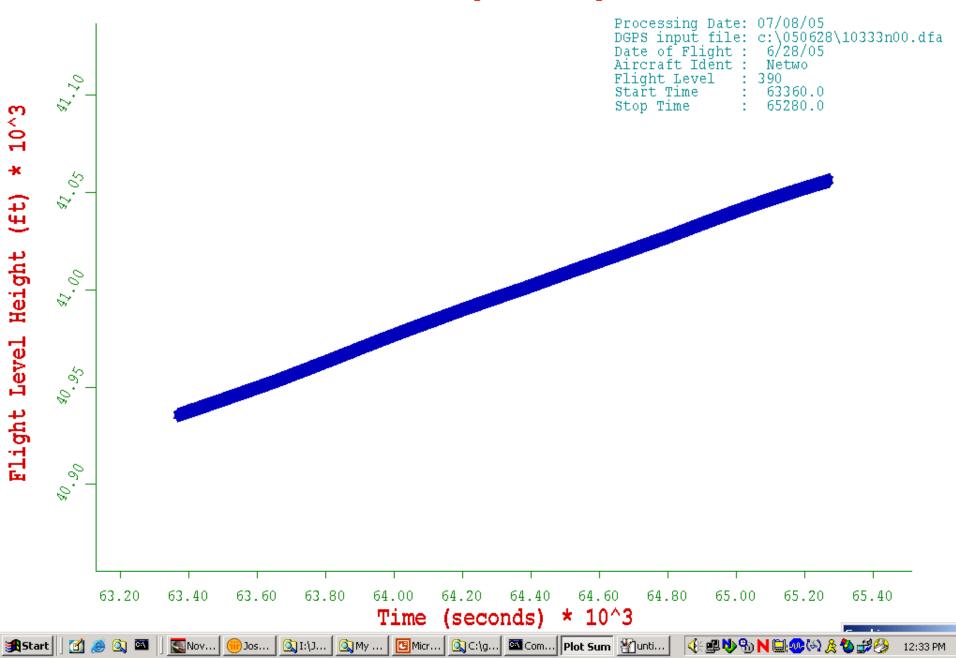
Geometric Height of Level Flight Segment

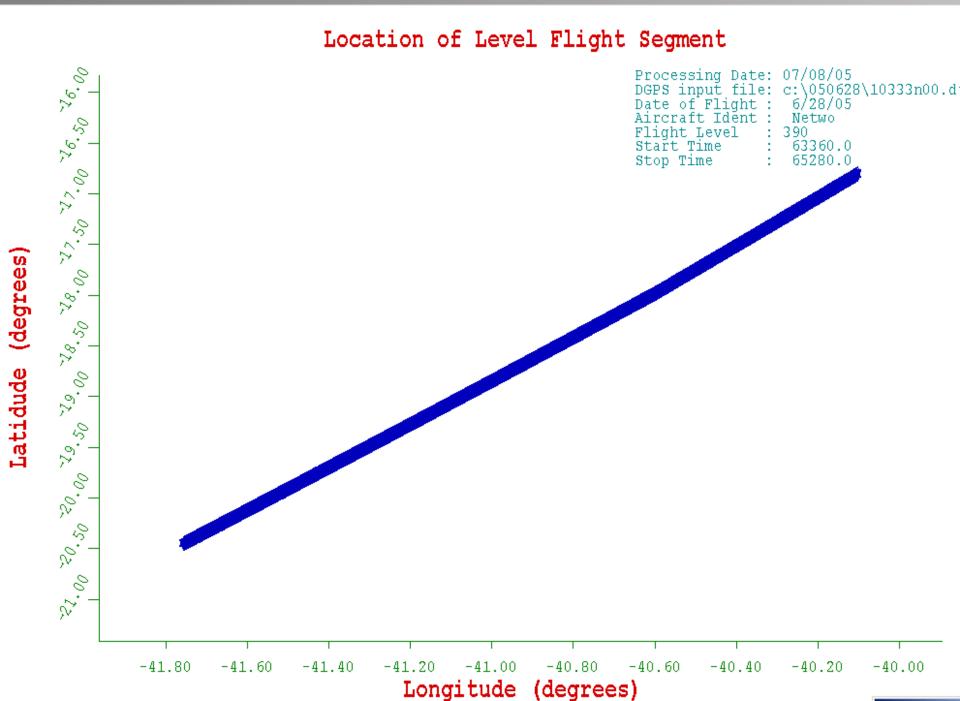


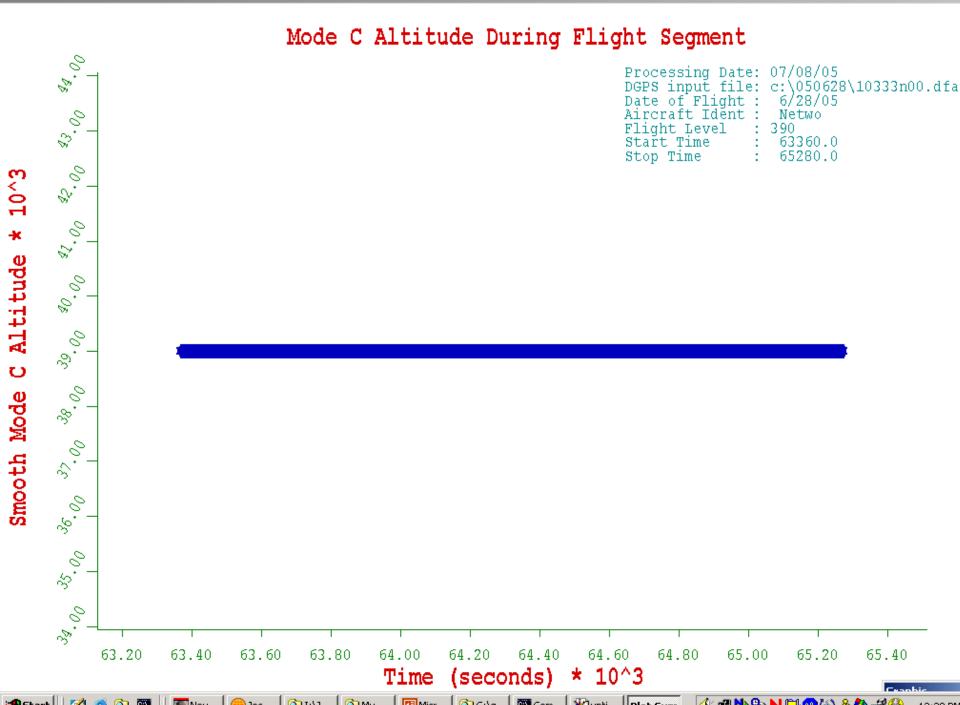
Geometric Height of Level Flight Segment



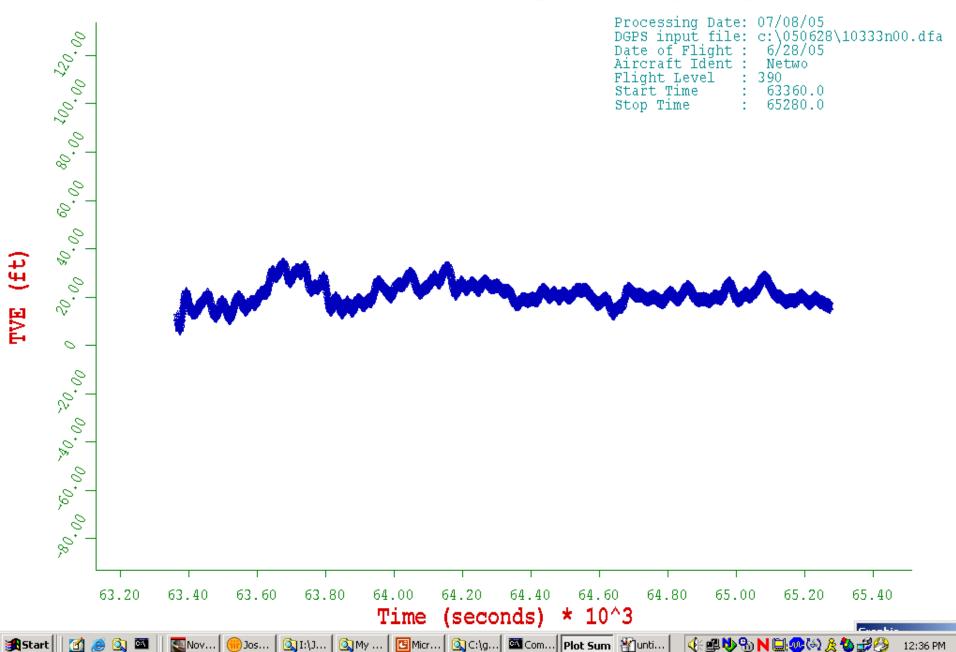
Geometric Height of Flight Level

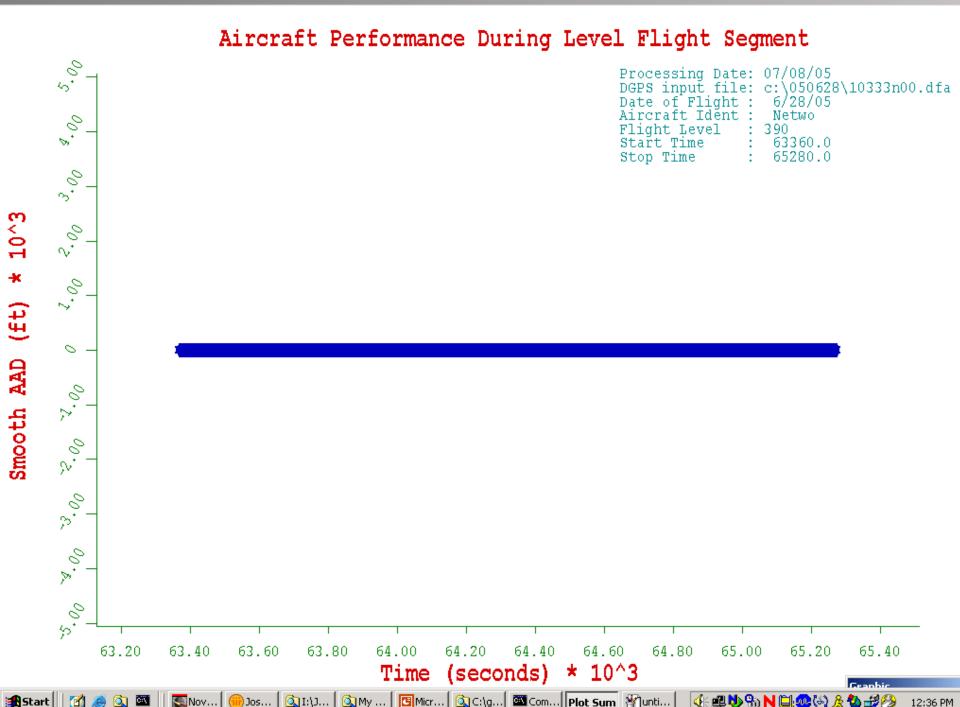




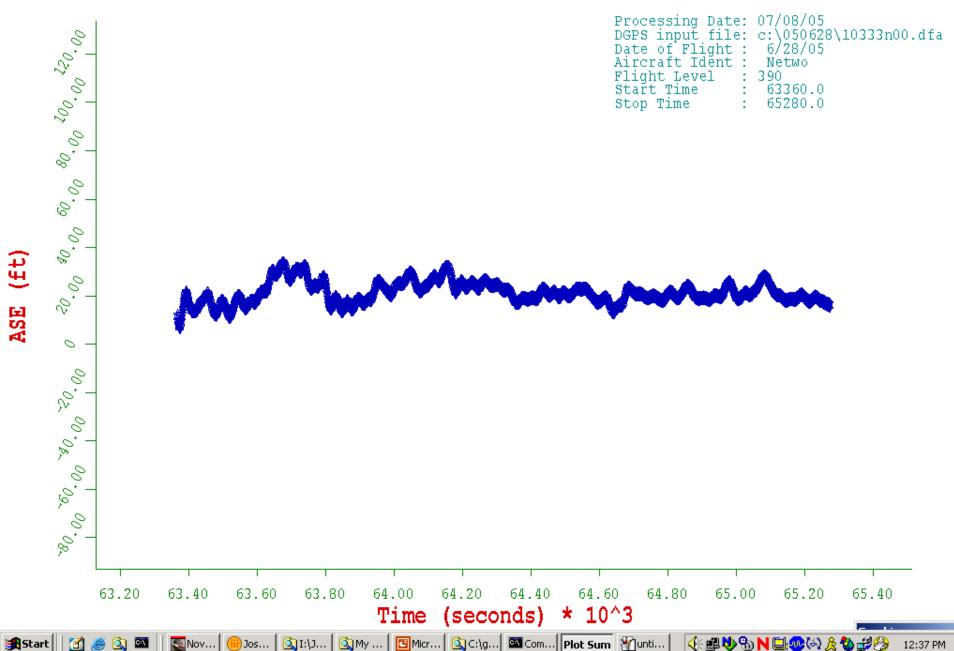


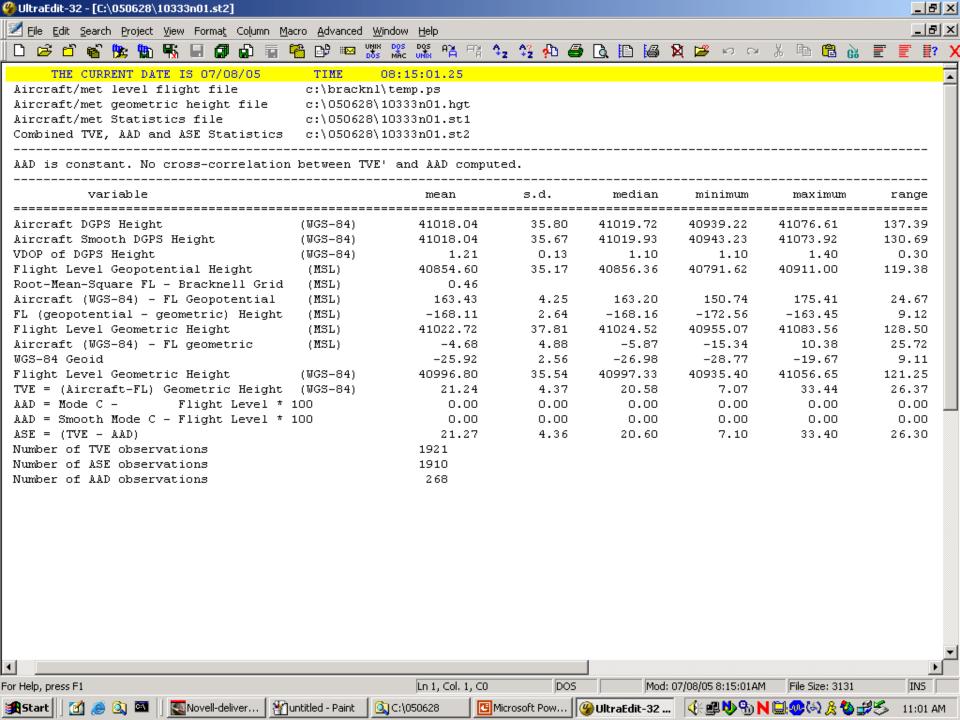
Aircraft Performance During Level Flight Segment





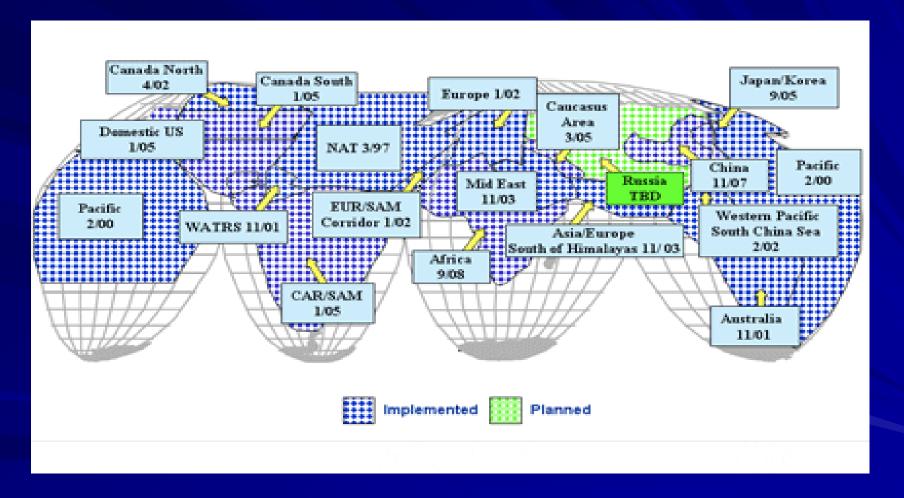
Aircraft Performance During Level Flight Segment







RVSM IN THE WORLD



TECHNICAL REVIEW OF RVSM

Thank you!

SAULO SILVA sdasilva@icao.int

The Global ATM System

Setting the Scene

Saulo Silva
ATM Section
Air Navigation Bureau, ICAO HQ

April 2010





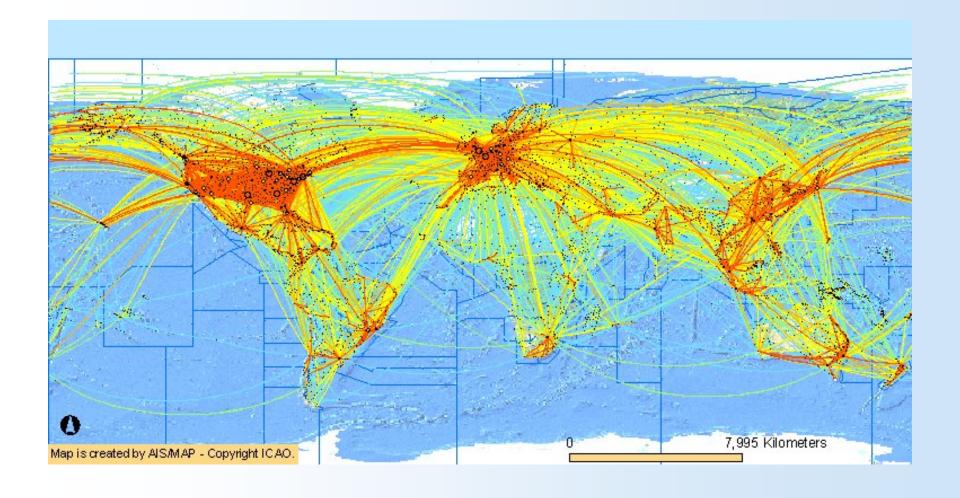
Presentation Outline

- What is a Global ATM system?
- How do we get there?
- Planning structure
- Expectations
 - NextGen SESAR
 - ICAO
 - States
- Conclusions





What is Global ATM? Physical connectedness



What is global ATM? Meeting expectations

- Meeting the expectations of the aviation community
 - meeting safety objectives
 - operate along preferred 4D trajectories (business trajectories)
 - scheduling
 - gate availability
 - environmental objectives
 - other business requirements





What is global ATM? Meeting expectations (cont'd)

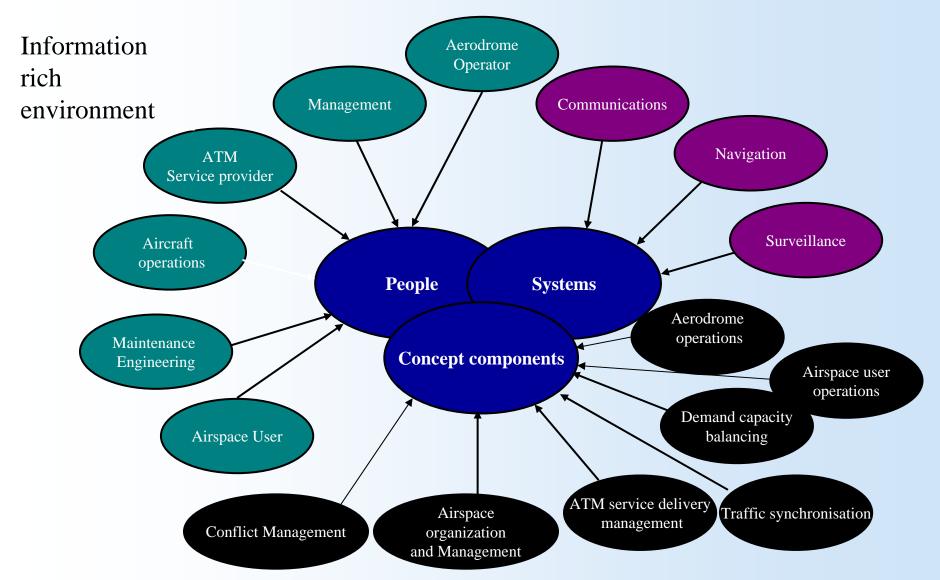
Major impediments

- the existing ATM system
- thousands of aircraft operators each have their own best outcomes
- best outcomes go beyond aircraft operators and extend outward to the larger ATM community as well





What is global ATM? Integration and a common vision



What is global ATM? Seamlessness-Interoperability

- A seamless, interoperable, worldwide system based on:
 - Seamless safety across all regions
 - For all users during all phases of flight
 - Physical connectedness
 - Homogeneous ATM areas and Major Traffic flows
 - Common requirements, Standards and procedures
 - Integration (TMAs, aerodromes)
 - Performance based equipment carriage requirements
 - Common aeronautical information exchange models
 - Meets environmental objectives





What is Global ATM? A wider perspective

- To make even greater gains in efficiency farreaching cooperation is necessary
- A global vision
- Wider planning perspectives
- Implementation of facilities and services over larger geographical areas
- A global framework for performance measurement





What is Global ATM? An example of a wider planning perspective

RVSM

- ICAO's role in supporting the realization of RVSM was and continues to be significant
- safety-related work leading to the development of Standards,
 Procedures and guidance material
- planning and safety assessments conducted by the regional planning groups
- RVSM could not have been implemented globally without ICAO's leadership





What is Global ATM? Working together

- Toward a common vision
 - global ATM Operational Concept
- Using a common planning framework
 - Global Air Navigation Plan, the regional air navigation plans and several other documents and tools
 - Global Aviation Safety Plan (GASP)
- Utilizing performance objectives
 - Targets, metrics, indicators
- Global interoperability and harmonization are key to making further improvements





Eleventh Air Navigation Conference How we get there

- Endorsed the global ATM operational concept
- Requested ICAO to:
 - develop ATM system requirements
 - address interoperability and seamlessness
 - define requirements for global AIM
 - publish the operational concept
 - amend the Global Plan
 - develop a performance framework





Eleventh Air Navigation Conference How we get there

That States and PIRGs consider the Global Air Navigation Plan for CNS/ATM Systems as a catalyst for change, providing a global safety and interoperability framework while allowing regional or local adaptation to efficiently meet regional and local needs





35th Session of the Assembly Endorses the global framework

- Assembly Resolution A35-15
- Calls upon States, regional planning groups and the aviation industry to use the ICAO Global ATM Operational Concept as the common framework to guide planning and implementation of CNS/ATM systems and to focus all such development work on the operational concept





Global performance initiatives How we get there

- Options for ATM improvements
- Relate to ATM objectives in older version of Global Plan
- Result in direct performance enhancements
- Meet performance objectives
- Based on Industry Roadmaps and current regional activities
- Bring near- and medium-term benefits to aircraft operators
- Regional planning groups establish work programmes





Global performance initiatives How we get there

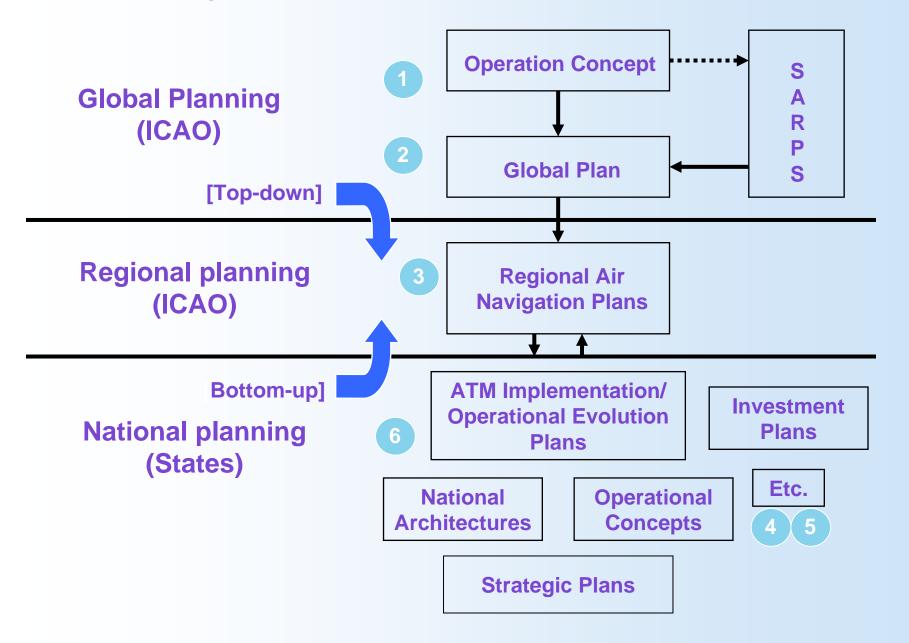
- Reduced vertical separation minima
- RNAV and RNP (Performance-based navigation)
- Dynamic and flexible ATS route management

- Functional integration of ground systems with airborne systems
- Aerodrome design and management
- Data link applications

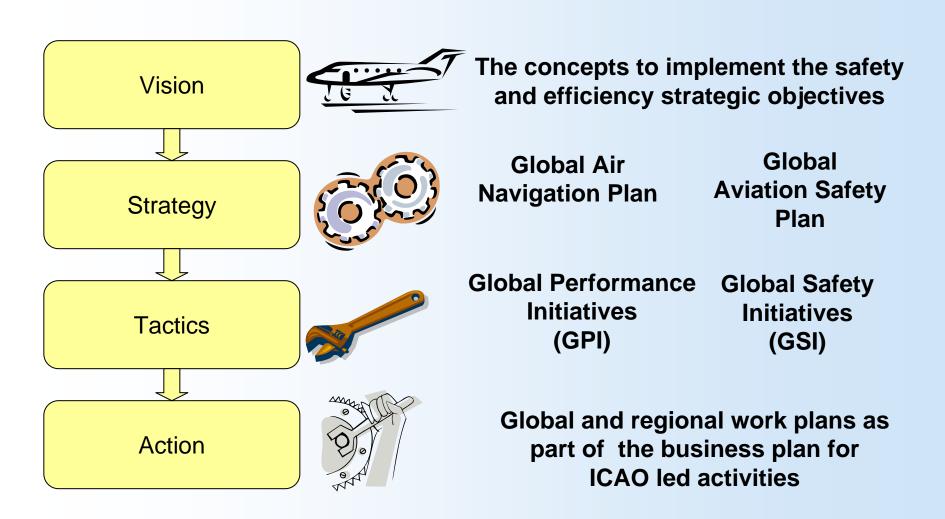




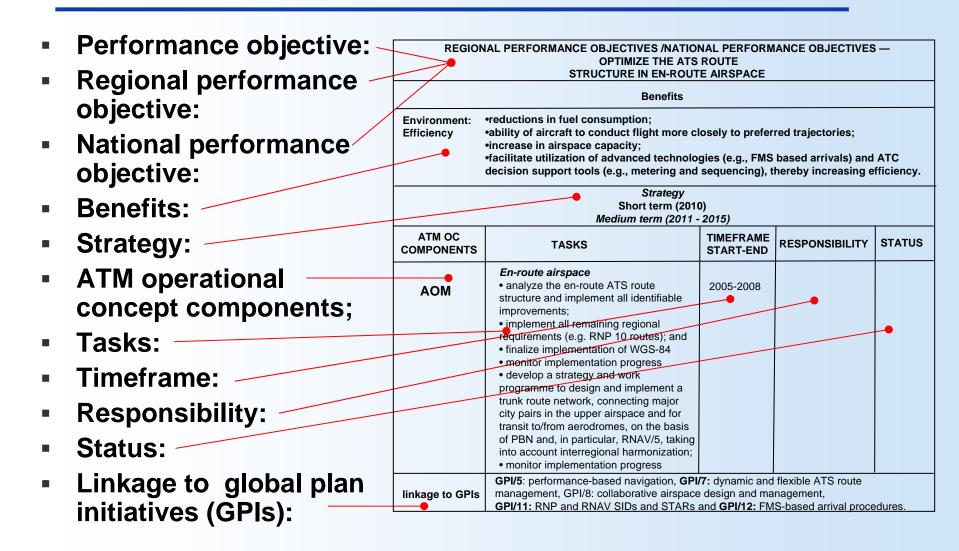
Planning structure



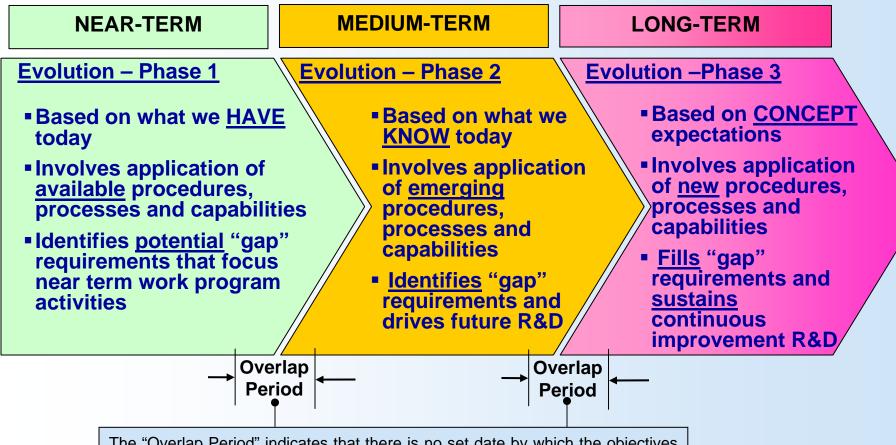
The ICAO Process Framework



Performance Framework Form



Transition Strategy



The "Overlap Period" indicates that there is no set date by which the objectives of each transition should be met – other than within a time band of perhaps 2-3 years. It also recognizes that some States or Regions may not have a specific performance requirement that would need the application of changes identified in the transition maps at the same time as another State or Region.

- NextGen (in their own words)
 - Many of the concepts build on ICAO's Global ATM Operational Concept which represents a globally harmonized set of concepts for the future
 - We recommend that ICAO assess NextGen and other future systems to advance harmonization efforts and to ensure global collaboration in the development and acceleration of standards for required future systems





- SESAR (in their own words)
 - Planning should be In accordance with the Global Plan
 - Planning should be based on specific performance objectives supported by Global Plan Initiatives
 - The terminology and methodology used in the Master Plan are consistent with ICAO





- ICAO
- To harmonize all the regional/national initiatives to guarantee seamlessness.





- States
- To guarantee that the best service is delivery at the correct time to the correct customer with high level of efficiency and attending the agreed levels of safety.





In Summary

- The goal is a more seamless Global ATM system
- We are getting closer
- Global ATM Operational Concept
- Global Air Navigation Plan
- We should work under one common umbrella
 - Performance based transition
 - Continued operational improvements
 - Toward a common vision
 - Using the ICAO framework
- Expectations





The Global ATM System

Thank you.

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