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Advanced Air Traffic Management

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Required Total System Performance (RTSP)

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Agenda



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- What is RTSP?
- RTSP performance hierarchy/heterarchy
- Model-based performance-driven requirements and assessment
- Some conceptual, institutional, and technical questions concerning RTSP
- Examples of RTSP-related Development Plans/Activities



- Three pillars
 - A **hierarchy** of ATM Performance Concepts
 - Accurate models of ‘**what drives what**’
 - e.g. cause/effect relationships between expectations, functions, system components, concept of use, architecture
 - Rigorous description of **traceable** performance parameters
 - An approach: ISO13236 Quality of Service Framework

What is RTSP (Contd.)?



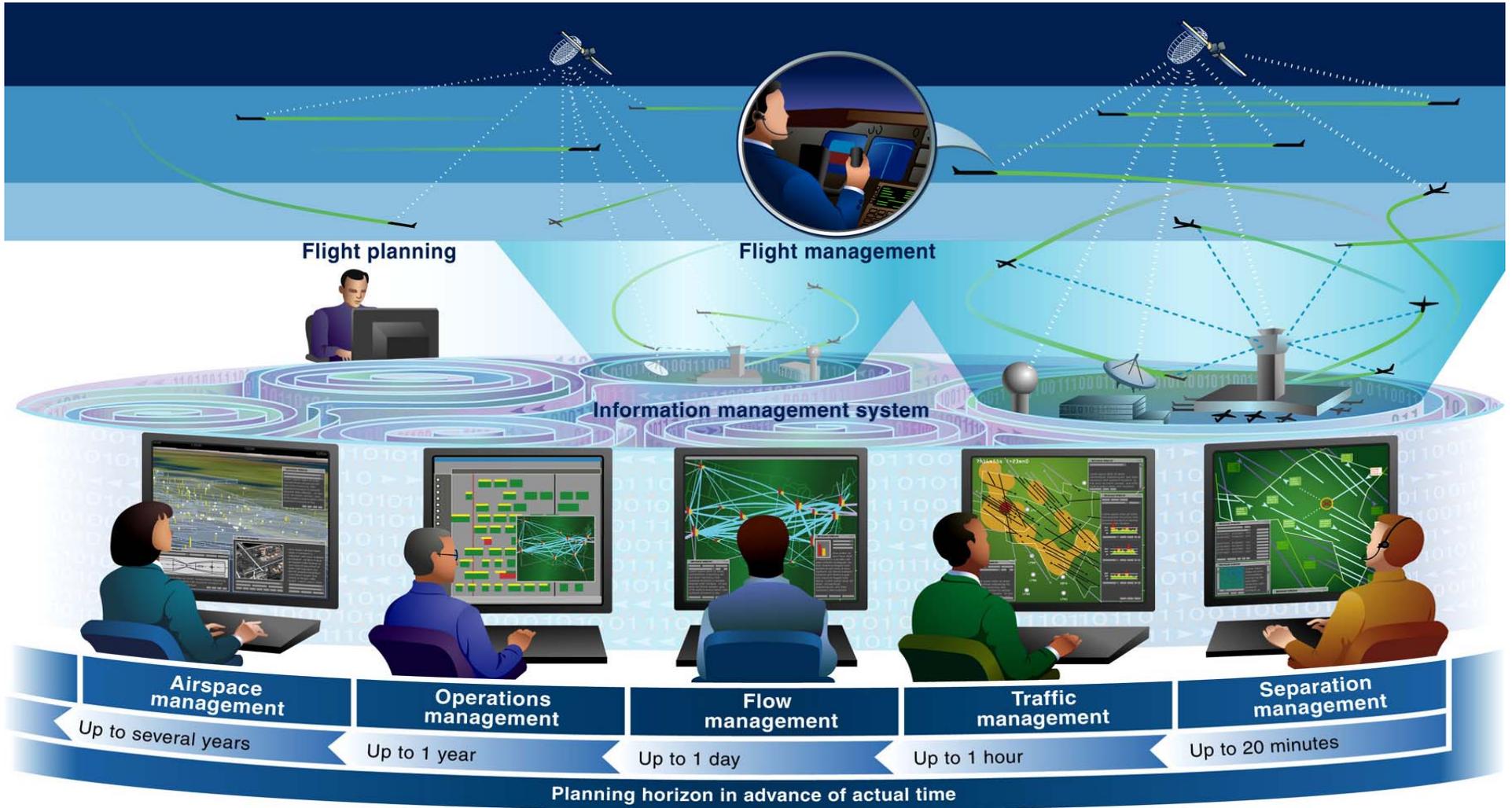
- NGATS (JPDO) FY08 Agency Budget Guidance: “One of NGATS key capabilities is to provide performance-based services that provide operational modes designed for different levels of user performance. A major element of this capability is RTSP for the total airspace system, including aircraft avionics and operator...”
- NGATS 2005 Progress Report: “However, it (RTSP) is incomplete, and little progress has been made towards comprehending RTSP as an integrated whole.”
- Unprecedented agenda for performance-based operation of future local, regional, and global ATM/CNS
- First time that ‘global ATM’ is conceived as a ‘system’
- Global ATM is really a ‘complex socio-technical system-of-systems’...that may not be completely ‘systematic’ in the traditional sense
- TSE and CSE (ICAO, MITRE, NECI, SFI et al)
- Performance-driven also implies ‘modeled’ assessment of ATM System
- Performance-driven and model-based ATM baseline operational behavior is necessary...beyond simple list of ‘metrics’
- RTSP is performance referent for all future local, regional, and global performance improvements i.e. Operational Improvements (OI) (e.g. ICAO, NGATS, SESAR)

Air Traffic Management Services

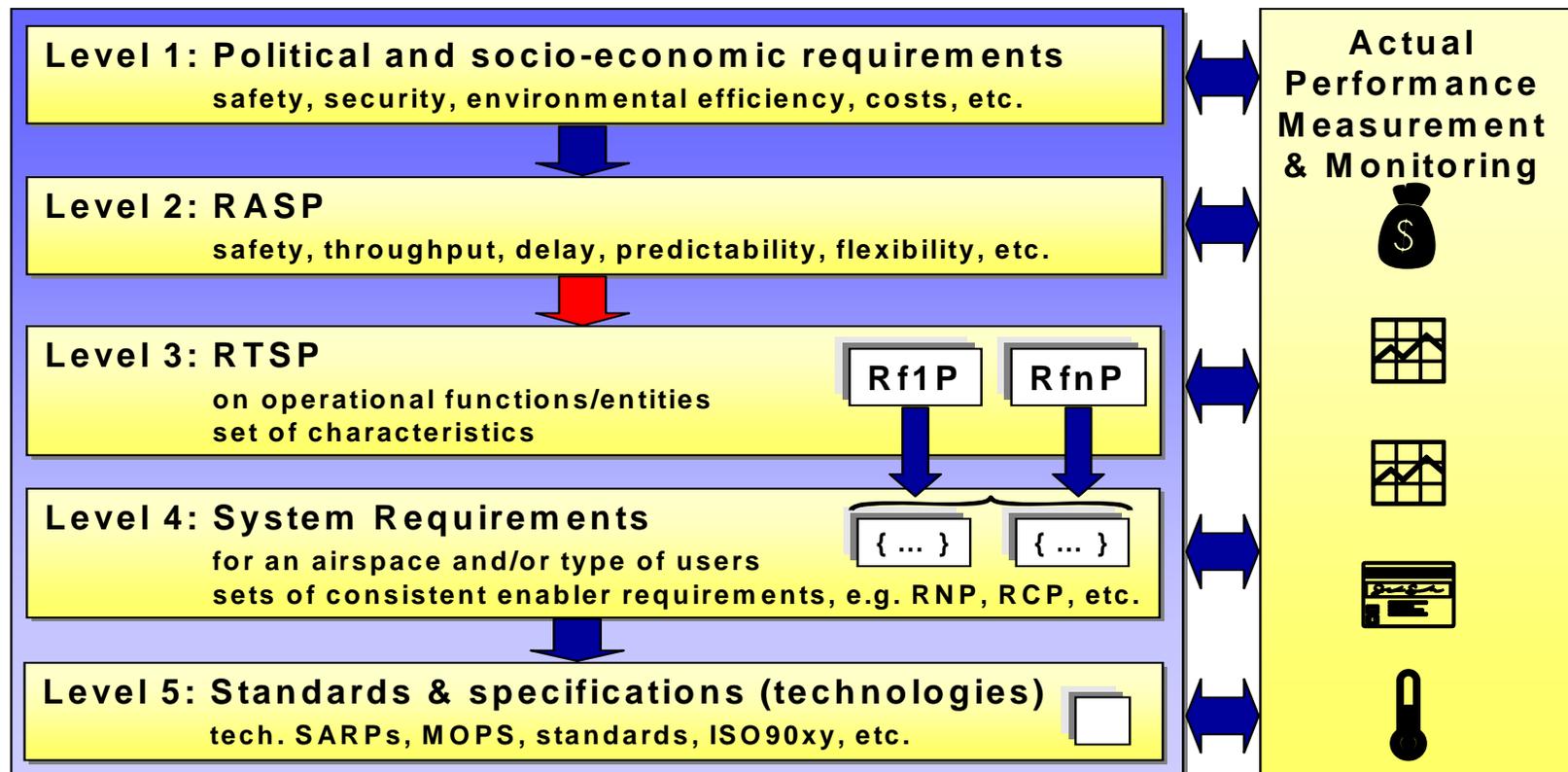


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Hierarchical ATM Performance Concepts



Arrival Management



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Case Study Assessment Framework

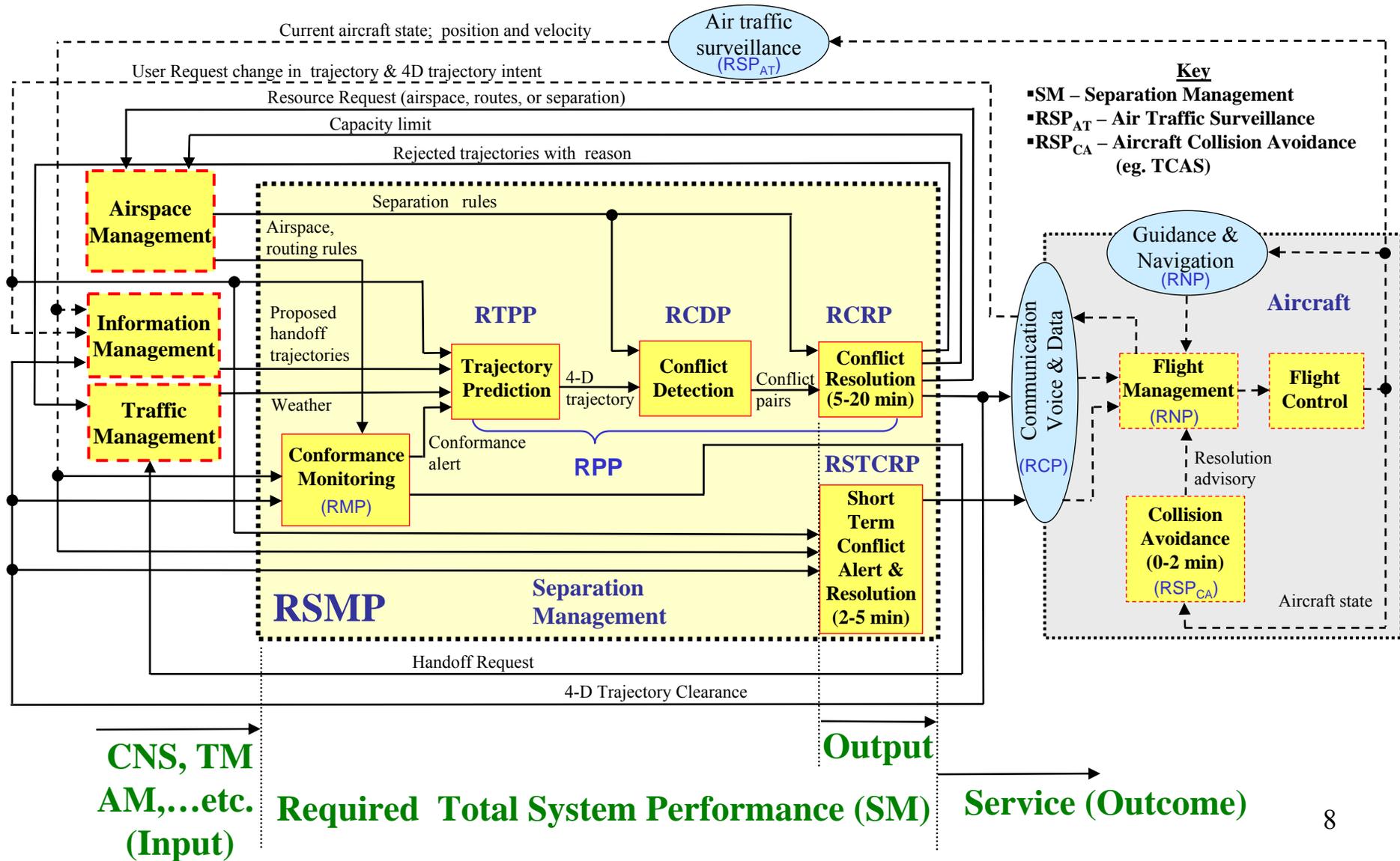
System Levels	Requirements and Design		Assessments and Analysis	
	Performance Requirements	Functional and Structural Descriptions	Performance Parameters & Trade Space	Methods, Tools, and Simulations
Air Transportation System	<p>Comprehensive Air Transportation System Performance Metrics and Parameters (Detailed performance and structural metrics)</p> <p>Measures of Mission</p>	<p>Arrival Management System Diagram</p>		<p>Method Tools and Simulation Diagrams</p>
Air Traffic Management System	<p>ATM System Performance Metrics (Detailed performance parameters: req. capacity, throughput, delay, predictability, accuracy, etc.)</p> <p>Req'd ATM System Perf.</p>	<p>Air Traffic Management System Diagram</p>	<p>ATM Performance Metrics Graphs</p>	<p>ATM Simulation Diagrams</p>
Service Level (Arrival Mgmt.)	<p>ATM System Performance Metrics (Detailed performance parameters: req. capacity, throughput, delay, predictability, accuracy, etc.)</p> <p>Req'd Total System Perf.</p>	<p>Arrival Management System Diagram</p>	<p>Service Level Performance Metrics Graphs</p>	<p>Service Level Simulation Diagrams</p>
System Architecture (A/C infrastructure, automation system, CNS systems, etc.)	<p>System Architecture Performance Metrics (Detailed performance parameters: req. capacity, throughput, delay, predictability, accuracy, etc.)</p> <p>Req'd Communication Perf. Req'd Navigation Perf. Req'd Surveillance Perf.</p>	<p>System Architecture Diagram</p>	<p>System Architecture Performance Metrics Graphs</p>	<p>System Architecture Simulation Diagrams</p>
Physical Architecture, (Technology, HW & SW)	<p>Physical Architecture Performance Metrics (Detailed performance parameters: req. capacity, throughput, delay, predictability, accuracy, etc.)</p> <p>Measures of Performance Standards and Recommended Practices (ICAO)</p>	<p>Physical Architecture Diagram</p>	<p>Physical Architecture Performance Metrics Graphs</p>	<p>Physical Architecture Simulation Diagrams</p>

Boeing AATM Separation Management Service/Concept



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An ATM/CNS Hierarchy/Heterarchy View



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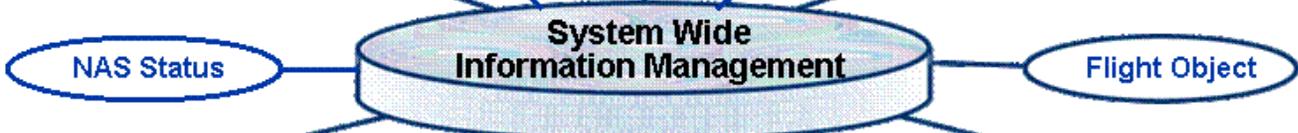
Operations



Applications/
Automation



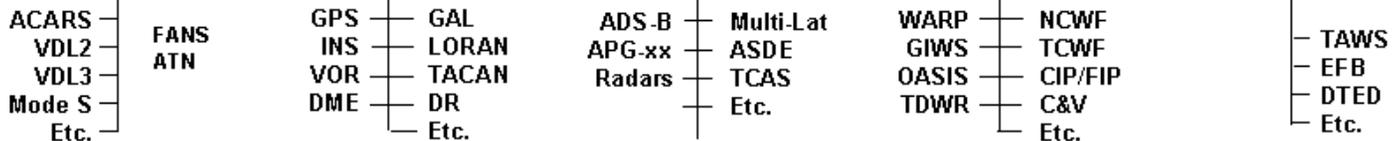
Network



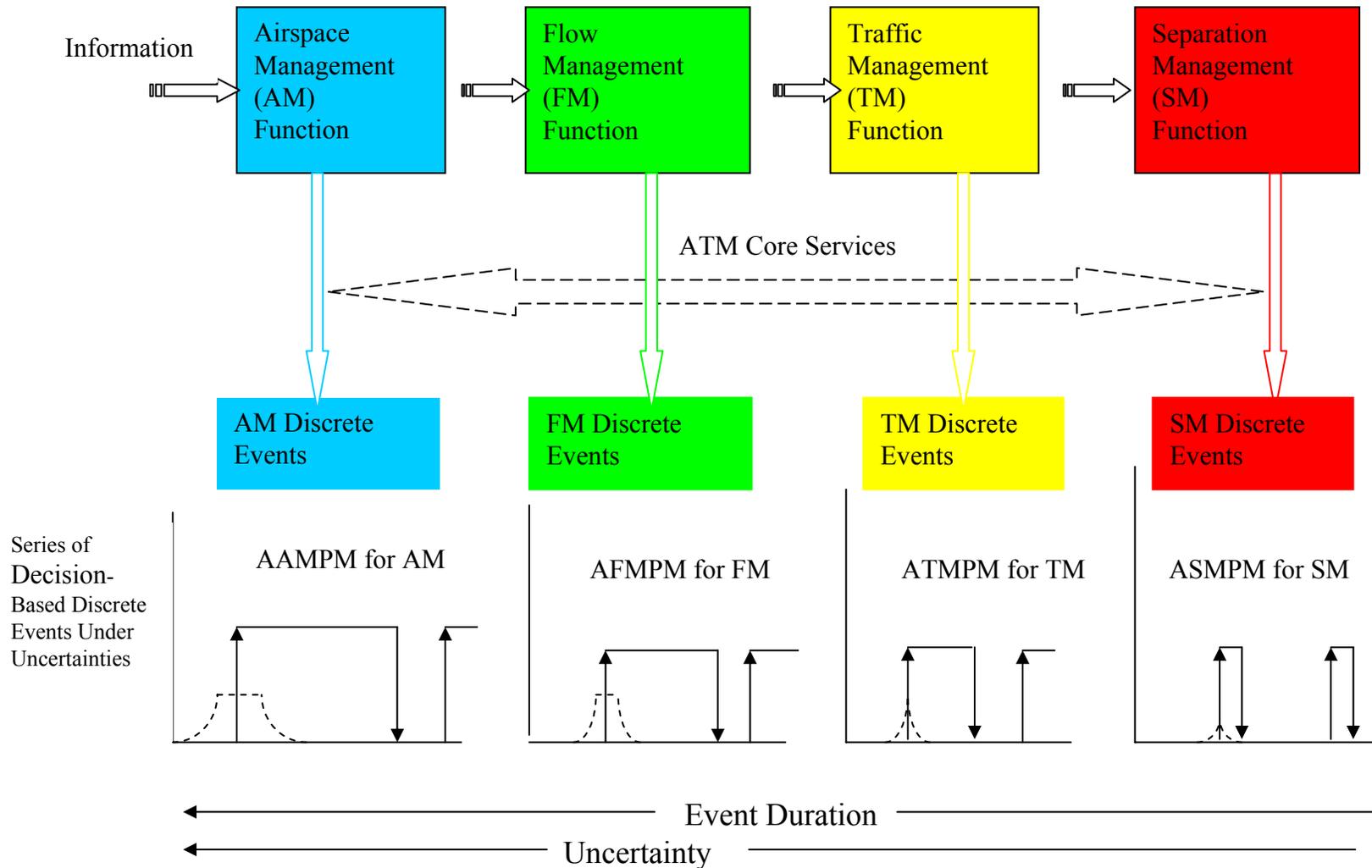
Functions



Systems/
Sub-Systems



ATM EVENTS: Normal, Rare-normal, Non-normal





RTSP = f (RNP, RCP, RSP...RXPs) enabled by 'lower' CNS systems

- **Required Navigation Performance – RNP (Domain-Specific Examples)**
 - RNP 4 - Oceanic procedural airspace, FANS operations etc.
 - RNP 1 - Future enroute requirement
 - RNP 0.3 - Terminal area/Approach with Vertical Guidance
- **Required Communications Performance – RCP (Functional Examples)**
 - RCP 1 - Communication for For Strategic and Procedural Operations (**Flow**)
 - RCP 2 - Communications to support regional planning and control. (**Traffic**)
 - RCP 3 - Com to support trajectory based separation assurance (**Separation**)
- **Required Surveillance Performance – RSP (Domain-Specific Examples)**
 - RSP 1 - Enroute
 - RSP 2 - Terminal Area
 - RSP 3 - Surface Operations
 - RSP 4 - Parallel Approaches

Some Conceptual, Institutional, and Technical Questions Concerning RTSP



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- What are the relationships between different ATM/CNS performance metrics in the 5-level performance hierarchy/heterarchy?
- What should be the emerging roles of ATMRPP to other performance panels (e.g. FAA PARC RNP, RCP, SASP, ANSEP...)?
- What are the minimum set of pertinent ATM operational events that conform to: normal (nominal), rare-normal, and non-normal (degraded) states?
 - How are they to be identified in general terms of a) initiation, b) duration, c) resolution that may require RTSP-related criteria?
- How does (should?) RTSP guide/influence the global ATM System emerging design process (e.g. human-centered, user-centered, system-centered) to insure interoperability, safety, predictability, efficiency, and...?
- Many more...?

Examples of RTSP-related Development Plans/Activities



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- ICAO ATMRPP through December 2007
 - Completion of Global ATM Performance Manual
 - ICAO/IATA Roadmap (update of PBTG)
 - ATMRPP post-2008
- System Dynamics Integrative Performance Platform
 - NAS Strategy Simulator (FAA/JPDO)
 - Boeing AATM iR&D 2006/2007 RTSP performance modeling
 - application to emerging ops concepts (e.g. ADS-B, ITP, TA, CBE...)

Backup Slides



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ATM/CNS 5-level Hierarchy Framework: Work-in-progress



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Levels	Minimal Description of Levels	Adapted IOOI Performance Metrics	Required Performance Metrics (Target)	Actual ('real' and/or modeled) and Monitored Performance Metrics
Level 1	Users', planners' 'decision-makers' expectations/desires	Impact	KPAs (e.g. Capacity, (e.g. 3X Baseline), Efficiency, Cost...Security) MOM	Actual Capacity Increase (e.g. 2.74 X Baseline Capacity)
Level 2	ATM core service provisions	Outcome	RASP (Required ATM System (Service) Performance) – MOE (e.g. Required Arrival Throughput Performance = 1.25 X Baseline	Actual Arrival Performance (e.g. 25% increase in AAR)
Level 3	Human + System Interdependent interactive total performance	Output	RTSP (Required Total System Performance) = f, g [RTPP, Required Trajectory Prediction Performance RCRP, Required Conflict Resolution Performance...]	ATSP = f (RXP...) TBD ATSP ~ ΠΣ (f, g) (ANP, ACP, ASP...AXPs)
Level 4	C, N, S + aggregate enabler functional performance	Input	RXPs where X is CNS + (e.g. RNP, Required Navigation Performance, RCP, Required Communication Performance, Require Environmental (noise, emissions...)	ANP, Actual Navigation Performance (e.g. within +/- 0.3 RNP) e.g. TSE (Total System Error) = NSE (Navigation Sensor Error) + FTE (Flight Technical Error), where + is equivalent to RSS
Level 5	Hardware/software Technical Performance Supporting C, N, S +	Technical (hardware, software, Wetware ,...et al)	RTP (Required Technical (hardware and/or software) Performance (e.g. SARPS, Standards, QOS, et al)	ATP, Actual Technical Performance (e.g. Navigation Sensor Error (+/-) 2 meters



ICAO OCD 11 Key Performance Areas

1. Capacity
2. Cost Effectiveness
3. Efficiency
4. Environment
5. Flexibility
6. Global Interoperability
7. Participation by the ATM Community
8. Predictability
9. Safety
10. Security



IATA RTSP Metrics: Efficiency

- **IATA paper** number for the ANC is: **AN-Conf/11-WP/50**
- For measuring **Efficiency**, **IATA suggests the following metric elements from an airline-centric, 'gate-to-gate' performance perspective:**
 - on time departure
 - ground movement (taxiing)
 - airport departure rate
 - restrictions that may prevent on-time departure and efficient climb-out
 - route of flight based on operational requirements, which would mainly be based on upper wind
 - ability to change route of flight en route (UPRs)
 - ability to assign an efficient cruising altitude
 - ability to allow descent for approach without delay
 - ability to assign an efficient unrestricted descent profile (such as control idle descents)
 - airport arrival rate
 - availability of high-speed taxiways to minimize runway occupancy
 - ground movement to arrival gate (taxiing)
 - charging policy

Metrics, Metrics, Metrics...



- RTSP could include:
 - 1) **ATM operational performance metrics (e.g. flexibility, delay...)**
 - 2) **ATM system and CNS+ performance metrics (e.g. RTPP, RCDP...)**
 - Safe separation minima
 - Trajectory prediction
 - ATM service delivery time: the timeliness of its delivery and effectiveness of what is provided..
 - Quality of meteorological data
 - Flexibility of the system (e.g. reaction to weather)
 - Flight data exchange coordination and communication (air/ground)
 - Human performance: training, licensing, certificates of competence
 - Automated functions: multi-radar tracking, correlation of radar track and flight plan, sector coordination...
 - Compliance with environmental requirements
 -



IATA RTSP Metrics: Regularity

- IATA's basic notion of **Regularity** is:
- “the provision of a system and service to an established routine and schedule, based on normal or accepted rules and standards...consistent with best practices and availability of services when required...” (page 5).
- Examples of **Regularity** are:
 - timeliness of aeronautical information services,
 - reliable meteorological services,
 - availability of advertised services (e.g. radar, nav aids, rescue and fire fighting service etc.),
 - predictable and consistent arrival and departure procedures that are captured in FMS logic,
 - search and rescue (SAR) and accident investigation
 - adherence to and consistent application of ICAO SARPs (most important Regularity principle!).

RTSP - Boeing History



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- 1996 Nakamura/Schwab RSP Paper $RSP = f(RNP, RCP, RMP)$
- 1999 – 2003 ICAO ATMCP OCD Development
- 2001 FAA (Steve Bradford)/Boeing ATM (Shakarian, Haraldsdottir, Schwab, Warren)
 - RTSP STCA Model: Report to FAA
 - RTSP STCA Paper/Presentation to 4th US/Europe ATM R&D Seminar
- 2002 Stockholm ICAO ATMCP Boeing Paper on STCA (Haraldsdottir, Shakarian)
- 2003 Seville Boeing (Shakarian, Haraldsdottir)/Eurocontrol (Bernard Miaillier):
 - RTSP and ICAO 5-level Performance Hierarchy
- 2003 Montreal 11th ANC Meeting: RTSP endorsed by ICAO ANC as Agenda Item #3
 - based on Simplified version of Boeing Separation Management Concept example (Bernard Miaillier presentation)

RTSP - Boeing History (contd.)



- 2004 Salvador ATM Performance (RASP, RTSP) given top priority
 - Final ATM Performance Manual (including Transition Strategies and roadmaps) to be released in December 2007.
 - AATM and BCA directly contribute to IATA Roadmap.
 - IATA Roadmap being incorporated within ATMRPP.
- 2005 Brussels Boeing paper re-emphasized RTSP ‘above’ and ‘below’ hierarchy (level 3):
 - RTSP as Key performance matrix, hinge, fulcrum, ‘intersection’ between ATM operational service delivery ‘above’ enabled by CNS technologies ‘below’ in the context of all 7 ICAO OCD so-called concept ‘components’ (e.g. Conflict Management, Traffic Synchronization, Demand/Capacity Balancing...et al) – similar to Boeing AATM/BCA Ops Concept.
 - Agreed by ICAO ATMRPP that concrete modeled examples of RTSP be developed for 2006 and 2007, and results be incorporated within the emerging ATM Performance Manual (2007).

Separation Management



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RTSP (RSMP) Separation Management	Delay-Transient Responsiveness and Operational Performance	Capacity-Throughput	Integrity-Accuracy	Reliability-Availability
RTSP = f (RSMP, RNP, RCP, RSP_{CA}, RSP_{AT})				
Required Separation Management Performance RSMP = g (RPP, RMP)				
Required Planning Performance RPP = h (RTPP, RCDP, RCRP)				
Required Trajectory Prediction Performance (RTPP)	Max time required for trajectory prediction; the update rate requirements; time required for computing new trajectory (function of lookahead time and trajectory prediction accuracy limitations, traffic conditions et al).	Maximum number of aircraft per sector (number of trajectories from Traffic Management) for trajectory prediction data processing;	Trajectory prediction accuracy (uncertainty) requirements; operational constraints on trajectory prediction within and between sectors;	Probability of successful conflict prediction pairs of aircraft; The reliability of trajectory prediction given an operative lookahead time.
Required Conflict Detection Performance (RCDP)	Max time required for human/machine conflict detection; machine conflict detection and annunciation + human decision-making responsiveness	Maximum number of pairs of aircraft per sector for trajectory conflict detection; data processing; human and machine (e.g. displays) interactive decisions workload and cognitive limits	Requirements for probability of undetected conflicts (e.g. missed detection); false alarm rate requirements for conflict detection.	Probability of successful conflict detection of pairs of aircraft per conflict event as a function of lookahead times;
Required Conflict Resolution Performance (RCRP)	Max time for human/machine conflict resolution including new trajectory computation and flight path stabilization to steady state conditions	Minimum spatio-temporal sector capacity required for conflict resolution; may be function of traffic density and flow structure; human workload capacity relationship to number of aircraft in airspace sector	The accurate, efficient, and timely trajectory re-planning action required to deliver a safe conflict resolution outcome involving pairs of aircraft in the context of other air traffic; human cum machine joint performance limits.	Reliability of conflict resolution plan: loop dynamic stability with traffic management in execution of conflict resolution plan; (e.g. minimization of the number of re-plan requests to achieve proper conflict resolution).