



# Future Communication Study – Action Plan 17 Final Conclusions and Recommendations Report

**ICNS Conference  
4 May 2008**

Nikos Fistas, EUROCONTROL, Brent Philips, FAA ATO  
and Jim Budinger, NASA Glenn Research Center

Jose Roca, EUROCONTROL

---

# Briefing Outline

- AP17 overview
- Technology Investigations
  - Europe (Step 1 and 2)
  - US (Phase I, II and III)
- Recommendations
  - Required Actions
- Documentation
- Next Steps

# AP17 in a slide

- ☑ FAA/NASA and EUROCONTROL
- ☑ Response to AN-Conf/11 outcome
- ☑ Support by ITT, MITRE and QinetiQ
- ☑ Contributions from France, Germany, Spain, Sweden, UK and ESA
- ☑ International Coordination and Communication (ICAO, Conferences)

## 6 Technical Tasks

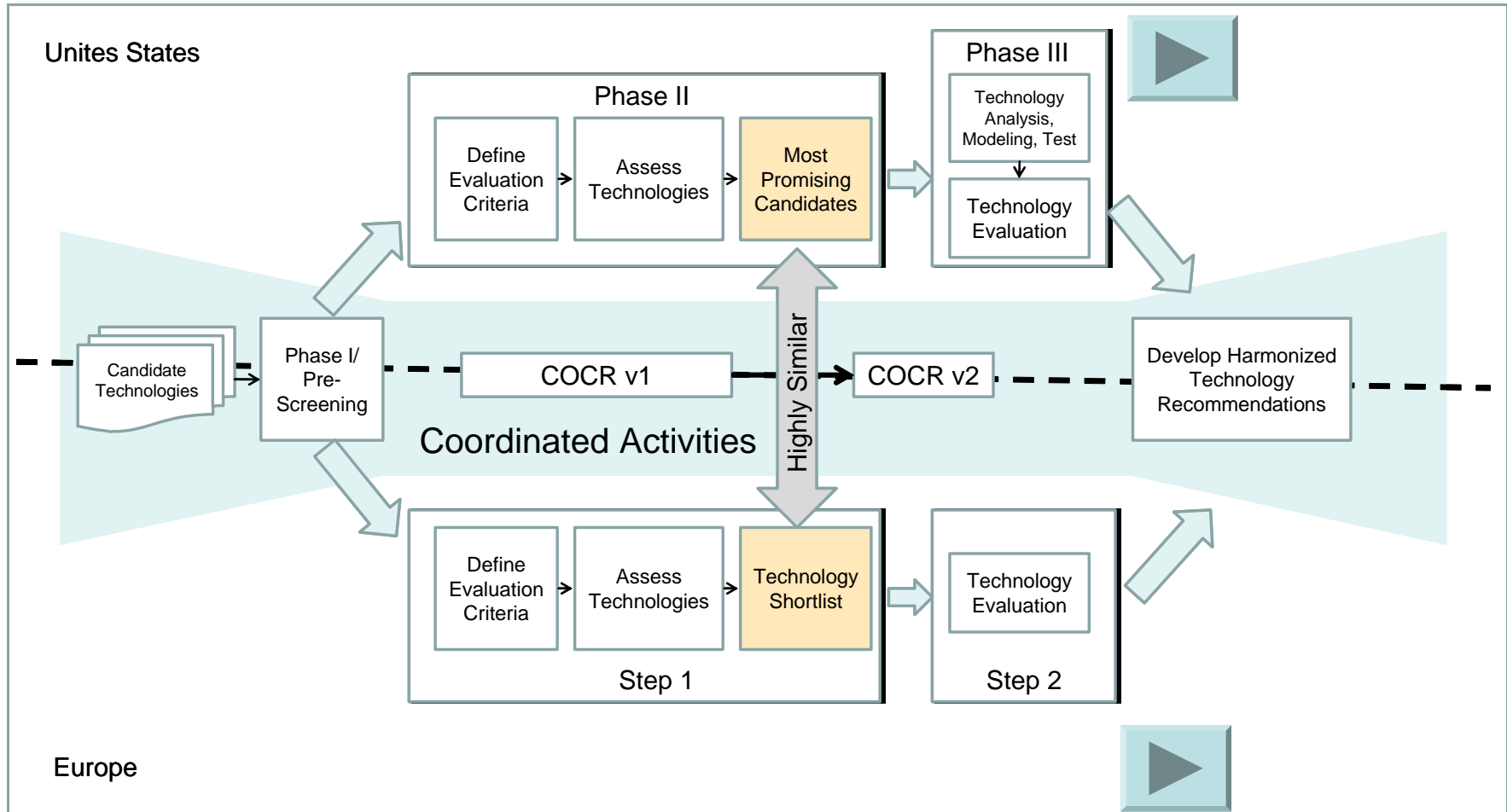
- Improvements to current systems
- Concept and Requirements
- Technology Evaluations
- Communication Roadmap
- Integration Aspects
- Spectrum Aspects

## 3 Business Tasks

- International Perspective
- Industry Participation
- Business Aspects

- ☑ Support to SESAR and NextGEN
- ☑ Recommendations and Actions

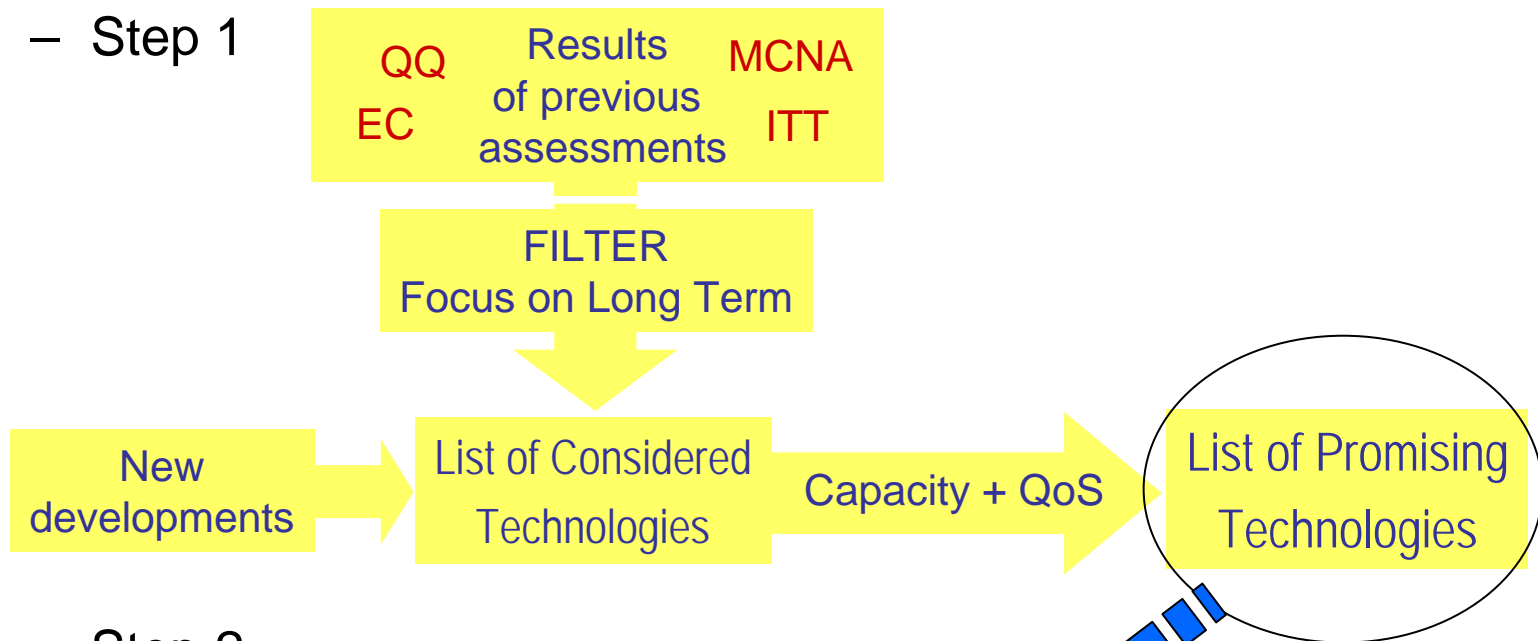
# AP17 Activities



# European Assessment Methodology

- Two step approach:

- Step 1



- Step 2



# European Assessment: Evaluation Criteria

- Essential Criteria
  - Spectrum Compatibility
  - Openness of Standards
- Desirable Criteria
  - RF Robustness
  - Technical Readiness Level
  - Flexibility
  - Ground Infrastructure Cost
- Performance Criteria
  - Capacity
  - Integrity
  - Availability
  - Latency

# European Assessment - Metrics

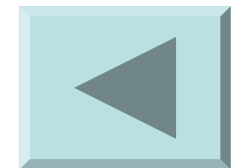
- Ranking was seen as the best way to compare technologies
  - 4 Classes have been defined each with an acceptance mask

Criterion Value	Security	TRL	Flexibility	Cost	Capacity	Integrity	Availability	Latency
1								
2								
3								
4								
5								

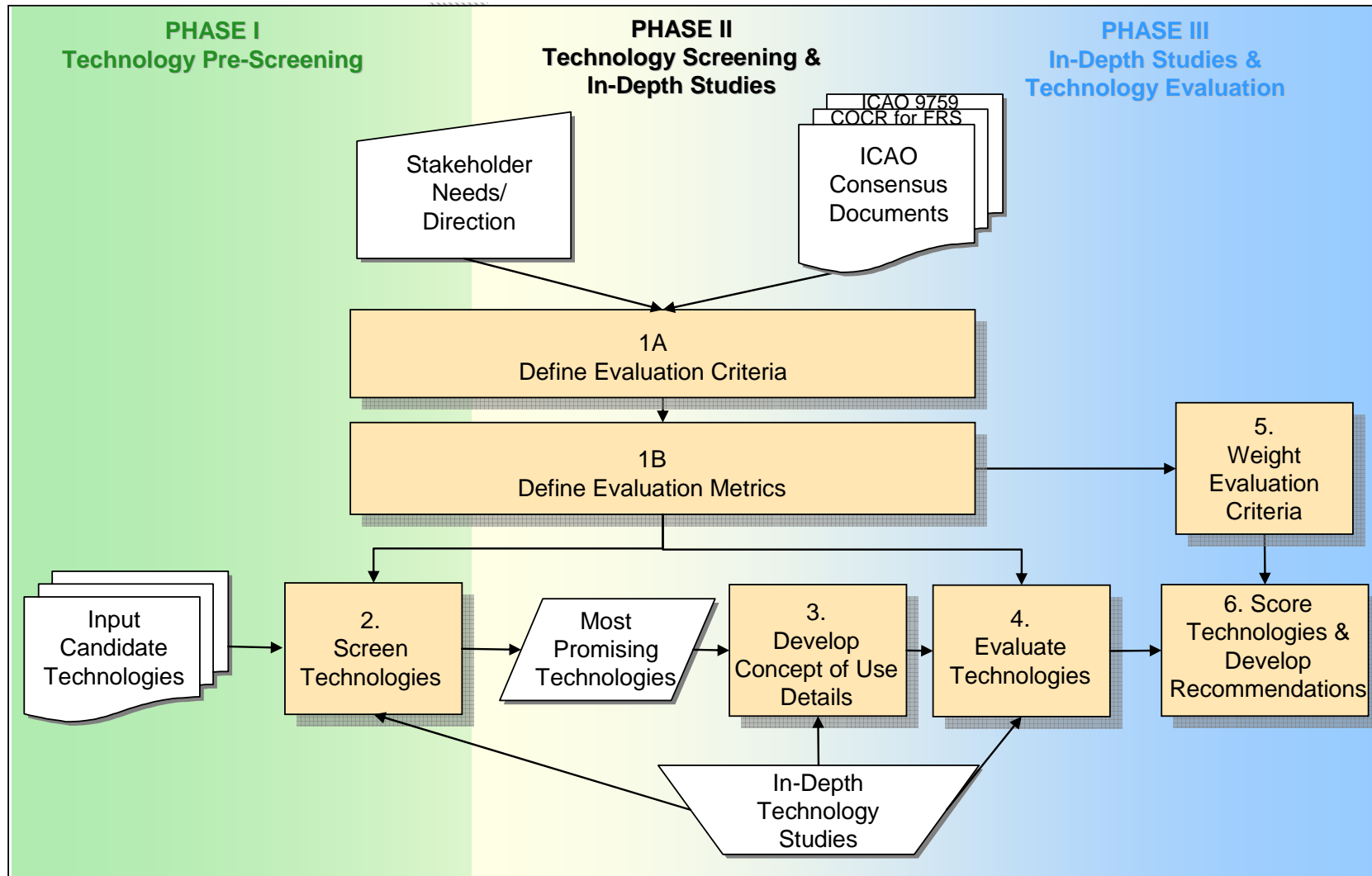
Class 3

Criterion Value	Security	TRL	Flexibility	Cost	Capacity	Integrity	Availability	Latency
1								
2								
3								
4								
5								

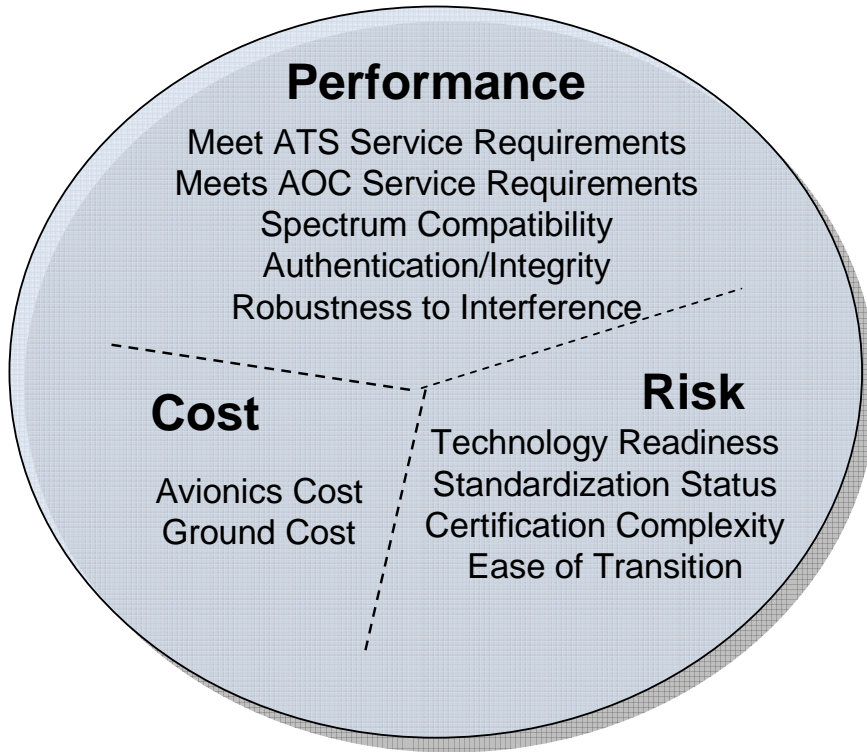
Class 4



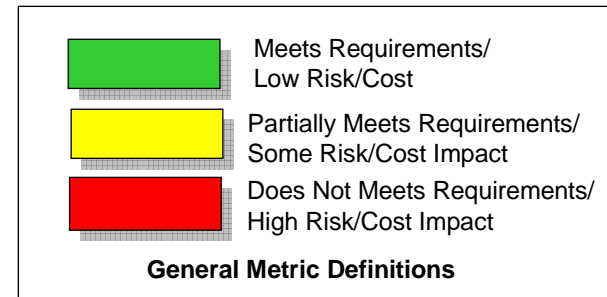
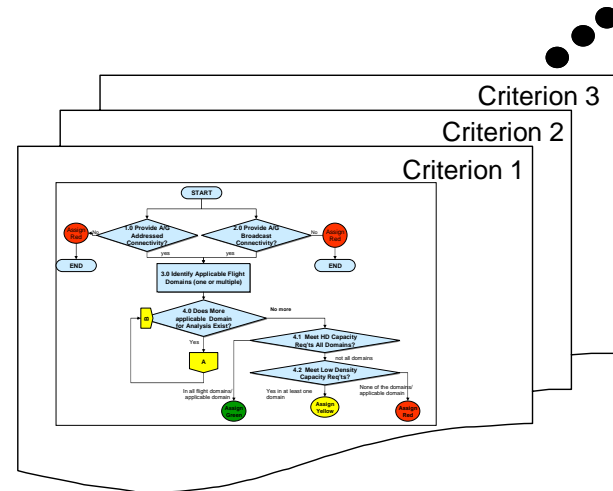
# US Assessment Methodology



# US Assessment: Evaluation Criteria

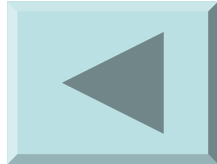
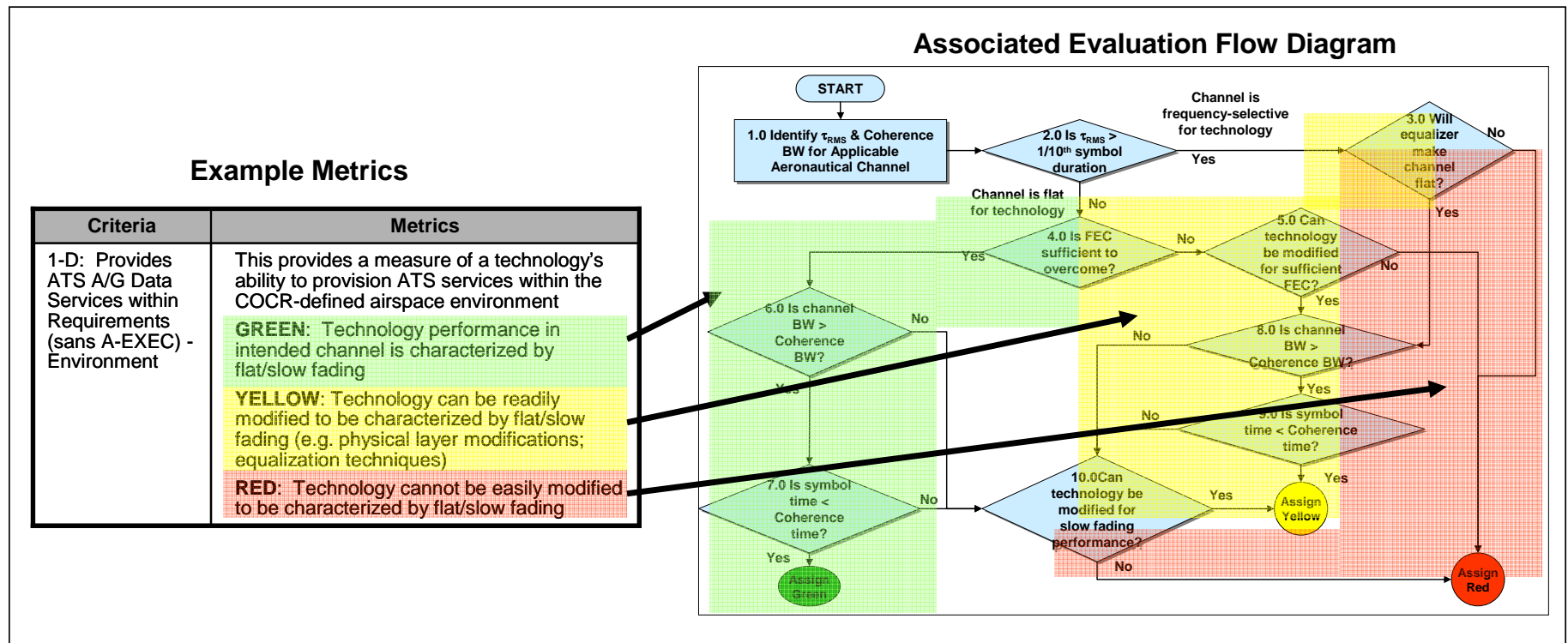


11 criteria traceable to the COCR and consensus ICAO documents were derived in FCS Phase II

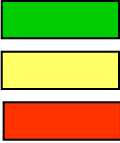


In FCS Phase III, criteria definitions and associated metrics were revised to reflect updates to the COCR and process diagrams to define the evaluation steps were developed

# US Assessment: Metrics



# Evaluation Criteria -- Comparison

Criteria Category	European Criteria	US/ITT Criteria
<b>Technical Performance</b>	<ul style="list-style-type: none"> <li>• Capacity</li> <li>• Integrity</li> <li>• Availability</li> <li>• Latency</li> <li>• Spectrum Compatibility</li> <li>• RF Robustness</li> </ul>	<ul style="list-style-type: none"> <li>• Meets ATS Service Requirements</li> <li>• Meets ATS&amp;AOC Requirements</li> <li>• Spectrum Compatibility</li> <li>• Authentication/Integrity</li> <li>• Robustness to Interference</li> </ul>
<b>Cost</b>	<ul style="list-style-type: none"> <li>• Openness of Standards</li> <li>• Flexibility</li> <li>• Cost</li> </ul>	<ul style="list-style-type: none"> <li>• Avionics Cost</li> <li>• Ground Cost</li> </ul>
<b>Risk</b>	<ul style="list-style-type: none"> <li>• TRL</li> </ul>	<ul style="list-style-type: none"> <li>• TRL</li> <li>• Standardization Status</li> <li>• Certification Complexity</li> <li>• Ease of Transition</li> </ul>
<b>Scale</b>	Numerical scale between 1 ~ 5	

# Evaluated Technologies

United States	Common Technologies	Europe
<b>Continental</b> <ul style="list-style-type: none"> <li>•P34/TIA-902</li> <li>•LDL</li> <li>•W-CDMA</li> </ul>	<ul style="list-style-type: none"> <li>•P34/TIA-902</li> <li>•LDL</li> <li>•W-CDMA</li> </ul>	<b>Continental</b> <ul style="list-style-type: none"> <li>•B-AMC</li> <li>•AMACS</li> <li>•Custom Satellite</li> </ul>
<b>Oceanic/Remote</b> <ul style="list-style-type: none"> <li>•Inmarsat SBB</li> <li>•Custom Satellite</li> </ul>	<ul style="list-style-type: none"> <li>•Inmarsat SBB</li> <li>•Custom Satellite</li> </ul>	<b>Oceanic/Remote</b>
<b>Airport</b> <ul style="list-style-type: none"> <li>•IEEE 802-16e</li> </ul>	<ul style="list-style-type: none"> <li>•IEEE 802-16e</li> </ul>	<b>Airport</b>

# US Detailed Technology Studies

	<b>In-Depth Study Topic</b>	<b>Note</b>
1	<b>L-Band Air/Ground Communication Channel Characterization</b>	Created ray-tracing simulation to develop tap-delay line models of the L-band aeronautical channel (960-1024 MHz) supporting evaluation of LDL and P34/TIA-902
2	<b>TIA-902 (P34) Performance Assessment</b>	<ol style="list-style-type: none"> <li>1. OPNET simulation of P34 net entry and data transfer performance</li> <li>2. MATLAB Simulink® model developed to assess P34/TIA-902 physical layer performance in the defined L-Band A/G channel</li> </ol>
3	<b>TIA-902 (P34) Technology Intellectual Property Assessment</b>	Assessment IP impact for patents claimed in P34/TIA-902 standards
4	<b>L-Band Digital Link (LDL) Technology Performance Assessment</b>	MATLAB Simulink® model developed to assess LDL physical layer performance in the defined L-Band A/G channel
5	<b>Wideband Code Division Multiple Access (WCDMA) Functional Assessment</b>	Functional analysis of UMTS/WCDMA network architecture
6	<b>L-Band Technology Cost Assessment for Ground Infrastructure</b>	L-Band business case analysis for an L-Band aeronautical ground infrastructure
7	<b>L-Band Interference Testing</b>	<p>UAT, Mode S interference modeling and simulation using SPW modeling tool for P34 and LDL waveforms</p> <p>1. Bench tests conducted to evaluate DME susceptibility to candidate FCS waveforms (based on WCDMA, P34, LDL definitions)</p>
8	<b>Satellite Technology Availability Performance</b>	Evaluation of satellite technology availability performance using fault-tree model of RTCA DO-TBD
9	<b>IEEE 802.16e Performance Assessment in Aeronautical C-Band Channel</b>	MATLAB Simulink® modeling of 802.16e on the surface environment implementing OU aeronautical C-band channel model

# European Detailed Technology Studies

## Technology studies by various entities in Europe

- AMACS was progressed by DSNA (France) and LFV (Sweden). Support was provided by NATS/Helios on performance evaluation
- P34 (TIA-902) was investigated by NATS/Helios in terms of performance and compatibility
- B-AMC studies were funded by EUROCONTROL through the B-AMC Consortium to define the overall system including performance and compatibility
- Review of previous EUROCONTROL activity on WCDMA
- Drew on work carried out in the U.S. for LDL and 802.16
- New satellites was progressed by ESA through the SATCOM for ATM Study, and INMARSAT SBB was evaluated based on the outcome of previous ECTL work.
- QinetiQ applied the evaluation criteria and developed a critique of each system
  - Developed joint technology conclusions with ITT and the Step 2 report

# European Evaluation Results

<b>Technology</b>	<b>Class</b>	<b>Frequency band</b>	<b>Application airspace</b>
<b>802.16e</b>	2	C-Band	Airport surface
<b>B-AMC</b>	3	L-Band	Airport surface, TMA, En-route
<b>P34 (TIA-902)</b>	4	L- Band	Airport surface, TMA, En-route
<b>AMACS</b>	4	L-Band	Airport surface, TMA, En-route
<b>LDL</b>	4	L-Band	Airport surface, TMA, En-route

# European Evaluation Results (2)

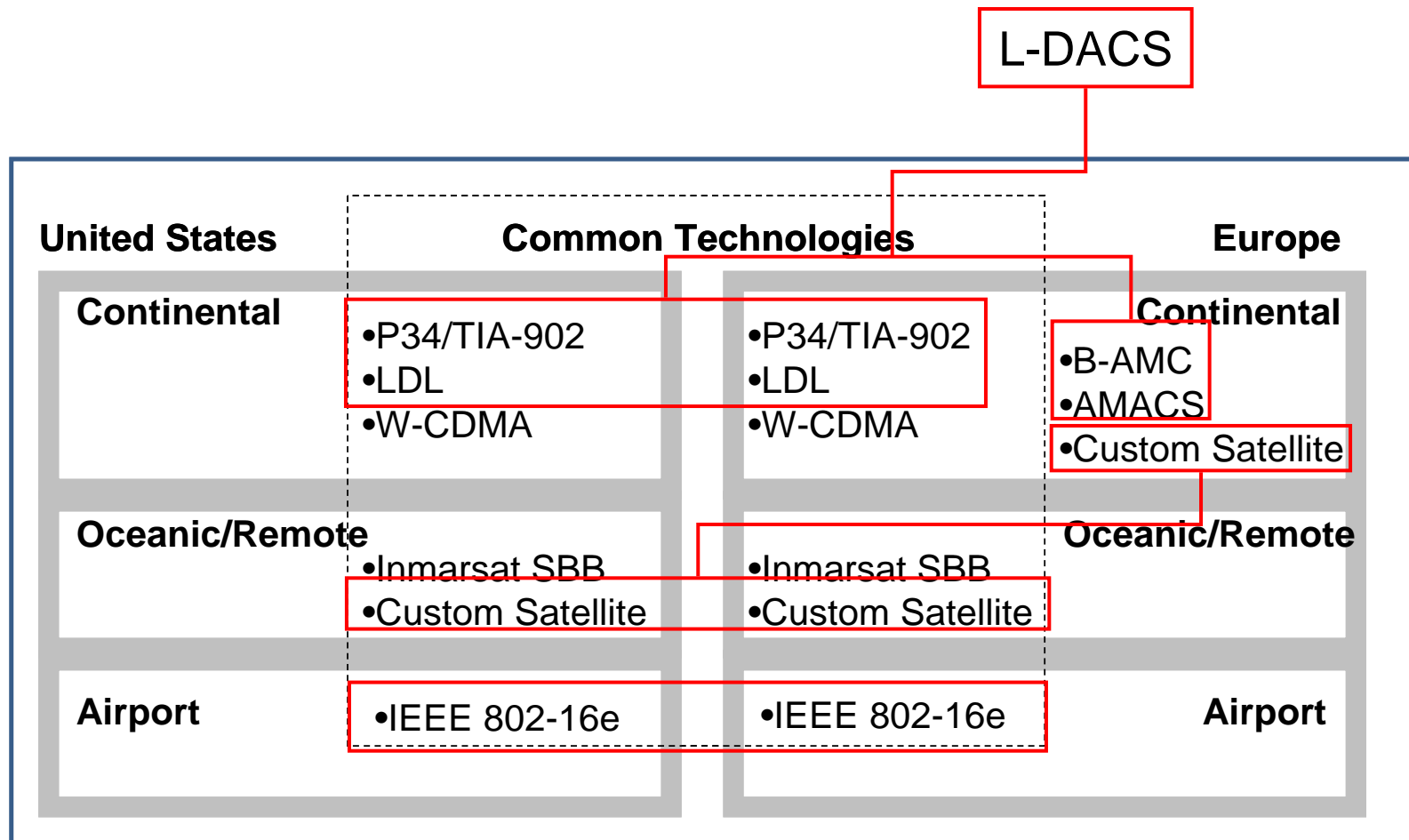
- Two technologies have been removed from further consideration
  - SBB
    - Does not meet all performance requirements
    - Satellite will reach the end of life by 2020
  - WCDMA
    - Need for large “clean” bands in L-Band
- New Satellite Systems
  - Placeholder for future developments
  - Emerging systems have been identified that could be considered as part of the FCI

# U.S. Evaluation Results

	Evaluation Criterion	TIA-902 (P34)	LDL	WCDMA	B-AMC	AMACS
1	Provides ATS A/G Data Services within Requirements (sans A-EXEC)	A - Capacity				
		B - PIAC				
		C - QoS				
		D - Environment				
2	Provides ATS AOC A/G Data Services within Requirements (sans A-EXEC)	A - Capacity				
		B - PIAC				
		C - QoS				
		D - Environment				
3	Technical Readiness Level					
4	Standardization Status					
5	Certification					
6	Ground Infrastructure Cost					
7	Avionics Cost					
8	Spectrum					
9	Authentication and Integrity					
10	Robustness to Interference					
11	Transition					

\* Gray indicates insufficient information at the time of evaluation

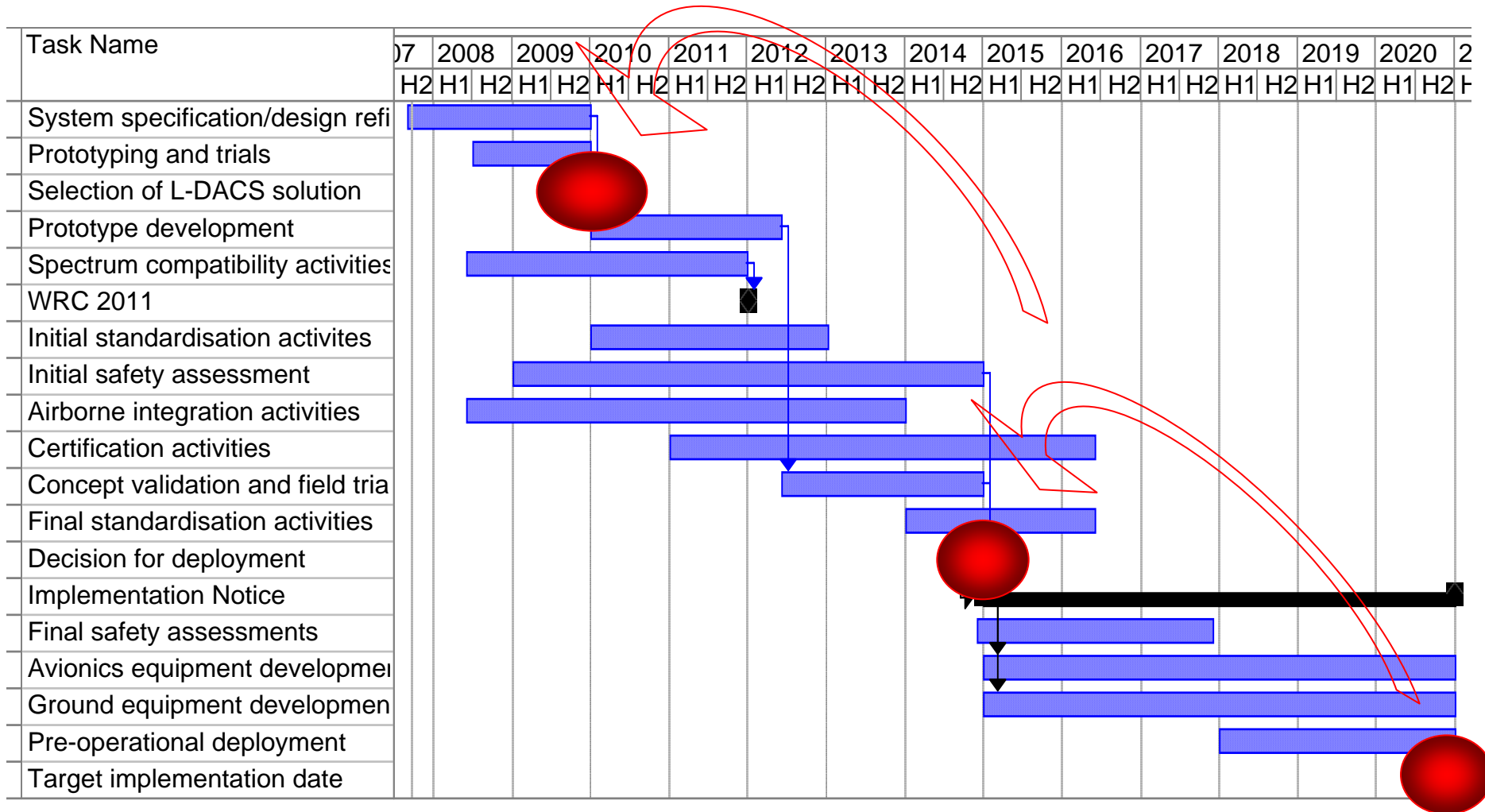
# Joint Proposals



# L-band Digital Aeronautical Communication System (L-DACS) Key Characteristics

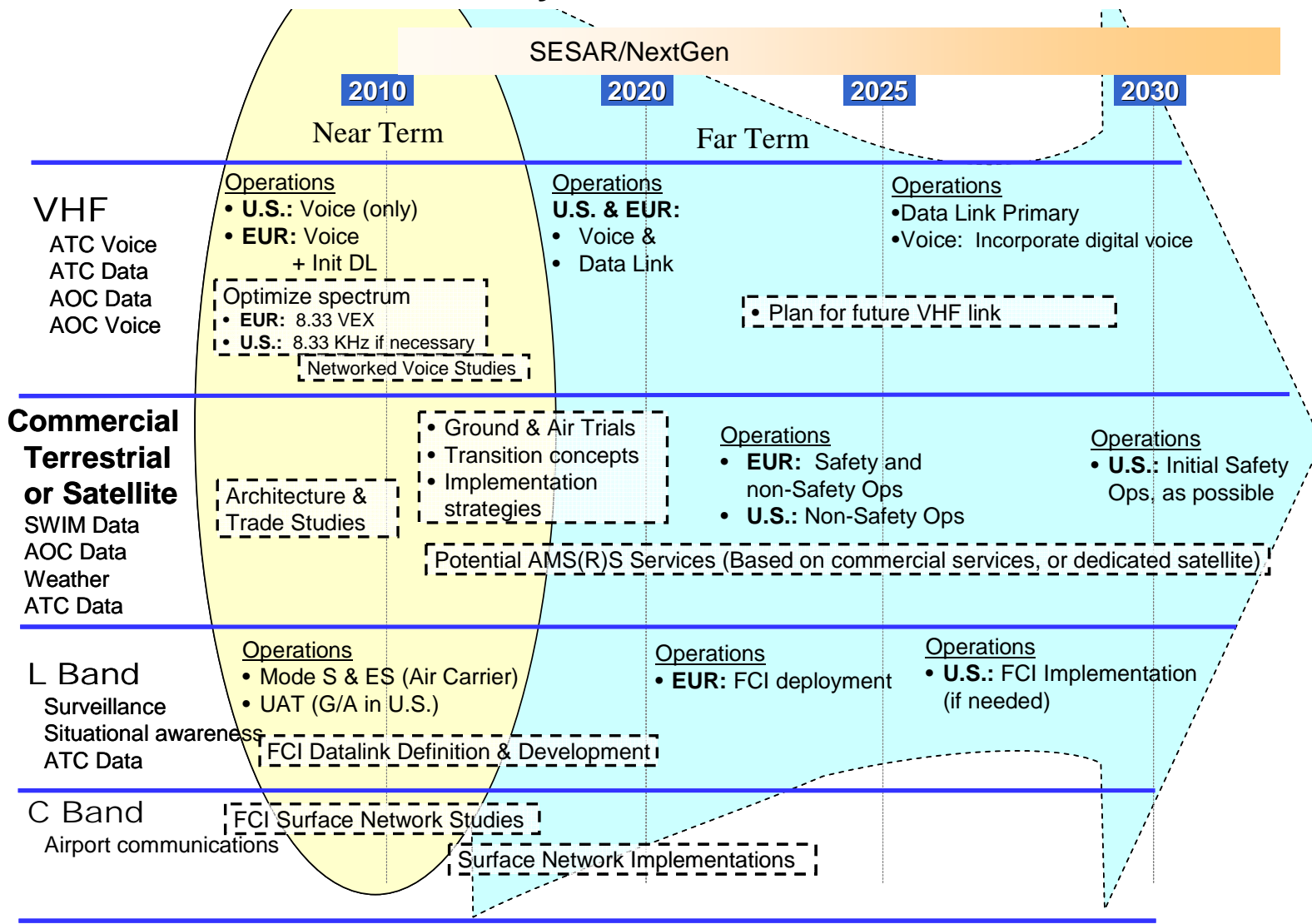
<b>Options</b>	<b>Access scheme</b>	<b>Modulation type</b>	<b>Origins</b>
<b>L-DACS 1</b>	FDD	OFDM	B-AMC, TIA 902 (P34)
<b>L-DACS 2</b>	TDD	CPFSK/GMSK type	LDL, AMACS

# L-band data link: Expedited Development and Deployment Plan



# Roadmap

## Future Comm Study: Communication Evolution Overview



# Observations: General

- The FCI must support ATS and AOC end-to-end communications including air/ground and air/air
- New communication components of FCI will be supporting primarily data communications
- **No single technology** meets all requirements across all operational flight domains
- To meet the diverse range of communications, the FCI will be a **system of systems** integrating **existing communication systems** (voice, VDL) as well as **new communications systems** to meet the operational requirements
- No COTS technologies have been identified that can be adopted as new components of the FCI without some modification
  - However, reuse of emerging technology and standards should be considered to the maximum extent possible to reduce risk and shorten development time




# Data Link Recommendations

- [R1] Develop a **new system based on the IEEE 802.16e** standard operating in the **C-band** and supporting the **airport surface environment**
- [R2] **Complete investigations** (with emphasis in proving the spectrum compatibility with other systems) for finalising the selection of a data link operating in **L-band** (L-DACS) and supporting the **continental airspace** environment, **aiming at a final decision by 2009**, to enable system availability for operational use by 2020
- [R3] Recognising that **satellite communications** remain the prime candidate to support oceanic and remote environments and that the considered future satellite systems **may also be able to support continental environments possibly complementing terrestrial systems**, monitor and **support developments** that will lead to globally available ATS satellite communications

# General Recommendations

- [R4] Recognising the importance of spectrum for the realisation of FCI, **ensure the availability of the required spectrum** in the appropriate bands.
- [R5] Promote/support activities that will enable/facilitate the **airborne integration of the selected technologies**.
- [R6] **Incorporate** in any new data link system, **provisions** for supporting **high QoS requirements** in an **end to end perspective**.
- [R7] Continue the **close cooperation** between the interested stakeholders and in particular between the FAA and EUROCONTROL in the realisation of the above recommendations

# Actions

- Per actor/stakeholder group
  - ANSPs, EUROCONTROL, FAA
  - Industry
  - Standardization Bodies
  
- Per activity type
  - C-band system
  - L-band system 
  - Satellite system
  - End to end QoS
  - Spectrum
  - Airborne Integration 
  - Standardization 



# C-band Datalink Actions

- [R1] Develop airport surface system based on IEEE 802.16e standard.
- [A1.1] Identify the portions of the IEEE standard best suited for airport surface wireless communications, identify and develop any missing functionality and propose an aviation specific standard to appropriate standardisation bodies;
- [A1.2] Evaluate and validate the performance of the aviation specific standard to support wireless mobile communications networks operating in the relevant airport surface environments through trials and testbed development;
- [A1.3] Propose a channelisation methodology for allocation of safety and regularity of flight services in the band to accommodate a range of airport classes, configurations and operational requirements
- [A0.4] Complete business analysis in relation to the FCI components and implementation from the perspective of the ground infrastructure and the airlines.

# L-band Datalink Actions (1/2)

- [R2] Complete investigations for selection of L-band datalink.
- [A2.1] Refine and agree on the interference environment and assumptions for the L-band compatibility investigations;
- [A2.2] Develop L-DACS prototypes for testing and trials to facilitate the technology investigations for the selection of the L-band data link;
- [A2.3] Complete the investigation of compatibility of candidate L-band data link with existing systems in the L-band particularly with regard to the onboard co-site interference and agree on the overall design characteristics;

...

# L-band Datalink Actions (2/2)

[R2] Complete investigations for selection of L-band datalink.

...

[A2.4] Complete evaluation of performance of candidate L- band data link against the appropriate requirements in the various environments; and

[A2.5] Considering the design trade-offs, propose the appropriate L-DACS solution for input to a global aeronautical standardisation activity; and

[A2.6] Evaluate and validate the performance of the proposed solution in the relevant environments through trials and test bed development.

[A0.4] Complete business analysis in relation to the FCI components and implementation from the perspective of the ground infrastructure and the airlines.



# Satellite Datalink Actions

- [R3] Monitor and support globally available ATS satellite communications.
- [A3.1] Continue monitoring the satellite system developments and assessment of specific technical solutions to be offered in the timeframe defined in the COCR as these next generation satellite systems become better defined;
- [A3.2] Update existing AMS(R)S SARPs performance requirements to meet future requirements; and
- [A3.3] In order to support the new AMS(R)S SARPs, consider the development of a globally applicable air interface standard for satellite communication systems supporting safety related communications.
- [A0.4] Complete business analysis in relation to the FCI components and implementation from the perspective of the ground infrastructure and the airlines.

# General Datalink Actions

[R6] Incorporate provisions for high QoS in an end to end perspective.

[A0.5] In order to finalise the selection of the new components of the FCI, carry out testing and validation within an end-to-end environment to ensure that the required QoS and performance can be achieved.

# Spectrum Related Actions

[R4] Ensure the availability of the spectrum

[A4.1] Continue to provide rationale to spectrum regulators on the need for additional AM(R)S spectrum to facilitate advances in aeronautical communication capabilities;

[A4.2] Provide support for compatibility studies between the FCI and other incumbent systems in any newly-allocated AM(R)S bands. This will include studies within ICAO regarding FCI compatibility with other aeronautical systems, and studies within the ITU regarding FCI compatibility with non-aeronautical systems; and

[A4.3] Continue to support the need for priority to AMS(R)S in the satellite L-band.

[A4.4] In the longer term, reconsider the potential use of the VHF-band for new technologies when sufficient spectrum becomes available to support all or part of the requirements.

# Industry Actions

[R5] Promote the airborne integration of the selected technologies.

[C1.1] Investigate the feasibility of a flexible airborne architecture and enablers such as software defined avionics, and multi-function, multi-mode antennas; and

[C1.2] Support activities to ensure that a flexible airborne architecture evolves to ease the cost and time of certification and readily accommodate new applications and technologies.



# FAA, EUROCONTROL, ANSPs, Airlines and ICAO Actions

[R1 to R7]

C-band, L-band and Satellite Data link and Spectrum Actions

+

[A0.1] Continue close cooperation in carrying out the actions and relevant activities.

[A0.2] Support activities and engage with aircraft manufacturers, aircraft operators and industry standard groups to ensure that a flexible airborne architecture evolves to ease the cost and time of certification and readily accommodate new applications and technologies; and

[A0.3] Encourage industry investigations into flexible airborne architectures, software defined avionics, and multi-function, multi-mode antennas.

# Standardisation & Certification Actions (including ICAO, RTCA, EUROCAE)

## Supporting recommendations R1, R2, R3, R5


- [B1.1] Initiate development of appropriate aviation specifications covering the 802.16e based system operating in the C-band;
- [B1.2] Await the outcome of actions 3.X to initiate development of appropriate aviation specifications covering the selected L-band data link;
- [B1.3] Update existing AMS(R)S SARPs performance requirements to meet future requirements;
- [B1.4] Consider the development of a new satellite communication standard for satellite systems supporting safety related communications; and
- [B1.5] Consider the re-evaluation of actual certification procedures (e.g. DO178/ED12) and/or development of an integrated SW development environment in order to decrease certification cost for future components (particularly SDR)



# Documentation

- “Action Plan 17 Final Conclusions and Recommendations Report”, EUROCONTROL/FAA/NASA, version 1.1, November 2007. Available at [http://www.eurocontrol.int/communications/gallery/content/public/documents/AP17\\_Final\\_Report\\_v11.pdf](http://www.eurocontrol.int/communications/gallery/content/public/documents/AP17_Final_Report_v11.pdf)
- “Future Communications Infrastructure – Step 2 Technology Assessment Results”, EUROCONTROL, October 2007, Available at [http://www.eurocontrol.int/communications/gallery/content/public/documents/FCI\\_Step%20%20Report\\_V10.pdf](http://www.eurocontrol.int/communications/gallery/content/public/documents/FCI_Step%20%20Report_V10.pdf)
- “Final Report on Technology Investigations for Provision of Future Aeronautical Communications“, FAA/NASA/ITT FCS Technology Investigation Final Report, NASA Contractor Report CR-2008-215144, April 2008. Available at <http://gltrs.grc.nasa.gov/reports/2008/CR-2008-215144.pdf>
- “Additional Technologies and Investigations for Provision of Future Aeronautical Communications“, FAA/NASA/ITT FCS Phase III Study Final Report, NASA Contractor Report CR-2008-214987, February 2008. Available at <http://gltrs.grc.nasa.gov/reports/2008/CR-2008-214987.pdf>
- “Communications and Operating Concept Document”, FAA/EUROCONTROL, version 2.0, May 2007. Available at <http://www.eurocontrol.int/communications/gallery/content/public/documents/COCR%20V2.0.pdf>
- “FCI – Technology Investigations: Evaluation Scenarios Document”, EUROCONTROL/FAA, version 1.0, April 2007. Available at [http://www.eurocontrol.int/communications/gallery/content/public/documents/FCS\\_Eval\\_Scenarios\\_V10.pdf](http://www.eurocontrol.int/communications/gallery/content/public/documents/FCS_Eval_Scenarios_V10.pdf)

# What next

- Endorsement by ICAO ACP  **Done**
  
- New FAA/ECTL Action Plan covering:
  - AP17 recommended actions
  - SESAR/NextGEN: coordination
  - ...
  
- Mature proposals for specific standardization work in ICAO/ACP
  
- Work with Industry to address integration aspects

# Thank you

## Additional information:

Nikos Fistas

[nikolaos.fistas@eurocontrol.int](mailto:nikolaos.fistas@eurocontrol.int)

Brent Phillips

[brent.phillips@faa.gov](mailto:brent.phillips@faa.gov)

Jim Budinger

[james.m.budinger@nasa.gov](mailto:james.m.budinger@nasa.gov)