WORKING TOGETHER FOR GLOBAL ATM

Florian Guillermet, SESAR JU
## Europe and US
### Key ATM figures

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<thead>
<tr>
<th>Category</th>
<th>Europe*</th>
<th>US**</th>
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<tbody>
<tr>
<td>Geographic area (million km² of airspace)</td>
<td>11.5</td>
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<tr>
<td>No. of countries</td>
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<td>No. of civil Air Navigation Service Providers</td>
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<td>Total staff</td>
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<td>No. of Air Traffic Controllers</td>
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<td>No. of en route centres</td>
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### Additional Information
- 21% share of General Aviation (GA)
- 15.2 million controlled flights
- 3.9% share of General Aviation (GA)
- 9.5 million controlled flights


*EUROCONTROL States excluding Oceanic areas and Canary Islands
**Area, flight hours and centre count refers to continental US (CONUS) only
U.S. – EU MoC: safeguarding NextGen – SESAR Interoperability

- Involves European and US industries steered by NextGen and SESAR
- In place since 2011 governed by a Joint Committee, a High Level Committee and a Coordination Committee
- 5 areas of collaboration
  - Transversal
  - Information Management
  - Trajectory Management
  - CNS and Airborne Interoperability
  - Collaborative Projects
The evolution of the cooperation

• Common positions towards ICAO to achieve global interoperability and standards

• Coordinated positions with the U.S./FAA:
  • European coordination under EC leadership
    – Development of the GANP/ASBU modules
    – ANC/12, ATConf/6, GA38
    – ANC Panels
    – ANB work groups and task forces
    – ANB organised Standardisation Round Table Discussions

• Towards industry standards bodies:
  • Agreeing positions to guide and support work in the joint work of EUROCAE WG´s and RTCA SC´s
• NextGen/SESAR “State of Harmonisation report”
  – 2014 view of the level of harmonisation and challenges ahead
  – Key areas for harmonisation requiring ICAO provisions or industry standards
  – Focus of discussion:
    • Trajectory Based Operations
    • Data Communications
WORKING TOGETHER FOR GLOBAL ATM

Edward L. Bolton Jr., NextGen
Operational

- High-altitude precision routes (PBN)
- Reroute based on weather or congestion
- Time-based sequencing of aircraft
- Precision departure paths (PBN)
- Reduced departure spacing
- Surface data sharing
- Integrated flight planning
- Optimized profile descents (PBN)
- Precision arrival paths (PBN)

Implementation

- TFDM
- PBN
- TBFM
- ASIAS
- AIM
- NWP

Transformational

- ADS-B
- CATM-T
- SWIM
- CSS-Wx
- NVS
- DataComm

Foundational

- Terminal Automation Modernization and Replacement
- En Route Automation Modernization
- Terminal Automation Modernization and Replacement
Need for Harmonization

Ensure that the same flight/aircraft can operate in all systems;
Ensure that common standards are available when needed;
Minimize costs by sharing results and efforts.
Collaboration Vehicle

- Memorandum of Cooperation (MoC) between U.S. / FAA and EU / SESAR for mutual cooperation in civil aviation R&D (NAT-I-9406) Mar 2011
  - Coordination Plans are harmonization activities of mid- and long-term applied research
• Provides a high-level summary of the current state of progress toward achieving the necessary level of interoperability between NextGen and SESAR

• Describe the collaborative activities that are being performed under Annex 1 of EU/US MoC

• Serves as an outline for consideration of the current issues at stake and the challenges ahead

• Demonstrates that differences are recognized and actions are taken to address them where necessary to ensure interoperability
Main Areas of Harmonization

Transversal Activities
- ICAO GANP and ASBU
- RPAS
- Cyber Security

Information Exchange & Mgmt
- SWIM
- Information Models – WXXM, FIXM, AIXM
- 4D Trajectory (4DT) Mgmt

CNS & Airborne
- Avionics Roadmap
- DataComm / Datalink Applications
- DataComm / Datalink Technology – AeroMACS
- ADS Services and Technology

Collaboration Projects
- AIRE
- Global SWIM Demonstrations
- Initial 4D Trajectory (i4D) Trials
Global Cooperation & Interoperability

Standards built on SESAR and NextGen developments will support harmonised Implementation and Regulation.

EUROCAE WG RTCA SC

Programme level coordination enhanced by interoperability and wider industry buy-in.

Global consensus to ensure world-wide interoperability.

ICAO GANP/ASBU’s

EU-US MoC SESAR-NextGen Coordination Activities

Industry Standards

ICAO

SESAR

NextGen

• EC/FAA Coordination
Thank you!
TRAJECTORY BASED OPERATIONS IN A GLOBAL CONTEXT

Olivia Nunez

SESAR JU
THE TRAJECTORY BASED OPERATIONS (TBO) CONCEPT

B0-TBO
Improved Safety and Efficiency through the initial application of Data Link En-Route

B1-TBO
Improved Traffic synchronization and Initial Trajectory-Based Operation

B3-05
Full 4D Trajectory-based Operations

B0-10
Improved Operations through Enhanced En-route Trajectories

B1-10
Improved Operations through Free Routing

B3-15
Integrated AMAN/DMAN/SMAN

B0-15
Improved Runway Traffic Flow through Sequencing AMAN/DMAN

B1-15
Improved Departure, Surface & Arrival Management

B3-25
Impr. Operational Perf. through the introduction of Full FF-ICE

B0-25
Increased Interop., Efficiency and Capacity through G/G Integration

B1-25
Efficiency and Capacity through FF-ICE/1 appl. before departure

B2-25
Impr. Coord. through multi-centre G/G integr: FF-ICE/1 and FO SWIM

B2-31
Enabling Airborne Participation in collaborative ATM through SWIM

B0-35
Impr. Flow Perf. through Planning based on a Network-Wide view

B1-35
Enhanced Flow Perf. through Network Operational Planning

B3-25
Impr. Operational Perf. through the introduction of Full FF-ICE

B0-80
Improved Airport Operations through Airport-CDM

B1-80
Optimised Airport Operations through Airport CDM

B2-35
Increased user involvement in the dynamic utilisation of the network
Global TBO concept definition: ICAO ATMRPP

Initiated March 2014 ATMRPP Toulouse

SESAR has contributed five WP based on SESAR V&V
- WP601: Accuracy of the flight trajectory – the need to manage uncertainty
- WP632 Comments on TBO
- WP636 Time adherence in TBO
- WP637 Sharing Trajectory Predictions in TBO
- WP652 TBO Concept Document (March 2015)

Other inputs: FAA (NextGen), Australia

DATACOM needs global standardization:

- EUROCAE WG78/ RTCA SC214 ATN Baseline 2 initial (2014) CPDLC, ADS-C, EPP, RTA min/max window downlink
- Group is working towards next ATN BLN 2 update
Airborne-ground trajectory sharing:

SESAR RBT concept

- Retain flexibility in the system: RBT revision/update
- Air/ground sharing in execution (RBT)
- RBT = FMS Active Flight Plan
- RBT ≠ ATC Clearance (but evolution towards longer clearances!)
- Do not constrain aircraft unless necessary!

Concept Development Based on V&V
EPP: A Key Improvement

Without EPP

With EPP

FROM INNOVATION TO SOLUTION
Once the A/C enters the ATC arrival horizon:

1. A/C downlink of 4D predicted trajectory (ADS-C), including ETA for metering fix.
2. ATC requests ETA min/max for metering fix (via ADS-C). A/C downlinks RTA min/max (via ADS-C) ATC uplinks feasible RTA.
3. Crew inserts RTA into the FMS, A/C downlinks EPP (via ADS-C).
4. 4D trajectory agreed by crew and ATC → Descent can be flown in full managed.
Next Steps in Sharing of Trajectory Data

- Register ATCO intention in ground system... and share it
- Improve TP
- Uplink with or without clearance: FMS flight optimization
- Symmetric concept (i.e. collaborative): crews initiate request to change RBT and/or clearance (downlink proposal to ATC)
- Lateral & Vertical...
- PBN (DRNP) spec uplink
- Wind uplink (ATC Winds)
- ...

“Pull the elastic” until the problem would be solved

Beyond current CPDLC/ADS-C:

Develop operational requirements for future DATACOM
Thanks for your attention
TRAJECTORY BASED OPERATIONS IN A GLOBAL CONTEXT

Steve Bradford

NextGen
Trajectory Operations
Three Transformations Required

- Transformation of Control Methods
- Transformation of Control Tasks
- Transformation of Information
Transformation of Methods

Procedural Based Control:
Control on Where We Think the Aircraft Is

- Landmark Navigation
- Radio Beacons
- Position Reports

Surveillance Based Control:
Control on Where We Know the Aircraft Is

- VOR/DME
- RADAR

Trajectory Based Control:
Control on Where We* Know the Aircraft Will Be

- RNP
- ADS-B
- DataComm

* Shared Trajectory
Turning the Corner on Delays and Inefficiency Requires Transformation of the System

Current efforts are based on providing information to the controller who then…

- needs to make a decision
- AND THEN
- relays this information with voice
- AND THEN
- provides all the monitoring with minimal support.

We must *transform* aviation to meet our challenges
Historical Interactions: Between Stakeholders w/o automation

Definitions:
- **Voice**: Communications is by voice (person to person)
- **Data**: Communications involving automation tools (automation to automation or automation to person)
Present Day Interactions: Between Automation and Stakeholders

Flow Management
Trajectory Management
Separation Management
Collision Avoidance

Definitions:
- **Voice**: Communications is by voice (person to person)
- **Data**: Communications involving automation tools (automation to automation or automation to person)
Future Interactions: Between Automation and Stakeholders

Definitions:
- **Voice**: Communications is by voice (person to person)
- **Data**: Communications involving automation tools (automation to automation or automation to person)
These transformations require

- Information exchange
  - Shared Environment (AIM, WX, Constraints)
  - Shared Trajectory (synchronized representations)
  - Shared Adjustments
DATA COMMUNICATIONS : SEPARATING THE ISSUES

David Bowen

SESAR JU
SESAR: 2020 Vision

Delivering best-in-class, globally interoperable and high-performing Air Transport for Airspace Users and Citizens

Enabling the delivery of safe, cost efficient and environmentally responsible Air Vehicle & ATM operations, systems and services

High Performing Airport Operations
Capacity, Safety, Environment, Efficient, Effective, Networked

Optimised ATM Network Services
Collaboration, Balancing Demand & Capacity, Environment, Efficiency

Advanced Air Traffic Services
Synchronisation, Capacity, Safety, Environment, Cost

Efficient communication services are required to enable the key features of SESAR

Enabling the Aviation Infrastructure
- Providing shared technical services across the aviation domain
- Communications, positioning, navigation, timing and SWIM information
- Air vehicle operations, systems & services
A Global Approach

- ICAO framework
- EUROCAE/RTCA

Spectrum availability is also critical
Separating the Issues

‘Data com’ Services
CPDLC, DCL, D-TAXI, i4D, etc ...

‘Data com’ networking
(FANS), ATN/OSI transition to ATN/IPS

Physical Data link
VDL/2 transition to Future L band etc...

Supporting Avionics
Retrofit and forward fit issues
(FMS, Display, etc)

Deployment
Budget, mandates, timescales
Framing the problem

2014>

Reduce routine tasks and voice communication

2018>

Enable Initial 4D Trajectory Ops + additional services

2025>

Full 4D Business / Mission Trajectory

ATN/ OSI
FANS 1/A

ATN/ OSI

ATN/ IPS

VDL-2 SATCOM

VDL-2 SATCOM*
Aeromacs

LDACS*
IRIS*
Aeromacs

Future Comm Infrastructure

FROM INNOVATION TO SOLUTION
Operational Needs and the Datacom services

Reduce routine tasks and voice communication

Enable Initial 4D Trajectory Ops + additional services

Full 4D Business / Mission Trajectory

**CPDLC:**
- ACL: ATC Clearance and Information service
- AMC: ATC Microphone Check service

Supported by:
- DLIC: Data Link Communications Initiation
- ACM: ATC Communications Management

- (European Datacom Mandate)

**CPDLC Including:**
- D-TAXI: Data Link Taxi Service
- CPDLC services supporting i4D

Enhanced position reporting providing future waypoints with time in seconds supported by **ADS-C EPP** (Extended Projected Profile)

Dynamic RNP and further applications currently being finalized

(Current scope of WG78/SC214)

**Advanced ATM Services to be defined** (Part of the work of SESAR in Europe)

+ Taking a fresh view of the requirements from a stakeholder needs perspective.
Datacom Networking

ATN/OSI FANS 1/A

ATN Standards & FANS1/A

Converged Standards

New Standards - TBD

FANS 1/A in Oceanic (ATN Baseline 1)

(ATN Baseline 2)

Transition to ATN/IPS

*OSI - Open Systems Interconnection Model

**IPS - Internet Protocol Suite
The future system (FCI) will be a system of systems integrating a number of communications sub networks.
Technology Roadmap

HF

VHF ACARS (continental)

SatCOM ACARS (global)

VDL Mode 2/ATN (continent)

New terrestrial (continental) e.g. LDACS?

New SatCOM (global) e.g. Iris?

Multi link Management

AeroMACS (airport)

Link 16 interconnection (Military)?

New flexible avionics

Legacy or currently implemented technology

Future technologies
Mandate 59/2009:
SES Data Link Services Implementing Rule (DLS IR) (EC Reg. 29/2009) specifies European implementation of data link.

Performance Issues:
Performance issues of VDL/2 recently raised a concern on the usability of the system. Some issues attributed to specific avionics installations but other problems remain to be solved.

EASA Study: April 2014
EASA conducted an investigation, under the mandate of the EC, into the performance issues of VDL/2 and published their report. The report identifies a 10-point Action Plan which the SJU has been asked to progress.

EC request to SESAR: June 2014
The EC wrote to the SJU requesting R&D actions on the points raised in the EASA report.

SJU Admin Board: June 2014
The SJU Admin Board gave the go ahead for the launch of an additional call to support the required actions on VDL/2.
EASA report recommendations:

EASA report has highlighted a 10-point Action Plan addressing simulations, measurement campaigns, flight trials and deployment planning. It is recommended in the EASA report that the SJU take on these actions.

Proposed approach to the required work:

A phased approach is proposed to respond to the EASA Action Points:

- **Phase 1**: Simulations, modelling and initial measurement campaign. 2014-2016
- **Phase 2**: Flight trials and limited ground infrastructure deployment. 2016-2018
- **Phase 3**: ‘Deployment focused’ actions including network and governance.

The first 2 phases are planned as part of SESAR and SESAR 2020 respectively.
Thank you for your attention

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#SESAR
@WorldATM_now
DATA COMMUNICATIONS

Steve Bradford

NextGen
Data Communications
Information requirements in support of TBO

- Information exchange
  - Shared Environment (AIM, WX, Constraints)
  - Shared Trajectory (synchronized representations)
  - Shared Adjustments
Required for Data Distribution

- **Network**
  - Cross-boundary coordination/distribution
- **Information Protocols for**
  - Publish/subscribe
  - Command and control – logon/address
- **Connectivity**
  - Ground-ground
  - Air-ground link(s)
- **Messaging**
  - Datacomm
  - AAtS
Communication of Data is Multi-Layer

• Harmonization efforts
  ✤ Messages
    • SC214/WG78, FIXM
  ✤ Pipelines
    • VDL-2, L-Band, Aeromacs, Satcomm,
  ✤ Protocols
    • ATN evolution
  ✤ Network
### Boeing’s Plan for NextGen and SESAR

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<th>Forward Fit</th>
<th>Retrofit</th>
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**Notes:**

1. FANS-1 and CMU LINK2000+ are mutually exclusive. Only one can be enabled due to differences in host system.
2. FANS-2 (integrated) is FANS-1 + LINK2000+.
3. FANS-3 (integrated) is FANS-1 + B2.
4. Most 737 customers have selected non-integrated CMU LINK2000+.
5. 777 will not have integrated LINK2000+. LINK2000+ does not support integration.
Internet Protocol Suite (IPS) Approach

• Initial IPS standards defined in ICAO Doc 9896
  – IPS provides initial technical provisions for application support over TCP/UDP and IP
  – Also supports legacy ACARS applications (AOC messaging, FANS-1/A)

• Ground rule is no changes to existing applications (e.g., LINK2000+ CPDLC) while moving away from OSI-based protocols
  – Avoids having to re-do flight decks, aircraft applications
  – Removes dependency on applications from OSI protocols
  – Creates a logical transition path to future IP-based communication links
  – Can support AOC, FANS-1/A, LINK2000+ and B2 applications
  – Can provide a common security framework (e.g., IPSec)

• Standards development
  – Introduced APIM to AEEC Systems Architecture and Interfaces (SAI) Subcommittee
Honeywell has provided a prototype IPS CMU
- Initial IPS application-level compatibility proven
- No changes to ATS functionality from the flight crew and avionics perspective

Successful demonstration of LINK2000+ message exchange using IPS over SwiftBroadband in November 2014
- CM and CPDLC messages exchanged between prototype Honeywell CMU and prototype Boeing ground system

Continuing activity through 2015
- Ground gateway requirements, including ATN and IPS compatibility
- Avionics impacts, including CMU and router
- VDLM2 investigation
- Mobility, addressing, and security
- TCP vs UDP
- Potential flight trials on Boeing 757 ecoDemonstrator
Towards global interoperability
Data Communications

Madrid, March 11, 2015
Agenda

• SESAR/NextGen convergence path on Datacom

• Datacom deployment in Europe

• ATN B2 “Extended Projected Profile”

• Airbus Datacom roadmap
SESAR / NextGen convergence path on Datalink

- SESAR path
  - ATN B1
  - ATN B2 → D-TAXI
  - EPP → 4DTRAD

- NextGen path
  - ATN B2 Rev B
  - SWIM
  - ATN B2 Rev B → 4DTRAD
  - Adv-IM
  - Dyn-RNP → D-TAXI
  - DCL
  - En Route
  - FANS 1/A
  - ADS-B-In
  - CAVS, CAPP, ...
  - ATC tools: EDA, TSS, ...

ATN B1
ATN B2 → D-TAXI
EPP → 4DTRAD
SWIM
ATN B2 Rev B → 4DTRAD
Adv-IM
Dyn-RNP → D-TAXI
DCL
En Route
FANS 1/A
ADS-B-In
CAVS, CAPP, ...
ATC tools: EDA, TSS, ...
ATN deployment in EUROPE

Priority is to solve ATN-VDL2 deployment issue in Europe

- VDLM2 Maturity study (ELSA)
  - List of potential root causes mid 2015
  - Recommended solutions (including multi-freq strategy) by mid-2016
  - Deployment under the SESAR Deployment Manager responsibility

- IRIS precursor to alleviate VDL2

- Centralized Services (feasibility study)
  - CS 9-1 to rationalize the ground infrastructure
  - CS 9-2 to optimize use of the air/ground bandwidth

ATN B1 mandate delay from 2015 to 2020 can still pave the way to PCP AF6 and ATN B2 (ADS-C / Extended Projected Profile):

- January 2025 for all ATS providers
- January 2026 for 20% of the fleet representing 45% of the flights
Extended Projected Profile (EPP)

EPP is the downlink of the FMS 4D predicted trajectory

EPP is one of the aircraft enablers of the I-4D concept
→ Traffic sequencing

EPP is the aircraft enabler of the Trajectory Based Operations (TBO) concept and the synchronisation of Air/Ground trajectories for:
→ Conformance Monitoring
→ Dynamic Capacity Balancing
→ Conflict Detection & Resolution
→ Complexity Management
→ Dynamic Airspace Allocation
Extended Projected Profile (EPP)

EPP down-link “on request” or “on event” or “periodic”

Downlink **up to 128 points**: next waypoints + significant trajectory changes points (e.g. top of climb, top of descent, cross over level, …) with:

- Latitude, Longitude, Altitude
- Estimated **time** and speed
- Vertical and Lateral type (e.g. flight plan waypoint, offset, overfly, …)
- Altitude, Speed and Time constraints (values and types, AT, AT OR ABOVE, …)
- ….

Downlink **ETA min / ETA max** for one waypoint / significant trajectory change

Downlink **Global** data not applying to individual waypoints (e.g. gross mass, …).
Extended Projected Profile (EPP)

• SESAR first assessment of EPP highlight a higher accuracy and stability of trajectory predictions compared to Ground TP

• Upcoming SESAR trials (PEGASE) will confirm EPP performance

• Then SESAR 2020 Very Large Scale Demonstrations will demonstrate the benefits with pioneer ANSP and Airlines during revenue flights
PEGASE (Providing Effective Ground & Air data Sharing via EPP) will perform data collection and quality analysis of EPP, taking benefits of AIRBUS ferry flights equipped with SESAR prototypes.

- EPP information will be shared with ANSPs, and ground manufacturer systems, for operational use.
- Off-line analysis will be performed for statistics on EPP performance and reliability.
Extended Projected Profile (EPP) – PEGASE trial

West Route

Center Route

East Route

100+ flights targeted From March 2015
To March 2016
Airbus Datacom roadmap

- Airbus plans to build an **A320 FANS A+C** in compliance with B2 standards (first release) to fulfill the AF6 requirement from the PCP Implementing Rule and support SESAR 2020 Very Large Demonstrations
  - Opportunity for roll-over on A330/A340 may be considered

- Airbus will focus on A320 first (main SESAR target), targeting both **forward-fit and retrofit** opportunities
  - Retrofit by software upgrade from a FANS B+ aircraft

- Airbus will develop a **FANS A+C+ upgrade** based on “B2 B” for all aircraft programs when deemed relevant
  - Objective would be to propose a new retrofit by software upgrade for A320s already equipped with FANS A+C
Airbus Datacom roadmap

- **IOC ATN B1 mandate**
  - B2 Rev A
  - B2 Rev B
  - Pre-requisites

- **IOC ATN B2**

- **DCL FANS 1/A**
  - En-Route FANS 1/A
  - ATN B2 (DC S2)

- **ATN B1**
  - ATN B2
  - PCP
  - Deployment

- **NextGen**
  - Bringing Early Benefits ...
  - Building Momentum ...
  - Converging !!

- **RTCA**
  - B2

- **SESAR**

- **Airbus**
  - (A320)
  - Inv
  - Dev
  - FANS B
  - FANS A+C
  - FANS A+C+

- **Pre-requisites**

- **2012**
  - 2014
  - 2016
  - 2018
  - 2020
  - 2022
  - 2024

- **2013**
  - 2015
  - 2017
  - 2019
  - 2021
  - 2023
  - 2025

- **TBC**

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Conclusion

Opportunity window for SESAR and NextGen convergence on DataComm with ATN Baseline 2 by 2023/2025

⇒ VDLM2 maturity to support ATN Baseline 1, then timely deployment of Baseline 2 is essential to not miss this opportunity window

SESAR and NextGen common need for Extended Projected Profile (Baseline 2 ADS-C) is driven by TBO

⇒ TBO operational benefits (BEBS principle), in combination with PCP AF6 financial incentives, is key for Airlines equipage
THANK YOU
## Airbus Plan for NextGen and SESAR

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<th>Model</th>
<th>Forward Fit</th>
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<td>FANS B+ (not integrated)</td>
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**Note:**
- FANS A+: Advanced Version with Enhanced Features
- FANS B+: Basic Version
- FANS A+C: Advanced System with Compatibility
- FANS A+C+: Advanced System with Compatibility and Enhancements
- (not integrated): Indicates optional integration

**Dates:**
- 11/03/2015
- WAC 2015
- Towards Global Interoperability
- Data communications
Thank you for your attention