Session 2

Avionics Roadmaps

Boeing Technology
Phantom Works

OATA

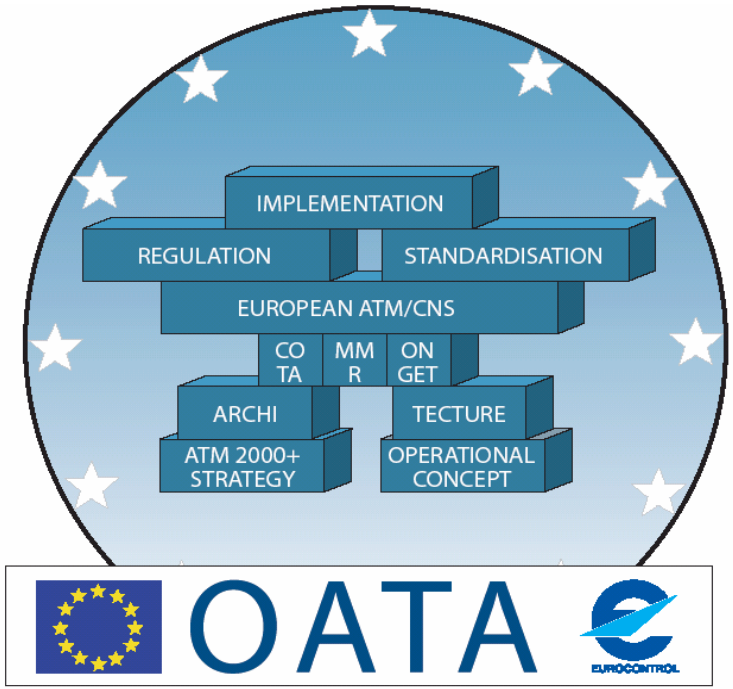
Avionics Study Report

6th October 2005, Toulouse

Summary

- The Context of the Avionics Study Report
- Objectives and Scope
- Methodology for the Study
- Overview of the Evolution of Avionics
- Conclusions

The Context of OATA



- Provide a model based on Eurocontrol ATM 2000+ Strategy and Operational Concept
- Deliver a reference architecture for the Single European Sky.
- Support the Standardisation and Regulation of future interoperable systems
- Serve as a Technical Framework for the implementation of Eurocontrol strategy.

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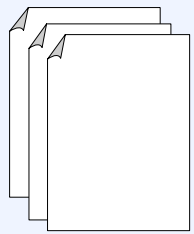
OATA Work Breakdown

- **OATA**
  - WP1 Project Management & QA
  - WP2 Initial Work
  - WP3 Operational and Scenario Use Cases
  - **WP4 Develop Logical Architecture**
    - **WP4.2 Develop Static Architecture**
      - **WP4.2.11 Develop Avionics Cluster**
  - WP5 Non Functional Requirements
  - WP6 Distributed System Support
  - WP7 Evolution and Transition
  - WP8 Validation
  - WP9 Safety



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Study Report on Avionics Systems For the Timeframe 2007,2011 and 2020

Authors & Reviewers

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Objectives

- Review avionics architecture expected to be implemented in the next 20 years
    - Focusing on the OATA target epoch 2011-2019
    - Considering two additional timeframes 2007-2011, 2020+
- Consider two complementary views of the avionics evolution in ATM
    - Eurocontrol vision – driven by operational needs
    - Industrial perspective – driven by implementation issues
- Gain as wide acceptance as possible from the various stakeholders
    - Timeframes used are aligned with Eurocontrol OCD epochs

Scope

- A study on the evolution of Avionics within CNS/ATM system considering views from key stakeholders.
- The study focuses on conceptual and functional issues
- Provide sufficient level of detail to develop the Avionics Cluster for the OATA Model

Methodology for the Study

Criteria & Considerations

Operational (current and foreseen operational needs, operational synergies, actors' roles & responsibilities)
Technological (technology availability, maturity, technology synergies)
Economical (stakeholders interests, potential benefits, cost implications)
Regulatory (standardization, certification & regulation Issues)
Others (environmental and/or political aspects that can lead to mandates, etc)

Assumptions

Concept Inception (T0)
Community acceptance (T0+2Y)
Standardization (T0+4Y)
Technology development (T0+7Y)
Regulations (T0+8Y)
User acceptance (T0+9Y)
Validation (T0+10Y)
Adoption (mandates T0+13Y)
Deployment & Validation (T0+15Y)

Sources of Information

Review & Analysis

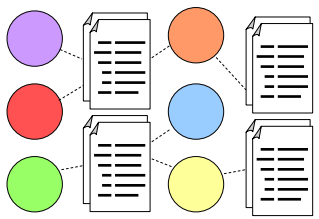
Operational Scenarios & Enabling Relationships

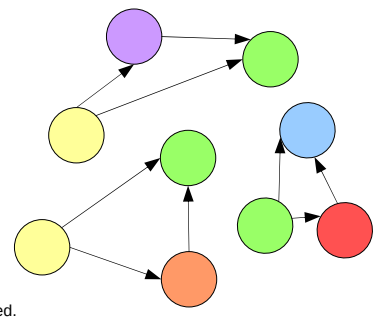
Analysis & Assessment

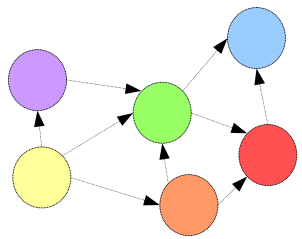
Precedence based on Avionics Evolution

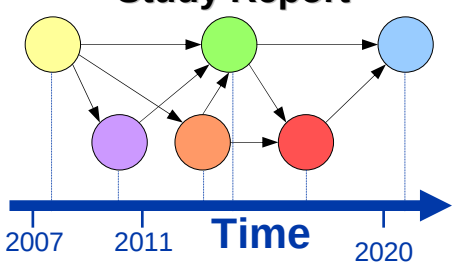
Assessment & Discussion

Study Report





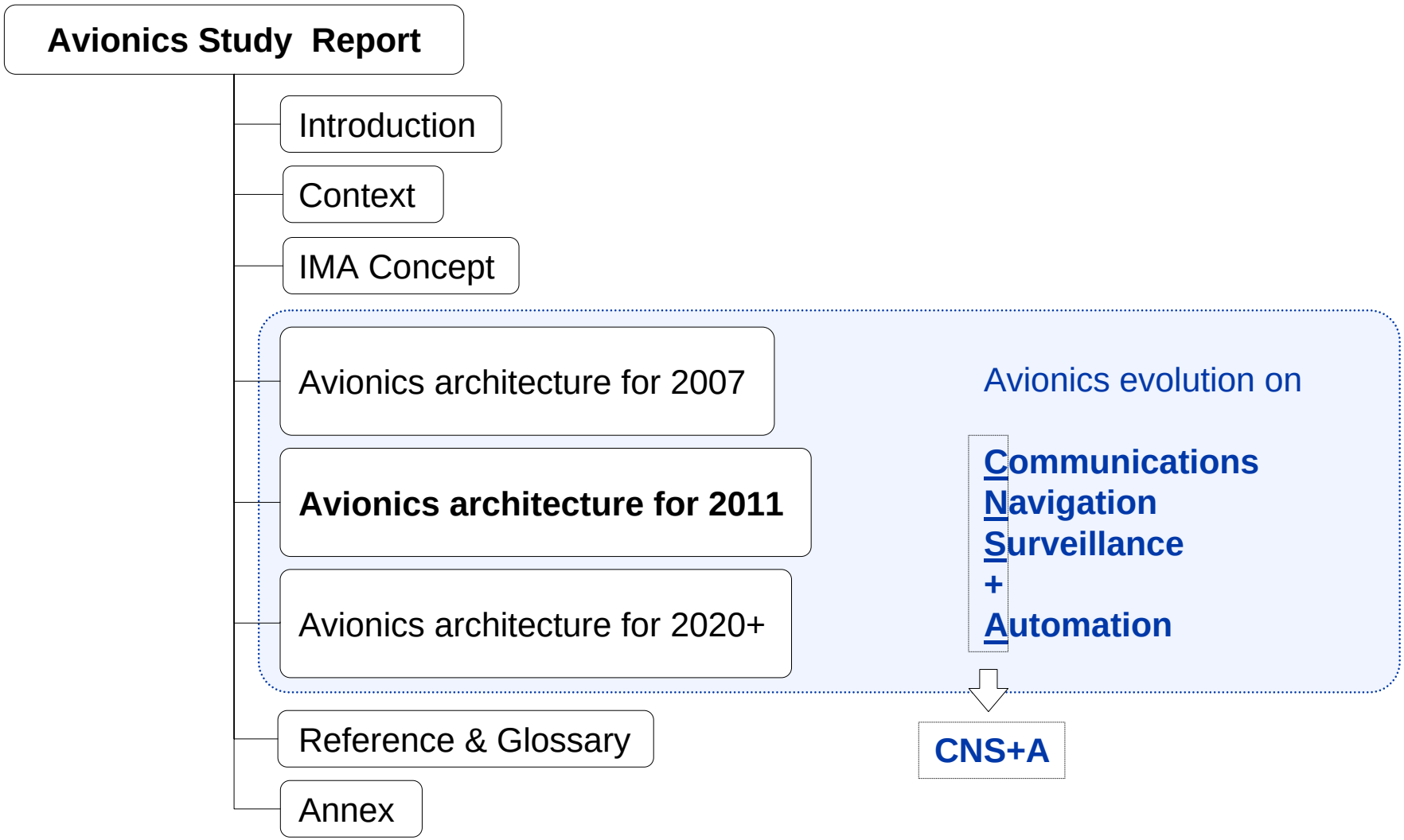




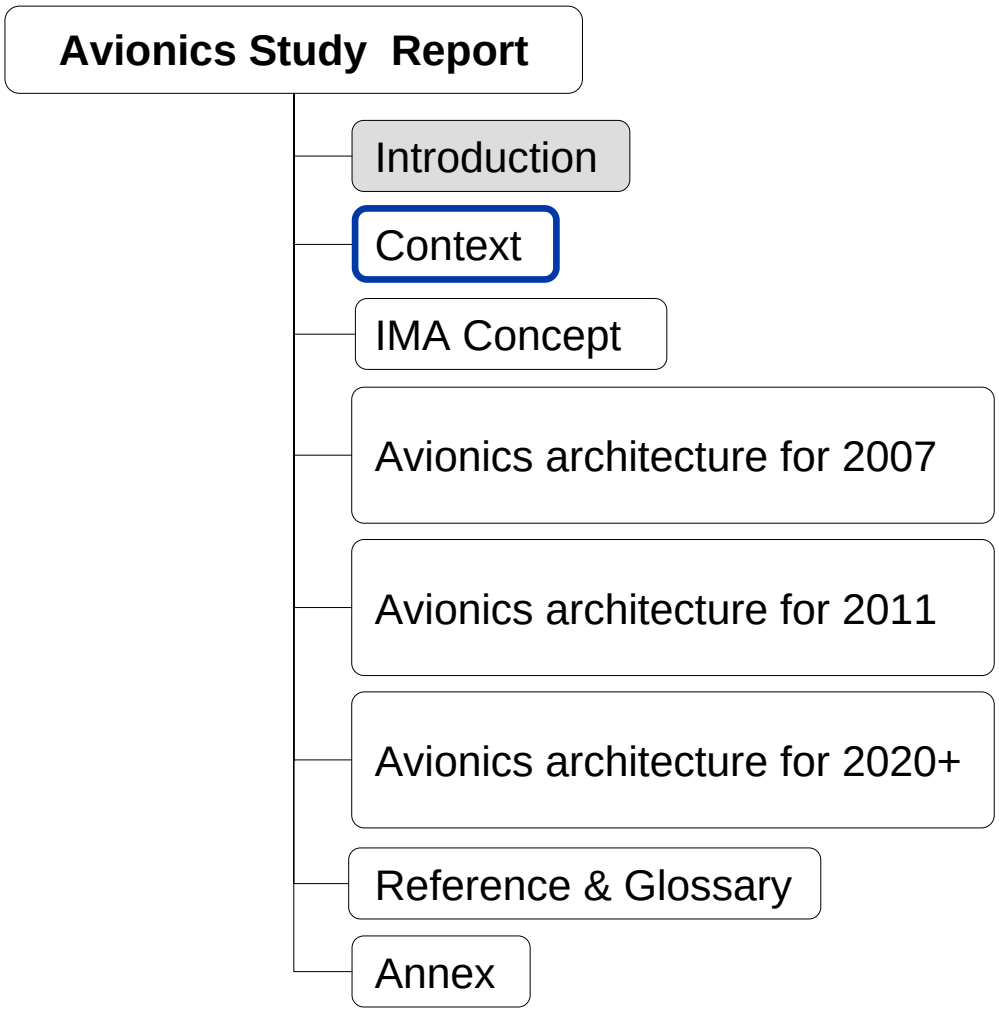
Main Sources of Information

Civil Aviation Authorities ICAO, FAA, JAA	ICAO Annex 6, Operation of Aircraft ICAO Annex 2, Rules of the Air Etc
Standardisation Bodies ARINC, RTCA, EUROCAE	ARINC 755-2 MMR ARINC 756-3 GNSS Navigation ARINC 702/702A FMS Etc
Government Bodies EC, EUROCONTROL, FAA	OPERATIONAL CONCEPT DOCUMENT (OCD) ATM STRATEGY 2000+ Etc
Users Airlines	Customer feedback (annual Avionics Conferences)
CNS Service Providers FAA, EUROCONTROL	Navigation Infrastructure Evolution Study, Eurocontrol CPDLC program, FAA Etc
Research Organizations AIAA, EC-FP, Helios, ATA, BR&TE	RNAV Business Case: Analysis Report, Helios Improved Taxi Prediction Algorithms, AIAA Etc
OEM Boeing & Airbus	Define the future global ATM system, Boeing ATM Aircraft in the future ATM system, Airbus Etc

Structure of the Avionics Study Report



Study Report Contents



Main Limitations in Today's CNS/ATM Operational Context

- Inability to fully exploit advanced onboard avionics capabilities
- Lack of information sharing between the different actors involved
- Lack of synchronization between air and ground systems
- Limited availability of accurate information concerning airborne intent and aircraft performance characteristics
- Tactically-oriented conflict detection and resolution

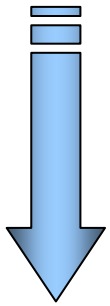
Context – Opportunities

Improvement Opportunities in the Future Operational Context

- Increase integration between air and ground automation systems
- Increase automation levels in both airborne and ground systems
- Introduce enablers for new and improved safety nets
- Dynamic use of airspace for de-confliction, sequencing and merging
- Strategically-oriented ATM system supported by advanced DSTs
- Increase flexibility to accommodate user preferences

Transition between Current and Future Contexts

Static ATM system based on rigid procedures and tactically-oriented management with limited information sharing and limited automation capabilities

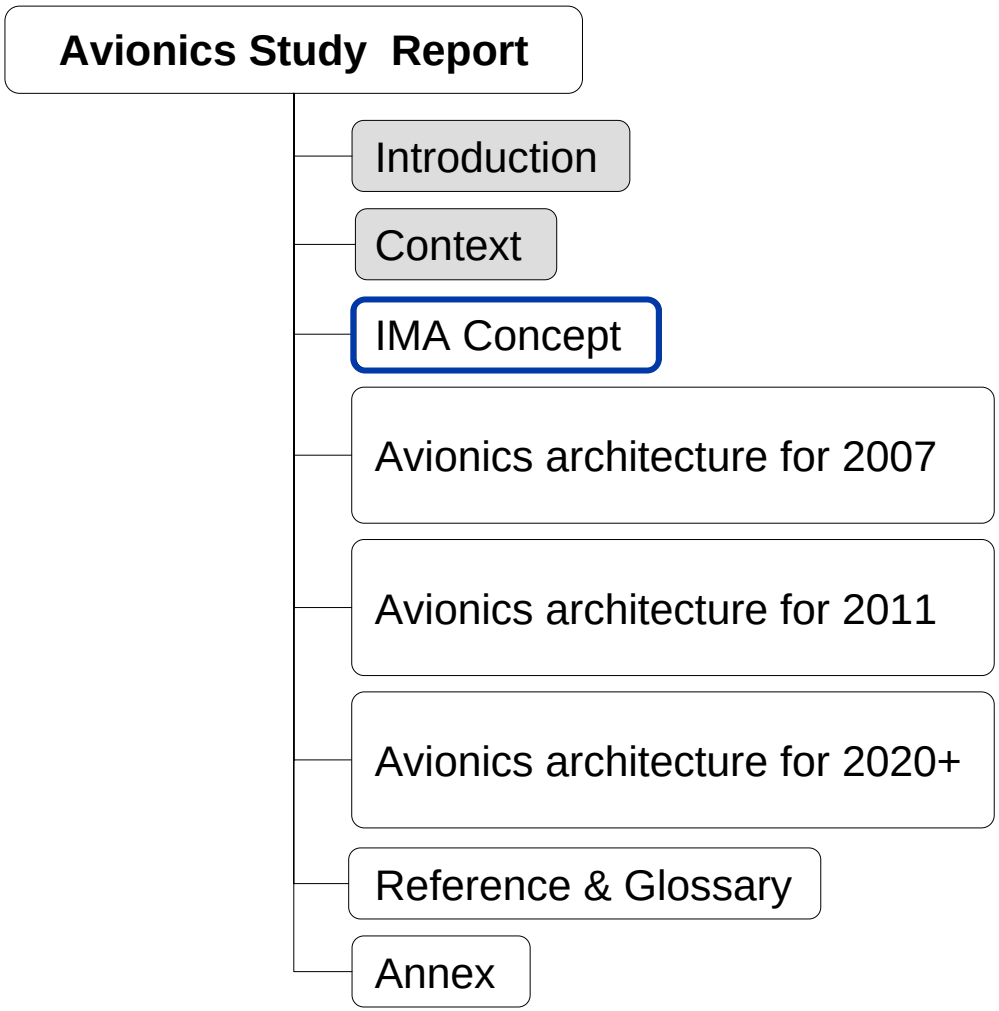


Proposed solutions by EUROCONTROL, FAA, ICAO, BOEING and ATA:

- Performance-driven
- Cost-effective
- Seamless
- Considering human-in-the-loop

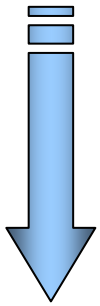
More co-operative system that will use advanced automation and intensive sharing of real time information to achieve accurate gate-to-gate flight management

Structure of the Avionics Study Report



Next Generation Avionics Architecture

Current Philosophy:
One Box per function (50 Systems and around 100 Computers).

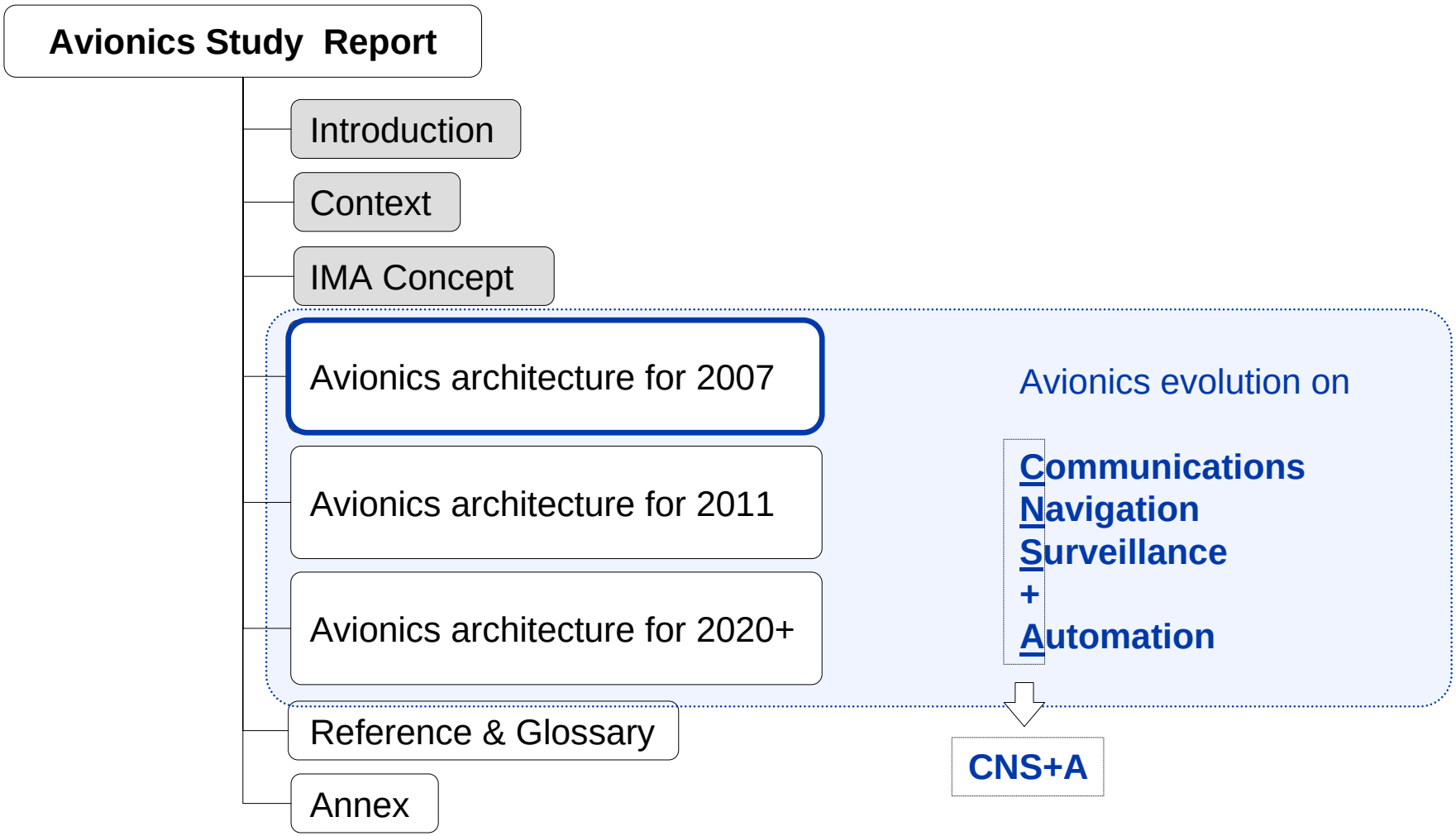


The new avionics architecture is progressively being implemented in the aircraft with the objective of:

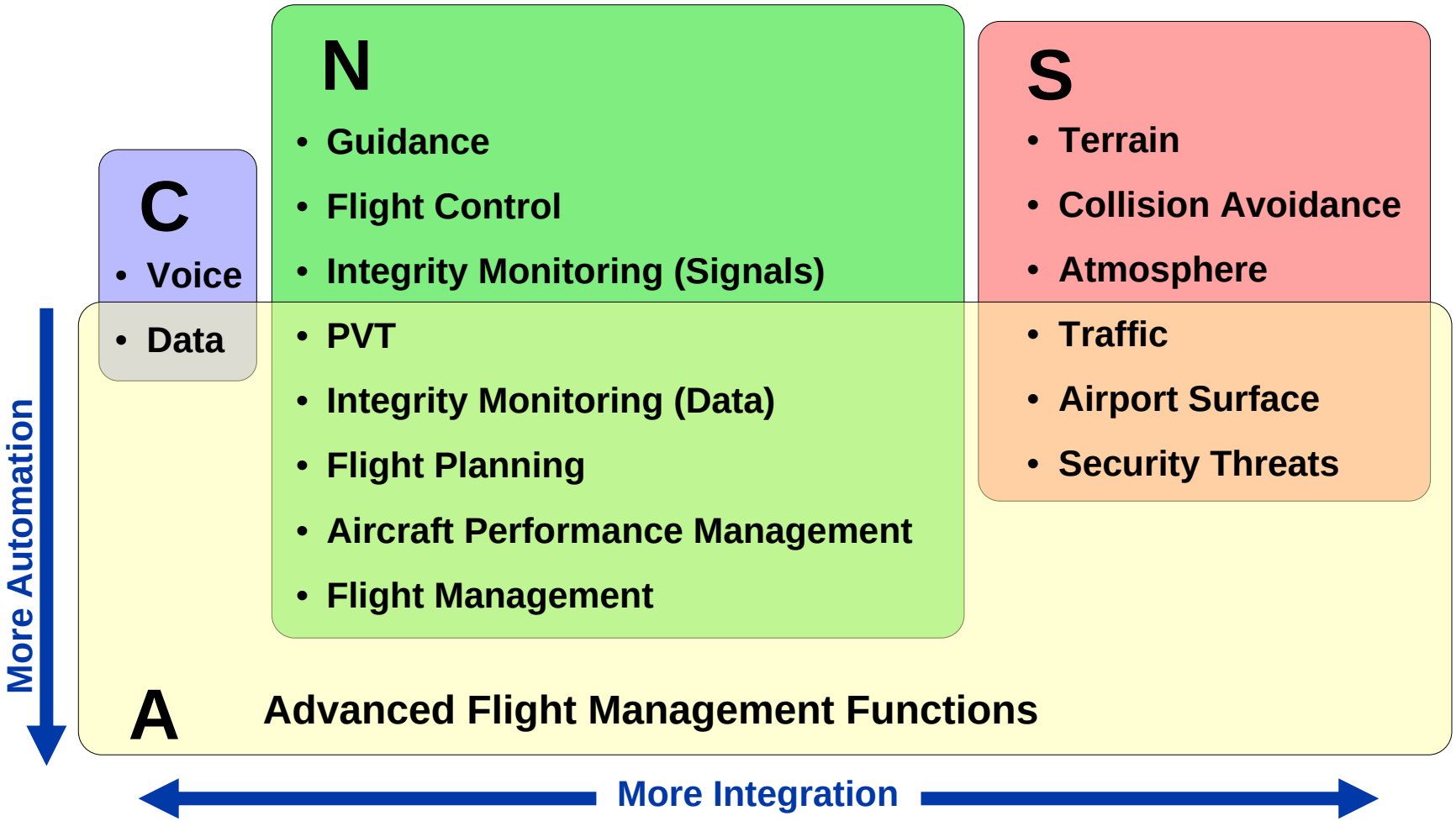
- Reducing the costs
- Facilitating the upgrades
- Improving the efficiency
- Rationalizing the certification requirements of avionics equipment

Evolution towards **I**ntegrated **M**odular **A**vionics - **IMA**
IMA architecture being implemented in:
- Boeing B787
- Airbus A380

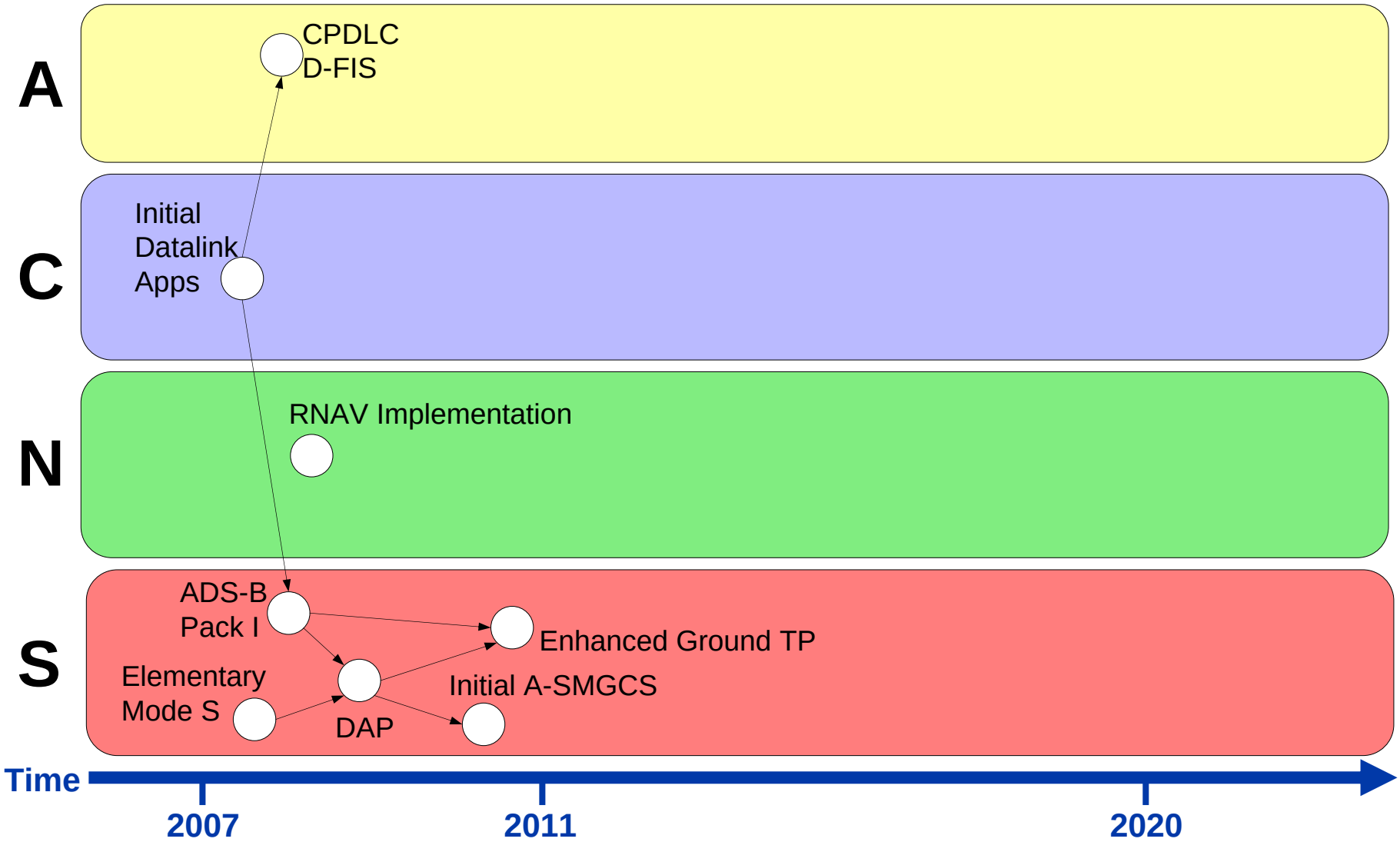
Structure of the Avionics Study Report



CNS+A Functions



CNS+A - Key Enablers



2007-2010 Timeframe

Key Technological Enablers:

- Wider adoption of datalink technology (Mode-S, VDLx, etc)
- Implementation of Air-Ground ADS-B applications

Key Assumptions:

- No change in Pilot/ATCO roles and responsibilities
- Aircraft equipage based on existing Avionics

2007-2010 – Communications

- Initial reduction of voice communications
- Increased use of datalinks for:
  - Non-critical communications
  - The transmission of routine information exchanges
  - Automation of services currently provided by voice
- Expected datalink applications and services:
  - CPDLC (ACL, ACM, DCL, DSC)
  - D-FIS (D-OTIS)

2007-2010 – Navigation

- Initial evolution from conventional guidance to area navigation:
  - Widespread use of B-RNAV en-route and P-RNAV in TMA
- Majority of Aircraft equipped with FMS (RNP-RNAV requirements)
- Possible certification of GPS based GBAS for GLS CATI (2009-2011?)
- Guidance & Position determination based on:
  - DME/DME Multilateration in continental areas
  - INS in oceanic and remote areas
  - GNSS: GPS & GLONASS + multi sensor integration
  - Spaced Based Augmentation Systems (SBAS) – EGNOS

2007-2010 – Surveillance (i)

- Integration between FMS and Surveillance Equipment, enabling:
  - The initial downlink of Airborne Parameters
  - ADS-B Package I air-ground applications:

    ADS-B-ACC / TMA / NRA / APT / ADD

Both Boeing & Airbus provide both Mode S ELS & EHS in new build aircraft, as well as facilitating the implementation of ADS-B Out.

2007-2010 – Surveillance (ii)

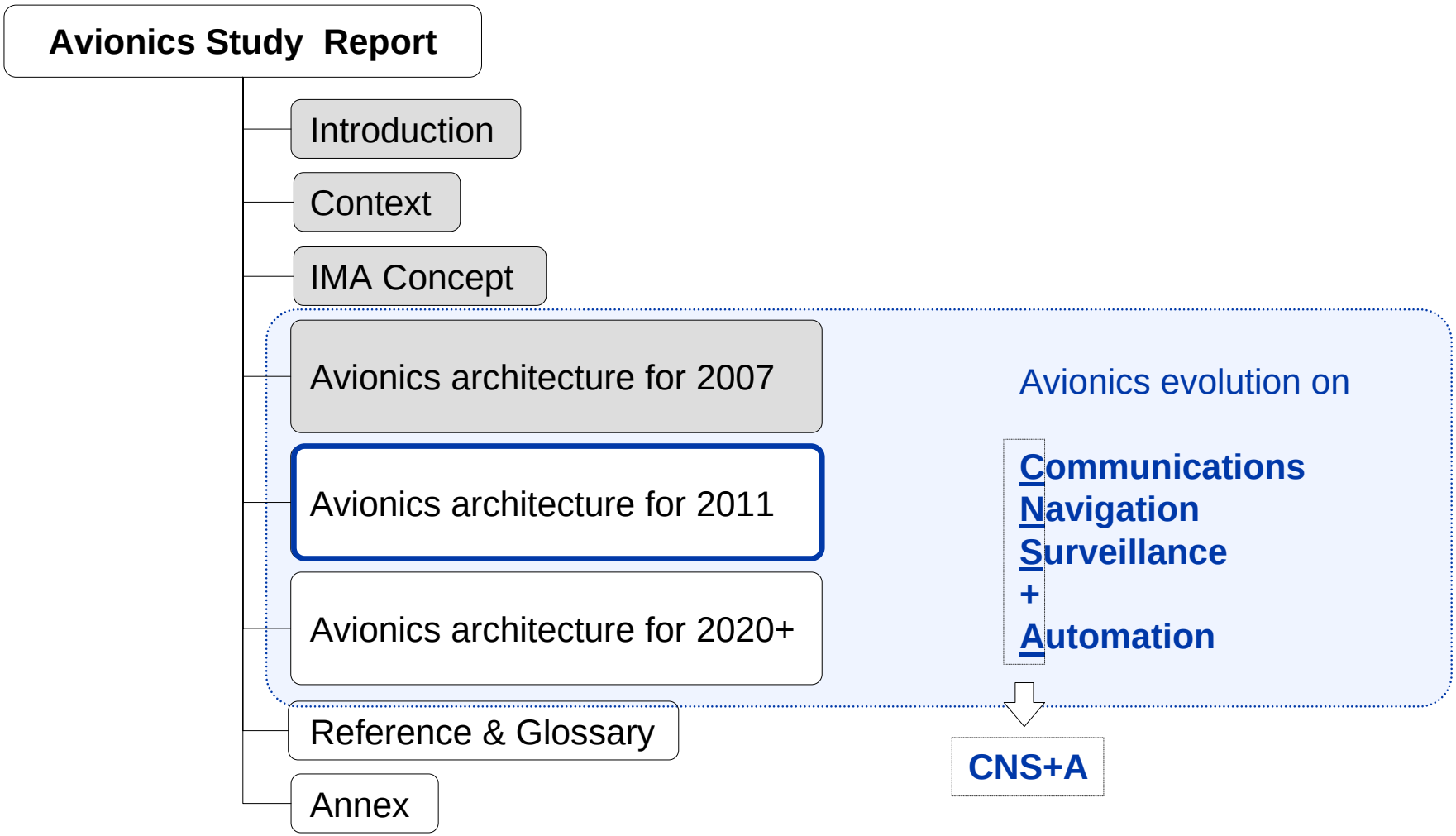
- Airport surface surveillance - A-SMGCS

- Commercial aircraft equipped with ACAS II and TAWS for traffic and terrain avoidance.

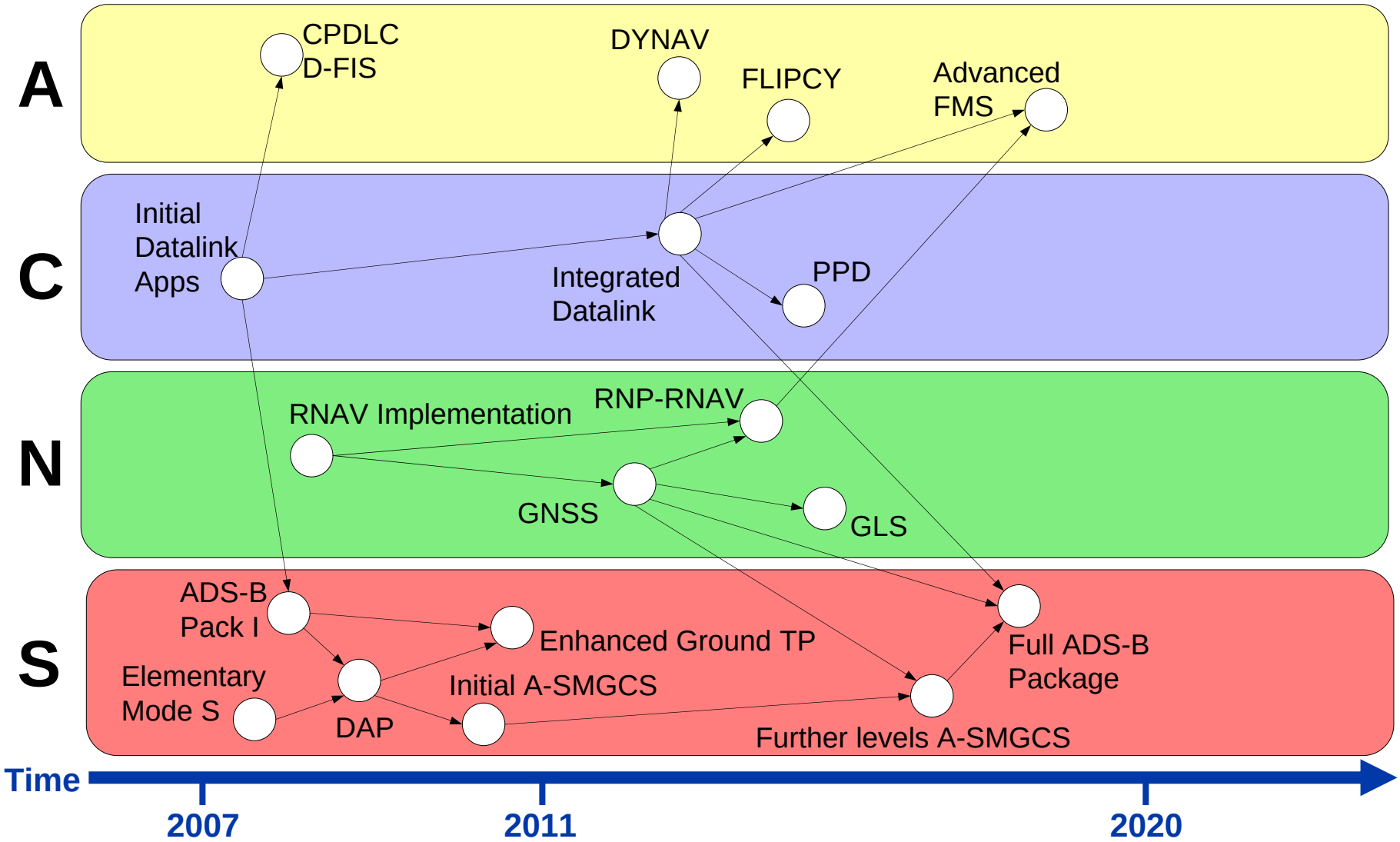
- Widespread use of Electronic Flight Bag (EFB) devices:
    - Basic “paper replacement” functions.
    - Own Ship position derived from GNSS over moving maps.

- Enhanced vision systems to increase situational awareness such as the Head Up Display system (HUD) available, but not in widespread use.

Structure of the Avionics Study Report



CNS+A - Key Enablers



2011-2019 Timeframe

Key Technological Enablers:

- Datalink system and FMS integrated with other Avionics
- Improved GNSS constellation is in place
- Full ADS-B package

Key Assumptions:

- Initial form of delegation, although unlikely
- Upgrades to existing Avionics

2011-2019 – Communications

- Voice communication remains as primary means for safety related information exchanges.
- Automated Downlink of Aircraft Parameters (ADAP)
- Additional flight information services: D-SIGMET, D-RVR
- Early forms of trajectory negotiation: DYNAV, FLIPCY
- Datalink issues:
  - FAA has recently withdrawn from VDL Mode 3
  - Some European states support the VDL Mode 4 for the future
  - Eurocontrol currently investigating a suitable datalink

2011-2019 – Navigation (i)

- Improved GNSS such as Galileo in place by 2011
- Transition to RNP-RNAV based airspace
- Ground Based Augmentation Systems certified later in this epoch
- Guidance & Position determination based on:
  - GNSS en-route and TMA. DME/DME in continental areas
  - INS in oceanic and remote areas
  - Wide expansion of GNSS Landing Systems (GLS)
  - ILS proposed as a backup
  - MLS is likely to be limited only to a few airports
  - Multi Mode Receivers supporting ILS, GLS and MLS expected to become widely used.

2011-2019 – Surveillance (i)

- Full ADS-B Package (ADS-B receiver, CDTI and ASAS processor) will enable the introduction of airborne surveillance applications:
  - Air traffic situational awareness and spacing applications:
    ATSA-SURF / AIRB / S&A / SVA / S&M / C&P
  - Potential for aircraft to share their weather data.
- However:
  - No standards or requirements to develop and install a CDTI.
  - Suggestions to use TIS-B technology temporarily to support the introduction of ADS-B-in

2011-2019 – Surveillance (ii)

- Additional automated downlink of Airborne Parameters supported by Mode S Enhanced Surveillance : PPD, CAP and SAP
- Enhanced route planning and control functions on the ground:
  - Delivery of taxi instructions by datalink.

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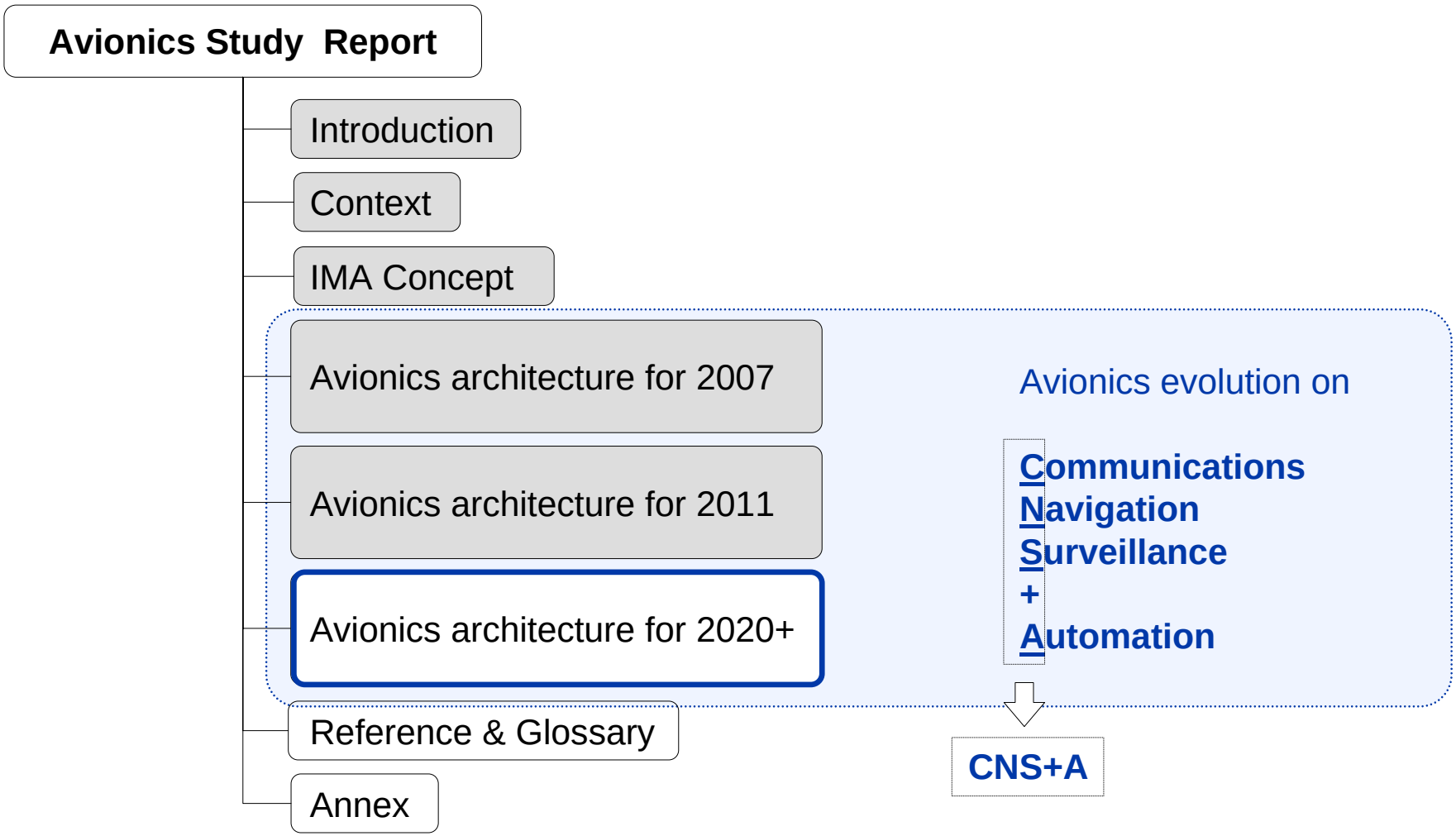
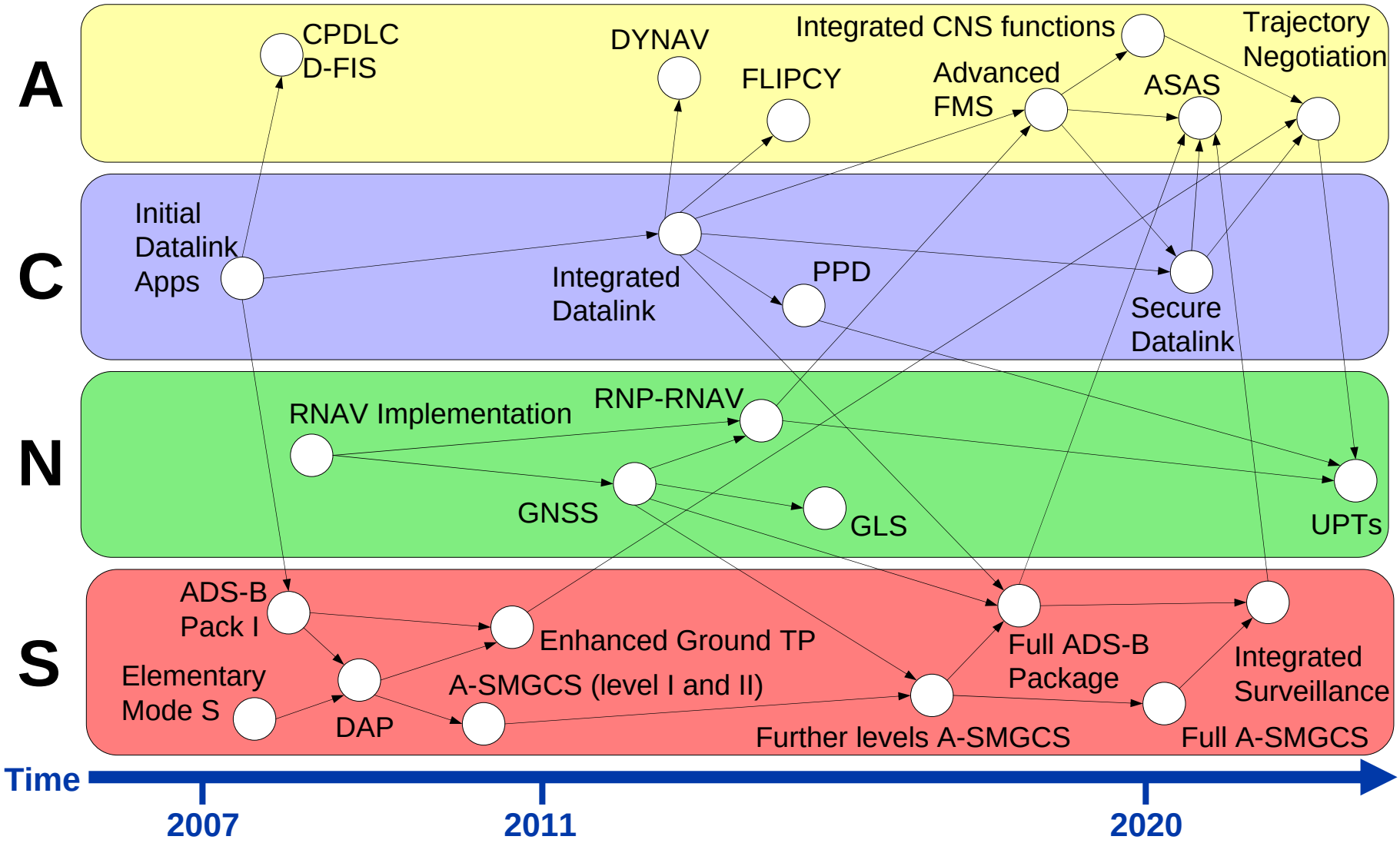


CNS+A - Key Enablers



2020+ Timeframe

Key Technological Enablers:

- A safety critical and secure datalink
- Common Information Management System (SWIM)
- Advanced guidance and navigational capabilities (4D RNAV)
- Next generation aircraft. FMS capable of managing CNS functions.
- GNSS is in place and certified as the primary means of navigation

2020+ Communications

- New communications system integrating voice and data communications:
  - Not a clear definition about the main features
  - Airbus is studying Digital voice architecture as an option
- Future communications based on real time sharing of information
- Advanced datalink services for trajectory negotiation:
  - COTRAC / GRECO
- Extensive interchange of aircraft intent

2020+ Navigation

- Exchange and negotiation of 4D trajectories to enable User Preferred Trajectories
- Advanced navigation capabilities to enable 4D-RNAV Operations
  - AIS requirements are yet to be specified
  - Improved benefits achieved if advanced DST are in place

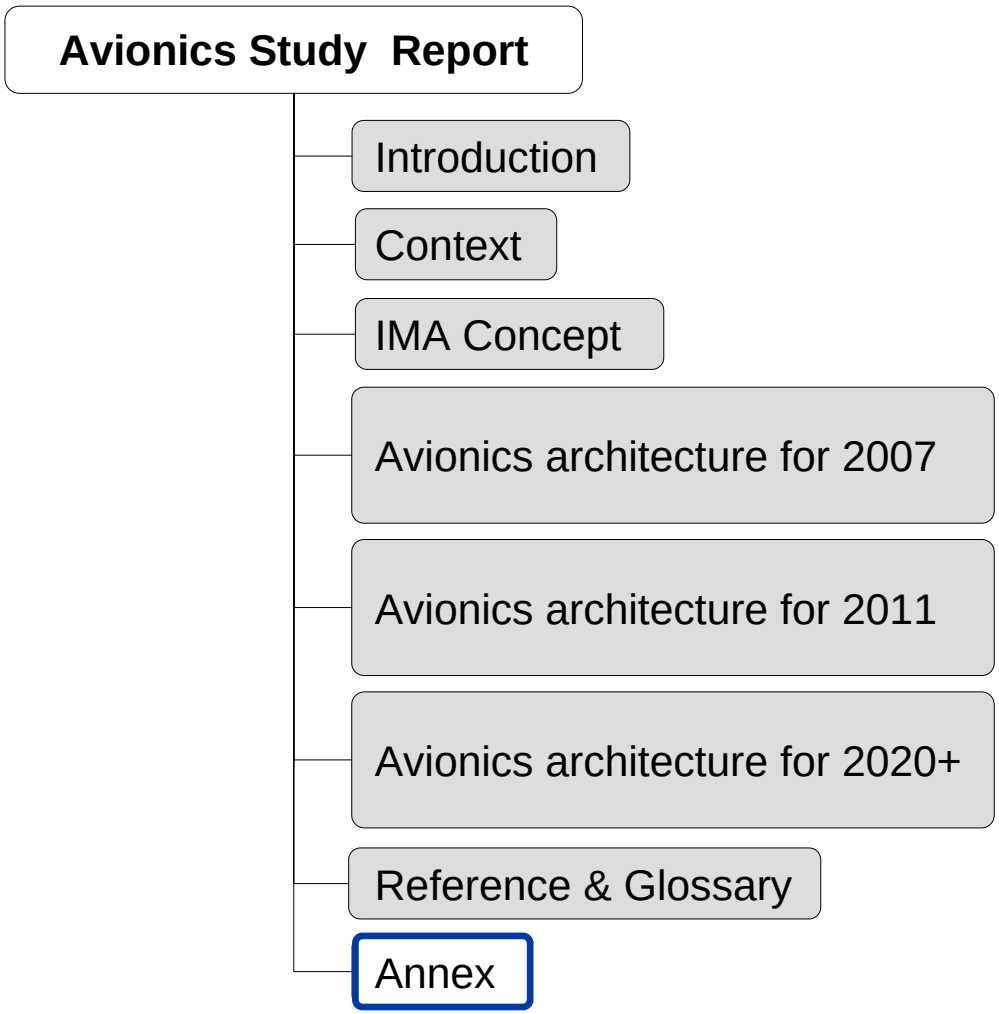
2020+ Surveillance

- Advances in sharing resources in an Integrated Surveillance System (ISS)
  - Integrate Traffic, Weather and Terrain Surveillance
  - Considers all available surveillance data when triggering alerts
- Role of ASAS is envisaged
  - Limited separation assistance to the flight deck
  - Autonomous operations potential in non core areas
  - Cost of avionics extremely high

2020+ Surveillance

- Future Collision Avoidance system ACAS III
  - Traffic and resolution advisories in both the vertical and horizontal planes
  - Unknown if it will ever be implemented

Structure of the Avionics Study Report



Annex

- Provides a bridge between this document and the Logical Architecture Model

Logical Architecture presents the 2011 timeframe as a set of UML diagrams:

- Identification of CNS infrastructure functions
- Identification of required data

Conclusions

- As Avionics evolves, future ATM will require:
  - A common understanding of the future aircraft trajectory
  - Greater integration of airborne data with ground systems
  - Increasing levels of autonomous operations
  - ATM based on trajectory exchange and negotiation
  - A significant research and standardisation effort

Conclusions

- Technologically enabled by:
  - Improved Datalink services
  - A common information management system
  - Improved GNSS system (Galileo)
  - Advanced FMS integrated with other Avionics
  - FMS capable of providing enhanced automation capabilities on top of CNS functions

Glossary

- ACL – Aeronautical Clearance Services
- ACM – ATC Comm Management
- DCL – Departure Clearance
- DSC – Downstream Clearance
- D-FIS – Datalink Flight Information Services
- D-OTIS – Datalink Operational Terminal Information Service
- DLIC – Datalink initiation capability
- ATSAW – Air traffic situational awareness
- GRECO - Graphical trajectory co-ordination
- COTRAC - Common Trajectory Co-ordination
- PPD – Pilot Preference Downlink
- CAP – Controller Access Parameters
- SAP – System Access Parameters
- ATSA-SURF / AIRB / S&A / SVA / S&M / C&P
- Surface / Airborne / See & Avoid / Successive Visual Approaches / Sequencing & Merging / Crossing & Passing

Session 2

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