Advanced Airborne Self Separation Concept of Operations

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iFly Final Presentation

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A³ ConOps Team

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iFly Partners and Reviewers contributing by providing feedback

iFly A3 ConOps has also benefitted from NASA's pro-bono involvement:

- NASA's advanced airborne self separation ConOps and research
- Active iFly participation by NASA Langley ATM Research Team
  - David Wing, Maria Consiglio
  - Frank Bussink, previously at LaRc on loan from NLR

Scope of Self Separation in iFly

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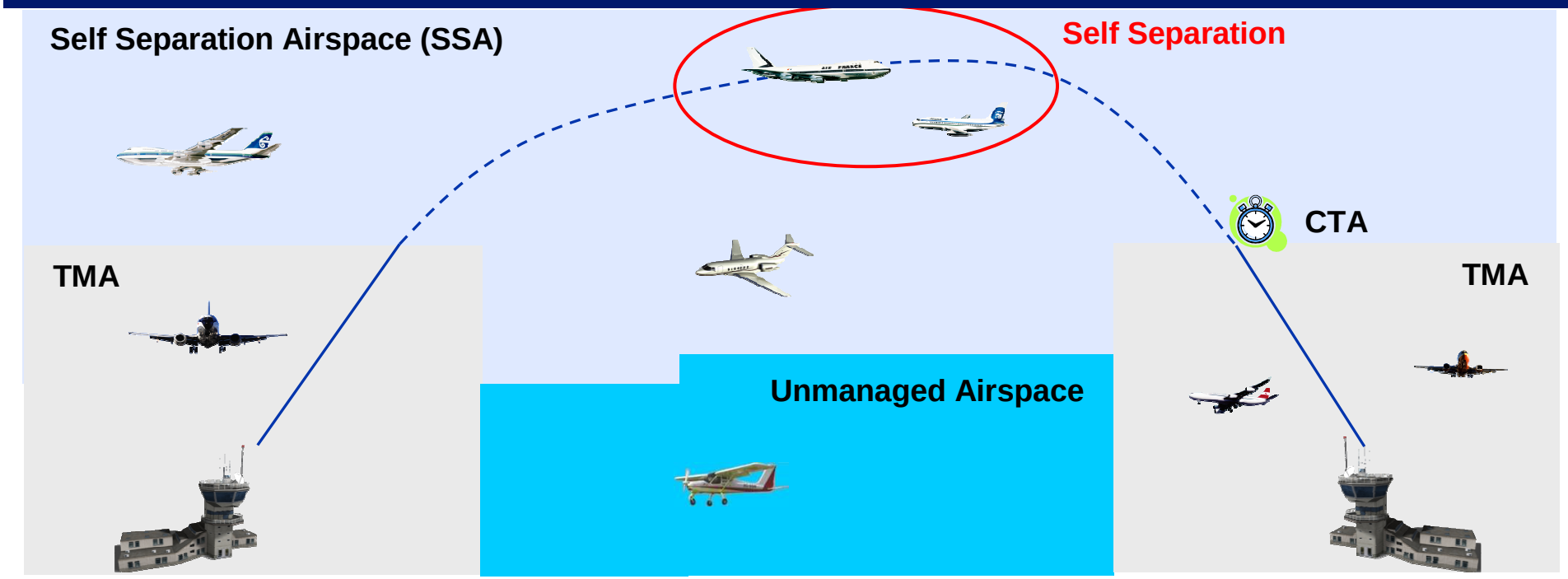
Aircraft in SSA adheres to the Flow Constraints at the TMA entry.



iFly's Scope:

- ✓ En-route phase of the flight
- ✓ All aircraft are equipped to self separate
- ✓ No ATC involvement
- ✓ Ground information sharing support

Out of iFly's Scope:

- x Mixed equipage
- x TMA/SSA transition procedures

A³ Concept of Operations – Main Elements

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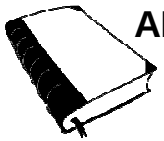
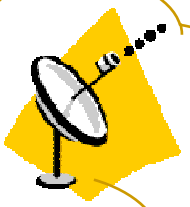
Self Separation: Framework allowing the flight crew to manage own trajectory in SSA.



Operational Rules:

- Coordination of trajectory changes
- Rights & Responsibilities

Information Sharing & Ground Support



Onboard Processes & Equipment:

- Required Onboard Functionalities
- Human – Avionics Interactions
- Onboard Procedures

**Autonomous Flight Rules*

Information Sharing – Objectives

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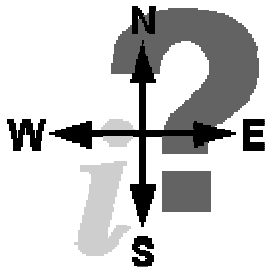
How to ensure effective decision making onboard autonomous aircraft?

When to change own trajectory?

- Potential Loss of Separation detected:
  - With other aircraft
  - With Area-to-avoid (restricted area, …)
- Predicted crossing of area with excessive traffic complexity
- Trajectory optimization



How to change the trajectory?

- How to coordinate simultaneous maneuver of multiple aircraft?
- How to avoid maneuver of excessive number of aircraft?
- How to avoid excessive maneuver of single aircraft?
- How to incorporate global strategic aspects?

Communications – Technology Means

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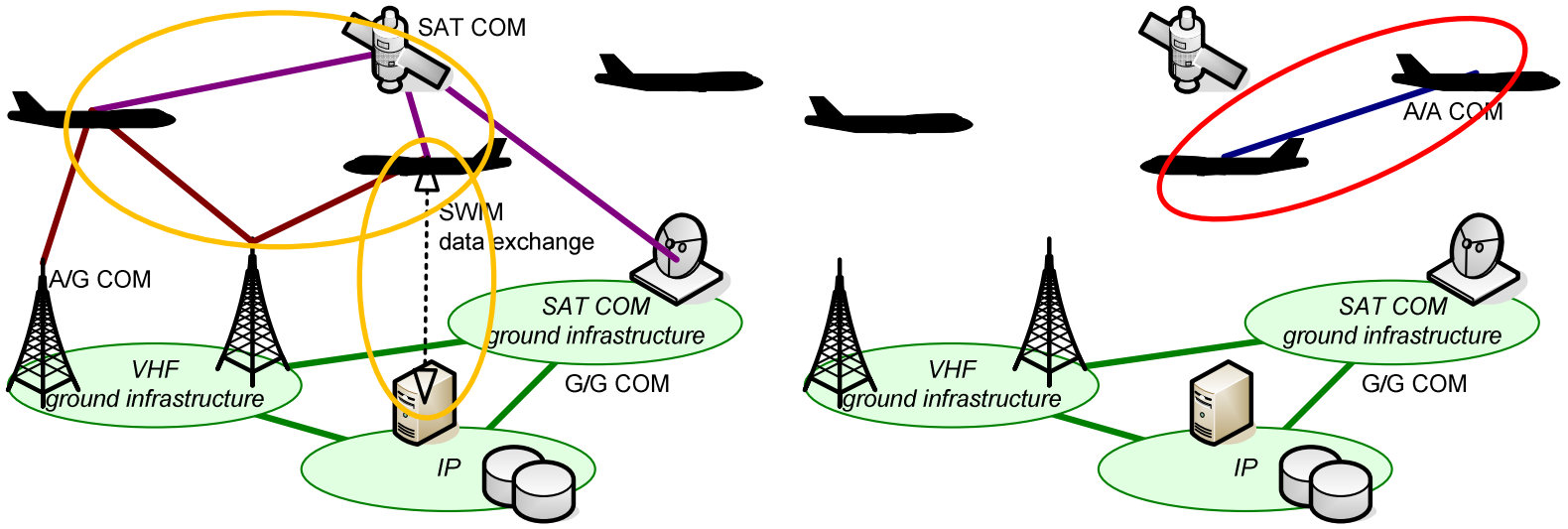
What are possible communication means and their limitations?

Primary Source of Information:

Reception of data broadcasted by other aircraft (ADS-B)



Secondary Source + Backup:

Querying ground infrastructure (e.g., SWIM)

Direct querying another aircraft

Information Sharing – Overall Picture

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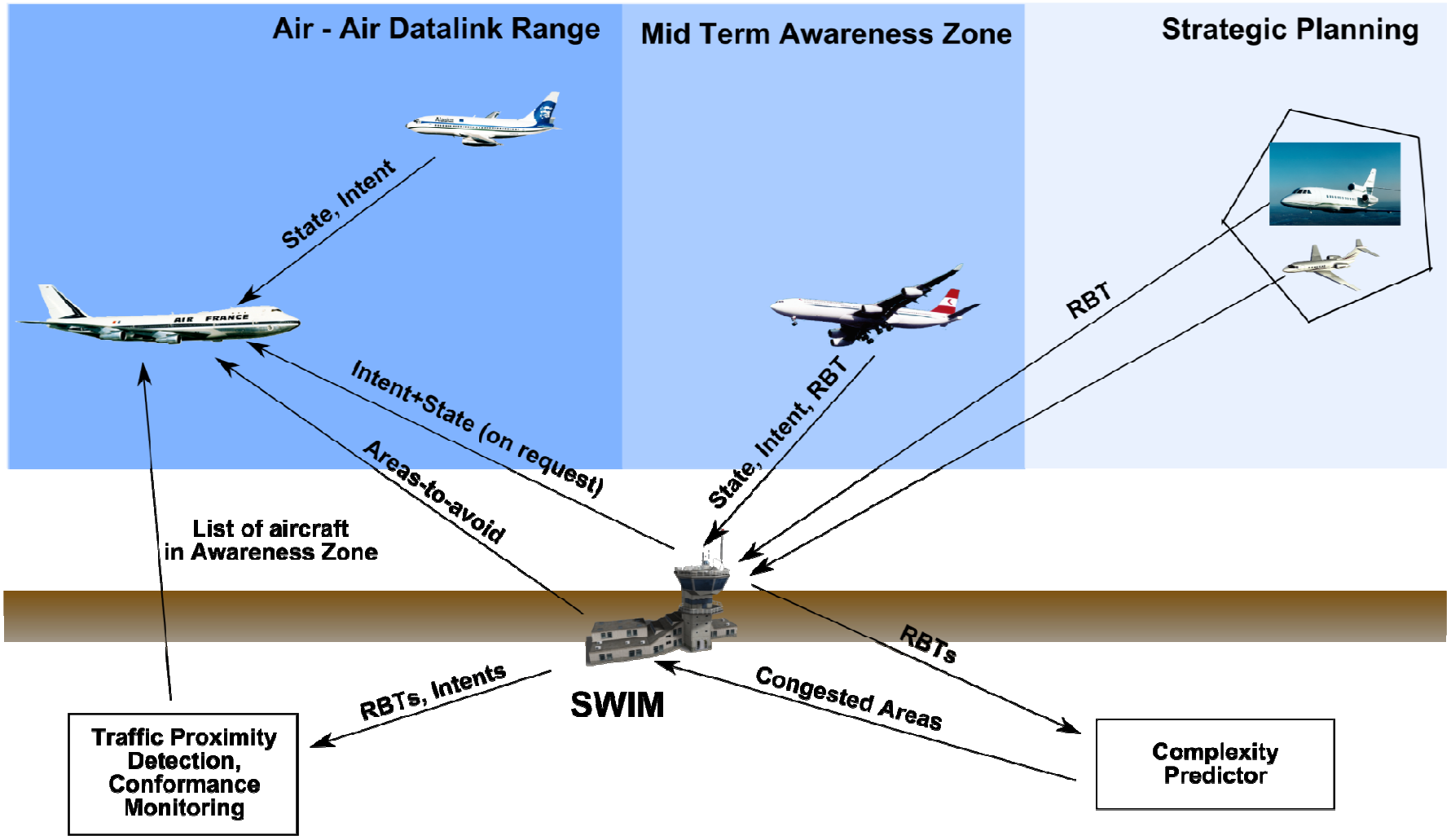
How to benefit from the SWIM infrastructure under deployment in SESAR?



Ground Support to Information Sharing

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How to effectively supplement direct Air-to-Air communication?

Essential new functions:

- **List of Surrounding Traffic:**

  Periodically computes for (and communicates to) each aircraft in SSA the list of traffic in its awareness zone.

- **Conformance Monitoring:**

  Continuously checks for all aircraft in SSA the conformance of the received state/intent information with corresponding trajectory (RBT) and automatically informs the surrounding aircraft about unexpected deviations.

- **Operational Constraints:**

  Provide to all aircraft in SSA information about operational constraints (e.g., restricted areas and other areas-to-avoid).

Traffic Information Backup:

- SWIM shall provide (on request) the latest state and intent information about the specified aircraft.

Strategic Support:

- Information from SWIM can be used by AOC/FOC or other service provider to detect the congestion areas (risk of excessive tactical maneuvering). This (and potentially other supporting) information can then be used for onboard trajectory optimization.

Information Sharing Services

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Different parts of airspace may be associated with different performance requirements.

Information Sharing Services	Limitations
Level 1: Air–Air Broadcast, State only	▪ Air–Air data link range ▪ Conflict Detection (CD) limited by accuracy of state-based trajectory prediction. ▪ No information back up
Level 2: Air–Air Broadcast, State + Intent	▪ Air–Air data link range ▪ CD limited by the range of available intent information ▪ No information back up
Level 3: Air–Air Broadcast + SWIM support, State + Intent	▪ Range defined by the area of interest (in principle) ▪ CD limited by the range of available intent information ▪ Information back up (point-to-point communication, SWIM)

iFly considers Level 3, but performance and safety assessment may be performed for multiple levels.

Separation Management – Operational View

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Key Assumption: No explicit communication between conflicting aircraft.

Two-level Process

Short-Term Time Threshold (STT)
(from predicted Loss of Separation)

CR Maneuver can be started before STT

Priority Rules

(only aircraft with low priority maneuvers)

CR Maneuver cannot be started before STT

Implicit Coordination

(all aircraft maneuver)

*CR = Conflict Resolution

Separation Management – Onboard View

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Flight path modifications = temporary lack of situation awareness for surrounding aircraft

Two envisioned CR processes

Trajectory Modification

- Full intent information available for surrounding aircraft, but
- More complex flight update
- Requires more time for flight crew to understand and decide
- Anticipated execution delay (flight crew information processing *) about 2 minutes.

Tactical Maneuvering

- Only limited intent information available to surrounding aircraft, but
- Simple
- Allows for fast reaction to a detected threat
- Anticipated execution delay (flight crew information processing*) about 30 s.

*Information processing includes 4 steps: info acquisition, info analysis, decision selection, and action implementation.

Airborne Separation Management – Overview

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A3 ConOps assumes 2 levels of separation management + collision avoidance

1. Level: Mid Term Conflict Resolution (priority rules)

2. Level: Short Term Conflict Resolution (implicit coordination)

Airborne Collision Avoidance

Airborne System & Processes Development

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Preliminary ED78a Analysis of the A^3 ConOps performed.

A3 Concept of Operations

Operational Services and Environment Description (OSED)

Operational Safety Assessment (OSA)

Operational Performance Assessment (OPA)

Airborne System Design Requirements (Functional Architecture)

A3 aircrew functions and responsibilities

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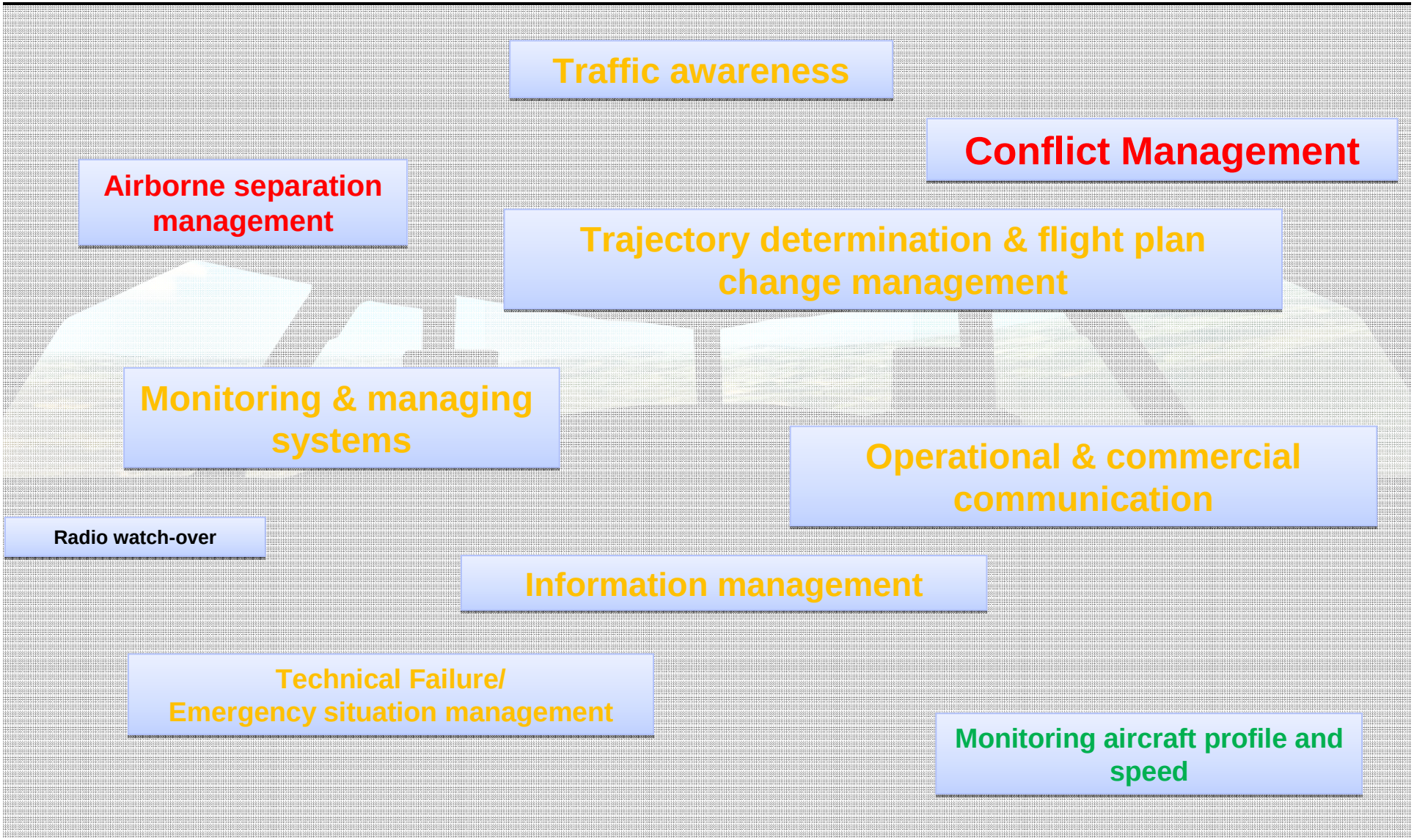
Preliminary HF Analysis on new/changing aircrew functions & responsibilities



Thank You!

http://ifly.nlr.nl

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A³ ConOps – References

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- ✓ ***iFly: ASAS Self Separation – Airborne Perspective*;** Presentation at ASAS-TN Workshop in Rome 2008, (Petr Cásek and Rosa Weber).
- ✓ ***Airborne System for Self Separation in Trajectory-Based Airspace*;** 7th Eurocontrol Innovative ATM Research Workshop, EEC Bretigny 2008 (Petr Cásek and Claudia Keinrath).
- ✓ ***Comparison of Pair-Wise Priority-Based Resolution Schemes Through Fast-Time Simulation*;** 8th Innovative Research (INO) Workshop, Bretigny, 2009 (Richard Irvine).
- ✓ ***Priority Rules in a Distributed ATM;*** 1st International Air Transport and Operations Symposium, TU Delft, 2010 (Petr Cásek and Silvie Luisa Brázdilová).