iFly: ASAS Self Separation – Airborne Perspective

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Honeywell

iFly Objectives

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Develop

Highly automated ATM design for en-route traffic based on autonomous aircraft concept

Autonomous Aircraft Advanced (A3) Concept of Operations

& Validate

- Assess the highest level of en-route traffic demand in which equipped aircraft can safely self separate
- Develop the airborne system requirements that must be met to ensure the safe 2025+ operations
- Cost –Effectiveness Analysis

Project Consortium

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Aviation Participants

- National Aerospace Laboratory (NLR)
- Honeywell
- Isdefe
- Dedale
- UK NATS En Route Ltd.
- Eurocontrol EEC
- DSNA-DTI-SDER

University Participants

- National Technical University of Athens
- University of Twente
- Ecole National de l'Aviation Civile
- University of Tartu
- Institut National de Recherche en Informatique et en Automatique
- University of Leicester
- Athens University of Economics And Business
- Eidgenossische Technische Hochschule Zurich
- University of l'Aquila
- Politecnico di Milano
- University of Cambridge

Unique blend of university and aviation partners!

Assumptions

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

Design & Validation Elements of iFly

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- **Human Factors – identification and analysis of responsibility issues, bottlenecks, information needs**
- **Traffic Complexity assessment – development of suitable metrics, prediction**
- **Conflict Resolution Algorithms – development of CR algorithms suitable for short, medium, and long term timeframe**
- **Complementary Safety-based design approaches:**

  1. **TOPAZ modeling and Monte Carlo simulation based Hazard and Collision Risk Analysis**
  2. **RTCA/Eurocae ED78a based System Safety Engineering**
  3. **Formal verification using critical observability analysis of hybrid automaton**

A3 Airborne System Objectives

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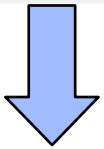
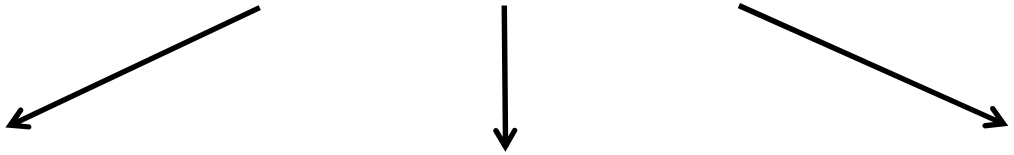
Objectives	Functionality
Safety	Separation Management
Performance (Flight Efficiency)	Trajectory management

Situation Awareness = Key Enabler



Information Sharing Process



Reliable **Continuous** **Effective**

Information Support

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Information Sharing Process

SM Characteristics

Level 1: Air–Air Broadcast, State only

- Air–Air data link range
- CD further limited by accuracy of state-based TP
- No information back up

Level 2: Air–Air Broadcast, State + Intent

- Air–Air data link range
- 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 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.

Situation Awareness

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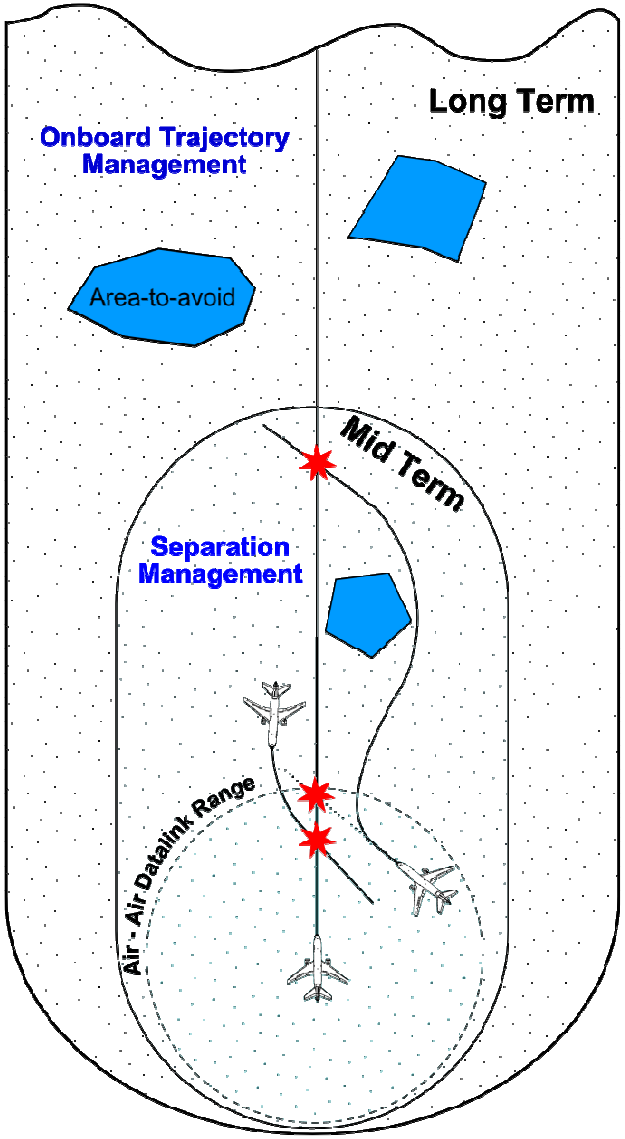

Areas of interest:

- **Long Term Awareness Zone(LTAZ)** – relevant for Trajectory Management (optimization)
- **Mid Term Awareness Zone(MTAZ)** – used for Separation Management
- **Air–Air Data link Range** – additional state-based Conflict Detection

SWIM and Envisioned Functionality

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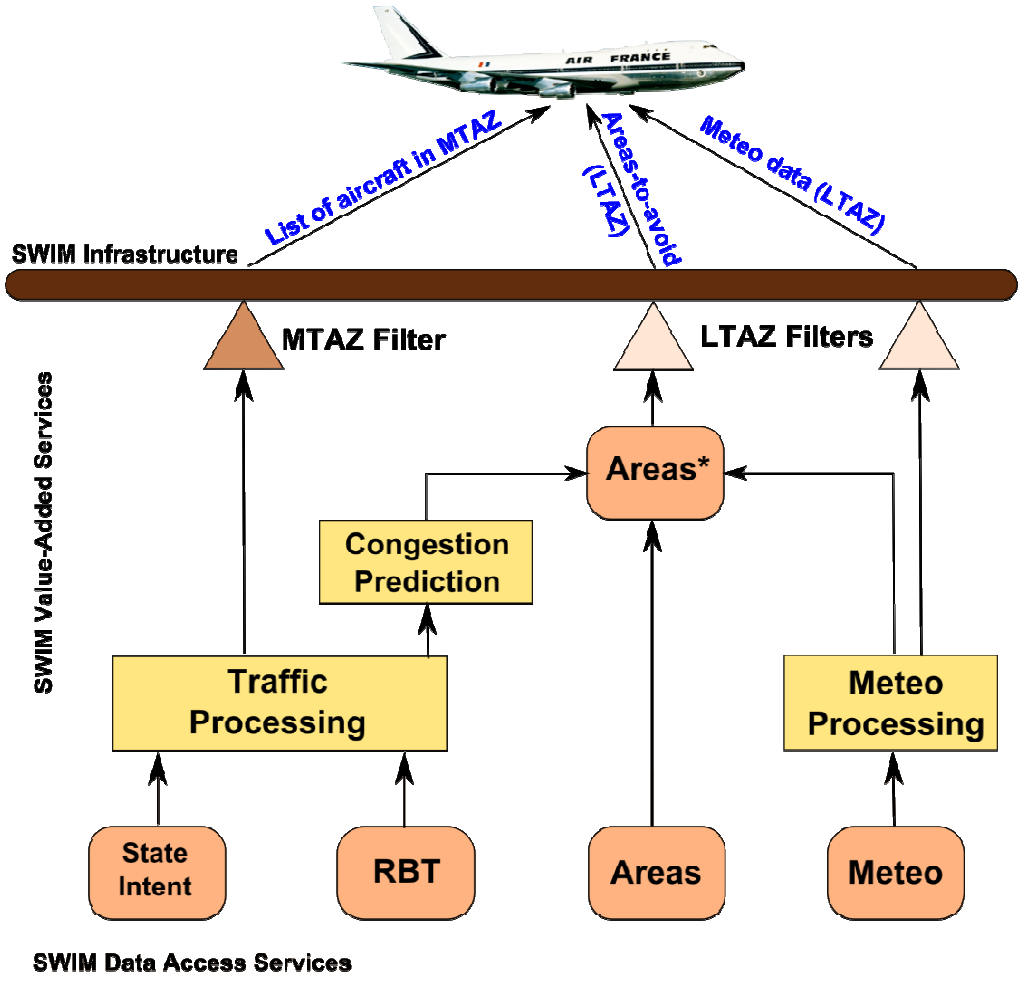

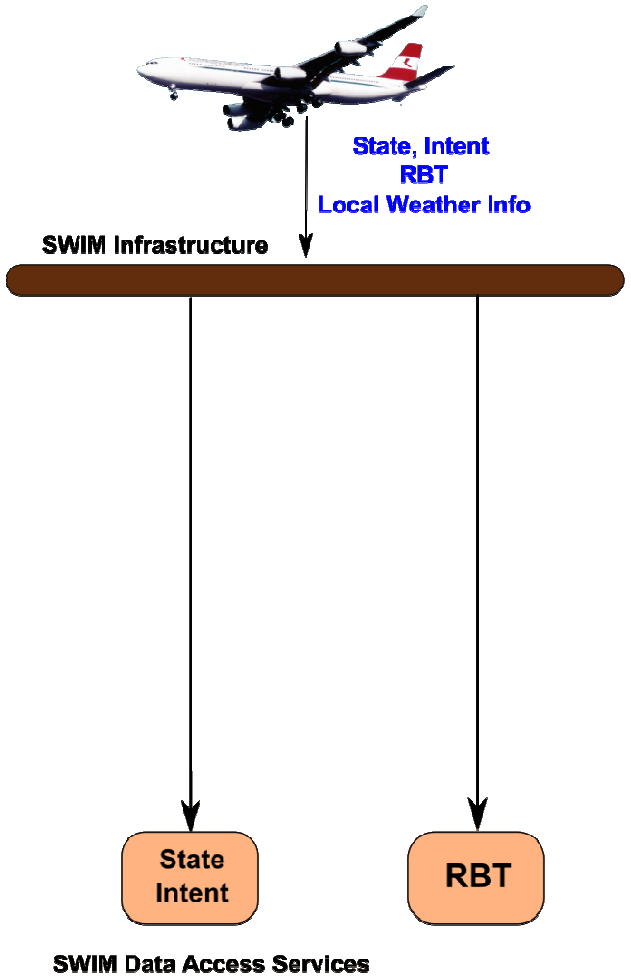

Data Link Communications (Traffic Data)

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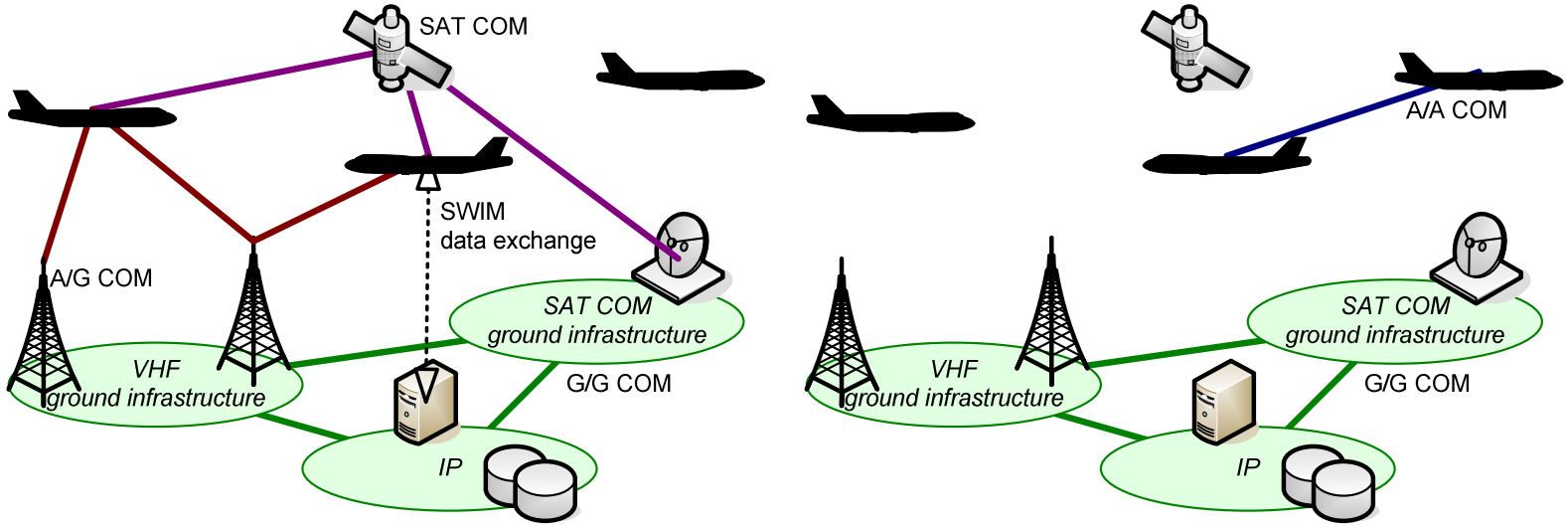
Reception of data broadcasted by other aircraft



Querying ground infrastructure (e.g., SWIM)

Direct querying another aircraft

A3 Airborne System Architecture Overview

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Information Management

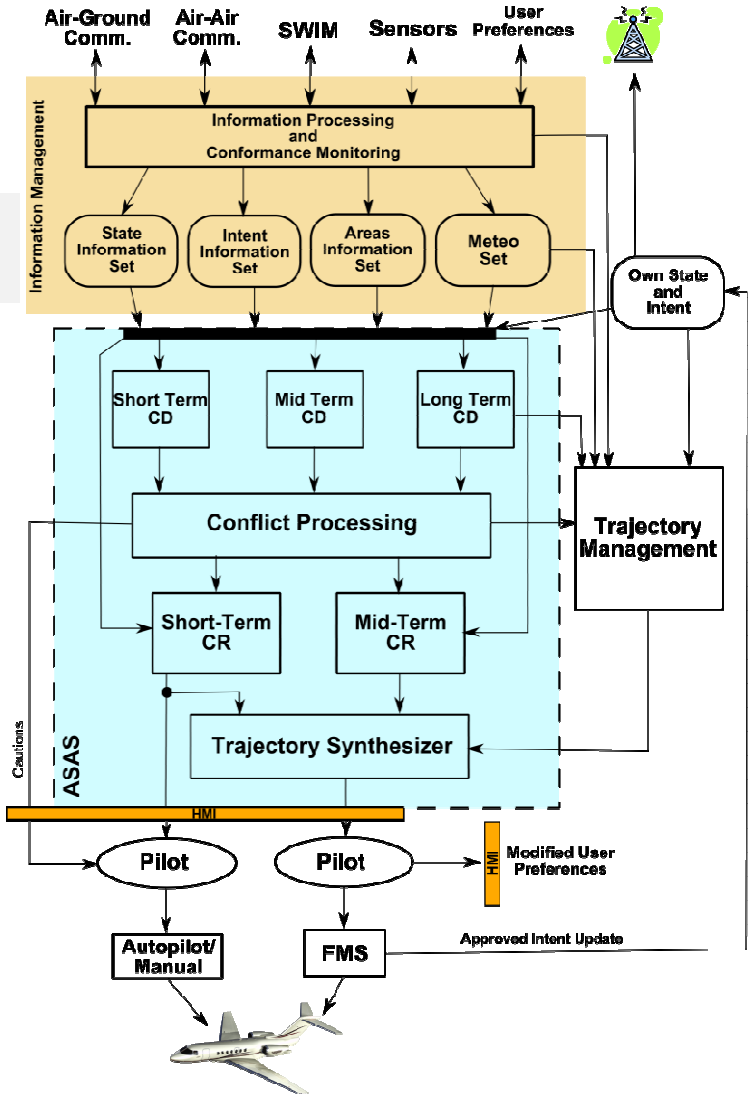
- Shields communications details
- Collect and process required data

Separation & Trajectory Management

- Situation Assessment
- Resolution Advisories

Human Machine Interface

- Situation Awareness
- Flight changes advisories



Information Management

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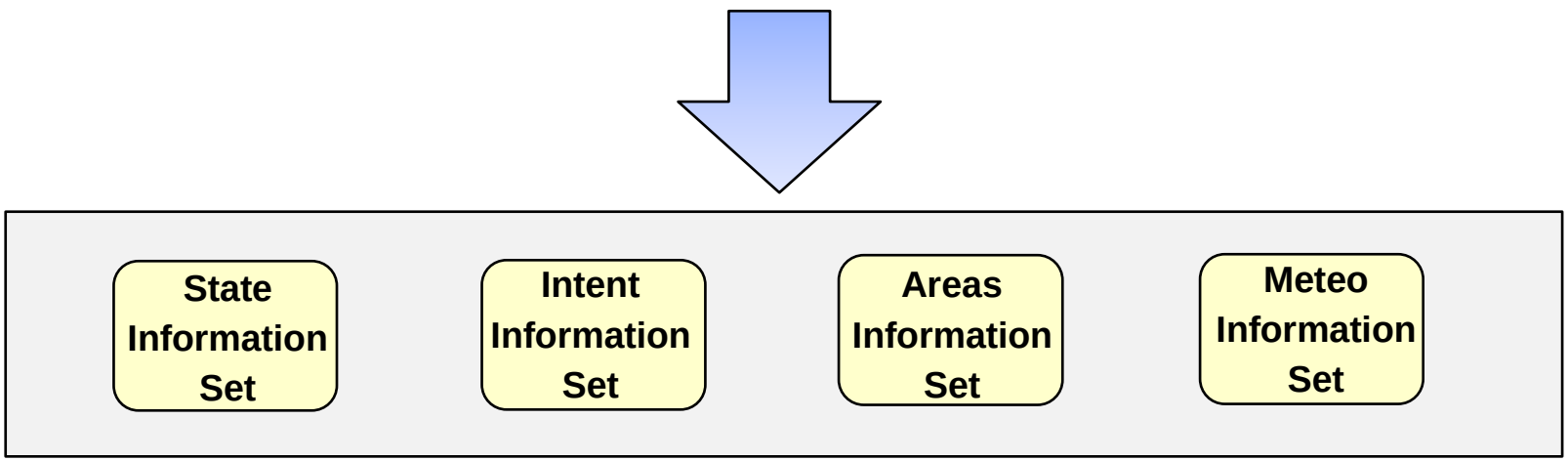
- ✓ Process all incoming broadcasted data
- ✓ Process the list of MTAZ traffic
- ✓ Query aircraft or SWIM for missing information
- ✓ Process areas-to-avoid (restricted areas, weather hazards, ...), uploaded meteo data and data from sensors (weather radar, EGPWS)
- ✓ Monitor the conformance of aircraft to the intent
- ✓ Data fusion to determine the most probable trajectories of aircraft



CD&R And Trajectory Management

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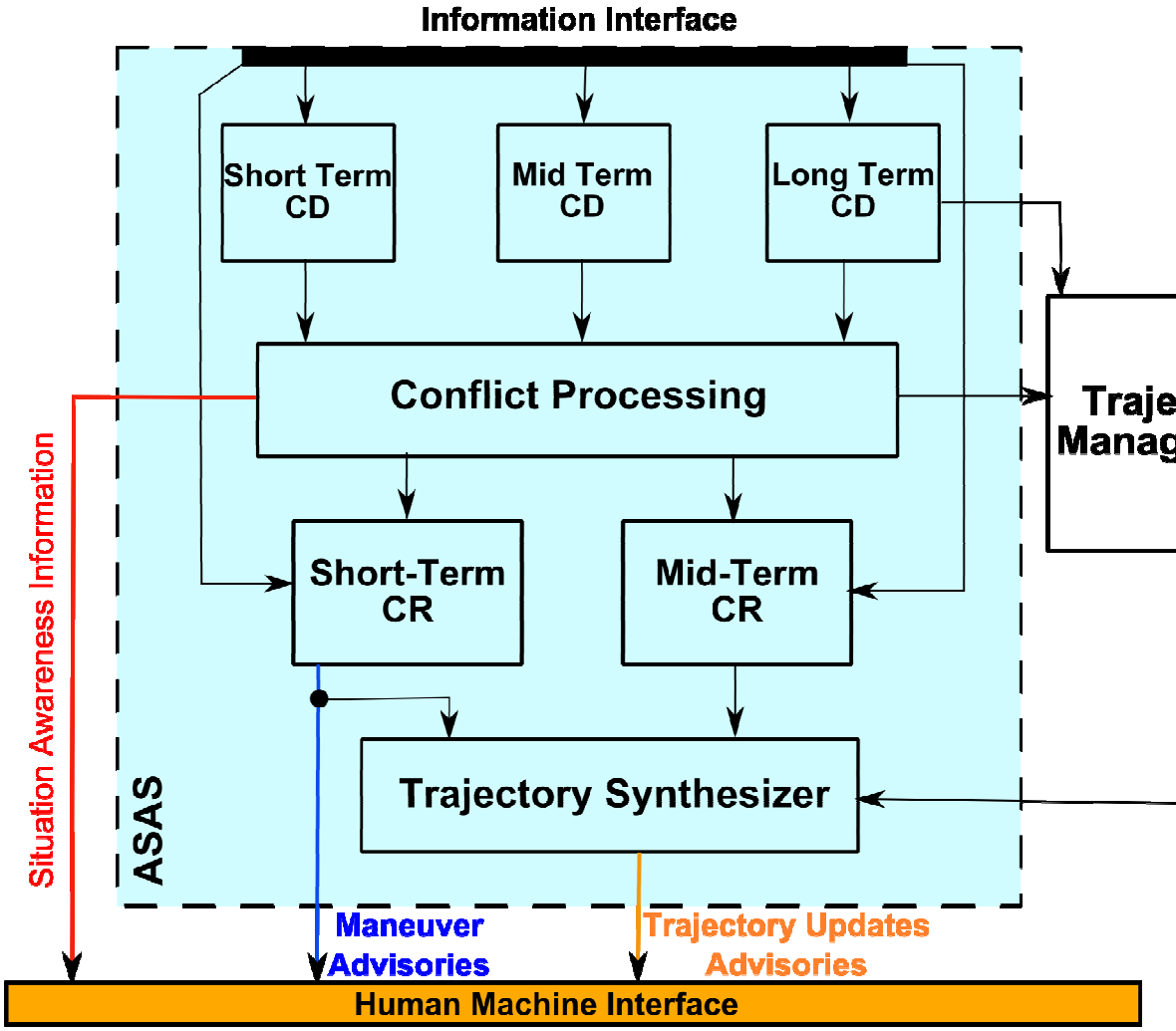

Mid Term Conflict:

1. Predicted LoS
2. Potential CR risk (complex situation)
   - ❑ Complexity, or
   - ❑ Maneuvering flexibility

Short Term Conflict:

- ❑ State-based predicted LoS

Long Term Conflict:

- ❑ Predicted LoS with Areas-to-avoid

A3 – iFly Next Steps

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- **Assessment Cycle**
  - Hazard and Collision Risk Analysis
  - Cost-Effectiveness Analysis
- **Second Design Cycle**
  - Integration of innovative methods (complexity, CR algorithms)
  - ConOps refinement
- **System Safety Engineering using ED78A methodology**
  - Airborne System Design Requirements
  - Non-airborne System Requirements

Airborne System Requirements

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- Provide aircrew with automation and decision support tools to ensure planned trajectory is clear of traffic, weather and restricted airspace
  - Integrated ownship and surveillance (ADS-B/C) data visualization
  - Real-time traffic, flow management and airspace hazard data;
  - Complementary conflict alerting and multiple resolution maneuvering options

  - HMI must be designed to allow for a quick and easy data input/understanding, which is tailored to users needs
  - Level of information
    - Amplification of human functions by machines
    - Situation awareness needs of ATM & aircrew

Surveillance Today

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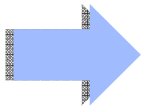
Separate Products

- TCAS (Collision Avoidance)
- EGPWS (Terrain Avoidance)
- Surface moving maps
- Weather Radars
- FMS (Navigation, Guidance, Flight Optimization)
- Multi-Function Radar Display
  - Weather
  - Terrain
  - Traffic
  - Lightning
  - FMS/NAV
  - Checklist



Integrated Surveillance Systems

- Integrated Hazard Avoidance System for BGA, e.g., Honeywell Bendix/King
  - Positioning
  - Weather avoidance
  - Traffic advisories
  - Terrain avoidance
- Aircraft Environment Surveillance System (AESS) – A380, A350, B787
  - TCAS
  - Mode-S transponder
  - EGPWS
  - 3D-Volumetric Wx radar

INAV Display

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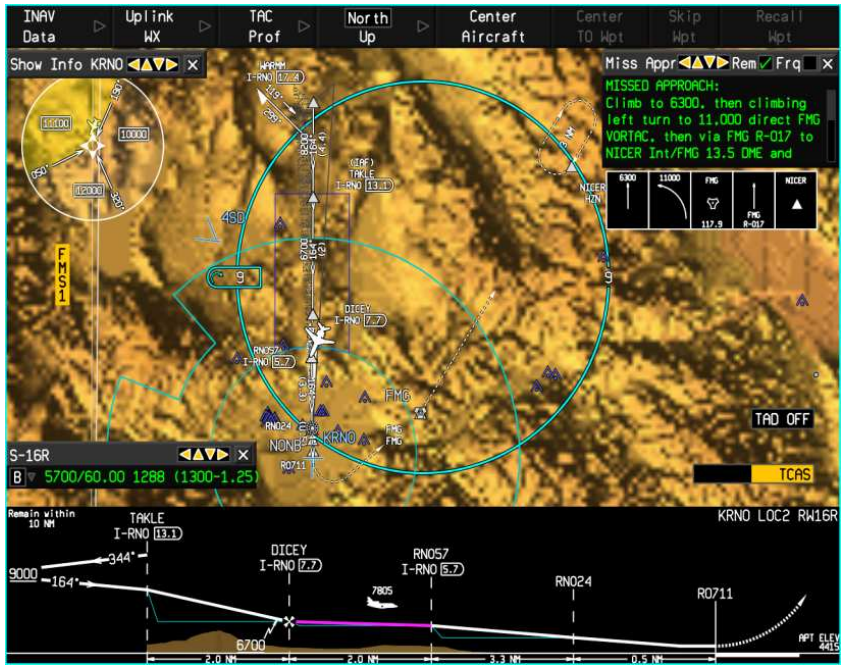
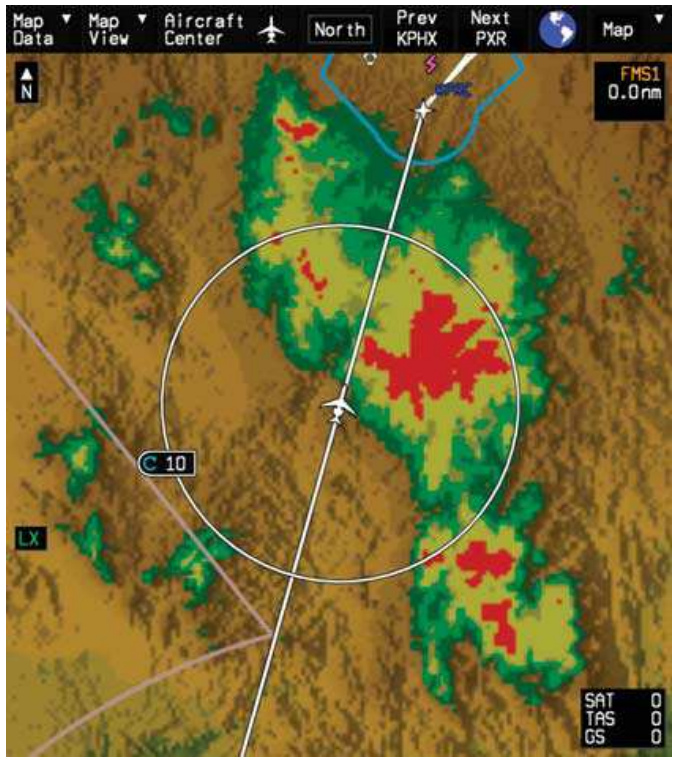


Navigation data

- ❑ Terrain database
- ❑ Airspace, Airways, Airports
- ❑ Active flight plan
- ❑ Vertical situation

Sensor data

- ❑ EGPWS cautions, warnings
- ❑ TCAS
- ❑ Airborne Wx radar
- ❑ Uplinked weather



INAV™ displays impediments and details of point to point flight, e.g.,

- Restrictive airspace, terrain
- Obstacles: weather and other aircraft
- Graphical Flight Planning™
- Vertical Situation Display (VSD)

Integrated PFD

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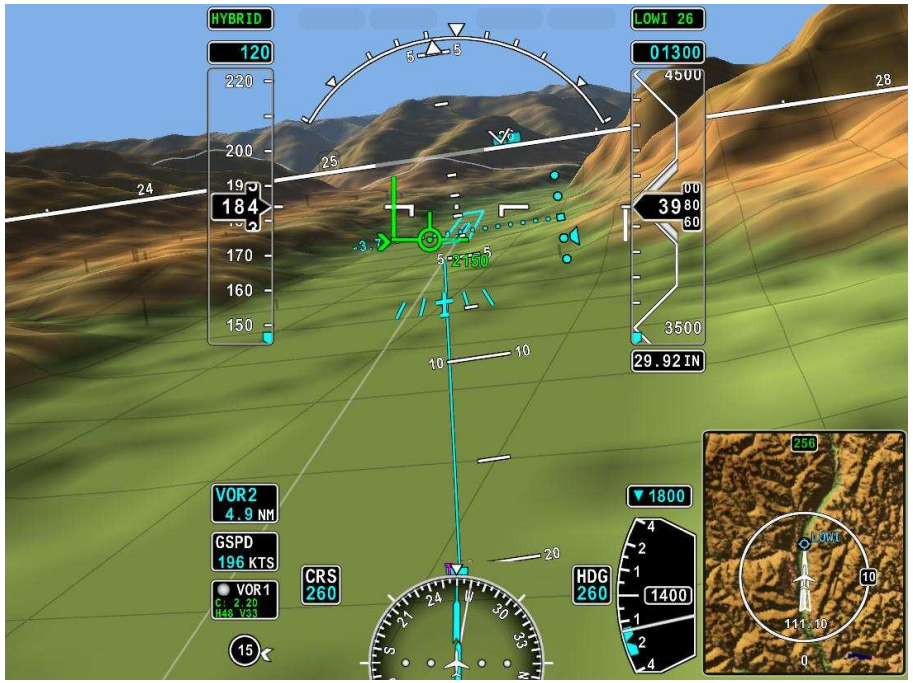
Synthetic and enhanced vision systems integrate ATM relevant data (e.g., air traffic, weather, RNP, 4-D navigation)



IPFD™ View of an offset approach

- MFD displays
  - navigational maps
  - engine data,
  - aircraft system data
  - TCAS
  - uplinked & sensed probabilistic weather data
  - video and other information

Cockpit Display of Traffic Information (CDTI)

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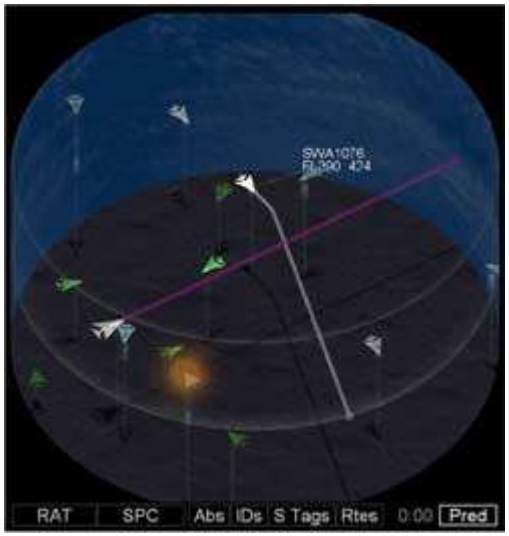
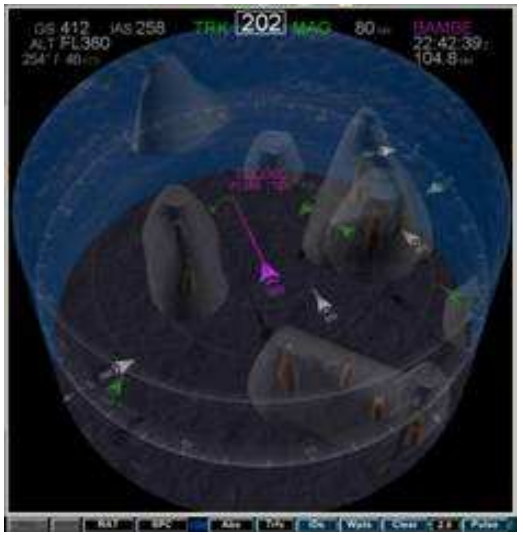
NASA Ames Flight Deck Research Laboratory

3D CDTI

2D/3D Weather Display: weather and terrain integrated into the CDTI display





http://human-factors.arc.nasa.gov/ihh/cdti/cdti.html

Advanced Cockpit Situation Display

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- Integrated CDTI and CD&R.
- Based on flight path “Intent”
- Detects conflicts up to 12 minutes in advance
- Presents pilot with list of pre-computed maneuvers
- User-preferred resolution types?

http://human-factors.arc.nasa.gov/ihh/cdti/CDR.html

Acknowledgements

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iFly A3 ConOps has 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

iFly Information

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Web site: http://iFLY.nlr.nl

Coordinator: Henk Blom (NLR)

A3 Concept of Operations documents:

- High level A3 available at the web site
- A3 ConOps will follow soon (final draft under review)

Thank You!