REAL TIME ADAPTIVE PROCESSING OF MULTISOURCE WEATHER DATA FOR IN-FLIGHT DECISION SUPPORT SYSTEM

Fabrizio Cuccoli

RaSS (Radar and Surveillance Systems) Lab.
CNIT (National Inter-university Consortium for Telecommunication - Italy)
Overall objective

Real time processing of the information incoming on board (be it related to weather or not) with the goal of suggesting the greenest (lowest pollution) and safe trajectories to pilots so as to avoid “no flight zones” (including dangerous weather areas revealed by the on-board weather radar).
Innovative Contributions (Selex_ES, RaSS CNIT):

1) Use of polarimetric weather radars

2) Artificial Intelligence (Q-AI agent) based algorithms for fast computing green-safe optimal trajectories in order to avoid dangerous areas

3) Upgrading the EFB (Electronic Flight Bag) to a DSS (Decision Support System) for facilitating pilots on the decision about trajectory changes in presence of evident external reasons (e.g. bad weather conditions, traffic)

4) Direct link between the radar output and the DSS for automatic and advanced classification of the weather phenomena

5) Data fusion tool for adaptive integration and correlation of the information coming from different information sources (weather and traffic)
Today

1) Non polarimetric radar, no weather classification (rain, hail, snow), no attenuation compensation
2) Three/four radar signal levels (green, yellow, red, magenta)
3) No real time ground weather radar/satellite info on board
4) No real time traffic status
5) Pilots know that they must avoid the red zones. This requires non negligible pilot workload, included ATC negotiation

Tomorrow

1) Polarimetric radar, weather classification, attenuation compensation
2) More weather info (color and classes)
3) Ground radar, satellite, traffic info on board
4) DSS processes all info and suggests solutions to pilots and ATC.
5) Significant workload reduction
Innovative Contributions - KLEAN project

1) Onboard polarimetric weather radar
2) Q-AI agent algorithms for fast computing of green-safe trajectories for avoiding no flight zone
3) customization of EFBs to a DSS for facilitating pilots’ decisions of trajectory changes in the presence of evident external weather change conditions
4) direct link between the radar output and the DSS for automatic and advanced classification of the weather phenomena (WRPP)
5) data fusion tool for adaptive integration and correlation of the information coming from different information sources (weather and traffic)

“Knowledge-based EFB for green flight trajectory decision aid”

GA # 306927 - JTI-CS-2011-3-SGO-03-016
KLEAN Objective

Developing a custom knowledge-based EFB (Electronic Flight Bag) with SW packages implementing:

- Advanced Weather Radar Post-processor (AWRP)
- Quasi-Artificial Intelligence (Q-AI) agent algorithms

A-WXR (TRL5) and Q-AI (TRL4) algorithms have been proposed by Selex-ES, a Finmeccanica Company, for green trajectory optimization (reduction of CO2 and NOX emissions as well as noise pollution).
The KLEAN architecture is based on advanced radar processing (WRPP).

- of the **on board weather radar**
- (in input to the EFB with a specific WRP to WRPP interface)
- and of **FMS DATA**
- (in input to the EFB with the **EID to Q-AI interface**)
- for the identification of the no flight zones that are the input for the trajectory optimization module (**Q-AI**)
- A graphical user interface (**GUI**) allows the interaction with users (pilots!) for commands and visualization
Selected EFB platform: Nexis
Rass CNIT workplace – KLEAN project

Ethernet links are used for simulating the FMS to the EFB and the Radar to the EFB interfaces through an proprietary UDP protocol.
- DSS DEMO - Dangerous weather event detected by the radar Post Processor

Risk marked only in case of hail detection

Q-AI Trajectory computation only by waypoints

• Current route for a Turin - Rome flight

DSS status at time $T_0$

• Active radar post processor

• Active Weather classification (polarimetric radar only)

• Weak weather event detected 80 km (dry snow $\rightarrow$ no risk)
- DSS DEMO - Dangerous weather event detected by the radar Post Processor

DSS status at the $T_0 + 1$ min

- Active radar post processor
- Active Weather classification (only in case of polarimetric radar)
- Larger Weak weather event detected (dry snow $\rightarrow$ no risk)
DSS DEMO - Dangerous weather event detected by the radar Post Processor

DSS status at the $T_0 +2$ min

- Active radar post processor
- Active Weather classification (only in case of polarimetric radar)
- Larger weather event risk zone delimited 80 km (hail $\rightarrow$ risk)
- DSS DEMO - Dangerous weather event detected by the radar Post Processor

- Active Trajectory Optimizer (waiting for risk zone alarm)

- Active radar post processor

- Active Weather classification (only in case of polarimetric radar)

- Weather event confirmed (hail → risk), larger risk zone intercepts the route 80 km

DSS status at the $T_0 + 3$ min
- DSS DEMO -
Dangerous weather event detected by the radar Post Processor

- Active Trajectory Optimizer (waiting for risk zone alarm)
- Dangerous event detected. Pilots alerted (red blinking frame)
- Optimal route avoiding the risk computed and proposed in purple
- Accept/refuse buttons activated

DSS status at the $T_0 +4$ min

- Active radar post processor
- Active Weather classification (only in case of polarimetric radar)
- Weather event confirmed, larger risk zone intercepts the route (hail → risk)
Innovative Contributions – WINFC project

1) Onboard polarimetric weather radar
2) Q-AI agent algorithms for fast computing of green-safe trajectories for avoiding no flight zone
3) customization of EFBs to a DSS for facilitating pilots on the decision of trajectory changes in presence of evident external weather change conditions
4) direct link between the radar output and the DSS for automatic and advanced classification of the weather phenomena (WRPP)
5) data fusion tool for adaptive integration and correlation of the information coming from different information sources (weather and traffic)

Weather INformation Fusion and Correlation for weather and traffic situational awareness

GA # 632536 - JTI-CS-2013-01-SGO-03-024
WINFC Objective

Development of an adaptive data processing module that, once installed on board, will collect and process information coming from weather and traffic data providers. Such module will be designed in order to collect and process data, to produce an overall awareness map integrating weather and traffic changes during the flight.

The awareness map is a risk map available to the pilot so that he/she can immediately detect hazard conditions, no matter whether they depend on weather or traffic changes.

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<tr>
<th>Participant Organization</th>
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<th>Country</th>
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<td>Atmosphere</td>
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WINFC architecture:

Simulation of On-board Data Sources

On-Board sensors
(lightning detector, WINS, ADS-B)

Updated weather forecast
(METAR, TAF, PIREP)

Updated information from AIS
(NOTAMs)

Other users & sources
(GPS, satellite receivers)

Advanced Weather Radar emulation

Weather & Traffic emulation

Fusion Software (GRIB format output)

I/Q or post processed

DISPLAY

« Fused constraints »

« Atomic constraints »

Historic Data Files (BD)
- DSS DEMO 2 -
dangerous weather event detected by the radar Post Processor and other external info

• On board weather radar: hail risk detected
• On board received satellite signals: possible weather risk beyond the attenuated radar signal
• Ground weather radar: hail risk detected
• Weather forecast: bad weather moving E-SE

• ATC: real time air traffic
- DSS DEMO 2 -
dangerous weather event detected by the radar Post Processor and other external info

- Risk zone are “fused” in two no flight zones for the trajectory optimizer
Innovative Contributions – XWALD project

1) Onboard polarimetric weather radar
2) Q-AI agent algorithms for fast computing of green-safe trajectories for avoiding no flight zone
3) Customization of EFBs to a DSS for facilitating pilots on the decision of trajectory changes in presence of evident external weather change conditions
4) Direct link between the radar output and the DSS for automatic and advanced classification of the weather phenomena (WRPP)
5) Data fusion tool for adaptive integration and correlation of the information coming from different information sources (weather and traffic)

Avionic X-band Weather signal modeling and processing vALidation through real Data acquisition and analysis

GA # 619236 - JTI-CS-2013-01-SGO-03-022
Diamond DA42 MPP

Prototype of new X band weather radar:
- Pulsed (compression)
- Fully polarimetric
- Forward looking

Measurement plan scheduled for 2015 in the Netherlands
Conclusions

1) A-WXR developed up to Technology Readiness Level 5 (TRL5 tests passed in June 2015).

2) Q-AI TRL4 tests passed in 2014. TRL5 achievement scheduled for Nov 2015.

3) KLEAN software runs on the EFB Nexis and is used on flight simulators of ATR72 (for TRL5 WRPP and Q-AI pollution reduction tests) and of Airbus A320 (for pilots and ATC workload analysis in using the DSS)

4) Positive feedbacks in terms of workload (both pilots and ATC) and objective fuel reduction using the proposed DSS trajectory solutions.

Next steps

1) Polarimetric radar: prototype and advanced post processor validation through experimental flights (started with XWALD).

2) KLEAN software: update with data fusion module for the EFB Nexis (started with WINFC) and migration to other EFB platforms.

3) Design and implementation of the data interfaces between radar/cockpit/FMS and DSS (started with KLEAN and WINFC)

4) DSS validation during true flights
General state

In Clean Sky 2, Selex ES (Finmeccanica) will shift its activities from System ITD to other IAPDs. Therefore, the development of the presented technologies will be pursued by CNIT alone, in agreement with Selex ES.

END of presentation
Thanks for your attention

Website:  klean.cnit.it
          xwald.cnit.it
          winfc.cnit.it

Email:  fabrizio.cuccoli@cnit.it