COMPASS

Safety Management *in*
Complex ATM System of Systems
*using* ICT approaches

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Context

- **SESAR WP E**: Long-Term and Innovative Research
- **Theme 3**: Mastering Complex Systems Safely
- **Focus**: Automated safety management support to human operators of complex ATM systems using ICT approaches

- **Project Type**: Medium
- **Duration of Project**: 30 Months
- **Total Budget**: 737,425.00 €
- **Total SJU Contribution**: 599,911.25 €

- **Name of Coordinator**: THALES
- **Name/s of Consortium Members**:
  - *University of York* (Technical Coordinator)
  - *RWTH Aachen University*
  - *INNAXIS Research Institute*
Overview and Motivation

• Air Traffic Management (ATM) systems are complex and heterogeneous; comprise a large number of communicating and interdependent components and sub-systems

• predominantly safety-related systems; failures can result in major accidents, loss of property, or loss of life. During the operation of an ATM system, its constituent parts produce a high volume of system-level events

• how to identify, using ICT approaches, combinations of events that predictably and with a high degree of probability lead to situations where safe operation is compromised
Challenges

- Components and systems of ATMs produce high volumes of potentially interrelated system events - i.e. multiple phenomena that have a common root cause
  - health statuses of individual devices
  - temperature/proximity readings
  - volume of traffic / structural complexity of the airspace

- Large number of possible combinations of events/measurements that can compromise safety - hard to capture/monitor manually

- Presence of potentially incomplete or unreliable information
Objectives

• deliver powerful and more automated safety management support to human operators of complex ATM systems

• use a data-driven, pattern-based approach and by combining state-of-the-art technology from data mining, intelligent modelling and complex event processing

• allow engineers to mine safety patterns from past data, filter and enrich these patterns using their expertise and domain knowledge, and then use these patterns to monitor running ATM systems in an automated manner
• automated safety warning technology and techniques that offer substantial promise in reducing the amount of human intervention in identifying potentially hazardous situations and generating warnings for ATM experts

• exploit and inculcate within the scope of SESAR research and development several novel technologies and theories from the ICT community specifically targeted at management of complex systems

• intelligent modelling techniques for safety management in ATM systems
COMPASS Technical Overview

Dimitris Kolovos
Technical Coordinator - COMPASS
University of York
Project Organisation
WP1: Post-Event Complex Data Management

• Aim
  – Analyse historical ATM data to identify patterns that will be used to develop knowledge about the occurrence of safety-related events

• Leading partner
  – Innaxis

• Contributors
  – Aachen, York
WP2: Safety Language

• Aim
  – Create ATM-specific modelling languages which serve as a basis for other parts of the project
    • Particularly a Domain Specific Language for Safety

• Leading partner
  – Aachen

• Contributors
  – Innaxis, York
WP3: Automated Early Safety Warning Mechanisms

• Aim
  – Develop automated Early Safety Warning Mechanisms (ESWM) for identifying event combinations that can lead to ATM system failure during operation

• Leading partner
  – York

• Contributors
  – Aachen, Innaxis
Project Organisation

WP1: Post-Event Complex Data Management

WP2: Safety Language

WP3: Automated Early Warning Mechanisms

WP4: Integration with Live Data

Pattern analysis

Grid

Dissemination of Results

Post-Event Data

Live Data

ATM expert

CEP

RCA

DSLs
DDR Data Analysis and Filtering

Massimiliano Zanin
INNAXIS
What’s wrong with DDR trajectories?
DDR trajectories within COMPASS

Different sources of information:
DDR trajectories within COMPASS

Last Filed Flight Plan

Flight Plan updated with radar tracks

\textit{m1 files} \hspace{1cm} \textit{m3 files}
Descriptive analysis
Descriptive analysis
Descriptive analysis

Detection of simple losses of separation

- Two aircraft have crossed the same point at the same FL
- FL > 200: to exclude approaches and departures
- Flights within European airspace
Descriptive analysis

200 events detected < 10 seconds in a single day!
The problem

When are $m_3$ trajectories updated?

“$m_3$ file includes $m_1$ information corrected when radar information showed too much vertical, horizontal or time variation compared to flight plan”

Small deviations are not recorded
Two types of flights

• **Real flights**, whose trajectories have been updated with radar information
  
  Mainly delayed flights ...

• **Ghost flights**, with unreal trajectories

  We need to detect these flights, and process them separately.
Proposed algorithm

$m3$ dataset

$m1$ dataset

Real flight

Difference greater than a threshold

Difference smaller than a threshold

$\text{Ghost flight}$

Difference between crossing times
Proposed algorithm

Problem:
which threshold use?

Solution:
Analyze the dynamics of the system to extract this information
Proposed algorithm

Hypothesis:

The number of potential conflicts increases with the square of the number of flight.

Density = \frac{\# \text{conflicts}}{(\# \text{flights})^2}
Filtered dataset

Reduction of two orders of magnitude
Next step I

Identification of *Congested Areas*

Flights in congested areas will have higher delays

*m3* information should be better updated
Next step II

Creation of a Confidence Index

Real flight

Unreliable

Ghost flight

Assessment of the confidence of any subsequent analysis
Thank you.