

COMPASS

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

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Project Coordinator, COMPASS

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



Today's partners for Tomorrow's aviation

- 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



Today's partners for Tomorrows aviation



- 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*

Expected Outcomes



Today's partners for Tomorrows aviation



- 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

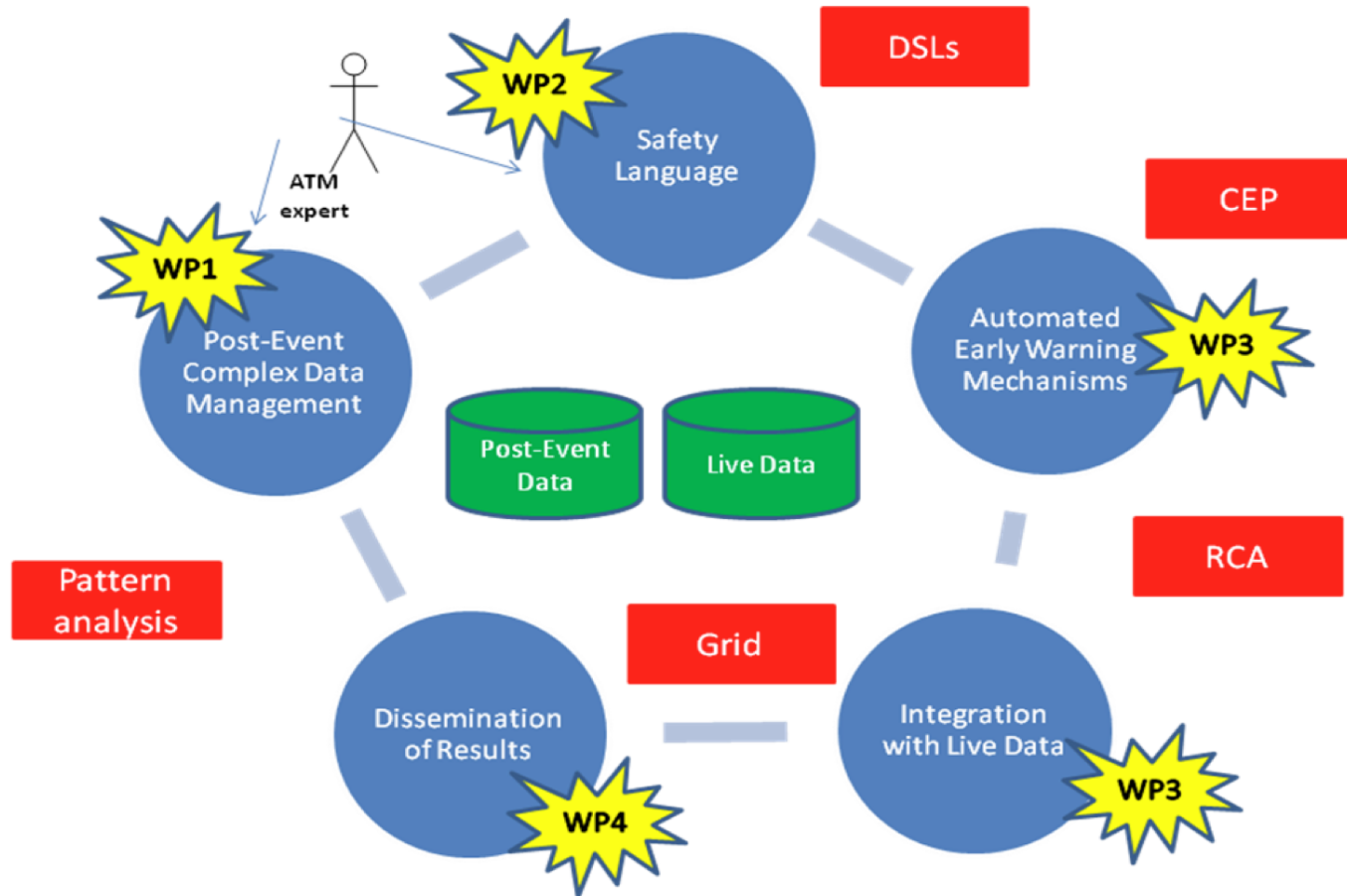
COMPASS Technical Overview

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

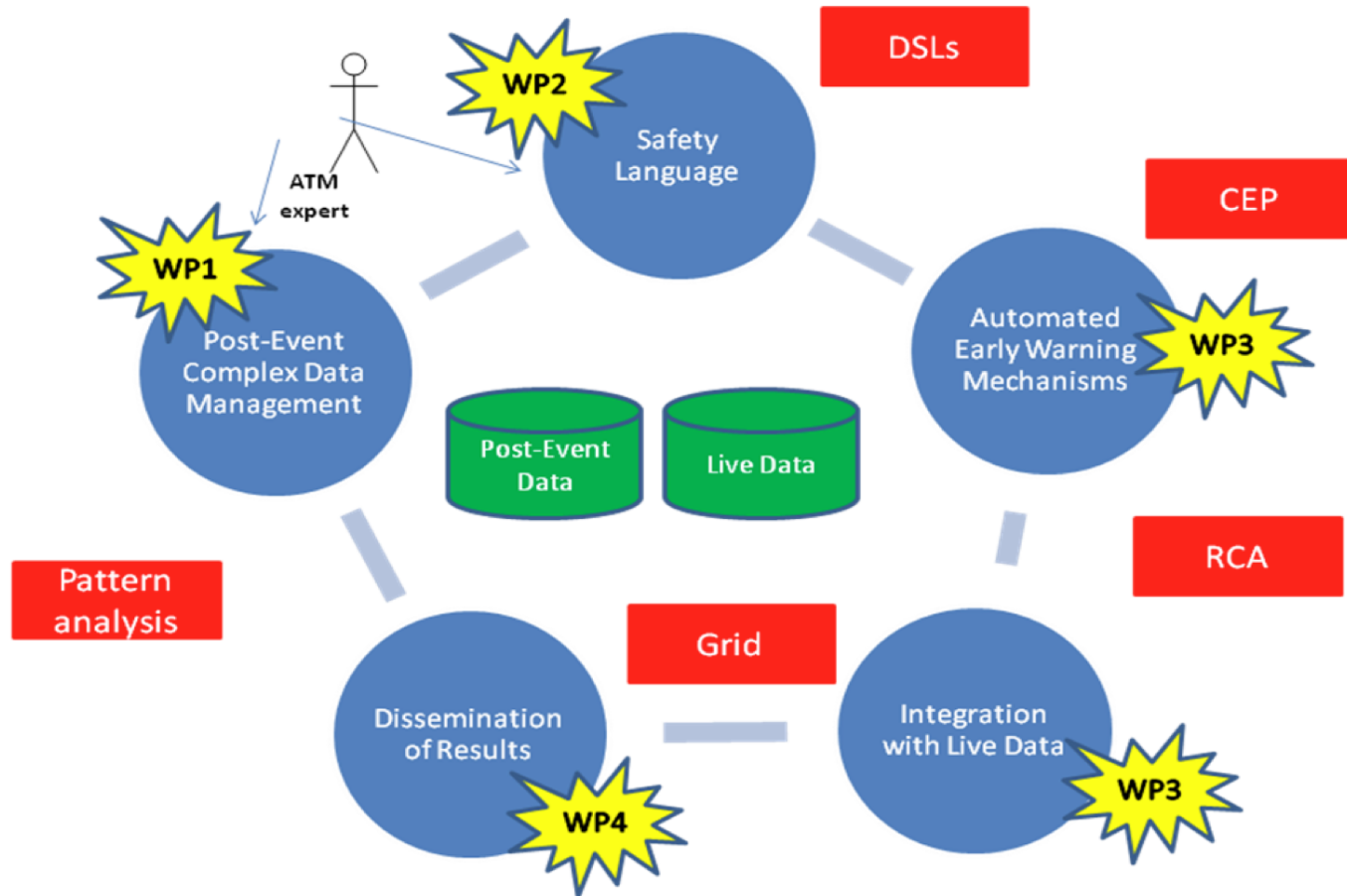
WP2: Safety Language

- 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



DDR Data Analysis and Filtering

Massimiliano Zanin

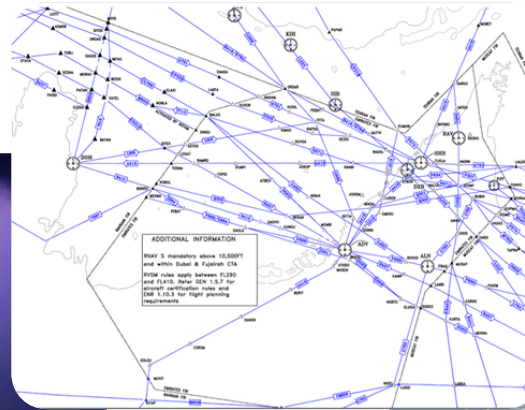
INNAXIS

What's wrong with DDR trajectories?



DDR trajectories within COMPASS

Different sources of information:



DDR trajectories within COMPASS

Differer

International Flight Plan

PRIORITY: <<= FF -> ADDRESSER(S): MMNDZRX MHTGZRX MKJKZRX
MUJHZRX KDEAYFYX MWCIFYX
MKJPYFX ZCH

PLN TIME: 181230-KDRIFYFYX<<=

SPECIFIC IDENTIFICATION OF ADDRESSER(S) AND/OR ORIGINATOR

1 MESSAGE: <<= FPL -> 2 AIRCRAFT IDENTIFICATION: N10999 3 FLIGHT RULES: Z 4 TYPE OF FLIGHT: G<<=

5 NUMBER: 1 TYPE OF AIRCRAFT: L35 6 WEIGHT TURBULENCE CAT.: M 7 EQUIPMENT: STC<<=

8 DEPARTURE AERODROME: KMSY 9 TIME: 1430<<=

10 CRUISE SPEED: 11 ROUTE: -N0440 F350- DCT HRV A321 FRISH/N040E390
UA321 DANUL UR640 MAMBI DCT GCM DCT

12 DESTINATION AERODROME: MWCR 13 TOTAL EST. TIME: 0210 14 ALTN AERODROME: MKJP 15 2ND ALTN AERODROME: <<=

16 OTHER INFORMATION: EET/ MMND 00+58 MHTG 01+36 MKJK 02+02
RMK/ ADCUS 4US 2CAN GRIMES

17 SUPPLEMENTARY INFORMATION (NOT TO BE TRANSMITTED IN FPL MESSAGE)

18 ENDURANCE: 19.1 20. PERIODS ON BOARD: 21. R 22. V 23. A

24. SURVIVAL EQUIPMENT: 25. P 26. L 27. G

28. FLARE: 29. X 30. X 31. M 32. J 33. J 34. L 35. F 36. V 37. V

38. DROGUES: 39. D 40. C 41. C 42. C 43. C 44. C 45. C 46. C 47. C 48. C 49. C 50. C

51. AIRCRAFT COLOUR AND MARKINGS: A/ WHITE BLUE

52. REMARKS: N/

53. PILOT-IN-COMMAND: GRIMES KHOU (73)644-8361 X<<=

FILED BY: ACCEPTED BY: ADDITIONAL INFORMATION:

Last Filed Flight Plan

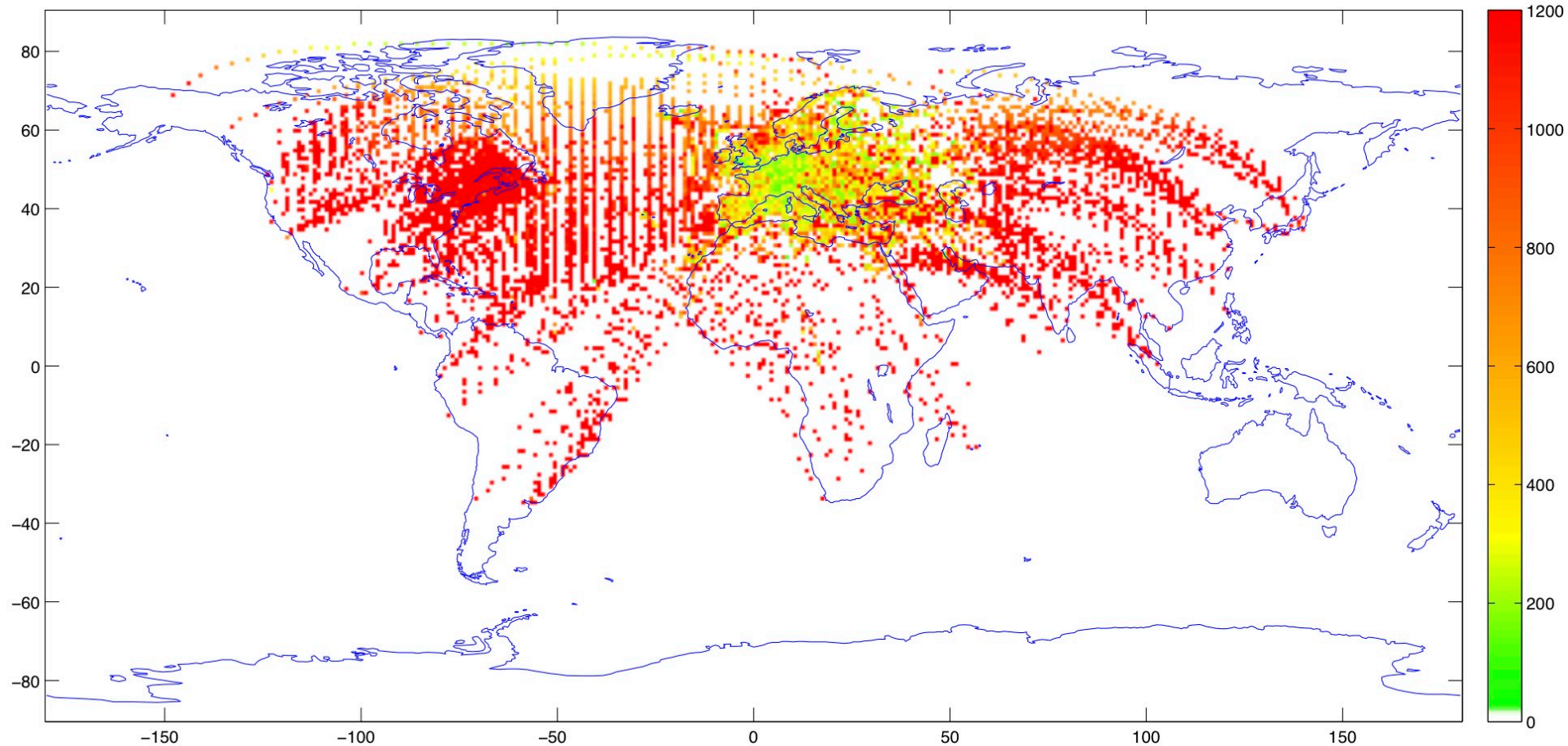
m1 files



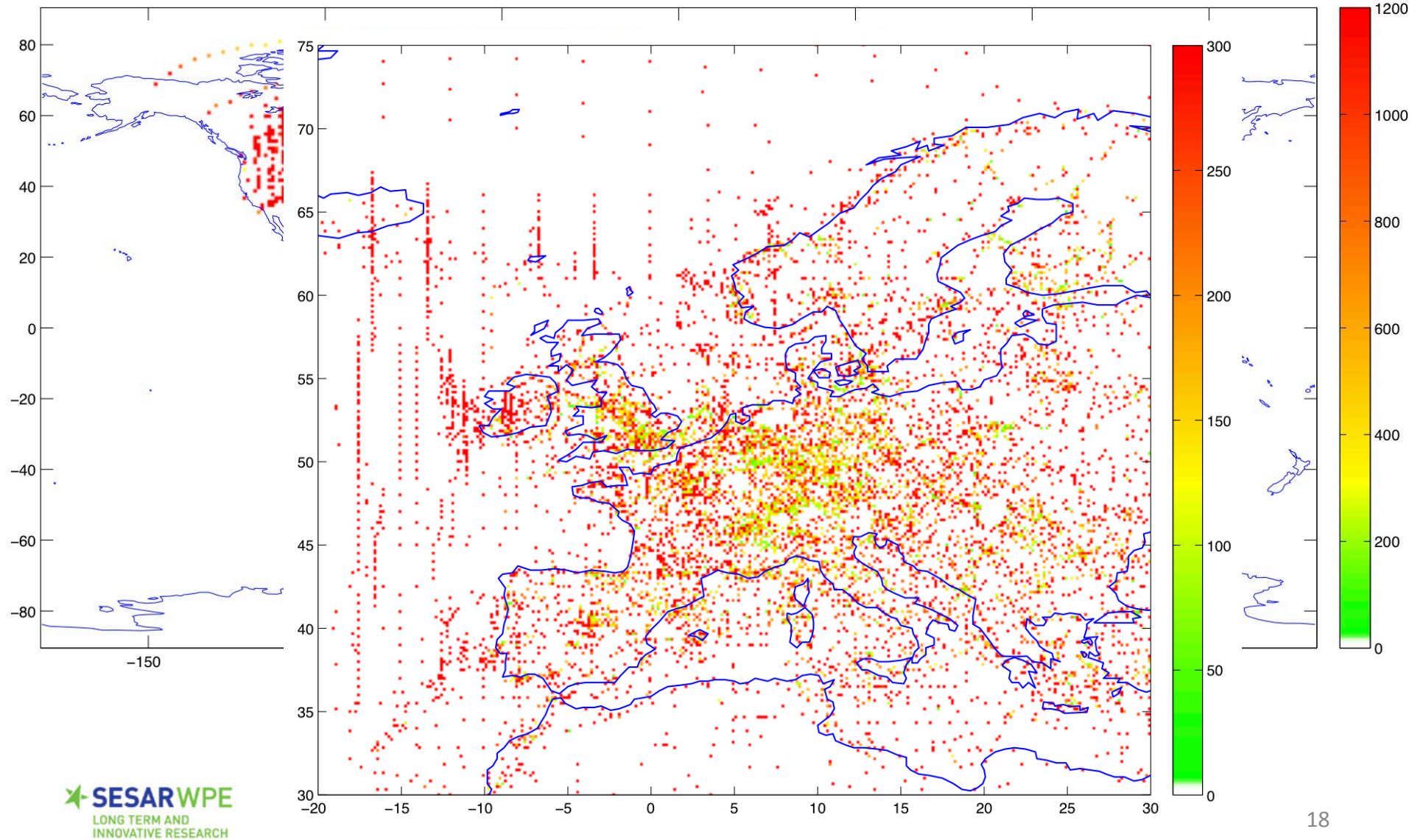
Flight Plan updated with
radar tracks

m3 files

Descriptive analysis



Descriptive analysis

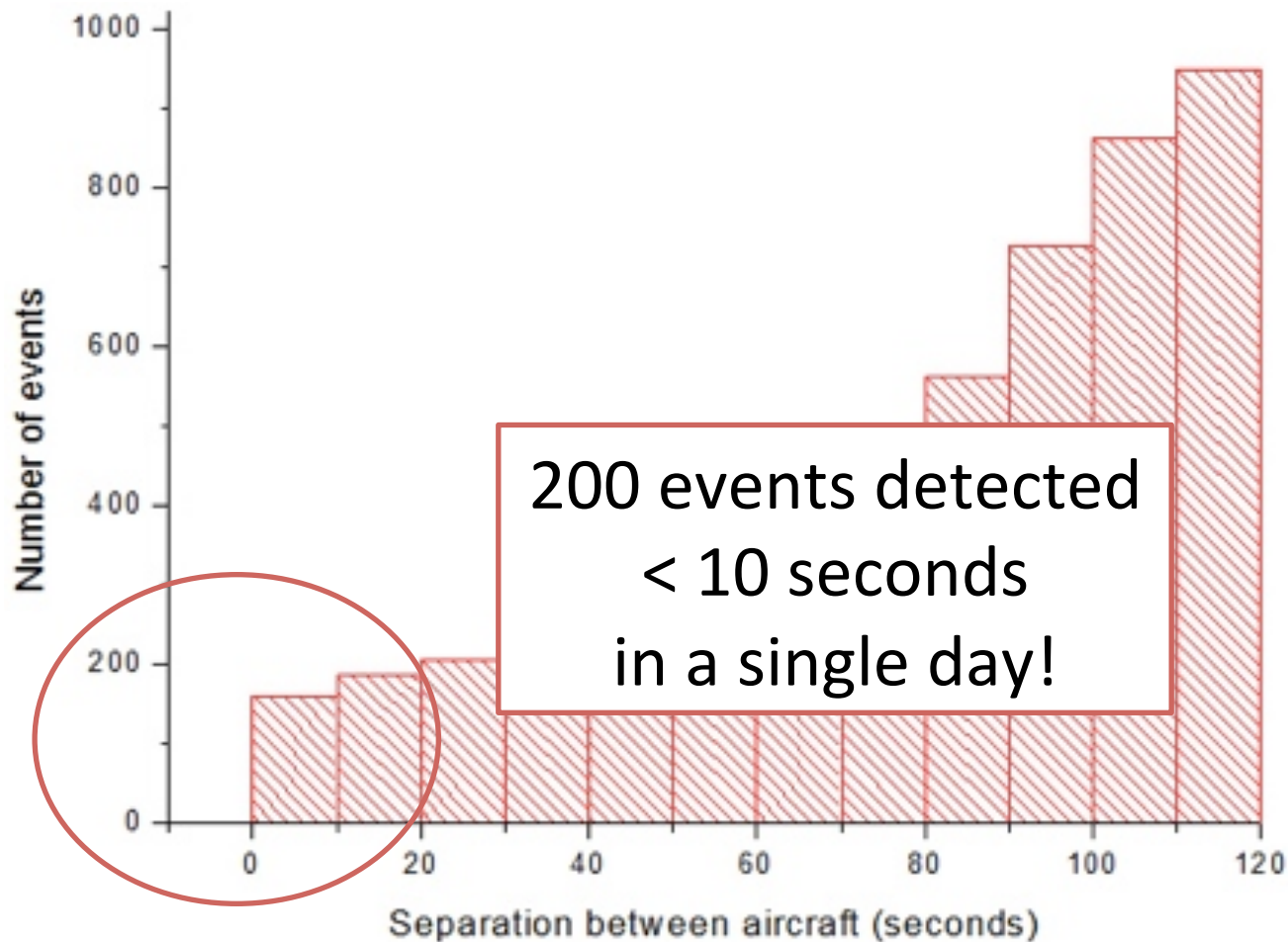


Descriptive analysis

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



The problem

When are *m3* trajectories updated?

“*m3* file includes *m1* 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 ...

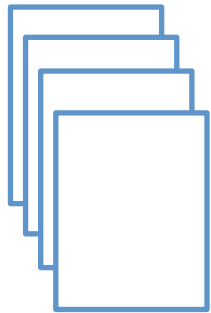
- *Ghost* flights, with unreal trajectories



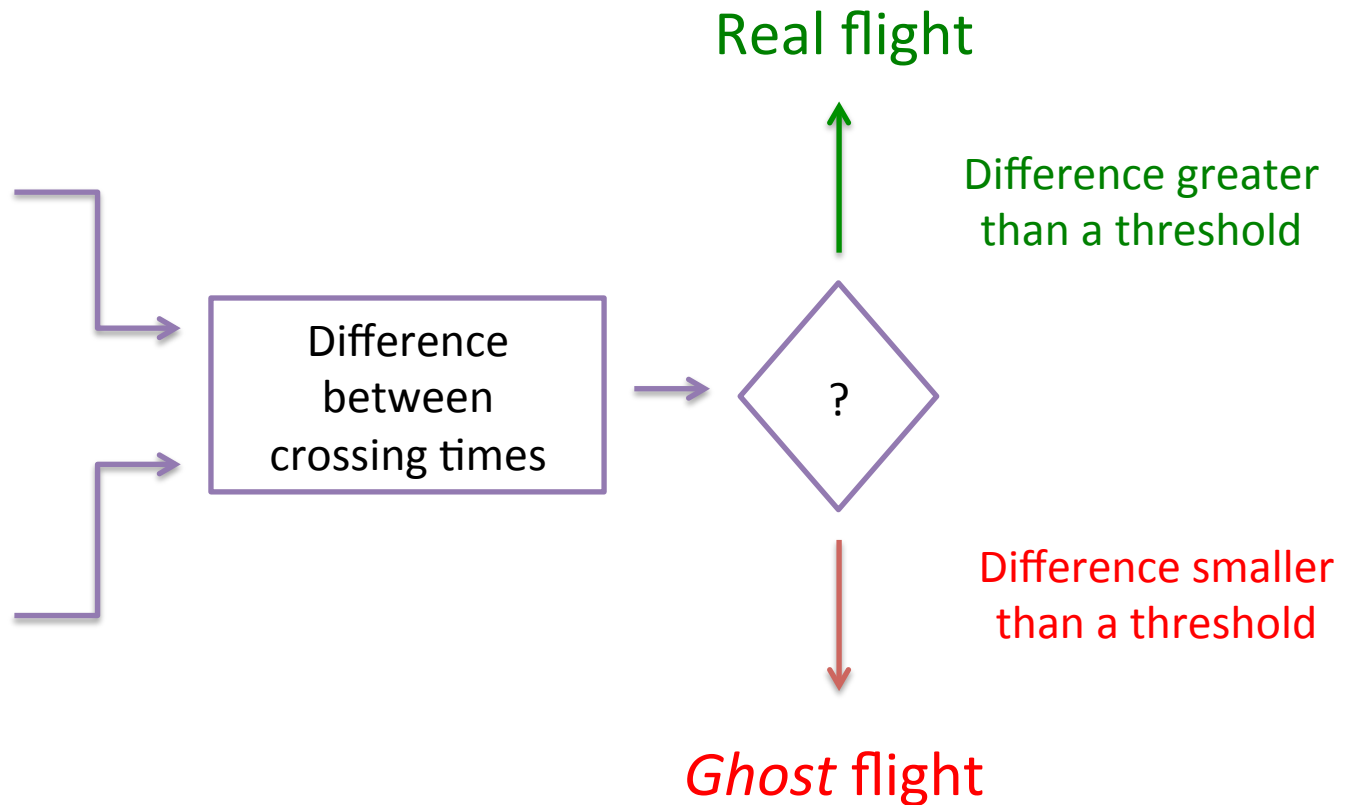
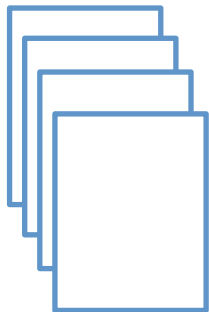
We need to detect these flights, and process them separately.

Proposed algorithm

m3 dataset



m1 dataset



Proposed algorithm

Problem:

which threshold use?

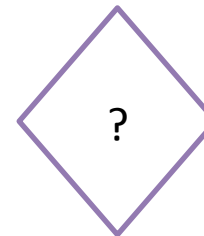
Solution:

Analyze the dynamics of the system
to extract this information

Real flight



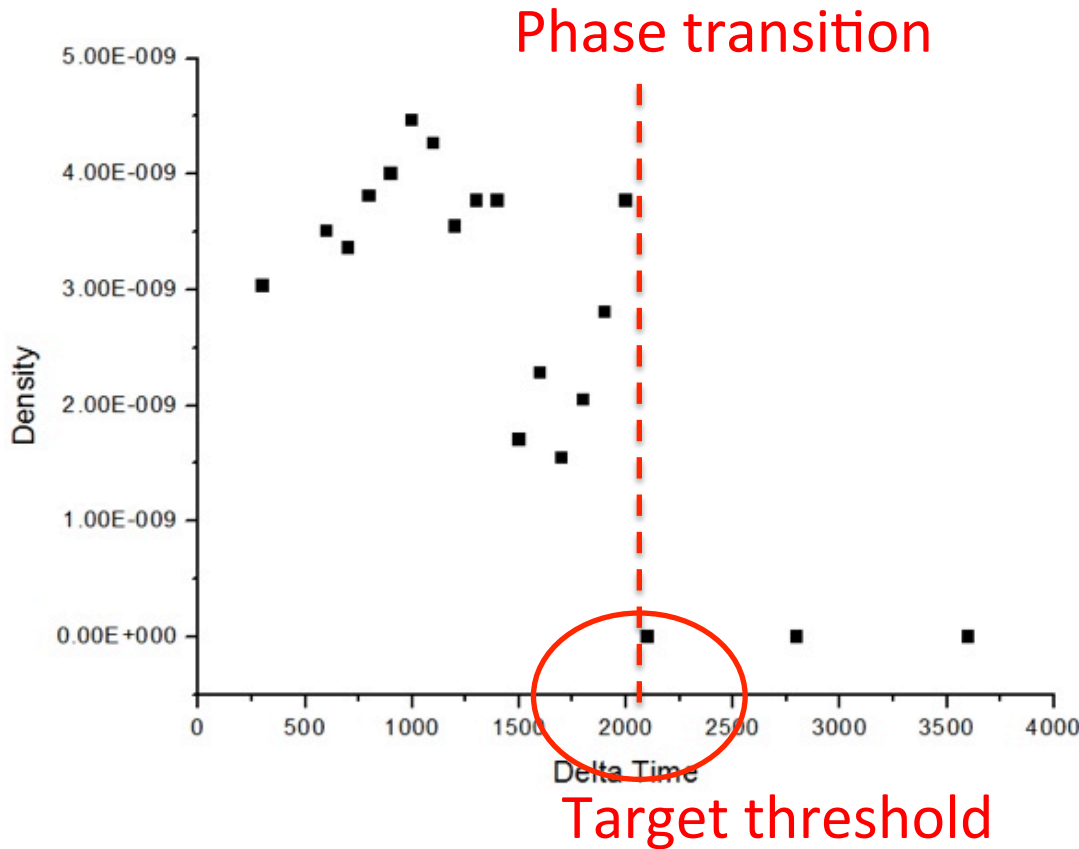
Difference greater
than a threshold



Difference smaller
than a threshold

Ghost flight

Proposed algorithm

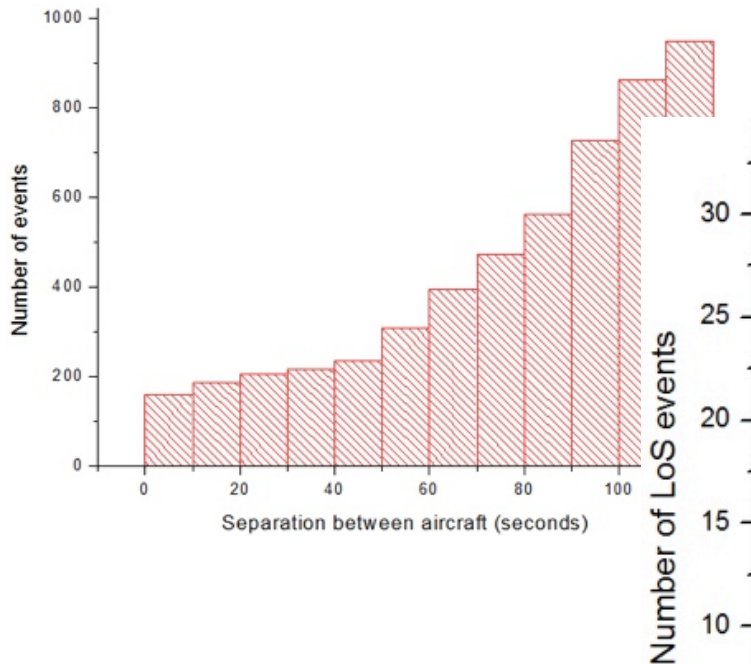


$$Density = \frac{\# conflicts}{(\# flights)^2}$$

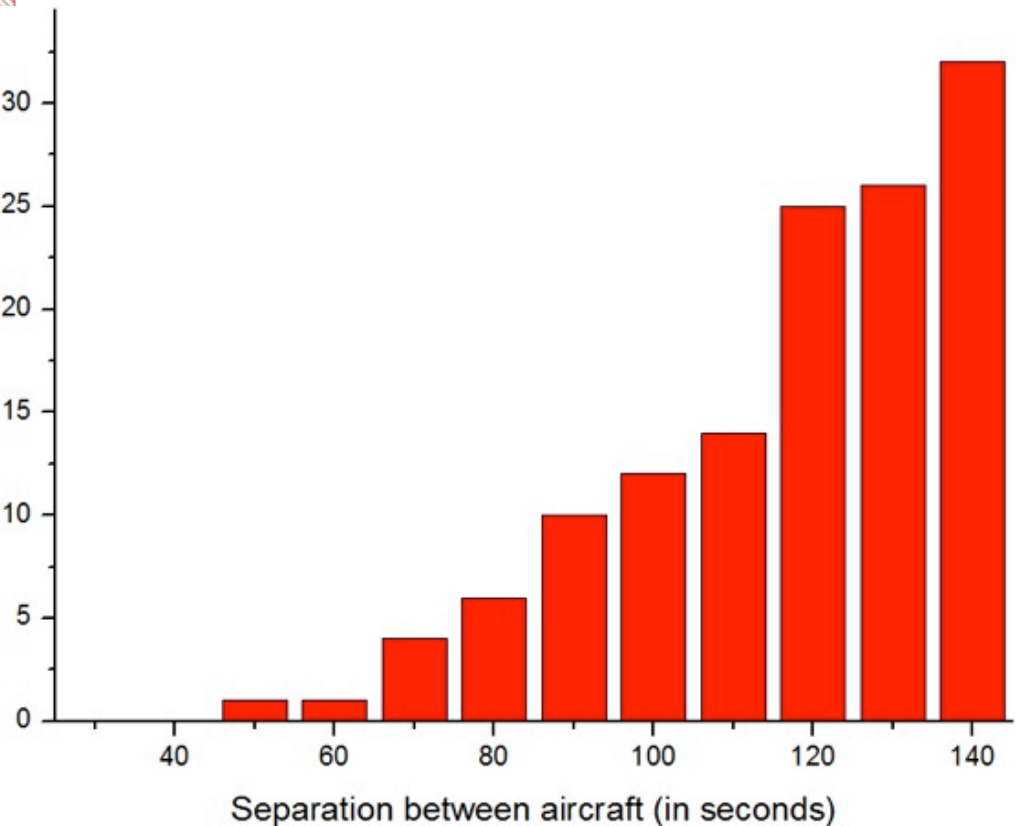
Hypothesis:

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

Filtered dataset

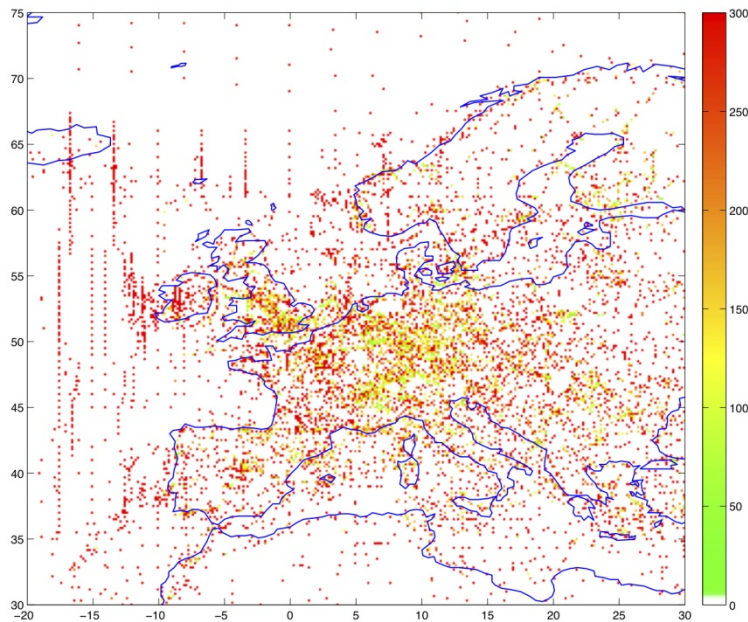


Reduction of two
orders of magnitude



Next step I

Identification of *Congested Areas*



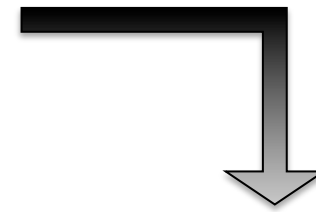
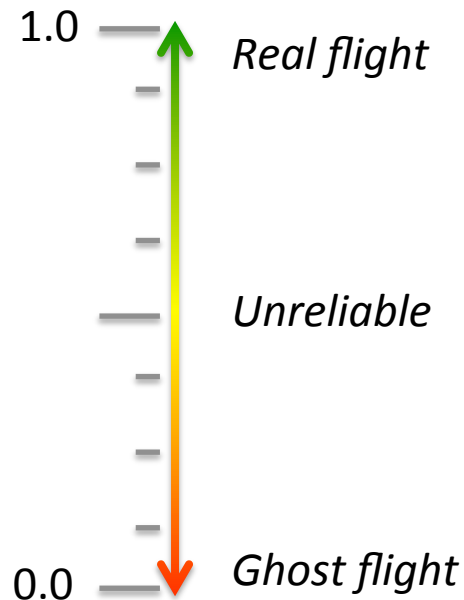
Flights in congested areas will
have higher delays



m3 information should be
better updated

Next step II

Creation of a *Confidence Index*



Assessment of the confidence
of any
subsequent analysis

Thank you.