FROM INNOVATION TO SOLUTION

SESAR: RECOGNISING EXCELLENCE

Benoit Fonck
SESAR Joint Undertaking

SESAR JOINT UNDERTAKING

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2014 SESAR Project Awards

✓ Recognise excellence within the SESAR Programme

- **Best in class award**

Highlight the project which best complies with performance indicators such as being on-time, within budget, managing well its risk assessment.

- **Outstanding project award**

Recognize the project with the most outstanding deliverables or tangible results contributing to SESAR's strategic objectives.

✓ 21 Nominations (by WP Leaders)

- ✓ 7 Best in Class projects
- ✓ 14 Outstanding projects

✓ Jury 2 SESAR Members and SJU authorities

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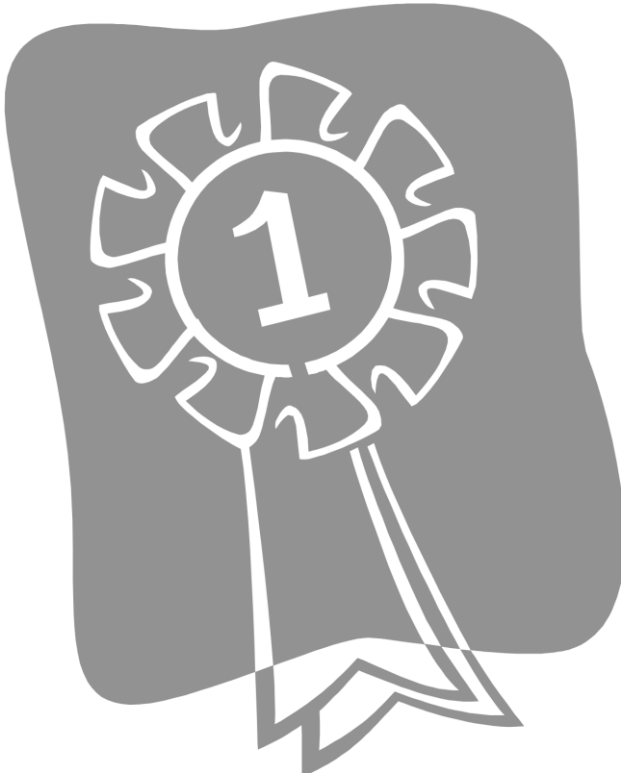
2014 Best in Class Award



P09.21

Framework for airborne ADS-B performance evaluation

Project Manager

Martina Stehlikova

Honeywell

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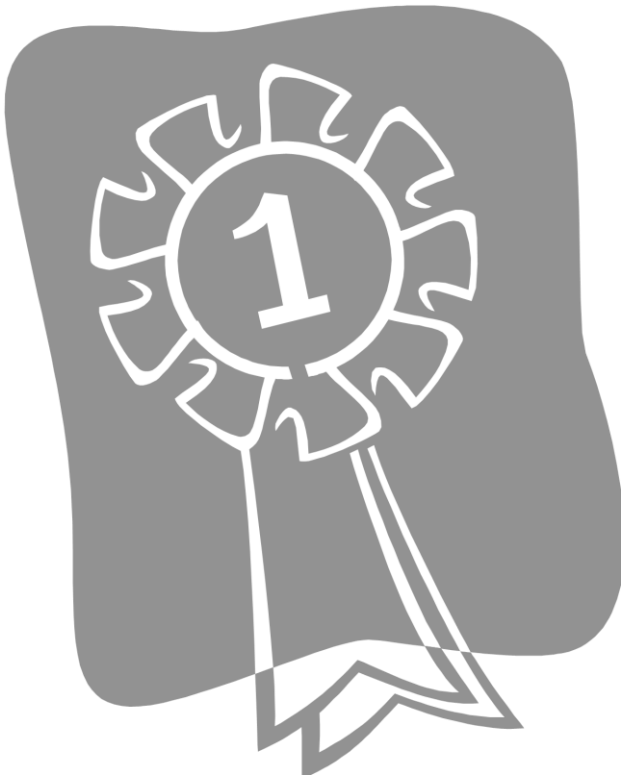
2014 Outstanding Project Award



E.02.06

Passenger Oriented Enhanced Metrics (POEM)

Project Manager

Andrew Cook

University of Westminster

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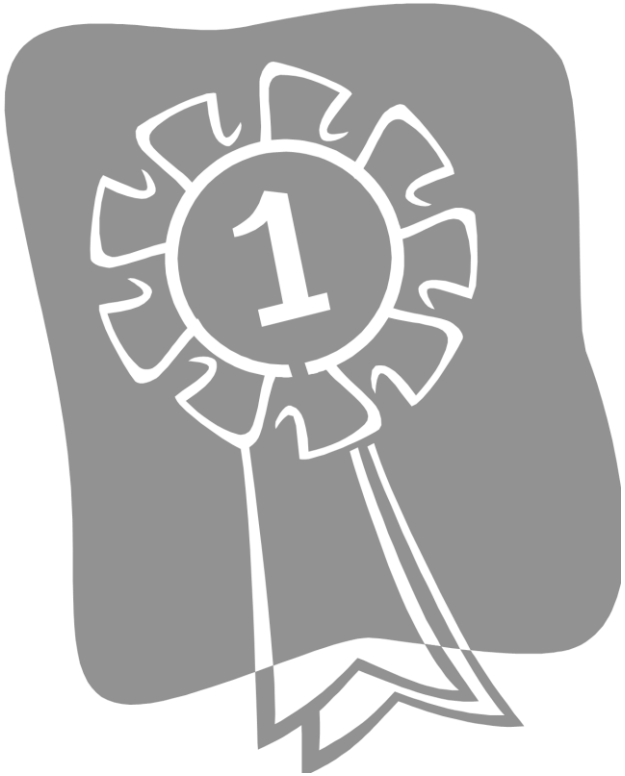
2014 Outstanding Project Award



P.06.07.01

Airport Safety Support Tools for Pilots, Vehicle Drivers and Controllers

Project Manager

Christelle Pianetti

DSNA

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SESAR 9.21: ADS-B – 1090 HIGHER PERFORMANCE STUDY

March 10, 2015

Presented by Milan Sopata, Honeywell

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Automatic Dependent Surveillance – Broadcast (ADS-B) Overview

Key surveillance technology for future ground and airborne based applications (situational awareness and separation applications)

Key enabler for future ATM identified by NextGen and SESAR

Increases situational awareness and airport capacity

Accurate position information and additional information broadcasted

En route Secondary Surveillance Radar (SSR)

2,000ft
Degrades from approx. **225ft at 5nm** to **2,000ft+ at 200nm**

10-12s
Update rate is **10-12 seconds**

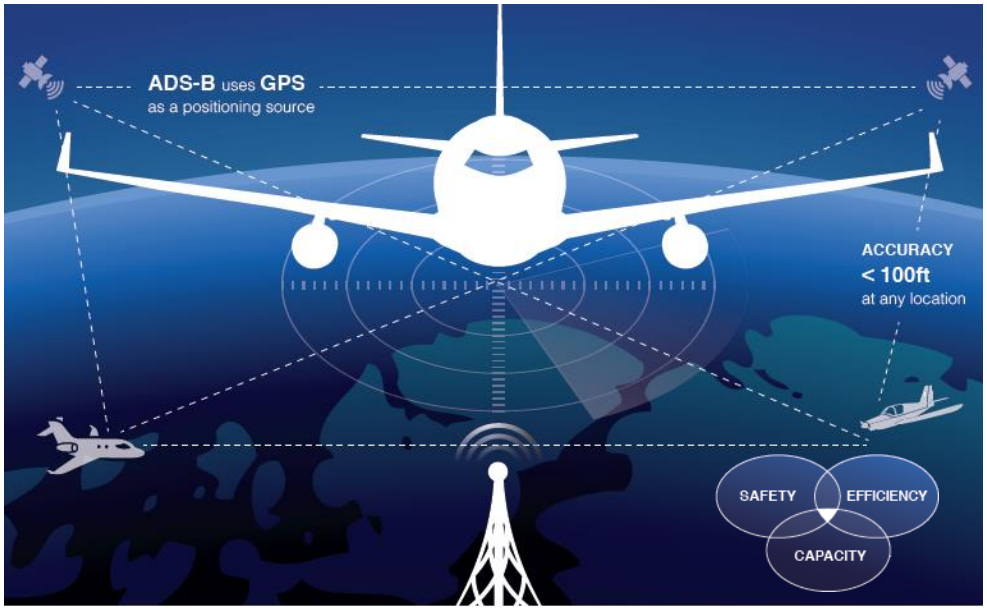
x20
ADS-B is **20 times more accurate** than SSR at its maximum range

Terminal Radar

775ft
Error ranges from **225ft at 5nm** to **775ft at 60nm**

4-6s
Update rate for Terminal Radar is **4-6 seconds**

x8
ADS-B is nearly **8 times better** in **accuracy performance**



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Why SESAR 9.21 project?

The Problem

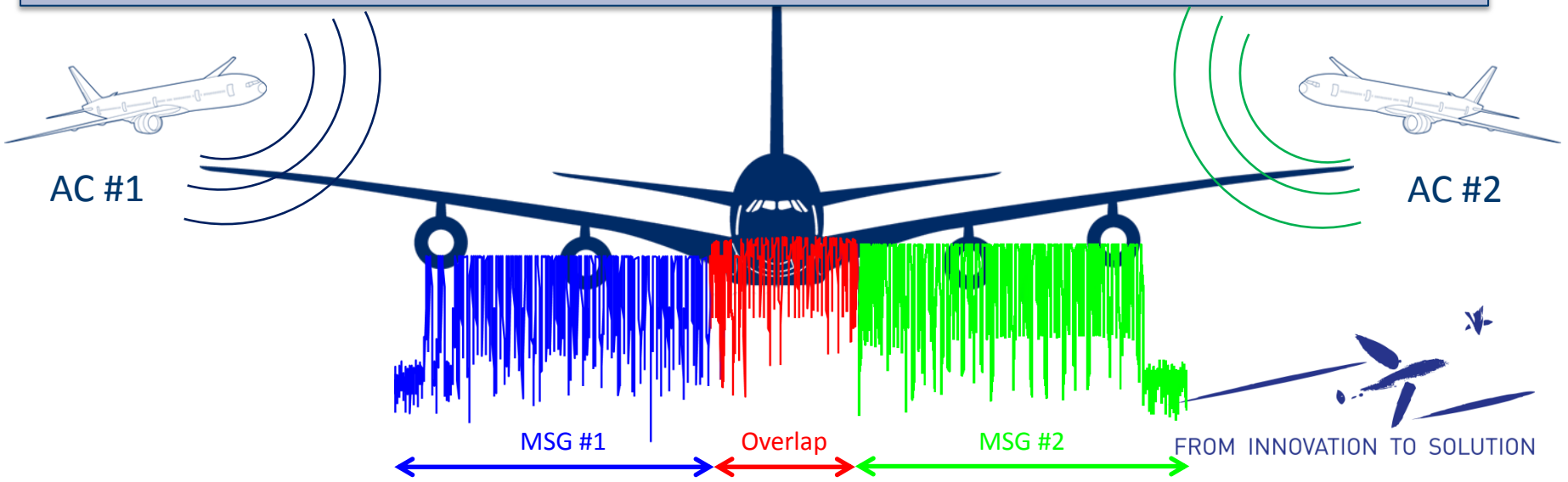
- 1090 MHz channel shared with: Mode-A/C, short Mode-S (TCAS), DME, military transmission (Mode-5)
- In highly congested areas can be the level of interference is too high → degradation of ADS-B message reception due to their overlap

How to solve the risk

- New link with higher performance (not a way due to cost increase)
- Minimize the probability of overlap of two or more messages (not possible)
- Reduce the level of interference by reduction of the number of interrogations (hybrid TCAS)
- Maximize the reception probability even in the case of overlapped messages → enhanced receiver

The Solution

- Enhanced Bit and Confidence Declaration (EBCD)
- Blind Beamforming for separation of ADS-B messages (BB)
- Sectorized Antennas (SA)



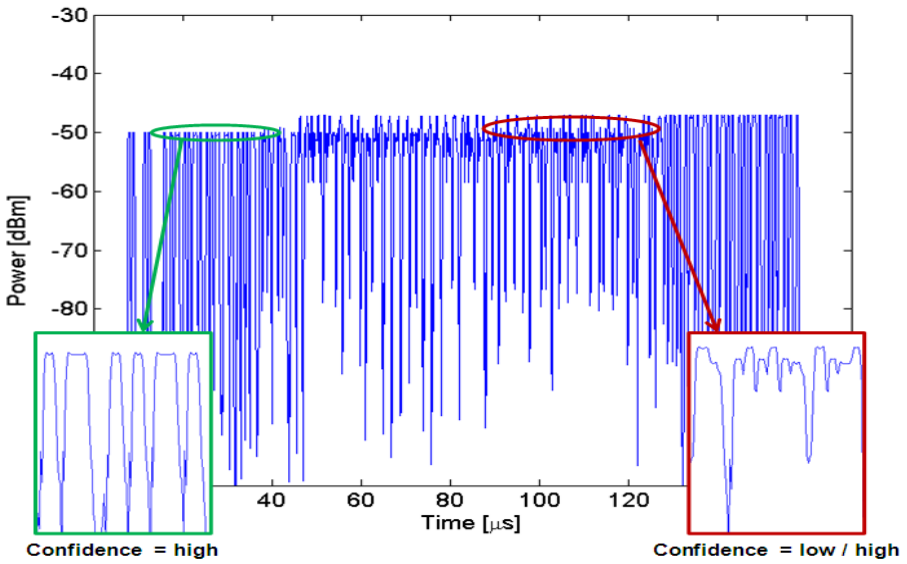
Mitigation Techniques - EBCD

Conventional ADS-B decoder outputs:

- estimated bit values
- confidence of this decisions (used by error correction)

EBCD provides:

1. More accurate bit and confidence values → higher reception rate
2. Exploits more sophisticated declaration mechanism in comparison to DO-260B/ED102A standards



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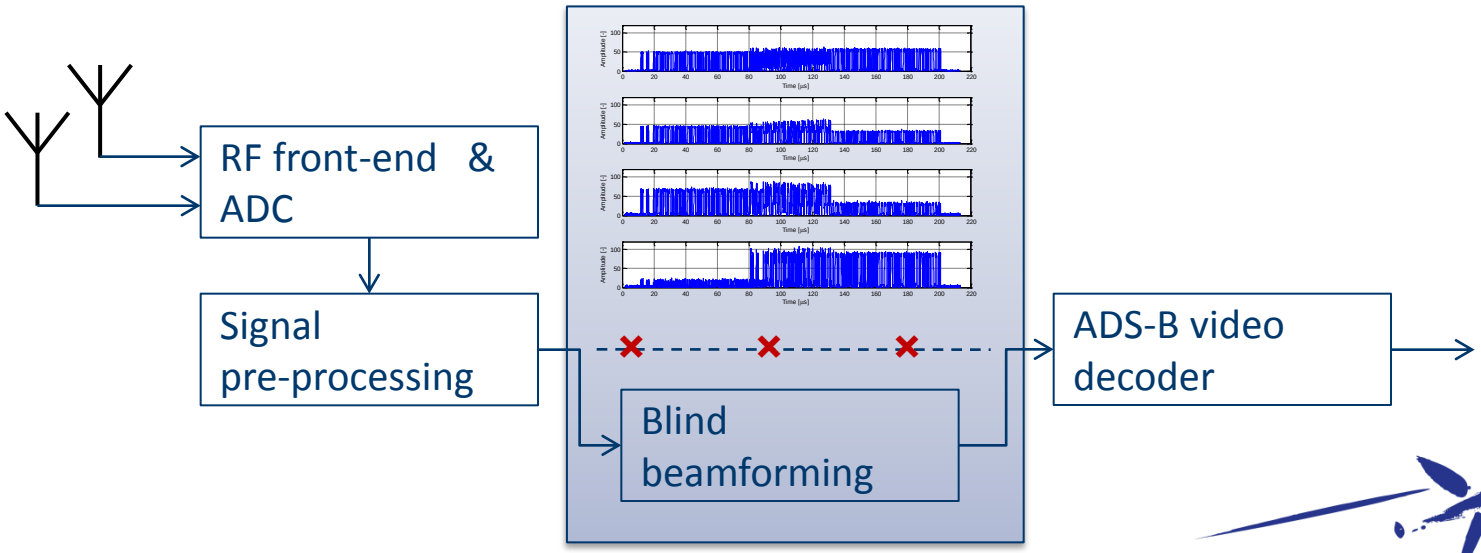
Mitigation Techniques - BB

Algebraic digital beamforming method

- Steering beams into preferred direction
- Performed in SW → it is possible to steer beams in two directions concurrently – no real steering
- No prior information about the channel (blind)

Separate signals prior to decoder processing („black box")



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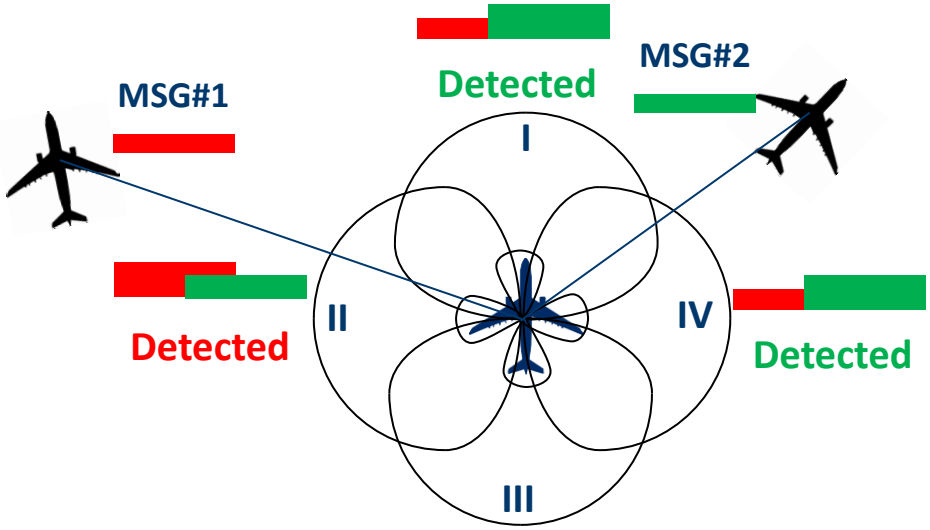
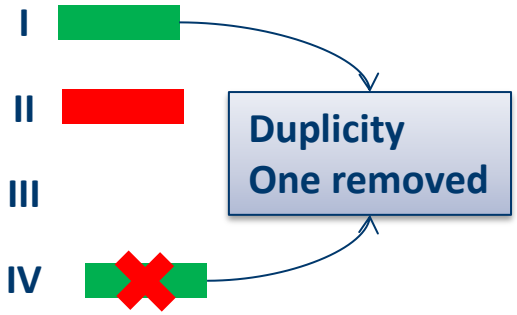
Mitigation Techniques – SA

Spatial diversity through the use of multiple directive beams instead of using a single omni-directional beam.

Uses multiple standard receivers that detects only one of messages →depends on which one is stronger

Parallel receivers are followed by duplicate check – need to check for duplicate detection in case when same message is detected





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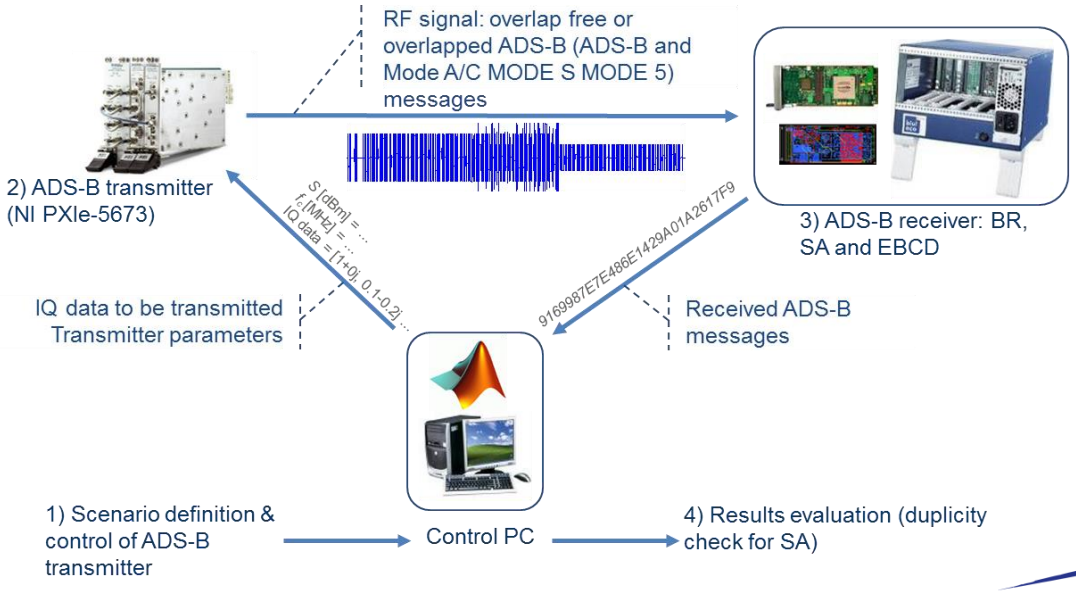
Simulations and Lab Prototyping

Massive simulations provided before prototyping to select the most feasible solution

- Full transmission and receive chain modeled
- Simulations provided for various scenarios including standard DO260B/ED102A + scenarios specific for the mitigation techniques
- Results shown feasibility for implementation

Implemented all three mitigation techniques in laboratory mock-up

- For laboratory test a new platform was designed including analog (RF) part and digital (processing part)
- Signal on the input was emulated to be able to test the receiver in same conditions and scenarios as during simulations



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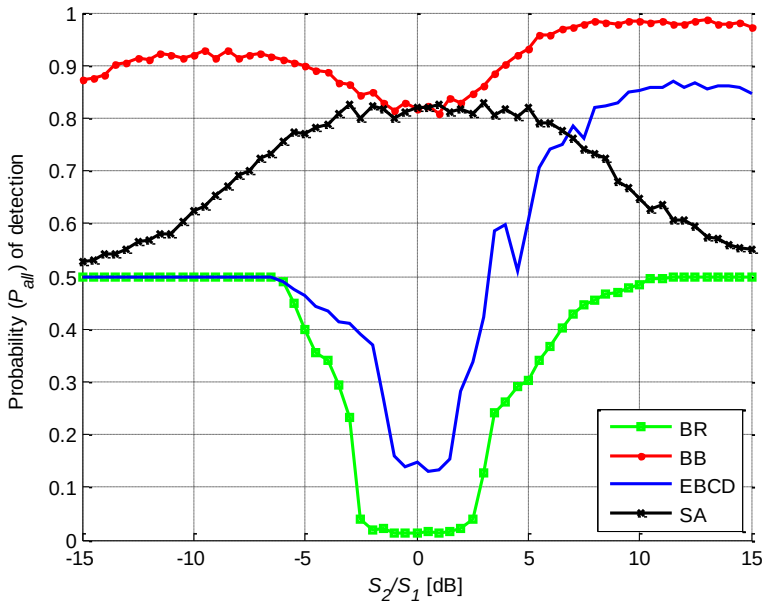
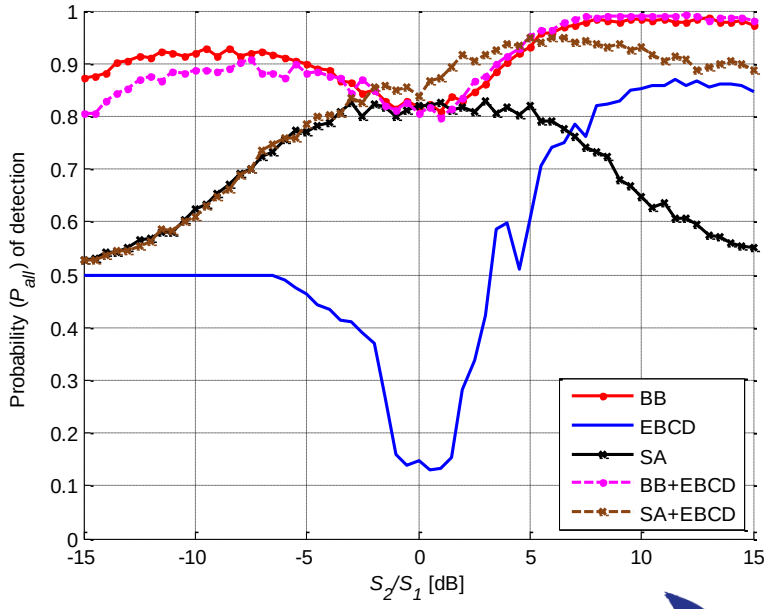
Receiver Performance Tests - Example

- Blind beamforming technique outperforms all other investigated techniques. This technique is however computationally demanding.
- Sectorized antennas technique outperforms baseline receiver and receiver with EBCD implemented. The performance of this technique is antenna pattern dependent.
- Receiver with enhanced bit and confidence declaration technique performs better than baseline receiver.

Probability of detection P_{all} for varying power ratio S_2/S_1

(including combination)





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Environmental Simulations

Provided by ESG → External subcontractor

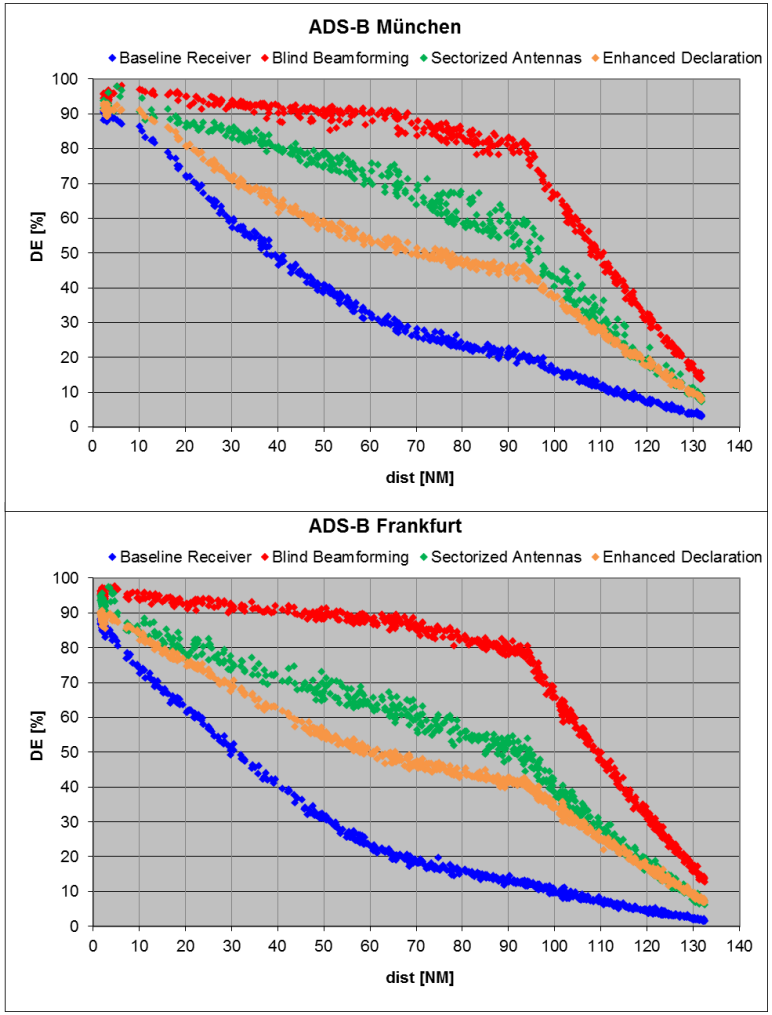
Coordinated with SESAR 15.01.06

Model set up according performance estimates

Results as for airspace in 2025

Results shown

- Increase of range for message detection
- Increase of update rate as required for use for specific applications



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Conclusions

- The project is successfully finished
- The results show that selected mitigation techniques are applicable and promising for use in the future when performance of receiver have to fulfill requirements from the new applications point of view
- The use of mitigation techniques can increase probability of detection by 20% (depends on the mitigation technique used)
- This can lead to increase of detection range and information update rate
- The mitigation methods are applicable without need for link definition changes, i.e. methods are backward compatible
- The results were presented in front of ICAO ASP TSG group with positive feedback
- Mitigation techniques might be a part of the future standards

Increase of probability of detection -> Extending range and update rate

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‘POEM’
Outstanding Project Award

Dr Andrew Cook (University of Westminster, London)
& on behalf of Innaxis (Madrid)

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Overview

- What is POEM about and why did we bother?
- The simulations in a nutshell
- How does complexity science fit in?
- A sample of key results
- Where next?

FROM INNOVATION TO SOLUTION

What is POEM about and why did we bother?

- Passenger-Oriented Enhanced Metrics
  - putting the passenger at the centre of service delivery
  - exploring new prioritisation strategies using new metrics
- Political motivation re. pax mobility, e.g. Commission:
  - roadmap to a Single European Transport Area for 2050 (2011)
  - 'Flightpath 2050', HLG on Aviation Research (2011)

    … 4 hour door-to-door target for 90% of passengers
  - on-going reviews to Regulation 261/2004 (2016?)
- Operational motivation
  - pax direct costs often dominate AO cost of delay (& behaviour)
  - even in pure G2G context, passenger delay > flight delay
  - no specific metrics – how measure?

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The simulations in a nutshell

- Evaluate flight and pax prioritisation strategies
  - currently 3 major scenario types (pax numbers, costs, policies)
- Use new metrics to measure performance trade-offs
  - classical (e.g. pax delay) and complexity (e.g. centralities)
- Investigate delay propagation through network
- First full-scale European simulation with explicit pax
  - captures full AO delay costs (pax, fuel, crew, maint.); 4 types
  - busiest 200 ECAC airports + 50 airports outside Europe
  - unexceptional, busy day in 2010 (17SEP10)
  - detailed decision-making rules (workshops; Reg. 261; IATA)
- Combined PaxIS (2.5m) and PRISME (30k) data
  - 150k distinct routings (itineraries)
  - respects MCTs, LFs, seat configurations

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A look inside one second …

[…](17-Sep-2010 12:25:00) 47 out of 49 of pax (95.92 pct.) of DLH_EDDLEGBB02:15877 were ready, flight over 80 pct. occupancy, no more delay added

(17-Sep-2010 12:25:00) Total cost of flight DLH_EDDLEGBB02:15877 departing at 17-Sep-2010 12:25:00 now estimated at 127.15 euros

(17-Sep-2010 12:25:00) No further pax delay will be introduced, thus flight DLH_EDDLEGBB02:15877 is now pushback ready, reaccommodating connecting pax

(17-Sep-2010 12:25:00) Pax group DLH1815:37550 of 2 inflex pax coming from DLH_EDDHEDDL06:12246 to EGBB did not make it to DLH_EDDLEGBB02:15877 (no more connections afterwards) and need to be reaccommodated

(17-Sep-2010 12:25:00) 2 inflex pax of group DLH1815:37550 of DLH_EDDHEDDL06:12246 that missed DLH_EDDLEGBB02:15877 were successfully reaccommodated in DLH_EDDLEGBB03:23396 same alliance, DLH1815/1:145607 Arrival: 17-Sep-2010 17:50:00 delay: 04:00'00" (airport wait 03:01'51")

(17-Sep-2010 12:25:00) Trying to reaccommodate the 80 pax waiting at EDDL:10 (DUS)

(17-Sep-2010 12:25:00) A total of 2 pax of DLH_EDDLEGBB02:15877 were left behind and all of them were successfully reaccommodated

(17-Sep-2010 12:25:00) Flight SAS_ENKBENGM03:15843 loading 67 pax and all of the 67 pax are not coming from a previous flight. There are NO connecting pax

(17-Sep-2010 12:25:00) There are 29 pax groups in SAS_ENKBENGM03:15843 connecting with another flight afterwards (SAS3310:87574, SAS3311:87575, SAS3312:87576, SAS3313:87577, SAS3314, […] (KSU-OSL)

How does complexity science fit in?

- Not one theory; system of systems – usually a network
  - multiple components, non-linear dynamics: can't predict
  - non-analytical models, e.g. agent-based
  - usually need to take uncertainty into account
- Emergent behaviour, e.g. delay propagation
- ATM = complex socio-technical system
- How can complexity science contribute?
  - user-defined nodes in topological networks
  - existing metrics such as centralities (causality)
  - existing methods such as community detection & percolation
- Complementary approach
  - classical and complexity

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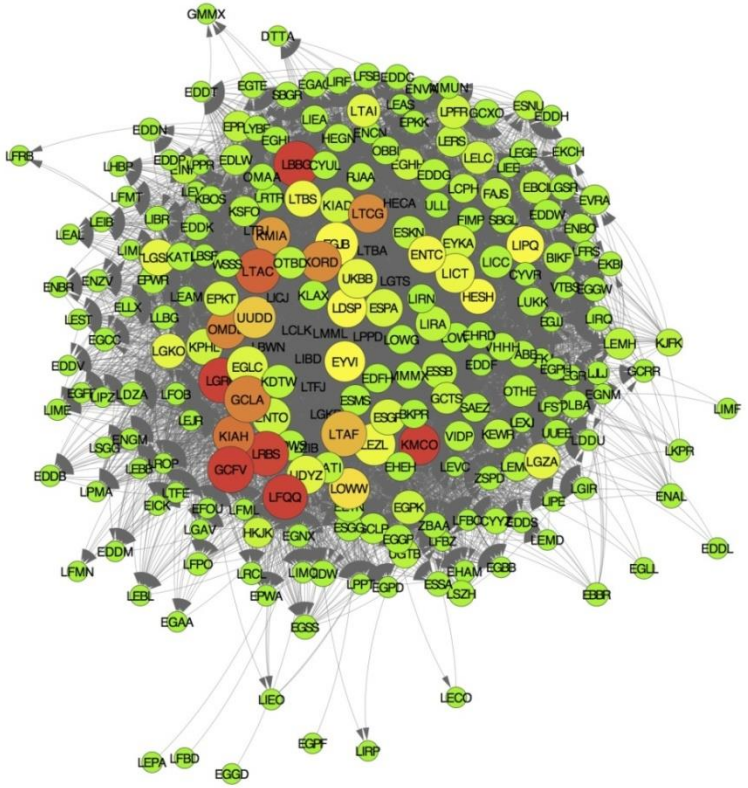
A sample of key results

- Cost-minimising aircraft wait rules (scenario A_1):
  - ↓ **€39** avg. cost / flight
  - ↓ **9.8 mins** avg. arr. / dlyd pax
  - ↑ **2%** reactionary (focus)
- All scenarios: no statistically significant changes in current flight-centric metrics
- Persistence of delay
  - hub back-propagation
  - role of smaller airports



- Delay topologies for A_1:
  - smaller communities
  - more susceptible

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Where next?

- Live model, on-going developments such as:
  - fidelity of various rules (flexible, event-driven; + CO_2?)
  - 2014 traffic with new costs; GDS integration; D2D context
- Exploring further use of valuable new metrics
  - passenger-centric; in context SES RP3 (2020 – 2024)?
  - increased focus on cost resilience
- Policy evaluation
  - e.g. Regulation 261; 'exploratory' policies
- Increased AO-level focus and software integration
  - strategic planning, trending context (e.g. a/c sizes & LFs)
- Parallel SESAR ConOps developments
  - e.g. UDPP (costs) and A-CDM (connectivity)

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SESAR PROJECT 06.07.01

AIRPORT SAFETY SUPPORT TOOLS

FOR PILOTS, VEHICLE DRIVERS AND CONTROLLERS

Outstanding project, 2014

Christelle Pianetti- DSNA (Project Manager, Airport Safety Nets Coordinator in SESAR)

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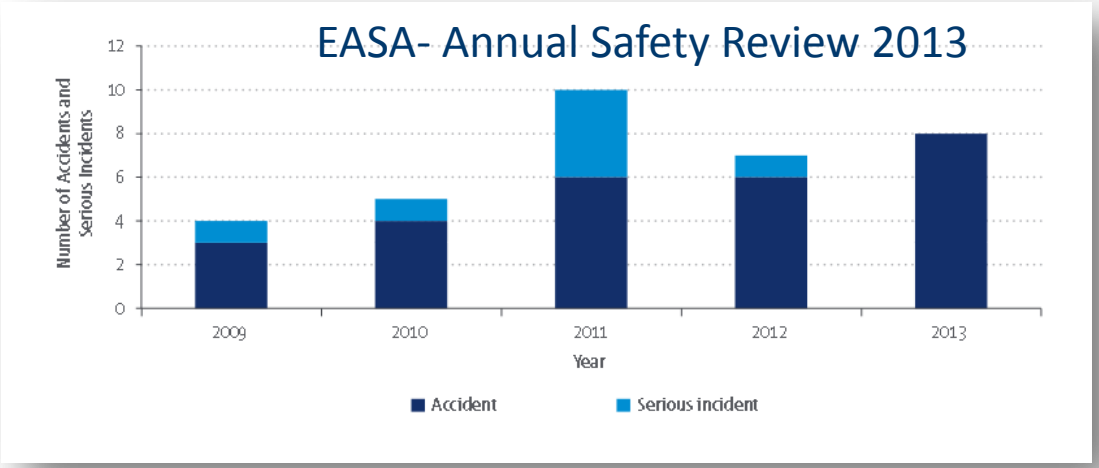
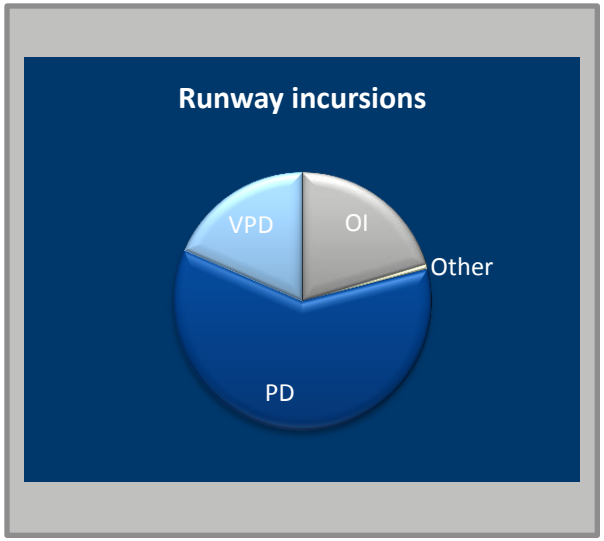
Airport Safety Support Tools - Problem statement

- Safety issues during surface operations



- Involving
  - Vehicle drivers,
  - Controllers and
  - Pilots



FAA runway statistics (2014)

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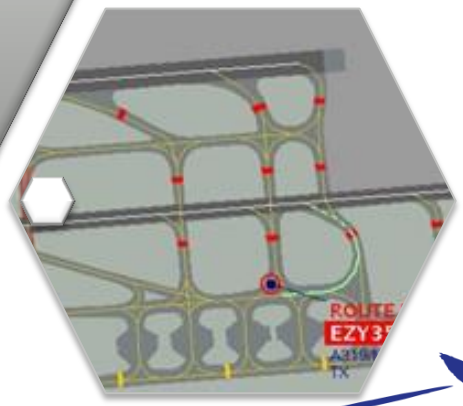
Airport Safety Support Tools – Solutions

Safety Support Tools for **Pilots**

Safety Support Tools for **Tower Controllers**

Safety Support Tools for **Vehicle Drivers**



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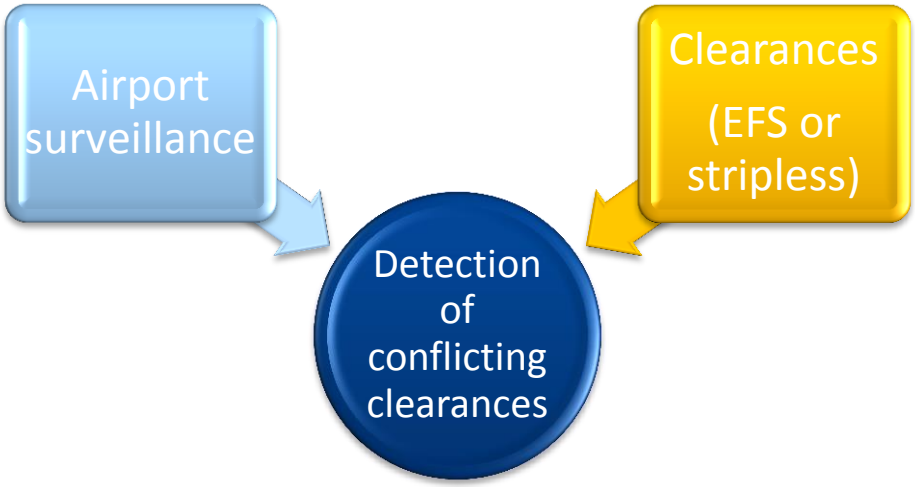
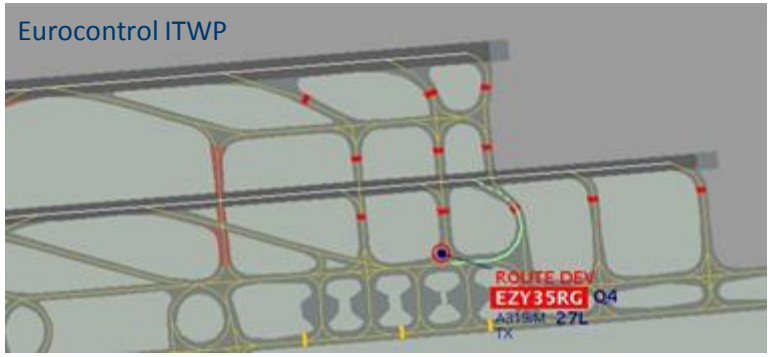
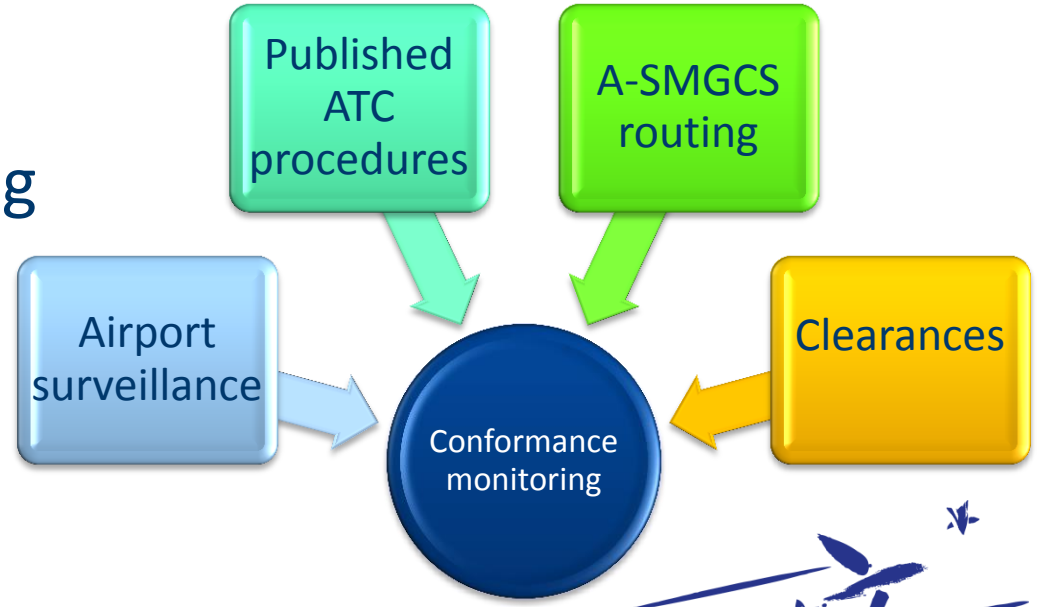
Safety Support Tools for Controllers

- Detection of conflicting clearances (runway operations)



- Conformance monitoring





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Safety Support Tools for Controllers- Initial results

- Increase of safety and situational awareness
- Highly dependent on airport layout/operations (e.g. specialized RWYs, crossing runways)
- Alerting vs preventing?

DFS prototype, 2012

DFS prototype, 2012

Eurocontrol ITWP

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Safety Support Tools for Controllers- Next steps

- 5 evaluations in different airport environments
  - Barcelona
  - Milano-Malpensa
  - Paris-CDG
  - Hamburg
  - Riga (shadow mode trials)

- Airport Safety Nets for Tower Controllers are part of 1st Pilot Common Project – IR (EU) 716/2014
  - Target for deployment
  - Date in PCP: 2021

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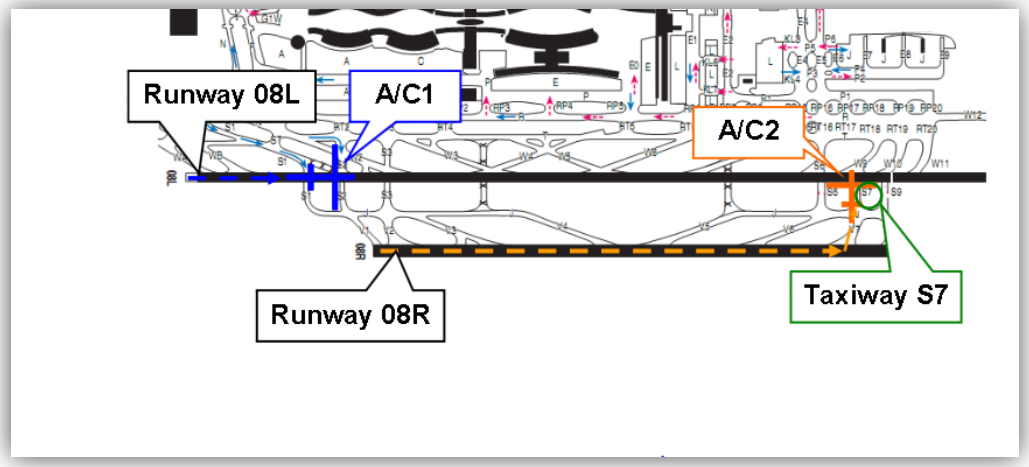
Safety Support Tools for pilots

- Traffic alerts
  - Detection of risk of collision with other traffic
  - Runway&taxiway operations



- Conformance monitoring
  - E.g. Runway unsuitable wrt the aircraft type, taxi route deviation

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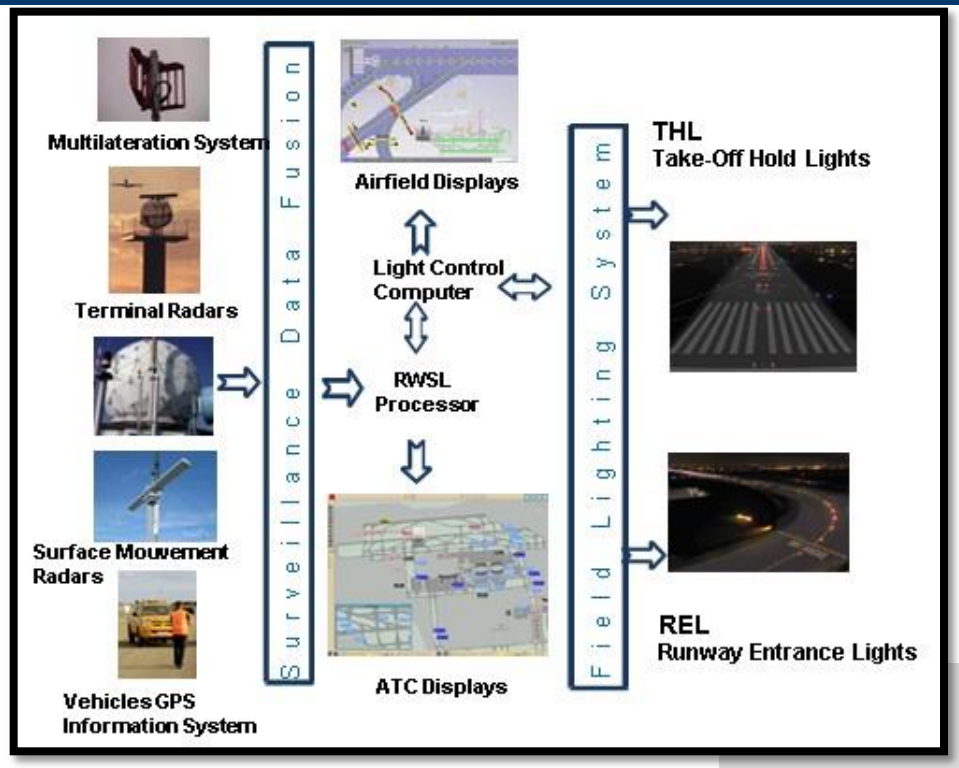
Runway Status Lights



Comprehensive V3 validation exercise scheduled at Paris-CDG airport by DSNA and SEAC/Aéroports de Paris, using a step-by-step approach

Step1
- CDG Test room
- Operational tuning

Step2
- CDG Central Tower
- Test/Operational network
- Shadow mode

Step3
- Northern Tower
- Closed RWY
- Dedicated vehicles/test aircraft

Step4
- Northern Tower
- Live operations
- Dedicated slots

Safety Support Tools for Vehicle Drivers

- Detection of risk of collision with aircraft on taxiways and runways
  - Moving map view of the traffic + alerts
- First evaluations in simulations
  - Stockholm-Arlanda Airport operational environment

Moving map (simulation)
NORACON

- Two live trials scheduled in 2015:
  - Paris-CDG
  - Dublin

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Airport Safety Support Tools - Conclusion

- SESAR project on Airport Safety support tool adresses:
  - Tower Controllers
  - Vehicle drivers
  - Pilots
- Operational interoperability of all Safety support Tools
- Integration of industrial prototypes
- Several additional validation exercises planned until May-2016
- Will feed standardisation groups
- One safety net candidate for deployment

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Airport Safety Support Tools - Partners in all projects

- Airport operators
- ANSPs
- Industry
- Institutions
- And: staff associations, airspace users

Coordinator

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Thanks for your attention

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