



RA Downlink Experiment

Methodological Issues

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Stakeholder "Open Day", Brétigny, 18 November 2005



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- Experimental Design Challenges
- RADE Validation Approach
- RADE-1 Aims & Key Findings
- RADE-2 Aims & Procedure



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Issues to be validated

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RA Downlink improves “local” Situation Awareness?

- No contradicting clearances;
- Traffic information;
- Post-conflict traffic planning.

RA Downlink does not deteriorate “global” Situation Awareness?

- Information overload;
- Distraction;
- Confusion;
- False alarms;
- Unclear pilot-controller responsibility.



"Swiss Cheese" Safety Metaphor

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Safety Hazards

Conflict Avoidance

Collision Avoidance

Potential for conflicting clearance

Responsibility Shifting

Training
Sectorization
Procedures
STCA
TCAS

DEFENSES

Mid-Air Collision

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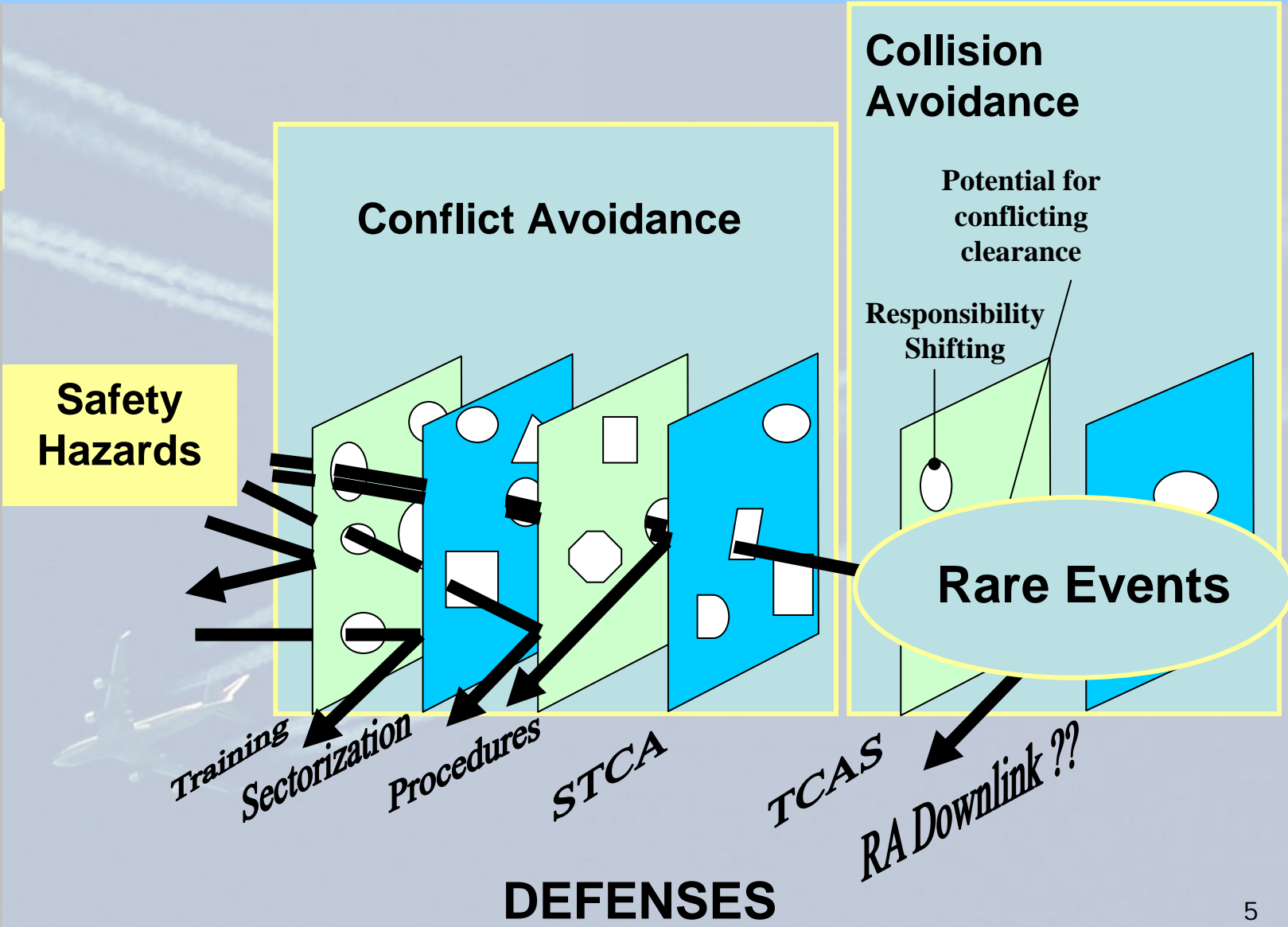
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"Swiss Cheese" Safety Metaphor

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RADE Validation Approach

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RADE Validation Approach

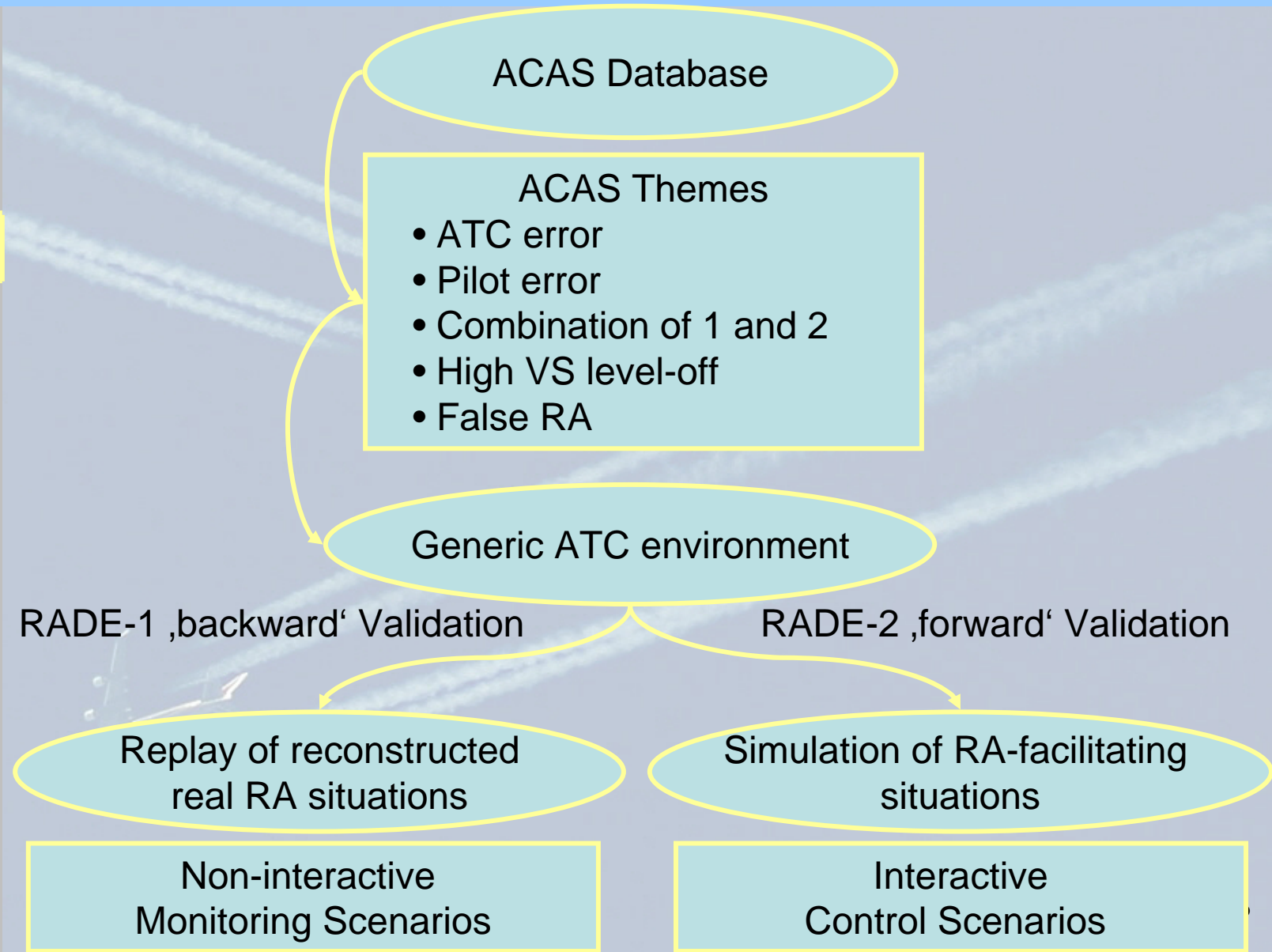
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RADE-1 * Methodology

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- Participants
 - 30 area controllers mixed in operational experience
- Set Up
 - Observation of 15 traffic scenarios
 - Based on real RAs
 - Supplemented with R/T and additional background traffic

* Full report available at:
<http://www.eurocontrol.int/ra-downlink/rade-1.html>



RADE-1 – Aims

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- Gather controller feedback about operational usefulness of RA downlink, through questionnaires and interviews.
- Explore interface options
- Assess and measure controller reaction to RA display





HMI Solutions

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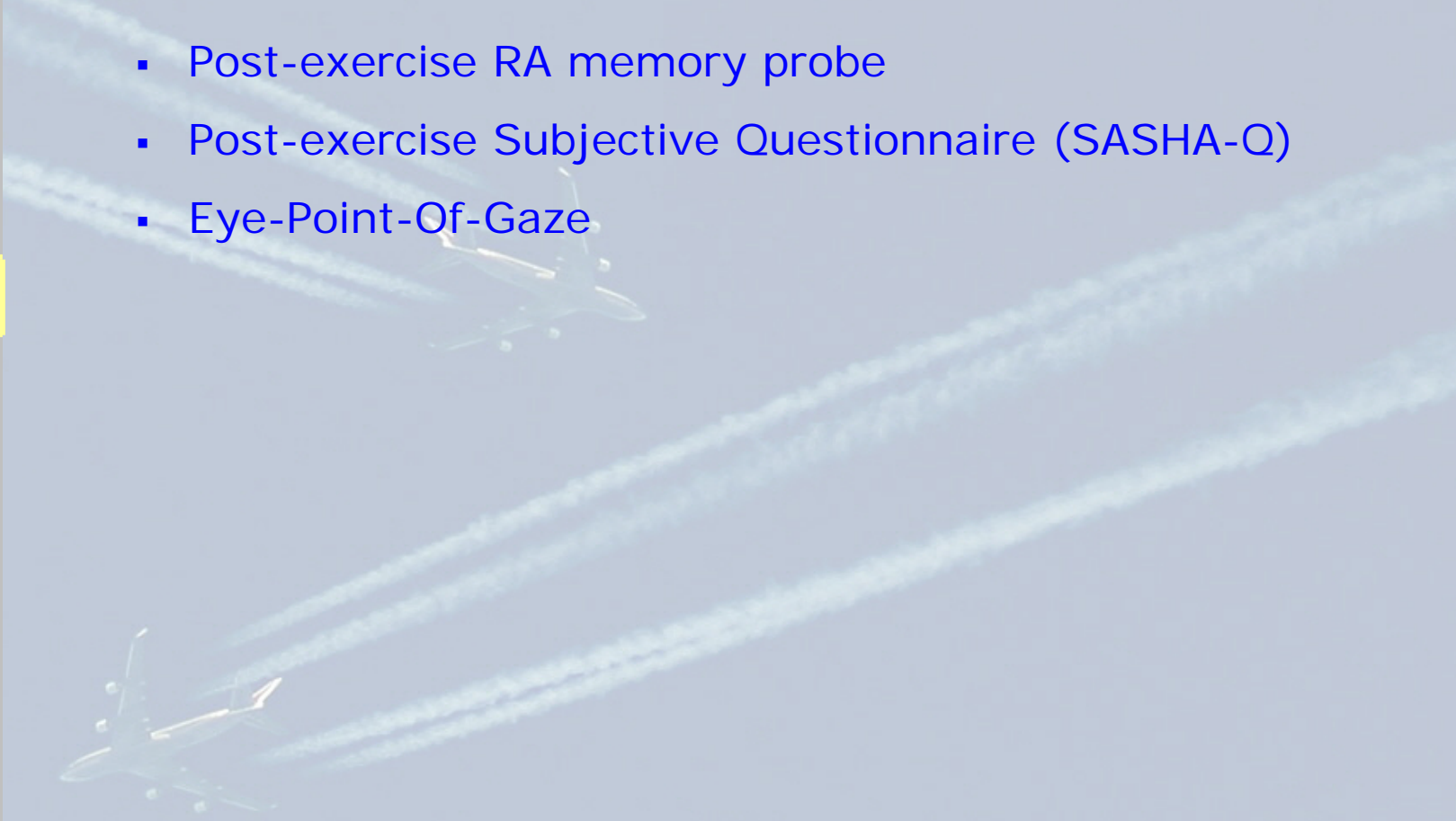
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- Options investigated
 - Visual Alert but no indication of RA sense
 - ➔ ▪ Visual Alert plus indication of exact RA sense
 - Visual/Auditory/Haptic Alert plus indication of exact RA sense
- Derived HMI Design Guiding Principles
 - RA information on the screen should not pose too high demands on the controller's attentional resources.
 - The controller needs to be immediately aware of whether an RA yields a deviation from the cleared flight path or not.



Situation Awareness

- Measurements
 - Post-exercise RA memory probe
 - Post-exercise Subjective Questionnaire (SASHA-Q)
 - Eye-Point-Of-Gaze



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Results:

Post-Exercise Memory Probe

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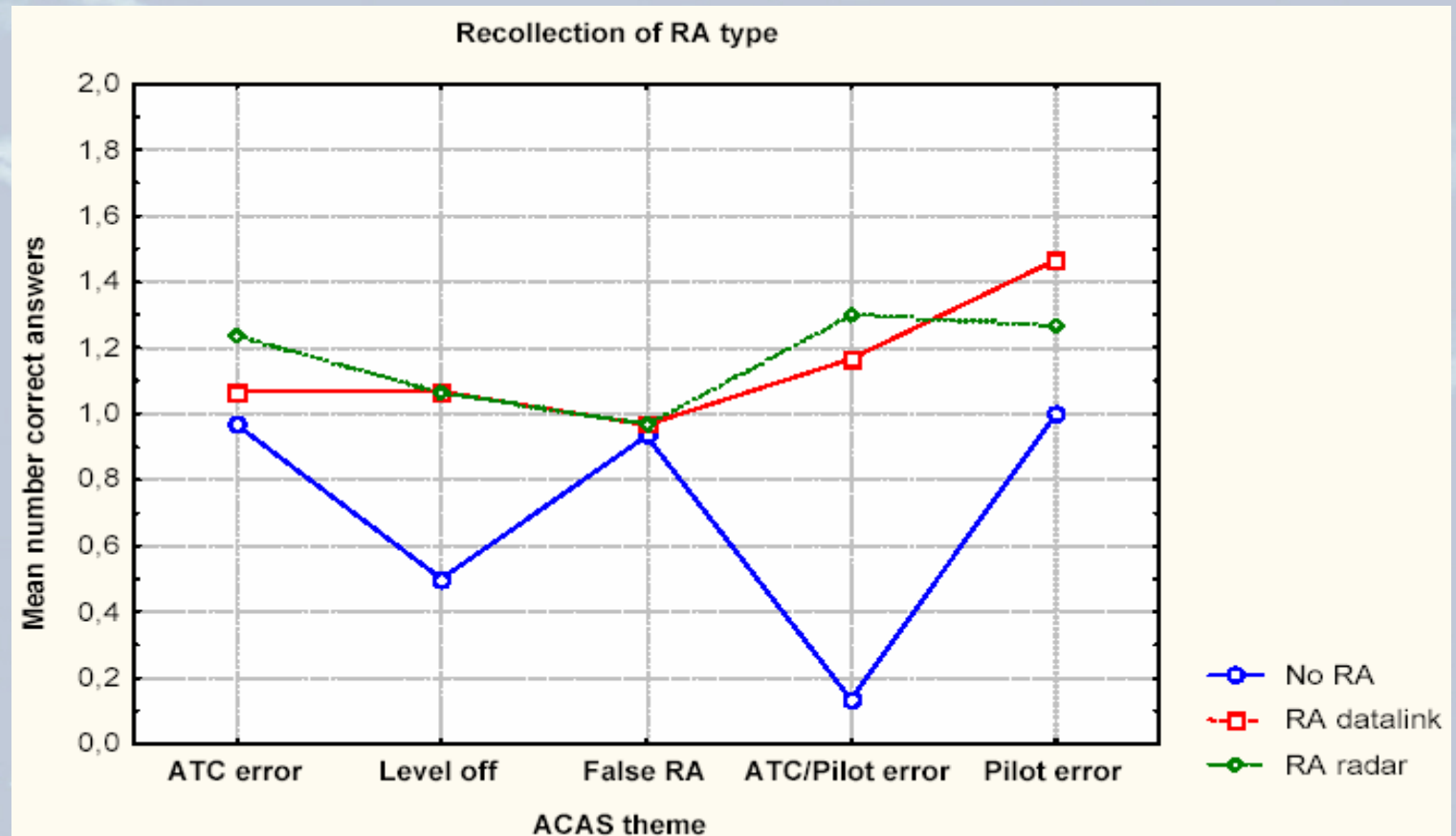
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Results (cont'd)

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- Subjective Situational Awareness rating collected after each scenario did not reveal any significant positive or negative effects of RA downlink.
- Eye tracking measurements did not point to unusual 'attention capture' to RA downlink icon at the expense of other traffic display information.





Results (cont'd)

Controller acceptance:

- The majority of participants saw clear operational benefits in the provision of RA information to the controller.
- If RA downlink is faster and more reliable than a pilot report, it can support controller's anticipation of aircraft manoeuvres.
- RA downlink may decrease the likelihood of contradictory ATC clearances.



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In order to realise benefits of RA downlink, two requirements need to be met:

- RA information on the screen should not pose too high demands on the controller's attention. In particular, the controller needs to be immediately aware of whether an RA yields a deviation from the cleared flight path or not.
- Operational procedures for the use of RA information need to be defined.





Conclusion

Results of RADE-1 were promising to proceed with the RADE-2 “forward” validation approach.

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RADE-2 Aims

- Evaluation of an RA Downlink Operational Concept.
- Obtain empirical data on controller reaction (performance, acceptance) in a realistic interactive simulation scenario setting involving an RA encounter.



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Experimental Variables

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- RA Downlink
 - Present
 - Absent
- Pilot report
 - Correct and timely
 - Delayed (RA report after the COC).
- Controller Position
 - Executive
 - Planner
- Manipulated in a $2 * 2 * 2$ experimental design resulting in a total of 8 simulation runs.
- The participants are not informed in advance which pilot report condition will be used.
- Experimental run order is different for each group.



RA Generation

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- The aim is to generate or facilitate RAs in a realistic and non-intrusive way.

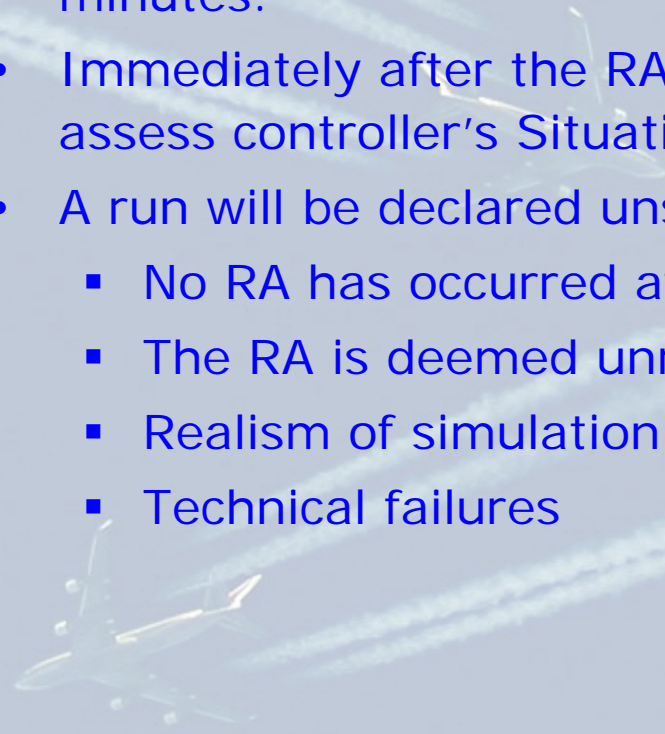
This is achieved by:

- Predicting controller's actions.
- Identifying traffic situations that may allow generation of an RA.
- Adjusting workload.
- Introducing errors.
- Varying aircraft behaviour.
- Sector characteristics.
- Similar call signs.
- Repeated attempts on the same aircraft or using the same method are avoided (as controllers find this annoying).



Successful Run Criteria

- Experimental run is deemed successful if an operationally realistic RA occurs.
- Once the RA occurs the scenario is terminated after 2-3 minutes.
- Immediately after the RA, probing questions are asked to assess controller's Situational Awareness.
- A run will be declared unsuccessful if:
 - No RA has occurred after 50 min.
 - The RA is deemed unrealistic
 - Realism of simulation has been lost for whatever reason
 - Technical failures



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Controller Error

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- Incorrect clearance or instruction.
- Undetected incorrect read-back.

Facilitating Methods for the SME:

- Increase workload by requesting a change of flight level or by requesting direct routing as often as realistic.
- Incorrect read-back.
- Read-back from the other airplane (using callsign similarity).





Pilot Error

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- Level bust.
- Turn instead of level change or vice versa (e.g. heading 310 instead of level 310).
- Any other non-compliance with ATC instructions/clearances.

Facilitating Methods for the SME:

- Pilot disobeys the clearance.
- Pilot selects a path along a wrong route.
- Slow pilot response





High Vertical Rate Level-off

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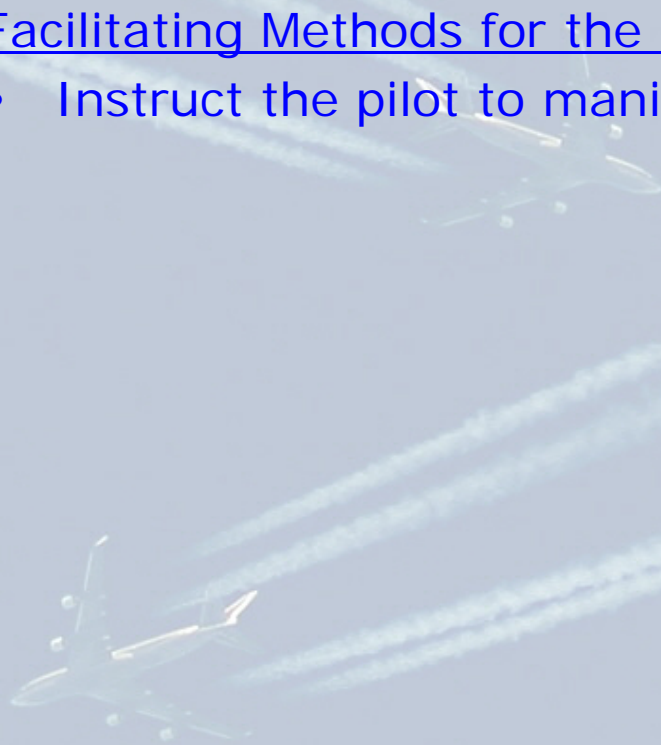
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- RA caused by high vertical speed prior to level-off 1000 feet apart from other aircraft.

Facilitating Methods for the SME:

- Instruct the pilot to manipulate the vertical rate.





Imminent Conflict

When a situation that potentially may result in an RA:

- Pilots may delay response to any calls from the controller.
- Pilots may distract the controller attention by making a call from an aircraft not involved in the potential conflict.
- SME Coordinator will create heavy coordination workload on the planning controller.



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RA Generation Guideline

- Controllers are exposed to the situations in which, despite their best efforts, conflict and RAs will occur.
- Controller confidence might be shaken.
 - Controllers must not be placed in the position when they have to justify themselves.
 - We never judge controller performance.



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Measurements

Situation Awareness

- Post-exercise RA memory probe
- Post-exercise Subjective Questionnaire (SASHA-Q)
- Situation Awareness online probe
- Post-exercise debriefing
 - replay with/without RA downlink display
 - think-aloud protocol



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Other Measurements

- Workload
 - NASA-TLX subjective workload rating
 - Late transfers (embedded secondary task workload index)
- Controller Acceptance
 - Simulation realism (post-exercise debriefing)
 - Operational Concept (post-experiment debriefing, final debriefing)
 - Replay with/without RA downlink display
 - Think-aloud protocol
- Simulation recordings

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Objective Measurements

- The number of instances:
 - when a controller issued an instruction to an aircraft with an RA.
 - when a controller gave traffic information to involved aircraft (i.e. aircraft with RA and third-party aircraft), as well as the quality of this traffic information.
 - of follow-up conflicts involving third-party aircraft and RA aircraft after RA manoeuvres.
- Number and severity of conflicts (in terms of spacing) that triggered RA events.
- Controllers' response times to pilot requests following an RA (unrelated to the RA situation).
- Average latency of RA display on CWP.

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Simulation Realism (preliminary)

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| | Group 1 | Group 2 | Group 3 |
|-----------------------------------|---------|---------|---------|
| Traffic situation shown realistic | 3.9 | 4.1 | 4.5 |
| RA event realistic | 4.1 | 3.8 | 4.1 |
| Pilot response to RA realistic | 5 | 4.4 | 4.9 |

Scale: 1 (not at all) to 5 (absolutely)



www.eurocontrol.int/ra-downlink

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