RA Downlink Experiment

Methodological Issues

Dr. Bernd Lorenz
DLR

Stakeholder “Open Day”, Brétigny, 18 November 2005

Contents of the Presentation

- Issues to be validated
- Experimental Design Challenges
- RADE Validation Approach
- RADE-1 Aims & Key Findings
- RADE-2 Aims & Procedure

Issues to be Validated

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

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

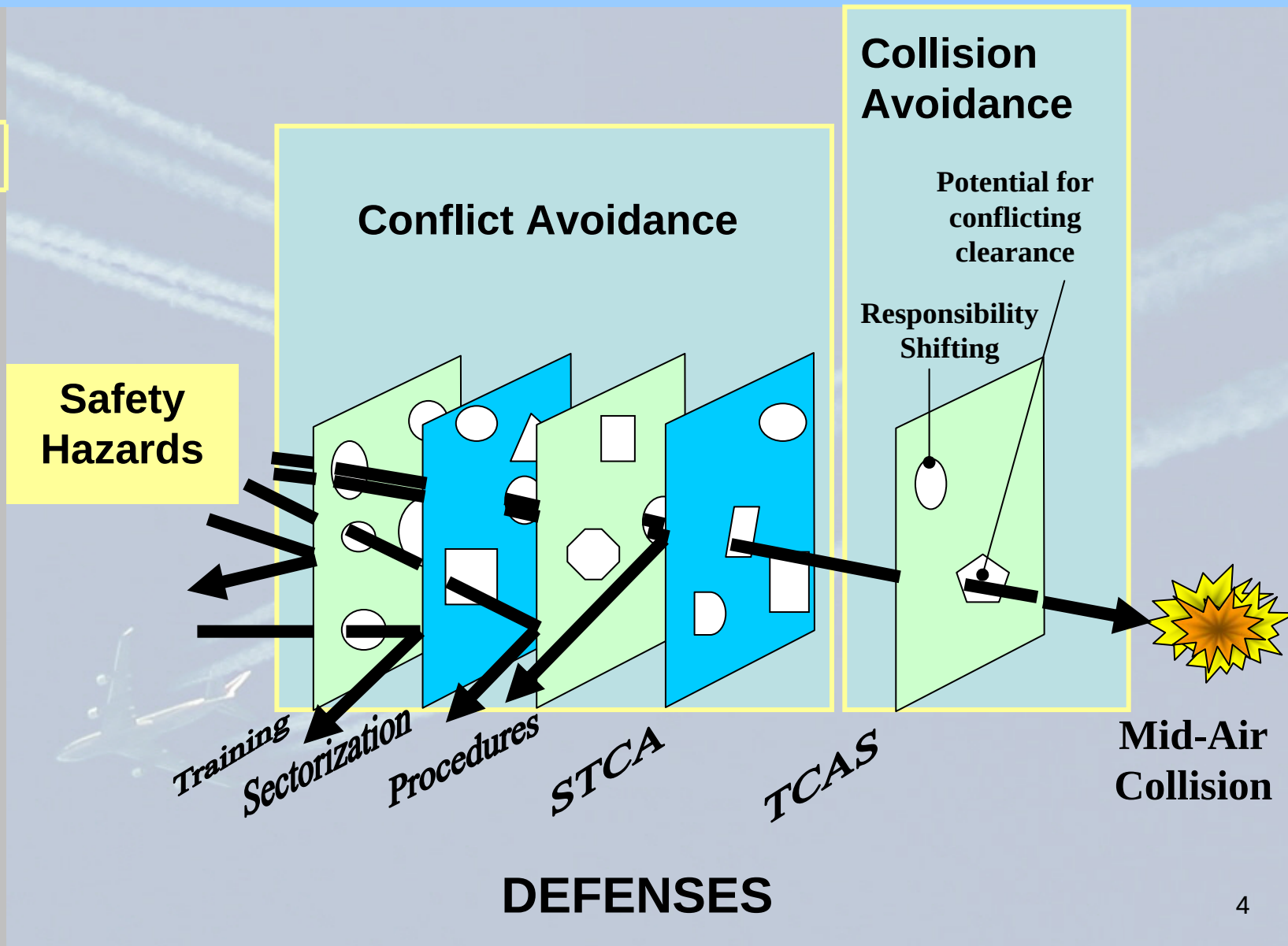
Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure



“Swiss Cheese” Safety Metaphor

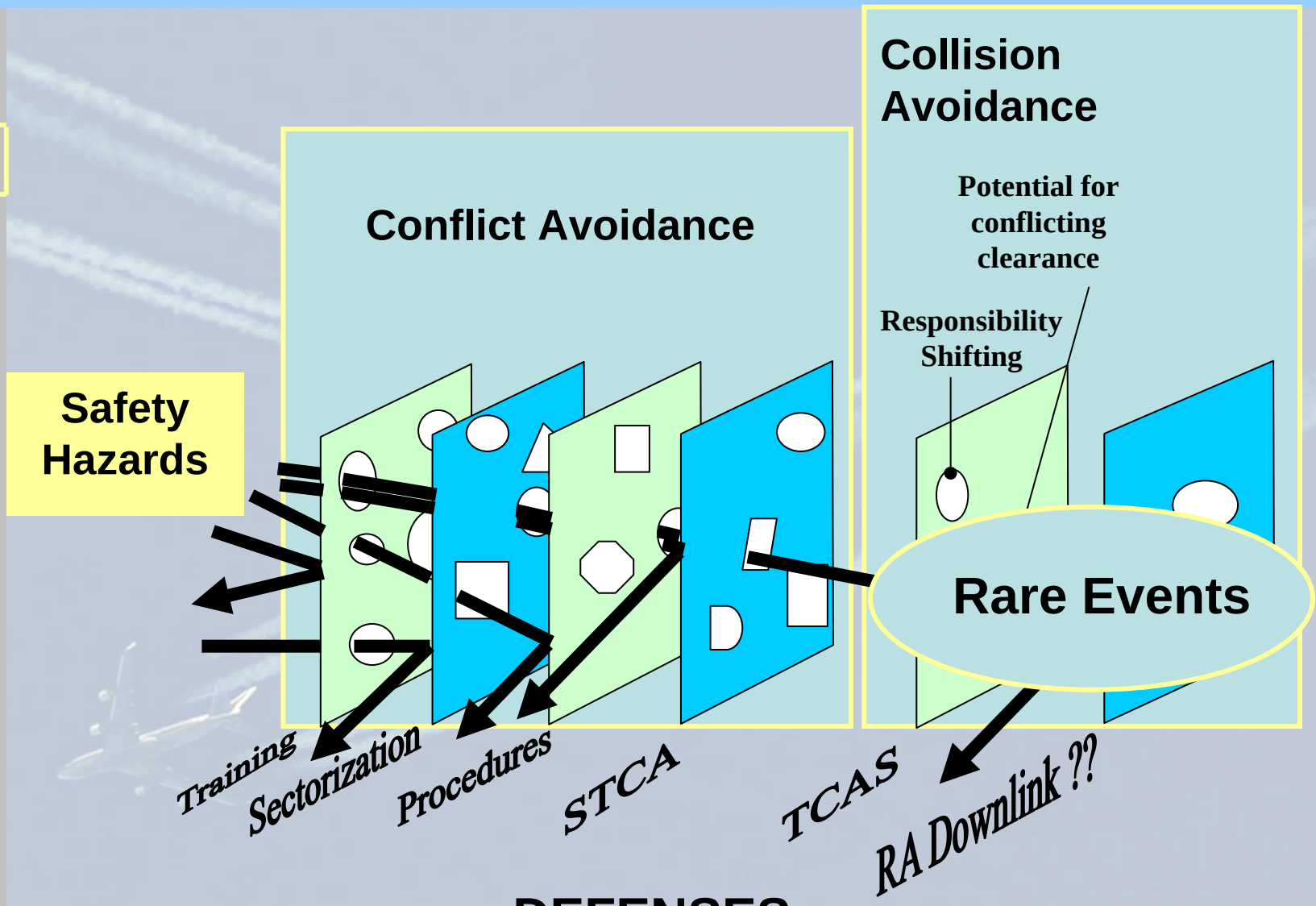
Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure



RADE Validation Approach

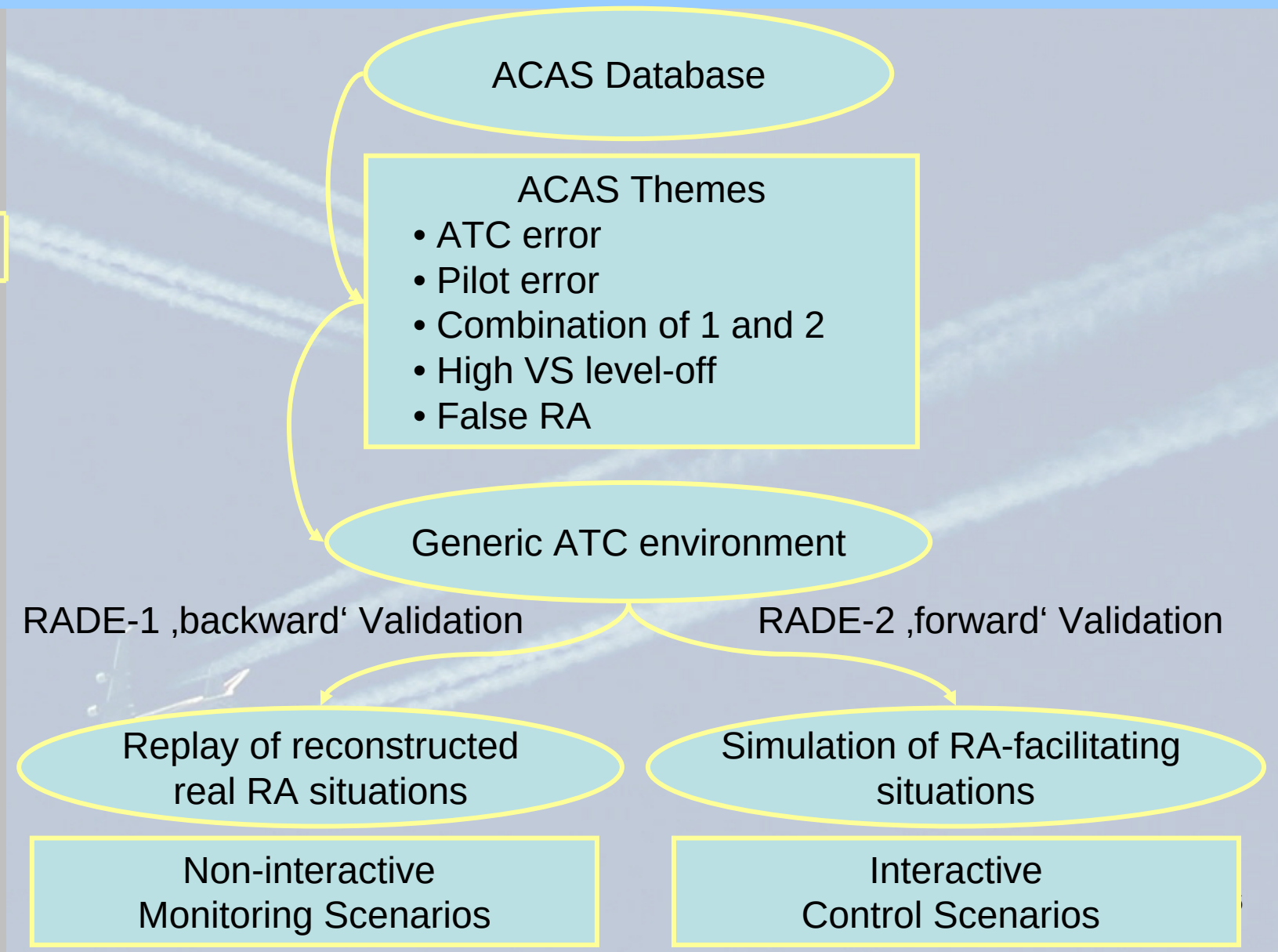
Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure



RADE-1* Methodology

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

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

Results:

Post-Exercise Memory Probe

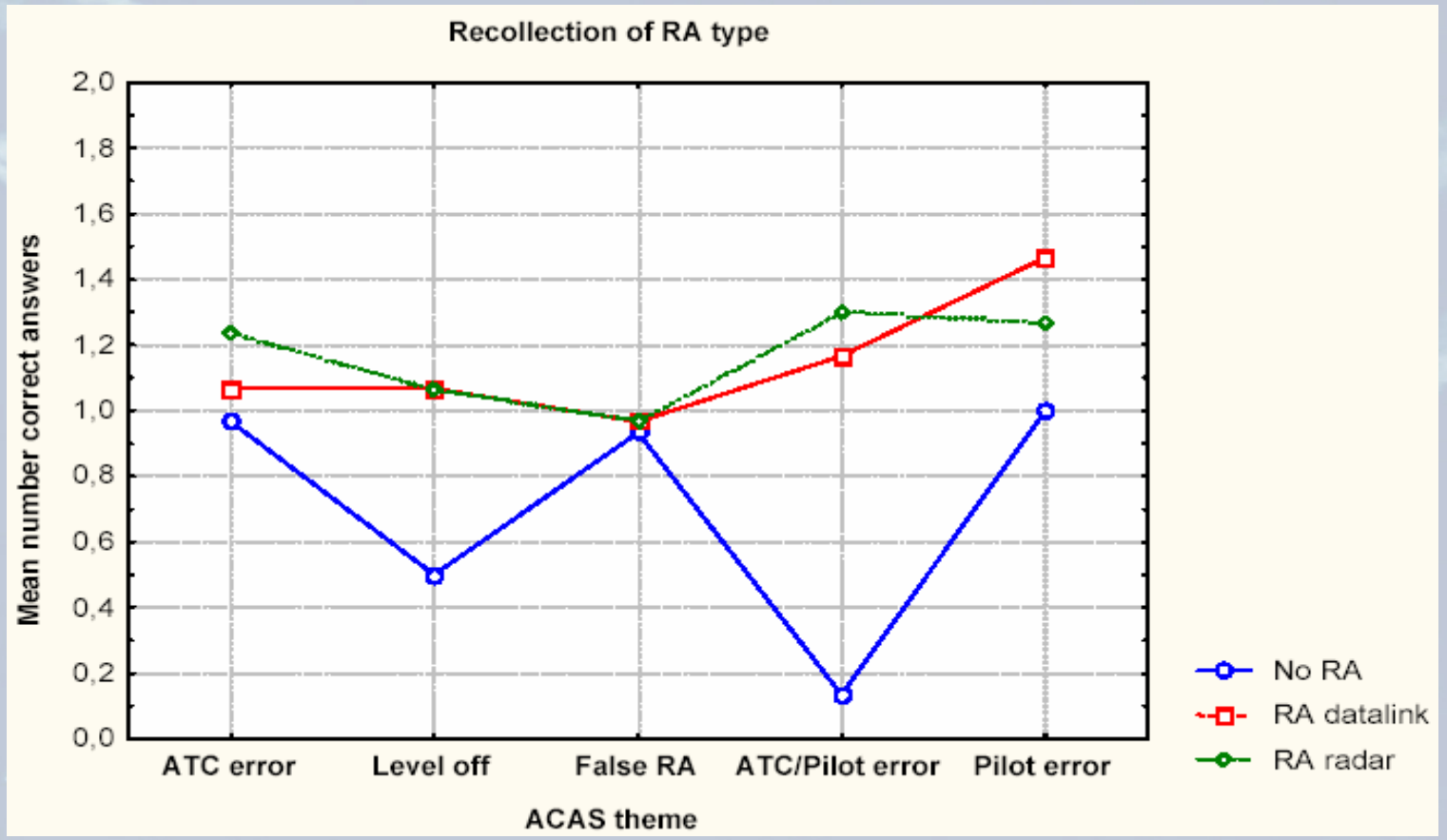
Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure



Results (cont'd)

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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)

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

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.

Results (cont'd)

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

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

RADE-2 Aims

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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.

Experimental Variables

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Controller Error

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

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.

RA Generation Guideline

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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.

Measurements

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

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

Other Measurements

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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

Objective Measurements

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

- 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.

Simulation Realism (preliminary)

Issues to be validated

Experimental Design Challenges

RADE Validation Approach

RADE-1 Aims & Key Findings

RADE-2 Aims & Procedure

	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

Email: ra-downlink@eurocontrol.int