Research challenges in air traffic management

INAIR 2015 Amsterdam

Colin Meckiff
Eurocontrol Experimental Centre
12th November 2015
Content

Research challenges in air traffic management

Challenge 1: Knowing what to research
Challenge 2: Performing meaningful experiments
Challenge 3: Red flags and implementation issues

Suggestions and final remarks
Content

Research challenges in air traffic management

Challenge 1: Knowing what to research
Challenge 2: Performing meaningful experiments
Challenge 3: Red flags and implementation issues

Suggestions and final remarks
Challenge 1: Knowing what to research

Source: ECAC/EUROCONTROL
Constraints to Growth study, March 2001
Challenge 1: Knowing what to research
Challenge 1: Knowing what to research

2015: UAS/RPAS?
2010: Eyjafjallajökull
Late-00s: Downturn
Mid-00s: Environment
2002: Überlingen, safety
2001: 9/11, security
Demand forecasts: capacity and delays
Content

Research challenges in air traffic management

Challenge 1: Knowing what to research
Challenge 2: Performing meaningful experiments
Challenge 3: Red flags and implementation issues

Suggestions and final remarks
Challenge 2: Performing meaningful experiments

It’s difficult to predict the effect of changes in ATM technology and/or procedures using robust scientific method for many reasons:

- Difficult to establish a **control** (baseline or reference) scenario
- Difficult to establish **significance** and/or replicate results
- Difficult to ‘**orthogonalise**’ experiments and outcomes
- Outcome bias due to **expectation**
- Impossible to understand **implications** for the overall ATM system

These are presented as challenges, not criticisms!
Challenge 2: Performing meaningful experiments

**Difficult to establish a control (baseline or reference) scenario**

- An essential and fundamental step in experimental design

- Control scenario should be designed so that during the experiment the only things that change are the input (independent) variables
  - The control has to be set in the same environment as the one used for the experiment
  - Can’t be the ‘real world’ if experiments are then done on a simulator
  - ... but you can’t insert half-baked changes into a live operational system

- Experimental platforms present an environment that may be inaccurate in almost every aspect compared with the real-world
  - E.g. traffic patterns, aircraft performance, pilot responses …
  - ... look and feel, ambiance in the ops room, attitude of subjects

- It is reported that in SESAR only 10% of experiments used an appropriate reference scenario
Challenge 2: Performing meaningful experiments

Difficult to establish significance and/or replicate results

- Another fundamental requirement of experimental design
- A particular difficulty with human-in-the-loop experiments
  - Maybe not so much for model-based
  - ... but “all models are wrong, some may be useful”
- Repetition also increases the likelihood of detecting non-nominal outcomes
- In any case each local context (sector, airport ...) is different - an experiment may only be relevant for a very small part of the system
- It is reported that in SESAR only 25% of experiments performed a sufficient number of repetitions to demonstrate significance
Challenge 2: Performing meaningful experiments

Difficult to ‘orthogonalise’ the experiments and outcomes

- That is, to establish clear causality for a particular outcome
  - For reasons mentioned above but also because key independent ‘variable’ cannot be isolated

- E.g. experiments designed to test a new controller tool may imply
  - A graphical interface that is substantially changed
  - New procedures with implications beyond the focus of the experiment
  - Specific traffic patterns engineered to exercise the new functions
  - … etc.
Challenge 2: Performing meaningful experiments

Outcome bias due to expectation

- Funding is conditional on expectation of positive outcomes
  - Level of funding $\propto$ expected chance of success

- Higher funding increases pressure for positive results

- Well illustrated by the 2012 European ATM Master Plan that is built on the explicit notion of ‘validation targets’
  
  “SESAR contributes to meeting these … performance objectives and drives R&D activities towards the achievement of a set of validation targets”

- New (2015) version of MP uses the expression ‘performance ambitions’!
Challenge 2: Performing meaningful experiments

Impossible to understand implications for the overall ATM system
Content

Research challenges in air traffic management

Challenge 1: Knowing what to research
Challenge 2: Performing meaningful experiments
Challenge 3: Red flags and implementation issues

Suggestions and final remarks
Challenge 3: Red flags and implementation issues

New technologies need to pass a set of ‘transversal’ checks
Ideally these are incorporated early in the process - in practice this is rare!

Have you demonstrated that it doesn’t make the system less safe?

Have you considered changes in human roles, responsibilities, training …?

Does it have an impact on noise, pollution, …?

Are new data and comms. secure? What are the threats?
Challenge 3: Red flags and implementation issues

Further key considerations that contribute to the business case:

- Are changes agreed by staff associations? At what price?
- Does new automation shift liability in case of an accident?
- How will the change be introduced (transition)? How long will it take?
- Is there a positive business case showing clear short- and long-term benefits for all key stakeholders?
Research challenges in air traffic management

Challenge 1: Knowing what to research
Challenge 2: Performing meaningful experiments
Challenge 3: Red flags and implementation issues

Suggestions and final remarks
Suggestions and final remarks

- Audit the research portfolio regularly and independently
  - With assurances that conclusions will be acted upon
  - Honestly identify, as early as possible technology that clearly won’t work
    - transition to SESAR2020 has provided this opportunity to some extent
    - … but not really independent!

- Ensure that the experimental (validation) process is independent from programme management and policy-making
  - Otherwise we just store up problems for later

- Incorporate transversal (/business case) considerations early in project planning

- Perform new research in the following areas applied to ATM:
  - Experimental design
  - Complexity science
  - Incentive for change, institutional and regulatory improvements
Some free publicity!

SESAR Innovation Days: 1-3 December 2015, Bologna, Italy
Still time to register
www.sesarinnovationdays.eu

ICRAT 2016: 20-24 June 2016, Philadelphia, USA
Call for papers open
www.icrat.org