Research challenges in air traffic management

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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

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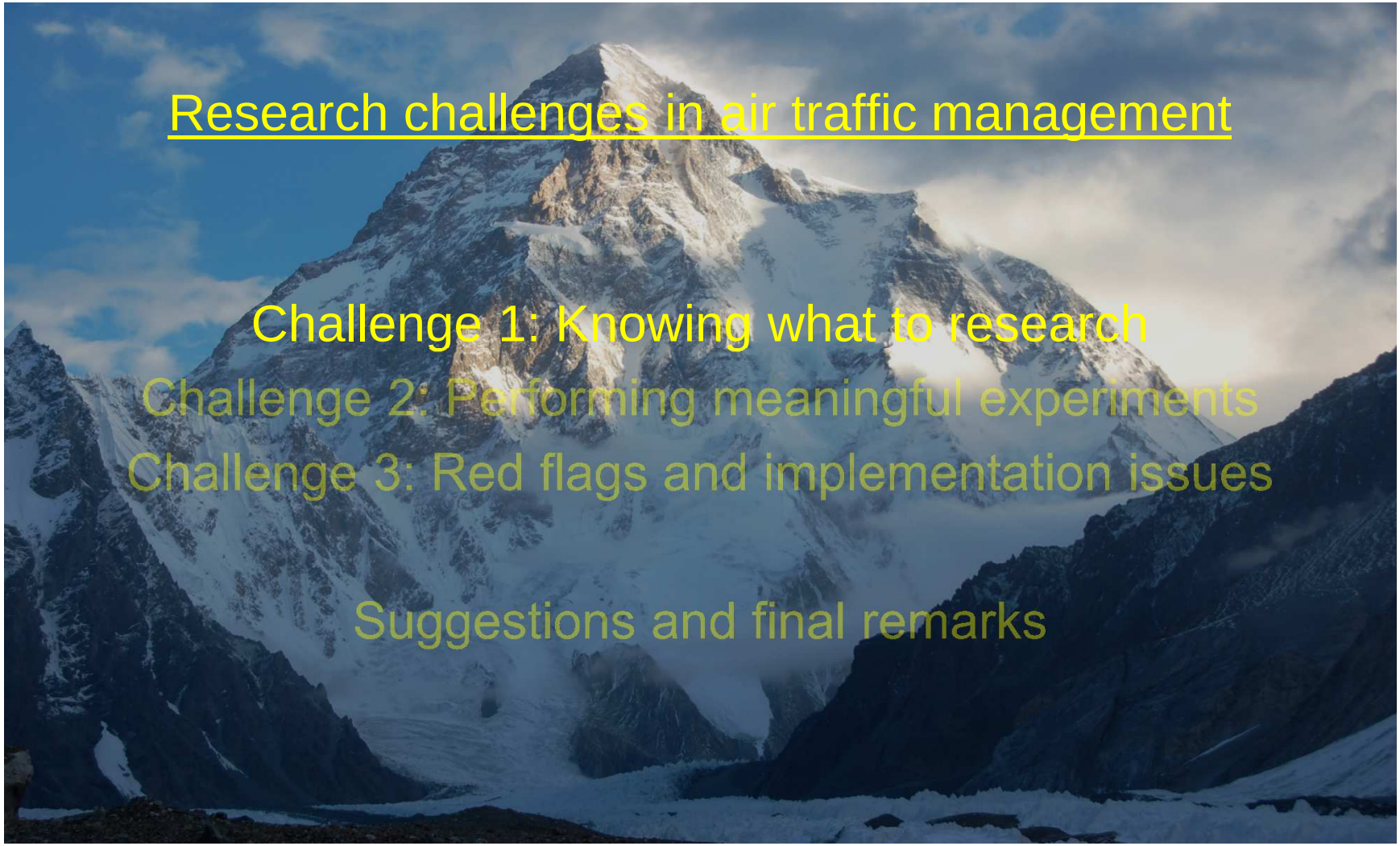
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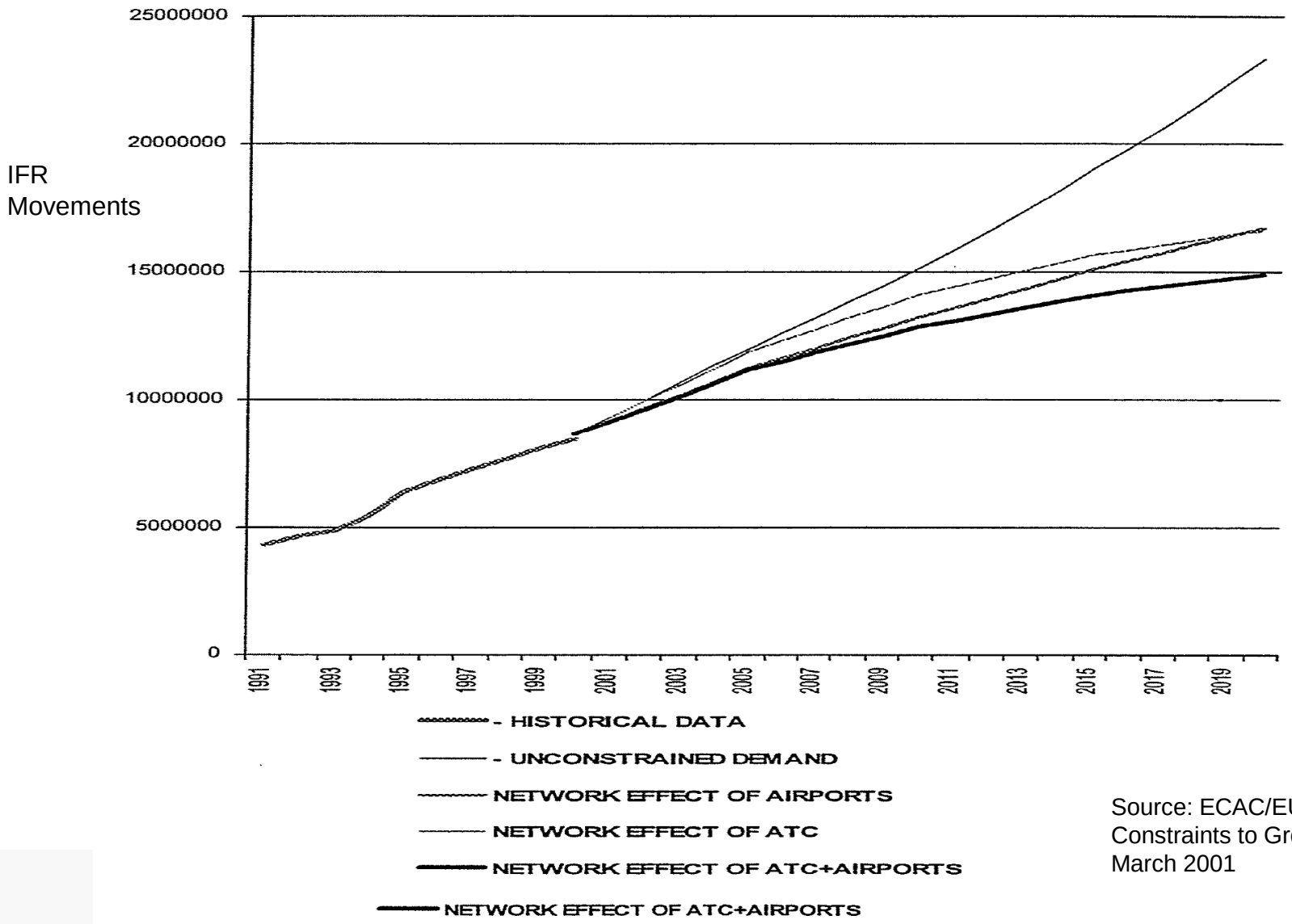
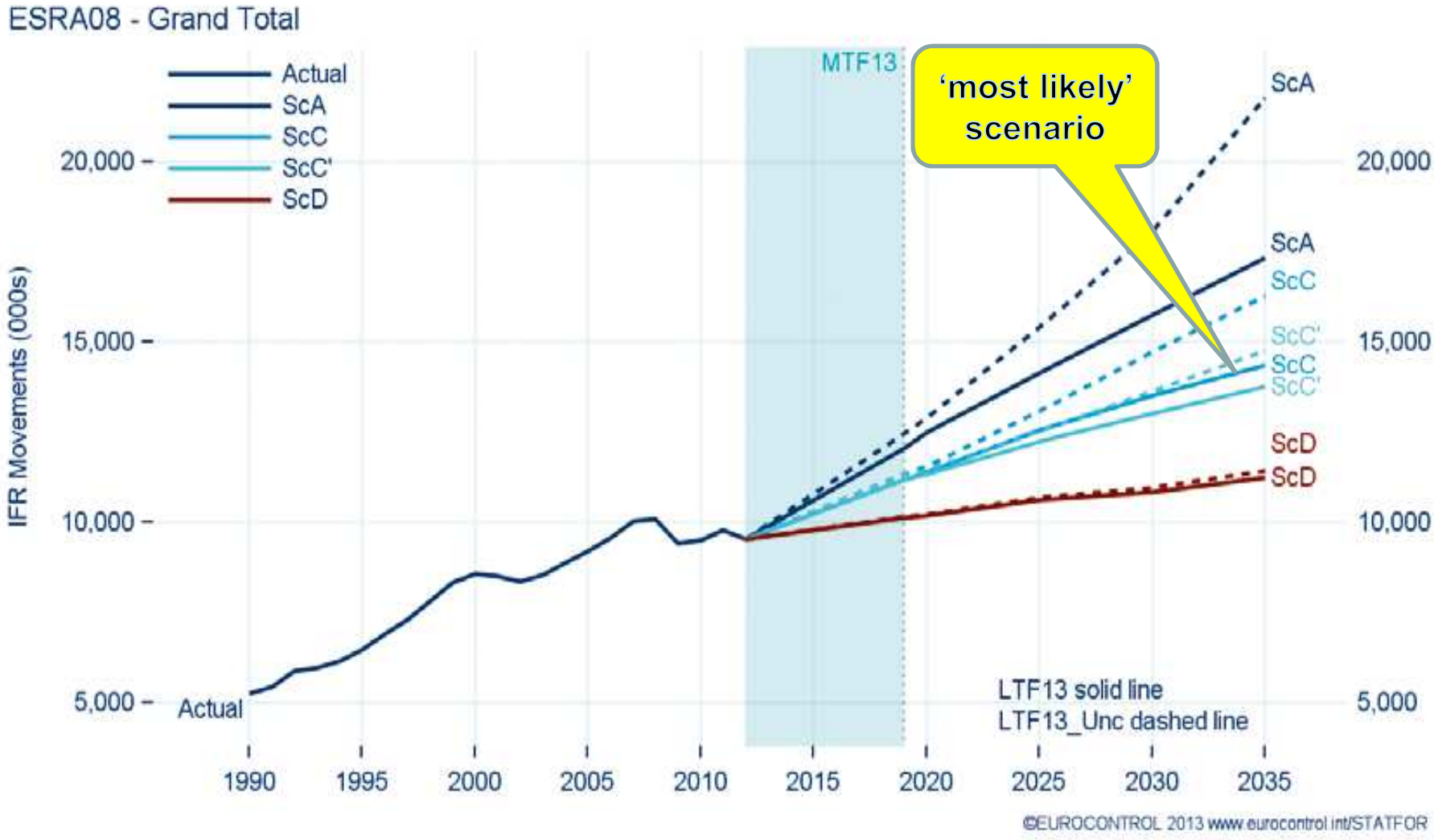
Challenge 1: Knowing what to research

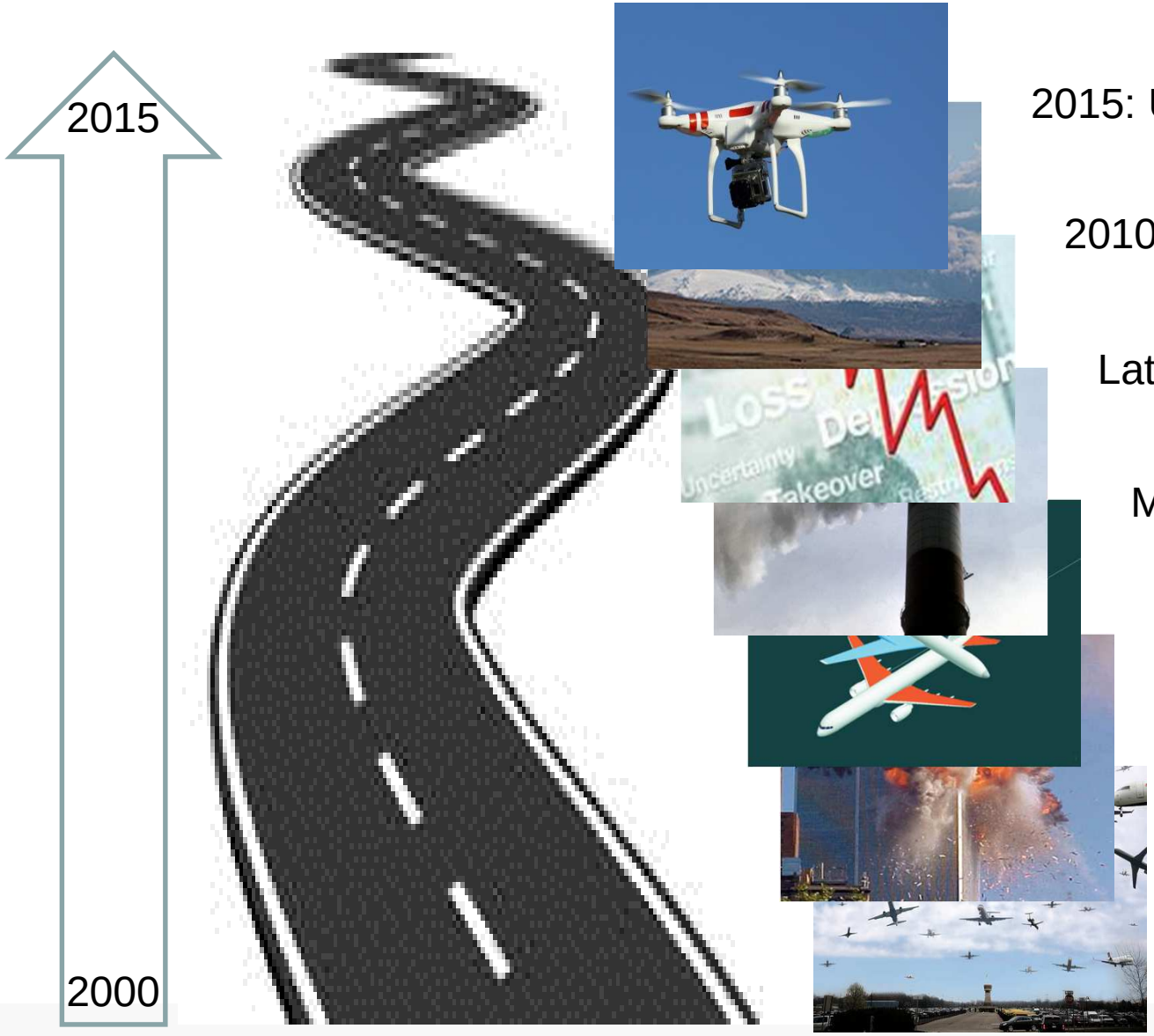


Source: ECAC/EUROCONTROL Constraints to Growth study, March 2001

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

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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

<u>Difficult to establish a control (baseline or reference) scenario</u>

- 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

EUROCONTROL

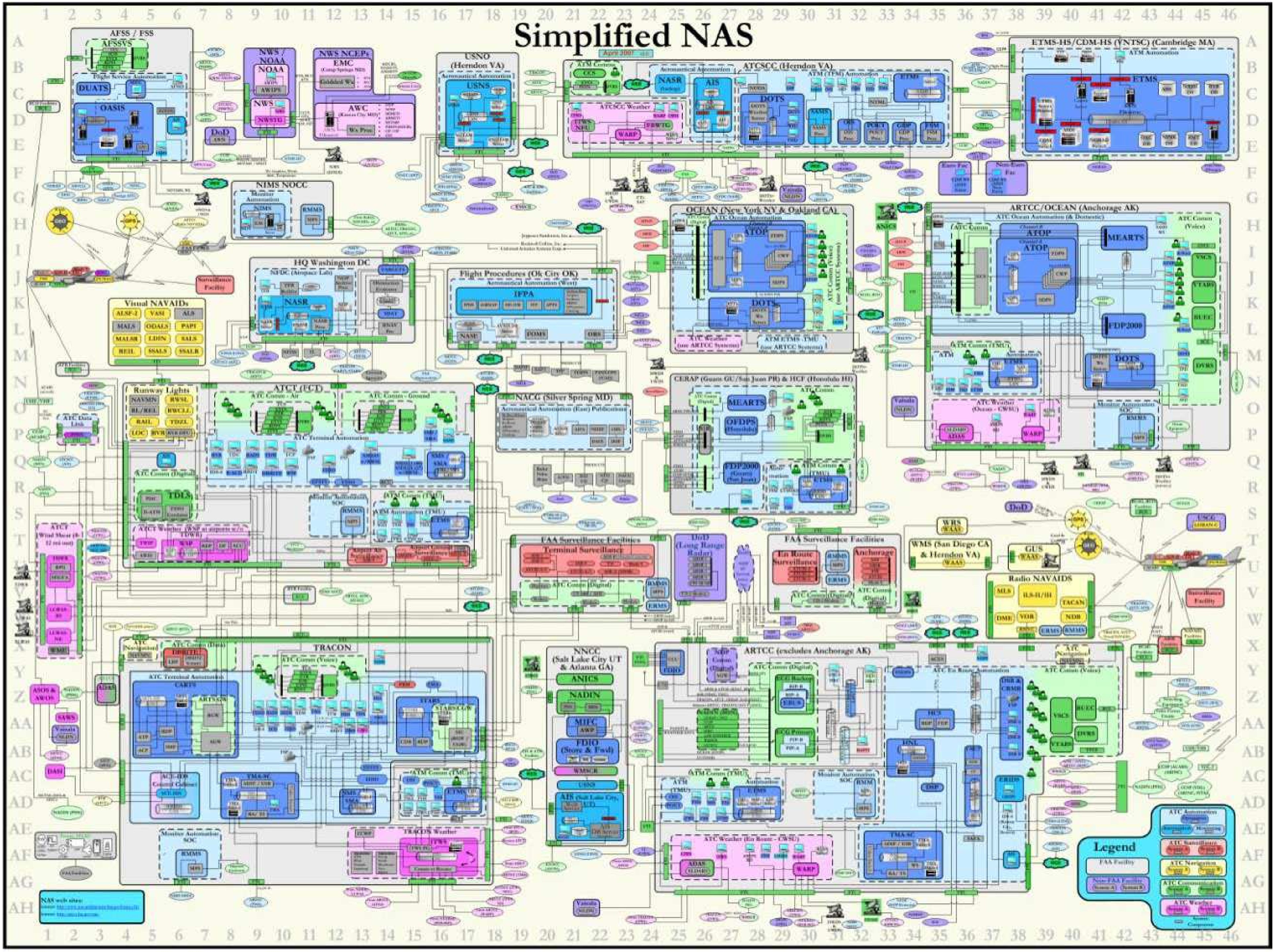
Outcome bias due to expectation

- Funding is conditional on expectation of positive outcomes
  - Level of funding ∝ 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


Simplified NAS
AFSS / FSS
NWS / NOAA
NWS NCEPs
USNO (Herndon VA)
ATCSCC (Herndon VA)
ETMS-HS/CDM-HS (VNTSC) (Cambridge MA)
NIMS NOCC
HQ Washington DC
Flight Procedures (Ok City OK)
OCEAN (New York NY & Oakland CA)
ARTCC/OCEAN (Anchorage AK)
Visual NAVAIDs
Runway Lights
ATCT (FCT)
NACG (Silver Spring MD)
CERAP (Guam GU/San Juan PR) & HCF (Honolulu HI)
FAA Surveillance Facilities
WMS (San Diego CA & Herndon VA)
Radio NAVAIDS
TRACON
NNCC (Salt Lake City UT & Atlanta GA)
ARTCC (excludes Anchorage AK)
Legend

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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 <u>business case</u> showing clear short- and long-term benefits for all key stakeholders?

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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