HELIOS

Management and technology consultants

EUROCONTROL Top 5 Safety Priorities: Risk of operations without transponder

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an egis company

Before we begin …
what are the effects of a total loss of transponder?

Aircraft not visible to ATC (secondary) radars

Safety nets used by ATC rendered ineffective

No TCAS RAs

And can it happen?

[MH370]

- [Transponder disabled]

Europe

- Recent examples of commercial aircraft returning to major airports

United States

- A commercial aircraft flew undetected for several minutes after departure
  - Transponder not activated (as opposed to failed)
  - Flew in close horizontal proximity to three other aircraft

South America

- Mid-air collision between business jet and commercial

A complex subject that deserves closer scrutiny

EUROCONTROL

- Safety Improvement Sub-group identified it as one of its “Top 5” safety priorities in 2012
- Decision based on workshops and data from 6 ANSPs

Helios

- Almost 10 years working with EUROCONTROL Safety Nets team – asked to support
- Safety specialists worked with EUROCONTROL on this study:
  ‘Risk of operations without an operating transponder or a dysfunctional one’

Ben Stanley

- Director of Helios and safety lead
- Lead author of the study

This presentation will cover

2 EUROCONTROL Operational Safety Study

Different to the other “Top 5” safety priorities

Top 5 safety priorities

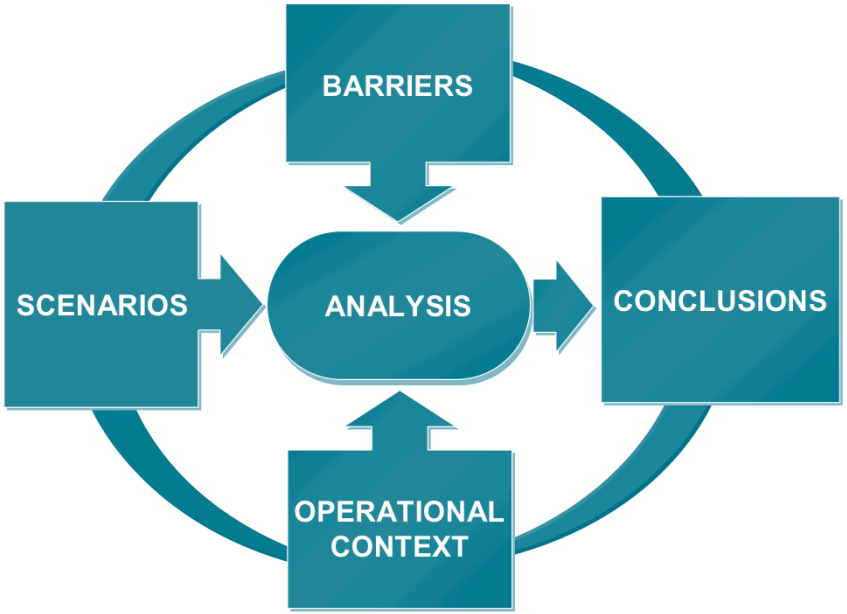
1. Risk of operation without transponder or with a dysfunctional one
2. Landing without ATC clearance
3. Detection of occupied runway
4. “Blind spot” – inefficient conflict detection with the closest aircraft
5. Conflict detection with adjacent sectors

Difference:

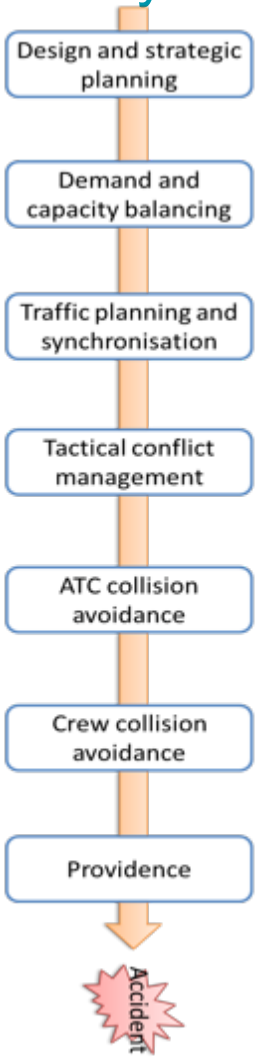
- Not so frequent – but can lead to high severity outcomes
- Technical causes (and preventative barriers) out of scope
- Focus on operational or technical mitigating barriers – the two are closely linked

Approach taken by the study

The generic ‘Top 5’ approach



Generic safety barrier model



Scenarios investigated

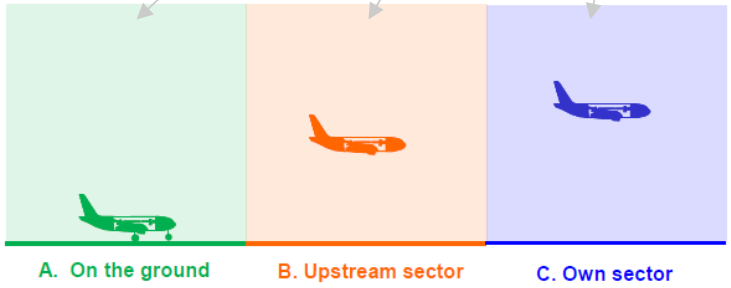
Numerous failure scenarios

	Loss			Intermittent			Corrupted			Duplicated			Incorrect		
Transponder	1A	1B	1C	5A	5B	5C									
Mode A	2A	2B	2C	6A	6B	6C	9A	9B	9C	12A	12B	12C	14A	14B	14C
Mode C	3A	3B	3C	7A	7B	7C	10A	10B	10C						
Mode S	4A	4B	4C	9A	9B	9C	11A	11B	11C	13A	13B	13C	15A	15B	15C

T1 C2 A3 S4

Specific modes investigated

- Total loss of transponder (T1)
- Corrupted Mode A code (A3)
- Intermittent Mode C (C2)
- Duplicated Mode S 24-bit address (S4)



3 Potential impacts

Total loss of transponder

Loss of track
- Controller cannot see transponder related information on working position
- Track lost if primary radar is not present
- Controller tools reliant on secondary surveillance do not operate or are unreliable

- Controller safety nets do not operate
- Controller unable to provide instructions for collision avoidance

- TCAS does not operate

Potential for an aircraft to “pass” through all the existing safety barriers up to “see and avoid”

Other failure modes

Impacts dependent on ATC system and local environment…

- System filtering parameters
- Alerting controllers to changes in track status
- Sector handover procedures

…and according to failure mode which can range from….

- No discernable impact, to
- Aircraft not visible to ATC/no TCAS RAs

Duplicated Mode S 24-bit address

- Significant (potential) impacts

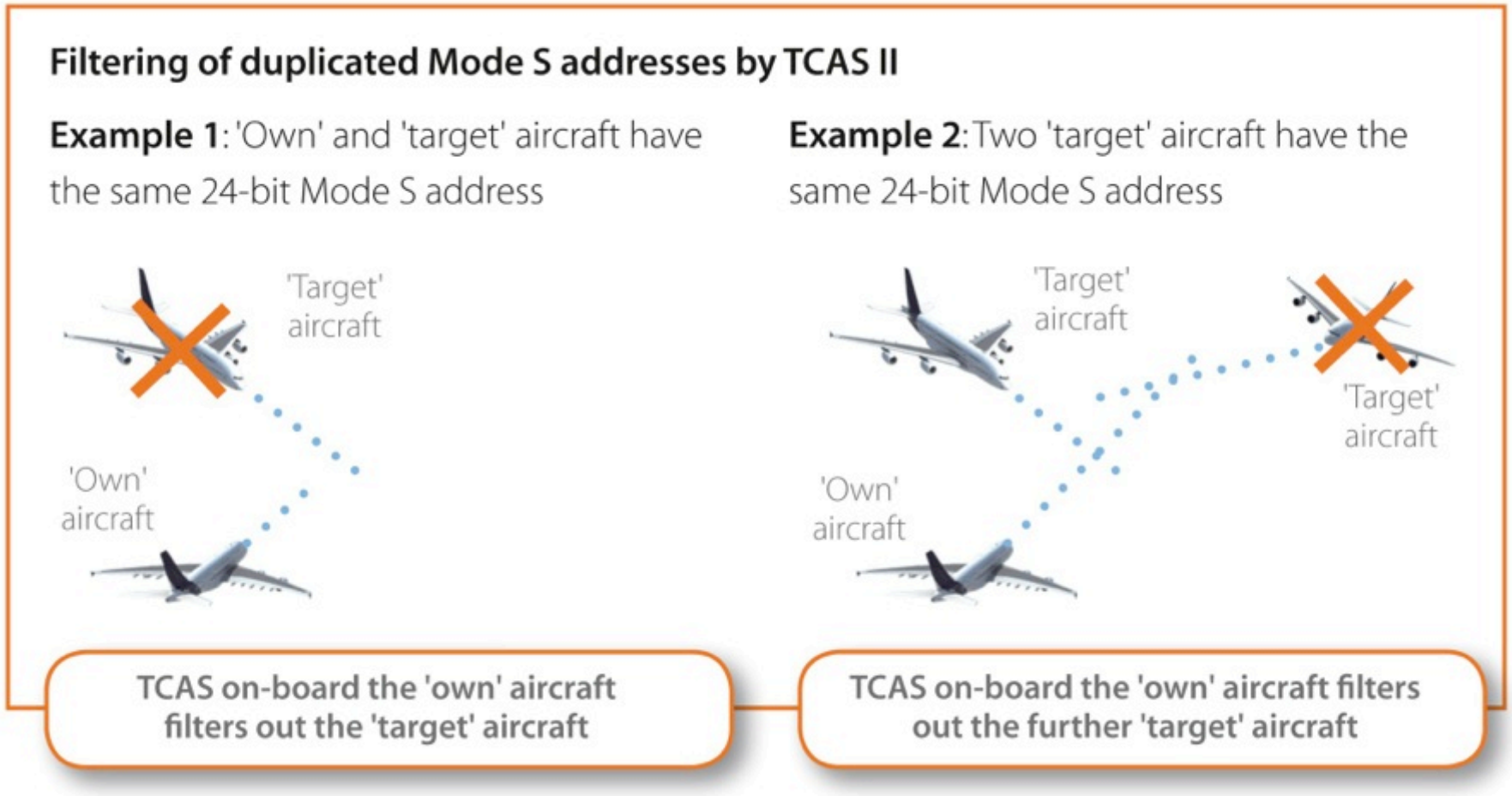
Duplicated Mode S 24-bit address - potential impact on ATC

Impact will depend on the local system / environment

- Displayed correctly
- Never initiated
- ‘Dropped’ by the system
- Swapped

An unlikely scenario – but it has happened

Duplicated Mode S 24-bit address - potential impact on TCAS



4 Mitigations

The effectiveness of mitigations was assessed against various scenarios

All were assumed to lead to loss of separation

Categorised by specific failure mode

operational (HMI) impact of that failure mode

…. and detection or otherwise by the ATCO

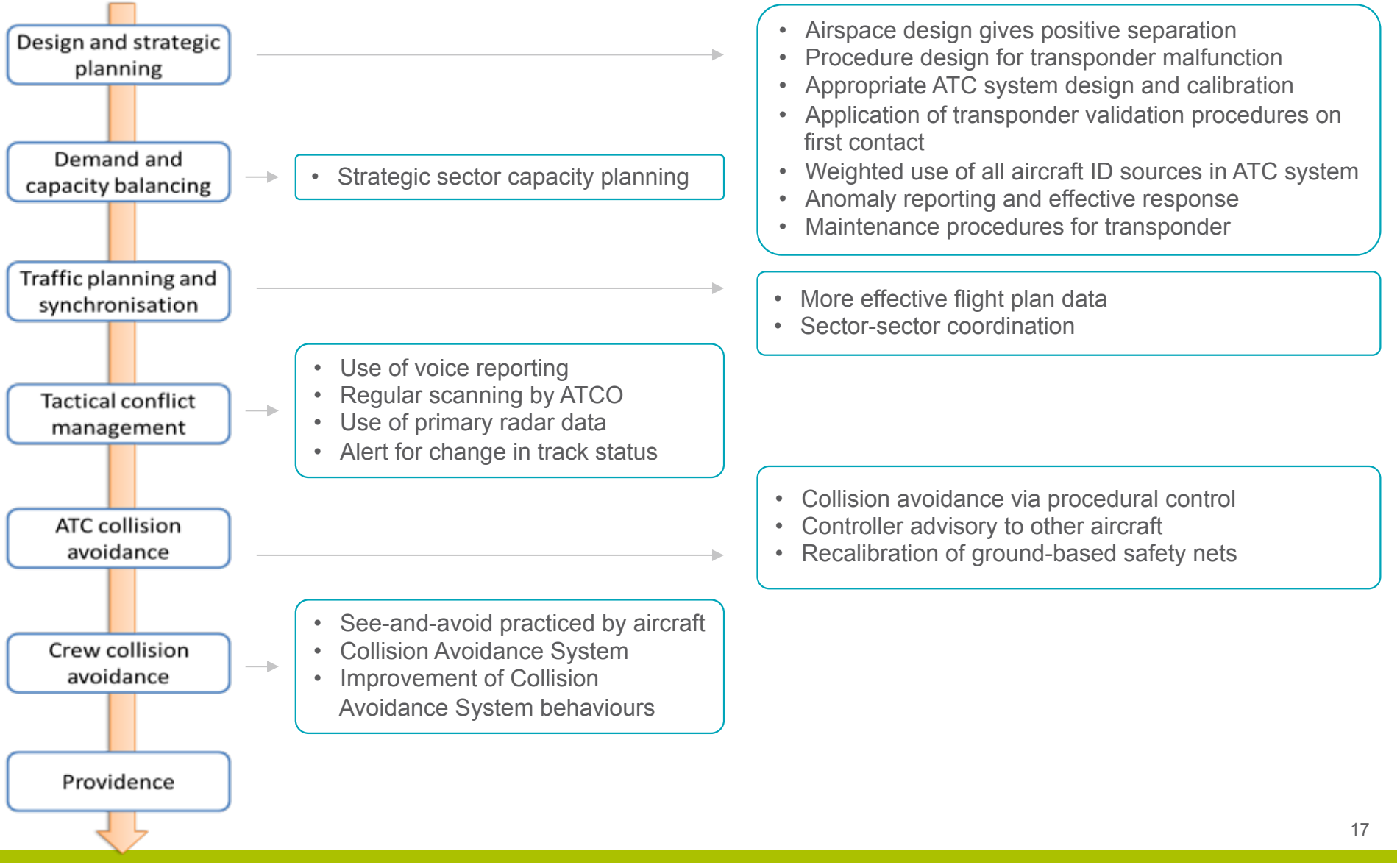
e.g. T1-S3

Loss of separation due to (i) loss of all track information on one aircraft and (ii) non-detection by the controller

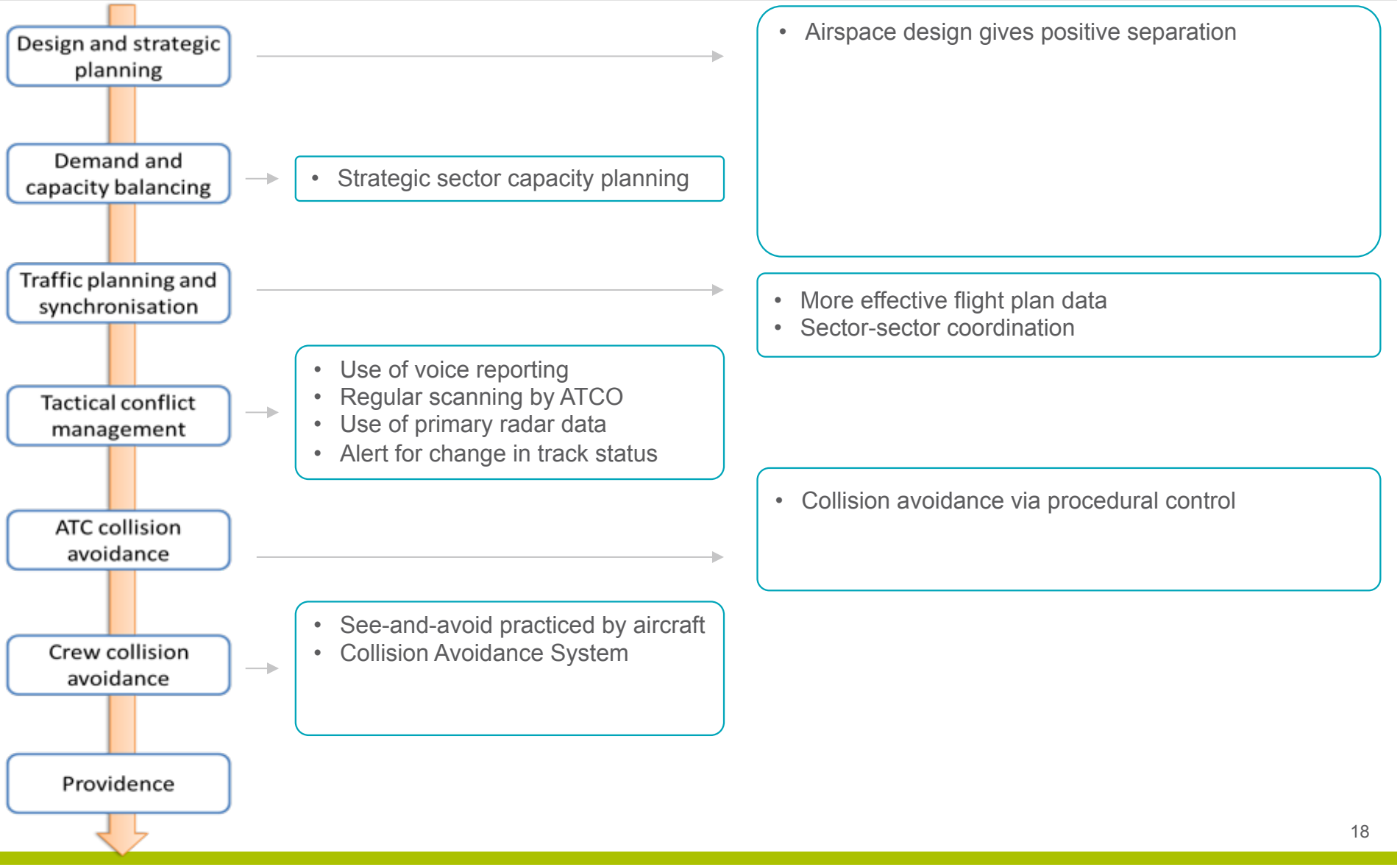
e.g. A3-S4

Loss of separation due to track swap between two aircraft due corrupt Mode A code leading to wrong aircraft receiving instruction

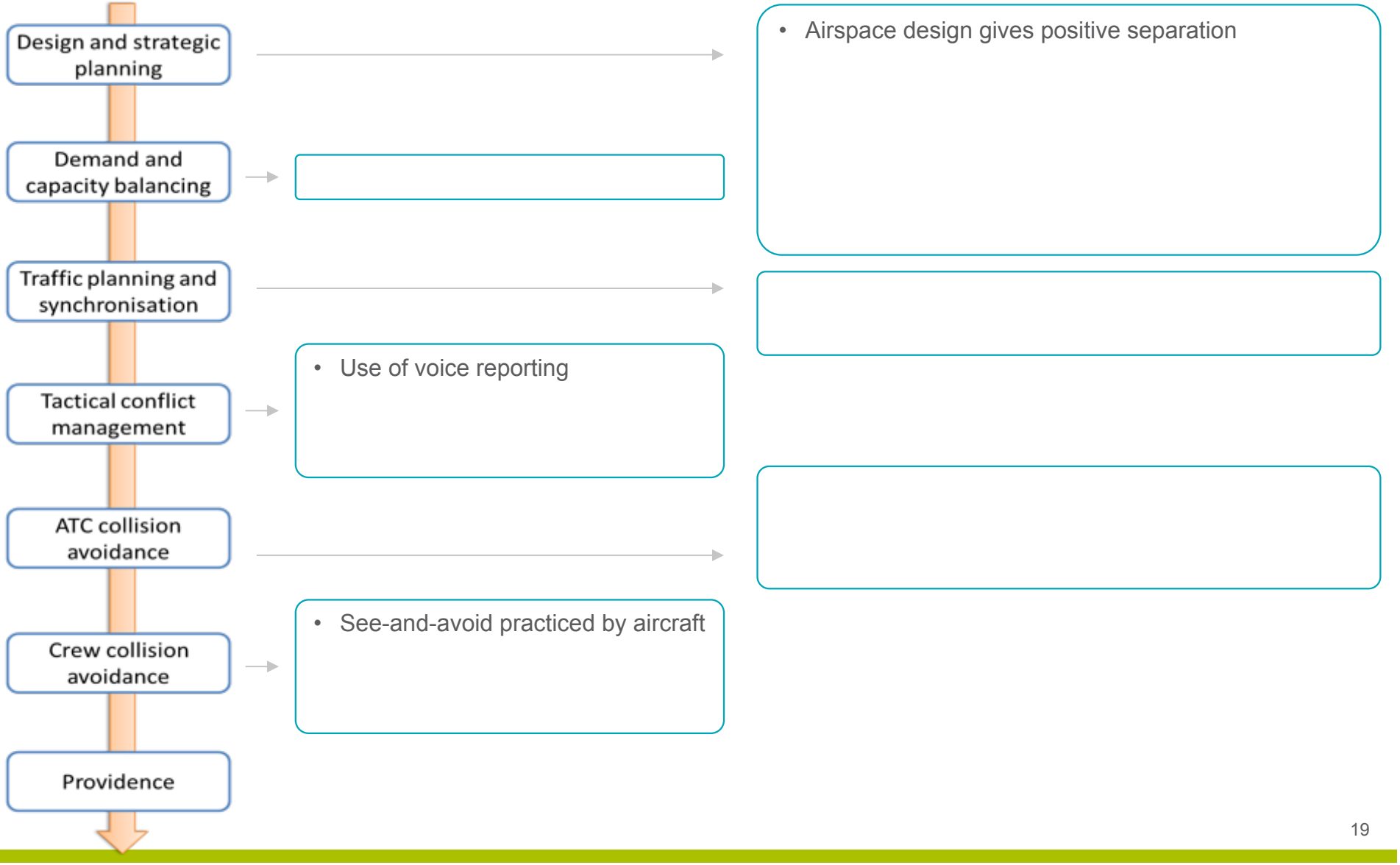
There are many mitigations



However, the list becomes smaller when mitigations **not applicable to all scenarios** are removed…

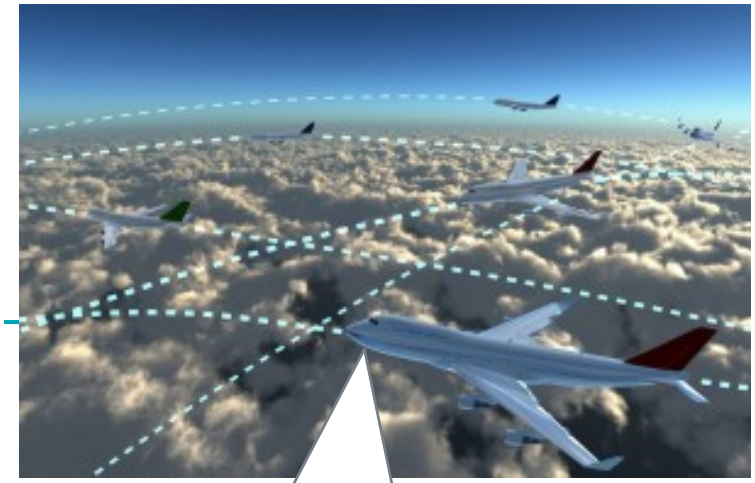


…and even smaller when we also remove mitigations that are **only effective for particular scenarios**



What are we left with?

1 Airspace design



2

3 Use of voice reporting

5 The near future

Will the risk alter in the future?

Tracks from primary radar

- Reduction in primary radar (for civil use through cost pressures)

Voice reporting

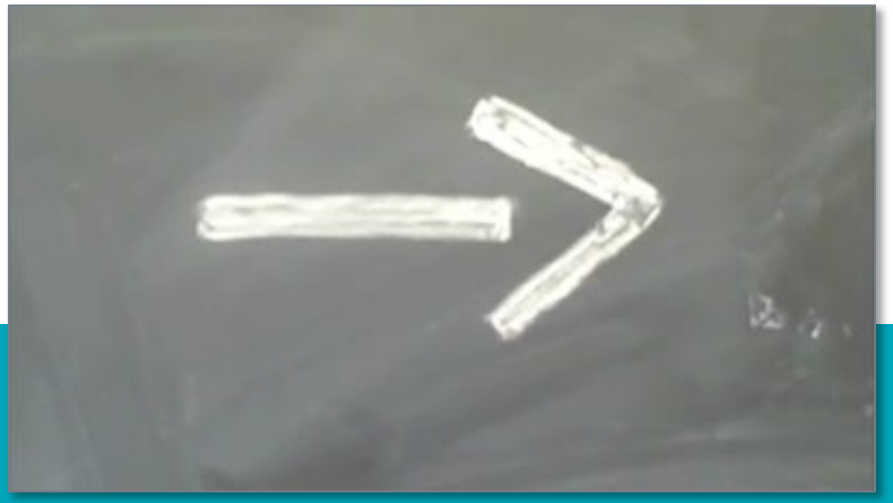
- Reduced with the application of procedural (silent) handovers (or stripless systems & datalink)

Effective airspace design

- Could be reduced by free-route airspace (if the concept results in conflicting routes)

Lower image sourced from http://www.nats.aero/wp-content/uploads/2012/07/env_profiles.gif

6 Conclusions



Recap – transponder failure

Total transponder failure

- Potential to make an aircraft invisible – to ATC, controller safety nets and TCAS

Other forms of transponder failure

- Impacts range from not discernable to the aircraft not being visible to ATC/TCAS
- Potential impacts associated with duplicated 24-bit Mode S address are significant

Mitigations

- No single fail-safe mitigation
- Only a small number of mitigations are effective across several potential failure scenarios
- Several mitigations available to address specific scenarios

Conclusions - what can industry do?

Ascertain

- The true effectiveness of the barriers/mitigations associated with the surveillance data chain
- The potential for the erosion of existing barriers/mitigations (e.g. voice reporting)
- The potential for new mitigations (taking account of modern ATC systems)

Ensure barriers are as strong as possible, e.g.

- Effective reporting & resolution of transponder anomalies
- Consideration of transponder malfunctions in ATC system design
- Effective warnings and procedures for air traffic controllers, with cross border compatibility