# *2020 Foresight - A Systems-Engineering Approach to Assessing the Safety of the SESAR Operational Concept*

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# ADS-B IN NON-RADAR AREAS – HOW TO APPROACH SAFETY?

Radar-like services in NRA using ADS-B

Separation down to “radar” levels
i.e. 5 nm or 3 nm

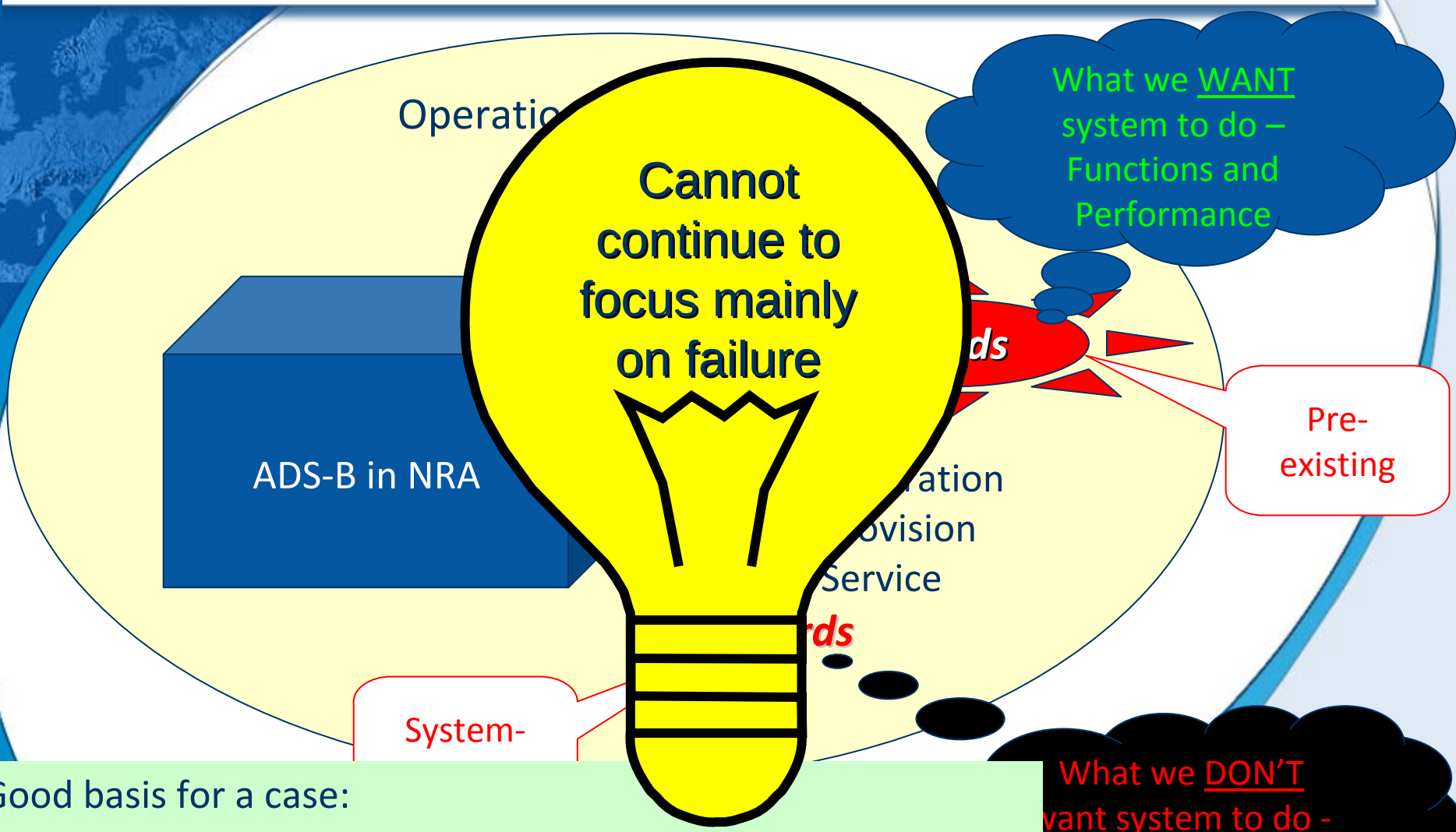
ADS-B end-to-end system
needs to be reliable

even if it were 100% so, would
that answer…

whether ADS-B would be safe enough to
support 3-5 nm separation…?

No! Risk of implementing a perfectly reliable
but unsafe ADS-B system

# ADS-B IN NON-RADAR AREAS – HOW TO APPROACH SAFETY?




Good basis for a case:

ADS-B can provide the same functionality (i.e. data presented to the Controller / support tools) and performance (data accuracy, resolution, latency, refresh rate, coverage etc)

# A BROADER APPROACH TO RISK ASSESSMENT AND MITIGATION

- ***Success*** approach:
  - to show that an ATM system will be acceptably safe in the **absence** of failure
  - addresses the ATM contribution to aviation **safety**
  - defined by Functional Safety Requirements
- ***Failure*** approach:
  - to show that an ATM system will still be acceptably safe, taking account of the possibility of (infrequent) failure
  - addresses the ATM contribution to aviation **risk**
  - defined by Safety Integrity Requirements

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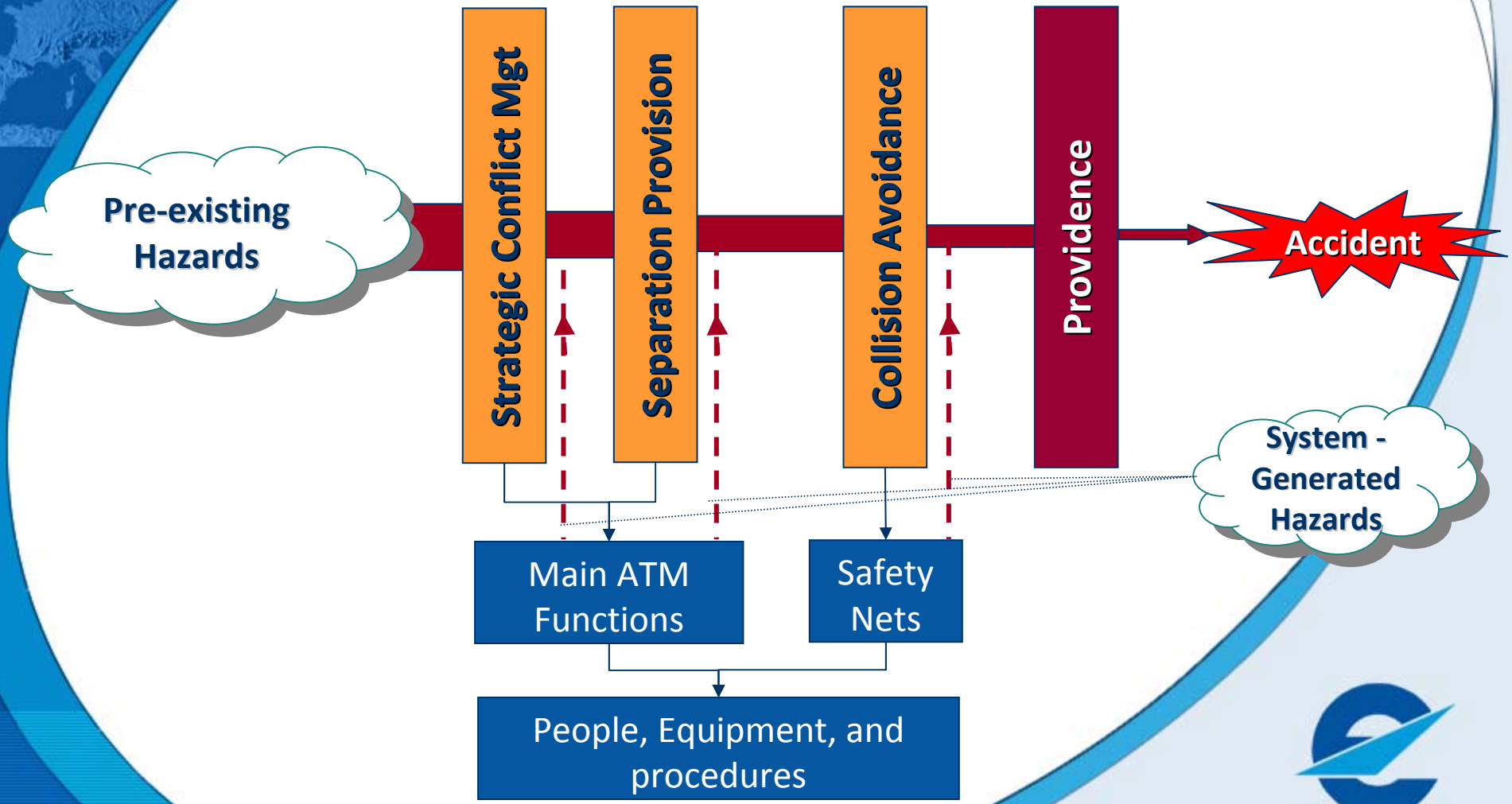
# ICAO GLOBAL ATM OPERATIONAL CONCEPT 2005

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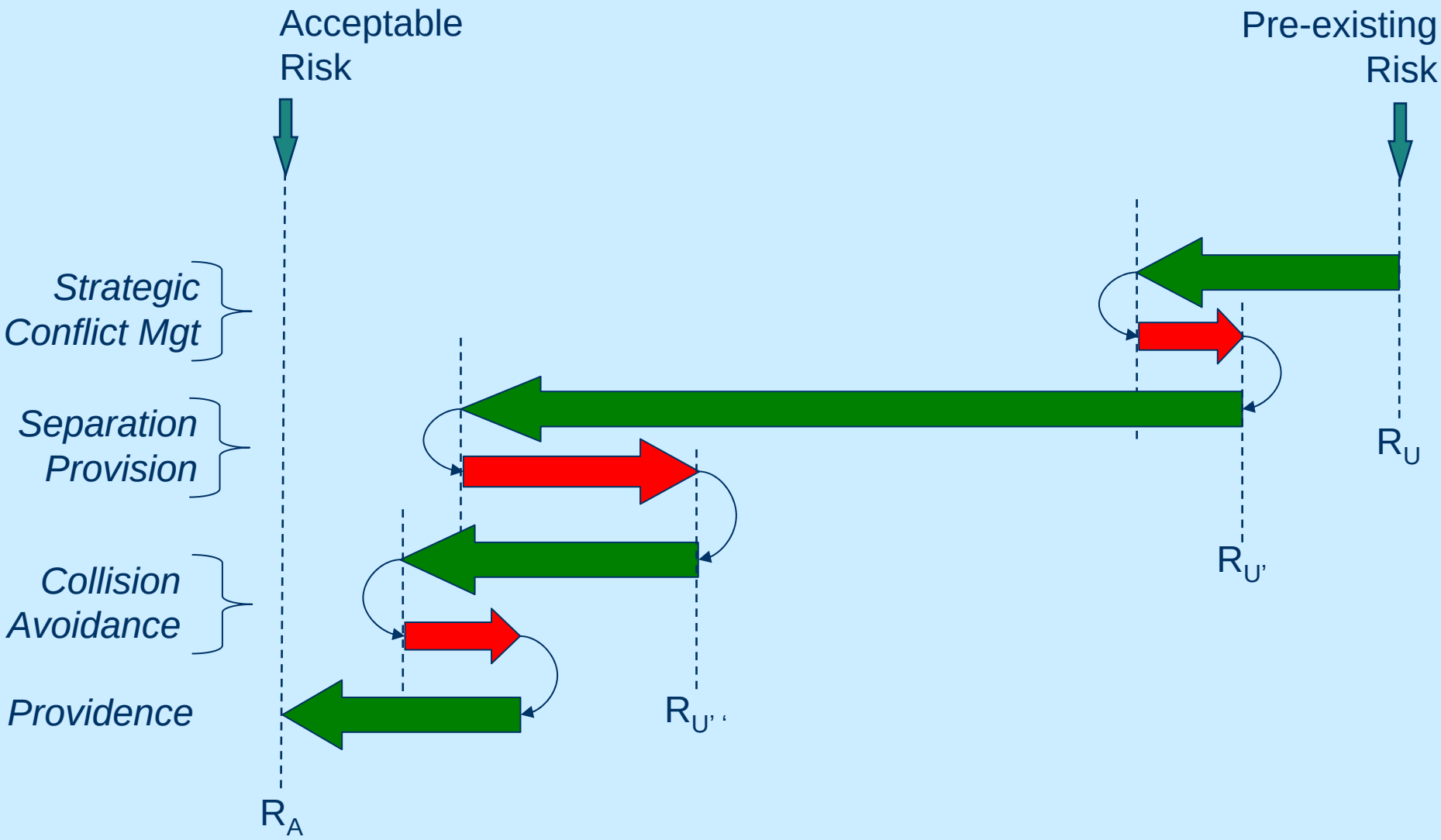
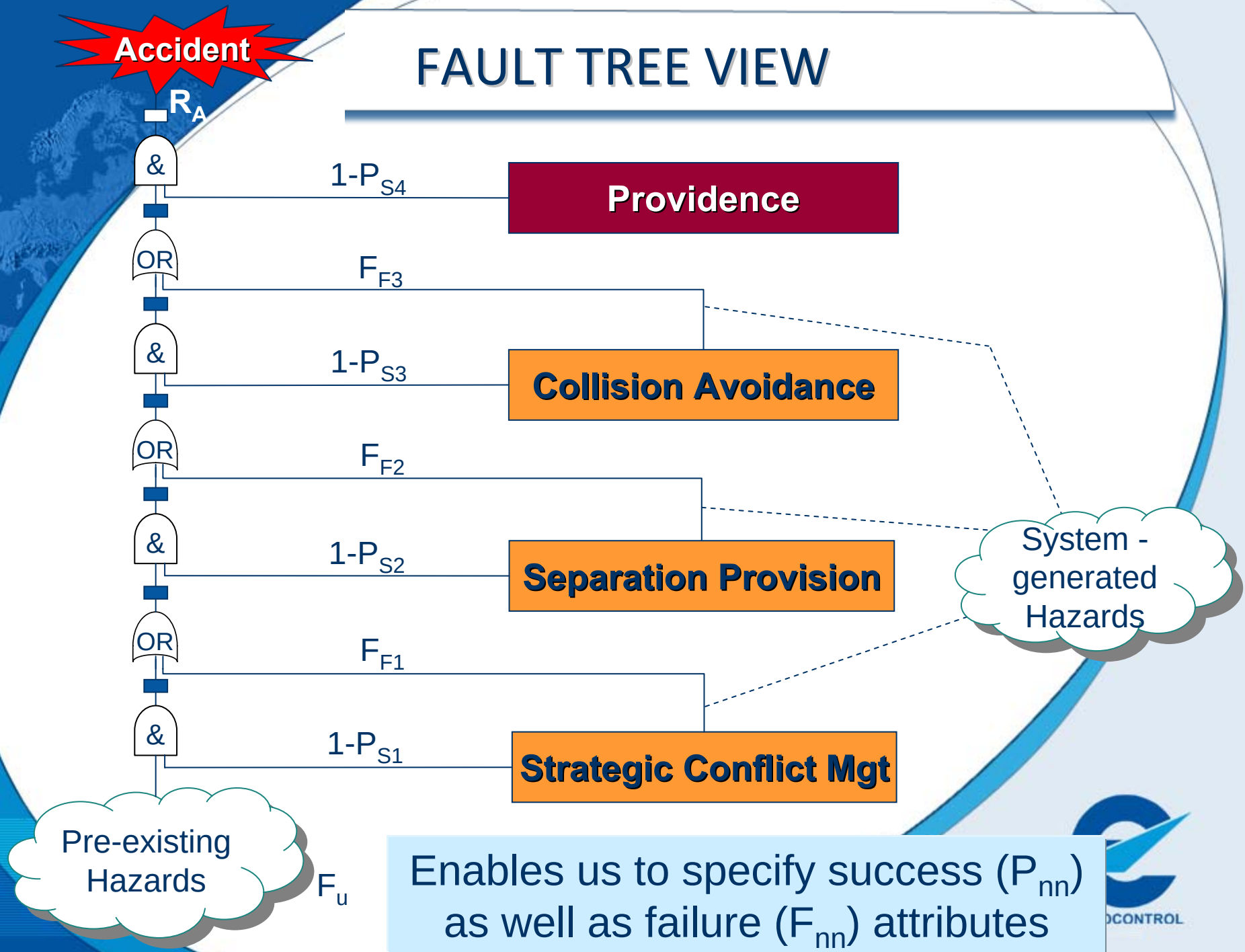
# ICAO GLOBAL ATM OPERATIONAL CONCEPT – RISK GRAPH



# FAULT TREE VIEW




Enables us to specify success ($P_{nn}$) as well as failure ($F_{nn}$) attributes

# SESAR AND SAFETY (1)

- SESAR is required to provide capacity to meet a 1.7-fold increase in traffic by 2020 – *[SESAR Deliverable D2]*
- SESAR safety performance is "to improve safety levels by ensuring that the [annual] number of …accidents …do not increase and, where possible, decrease" - *[SESAR Deliverable D2]*
- *EP3 Whitepaper on SESAR Safety Targets* shows that satisfying both of the above requires the accident rate per flight hour to **reduce**, from 2005 levels, by:
  - x3 for MAC accidents
  - x1.7 for CFIT accidents

# SESAR AND SAFETY (2)

- Safety … requirements will address both:
  - the need for ATM to maximize its contribution to aviation safety and
  - the need for ATM to minimize its contribution to the risk of an accident

*[SESAR Deliverable D4]*

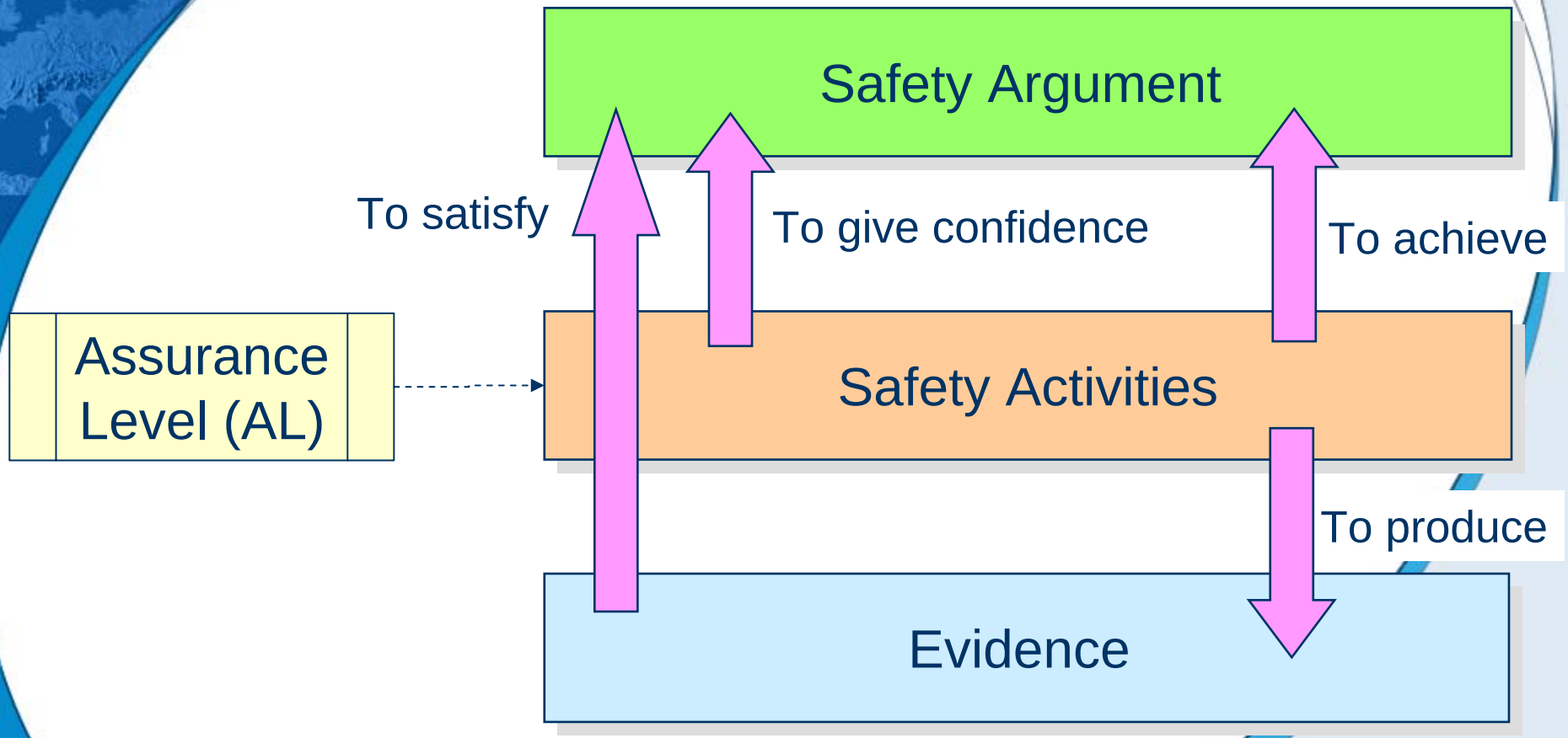
- End-to-end ATM system needs to deliver:
  - greater *functionality & performance* – to mitigate the (pre-existing) risk of an accident, inherent in aviation
  - improved *integrity* (plus some additional *f&p*) – to mitigate the (system-generated) risk of failure within the ATM system causing an accident
- Need to address **both** bullets in each case – addressing only the second is not enough!! *[SESAR Safety Management Plan]*

# THE BIG QUESTIONS FOR THE SESAR DEVELOPMENT PHASE

- Will the ATM system have sufficient safety functionality & performance?
- Will it work properly, under all normal conditions of the operational environment that it is likely to encounter?
- What happens under abnormal conditions of the operational environment?
- What happens in the event of a failure within the ATM system?
- Are the Safety Requirements realistic – *i.e.* could a system be built to deliver them?
- Can we believe the answers to the above?

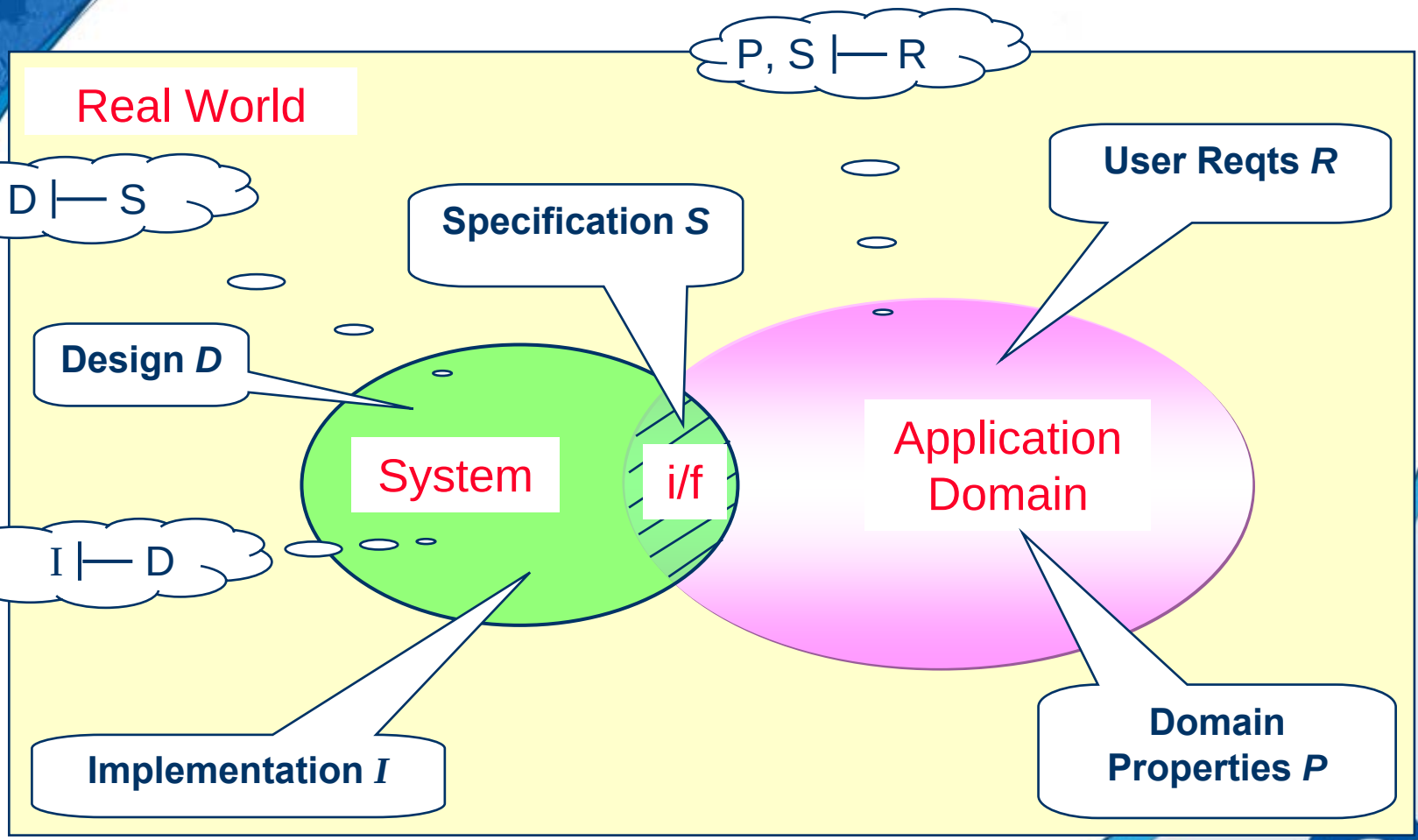
So how does one go about it?!

# AN ARGUMENT-DRIVEN APPROACH




But how do we develop a satisfactory Safety Argument?

# WE USE A REQUIREMENTS-ENGINEERING MODEL!




Each of the “think bubbles” is a logical statement – hence can be expressed as an Argument

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# HIGH-LEVEL SAFETY ARGUMENT - EXAMPLE

**Cr001**
*Acceptably safe* is defined by the *Safety Targets* – see Arg 1.1

**C001**
Applies to the Operational Environment described in Section 2 of the En-route Safety Design Document

**Arg 0**
SESAR En-route Operations will be *acceptably safe.*

**A0001**
*Assumptions* as per section 8.1 of the PSC

**J0001**
Justification as per Section 2.2 of the PSC

Argue on basis of a safe Specification and Logical Design, full Implementation of that design, safe Transition into service and Safety Monitoring for whole operational service life

So, what about the safety activities and evidence??

**Arg 1**
SESAR En-route ATM system has been specified to be *acceptably safe*

[tbd]

**Arg 2**
SESAR En-route ATM system has been designed to be *acceptably safe*

[tbd]

**Arg 3**
SESAR En-route ATM system Design has been implemented completely & correctly

[tbd]

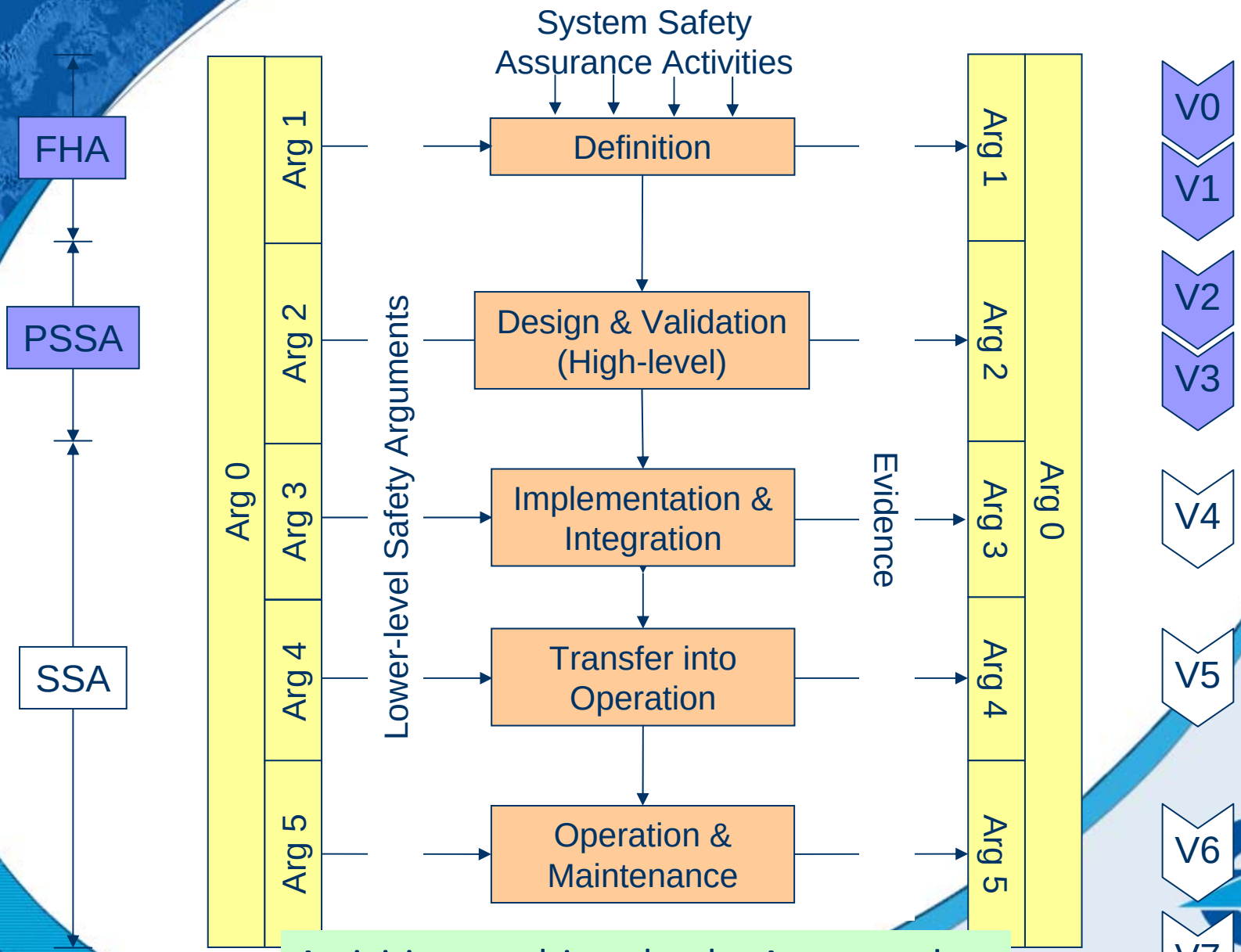
**Arg 4**
Transition from current state to full SESAR En-route ATM system will be acceptably safe

[tbd]

**Arg 5**
SESAR En-route ATM system will be shown to operate *acceptably safely* throughout its service

[tbd]

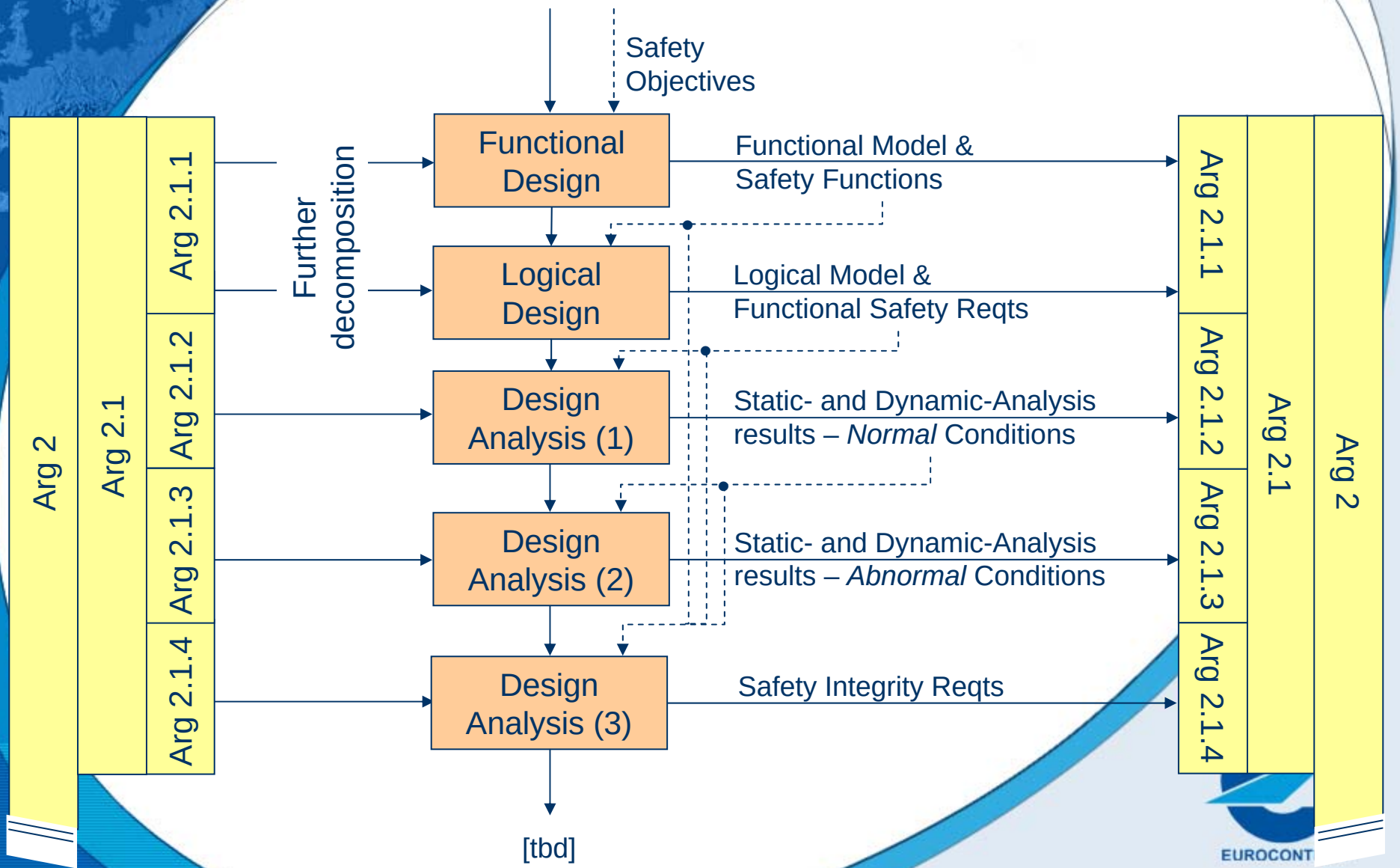
# LIFECYCLE VIEW - OVERALL




Activities are driven by the Argument!

# LIFECYCLE VIEW – LOGICAL DESIGN (ARG 2)

Figure 20



# CONCLUSION

- In the face of more radical changes, we cannot sustain:
  - piecemeal approach to safety, or
  - pre-occupation with system failure at the expense of functionality and performance
- The solution – a broader approach to safety assessment
  - usage of a model of aviation safety that will provide suitable safety criteria for the components of the overall SESAR concept
  - the inclusion of the operational perspective within the scope of risk assessment

"Application of good systems-engineering practices to system safety assessment"!

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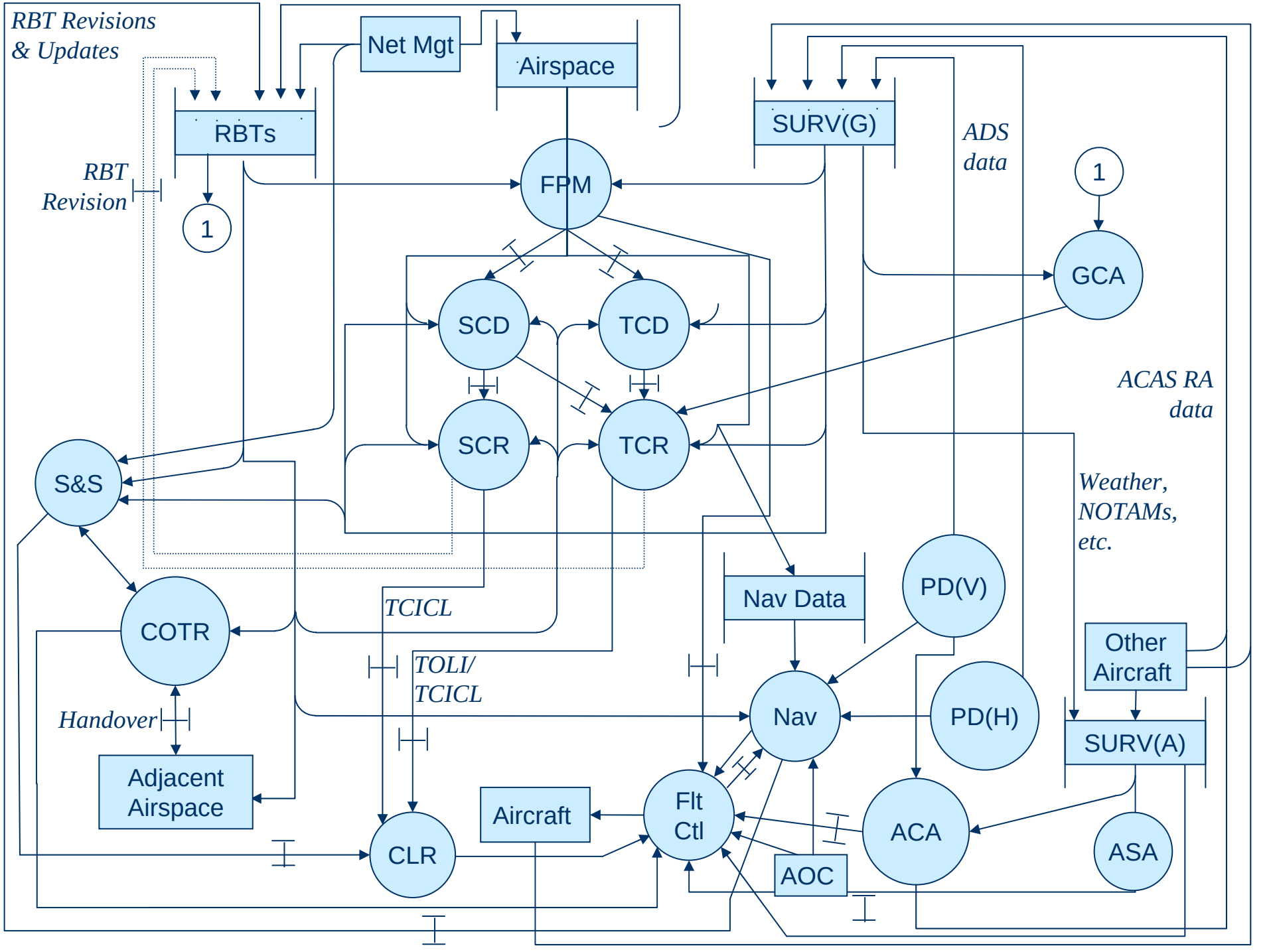
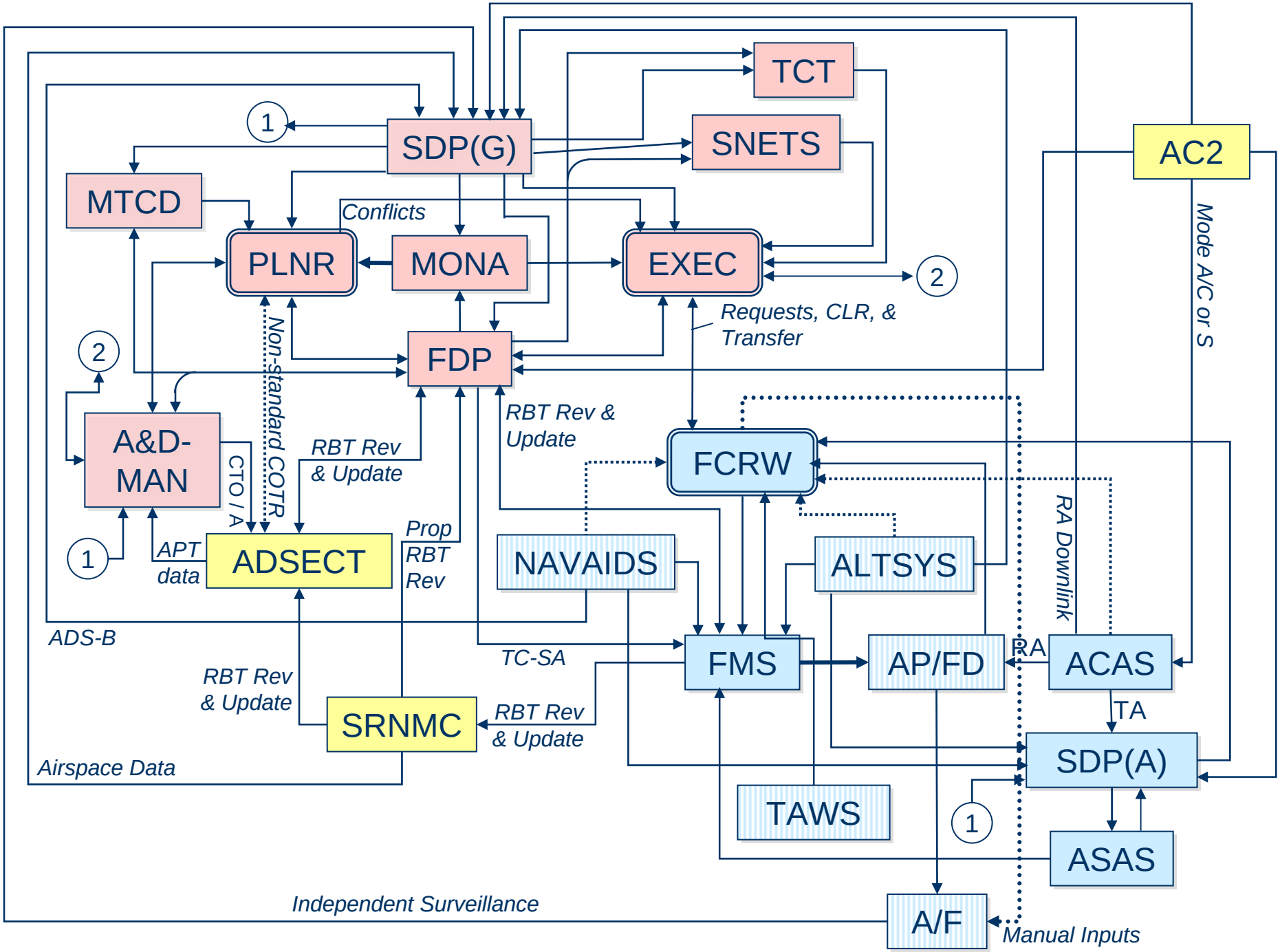

RBT Revisions & Updates
Net Mgt
Airspace
RBTs
SURV(G)
ADS data
RBT Revision
1
FPM
1
GCA
SCD
TCD
ACAS RA data
SCR
TCR
S&S
Weather, NOTAMs, etc.
PD(V)
Nav Data
TCICL
COTR
Other Aircraft
TOLI/ TCICL
Nav
PD(H)
Handover
SURV(A)
Adjacent Airspace
Aircraft
Flt Ctl
ACA
CLR
ASA
AOC


TCT
SDP(G)
SNETS
AC2
MTCD
Conflicts
PLNR
MONA
EXEC
Mode A/C or S
ADS-B
Requests, CLR, &
Transfer
FDP
Non-standard COTR
RBT Rev &
Update
A&D-
MAN
CTO / A
RBT Rev
& Update
FCRW
RA Downlink
Prop
RBT
Rev
APT
data
ADSECT
NAVAIDS
ALTSYS
ADS-B
TC-SA
FMS
AP/FD
RA
ACAS
RBT Rev
& Update
TA
SRNMC
RBT Rev
& Update
SDP(A)
Airspace Data
TAWS
ASAS
Independent Surveillance
A/F
Manual Inputs

# A FEW FUNCTIONAL SAFETY REQUIREMENTS

- The AMAN sub-function shall compute a Controlled Time of Overfly (CTO) for waypoints extending out well into En-route Airspace (typically as far as 200 nm) and down to a CTA at the Final Approach Fix or at a final merge point
- The AMAN sub-function shall generate speed advisories for Aircraft without an RTA capability
- The EXEC shall resolve any conflicts, as follows:
  - where the situation is time-critical, issue an “openloop” clearance to one or both Aircraft involved, or
  - where possible, and the situation is less time-critical, issue a trajectory change to resolve the conflict but return the Aircraft to its original route, or
  - where proposed by the PLNR and judged appropriate, for crossing / passing traffic, delegate separation responsibility to the FCRW according to the agreed and authorized RBT

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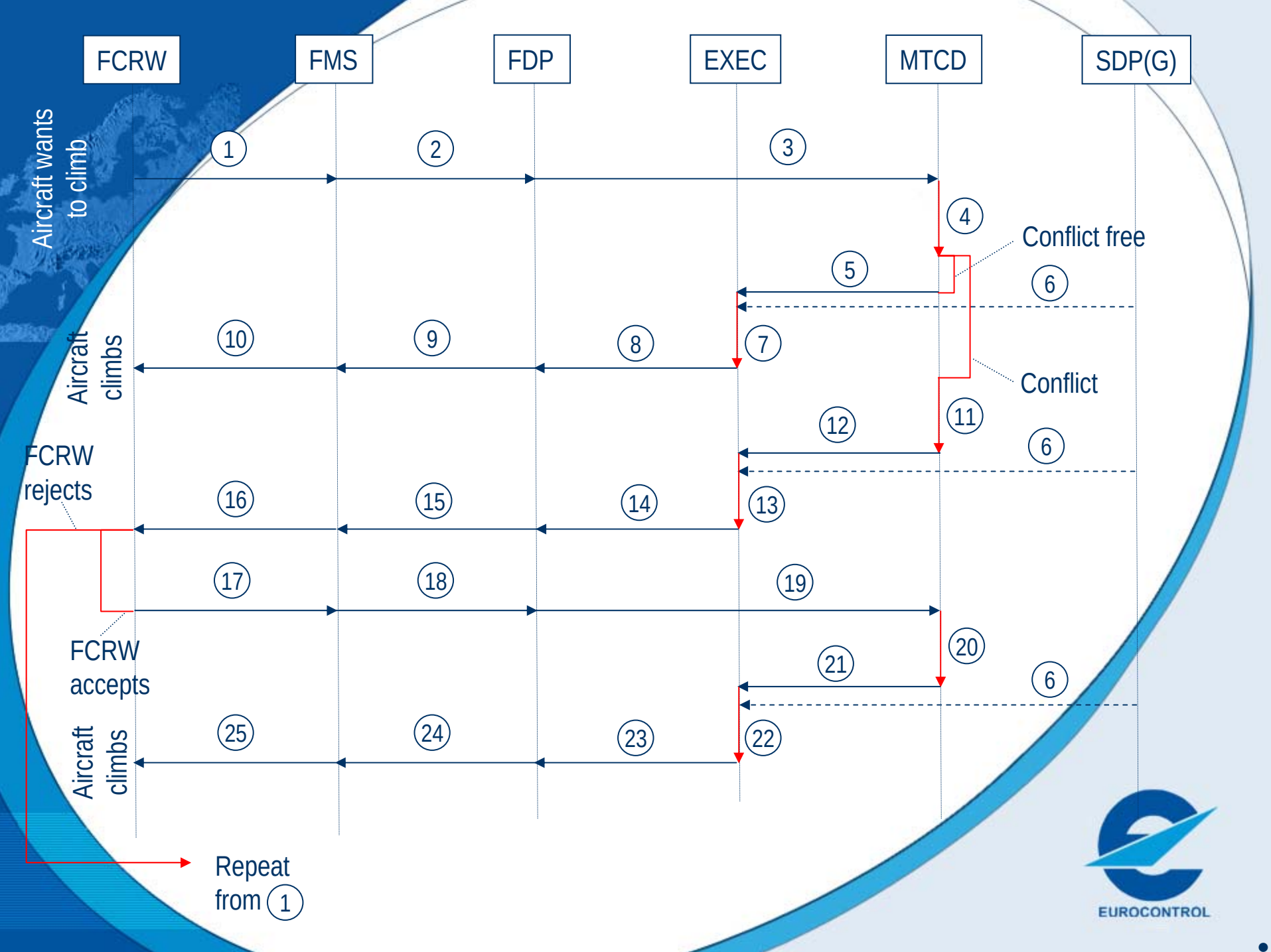
FCRW
FMS
FDP
EXEC
MTCD
SDP(G)
Aircraft wants to climb
1
2
3
4
Conflict free
5
6
Aircraft climbs
10
9
8
7
Conflict
11
12
6
FCRW rejects
16
15
14
13
17
18
19
FCRW accepts
20
21
6
Aircraft climbs
25
24
23
22
Repeat from 1