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How To Enhance Bowtie Analysis Using Systems Theoretic Accident Modelling & Processes (STAMP)

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Agenda

- Bowtie Brief Overview
- Brief overview of how we “enhance” existing Bowtie Analysis
- EXAMPLE Bowtie: “*UK CAA: Significant 7*”
- Focus on: Safety Control Structure **Modelling**
- Findings & Biggest Takeaways

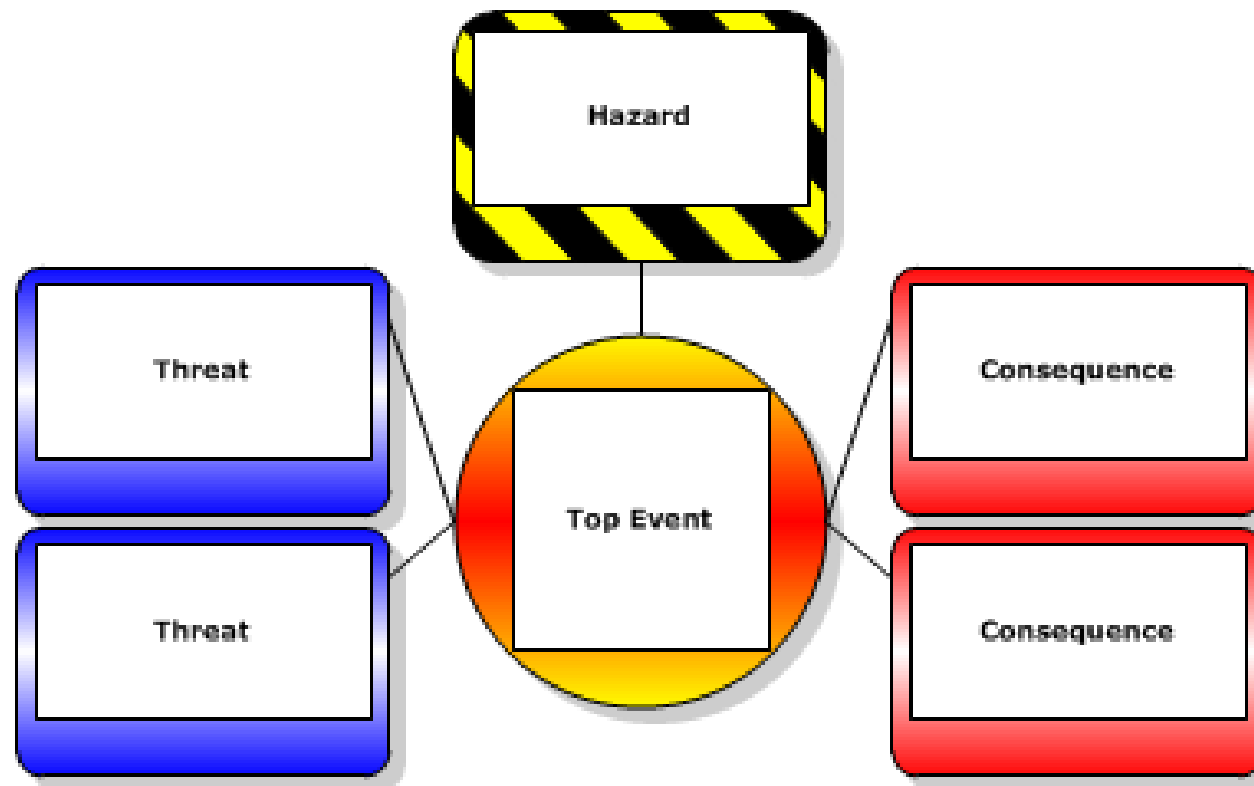
Bowtie Analysis: Quick Qs

- Familiar with it?
- Used it?
- Found it valuable?
- Had Issues?



<http://www.ralphlauren.co.uk/product/images?productId=52353391&zoom=1&color=1001476&view=1>

What is Bowtie Analysis?



<https://www.caa.co.uk/Safety-Initiatives-and-Resources/Working-with-industry/Bowtie/>

What is Bowtie Analysis?

- “The origins of bowtie... a simplified fusion of fault and event tree methodologies”
FTA + ETA = Bowtie



- Or quite simply, Brainstorming: Causes, Effects and Scenarios.
- Bowtie Analysis is a “Barrier-based” approach, i.e. utilises a Direct-Causality Accident Causation Model (Swiss Cheese!)
- Referred to in ICAO’s Safety Management Manual (SMM)
- Used across Industries, including: Aerospace, Rail + Oil & Gas

<https://www.caa.co.uk/Safety-Initiatives-and-Resources/Working-with-industry/Bowtie/>

How do we “enhance” existing Bowtie Analysis?

- 1) Recognise the limitations of:
 - Bowtie Analysis **Method**
 - Existing Bowtie **Analysis** (potential limitations)
- 2) Use the existing Bowtie Analysis as a starting point for a STAMP-based Assessment

Essentially, what I'm saying is...

- Do a STAMP-based Assessment, but use some of the existing information within the Bowtie Analysis as the starting point.

Please Note: I am NOT suggesting that the Bowtie and STAMP Assessment should be merged (they are fundamentally incompatible). I am simply saying that the information contained in an existing Bowtie Analysis could be used as a starting point to do a STAMP-based Assessment (much like using a CONOPs document, or discussions with SMEs).

As with all sources of information, they may be incomplete and potentially missing critical information. Caution is recommended when using any source of information to perform an analysis.

Furthermore, I am NOT suggesting that the “causal-relationships” depicted by the Bowtie Analysis be carried through into the STAMP HCS, and nor can they be carried through due to the fundamental differences between the Accident-Causality Models Bowtie and STAMP are based upon.

How do we actually do it?

- Take an existing Bowtie Analysis
- **Define** Accidents & Hazards

STAMP-based
Assessment

- **Model** the Safety Control Structure
- **Identify** potentially Unsafe Control Actions (UCAs)
- **Identify** associated UCA Causal Scenarios
- **Allocate** “findings” to appropriate Stakeholders for management.

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Focus of this presentation



UK CAA: Significant 7

- **Loss of Control:** 1.1 Aircraft upset
- **Runway Excursion:** 2.1 Inability to stop within distance
- **CFIT:** 3.1 Terrain separation deteriorating below normal requirements
- **Runway Incursion:** 4.1 Incorrect presence of aircraft on protected area
- **Airborne Conflict:** 5.1 Close proximity with another aircraft
- **Ground Handling:** 6.1 Outside mass and balance envelope
- **Fire:** 7.1 Hidden area fire

Refer to:

- CAA PAPER 2011/03 “CAA ‘Significant Seven’ Task Force Reports”
- CAA 2009/11 Safety Plan (CAP 786)

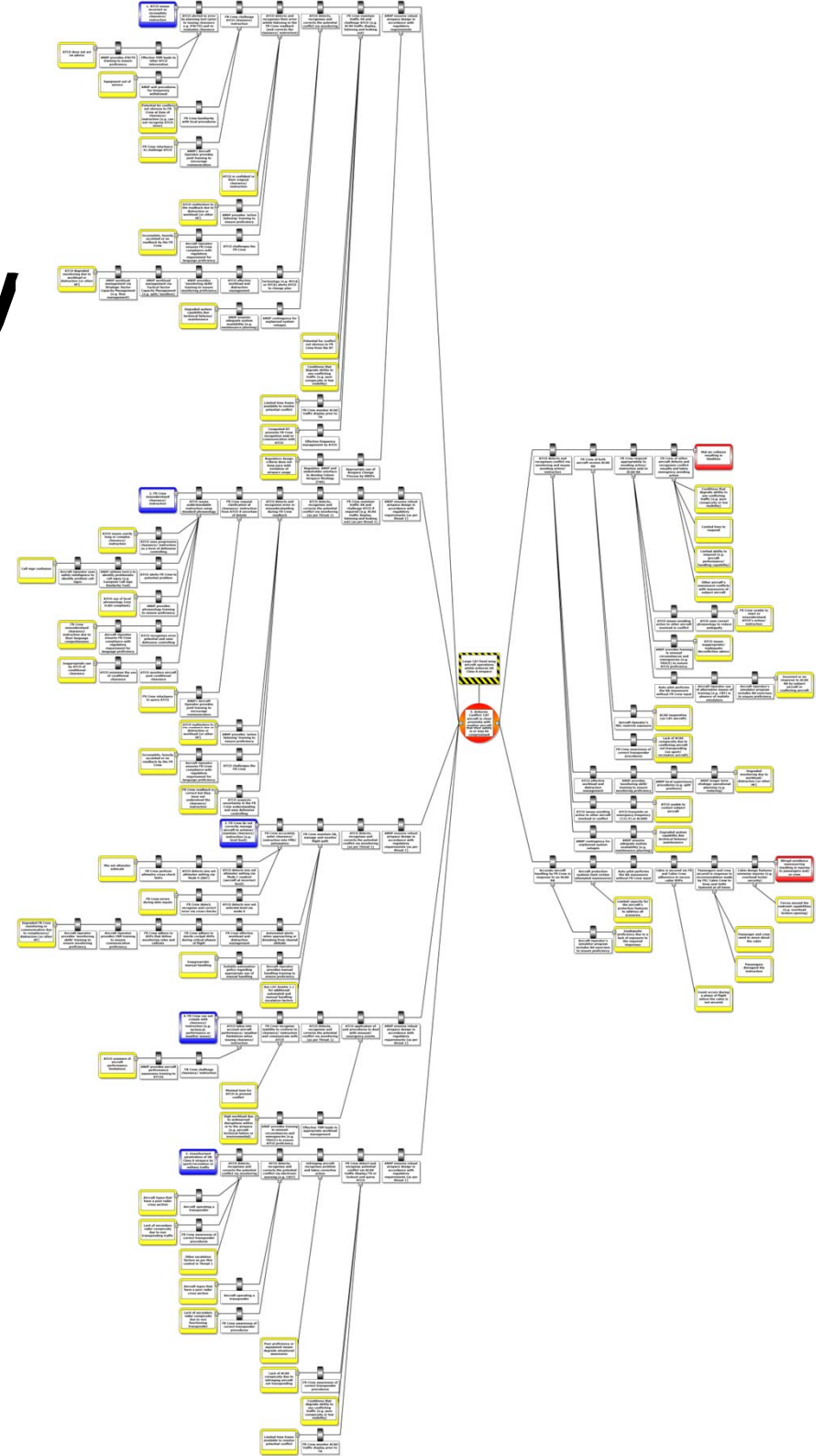
Airborne Conflict

5.1: Close Proximity



- <http://www.caa.co.uk/Safety-Initiatives-and-Resources/Working-with-industry/Bowtie/>
- <http://www.caa.co.uk/Safety-initiatives-and-resources/Working-with-industry/Bowtie/Bowtie-templates/Bowtie-document-library/>

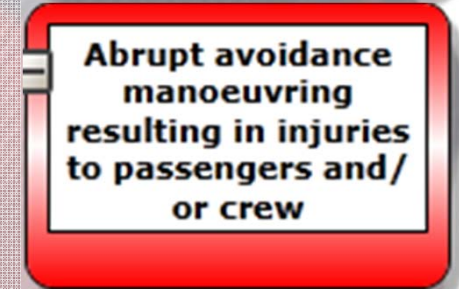
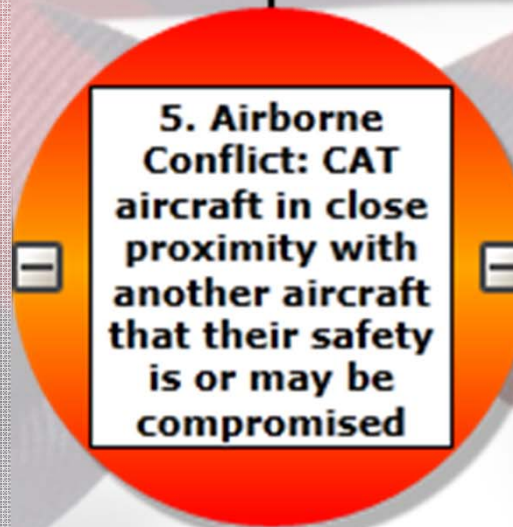
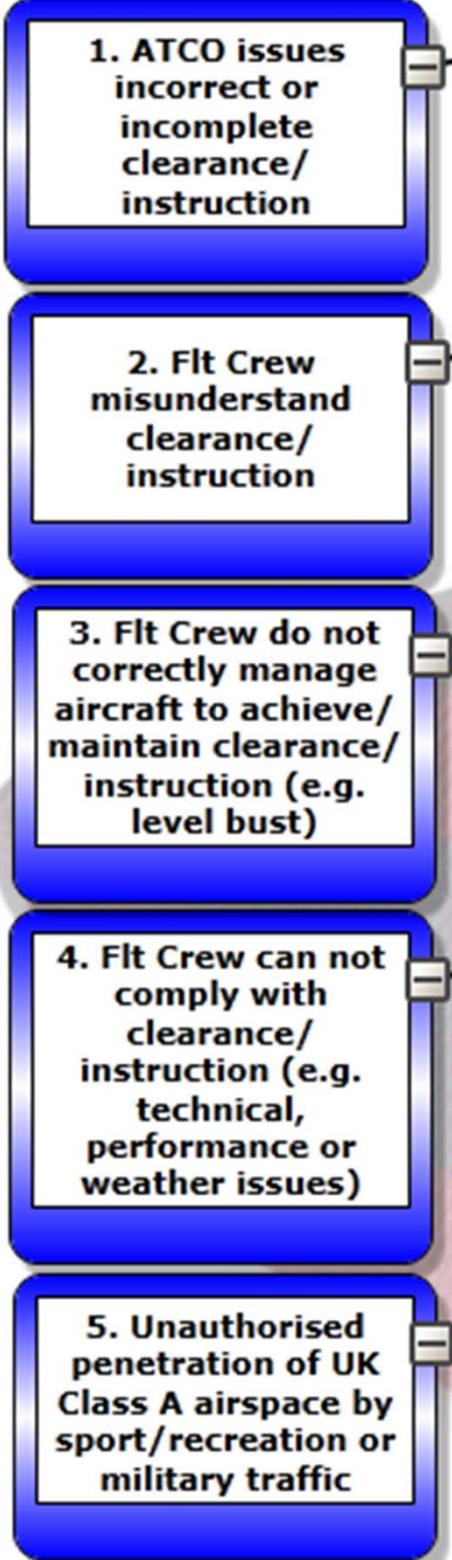
CAA is the intellectual owner of the Bowtie models presented
Bowtie Models © CAA



Airborne Conflict 5.1: Close Proximity

[Leveson, 2012] "Engineering a Safer World"

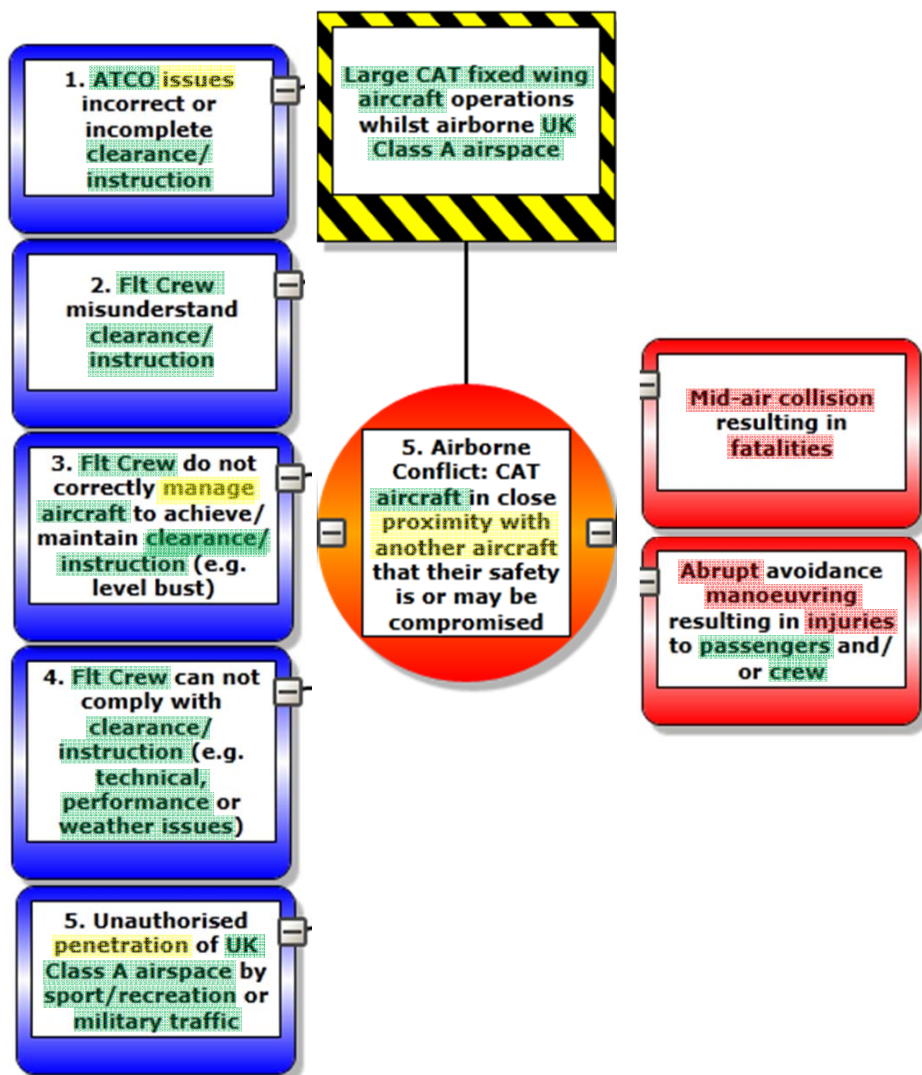
Hazard: A system state or set of conditions that, together with a particular set of worst-case environmental conditions, will lead to an accident (loss).



Hazard:
Loss of Safe Separation?

Notice the language used:
"Something" has gone "wrong" or "failed" in some way.

STAMP: HCS Modelling



Controllers / Controlled Processes / Actuators / Sensors / Disturbances (System Components)	Interactions / Relationships (Control Actions / Feedback)	Outcomes to be avoided (Accidents)
Large CAT Fixed Wing Aircraft UK Class A Airspace ATCO Clearance / Instruction Flight Crew Passengers Weather Undescribed* Technical / Performance Issues Sport / Recreation Traffic Military Traffic	Flight Path Trajectory / Aircraft Proximity Issuing Clearance / Instruction "Manages" aircraft Penetration of Airspace	Mid-Air Collision Fatalities Abrupt Manoeuvring Injuries

HCS Modelling

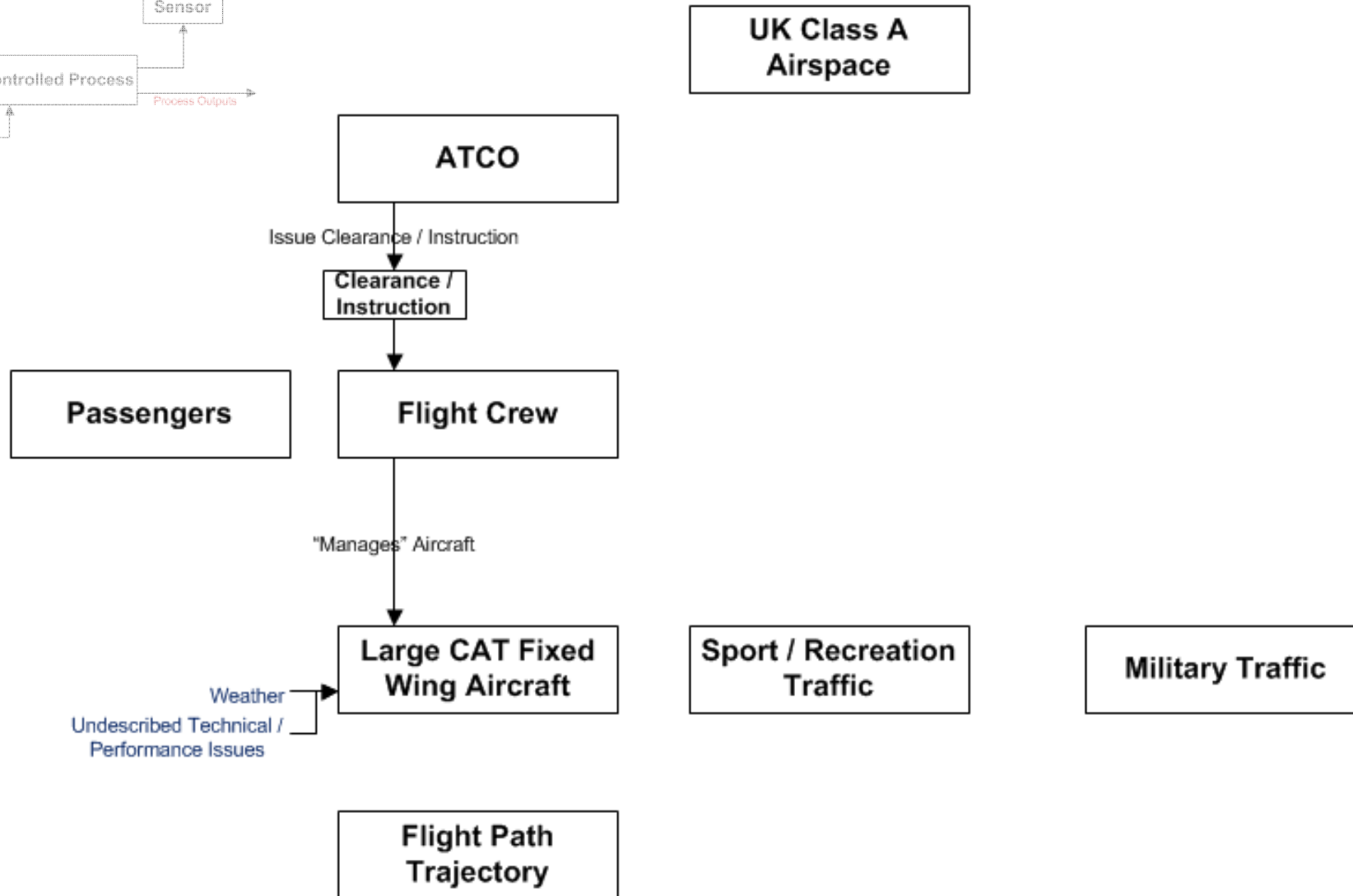
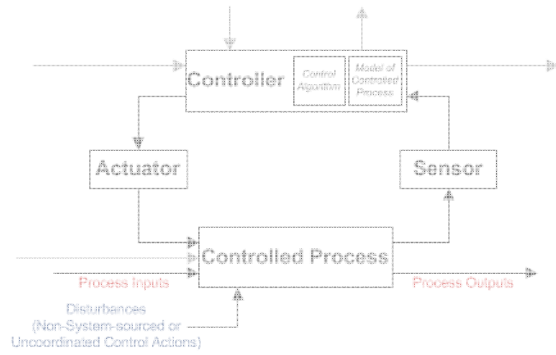
- Prompts Analyst to think about:
 - System Hierarchy / Structure / Boundaries
 - System Components: Humans, Hardware, Software & Data
 - Functions & Responsibilities (of System Components)

HCS Modelling

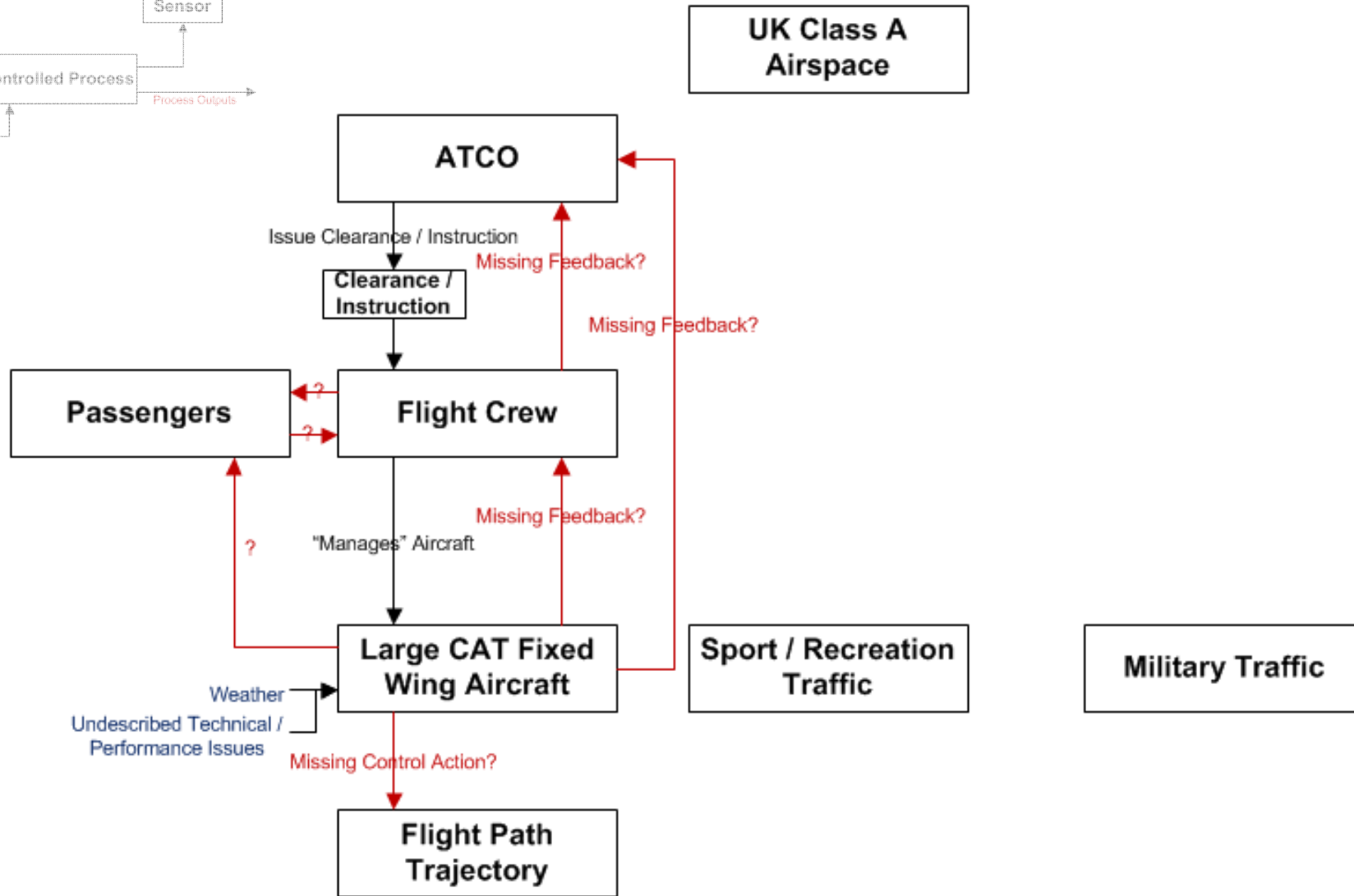
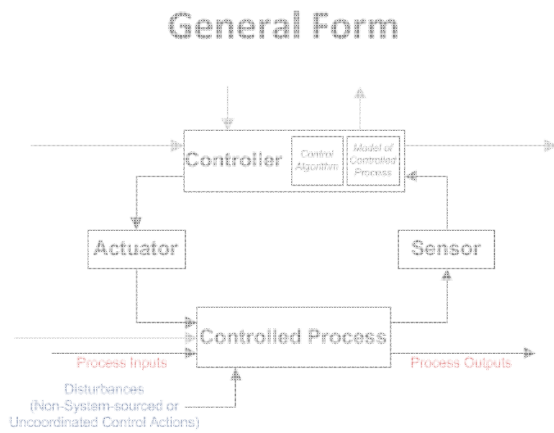
- Prompts Analyst to think about:
 - Control / Feedback Priorities (Sequence / Timing)
 - Interactions / Relationships
 - between Components
 - Indirect / across different levels of System Hierarchy

Raw Bowtie ==> STAMP HCS

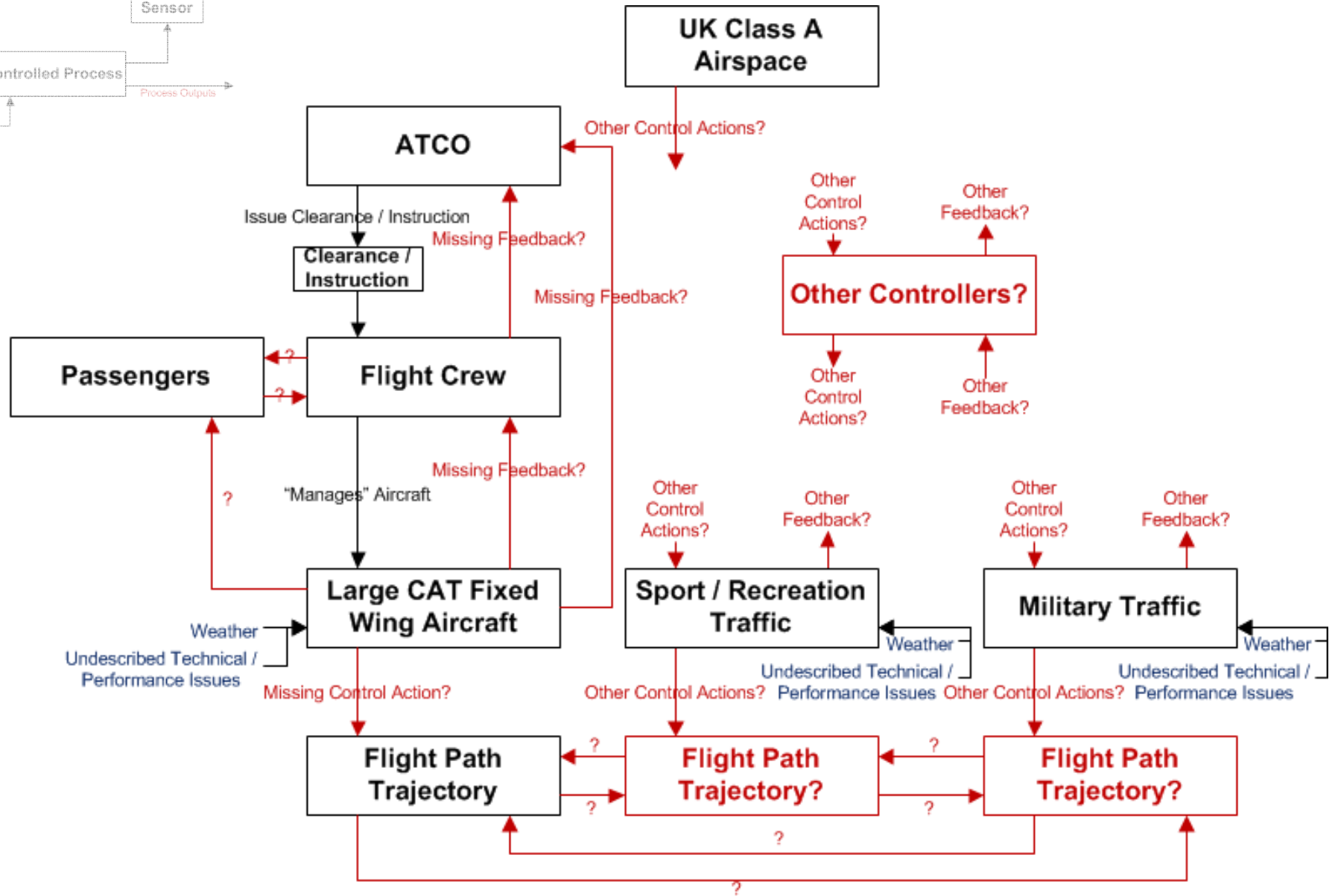
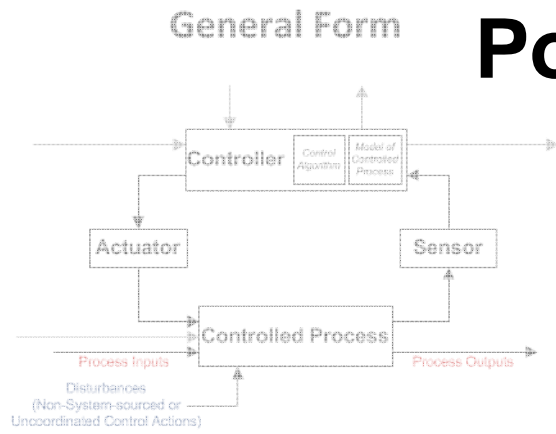
General Form



Everything is a “feed-back loop”, so... “Close-the-loop”



Potentially missing aspects? Significant?



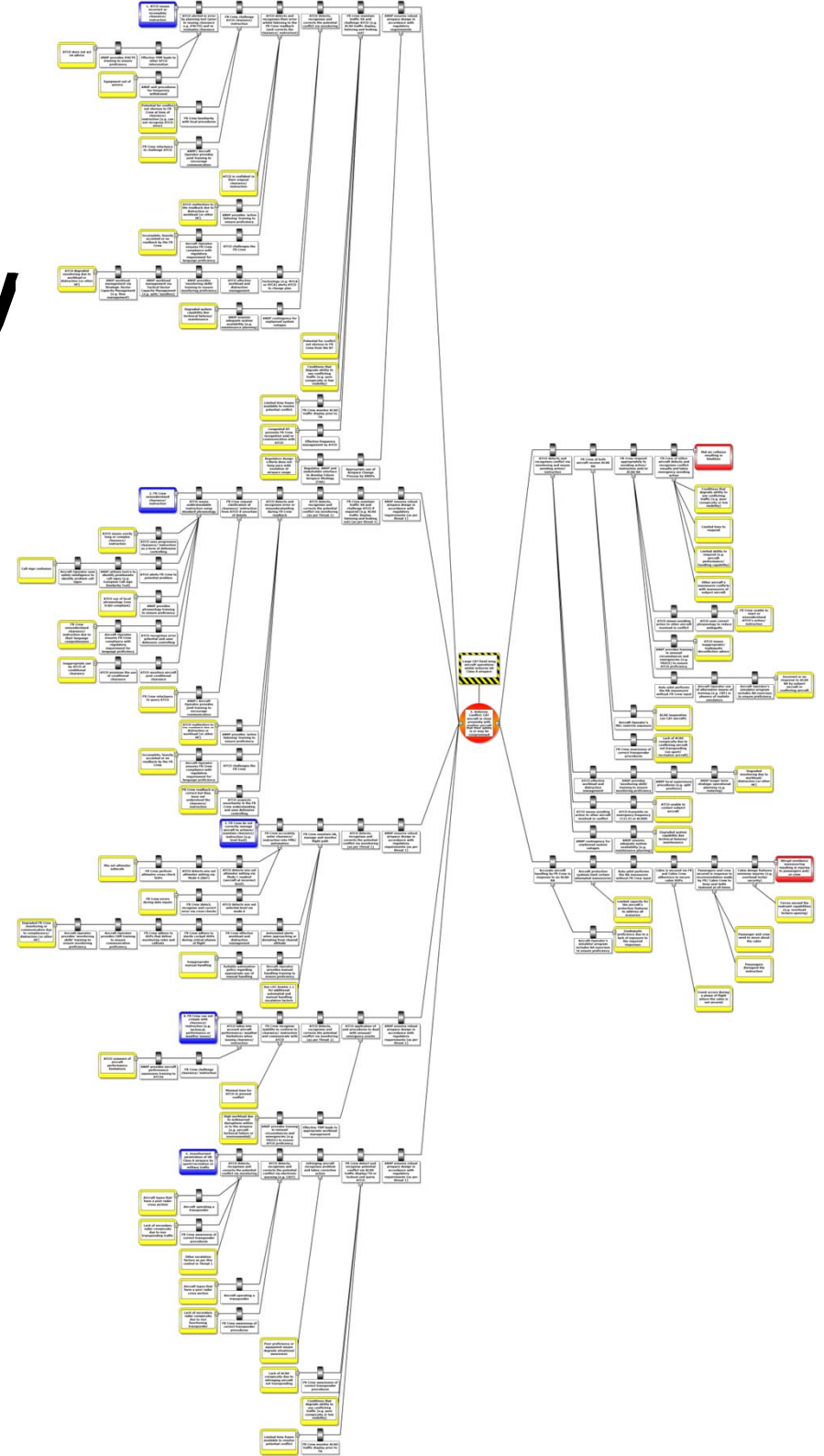
Lets get into detail...

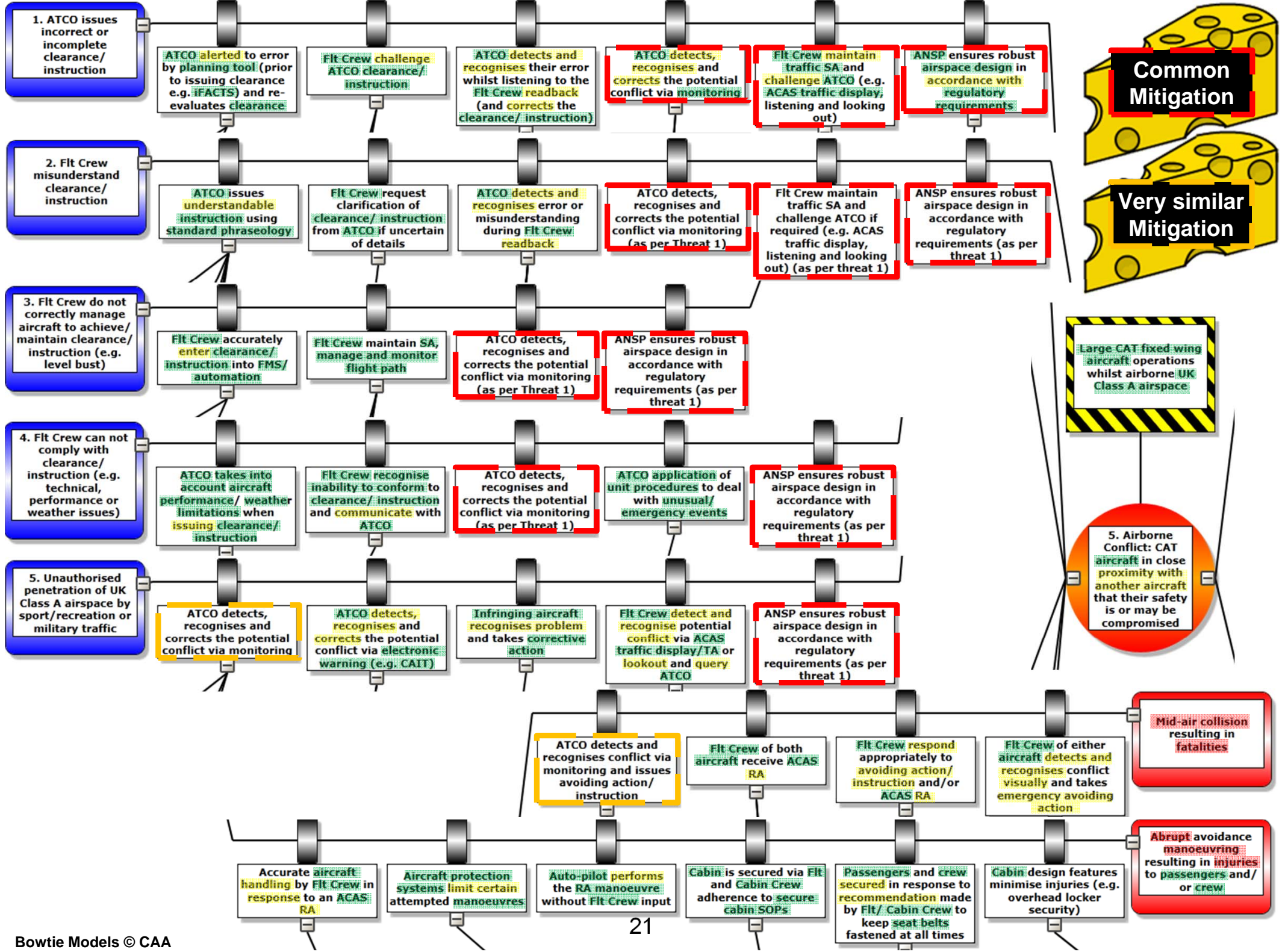
Airborne Conflict

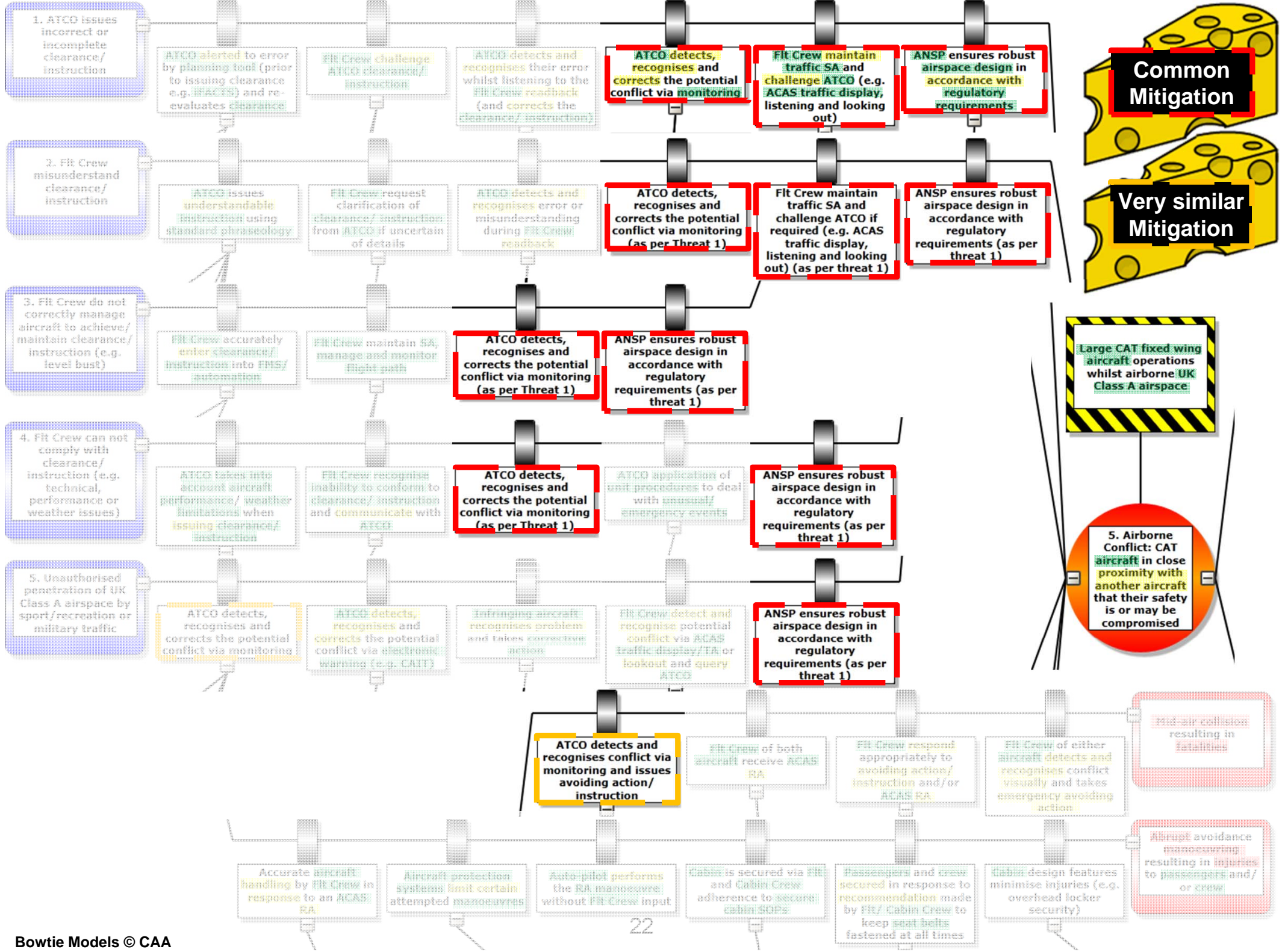
5.1: Close Proximity

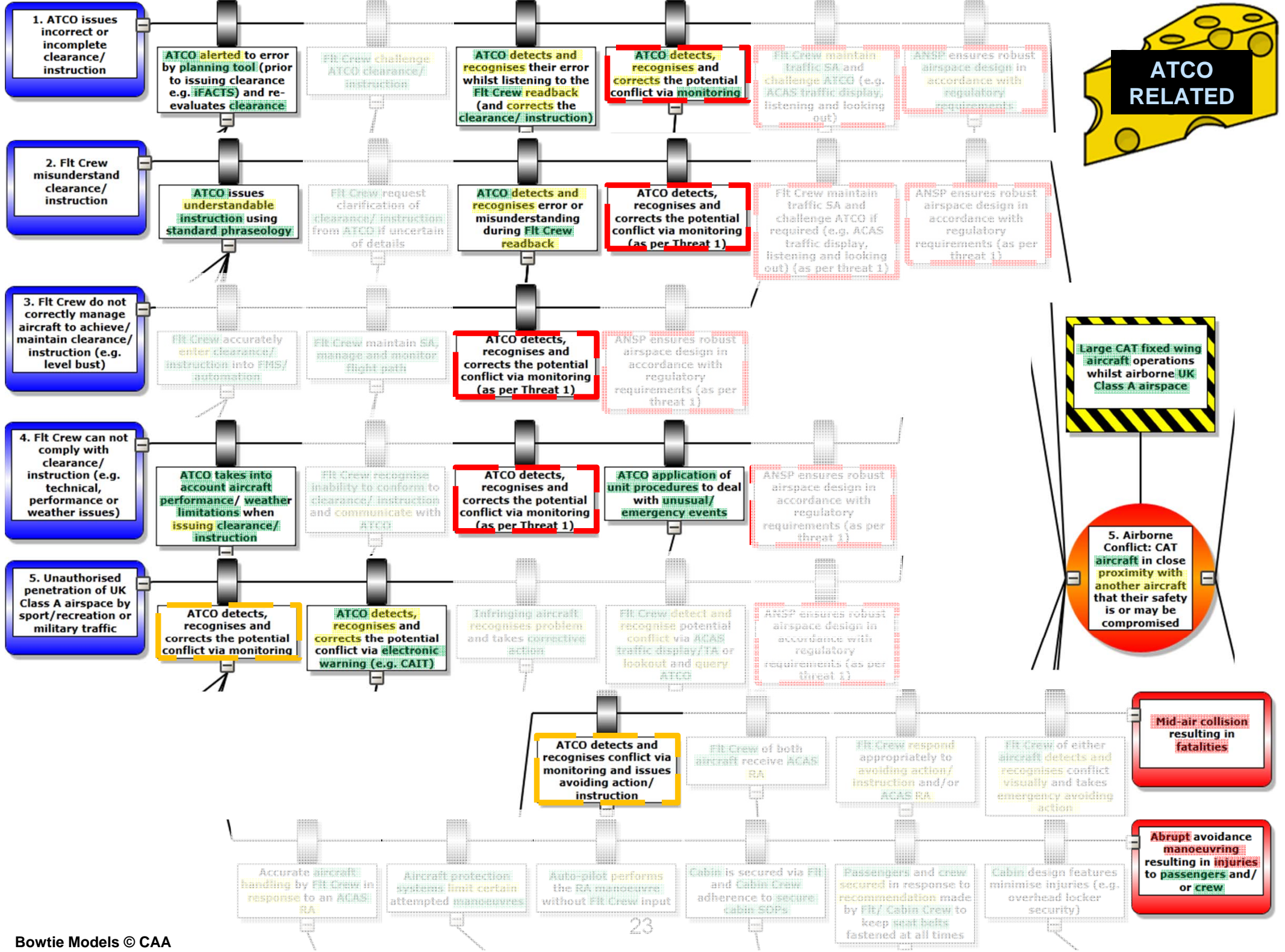


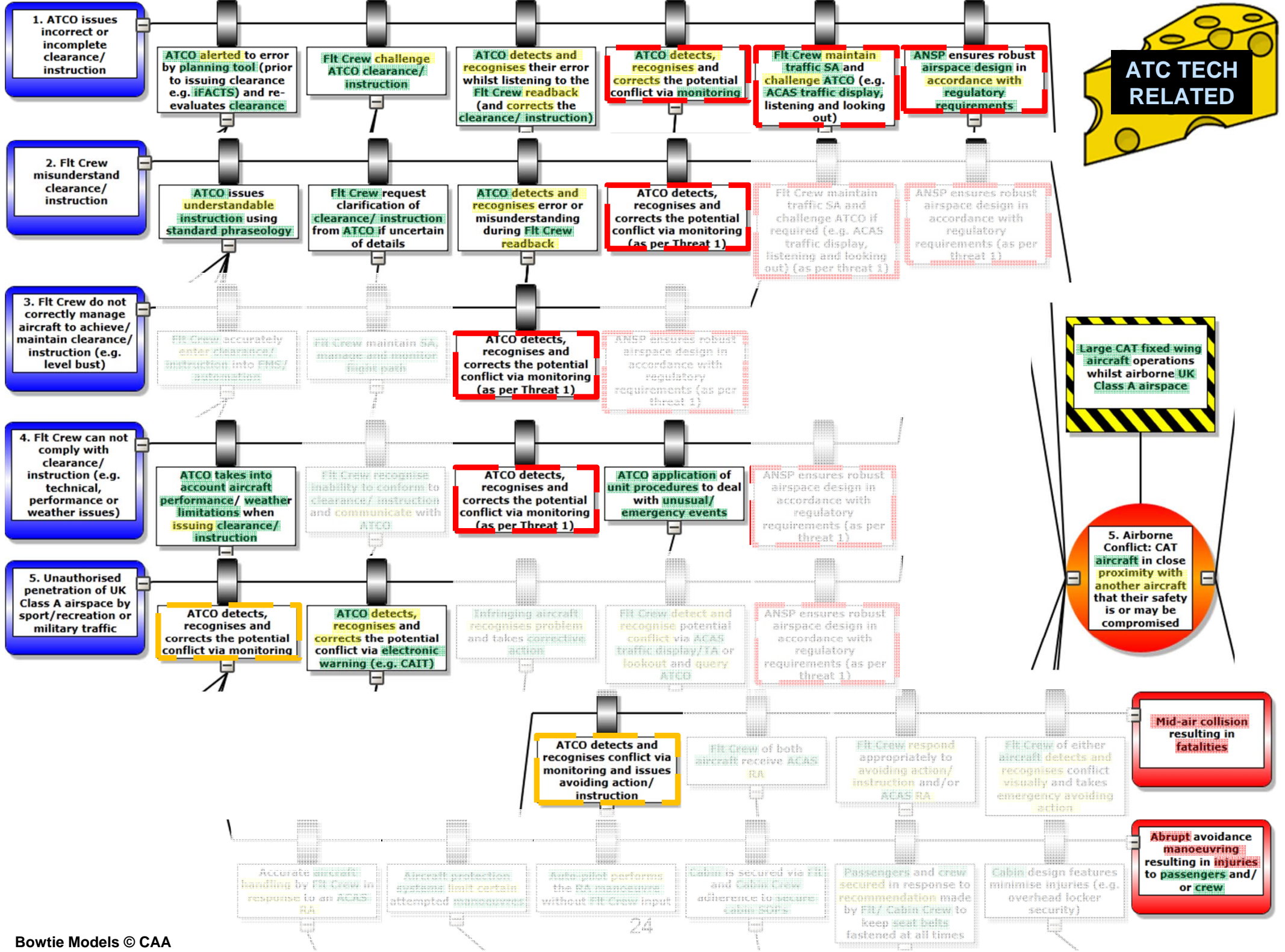
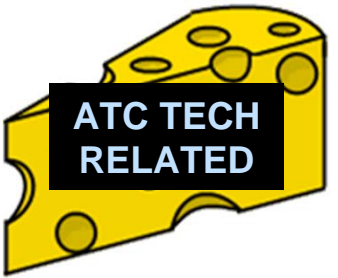
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Bowtie models presented
Bowtie Models © CAA

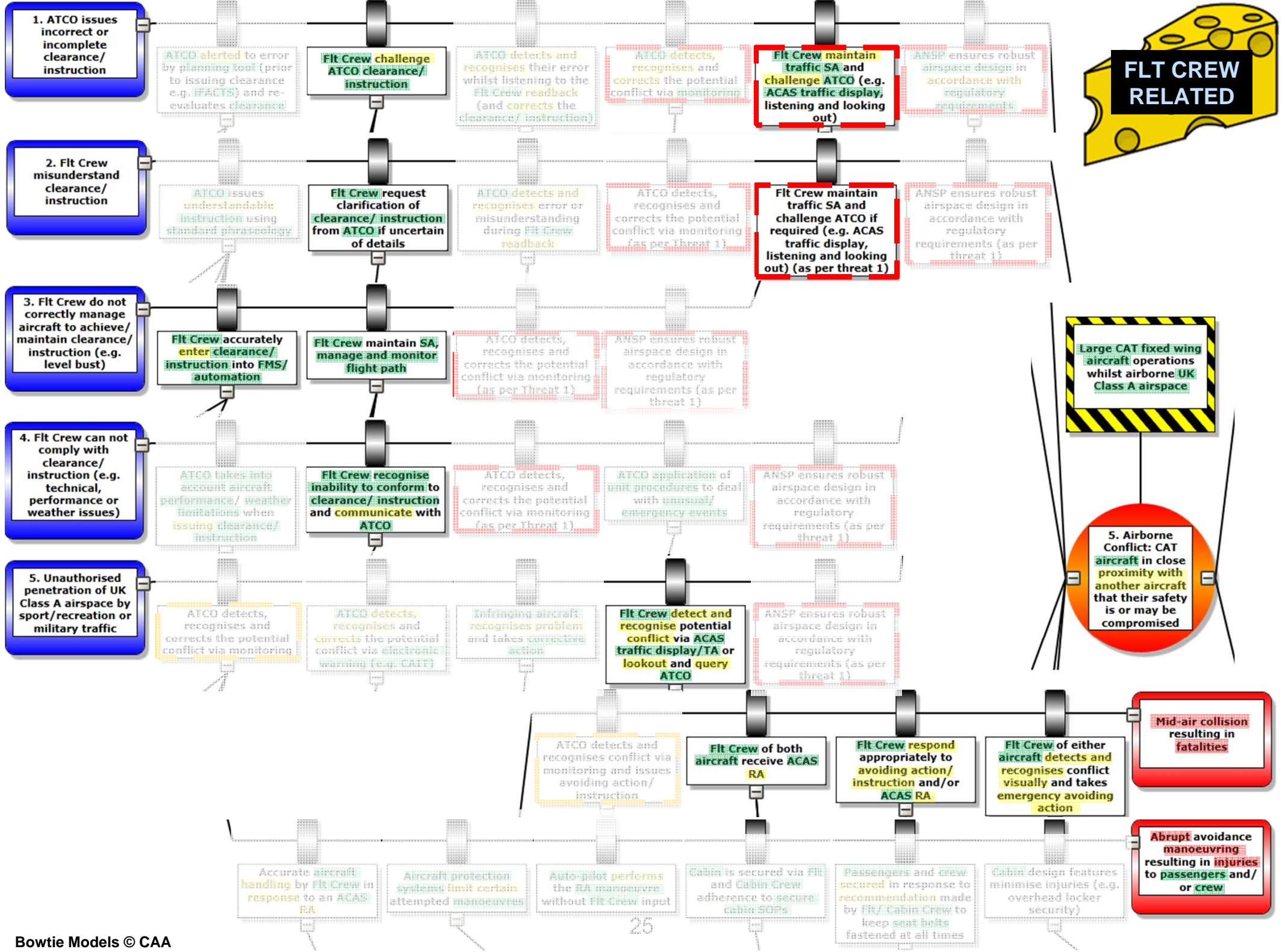




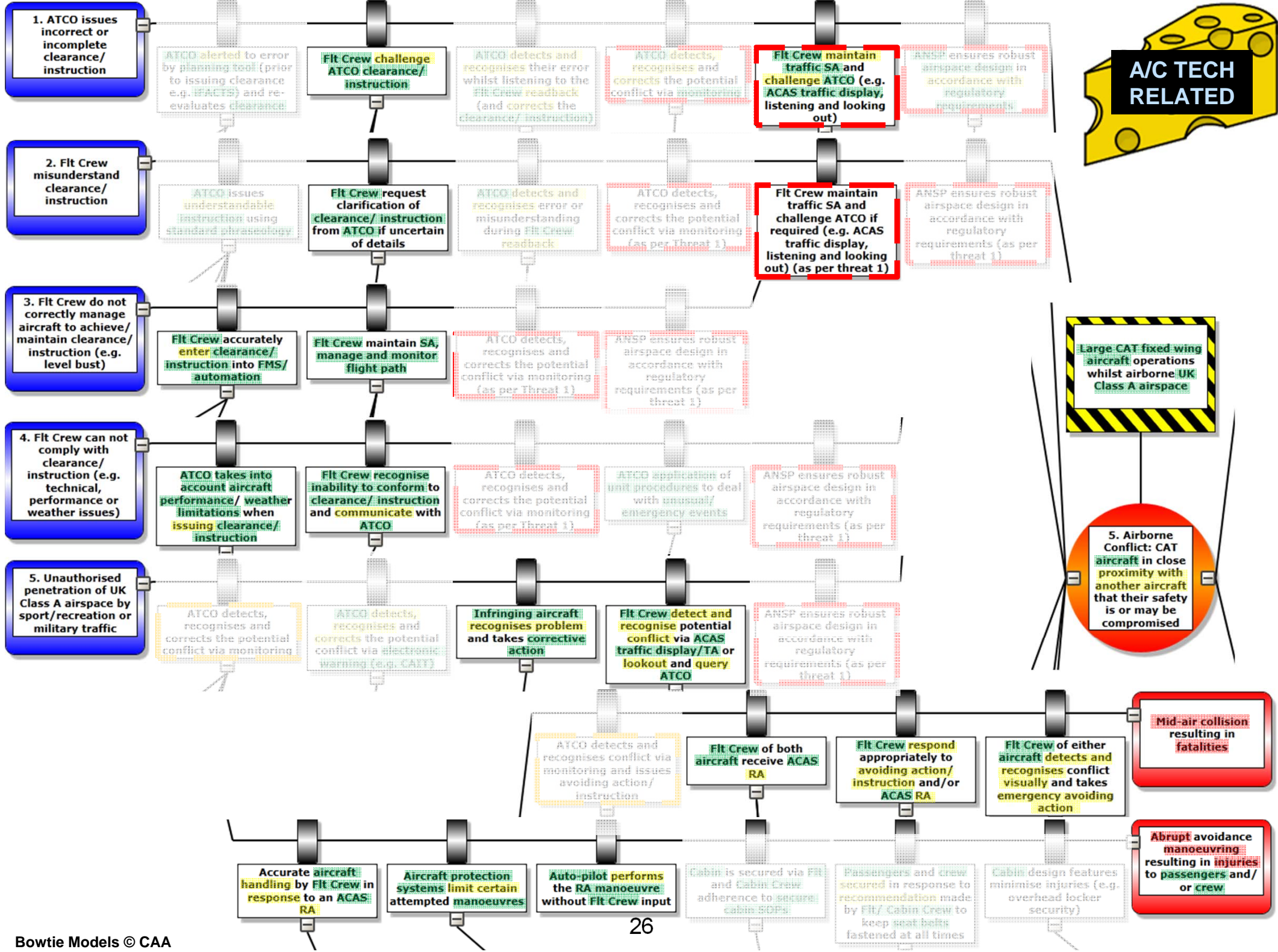


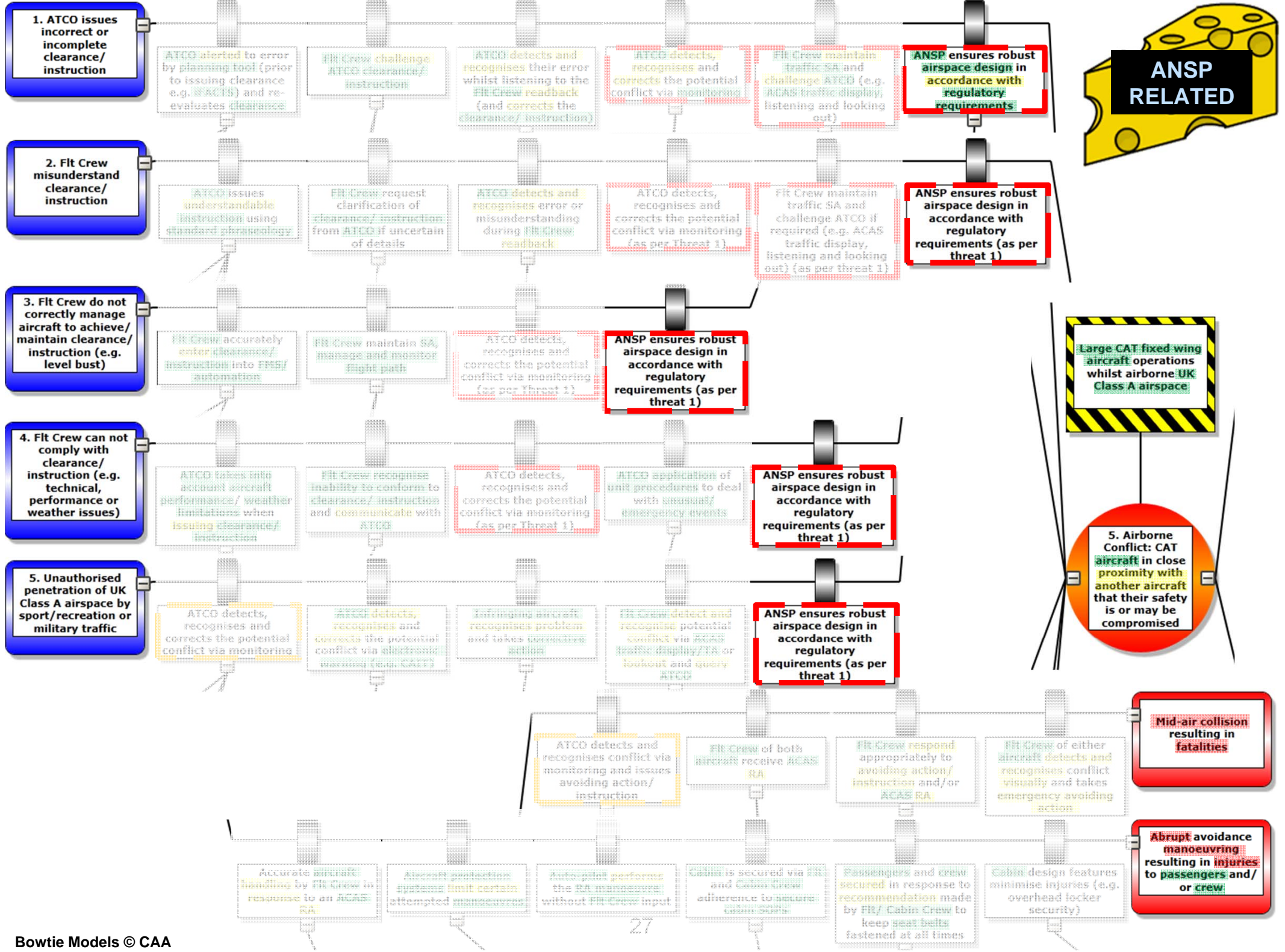






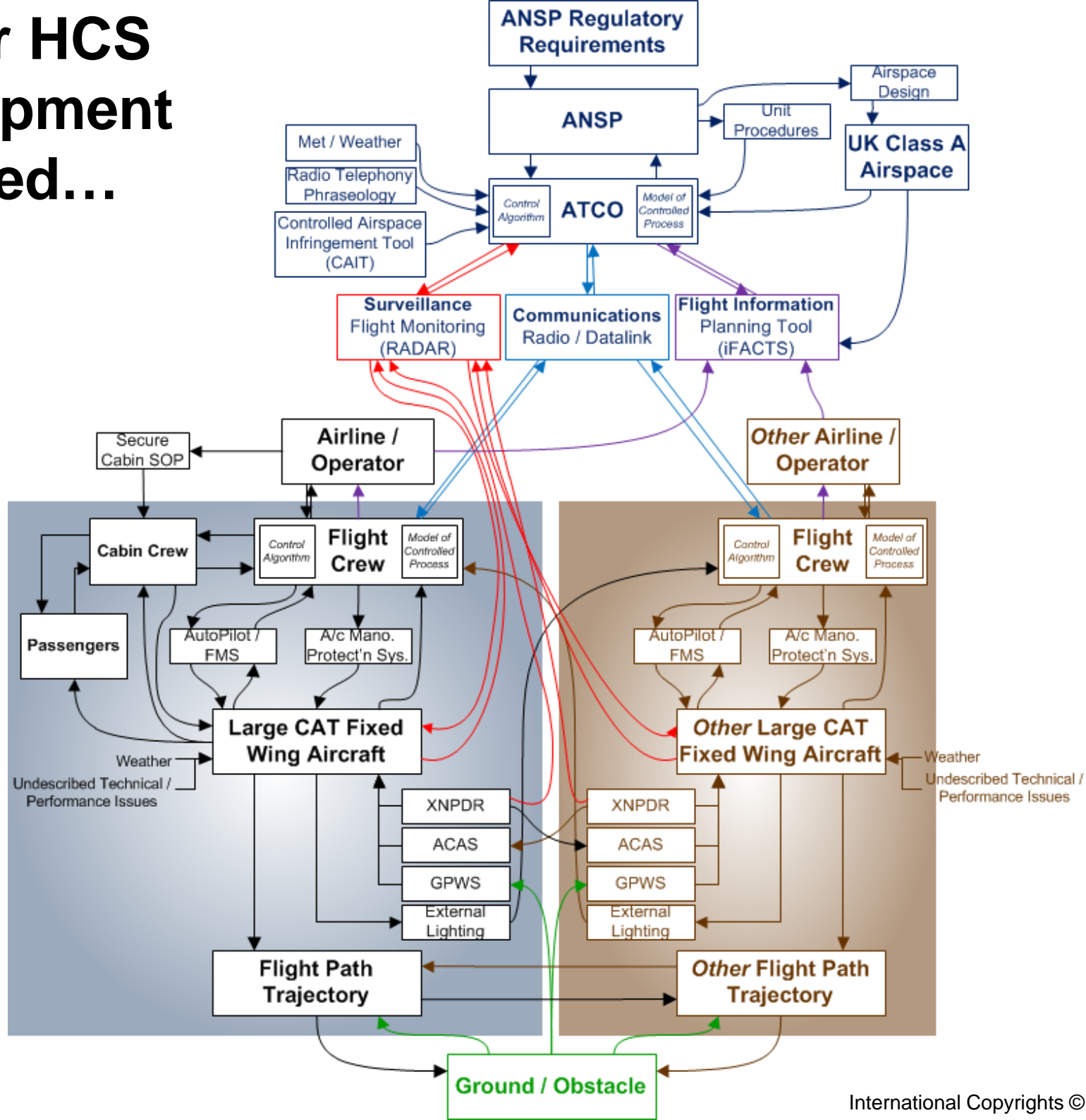
A/C TECH RELATED





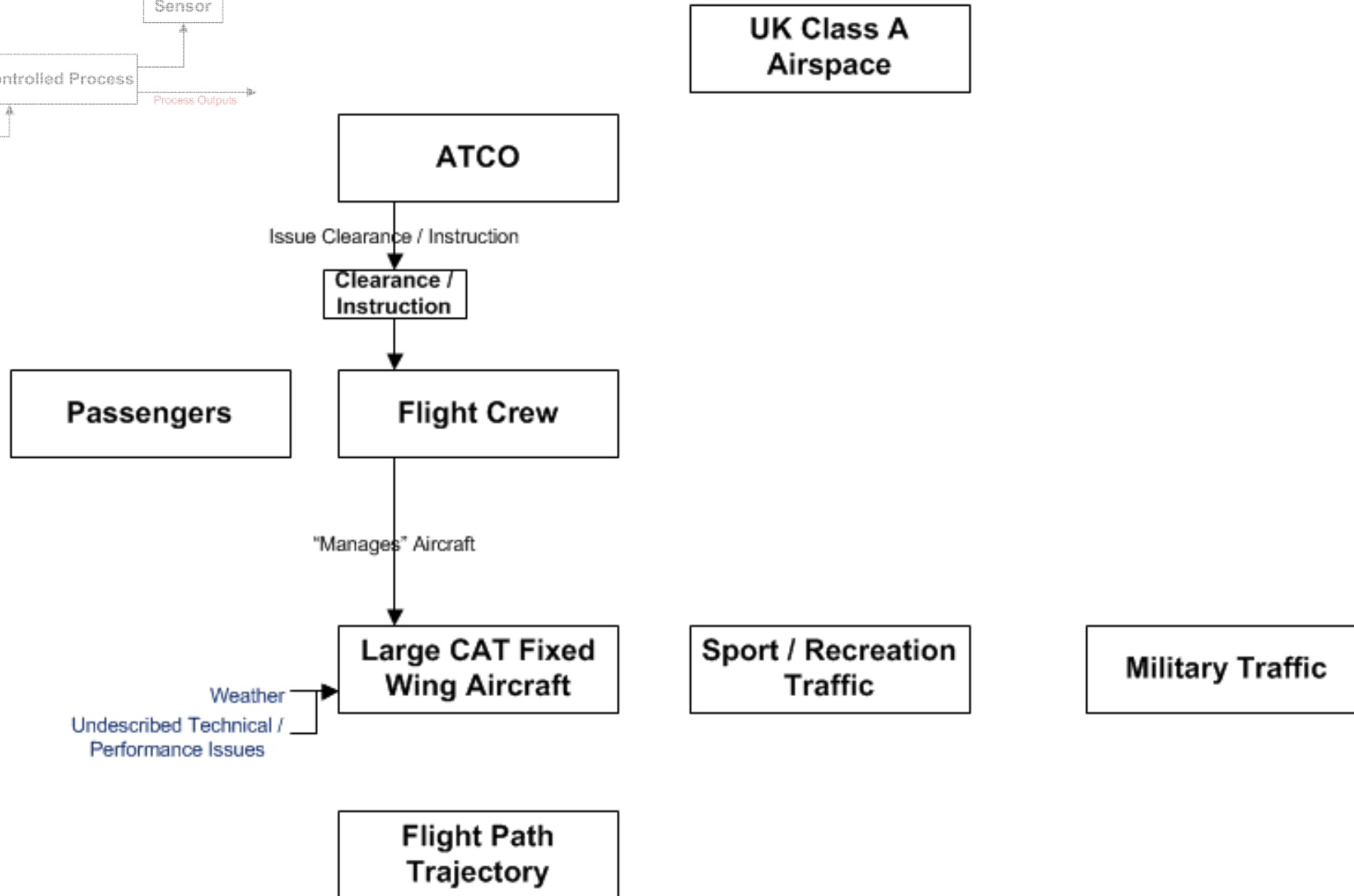
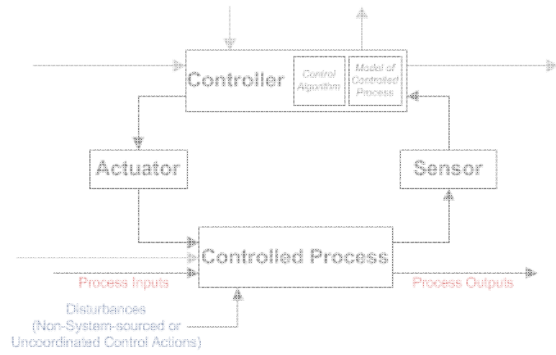
Controllers / Controlled Processes / Actuators / Sensors / Disturbances (System Components)		Interactions / Relationships (Control Actions / Feedback)	
Large CAT Fixed Wing Aircraft	ANSP	AutoPilot	Flight Path Trajectory / Aircraft Proximity
UK Class A Airspace	Airspace Design	Cabin Crew	Issues Clearance / Instruction
ATCO	Regulatory Requirements	Cabin	“Manages” aircraft
Clearance / Instruction	Standard Phraseology	Seat Belts	Penetration of Airspace
Flight Crew	FMS / Automation	Secure Cabin SOP	Planning Tool Alerts
Passengers	Flight Path Monitoring (Flight Crew)		Challenge Clearance / Instruction
Weather	Account for Aircraft performance / weather limitations		Detection, Recognition & Correction
Undescribed* Technical / Performance Issues	Recognise inability to confirm to clearance / instruction		Readback
Sport / Recreation Traffic	Unit Procedures (Unusual / Emergency Events)		Enter into FMS/ Automation
Military Traffic	Electronic Warning (e.g. Controlled Airspace Infringement Tool (CAIT))		CAIT Alerts
Planning Tool (iFACTS)	Infringing Aircraft		ACAS Resolution Advisory (RA)
Flight Monitoring (RADAR)	Aircraft Protection System		Aircraft Handling
Traffic Situation Awareness (Flight Crew)			Aircraft Protection System Manoeuvre limits
ACAS & Traffic Advisory (TA) / Traffic Display			RA Manoeuvre
			Emergency Avoiding Action
			Secure Cabin

Further HCS Development Required...



Raw Bowtie ==> STAMP HCS

General Form



Enrichment: Findings Overview

- Bowtie
 - Bowtie Analysis quickly becomes complicated, subjective & difficult to comprehend:
 - Especially where scenarios / common interactions occur, either in time, sequence, or physical space.
 - Inconsistent / inappropriate use of Positive / Negative language when describing Scenarios (Failure-focused, ignores “dangerous-successes”).

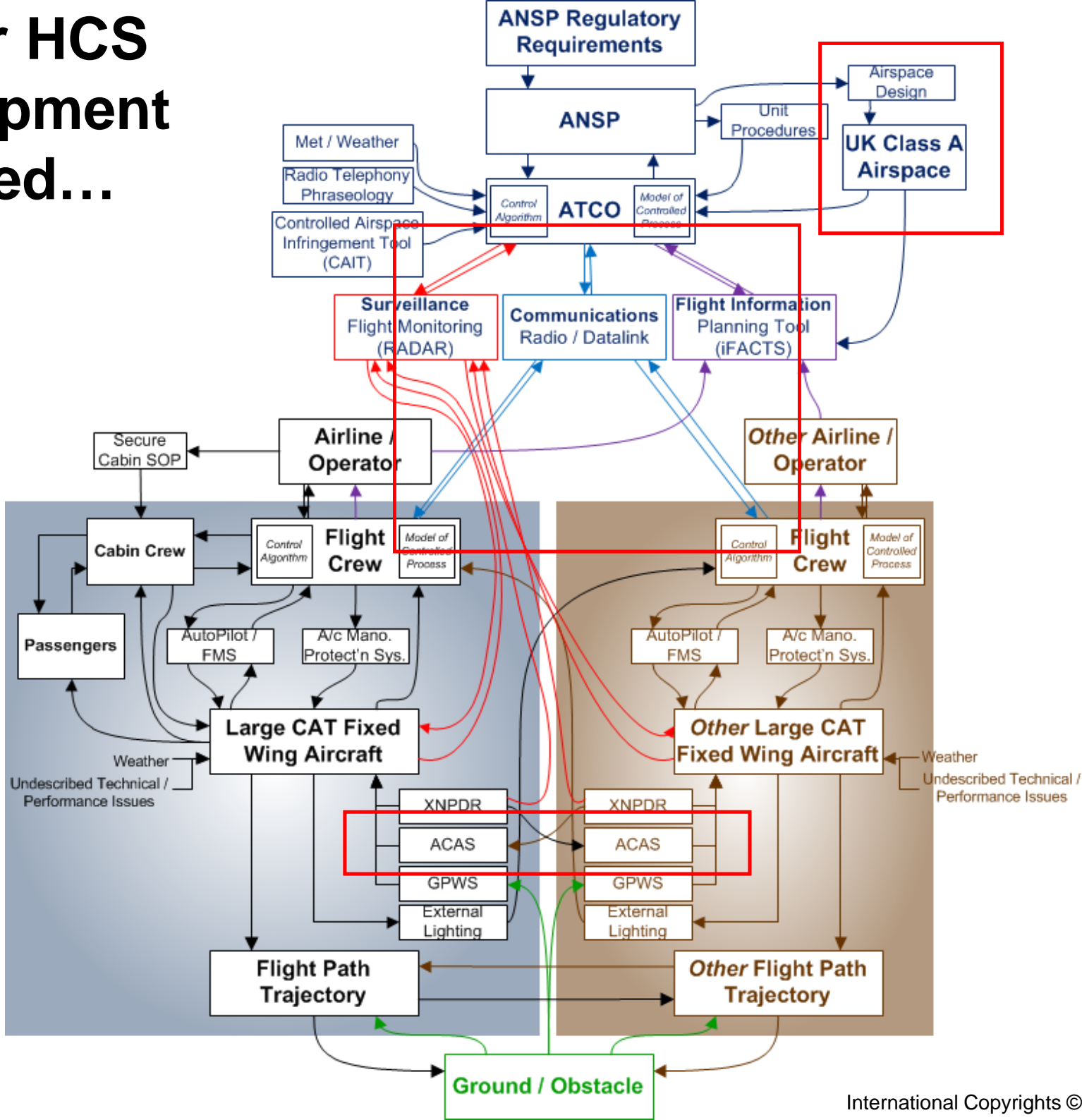
Enrichment: Findings Overview

- Bowtie
 - Bowtie creation helps to focus Analyst's attention, but also distracts and confuses, especially when multiple team members are involved.
 - Bow-tie form obscures interactions & other potentially unsafe scenarios.
 - Emphasises / Forces subjective oversimplification (to avoid the Bowtie getting too big).

Enrichment: Findings Overview

- STAMP + HCS Modelling
 - HCS Creation + “Closing-the-loop” focuses Analysts attention
 - Highlights interactions & other potential unsafe scenarios not already considered by the Bowtie, including:
 - No strict-failure scenarios, e.g. unable to visually acquire proximate Aircraft on collision trajectory.
 - Normal conditions that are potentially unsafe, e.g. Flight without ACAS or unreliable / blocked Radio Comms. (Signal Strength / Interference)

Further HCS Development Required...



Enrichment: Findings Overview

- STAMP + HCS Modelling
 - Highlights weak “controls / mitigations”: Over-accounted / optimistic.
 - Provides an objective Framework (the HCS) such that a common Mental Model is shared amongst Analysts, which helps Scenarios to be described and analysed with ease.

Biggest Take Aways

- STAMP enables very focused and specific assessments of complex scenarios.
- STAMP identifies many more causal scenarios than Bowtie (and other Traditional Methods).
- STAMP enables specific Safety Requirements / Constraints to be defined.

February 25th STAMP Introduction Webinar Replay:

<https://youtu.be/8bzWvII9OD4>

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