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SINGAPORE AVIATION SAFETY SEMINAR SASS

FLIGHT SAFETY FOUNDATION

SINGAPORE AVIATION ACADEMY

Singapore Aviation Safety Seminar (SASS)
March 28-30, 2017
Singapore Aviation Academy

The way ahead in aviation safety; time for a new approach.

Dr Rob Lee, AO, FRAeS, FCILT

International Consultant in Human Factors and Systems Safety

GPCAPT, RAAFSR.

Some history…

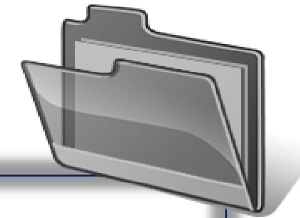
The Systemic Approach to Air Safety Investigation

- adopted by BASI in the mid 1980's became an ICAO Standard in 1994 (Annex 13)
- a **system** is:
  - an integrated assemblage of components, typically made up of people, hardware and software, that **interact** with each other to fulfil a common purpose that is greater than the sum of the individual purposes of the separate components.
    - *such as 'safe, effective, efficient and profitable aviation operations'; effective and efficient military aviation.*
    - *(after Kenyon de Greene, ed.,"Systems Psychology", 1970)*

Annex 13 to the Convention on International Civil Aviation

Aircraft Accident and Incident Investigation 10th Edition July 2010

Paragraph 1.17 - Organisational and Management Information



Pertinent information concerning the organizations and their management involved in influencing the operation of the aircraft.

The organizations include, for example, the operator; the air traffic services, airway, aerodrome and weather service agencies; and the regulatory authority.

The information could include, but not be limited to, organizational structure and functions, resources, economic status, management policies and practices, and regulatory framework.

The Reason Model of Systems Safety

- The Reason Model was endorsed by ICAO as a guide to the investigation of organisational and management factors.

Dr Alan Diehl, NTSB, 1970s

Downeast Airlines DH-6-200, 30 May, 1979

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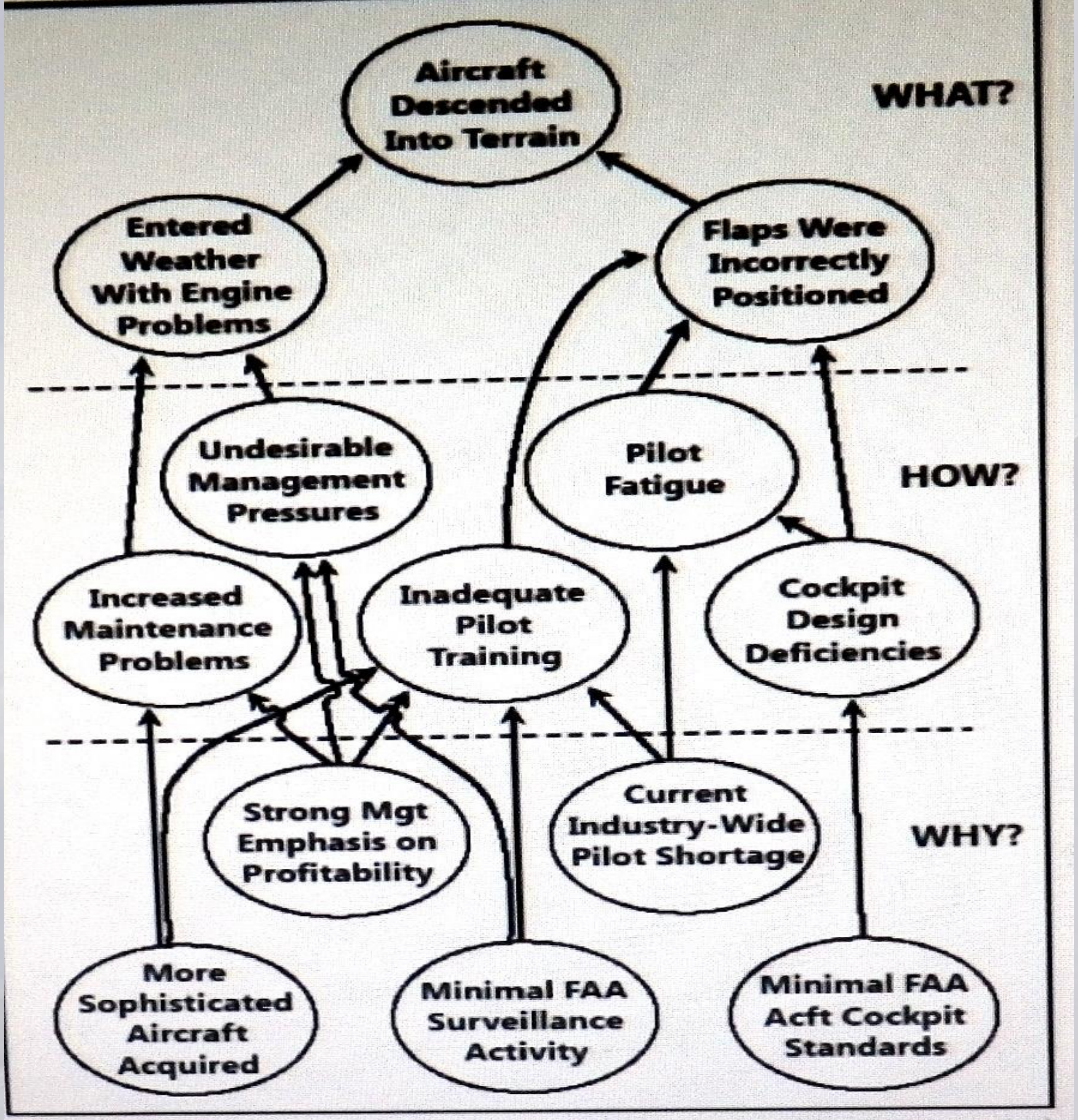

(Sketch by the Author)

Figure 3. What, How, Why Flowchart for the Downeast Crash.

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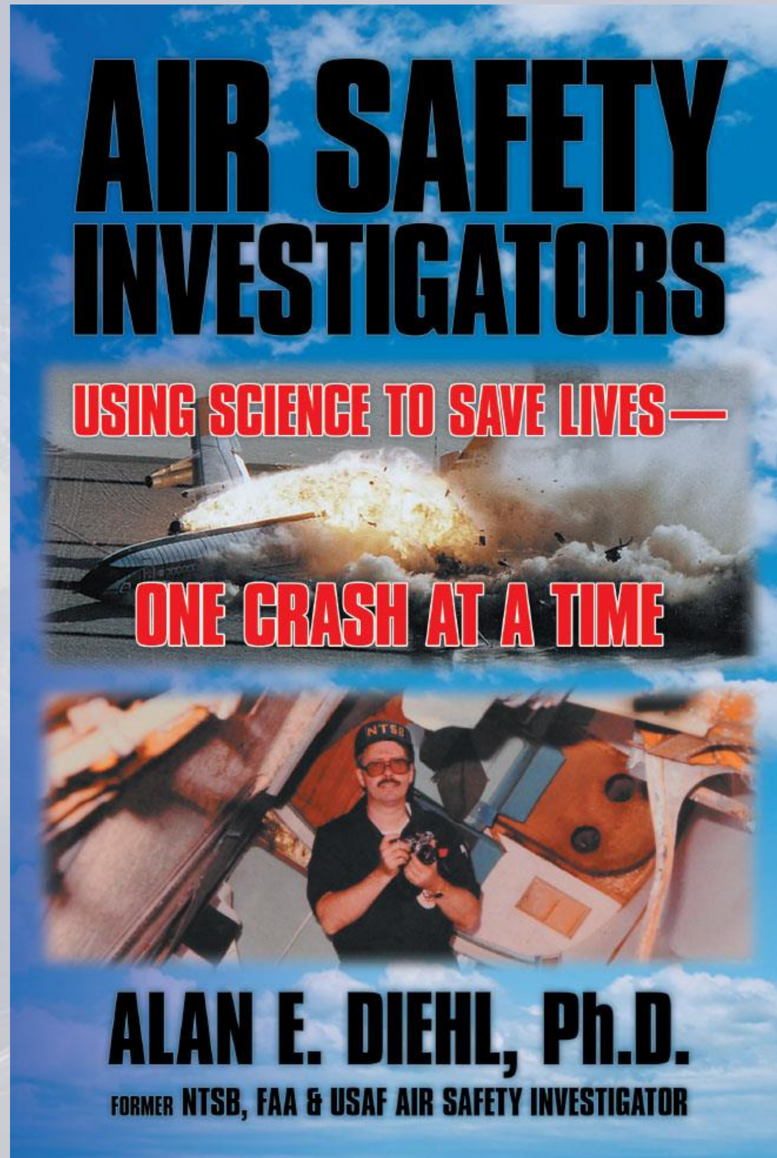

AIR SAFETY
INVESTIGATORS
USING SCIENCE TO SAVE LIVES—
ONE CRASH AT A TIME
NTSB
ALAN E. DIEHL, Ph.D.
FORMER NTSB, FAA & USAF AIR SAFETY INVESTIGATOR

First investigation using the Reason Model

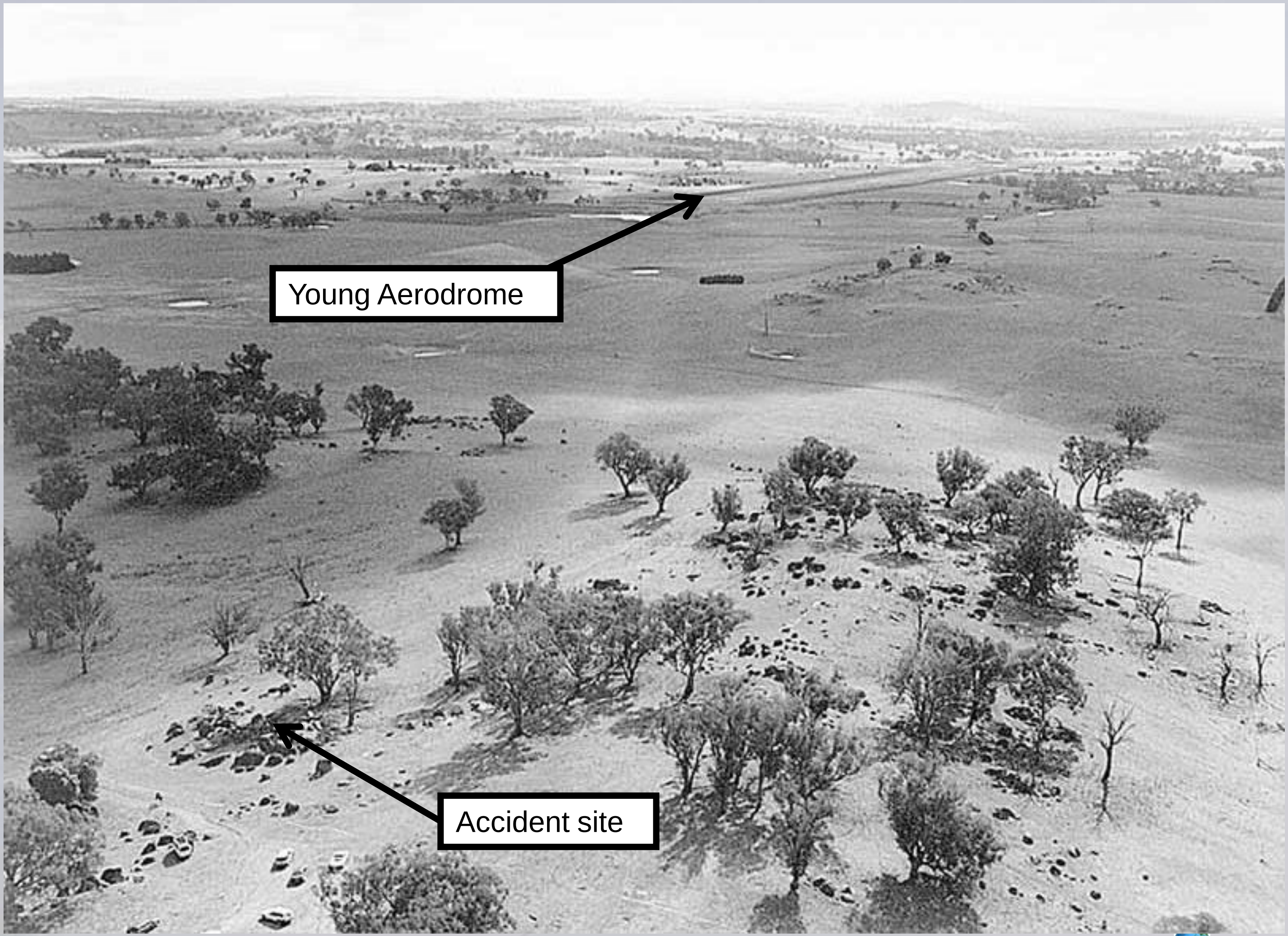
BASI INVESTIGATION REPORT

9301743

Piper PA31-350 Chieftain VH-NDU

Young, NSW

11 June 1993


Young Aerodrome
Accident site

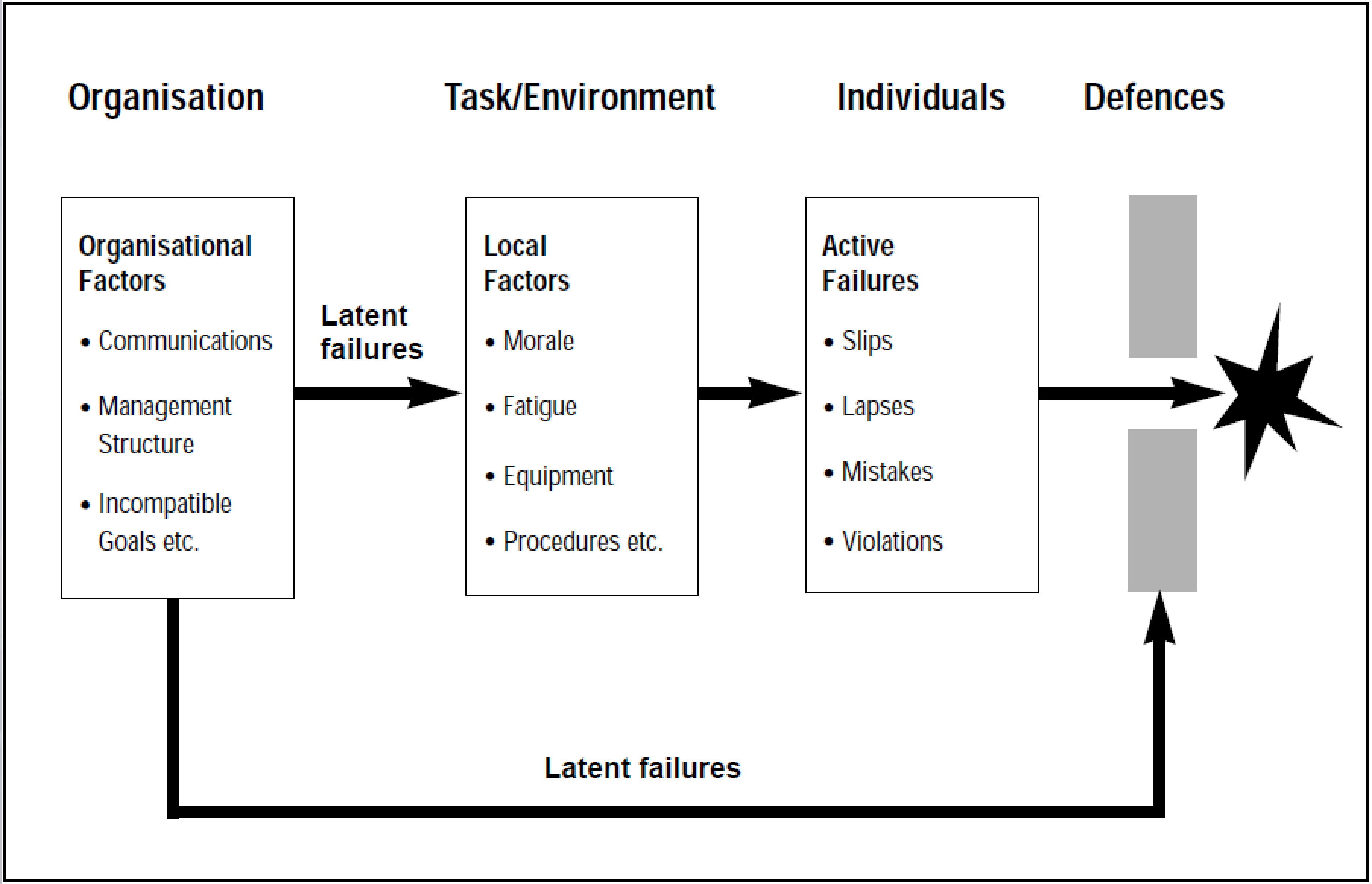


Figure 14 Diagram of the basic Reason model showing the elements of an 'organisational accident'.

Significant factors

1. The cloudbase in the Young circling area was below the minimum circling altitude, associated with dark night conditions and limited ground lighting.
2. The workload of the pilot-in-command was substantially increased by the effects of aircraft equipment deficiencies, with a possible consequent degrading of his performance as a result of skill fatigue.
3. The instrument approach and landing charts did not provide the flight crew with terrain information adequate for the assessment of obstacle clearance during a circling approach.
4. The Monarch operations manual did not provide the flight crew with guidance or procedures for the safe avoidance of terrain at Young during a night-circling approach.
5. The aircraft descended below the minimum circling altitude without adequate monitoring of obstacle clearance by the crew.
6. The visual cues available to the flight crew were insufficient as a sole source of height judgement.
7. **There were organisational deficiencies in the management and operation of RPT services by Monarch.**
8. **There were organisational deficiencies in the safety regulation of Monarch RPT operations by the CAA.**

Department of Transport and Regional Development

Bureau of Air Safety Investigation

INVESTIGATION REPORT
9402804

Rockwell Commander 690B VH-SVQ
en route Williamtown to Lord Howe Island
New South Wales
2 October 1994

Note: this is a generic image of the aircraft type

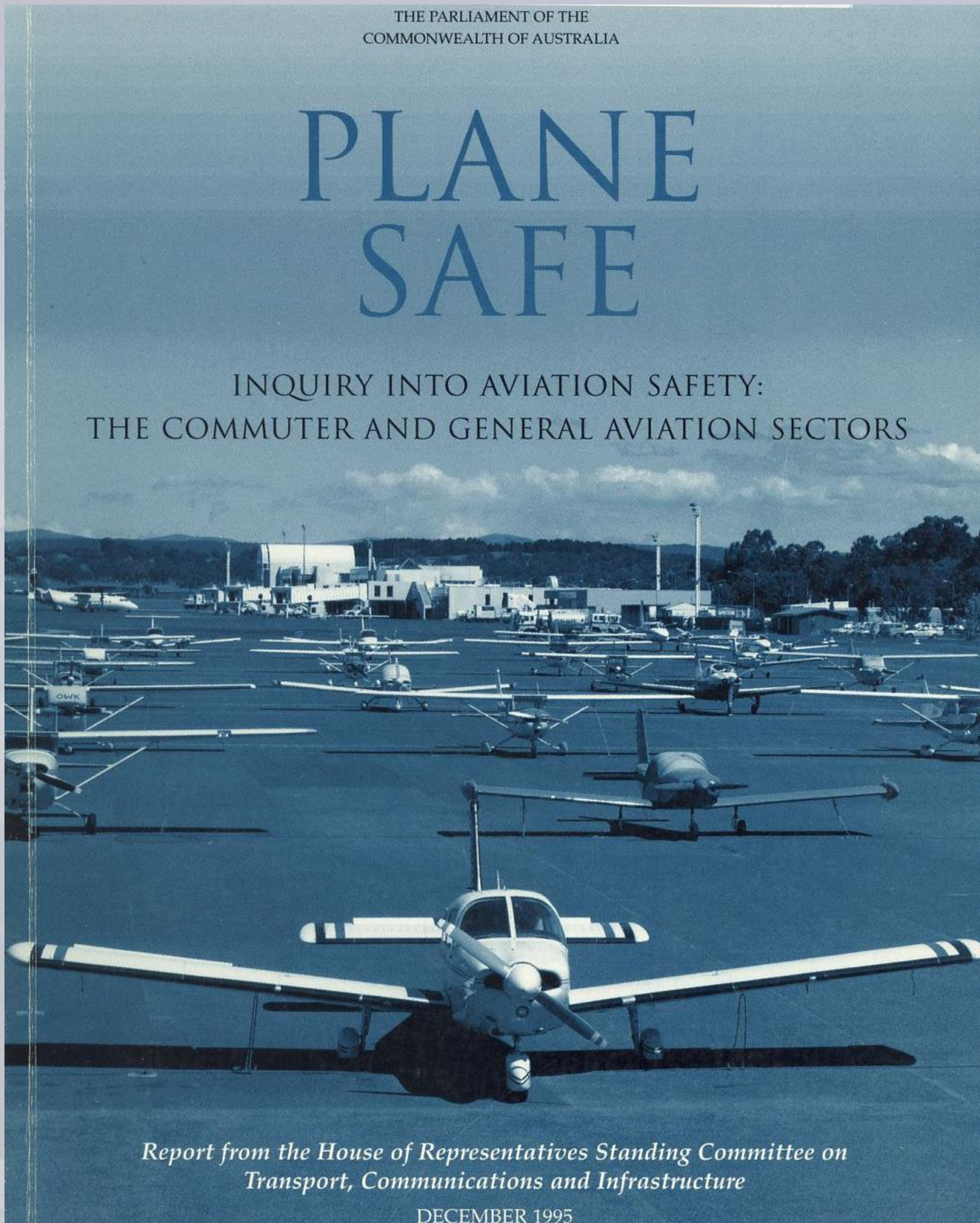
BASI
Bureau of Air Safety Investigation

Released by the Secretary of the Department of Transport and Regional Development under the provisions of Section 19CU of part 2A of the Air Navigation Act (1920).

Commission of Inquiry into the Relations Between the CAA and Seaview Air (Staunton)

- South Pacific Airmotive DC-3, Botany Bay, 24 Apr 1994

- Ansett B747, Sydney, 19 Oct 1994



Ultimate outcome:
CAA split into
Air Services
Australia and
CASA,
6 July, 1995

An example of a contemporary systemic investigation:

The Lockhart River Accident: a case study in system failure

Australian Government

Australian Transport Safety Bureau

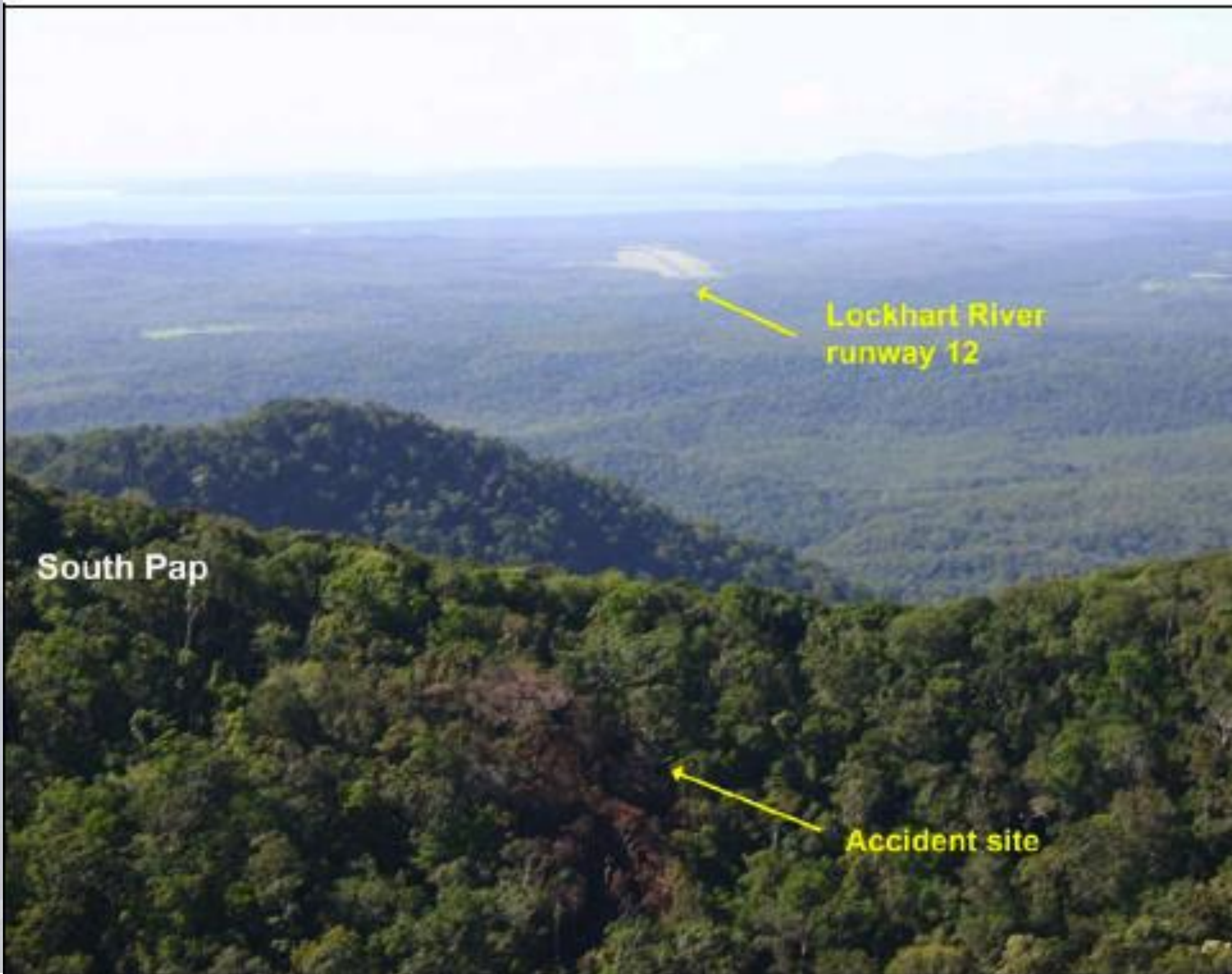
ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Report 200501977

Final

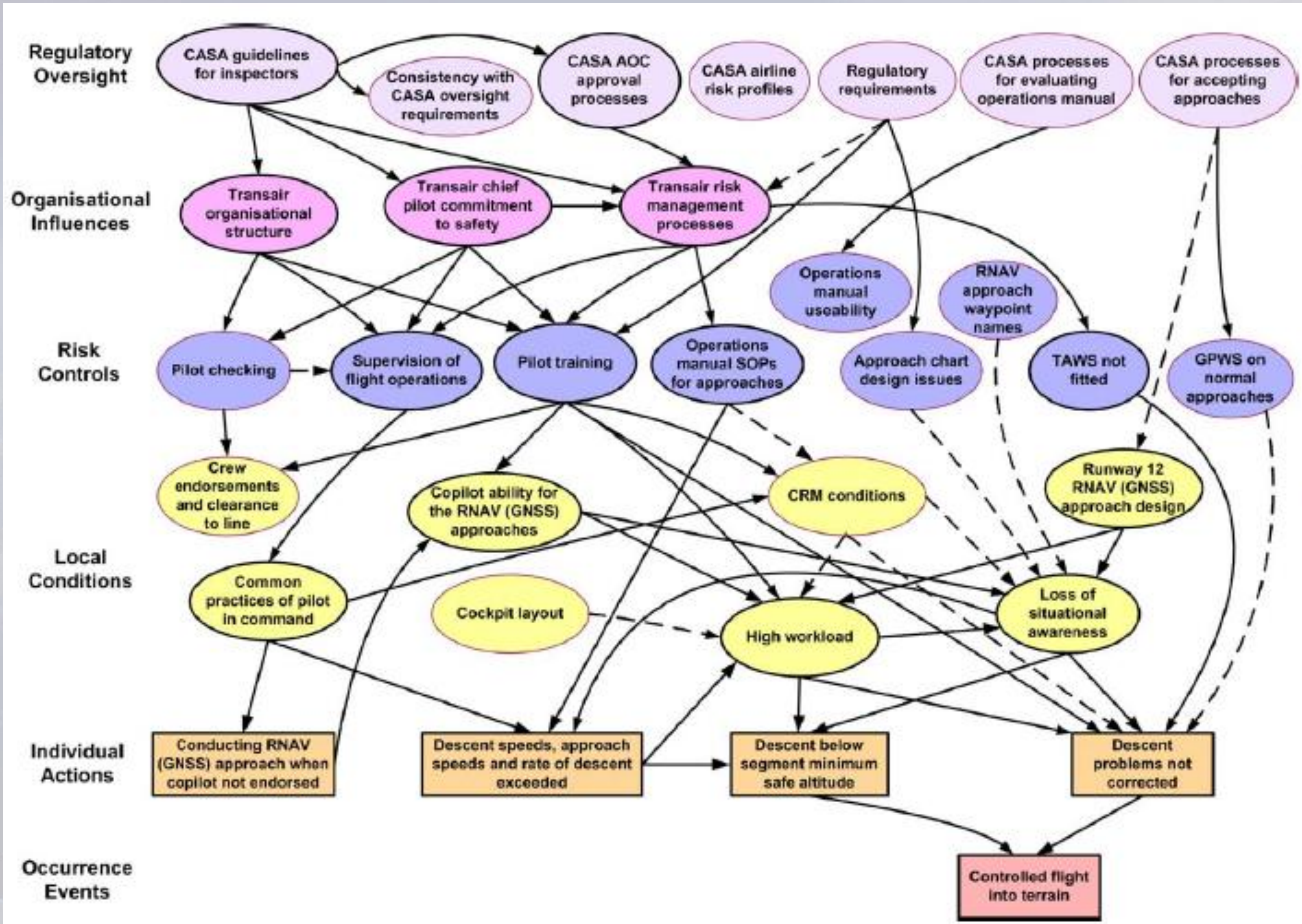
Collision with Terrain
11 km NW Lockhart River Aerodrome
7 May 2005
VH-TFU
SA227-DC (Metro 23)

Figure 19: General view of the accident site looking toward the south-east



Ltd

Figure 21: View along the direction of travel showing the rock outcrop and main wreckage in the background



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The systemic approach to air safety investigation became an ICAO Standard in 1994

- The safety outcomes of the international adoption of a systemic approach to air safety investigation since 1994 have been the key drivers for the adoption of safety management systems in civil aviation.

The past…1991

F-104 in Germany

916 aircraft in service 1960 - 1987
292 aircraft lost
Attrition: 31.8%
115 fatalities

RAAF Mirage III

116 aircraft in service 1963 - 1987

43 aircraft lost

Attrition: 37.06%

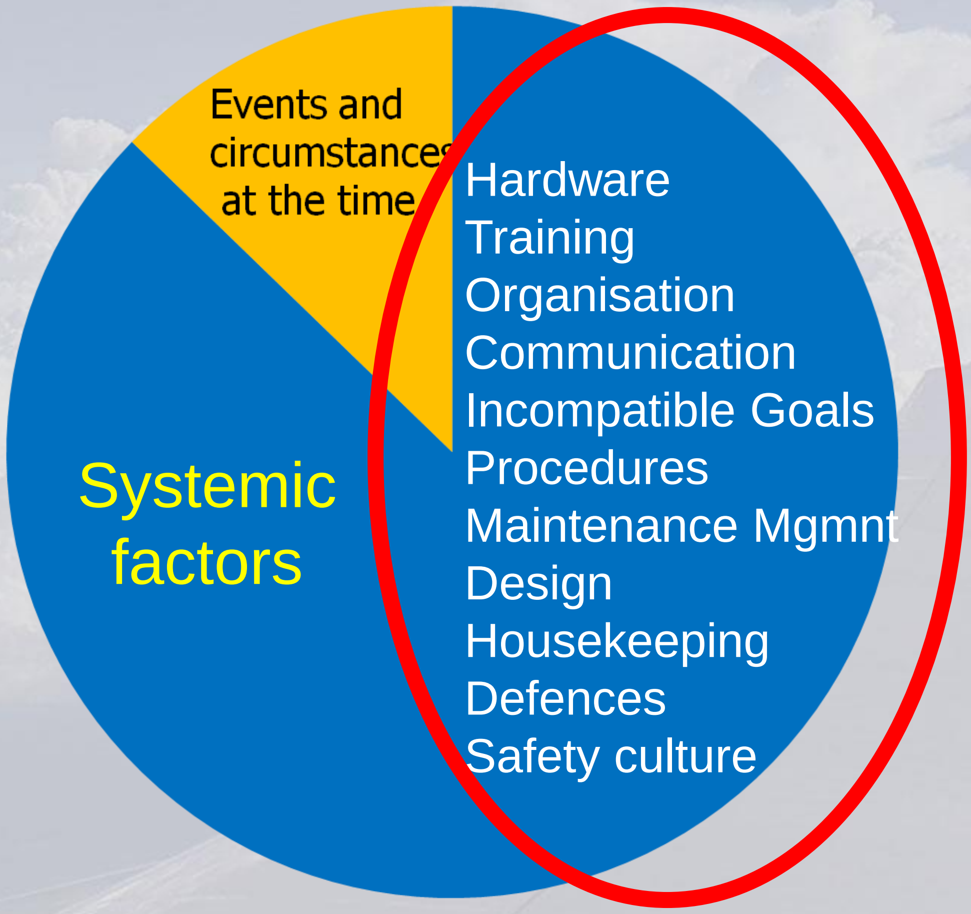
14 fatalities

The present….

The reasons why SMS have become ICAO Standards

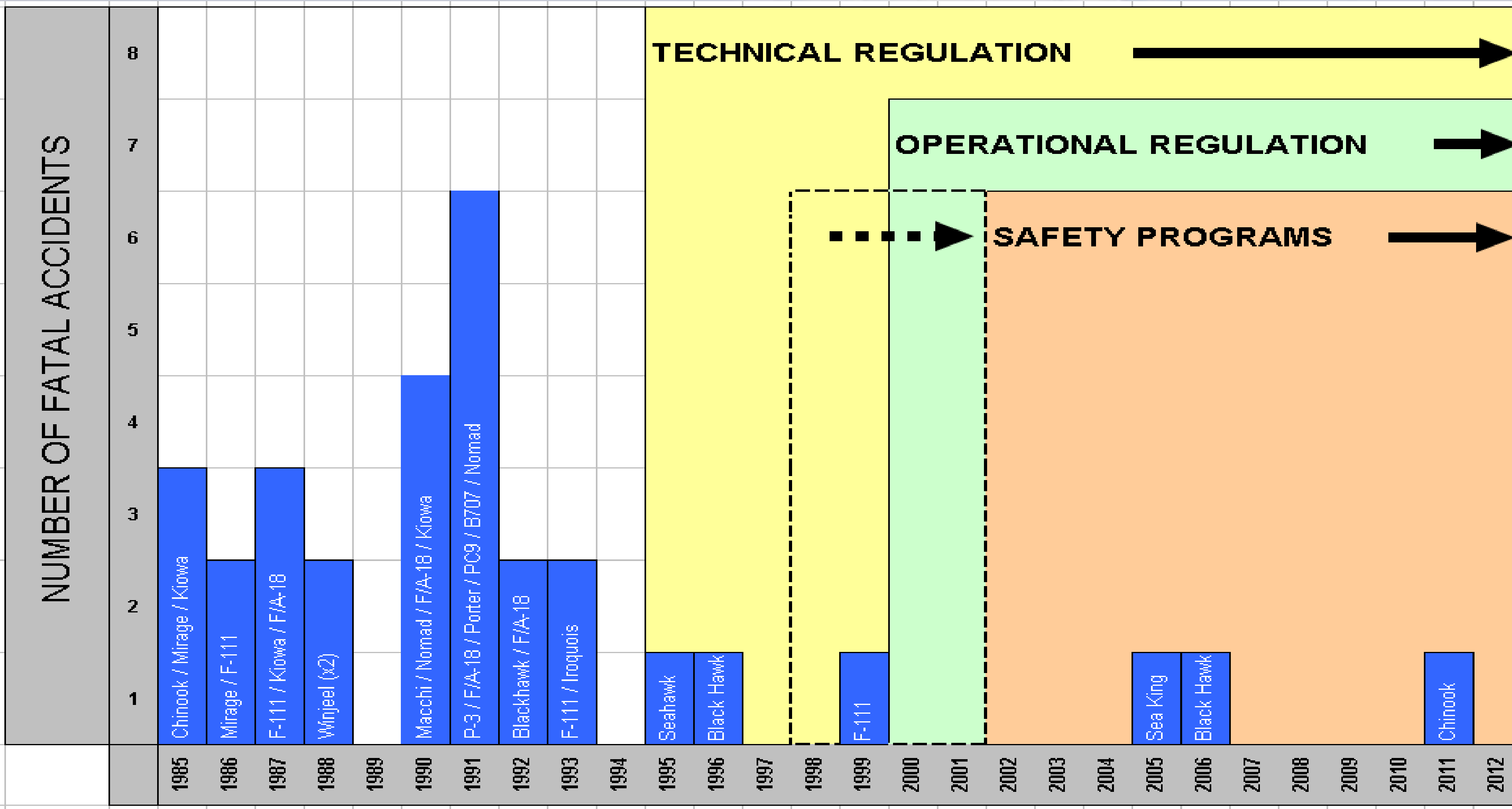
In virtually all aviation accidents and serious incidents, the subsequent systemic investigation has shown that:

- The primary contributing factors were all present before the accident/incident.
- In most cases they were common knowledge, and had been formally documented.
- In all cases, they could, and should, have been identified and rectified before the accident.



Total factors contributing to accidents

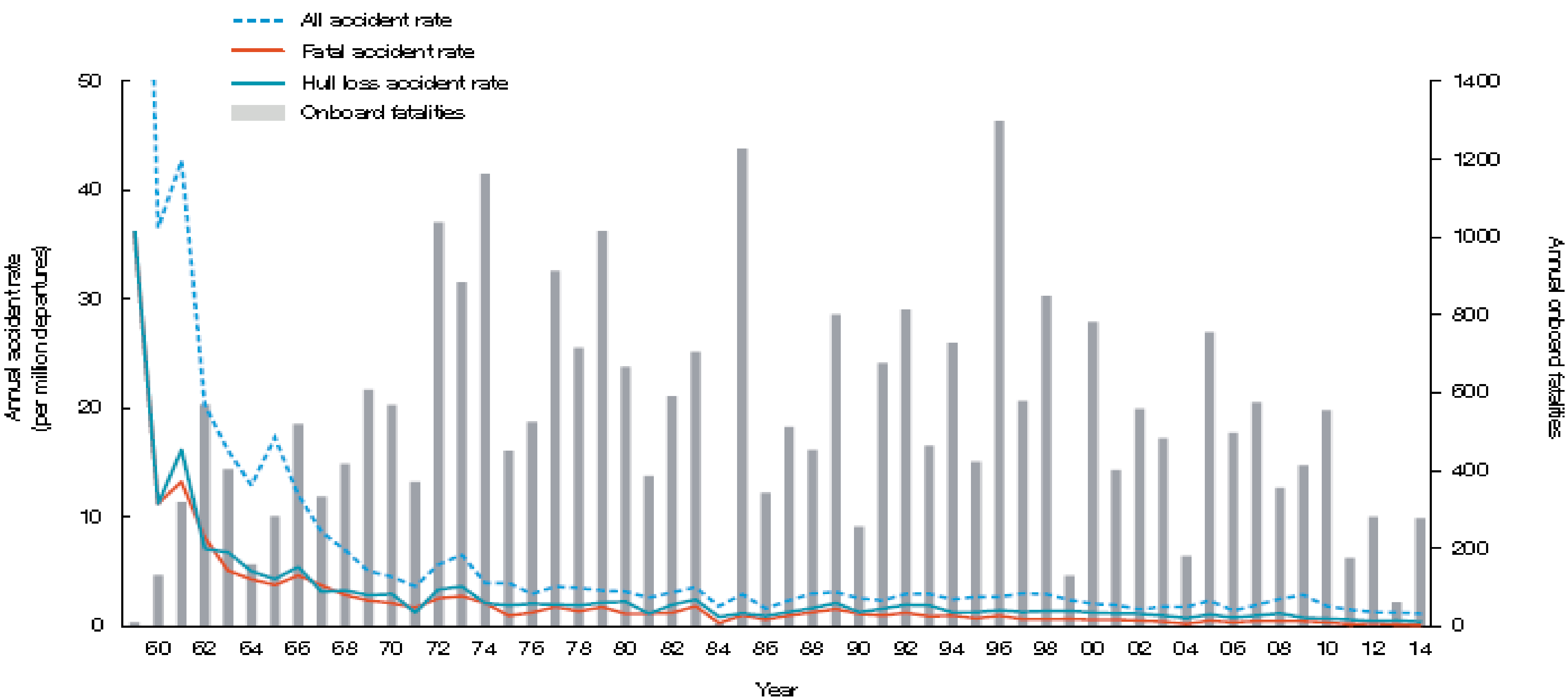
ADF FATAL ACCIDENTS 1985 - CURRENT



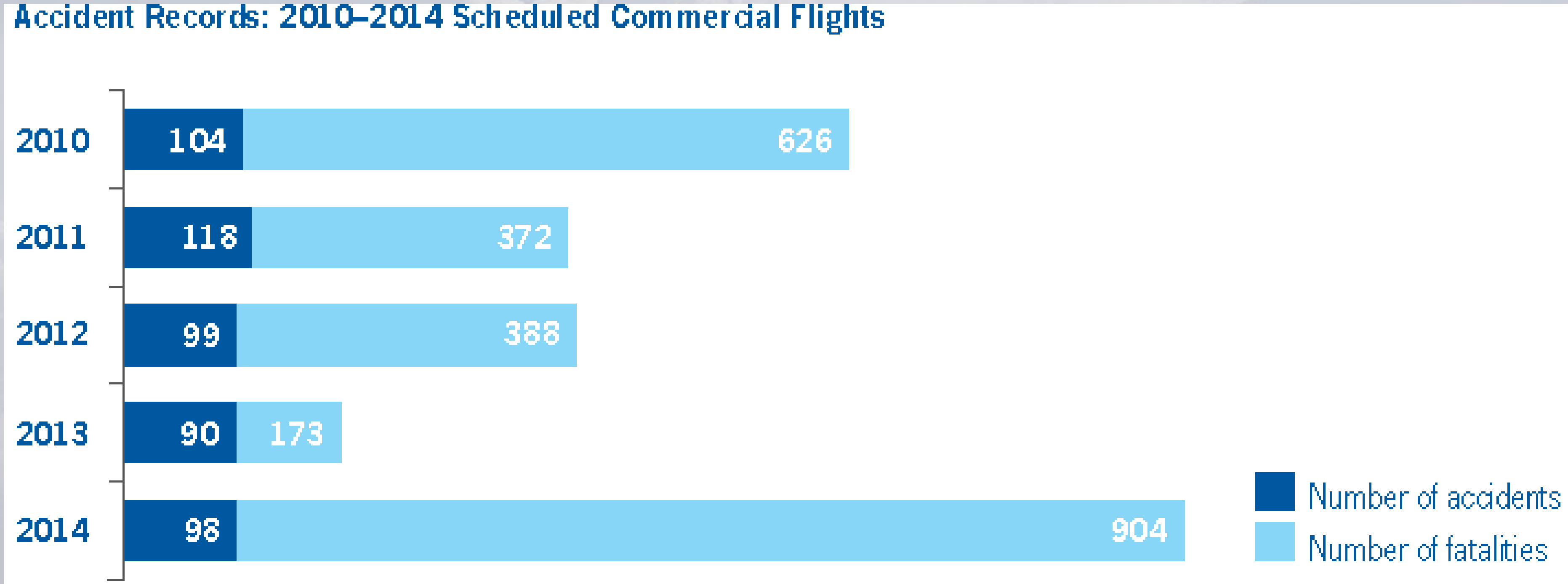
Civil aviation accident data (Boeing, 2015)

Accident Rates and Onboard Fatalities by Year

Worldwide Commercial Jet Fleet | 1959 through 2014



https://www.youtube.com/watch?v=SrZSelcIxWM



Source: ICAO Safety Report, 2015 edition

The future

100 years improving aviation safety

AAIB

Air Accidents Investigation Branch

1915 ~ 2015

AAIB Centenary Conference 14 October 2015

'100 Years of Accident Investigation - what's next?'

London,14 October 2015.

ISASI Award of Excellence, 2015

Learning from and Preparing for Traditional Airline Accident Investigation While Transitioning to SMS Risk-Based Investigation

Timothy Logan, Senior Director Safety Risk Management,
Dennis Post, Senior Safety Investigator, Southwest Airlines

Members of the next generation of investigators are entering an industry in which operational safety risks are more often identified through safety data and voluntary reporting programs (ASAP, FOQA, LOSA, VDRP) than accidents. Never before has the full might of the industry been able to shift toward predictive investigations rather than reactive.

The "new" airline safety investigator is entering an industry where the work of the "old" safety investigator has nearly been made self-extinct.

The authors propose to describe how the next generation of investigators will need to transition from often years-long accident investigations to quicker, tactical, risk-based investigations without sacrificing depth or quality.

Prescriptive & Performance based environment

Prescriptive based environment

Regulations as <u>administrative</u> controls

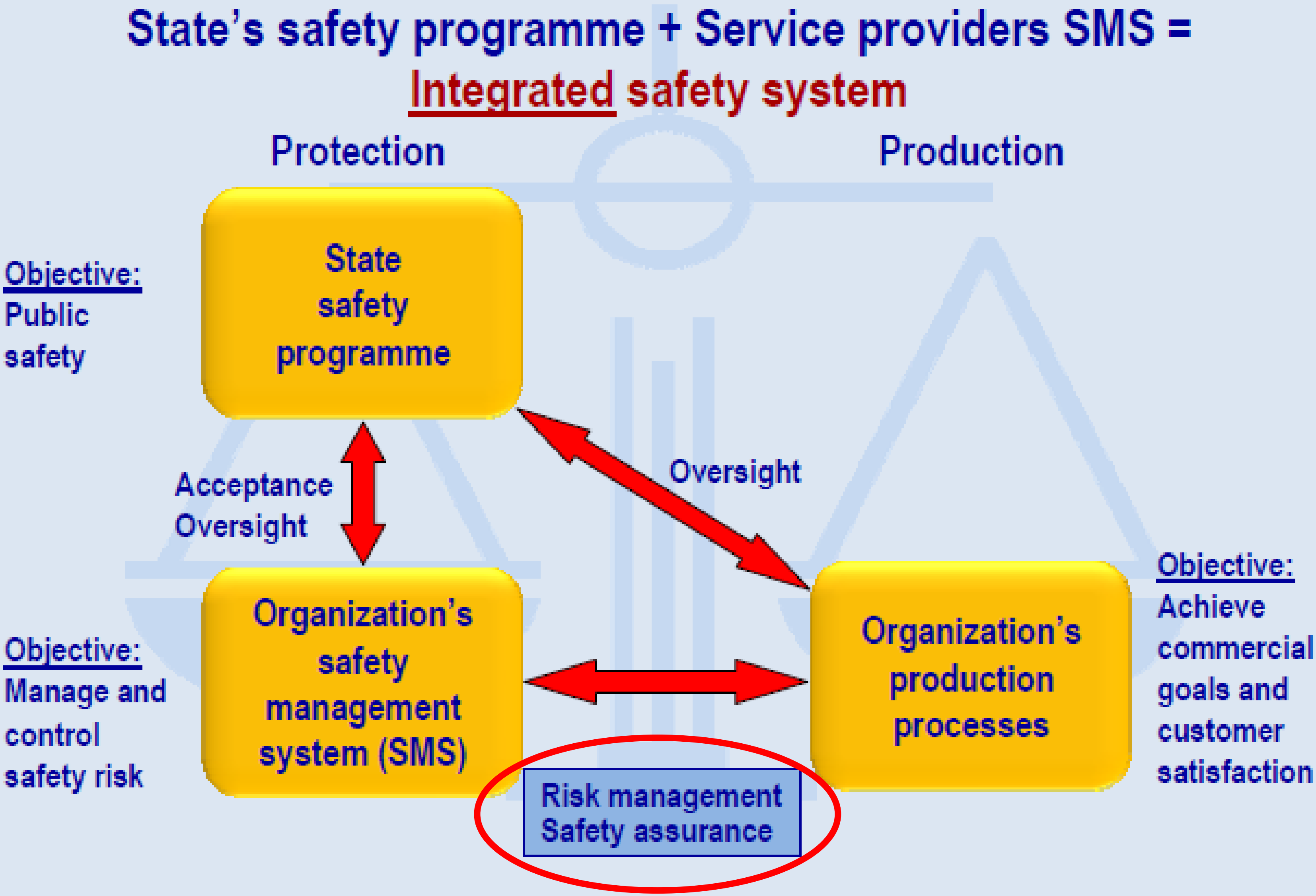
- Rigid regulatory framework
  - Inspections
  - Audits
    - ✓ ***Regulatory compliance***

Performance based environment

Regulations as <u>safety risk</u> controls

- Dynamic regulatory framework
  - Data based identification
  - Prioritization of safety risks
    - ✓ ***Effective safety performance***

A vision of the future – Integration



ICAO Annex 19 SMS Components and Elements

1. Safety policy and objectives

1.1 Management commitment and responsibility

1.2 Safety accountabilities

1.3 Appointment of key safety personnel

1.4 Coordination of emergency response planning

1.5 SMS documentation

2. Safety risk management

2.1 Hazard identification

2.2 Safety risk assessment and mitigation

3. Safety assurance

3.1 Safety performance monitoring and measurement

3.2 The management of change

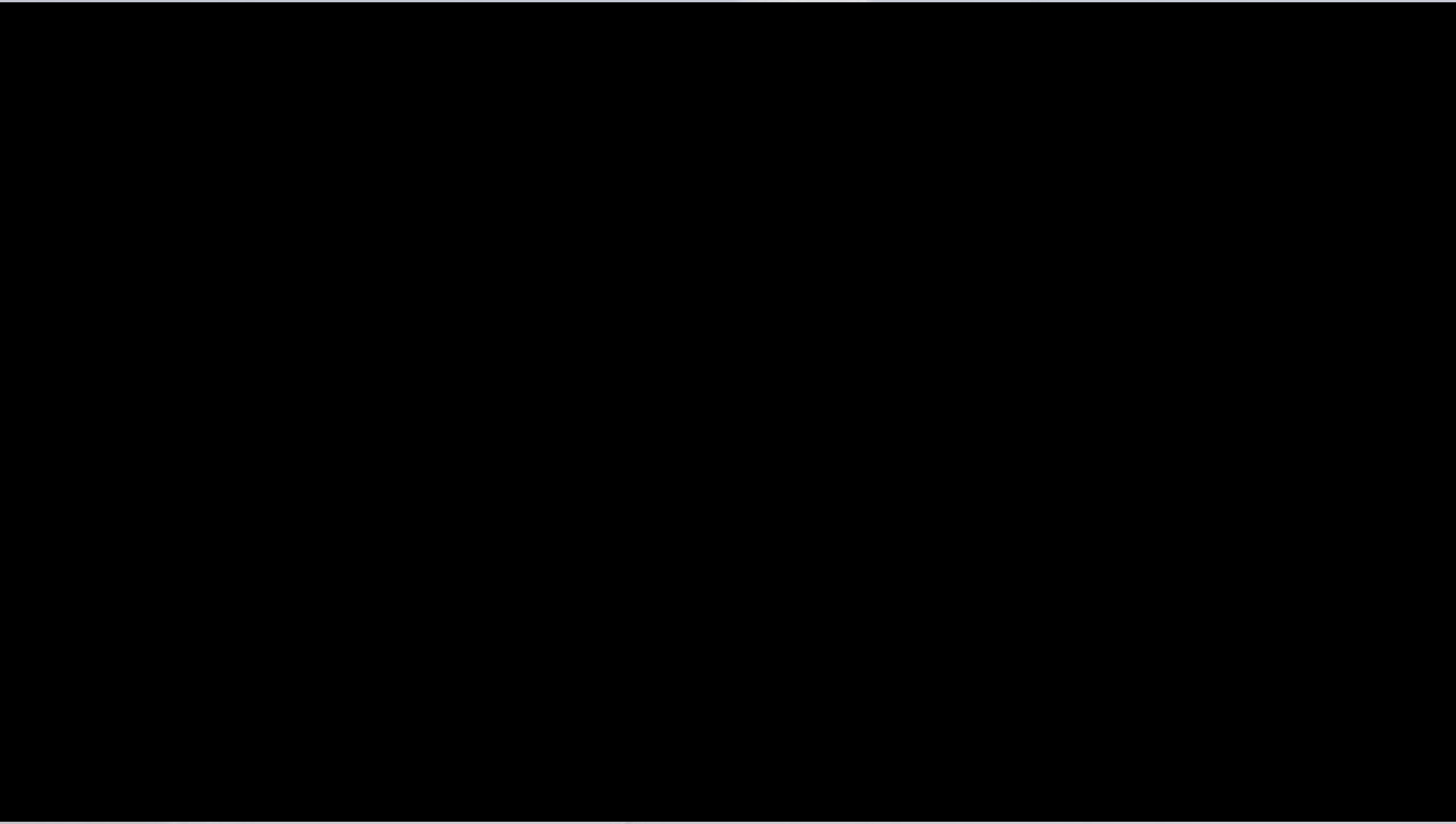
3.3 Continuous improvement of the SMS

4. Safety promotion

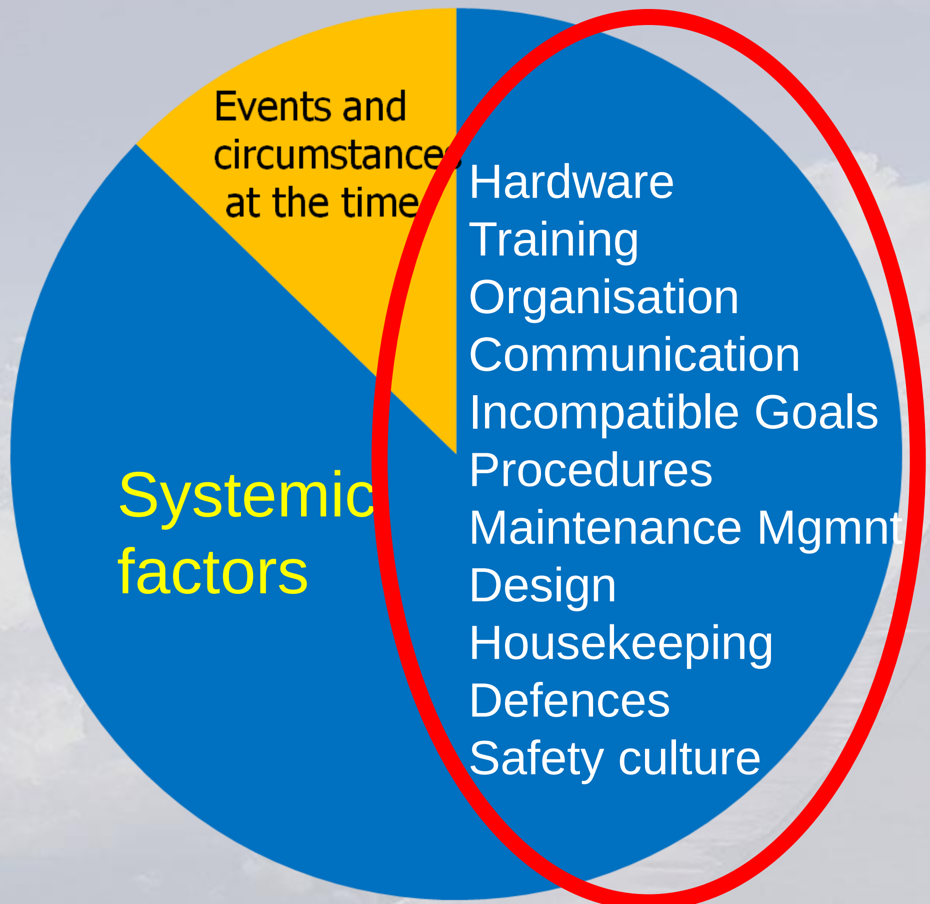
4.1 Training and education

4.2 Safety communication

The future….



https://www.youtube.com/watch?v=g4WVKrXAaN0



- Total factors contributing to accidents.
- What are the safety lessons from this situation?


ICAO
SAFETY
Safety Report
2015 Edition

A Coordinated, Risk-based Approach to Improving Global Aviation Safety

The air transport industry plays a major role in world economic activity. One of the key elements to maintaining the vitality of civil aviation is to ensure safe, secure, efficient and environmentally sustainable operations at the global, regional and national levels.

A specialized agency of the United Nations, the International Civil Aviation Organization (ICAO) was created in 1944 to promote the safe and orderly development of international civil aviation throughout the world.

ICAO sets the Standards and Recommended Practices (SARPs) necessary for aviation safety, security efficiency and environmental protection on a global basis. ICAO serves as the primary forum for co-operation in all fields of civil aviation among its 191 Member States.

Improving the safety of the global air transport system is ICAO's guiding and most fundamental Strategic Objective. The Organization works constantly to address and enhance global aviation safety through the following coordinated activities:

- Policy and Standardization initiatives.
- Monitoring of key safety trends and indicators.
- Safety Analysis.
- Implementing programmes to address safety issues.

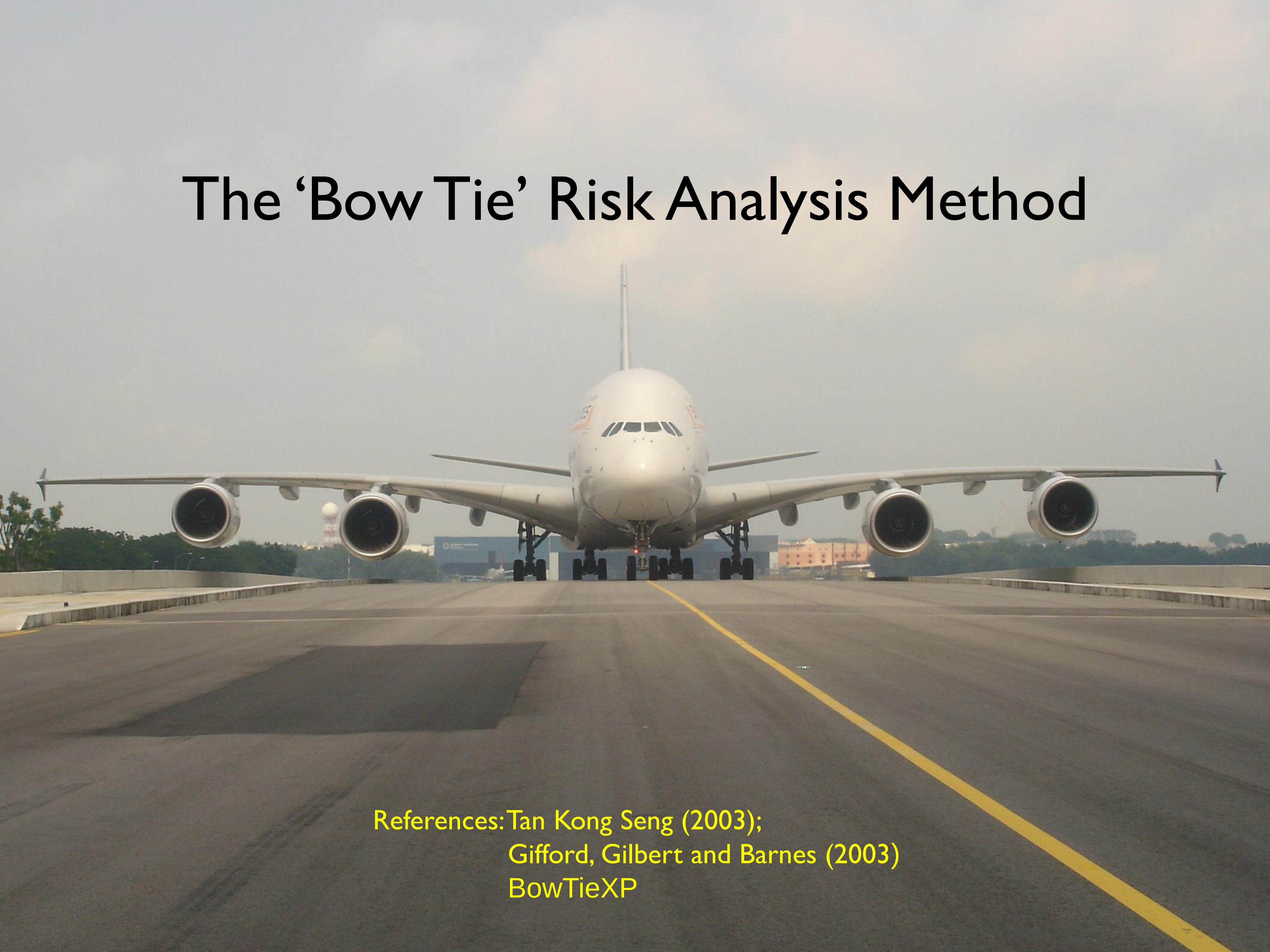
In every case, these activities are augmented by ICAO's detailed appraisal of global and regional aviation safety metrics on the basis of established risk management principles — a core component of contemporary State Safety Programmes (SSP) and Safety Management Systems (SMS). Applying these principles in the field of aviation safety requires ICAO to pursue a strategy comprised of proactive and reactive safety analysis and risk management processes.

"In all of its coordinated safety activities, ICAO strives to achieve a balance between assessed risk and the requirements of practical, achievable and effective risk mitigation strategies."

This report provides updates on safety indicators including accidents occurring in 2014 and related risk factors, taking as a benchmark the analysis in previous reports.

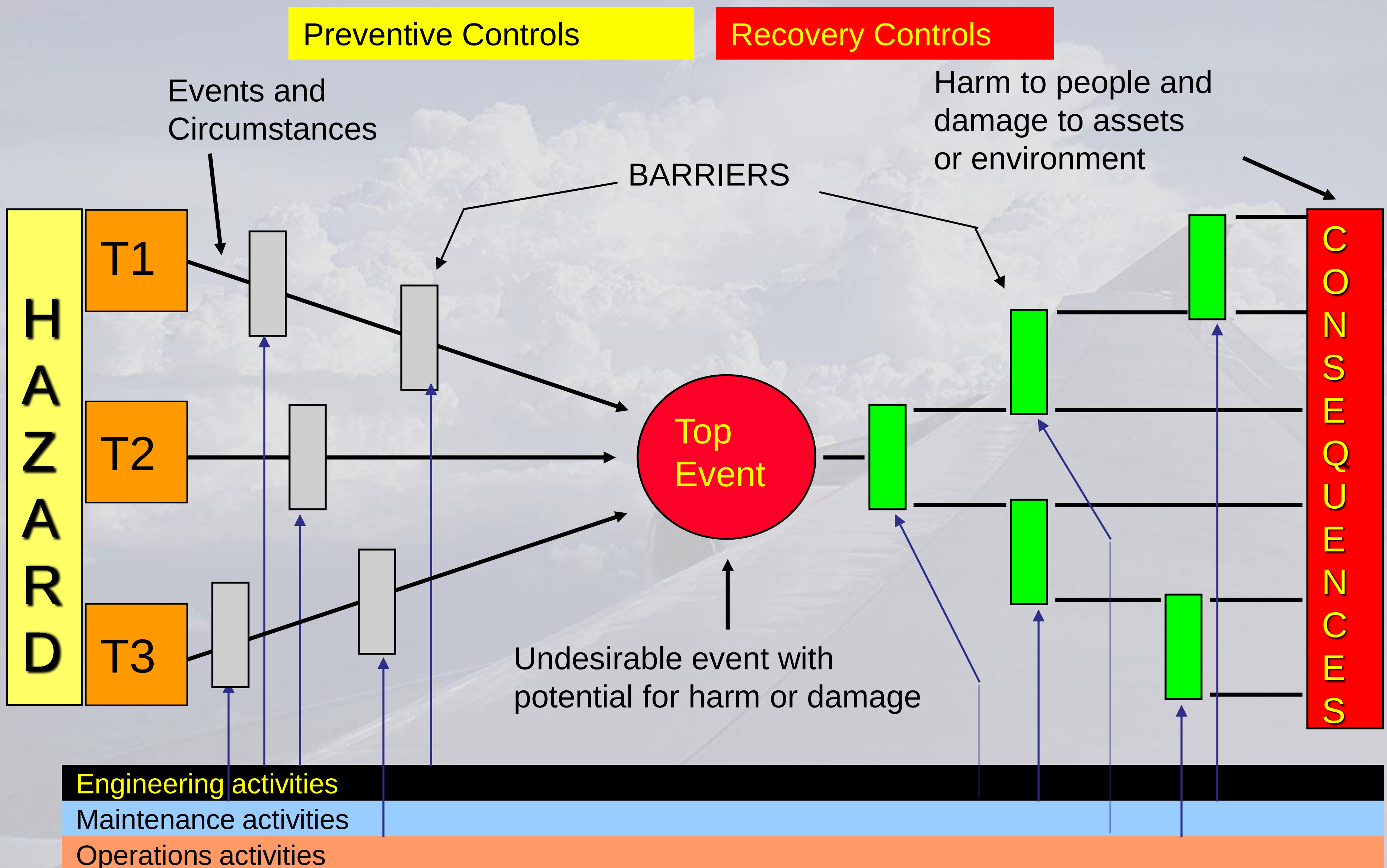
"In all of its coordinated safety activities, ICAO strives to achieve a balance between assessed risk and the requirements of practical, achievable and effective risk mitigation strategies."

The 'Bow Tie' Risk Analysis Method



References: Tan Kong Seng (2003);
Gifford, Gilbert and Barnes (2003)
BowTieXP

Basic Bow Tie Concept



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UK CAA "Significant Seven" Bow Tie Templates (2014)

http://www.caa.co.uk/default.aspx?catid=2816

UK Military Aviation Authority

- MAA Bow Ties
- https://www.gov.uk/government/publications/bow-tie-methodology-in-the-military-aviation-authority

Australian Government
Department of Defence

Defence Aviation Safety Authority

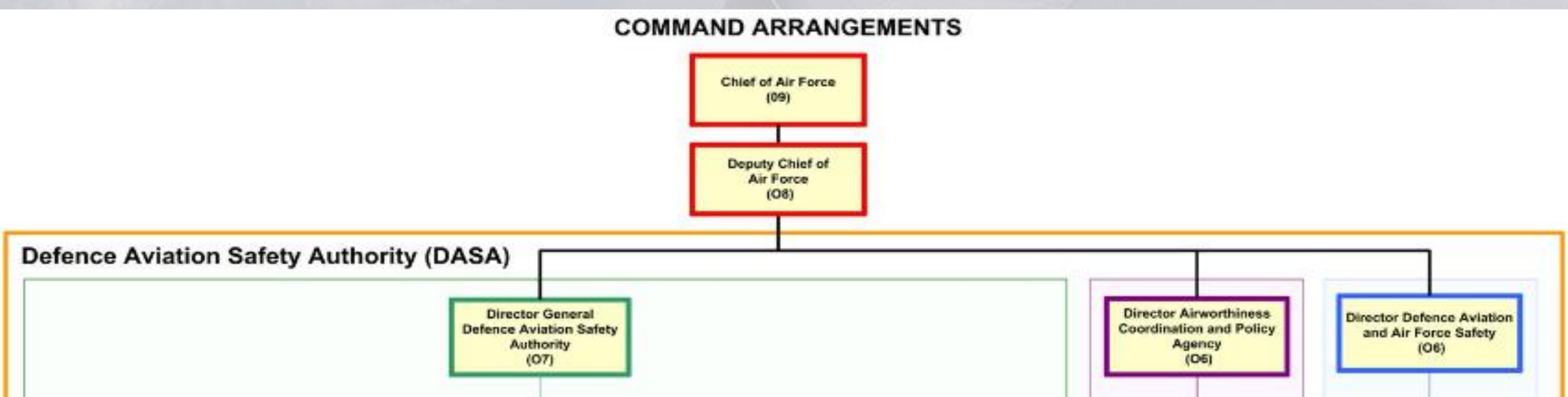
Department of Defence › DASA › Home

Information

- Home
- About Us
- Defence Aviation Safety Regulation

The Defence Aviation Safety Authority

In accordance with Joint Directive 24/2016 The Defence Aviation Safety Framework PDF-237KB, the Defence Aviation Safety Authority (DASA) is responsible for enhancing and promoting the safety of military aviation. This objective is primarily achieved through implementation of a Defence Aviation Safety Program (DASP) that supports compliance with statutory safety obligations and assures the effective management of aviation safety risks. The DASA comprises three organisational entities that operate collectively to administer and execute the DASP on behalf of the Defence Aviation Authority (Defence AA).



100 years improving aviation safety

AAIB

Air Accidents Investigation Branch

1915 ~ 2015

AIRCRAFT ACCIDENT REPORT 1/2017

AAIB
Air Accidents Investigation Branch

Report on the accident to
Hawker Hunter T7, G-BXFI
near Shoreham Airport
on 22 August 2015

The ARMS Methodology for Operational Risk Assessment in Aviation Organisations

Developed by the ARMS Working Group, 2007-2010

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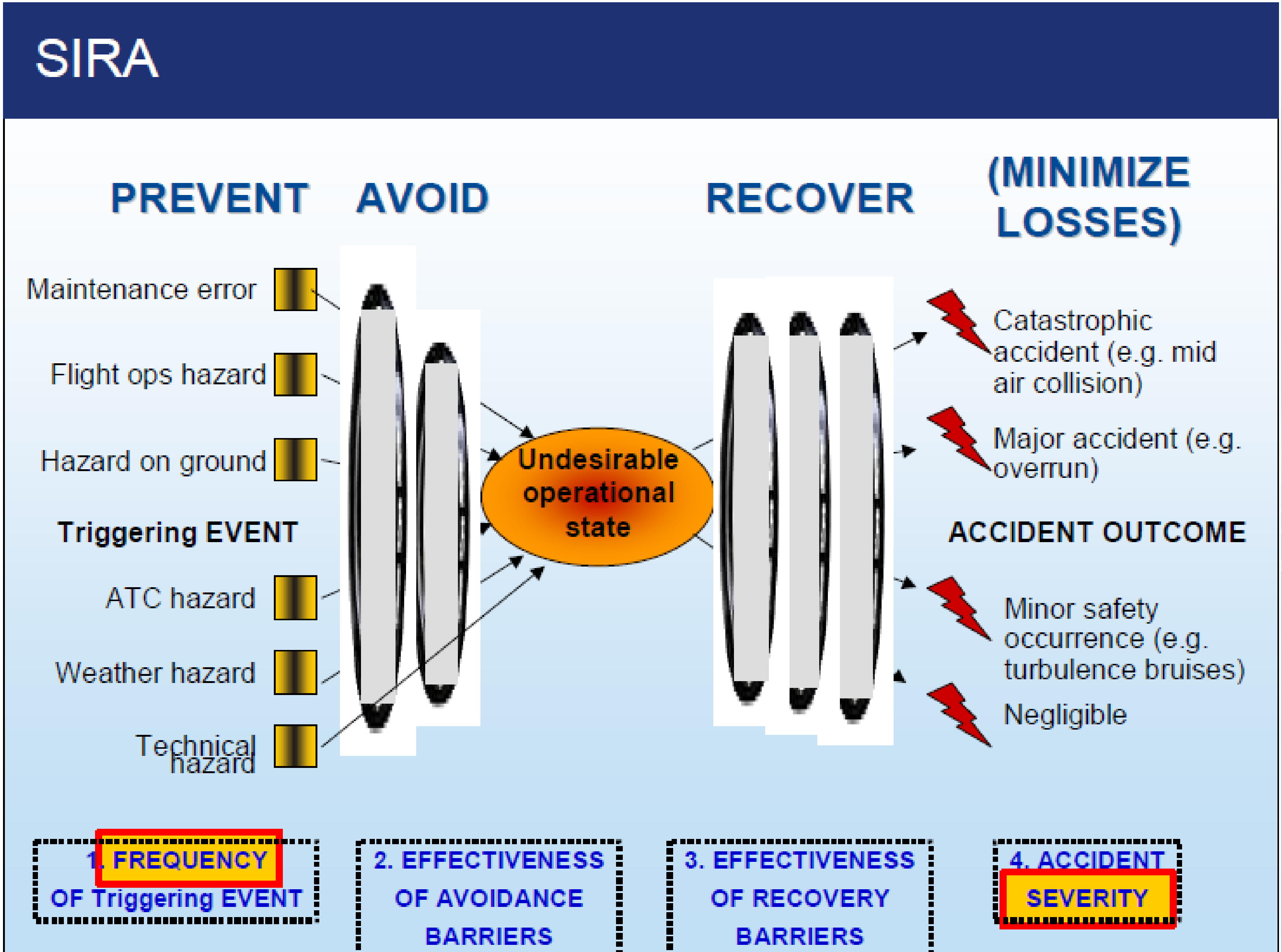
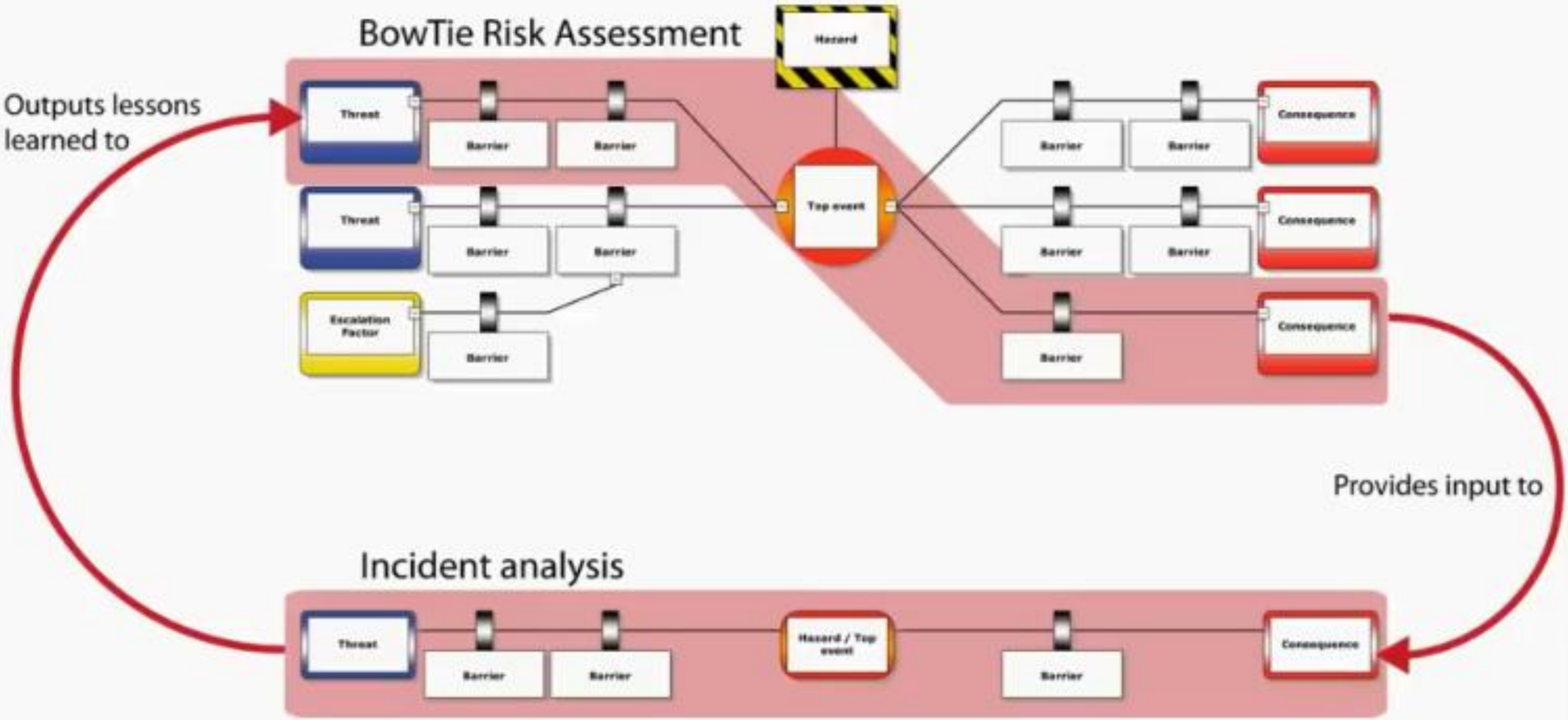


Figure 7. The model behind the Safety Issue Risk Assessment.

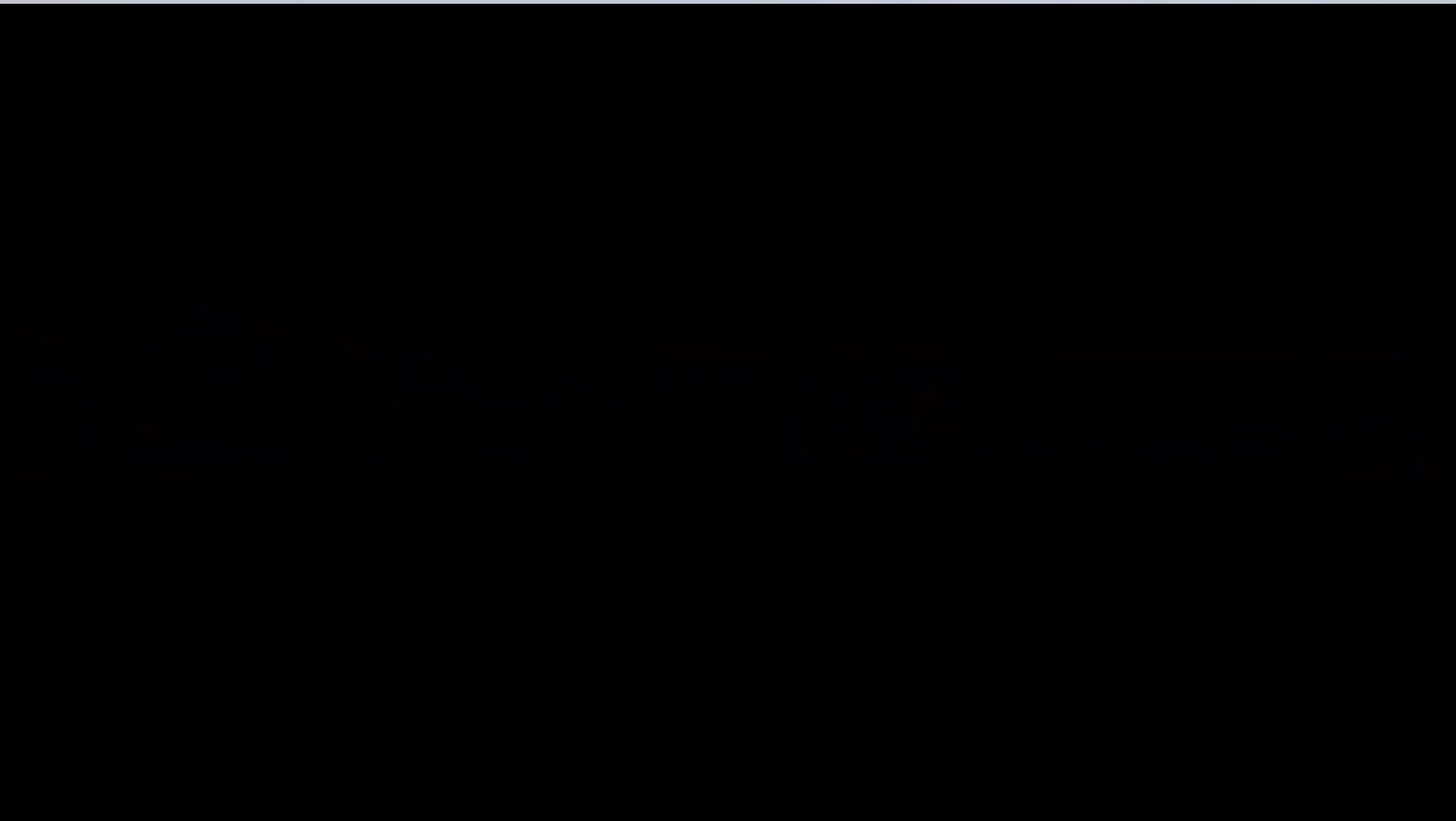
BowTie and incidents



Video:
https://www.youtube.com/watch?v=0MPaZ2pssio

Bow Ties and air safety investigation

- In terms of the Bow Tie methodology, an air safety incident is a ‘top event’, in which the preventive controls have failed, but the recovery controls have worked, and the incident did not develop into an accident.
- An example of a top event (potential collision) followed by a successful recovery control (evasive manoeuvre)…

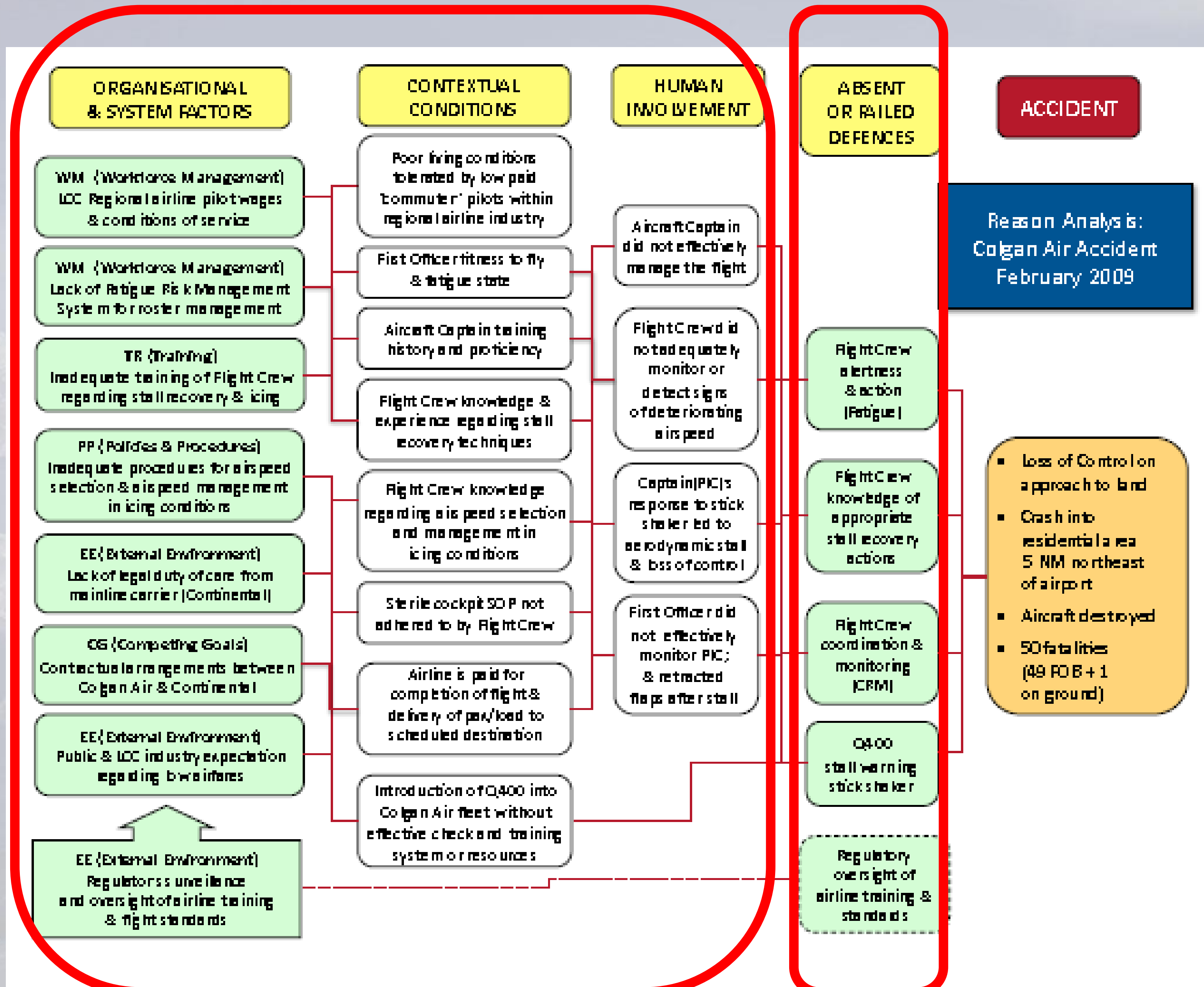


https://www.youtube.com/watch?v=1N5THRSp4hM

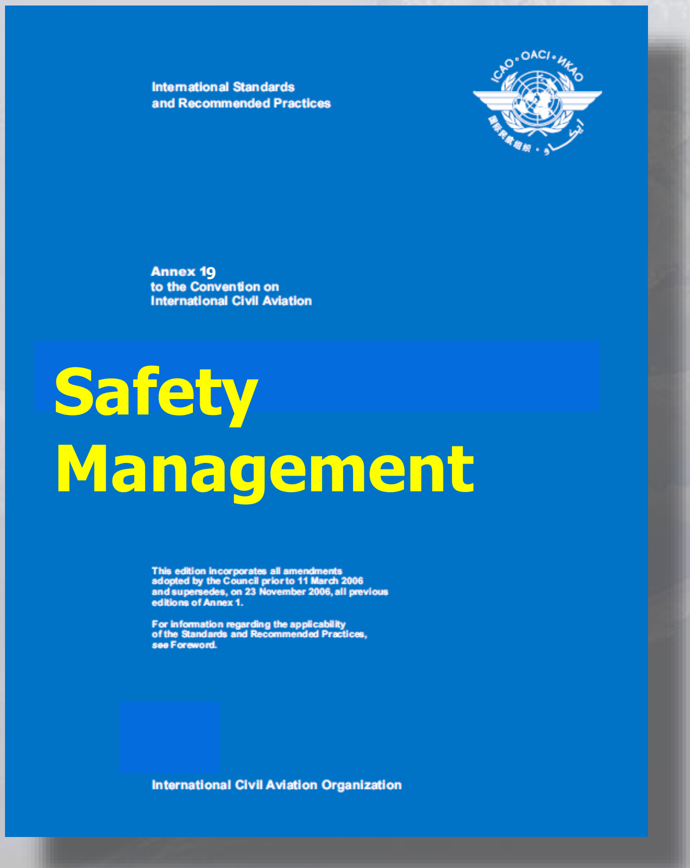
- Pre-existing deficiencies in organisational or systemic factors manifest themselves in escalation factors, and lack of escalation controls.
- These reduce or eliminate the effectiveness of the primary controls, such as SOPs.
- Most controls in aviation are procedural (SOPs)
- Typical escalation factors affecting procedures are:
  - non-compliance
  - poor communication
  - inadequate CRM
  - human error
  - training deficiencies
  - overly complex procedures
- All of these are human factors.

Sources of Escalation Factors

Controls



Annex 19



Annex 19 - Safety Management

On February 25th 2013, after 30 years, the Council adopted unanimously a new Annex to the Chicago Convention, Annex 19 on Safety Management.

Event-based safety management – the "traditional" approach

- Systemic investigation of large numbers of air safety incidents and accidents has served the industry well.
- We have learnt that system failures, such as incidents and accidents, are the malevolent combination of pre-existing systemic deficiencies with events and circumstances at the time of the occurrence.
- It is this combination in itself which creates the system failure. There is no "root cause".
- At the systemic level, accidents and incidents are not linear; they are multivariate.
- There is no "chain of events"; nor a simple cause-effect relationship.

Control-based Safety Management

- Hundreds of specific scenarios in a particular category, CFIT, runway incursions, breakdown in separation, and so on are outcomes of failures of the same sets of controls in each generic category.
- Therefore we need to focus our safety management on these controls
  – rather than on going through in minute detail large numbers of individual specific events within each generic category.
- These sets of controls are common factors in each generic category


Position verrouillée - Vue 00
Temps : 02h 9mn 59s 000
PNF
PF
STALL
MASTER WARN
STAB
-2
MASTER CAUT
N1 %
99
99
TO GA
FLX
CL
AOA
G
350
.803
.808

AF447, 1 June 2009


-00:00:21
XL Airways Germany Flight 888T
(GXL888T) 27 November 2008
Alt: 3800 ft
Pitch: UP 57°
Bank: L 40°
Speed: >40 kts
Config: F3
A320

Temps : 15:45:14
STALL WARNING
EPR
EGT
°C
FF KG/H
4420
FF KG/H
4483
N2 %
91.8
N1
%
N2 %
91.8
FOB: 3008 KG
FULL
Manettes de poussee
TOGA
CL
IDLE
Stabilisateur
Rudder pedal


Temps : 15:45:43
STALL WARNING
SPD LIM
157
2000
EPR
1.457
1.455
EGT
°C
516
510
FF KG/H 4046
FF KG/H 4051
N2 % 91.5
N2 % 91.3
N1
%
87.7
87.6
FOB: 2944 KG
S
F
FULL
Manettes de poussee
TOGA
CL
IDLE
Stabilisateur
Rudder pedal


Temps : 15:46:01
STALL WARNING
Manettes de poussee
TOGA
CL
IDLE
Stabilisateur
Rudder pedal
EPR
EGT
°C
N1
%
FF KG/H
4207
FF KG/H
4192
N2 %
90.9
N2 %
90.6
1.432
1.414
517
510
86.1
86.1
FOB: 2944 KG
SPD
LIM
157
2000
149

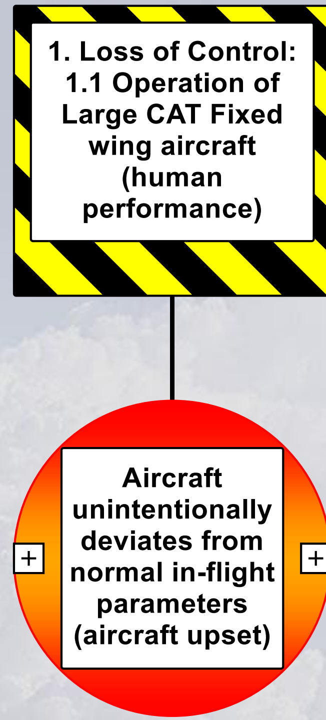
Air Asia Indonesia Flight 8501, 20 March 2015

Time (UTC)	From	To	Description
2317:41	P1		"My God."

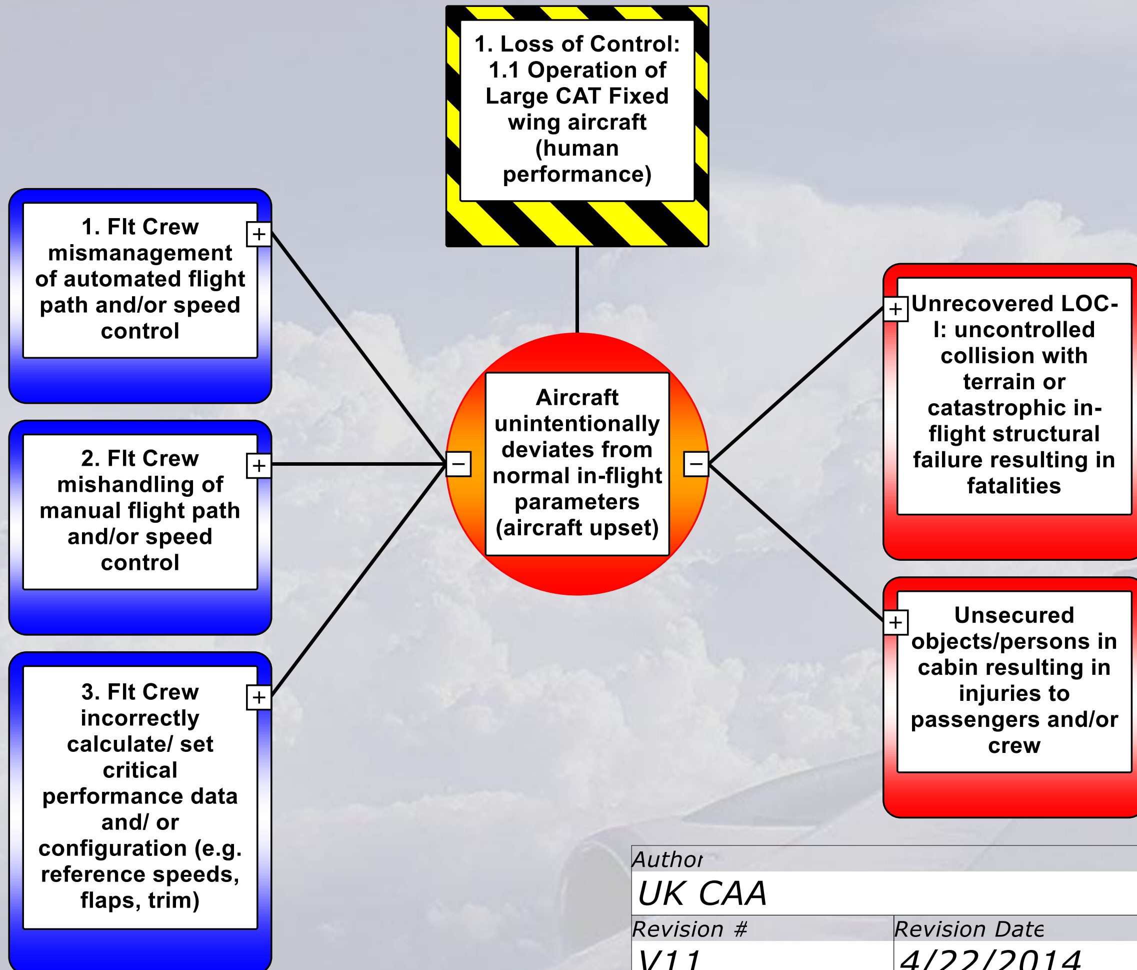
Figure 29: Attitude recovered

Conditions:

Speed (knots)	170 (ISIS)	37 (CAS)
Alt (feet)	28340	
Rudder	0°	
Roll	-2 °	
Pitch	0	
AOA	41.1°	
VS (fpm)	-15500	
N1	73 %	
EGT	589°C	
TLA	44.3	
Sidestick	**PIC** P: 15° R: 14°	**SIC** P: -16° R: -7°



Author	
UK CAA	
Revision #	Revision Date
V11	4/22/2014
Reference #	
LOC 1.1	
Notes	
Final template for tailoring - visit www.caa.co.uk/bowtie for more information and to accept conditions of use	



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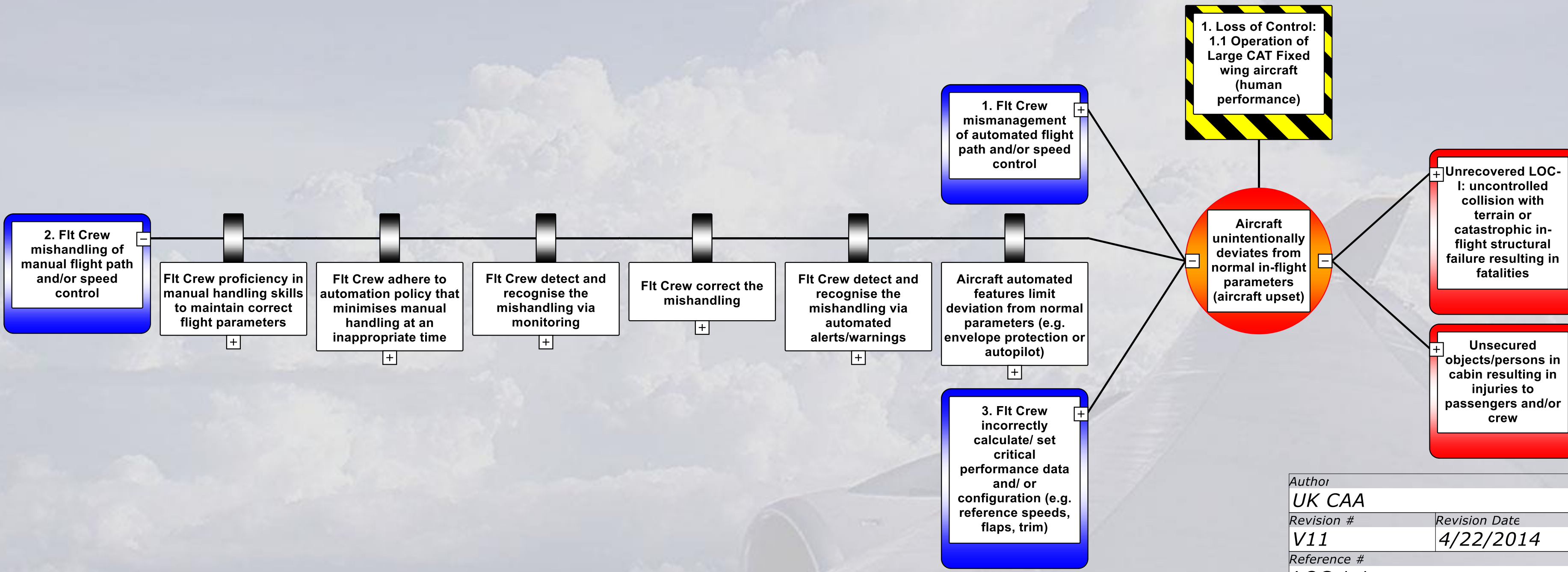

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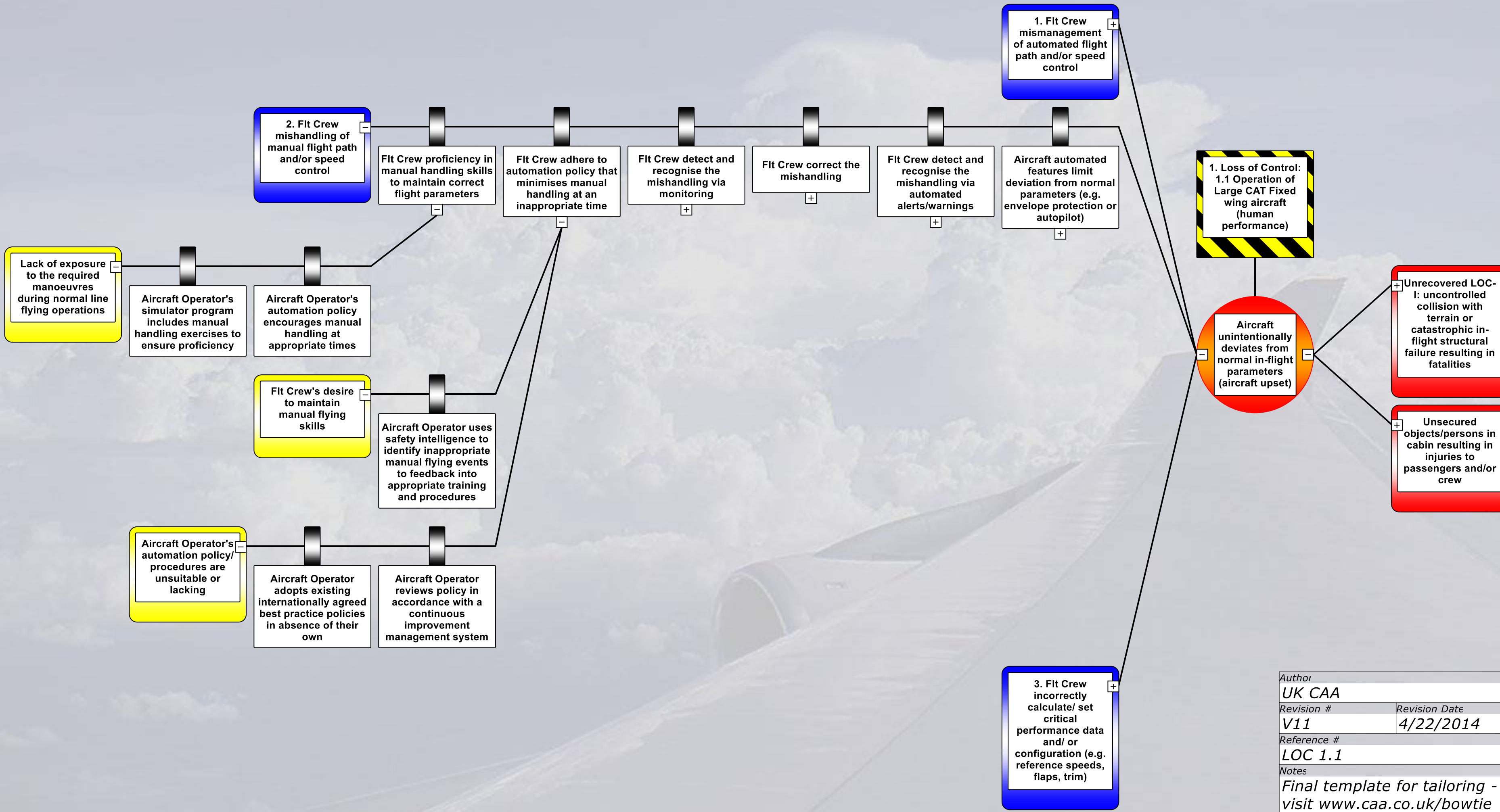

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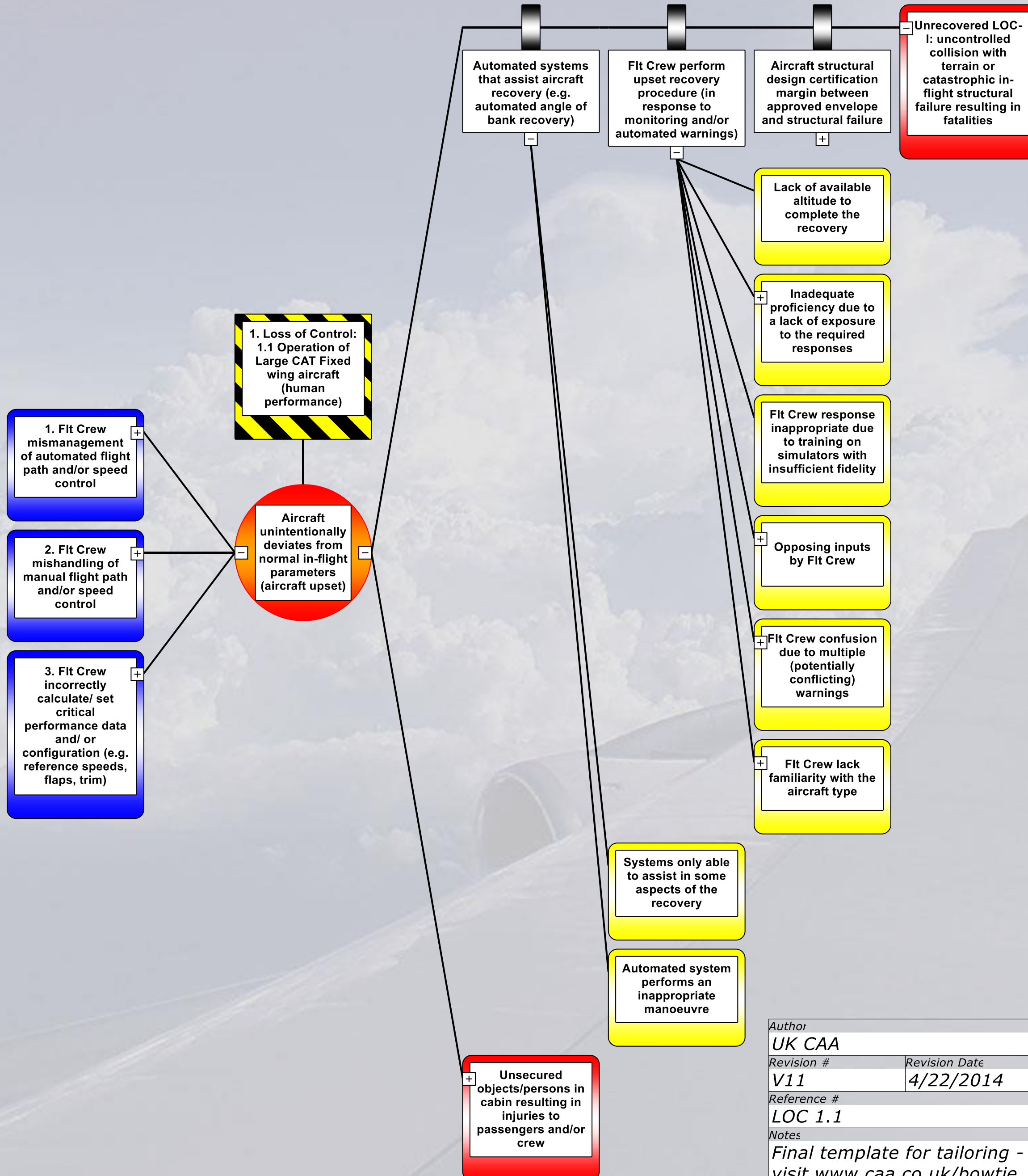

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Reference #	
LOC 1.1	
Notes	
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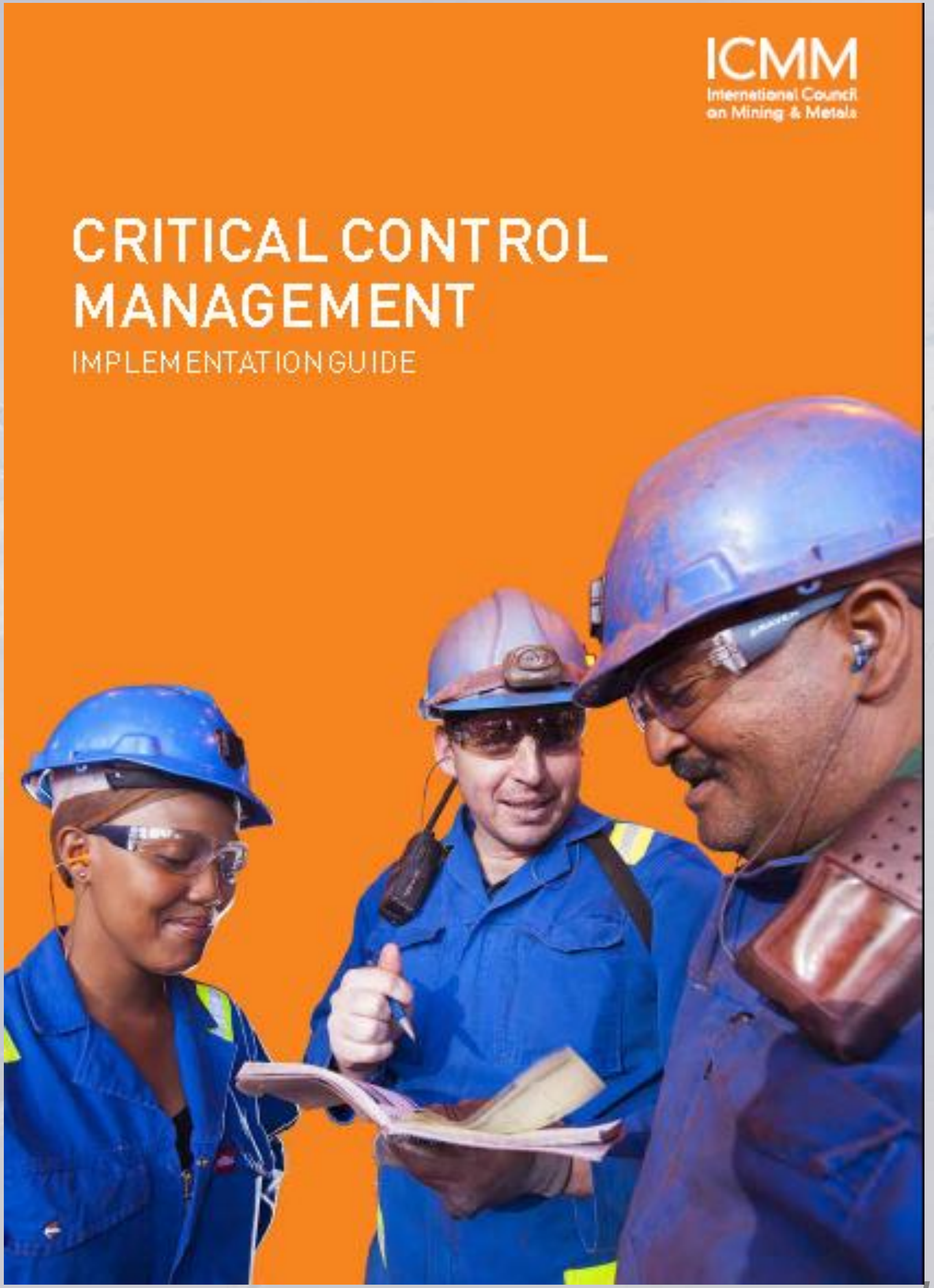
The integration of investigation and risk management

- The **reactive** investigation process and the **proactive** risk management process both consider the same elements of the Reason Model
  - one before the category of the occurrence, and one after an actual event in that category
- Therefore we need to employ an **INTEGRATED** approach to both

Critical Control Management

What is the Critical Control Management (CCM) process?

- The CCM process is a practical method of improving managerial control over rare but potentially catastrophic events by focusing on the critical controls.



Document, published Dec 2015
Source: Peter Wilkinson
NSC ARPANSA

The CCM approach is based on:

- having clarity of those controls that really matter: these are the critical controls
- defining the performance required of the critical controls
- determining what the critical control has to do to prevent the event occurring
- deciding what needs to be checked or verified to ensure the critical control is working as intended
- assigning accountability for implementing the critical control – who has to make it work?
- reporting on the performance of the critical controls.

Underlying assumptions of the CCM process

Assumption 1

- The majority of undesired events within the Aviation industry are known, as are the controls.

Assumption 2

- Most serious events, such as accidents, are associated with failures to effectively implement known controls, rather than not knowing what the risks and controls should be.

Assumption 3

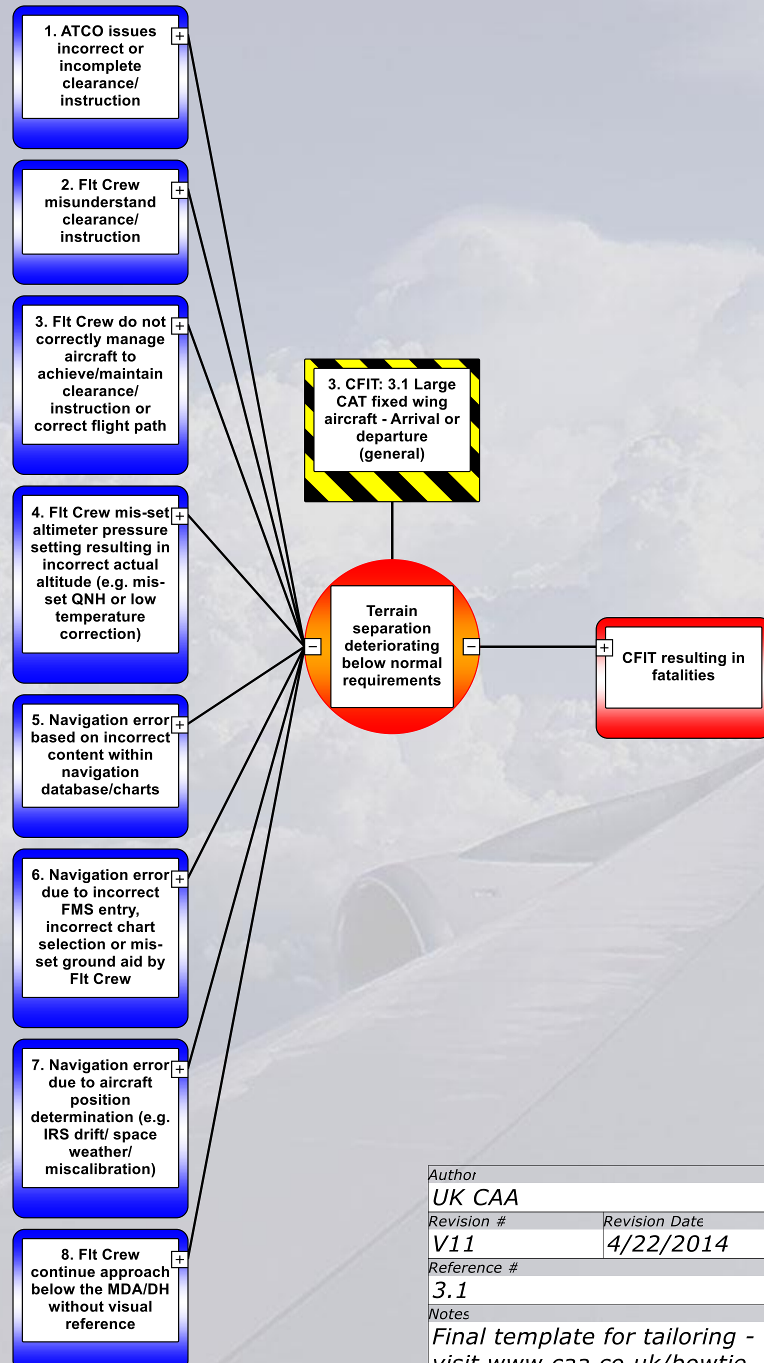
- More can be less. A hazard management plan of 50 pages will often contain a large number of controls, which can be complex to understand, implement and monitor. This can lead to less robust management of critical controls. Less can be more. The fewer number of controls, the more robustly they can be monitored.

Assumption 4

- Some controls are more important than others. These critical controls should be monitored more regularly.

Asiana Flight 214

San Francisco
6 July 2013



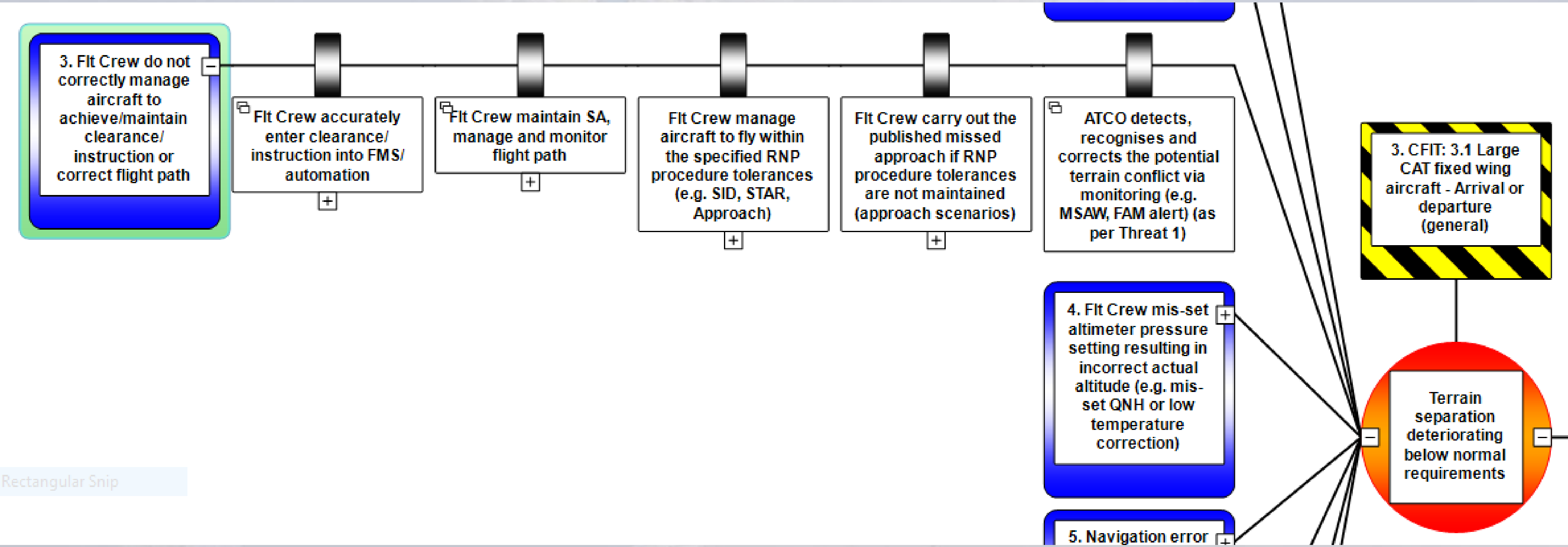
Author
UK CAA

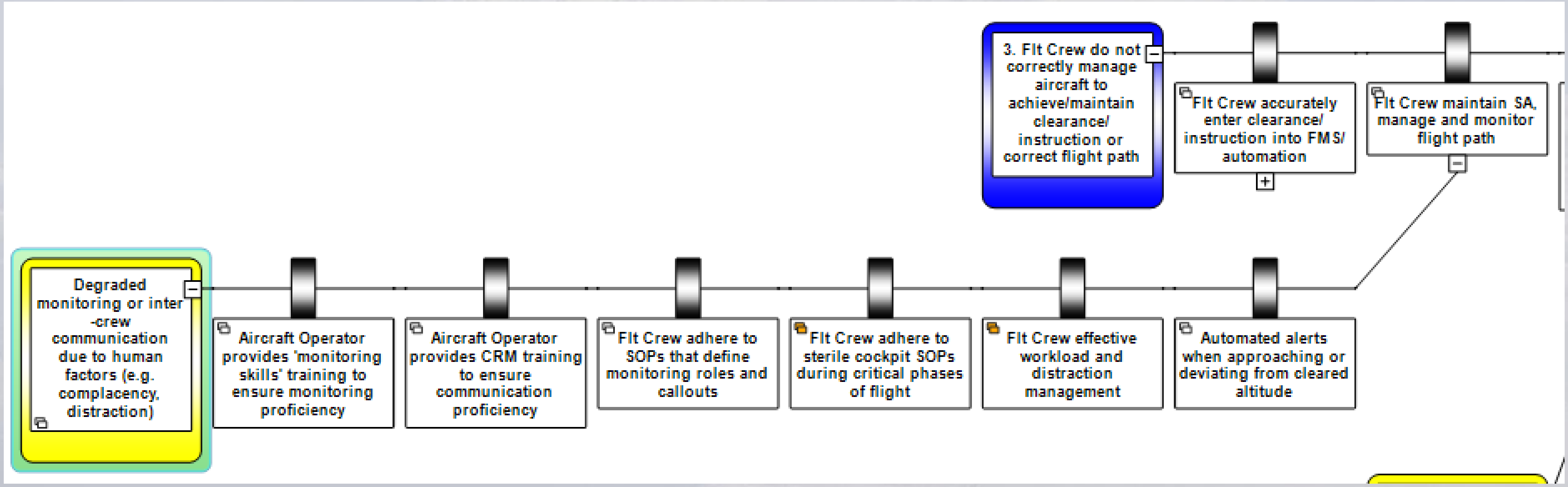
Revision #	Revision Date
V11	*4/22/2014*

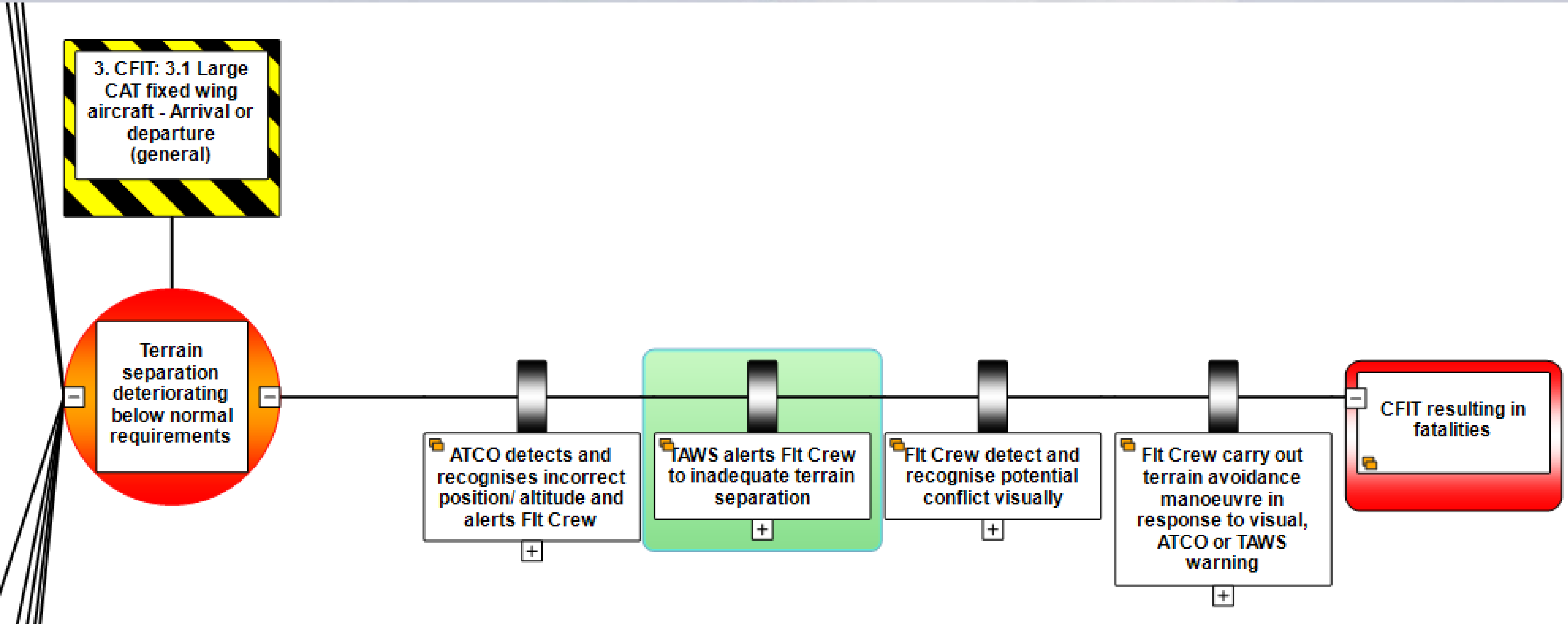
Reference #
3.1

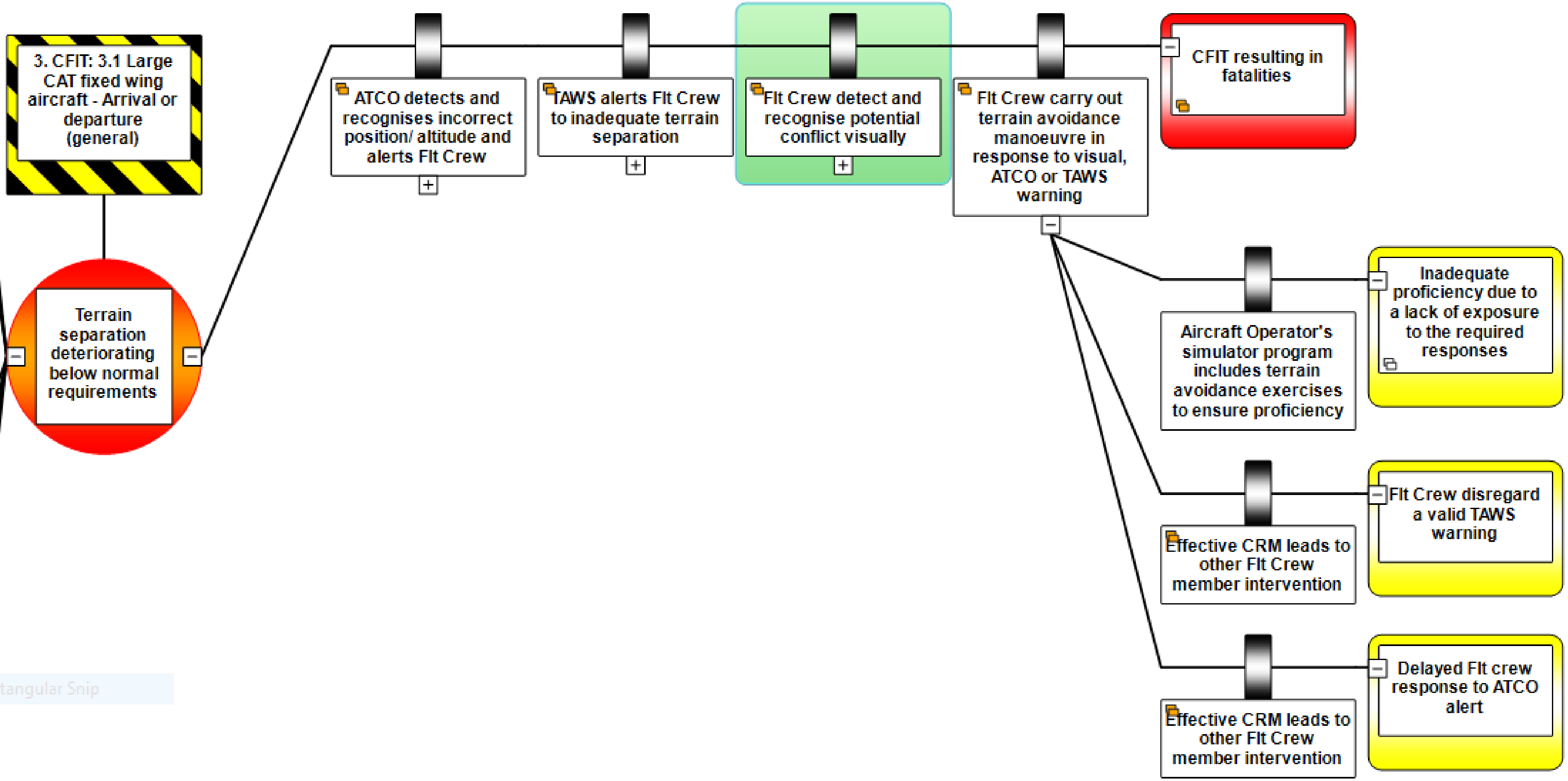
Notes
Final template for tailoring - visit www.caa.co.uk/bowtie for more information and to accept conditions of use

Lee and Burdekin Pty Ltd


3. Flt Crew do not correctly manage aircraft to achieve/maintain clearance/ instruction or correct flight path
Flt Crew accurately enter clearance/ instruction into FMS/ automation
Flt Crew maintain SA, manage and monitor flight path
Flt Crew manage aircraft to fly within the specified RNP procedure tolerances (e.g. SID, STAR, Approach)
Flt Crew carry out the published missed approach if RNP procedure tolerances are not maintained (approach scenarios)
ATCO detects, recognises and corrects the potential terrain conflict via monitoring (e.g. MSAW, FAM alert) (as per Threat 1)
3. CFIT: 3.1 Large CAT fixed wing aircraft - Arrival or departure (general)
4. Flt Crew mis-set altimeter pressure setting resulting in incorrect actual altitude (e.g. mis-set QNH or low temperature correction)
Terrain separation deteriorating below normal requirements
5. Navigation error
Rectangular Snip


3. Flt Crew do not correctly manage aircraft to achieve/maintain clearance/ instruction or correct flight path
Flt Crew accurately enter clearance/ instruction into FMS/ automation
Flt Crew maintain SA, manage and monitor flight path
Degraded monitoring or inter -crew communication due to human factors (e.g. complacency, distraction)
Aircraft Operator provides 'monitoring skills' training to ensure monitoring proficiency
Aircraft Operator provides CRM training to ensure communication proficiency
Flt Crew adhere to SOPs that define monitoring roles and callouts
Flt Crew adhere to sterile cockpit SOPs during critical phases of flight
Flt Crew effective workload and distraction management
Automated alerts when approaching or deviating from cleared altitude

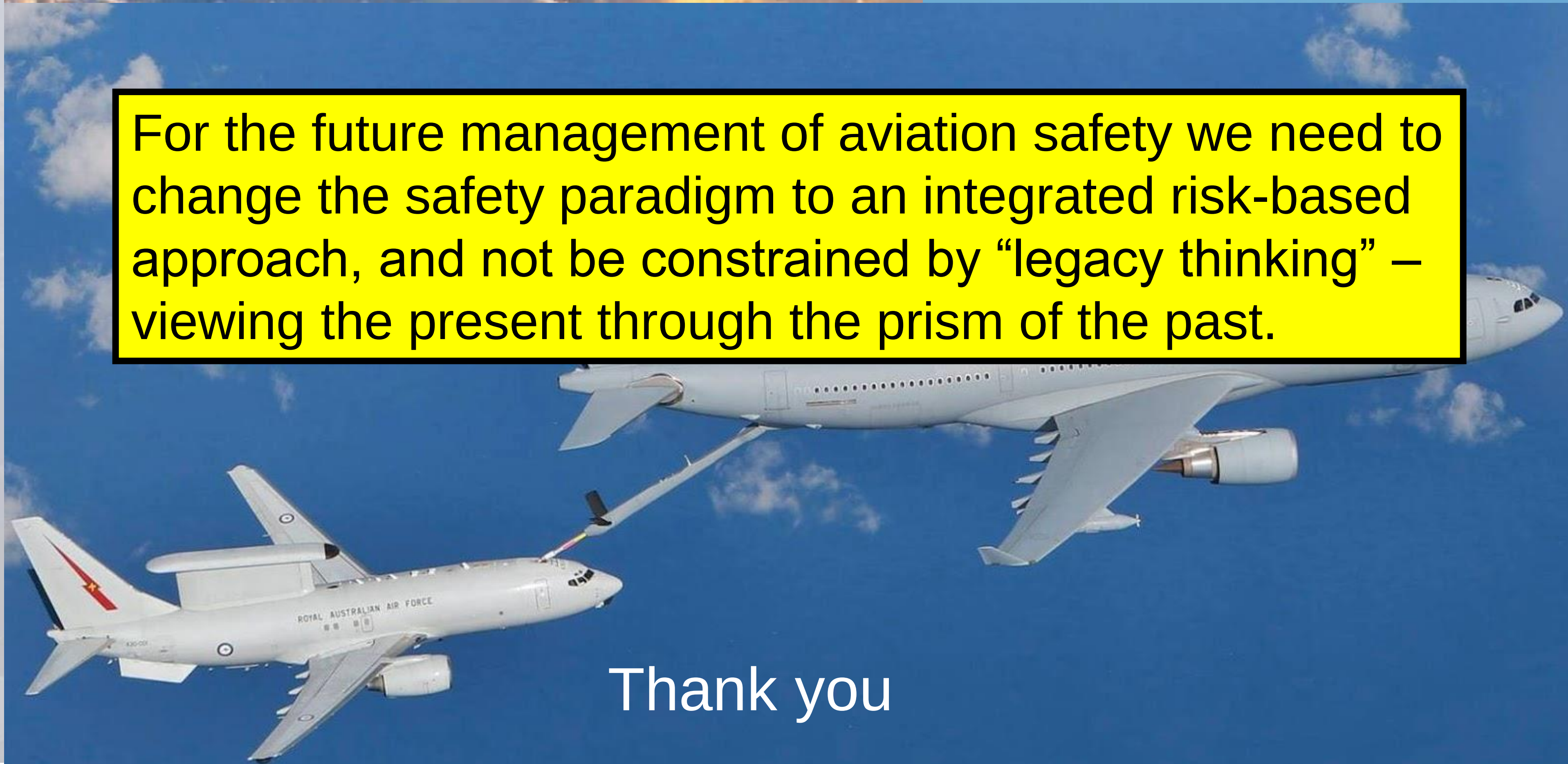

3. CFIT: 3.1 Large CAT fixed wing aircraft - Arrival or departure (general)
Terrain separation deteriorating below normal requirements
ATCO detects and recognises incorrect position/ altitude and alerts Flt Crew
TAWS alerts Flt Crew to inadequate terrain separation
Flt Crew detect and recognise potential conflict visually
Flt Crew carry out terrain avoidance manoeuvre in response to visual, ATCO or TAWS warning
CFIT resulting in fatalities



tangular Snip

Benefits of the critical control management approach

- focuses on a smaller and more manageable number of risk controls - the critical controls
- uses bowties, which provide a simple and readily understood picture of the links between the occurrence, the contributing factors, and the critical controls to prevent it occurring and minimise the consequences if it does
- documents the critical controls in a simple format, making explicit the performance required of them, how they are to be checked and who is responsible for them



For the future management of aviation safety we need to change the safety paradigm to an integrated risk-based approach, and not be constrained by “legacy thinking” – viewing the present through the prism of the past.

Thank you