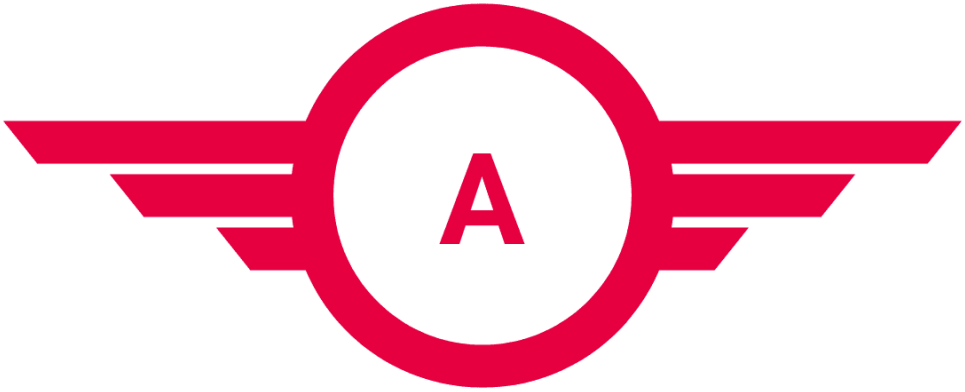


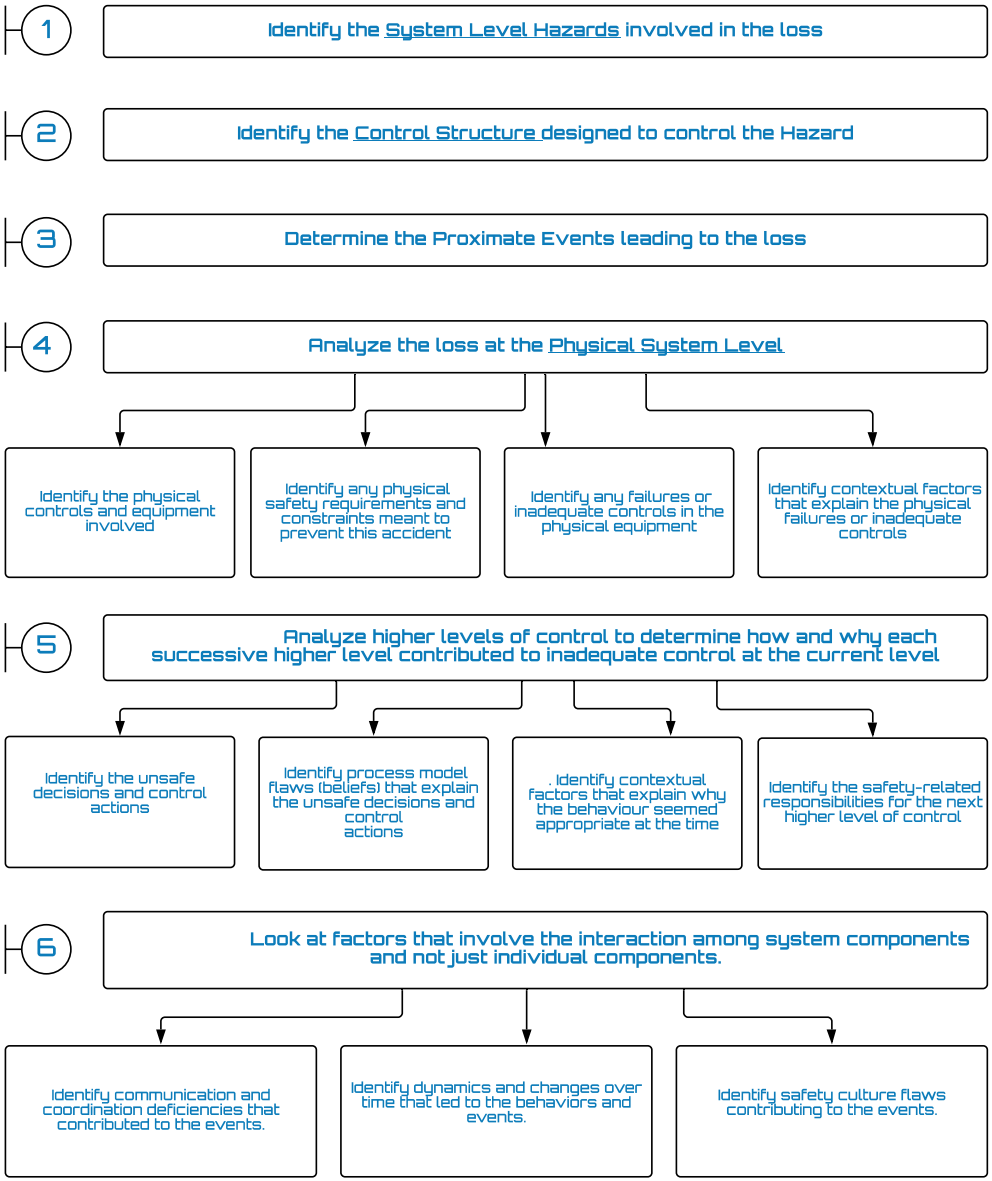
Accident Investigation

Causal Analysis using System Theory

CAST - Causal Analysis using System Theory (CAST): Implementation and Integration

Presented by: Darren Straker, Hong Kong (EDT = 12)

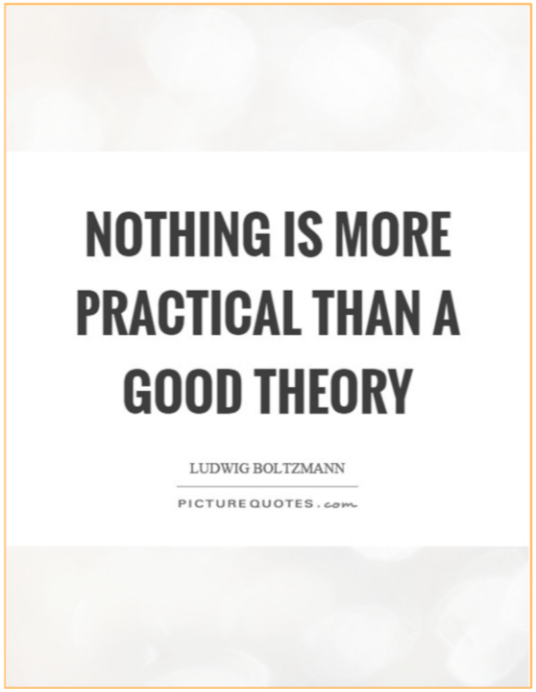
CAST Process



CAST-Causal Analysis using System Theory:
Implementation – How and Why?

Tab 1 | Tab 2 | Tab 3

Comments and feedback for three years of advocating CAST for complex accidentinvestigation.



1)What is the reason you don't agree with the concept of 'Root Cause'

2)I do not understand 'Control Structures'

3)I do not understand how to factor subjectivity into 'Process Models'

4)Mental Models are notaccepted as valid in ourorganization

5)CAST is difficult toi ntegrate into our current organizational structure which is predominantly Bow-Tie based through an IT supported process

7) How does CAST work

8) Does it improve safety recommemdations

9) It looks complicated and time consuming

10) Is there a manual or SOP written

11) What are the Training Requirements

12) Bow-Tie works fine, why use a new tool

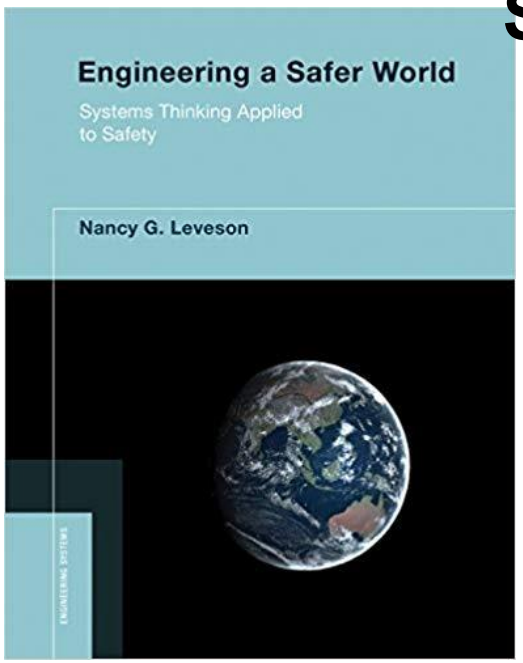
ICAO' strategic goal of ONE year to complete Accident Investigations and 50% of accidents have no final report published.

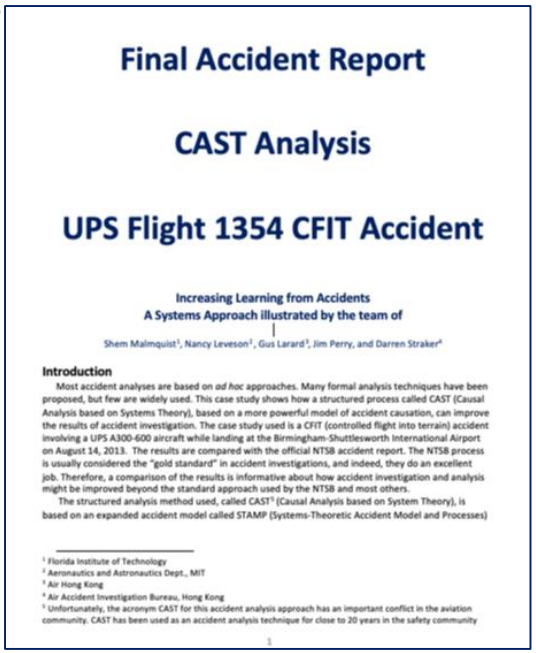
- CAST is prescriptive - embedded in the CAST ‘procedure’ is the idea of Optimisation.
- During the initial stage of an CAST accident investigation, following identification of the SYSTEM LEVEL HAZARDS, CONTROL STRUCTURE, PROXIMTE, the CAST Analysis will:

CAST Generates Questions:
'Why’ and then ‘How’

- Grouping the focus of the questions allows for faster orientation of the investigation
- Cost effective, resource allocation is simplified, and reports are completed faster when it is practical to do so.
- Good for complex Investigation with significant Human/Machine Interface areas

CAST Analysis Integrated into the Annex 13 SARP's




Final Accident Report

CAST Analysis

UPS Flight 1354 CFIT Accident

Increasing Learning from Accidents
A Systems Approach illustrated by the team of

Shem Malmquist[1], Nancy Leveson[2], Gus Larard[3], Jim Perry, and Darren Straker[4]

Introduction

Most accident analyses are based on *ad hoc* approaches. Many formal analysis techniques have been proposed, but few are widely used. This case study shows how a structured process called CAST (Causal Analysis based on Systems Theory), based on a more powerful model of accident causation, can improve the results of accident investigation. The case study used is a CFIT (controlled flight into terrain) accident involving a UPS A300-600 aircraft while landing at the Birmingham-Shuttlesworth International Airport on August 14, 2013. The results are compared with the official NTSB accident report. The NTSB process is usually considered the "gold standard" in accident investigations, and indeed, they do an excellent job. Therefore, a comparison of the results is informative about how accident investigation and analysis might be improved beyond the standard approach used by the NTSB and most others.

The structured analysis method used, called CAST[5] (Causal Analysis based on System Theory), is based on an expanded accident model called STAMP (Systems-Theoretic Accident Model and Processes)

[1] Florida Institute of Technology
[2] Aeronautics and Astronautics Dept., MIT
[3] Air Hong Kong
[4] Air Accident Investigation Bureau, Hong Kong
[5] Unfortunately, the acronym CAST for this accident analysis approach has an important conflict in the aviation community. CAST has been used as an accident analysis technique for close to 20 years in the safety community

1

Observation

Under the supervision of Prof Leveson a group of experts recently reanalysed, using the final published report as source data, the final accident reports of high profile major accident's.

The focus of the reports differed from the official versions as did the safety recommendations. Focus, Emphasis, Prioritization and the Conclusions differed from the Official State Final Report

Understanding Accident Analysis

Abstract

The quality of a safety investigation's analysis activities plays a critical role in determining whether the investigation is successful in enhancing safety. However, safety investigations require analysis of complex sets of data and situations where the available data can be vague, incomplete and misleading. Despite its importance, complexity, and reliance on investigators' judgements, analysis has been a neglected area in terms of standards, guidance and training of investigators in most organisations that conduct safety investigations.

Analysis drives investigation.

The quality of the Safety Recommendations are directly linked to the quality of the Analysis

CAST is structured, it's a prescriptive process that has the intent to capture the complete accident causation to ensure understanding of the entire accident process and all systemic causal factors involved

This includes not only the verifiable known factual information but also the subjective human factors and empirical evidence.

CAST Process

1. Identify the System Level Hazards involved in the loss
2. Identify the Control Structure designed to control the Hazard
3. Determine the Proximate Events leading to the loss
4. Analyze the loss at the Physical System Level
   - Identify the physical controls and equipment involved
   - Identify any physical safety requirements and constraints meant to prevent this accident
   - Identify any failures or inadequate controls in the physical equipment
   - Identify contextual factors that explain the physical failures or inadequate controls
5. Analyze higher levels of control to determine how and why each successive higher level contributed to inadequate control at the current level
   - Identify the unsafe decisions and control actions
   - Identify process model flaws (beliefs) that explain the unsafe decisions and control actions
   - . Identify contextual factors that explain why the behaviour seemed appropriate at the time
   - Identify the safety-related responsibilities for the next higher level of control
6. Look at factors that involve the interaction among system components and not just individual components.
   - Identify communication and coordination deficiencies that contributed to the events.
   - Identify dynamics and changes over time that led to the behaviors and events.
   - Identify safety culture flaws contributing to the events.

Summary of Investigative Model Groups

The reason for reluctance to adopt System Safety investigation and the very low uptake of implementation by States or Regions are varied. Some States have imbedded IT systems and legacy software for example Bow-Tie, some States view CAST as complex: Current States and Regions using Systemic investigative methods is only **3%**

Hogeschool van Amsterdam
Amsterdam University of Applied Sciences

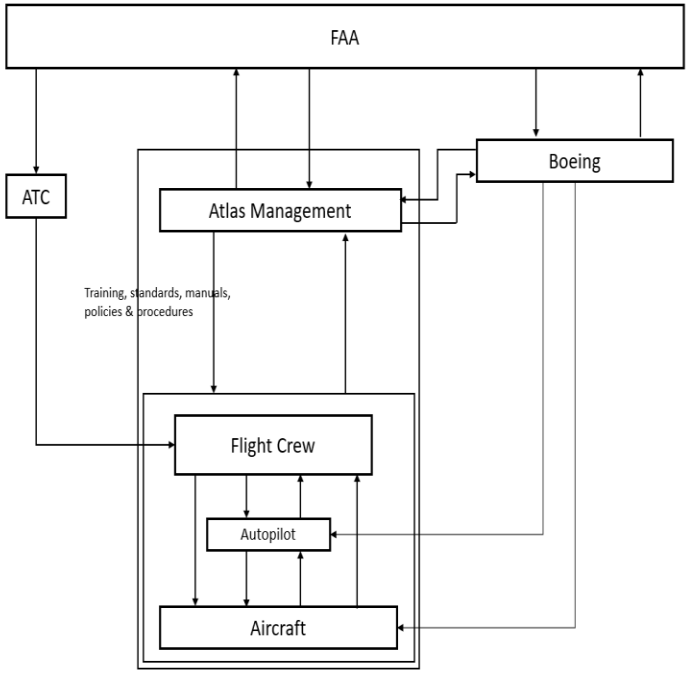
University of Bolton
Teaching Intensive, Research Informed

SAFETY/ACCIDENT MODEL GROUPS

Type	Brief description	Example model(s)	Code	
Sequential	Direct cause-effect relationships: clearly defined timeline of failures, errors and violations that lead to an event.	Domino	SEQ	40+%
Epidemiological	Direct and indirect cause-effect relationships: clearly defined timeline of active failures along with long-lasting effects of latent problems that contribute to active failures.	Swiss cheese	EPD	40+%
Systemic	Dynamic, emerging and complex system behaviours: examining interactions, interdependencies and relationships between parts to understand a system as a whole, including effects of the behaviour of individual elements.	STAMP AcciMap	SYS	3%

STAMP – Basic Constructs

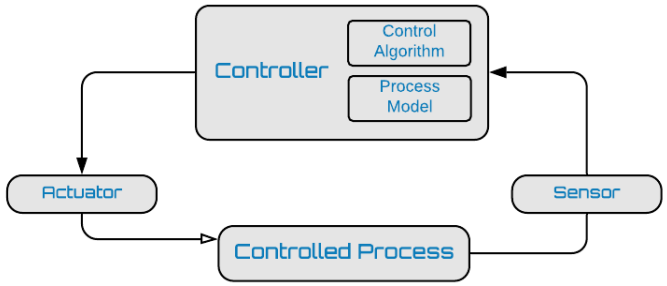
Hierarchical Control Structures



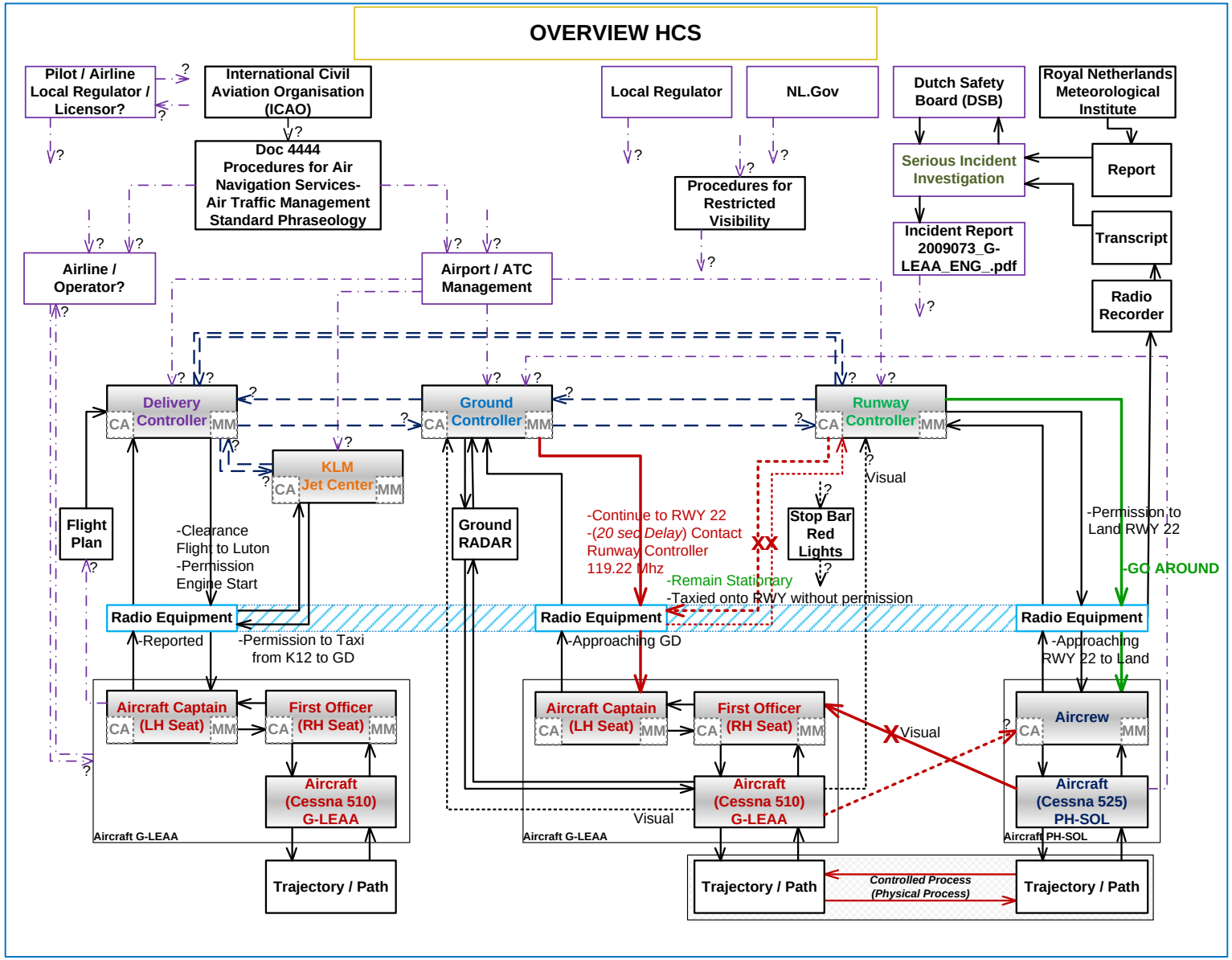
Safety Constraints

In **STAMP**, accidents are conceived as resulting not from component failures, but from inadequate control or enforcement of **safety**-related **constraints** on the development, design, and operation of the system. The most basic concept in **STAMP** is not an event, but a **constraint**

Process Models



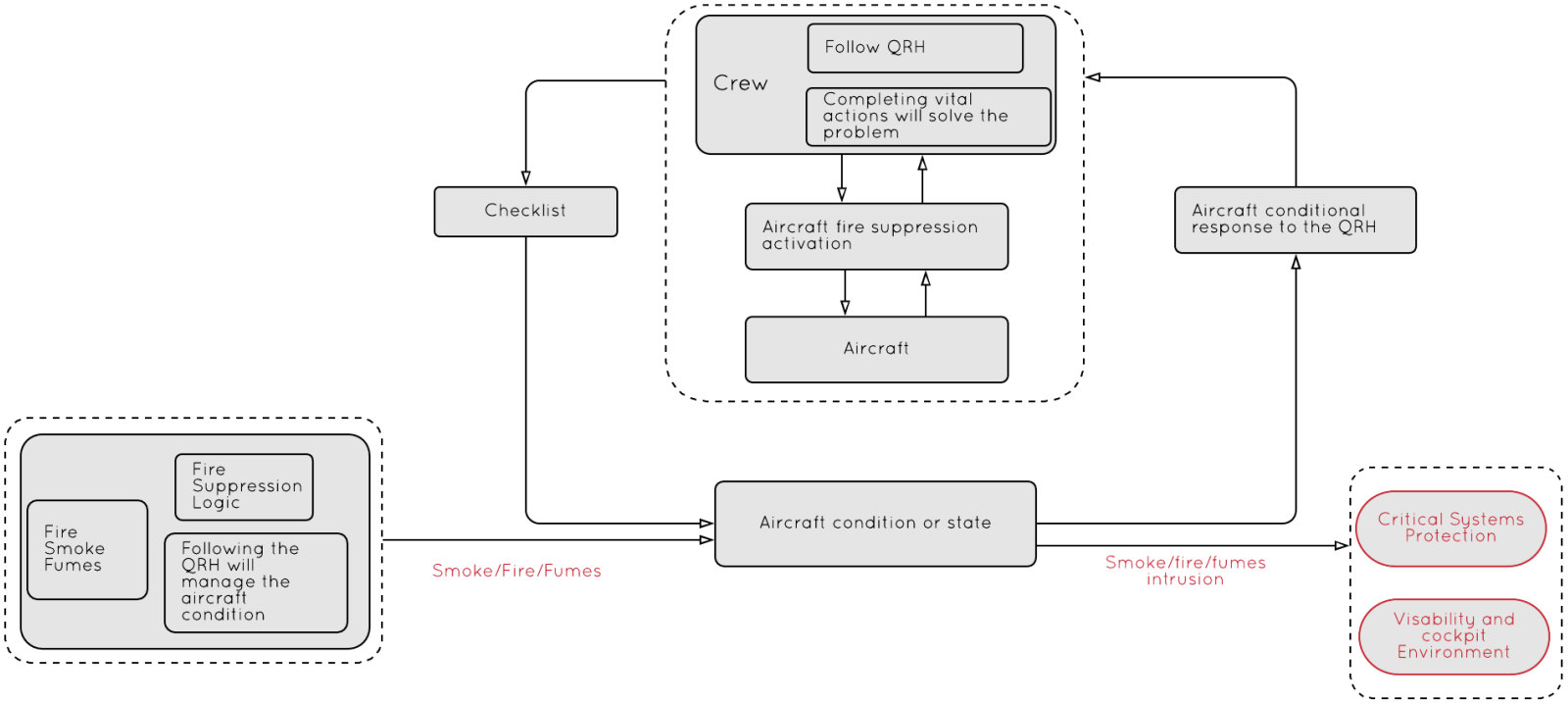
CAST Control Structure Complexity



Data Determination – Proximate Events

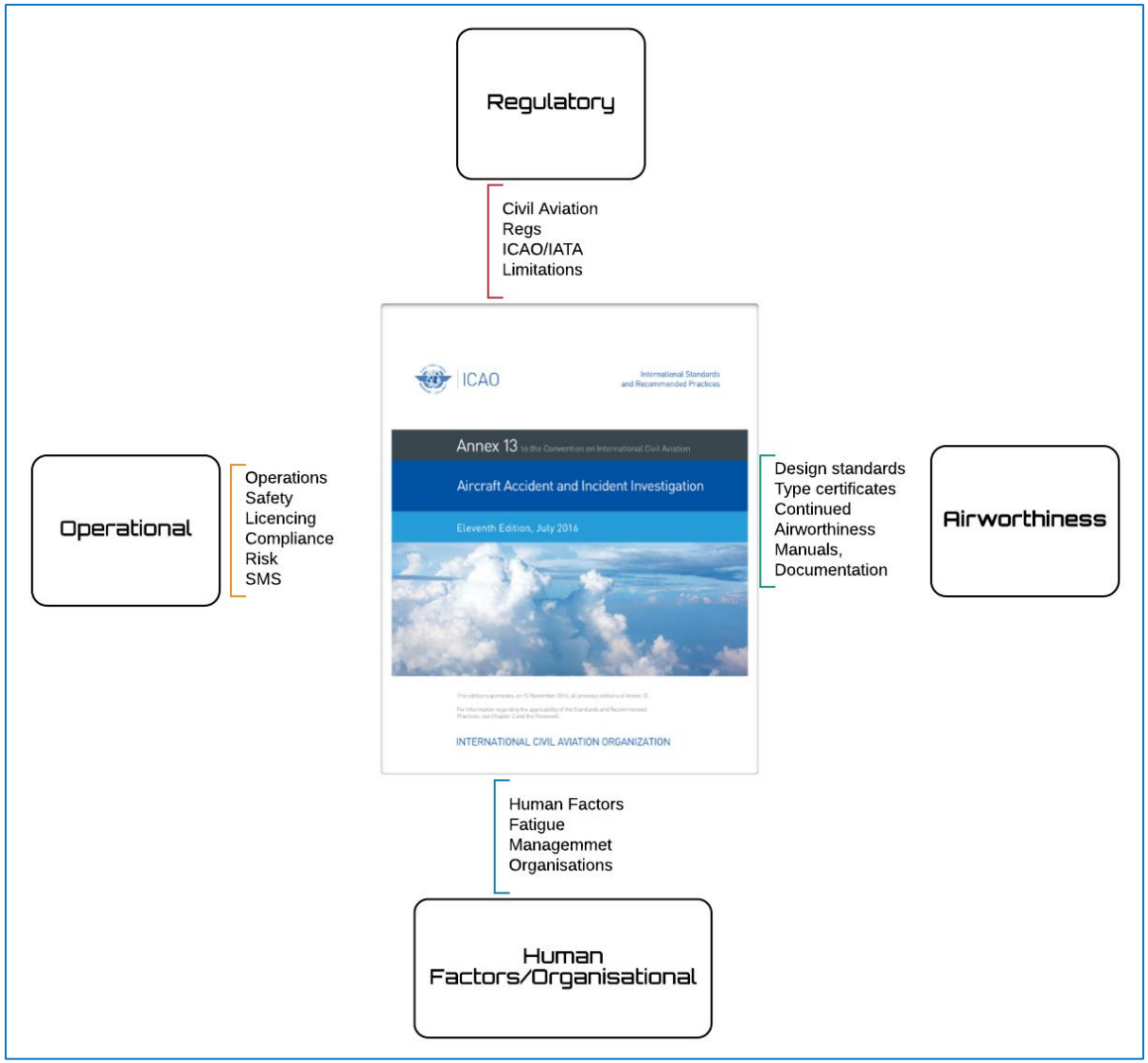
The Process Model allows the Human Factors component and experience to be introduced.

A major improvement, as factoring in knowledge and experience into second guessing a motive for a crew action is subjective and can be problematic unless justified to a reasonable level of confidence



Crew Awareness to Control Smoke in the Cockpit

ICAO Annex 13 Frames of Reference



1. Factual

All information relevant to an understanding of the factual information, analysis and conclusions is included under each appropriate heading;

2. Analysis

Analyse, as appropriate, only the information documented in 1. — Factual information and which is relevant to the determination of conclusions and causes and/or contributing factors.

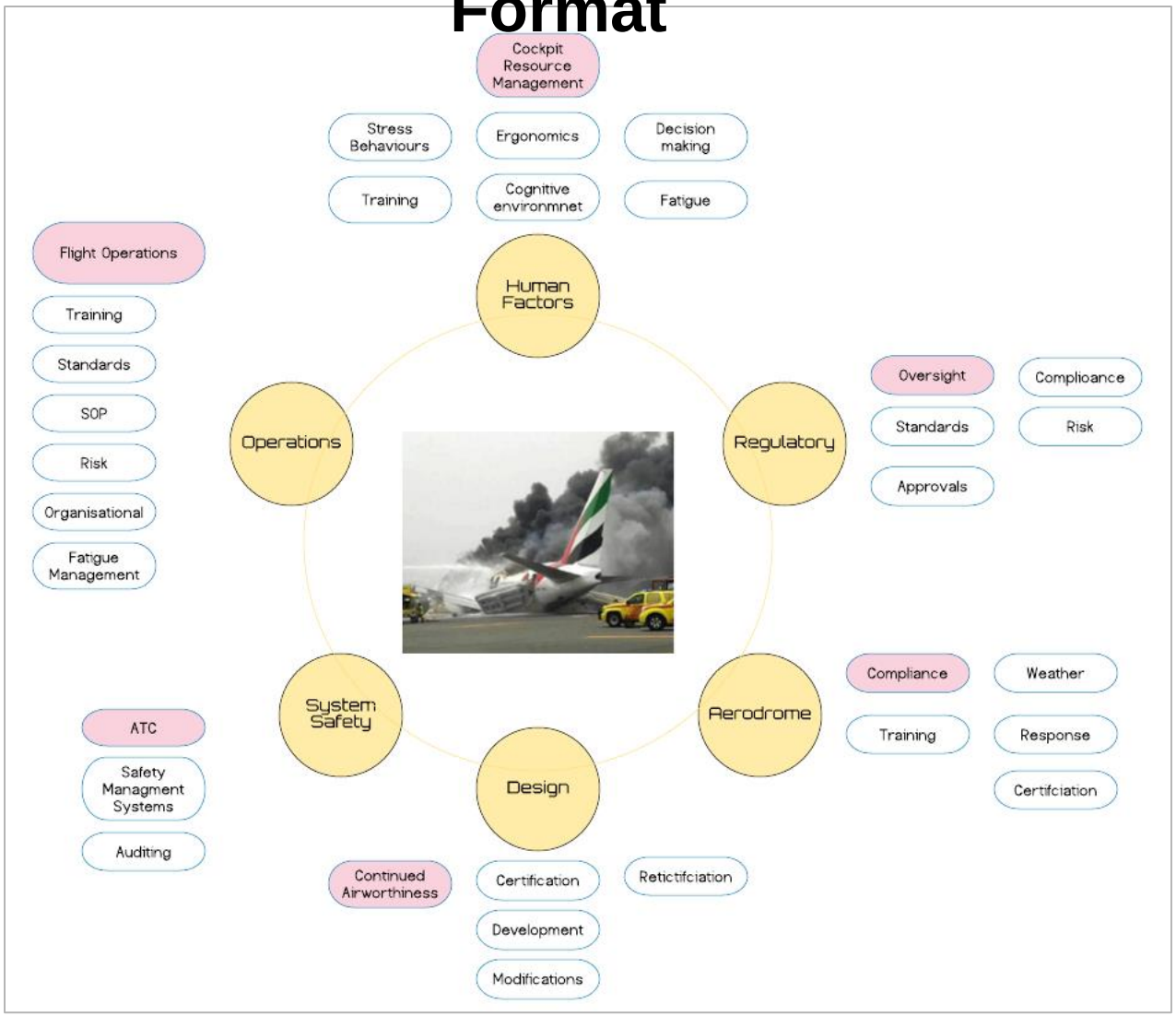
3. Conclusions

List the findings, causes and/or contributing factors established in the investigation. The list of causes and/or contributing factors should include both the immediate and the deeper systemic causes and/or contributing factors.

4. Safety Recommendations

As appropriate, briefly state any recommendations made for the purpose of accident prevention and identify safety actions already implemented

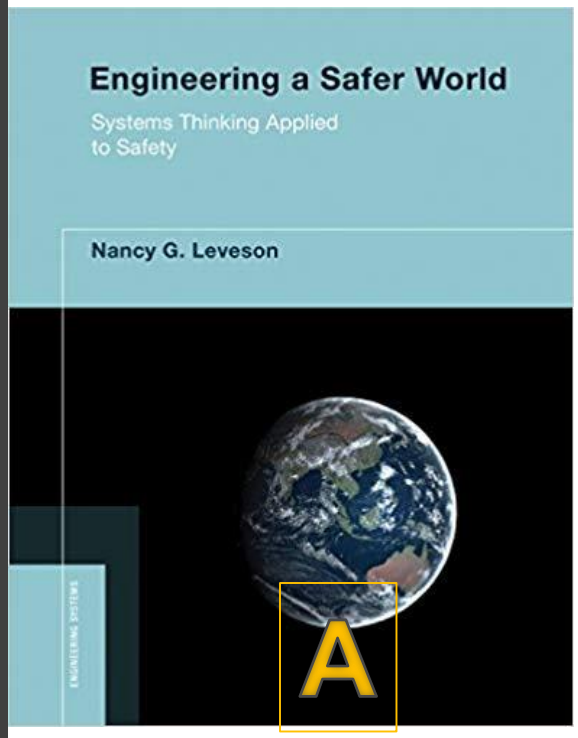
CAST Integration into the ICAO Annex 13 Format

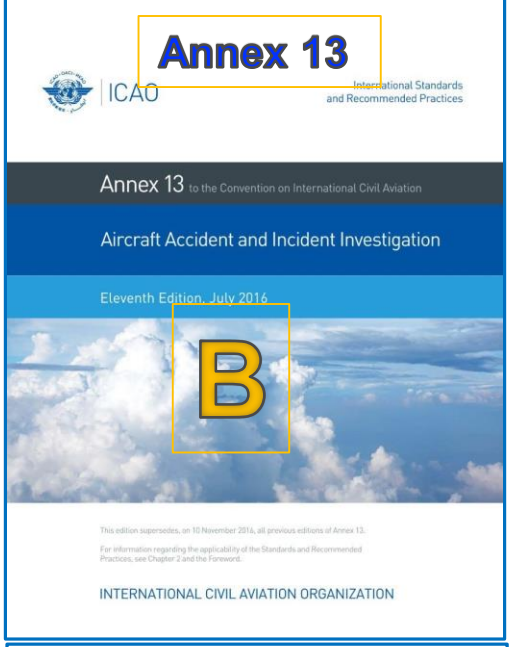


Typical Major Accident Areas of Investigation

A+B=C?

CAST





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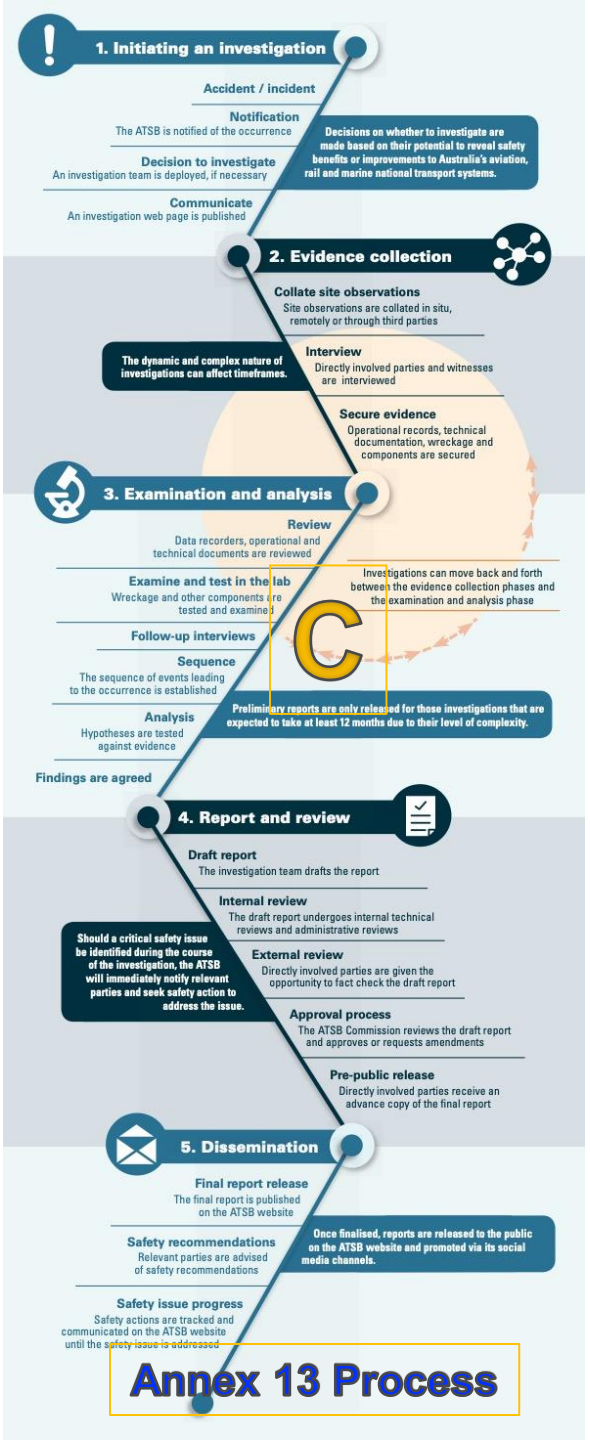


CAST Analysis Integrated into the Annex 13 SARP's



Observation

The initial benefit could be GA and commercial aircraft under 5700kg:

Justification:

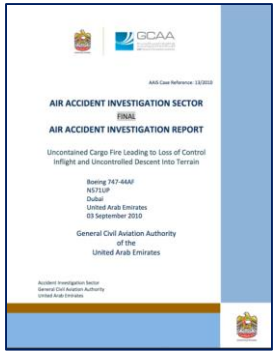
Less depth of knowledge is required, less specialisation (Human Factors is normally HFACS), more flexibility to implement an overall CAST process where subjectivity is less critical (Mental Models and assumptions) and methods can be prescriptive with lower time frames for completion.

Adopted as a standard working model it will simplify investigation, optimise the report writing and reduce the investigation timelines for effective safety improvements across the board.

Does CAST Improve Investigative Quality?

Duration of the Investigation: Sept 2010 – May 2013: 36 months

Safety Recommendations: Thirty Six [36]



Checklists

Crew Alerting

Full Face Oxygen Mask

SFF Training

Evidence Based Training

Safety Recommendations

ICAO

ICAO Technical Instructions

GCAA

Single Points of Failure

Active Fire Detection

Fire Standards

Certification

Critical Systems Protection

Descent Fire Guidance

ULD Design

Eight safety recommendations were excluded based on the inclusion criteria:

- ATC/ANS procedures
- Operator's risk analysis
- SMS processes
- IATA dangerous goods standards
- Specific design requirements for cargo aircraft.

SR's focused on Technical/Design/Regulatory/Standards Approvals/Cargo/Operations/Ignition sources for lithium battery fires

CAST REVIEWED SAFETY RECOMMENDATIONS

Safety Recommendations: Forty Six [46] **36 to 46**

NVG/IR Cameras

Training Options

Checklists

Crew Alerting

Full Face Oxygen Mask

SFF Training

Evidence Based Training

Total Number of SR's increases

Distribution Changes

The End