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

Presented by: Darren Straker, Hong Kong (EDT = 12)
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 behavior 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.
CAST-Causal Analysis using System Theory: Implementation – How and Why?

Comments and feedback for three years of advocating CAST for complex accident investigation.

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 not accepted as valid in our organization
5) CAST is difficult to integrate into our current organizational structure which is predominantly Bow-Tie based through an IT supported process
6) How does CAST work
7) Does it improve safety recommendations
8) It looks complicated and time consuming
9) Is there a manual or SOP written
10) What are the Training Requirements
11) Bow-Tie works fine, why use a new tool
During the initial stage of an CAST accident investigation, following identification of the SYSTEM LEVEL HAZARDS, CONTROL STRUCTURE, PROXIMTE, the CAST Analysis will:

- 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

ICAO's strategic goal of ONE year to complete Accident Investigations and 50% of accidents have no final report published.
CAST Analysis Integrated into the Annex 13 SARP's

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.
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

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### 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%.

#### SAFETY/ACCIDENT MODEL GROUPS

<table>
<thead>
<tr>
<th>Type</th>
<th>Brief description</th>
<th>Example model(s)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sequential</strong></td>
<td>Direct cause-effect relationships: clearly defined timeline of failures, errors and violations that lead to an event.</td>
<td>Domino</td>
<td>SEQ</td>
</tr>
<tr>
<td><strong>Epidemiological</strong></td>
<td>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.</td>
<td>Swiss cheese</td>
<td>EPD</td>
</tr>
<tr>
<td><strong>Systemic</strong></td>
<td>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.</td>
<td>STAMP AcciMap</td>
<td>SYS</td>
</tr>
</tbody>
</table>
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.
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.
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
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.

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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]

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]

Total Number of SR’s increases

Distribution Changes

Safety Recommendations

ICAO

ICAO Technical Instructions

Operator Risk

SMS

RISK

RISK

Single Points of Failure

Active Fire Detection

Fire Standards

Certification

Critical Systems Protection

Descent Fire Guidance

Packaging

ULD Design

Screening

36 to 46
The End