Effectiveness of CAST, 5M and HFACS in Accident Investigation and Prevention

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STAMP Workshop 2021
Agenda

➢ Introduction
➢ Case Study
➢ 5M
➢ HFACS
➢ STAMP/CAST
➢ Results and Outlook

Source: https://www.pinterest.at/pin/551409548120671421/
“It all depends on how we look at things, and not how they are in themselves.”

C.G. Jung

Source: https://i.pinimg.com/236x/06/50/b7/0650b704b1f940db719e0dc954aa168b--fruit-salads-fruit-bowls.jpg
Motivation: further development of Flight Safety System & test effectiveness of different tools for practical application

Research Question: determine differences between specific accident analysis models

Method: qualitative and quantitative, comparative analysis of different accident analysis methods.
Case Study

Loss of Tail-Rotor Effectiveness (LTE)

Source: YouTube
Case Study

- Light helicopter
- Unplanned Outside Landing
- High Mountainous Terrain
- High TOW
- High Density Altitude
- Low Airspeed
- Tailwind

→ Loss of Tail-Rotor Effectiveness (LTE)

Source: BMLV, Gorup & Käfer
Accident Investigation after 5M

- Items (34)
- Findings & Causes (14)
- Error Chain (7)
- Recommendations (5)

Diagram showing the distribution of items, findings, causes, error chain, and recommendations.
HFACS

ORGANISATIONAL INFLUENCES

- Resource Management
- Organisational Climate
- Organisational Process

UNSAFE SUPERVISION

- Inadequate Supervision
- Planned Inappropriate Operations
- Failed to Correct a Known Problem
- Supervisory Violations

PRECONDITIONS FOR UNSAFE ACTS

- Physical Environment
- Technological Environment
- Physical/Mental Limitations
- Adverse Mental States
- Adverse Physiological States
- Crew Resource Management
- Personal Readiness

UNSAFE ACTS OF OPERATORS

- Decision Errors
- Skill-Based Errors
- Perceptual Errors
- Violations

Source: https://www.researchgate.net/profile/Gizem_Serin/publication/326478796/figure/fig1/AS:650030385995776@1531990729001/Overview-of-Human-Factor-Analysis-and-Classification-System-HFACS-Adapted-from.png

Source: https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcRb6yiw2pfk7NqbsVsnsZO_71-0V4O4GCWjhR-4Dtx_N6aXc96S
<table>
<thead>
<tr>
<th>Resource Management</th>
<th>Organizational Climate</th>
<th>Organizational Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant budget restraints</td>
<td>Struggle for survival</td>
<td>Self-promoting of the squadron</td>
</tr>
</tbody>
</table>

**Organisational Influences**

**Unsafe Supervision**

<table>
<thead>
<tr>
<th>Inadequate Supervision</th>
<th>Planned Inappropriate Operations</th>
<th>Failed to Correct a Known Problem</th>
<th>Supervisory Violations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient constraints against “adapted” regulations</td>
<td>NIL</td>
<td>No FSTD</td>
<td>Deviation of standard mission preparation time</td>
</tr>
</tbody>
</table>

**Unsafe Events**

<table>
<thead>
<tr>
<th>Physical Environment</th>
<th>Technological Environment</th>
<th>Physical/Mental Limitations</th>
<th>Adverse Mental State</th>
<th>Adverse Physiological State</th>
<th>CRM</th>
<th>Personal Readiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine terrain</td>
<td>LTE-susceptible A/C</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>Low but sufficient</td>
</tr>
<tr>
<td>No vegetation</td>
<td>Ineffective consideration of tail rotor limits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Preconditions for Unsafe Acts**

<table>
<thead>
<tr>
<th>Decision Errors</th>
<th>Skill-Based Errors</th>
<th>Perceptual Errors</th>
<th>(Routine) Violations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neglect of general wind direction</td>
<td>Only theoretical knowledge of LTE</td>
<td>Surface wind conditions not recognized</td>
<td>No W&amp;B</td>
</tr>
<tr>
<td>Rely on wind-drift</td>
<td>Possibly incorrect LTE-countermeasures</td>
<td></td>
<td>Excess MTOW</td>
</tr>
<tr>
<td>Approach with tailwind</td>
<td></td>
<td></td>
<td>Insufficient preparation</td>
</tr>
</tbody>
</table>

**HFACS Overlay to 5M**
HFACS Overlay to 5M

Failed to Correct a Known Problem
- No FSTD
- No learning from past occurrences
- Insufficient procedures for OSL

Physical Environment
- Alpine terrain
- No vegetation
- Light winds

Technological Environment
- LTE-susceptible A/C
- Ineffective consideration of tail rotor limits

Personal Readiness
- Low but sufficient
- Inert LTE-Knowledge

Decision Errors
- Neglect of general wind direction
- Rely on wind-drift
- Approach with tailwind

Skill-Based Errors
- Only theoretical knowledge of LTE
- Possibly incorrect LTE-countermeasures

Perceptual Errors
- Surface wind conditions not recognized

(Routine) Violations
- No W&B
- Excess MTOW
- Insufficient preparation
- OSL against valid rules

Unorganisational Influences

Unsafe Supervision

Preconditions for Unsafe Acts

Unsafe Acts of Operators
Pilot in Command

Safety Requirements and Constraints Violated:
- no preflight-planning including W&B
- no operational and tactical contingencies
- A/C-operation in accordance with publications
- no planning of safety margins
- no communicate restrictions, if necessary
- no use of purposeful means to ensure safe OSL
- no mission briefing

Context:
- last flight during a two-week live exercise
- “simple” mission
- supposed SA for mission orders at short-notice
- OSL inside reconnaissance area
- focus on engine torque limits, not tail-rotor limits
- over-reliance in regard to A/C-power
- no FSTD available for emergency training

Mental/Process Model Flaws:
- unplanned and unbrieﬁed high mountain OSL
- exceedance of MTOW not recognized
- LTE-enabling factors not consciously present
- wrong feeling of LTE-controllability and safety
- no desire to gain maximum safety buffer
- unplanned OSL generally accepted and tolerated
- rather “exercise” than operational mindset

Dysfunctional Interactions:
- did not question the landing site in terms of tactics
- ineffective CRM

Contributory Control Actions:
- no W&B
- A/C fueled to its maximum
- approach to OSL with tailwind
- possibly ineffective LTE-management

Missing or Imperfect Feedback:
- insufficient A/C drift cues due to light wind
- no or insufficient visual cues for surface wind assessment
- rapid change of A/C behaviour without warning signs

Controller
Model of controlled Process
Control Actions
Feedback
Controlled Process

• Possible Questions
• Safety Constraints

- Safety Requirements & Constraints
- Context
- Mental/Process Model Flaws
- Dysfunctional Interactions

Source: Käfer
STAMP / CAST Analysis

Society → Political Administration → Ministry of Defense

A/C-Manufacturer → Armed Forces → MoD Safety Cell

Air Force Level → Air Force SMS

Brigade Level → Brigade SMS

Helicopter Squadron → Aerial Reconnaissance Unit

LiveEx-Organization & BAE → Helicopter Detachment Commander

Environmental Factors

- Wind
- Terrain
- Altitude
- Temperature

PIC → FLIR-Operator → ARP1

Helicopter

Area of STAMP/CAST-Analysis

QR

4
8
28
4
58
107

SC

23
10
9
5
8
61

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Comparison of Results - Quantitative

5M vs. CAST - Quantitative Comparison

- Items (34)
  - 5M: 40
  - CAST: 20
- Causes (14)
  - 5M: 20
  - CAST: 10
- Possible Questions (32+75)
  - 5M: 32
  - CAST: 75
- Safety Constraints (61)
  - 5M: 61
  - CAST: 61
Comparison of Results - Quantitative

5M-Items vs CAST Questions Raised

5M: 34
CAST: 107

5M-Causes vs CAST Safety Constraints

5M: 14
CAST: 61
Comparison of Results - Quantitative

HFACS-Overlay

"Down and In"

"Up and Out"

5M- Items  5M-Causes  CAST - Questions Raised  CAST - Safety Constraints

- Unsafe Acts
- Preconditions for Unsafe Acts
- Unsafe Supervision
- Organizational Influences
Comparison of Results - Qualitative

5M Analysis

Considered Levels: 3

STAMP/CAST Analysis

Considered Levels: 7
Comparison of Results - Qualitative

**5M-Model:**

+ simple model
+ suitable for quick risk assessment
+ retrospective and prospective use possible

- lack of instructions how to use
- no interactions and processes analysed
- no systemic approach
- focus on operational level
- no graphical illustration
- reduced number of findings and recommendations
Comparison of Results - Qualitative

**HFACS:**
+ based on Swiss-Cheese-Model
+ broad focus up to organizational level
+ clear aviation-related taxonomy
+ easy to understand, simple method

- classification (not a model)
- little power in determining the causality
- no interactions and processes analysed
- only retrospective use possible
- simplistic view of human factors
- lack of systemic or procedural factors
STAMP/CAST:
+ comprehensive and up-to-date model
+ focus on systemic interactions and developments
+ suited for big-scale analyses
+ enables to raise the right questions (context, why?)
+ raises many questions, by that best answers
+ helps to determine effective preventive actions
+ steep learning curve

- great amount of data and domain knowledge
- complex and extensive model
- not a simple application at operational level
Future work with STAMP/CAST

- Tailored models specific for the organisation and its processes
- Templates that are easy applicable to foster acceptance in the organization
- Using STPA to improve the Safety Management System simplifies the application of CAST
Thank you for your attention!

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