METRIC FOR THE SELF-ASSESSMENT OF AVIATION SAFETY MANAGEMENT SYSTEMS

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BACKGROUND
CURRENT CHALLENGES FOR AVIATION COMPANIES

• Small – Medium Enterprises: lack of adequate safety/operational data to monitor safety
• Large companies: operational/safety data available, but they need leading metrics of better quality
• How to move from compliance-based to performance-based monitoring?
WE INITIATED A PROJECT TO HELP SME’S TO BETTER MEASURE THEIR SAFETY

• How to measure the safety of operations without the benefit of large amounts of safety relevant data?

• Investigate link between specific safety management activities in aviation and safety outcomes

• The project will create new knowledge in leading safety indicators

• Thus enable both SMEs and large companies to measure proactively the safety of their operational activities.
RESEARCH PROJECT

Phase 1: Current Situation

Sep 15 – Dec 16

Phase 2: Development of new safety metrics

Jan 17 – Dec 17

Phase 3: Application of metrics and validation

Jan 18 – Dec 18

Phase 4: Development of a tool

Jan 19 – Dec 19
SMS ASSESSMENT IS ONE OF 6 POTENTIAL NEW SAFETY METRICS

- SMS assessment
- Safety culture prerequisites
- Risk control effectiveness
- Resource gaps
- Work-as-imagined vs work-as-done at the task level
- System complexity / coupling
THE ICAO SMS CONSISTS OF 4 COMPONENTS AND 12 ELEMENTS
GENERAL REMARKS ON CURRENT SMS ASSESSMENT TOOLS IN AVIATION

- Current tools have been developed mainly through brainstorming and experience – not using a systematic analysis
- Difficult to customize to size and complexity of company
- Vague measurement scales - unquantified assessment results
- Design and Implementation do not consider:
  - timeliness of SMS processes
  - mutual dependencies of SMS activities
- Effectiveness of SMS not measured – often confused with institutionalisation or outcomes
# Work as Imagined vs Work as Done

<table>
<thead>
<tr>
<th>Work as Imagined</th>
<th>Work as Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dislocated in time/place from execution</td>
<td>Real-time execution</td>
</tr>
<tr>
<td>No/limited feedback</td>
<td>Immediate feedback</td>
</tr>
<tr>
<td>Very stable</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Predetermined input variability</td>
<td>Real-time input variability</td>
</tr>
<tr>
<td>Stable environment</td>
<td>Real-time environment variability</td>
</tr>
<tr>
<td>Relies on sufficient training &amp; knowledge</td>
<td>Voids in training &amp; knowledge</td>
</tr>
<tr>
<td>Motivation taken for granted</td>
<td>Sensitive to motivation</td>
</tr>
</tbody>
</table>

- Leveson (2011): Flaws in Feedback and Control Inputs
- Dekker (2014): Work as Done vs Work as Imagined
- Hale & Borys (2013): Work to Rule
- Shorrock (2016): The Varieties of Human Work
STAMP HAS BEEN USED TO IDENTIFY THE GAP BETWEEN WAD AND WAI

Work-as-Imagined  Work-as-Done location X

Boelhouwer 2016
WHY USE STPA?

- UCAs -> Requirements: reflect the institutionalisation of SMS.
- Loss scenario’s:
  - reasons that have led to the UCAs detected.
  - Ineffective/incorrect CAs: reflect capability factors to run the SMS activities.
  - SMS can be correctly designed and implemented according to its design, but its deliverables can yet be unachievable.
  - A low capability level can signal that an SMS might not be suitably tailored to the organisation.
OBJECTIVE
OBJECTIVE

• Generate a self-assessment tool to determine the gap between the SMS standards (Work-as-Imagined) and actual use (Work-as-Done) as a quantifiable measure of SMS effectiveness
METHOD
WE USED STANDARD STPA

Leveson & Thomas 2018
LOSS SCENARIO’S

a) Why would Unsafe Control Actions occur?

b) Why would control actions be improperly executed or not executed?

Leveson & Thomas 2018
DISTANCE VECTORS ALLOW FOR COMPARISON OF WAD AND WAI

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1 \\
1 \\
1 \\
1 \\
\vdots \\
1 \\
1
\end{pmatrix}
\]  \[ \begin{pmatrix}
1 \\
1 \\
1 \\
0 \\
\vdots \\
1 \\
0
\end{pmatrix}
\]
RESULTS
SYSTEM ACCIDENTS

- A-1. Level 1 SMS audit findings for non/compliance\(^1\)
- A-2. Poor safety performance

\(^1\) Assumption: ICAO standard reflects sufficient & necessary SMS design
SYSTEM HAZARDS

- H-1. SMS is not designed according to standards (A-1, A-2)
- H-2. SMS is not implemented according to standards (A-1, A-2)
- H-3. SMS is not suitable for the organization (A-1, A-2)
- H-4. SMS is not effective (A-2)
AVAC-SMS: SYSTEM LEVEL CONSTRAINTS

- SR-1: SMS shall be designed according to standards
- SR-2: SMS shall be implemented according to standards
- SR-3: SMS shall be suitably scaled for the organization
- SR-4: SMS shall be effective
CONTROL HIERARCHY – HIGH-LEVEL
CNTRL HIERARCHY – POLICY & OBJECTIVES
CONTROL HIERARCHY – PROMOTION
<table>
<thead>
<tr>
<th>SMS component</th>
<th>SMS element</th>
<th>Control Actions (#)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Design</td>
<td>Impl.</td>
</tr>
<tr>
<td>Safety Policy &amp; Objectives</td>
<td>Management Commitment and Responsibility</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Accountabilities and Responsibilities</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Assignment of Resources &amp; Appointment of Key Personnel</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Coordination of Emergency Response Planning</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SMS Documentation</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Safety Risk Management</td>
<td>Hazard Identification</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Risk Assessment and Mitigation</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Safety Assurance</td>
<td>Safety Performance Monitoring &amp; Measurement</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>The Management of Change</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Continuous Improvement of SMS</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Safety Promotion</td>
<td>Training &amp; Education</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Safety Communication</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>51</td>
<td>50</td>
</tr>
</tbody>
</table>
EXAMPLES OF HAZARDOUS IF PROVIDED:

1. Defines a just culture policy When have not achieved maximum internal agreement
2. Defines safety objectives when safety policy has not been defined
3. Defines policy/procedures for voluntary reporting when just culture policy has not been defined
4. Defines safety accountabilities when overall organisational accountabilities have not been defined
5. Defines safety responsibilities when authorities per role/function have not been defined
6. Appoints safety personnel When competency criteria have not been defined
7. Provides technical equipment for the implementation of safety policy When specifications have not been defined
8. Approves organisational changes when a change management method has not been defined or applicability criteria are not met
9. Approves SMS changes when possible conflicts with other management systems have not been assessed
10. Implements just culture policy When there are no valid evidence and personal accounts
11. Performs risk assessment when risk assessment method has not been defined
12. Develops risk controls when methodology for developing risk controls has not been defined
13. Monitors safety performance when indicators do not meet quality criteria or data are not sufficiently reliable/accurate when data analysis of voluntary or mandatory reporting systems has not been completed
EXAMPLES OF HAZARDOUS IF PROVIDED:

14. Evaluate effectiveness of all risk controls when a method has not been defined
15. Implements organisational changes when not approved by management or resources are not available
16. Provides safety communication when internal or external safety information has not been collected and respective background is not known
17. Publishes an Emergency Response Plan (ERP) when all relevant internal and external interfaces are not known
18. Defines a risk assessment method when authorities per function/role have not been defined (or not known)
19. Performs risk assessment when risk assessment method has not been defined
20. Develops risk controls when methodology for developing risk controls has not been defined
21. Evaluate effectiveness of all risk controls when a method has not been defined
22. Monitors safety performance when indicators do not meet quality criteria and data are not sufficiently reliable/accurate
23. when data analysis of voluntary or mandatory reporting systems has not been completed
24. Designs safety education/training programs when particular needs per job function/role have not been collected
25. Provides safety communication when internal or external safety information has not been collected and respective background is not known
LOSS SCENARIO’S FOR LOW SMS INSTITUTIONALISATION

• The SMS element is documented inadequately/poorly (e.g., clarity, accuracy).
• The SMS element activities are not sufficiently known.
• Inadequate information and feedback required to perform the activities of the SMS element.
• Information and feedback required to perform the activities of the SMS element are provided with a delay.
• Information and feedback needed to perform the activities of the SMS element are corrupted or of poor quality.
LOSS SCENARIO’S FOR LOW SMS CAPABILITY

• Example questions
  • How capable do you feel of executing your tasks related to this element?
  • How adequate are the means available to you to execute the tasks related to this element?
  • To what degree do you conflict with other persons that work on the same tasks of the SMS element?
  • How adequate is the information from other organisational and SMS activities you need to execute the tasks of this element?
  • How timely do you receive necessary information from other organisational and SMS activities to execute your tasks of this element?
  • To what degree do external factors disturb you in the execution of your tasks of this element?
LOSS SCENARIO’S FOR LOW SMS EFFECTIVENESS

• Questions:
  • To what degree is the amount of activities related to this element adequate to support your daily tasks?
  • To what degree is the quality of the activities related to this element sufficient to support your daily tasks?
  • How timely are the activities related to this element executed to support your daily tasks?
SURVEY QUESTIONS REQUIRE A SCORE TO IDENTIFY GAP WAD - WAI

Controls (designed & documented, implemented, dependencies)

<table>
<thead>
<tr>
<th>SMS Component</th>
<th>SMS Element</th>
<th>Code</th>
<th>Check if:</th>
<th>Extent of Realising the Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCR1</td>
<td>There is a safety policy</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>MCR2</td>
<td>The organisational policy views safety as core business function</td>
<td></td>
<td></td>
<td>70%</td>
</tr>
<tr>
<td>MCR3</td>
<td>Safety personnel participate in all management meetings across different organizational levels</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>MCR4</td>
<td>Safety is a parameter during decision-making during all management meetings across different organizational levels</td>
<td></td>
<td></td>
<td>70%</td>
</tr>
<tr>
<td>MCR5</td>
<td>Possible need to change the safety policy has been always discussed during significant changes within the organization (e.g., overall business objectives) or of external conditions</td>
<td></td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>MCR6</td>
<td>Current safety policy is included in all safety education/training programs</td>
<td></td>
<td></td>
<td>0%</td>
</tr>
</tbody>
</table>
WE HAVE PRODUCED THE TOOL AND IT IS CURRENTLY BEING PILOTED

**Management Commitment & Responsibility**

Brief description of element: Management’s primary responsibility for ensuring a safe and efficient operation is discharged through ensuring adherence to Standard Operating Procedures (safety compliance) and establishment and maintenance of a dedicated SMS that establishes the necessary safety risk controls (safety performance).

There is a safety policy

Yes

No

The overall organisational policy views safety as one of the core business functions.
WE HAVE PRODUCED THE TOOL AND IT IS CURRENTLY BEING PILOTED

• SAFETY DEPARTMENT
  • 149 SMS assessment points
  • 48 SMS assessment points (4 questions per SMS element):
  • 16 SMS assessment points (4 questions per SMS component):

• MANAGERS/SAFETY STAFF AND END-USERS
  • SMS element level: 72 questions for managers/safety staff – 36 questions for end-users
  • SMS component level: 24 questions for managers/safety staff – 12 questions for end-users
  • Overall SMS: 6 questions for managers/safety staff – 3 questions for end-users
WE HAVE PRODUCED THE TOOL AND IT IS CURRENTLY BEING PILOTED

- **SAFETY DEPARTMENT**
  - 149 SMS assessment points:
    [https://hva.eu.qualtrics.com/jfe/form/SV_2gZWLD0iEzsojvT](https://hva.eu.qualtrics.com/jfe/form/SV_2gZWLD0iEzsojvT)
  - 48 SMS assessment points (4 questions per SMS element):
    [https://hva.eu.qualtrics.com/jfe/form/SV_6iqnu4hqtapx5gF](https://hva.eu.qualtrics.com/jfe/form/SV_6iqnu4hqtapx5gF)
  - 16 SMS assessment points (4 questions per SMS component):

- **MANAGERS/SAFETY STAFF AND END-USERS**
  - SMS element level: 72 questions for managers/safety staff – 36 questions for end-users
    [https://hva.eu.qualtrics.com/jfe/form/SV_3WavOt4xxQuUf09](https://hva.eu.qualtrics.com/jfe/form/SV_3WavOt4xxQuUf09)
  - SMS component level: 24 questions for managers/safety staff – 12 questions for end-users
    [https://hva.eu.qualtrics.com/jfe/form/SV_4OCXRHNaFYH1DDL](https://hva.eu.qualtrics.com/jfe/form/SV_4OCXRHNaFYH1DDL)
  - Overall SMS: 6 questions for managers/safety staff – 3 questions for end-users
    [https://hva.eu.qualtrics.com/jfe/form/SV_eaEi1isBzYraUHX](https://hva.eu.qualtrics.com/jfe/form/SV_eaEi1isBzYraUHX)
  - Trial code for any company: 99747
  - There is a question within the survey that asks the participants about their role, and then shows only the relevant questions
LESSONS LEARNED

• STPA applicable to the management part of a socio-technical system
• Use of *loss scenario’s* for STPA to determine causal factors - novel compared to other SMS tools
• Ability to zoom-in and zoom-out of the SMS - not offered by other tools
  • SMS elements (12)
  • SMS components (40)
  • Individual SMS processes (N)
• Scoring system somewhat arbitrary
THANK YOU FOR YOUR ATTENTION

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