USING STPA FOR EVALUATING AVIATION SAFETY MANAGEMENT SYSTEMS (SMS)

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BACKGROUND
THE SMS ELEMENTS (1/2)

• Policy & Objectives
  • Management commitment & responsibility
  • Safety accountabilities
  • Appointment of safety key personnel
  • Coordination of emergency response planning
  • SMS documentation

• Safety Risk Management
  • Hazard identification
  • Safety risk assessment and mitigation

(ICAO, 2013)
THE SMS ELEMENTS (2/2)

• Safety Assurance
  • Safety performance measurement and monitoring
  • Management of change
  • Continuous improvement of SMS

• Safety Promotion
  • Training and education
  • Safety communication

(ICAO, 2013)
SMS EVALUATION: CURRENT SITUATION

• Compliance checks are a long-established practice:
  • SMS is designed according to standards.
  • SMS activities are performed according to SMS documentation.
SMS EVALUATION: CURRENT SITUATION

• Recent focus on performance-based evaluation: work is done as planned **and** generates the desired output.

• However:
  • Performance-based evaluation is still solely linked to process outputs.
  • SMS elements are evaluated individually without considering their interactivity and interdependency.
RESEARCH METHODOLOGY
RESEARCH SCOPE

- Comparison of indicative aviation SMS evaluation tools.
- Identification of weaknesses and strengths of current tools based on comments from experts.
- Application of the STPA method on SMS.
- Development of requirements and respective evaluation topics to be used by auditors as means to assess performance of SMS in an efficient and inclusive way.
ANALYSIS OF CURRENT TOOLS

• Analysis of indicative SMS evaluation tools in order to assess:
  • Coverage of each of the four SMS pillars.
  • Level of system maturity addressed (Plan – Do – Check – Act).
  • Identification of strengths and weaknesses of SMS evaluation tools through content analysis of comments provided by 5 experts.
STUDY SAMPLE: TOOLS ANALYSED BY RESEARCHERS

- Australian Civil Aviation Safety Authority
- Eurocontrol
- French Safety Directorate of Civil Aviation
- SHEL Aircraft International (2 tools)
- Singapore Civil Aviation Authority
- Transport Canada Civil Aviation
- UK Civil Aviation Authority
STUDY SAMPLE: TOOLS COMMENTED BY EXPERTS

- Safety Management International Collaboration Group
- Civil Air Navigation Services Organisation (2 tools)
- Transport Canada Civil Aviation
- SHEL Aircraft International
- Civil Aviation Authority Singapore
APPLICATION OF STPA (1/2)

• Application of STPA on the SMS (ICAO Safety Management Manual).
• Depiction of interactions amongst SMS controllers and processes.
• Statement of UCAs and requirements.
• Responsibilities per controller.
• Suggestion for SMS evaluation topics.
• Comparison of results with current SMS evaluation tools.
APPLICATION OF STPA (2/2)

- Causal factors were not stated under the concept that:
  - SMS evaluation will initially focus on the fulfilment of requirements sourcing from Unsafe Control Actions (STPA step 1) and depicting system performance.
  - If a requirement is not met, organization shall identify causal factors and apply remedies (STPA step 2).
RESULTS
## ANALYSIS OF CURRENT TOOLS: SMS PILLARS & MATURITY LEVEL

<table>
<thead>
<tr>
<th>POLICY &amp; OBJECTIVES</th>
<th>SAFETY RISK MANAGEMENT</th>
<th>SAFETY ASSURANCE</th>
<th>SAFETY PROMOTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>44%</td>
<td>23%</td>
<td>21%</td>
<td>12%</td>
</tr>
<tr>
<td>15 - 88 topics</td>
<td>0 – 69 topics</td>
<td>1 – 45 topics</td>
<td>1 – 35 topics</td>
</tr>
<tr>
<td>Median: 25</td>
<td>Median: 12.5</td>
<td>Median: 13</td>
<td>Median: 4.5</td>
</tr>
<tr>
<td></td>
<td><strong>Total topics:</strong> 22 – 237 (median: 49.5)**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLAN (DESIGN)</th>
<th>DO (OPERATION)</th>
<th>CHECK (MONITORING)</th>
<th>ACT (IMPROVEMENT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38%</td>
<td>38%</td>
<td>19%</td>
<td>5%</td>
</tr>
<tr>
<td>5 – 97 topics</td>
<td>8 – 82 topics</td>
<td>1 – 46 topics</td>
<td>0 – 12 topics</td>
</tr>
<tr>
<td>Median: 23</td>
<td>Median: 22</td>
<td>Median: 11</td>
<td>Median: 1.5</td>
</tr>
</tbody>
</table>

50% of the tools do not include surveys as method of evaluating system performance
## EXPERTS’ COMMENTS ON CURRENT TOOLS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completeness (ICAO SMS / SMM pillars &amp; elements)</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>Performance &amp; effectiveness addressed</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>Guidance for use of the tool</td>
<td>54%</td>
<td>46%</td>
</tr>
<tr>
<td>Comprehensibility</td>
<td>62%</td>
<td>38%</td>
</tr>
<tr>
<td>Structure</td>
<td>14%</td>
<td>86%</td>
</tr>
</tbody>
</table>
STAMP: ACCIDENTS, HAZARDS & REQUIREMENTS

• Accidents
  • A-1: Operations’ certification is suspended
  • A-2: Safety events lead to losses beyond acceptable limits

• Hazards
  • H-1: SMS design flaws (A-1, A-2)
  • H-2: Large gap between design & implementation of SMS (A-1, A-2).

• High-level requirements
  • SMS shall be designed according to standards and address operation, monitoring and improvement of all SMS processes
  • Gap between SMS design and implementation shall be maintained under a predetermined threshold
## STPA STEP 1: UCA

- **78 Unsafe Control Actions:**
  - Policy & Objectives: 28
  - Safety Risk Management: 18
  - Safety Assurance: 22
  - Safety Promotion: 10

<table>
<thead>
<tr>
<th>Control action</th>
<th>Not providing</th>
<th>Providing</th>
<th>Too late, Too early, or Out of sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety department provides safety communication (SC)</td>
<td>Safety department does not provide SC when safety information is available from internal and external sources</td>
<td>Safety department provides SC when complete background of communication information is not available</td>
<td>Too late: Safety department provides SC after effective dates of SMS and safety related changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Safety department provides SC when safety communication is not customized to each position</td>
<td></td>
</tr>
</tbody>
</table>
# STPA STEP 1: REQUIREMENTS AND EVALUATION TOPICS FROM UCA

<table>
<thead>
<tr>
<th>SMS Pillar</th>
<th>Number of requirements</th>
<th>Requirements check</th>
<th>Survey topics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Documentation / records check topics</td>
<td></td>
</tr>
<tr>
<td>Policy &amp; Objectives</td>
<td>10</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Safety Risk Management</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Safety Assurance</td>
<td>6</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Safety Promotion</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>25</strong></td>
<td><strong>30</strong></td>
<td><strong>16</strong></td>
</tr>
<tr>
<td>SMS Pillar</td>
<td>Requirement</td>
<td>Requirement check</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Policy &amp; Objectives</td>
<td>SMS and safety objectives shall be balanced with other organizational objectives based on predefined method / criteria</td>
<td>Check whether safety objectives have been achieved at about the same extent as other organizational objectives (e.g., finance, production, quality)</td>
<td>Ask staff whether balance of various organizational objectives (e.g., safety, efficiency, quality, security) is maintained</td>
</tr>
<tr>
<td></td>
<td>Check for documented decision criteria referring to maintenance of balance when establishing or changing various organizational objectives</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# RESPONSIBILITIES PER CONTROLLER

<table>
<thead>
<tr>
<th>Controller</th>
<th>Safety Policy &amp; Objectives</th>
<th>Safety Risk Management</th>
<th>Safety Assurance</th>
<th>Safety Promotion</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior management</td>
<td>7</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Safety department</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Managers</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Employees</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>Quality department</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>External organizations</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>
# COMPARISON OF STPA RESULTS WITH TOOL ANALYSIS RESULTS

<table>
<thead>
<tr>
<th>Pillar</th>
<th>Audit topics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STPA based (checks &amp; surveys)</td>
</tr>
<tr>
<td>Policy &amp; Objectives</td>
<td>23</td>
</tr>
<tr>
<td>Safety Risk Management</td>
<td>7</td>
</tr>
<tr>
<td>Safety Assurance</td>
<td>10</td>
</tr>
<tr>
<td>Safety promotion</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>46</strong></td>
</tr>
</tbody>
</table>
CONCLUSIONS & NEXT STEPS
CONCLUSIONS: CURRENT TOOLS

• Incorporate professional experience but are not based on a systematic analysis of the SMS.
• Are highly variable in the extent they cover SMS processes and evaluate system maturity level.
• Assess SMS processes individually without considering interconnections.
• Address mainly compliance and operation.
• Some extensive tools include “failures” of system components.
CONCLUSIONS: STPA BASED APPROACH (1/2)

• Combination of systematic analysis and professional experience.
• Requirements address individual SMS elements and their interactions.
• Evaluation activities combine documentation checks and survey questions that collectively provide information for SMS performance.
• Addresses the highest level of maturity: if a system consistently performs well, then it exists, is running and is subject to improvements.
CONCLUSIONS: STPA BASED APPROACH (2/2)

• It initially focuses on HOW SMS performs and NOT WHY performance might not have been achieved.
• It consists of a manageable set of 46 evaluation topics, a number close and lower than the median of current SMS evaluation tools.
• If used, might reduce the workload of auditors and duration of audits, leading to saving of resources.
• Although it is based on ICAO SMS, it can be used in other industry sectors.
NEXT STEPS

• Compile a document including an SMS performance-based evaluation tool and respective guidance for its use.
• Ask from organizations to try the tool and provide feedback.
• Adjust the tool according to comments, and publish it.
• Proceed to STPA step 2 and populate the list of requirements, so to enable organizations assess their SMS deeper.
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