Accident Causation and Prevention

- Aircraft accidents are the result of multiple risk-factor chains that interact and cumulate over time.
- Operational errors immediately prior to an accident tend to be but part of a much larger error sequence at Organizational or ‘system’ level that causes individuals to be ‘set up for failure’.
- Accident have systemic roots and require a systemic solution: Safety Management Systems: ensures teams and individuals are ‘set up for success’.

- SMS is not new: it has evolved over 50 years in complex industries (e.g. nuclear, maritime, rail).
- Aviation SMS is not yet widely regulated in the aviation industry, but is gaining momentum: Air Transport Canada, CASA, UK CAA, ICAO requirement from 2009. All these current models tend to share similar features.
- Considerable experience has been built in the application of SMS to helicopter operations, primarily through the major Clients (Shell, ExxonMobil, Woodside, OGP etc): this experience currently represents ‘industry best practice’.

Zotov Error Mapping
The Evolution of Aviation SMS

We can now apply the lessons learned over 100 years

- 1900: Aviation
- 1960: Aviation Combat

- Aerospace: ‘Apollo 1’
- Industrial Safety
- ‘Commercial’ Industries

- System Safety in Engineering
SMS Standards and Guidelines

SMS has been developing within aviation for the past ten years and is now guided by a widening range of Regulatory Standards, recommended practices, Client requirements and academic research, for example:

- The International Civil Aviation Organization (ICAO)
- Oil and Gas Producers Forum (OGP)
- Shell, ExxonMobil, Woodside etc
- United Kingdom Civil Aviation Authority
- International Business Aircraft Operators Organization
- Air Transport Canada
- Australia Civil Aviation Safety Authority
- The US Federal Aviation Authority

These Guidelines and Regulations represent the blending of QMS, complex industry SMS, aviation human factors and traditional flight safety.
The Primary Elements of an SMS

- Objectives
- Organization Structure
- Accountabilities
- Responsibilities
- Policy
- Process Definition
- Document Structure
- Resources
- Standards
- Competence
- Service Acquisition, Contractors
- Communication and Information management
- Hazard Identification
- Risk Management
- Quality/Safety Plans
- Asset Integrity Work Environment
- Management of Change
- Emergency Planning
- Evaluation and KPI's
- Performance Monitoring
- Corrective Action
- Prevention Action
- Incident Reporting
- Audit
- Records
- Management Review
- Continuous Improvement
- Customer Focus
- Culture and workforce involvement
- Management Commitment
- Customer Focus
- Human Factors
- Plan
- Check
- Feedback
- Do

Safety Case
Safety Case: Purpose

Is a good set of Rules and Procedures not enough?

A comprehensive set of Rules, standards and procedures in aviation operations will assure a certain level of human reliability, however:

• Aviation takes place in a dynamic environment: changes may render Rules, standards and procedures obsolete or inadequate
• Rules, standards and procedures may be based on a given level of knowledge that is imperfect
• Although individual procedures may be well considered, there may be a lack of coherence between individual procedures
• Conditions may be such that procedures are disobeyed, cannot be obeyed or are not adequately understood

A Safety Case is the primary tool for seeking out and controlling latent risk factors within any given scope of operations so that conditions and procedures may be improved accordingly
There is no evil here, just the tension between the goals we set and the risks we take and the limits of human and machine.

A Safety Case is a formal method for balancing goals against risks and to compensate for the limits of human and machine.
The Safety Case

A Safety Case is defined as “The documented description of the major hazards inherent in the scope of activities and the process and means employed to control these hazards to a level that is considered to be As Low As is Reasonably Practicable (ALARP)”

The Safety Case proves (demonstrates) that safety is being managed as a critical business function and that the Organization is showing ‘due care’ – first line of legal defence to counter:

- **Corporate Negligence**: Where no risk assessment was carried out, and the risk therefore not identified
- **Corporate Complacency**: Where the risk was identified and assessed but then ignored
- **Corporate Inactivity**: Where the risk was identified and assessed, but inappropriate action was taken

A Safety Case is primarily Proactive is that it creates the potential for safer operations

A Safety Case is also Reactive in that it provides Corporate defense in the unfortunate event of an accident
Key Features of an Aviation Safety Case

A Safety is a **Process** that culminates in a **Document**. This Document:

- Describes the scope of the particular operation
- Summarises how the SMS elements are applied to the particular operation
- Identifies and describes the safety critical activities associated with the operation
- Provides evidence that all potentially significant hazards and associated effects have been identified, the risks fully assessed and adequate hazard management controls are in place
- Lists any safety deficiencies and provides a targeted work program to achieve safety improvement
- Presents the conclusions reached in the Safety Case
- Contains a formal Statement of Fitness for the operation

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The Helicopter Offshore Safety Case is based on a template formed through the analysis of some 2000 helicopter accidents and evolved through practical application over a period of ten years.
SMS Implementation Model

Development and Implementation of the SMS

① Develop SMS Policy, Process and Procedure

② Develop SMS Competencies

③ Application of the SMS
Generic Safety Case Process: Offshore

1. **Description of the Operation**
   - Offshore helicopter, Operations

2. **Identify Primary Processes**
   - Primary Processes
   - Workshops

3. **Identify Critical Activities**
   - Sub-Activities
   - Workshops
   - Matrix

4. **Formulation of Controls (‘ALARP’)**
   - ‘Bow Tie’
   - Model Template (1800 accidents)

5. **Risk Analysis**
   - Matrix

6. **Hazard Identification**
   - Workshops
   - Conformance

7. **Gap Analysis Remedial Action Plans**
   - Assessments
   - Continuous Improvement

8. **Safety Case Document**
   - Offshore Safety Case Document

**Sub-Activities**
- Gap Analysis Remedial Action Plans
- Continuous Improvement
- Assessments
- Model Template (1800 accidents)
- Workshops
- Conformance

**Application of the SMS**
Primary Sources of Hazard Identification

Internal Sources

- In-House Safety Audits
- (Safety) Meetings
- Hazard Reporting Systems
- Company Experience
- ‘Brainstorming’
- Workforce Input
- Company Systems

Safety Critical Processes

- Observation
- Analysis

Key operational processes

- Reveals ‘critical activities’
- Focuses on the ‘status-quo’
- Buy-in
- Follows a logical sequence
- Very specific controls
- May miss high risks

External Sources

- Internet databases
- Industry workgroups
- Government initiatives
- External Audit Reports
- Regulator’s Opinion
- Safety Publications
- Client Inputs

Formal Hazard Models

- Shell
- NASA

Ongoing hazard identification

- Relevant, ‘Buy-In’
- ‘Local thinking’

Big picture, high risk killer hazards

- Primary threats
- No buy-in

‘One-off’ corporate exercise

- Very thorough
- Huge resources
## Primary Hazardous Events

<table>
<thead>
<tr>
<th>Category</th>
<th>#/792</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of Tail Rotor Effectiveness</td>
<td>76</td>
<td>9.6%</td>
</tr>
<tr>
<td>Dynamic Rollover(+tiedown)</td>
<td>68</td>
<td>8.6%</td>
</tr>
<tr>
<td>Settling, power margins</td>
<td>22</td>
<td>2.7%</td>
</tr>
<tr>
<td>Unsuccessful autorotation</td>
<td>162</td>
<td>20.5%</td>
</tr>
<tr>
<td>External load/line</td>
<td>21</td>
<td>2.6%</td>
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<tr>
<td>Fuel exhaustion</td>
<td>29</td>
<td>3.6%</td>
</tr>
<tr>
<td>VMC ⇒ IMC (inc white out)</td>
<td>86</td>
<td>10.8%</td>
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<tr>
<td>CFIT</td>
<td>51</td>
<td>6.4%</td>
</tr>
<tr>
<td>Wirestrike</td>
<td>64</td>
<td>8.1%</td>
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<tr>
<td>Obstacle strike</td>
<td>52</td>
<td>6.5%</td>
</tr>
<tr>
<td>Landing Surface condition</td>
<td>8</td>
<td>1.0%</td>
</tr>
<tr>
<td>Winds/gusts</td>
<td>10</td>
<td>1.0%</td>
</tr>
<tr>
<td>Icing induced (power loss)</td>
<td>11</td>
<td>1.0%</td>
</tr>
<tr>
<td>Density-altitude</td>
<td>20</td>
<td>2.5%</td>
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<tr>
<td>TR + Power Train</td>
<td>41</td>
<td>5.1%</td>
</tr>
<tr>
<td>Engine fail/ “Power loss”</td>
<td>146</td>
<td>18.4%</td>
</tr>
<tr>
<td>Hydr/Fuel/Oil Systems</td>
<td>47</td>
<td>5.9%</td>
</tr>
<tr>
<td>Air frame</td>
<td>6</td>
<td>&lt;1.0%</td>
</tr>
<tr>
<td>False instr. indications</td>
<td>2</td>
<td>&lt;1.0%</td>
</tr>
</tbody>
</table>

## Primary Event

<table>
<thead>
<tr>
<th>Primary Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mechanical Failure / Power Loss</td>
</tr>
<tr>
<td>2. Failed Autorotation</td>
</tr>
<tr>
<td>3. Inadvertent VMC ⇒ IMC</td>
</tr>
<tr>
<td>4. Controlled Flight Into Terrain</td>
</tr>
<tr>
<td>5. Loss of Tail Rotor Effectiveness</td>
</tr>
<tr>
<td>6. Dynamic Roll-Over</td>
</tr>
<tr>
<td>7. Wire/Obstacle Strike</td>
</tr>
<tr>
<td>8. Degraded Power Margins</td>
</tr>
<tr>
<td>9. External Load Handling</td>
</tr>
<tr>
<td>10. Fuel Exhaustion</td>
</tr>
<tr>
<td>11. Wind/Gusts</td>
</tr>
<tr>
<td>12. Passenger into Rotors</td>
</tr>
<tr>
<td>13. Misjudgment of landing surface</td>
</tr>
<tr>
<td>14. Mid-Air /Ground Collision</td>
</tr>
<tr>
<td>15. Pilot Incapacitation</td>
</tr>
<tr>
<td>16. Birdstrike</td>
</tr>
</tbody>
</table>
Step 1: Determine Primary Events

Step 2: Link Event to Bow Tie and 3 ‘Gates’ to Manage Risk

Step 3: Link to Three Levels of Risk Control

Primary Hazards

- Accident Database Analysis
- Event Categorisation
- Specific Event

The Bow-Tie

Hazardous Event

Risk Controls: Organization
Risk Controls: Team
Risk Controls: Individual

Predicting and Preventing the Event
Detecting and Recovering Prior to Final Consequence
Mitigating the Effects of the Final Consequence