ATO
Safety
Risk
Management

Presented By:
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Federal Aviation Administration
Air Traffic Organization-Office of Safety
Manager, Safety Risk Management
What Is the FAA’s Safety Management System?

SMS Definition*

• An integrated collection of processes, procedures, policies, and programs that are used to assess, define, and manage the safety risk in the provision of ATC and navigational services

* AOV Safety Oversight Circular 08-06, ATO Safety Management System (SMS) Definitions
SMS Components

- Safety Policy
- Safety Promotion
  - Identified New Hazards
  - NAS Changes Needed
- Safety Assurance
  - Monitor NAS & mitigations through:
    - Audits & Evals
    - Investigations
    - Data Analyses
- SRM
  - Identify hazards
  - Analyze, assess, knowingly accept, and mitigate risk
  - Monitoring plans

SMS Components:
- ORGANIZATIONAL SAFETY CULTURE
  - SMS Orders
  - Lessons Learned
  - SMS Training
  - SMS Manual
  - SMS Implementation Plan

- Safety Communications

Federal Aviation Administration
SMS in the FAA ATO

• Formal system approach to managing the safety risk of Air Traffic Control (ATC) and navigation services

• Provides consistent processes and documentation in managing safety risk

• Provides a standardized methodology to identify and address safety hazards that occur within the National Airspace System (NAS) or in which some element of the NAS is a contributing factor

• FAA Flight Plan Goal
SMS Historical Highlights

- **1996**: The National Civil Aviation Review Commission reviews the FAA’s safety practices.
- **2000**: FAA team studies concept of SMS.
- **2003**: ATO established as a performance-based organization.
- **2005**: FAA Order 1100.161, Air Traffic Safety Oversight, formally creates AOV.
- **2007**: ATO adopts Order JO1000.37.
- **2009**: AOV conducts ATO SMS assessment.
- **2010**: ATO SMS implementation deadline.
Safety Risk Management
Risk Assessment of **ALL** Changes

**ASSESS THE RISK**

Baseline as of March 14, 2005

SAFE?

**NAS**

**CHANGE**

Continuous Monitoring

Impact to Safety?

**Maintain and Improve the Safety of the NAS**

**National Airspace System:** Is comprised of airspace; airports; aircrafts; pilots; air navigation facilities; air traffic control (ATC) facilities; communication, surveillance, navigation, and supporting technologies and systems; operating rules, regulations, policies, and procedures; and the people who implement, sustain, or operate the system components.
Safety Risk Management and the ATO

Safety Risk Management → Describe System → Identify Hazards → Analyze Risk → Assess Risk → Treat Risk

- Airspace Change
- New Procedure
- Airport Change
- New System
- Mods.
SRM Decision Process

Change Proposed

Does It Affect the NAS?
- Yes
  - Further Safety Analysis Conducted
  - Is Risk Level Acceptable?
    - Yes
      - Risk Level Acceptable Documented in SRMD
    - No
      - Risk Level Unacceptable Documented in SRMD
  - No Further Analysis Necessary
- No
  - No Further Analysis Necessary

Could This Introduce Safety Risk Into the NAS?
- Yes
  - Further Safety Analysis Conducted
  - Is Risk Level Acceptable?
    - Yes
      - Risk Level Acceptable Documented in SRMD
    - No
      - Risk Level Unacceptable Documented in SRMD
- No
  - No Further Analysis Necessary

Decision Documented in SRMDM
SRM Process

**Describe System**
- Define scope and objectives
- Define stakeholders
- Identify criteria and plan for risk management effort (including any modeling/simulation potentially required)
- Describe system/change (use, environment, and intended function, including planned future configuration)

**Identify Hazards**
- Identify hazards (what can go wrong?) that exist in the context of the NAS change
  - Use structured approach
  - Be comprehensive (and do not dismiss hazards prematurely)
  - Employ lessons learned and experience supplemented by checklists

**Analyze Risk**
- For each hazard:
  - Identify existing mitigations/controls
  - Determine risk (severity and likelihood) of outcome
    - Qualitative or quantitative (preferred)

**Assess Risk**
- Rank hazards according to the severity and likelihood of their risk
- Select hazards for detailed risk treatment (based on risk)

**Treat Risk**
- Identify feasible mitigation options
- Develop risk treatment plans
- Implement and verify
- Monitor
## Severity Definitions

<table>
<thead>
<tr>
<th>Effect On:</th>
<th>Minimal</th>
<th>Minor</th>
<th>Major</th>
<th>Hazardous</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATC Services</td>
<td>Conditions resulting in a minimal reduction in ATC services, or a loss of separation resulting in a Category D Runway Incursion (RI)(^1), or proximity event</td>
<td>Conditions resulting in a slight reduction in ATC services, or a loss of separation resulting in a Category C RI(^1), or Operational Error (OE)(^2)</td>
<td>Conditions resulting in a partial loss of ATC services, or a loss of separation resulting in a Category B RI(^1), or OE(^2)</td>
<td>Conditions resulting in a total loss of ATC services, (ATC Zero) or a loss of separation resulting in a Category A RI(^1) or OE(^2)</td>
<td>Conditions resulting in a collision between aircraft, obstacles or terrain</td>
</tr>
<tr>
<td>Flight Crew</td>
<td>– Flightcrew receives TCAS Traffic Advisory (TA) informing of nearby traffic, or, – Pilot Deviation (PD) where loss of airborne separation falls within the same parameters of a Category D OE (^2) or proximity Event – Minimal effect on operation of aircraft</td>
<td>– Potential for Pilot Deviation (PD) due to TCAS Preventive Resolution Advisory (PRA) advising crew not to deviate from present vertical profile, or, – PD where loss of airborne separation falls within the same parameters of Category C (OE) (^2), or, – Reduction of functional capability of aircraft but does not impact overall safety e.g. normal procedures as per AFM</td>
<td>– PD due to response to TCAS Corrective Resolution Advisory (CRA) issued advising crew to take vertical action to avoid developing conflict with traffic, or, – PD where loss of airborne separation falls within the same parameters of a Category B (OE) (^2), or, – Reduction in safety margin or functional capability of the aircraft, requiring crew to follow abnormal procedures as per AFM</td>
<td>– Near mid-air collision (NMAC) results due to proximity of less than 500 feet from another aircraft or a report is filed by pilot or flight crew member that a collision hazard existed between two or more aircraft – Reduction in safety margin and functional capability of the aircraft requiring crew to follow emergency procedures as per AFM</td>
<td>– Conditions resulting in a mid-air collision (MAC) or impact with obstacle or terrain resulting in hull loss, multiple fatalities, or fatal injury</td>
</tr>
</tbody>
</table>
### Severity Definitions (cont’d)

<table>
<thead>
<tr>
<th>Hazard Severity Classification</th>
<th>Minimal</th>
<th>Minor</th>
<th>Major</th>
<th>Hazardous</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Flying Public</td>
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<tr>
<td>Minimal injury or discomfort to passenger(s)</td>
<td>– Physical discomfort to passenger(s) (e.g. extreme braking action; clear air turbulence causing unexpected movement of aircraft causing injuries to one or two passengers out of their seats)</td>
<td>– Physical distress on passengers (e.g. abrupt evasive action; severe turbulence causing unexpected aircraft movements)</td>
<td>– Serious injury to passenger(s)</td>
<td>– Fatalities, or fatal injury to passenger(s)</td>
<td></td>
</tr>
<tr>
<td>Minimal injury or discomfort to passenger(s)</td>
<td>– Minor injury to greater than zero to less or equal to 10% of passengers</td>
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<tr>
<td>Minor</td>
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<td>Minor injury - Any injury that is neither fatal nor serious.</td>
<td>– Minor injury to greater than 10% of passengers</td>
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<tr>
<td>Major</td>
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<tr>
<td>Major injury - Any injury which: (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.</td>
<td>– Minor injury to greater than 10% of passengers</td>
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<tr>
<td>Hazardous</td>
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<tr>
<td>Serious injury - Any injury which: (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.</td>
<td>– Serious injury to passenger(s)</td>
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<td>Hazardous</td>
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<td>Fatal injury - Any injury that results in death within 30 days of the accident.</td>
<td>– Fatalities, or fatal injury to passenger(s)</td>
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</tr>
</tbody>
</table>
## Likelihood Definitions

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Quantitative Description</th>
<th>Qualitative Description</th>
<th>ATC Service/ NAS Level System</th>
<th>Per Facility</th>
<th>NAS-wide</th>
<th>Flight Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequent A</strong></td>
<td>Probability of occurrence per operation/ operational hour is equal to or greater than 1x10(^{-3})</td>
<td>Expected to occur about once every 3 months for an item</td>
<td>Continuous experienced in the system</td>
<td>Expected to occur more than once per week</td>
<td>Expected to occur more than every 1-2 days</td>
<td>Probability of occurrence per operation/ operational hour is equal to or greater than 1x10(^{-6})</td>
</tr>
<tr>
<td><strong>Probable B</strong></td>
<td>Probability of occurrence per operation/ operational hour is less than 1x10(^{-3}), but equal to or greater than 1x10(^{5})</td>
<td>Expected to occur about once per year for an item</td>
<td>Expected to occur frequently in the system</td>
<td>Expected to occur about once every month</td>
<td>Expected to occur about several times per month</td>
<td>Probability of occurrence per operation/ operational hour is less than or equal to 1x10(^{-5}) but equal to or greater than 1x10(^{3})</td>
</tr>
<tr>
<td><strong>Remote C</strong></td>
<td>Probability of occurrence per operation/ operational hour is less than or equal to 1x10(^{-5}) but equal to or greater than 1x10(^{7})</td>
<td>Expected to occur several times in life cycle of an item</td>
<td>Expected to occur numerous times in system life cycle</td>
<td>Expected to occur about once every year</td>
<td>Expected to occur about once every few months</td>
<td>Probability of occurrence per operation/ operational hour is less than or equal to 1x10(^{-7}) but equal to or greater than 1x10(^{-5})</td>
</tr>
<tr>
<td><strong>Extremely Remote D</strong></td>
<td>Probability of occurrence per operation/ operational hour is less than or equal to 1x10(^{-7}) but equal to or greater than 1x10(^{9})</td>
<td>Unlikely to occur, but possible in an item's life cycle</td>
<td>Expected to occur several times in the system life cycle</td>
<td>Expected to occur about once every 10-100 years</td>
<td>Expected to occur about once every 3 years</td>
<td>Probability of occurrence per operation/ operational hour is less than or equal to 1x10(^{-7}) but equal to or greater than 1x10(^{-5})</td>
</tr>
<tr>
<td><strong>Extremely Improbable E</strong></td>
<td>Probability of occurrence per operation/ operational hour is less than 1x10(^{-9})</td>
<td>So unlikely that it can be assumed that it will not occur in an item's life cycle</td>
<td>Unlikely to occur, but possible in system life cycle</td>
<td>Expected to occur less than once every 100 years</td>
<td>Expected to occur less than once every 30 years</td>
<td>Probability of occurrence per operation/ operational hour is less than 1x10(^{-9})</td>
</tr>
</tbody>
</table>
## FAA-ATO Safety Risk Matrix

<table>
<thead>
<tr>
<th>Severity</th>
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<td>Likelihood</td>
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<tr>
<td>Frequent A</td>
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</tbody>
</table>

- **High Risk**
- **Medium Risk**
- **Low Risk**

* Unacceptable with Single Point and/or Common Cause Failures
Risk Classification

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>High Risk: Unacceptable Risk</td>
<td></td>
</tr>
</tbody>
</table>
  - Change cannot be implemented unless hazard’s associated risk mitigated so that risk reduced to medium or low level  
  - Tracking, monitoring, and management are required  
  - Hazards with catastrophic effects caused by:  
    - Single point events or failures,  
    - Common cause events or failures, or  
    - Undetectable latent events in combination with single point or common cause events  
    - are considered high risk, even if possibility of occurrence is extremely improbable |
| Medium Risk: Acceptable Risk |  
  - Minimum acceptable safety objective  
  - Change may be implemented but tracking, monitoring, and management are required |
| Low Risk: Acceptable Risk |  
  - Acceptable without restriction or limitation  
  - Hazards not required to be actively managed, but must be documented |
Reduced Vertical Separation Minimum
Example-RVSM

• RVSM reduces the vertical separation for FL290 through FL410 from the traditional 2,000-foot minimum to 1,000-foot separation.

• RVSM creates exclusionary airspace and only approved aircraft may operate within the stratum.

• This airspace change adds six additional flight levels, which create benefits for Air Traffic Service (ATS) providers and aircraft operators.

• The additional flight levels enable aircraft to safely fly more optimal profiles, gain fuel savings, and increase airspace capacity.
RVSM

Conventional Vertical Separation Minimum

FL 410
FL 390
FL 370
FL 350
FL 330
FL 310
FL 290

Reduced Vertical Separation Minimum

FL 430
FL 410
FL 400
FL 390
FL 380
FL 370
FL 360
FL 350
FL 340
FL 330
FL 320
FL 310
FL 300
FL 290

Federal Aviation Administration
Risk Analysis

• The feasibility of reducing Vertical Separation Minimum (VSM) above Flight Level (FL) 290, while maintaining an equivalent level of safety, is dependent on operational judgment and a thorough assessment of associated risks.

• The total risk associated with RVSM is a derivative of two factors: the technical risk due to aircraft height-keeping performance and the operational risk due to any vertical deviation of aircraft from their cleared flight levels due to error by the flight crew or Air Traffic Control (ATC).

• The overall collision risk within RVSM airspace is assessed against a Target Level of Safety (TLS) of 5x10^-9 fatal accidents per flying hour.
Hazard Analysis
Large Height Deviation Hazard Bow-Tie

• One of the hazards identified for (the implementation of) RVSM is a Large Height Deviation (LHD).

• Any deviation from the assigned or anticipated altitude (that altitude that the controller believes the aircraft to be at, or the pilot believes he/she is to be at, or that the aircraft is climbing or descending to) of 300 feet or greater constitutes a large height deviation.
RVSM Bow Tie

- A simplified overview of the LHD hazard, with some of the high-level causes identified on the left side in rectangles. These causes can then be broken down further into sub-causes. To the right of the hazard, the system states associated with the hazard are identified.

- In essence, Figure I.3 summarizes the two main identified potential outcomes, namely ‘Mid-Air Collision’ and ‘Loss of Separation.’ The effects have then been rated for severity in accordance with Table 3.3, indicating four catastrophic potential outcomes and four minor potential outcomes.
**RVSM**

- The probability of a Mid-Air Collision in the WATRS Region was extracted from the Safety Risk Management: Worst Credible Outcome Likelihood Values for Mid-air Collisions (MACs) and Controlled Flights into Terrain (CFITs), August 24, 2005, by using the MAC Probability Value in an En Route environment.

- Note: The validity and completeness of (available) data or representative SMEs play a major role in the validity of the calculated likelihoods for the different scenarios.
### Example of Documenting Hazard

<table>
<thead>
<tr>
<th>No. &amp; Seg.</th>
<th>Hazard Description</th>
<th>Causes</th>
<th>System State</th>
<th>Existing Controls &amp; Requirements</th>
<th>Possible Effects</th>
<th>Severity/ Rationale</th>
<th>Likelihood / Rationale</th>
<th>Current Risk</th>
<th>Recommended Safety &amp; Seg. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>H001</td>
<td>Message is misleading to one or more aircraft</td>
<td>a. Ground user interface failure [F1,HW,SW]</td>
<td>En Route and Terminal airspace</td>
<td>R-P1: System shall comply with RTCA SC-214 CPDLC Operational Safety and Performance Requirements [F1-F7]</td>
<td>If the corruption is in a clearance, this could result in the acceptance and execution of an erroneous clearance. Flight crew receives misleading message. A clearance is transmitted and reaches an unintended aircraft. The aircrew does not realize that the clearance is not for them and accepts the clearance. Flight crew does not receive a cleared message. A clearance controller and resolved with tactical (voice) communications, resulting in slight increase in workload. Detected with short time to converging routes, could result in moderate or high operational error.</td>
<td>CATASTROPHIC</td>
<td>EXTREMELY IMPROBABLE</td>
<td>MEDIUM</td>
<td>S2 TBO operations with RTCA ENV-B aircraft counts; PHA-SR-3 The ground automation system shall provide automated conflict detection and resolution in HPA.</td>
</tr>
<tr>
<td>S1,S2</td>
<td>a. corrupted</td>
<td>b. late</td>
<td>DCL issued at surface, potential hazard occurs after takeoff phase</td>
<td>R-H1: System shall conform with the FAA Human Factors Design Standard (HFDS) [F1,F2]</td>
<td>End-to-End initiating failure rate &lt; Remote per msg. RTCA OPA CPDLC Failure of integrity = ~1E-6/transaction</td>
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<tr>
<td></td>
<td>b. spontaneously generated</td>
<td>c. out of sequence</td>
<td>High density traffic</td>
<td>R-F1: System shall notify the controllers of failures that have an operational impact. [F1,F2]</td>
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<td></td>
<td>d. misdirected</td>
<td>f. 4D-Trajectory inconsistent between A/G</td>
<td>Instrument Meteorological Conditions (IMC) under Instrument Flight Rules (IFR) conditions</td>
<td>EC-28: Controller procedures exist for determining the position of an aircraft before issuing taxi instructions or takeoff clearance (FAA Order 7110.65 3-1-7. POSITION DETERMINATION). [F2,F6]</td>
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<tr>
<td></td>
<td>e. out of sequence</td>
<td>g. Executed Flight Path is not compliant with the cleared constraints (e.g., incorrectly executed)</td>
<td>Aircraft on a converging or collision course after an initiating failure</td>
<td>(e9)</td>
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<td></td>
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<td>E1: INITIATING FAILURE CONTROLS</td>
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# FAA-ATO Safety Risk Matrix

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<td>Extremely Improbable E</td>
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</tbody>
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* Unacceptable with Single Point and/or Common Cause Failures

**Legend:**
- High Risk
- Medium Risk
- Low Risk

**TREAT THE RISK**
Effectively treating risk involves:

- Identifying feasible mitigation options
- Selecting best balanced response
- Developing risk treatment plans
- Implementing and verifying
- Monitoring the hazards to ensure risk levels are achieved
# Safety Order of Precedence

<table>
<thead>
<tr>
<th>Description</th>
<th>Priority</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design for minimum risk</td>
<td>1</td>
<td>Design the system (e.g., operation, procedure, or equipment) to eliminate risks. If the identified risk cannot be eliminated, reduce it to an acceptable level through selection of alternatives.</td>
<td>• If a collision hazard exists because of a transition to a higher Minimum En route Altitude at a crossing point, moving the crossing point to another location would eliminate the risk</td>
</tr>
</tbody>
</table>
| Incorporate safety devices               | 2        | If identified risks cannot be eliminated through alternative selection, reduce the risk via the use of fixed, automatic, or other safety features or devices, and make provisions for periodic functional checks of safety devices. | • An automatic “low altitude” detector in a surveillance system  
• Ground circuit in refueling nozzle  
• Automatic engine restart logic |
| Provide warning                           | 3        | When neither alternatives nor safety devices can effectively eliminate or adequately reduce risk, warning devices or procedures are used to detect the condition and to produce an adequate warning. | • A warning in an operator’s manual  
• “Engine Failure” light in a helicopter  
• Flashing warning on a radar screen |
| Develop procedures and training          | 4        | Where it is impractical to eliminate risks through alternative selection, safety features, and warning devices: procedures and training are used, with management approval for catastrophic or hazardous severity. | • A missed approach procedure  
• Training in stall/spin recovery  
• Procedures for loss of communications |
SRM Document (SRMD)

- SRMD defines the proposed change and the SRM process used
- Must be completed for all changes that affect the NAS as defined in the ATO SMS Manual and any change that can affect the safety of the NAS
- Length and depth varies based on type and complexity of change
- Approved SRMD must be retained by change proponent and provided to ATO Office of Safety Services (upon request) and AOV (upon request)
- Updated or changed as project progresses
- Existing risk management documentation may satisfy some SRMD requirements
## Risk Acceptance

<table>
<thead>
<tr>
<th>Safety Risk</th>
<th>Initial High Risk*</th>
<th>Medium or Low Initial Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stay Within a Service Unit</td>
<td>Risk Accepted by:</td>
<td>Risk Accepted Within:</td>
</tr>
<tr>
<td></td>
<td>Service Unit VP</td>
<td>Service Unit</td>
</tr>
<tr>
<td>Span Service Units</td>
<td>Each Affected Service Unit VP</td>
<td>Each Affected Service Unit</td>
</tr>
<tr>
<td>Affect LOBs Outside the ATO (e.g., ARP and/or AVS)</td>
<td>Each Affected Service Unit VP and Each Associate Administrator</td>
<td>Each Affected Service Unit and LOB</td>
</tr>
</tbody>
</table>

* Please note that initial high risk must be mitigated to medium or low before acceptance
Hazard Tracking and Risk Resolution

- Ensuring requirements and mitigations for initial medium and high risk hazards are implemented
  - Defining additional safety requirements
  - Verifying implementation
  - Reassessing risk to ensure hazard meets risk level requirement and assessment

- ATO requires organizations to formally identify all hazards, and track and monitor all initial medium and high risk hazards for the lifecycle of the system or change, or until they mitigate the risk to low
SRMTS

- The Safety Risk Management Tracking System (SRMTS) is a web-based comprehensive tool housed on the ATO Portal for the tracking of SRM efforts, hazards, risk mitigations and monitoring the predicted residual risk.

SRMTS allows users to:

- Improve tracking of SRM efforts, hazards and the predicted residual risk
- Provide a centralized document repository for SRM documentation
- Automate hazard analyses
- Improve efficiency of the application of SRM
- Improve reporting capabilities and trends analysis