Loss of Control - Environmental Conditions

Safety Risk Assessment

Version 1.0 December 24

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Fact Sheet

Safety Issue			
Loss of Control in Flight – Environmental Conditions			
Regional Exposure	*All Regions*	Sector Exposure	*Industry Wide*
Key Risk Area	*Loss of Control*	Proximity	*Current*

Issue Description

An aircraft upset / deviation from its intended flight path caused by one of the following environmental conditions: turbulence, icing conditions, thunderstorms or volcanic ash.

Safety Risk Assessment Purpose and Scope:

The purpose of this safety risk assessment is to support the development of risk assessments by operators to mitigate against an aircraft upset leading to a loss of control.

The SRA has been compiled by a multi-disciplinary team led by IATA with subject matter experts from IATA member airlines. The contents have been validated by IATA's Safety Group (SG) and Flight Operations Group (FOG).

A generic bow tie risk model has been developed highlighting environmental threats that could lead to an aircraft upset and ultimately a loss of control. Preventive and recovery risk controls are highlighted. This risk model should be tailored to an operators own individual operating profile.

Risk controls are also linked to IOSA Standards and Recommended Practices (ISARPs). Those risk controls assessed by IATA as not being fully effective have several safety improvement recommendations assigned to them, these are also consolidated in the form of a Detailed Implementation Plan.

ISARPs linked to risk controls are provided as an input in the IATA Operational Safety Audit program as part of the audit scope.

The full bow tie model is contained in Annex A and is made available in a BowTieXP file in the Safety Issue Hub. The risk control register is also provided as a complementary MS Excel file.

Recommendations Summary

1. **Operators** should complete a risk assessment for Loss of Control, tailoring this generic risk assessment to their own operation, and regularly review it.

2. **Operators** should use flight simulation training devices (FSTD) to train flight crew for managing the risks associated with various environmental hazards, including adverse weather.

3. **IATA** to collaborate with **simulator manufacturers** to improve the FSTD fidelity to simulate various environmental hazards, including adverse weather.

4. **Operators** should provide theoretical and practical training to flight crews in the effective use of weather radar systems applicable to their type of aircraft, including advanced weather radar functions and its limitations.

5. **Operators** should use scenario-based training (SBT) in FSTDs representing their specific operational environment.

6. **IATA** to collaborate with **weather radar manufacturers** to enhance the weather radar echo return capability to detect the different levels of precipitation in order to produce the optimal radar return imagery display for a given type of precipitation to flight crews.

7. **IATA** to raise awareness among **Air Navigation Service Providers (ANSPs)** regarding the provision of alternative departure and arrival routings for operators where possible by ANSPs, in advance in case of weather developments, traffic patterns, or congestion.

8. **Operators** should ensure that dispatchers/flight planners have the necessary competence to adapt to any route changes pre-flight, including making adjustments at short notice to fuel, weight and balance, and departure/arrival times, based on available and reliable ATC and weather information.

9. **Operators** should ensure dispatchers/flight planners are able to provide contingency routes for dynamic rerouting to avoid environmental hazards if required.

10. **IATA** to promote the installation of weather forecasting applications on Electronic Flight Bags (EFB) where real time weather updates are provided to flight crew on

EFB in visual format that includes turbulence prediction at various altitudes (such as Turbulence Aware).

11. **Operators** should describe in their operation manual a Threat and Error Management (TEM) based decision making process to be applied by the flight crew in operations.

12. **Operators** should implement the latest best practice regarding Upset Recovery and Prevention Training (UPRT).

13. For SBT as part of competency-based training and assessment (CBTA) and evidence-based training (EBT), **operators** should use operational and training data (including FOQA/FDM data) to create realistic training scenarios, taking into account the FSTD fidelity, flight crew feedback, and human performance aspects.

Bowtie as a Risk Assessment Methodology

One effective way to manage risk is using the bowtie model. This model is useful in identifying and mapping potential threats and unsafe operational states that could lead to undesirable consequences. In addition, the bowtie model also considers the safety controls that can help organizations mitigate the risk of undesirable outcomes.

Leveraging the different components of the bowtie model, organizations can attain a comprehensive overview of potential safety risks, allowing them to take proactive measures to prevent accident scenarios.

Loss of Control Bowtie – Environmental Conditions

The bow tie contains threats from environmental conditions to which an aircraft may be exposed. Threats from technical causes such as engine failure and/or multiple system failures are outside the scope of the bow tie.

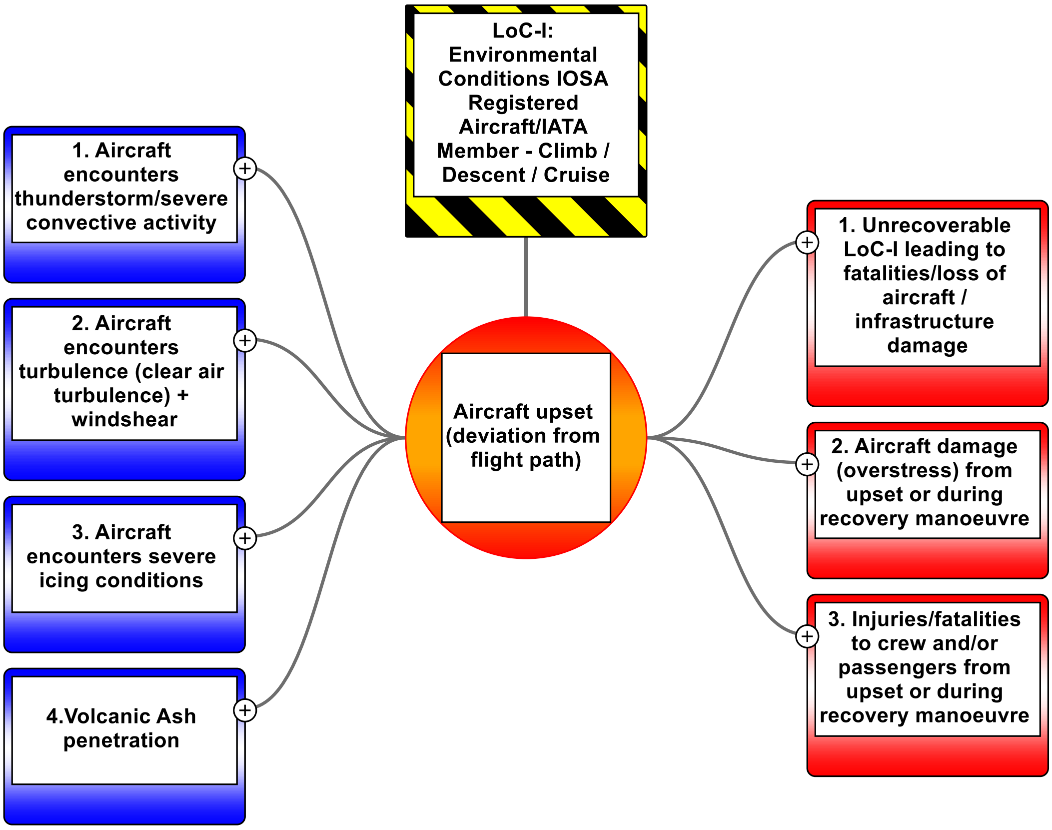


Figure 1 Loss of Control bow tie diagram

Managing Risk - How to use bow ties as an effective tool.

A bowtie is a tool used in risk management that helps safety practitioners describe, depict, and comprehend the safety risk landscape of specific operational scenarios. When a bowtie is completed, it gives a tailored overview of the risk and provides a framework for targeting data collection to improve the risk management strategy.

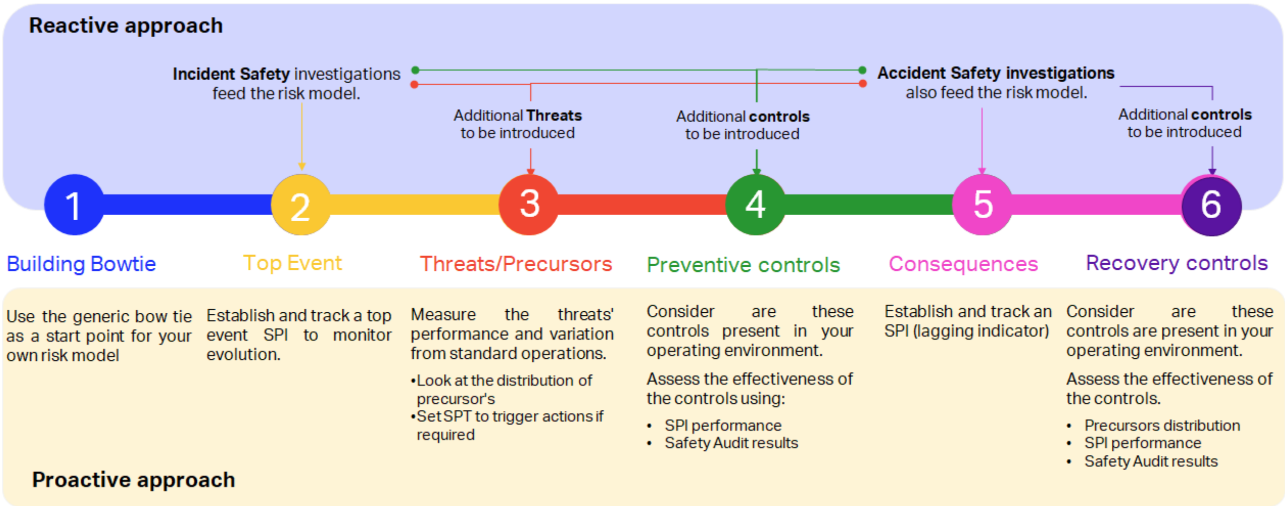


Figure 2 How to use a Bowtie.

Recommendation

1. **Operators** should complete a risk assessment for Loss of Control, tailoring this generic risk assessment to their own operation, and regularly review it.

Consideration. Sometimes proactive safety management is thought of as only identifying *non-compliance* and *unreported hazards*. However, solely focusing on these activities still results in a reactive approach. Truly proactive safety management involves collecting data and analyzing operations to uncover trends and identify patterns and relationships to transform data into safety knowledge. It allows risk management to evolve from a reactive to a proactive data-driven approach, as outlined below.

Hazard

Relates to a condition with the potential to cause a potential unsafe operational state, loss, or damage. The scope of this risk assessment operations worldwide for IATA member aircraft/IOSA registered carriers impacted by environmental conditions as the source of potential aircraft upset (deviation from flight path).

Top Event

It is defined as a point in time that describes the organization's loss of control over a hazard resulting in an unsafe operational state or undesired safety state. Therefore, this risk assessment outlines *aircraft upset (deviation from flight path)* as the top event.

The bowtie risk model is considered a snapshot of the risk at a given time. However, when combined with the appropriated Safety Performance Indicators (SPI), it becomes a dynamic analysis tool that helps to make informed decisions, ensure appropriate management strategies, and address resource allocation.

Call to action. Establish and track the Top Event – Aircraft Upset with an SPI(s) to monitor its evolution.

Consideration. Monitoring *aircraft upset (deviation from flight path)* through an SPI is a reactive approach since it only considers the unsafe operational state after it has occurred. However, this SPI is still an essential parameter to identify *aircraft upset (deviation from flight path)* as an emergent safety issue.

Using FDM (flight data monitoring data) / Flight Operations Quality Assurance (FOQA) data, suggested SPIs to measure the top event include:

- Flight parameter exceedances (deviations from intended airspeed, pitch, bank, roll)
- Overspeed (vertical or configuration)
- Stick shaker / stick push events / stall warnings

Threats

Threats can potentially cause the top event. In other words, a threat is a precursor to an undesired safety state. In the context of this risk assessment, *aircraft upset (deviation from flight path)* may result from the following precursors.

Threats
1. Aircraft encounters thunderstorm/severe convective activity
2. Aircraft encounters turbulence (clear air turbulence) + windshear
3. Aircraft encounters severe icing conditions
4.Volcanic Ash penetration

Table 1 - Aircraft upset (deviation from flight path)

Considerations. Exposure to the four identified threats is likely to vary depending on the sphere of operation/aircraft routings and the season. Some threats such as turbulence will likely be constant or year-round exposure, while exposure to volcanic ash is likely to be the threat with the lowest level of exposure.

Call to action. Assess exposure to the identified environmental threats of an aircraft upset as part of the risk assessment process.

Preventive Controls

Prevention controls prevents a threat from leading to the top event. Collectively prevention controls comprise the strategy to reduce and control the risk of having *aircraft upset (deviation from flight path)*. The table below lists preventive controls for each *aircraft upset (deviation from flight path)* precursor or threat.

Prevention controls in **blue** have associated safety improvement actions.

Preventive controls against threats – AIRCRAFT UPSET (DEVIATION FROM FLIGHT PATH)	**Tht 1**	**Tht 2**	**Tht 3**	**Tht 4**
Air traffic controller provides information to flight crew to amend flight path	X	X		X
Aircraft conforms with type design and is maintained in accordance with AMP	X	X	X	X
Aircraft is equipped with (advanced) airborne weather radar	X	X		
Application of the clean aircraft concept for take-off (including application of de/anti-icing fluid)			X	
Flight Crew Compliance with SOPs (including pilot monitoring, CRM)	X	X	X	X
Flight crew follow abnormal operating procedure for volcanic ash encounter (including 180 turn/descending turn)				X
Flight crew follow in flight procedure for encountering icing conditions			X	
Flight crew initiate heading/level change to avoid thunderstorm	X			
Flight crew initiate heading/level change to avoid turbulence		X		
Flight crew initiate turn to avoid volcanic ash cloud				X
Flight crew reporting of hazardous conditions to air traffic controller	X	X	X	X
Flight Crew Training in SOPs and Upset Prevention and Recovery Training (UPRT)	X	X	X	X
Flight planning / provision of meteorological information to flight crew	X	X	X	
On-board aircraft equipment to operate in icing conditions			X	
Operator SMS (including safety culture)	X	X	X	X
Operator SOPs	X	X	X	X
Operator uses EBT/CBTA for training	X	X	X	X
Operator uses IATA Turbulence Aware		X		

Table 2 Preventive controls to threats

Considerations A number of risk controls are common across multiple threats, acting to prevent the hazard from being released, or in this case an aircraft upset. Examples being an operator's safety management system or the effective training and following of standard operating procedures.

The following risk controls have been identified by IATA as having potential to be made more robust through the implementation of safety improvement recommendations:

Aircraft is equipped with (advanced) airborne weather radar

The aircraft's onboard weather radar is a key control for both turbulence encounters and thunderstorms to prevent an aircraft upset. Weather radar vary considerably between aircraft types, with so called advanced weather radar on modern aircraft offering considerably more functionality than legacy types when interpreting and displaying information.

However, in order to fully exploit this functionality, flight crew need to be competent in these advanced functions. This can be compounded by the type of weather radar used in the simulator not being representative of the equipment found on the aircraft.

Recommendations

2. **Operators** should use flight simulation training devices (FSTD) to train flight crew for managing the risks associated with various environmental hazards, including adverse weather.

3. **IATA** to collaborate with **simulator manufacturers** to improve the FSTD fidelity to simulate various environmental hazards, including adverse weather.

4. **Operators** should provide theoretical and practical training to flight crews in the effective use of weather radar systems applicable to their type of aircraft, including advanced weather radar functions and its limitations.

5. **Operators** should use scenario-based training (SBT) in FSTDs representing their specific operational environment.

6. **IATA** to collaborate with **weather radar manufacturers** to enhance the weather radar echo return capability to detect the different levels of precipitation in order to produce the optimal radar return imagery display for a given type of precipitation to flight crews.

Flight planning / provision of meteorological information to flight crew

Effective flight planning ensures that exposure to the identified threats to an aircraft upset are minimised. Meteorological information is a key input to flight crews' **situational awareness** (perception, comprehension, projection).

Recommendations

7. **IATA** to raise awareness among **Air Navigation Service Providers (ANSPs)** regarding the provision of alternative departure and arrival routings for operators where possible by ANSPs, in advance in case of weather developments, traffic patterns, or congestion.

8. **Operators** should ensure that dispatchers/flight planners have the necessary competence to adapt to any route changes pre-flight, including making adjustments at short notice to fuel, weight and balance, and departure/arrival times, based on available and reliable ATC and weather information.

9. **Operators** should ensure dispatchers/flight planners are able to provide contingency routes for dynamic rerouting to avoid environmental hazards if required.

10. **IATA** to promote the installation of weather forecasting applications on Electronic Flight Bags (EFB) where real time weather updates are provided to flight crew on EFB in visual format that includes turbulence prediction at various altitudes (such as Turbulence Aware).

IATA Turbulence Aware

Operator SOPs

Following standard operating procedures is a critical risk control as it is common to every threat line in the bow tie risk model that can directly cause an aircraft upset. However, for a variety of reasons, flight crew may not comply with Standard Operating Procedures.

- Individualism: overconfidence or a belief that their experience allows them to take shortcuts can lead individuals to disregard established procedures.

- Complacency: routine tasks can result in complacency, causing individuals to become less vigilant and potentially overlook critical steps in a procedure.

- Frustration: complex or poorly designed SOPs can be frustrating to follow, leading some to take shortcuts or workarounds.

- Inadequate SOP Design: SOPs that are unclear, outdated, or don't address real-world scenarios can create confusion and tempt individuals to deviate for a more effective solution.

Recommendations

11. **Operators** should describe in their operation manual a Threat and Error Management (TEM) based decision making process to be applied by the flight crew in operations.

Flight Crew Training in SOPs, Upset Prevention and Recovery Training (UPRT) and Operator uses CBTA/EBT for training

Recommendations

12. **Operators** should implement the latest best practice regarding Upset Recovery and Prevention Training (UPRT).

    See **IATA's Guidance Material and Best Practices for Upset Prevention & Recovery Training** for further information.

13. For SBT as part of competency-based training and assessment (CBTA) and evidence-based training (EBT), **operators** should use operational and training data (Including FOQA/FDM data) to create realistic training scenarios, taking into account the FSTD fidelity, flight crew feedback, and human performance aspects

Risk Control Effectiveness

Measuring Threats performance/behaviour enables operators to track deviations from the SOPs or a given threshold. /It allows early detection of patterns and non-standard cases.

Monitoring Lagging SPI such as materialized incidents and near misses. will contribute to evaluating if the controls in place are working as expected.

Annex A provides information on the preventive controls linked to IOSA Standards and recommended practices that might help address controls-based safety audits.

Table 3 provides general guidance on assessing the top event risk model's safety controls effectiveness.

Threats SPIs	Top Event SPIs	Control Effectiveness
Trend Up ⬆	Trend Up ⬆	Non-effective, controls are in place but don't mitigate the risk
Trend Up ⬆	Constant ⇨	Non-Effective, controls are not working as expected
Trend Up ⬆	Trend Down ⬇	Most of the controls are non-effective, there is a control containing the risk
Constant ⇨	Trend Up ⬆	Non-Effective, Controls are not working as expected
Constant ⇨	Constant ⇨	Limited, Controls have a restricted action over the threads
Constant ⇨	Trend Down ⬇	Limited, there is a weak control unable to turn the threats trend down
Trend Down ⬇	Trend Up ⬆	Limited, there is a weak control failing to contain the top event trend
Trend Down ⬇	Constant ⇨	Limited, there is a weak control unable to turn the Top Event down
Trend Down ⬇	Trend Down ⬇	Effective, controls work as expected

Table 3 Control's Effectiveness Assessment

Gaining insights from subject matter experts is crucial in refining the effectiveness of aircraft upset controls. It is important to consider the nature of the controls, which can be technology, procedures, regulations, or training, as they might be weakened by human performance. The assessment of control effectiveness is relevant to allocate resources efficiently, strengthen the appropriate controls, and achieve an efficient and successful aircraft upset mitigation to avoid any further associated consequences.

Risk Control Tagging

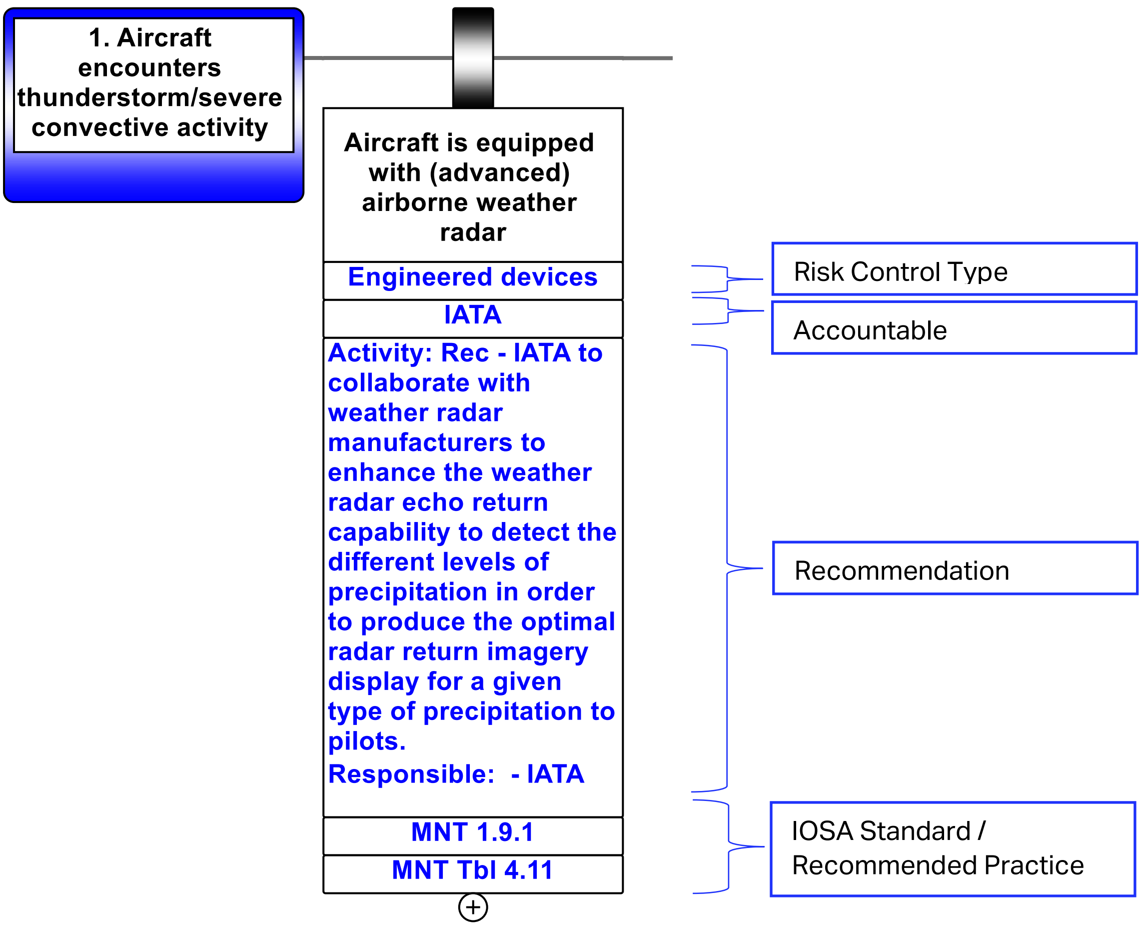
The identified risk controls that describe the mitigating activity have been tagged with additional information appended to the control:

- Accountable – the organization/actor primarily accountable for the risk control and typically able to directly impact its effectiveness. E.g. '*Aircraft operator*', '*aerodrome*' or 'MRO (Maintenance Repair Organization)'

- Risk control type – whether the control is an:
    - Engineered device
    - Human sensory action
    - Training/proficiency (including associated training specific policy)
    - Policy/procedure

- Activity – Recommendation for Safety Improvement

- ISARP – identified IOSA standards and recommended practices from the IOSA Standards Manual (ISM) that link with the risk control activity. E.g. MNT 1.9.1. – Aircraft Systems/Equipment.



Consequence

The consequence is a potential accident scenario resulting from the top event that directly results injuries, fatalities or aircraft loss/damage. Aircraft upset (deviation from flight path) may lead to the following accident scenarios.

Consequence
1. Unrecoverable LoC-I leading to fatalities/loss of aircraft / infrastructure damage.
2. Aircraft damage (overstress) from upset or during recovery manoeuvre.
3. Injuries/fatalities to crew and/or passengers from upset or during recovery manoeuvre.

Table 4 Potential consequences.

Consideration Three consequences have been identified following an aircraft upset. In addition to the aircraft becoming unrecoverable, injuries or fatalities may be sustained following an upset and the subsequent recovery. Loose articles, the movement of cabin baggage, whether passengers are seated with their seatbelt fastened and an ongoing trolley service may influence the extent of any injuries.

Recovery controls

Considered as the barriers that prevent the top event from developing into an accident scenario or reduce the severity of the accident. It should be noted a number of the recovery controls relate to activities carried out by third parties.

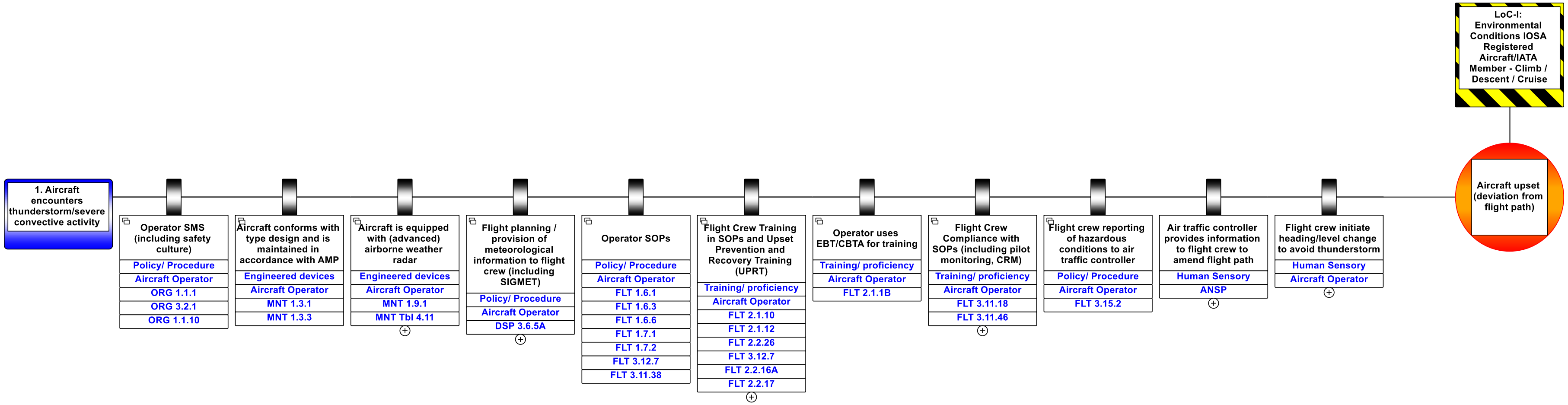
Recovery controls following the top event – AIRCRAFT UPSET (DEVIATION FROM FLIGHT PATH)	**Csq 1**	**Csq 2**	**Csq 3**
Aircraft Modern Flight Envelope Protection	X	X	
Flight crew follow appropriate recovery procedure (stall recovery / effective upset recovery techniques)	X	X	
Operator seat belt policy for passengers and crew			X
Stowage of hand-luggage			X
Trolley service policy during turbulence/unstable weather conditions			X

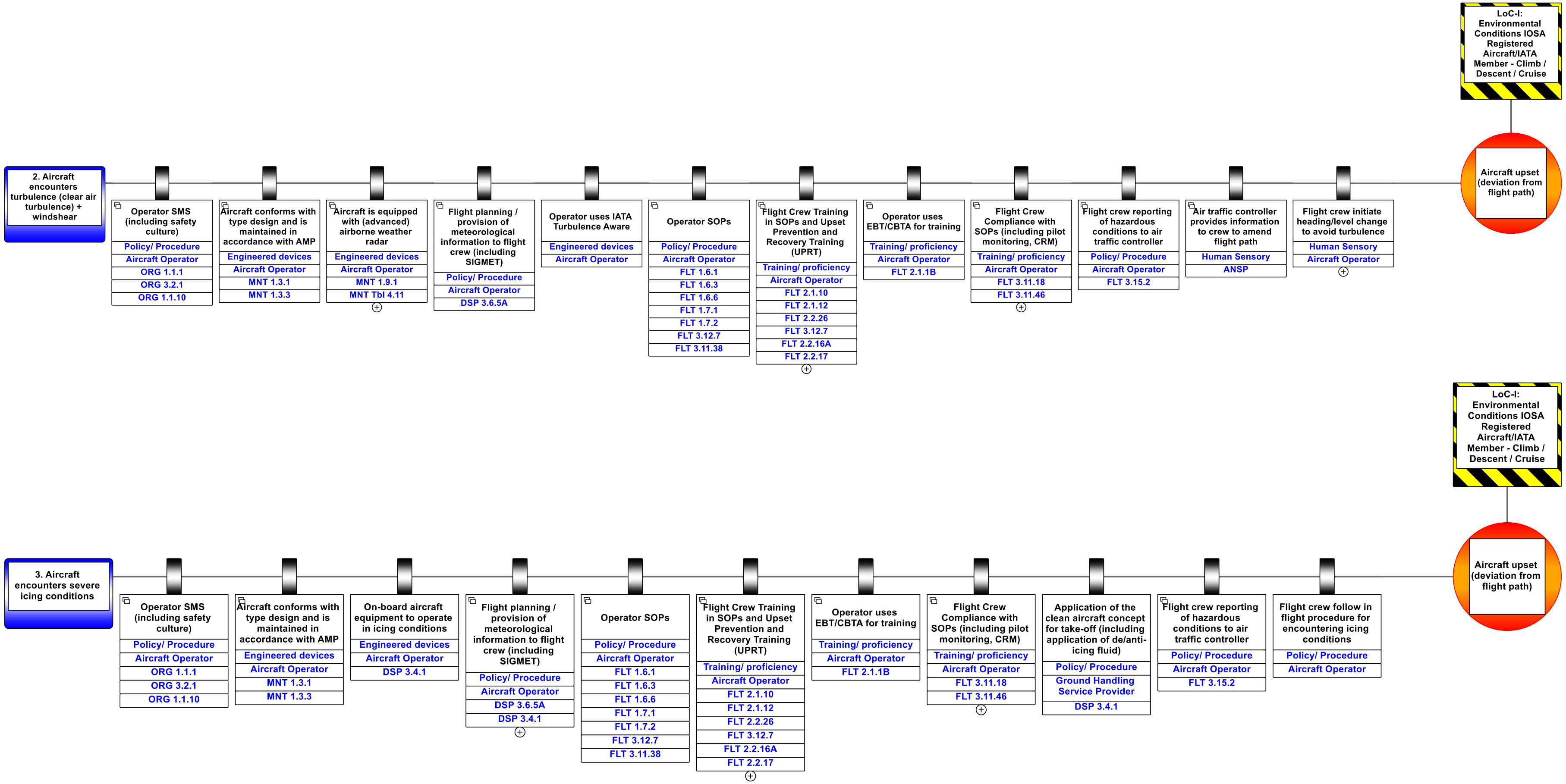
Table 5 Recovery controls to consequences

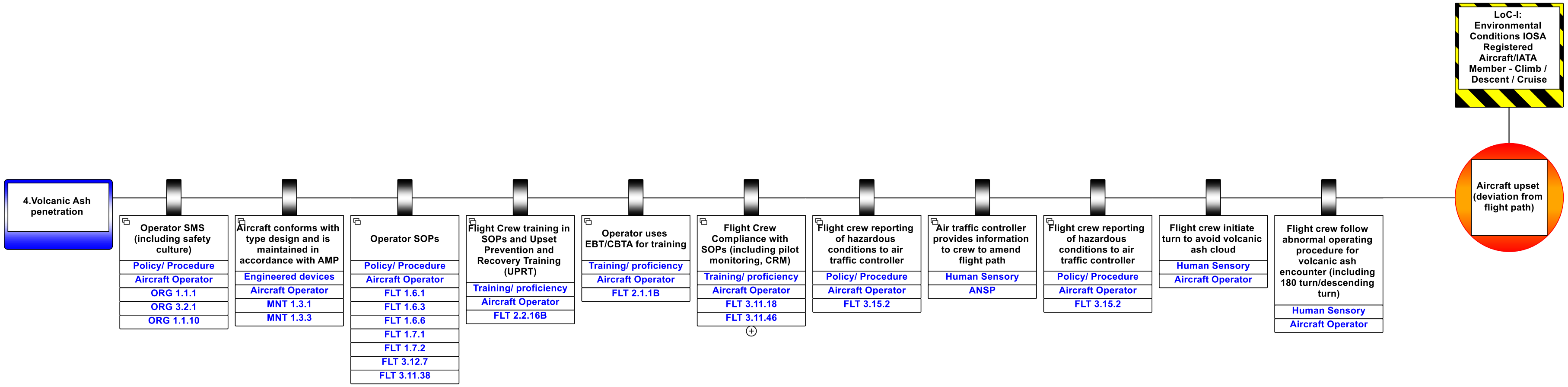
Considerations. Aircraft flight envelope protection is specific to an aircraft type, with the level of protection afforded by legacy aircraft such as the 737 classic of ATR being variable.

Annex A - Loss of Control bow tie risk model expanded.

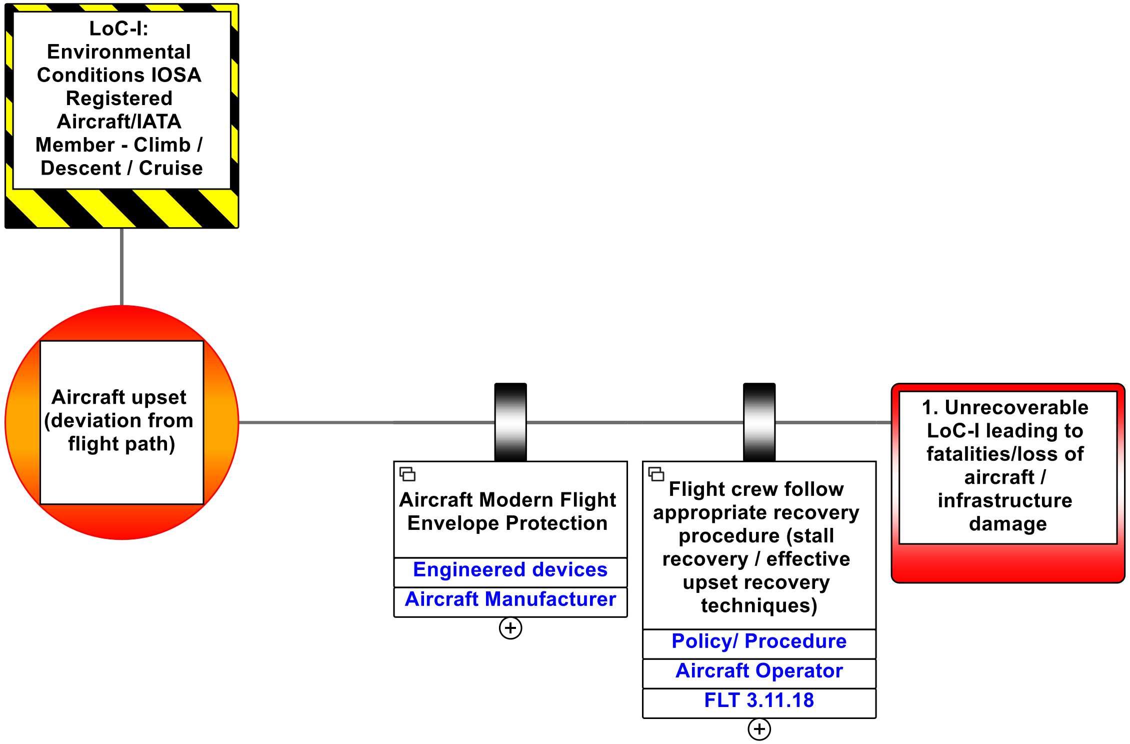
Threats

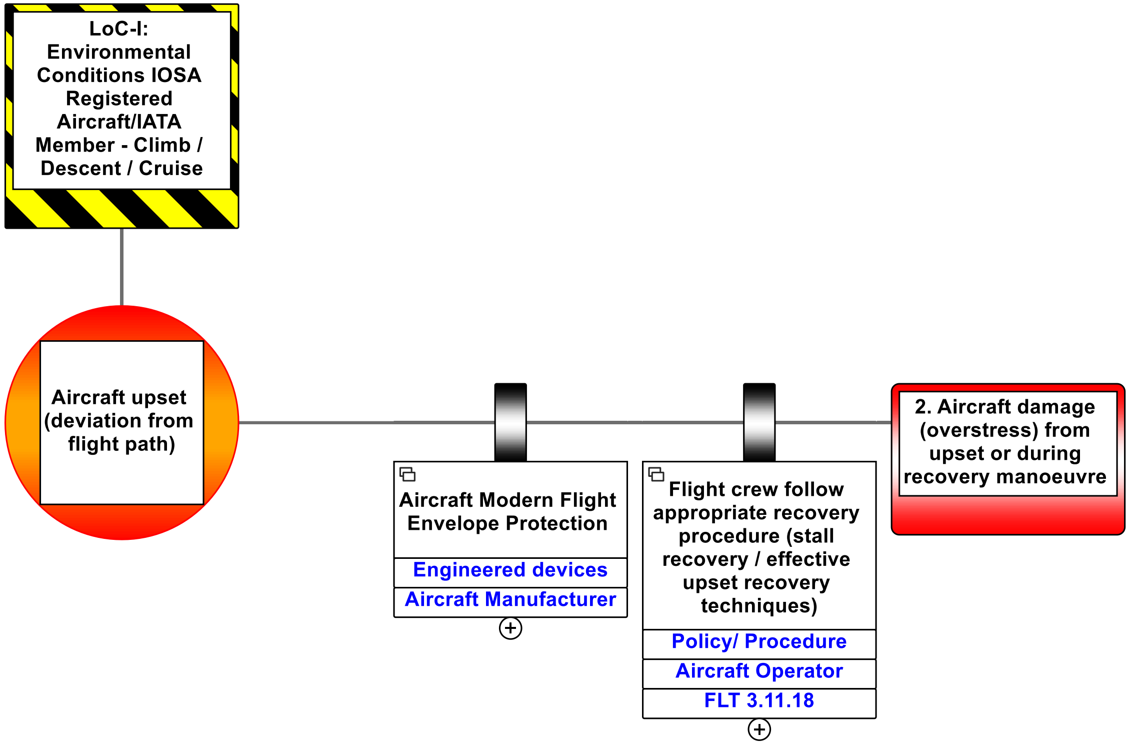


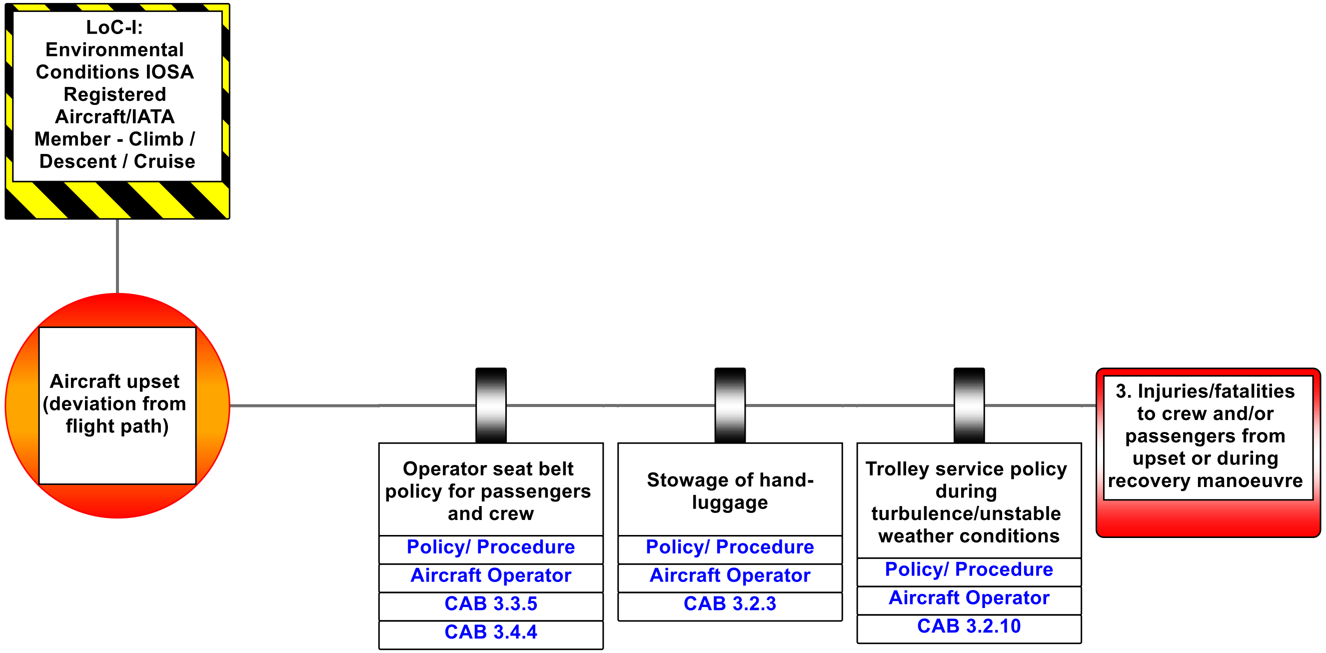

LoC-I: Environmental Conditions IOSA Registered Aircraft/IATA Member - Climb / Descent / Cruise
2. Aircraft encounters turbulence (clear air turbulence) + windshear
Operator SMS (including safety culture)
Policy/ Procedure
Aircraft Operator
ORG 1.1.1
ORG 3.2.1
ORG 1.1.10
Aircraft conforms with type design and is maintained in accordance with AMP
Engineered devices
Aircraft Operator
MNT 1.3.1
MNT 1.3.3
Aircraft is equipped with (advanced) airborne weather radar
Engineered devices
Aircraft Operator
MNT 1.9.1
MNT Tbl 4.11
Flight planning / provision of meteorological information to flight crew (including SIGMET)
Policy/ Procedure
Aircraft Operator
DSP 3.6.5A
Operator uses IATA Turbulence Aware
Engineered devices
Aircraft Operator
Operator SOPs
Policy/ Procedure
Aircraft Operator
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
FLT 3.12.7
FLT 3.11.38
Flight Crew Training in SOPs and Upset Prevention and Recovery Training (UPRT)
Training/ proficiency
Aircraft Operator
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 3.12.7
FLT 2.2.16A
FLT 2.2.17
Operator uses EBT/CBTA for training
Training/ proficiency
Aircraft Operator
FLT 2.1.1B
Flight Crew Compliance with SOPs (including pilot monitoring, CRM)
Training/ proficiency
Aircraft Operator
FLT 3.11.18
FLT 3.11.46
Flight crew reporting of hazardous conditions to air traffic controller
Policy/ Procedure
Aircraft Operator
FLT 3.15.2
Air traffic controller provides information to crew to amend flight path
Human Sensory
ANSP
Flight crew initiate heading/level change to avoid turbulence
Human Sensory
Aircraft Operator
Aircraft upset (deviation from flight path)
LoC-I: Environmental Conditions IOSA Registered Aircraft/IATA Member - Climb / Descent / Cruise
3. Aircraft encounters severe icing conditions
Operator SMS (including safety culture)
Policy/ Procedure
Aircraft Operator
ORG 1.1.1
ORG 3.2.1
ORG 1.1.10
Aircraft conforms with type design and is maintained in accordance with AMP
Engineered devices
Aircraft Operator
MNT 1.3.1
MNT 1.3.3
On-board aircraft equipment to operate in icing conditions
Engineered devices
Aircraft Operator
DSP 3.4.1
Flight planning / provision of meteorological information to flight crew (including SIGMET)
Policy/ Procedure
Aircraft Operator
DSP 3.6.5A
DSP 3.4.1
Operator SOPs
Policy/ Procedure
Aircraft Operator
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
FLT 3.12.7
FLT 3.11.38
Flight Crew Training in SOPs and Upset Prevention and Recovery Training (UPRT)
Training/ proficiency
Aircraft Operator
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 3.12.7
FLT 2.2.16A
FLT 2.2.17
Operator uses EBT/CBTA for training
Training/ proficiency
Aircraft Operator
FLT 2.1.1B
Flight Crew Compliance with SOPs (including pilot monitoring, CRM)
Training/ proficiency
Aircraft Operator
FLT 3.11.18
FLT 3.11.46
Application of the clean aircraft concept for take-off (including application of de/anti-icing fluid)
Policy/ Procedure
Ground Handling Service Provider
DSP 3.4.1
Flight crew reporting of hazardous conditions to air traffic controller
Policy/ Procedure
Aircraft Operator
FLT 3.15.2
Flight crew follow in flight procedure for encountering icing conditions
Policy/ Procedure
Aircraft Operator
Aircraft upset (deviation from flight path)


LoC-I: Environmental Conditions IOSA Registered Aircraft/IATA Member - Climb / Descent / Cruise
4.Volcanic Ash penetration
Operator SMS (including safety culture)
Policy/ Procedure
Aircraft Operator
ORG 1.1.1
ORG 3.2.1
ORG 1.1.10
Aircraft conforms with type design and is maintained in accordance with AMP
Engineered devices
Aircraft Operator
MNT 1.3.1
MNT 1.3.3
Operator SOPs
Policy/ Procedure
Aircraft Operator
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
FLT 3.12.7
FLT 3.11.38
Flight Crew training in SOPs and Upset Prevention and Recovery Training (UPRT)
Training/ proficiency
Aircraft Operator
FLT 2.2.16B
Operator uses EBT/CBTA for training
Training/ proficiency
Aircraft Operator
FLT 2.1.1B
Flight Crew Compliance with SOPs (including pilot monitoring, CRM)
Training/ proficiency
Aircraft Operator
FLT 3.11.18
FLT 3.11.46
Flight crew reporting of hazardous conditions to air traffic controller
Policy/ Procedure
Aircraft Operator
FLT 3.15.2
Air traffic controller provides information to crew to amend flight path
Human Sensory
ANSP
Flight crew reporting of hazardous conditions to air traffic controller
Policy/ Procedure
Aircraft Operator
FLT 3.15.2
Flight crew initiate turn to avoid volcanic ash cloud
Human Sensory
Aircraft Operator
Flight crew follow abnormal operating procedure for volcanic ash encounter (including 180 turn/descending turn)
Human Sensory
Aircraft Operator
Aircraft upset (deviation from flight path)

Consequences




LoC-I: Environmental Conditions IOSA Registered Aircraft/IATA Member - Climb / Descent / Cruise
Aircraft upset (deviation from flight path)
Aircraft Modern Flight Envelope Protection
Engineered devices
Aircraft Manufacturer
Flight crew follow appropriate recovery procedure (stall recovery / effective upset recovery techniques)
Policy/ Procedure
Aircraft Operator
FLT 3.11.18
2. Aircraft damage (overstress) from upset or during recovery manoeuvre



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