Aircraft Tail Strikes – Take Off/Landing

Safety Risk Assessment

Version 1 Dec 2023

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Tail Strike - Fact Sheet

Safety Issue			
Tail Strike – Takeoff , Landing and go around			
Regional Exposure	**All regions**	**Sector Exposure**	**All sectors**
Key Risk Area	**Runway Safety**	**Proximity**	**Current/~~Emerging/Future~~**

Summary of the Issue

A Tail Strike occurs during take-off, landing or go-around when the attitude of an aircraft is such that the tail contacts the runway, which can subsequently lead to outcomes such as loss of control (LOC), runway excursion (RE), resulting in substantial aircraft damage.

According to the Global Aviation Data Management- GADM by IATA, tail strike events accounted for 9% of all accidents in the past ten years (2013-2022). In 2022, more than 250 airlines participating in the GADM program reported 24 Tail Strikes, of which 25% (6 events) were rated as accidents. From January to October 2023, there have been 43 recorded Tail Strikes. However, It is expected that this number will increase to approximately 50 once the Incident Data eXchange program consolidates the full year's performance.

Most tail strike accidents occur during landing. Over ten years (2013-2022), 79% of tail strike accidents occurred during landing or go-around. According to the IATA interactive safety report, the common factors contributing to tail strikes are unstable approach, excessive approach energy resulting in long or bounced landings, floating along the runway, crosswind mishandling, gusty winds, and turbulence.

Although there is typically a low risk of fatalities, these occurrences can cause significant damage to aircraft, resulting in millions of dollars in repairs and lost revenue for operators.

Aircraft damage is usually more severe in the landing phase; the worst-case scenario is related to a Tail Strike before the landing gear touches down, causing damage to the aircraft pressure bulkhead.

Safety Risk Assessment Purpose and Scope:

This document provides a structured approach for analyzing Tail Strikes to support stakeholders in assessing and mitigating the associated risk. It provides a standard description of potential threats, avoidance controls, including those linked to IOSA standards and recommended practices, and escalation factors related to Tail Strikes, along with recovery controls that prevent them from escalating into accidents that cause damage to aircraft.

As a Safety Risk Assessment, it serves as a resource to assist IATA members in determining if their safety controls effectively control Tail Strike risk or if additional mitigation actions are required.

Recommendations Summary

To address Tail strikes, IATA invites operators to:

- Develop/update their risk model using the appropriate assessment technique to manage Tail Strike risks.
- Establish and track the Top Event - Tail Strike's SPI to monitor its evolution.
- After a Tail Strike, it is important to integrate investigation conclusion into the Tail Strike risk model. This helps focus on control effectiveness and identify areas for improvement to enhance existing controls or introduce new ones.
    - Design communication material based on the lessons learned and distribute into internal communication channels to ensure Safety Awareness of the Tail Strike Events.
    - Update the Pilot Training Programs according to the Tail Strikes precursors (Table 1), including specific maneuvers in the Simulator sessions.
- Create a process to map safety intelligence onto the risk assessment tool such as the proposed bowtie. Use SPIs to track precursors related to Tail Strike and trigger actions when deviating from the target or reaching the limit of control.
- Develop controls-based audits according to the risk model and assess the effectiveness of controls in place.
- Check and consider The IATA Annual Safety Report -Recommendations for accident prevention in aviation - tail strike section.

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.

Tail Strike – Take off Phase.

Based on available accident reports and the IATA Global Aviation Data Management Program, a collaborative task force from IATA has identified the most common threats that lead to tail strikes during take-off and their potential undesired outcomes. The figure below provides a general overview of the identified threats.

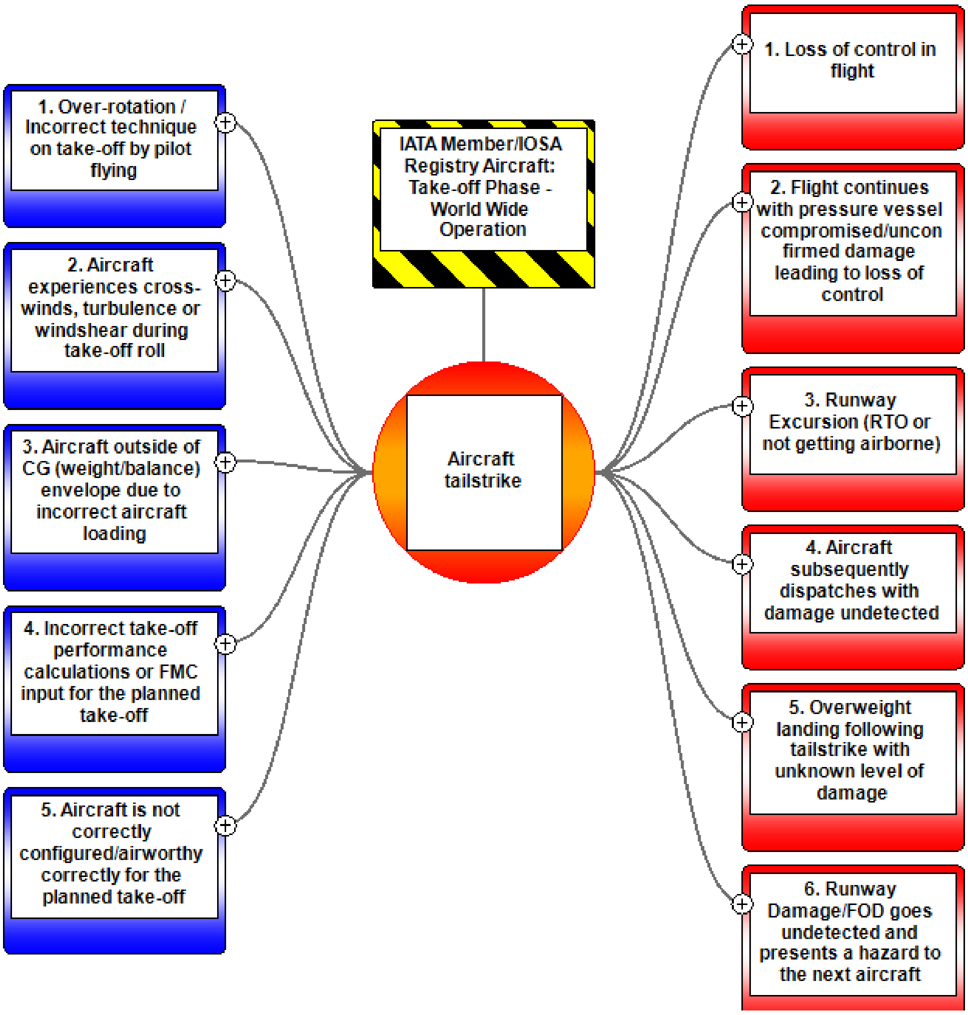


Figure 1Tail Strike Risk Model – Take Off phase.

See Annex A for the Tail Strike-Take Off phase expanded version.

Tail Strike – Landing Phase.

In the landing phase, Figure 2 presents a visual representation of the threats that potentially may lead to Tail strikes.

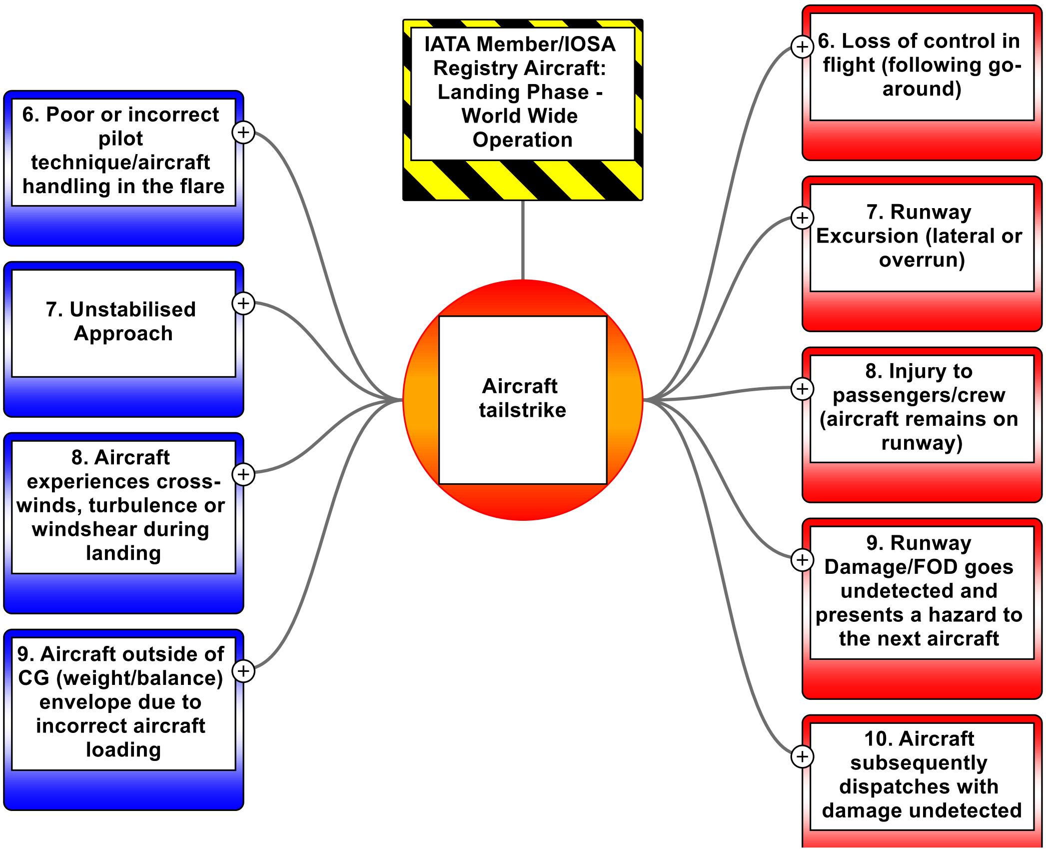


Figure 2 Tail Strike Risk Model - Landing Phase

See Annex B for the Tail Strike-Landing phase expanded version.

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.

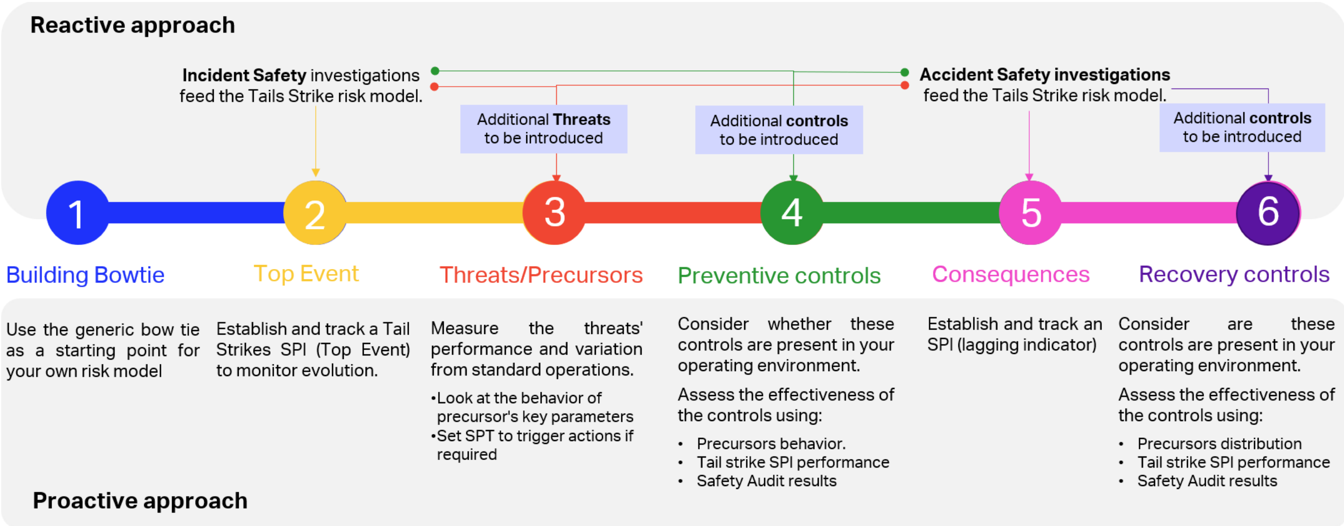


Figure 3 How to use a Bowtie.

Call to action. To ensure effective risk management on Tail Strikes, organizations are encouraged to build their risk model using Bowtie or **other appropriate risk analysis methods. The risk model provided in this document should be used as a general reference only.**

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. This risk assessment points to worldwide take-off and landing operations as the source of potential Tail strikes.

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 Tail Strikes 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 - Tail Strike's SPI to monitor its evolution.

Consideration. Monitoring Tail Strikes 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 Tail Strikes as an emergent safety issue. It will prompt further risk model analysis when frequency of occurrence deviates from the organization's objectives. Moreover, it provides a valuable data point that can be used to assess the preventive control's effectiveness against the threats or precursors.

Threats.

Should be understood as a potential cause of a top event. In other words, a threat is a precursor to an undesired safety state. In the context of this risk assessment, Tail Strikes may result from the following precursors.

Precursors	Take-off	Landing
Tht 1 Over-rotation/ incorrect technique	X	
Tht 2/8 Crosswinds, turbulence, or wind shear	X	X
Tht 3/9 Aircraft outside CG envelope due to incorrect loading.	X	X
Tht 4 Incorrect performance calculations/FMS data input.	X	X
Tht 5 Incorrect aircraft configuration for the planned take-off.	X	
Tht 6 Incorrect technique/aircraft handling in the flare		X
Tht 7 Unstable approach		X

Table 1 Tail Strikes precursors.

Call to action. During the investigation process following a Tail Strike (Reactive Standpoint), it is recommended to review the influence of the precursors included in Table 1 and other potential threats. The purpose is that safety investigations feed the Tails Strike risk model to ensure all relevant threats/precursors are included in the model. It will lead the organization to focus on the controls' effectiveness and the need to build a safety improvement plan to enhance the existing controls or identify the need to introduce new controls. The bowtie risk model can support the investigation by identifying which controls were eroded and which, if any, remained effective.

According to the IATA Annual Safety Report, over the last 5 years (2018-2022), the industry has recorded 31 tail strikes rated as accidents. The new version of the IATA Annual Safety Report provides access to Tail Strikes accident data, both globally and regionally. This is a valuable source of information regarding accident precursors trends and patterns, allowing members to gain insights to fuel proactive risk management activities. Annex C lists cited aviation accidents and investigation reports worldwide from 2018.

From a proactive approach, it is recommended to establish a process to map safety intelligence onto the bowtie by setting and tracking SPIs related to Tail Strike's precursors (bowtie threats), including criteria to trigger actions if the SPI deviates from the target or reaches the predefined limit of control. Learning From All Operations Concept Case Study: Take-off Rotation (Flight Safety Foundation 2022) is an insightful resource to understand how to measure the threats/precursor's performance.

Establishing Tail Strikes precursor related SPIs implies expanding the organization's capability to monitor operation and detect precursor's performance through the FDM program by:

- Monitoring the use of aircraft controls during the take-off (rotation technique) and landing (flare technique) and detecting non-standard cases related to:
    - Rotation rate/Pitch angle
    - Early rotations
    - Pitch angle vs main landing gear compress and extend.
    - Flare too high.
    - Prolonged hold-off for smooth touchdown.
    - Bounce at touch down.
- Estimating crosswind during take-off, approach, and landing and detecting abnormal values.
- Detecting CG out of limits on take-off or not consistent with pitch trim settings and identifying non-standard cases.
- Discovering erroneous data entry or calculation errors, which could lead to incorrect thrust settings, incorrect V speeds, or incorrect target approach speeds.
- Identifying inappropriate aircraft configurations (lifting devices, pitch trim) which could cause take-off and landing performance problems.
- Find take-offs from intersections in conjunction with late or slow rotation and estimate the runway remaining ahead of the aircraft at lift-off and detect abnormal values.
- Identifying and quantifying unstable approaches related to
    - A decrease in speed (significantly below Vapp) before the flare.
    - Sink rate too high just before the aircraft reaches the flare height.

The "Guidance for the Implementation of Flight Data Monitoring Precursors (EASA 2022)" is a useful document that provides recommendations and industry best practices for measuring and monitoring the precursor mentioned above. Operators can also find guidance on customizing the flight data recorder's data frame to monitor specific precursors.

Considerations. Measuring Tail Strike's precursors rather than monitoring Tail Strike is more proactive approach to risk management. It involves expanding the scope of safety performance monitoring activities to include a close examination of all operations including lower severity events rather than solely high severity events such as the Tail Strike.

Preventive Controls

Should be understood as a barrier that prevents a threat from becoming a top event. Collectively prevention controls comprise the strategy to reduce and control the risk of having Tail Strikes. The table below lists preventive controls for each tail strike precursor or threat during take-off.

Preventive controls against threats – TAKE OFF	Tht 1	Tht 2	Tht 3	Tht 4	Tht 5
Operator SMS / Operator FDM Program	X	X	X	X	X
Operator SOPs	X	X	X		X
Flight Crew Compliance with Operator SOPs	X	X	X		X
Flight Crew Training in Operator SOPs	X	X	X		X
Flight Crew initiate rejected Take-off		X		X	X
Operator SIM training for a range of take-off conditions/locations, including EBT/CBTA.	X	X			
Information to flight crew via NOTAM / operational crew notice		X			
Future: Take-off configuration warning to flight crew					X
Crew resource management	X				
Gross error check is performed by the flight crew				X	
Ground handler uses operator loading procedure (SOP)			X		
On ground Windshear Detection		X			
ATS Unit notifies flight crew of adverse weather conditions		X			
Dispatch control system produces an accurate load sheet			X		
Take-off configuration (flap and stab trim) warning to flight crew					X
State provision of AIP data				X	
Conventional take-off performance calcs (i.e., charts...)				X	
Warning system (Take-Off Securing (TOS) function) or equivalent alerts flight crew to error				X	
Flight crew use of electronic flight bag to calculate performance				X	
Aircraft detection systems to provide warnings for CG/mass exceedances			X		
Flight Planning - MET briefing		X			

Table 2 Preventive controls to threats (Take-Off).

A comprehensive risk mitigation strategy requires a clear set of standard operating procedures and well-trained flight crews who are competent in the use of countermeasures to mitigate threats. Additionally, the operator must have the capacity to monitor standard operating deviations through a mature flight data monitoring program under the operator SMS framework.

Table 3 presents preventive controls for tail strike precursors during landing.

Preventive controls to threats - LANDING	Tht. 6	Tht. 7	Tht. 8	Tht. 9
Operator SMS / Operator FDM Program	X	X	X	X
Flight Crew Compliance with Operator SOPs	X	X	X	X
Operator SIM training for a range of landing conditions/locations, including EBT / CBTA.	X	X	X	
Operator SOPs	X	X	X	
Flight Crew initiate go-around.	X	X	X	
Flight Crew Training in Operator SOPs	X	X	X	
ATS Unit notifies flight crew of adverse weather conditions			X	
Operator provides info to flight crew - company NOTAM / operational crew notice.			X	
Aircraft Wind Shear Radar Detection		X	X	
Dispatch control system produces an accurate load sheet				X
ATS unit applies standardized approach procedures		X		
Operational Documentation (Part C)/ Destination Briefings for Specific Aerodrome			X	
Runway Awareness and Advisory System		X		
Operator Scheduling of Flight Crew to reduce frequent a/c variant/type changes (e.g., A321/A320 or B737)	X			
Aircraft detection systems to provide warnings for CG/mass exceedances				X
Decision support tools on board (via dispatch from ACARS or connected flight deck) - regular update on MET			X	
Ground Handler confirming aircraft is correctly loaded				X
Flight crews are notified in flight of inaccurate CG/weight and update FMC				X
On ground Windshear Detection			X	
Flight Planning - MET briefing			X	

Table 3 Preventive controls to threats (Landing).

Call to action. Identify controls that prevent each threat from leading to a Tail Strike. Use the provided controls as reference only as they vary from operator to operator. Additionally, ensure preventive controls listed in Table 2 and 3 are documented, implemented, and trained as required.

Develop controls-based audits (also known as safety audits) according to the risk model to assess the effectiveness of the controls in place. Assessing the control effectiveness intends to determine to what extent preventive controls reduce the risk of tail strikes.

According to ICAO Doc 9859, safety audit performance might be a way to assure the effectiveness of safety risk controls. Therefore, the Operator's IOSA safety audit performance can be used as input to assess the control's effectiveness. However, it should be evaluated with leading and lagging safety performance indicators and insights from subject matter experts.

Consideration. Evolving to a proactive and controls-oriented management approach is about understanding how and when safety controls become ineffective before an event occurs. It helps identify areas where resources could be allocated to proactively reduce the risks of suffering tail strikes.

Adopting the controls-based proactive approach expands safety audits' scope beyond focusing on regulatory compliance. A control in place does not necessarily mean that it is effective. This concept is linked to the evolving Risk-based IOSA Program.

Measuring the effectiveness of safety controls has always been challenging. However, to ensure a comprehensive effectiveness assessment, IATA proposes to follow three essential steps, as shown in the following Figure.

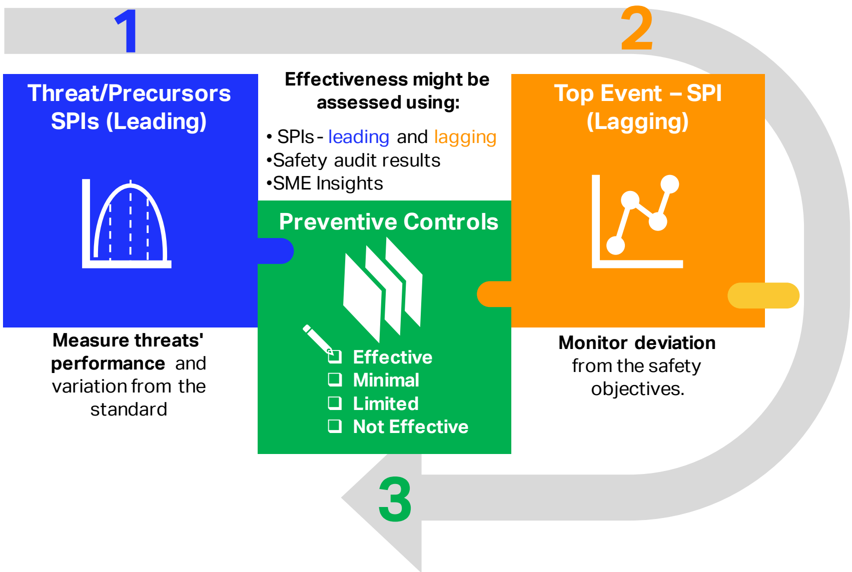


Figure 4 Assessing Controls Effectiveness

Measuring Threats performance/behavior enables operators to track deviations from the SOPs or a given threshold. *I.e., flare technique -To high flare trend, prolonged hold off for smooth touch down-*. It allows early detection of patterns and non-standard cases.

Monitoring Lagging SPI such as materialized Tail strikes and near misses. *I.e., High pitch, "pitch pitch" call-out activation.* It will contribute to evaluating if the controls in place are working as expected.

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

Table 4. provides general guidance on assessing the Tail Strike 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 4 Control's Effectiveness Assessment

Gaining insights from subject matter experts is crucial in refining the effectiveness of Tail Strike 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 Tail Strike mitigation to avoid any further associated consequences.

Consequence

Defined as a potential accident scenario resulting from the top event that directly results in loss or damage. Tail Strikes may lead to the following accident scenarios.

Accident scenarios	Take-off	Landing
Csq 1/6 Loss of control in flight	X	X
Csq 2 Aircraft pressure vessel Undetected damage	X	
Csq 3/7 Runway Excursion	X	X
Csq 4/10 Aircraft subsequently dispatched with undetected damage.	X	X
Csq 5 Overweight Landing after a Tail Strike	X	
Csq 6/9 Runway Damage/FOD undetected for next Aircraft	X	X
Csq 8 Injury to passenger		X

Table 5 Tail Strikes potential consequences.

Call to action. Review the consequences mentioned above, when building a Tail Strike risk model, and include any potential but credible potential outcome given a specific operational context.

Consideration. The occurrence of a Tail Strike classified as an accident initiates a thorough investigation by authorities. The findings of this investigation should be utilized to implement immediate corrective actions (the traditional approach) and to improve the organization's Tail

Strikes risk model, which will help to mitigate the re-occurrence in the long term since it might provide valuable information on new threats and missing/ineffective preventive controls. Moreover, it delivers valuable information as to why the recovery controls failed.

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, such as an aerodrome Rescue and Fire Fighting (RFFS).

Recovery controls to Top event – TAKE OFF	**Csq 1**	**Csq 2**	**Csq 3**	**Csq 4**	**Csq 5**	**Csq 6**
Aircraft Crashworthiness and Survivability	X	X	X		X	
Aerodrome Rescue and Fire Fighting Service	X	X	X		X	
Operator Emergency Response Plan	X	X	X		X	
Flight Crew Training in Operator SOPs	X		X			
Operator SOPs	X		X			
ATC Notify flight crew when a tail strike occurs		X		X		
Passengers detect a tail strike and notify the flight crew		X		X		
Cabin crew detects a tail strike and notifies the flight crew		X		X		
Flight Crew Compliance with Operator SOPs	X		X			
Damage is indicated on the tail skid				X		
Damage detected by flight crew walk around				X		
Aircraft notification of aircraft damage				X		
Engineers detect damage during walk-around				X		
Runway Inspection performed by aerodrome operations						X
Third-party aircraft crew observe tail strike and notify flight crew				X		
Ground handlers detect damage				X		
Arrester Beds at Aerodrome			X			
Crew follow overweight landing checklist					X	
Flight crew initiate diversion to alternate/departure aerodrome		X				
Passengers Observe FOD						X
The flight crew notified the ATS Unit of the tail strike						X
Safety margin within landing distance required (LDR) calculation			X			
Flight crew receive pressurization indication/warning		X				
Aircraft flight envelope protection	X					
Flight Crew Document Tailstrike Damage in the Tech Log	X					

Table 6 Recovery controls to consequences (Take-Off)

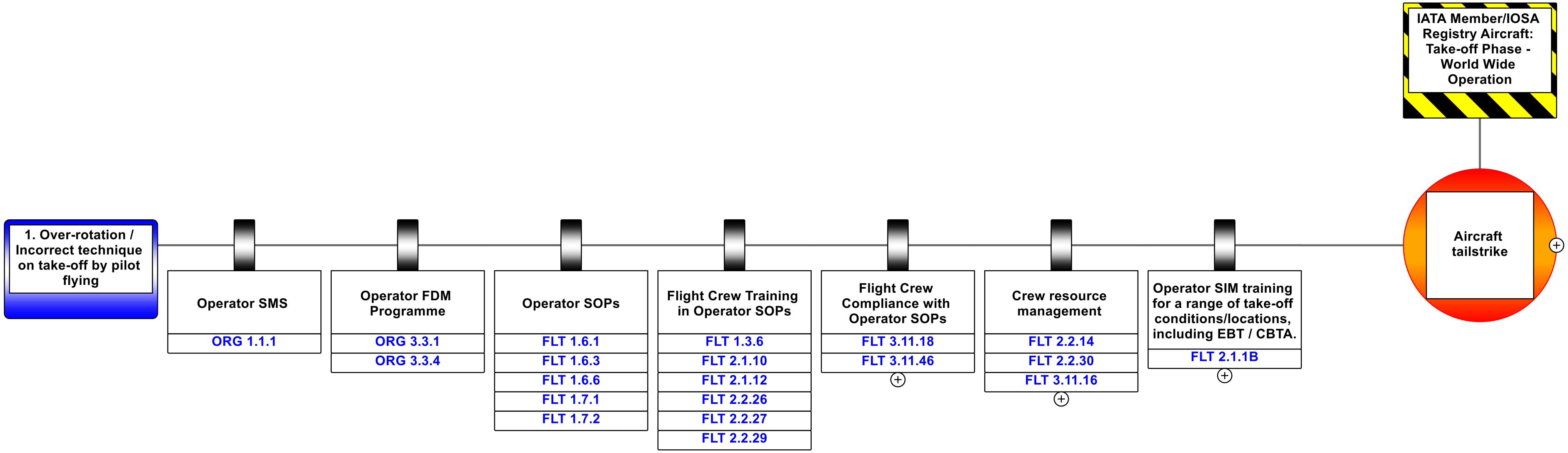
Recovery controls to Top event – Landing	Csq 6	Csq 7	Csq 8	Csq 9	Csq 10
Operator Emergency Response Plan	X	X	X		
Flight Crew Training in Operator SOPs	X	X	X		
Operator SOPs	X	X	X		
Flight Crew Compliance with Operator SOPs	X	X	X		
Aerodrome Rescue and Fire Fighting Service	X	X	X		
Aircraft Crashworthiness and Survivability	X	X			
Aircraft flight envelope protection	X				
Safety margin within landing distance required (LDR) calculation		X			
ATC observed a tail strike and notified the flight crew					X
Passengers Observe FOD				X	
Cabin crew detects a tail strike and notifies the flight crew					X
The flight crew notified the ATS Unit of a tail strike				X	
Damage detected by flight crew walk around					X
Ground handlers detect damage					X
Damage is indicated on tailskid					X
Aircraft notification of aircraft damage					X
Third-party aircraft crew observe tail strike and notify flight crew					X
Runway Inspection performed by aerodrome operations				X	
Aircraft Certification Crashworthiness and Survivability			X		
Arrester Beds at Aerodrome		X			
Flight Crew Document Tail strike Damage in the Tech Log					X
Engineers detect damage during walk-around					X

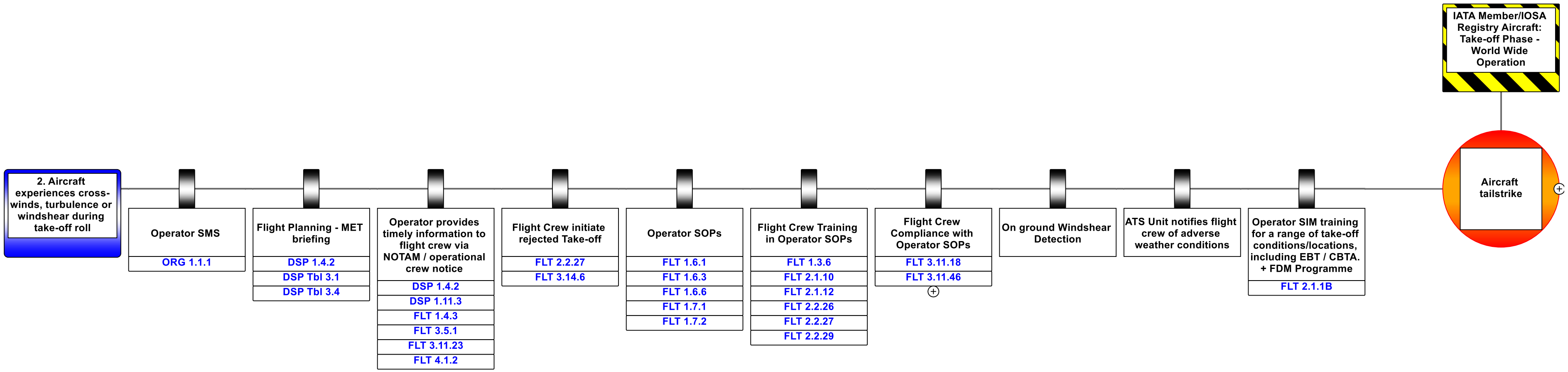
Table 7 Recovery controls to consequences (Landing)

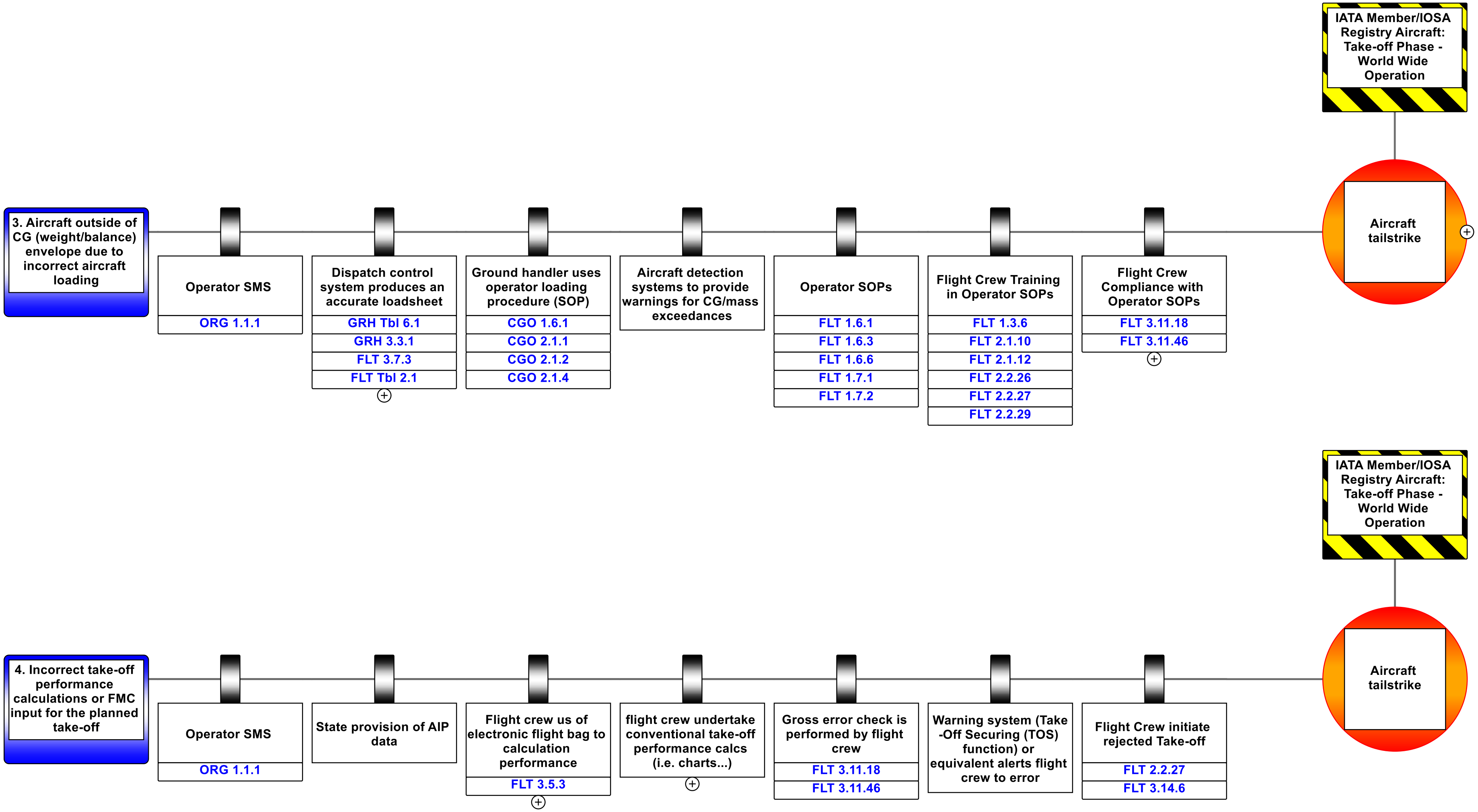
Call to action. Identify recovery controls that reduce the likelihood or severity of Tails strikes becoming accidents. Some don't prevent but reduce the severity. E.g. ERP, aerodrome RFFS. Use the provided controls as reference only as they vary from operator to operator. Additionally, develop controls-based audits according to the risk model and assess the effectiveness of the controls in place.

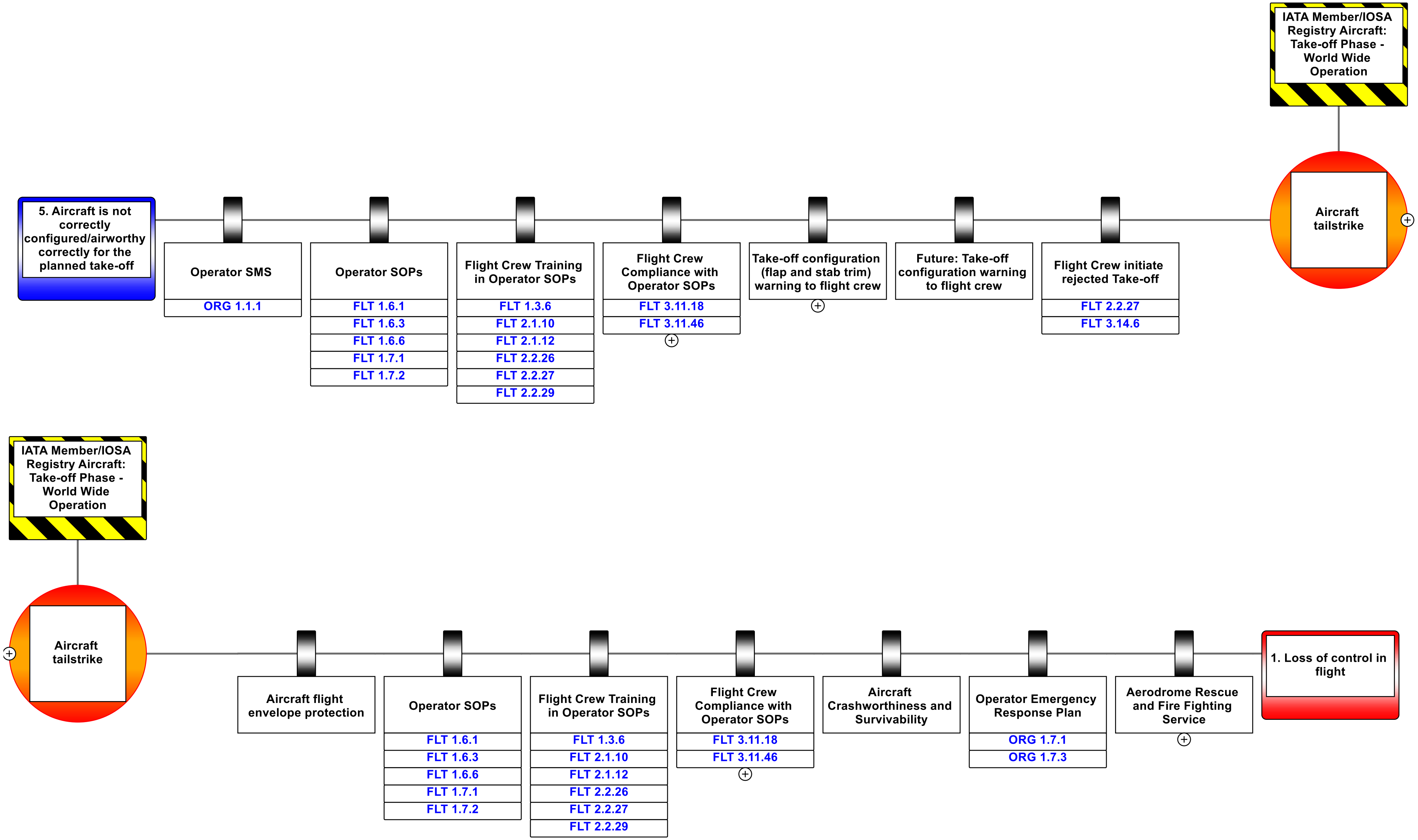
As part of the overall risk assessment, consider how to assess the effectiveness of prevention controls that relate to activities carried out by third parties, such as aerodrome.

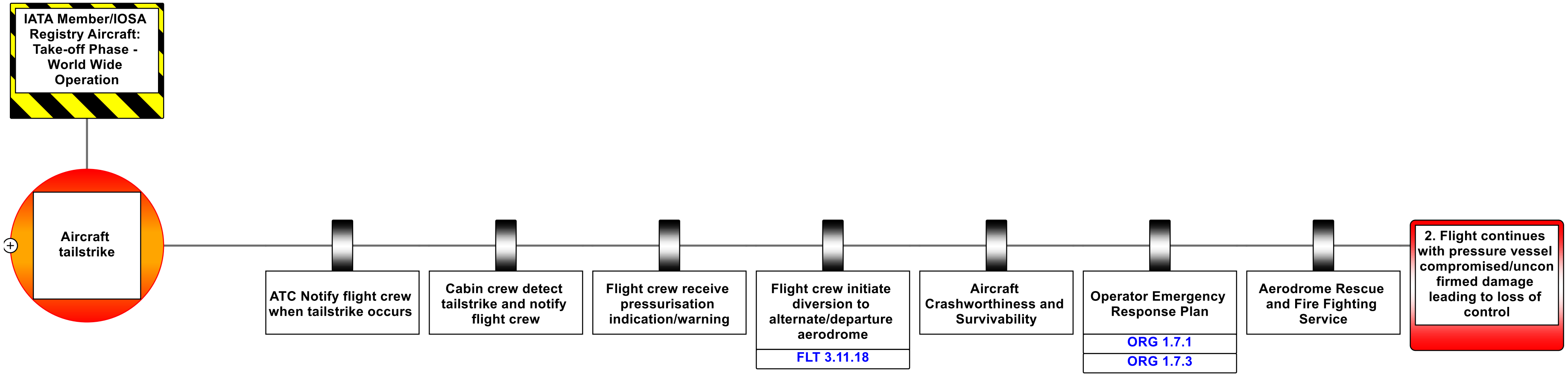
Annex A Tail strike risk model expanded – Take Off.

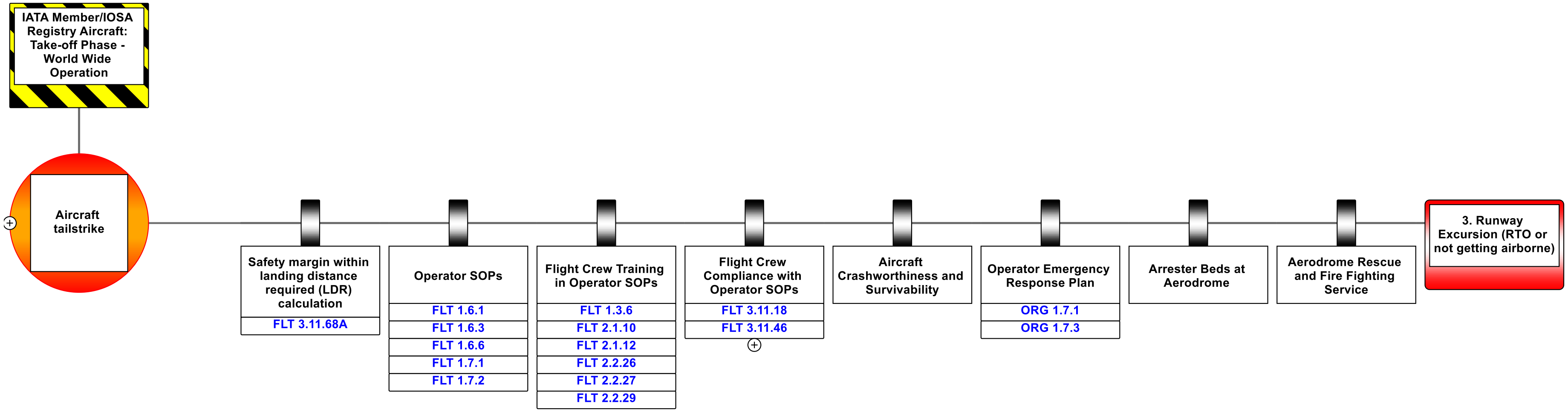


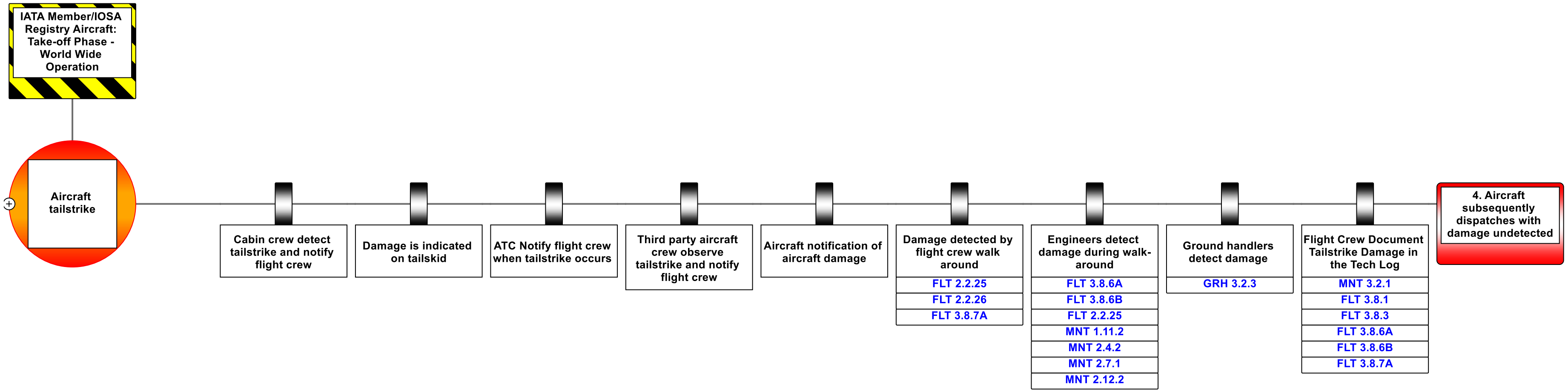


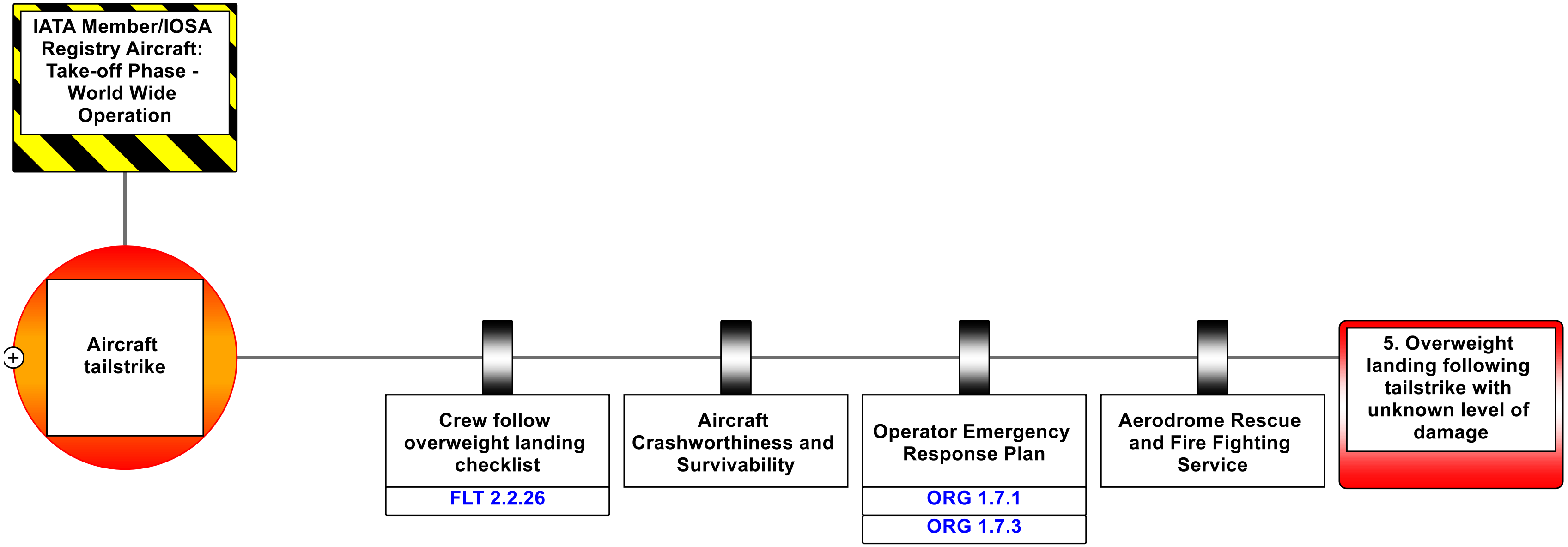

IATA Member/IOSA Registry Aircraft: Take-off Phase - World Wide Operation
3. Aircraft outside of CG (weight/balance) envelope due to incorrect aircraft loading
Operator SMS
ORG 1.1.1
Dispatch control system produces an accurate loadsheet
GRH Tbl 6.1
GRH 3.3.1
FLT 3.7.3
FLT Tbl 2.1
Ground handler uses operator loading procedure (SOP)
CGO 1.6.1
CGO 2.1.1
CGO 2.1.2
CGO 2.1.4
Aircraft detection systems to provide warnings for CG/mass exceedances
Operator SOPs
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
Flight Crew Training in Operator SOPs
FLT 1.3.6
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 2.2.27
FLT 2.2.29
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Aircraft tailstrike
IATA Member/IOSA Registry Aircraft: Take-off Phase - World Wide Operation
4. Incorrect take-off performance calculations or FMC input for the planned take-off
Operator SMS
ORG 1.1.1
State provision of AIP data
Flight crew us of electronic flight bag to calculation performance
FLT 3.5.3
flight crew undertake conventional take-off performance calcs (i.e. charts...)
Gross error check is performed by flight crew
FLT 3.11.18
FLT 3.11.46
Warning system (Take -Off Securing (TOS) function) or equivalent alerts flight crew to error
Flight Crew initiate rejected Take-off
FLT 2.2.27
FLT 3.14.6
Aircraft tailstrike

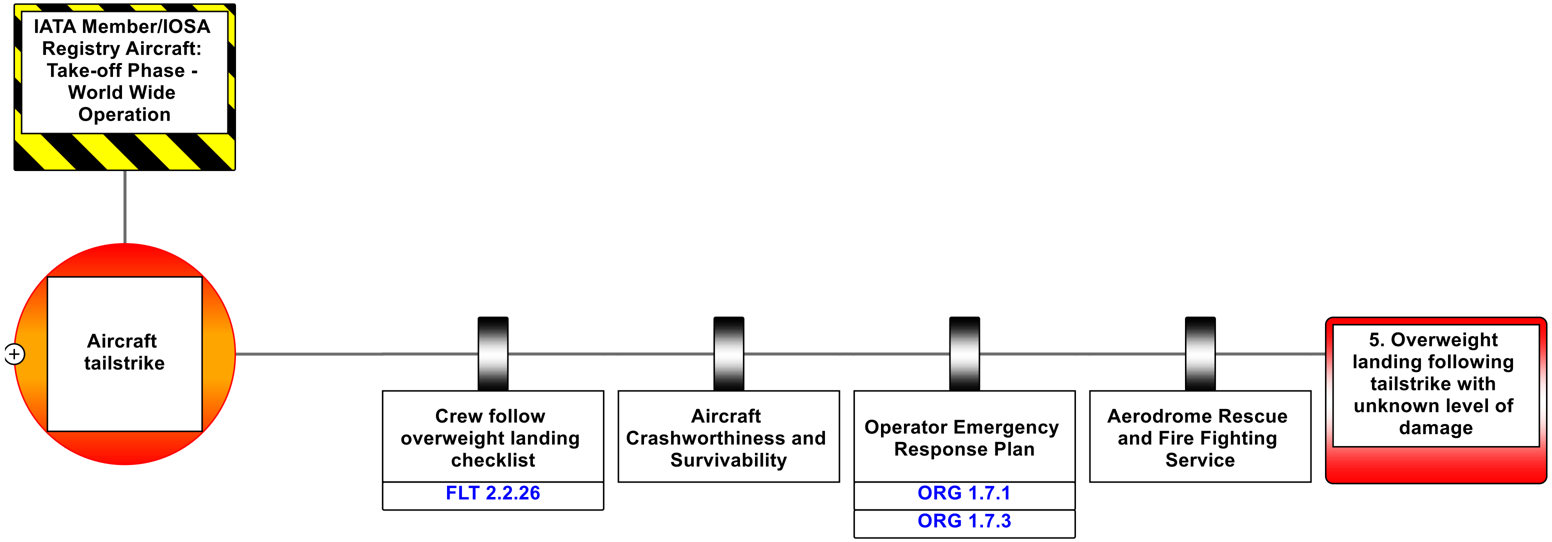

IATA Member/IOSA Registry Aircraft: Take-off Phase - World Wide Operation
5. Aircraft is not correctly configured/airworthy correctly for the planned take-off
Operator SMS
ORG 1.1.1
Operator SOPs
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
Flight Crew Training in Operator SOPs
FLT 1.3.6
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 2.2.27
FLT 2.2.29
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Take-off configuration (flap and stab trim) warning to flight crew
Future: Take-off configuration warning to flight crew
Flight Crew initiate rejected Take-off
FLT 2.2.27
FLT 3.14.6
Aircraft tailstrike
IATA Member/IOSA Registry Aircraft: Take-off Phase - World Wide Operation
Aircraft tailstrike
Aircraft flight envelope protection
Operator SOPs
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
Flight Crew Training in Operator SOPs
FLT 1.3.6
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 2.2.27
FLT 2.2.29
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Aircraft Crashworthiness and Survivability
Operator Emergency Response Plan
ORG 1.7.1
ORG 1.7.3
Aerodrome Rescue and Fire Fighting Service
1. Loss of control in flight


IATA Member/IOSA Registry Aircraft: Take-off Phase - World Wide Operation
Aircraft tailstrike
ATC Notify flight crew when tailstrike occurs
Cabin crew detect tailstrike and notify flight crew
Flight crew receive pressurisation indication/warning
Flight crew initiate diversion to alternate/departure aerodrome
FLT 3.11.18
Aircraft Crashworthiness and Survivability
Operator Emergency Response Plan
ORG 1.7.1
ORG 1.7.3
Aerodrome Rescue and Fire Fighting Service
2. Flight continues with pressure vessel compromised/unconfirmed damage leading to loss of control


IATA Member/IOSA Registry Aircraft: Take-off Phase - World Wide Operation
Aircraft tailstrike
Safety margin within landing distance required (LDR) calculation
FLT 3.11.68A
Operator SOPs
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
Flight Crew Training in Operator SOPs
FLT 1.3.6
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 2.2.27
FLT 2.2.29
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Aircraft Crashworthiness and Survivability
Operator Emergency Response Plan
ORG 1.7.1
ORG 1.7.3
Arrester Beds at Aerodrome
Aerodrome Rescue and Fire Fighting Service
3. Runway Excursion (RTO or not getting airborne)


IATA Member/IOSA Registry Aircraft: Take-off Phase - World Wide Operation
Aircraft tailstrike
Cabin crew detect tailstrike and notify flight crew
Damage is indicated on tailskid
ATC Notify flight crew when tailstrike occurs
Third party aircraft crew observe tailstrike and notify flight crew
Aircraft notification of aircraft damage
Damage detected by flight crew walk around
FLT 2.2.25
FLT 2.2.26
FLT 3.8.7A
Engineers detect damage during walk-around
FLT 3.8.6A
FLT 3.8.6B
FLT 2.2.25
MNT 1.11.2
MNT 2.4.2
MNT 2.7.1
MNT 2.12.2
Ground handlers detect damage
GRH 3.2.3
Flight Crew Document Tailstrike Damage in the Tech Log
MNT 3.2.1
FLT 3.8.1
FLT 3.8.3
FLT 3.8.6A
FLT 3.8.6B
FLT 3.8.7A
4. Aircraft subsequently dispatches with damage undetected


IATA Member/IOSA Registry Aircraft: Take-off Phase - World Wide Operation
Aircraft tailstrike
Crew follow overweight landing checklist
FLT 2.2.26
Aircraft Crashworthiness and Survivability
Operator Emergency Response Plan
ORG 1.7.1
ORG 1.7.3
Aerodrome Rescue and Fire Fighting Service
5. Overweight landing following tailstrike with unknown level of damage



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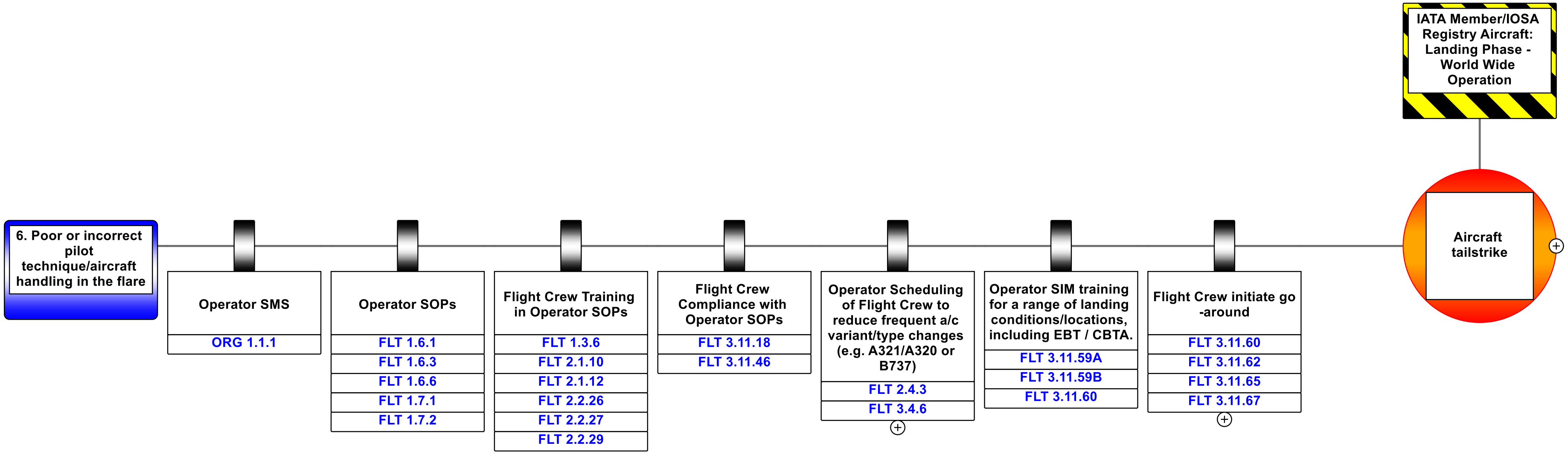
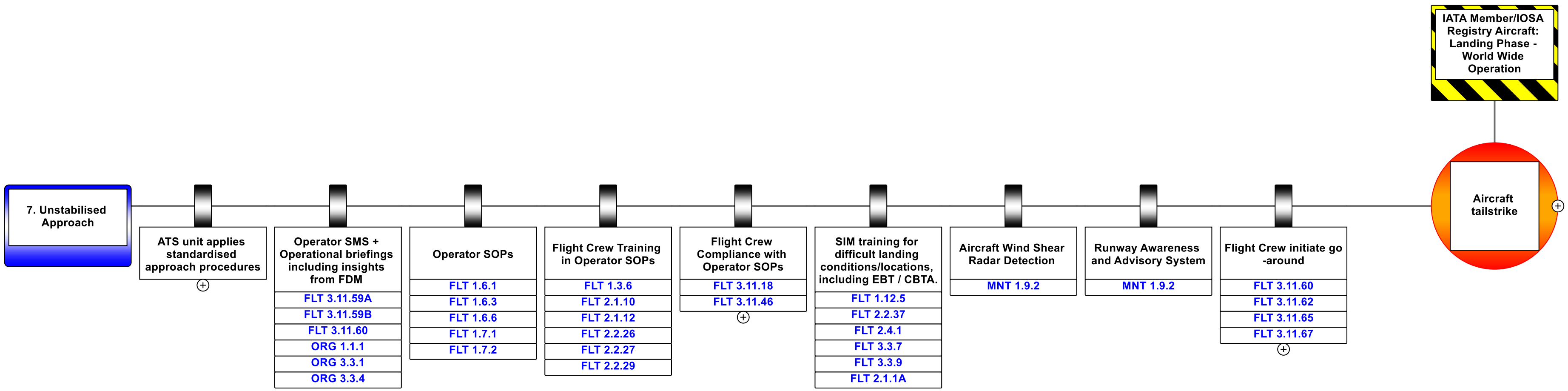
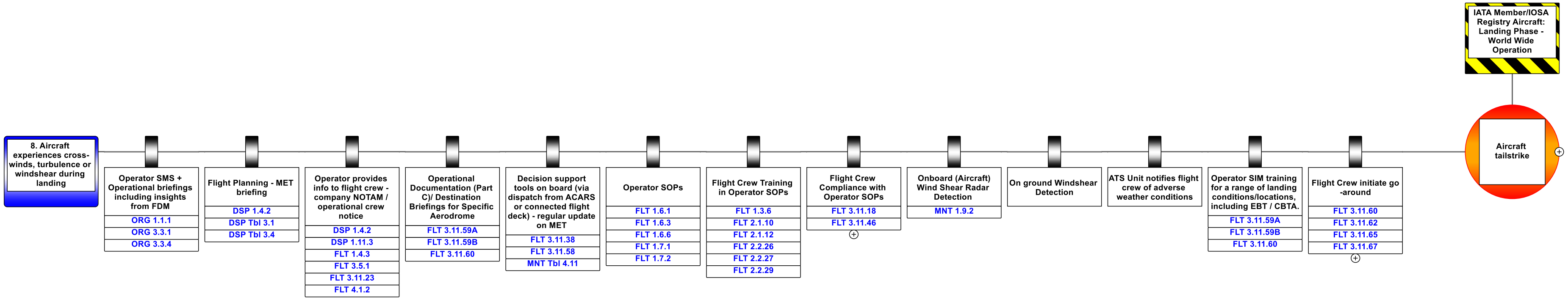
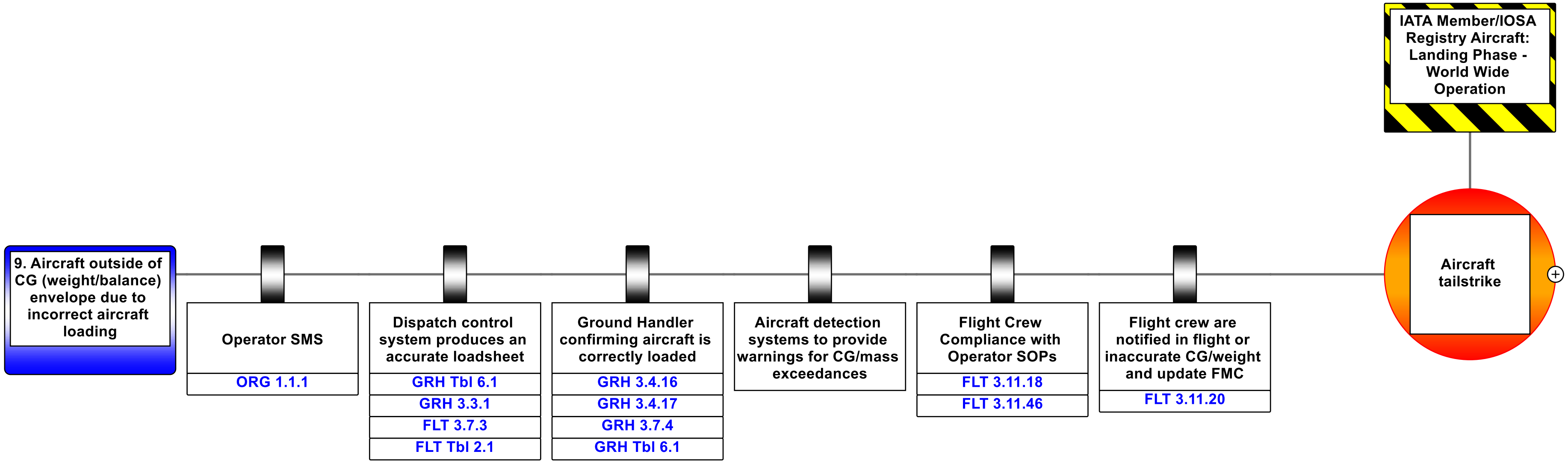
Annex B Tail strike risk model expanded – Landing.



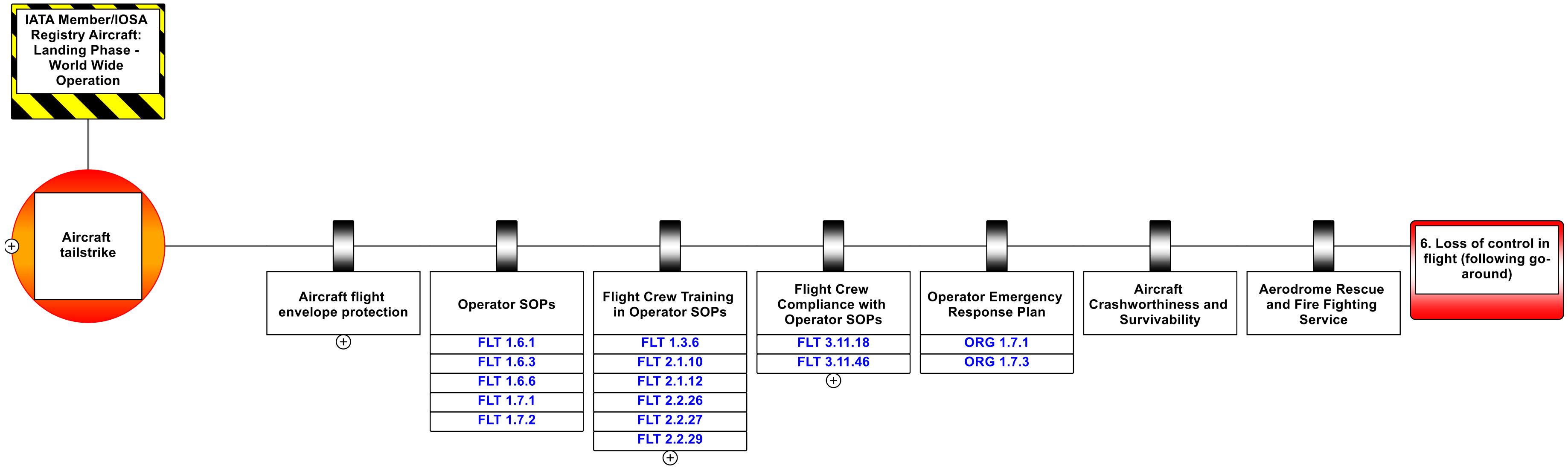


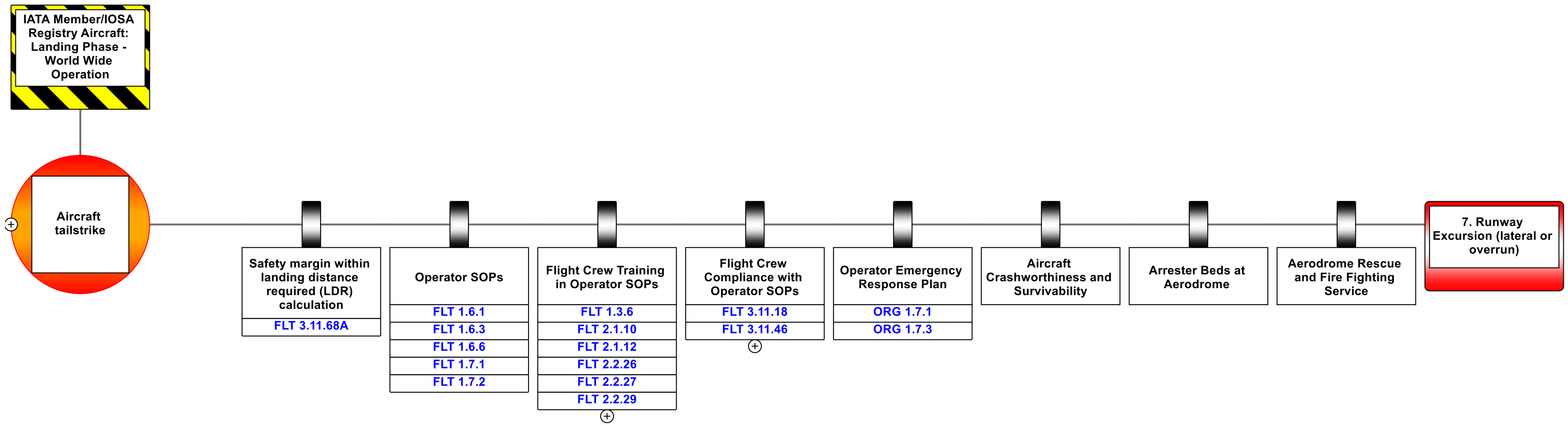


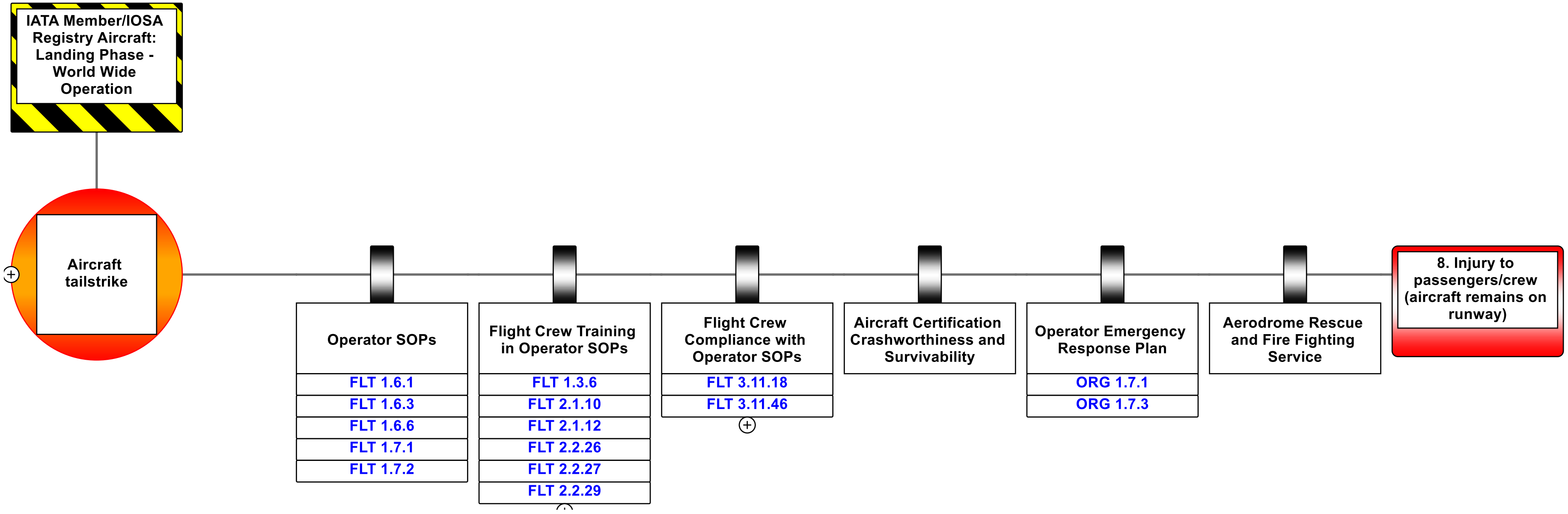
IATA Member/IOSA Registry Aircraft: Landing Phase - World Wide Operation
8. Aircraft experiences cross-winds, turbulence or windshear during landing
Operator SMS + Operational briefings including insights from FDM
ORG 1.1.1
ORG 3.3.1
ORG 3.3.4
Flight Planning - MET briefing
DSP 1.4.2
DSP Tbl 3.1
DSP Tbl 3.4
Operator provides info to flight crew - company NOTAM / operational crew notice
DSP 1.4.2
DSP 1.11.3
FLT 1.4.3
FLT 3.5.1
FLT 3.11.23
FLT 4.1.2
Operational Documentation (Part C)/ Destination Briefings for Specific Aerodrome
FLT 3.11.59A
FLT 3.11.59B
FLT 3.11.60
Decision support tools on board (via dispatch from ACARS or connected flight deck) - regular update on MET
FLT 3.11.38
FLT 3.11.58
MNT Tbl 4.11
Operator SOPs
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
Flight Crew Training in Operator SOPs
FLT 1.3.6
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 2.2.27
FLT 2.2.29
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Onboard (Aircraft) Wind Shear Radar Detection
MNT 1.9.2
On ground Windshear Detection
ATS Unit notifies flight crew of adverse weather conditions
Operator SIM training for a range of landing conditions/locations, including EBT / CBTA.
FLT 3.11.59A
FLT 3.11.59B
FLT 3.11.60
Flight Crew initiate go -around
FLT 3.11.60
FLT 3.11.62
FLT 3.11.65
FLT 3.11.67
Aircraft tailstrike

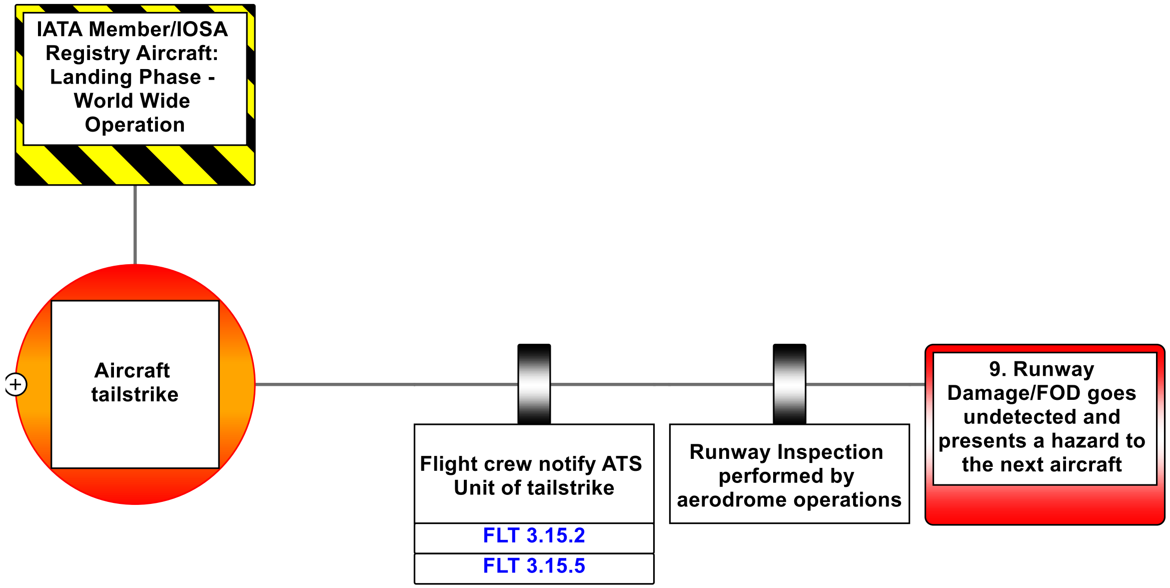


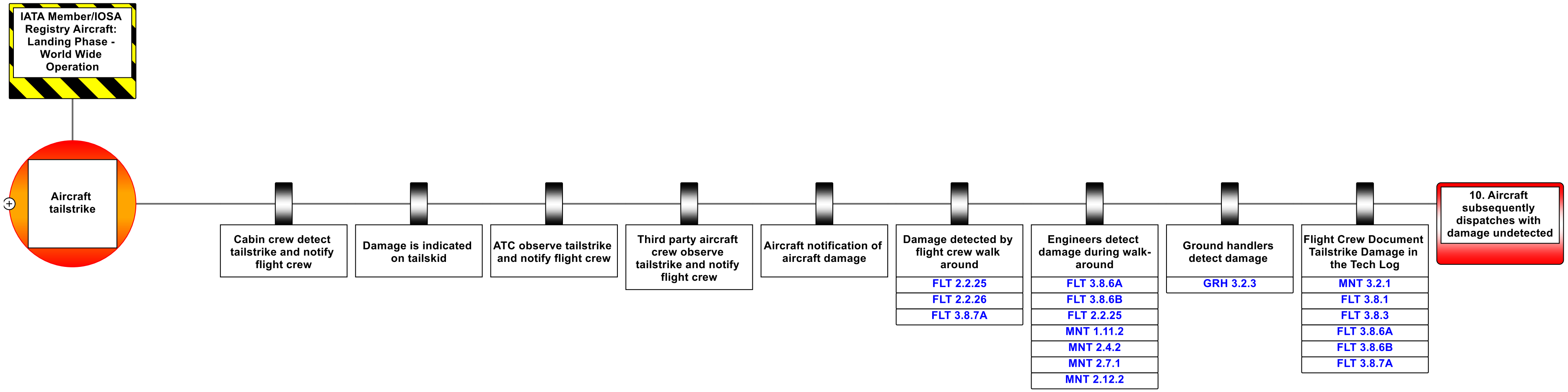
IATA Member/IOSA Registry Aircraft: Landing Phase - World Wide Operation
9. Aircraft outside of CG (weight/balance) envelope due to incorrect aircraft loading
Operator SMS
ORG 1.1.1
Dispatch control system produces an accurate loadsheet
GRH Tbl 6.1
GRH 3.3.1
FLT 3.7.3
FLT Tbl 2.1
Ground Handler confirming aircraft is correctly loaded
GRH 3.4.16
GRH 3.4.17
GRH 3.7.4
GRH Tbl 6.1
Aircraft detection systems to provide warnings for CG/mass exceedances
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Flight crew are notified in flight or inaccurate CG/weight and update FMC
FLT 3.11.20
Aircraft tailstrike


IATA Member/IOSA Registry Aircraft: Landing Phase - World Wide Operation
Aircraft tailstrike
Aircraft flight envelope protection
Operator SOPs
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
Flight Crew Training in Operator SOPs
FLT 1.3.6
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 2.2.27
FLT 2.2.29
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Operator Emergency Response Plan
ORG 1.7.1
ORG 1.7.3
Aircraft Crashworthiness and Survivability
Aerodrome Rescue and Fire Fighting Service
6. Loss of control in flight (following go-around)


IATA Member/IOSA Registry Aircraft: Landing Phase - World Wide Operation
Aircraft tailstrike
Safety margin within landing distance required (LDR) calculation
FLT 3.11.68A
Operator SOPs
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
Flight Crew Training in Operator SOPs
FLT 1.3.6
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 2.2.27
FLT 2.2.29
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Operator Emergency Response Plan
ORG 1.7.1
ORG 1.7.3
Aircraft Crashworthiness and Survivability
Arrester Beds at Aerodrome
Aerodrome Rescue and Fire Fighting Service
7. Runway Excursion (lateral or overrun)


IATA Member/IOSA Registry Aircraft: Landing Phase - World Wide Operation
Aircraft tailstrike
Operator SOPs
FLT 1.6.1
FLT 1.6.3
FLT 1.6.6
FLT 1.7.1
FLT 1.7.2
Flight Crew Training in Operator SOPs
FLT 1.3.6
FLT 2.1.10
FLT 2.1.12
FLT 2.2.26
FLT 2.2.27
FLT 2.2.29
Flight Crew Compliance with Operator SOPs
FLT 3.11.18
FLT 3.11.46
Aircraft Certification Crashworthiness and Survivability
Operator Emergency Response Plan
ORG 1.7.1
ORG 1.7.3
Aerodrome Rescue and Fire Fighting Service
8. Injury to passengers/crew (aircraft remains on runway)


IATA Member/IOSA Registry Aircraft: Landing Phase - World Wide Operation
Aircraft tailstrike
Flight crew notify ATS Unit of tailstrike
FLT 3.15.2
FLT 3.15.5
Runway Inspection performed by aerodrome operations
9. Runway Damage/FOD goes undetected and presents a hazard to the next aircraft



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Annex C Tail Strikes - Rated as Accidents Last 5 Years

Occurrence Date	Aircraft Type	Operator Region	Investigation Link	Region of Occurrence	Investigation Status	Final Report Published	Phase of Flight	IOSA Member
12/14/2018	A321	CIS	VQ-BCE	CIS	No Info	No	Take Off	Yes
12/11/2018	B777-300	NAM	C-FITW	NASIA	Final report	Yes	Landing	Yes
7/26/2018	B757-200	CIS	UP-B5705	CIS	No Info	Yes	GOA	Yes
7/16/2018	B737-800	LATAM/CAR	LV-HQY	LATAM/CAR	Final report	Yes	Take Off	No
6/10/2018	B737-800	NAM	N276EA	EUR	No Info	No	Landing	No
5/2/2018	B737-800	EUR	OO-JAY	MENA	Final report	Yes	Landing	No
4/17/2018	Dash 8-400	EUR	G-JECX	EUR	Final report	Yes	Landing	Yes
4/1/2018	A321	ASPAC	VN-A353	ASPAC	No Info	No	Landing	Yes
12/31/2018	B 757-2B7 (WL)	NAM	N938UW	NAM	Final report	Yes	Landing	Yes
7/31/2018	B 757-200	NAM	N192AN	NAM	Final report	Yes	Taxi	Yes
9/7/2019	ATR 72	LATAM/CAR	HK-5041	LATAM/CAR	Final report	Yes	Landing	No
8/8/2019	A321	NAM	N717FR	NAM	Final report	Yes	Landing	Yes
6/9/2019	B737-900	NAM	N75436	NAM	Final report	Yes	Landing	Yes
2/8/2019	A321	EUR	SE-RKA	EUR	Final report	Yes	Landing	No
1/26/2019	ATR 72	ASPAC	VT-AIX	ASPAC	Final report	Yes	Landing	No
3/21/2020	B757-200	NAM	N193AN	NAM	Final report	Yes	Landing	Yes
2/1/2020	B747-400	EUR	TC-MCT	MENA	No Info	Yes	Take Off	Yes

Occurrence Date	Aircraft Type	Operator Region	Investigation Link	Region of Occurrence	Investigation Status	Final Report Published	Phase of Flight	IOSA Member
12/12/2021	A320	NAM	N307FR	NAM	Final report	Yes	Landing	Yes
10/15/2021	A321	LATAM/CAR	PT-MXF	LATAM/CAR	No report	No	Take Off	Yes
9/27/2021	B757-200	NAM	N12125	NAM	Final report	Yes	Landing	Yes
9/23/2021	A321	NAM	N208HA	NAM	Final report	Yes	Landing	Yes
8/11/2021	MD-11	NAM	N296UP	NAM	Final report	Yes	GOA	Yes
2/1/2021	B747-8	ASPAC	JA13KZ	ASPAC	No report	No	Landing	Yes
10/6/2022	B787-9	AFI	ET-AYC	AFI	No Info	No	Landing	Yes
8/6/2022	B757-200	NAM	N540US	NAM	Preliminary report	No	GOA	Yes
5/18/2022	A320	NAM	N331FR	NAM	No Info	No	Landing	Yes
5/6/2022	B737-800	EUR	YR-BMM	EUR	No report	No	Landing	Yes
2/8/2022	A330-300	EUR	PH-AKE	NAM	No Info	No	Take Off	Yes
1/22/2022	A320	NAM	N760JB	NAM	Preliminary Report	No	Take Off	Yes
1/02/2023	A321-252NX	ASPAC	VT-ILR	ASPAC	No Info	No	Unknown	Yes
3/22/2023	A320-200	NAM	N1902U	NAM	Final report	Yes	Landing	Yes