A Human Factors Approach to Preventing Tail Strikes

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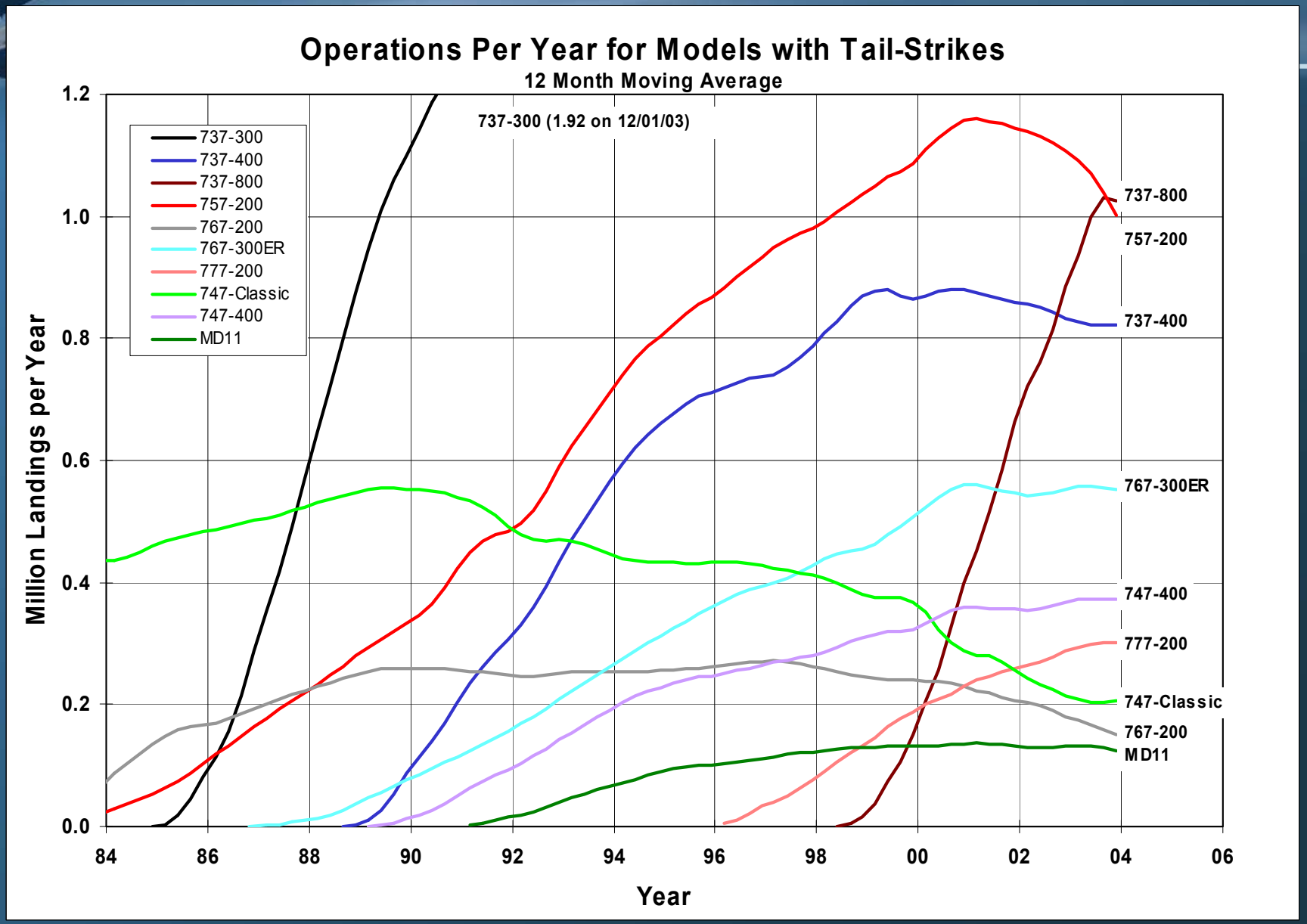
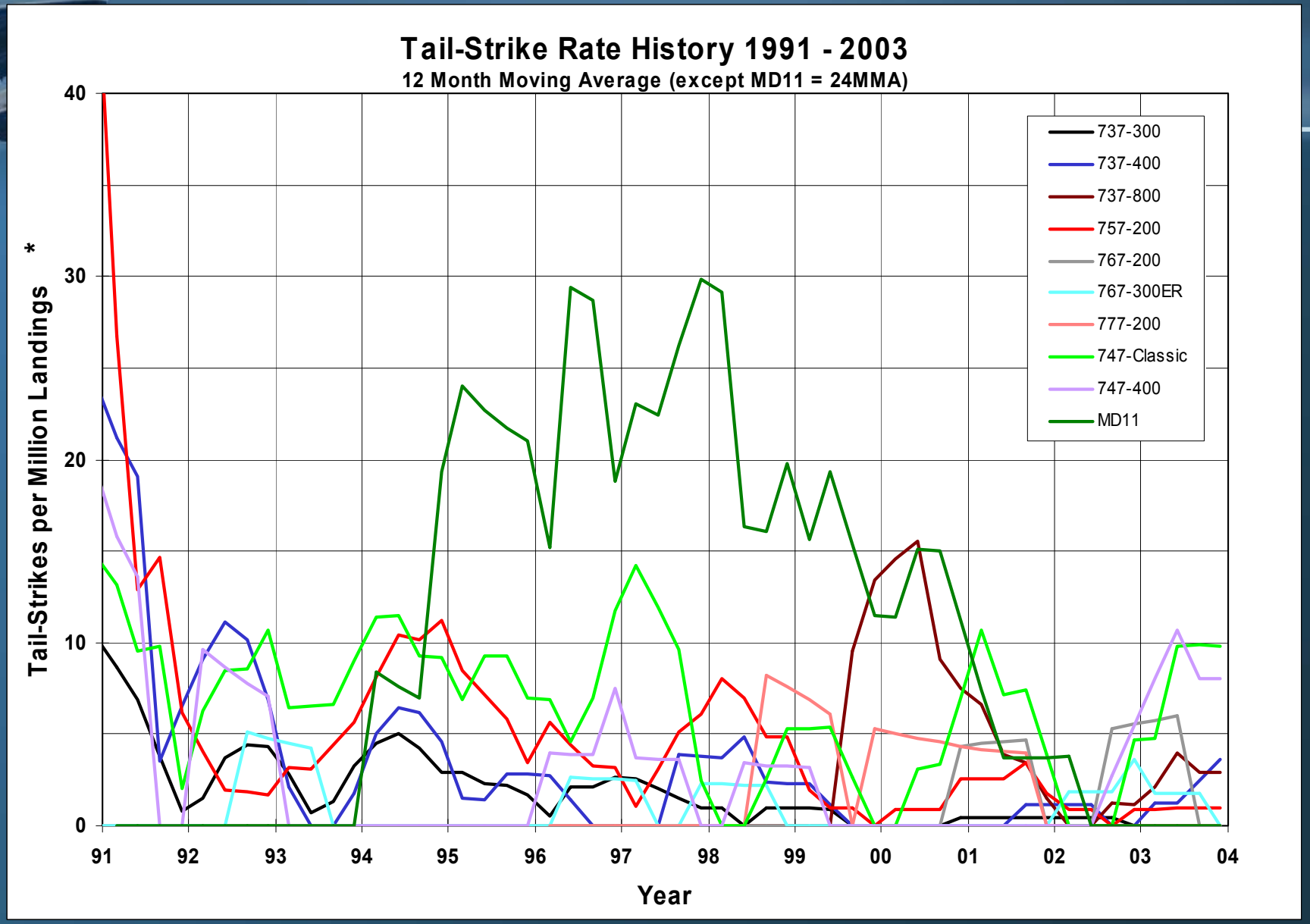
Presentation Overview

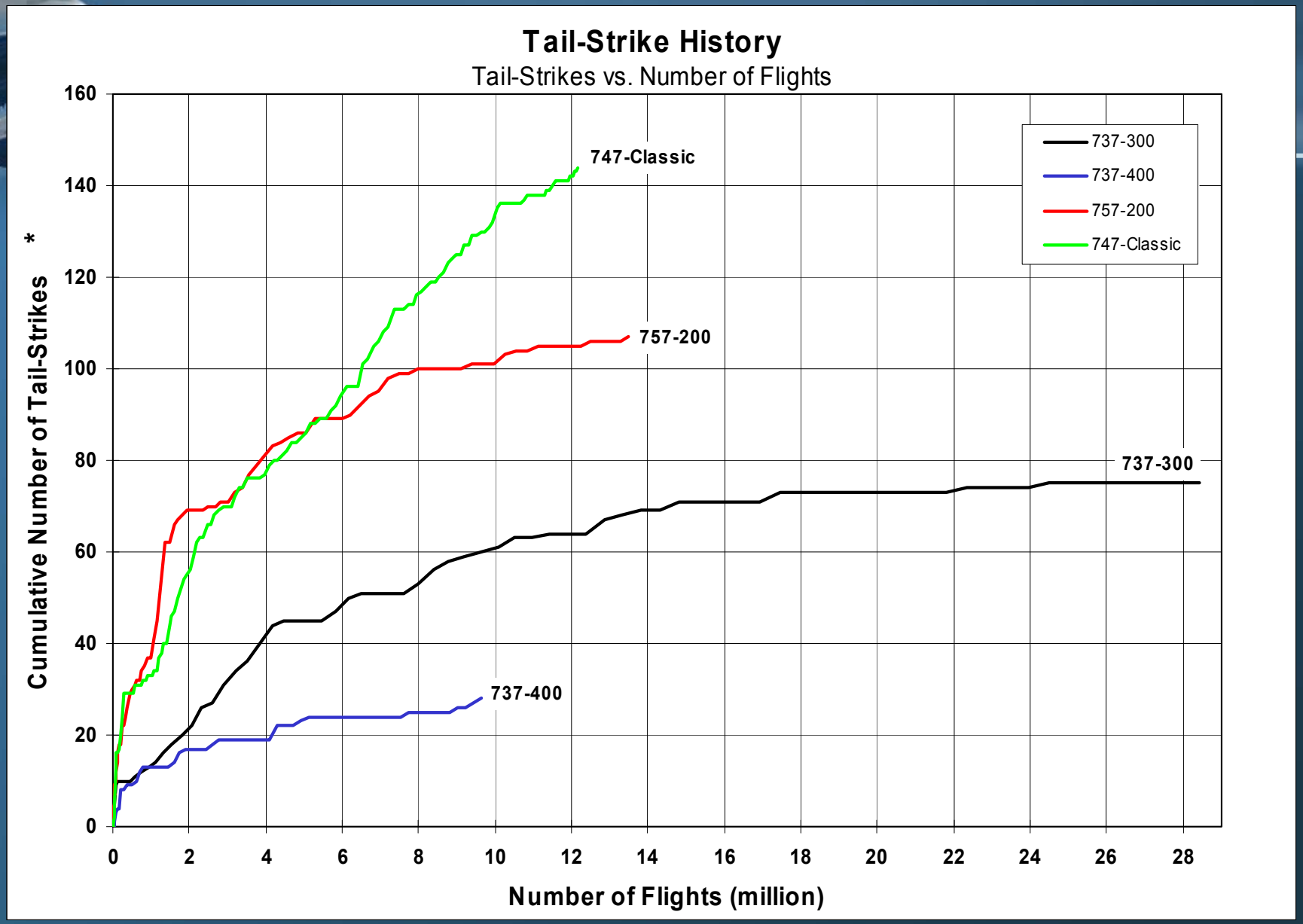
- Tail strike statistics as of 2003
- Engineering/procedural improvements & general information
- Human factors review of a 2003 tail strike
- Review causes and prevention
- Future strategy for tail strike prevention
- Training recommendations
- Summary


Operations Per Year for Models with Tail-Strikes
12 Month Moving Average
737-300 (1.92 on 12/01/03)
737-300
737-400
737-800
757-200
767-200
767-300ER
777-200
747-Classic
747-400
MD11
Million Landings per Year
1.2
1.0
0.8
0.6
0.4
0.2
0.0
84
86
88
90
92
94
96
98
00
02
04
06
Year
737-800
757-200
737-400
767-300ER
747-400
777-200
747-Classic
767-200
MD11



* Tail skid contacts without damage are not included.

MD11 contacts with only VHF antenna or drainmast damage are not included.



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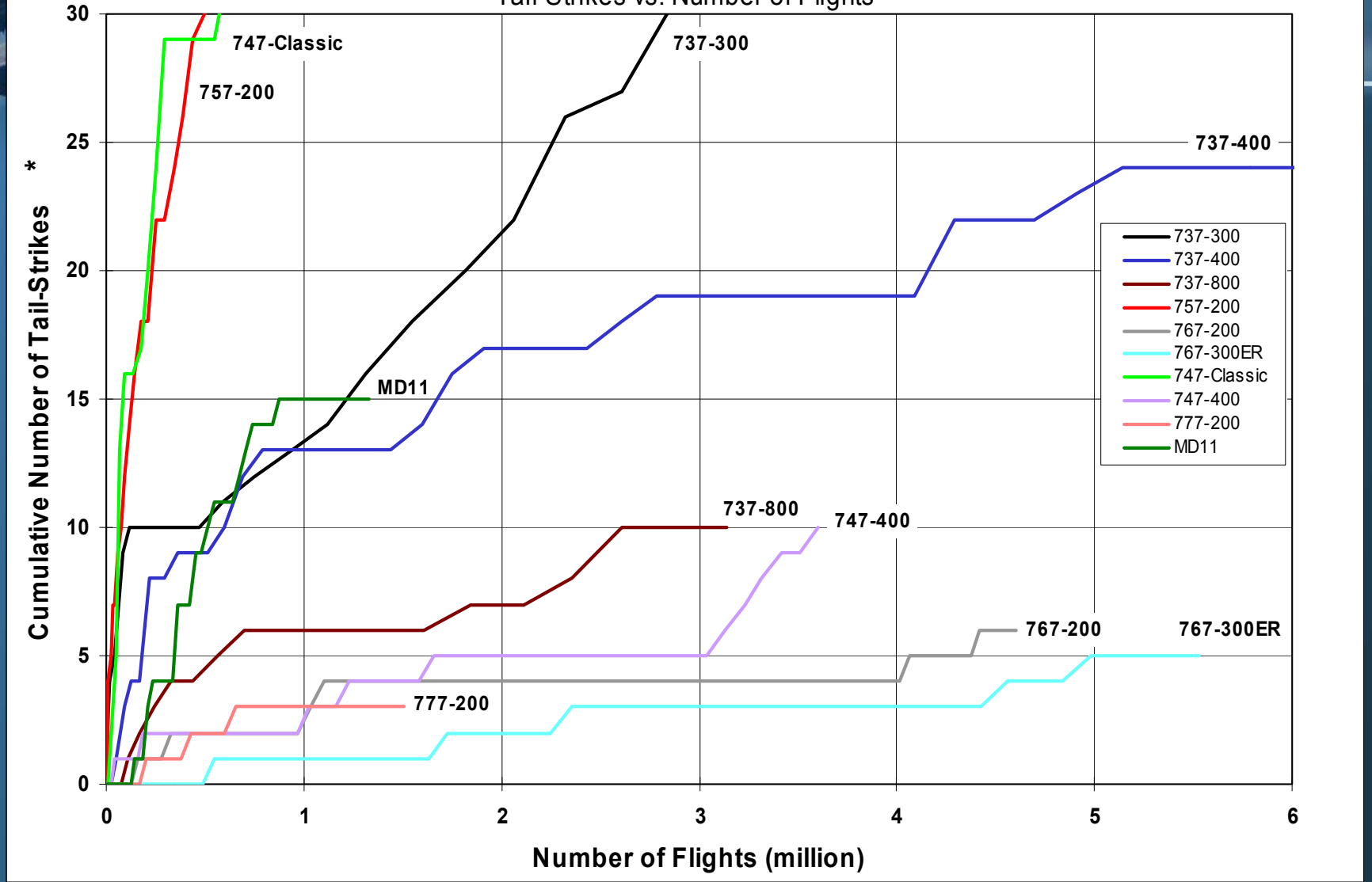
Tail-Strike History

Tail-Strikes vs. Number of Flights



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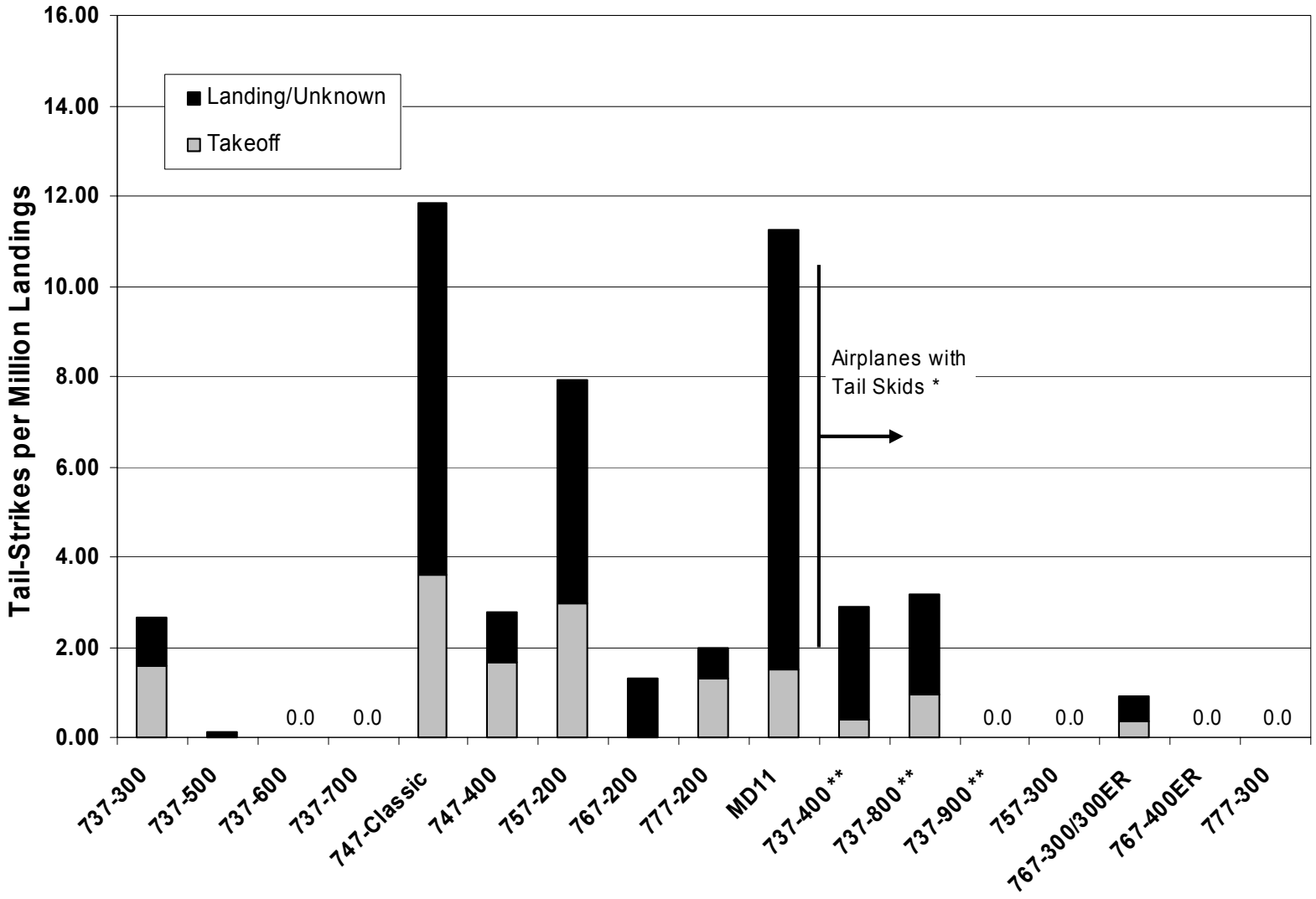
Takeoff and Landing Tail-Strike Rates

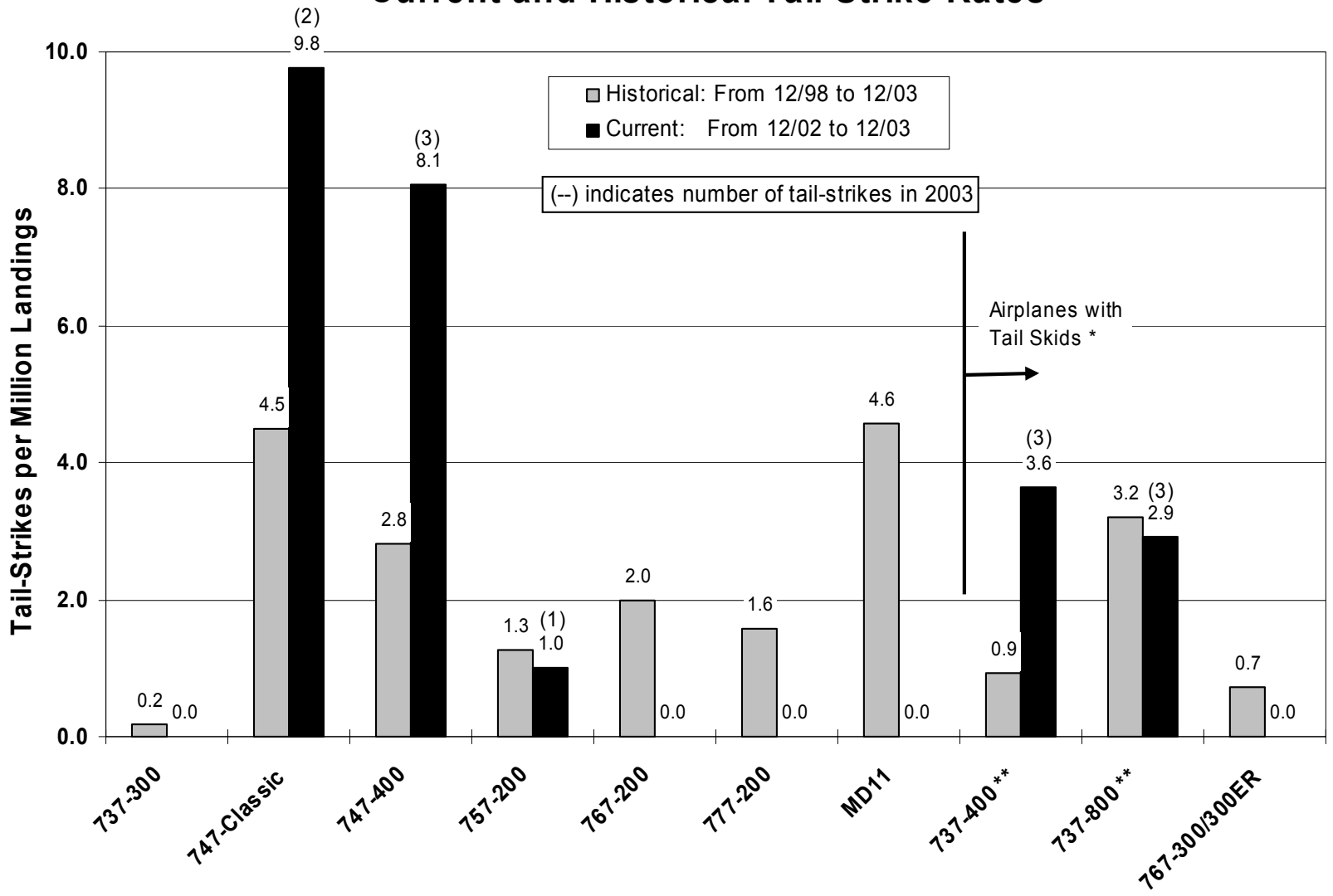
From Entry Into Service Through 12/1/03



* Tail skid contacts without damage are not included.

** 737-400/-800/-900 tail skids not designed for landing protection.

Current and Historical Tail-Strike Rates



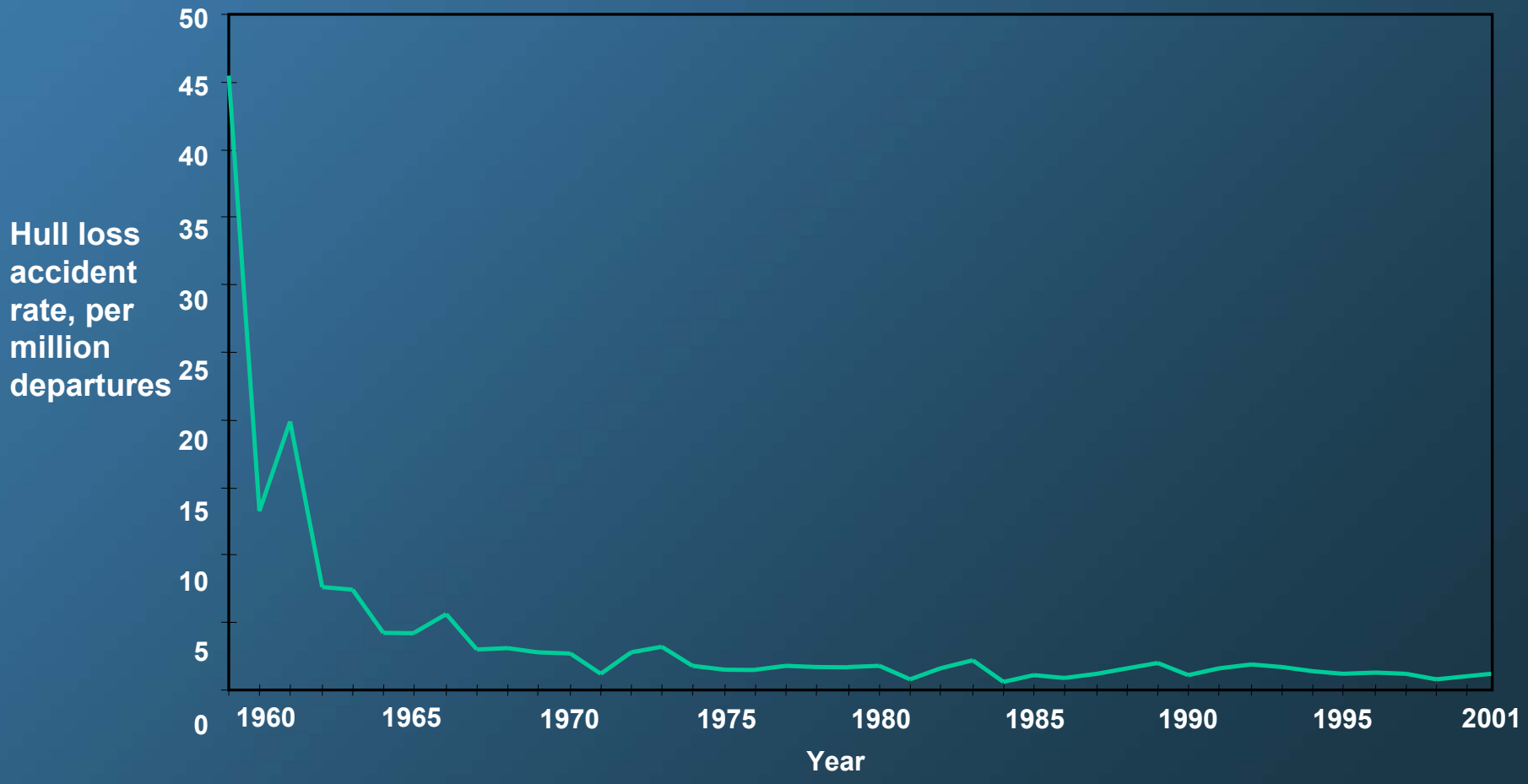
* Tail skid contacts without damage are not included.

** 737-400 and 737-800 tail skids not designed for landing protection.

Engineering/Procedural Improvements & General Information

- Newer designs incorporate improved elevator feel systems
- Aircraft such as the 737-400, 737-800/900, 767-300, 777-300, 757-300, 767-400 have tail skids which prevent damage from takeoff tail strikes but not landing tail strikes
- Longer bodied Boeing airplanes use relative higher rotation speeds (speed additives to V1,VR, and V2, to maintain equivalent tail clearance)
- More tail strikes occur on landing than on takeoff
- Tail strikes are cyclic

Worldwide Hull Loss Accident Rate 1959 -2001



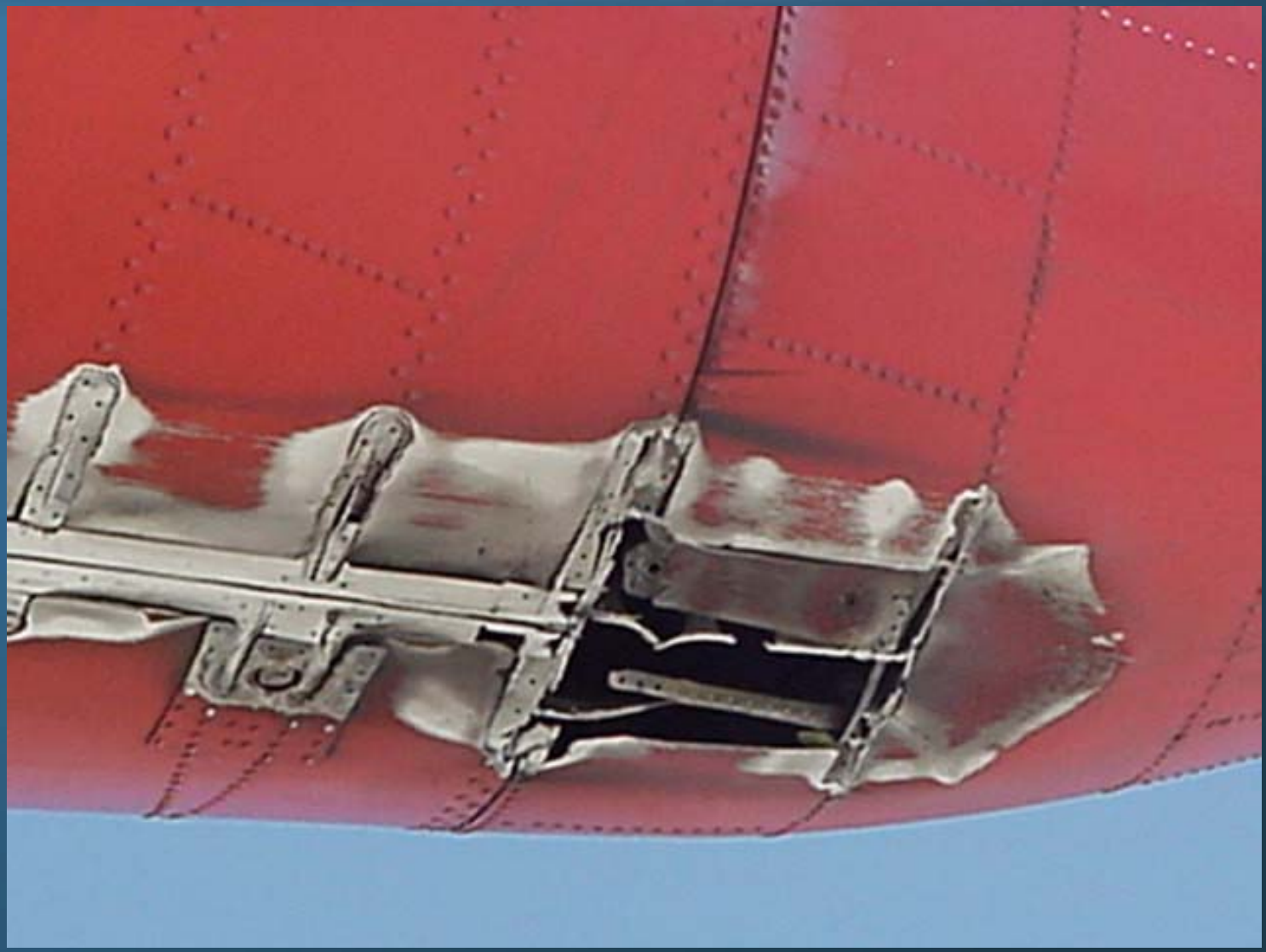
1950 -2000

- Focused on accidents, specifically hull loses
- Lessons learned from the accidents were used to improve aviation safety

21st Century, A Different Approach

- For Every Accident There Are 100 Close Calls!
- Focus not only on accidents but just as important the close calls, incidents, and lessons learned from each flight
- LOSA, ASAP, FOQA, and AQP have much to offer!
- Study accidents, flight deviations, and incidents from a human factors perspective
- Specifically from a “Threat & Error Management Perspective”

747 Classic Tail Strike



Human Factors

- Man is error prone
- Crews can and will occasionally string a chain of errors resulting in an accident!
- The error chain for a tail strike accident can be very short!
- Stop the accident by breaking the error chain. How?

Threat & Error Management-Crew Resource Management Concept-
Newest Generation of CRM

Threat and Error Management

Threat and Error Management

- Significant in:
  - Accident Investigation
  - LOSA, FOQA, ASAP
  - Training
  - Evaluation
  - Design
  - The way an airline operates

Definition of Terms

- **Threats:** are situations external to the flight deck, that must be managed by the cockpit crew during normal, everyday flights. Such events increase the operational complexity of flight and pose a safety risk to the flight at some level.
- **Errors:** are ***actions*** or ***inactions*** by the crew that lead to deviations from organisational or flight crew intentions or expectations. Errors in the operational context tend to reduce the margin of safety and increase the probability of accidents or incidents.

Threats

- Crew was in delay and was rushed
- The airplane was dispatched with an inoperative APU, with hot weather and minimal air on the flight deck and cabin. The center fuel pump gauge was on a MEL
- Non-standard cross bleed start procedure
- The scavenge fuel pump was on a MEL
- Flight Engineer busy working technical issues and mechanical portion of his seat failed
- Second flight engineer working in the cabin with passenger issues

How Did The Crew Manage The Threat?

- 20 minutes sterile cockpit rule was broken
- The way duties were delegated while the crew was rushing to catch up with the delay--- broke down the safety net
- Flight Engineer was overloaded
- The crew was rushing

Errors

- Engineer entered Takeoff Data using zero fuel weight as gross weight into the computer. Data was entered incorrectly and data insertion not checked.
- Data computer for takeoff calculations was not used per correct procedure:
  - Error was over 220,000 lbs
  - V1:123, VR:123, V2:142 (Incident Speeds)
  - V1:154, VR:164, V2:171 (Tech. Order Speeds)
- Captain checked numbers instead of First Officer who was trained/required
- Data was double checked but no indication it was compared to the Load Sheet
- No one on the flight deck did a "Reasonable Check!"

Was the crew under stress?

How Did The Crew Manage Errors & Aircraft Undesired States?

- Data Insertion? Error-undetected
- 1st Rotation-Undesired Aircraft State-Managed
- 2nd Rotation-Undesired Aircraft State-Managed
- Tail Strike Discovery? Managed past errors

Takeoff Risk Factors

- Mis-trimmed stabilizer
- Improper Rotation Techniques
- Improper use of the flight director
- Rotation prior to VR-either:
  - Early rotation: Too aggressive, misinterpretation
  - Early rotation: Incorrect takeoff speeds (Human Factors)
- Excessive initial pitch attitude
- Crosswinds

Review Proper Takeoff Techniques

- Use normal takeoff rotation technique
- Do not rotate early
- Do not rotate at an excessive rate or to an excessive attitude
- *Ensure takeoff V speeds are correct and adjusted for actual thrust used
- Consider use of greater flap setting to provide additional tail clearance
- Manage gusty winds and use proper amount of flight controls during crosswinds

Note: From a human factor perspective, a common error with a high level of consequence

Tail Strikes During Gusty Crosswind Conditions

- Boeing Flight Crew Training all model change
  - Use max takeoff thrust
  - Momentarily delay rotation during the gust
  - Use normal rate of rotation
  - Limit control wheel input to maintain wings level
  - Avoid excessive control wheel displacement
  - Smoothly transition from slip after liftoff

Landing Risk Factors

- Un-stabilized approach
- Holding airplane off the runway in the flare
- Mis-handling of crosswinds
- Over-rotation during go-around

****Note: Tail strikes on landing generally cause more damage. The tail may strike the runway before the main gear damaging the aft pressure bulkhead.***

Landing Risk *Danger*

- Landing tail strike damage can cause pressure bulk head failure
- Short term, if damage is not corrected or flight is continued-risk of structural failure
- Long term, if repair was not properly corrected-risk of structural failure

Maintenance Issue

- Post tail strike flight-ensure maintenance inspection prior to next flight
  - Maintenance inspection must be accomplished by qualified maintenance
  - Aircrew is ***not*** qualified to conduct the inspection

Proper Landing Techniques

- Maintain an airspeed of Vref + 5 knot minimum to start of flare and fly the approach at “Specified Target Airspeed”
- Airplane should be in trim at start of flare; do not trim in the flare or after touchdown
- Do not “hold the airplane off” in an attempt to make an excessively smooth landing
- Use only appropriate amount of rudder/aileron during cross wind approaches and landing
- Immediately after main landing gear touchdown, release back pressure on control wheel and ***fly*** the nose wheel onto the runway
  - Do not allow pitch attitude to increase after touchdown
  - Do not attempt to use aero braking - ***it does not work*** !

Future Strategy For Accident Prevention

- TEM is a major strategy to prevent cyclic occurrences of tail strikes
- TEM Training-Aircrews, Instructors, Check Airman, and Safety Personnel
- Threat and Error Management becomes part of the way aircrews operate:
  - Used in Flight Operations
  - Major emphasis during all crew training and evaluations

Training Recommendations

- As the crew member:
  - Assess yourself in training or during your next operational takeoff and landing
  - Assess each other's rotation rates and techniques
  - When training in the simulator, check your tail clearance if this function is installed
- As the trainer:
  - Evaluate tail clearance during takeoffs and landings
  - Use scenarios that create "Threats" that can test and measure the crew's capability to prevent tail strikes
  - Evaluate how the crew deals with errors

Continental Airlines Tail Strike Prevention Program

- Reduced operational tail strikes to almost nil
- Use of a crew *self* monitoring tail strike clearance tool
  - Pitch report for every takeoff and landing available for crew review
  - If within 1 degree of maximum it auto prints
  - Air Canada is adopting

To Prevent Tail Strikes

- Crew members:
  - Adhere to proper takeoff and landing techniques
  - Apply the lessons learned. Know the pitfalls.
  - Don't assume! Double check the takeoff data, especially if something doesn't look right. Coordinate insertion of the ZFW with another crew member. Double check data with the load sheet.
  - Must know their airplane! Have an idea about the T/O and Approach speeds. When setting airspeed bugs always do a "Reasonable Check!"
  - Must be aware of the differences between models and types, especially when transitioning from other equipment
  - If a tail strike occurs, follow the CHECKLIST!
  - Assess your takeoffs and landings.

To Prevent Tail Strikes

- The Airline should:
  - Stress proper landing and takeoff techniques during all training and evaluations
  - Make “Tail Strike Prevention” part of the safety program: Posters, Briefings, Videos, CBT, CD’s, etc.
  - Use a tail clearance measuring tool for all takeoffs and landings during simulator training and evaluations, (provide feedback to crews)
  - Use a self measuring tail strike crew reporting tool!
  - Ensure that FOQA is not used as a punitive device

Final Thought

- Use “Threat & Error Management” to:
  - Manage the threats
  - Mitigate and reduce errors