



Developments in Aircraft Engine Design for Bird Ingestion



ICAO Wildlife Symposium

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Presented by:

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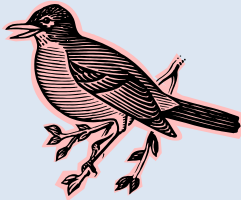


Pratt & Whitney

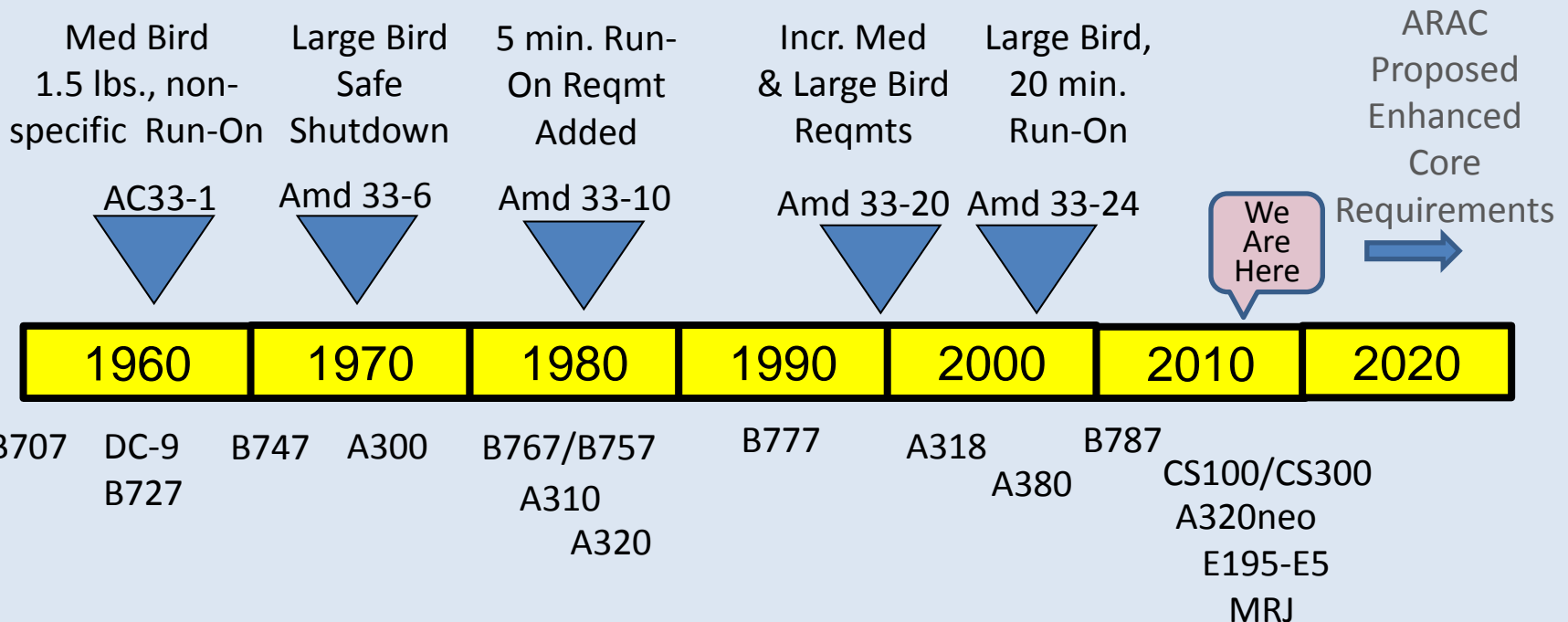
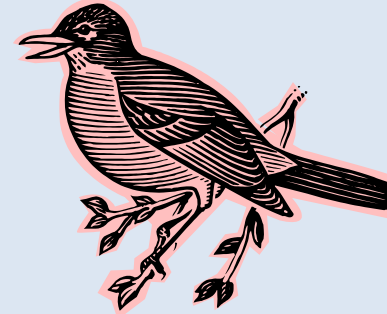
A United Technologies Company

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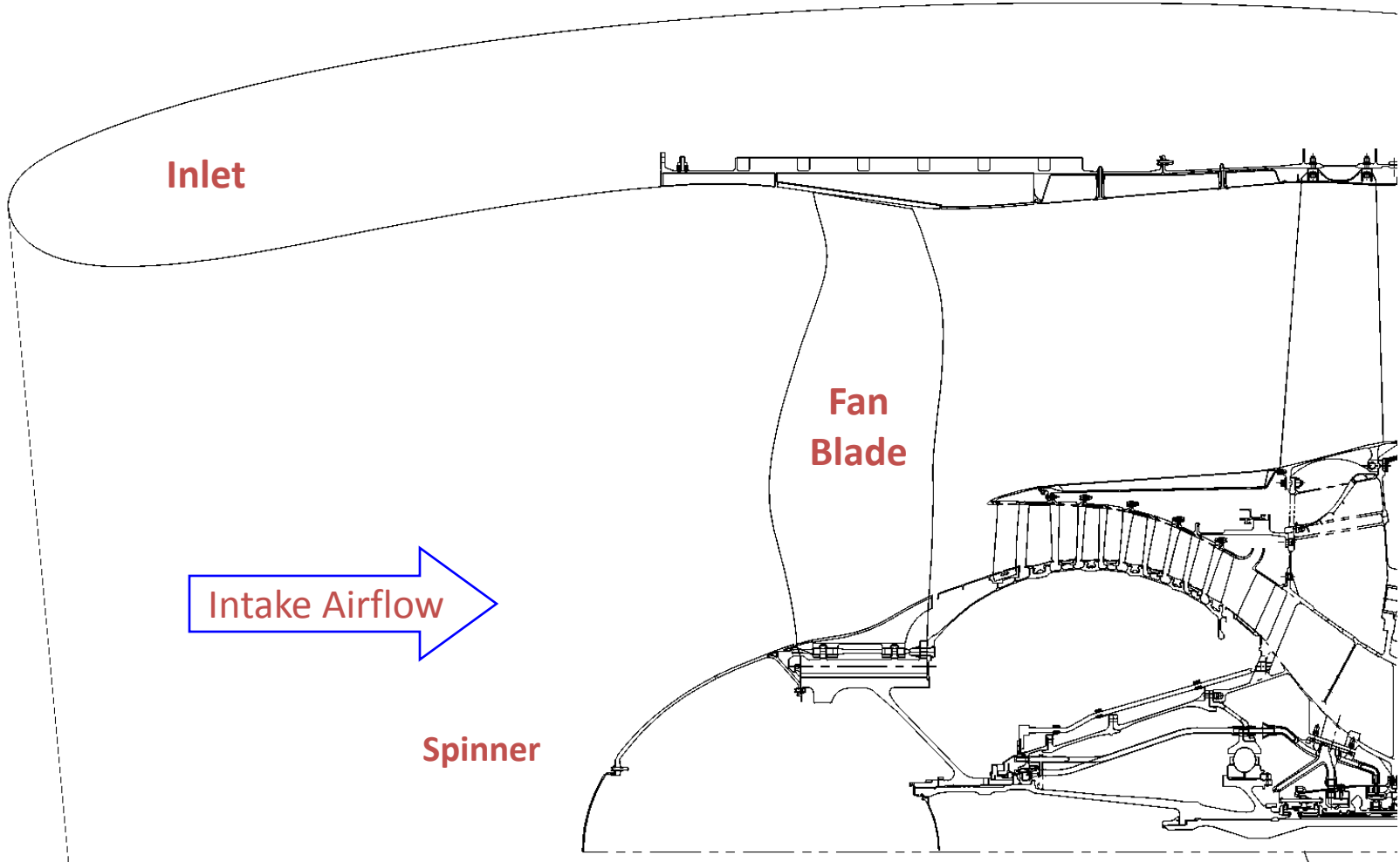
FAA Bird Requirements Evolution



Increased Regulations due to Industry Study of Bird Populations

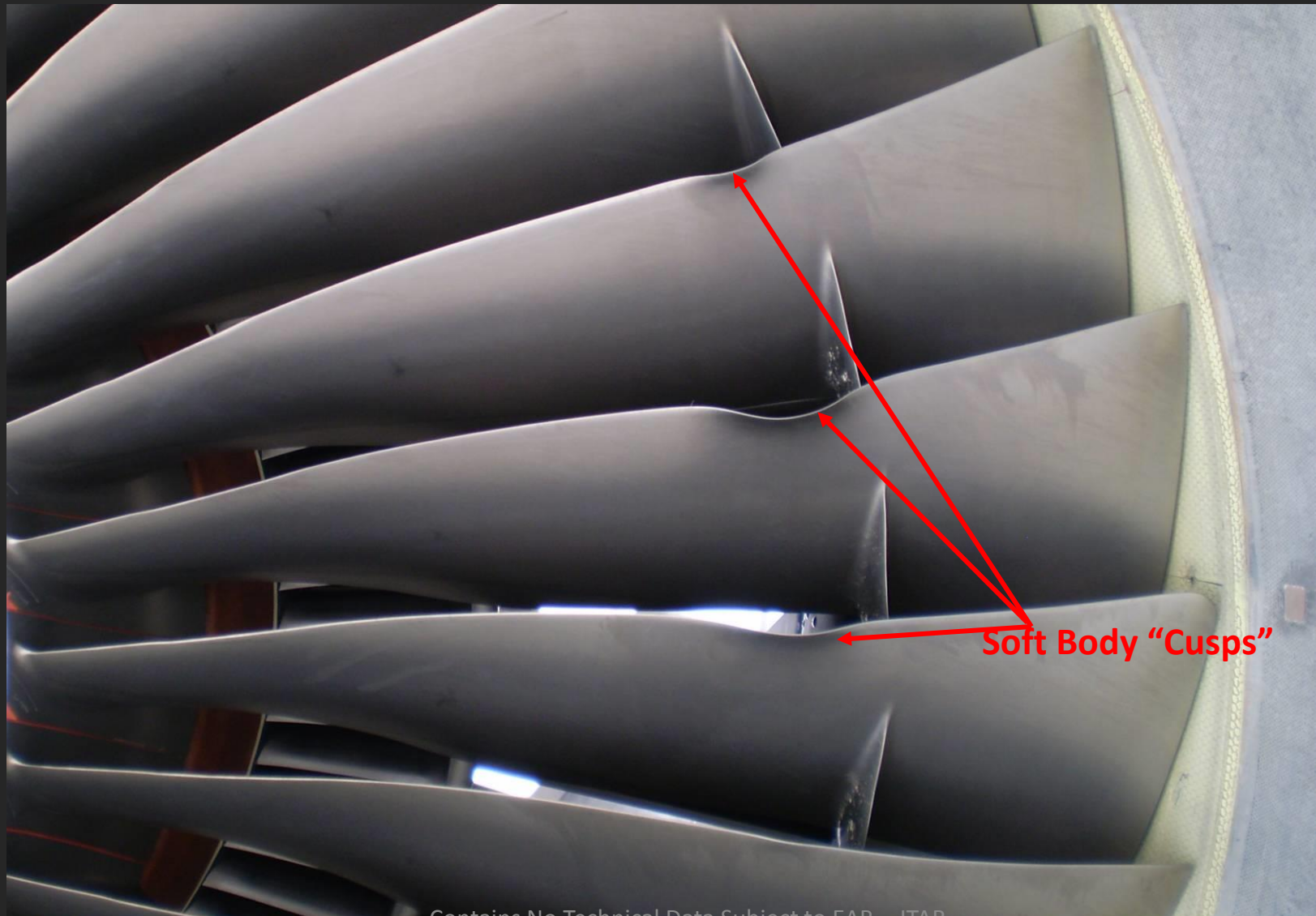


High By-Pass Turbofan Engine

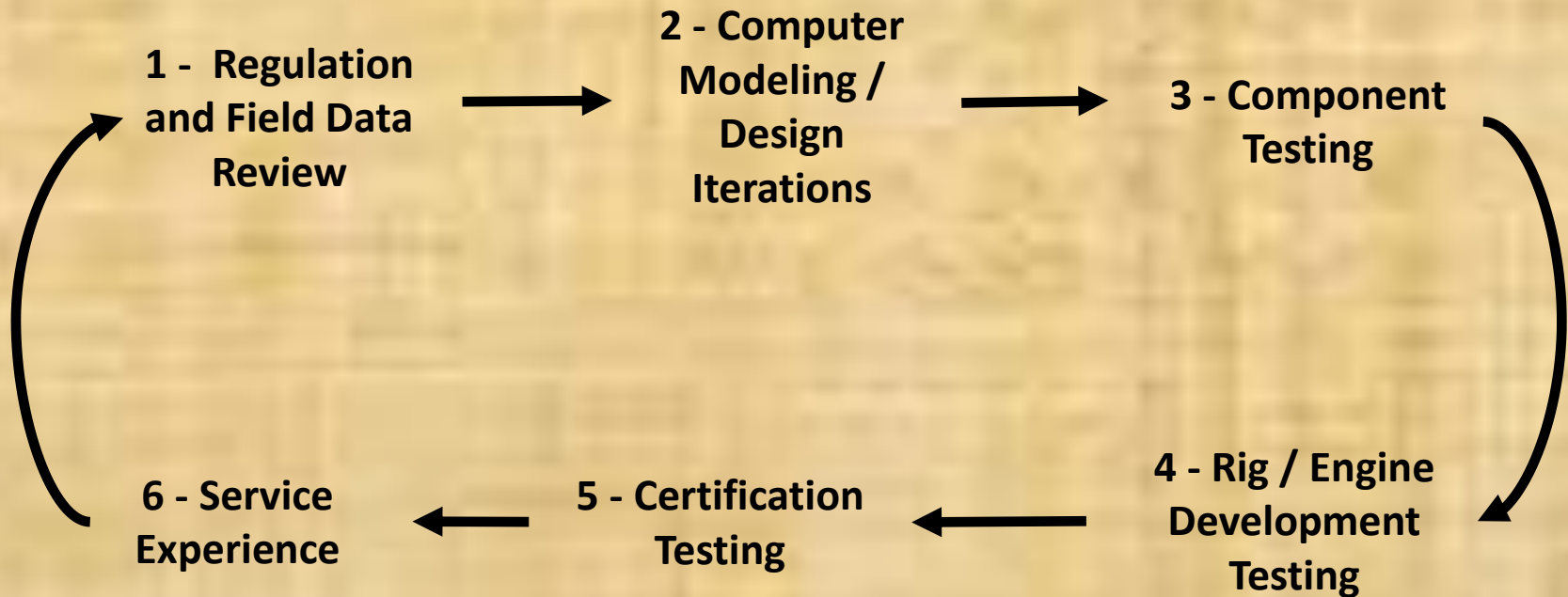


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Bird Strike – Typical Fan Blade Damage

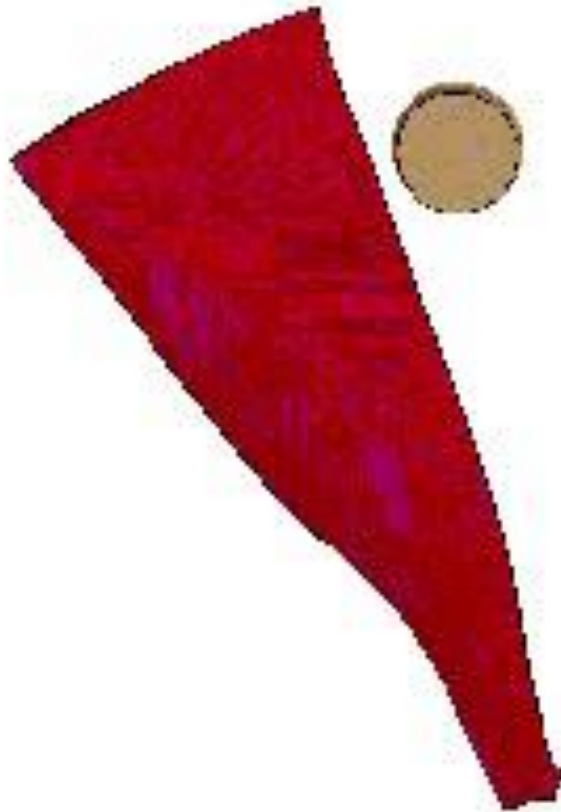


Design Process for Bird Strike Mitigation



Computer Modeling

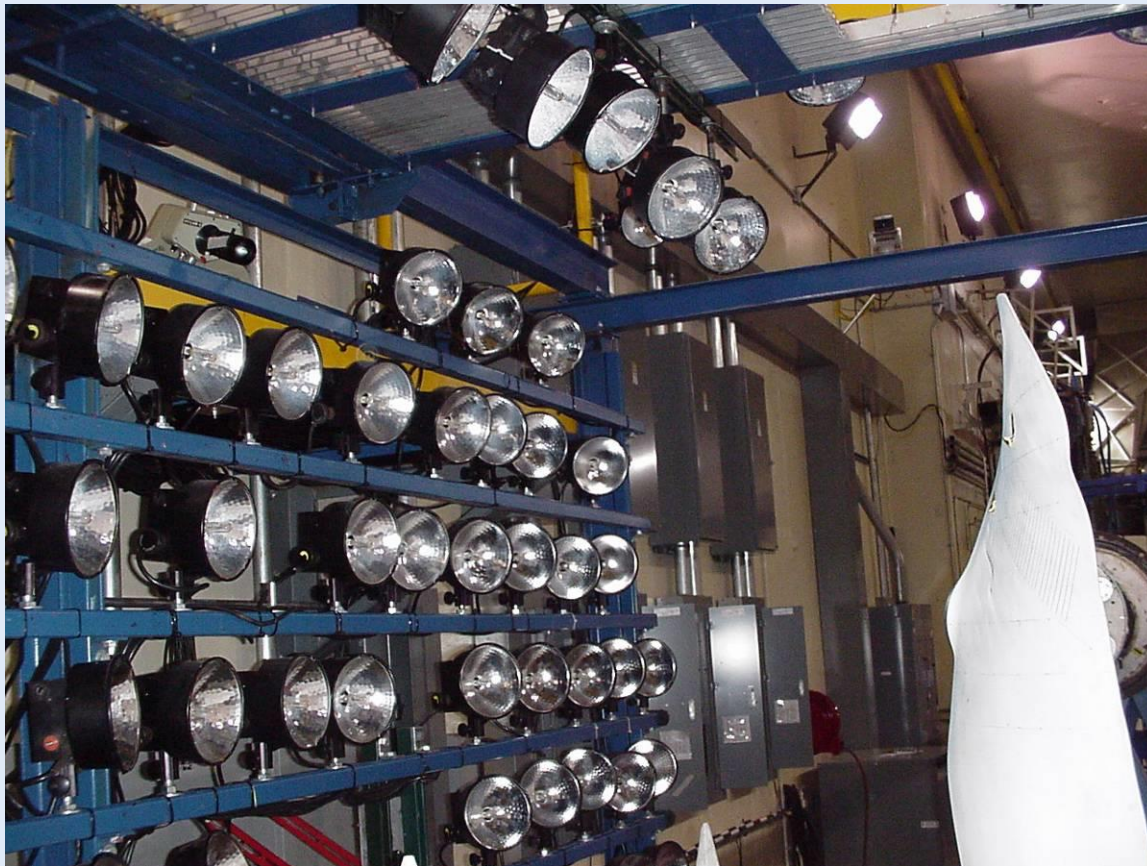
Fan blade design is optimized via computer modeling for bird strike response



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Component Testing

Fan blades are lab tested at component level to verify computer model predictions

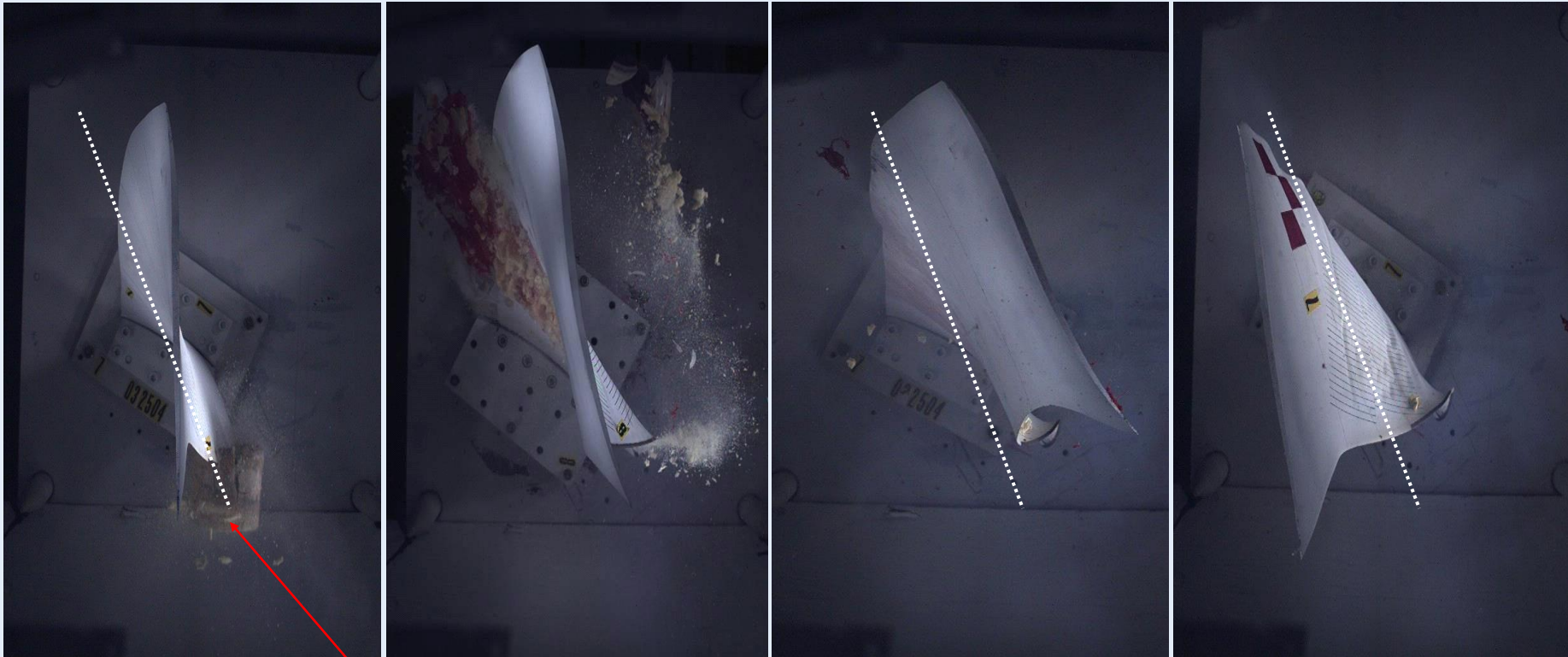


Top view of jelly bird
impacting fan leading edge
(above)

Fan blade component test
set-up (left)

Component Testing

Fan component test – structural model calibration data and confirmation of fan bird impact response



Jelly Bird

Rig Testing

Fan rotor rig test – confirmation of fan bird impact response



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Bird Certification Requirements

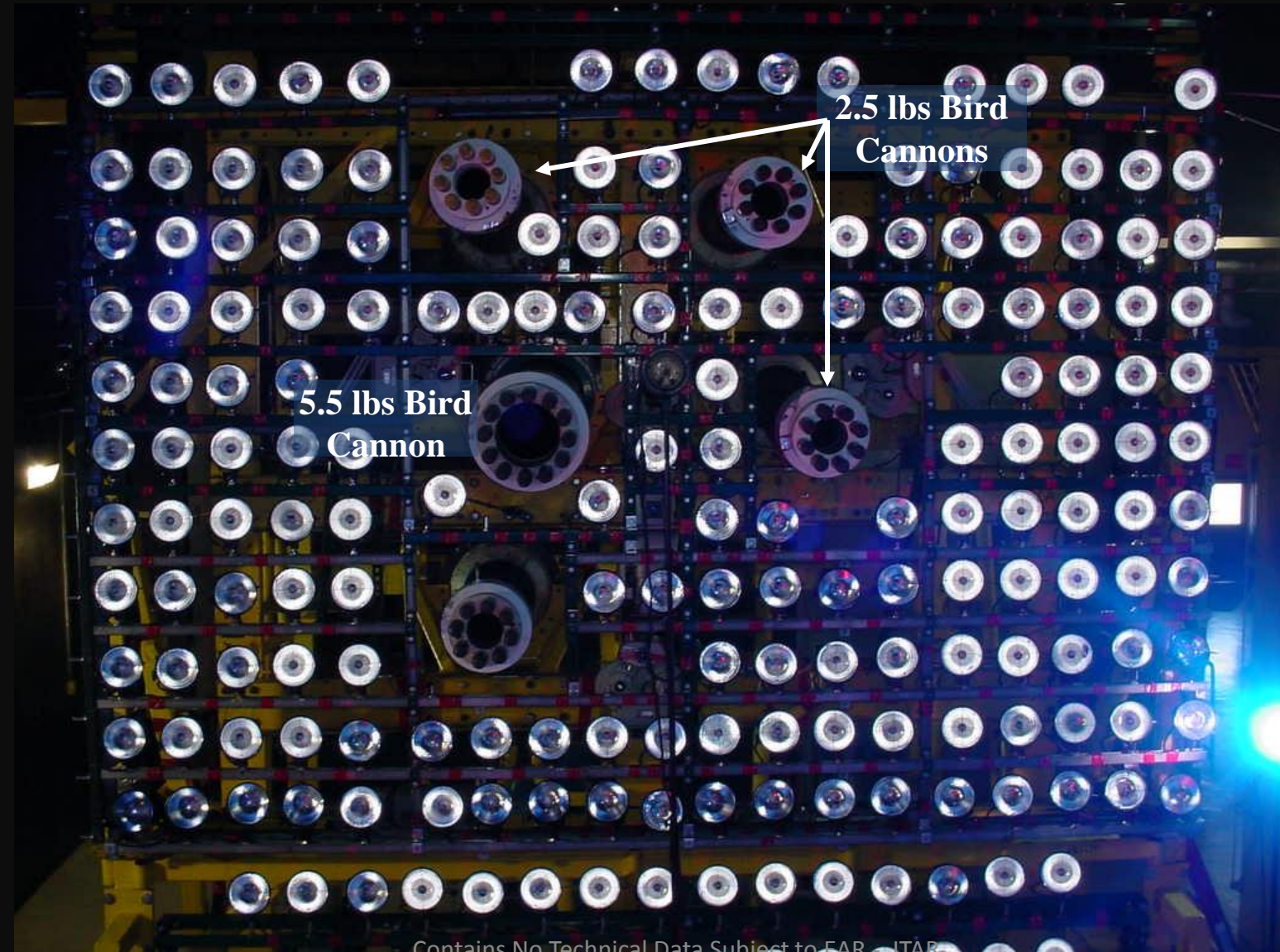
- Engine ingestion test bird sizes and quantities are established by federal regulations based on engine size (inlet area)
- For large engines
 - Four medium flocking birds (2.5 lbs.) with core ingestion
 - Bird speed at most critical fan conditions > V1 (takeoff rotation decision speed)
 - All birds ingested within one second
 - Demonstrate sustained operation at $\geq 75\%$ take-off thrust
 - Provide sufficient power for aircraft ATB/diversion and safe landing
 - One large flocking bird (5.5 lbs.) targeted at critical fan location
 - Bird Speed is 200 knots (230 MPH)
 - Demonstrate sustained operation at $\geq 50\%$ take-off thrust
 - Provide sufficient power for aircraft ATB and safe landing
 - One large single bird (8 lbs.) targeted at critical fan location
 - Bird speed is 200 knots
 - Verify safe engine shutdown

Bird Ingestion Test Setup



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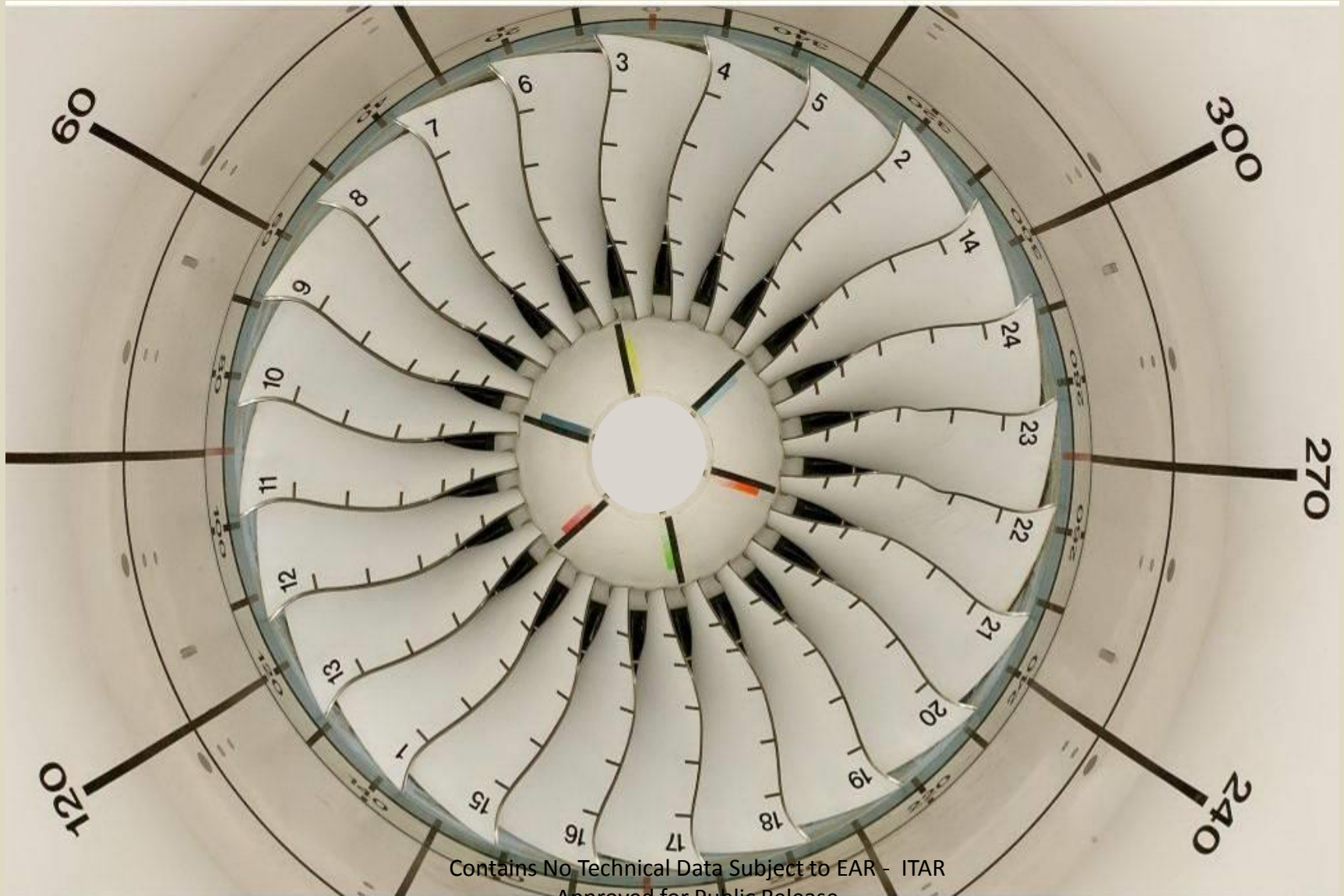
Bird Ingestion Test – Lights & Cannons



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Bird Ingestion Test – Fan Blades & Inlet



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Bird Ingestion Test – Birds



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Large Bird (8 lbs.) Test



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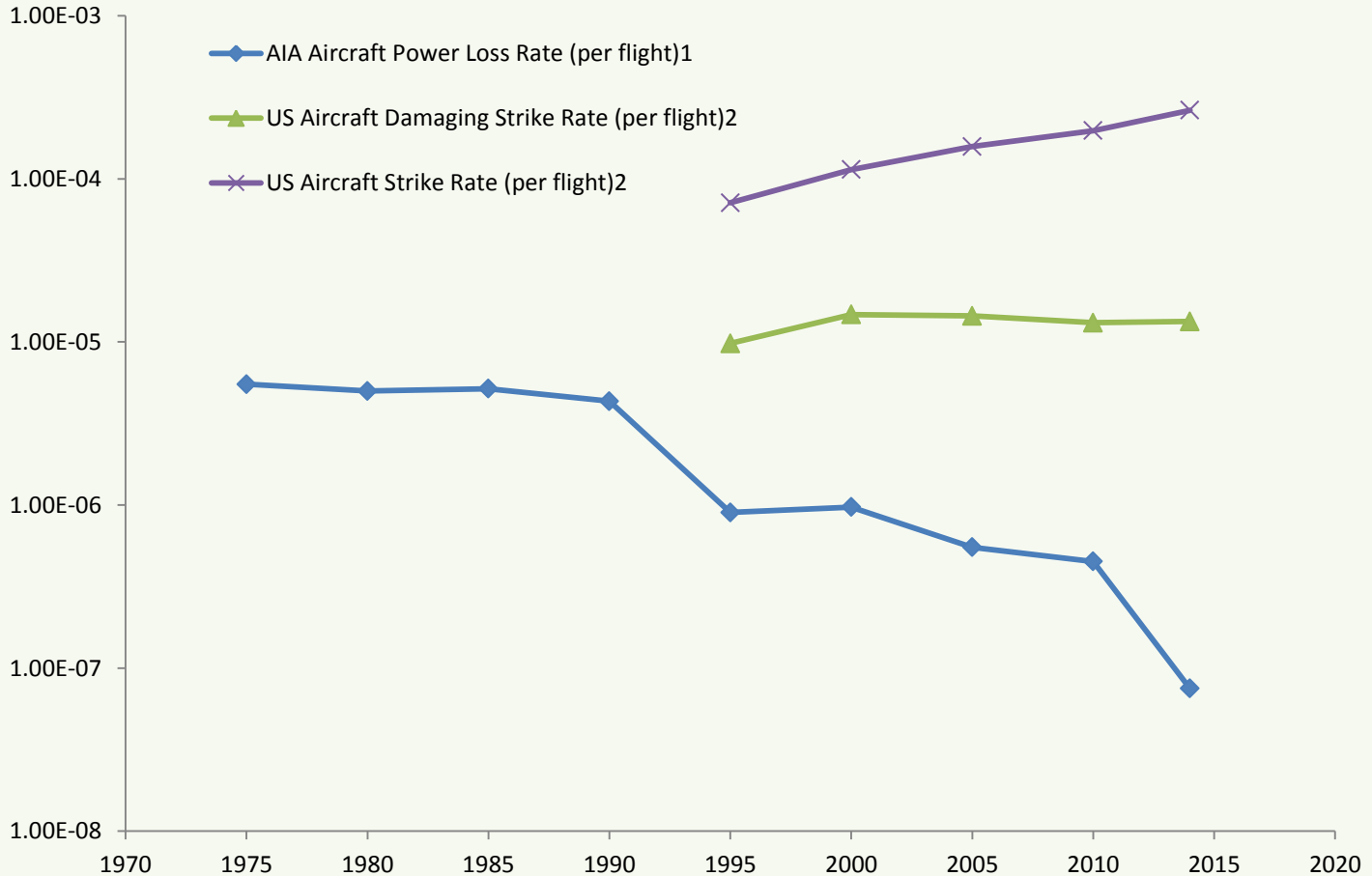
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Examples of Turbofan Continuous Design Improvements

- Shroudless fan airfoils
- Automatic surge recovery logic
- Automatic restart logic
- Improved compressor vane retention designs
- Optimized rain/hail/FOD core rejection geometry
- Reduced fan rotor speeds

Continuous Improvement Results

Aircraft Bird Strike Trends (4 year rolling avg.)



Summary

- Regulations have evolved over time to address the bird ingestion into aircraft engines as the understanding of the threat developed, and continue to evolve as we gain more knowledge about the threat.
- Everyone is doing their part to manage avian threats to all aircraft; regulators, manufacturers, airport operators and wildlife managers.
- Pratt & Whitney is proud of the engine advancements that have been achieved to reduce the threat of bird strikes to aircraft flight.
- Pratt & Whitney continues to work side by side with the industry and regulators to further mitigate the bird strike threat to aviation safety.

QUESTIONS?



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