# Virtual Sully: Autopilot with Multi-Level Adaptation for Handling Large Uncertainties

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Challenge:

- In 2009, Airbus 320 **lost both engines** shortly after takeoff due to bird strike.
- Flight control outside of the operation window.
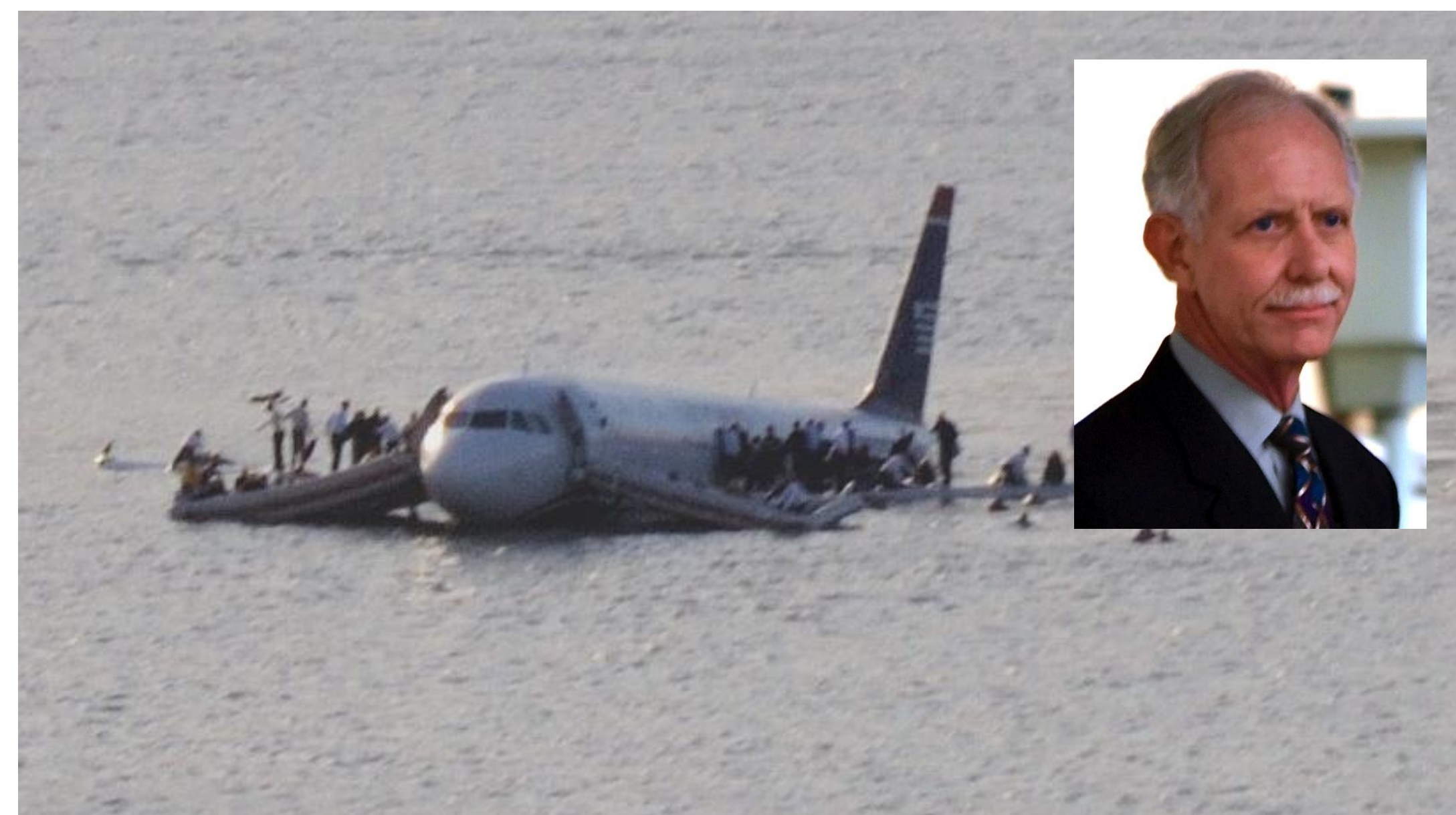
(Credit: Wikipedia)

What does it take to achieve the goal of fully autonomous autopilot (Virtual Sully) that can make the right decision in the presence of unexpected large uncertainties?

Sully Capability:

What Sully did

- Identified remaining capability
- Estimated compromised flight envelope
- Operated the aircraft within the estimated flight envelope
- Estimated the reachable landing regions
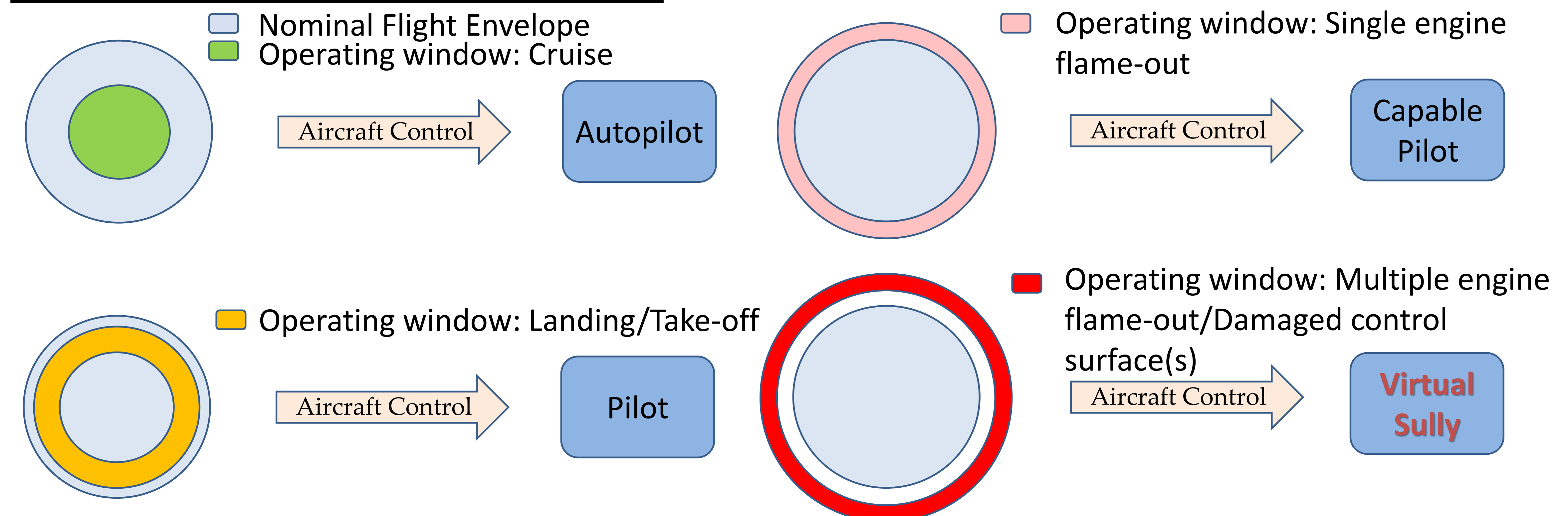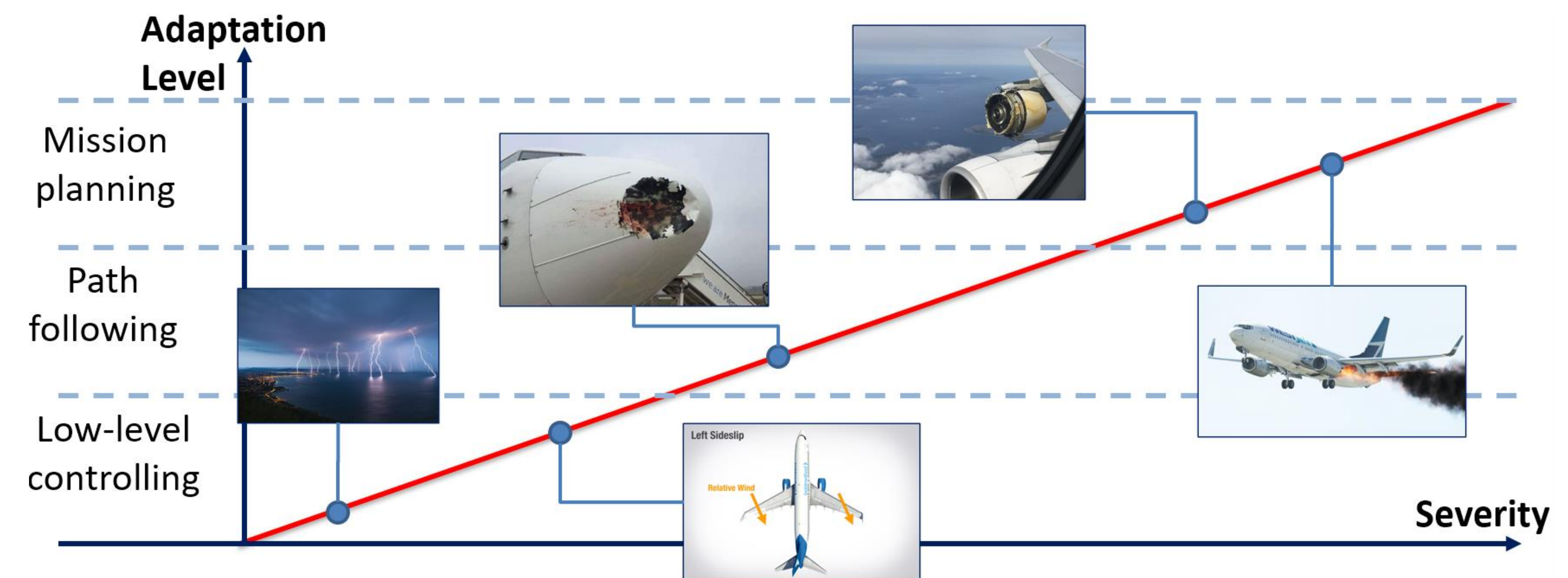- Conducted safe landing
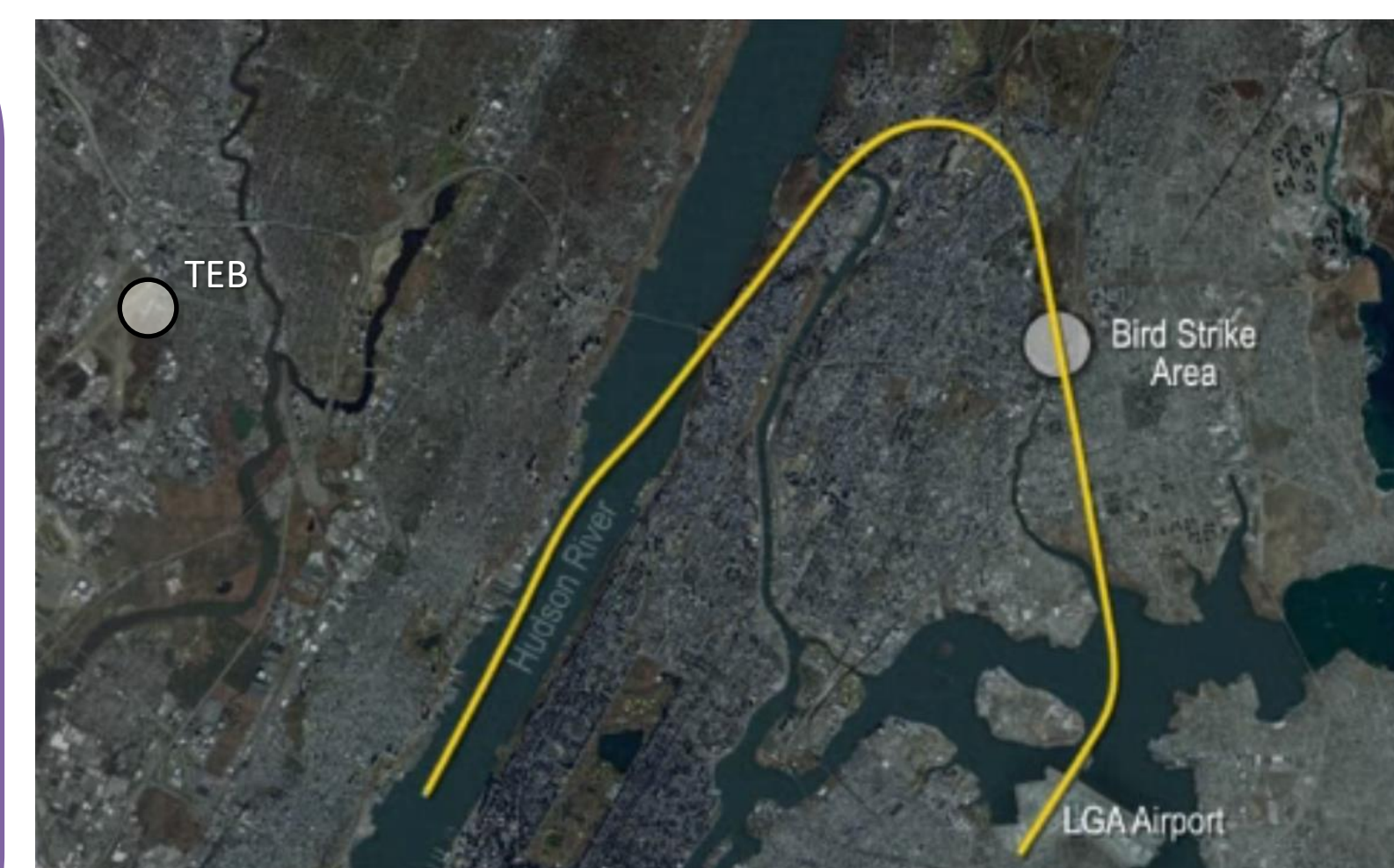
(Credit: NTSBgov)

What Virtual Sully needs

- Monitor and do capability auditing for flight envelope estimation
- Evaluate the mission feasibility given the model of a damaged airplane
  - Plan a new safe mission if needed
- Adaptively select the best controller for flight stability
  - Use $\mathcal{L}_1$ adaptive controller for low-level robust high-assurance control

Outside of Envelope Challenge:

- Nominal Flight Envelope
- Operating window: Cruise

Aircraft Control → Autopilot

- Operating window: Single engine flame-out

Aircraft Control → Capable Pilot

- Operating window: Landing/Take-off

Aircraft Control → Pilot

- Operating window: Multiple engine flame-out/Damaged control surface(s)

Aircraft Control → Virtual Sully

Solution: Multi-level adaptation with Cyber-space support

Adaptation Level

- Mission planning
- Path following
- Low-level controlling

Severity

- Two-way adaptation can deal with very large uncertainties.
- Reduced functionality for complexity reduction.

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