UPRT Global Status

Issues arising in the last year

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Issues arising in the last year

- **Most important points**
  - Being too aggressive (e.g., “push”, pitching to return to safe speed, rolling)
  - How to do surprise/startle?
  - Continued learning through repetition (e.g., stall recovery, what the PFD is telling you, unloading before rolling, pitch damping, V-n diagram)

Issues arising in the last year

- **“Push-roll-power-stabilize” mantra arose again**
  - “Push” has resulted in at least two serious incidents in the U.S.
  - “Push” is not in the wording of consensus OEM recommendations
  - A “push” mindset can lead to unnecessary overcontrol and injuries
  - One operator has changed “Push” to “Pitch” to minimize phraseology change

Issues arising in the last year

- **Aggressive recovery from upset to get back below Vmo/Mmo**
  - Pilot pitches to 15 degs after overspeed to reduce speed as quickly as possible, and then gets quite an unload when returning pitch to normal
  - While exceeding Vmo/Mmo is discouraged, these speeds are set so that it is improbable that you will exceed Vdf and Mdf
    - Typically, Vmo = 0.8 * Vdf; Mmo = Mdf – 0.07
    - OEM flies airplane to Vdf and Mdf
  - One should not dally at high speed, but smooth and deliberate inputs can help from making the situation worse

Issues arising in the last year

- **Flight idle at FL390 to prevent Vmo/Mmo exceedance from turbulence**
  - In general, when faced with an upset, guidance is to reduce automation and then initiate appropriate recovery
  - Crews need to be vigilant of potential perils, that is, not to make situation worse
    - Overcontrol situations occur where crews then get too slow and then cycle between MCT and idle
  - Useful to combine current speed, barber poles, and speed-trend vector to develop a response that is proportional to the upset
  - One operator has included a mountain wave scenario to practice these responses in the simulator

Issues arising in the last year

- **As long as you are unloaded (less than 1g), can you apply full lateral control (one-sided) up to Vmo? Or is it up to Va?**
  - Airplane is structurally designed for following loading conditions (part 25.349):
    - For load factors of 0g and 1.67g:
      - At maneuvering speed (Va), sudden deflection of aileron to its stop
      - At Vc, an aileron deflection that gives you the roll rate that you get for a full aileron deflection at Va
      - At Vd, an aileron deflection that gives you 1/3 of the roll rate that you get for a full aileron deflection at Va
  - So, full deflection ok up to Va, as long as load factor is not excessive
  - Smooth, deliberate, and proportional inputs remains the best strategy, as always
  - AURTA says “pilots must be prepared to use full flight control authority if the situation warrants it”

Issues arising in the last year

- **How do we do better surprise & startle training?**

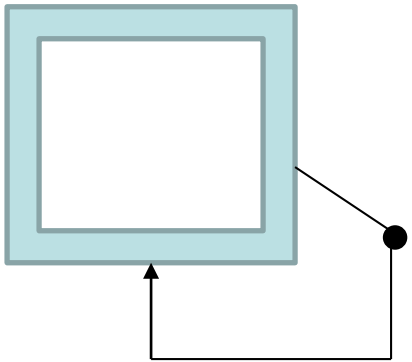
Startle/surprise prevalence

- ABX Air DC-8 – unexpected stall buffet 12 kts too early
- XL Airways A320 – unexpected stall in normal law, AOA vanes froze
- Colgan 3407 – unexpected shaker, still slowing to Vref
- Turkish 1951 – unexpected speed loss (A/T in retard flare)
- Air France 447 – unexpected complete loss of airspeed
- Pinnacle 3701 – unexpected shaker, pusher, dual engine loss
- Air Asia 8501 – unexpected alternate law w/ breaker pulls
- Lion Air 610 –unexpected column forces from MCAS activations

Be prepared

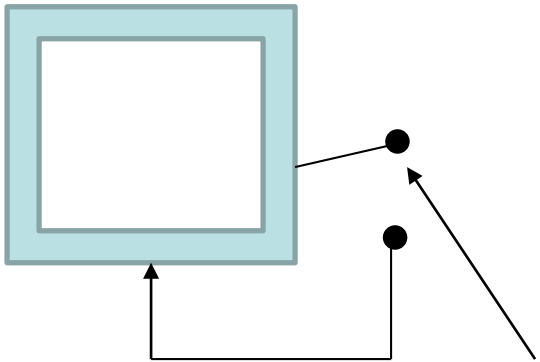
Definitions and how it works

Current frame,
mental model



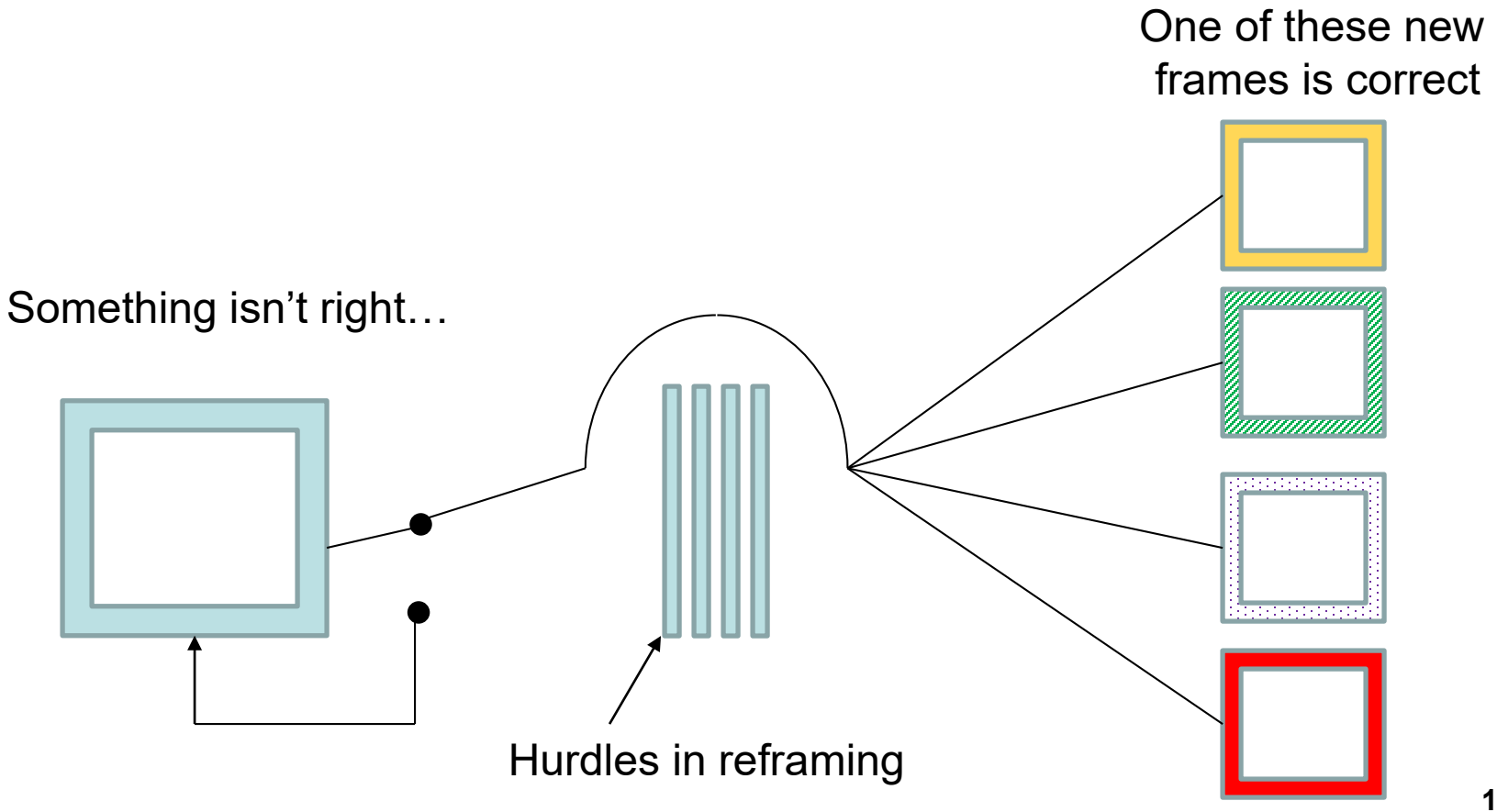
Definitions and how it works

Something isn’t right…



Have to overcome confirmation bias to switch

Definitions and how it works



Definitions and how it works

- **Hurdles in reframing (adapted from A. Rankin, 2016)**
  - Absence of salient cues (not selecting B737 second A/P on approach, then TOGA surprise)
  - Disturbances (deviation caused by atmospherics even with A/P and A/T on)
  - Conflicting data (AF447, pitch and power seem right…why such large descent rate?)
  - Narrow interpretations (fuel imbalance incorrectly identified as a fuel leak)
  - Rapid transitions (TOGA instead of A/T disconnect, or inadvertent slats)
  - Insufficient systems knowledge (MCAS)
  - Multiple goals and tradeoffs (pilots switching roles, crew swaps)
  - Uncertainty management (A/P frequently disconnects and cannot determine why)
  - Communication (4 pilots and tech in cockpit with faulty landing gear…different opinions on how best to land)

Ways to induce surprise

1. **Create expectations…then violate them**
2. **Mimic the in-flight atmosphere**
   - Insert surprises in a line-operational context
   - Wear uniforms, seat harness, headphones…don't reduce sound volume
   - "If you wouldn't do it in the aircraft, don't do it in the simulator" (D.P. Davies, former CAA Chief Pilot, 1975)
3. **Add distractions and stress**
   - Communication with company, unrelated chatter, instructor ruses
4. **Have a bevy of "hot keys" with pre-programmed scenarios that instructor can invoke when conditions #2 and #3 are satisfied**

Other examples of inducing surprise

(adapted from W. Martin article 2015; all need careful implementation)

- **Unexpected stall warnings (tailwinds, weight)**
- **Runaway trim on takeoff**
- **False stall warning on takeoff**
- **Cargo fire just prior decision altitude**
- **Unexpected EGPWS activation**
- **TCAS RA while busy with another task**
- **Wakes**
- **Multiple malfunctions, like engine fire while in the QRH for something else**
- **A/T failure during leveloffs**
- **A/P disconnect in complicated RNAV approach with traffic**
- **Altitude capture failure with traffic**
- **Dual AC bus failure at 500 ft on approach**
- **Compressor stall during go around**

Insert distraction immediately prior to heighten effect

Ways to train and manage it

- **This is the hard part**
- **Have a “conditioned expectation of normalcy” – W. Martin**
  - Practice emergencies in the sim for, perhaps, 4 days a year
  - Remainder of the 360+ days are often routine and emergency-free
- **Heavy emphasis on many “immediate action events”**
  - EGPWS activation, rejected takeoff, reactive windshear, stall warning, loss of cabin pressure, TCAS RA
  - Some say we are overtrained on these

Ways to train and manage it

- **Startle & surprise training IS NOT:**
  - UPRT
  - Scenarios
  - Startling and surprising pilots
- **Startle & surprise training IS:**
  - Practicing skills that help pilots deal with ANY unexpected situation

- E. Boland, Dutch NLR, 2016

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Ok, that sounds great. How?

Ways to manage startle/surprise from aviation research

- **Remain skillful in management of technical maneuvers**
- **Judgment skill training (see Kochan, 2005)**
- **Train/practice/test responses for abnormal events in a different way each time**
  - "Change it up," "turn off the automation," and "reevaluate your testing practices" (see Casner, 2013)
- **Adapt CRM training to develop resilience**
- **Metacognitive/cognitive flexibility training (don't just watch FOX NEWS)**
- **Introduce low-cost methods into the training curriculum:**
  - Encourage "in-flight discussions" about unexpected events/surprises
  - Mental simulation (chair flying)

Ways to manage startle/surprise from aviation research

- **Several mnemonic approaches being implemented**
  - ROC: Relax, Observe, Check colleague
  - BAD: Breathe, Analyze, Decide
  - 3R's: Resist, Relax, Reassess
  - FOCUS: Feel, Observe, Control, Unite, Speak
  - COOL: Calm down, Observe, Outline, Lead
- **All aimed at, perhaps, "keeping your chimp under control" (E. Boland)…or jumping to conclusions**
- **Several (ROC, COOL) have been tested and show improvements <u>in the simulator</u>**

Ways to manage startle/surprise from aviation research

- **Useful suggestions adapted from Dutch 2016 study:**
  - Re-framing knowledge
    - What are your frames today, based on your system knowledge?
    - What observations would cause you to question your current frame?
    - What strategies would you use to make sense of a problem?
  - Re-framing practice using surprise scenarios
    - Practice separating the signal from the noise
    - Identifying anchors for selecting the right frame
  - Go-to control strategies (managing L,D,T, & W can get complicated)
    - Appropriate pitch and power initially buys time
    - Path and speed assessment follows, and have had breakdowns here
    - Understanding possible strengths/weaknesses of such strategies

Issues arising in the last year

Minimum maneuvering speed increases with altitude – buffet protection

Shaker speed increases with altitude – Mach effect

Issues arising in the last year

- **Understanding the PFD**

AoA margin
to shaker

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= IAS*sqrt(AOA/AOA_Shaker_Activation)

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AoA margin
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= IAS*sqrt(AOA/AOA_Shaker_Activation)

Why?

L=(1/2)*(density)*
(wing area)*
(lift_curve_slope)
*IAS^2*AOA

L=(1/2)*(density)*
(wing area)*
(lift_curve_slope)
*IAS_shaker^2
*AOA_shaker

Set these equal, solve

Issues arising in the last year

- **Why unload before rolling?**
  - Better roll control – don't have to worry about stalling downward aileron
  - Reducing unwanted dynamics –
    - like adverse yaw (roll left, nose right, which tries to stop the left roll)
    - this effect increases with AoA, so unloading reduces effect
  - Insurance
    - Might have to pull at the end, so give yourself margin early
    - Lower AoA gives you margin from other atmospheric disturbances
    - If you are inverted, less AoA means less lift pointing towards the ground

Issues arising in the last year

Pitch damping at different altitudes

5,000 ft

FL350

- For the same IAS, the pitch damping at FL350 is less because the TAS is higher

Issues arising in the last year

(IAS=200 kts, 5 deg/sec nose down, 747 example)

5,000 ft

True airspeed 215 kts

Downflow at tail

Tail AoA=1.4 degs

FL350

True airspeed 347 kts

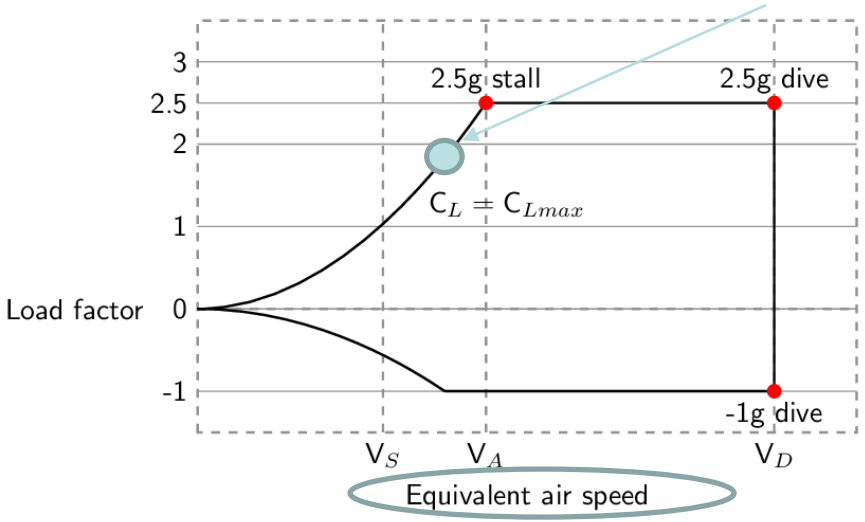
Same downflow at tail, as pitch rate is the same

Tail AoA=0.88 degs

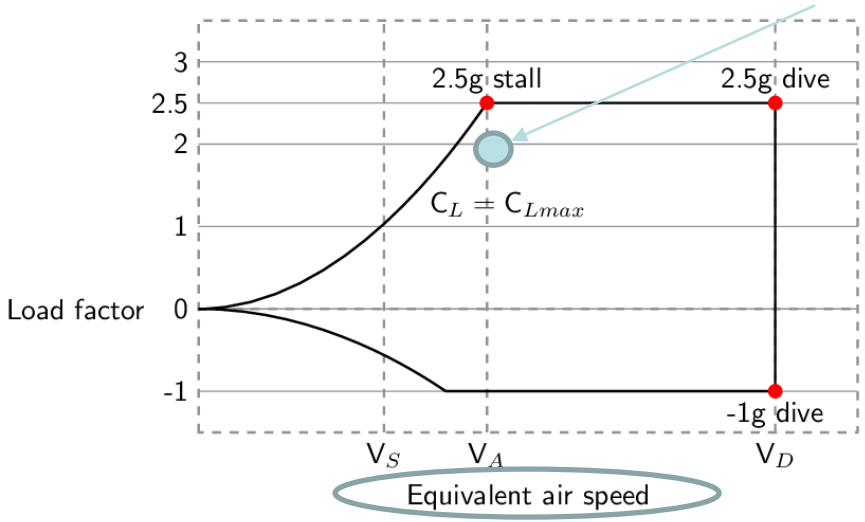
37% less AoA results in 37% less lift at the tail….less damping

Issues arising in the last year

Low altitude – stalls occur on curve



High altitude – stalls occur higher speed



Problem is that we have mutated the V-n diagram to use indicated airspeed, and we have not accounted for compressible (Mach) effects

It could be fixed, but does it have to be fixed? Diagram useful for g-loads

Issues arising in the last year

- Making events “looking pretty” and missing the big picture
- Although vast majority of UPRT is training, some maneuvers, like recovery from approach-to-stall are still part of standard checking
- In many flight conditions, incorrectly applying thrust as your first step will result in a “beautiful looking” recovery
- In a few flight conditions, like when you are mis-trimmed, that technique could cause loss-of-control
- A U.S. operator struggling with this issue plans to examine mis-trimmed recoveries in the next training cycle
- Also have a few renegades exploring bizarre recovery strategies like deploying speedbrakes first
- Don’t do these things

Issues arising in the last year

- **U.K. CAA Safety Notice SN-2020/018, 8 December 2020: "Avoidance of Loss of Control In-flight; Pilot Awareness of Aircraft State, During Periods of Multiple Malfunctions and Flight Control Issues"**
  - Highlight recent LOC-I accidents, specifically systems knowledge and technical competence for dealing with
    - Multiple system malfunctions with possible unexpected flight control inputs
    - Cognitive degradation from 'surprise and startle'
  - States key components for safe outcomes are
    - Appropriate aircraft system knowledge
    - Technical competence
    - Strategies for coping with surprise and startle effects
    - Correctly prioritising workload
  - Action to be taken – Operators and ATOs should
    - Identify potential gaps in manual flying skills, system knowledge and crew intervention methods
    - Specific consideration to type-specific flight control issues and flight control downgrade scenarios where manual handling may be required
    - Crew's ability to control the aircraft flight path in a deliberate manner, when exposed to multiple malfunctions should be demonstrated, particularly during high workload situations
    - Exposure to unexpected flight control inputs must also be considered
    - Lists some additional requirements on reducing cognitive degradation, monitoring skills, failure management
- **How far to go with multiple malfunctions becomes controversial**

Issues arising in the last year

- **“Can’t seem to find high altitude full-stall recovery requirement”**
  - Because there isn’t one
  - U.S. regulations (121.423(c)) require that you perform a full-stall recovery every 24 months, but the flight condition is unspecified
  - Advisory Circular 120-109A recommends a high-altitude stall prevention exercise (e.g., recover at first indication), but this is only guidance
  - That said, I am a big fan of high-altitude full-stall training
    - Teaches you to be deliberate, but gentle in some airplane types
    - Shows that gravity, not thrust, is the force that enables you to recover

Issues arising in the last year

- **Buffet modeling and simulator qualification**
  - The simulator buffet does not have to match the airplane
  - The airplane buffet is typically stronger
  - The AoA at which the buffet starts matches the airplane within a tolerance
  - The 3 predominant simulator frequencies must match the airplane within a tolerance
  - Upgraded simulators improved the stall buffet substantially, particularly by increasing severity
    - Still, the severity does not have to match the airplane

Issues arising in the last year

- **What is my current maneuvering speed, Va?**
  - Answer can be complicated, as Va varies with weight and altitude (due to compressibility actually)
  - Regulations require Va be published for flaps up, but allows manufacturer to select corresponding weight and altitude
  - I know one manufacturer who published Va for weights and altitudes
  - I know one manufacturer who publishes Va for different altitudes at max gross weight
  - I know one manufacturer who publishes one Va

Issues arising in the last year

- **What about turbulence penetration speed, Vb?**
  - Regulations require this speed be published, but OEMs have flexibility
  - Vb is different from Va, as turbulence can cause a speed increase
  - I know one airplane where Va varies from 260 kts to 307 kts, but a single Vb is given, which is 280 kts, of M0.76
  - Trade off between keeping it simple versus physically accurate

Issues arising in the last year

- **How do following speeds relate: Vmd, CI=0, ECON, LRC?**
  - CI=0 gives maximum range cruise, not accounting for winds
    - For a turbojet, this would be minimum drag speed, Vmd
    - For a turbofan, thrust goes down with speed, so speed for maximum cruise will be below the minimum drag speed
  - ECON accounts for winds; that speed gives you best ground fuel mileage
  - LRC is speed that gives you 99% of the best ground fuel mileage (introduced as a compromise to get good fuel mileage, but at a better cruise time)

Issues arising in the last year

- **B757s and B767s are related aircraft, but can have important UPRT differences**
- **For instance, most B767s (except the B767-400) have a stick nudger that activates near the full stall AoA**
  - Had a operator doing full stall training, but not reaching nudger activation, which is important
- **The B757-300 airplane has elevator feel shift, which increases the column forces near the full stall AoA, but there are no B757-300 simulators (the B757-200 does not have this feature)**
- **The B767-400 has elevator feel shift**
- **As an operator, these force changes that occur at the pilot-vehicle interface can be very important**

Summary

- **Most important points**
  - Being too aggressive (e.g., “push”, pitching to return to safe speed, rolling)
  - How to do surprise/startle?
  - Continued learning through repetition (e.g., stall recovery, what the PFD is telling you, unloading before rolling, pitch damping, V-n diagram)