

RE-DEFINING LOC-I?

Work in Progress

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Outline

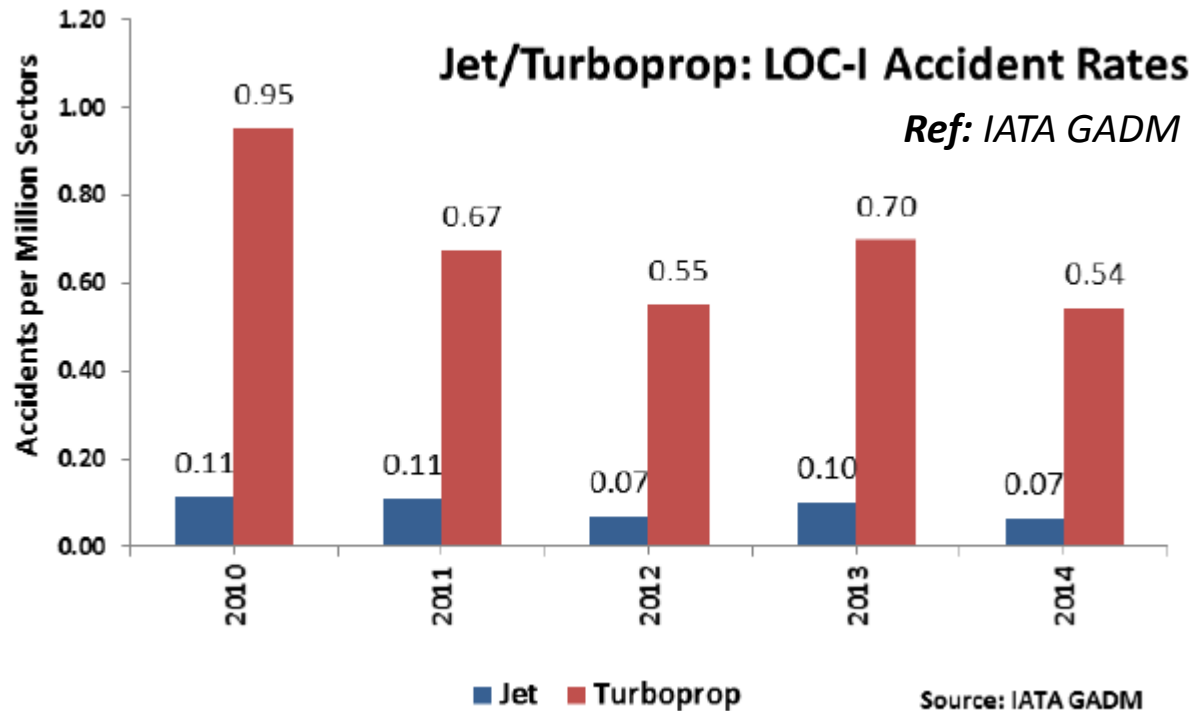


- Introduction
- Current definitions of LOC-I
- Previous Studies
- Human (Pilot) in the Loop Control
- Stalls & Upsets
- Recap
- Revised Definition?
- Future (& Current) Research @CMT

Introduction

- Generally accepted definitions of LOC-I lack clarity and detail
- A clear and comprehensive definition is fundamental to the development of future intervention strategies for prevention, recognition and recovery
- An FDM/FOQA programme including LOC-I requires detailed, unambiguous (event) data-driven definition to identify pre-cursors

Statistics



Turboprop aircraft had a significantly higher average rate of LOC-I (0.68 per million flights) when compared to Commercial Jets (0.09)

(Turboprops generally operate at lower height AGL and at slower speeds and are more susceptible to environmental factors such as icing/gust disturbance?)

LOC-I Definitions*....

flightpath
control
flight
intended
deviation
aircraft
Loss
refers aerodynamic-stalls
controlled manifestation
following failures
envelope unable
includes while
unintended
In-Flight
extreme path ground
events maintain systems
accidents
significant
departure
crew including
inflight
LOC-I
operational
upsets
resulting
unrecoverable

**Based on IATA, JSAT, EASA, CICTT Definitions*

Previous Studies – Causal Factors

Human Induced

- Manual handling errors
- Poor Energy Management
- Automation Effects On Human Induced Loss-Of-Control
- Spatial Disorientation
- Improper Procedures

Systems Induced

- Poor systems design
- Poor energy management
- Poor redundancy management
- Autopilot modes leading to loss of control
- Erroneous sensor data
- Pilot induced oscillation
- Loss of control power, authority, or effectiveness
- Display errors
- Propulsion system faults/failures/damage
- Fire

Externally Induced

- Icing
- Turbulence
- Degrading Visibility
- Heavy Rain
- Low-Level Windshear

Previous Studies 3Cs

Causal & Contributing Factors

- **Adverse onboard conditions:**
 - **vehicle impairment**
 - » Inappropriate vehicle configuration, contaminated airfoil, improper loading, vehicle damage to airframe and engines
 - **system faults, failures, and errors**
 - » Control component, engine, sensor system, flight deck instrumentation, non-control component
 - **inappropriate crew action / inaction**
 - » Loss of aircraft attitude, energy, or system state awareness, aggressive maneuver, abnormal control input, ineffective recovery, improper procedure, crew fatigue / impairment
- **External hazards and disturbances:**
 - **inclement weather & atmospheric disturbances**
 - » wind shear, turbulence, rain / thunderstorms, snow / icing, wake vortices
 - **poor visibility** (fog / haze, night)
 - **obstacle** (fixed or moving)
- **Abnormal dynamics & vehicle upsets:**
 - abnormal vehicle dynamics & control response
 - abnormal attitude, airspeed, angular rates, asymmetric forces, or flight trajectory
 - uncontrolled descent (including spiral dive)
 - stall/departure from controlled flight



Primary Causes

1. Entry into vehicle upset condition (e.g., Stall / Departure)
2. Reduction or loss of control effectiveness
3. Changes to vehicle dynamic response and handling / flying qualities (including asymmetric effects)
4. Combinations of the above (1-3)



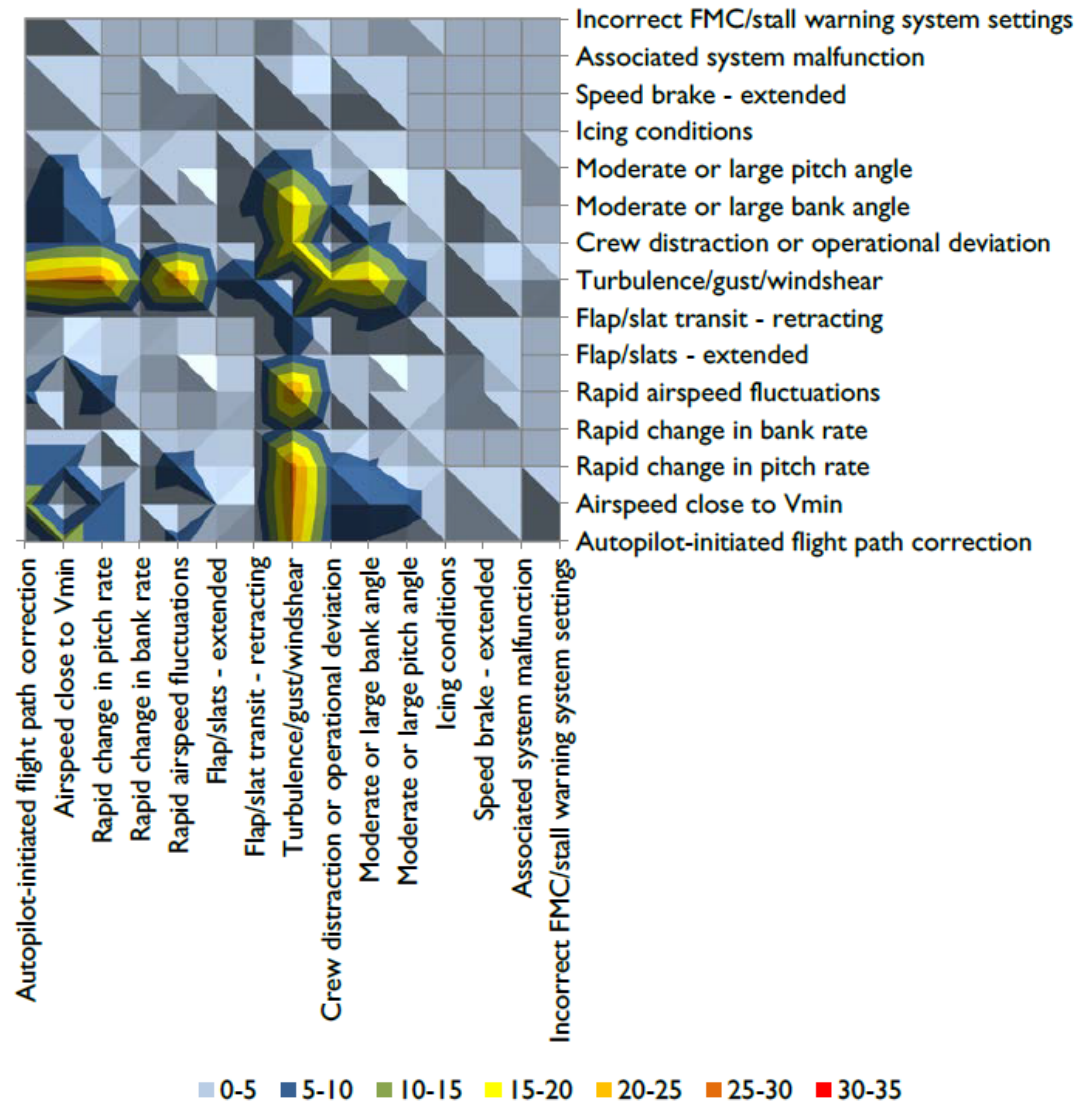
LOC Characteristics

LOC: aircraft motion that is characterized by one or more of the following: ^{1,2}

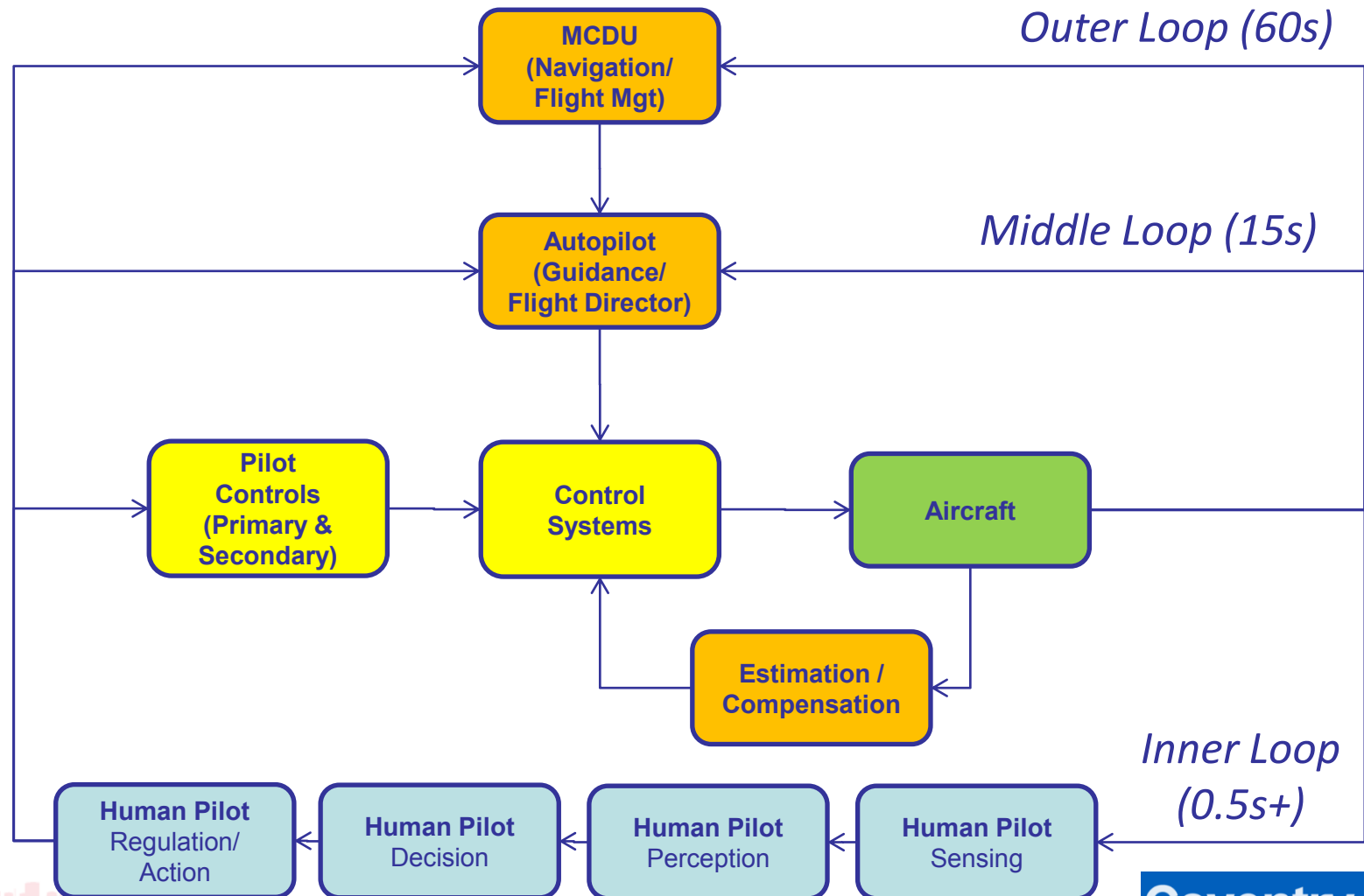
- outside normal envelopes (adjusted for flight phase)
- not predictably altered by pilot control inputs (i.e. aircraft response is no longer predictable to the pilot)
- characterized by nonlinear effects that degrade handling qualities
 - kinematic / inertial coupling
 - disproportionately large responses to small state variable changes,
 - oscillatory / divergent behavior
- likely to result in high angular rates / displacements,
- characterized by the inability to maintain heading, altitude, and wings-level flight
- flight path is outside of acceptable tracking tolerances and cannot be predictably controlled by pilot (or autoflight system) inputs

Note: LOC need not be unrecoverable

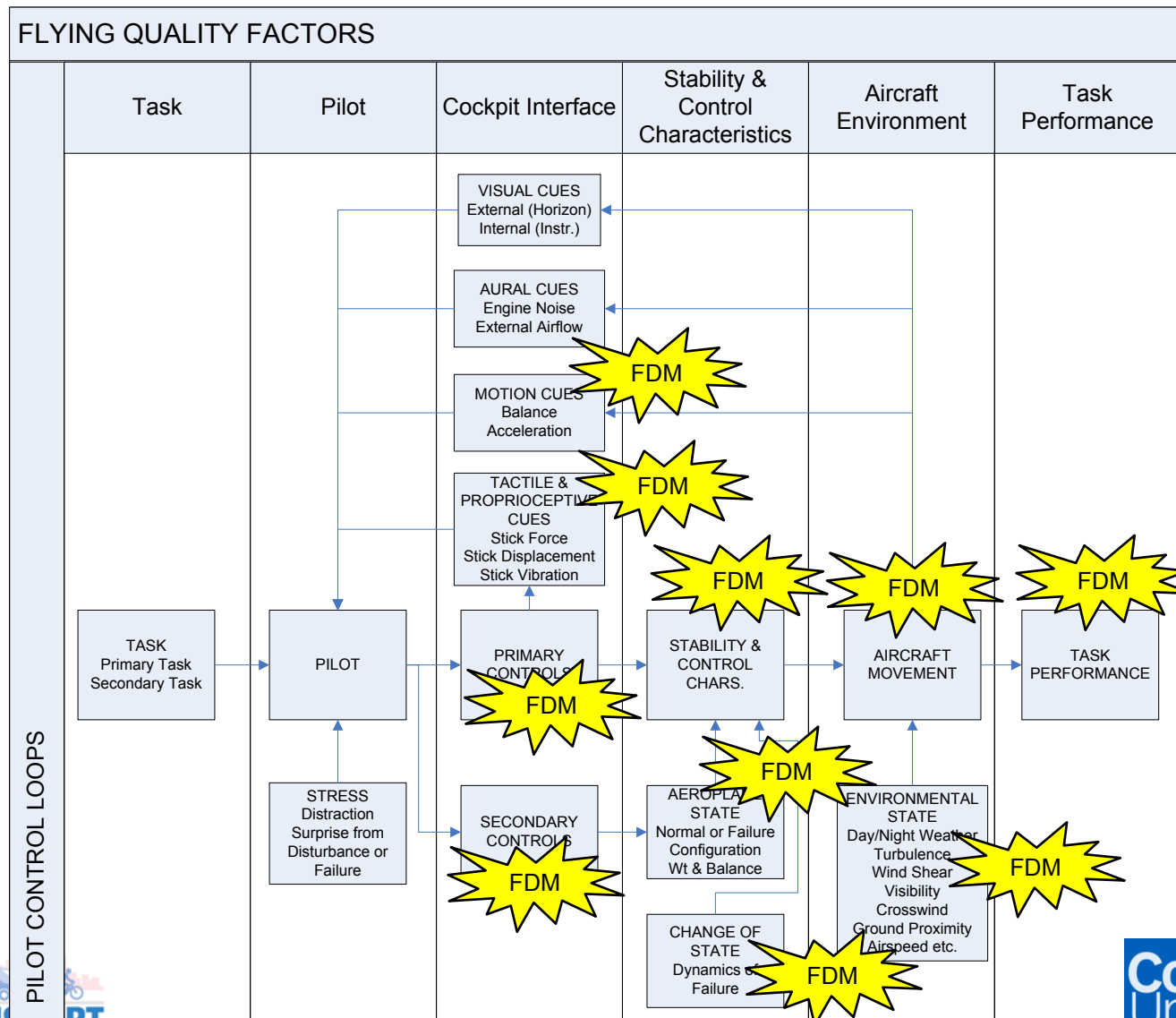
Pre-cursors to Stick Shaker Activation Event Analysis (2008-2012)



Control - Human (Pilot) in the Loop



Manual Control (Inner Loop)

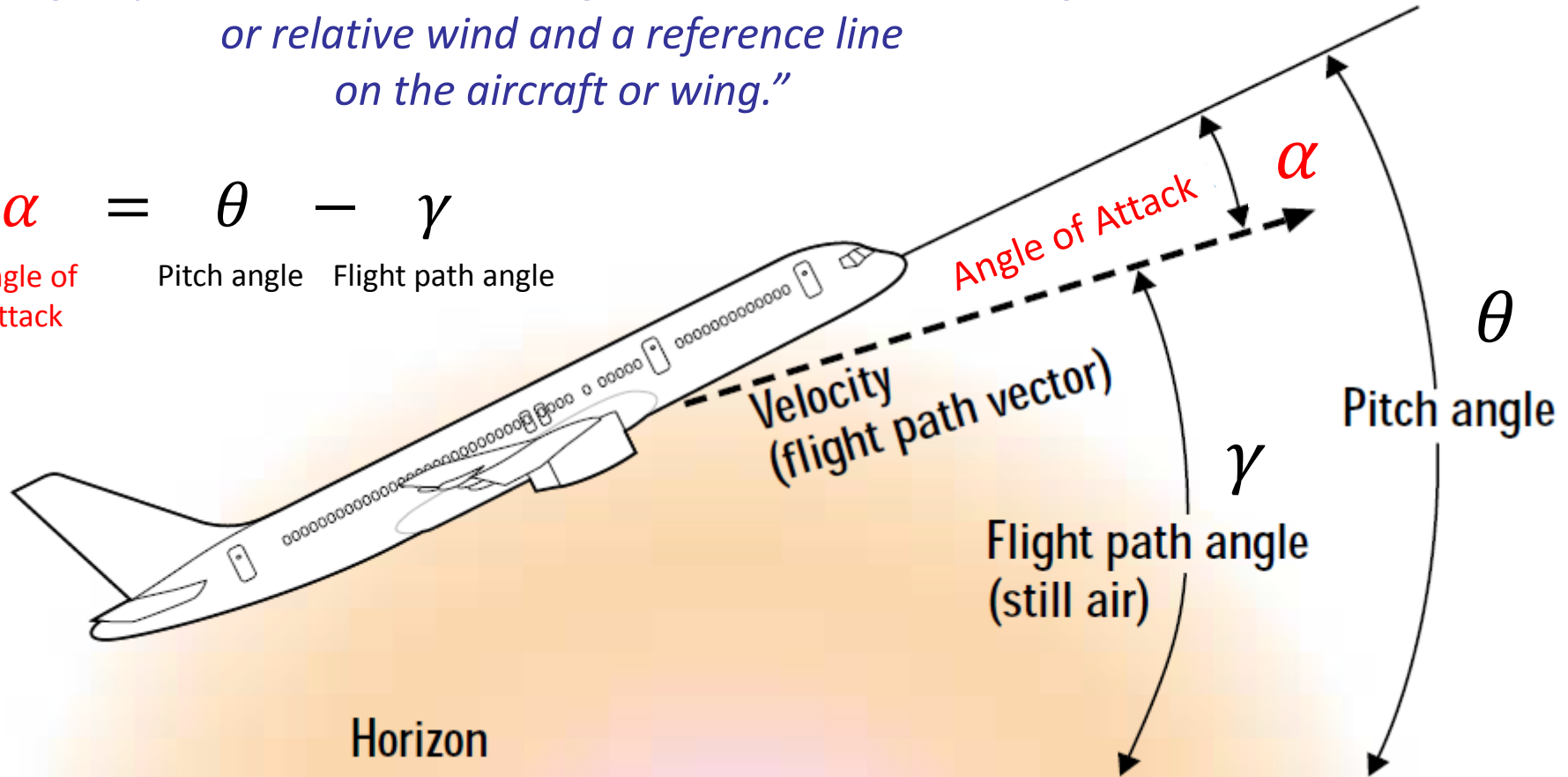


Intended Flightpath

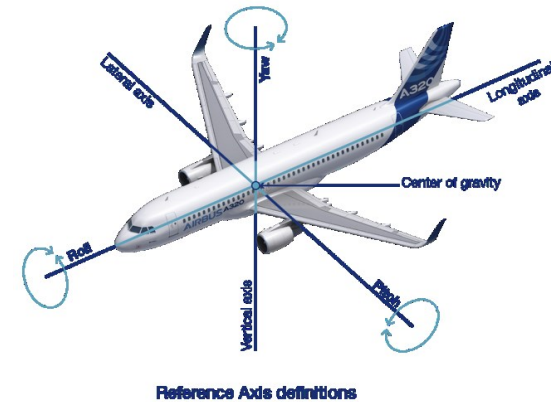
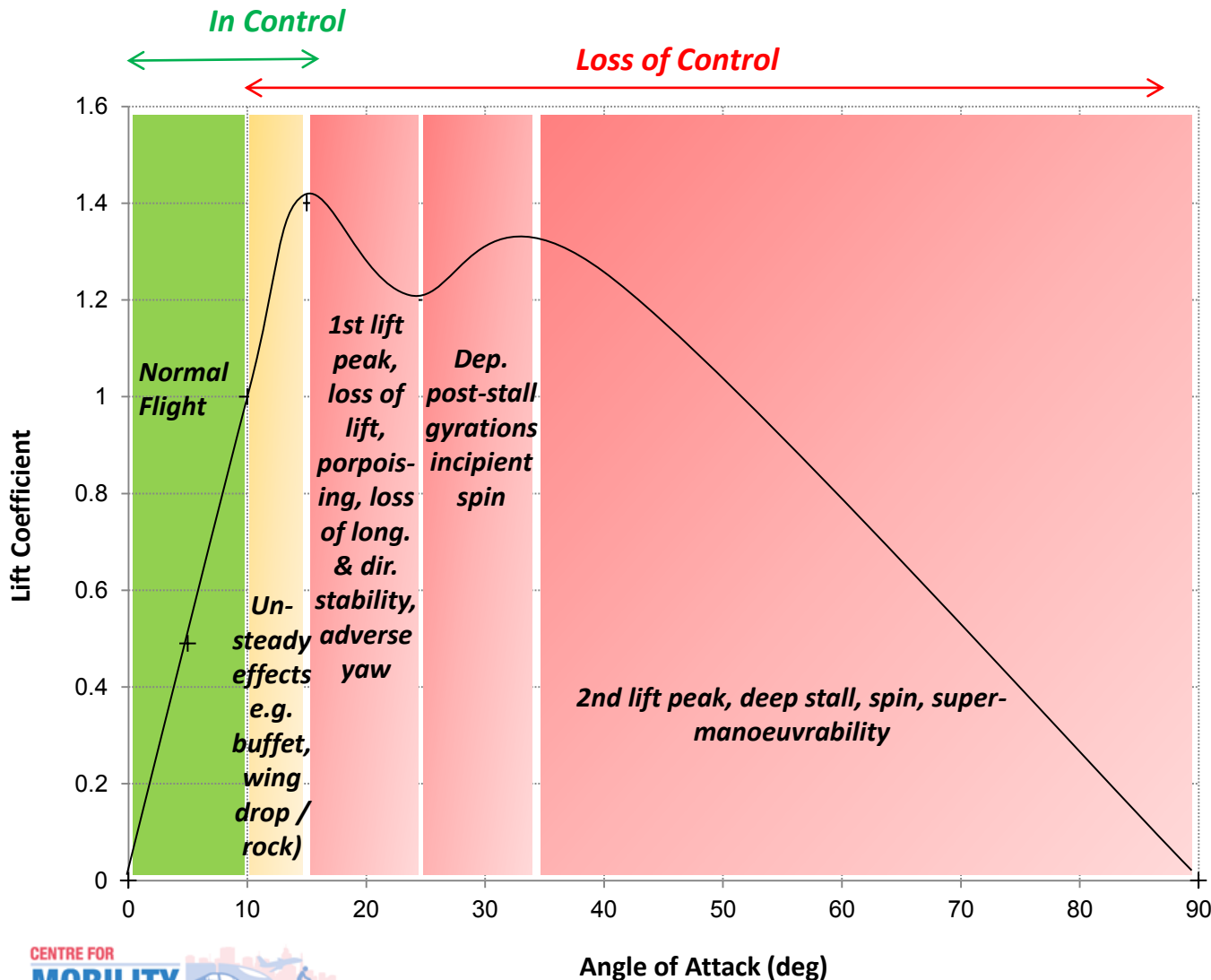
“Angle of attack (AOA) is the angle between the oncoming air or relative wind and a reference line on the aircraft or wing.”

$$\alpha = \theta - \gamma$$

Angle of attack Pitch angle Flight path angle



Stalls & Flight Regimes (Jet Transport)



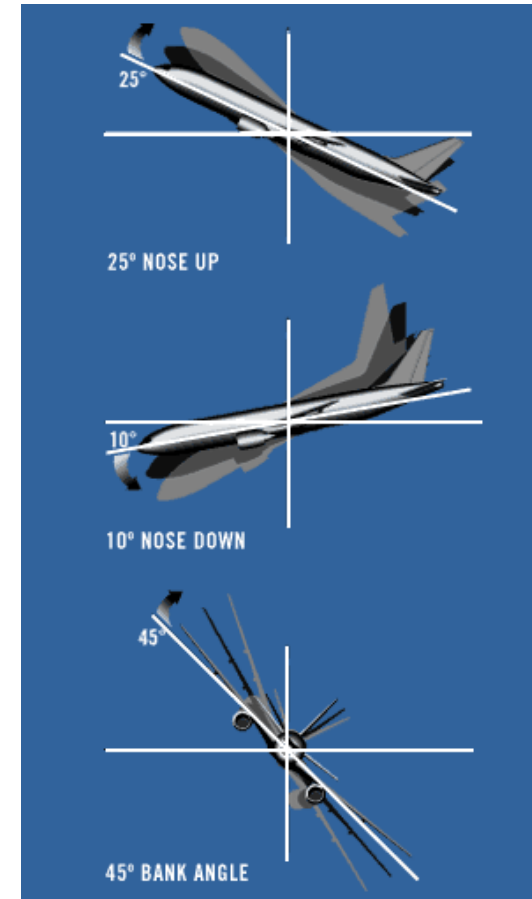
....Stability & Control needs consideration not only in **Pitch** but also in **Roll & Yaw**

Upsets

- Pitch Attitude
 - < 10 deg Nose Down or
 - > 25 deg Nose Up
- Bank Angle > 45 deg
- Flight within the above but at airspeeds inappropriate for conditions

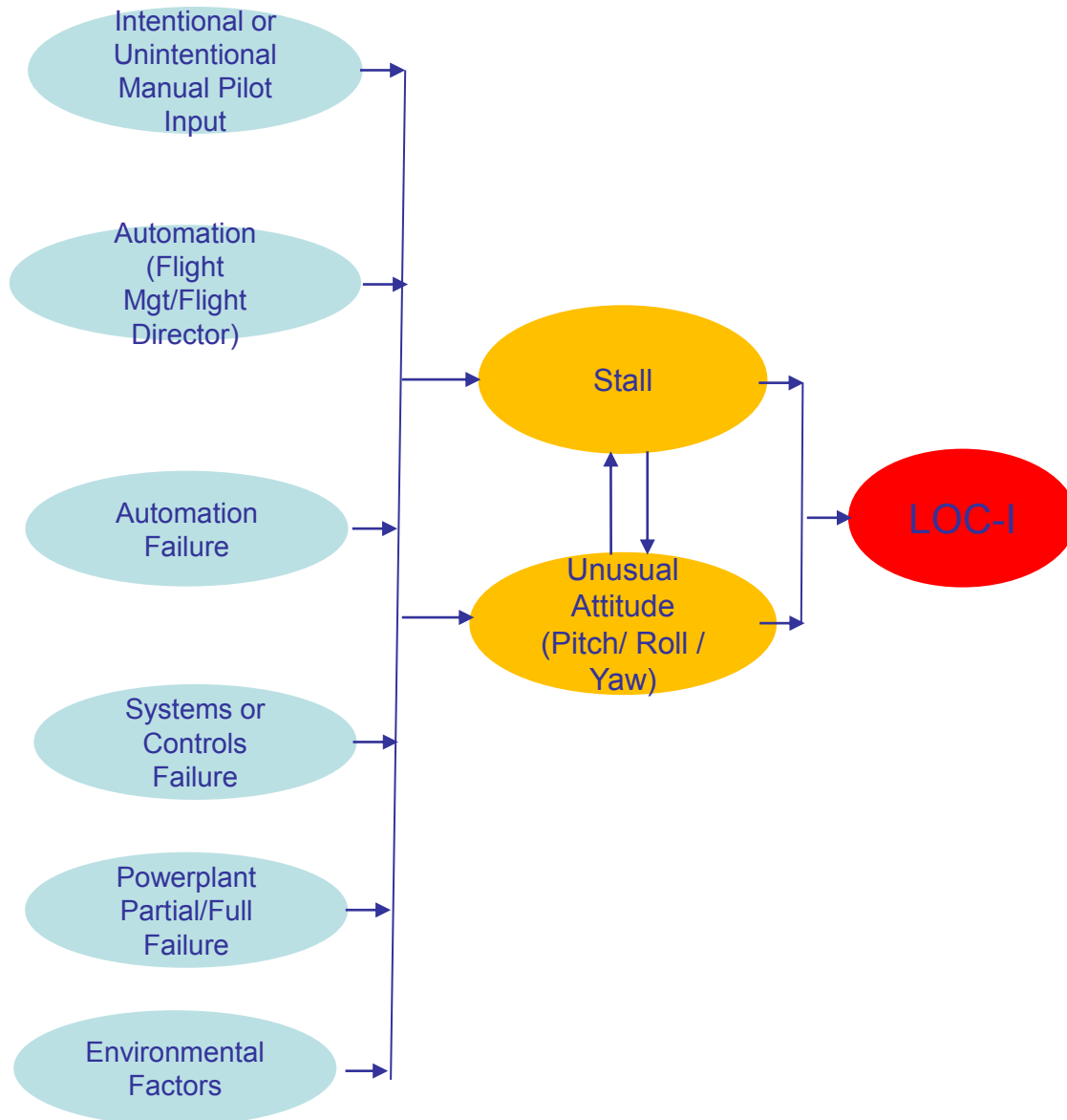
But what about:-

- *Alpha/Beta?*
- *Rate of change of Pitch/Roll/ Yaw?*

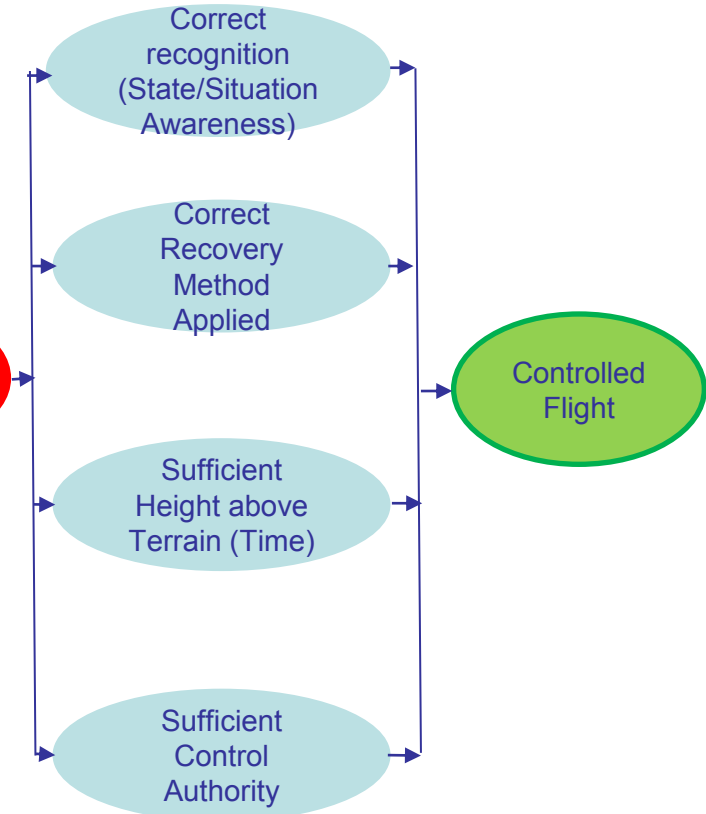


Recap/Summary

“Triggers”



“Recovery Factors”



Revised Definition?



- Deviation from intended flight path such that the safety of crew, passengers & aircraft is significantly threatened
- Maybe triggered by:-
 - intentional or unintentional manual pilot control input
 - automation (Flight Mgt. or Flight Director)
 - automation and/or system(s) failure
 - environmental factor(s)
 - or any combination of the above
- Resulting in a:-
 - Unusual attitude in pitch, roll, yaw or any combination or
 - Full aerodynamic stall, asymmetric stall or tail stall
- That maybe recoverable if:-
 - recognised by the crew (SA) given
 - sufficient height above terrain &
 - sufficient pitch, roll & yaw control authority (controllability)

Questions?

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