Aftermath

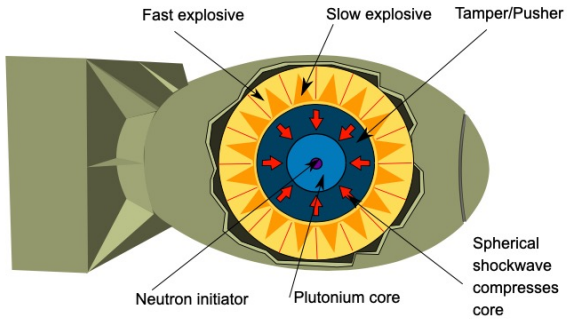
Where are we now?

Key Concepts

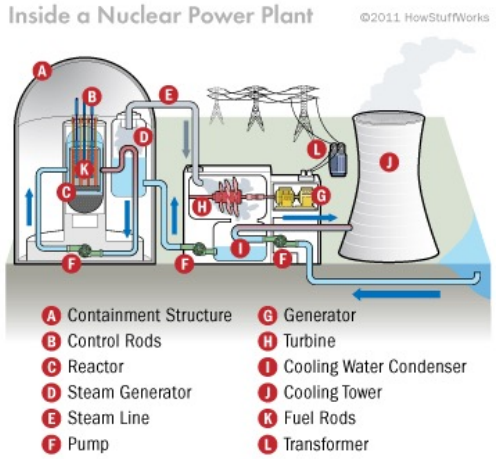
- Complicated vs. Complex
- Efficiency vs. Resiliency
- The myth of a free lunch
  - You can create systems that are both efficient and resilient
    - Hint: You cannot. That's called a free lunch. There is no such thing as win/win. There is no such thing as perpetual motion

Complicated vs. Complex

- Complicated
  - A nuclear bomb is complicated

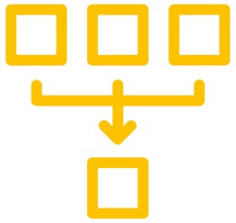


- Complex
  - A nuclear reactor is complex



Efficient vs. Resilient

- Combining multiple job functions into one is efficient
  - Saves money and overhead
    - Example Amazon combines your orders into one shipment



- Separating job functions into many is resilient
  - Creates redundancy and cross-checks
    - Example: Roots of a tree

The Myth of the Free Lunch

- Companies in their youth tend to organize around a resilient architecture
  - Resiliency represents investment and protection of investment
- As companies age, there is inevitable pressure to become more efficient
  - Efficiency represent the extraction of value (ex: dividends)
- A pervasive myth then develops that a company can be both resilient (innovative, creative) and efficient (profitable)
  - Why? Because we want to believe it's possible to have both. To have a free lunch

Review

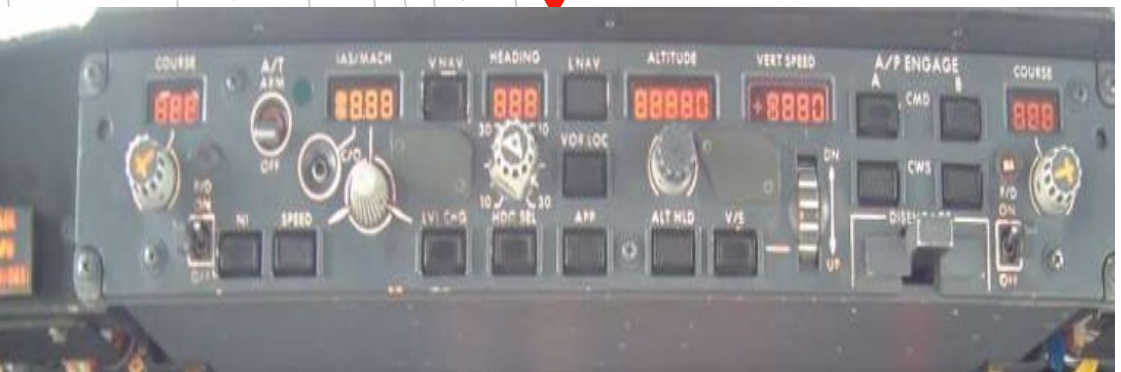
- MCAS added to counter un-disclosed aerodynamic differences between 737-MAX and 737-NG
  - Differences due ostensibly to change in engines
- Took as inputs
  - Flap position (inop if flaps down (landing/taking off))
  - Single angle of attack sensor (737MAX has 2 but only one is used on any given flight)
- Aggressively drove the horizontal stabilizer (most powerful control surface on the airplane) nose-down if angle of attack exceeded threshold
  - Producing control-column forces greater than the strength of the pilots in seconds
  - Moved stabilizer in fixed increments
- Reset generated repetitive commands

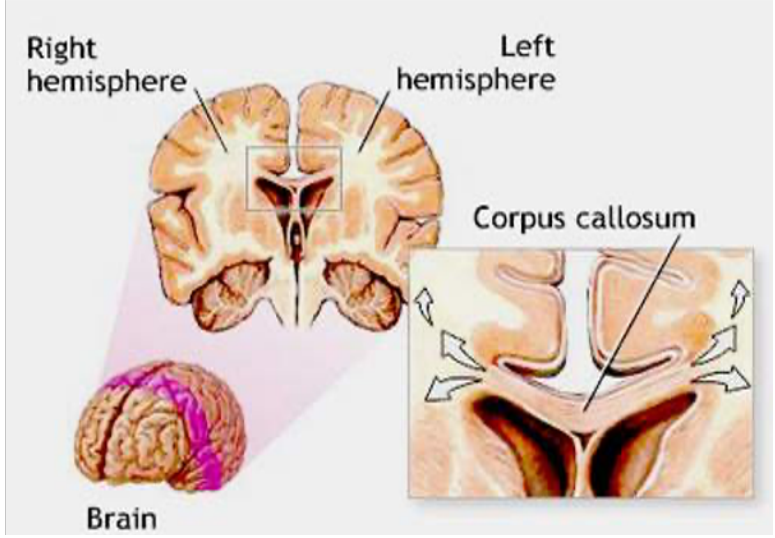
What have they changed?

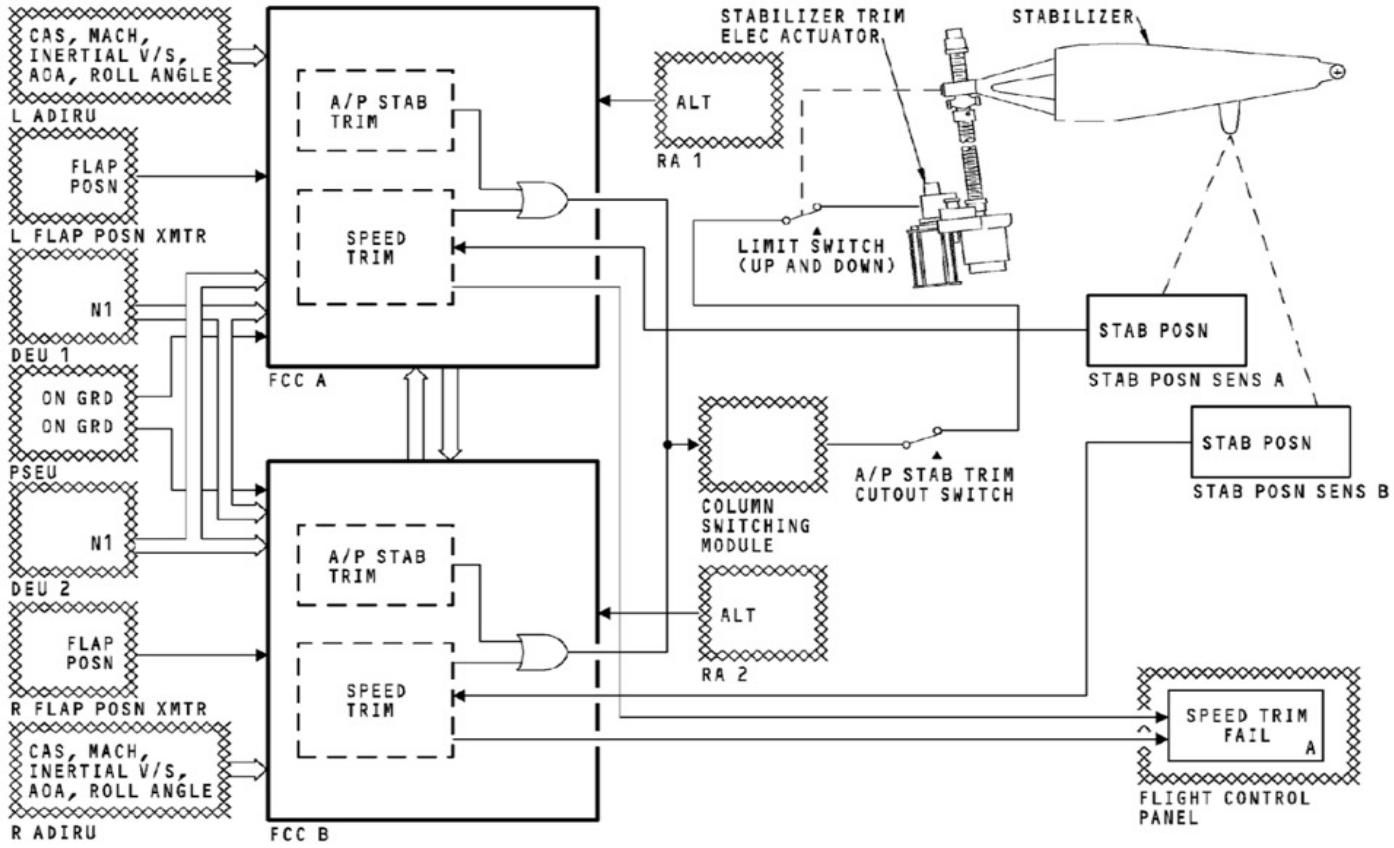
- MCAS now compares the two angle of attack sensors to one another
  - If they do not agree, MCAS will not activate
- MCAS will only activate a single time (no repetitive action)
- MCAS will not move horizontal stabilizer enough to preclude manual control of the airplane (control column forces)
- Standby autopilot now monitors active autopilot and will shut it down if it detects excessive trim commands

(Source: https://www.faa.gov/foia/electronic_reading_room/boeing_reading_room/media/737_RTS_Summary.pdf)

737 MAX Autopilot







Analysis

- Biggest change is the utilization of the existing communication channel between the two autopilots so that:
  - The standby autopilot can feed AOA information to the active autopilot
  - The standby autopilot can shut down the active autopilot if it goes haywire

The big problem

- Big technical problem is the increase in complexity
  - Many new failure modes
  - Little faith that Boeing/Collins could implement this safely given the complete incompetence of the original design

The bigger problems

- Neither Boeing nor the FAA are acting like organizations that have faith in themselves to have fixed the problem
- Neither Boeing nor the FAA are acting like organizations that are comfortable they have fully disclosed the nature of the problems to begin with

How another manufacturer handled a similar problem

- In the 1980s, Piper aircraft produced a very high performance piston single
  - Called the Malibu
  - Pressurized and all-weather
- Like Boeing's 737, the Malibu produced a majority of Piper's profits
- A statistically large number of them began to have in-flight breakups

Malibu

- The FAA and Piper grounded all Malibus until an investigation could be completed
  - Piper paid Malibu owners for alternate transportation during the grounding
- In conjunction with the NTSB and the FAA, Piper conducted an extensive series of test flights of instrumented aircraft, often placing the aircraft well outside its certified and design limits
- The results of these tests were made public
  - Piper even invited journalists to come along on the tests!
- The final conclusion was that the accidents were being caused by pilots new to the Malibu and new to high-performance all-weather flights and not due to the aircraft itself
  - An extensive pilot training curricula was designed and is now an essential insurance requirement for any Malibu owner
  - The in-flight breakups virtually ceased by the early 1990s and the Malibu continues, thirty years later, to be Piper's biggest (dollar) seller

In contrast…

- Boeing has refused to disclose any data associated with its flight tests of the 737 MAX
  - Cites "proprietary nature of the data"
- Will not disclose the exact nature of the aerodynamic issue that MCAS was designed to address
- Will not disclose the pitch regimes in which a 737 MAX starts to depart from "normal" (i.e. 737 NG) behavior
- Insists that pilots need not be trained on how the 737 MAX acts when MCAS is disabled even though a disabled MCAS system is much more likely now
- Continues to insist that MCAS does not address fundamental handling or aerodynamic issues with the airframe but is only there to improve the airplane's handling and make it more like the 737NG
  - *IF THIS WERE TRUE THEN WHY NOT REMOVE MCAS ALTOGETHER?*