

Presented by

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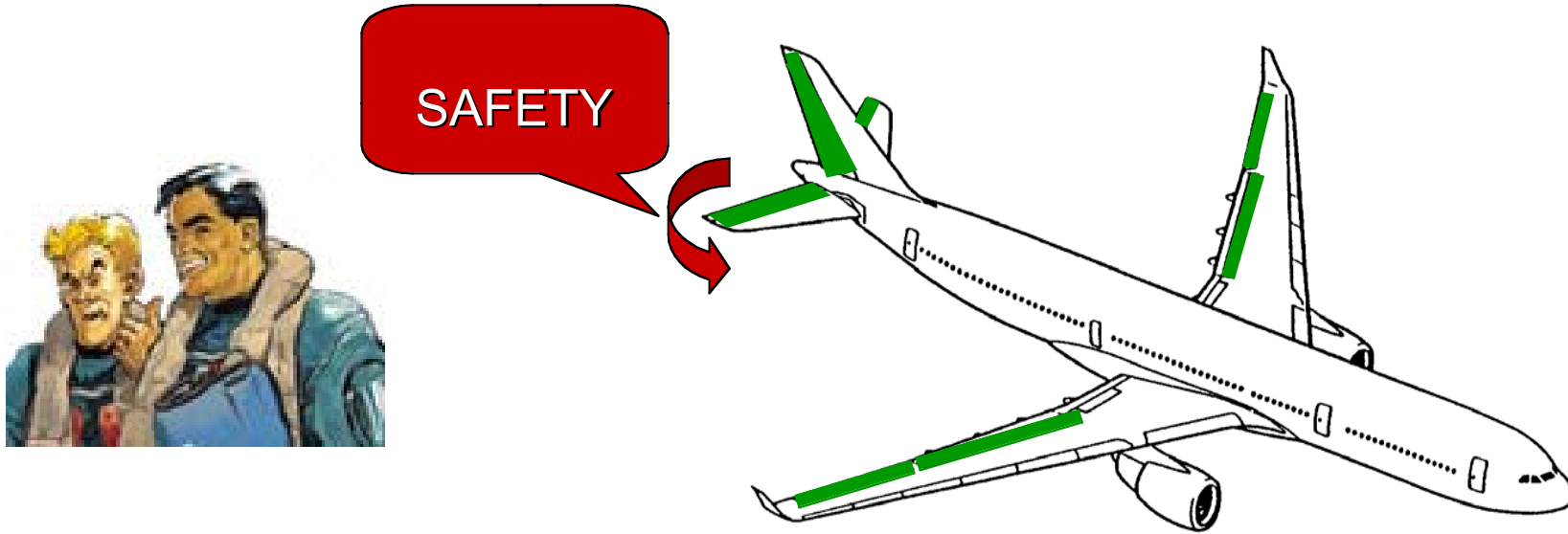
# AIRBUS FLY-BY-WIRE A TOTAL APPROACH TO DEPENDABILITY



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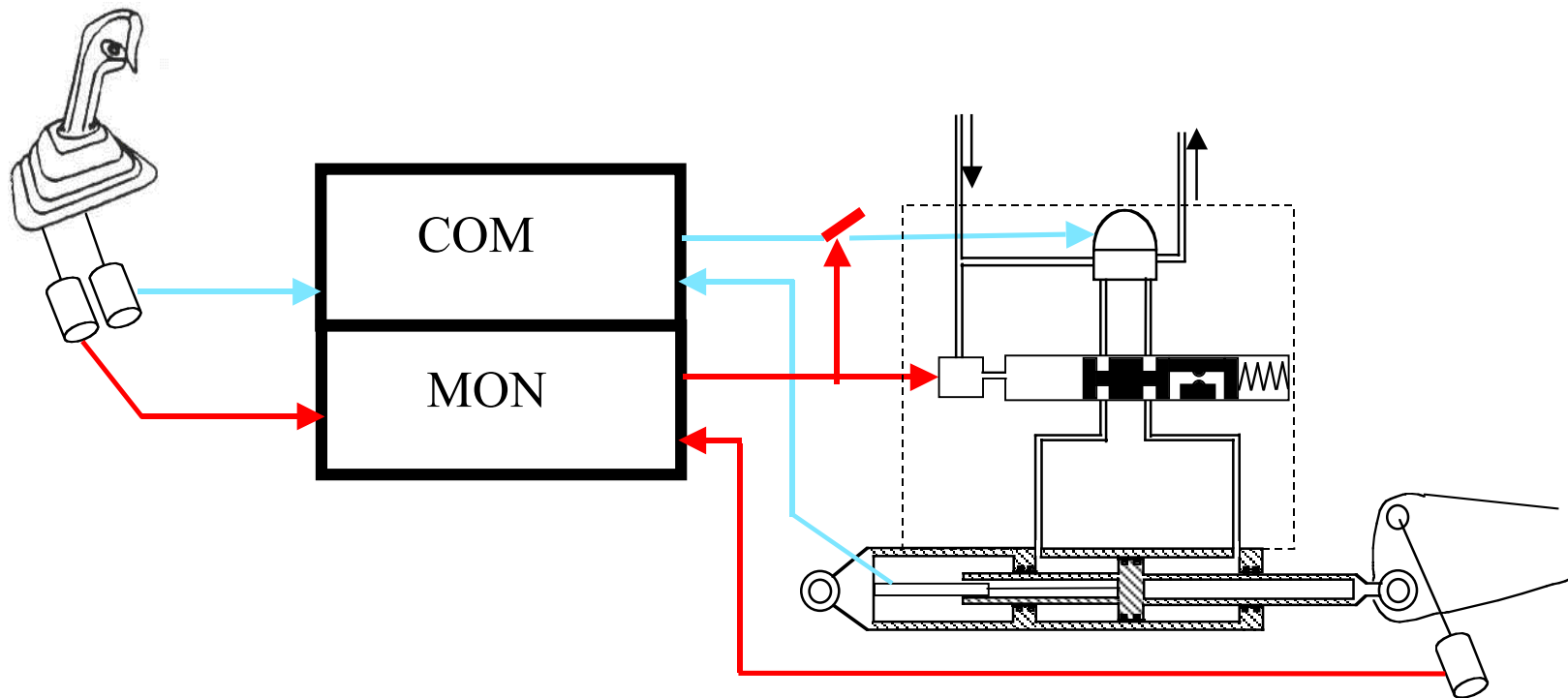
- Background
  - ▶ What is « fly-by-wire »
  - ▶ Dependability attributes
- Coverage of (some) dependability threats
  - ▶ Physical faults
  - ▶ Design & manufacturing errors
  - ▶ Particular risks
  - ▶ Human-Machine Interface
- Concluding words

# AIRBUS FLY-BY-WIRE: BACKGROUND



# PHYSICAL FAULTS

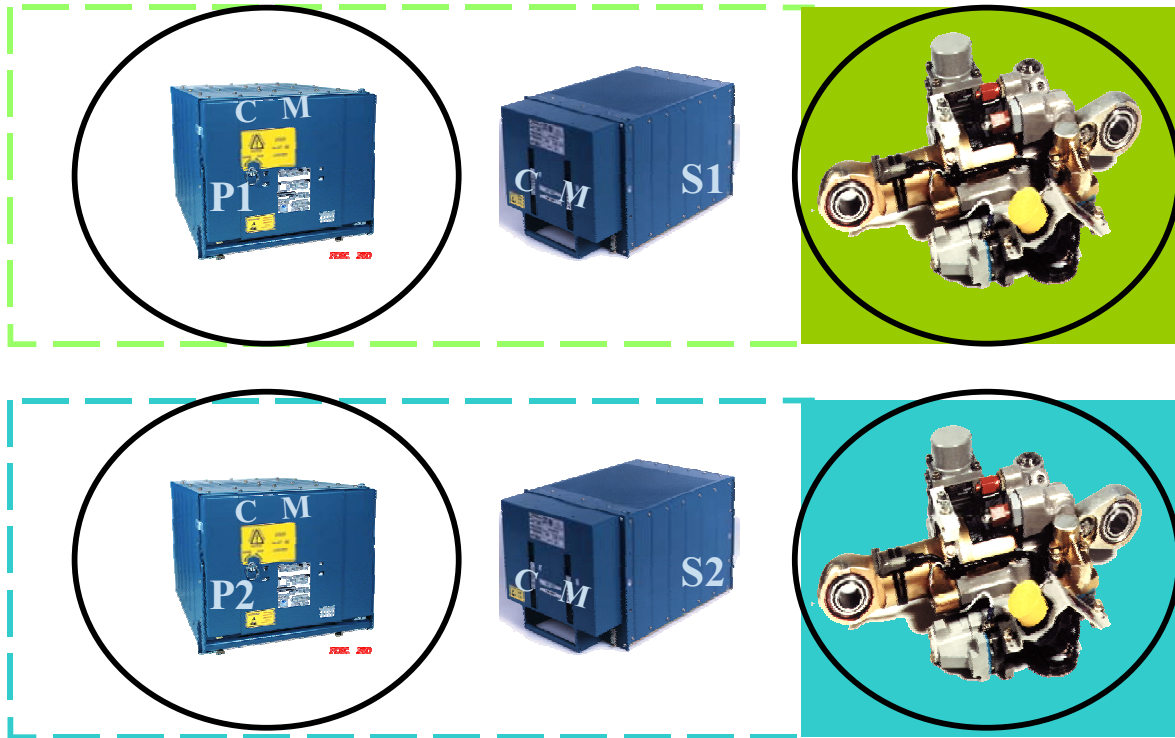
SAFETY



COMMAND & MONITORING COMPUTER

# PHYSICAL FAULTS

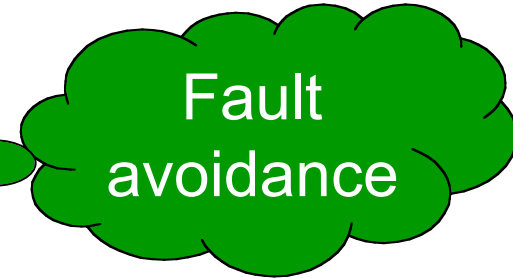
AVAILABILITY



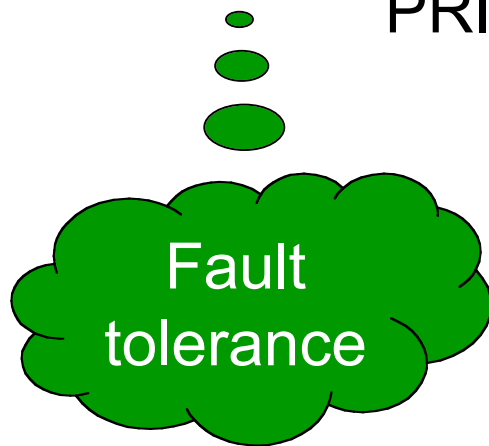
REDUNDANCY  
ACTIVE / STAND-BY  
P1/Green → P2/Blue → S1/Green → S2/Blue

# DESIGN & MANUFACTURING ERROR

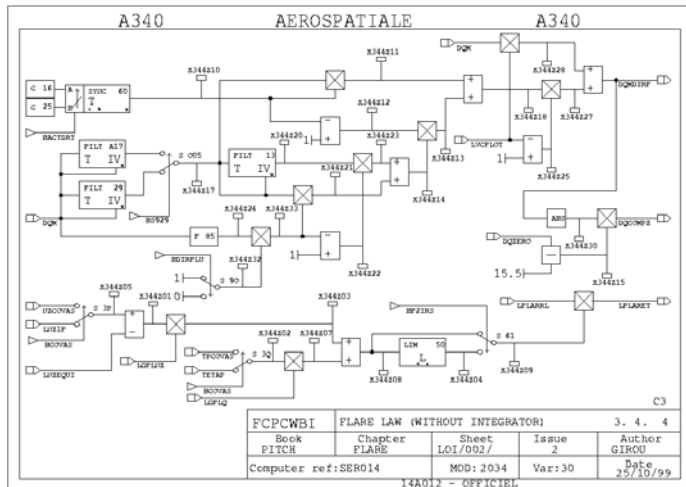
Airbus Fly-by-Wire:  
system is developed to ARP 4754 level A  
Computers to DO178B & DO254 level A  
(plus internal guidelines)



Two types of dissimilar computers are used  
PRIM  $\neq$  SEC



# DESIGN & MANUFACTURING ERROR



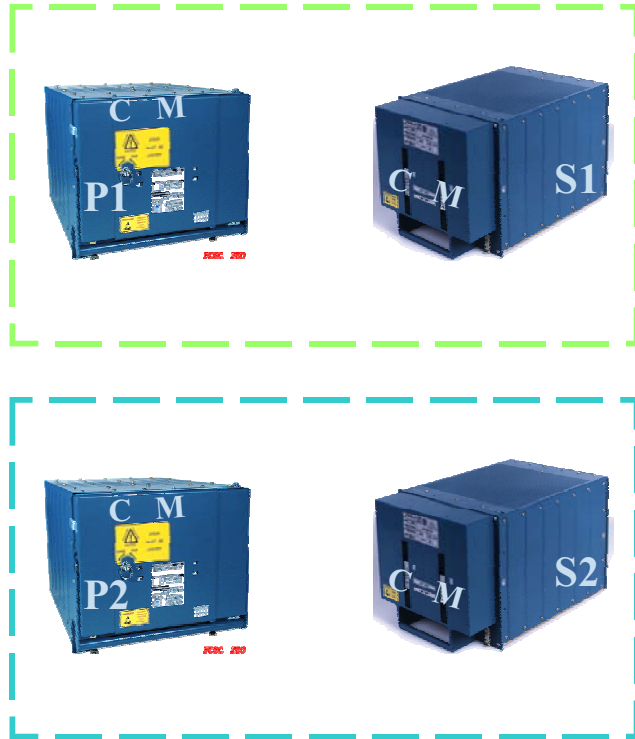
## FUNCTIONAL SPECIFICATION

- interface between aircraft & computer sciences
- automatic code generation

- Classical V&V means, plus
  - virtual iron bird (simulation)
  - some formal proof



# DESIGN & MANUFACTURING ERROR



## FAULT TOLERANCE

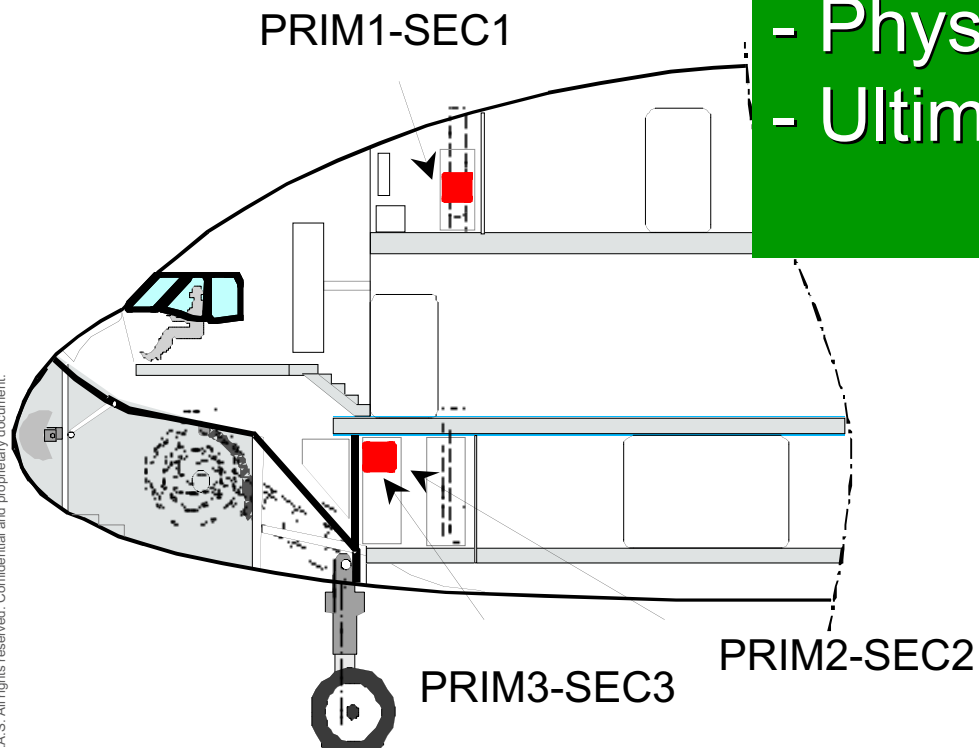
- SEC simpler than PRIM
- PRIM HW  $\neq$  SEC HW
- 4 different software
- data diversity
- From “random” dissimilarity to managed one
- Comforted by experience



# PARTICULAR RISKS

## COMMON POINT AVOIDANCE

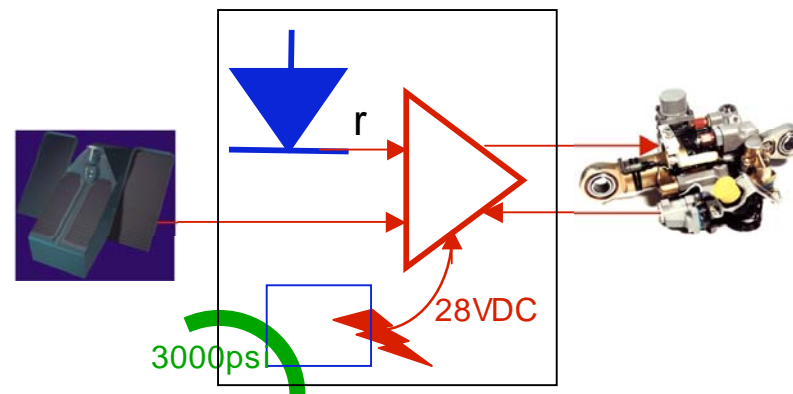
- Qualification to environment
- Physical separation
- Ultimate back-up



# PARTICULAR RISKS

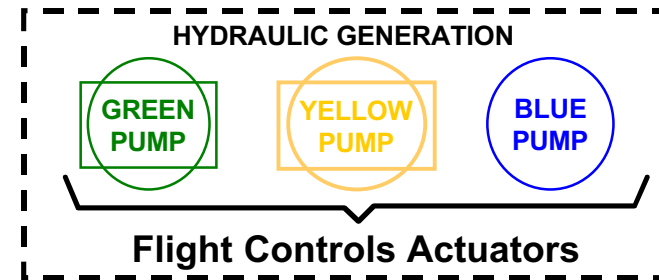
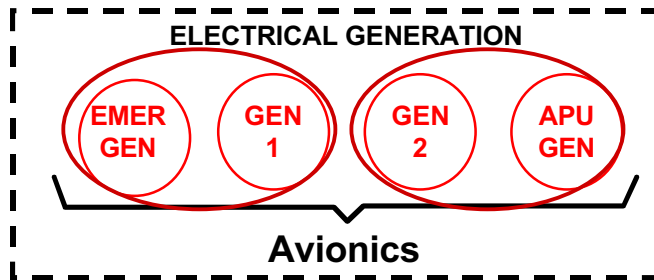
## ULTIMATE BACK-UP

- Continued safe flight while crew restore computers
- Expected to be Extremely Improbable
- No credit for certification
- From mechanical (A320) to electrical (A380 & A400M)

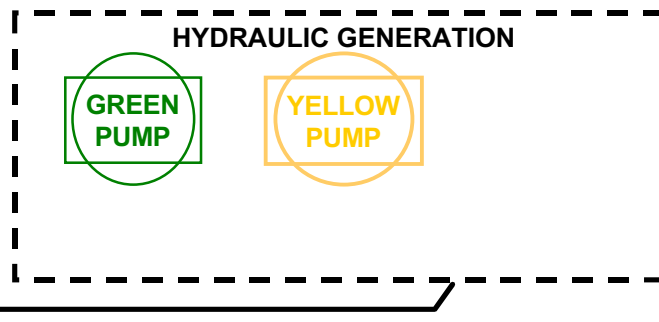
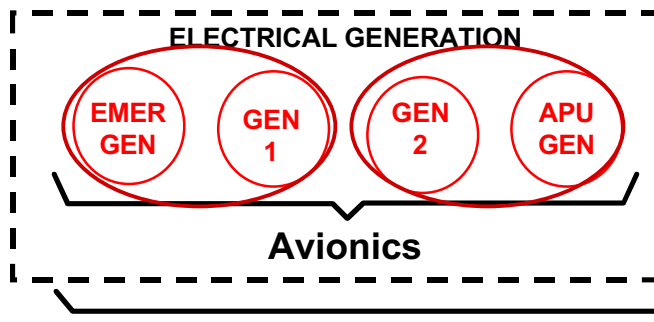


# ELECTRICAL ACTUATION

- A320 ... A340



- A380 A400M

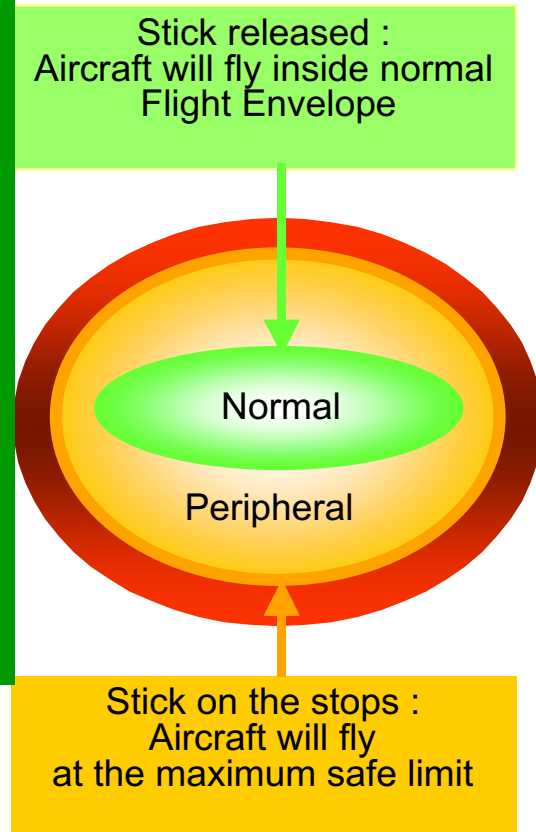


Flight Controls Actuators

**MORE REDUNDANCY  
DISSIMILAR (HYDRAULIC / ELECTRICAL)  
INCREASED SEGREGATION**

# HUMAN-MACHINE INTERFACE

- Reduction of crew workload & fatigue
- Situation awareness
- System reconfiguration
- Flight envelope protections
  - TCAS, TAWS ...
  - Airbus protections



Let the crew concentrate on trajectory

# AIRBUS FLY-BY-WIRE A TOTAL APPROACH TO DEPENDABILITY

## CONCLUDING WORDS

Joint effort for improvement

- FAA/JAA/... Airbus/Boeing/...
- Regulations and practices improvement based on
  - Type certifications experience
  - In-service incidents & accidents
- For in-service airplane & under design

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