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RÉPUBLIQUE FRANÇAISE

MINISTÈRE DE LA DÉFENSE
ET DES ANCIENS COMBATTANTS

Rotorcraft HIRF Qualification and Accident Investigations

driven by model based analysis

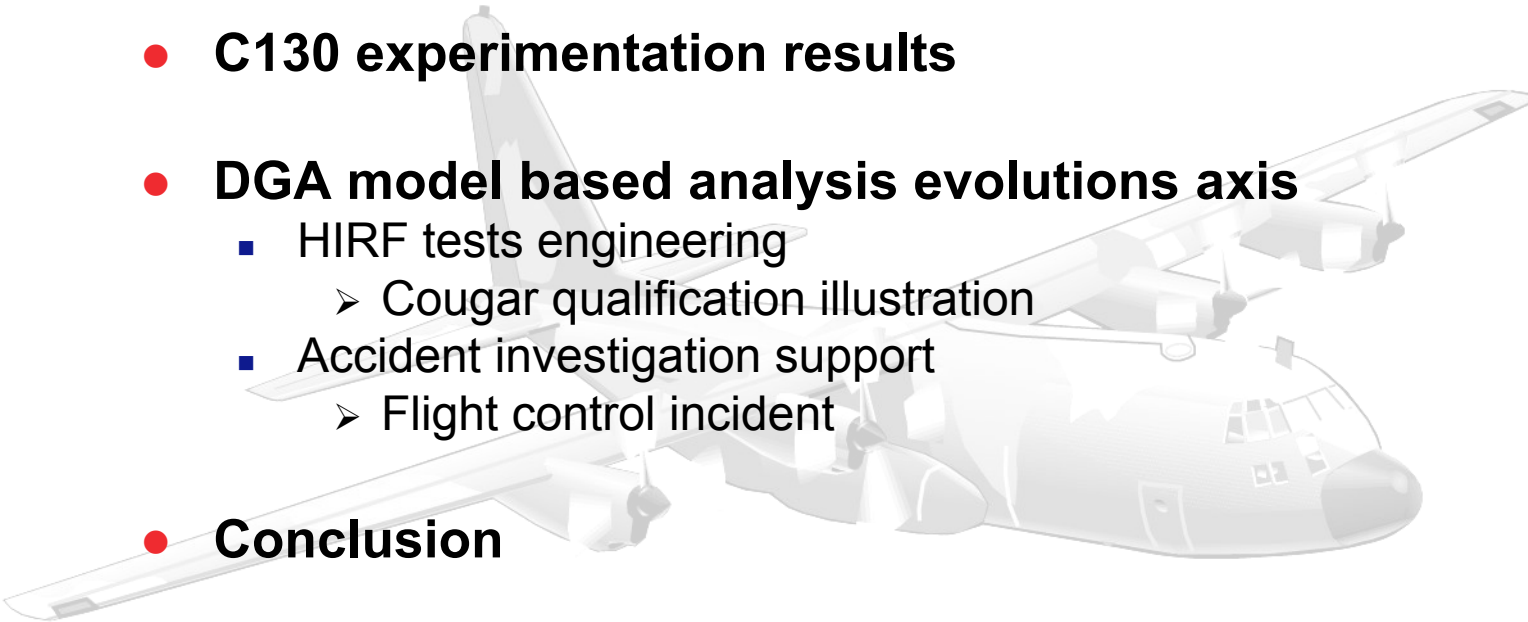


DIRECTION GÉNÉRALE DE L'ARMEMENT



Contents

- **Introduction**
- **C130 experimentation results**
- **DGA model based analysis evolutions axis**
 - HIRF tests engineering
 - Cougar qualification illustration
 - Accident investigation support
 - Flight control incident
- **Conclusion**





Contents

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Introduction



DGA missions :

- Equipping the armed forces
- Preparing for the future
- Promoting defence equipment exports





Introduction

Air Mobility



Environment
& Vulnerability

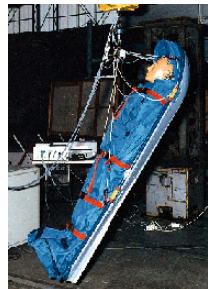


Structures



Aircraft safety

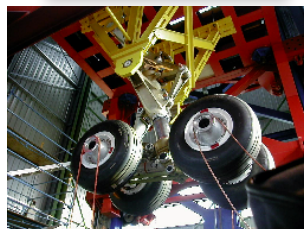
Mission
Sub-Systems



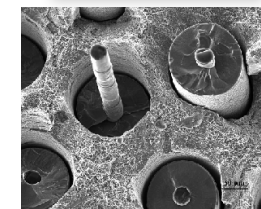
Test Rig
Engineering



Systems &
Sub-systems



Materials



Embedded Systems
and Software





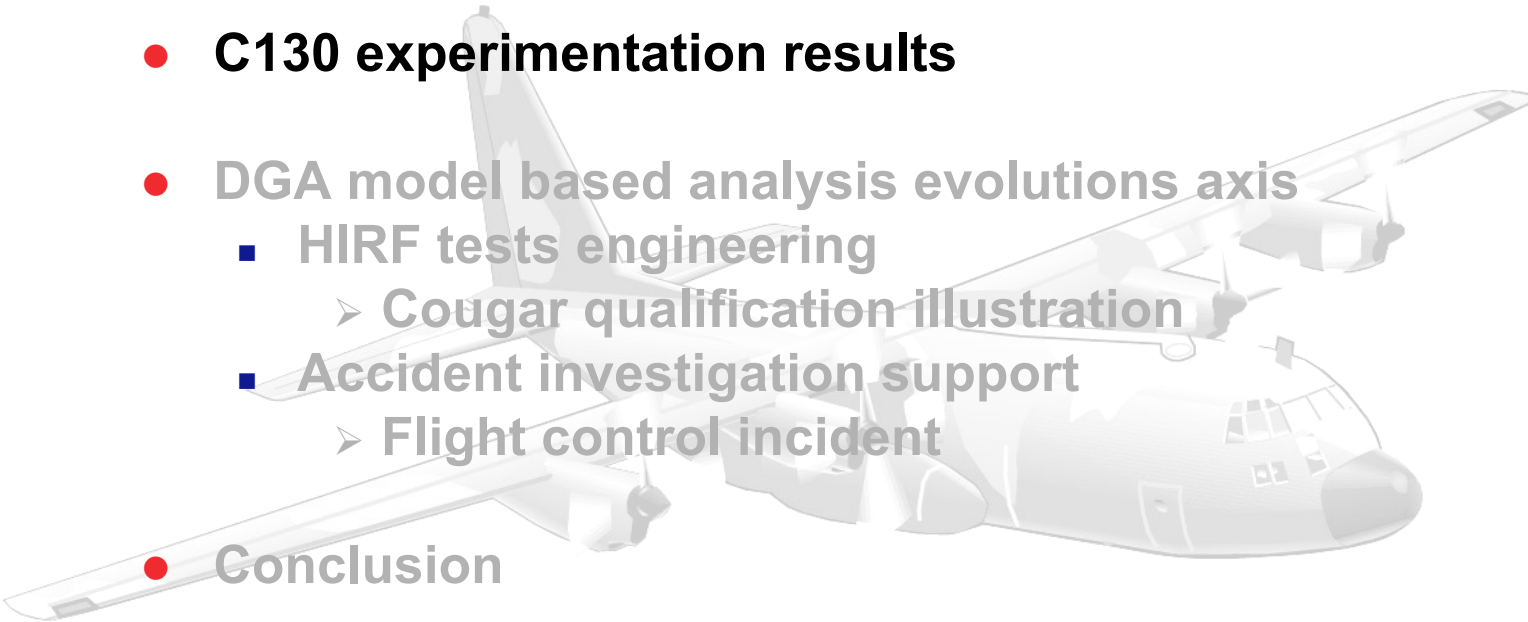
Introduction

- **"Embedded Systems and Software" activities**
 - Complex systems dependability
 - Safety analysis validation (ARP 4754) :
 - Functional (FHA)
 - Organic (PSSA / SSA)
 - Zonal (ZHA / ZSA)
 - Software and complex electronic hardware certification (DO-178 and DO-254)
 - Audits depending on Development Assurance Level (DAL)
 - Qualification tests engineering (DO-160, ED107)
 - Aggression level depending on DAL or safe path
- **BEAD and Justice minister request**



Contents

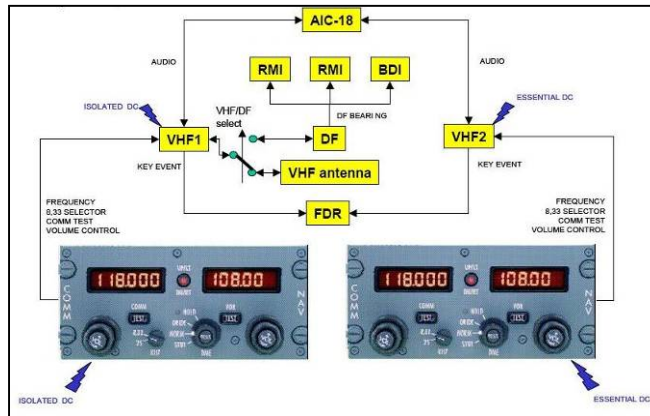
- Introduction
- **C130 experimentation results**
- DGA model based analysis evolutions axis
 - HIRF tests engineering
 - Cougar qualification illustration
 - Accident investigation support
 - Flight control incident
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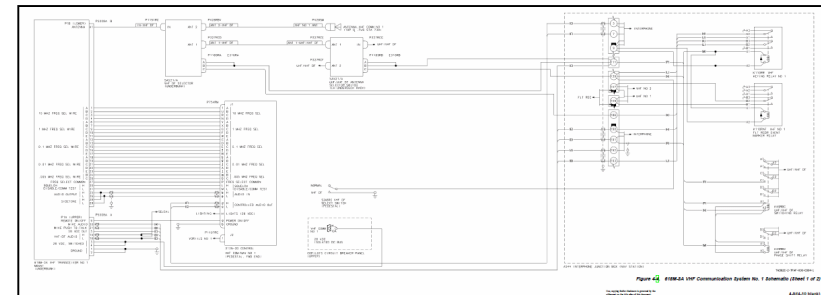


C130 experimentation results

Architecture diagram

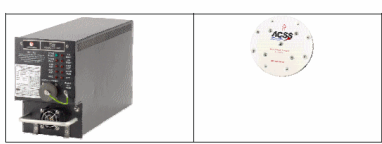


Wiring diagram



Functional description

La fonction surveillance s'appuie sur l'installation d'un nouvel IFF TSC2000 intégrant une capacité Mode S et sur un TCAS.




L'IFF TSC2000 utilisera les 2 antennes de l'IFF NRA17 actuellement installées. Le TCAS utilisera 2 nouvelles antennes TCAS directionnelles.

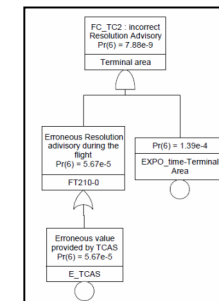
La modification proposée permet d'exploiter la capacité ELS (Surveillance Élémentaire) du TSC 2000.

Un voyant spécifique sera installé pour permettre d'avertir de l'utilisation du Mode 4.

Les règlements CS-25 recommandant que l'altitude utilisée par le Mode S soit celle du pilote, il est proposé d'introduire un altimètre digital qui puisse être contrôlé par l'équipage. Il est proposé d'installer cet altimètre en supplément de la chaîne altimétrique actuelle. Il sera installé sur la planche de bord pilote/copilote. Les pilotes devront régler cet altimètre sur le calage du pilote en fonction et vérifier régulièrement la cohérence entre ces 2 équipements.



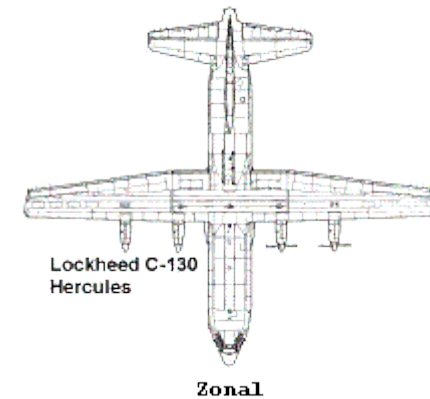
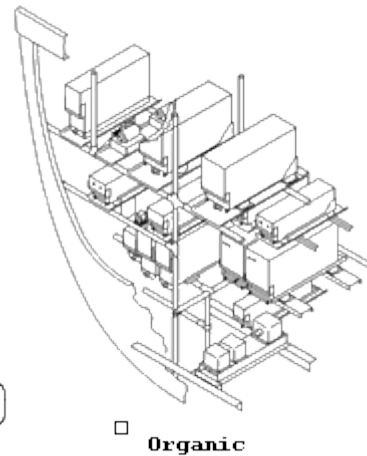
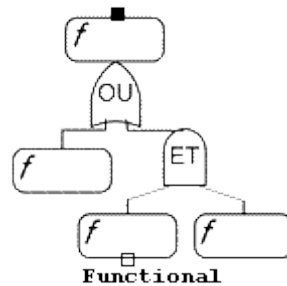
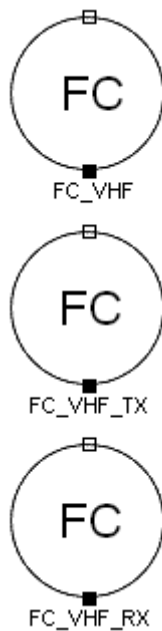
Safety analysis





C130 experimentation results

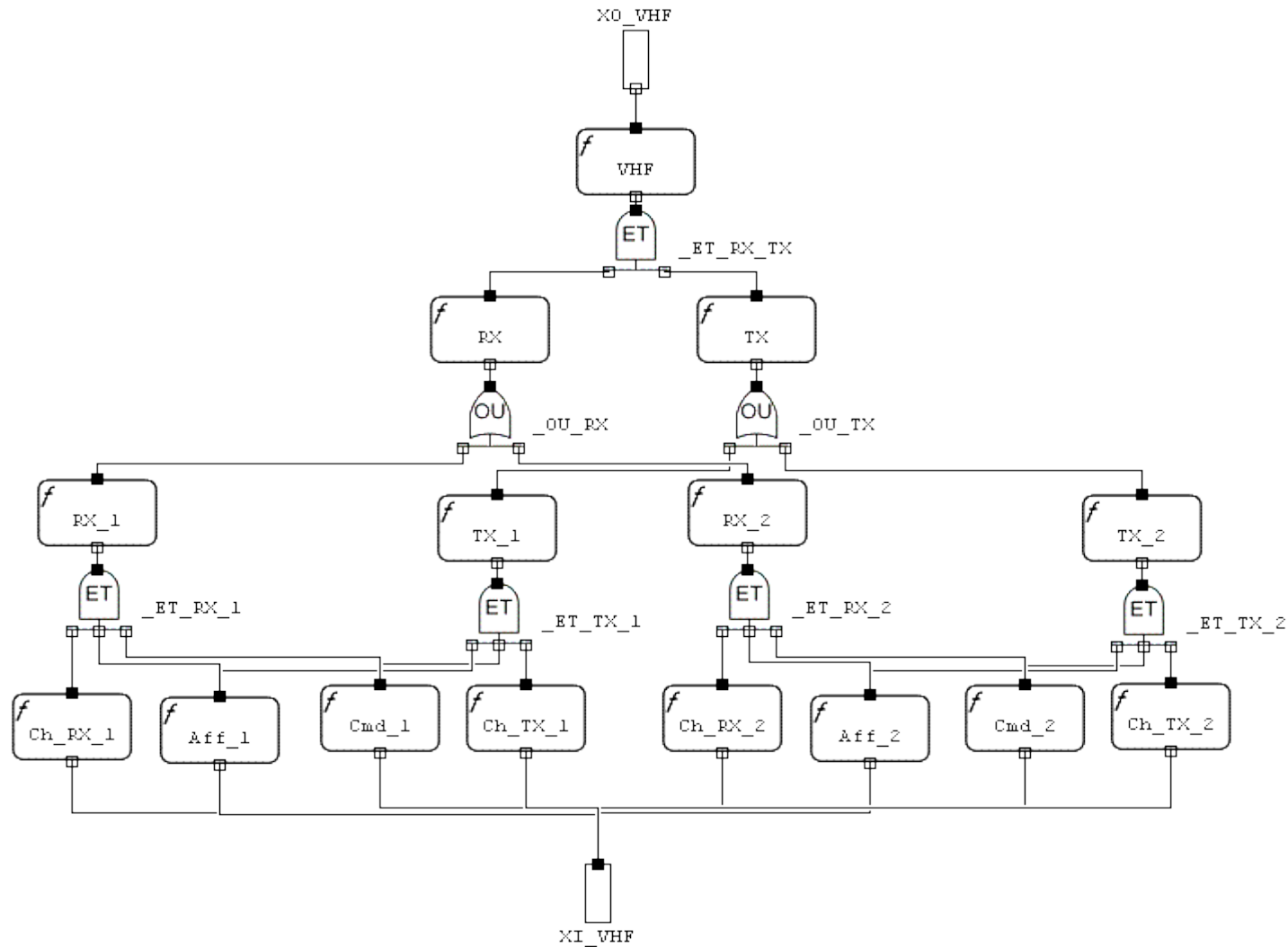
- **VHF Communication System**





C130 experimentation results

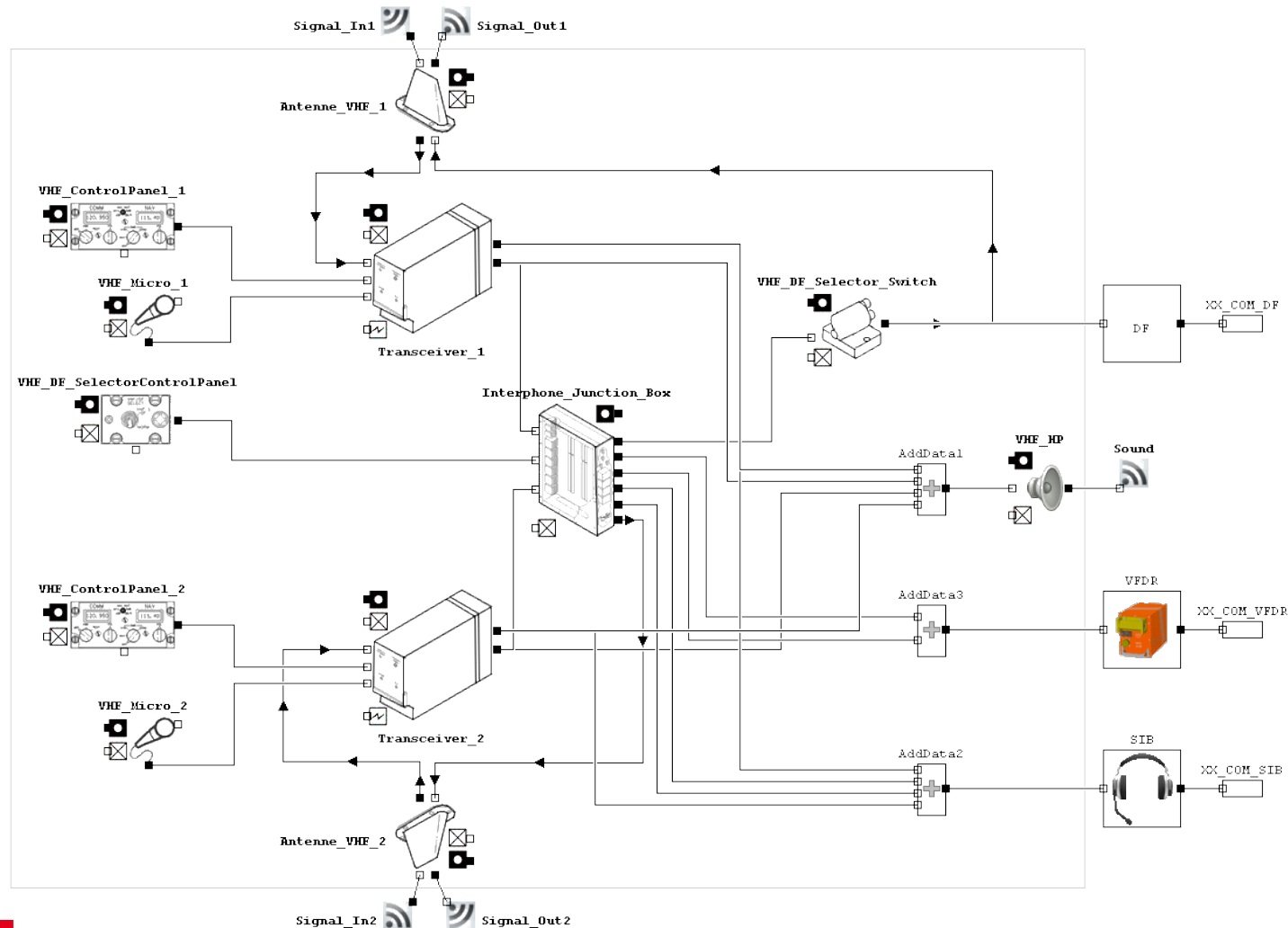
- Functional view





C130 experimentation results

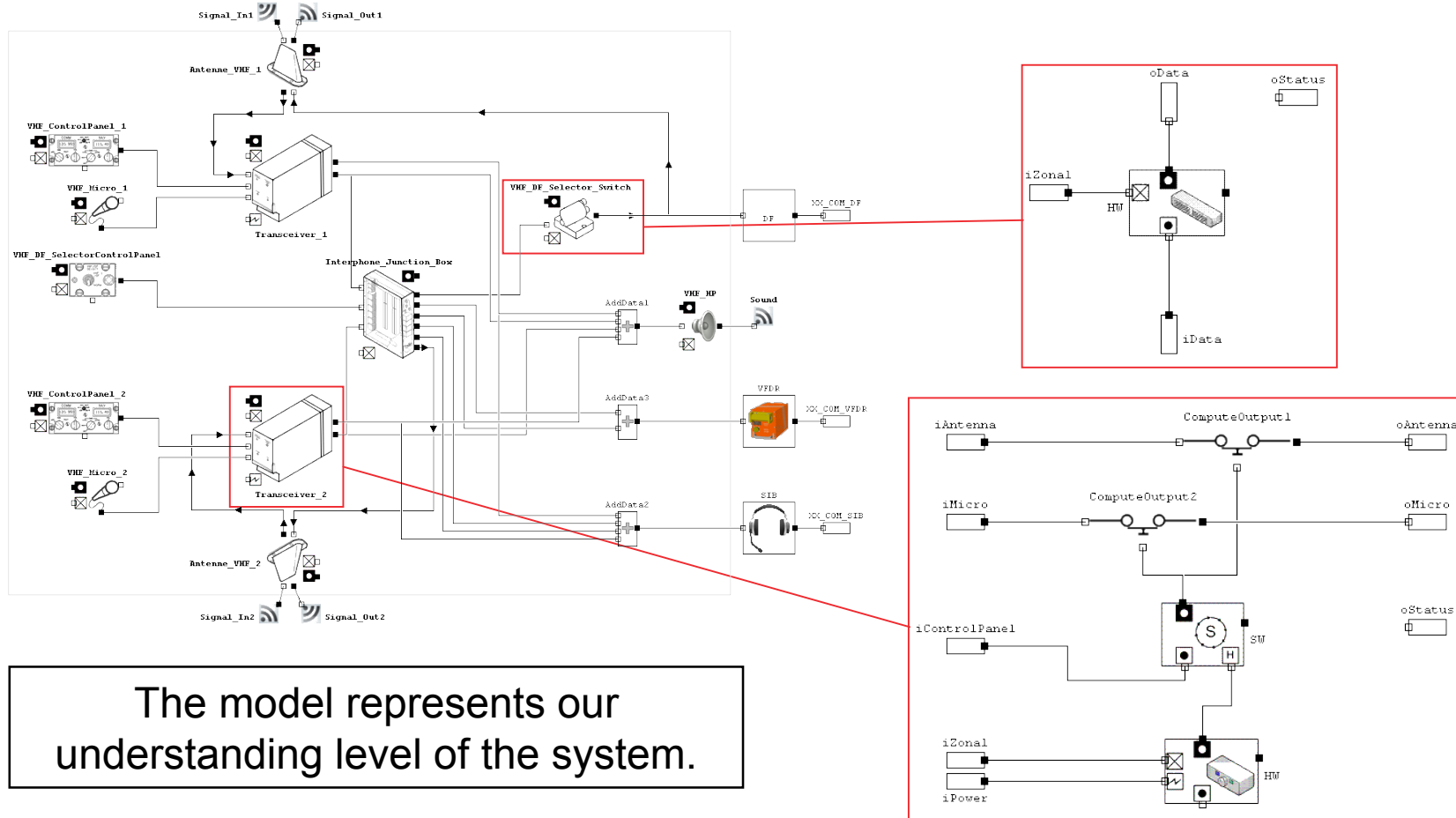
■ Organic view





C130 experimentation results

■ Organic view

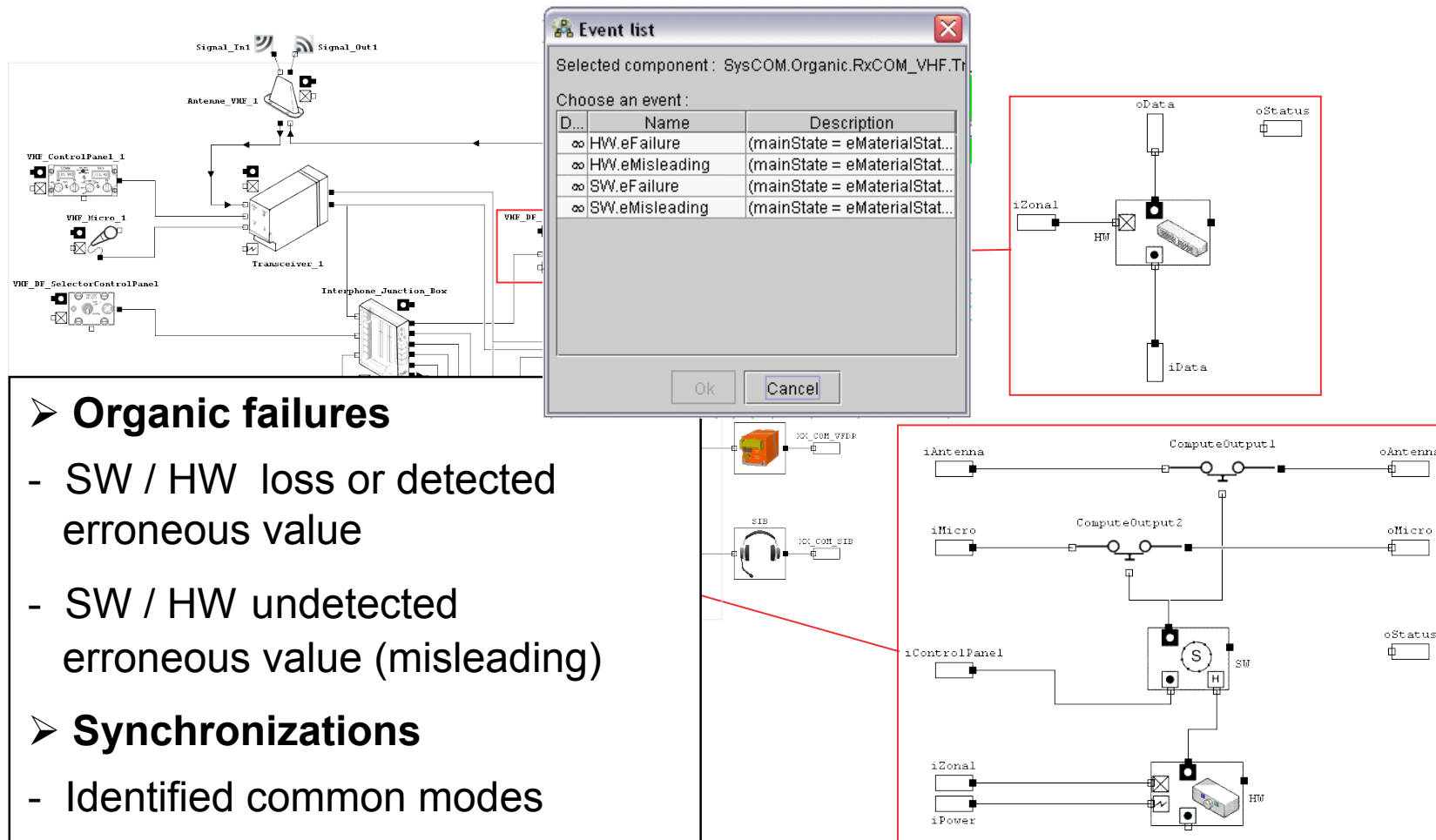


The model represents our understanding level of the system.



C130 experimentation results

■ Organic view



➤ Organic failures

- SW / HW loss or detected erroneous value
- SW / HW undetected erroneous value (misleading)

➤ Synchronizations

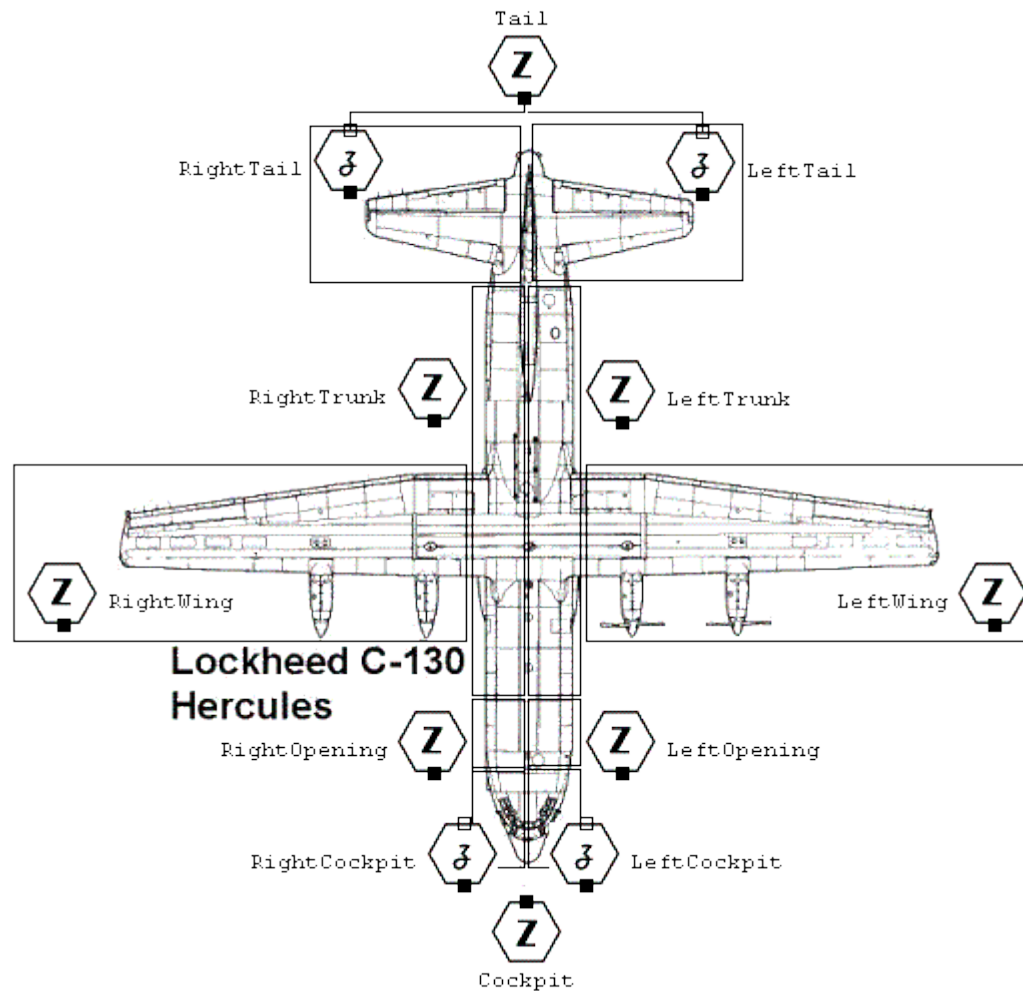
- Identified common modes





C130 experimentation results

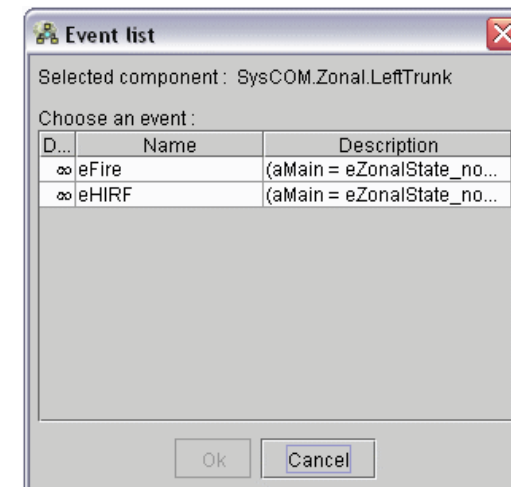
■ Zonal view



Lockheed C-130
Hercules

➤ Zonal threats

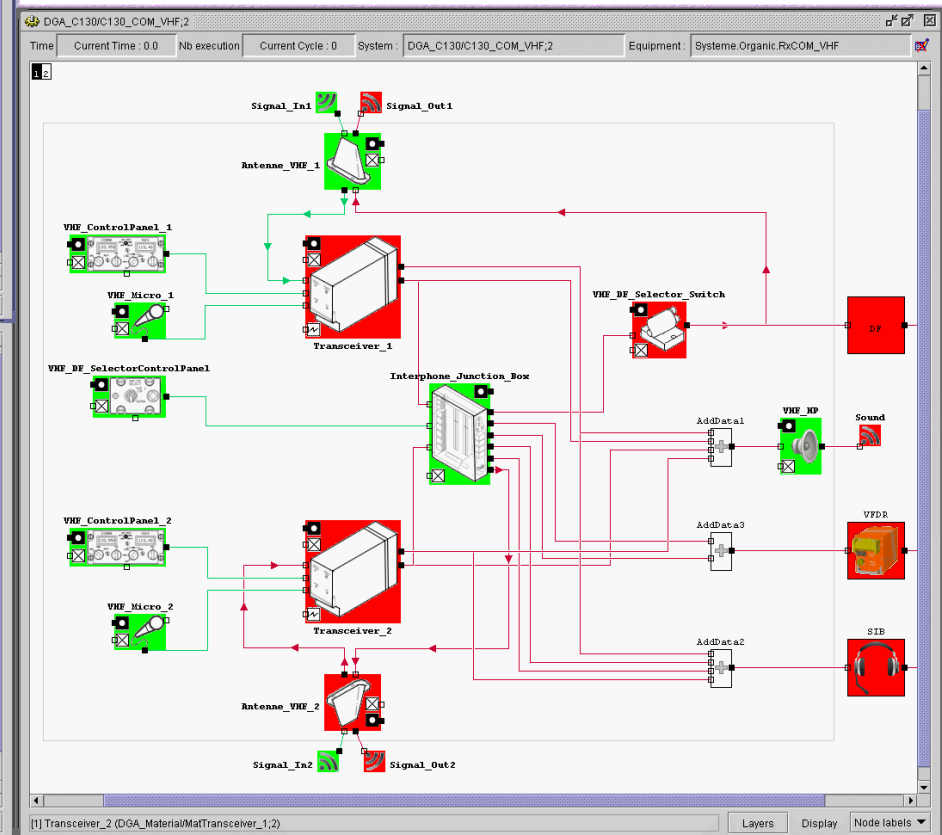
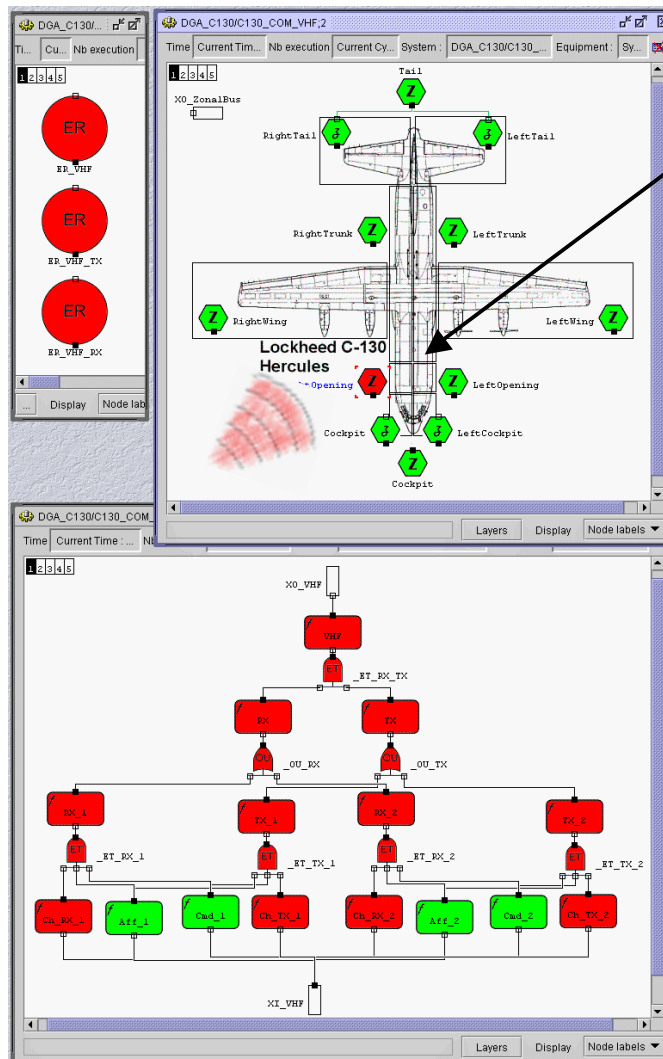
- fire
- HIRF aggression
- lightning
- bird strike





C130 experimentation results

➤ Zonal threat :
HIRF aggression





C130 experimentation results

- **Quantitative & qualitative analysis**
 - Fault tree & Sequence generation
 - Minimal cuts number at a given order
 - ➔ common modes, particular risks, zonal analysis
 - Probability verification
 - Development Assurance Level (DAL) allocation verification
 - unit validation
 - easy to refine & modify
 - easy to integrate
 - emergent properties





C130 experimentation results

- **Architecture quality analysis**
 - **Optimal qualitative rendering** through the minimal cuts
 - Candidate architectures comparison
- **Complexity control**
 - Better system understanding help
 - **Emergence of properties**
 - Common modes control
- **Collaborative work / capitalization**
 - Usable tool within a joined team
 - Reusable and customizable framework
- **Interfacing with Industry**
 - Used by industrials
 - Professional tool specialized in Safety analysis



Contents

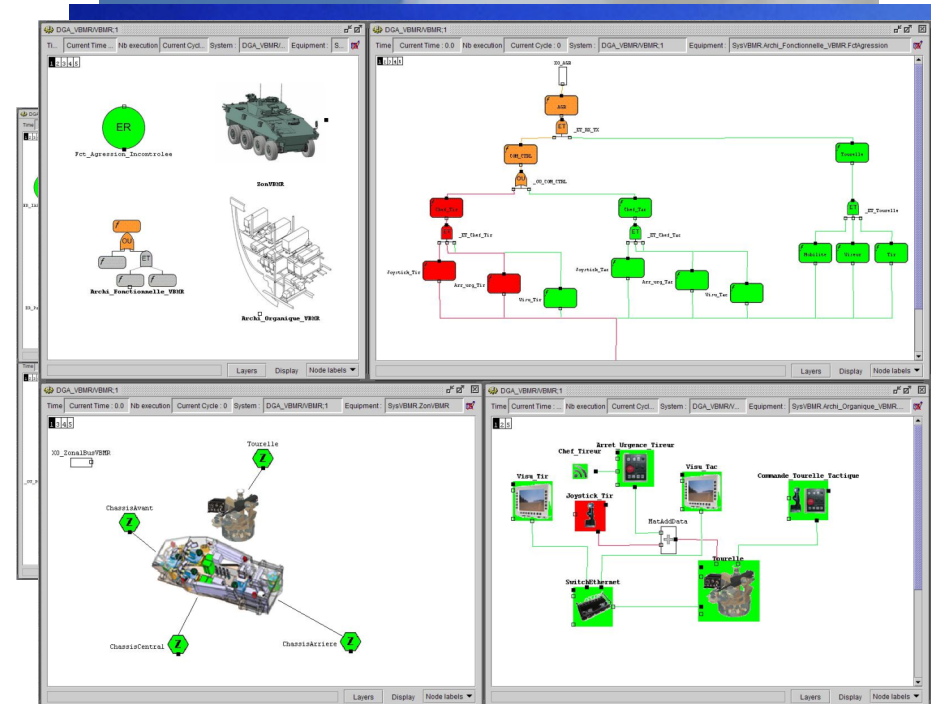
- Introduction
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Since C130 experimentation in 2010

- **Around 10 various Altarica models have been produced**
 - MRTT, Multi-Role Tanker Transport (Navigation systems)
 - VBMR (Army vehicle system)
 - MdCN, Nuclear Submarine Missile
 - Hawkeye (Navigation systems)
 - C160, Transall (flight control system)
 - Cougar, military Super-Puma AS532 (Decoy Launcher System)
 - ACCS (French Air Force Air Traffic Management)
 - TSMPF (Naval Tactical Communication System)





HIRF tests engineering

- **Hight Intensity Radieted Fields**
 - Severe electromagnetic environment (more than 200V/m)
- **Aircraft system must perform their function close to the carrier radar**





HIRF tests engineering

- **Antenna**

- **Anechoic chamber**

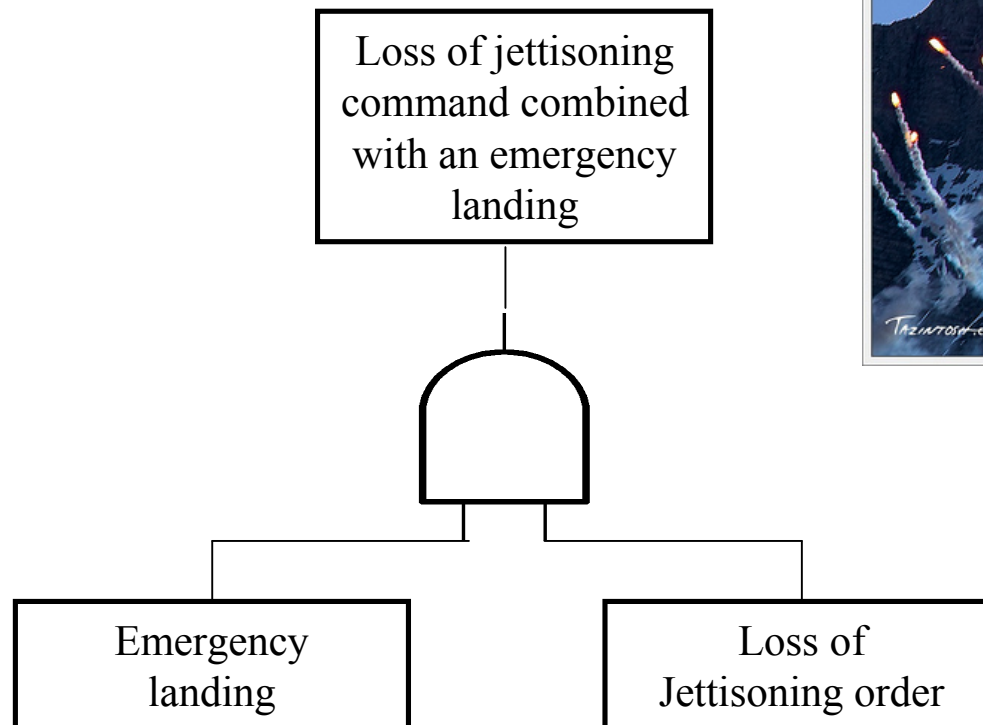
- **Digital data links**





Cougar Decoy Launcher system

- « Catastrophic » failure condition





Cougar HIRF tests instrumentation

- **Data links**
 - FADEC and VMS ARINC 429 data links
 - Decoy Launcher CAN networks
 - ...
- **Camera**
- **Position sensor**
- ...





Accident Investigations

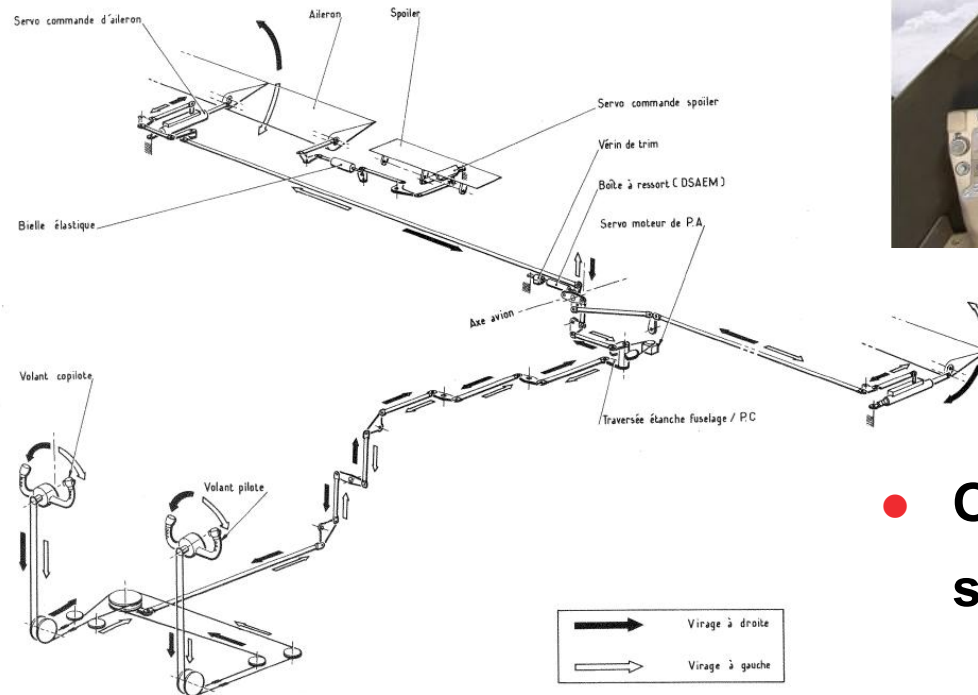
- **Requests**
 - BEA/BEAD
 - Failure identification
 - Justice minister
 - Responsibility identification
- **Expertise domains**
 - Structural
 - Materials
 - Digital Embedded Systems (flight control, avionics,...)
 - ...





Accident Investigations

- **Complex Architecture**



- **Old system without safety analysis**



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Conclusion

- **Scope of the dependability process**
 - at DGA Aeronautical Systems level
 - support for critical systems and software certification
 - support for qualification test assessment
 - support for accident investigation
 - at DGA level
 - support to design architects for :
 - **Airworthiness Authorities** issues
 - **technical risk control** of a program
- ➔ Modelling drives our assesment process efficiency



Next evolutions

- **Model based security assesment**
- **Model coupling with electromagnetic simulation**
 - Assess lightning impact on system

Vincent Louis, Florian Many





Questions

