Diagnosis and fault-tolerant control for a multi-engine cluster of a reusable launcher with sensor and actuator faults

Renato Murata[1,2]

PhD Advisors: Julien Marzat[1], Hélène Piet-Lahanier[1], Sandra Boujnah[2], François Farago[2]

[1]DTIS, ONERA, Université Paris-Saclay, Palaiseau, Île-de-France, 91123, France
[2]CNES, Sous-Direction Techniques Systèmes de Transport Spatial, Paris, Île-de-France, 75612, France

Problem statement

Challenge: complete the mission even in the presence of faults.

The system considered here is the reusable launcher propulsive cluster. It is composed of:

- Multiple Liquid-Propellant Rocket Engines (LPRE)
- Thrust Vector Control (TVC)
- Propellant feeding system

Figure 1: Saturn V engine cluster. Image by INFINITY Science Center via collectspace

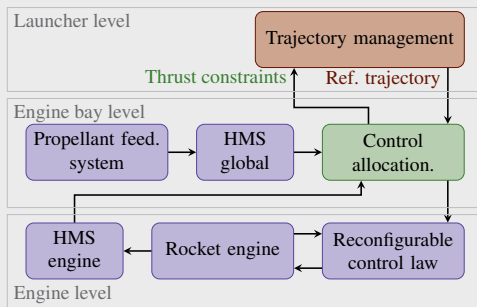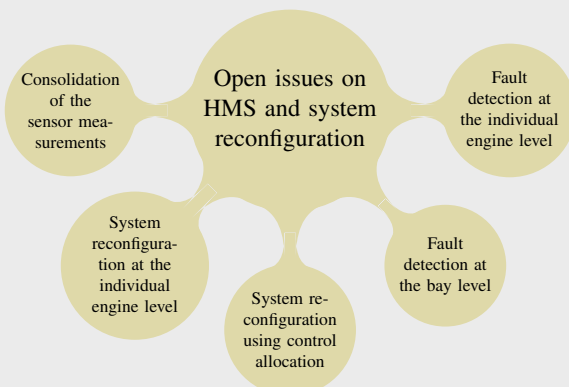**Solution: an active fault tolerant control structure.**

Figure 2: Possible functional architecture

Expected contribution

Open issues on HMS and system reconfiguration

Consolidation of the sensor measurements

Fault detection at the individual engine level

System reconfiguration at the individual engine level

System reconfiguration using control allocation

Fault detection at the bay level

Work performed and next steps

Faults simulated: A leakage fault was simulated in four parts of the propellant feeding lines: at the main and secondary lines of the oxidizer feeding system.
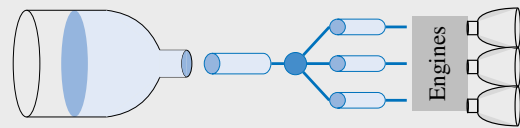

Figure 3: Oxidizer feeding system scheme

Fault detection and localization method: State observers are used to estimate important variables of the system.

The **difference** between the measured and the estimated variables is used for **fault detection and localization**.

The performance of **three observers schemes** were compared: Luenberger observer, Unknown Input Observer (UIO) and High Gain Observer (HGO).

Table 1: Observer schemes performance

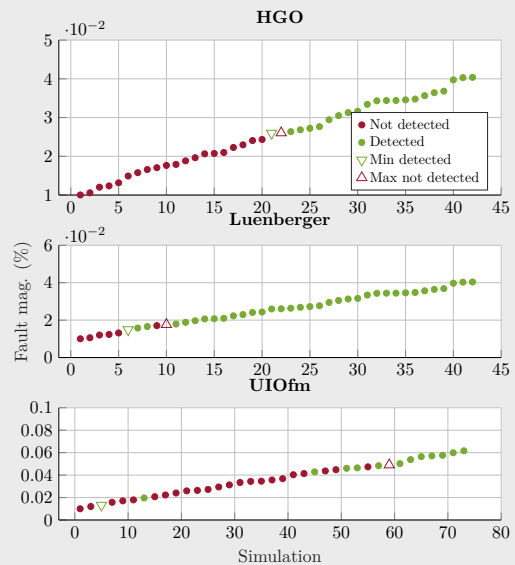| Observer scheme	Fault detection and localization performance	False alarm rate
HGO	92.44%	0%
Luenberger	80.33%	0.33%
UIO	72.00%	16.67%

Figure 4: f_{s2} detection limit

Next steps:

- Development of a complete propulsive cluster model
- Apply the observer-based strategy for detection of other types of faults
- Study the system reconfiguration in case of faults