Design and testing of Clustered components for modular spacecraft architectures

Admission to the first year

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Spacecraft/mission architecture

Given mission requirements, we need to chose system architecture. It will either be

- Monolithic
- Distributed

  (Constellation, Clusters,

  Fractured architecture)

Figure: F6 concept

Monolithic architecture design

Pro

- Highly integrated
- State of the art

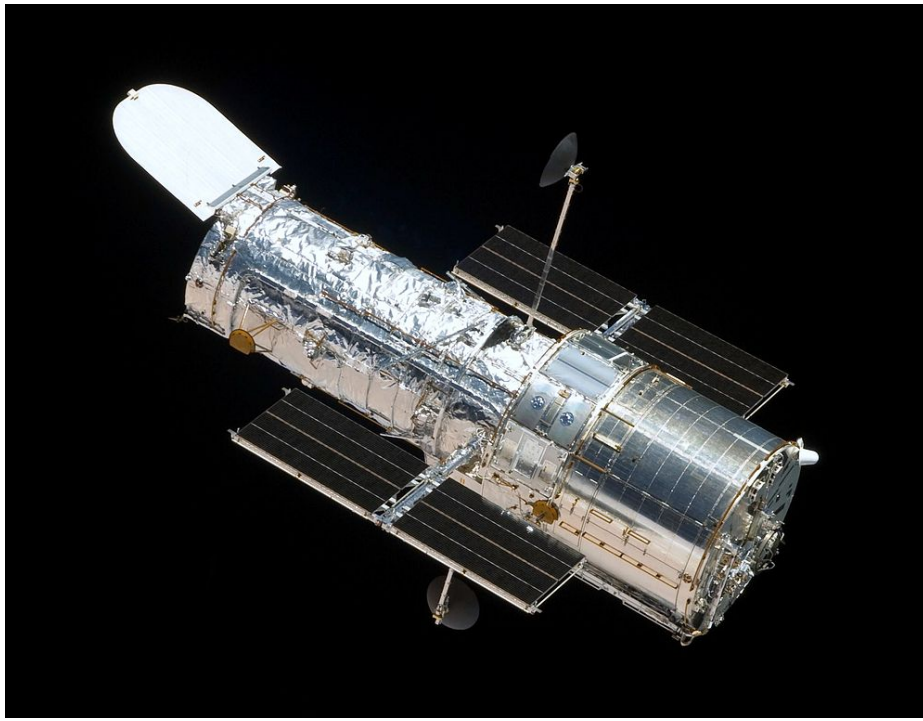

Figure: Hubble ST as an example of highly integrated and complex system

Monolithic architecture design

Pro

- Highly integrated
- State of the art

Cons

- Long development
- Emergent behaviours
- Fragile

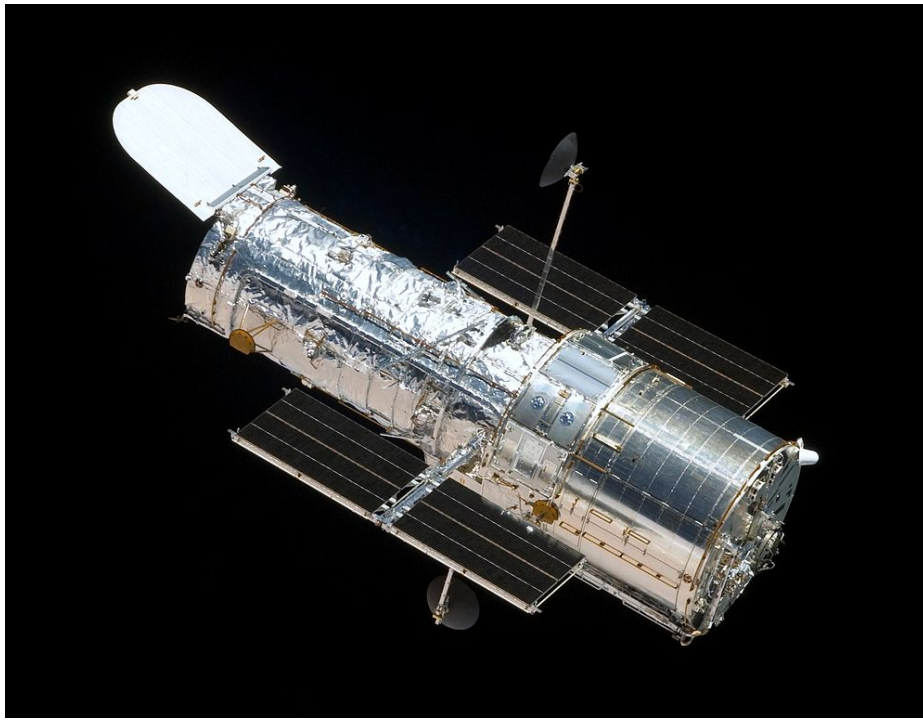

Figure: Hubble ST as an example of highly integrated and complex system

Increasing the number of agents increases complexity and flexibility

- Still designed on **predicted needs**
- Complex and costly
- Tolerant to single spacecraft failure

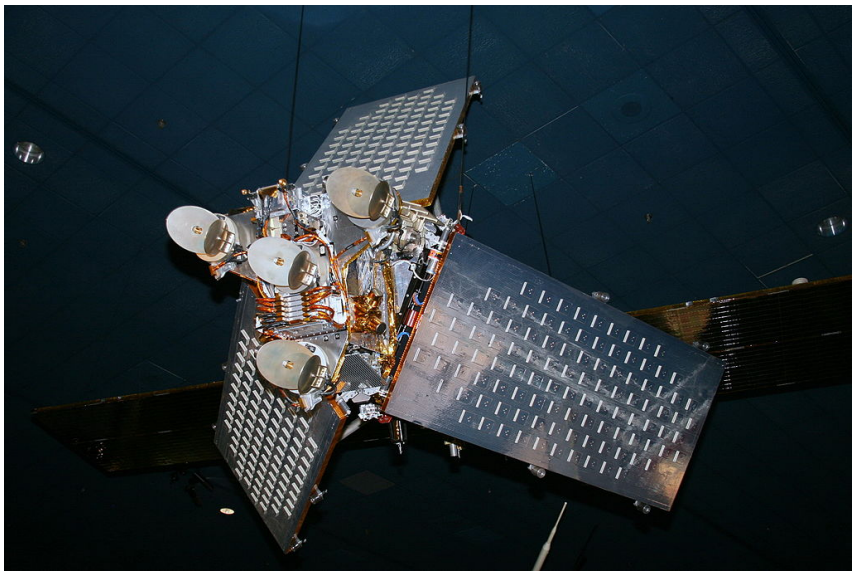

Figure: Iridium spacecraft

Fractioned spacecraft

Future Fast, Flexible, Fractionated, Free-Flying Spacecraft united by Information eXchange

Three degrees of fractionation

- Homogeneity (number of types of modules)
- Number of modules per type
- Type of exchange

Figure: F6 project, DARPA (cancelled in 2013)

Innovation

The value proposition for fractured Space Architectures [1]

- Lower risk, lunch cost and development time
- More flexible
- More parts
- More complexity

There are two different options:

- Modular design using fractured architectures
- Modular on-orbit reconfigurability

[1] DARPA 2006

Core concept

Flexibility helps managing the effects of uncertainties.

If the system is **flexible** you can accommodate changes in requirements as they appear. (By adding new modules/satellites to the constellation)

Innovation

- It can be shown that, for simple systems introducing **diverse redundant components** increases flexibility, which can lower overall system costs in the face of uncertainty.

- Even within a single spacecraft, fractured system design might allow for flexibility and lower overall system costs.

Possible applications in ADCS

- New design methodology for fractured system design, without choosing a metrics to retain flexibility. (Characterization of the frontier of the mission worthy portion of the design space)
- In a modular system, parameters such as main moment of inertia may be seen as DOF for the ADCS. Authority requirement may change

Methodology

- WP1: **Analytical characterization** of simple model[2] for Fault Tolerant Control and Redundancy management

[2] linear dynamics, deterministic

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- WP2: **Consideration** of secondary non linear effects, emergent behaviours and stochastic processes.

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Methodology

- WP1: **Analytical characterization** of simple model[2] for Fault Tolerant Control and Redundancy management
- WP2: **Consideration** of secondary non linear effects, emergent behaviours and stochastic processes.
- WP3: Development of **experimental set up** to corroborate the model assumptions

[2] linear dynamics, deterministic

Thanks for the attention!