A systems engineering framework for integrating stores with aircraft

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The scope of aircraft and stores

- Definition of **aircraft store**: “Any device intended for internal or external carriage and mounted on aircraft suspension and release equipment, whether or not the item is intended to be separated in flight from the aircraft” (MIL-HDBK-1763, 1998)
- A vast variety of possible aircraft and store combinations.
  - Literally anything can be the store (e.g. Space Shuttle on the Boeing 747)
- A unique category of airworthiness considerations
  - No specific civil regulations for store integration – airworthiness is motivated by reference to military guidelines.


https://breakingdefense.com/2019/06/house-armed-services-scrutinizes-f-35-costs-abms-army-modernization/

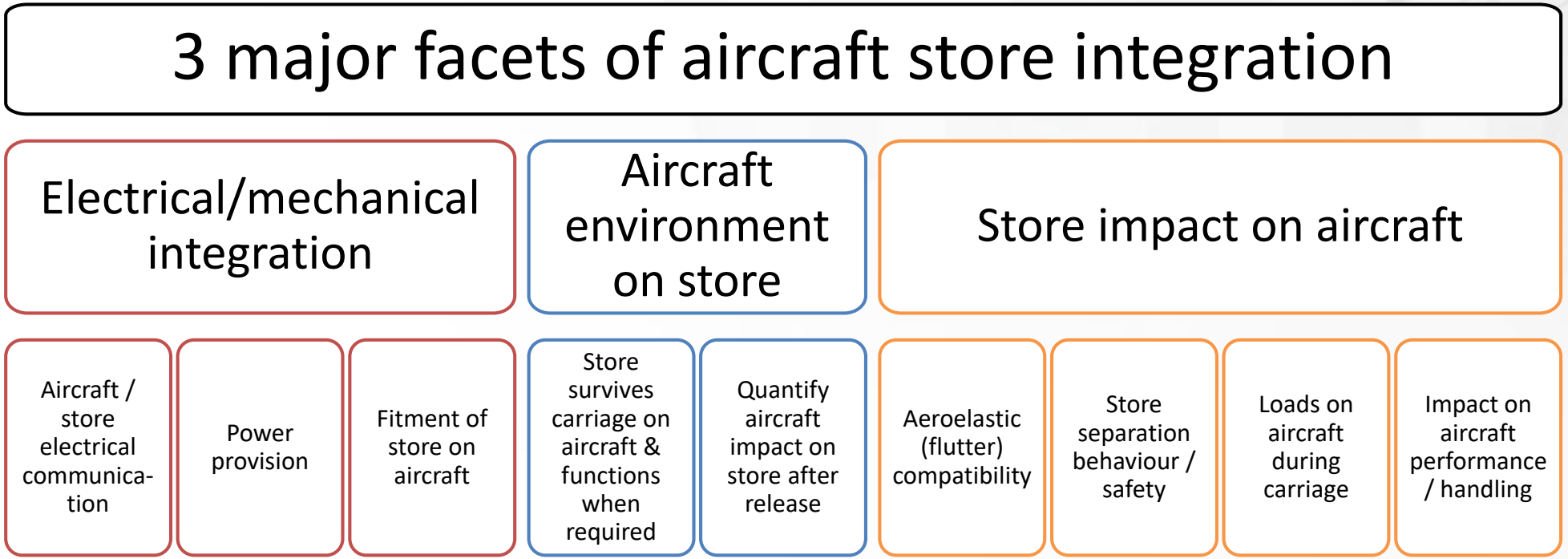

https://www.fz.be/denel-rooivalk-ah-2


https://en.m.wikipedia.org/wiki/File:MQ-9_Reaper_-_090609-F-(cropped).jpg


https://en.wikipedia.org/wiki/List_of_Shuttle_Carrier_Aircraft_flights#/media/File:STS117TakeoffEdwardsSCA.jpg

What is involved in integrating stores with aircraft?

- Significant engineering complexity due to multidisciplinary nature of store integration (MIL-HDBK-1763).



- Significant management complexity due to different parties involved:
  - Customer air force / aircraft operator
  - Customer procurement agency
  - System safety authority / civil aviation regulator
  - Aircraft OEM
  - Store OEM
  - Flight test organisation

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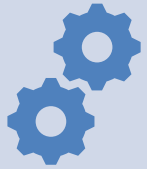

Systems engineering (SE) approach should be used to manage complexity & deliver specified integrated capabilities

Based on systematic process of problem description, decomposition, analysis, solution synthesis and verification & validation

SE framework for aircraft stores integration developed and implemented at the CSIR is outlined

Proven over multiple projects to reduce risk, costs and leads to positive outcomes

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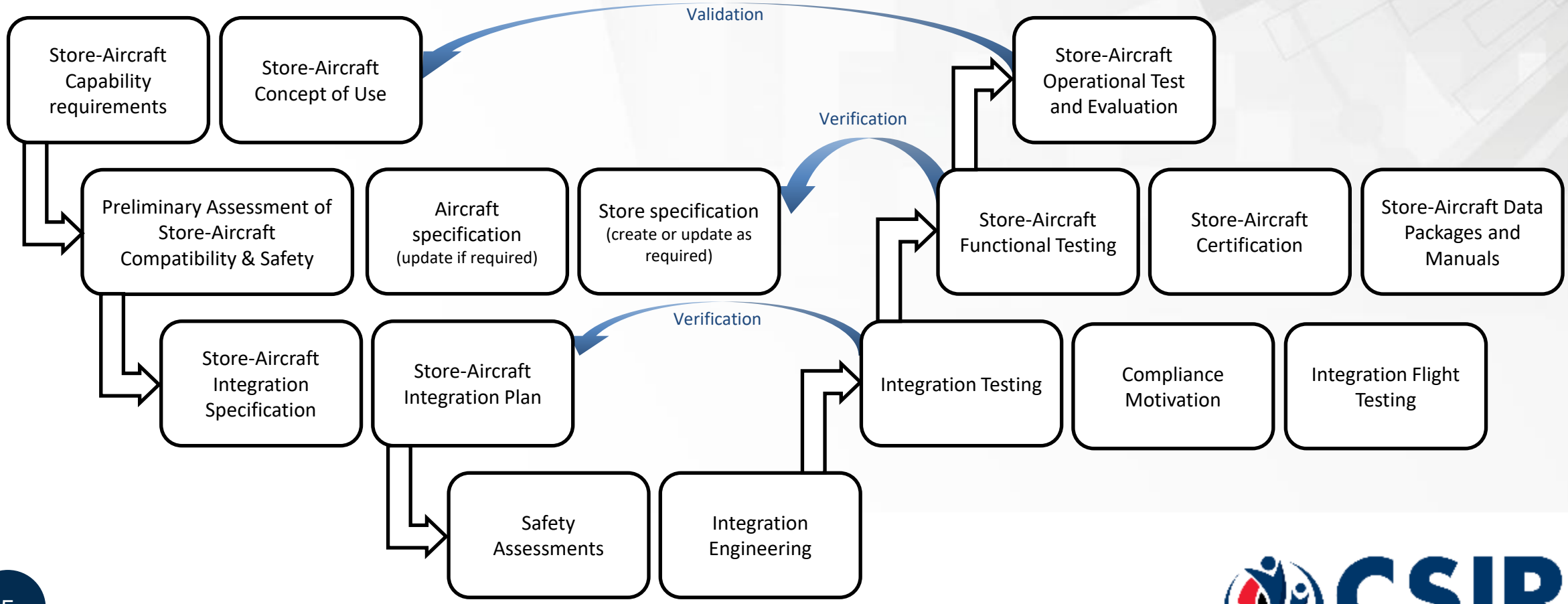

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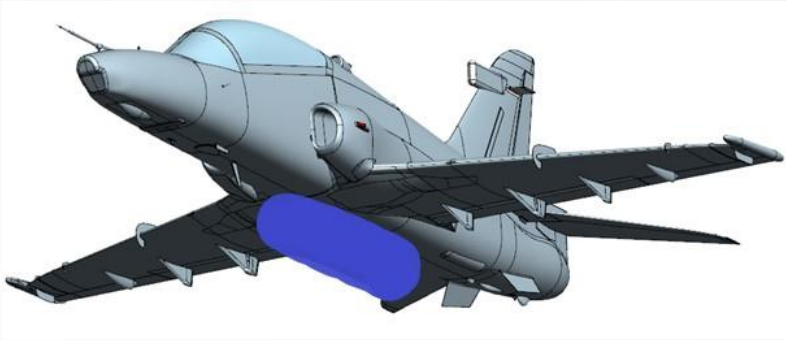
Two case studies

- **First case:** Inundu electronic warfare training pod developed by the CSIR
  - Developed and integrated using the framework presented here. Successfully integrated with multiple types of aircraft in a short space of time

- **Second case:** electronics pod from an external party
  - Not developed/integrated within this systems engineering framework



- Impact of the two approaches are contrasted relative to some of the parameters in the systems engineering framework in the following table

Two case studies

Parameter	CSIR Inundu Pod 	Other Pod 
Store-aircraft capability requirements defined?	Yes, complete User Requirements Specification developed at the outset	Pod technical requirements defined without reference to aircraft carriage
Store-aircraft Concept of Use (CONUSE) defined?	Yes, CONUSE used to define the Aircraft-Store environment.	CONUSE was only drafted when the pod was being assembled.
Preliminary assessment of store-aircraft compatibility performed?	Pod was designed from the outset to maximise compatibility with targeted aircraft platforms using analogy to already integrated stores. Safety concerns were assessed and addressed from the outset.	Preliminary assessment of store-aircraft compatibility was only performed when the pod was almost complete. It was found that the pod was not compatible with the aircraft. A significant redesign and rebuild was required to achieve aircraft compatibility. This delayed the project by 2 years and increased costs significantly.
Store-aircraft integration specification developed?	A store specification was developed that carefully addressed integration with multiple types of aircraft at the beginning of pod development.	The store-aircraft integration specification was only developed after the preliminary assessment of store-aircraft compatibility.
Integration engineering?	The pod was designed from the outset to have no electrical interfaces with the aircraft, facilitating rapid integration.	Integration of this pod requires (reversible) modifications to the aircraft's electric power supply and store databus systems along with a modified centreline pylon.
Aircraft integration?	The pod was integrated with three different types of aircraft(Hawker Hunter, Denel Cheetah C/D and BAE Hawk) in three years.	The pod will make its first flight much later than originally planned.

Conclusions

Systems engineering is an effective approach to manage the complexity of aircraft store integration.

Tracing and unpacking requirements from the aircraft/store capability requirements and CONUSE through the integration, design and implementation helps to ensure full and safe integration with lower risk.

The engineering of aircraft integration should start at the beginning of the store development program. Delaying this effort can have significant impact on the project.

Key store integration activities have been mapped to the systems engineering “Vee” diagram by the CSIR. This conceptual framework has been applied successfully to several store integration projects.

Thank you