Temasek Defence Systems Institute

A Digital Twin Model-based System Engineering (MBSE) Approach to Failure Analysis for an Engine System

Author: Yap Xue Yong (ST Engineering)
Thesis advisor: Dr. Douglas L. Van Bossuyt
Co-advisors: Mark M. Rhoades and Jason Bickford

Objectives: To reduce costs

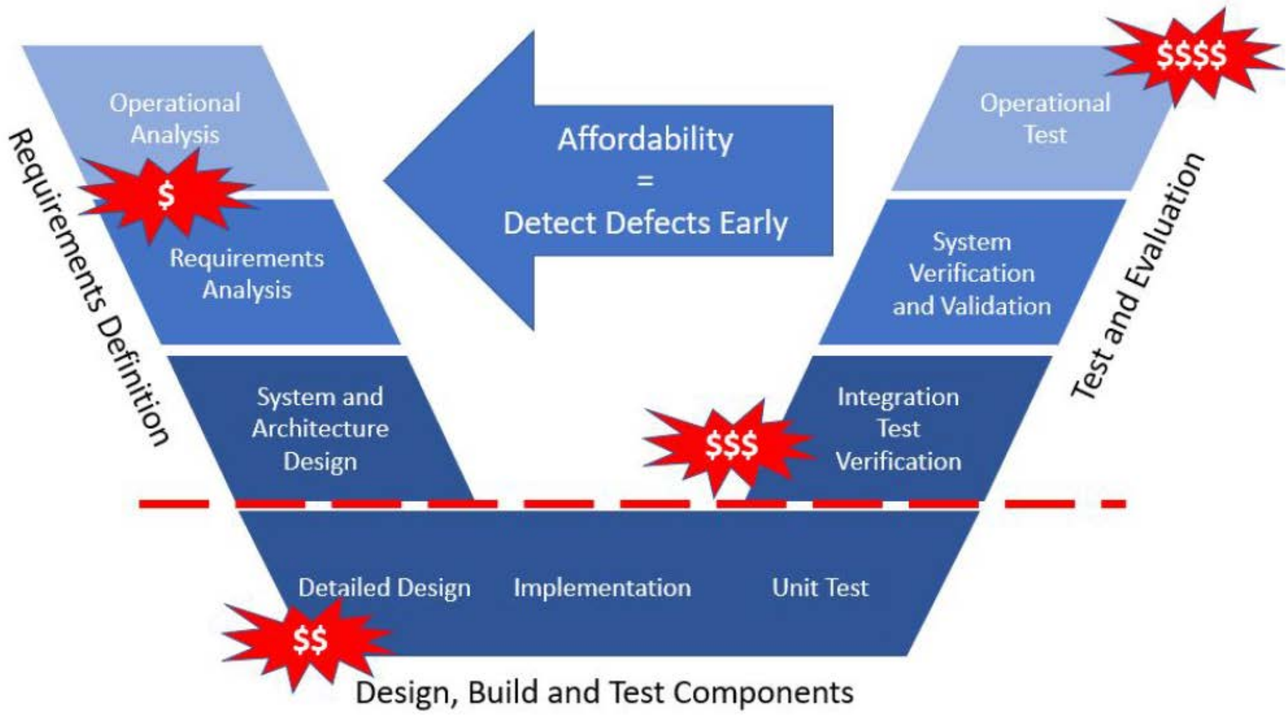
- Understanding the process of failure analysis through a corrective and preventative maintenance cycle under a typical operating scenario
- Seeking to aid engineering efforts in managing system failures in terms of Reliability, Availability and Maintainability (RAM)

Research Ideas:

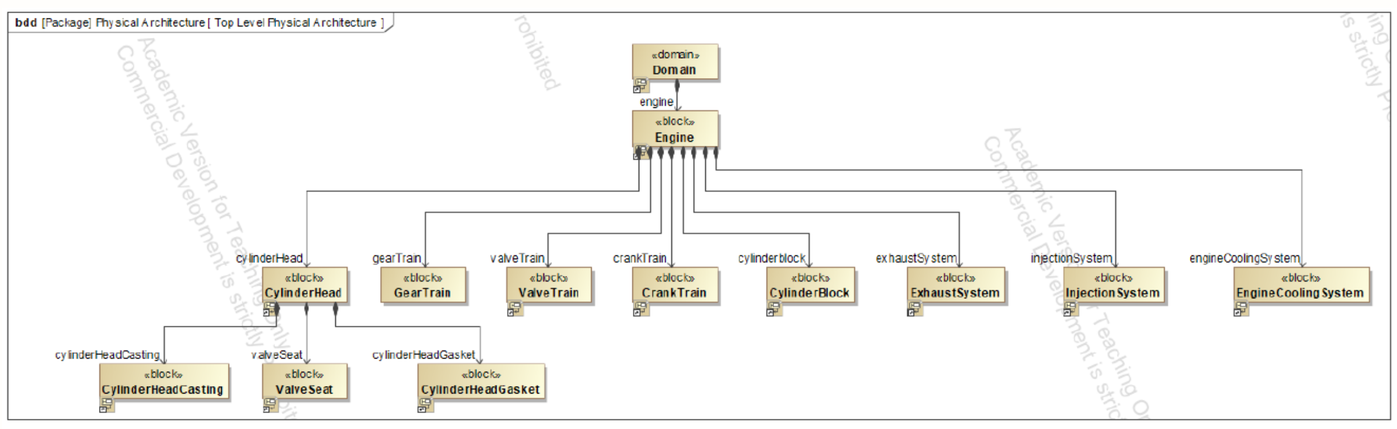
- To develop a step-by-step SE approach on failure analysis and availability study (RAM interchangeable)
- Incorporation of proven failure analysis methods (FMEA, FTA, etc) into a MBSE simulated operation scenario for an engine system
- Creation of a universal operating scenario, starting from component level to subsystem level to system

Methodology:

- Usage of Dassault Systems CAMEO Magic System of Systems Architecture (MSOSA) for simulation purposes
- Discrete event simulations in sets of different step intervals to collect parameters that compute outputs such as operation time (or operational availability)



V-model for Failure Detection. Adapted from [1].



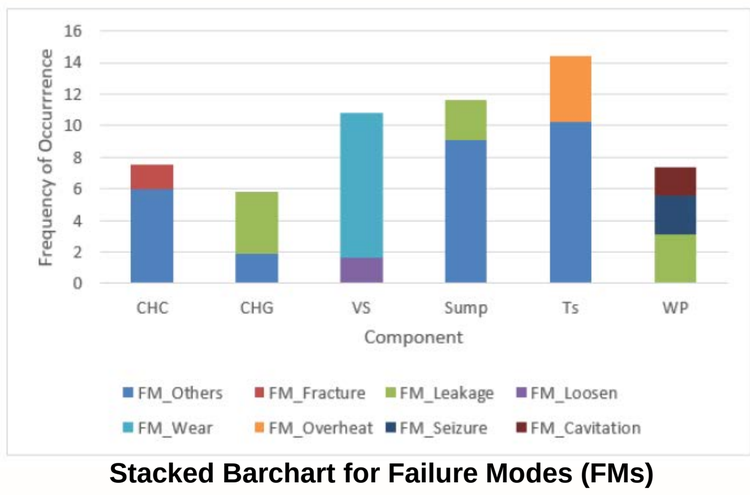
Physical Architecture of the System of Interest

Results: Inaccurate results due to semantic errors in modeling

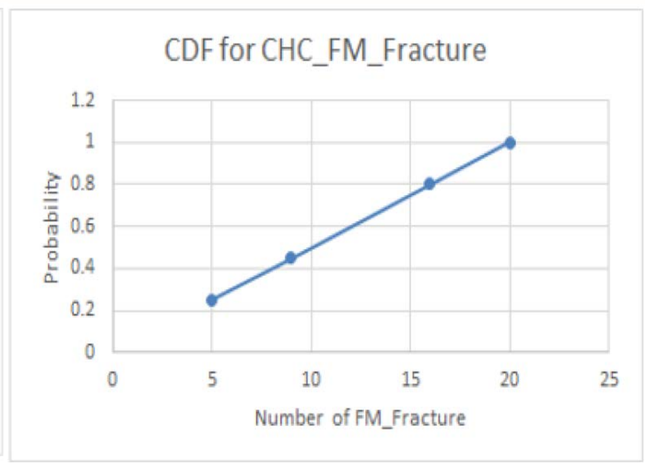
- Step counters were asynchronous from component to subsystem levels; e.g. subsystem operation time of 500s vs component operation time of 300s
- Race condition impeded the simulations

Benefits of Research:

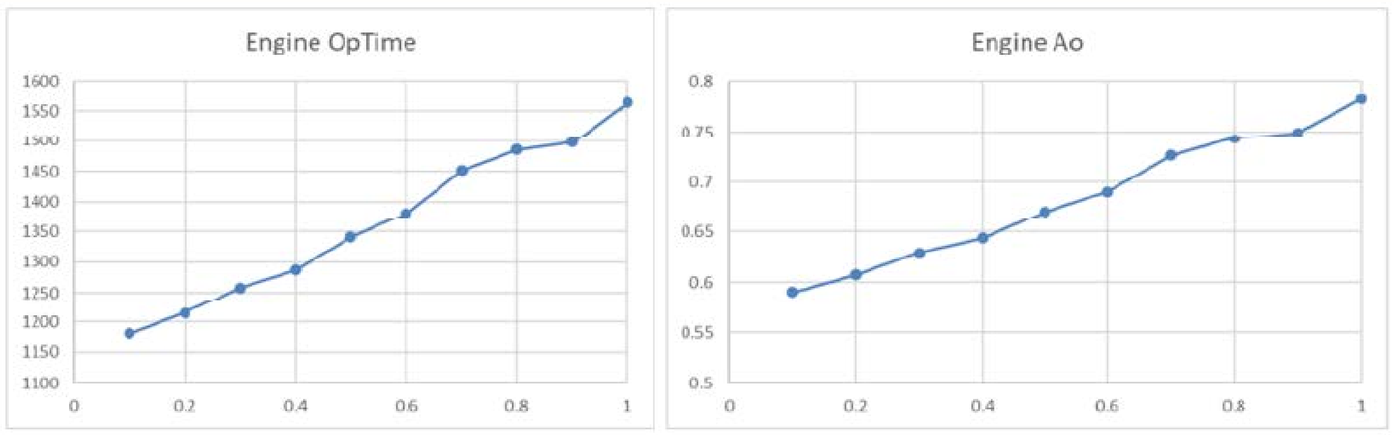
- Traceability of known failures in the system
- Virtual understanding of the system state transition in the context of failure analysis and maintenance
- Computation of simple parameters of interest such as number of failures and operation time at component and subsystem levels
- Better support for decision makers in maintenance planning and product design



Stacked Barchart for Failure Modes (FMs)



Cumulative Distribution Function for specific FM



Cumulative Probability Charts for EngineOpTime and Operational Availability

Follow-up Research Activities:

Once the underlying issues are resolved, the results are to be validated against that of a corresponding real-world system.

Reference:
[1] J. D'Ambrosio and G. Soremekun, "Systems engineering challenges and MBSE opportunities for automotive system design," in 2017 IEEE International Conference on Systems, Man, and Cybernetics (SMC). IEEE, 2017, pp. 2075–2080.

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