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ARCHITECTURAL CONSIDERATIONS FOR DATA ENTRY IN SUSTAINMENT MODELING

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ABSTRACT

This extended abstract examines the architectural considerations for data entry in sustainment Modeling and Simulations (M&S). It highlights the necessity of having a flexible yet robust data architecture that can accommodate various data types, including early design engineering estimates, test data, and post-deployment maintenance data, which often come in different formats. By establishing a data structure that facilitates efficient extraction, transformation, and loading from multiple sources, sustainment models can be quickly developed using the best available information. A case study involving a commercial off-the-shelf fixed-wing aircraft—used and maintained by the U.S. military for decades—demonstrates the architecture's adaptability across the system lifecycle. The new M&S framework supports dynamic model design and integration with evolving data inputs, enabling scalable, timely, and insightful trade-off analyses that meet the tight schedules encountered by program managers.

1 INTRODUCTION

This paper presents a sustainment Modeling and Simulation (M&S) architecture designed to align with real-world operations, supply chains, and maintenance processes. At its core is a sustainment model—an analytical suite of tools that optimizes lifecycle support plans for complex systems. The goal is to minimize sustainment costs while ensuring mission readiness. Sustainment models utilize technical data, such as component costs, failure rates, repair times, and procurement times. They also consider the support structures transportation times, personnel, and support and test equipment locations and cost. Additionally, operational data such as mission profiles and sortie rates are incorporated. Advanced analytics are employed to forecast and assess uncertainty.

The integration of various initiatives, including improved policies, modern data collection systems, and digital twins, enhances realism. However, this integration is often constrained by legacy modeling and simulation (M&S) frameworks that were not designed for today's data environments. This paper proposes a specially designed M&S architecture that fully incorporates these contemporary initiatives.

2 MAINTENANCE PROCEDURES

A critical aspect of sustainment modeling is the ability to translate real-world maintenance activities into structured formats suitable for simulation, enabling accurate cost and readiness forecasts. To support this, we have analyzed procedures and processes for both unscheduled and preventive maintenance events and developed M&S workflows that accurately represent the associated task requirements and repair actions. These workflows have been rigorously tested to capture the full spectrum of maintenance activity—from simple component replacements to complex repair sequences involving diagnostics and cascading failures.

The underlying architecture supports seamless integration of varied data sources—including vendor engineering estimates, test outcomes, and databases—regardless of format or fidelity. This adaptability ensures the simulation framework remains current and responsive, evolving alongside new data inputs throughout the system lifecycle.

3 SCENARIO BASED MODELS

Scenario-based modeling links operational profiles with the system's support structure and technical characteristics. By connecting the demands of operational missions to potential failure behaviors and support options, program planners can assess how various operational plans, supply strategies, and repair processes affect readiness and costs.

4 CASE STUDY

To evaluate our architecture, we utilized historical data from a fixed-wing aircraft. This model effectively captured historical performance trends and aligned well with sustainment cost reports. We enhanced the model further by aligning the data inputs with key acquisition documents, such as the Reliability, Availability, and Maintainability - Cost Rationale Report and the Initial Capability Document (ICD). This adaptation resulted in a digital representation of the system, which supports early decision-making by providing requirement-based estimates for sustainment costs and readiness. As we gather data from vendors, tests, and field operations, the use-case model illustrates how the models will naturally evolve, establishing a foundation for predictive analytics throughout the acquisition phases.

5 SUMMARY

This architecture transforms sustainment modeling from fragmented, isolated datasets and tools sets into an integrated, data-driven approach. It allows models to scale, evolve, and facilitate timely decision-making within acquisition constraints. The case study of fixed wing aircraft demonstrates its effectiveness in real-world conditions, providing a foundation for future studies and establishing a repeatable framework for upcoming programs.

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