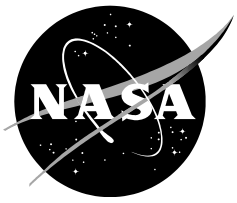
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A Systems Model for System-Wide Safety Safety Demonstrator (SD-1):
Wildfire Response Operations

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August, 2022

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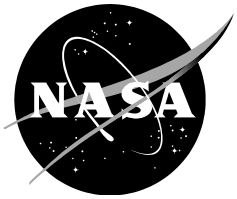
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Real-Time Risk Assessment (RTRA) Team,

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Abstract

The aim of this internship-based project was to contribute to the ongoing development of a systems model for System-Wide Safety's (SWS) first Technical Challenge 5 (TC5) series Safety Demonstrator (SD-1), which will be a demonstration of an In-Time Aviation Safety Management System (IASMS) in emerging wildfire response operations.

Using Models-Based Systems Engineering (MBSE) principles to develop the model, I organized and traced previously collected stakeholder needs from the Spring 2022 NASA System-Wide Safety Wildland Firefighting Operations Virtual Workshop (https://nari.arc.nasa.gov/sws-wildfire) to system elements, creating connections which can be used in the future by the project engineers to identify and address requirements gaps throughout the system design process. I also identified and modeled preliminary use case scenarios for aerial assets in the demonstrator and, building on previously produced preliminary high-level models of the 8 SD-1 Services, Functions, and Capabilities (SFCs) and their IASMS data flows, worked to model the Real-Time Risk Assessment (RTRA) tool as an implementation of Risk Assessment and Management that can take in multiple sets of data monitored by SFCs.

Project deliverables include stakeholder requirements tables and matrices and systems model diagrams produced with MagicDraw software in the SysML Systems Modeling Language, with eventual plans to connect model diagrams to a Department of Defense Operational Viewpoint (OV-1) graphic, a high-level operational concept graphic that will be used to visualize the SD-1 scenario in a future phase.

The system model serves to provide a common understanding of the scope of and activities necessary for the completion of SD-1, and traces how stakeholder needs are to be addressed.

Introduction and Background

The Wildfire Scenario

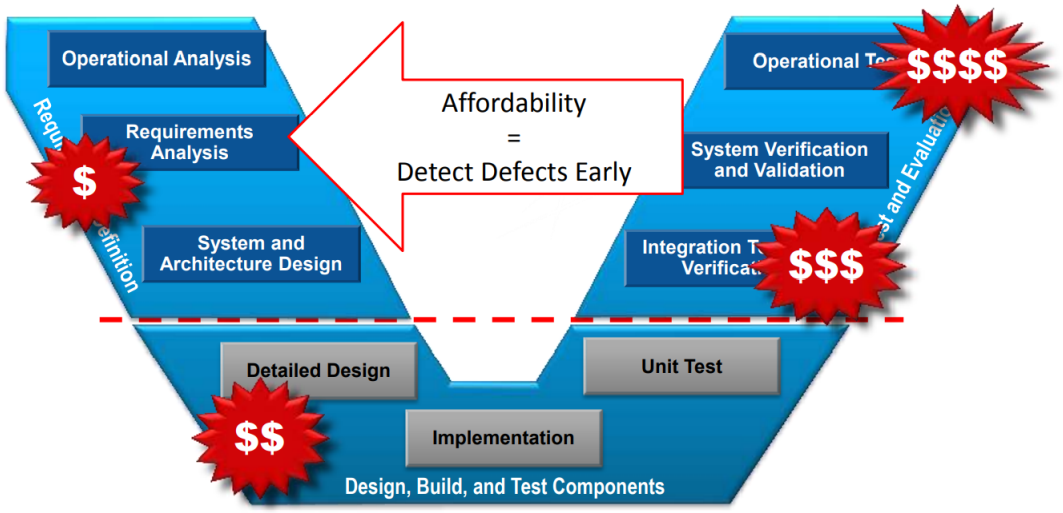
The introduction of unmanned aerial assets into the wildfire fighting ecosystem has the potential to reduce the risk to humans, both from fatalities during aerial operations and by improving situational awareness through improved data collection, fusion, and display. The Safety Demonstrator 1 (SD-1) is part of the Technical Challenge 5 (TC5) series devised by System-Wide Safety to develop the In-Time Aviation Safety Management System (IASMS) concept through increasingly complex and risk critical operational scenarios, while also meeting a humanitarian need by developing the use of aerial assets in disaster-oriented operations.

The Current Phase of SD-1 Development

In support of the TC5-03-01 Initial Stakeholder Engagement Concept of Operations Development milestone and the upcoming TC5-03-02 Identification of key gaps and prioritization of NASA, SWS milestone, the top goal of the internship project was to review and model stakeholder requirements to enable their allocation to preliminary mission, safety, and traffic scenarios, and to a current list of 8 IASMS SFCs that are under consideration for SD-1.

Model-Based Systems Engineering (MBSE)

Systems Engineering processes at NASA make wide use of Model-Based Systems Engineering (MBSE) principles, tools, and languages. MBSE replaces traditional document-centric engineering practices [3] with a model-centric practice in which the model as an abstraction of the System of Interest (SoI) becomes the chief artifact. The model preserves system elements and their linkages explicitly. Model-centric design increases the ability to manage system complexity and improves communications, enhancing knowledge capture and transfer and the evaluation of Consistency, Correctness, and Completeness across a project [4]. It also supports both traceability and validation and verification steps throughout the design process, which in turn enables complex development lifecycles [4]. A modified version of a classic Systems Engineering process model known as the “V model” shows how MBSE incorporates ongoing validation throughout the engineering process.



From Laura E. Hart, Introduction to Model-Based System Engineering (MBSE) and SysML. Presented for Lockheed Martin at INCOSE in July of 2015.

This version of “the V” emphasizes the monetary benefits of being able to detect design defects early on; other authors emphasize this ability in terms of how MBSE enables dynamic development cycles.

SysML is the most widely used systems modeling language available [6]. It is an extension of the Unified Modeling Language (UML2) developed for the field of software engineering. The Dassault Systèmes MagicDraw platform is one of several software tools available for use with SysML [3].

Summary of Work

Approach and Preparation

In the first phase of the internship, I completed the SysML Fundamentals course offered through MTSI Digital Engineering Academy (https://www.mtsi-va.com/), a program that utilizes the Dassault Systèmes MagicDraw platform used in multiple Systems Engineering processes at NASA. I consulted additional MBSE and SysML written resources to learn Models-Based Systems Engineering principles and SysML language fundamentals including classification and use of model diagrams, elements, and relationships.

I also reviewed documents and publications associated with SD-1, including the IASMS Concept of Operations [2], the SD-1 concept video storyboard and SD-1 related presentations, the parallel NASA Scalable Traffic Management for Emergency Response Operations (STEReO) and System Modeling and Analysis of Resiliency in STEReO (SMARt-STEReO) Concept of Operations [5][7], and publications on RTRA (Real-Time Risk Assessment) [1][8].

Description of NASA Digital and Human Resources

I conducted my work on the project with a MagicDraw license installed on my NASA computer along with the SysML extension. I did not have access to the NASA Cloud capabilities for MagicDraw as an intern, so I worked with a copy of the model file; additionally, I created my own sandbox file to use to experiment with different ways to model and completed most of the modeling elements I created or modified there.

All Systems Engineering processes involve communication with internal and external stakeholders. I had access to the 2022 Workshop proceedings and to derived details included in the Workshop Report draft, including derived NGO (Needs, Goals, and Objectives) Requirements. I conducted several meetings with NASA SD-1 project leads and viewed technical presentations with project updates. I also conducted several meetings with NASA Researchers to collect technical details about RTRA.

I was also connected to NASA community resources such as MBSE interns and the MBSE Community of Practice as well as with NASA partners through a regular cycle of meetings.

Results and Conclusions

A first list of stakeholder requirements, covering the needs of the firefighting community with respect to data, communications, and aerial safety, was captured by reviewing the report from the Spring 2022 NASA System-Wide Safety Wildland Firefighting Operations Virtual Workshop (https://nari.arc.nasa.gov/sws-wildfire). The workshop leaders had derived a list of 3 major stakeholder requirements that could be addressed by SD-1 with respect to aerial safety. These derived requirements were modeled and connected to the SWS IASMS (In-Time Aviation Safety Management System) and to the goals of SD-1 and the needs of Aerial Safety and Firefighting Safety. The overlap between stakeholder requirements and the scope of SD-1 was further evaluated through a series of meetings and versions of the model, which allowed the requirements relationships to be refined further.



Requirements Derivation Map showing requirements traced to a Firefighting Safety Need, produced in Dassault Systèmes MagicDraw tool

The preliminary list of SFCs and mission scenarios under consideration for SD-1 were gathered from developing project documentation, the recent TC-5 Annual TechTalk, and conversations with project leaders. Traffic scenarios were considered with reference to concept of operations documentation from the related STEReO and SMARt-STEReO projects, which focus on traffic management and the resiliency of the traffic management concept proposed by STEReO, respectively, for use in aerial wildfire fighting.

Building upon previous interns' modelling of the wildfire fighting operations and communications, work for this internship project included refining the modeling of top-level aerial operations. Additions include preliminary aerial mission scenarios and traffic scenarios as use cases, to which stakeholder requirements could be allocated, within the Wildfire Scenario system context. Requirements are also directly allocatable to IASMS SFCs, which are currently modeled at a very high level in the Systems Model.

Model diagrams created using SysML in MagicDraw:

- Requirements Tables
- Derived Requirements Flow
- Requirements Trace Matrices
- Requirements Allocation Matrices
- Requirements Maps
- High-level diagrams of possible mission scenario use cases and activities
- High-level modeling of Real-Time Risk Assessment (RTRA) as an implementation of Risk Assessment and Risk Management

The systems model-as-artifact serves as a dynamic, living tool throughout the development process of any system. As discussed above, the main benefit of MBSE is that the ability to trace elements and validate the model remains visible throughout the design process, and changes and modifications to the system elements or relationships are centralized.

This is an early phase in the SD-1 project, and the connections between mission and traffic scenarios, stakeholder requirements, and SFCs (Services, Functions, and Capabilities) modeled in this phase will be built on and modified over the next 2.5 years leading up to the SWS Safety Demonstrator scheduled for early 2025.

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