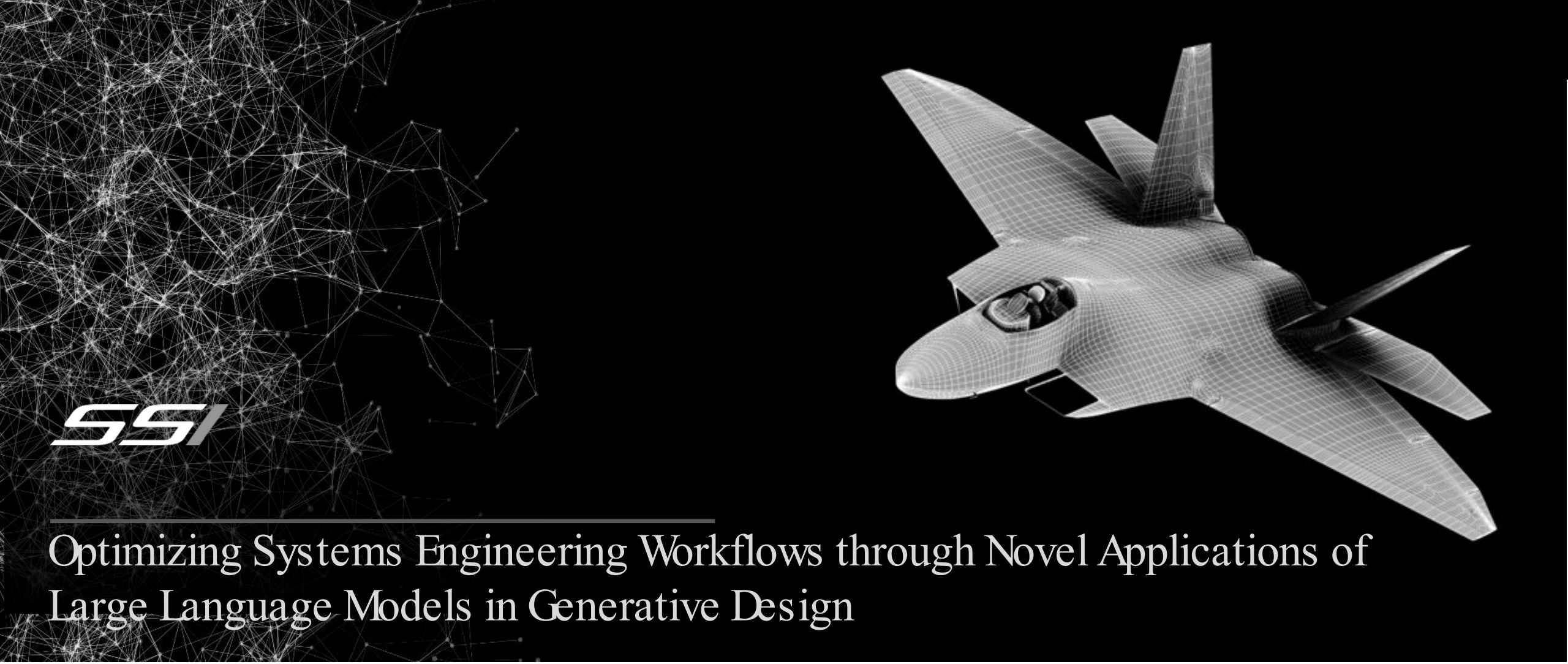

Optimizing Systems Engineering Workflows through Novel Applications of Large Language Models in Generative Design

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Additional Research : Nolan Peterson

Individuals Involved

Ryan Pykor
SSI

A Lead Systems Engineer at SSI, Ryan has supported multiple ground vehicle and robotic programs applying skills in systems analysis and design to aid decision makers through the development of Whole Systems Trade Study models. Ryan received a Bachelors of Science degree in Biomedical Engineering, a Masters of Science in Biomedical Engineering, and a Master of Science in Data Science from Wayne State University. Ryan is also an OMG Level II Certified Systems Modeling Professional.

Ed Serzo
SSI

A Principal Software Engineer at SSI, Ed Serzo has over twenty five years of experience in Software Architecture, Software Engineering, and Data Architecture in the Networking, Automotive, Utility, and Research sectors. Ed received a BS from Michigan State University, and a Masters in Computer Science from Georgia Institute of Technology.

Nolan Peterson
SSI

Nolan Peterson is an Intern and Analyst supporting SSI research and development programs. His contributions include surveying Large Language Model capability and providing inputs to the team to assess suitability for SSI's model based exchange project for the US Air Force. Nolan has also collected data and taken measurements for use on other SSI projects, such as the Collaborative Trade Study project for NASA. Nolan is a senior at the International Academy, Okma, and he has completed Georgia Tech's Introduction to Model Based Systems Engineering.

Objectives

Optimize and enhance system engineering workflows through applications of large language models (LLM)

- Creation of SysML artifacts – produce SysML diagrams without extensive understanding of modeling language and reliance on modeling software
- Bridge the gap between legacy digital engineering artifacts and system models – leverage LLMs to contextualize unstructured documents into a well-defined schema
- Ensure safety, correctness and repeatability through implementation of deterministic layers and model pipeline

Introduction to Large Language Models (LLM)

What are language models?

- Language models are machine learning models that aim to predict and generate plausible language[1]

How do language models work?

- These models work by estimating the probability of a token or sequence of tokens occurring within a longer sequence of tokens[1]
  - token - word, sentence, or series of sentences

```
When I hear rain on my roof, I _______ in my kitchen.
```

```
cook soup 9.4%
warm up a kettle 5.2%
cower 3.6%
nap 2.5%
relax 2.2%
...
```

What makes a language model "large"?

- Large can refer to either the number of parameters in the model or number of words in the training dataset[1]

Where are large language models used?

- LLMs are the driving force behind the popular applications ChatGPT and Bard
- More recently, custom applications driven by use of LLMs on custom data sources (langchain, open source LLMs)

[1] https://developers.google.com/machine-learning/resources/intro-llms

Leveraging Generative AI to create SysML Artifacts

Behavior

Input: "User Story" or textual description of a process and output schema

Leverage LLM to:

- Identify system/actor
- Identify actions performed in activity
- Assign actions to system/actor
- Determine order of actions
- Output in structured format (.json) with specific schema

Output: activity diagram with swimlanes, actions, and control flows

Structure

Input: Textual description of system to be modeled and output schema

Leverage LLM to:

- Create textual version of block definition diagram
- Output in structured format (.json) with specific schema

Output: block definition diagram with composition and association relationships

Leveraging Generative AI to create SysML Artifacts – Behavior

"User Story"

After arriving at the delivery location, the autonomous delivery vehicle deploys its onboard micro-drone. The flying drone flies around the property and takes a video survey. The autonomous delivery vehicle's onboard planning computer uses the video information to select the best location (a porch for example) to leave the package. The onboard planning computer then maps the best path from the delivery vehicle to the package deposit location...

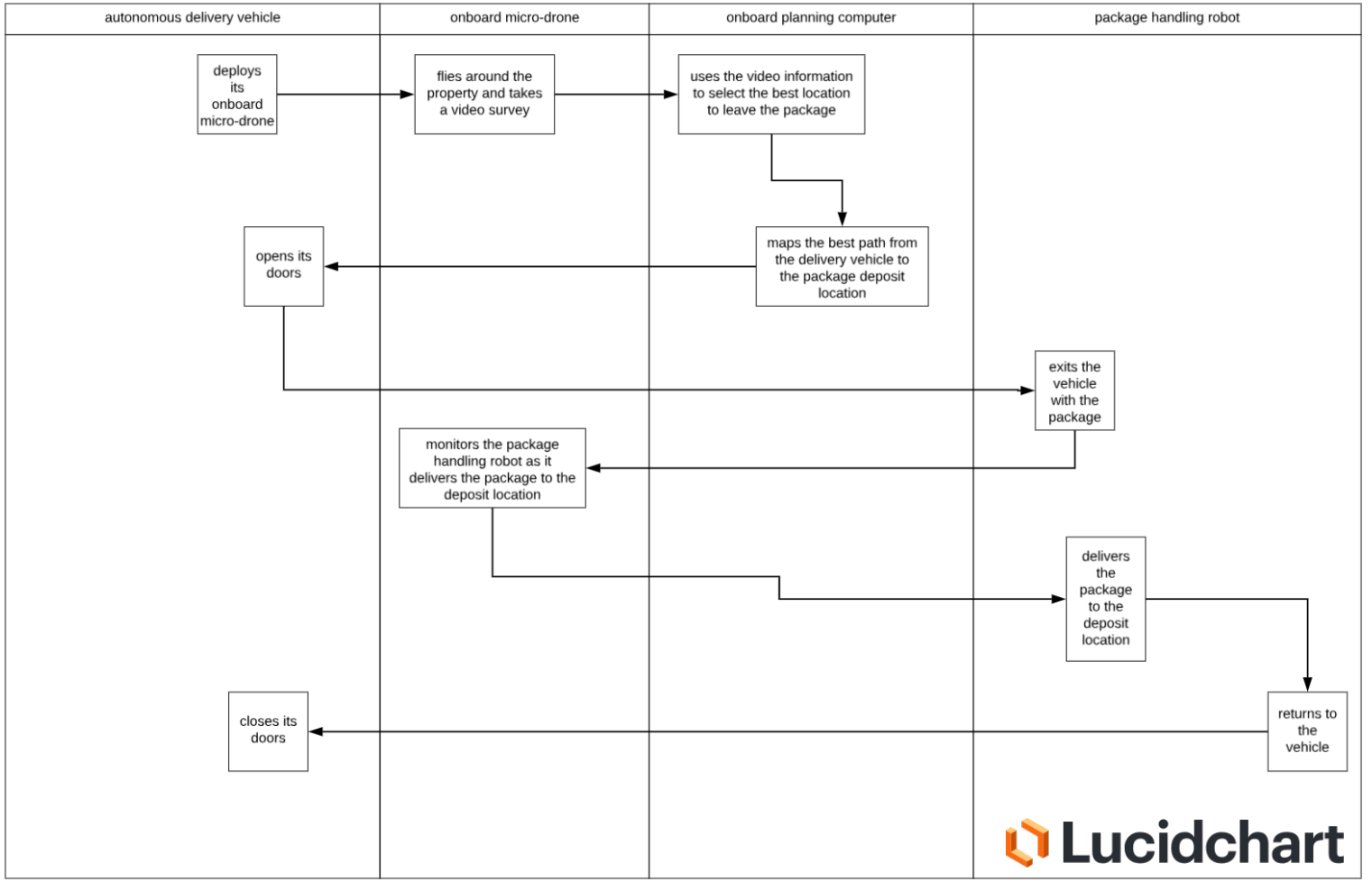
LLM
Prompt template:
1. Clear, specific step by step instructions to complete the task
2. Asks for structured output following given schema

.json

python™

Format mapping layer

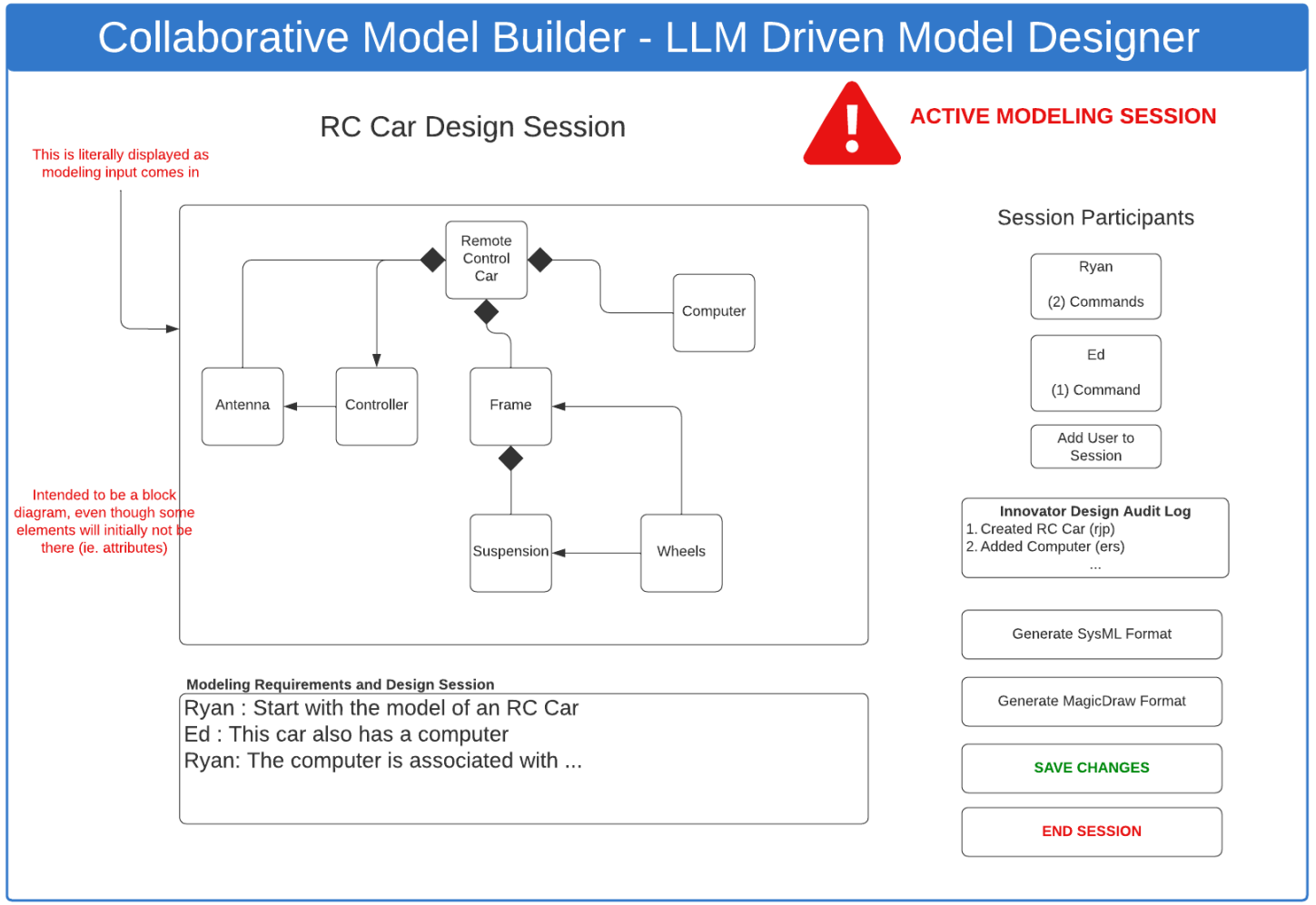
Lucidchart input format



Leveraging Generative AI to create SysML Artifacts – Structure

Remote Control Car
Must include: battery, motor, remote control, chassis

LLM
Prompt template:
1. Clear, specific step by step instructions to complete the task
2. Asks for structured output following given schema



MbX – Bridging Legacy Digital Engineering Artifacts

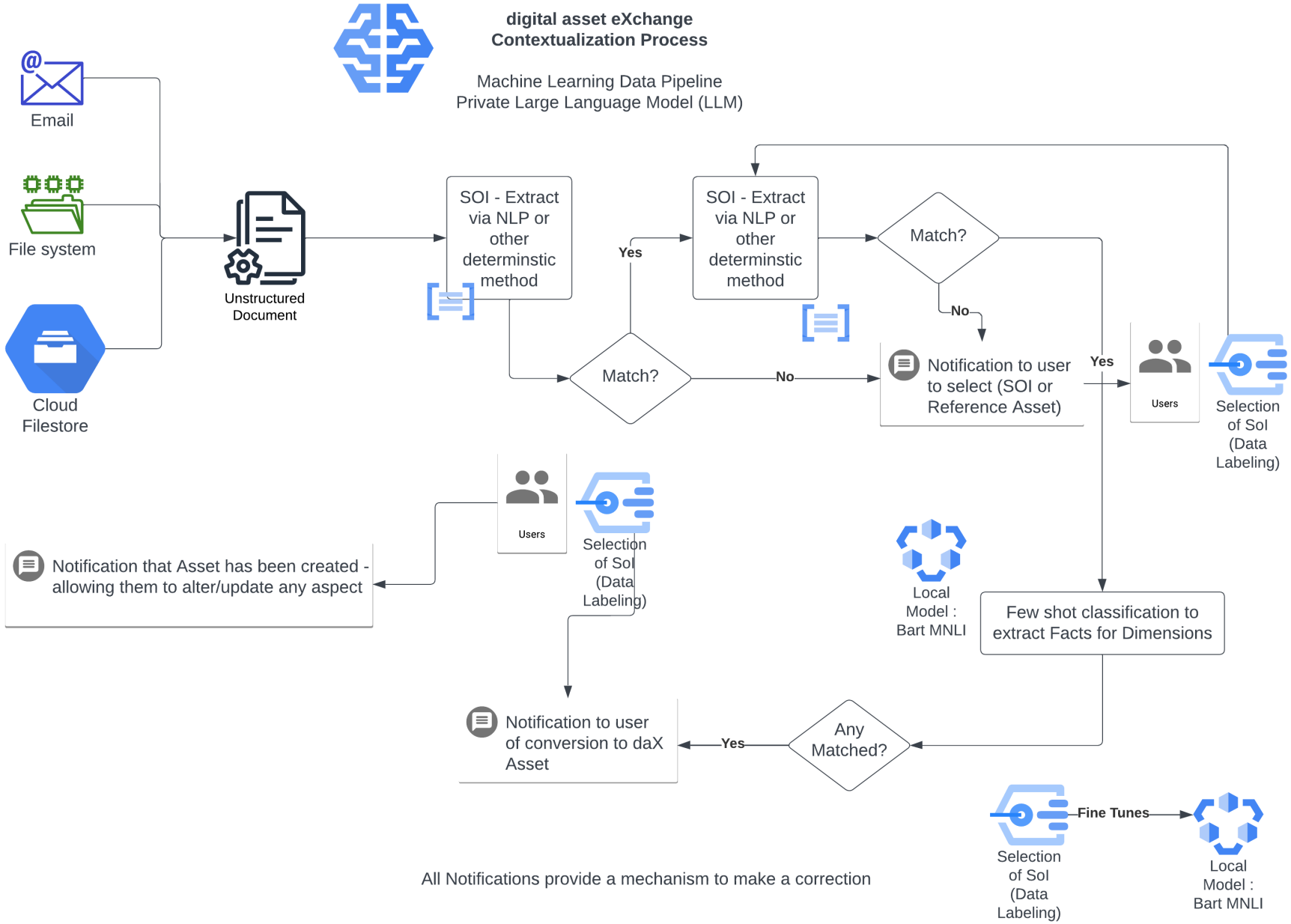
Bridging legacy digital engineering artifacts and System/Analytical Models

Artifacts such as text documents or emails are ingested and contextualized utilizing a Large Language Model

SysML Models in MagicDraw can also push their context (via a MagicDraw plugin) into mbX

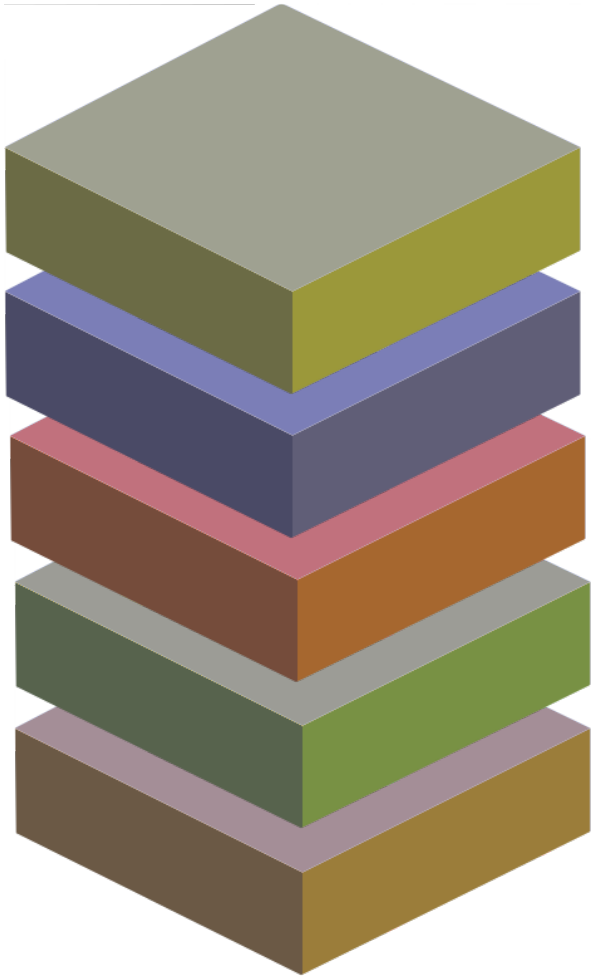
The common format between the two consists of a basic ontology – System of Interest, System of Interest Family, Reference Asset and Dimensional Data (Facts – ie. Size, Weight, Power, Cost)

MbX – Contextualization Service and ASoT



Safety – Layers around the Production LLM

Multi Layered Approach to Improving Trust and Use



Human acceptance (LLM09 - Overreliance) - Submitter Notification + ASoT Selection

Execution Verification (LLM09 - Overreliance)

Model Execution

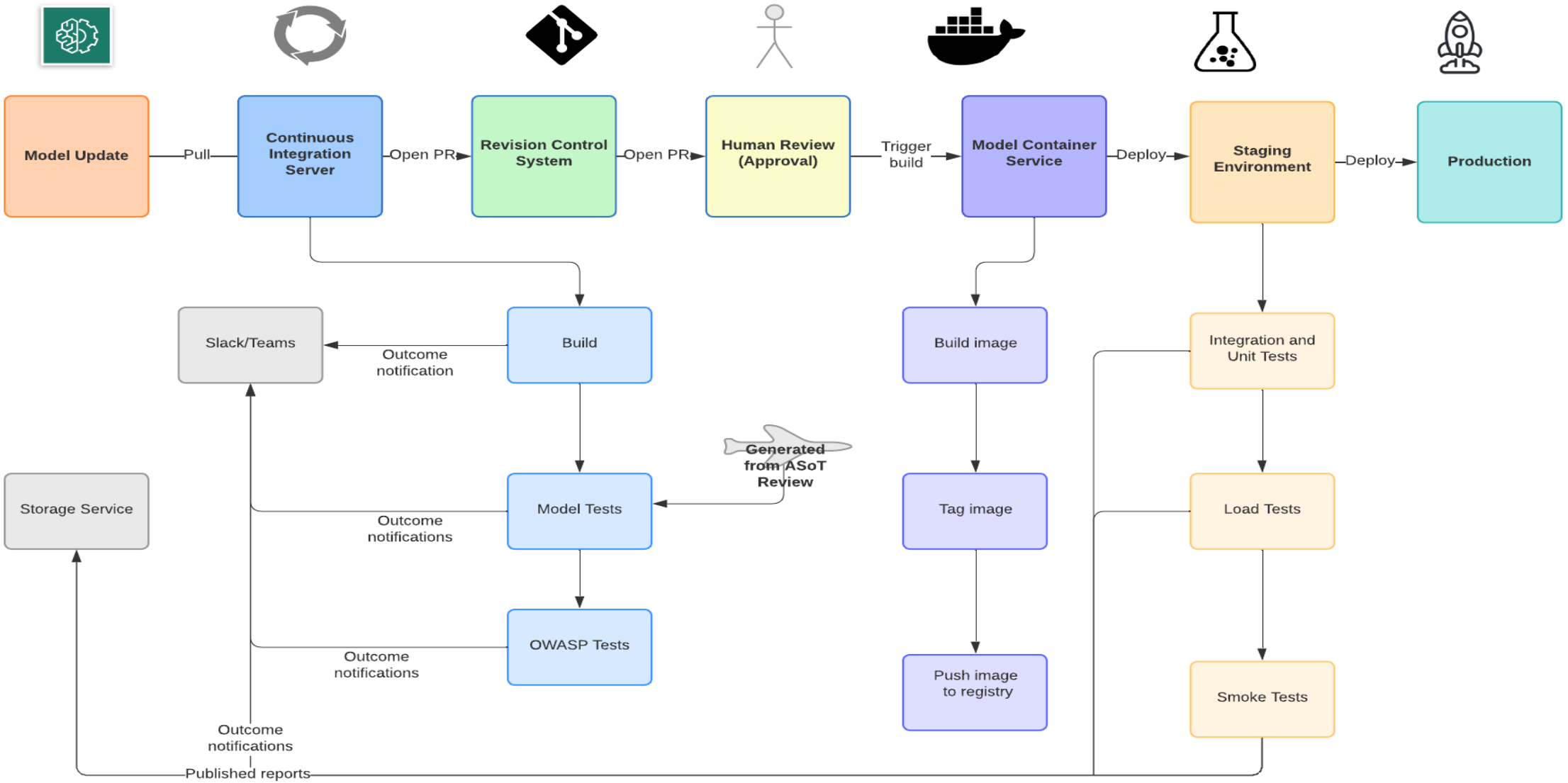
Parameterizing the Prompt (LLM01 Prompt Injection)

Queuing and Limiting of Jobs (LLM04 Denial of service)

Reference : OWASP Top 10

https://owasp.org/www-project-top-10-for-large-language-model-applications/assets/PDF/OWASP-Top-10-for-LLMs-2023-v05.pdf

Safety - Verification and Validation – Model Pipeline



Purpose is to ensure the correctness and reproducibility of LLM responses

Thank you!

For interest in continuing the conversation, future collaboration opportunities, or availability of proof of concepts presented, please contact Ryan Pykor or Ed Serzo

Ryan Pykor: rpykor@systemxi.com
Ed Serzo: eserzo@systemxi.com

Air Force SIBR Background
Company Name: System Strategy, Inc
mbX
Topic Number: AF203-DCSO3
Proposal Number: F2D-1683
SBC Control ID: 000693913
Concluding December 2023

NASA SIBR Background
Company Name: System Strategy, Inc
Collaborative Multidimensional Trade Space Analysis Capability
Proposal Number: 23-1- S17.02-1729

Currently in Phase I