34th Annual INCOSE international symposium

hybrid event

Dublin, Ireland
July 2 - 6, 2024

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

Individuals Involved

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.

Ryan Pykor

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.

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, character, 'subwords'. In domains outside of language models, tokens can represent other kinds of atomic units. For example, in computer vision, a token might be a subset of an image.

What makes a language model "large"?
Large can refer to either the number of parameters in the model or number of tokens in the training dataset[1]

Where are large language models used?
LLMs are the driving force behind the popular applications ChatGPT and Gemini (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...

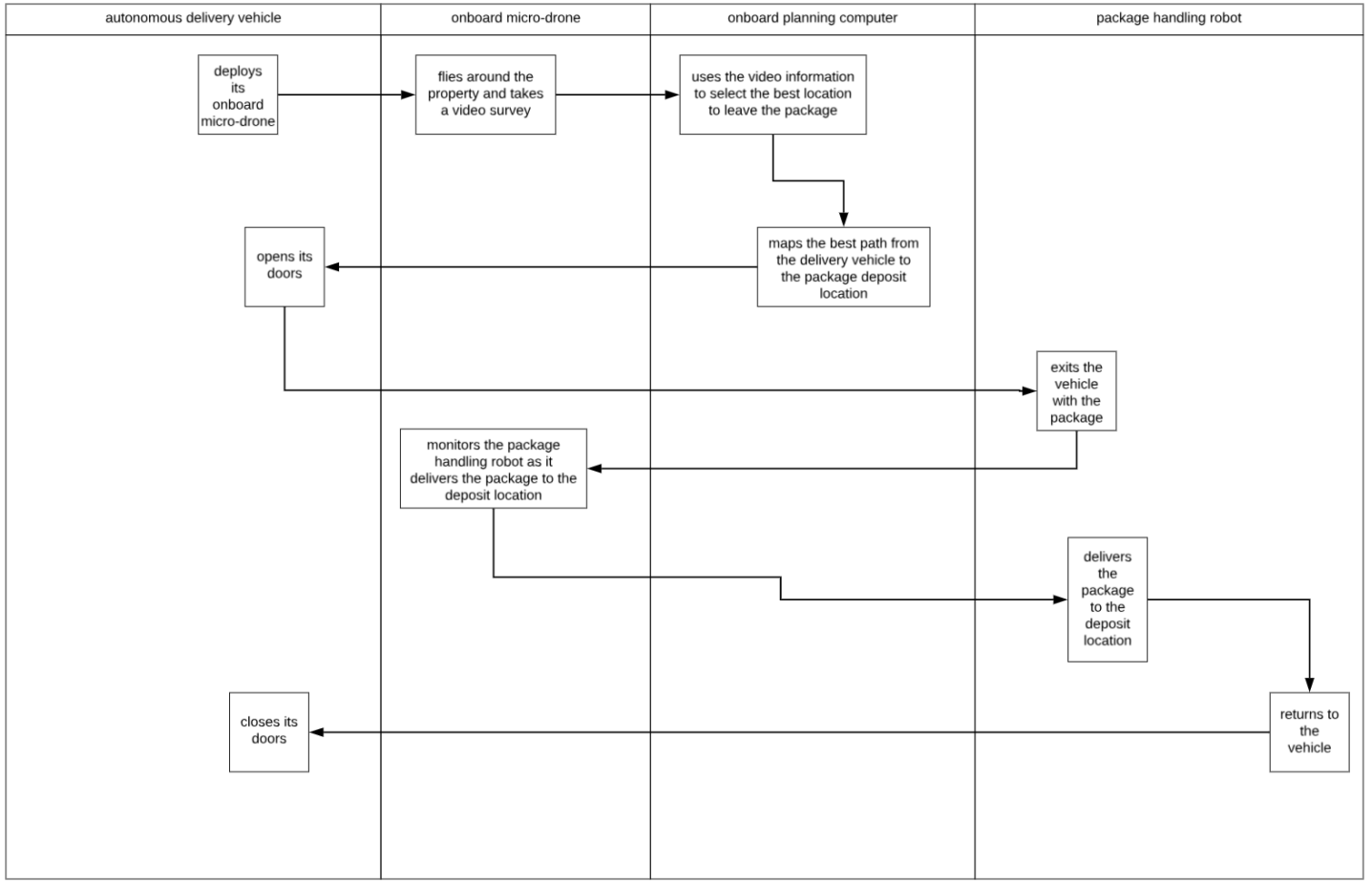
LLM
Prompt template:
1. Clear, specific step by step instructions to complete the task
2. Asks for structured output following given schema

.json

python™

Format mapping layer

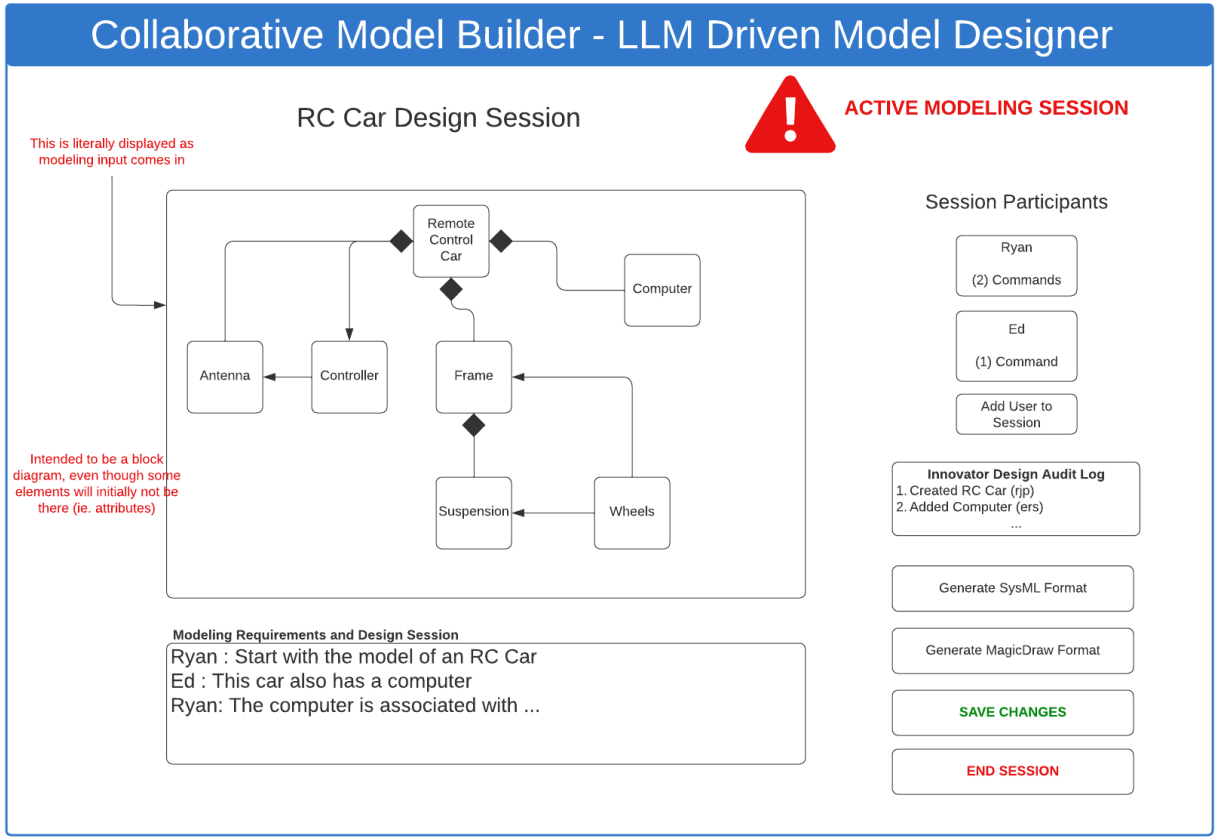
Lucidchart input format



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



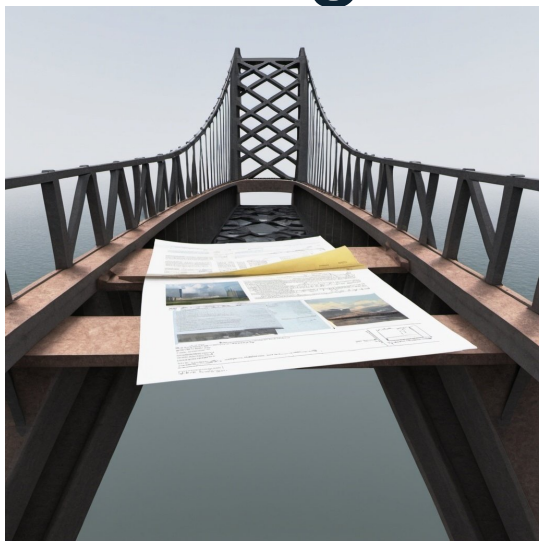
Systematic Approach for Best Results

- Human in the Loop
- Decide on metrics (+metric weight) for model output
  - Completeness
    - Penalty for Hallucinations
  - Accuracy
    - Validate using the model
  - Speed
  - Step Ordering
    - Parallel (Value)
    - Sequential (Value)
- Selection of Artifacts and Model
- Prompt Generation and Iteration
  - DSPy as the future?
- Apply a process to measure results >> LLMOps

mbX – Bridging Legacy Digital Engineering Artifacts

Normalization of Data

* Word, Email, PDFs, …
* Subject Matter Expert
* Analytical Models
* System Models
* Simulations, Tests, …



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 (SoI), SoI Variant, SoI Instantiation, Base Asset and Dimensional Data > Dimensions + Facts – ie. Size, Weight, Power, Cost

Data Today

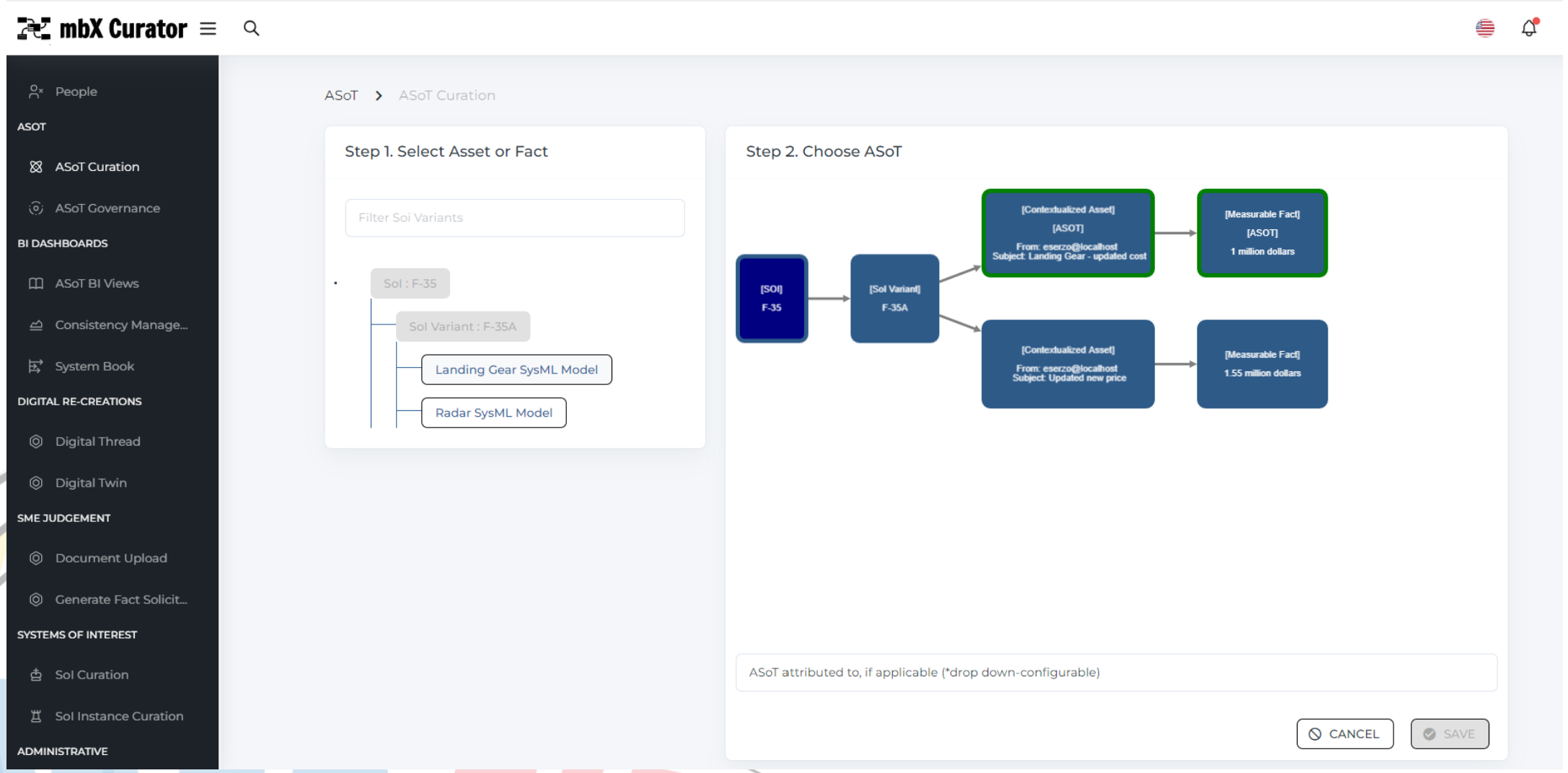
1. Generate Data
2. Projects to find generated data
3. Buy ins to pool data
4. Pool data into Data Lake
5. Massive ETL Projects that try to match data experts with SMEs -- ETL occurs after data has been aggregated
6. Data in data warehouse

Proposed Future

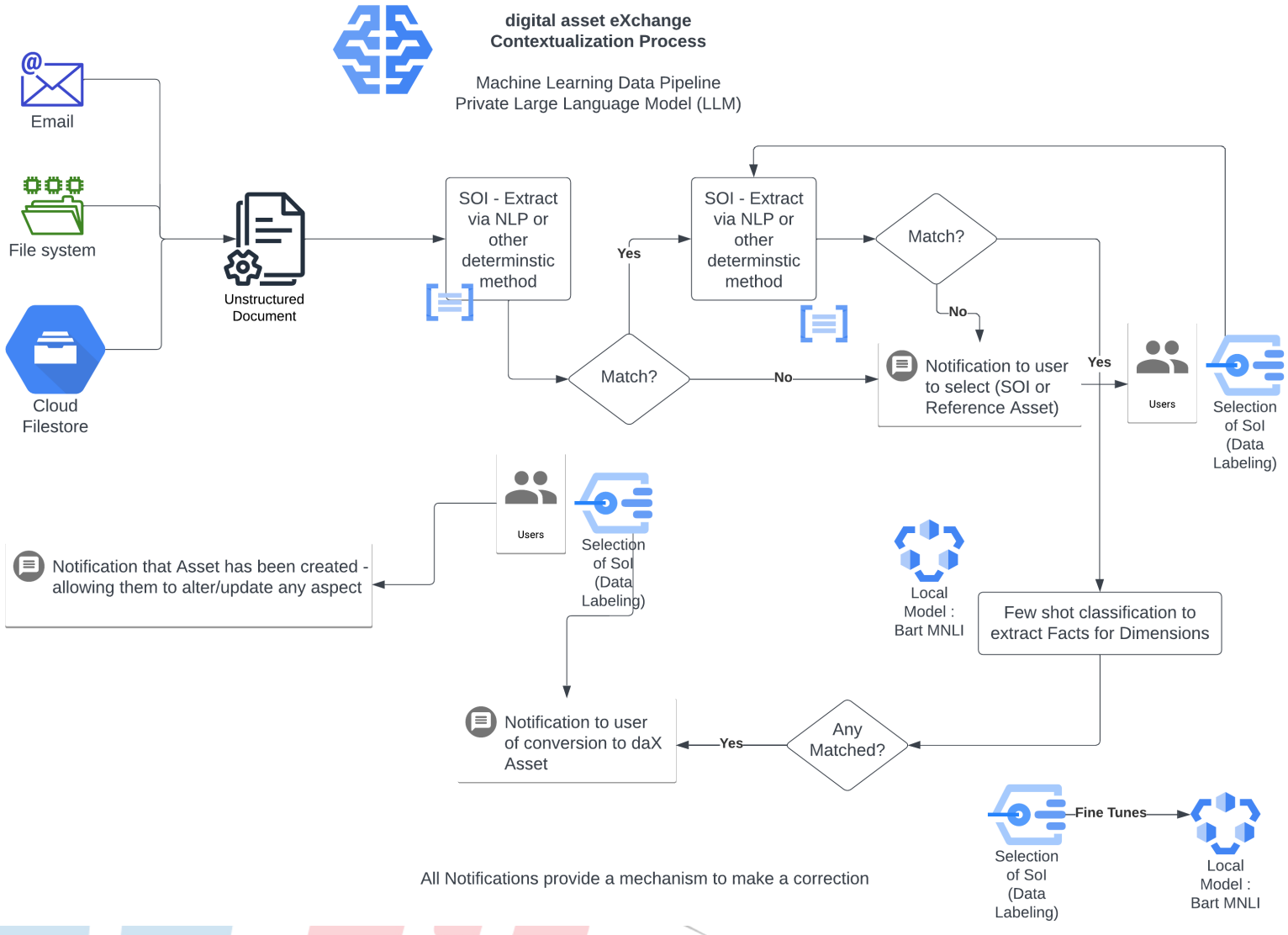
1. Work with a data modeler (1 type of data expert), capture dimensions and base (reference) asset
2. Generate Data

- Interpret data directly into data warehouse leveraging LLM

Authoritative Source of Truth (ASoT)



mbX – Contextualization Service and ASoT



Thank you!

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

Ed Serzo: eserzo@systemxi.com
Troy Peterson : tpeterson@systemxi.com

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

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

Currently in Phase II

34th Annual INCOSE international symposium

hybrid event

Dublin, Ireland
July 2 - 6, 2024

www.incose.org/symp2024
#INCOSEIS