

## GUIDE

Generating User-centric Intelligent Designs for Digital Engineering

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### What are you trying to do?



Generate a digital engineering model (SysML: requirements, structure, behavior) "artifacts" from document-based requirements and design narratives.

- How is it done today, and what are the limits of current practice?
  - Skilled practitioners use a GUI to build digital models by hand through analysis of reference documents. Practitioners are in short supply in industry and are also needed to address later stages of the product development lifecycle.
- ▶ What is new in your approach and why do you think it will be successful?
  - Use of new LLMs and GPT4 shows promise in understanding documents and generating structured results like SysML (*maybe...*).
- ▶ Who cares? If you are successful, what difference will it make?
  - Agile Digital Engineering is a core component of Leidos' Mission Systems and Integration (MS&I) market area strategy. Al-assisted generation of initial system models will accelerate program startup and promote consistent rigor across MS&I programs.

### **Experiment Setup**



- Protocol: A group of system modelers were given a user scenario from a submitted RFP and instructed to create a list of requirements and an activity diagram within a maximum amount of time of 5 hours. They were also provided a follow-up questionnaire to reflect on their experience. The models are scored across 31 quantitative and qualitative metrics.
- Participants: Modelers divided into two levels by professional modeling experience: Associates and SMEs.
  - Within each sample group:
    - **Control** one modeler followed their usual procedure, with no GPT input
    - GPT-assisted:
      - > Accelerated given an initial diagram and requirements list generated by GPT
      - > Open Access given a list of proposed prompts and free access to GPT
  - Some notes about our participants:
    - All Associates had a domain-relevant background
    - None of the participants were at all familiar with the proposal or specific scenario used
    - We know that 6 participants is not statistically significant\*\*

### **Experiment Setup**



### What we did:

- Participants received an email with the scenario and any other appropriate other materials for their group
- They returned models via email to the team leads
- Created models were then:
  - Anonymized (stripped of identifying information (where possible))
  - Delivered to a DE SME for evaluation. The evaluator:
    - > Was previously familiar with the proposal, having been on the original response team
    - > Had access to the original response team's developed models for comparison

### **Evaluation**:

- The evaluator returned the completed metrics questionnaire for each model
- After all models were annotated, we held a qualitative interview to get more qualitative feedback regarding each one

# Less Talk More Prompts How about a Demo?

### **Scenario – Well Child Care**

#### Scenario #4 - Well Child Care

The intent of this scenario is to demonstrate those features that are specific to the delivery of well child care services. This scenario consists of demonstration of growth charts, immunization functions, and anticipatory guidance.

Patient History: The patient is a 6-month old infant who was born at a private-sector hospital in an adjacent state, received initial Hepatitis B vaccine (HepB #1) before discharge (at the private-sector hospital). Had a well-child visit at this IHS facility at 2 months of age, and received three vaccines (Hib #1, DTaP #1, and IPV #1). However, at that visit the parents declined the others that were offered (HepB #2, RV1 #1, and PCV13 #1) because they felt that was too many shots. The child missed the scheduled 4-month visit and related immunizations.

At this 6-month well-child visit, the nurse notes that the EHR does not show the HepB #1 that the parent reports the patient received after delivery, so consults the state Immunization Information System (IIS) and records the information about this vaccine into the EHR. The clinician then uses the EHR to review the infant's growth, expected development milestones, and view age- appropriate anticipatory guidance for the parents. The system's capabilities to support immunization status review, current recommended vaccines, and immunization forecasting to inform scheduling of the next well-child visit are also demonstrated.

Role	Task
Nurse/Provider	Demonstrate age-specific growth chart with longitudinal view (pre-populated with scenario- appropriate data).
	Demonstrate adding new data and how the growth chart is updated.
Provider	Demonstrate age-appropriate patient/parent education and anticipatory guidance.
Nurse/Provider	Demonstrate immunization history for pediatric patient.
Nurse/Provider	Demonstrate how a user would document an immunization received elsewhere, e.g.
	incorporating the HepB #1 information discovered on the State IIS.
Nurse/Provider	Demonstrate how the EHR shows immunizations due, taking into consideration the vaccine
	received elsewhere. This includes catch-up guidance for delayed immunizations and
	forecasting next doses.

- Based on your provided scenario, you can develop a SysML model to capture the system functionality. Here are some possible SysML diagram types you might want to use, and how they might relate to your scenario:
- Use Case Diagram: You can begin with this to represent the high-level functions of your system. Each task performed by a nurse/provider could be a use case. The 'Nurse/Provider' and 'Provider' would be the actors interacting with these use cases.
- Activity Diagram: You can use this to represent the workflow of a specific scenario. For example, a "6-month well-child visit" could be an activity, with actions such as 'Review growth chart', 'Record vaccine information', 'Review immunization status', etc. You can also model decisions such as what to do when parents decline certain vaccines.
- Block Definition Diagram (BDD): This is useful for defining the 'system' and its capabilities. In your case, the 'system' could be the EHR and its functionalities such as 'Display growth chart', 'Record vaccine information', 'Forecast immunization schedule', etc.
- Internal Block Diagram (IBD): This illustrates the relationships between the parts of the system. In this case, how the different functionalities of the EHR interact with each other.
- 5. Sequence Diagram: To demonstrate interactions between different actors (nurse/provider and the EHR) in a time-ordered sequence. For example, a sequence diagram can illustrate how a nurse retrieves vaccine information from the State IIS and records it into the EHR, then how the EHR updates the immunization due status.
- State Machine Diagram: You could use this to represent the state changes of a patient's immunization status, from 'Immunization due' to 'Immunization received'.
- Parametric Diagram: This could be used to represent constraints and relationships in the system, like the relationship between a patient's age and the expected immunization schedule.

Remember, SysML is a rich langua

### **Use Case Diagram for the Scenario**

Sure, let's decompose the tasks into requirement statements for each role.

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#### Role: Nurse/Provider

- 1. The system shall provide a feature to display an age-specific growth chart with a longitudinal view, pre-populated with scenario-appropriate data.
- 2. The system shall allow the addition of new data points to the growth chart and update the chart accordingly.
- 3. The system shall provide a feature to access and display the immunization history of a pediatric patient.
- 4. The system shall provide a feature to document an immunization that was received elsewhere, such as incorporating the HepB #1 information from the State IIS.
- 5. The system shall indicate due immunizations, considering vaccines received elsewhere, providing catch-up guidance for delayed immunizations, and forecasting the next doses.

#### **Role: Provider**

1. The system shall provide age-appropriate patient/parent education resources and anticipatory guidance.

#### Role: Nurse

- 1. The system shall support obtaining electronic consent for immunizations, integrated with a signature device.
- 2. The system shall allow documentation of administered immunizations, including details such as CVX code, lot number, VIS S Regenerate response



### **Requirements Allocation Matrix**

Sure, let's decompose the tasks into requirement statements for each role.

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### **Internal Block Diagram**





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### **State Machine Diagram**

#### A Please generate a state diagram

- As a text-based AI model, I can't directly create visual diagrams. However, I can describe to you how you might create a state diagram based on the scenario you provided, particularly focusing on the 'Immunization Status' of the child:
- State 1 Immunization Due: This is the initial state. When the patient is due for a scheduled vaccination, the system is in this state.
- Transition 1 Immunization Administered: If the immunization is administered, the system transitions from 'Immunization Due' to 'Immunization Received' state. This transition is triggered by the 'Document Administered Immunization' use case.
- 3. State 2 Immunization Received: In this state, the child has received the due immunization.
- Transition 2 Next Immunization Due: The system goes back to 'Immunization Due' state when the next immunization becomes due. This transition is triggered by the passage of time or specific age milestones.
- Transition 3 External Immunization Documented: If an immunization was received elsewhere and is then documented in the EHR (as per 'Document External Immunization' use case), the system transitions from 'Immunization Due' to 'Immunization Received'.

These states and transitions provide a simplified view of how the system tracks a patient's immunization status. In reality, you would likely have additional states and transitions to handle different scenarios (e.g., missed appointments, refused immunizations, etc.). The exact details would depend on the specific requirements of your system.



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### **Activity Diagram**

As a text-based AI model, I can't directly create visual diagrams. However, I can describe how 📋 🖒 🖓 you might construct an activity diagram based on the tasks given in your scenario. 1. Start Node: The starting point of the activity. 2. Activity 1 - View Age-Specific Growth Chart: Nurse/Provider views the growth chart. 3. Activity 2 - Update Growth Chart: Nurse/Provider adds new data to the growth chart. 4. Activity 3 - View Age-Appropriate Anticipatory Guidance: Provider views the education resources and anticipatory guidance. 5. Activity 4 - View Immunization History: Nurse/Provider views the immunization history of the patient. 6. Decision Node - External Immunization?: A decision point to check if there are any external immunizations. 7. Activity 5 - Document External Immunization: If there are external immunizations, the Nurse/Provider documents the immunization in the system. 8. Activity 6 - View Immunizations Due: After checking the external immunization or if there are no external immunizations, the Nurse/Provider views due immunizations and forecasting of next doses. 9. Activity 7 - Obtain Electronic Consent for Immunizations: Nurse obtains electronic consent for the due immunizations. 10. Activity 8 - Document Administered Immunization: After obtaining the consent, Nurse documents the administered immunizations. 11. End Node: This represents the end of the activities. Please note that transitions (represented by arrows) between activities are used to show the flow of the activities. The decision node represents a point where the flow of control can diverge based on a condition. G Regenerate response



### **Experiment Results**



Experience Level	Sample Group	Time Taken	Included Diagrams	Qualitative Ranking	Quantitative Ranking
Associate	Open	5h30	2	1	1 (82.35%)
Associate	No	4h35	2	2	2 (77.84%)
Associate	Accelerated	5h00	2	3	3 (71.37%)
SME	Open	2h00	10	1	1 (80.88%)
SME	Accelerated	1h30	2	2	2 (70.59%)
SME	No	2h25	5	3	3 (68.54%)
ChatGPT 3.5	Yes	0h05	2	Last	Last (38.24%)

- Modelers with open access to ChatGPT were ranked 1 in both Qualitative and Quantitative scoring.
- The SME with open access to ChatGPT provided 8 additional developed resources that would normally be included in the modeling process.
- Although ranked last in raw output, GPT still produced ~40% of minimum content we requested....in 5 minutes.

### **Some Random Thoughts**



- ► GPT will sometimes not "cooperate", which really throws off some new users
  - New users would likely benefit from a formal introduction or tutorial on GPT to demonstrate its functionality, interface, and how to work around some of the common pitfalls
- Don't ask ChatGPT to do math
- You need to review ChatGPT's work
- Pay attention to ChatGPT's initial output. If ChatGPT is going to hallucinate, its initial response may be a strong indicator that it doesn't know a topic.
- Did not generate a solution, had ChatGPT create artifacts for the problem domain (i.e. MagicGrid).



## Thank you!

**Questions?** 

### **Backup Slides: Evaluation Metrics**



- Focus on four model sections:
  - Documentation
  - The requirements list
  - The activity diagram
  - Extras
- The evaluator is measuring 31 different aspects of each model for comparison in these general categories:
  - **Completeness** (number of requirements/elements/types/connections, presence of adequate documentation, how many of each are present in the evaluated model vs. the proposed model)
  - Consistency (consistency of requirements/elements/types/connections presentation and use, presence of redundant elements/connections)
  - Correctness (number of correct vs incorrect elements and connections, inclusion of relevant requirements/elements/connections, inclusion of informative requirements/elements/connections, how many are captured by the evaluated model vs. the proposed model)
  - Simplicity (layout readability, presence of documentation)
  - **Traceability** (are the elements/types/connections mapped to requirements, are the elements/connections laid out in a reasonable/understandable/usable order)

### **Backup Slides: Evaluation Questions**



Is there documentation present within the included file?	How many elements are relevant to identified requirements?			
If documentation is present, how much of the documentation is present in the correct attributes?	How many of the elements are relevant to the scenario?			
How many obvious opportunities for documentation inclusion were missed?	How many of the relevant elements are present in the proposed model?			
Is a requirements list present in the included file?	How many of the elements are irrelevant to the scenario?			
How many are there?	How many of the elements are redundant?			
How many are informative based on the scenario?	Are the elements in the correct order?			
How many are relevant to the scenario?	How many connections are relevant to identified requirements?			
How many of the requirements are irrelevant to the scenario?	How many connections are relevant to the scenario?			
How many minimum necessary requirements were not present in this model?	How many of the relevant connections are present in the proposed model?			
How many of the requirements are redundant?	How many of the connections are irrelevant to the scenario?			
Are the requirements consistently presented?	How many of the connections are redundant?			
Is an Activity Diagram present in the included file?	How many of the connections are correct?			
How many element types are there total?	Are the elements consistently presented?			
How many element types are <b>not</b> correct?	Are the connections consistently presented?			
How many connection types are there total?	Is the Activity Diagram layout reasonable? If no, why not?			
How many connection types are <b>not</b> correct?	What extras are included, if any?			

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