



**International Council on Systems Engineering**  
*A better world through a systems approach*

# Welcome to the INCOSE Webinar Series

Wednesday, 20<sup>st</sup> March 2024 – Webinar 172

**INCOSE Webinar 172:**

# **Enhancing Systems Engineering Through Generative Artificial Intelligence (GAI)**

Presented by Steven Dam



# Thank you to our 2024 Webinar Sponsors!



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# About the INCOSE Webinar Series

- Piloted in 2008 from a “CAB Need”
- A virtual offering aimed to provide relevant technical information from INCOSE professionals on current systems engineering topics; on a regular basis through an easy to access platform / media type
- Held once a month (normally on the 3<sup>rd</sup> Wednesday)

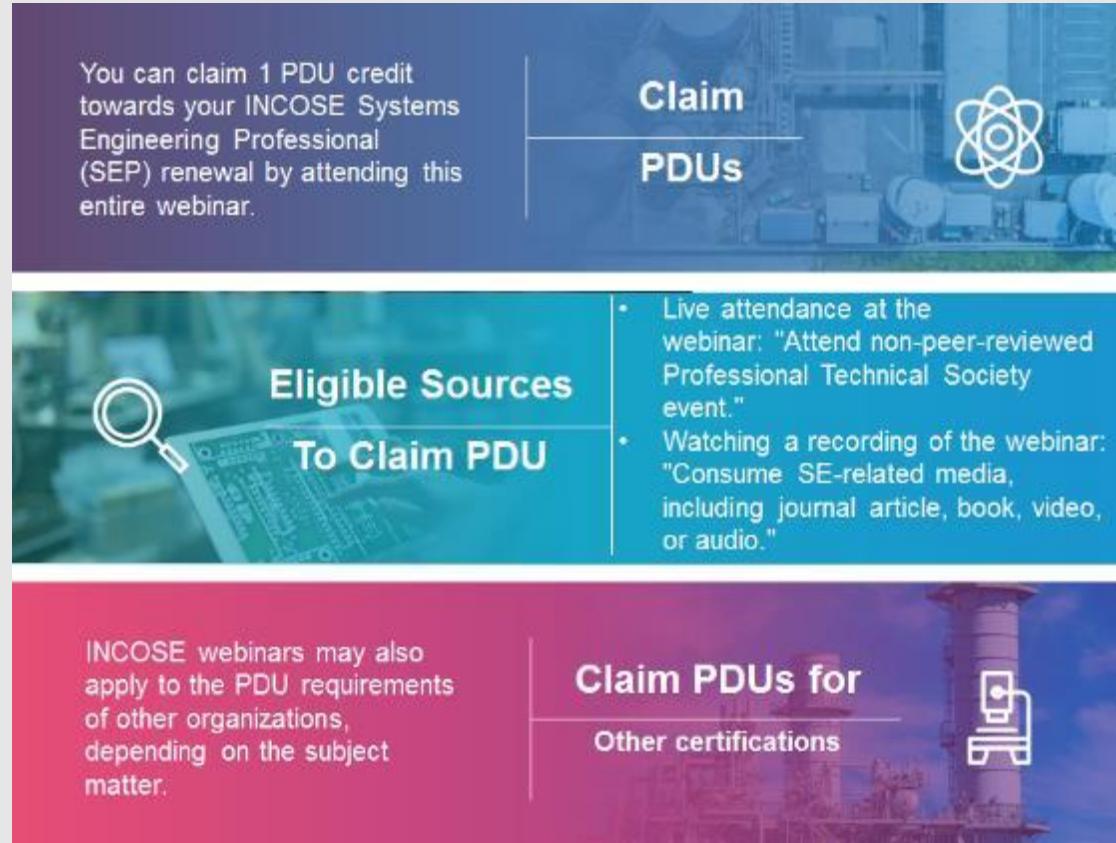


Questions? Comments? Suggestions?  
Email us at [webinars@incose.net!](mailto:webinars@incose.net)

# Webinars & SEP PDU\* Credits

More information can be found  
on [Renewing Certification](https://incose.org)  
(incose.org)

\*PDU – Professional Development Unit



The slide is divided into three main sections: a top banner, a middle section, and a bottom section. The top banner features a blue gradient background with a faint image of a circuit board and a white atom icon. It contains the text 'You can claim 1 PDU credit towards your INCOSE Systems Engineering Professional (SEP) renewal by attending this entire webinar.' and 'Claim PDUs'. The middle section has a teal background with a magnifying glass icon over a blurred image of a computer screen displaying code. It contains the text 'Eligible Sources To Claim PDU' and a bulleted list of two ways to claim PDUs. The bottom section has a red background with a blurred image of a lighthouse. It contains the text 'INCOSE webinars may also apply to the PDU requirements of other organizations, depending on the subject matter.' and 'Claim PDUs for Other certifications'.

You can claim 1 PDU credit towards your INCOSE Systems Engineering Professional (SEP) renewal by attending this entire webinar.

Claim  
PDUs

Eligible Sources  
To Claim PDU

- Live attendance at the webinar: "Attend non-peer-reviewed Professional Technical Society event."
- Watching a recording of the webinar: "Consume SE-related media, including journal article, book, video, or audio."

INCOSE webinars may also apply to the PDU requirements of other organizations, depending on the subject matter.

Claim PDUs for  
Other certifications

# Webinar Program

- ✓ **Welcome** (2-5 minutes)
- **Presentation** (40-45 minutes)
- Please use Q&A feature via Zoom to enter your questions
- **Q&A Session** (10 minutes)
- Questions will be selected and asked by the Host
- **Brief Closing** (2-5 minutes)

# This Webinar is being recorded.

The full recording and slide deck will be made available to all INCOSE members and CAB Associates within 10-12 business days from original air date in the Professional Development Portal (PDP).

**Questions? Comments? Suggestions?**  
Email us at [webinars@incose.net](mailto:webinars@incose.net)!



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*A better world through a systems approach*

# Enhancing Systems Engineering Through Generative AI (GAI)



## Dr. Steven Dam

SPEC Innovations President & Founder, Inventor of Innoslate

### Professional experience

Dr. Dam has been involved with structured analysis, software development, and systems engineering for over 45 years.

He has authored four systems engineering-based books, including his most recent, "Real MBSE: Model-Based Systems Engineering Using LML and Innoslate."

### Expertise

- B.S. and Ph.D. in Physics
- INCOSE-certified ESEP
- 2024 AIAA Associate Fellow
- INCOSE 2023 Founder's Award Recipient

# Today's Agenda

- What is AI & GAI?
- Early AI/NLP Techniques Used in Innoslate
- NASA STTR Research Results
- GMU Graduate Research Project Results
- Potential Benefits and Limitations of AI4SE
- What does AI4SE mean for Engineers and their Projects?

# What Is AI and Generative AI?

AI stands for Artificial Intelligence. It refers to the ability of machines to perform tasks that would normally require human intelligence, such as learning, problem-solving, decision-making, and pattern recognition.\*

Generative AI is the capability to generate text, images or other data using models, often in response to prompts. Generative AI models learn the patterns and structure of their training data and then generate new data that has similar characteristics.\*

***Generative AI has been recently popularized by ChatGPT***

\*Derived from Google Definition

# What do people think of when you say AI?



# Current State of AI

AI techniques have potential to enhance  
systems engineering

# AI-Generated Images

**Hotpot**

AI Graphics ▾ AI Game Tools ▾ AI Writing ▾ ChatGPT ▾

AI Art Generator

Turn imagination into art. Our AI image generator brings imagination to life, producing stunning art, illustrations, and images in seconds. Unleash creativity and express yourself in new ways with the power of AI. Simply enter a few words, and watch Hotpot transform text into incredible art.

See [AI Headshot Generator](#) to reimagine yourself with AI.

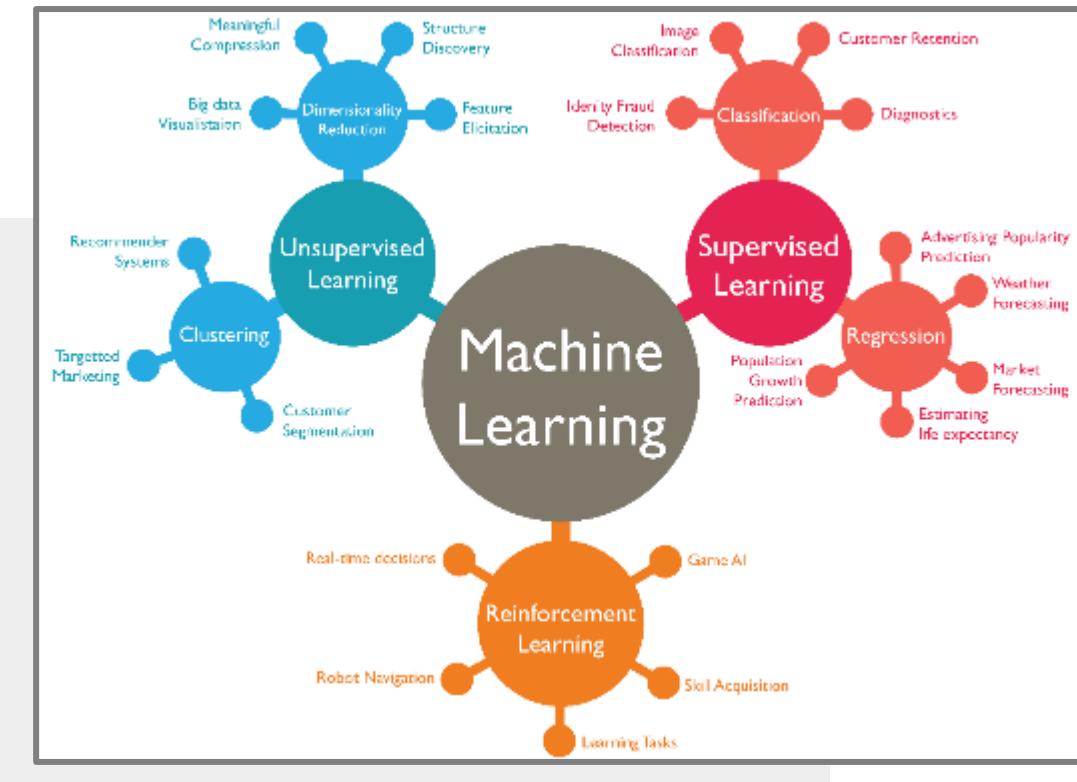
Explore [AI Art Gallery](#) for recent creations.

What should AI draw?

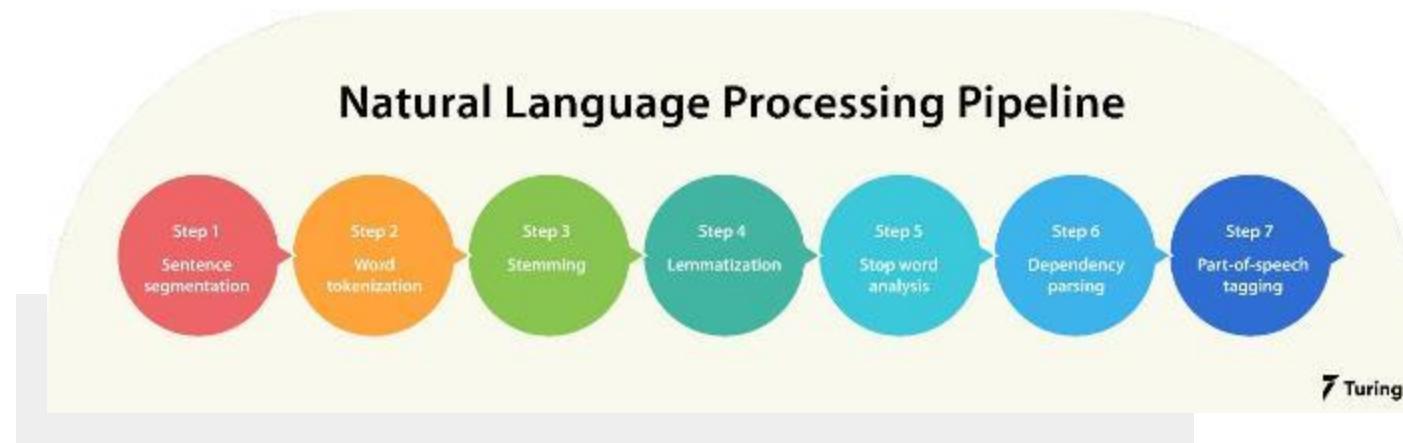
Ask AI for ideas 400 

Style Hotpot Art 8 

# Machine Learning



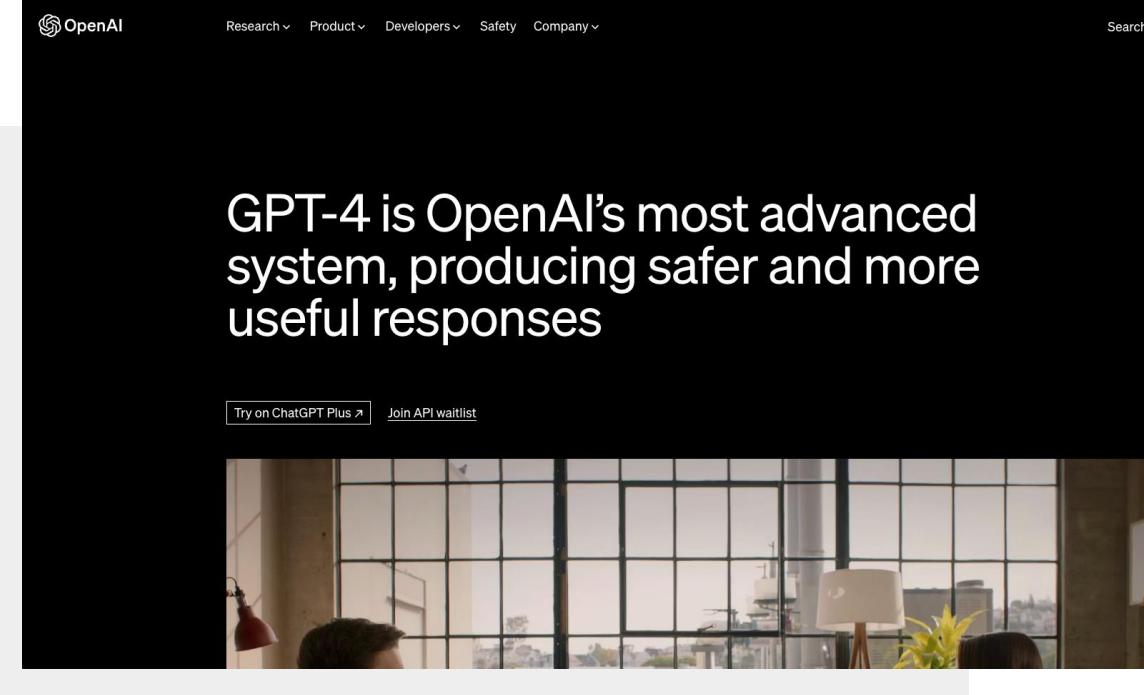
# Natural Language Processing



# Computer Vision



# Large Language Models (LLM)



The image is a screenshot of the OpenAI website. At the top, there is a navigation bar with the OpenAI logo, a search bar, and links for Research, Product, Developers, Safety, and Company. The main content area features a large, bold, white text block on a black background that reads: "GPT-4 is OpenAI's most advanced system, producing safer and more useful responses". Below this text are two buttons: "Try on ChatGPT Plus" and "Join API waitlist". At the bottom of the main content area is a large, dark image showing a person's head in profile, looking out of a window with a grid pattern. The window looks out onto a cityscape with buildings and trees. The overall layout is clean and modern.

OpenAI

Research ▾ Product ▾ Developers ▾ Safety Company ▾

Search

GPT-4 is OpenAI's most advanced system, producing safer and more useful responses

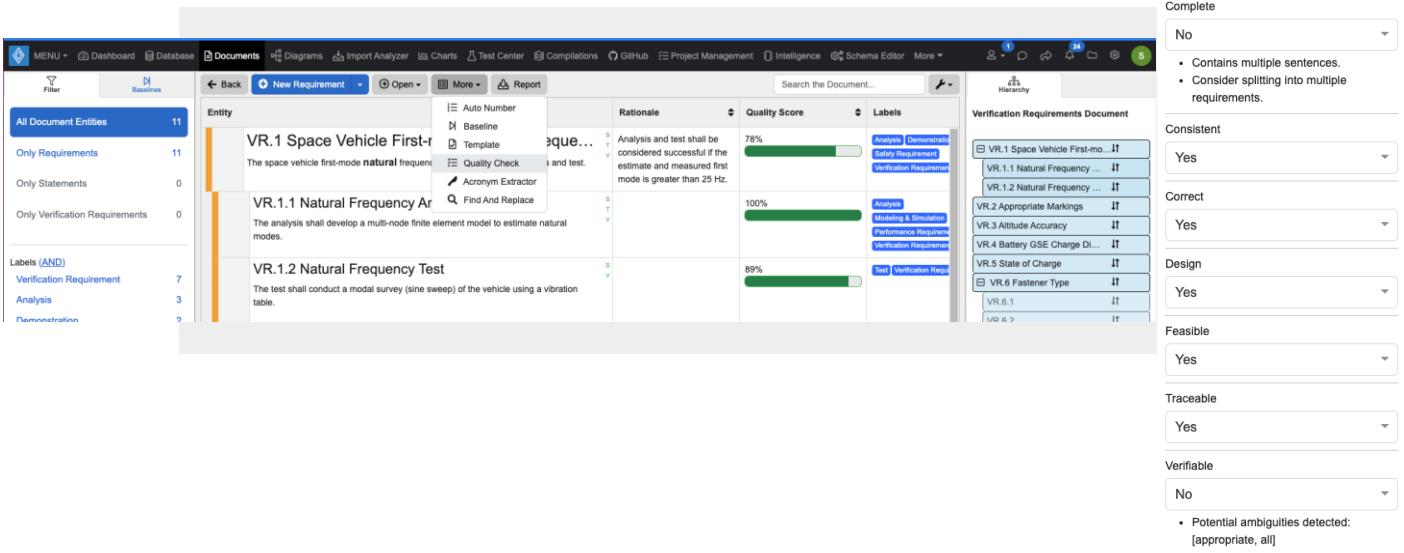
Try on ChatGPT Plus ↗ Join API waitlist



# Early Application of AI to Innoslate

Innoslate began use of AI/NLP in 2015

# Requirements Quality Checker



The screenshot displays the INCOSE Requirements Quality Checker interface. The main view shows a list of requirements under the 'Entity' tab. Each requirement includes a title, a rationale, and a 'Quality Score' bar. The 'Quality Score' for VR.1 Space Vehicle First-mode natural frequency is 78%, for VR.1.1 Natural Frequency Analysis is 100%, and for VR.1.2 Natural Frequency Test is 89%. The interface also includes a sidebar with various filters and a detailed view of the selected requirement.

Requirement	Rationale	Quality Score
VR.1 Space Vehicle First-mode natural frequency	The space vehicle first-mode natural frequency shall be considered successful if the estimate and measured first mode is greater than 25 Hz.	78%
VR.1.1 Natural Frequency Analysis	The analysis shall develop a multi-node finite element model to estimate natural modes.	100%
VR.1.2 Natural Frequency Test	The test shall conduct a modal survey (sine sweep) of the vehicle using a vibration table.	89%

**Verification Requirements Document**

- VR.1 Space Vehicle First-mode natural frequency
- VR.1.1 Natural Frequency Analysis
- VR.1.2 Natural Frequency Test
- VR.2 Appropriate Markings
- VR.3 Attitude Accuracy
- VR.4 Battery GSE Charge Discharge
- VR.5 State of Charge
- VR.6 Fastener Type
- VR.8.1
- VR.8.2

**Quality Score**  
67%

**Clear**  
Yes

**Complete**  
No

- Contains multiple sentences.
- Consider splitting into multiple requirements.

**Consistent**  
Yes

**Correct**  
Yes

**Design**  
Yes

**Feasible**  
Yes

**Traceable**  
Yes

**Verifiable**  
No

- Potential ambiguities detected: [appropriate, all]

# Requirements Traceability Assist

The screenshot shows the INCOSE Test Center interface with the 'Analyzer' tab selected. In the left sidebar, under 'Requirements Traceability', the 'Traceability Matrix' option is highlighted. The main area displays a traceability matrix for a 'Propulsion Module Acceptance' test case. The rows represent acceptance criteria (e.g., 'TC.1.1 Propulsion Module Acceptance Test', 'TC.1.1.1 Propellant Tank Leak Test') and the columns represent various test types (e.g., 'VR.1 System Acceptance Test', 'VR.1.1 Natural Frequency Test', 'VR.1.2 Appropriate Markings'). The matrix cells are marked with checkmarks to indicate successful traceability.

This screenshot shows the same traceability matrix interface, but with a different configuration. The rows and columns are identical to the first screenshot. The matrix cells are now color-coded: green for successful traceability, red for partially successful or suspect traceability, and grey for unverified or failed traceability. This visual representation allows for a quick assessment of the overall traceability status across the entire matrix.

# Intelligence View

Intelligence Dashboard

Overall Analysis: Pass Rate: 39%

Global Analysis: Analyzed 2522 entities with 95% (95) applicable heuristics passing the analysis

Asset Analysis: Analyzed 176 Assets with 40% (61) applicable heuristics passing the analysis

Conduit Analysis: Analyzed 47 Conduits with 50% (48) applicable heuristics passing the analysis

Bar Analysis: Analyzed 205 Actions with 41% (71) applicable heuristics passing the analysis

Action Analysis: Analyzed 52 Input/Outputs with 55% (50) applicable heuristics passing the analysis

I/O Analysis: Analyzed 277 Requirements with 22% (29) applicable heuristics passing the analysis

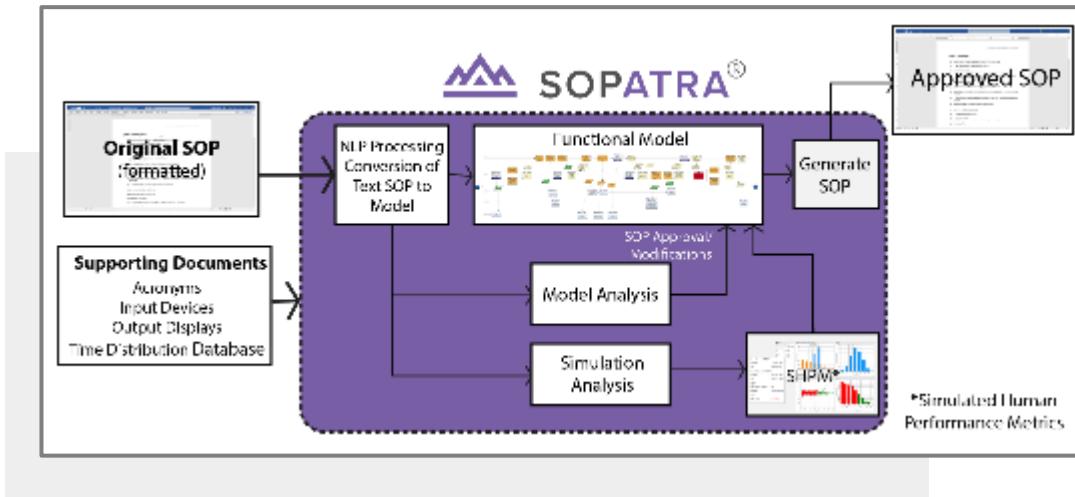
Requirement Analysis: The following entities are mentioned in the requirement description, but have not been...

# NASA STTR Research Results

In collaboration with George Mason University

# Phase I

- Phase I resulted in the development of Sopatra
- Sopatra imports an MS Word File and transforms the text into behavior diagrams using NLP
- A special version of the Innoslate Monte Carlo simulator is used to analyze the diagram



# Phase II

- Phase II continued research in NLP and GAI to see how to improve Sopatra

The screenshot shows the Project Dashboard for the 'Complete FireSAT Model' project. The dashboard includes the following sections:

- Project Status:** A bar chart showing V&V Status with categories: Not Run (1), Passed (1), In Progress (3), and Failed (1).
- Countdown Clock:** A digital clock showing - 9 09 56 02 Days HR MIN SEC, with a note that it counts up since 7/31/2023 12:00:00 am.
- Key Classes:** A pie chart showing the distribution of requirements: Action (blue), Asset (light blue), Cost (light blue), Risk (light blue), and Requirement (orange).
- Action Diagram:** A process flow diagram for the 'RM.1 FireSAT Design Reference Mission (DRM) (U)'. The steps are:
  - Start
  - RM.1.1: Launch Payload to Space
  - Decision: If successful, continue to RM.1.2; otherwise, Error Report.
  - RM.1.2: Continue Commissioning
  - Decision: If successful, continue to RM.1.3; otherwise, Error Report.
  - RM.1.3: Perform Initial Commissioning
  - Decision: If successful, continue to RM.1.4; otherwise, Error Report.
  - RM.1.4: Perform Final Commissioning
  - Decision: If successful, continue to RM.1.5; otherwise, Error Report.
  - RM.1.5: Update to General Ops
  - Decision: If successful, continue to RM.1.6; otherwise, Error Report.
  - RM.1.6: Perform Final Commissioning
  - Decision: If successful, continue to RM.1.7; otherwise, Error Report.
  - RM.1.7: Uninstall
  - End
- AI Assistant (General):** A blue callout box containing the text: "Requirements analysis is the process of understanding, documenting, and evaluating the needs and expectations of stakeholders for a system, product, or project. It involves gathering and analyzing information to define the functional and non-functional requirements that the system should meet. Requirements analysis helps ensure that the final solution aligns with the stakeholders' needs and provides a solid foundation for the design and development of the system. It typically includes activities such as identifying stakeholders, eliciting requirements, prioritizing and organizing requirements, and validating and verifying requirements." Below this is a 'What is requirements analysis?' link.
- Comments Feed:** A list of comments from user 'stevendan' with various status updates.
- Activity Feed:** A list of recent activity from user 'stevendan'.
- Bottom Navigation:** Buttons for Capacity, OutDAF Product, On-4a, On-4b, On-8bOn-4a, and Top 10 Recent Requirements.

# Phase II

- That work led to the implementation of ChatGPT into Innoslate to experiment with its application for SE

**Innoslate Help (AI Powered)**

NOTE: The information provided may not always be up-to-date and accurate. If you are looking for additional help, please submit a support ticket.

How do I add cost to the model?

To add cost to the model, you can use the "Cost" entity in the simulation. The cost can be added to the simulation's total cost by setting the "Amount" attribute of the cost. If you want the cost to be calculated based on the duration of the model element, you can set the "Rate" attribute to "Per Hour". If you want the cost to be a fixed value regardless of the duration, you can set the "Rate" attribute to "Fixed".

Resolved

testing

My comment

stevendam 5/9/2023

stevendam 7/20/2018

stevendam 5/19/2020

stevendam 8/16/2018

stevendam It could be helpful

Activity Feed

stevendam updated As-is 1 Deleted Fires

Action Diagram has been updated

Send a message

# Phase II

- Additional suggested enhancements to Sopatra were also developed

The screenshot shows the Sopatra software interface. On the left, a requirement document is displayed with the title 'Requirement'. The document details a 'Natural Frequency Test' for a 'VR.1.2 Natural Frequency' requirement. The test description states: 'The test shall conduct a modal survey (sine sweep) of the vehicle using a vibration table. The test shall use a modal survey (sine sweep) of the vehicle using a vibration table.' The 'Rationale' section includes a table with 'Quality Score' and 'AI Assistant' columns. The 'Quality Score' column shows values of 89%, 67%, 78%, 67%, 67%, 56%, 67%, and 56% for various test steps. The 'AI Assistant' column provides descriptions for each step, such as 'To conduct a modal survey (sine sweep) of a vehicle using a vibration table, you will need to follow these general steps: 1. Prepare the vehicle. Ensure that the vehicle is securely mounted on the vibration table. Make sure all loose items are removed or secured to prevent damage during the test.' and 'Send a message'.

# GMU Graduate Research Project Results

- SPEC Innovations sponsored a graduate research project (capstone) entitled: “A Proposal for Integrating Generative AI into Innoslate”
- Although the focus was on Innoslate, a number of the lessons learned from the project have value for other tool vendors, researchers, and practitioners
- The goal for the project (as developed by the students) was to: *“unveil a vision where tasks and processes are not just facilitated but revolutionized”*

# GMU Graduate Research Project Results

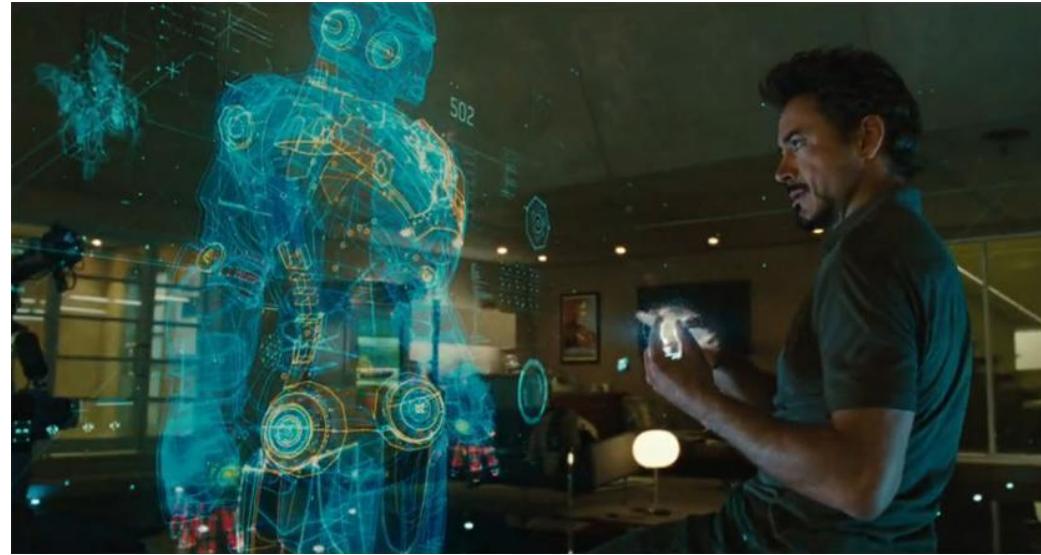
- The result of this work included several opportunities
- The general opportunities were:
  - Use of GAI in generating quality scores and recommending changes
  - Use GAI to create diagrams and enhance the layout automatically
  - Use GAI to generate test cases from the requirements
- Although these recommendations may not be unique (and some tools have already incorporated portions of these ideas), they show how having GAI built into a product can provide the means to enhance how we do systems engineering

# Potential Benefits and Limitations of AI4SE

- Potential benefits
  - Speed up analysis and development of complex systems
  - Enable greater understanding of the risks associated with the project
  - Aid in optimization of the system for all the “illities” and constraints
- Limitations
  - GAI can only get us so far ... it will not replace the systems engineer it will enhance us
  - GAI needs to learn from limited datasets (IP/Security issues)
  - Methods to reduce “hallucinations” from GAs must occur for us to trust the results

# What does AI4SE mean for Engineers and their Projects?

- An interactive, digital assistant to make systems engineering fast, better, and cheaper
- We may need technologies not even thought of at this time to make that feasible
- Clearly, AI will play a major role in achieving this vision



***Innoslate Version 20 = Jarvis?***

[Jarvis Video](#)

# Let's connect

Connect with me and SPEC Innovations for future content on Innoslate and the industry.

## Dr. Steven Dam

SPEC Innovations President & Founder, Inventor of Innoslate

**I** [linkedin.com/steve-dam](https://www.linkedin.com/in/steve-dam)

**x** [@StevenHDam](https://twitter.com/StevenHDam)

**e** [steven.dam@specinnovations.com](mailto:steven.dam@specinnovations.com)

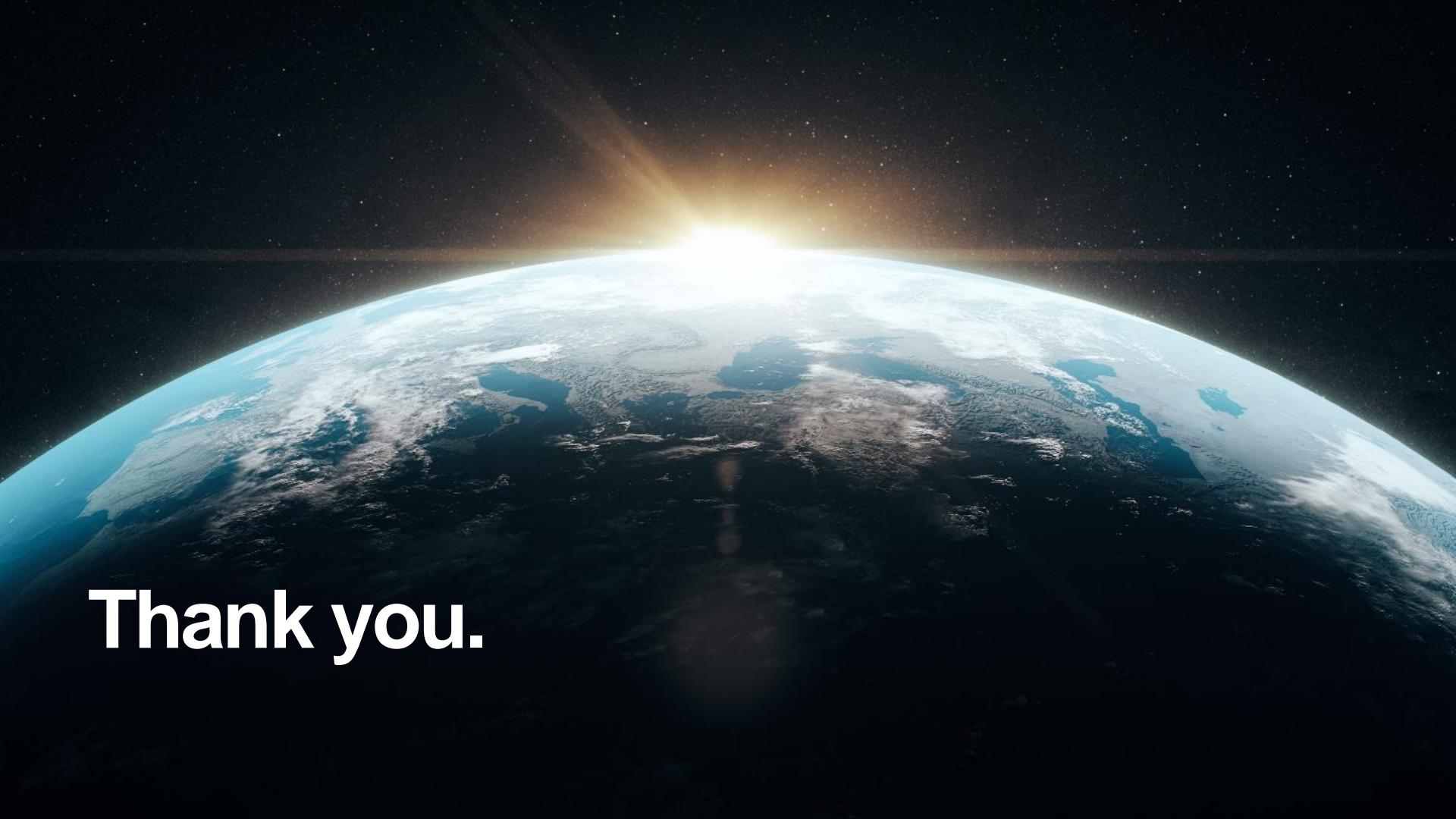
## SPEC Innovations

Creators of Innoslate & Sopatra

**w** [specinnovations.com](https://specinnovations.com)

**I** [linkedin.com/company/specinnovations](https://www.linkedin.com/company/specinnovations)

**e** [info@specinnovations.com](mailto:info@specinnovations.com)



Thank you.

# Q&A Session

Please submit your questions in the Zoom's Q&A feature.

# Next Month's Webinar:

Wednesday, 17<sup>th</sup> April  
2024 at 10:00 AM  
EST / 15:00 UTC

*What is an ESEP and  
why should I become  
one?*

Presented by David Ward &  
Courtney Wright

# Quick Reminders

- All the previous webinars are now located in the [Professional Development Portal \(PDP\)](#).
- Attending a Webinar does count as 1 PDU credit towards your SEP renewal



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