



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

Welcome to the INCOSE Webinar Series

Wednesday, 20st March 2024 – Webinar 172

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INCOSE Webinar 172:

Enhancing Systems Engineering Through Generative Artificial Intelligence (GAI)

Presented by Steven Dam



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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 3rd Wednesday)






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More information can be found
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*PDU – Professional Development Unit

<p>You can claim 1 PDU credit towards your INCOSE Systems Engineering Professional (SEP) renewal by attending this entire webinar.</p>	<h2>Claim PDUs</h2> 
 <h2>Eligible Sources To Claim PDU</h2>	<ul style="list-style-type: none"> • 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."
<p>INCOSE webinars may also apply to the PDU requirements of other organizations, depending on the subject matter.</p>	<h2>Claim PDUs for Other certifications</h2> 

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?
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International Council on Systems Engineering
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.

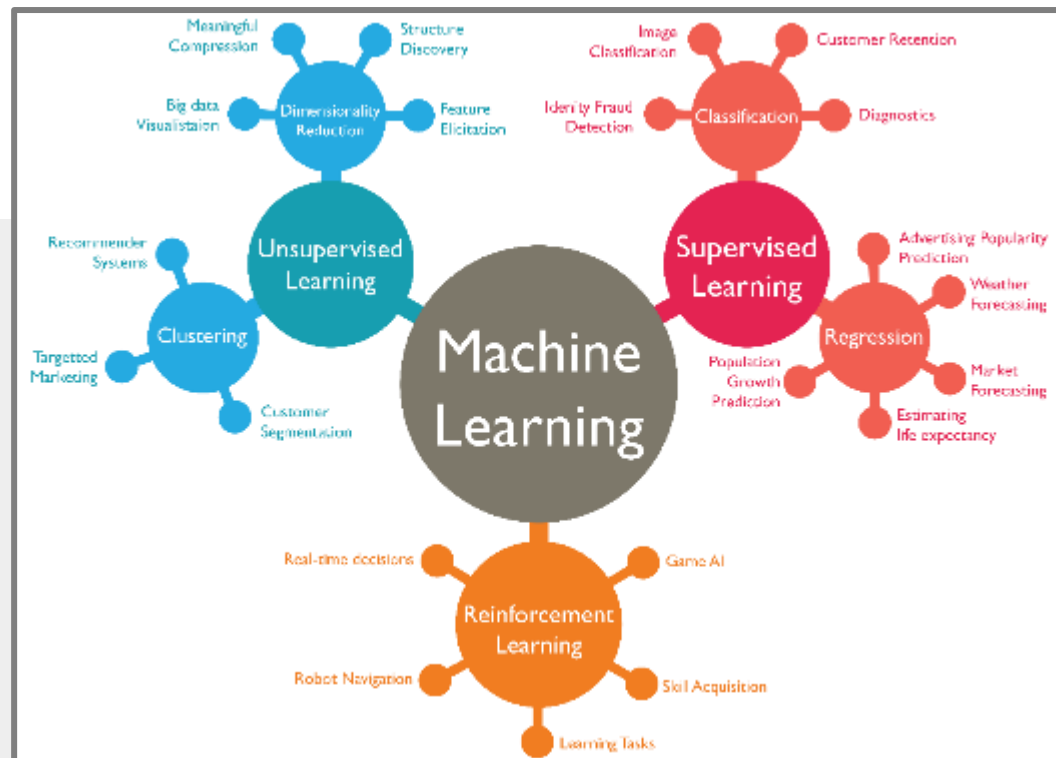
What should AI draw?

[Ask AI for ideas](#) 400 

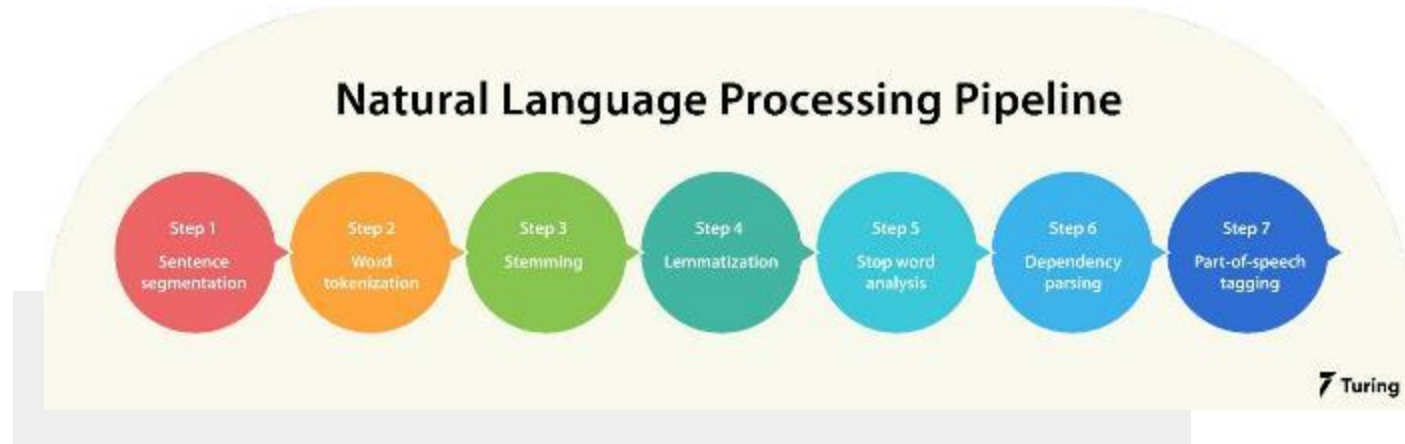
Style 

[Hotpot Art 8](#)

Machine Learning



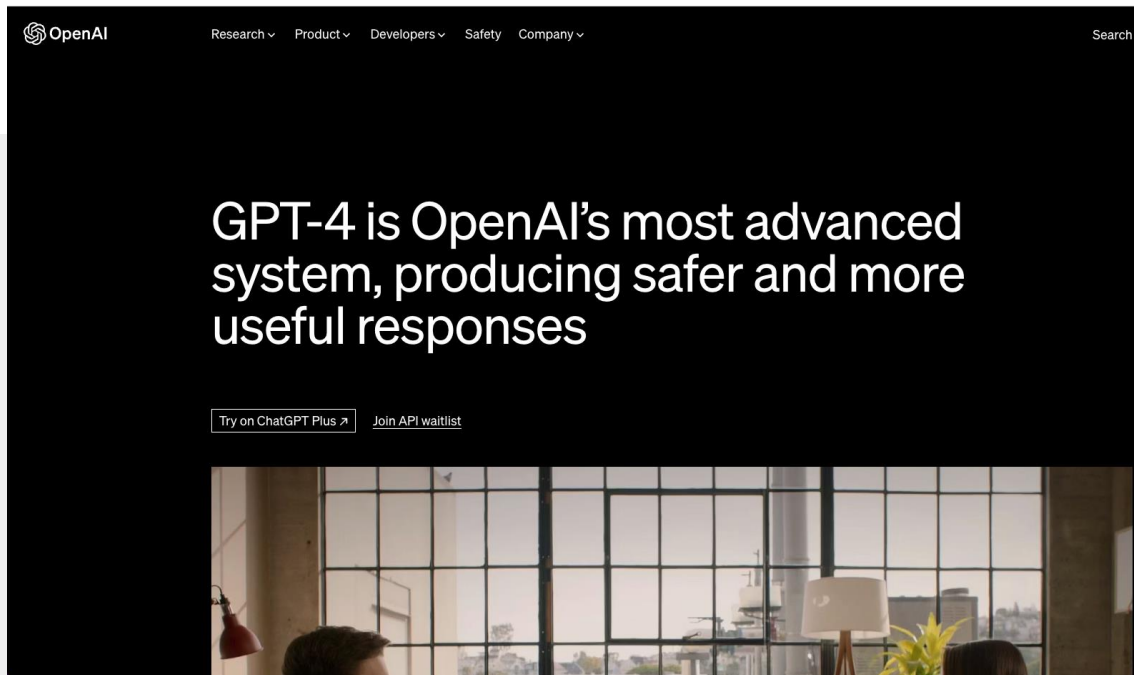
Natural Language Processing



Computer Vision



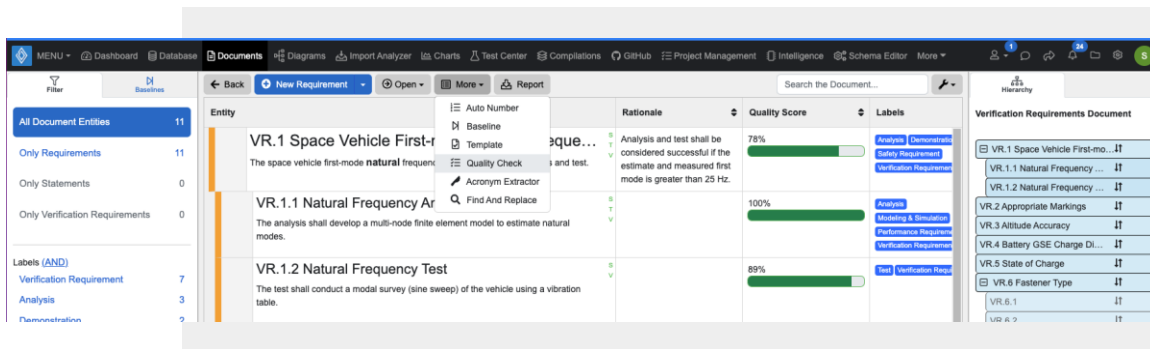
Large Language Models (LLM)



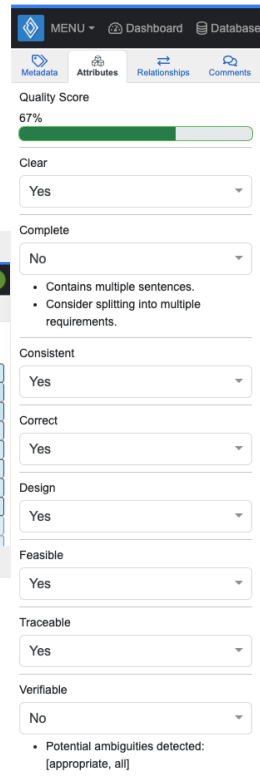
Early Application of AI to Innoslate

Innoslate began use of AI/NLP in 2015

Requirements Quality Checker



Entity	Rationale	Quality Score	Labels
VR.1 Space Vehicle First-mode Natural Frequency	The space vehicle first-mode natural frequency shall be estimated and test.	78%	Analysis, Demonstration, Safety Requirement, Verification Requirement
VR.1.1 Natural Frequency Analysis	The analysis shall develop a multi-node finite element model to estimate natural modes.	100%	Analysis, Modeling & Simulation, Performance Requirement, Verification Requirement
VR.1.2 Natural Frequency Test	The test shall conduct a modal survey (sine sweep) of the vehicle using a vibration table.	89%	Test, Verification Requirement



MENU Dashboard Database

Metadata Attributes Relationships Comments

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]

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.6.1

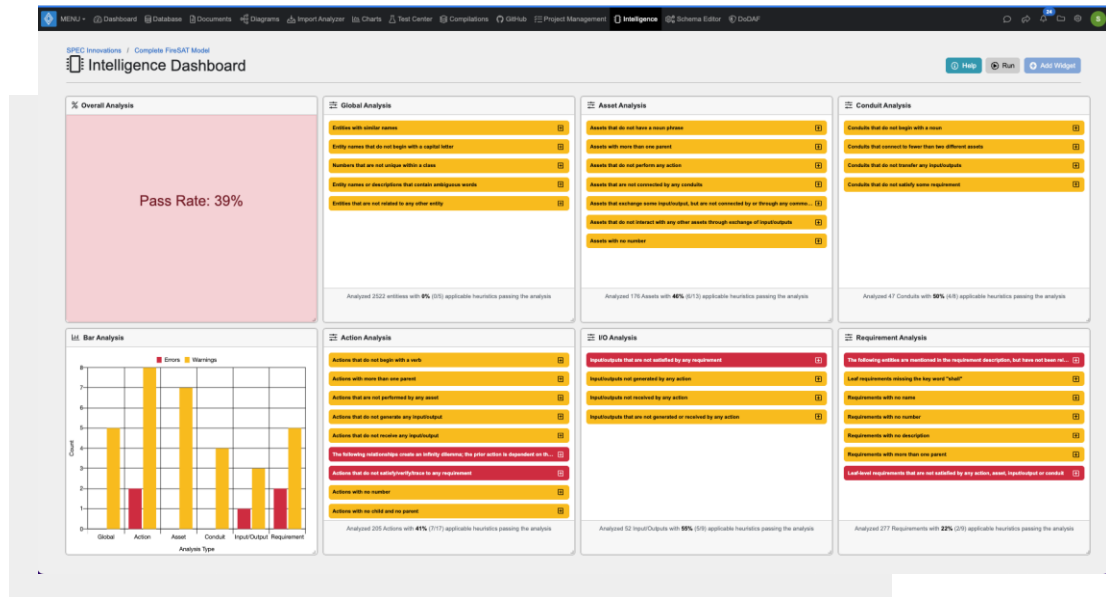
VR.6.2



Meets all propulsion module acceptance criteria



Intelligence View

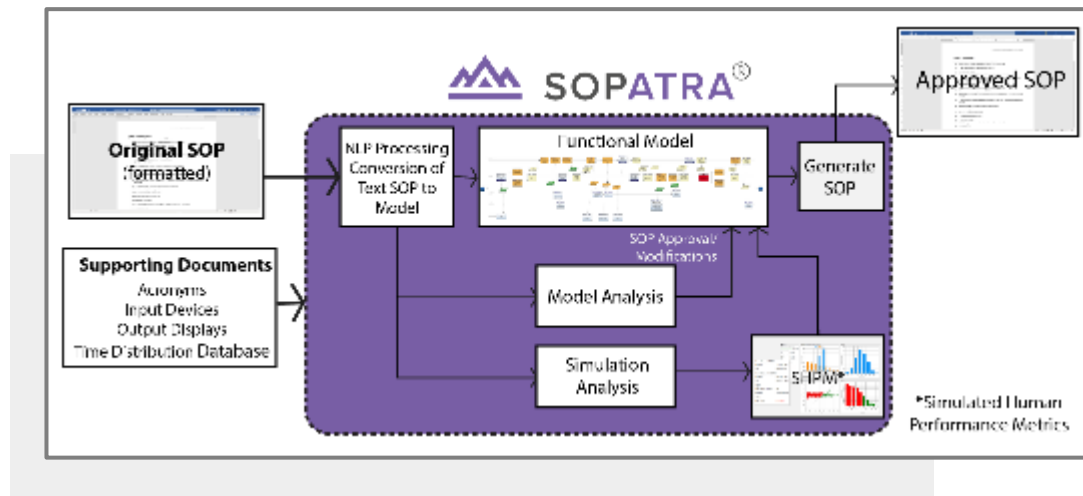


NASA STTR Research Results

In collaboration with George Mason University

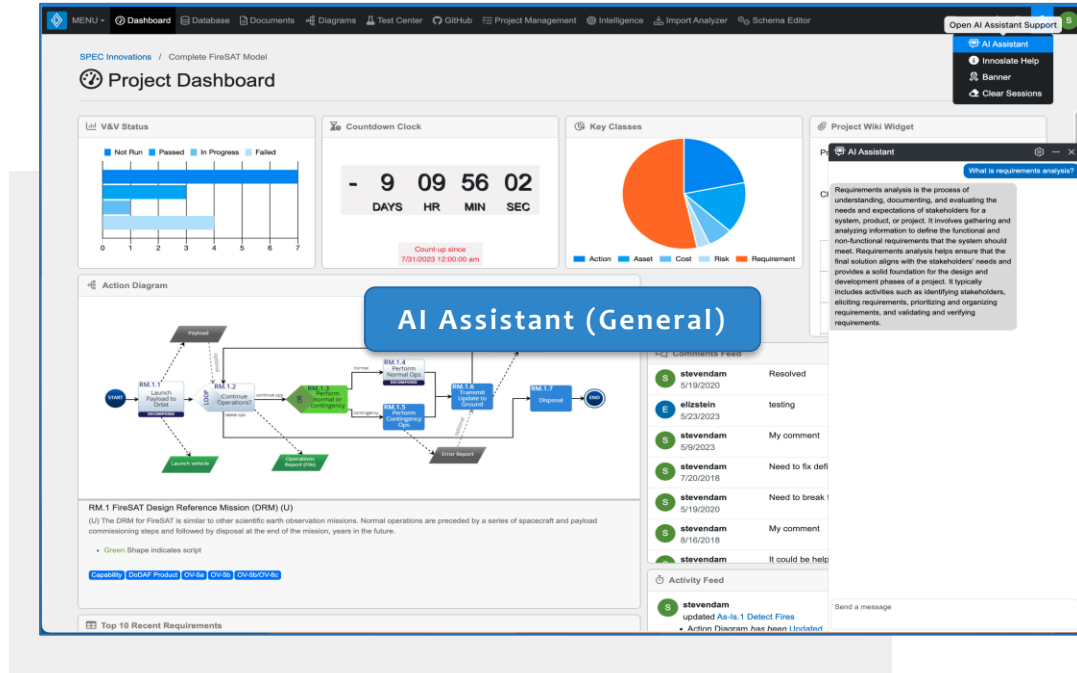
Phase I

- 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



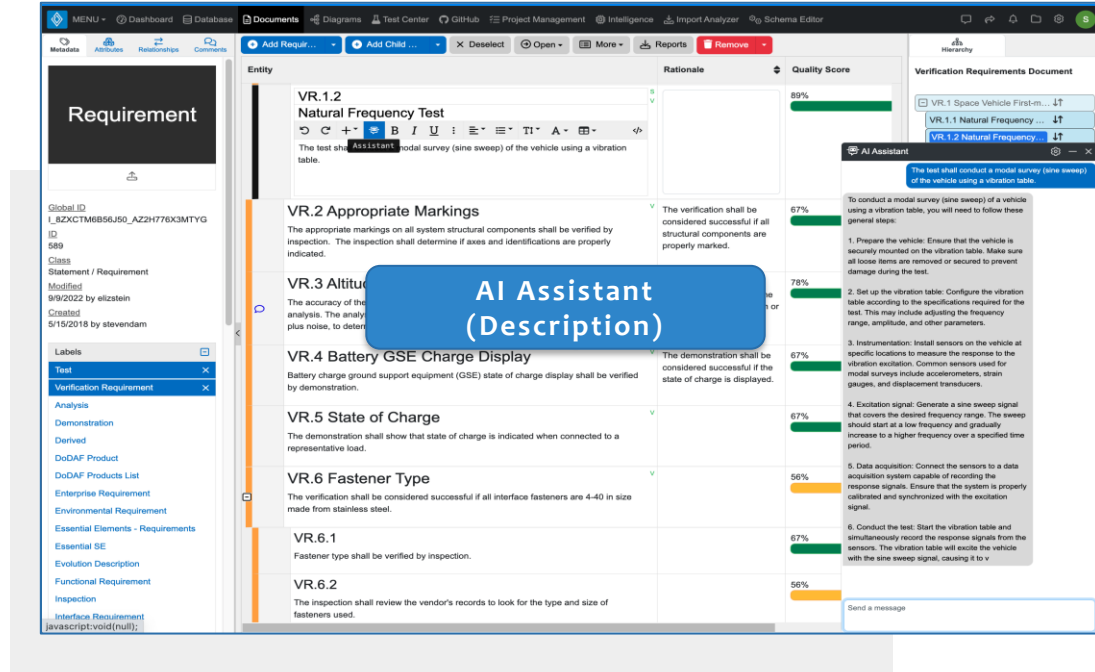
Phase II

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



Phase II

- Additional suggested enhancements to Sopatra were also developed



The screenshot displays the Sopatra software interface, which is a requirements management tool. The main window shows a list of requirements, each with a description, rationale, and a quality score. An AI Assistant overlay is visible, providing a detailed description of the requirements.

Entity	Rationale	Quality Score
VR.1.2 Natural Frequency Test The test shall conduct a modal survey (sine sweep) of the vehicle using a vibration table.		89%
VR.2 Appropriate Markings The appropriate markings on all system structural components shall be verified by inspection. The inspection shall determine if axes and identifications are properly indicated.	The verification shall be considered successful if all structural components are properly marked.	67%
VR.3 Altitude The accuracy of the analysis. The analysis shall include plus noise, to determine the accuracy of the analysis.		78%
VR.4 Battery GSE Charge Display Battery charge ground support equipment (GSE) state of charge display shall be verified by demonstration.	The demonstration shall be considered successful if the state of charge is displayed.	67%
VR.5 State of Charge The demonstration shall show that state of charge is indicated when connected to a representative load.		67%
VR.6 Fastener Type The verification shall be considered successful if all interface fasteners are 4-40 in size made from stainless steel.		56%
VR.6.1 Fastener type shall be verified by inspection.		67%
VR.6.2 The inspection shall review the vendor's records to look for the type and size of fasteners used.		56%

AI Assistant (Description)

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.
2. Set up the vibration table. Configure the vibration table according to the specifications required for the test. This may include adjusting the frequency range, amplitude, and other parameters.
3. Instrumentation: Install sensors on the vehicle at specific locations to measure the response to the vibration excitation. Common sensors used for modal surveys include accelerometers, strain gauges, and displacement transducers.
4. Excitation signal: Generate a sine sweep signal that covers the desired frequency range. The sweep should start at a low frequency and gradually increase to a higher frequency over a specified time period.
5. Data acquisition: Connect the sensors to a data acquisition system capable of recording the response signals. Ensure that the system is properly calibrated and synchronized with the excitation signal.
6. Conduct the test: Start the vibration table and simultaneously record the response signals from the sensors. The vibration table will excite the vehicle with the sine sweep signal, causing it to vibrate.

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

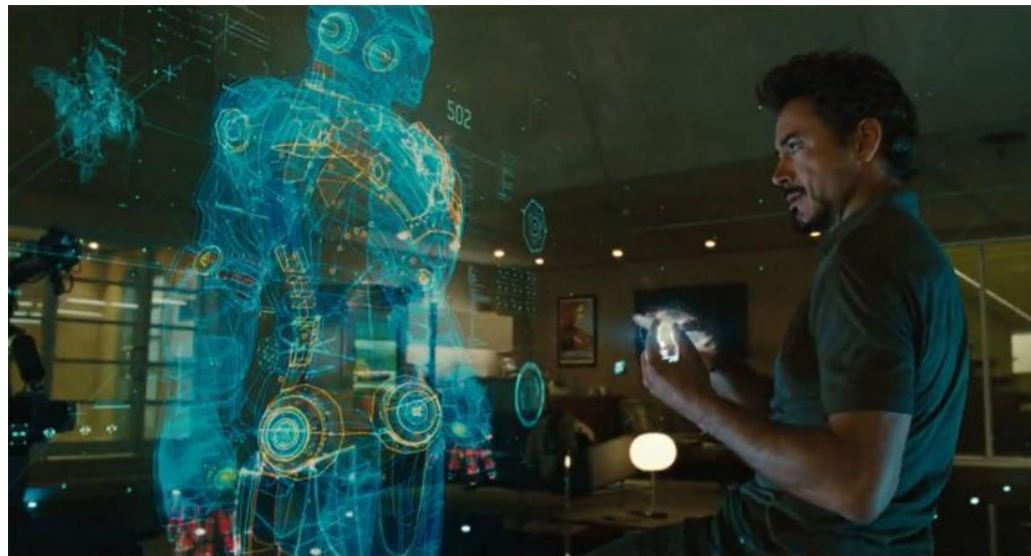
- The result of this work included several opportunities
- The general opportunities were:
 - Use of GAI in generating quality scores and recommending changes
 - Use GAI to create diagrams and enhance the layout automatically
 - Use GAI to generate test cases from the requirements
- Although these recommendations 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 GAIs 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

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x @StevenHDam

e steven.dam@specinnovations.com

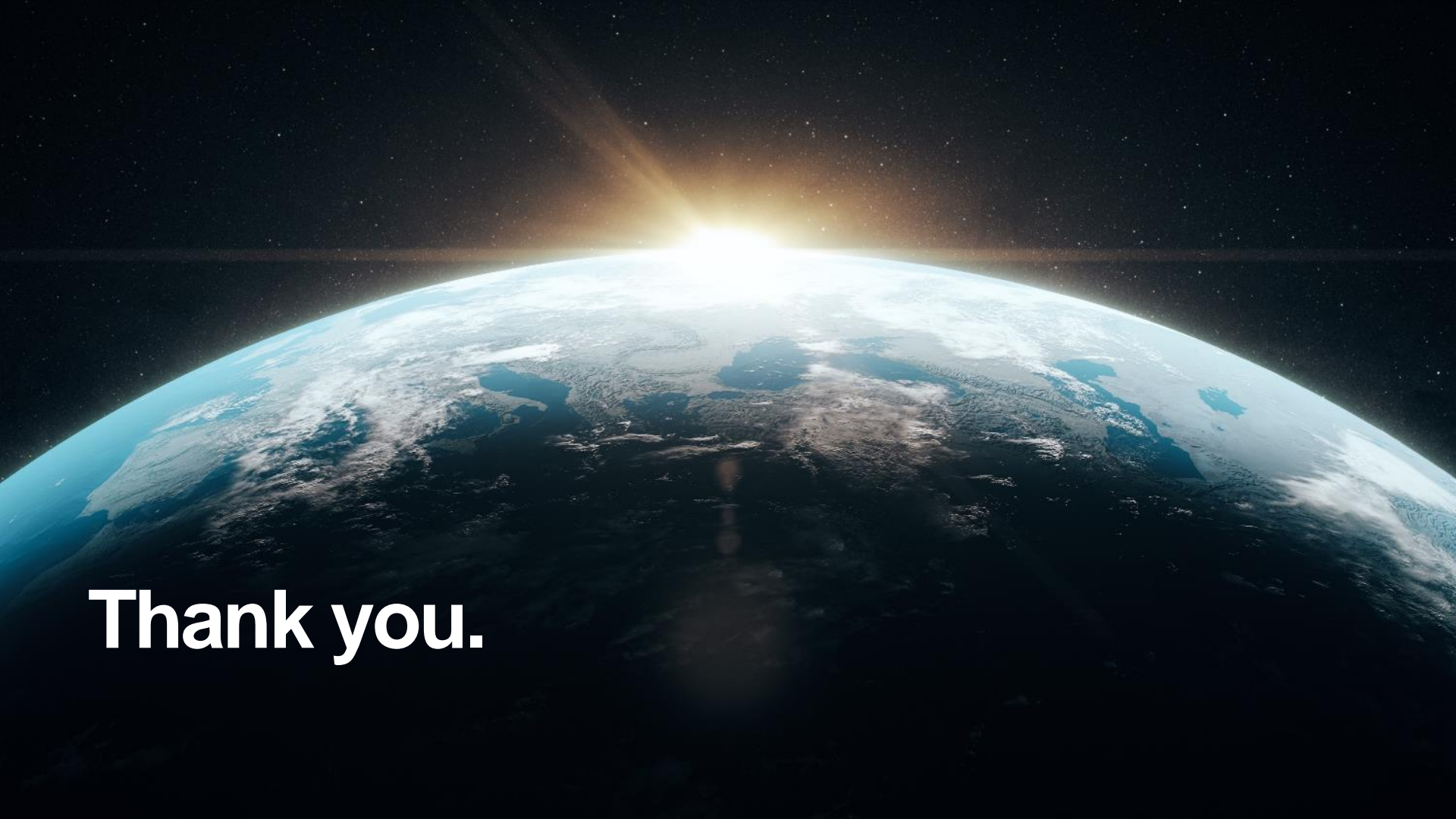
SPEC Innovations

Creators of Innoslate & Sopatra

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

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Thank you.

Q&A Session

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

Next Month's Webinar:

Wednesday, 17^h 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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