# Survey Preamble

This survey is being administered and distributed by the American Institute of Aeronautics and Astronautics Digital Engineering Integration Committee (DEIC) Computational Design and Analysis for Digital Engineering (AIAA DEIC-CoDADE) Subcommittee.

A first objective of this survey is to **understand the impacts of computational methods, data, infrastructure, and organizational culture on the maturity of different non-deterministic methods with respect to interoperability and using those methods appropriately**. This impact analysis will focus on multiscale applications, coupled physics, infrastructure scalability, handling disparate types of data and software. Non-deterministic methods can include, but are not limited to, data-derived, probabilistic/stochastic, and combined stochastic/deterministic models, of which AI is one example.

A second objective of this survey is to **elicit the role that individuals see digital engineering play with respect to maximizing interoperability and promoting the appropriate use of non-deterministic methods**.

The results from this survey will **inform the development of additional guidelines aimed at promoting the appropriate use of AI and maximizing interoperability**.

This survey refers to several terms that are defined below for your convenience.

**Appropriate use of AI** – The use of AI in an appropriate manner is an element of using AI responsibly. Responsible use of AI “lies with those persons with authorities for and over the design, requirements definition, development, acquisition, testing, evaluation, and training for any DoD system, even AI ones” (DoD Defense Innovation Board [1]). Appropriate use would require ensuring that the engineers have a full-scale, life cycle-oriented view of where their data comes from, how their models are being used and certified, are the results from using those models consistent, and what sorts of decisions are being made using said models. These would seek to answer two questions: (1) Are the models, data, and decision-making process appropriate for the desired application? (2) Are the models, data, and results from applying the models able to support quantification of uncertainty and establishing trust?

**Interoperability** - According to DoD Instruction 8330.01 [1], interoperability is defined as the ability of systems, units, or forces to provide data, information, materiel, and services to, and accept the same from, other systems, units, or forces, and to use the data, information, materiel, and services exchanged to enable them to effectively operate together. In the context of non-deterministic methods (including, but not limited to, AI), the goal is to emphasize how interoperability of these methods with other digital infrastructure can be supported in an appropriate manner. Considering the described requirements for appropriate use of AI, the notion of interoperability of infrastructure required for using AI is central to ensuring appropriate use.

**Digital twin** - A set of virtual information constructs that mimics the structure, context and behavior of an individual / unique physical asset, or a group of physical assets, is dynamically updated with data from its physical twin throughout its life cycle and informs decisions that realize value (AIAA Digital Twin Position Paper).

**Digital thread**: A collection of linked authoritative digital information pertaining to a process, product, or system, whose consistency is actively managed throughout the life cycle. This enables accessibility, traceability, currency, applicability, and credibility of information, thus facilitating the capture, communication, and use and reuse of knowledge to efficiently inform decisions that realize value (AIAA Digital Thread Position Paper).

For further information about the survey or the DEIC-CoDADE subcommittee, please email Abhishek Ram ([aram@draper.com](mailto:aram@draper.com)). All of us in the DEIC-CoDADE subcommittee would like to thank you for the time and effort taken to respond to the survey questions.

# Questions About Your Organization

1. My organization most aligns with:
   1. Government
   2. Military / Defense
   3. Commercial / Industrial
   4. Academia
   5. Federally Funded, Research & Development Center (FFRDC)
   6. University Affiliated Research Center (UARC)
   7. Professional society
   8. Other
2. How large is your organization?
   1. N/A: Independent contractor / government / academic
   2. Small business (<100 people)
   3. Medium-sized business (100 – 1500 people)
   4. Large business (>1500 people)
3. How many years of experience does your workforce have?

**[Select All That Apply]**

* 1. 0 to 4 years
  2. 5 to 9 years
  3. 10 to 19 years
  4. 20 to 29 years
  5. 30 years or more

# Questions About Your Experience

1. How long have you been in the science & engineering workforce?
   1. 0 to 4 years
   2. 5 to 9 years
   3. 10 to 19 years
   4. 20 to 29 years
   5. 30 years or more
2. How long have you been in your current organization?
   1. 0 to 4 years
   2. 5 to 9 years
   3. 10 to 19 years
   4. 20 to 29 years
   5. 30 years or more
3. How would you classify your experience and expertise in these subject areas?

**[List of Subject Areas with Options to Choose Levels of Expertise Next To Them]**

e.g., Subject Area \_\_\_\_\_\_ {Dropdown Box With List of Levels of Expertise ^see question above}

1. Regarding which subject areas would you feel comfortable answering survey questions?

**[Select All That Apply]**

1. Computational Design and Analysis Framework Development
2. Enterprise Data and Software Architecture
3. Hardware and Software Infrastructure Co-Design
4. The Role of Organization Strategy and Culture

# Computational Design and Analysis Framework Development

1. Select appropriate level of *personal* professional experience and expertise in:  
   **[None / Dabbled / Learning / Occasional / Commonplace]**
   1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, CHT, FSI, etc.)
   2. Coupled Multiphysics Mod/Sim
   3. Multiscale Mod/Sim (single or multi-physics/discipline)
   4. Multifidelity Mod/Sim (single or multi-physics/discipline)
   5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
   6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
   7. AI/ML applied to sophisticated automation, data analysis, etc.
   8. Hybrid AI/ML + traditional modeling/simulation integrated methods
   9. Other: [Request Short Answers]
2. Select your best estimate of your *enterprise’s* experience and expertise in:  
   **[None / Dabbled / Learning / Occasional / Commonplace]**
   1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, CHT, FSI, etc.)
   2. Coupled Multiphysics Mod/Sim
   3. Multiscale Mod/Sim (single or multi-physics/discipline)
   4. Multifidelity Mod/Sim (single or multi-physics/discipline)
   5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
   6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
   7. AI/ML applied to sophisticated automation, data analysis, etc.
   8. Hybrid AI/ML + traditional modeling/simulation integrated methods
   9. Other: [Request Short Answers]
3. Select your best estimate of your *collaborator’s* *(beyond your enterprise)* experience and expertise in:  
   **[None / Dabbled / Learning / Occasional / Commonplace]**
   1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, CHT, FSI, etc.)
   2. Coupled Multiphysics Mod/Sim
   3. Multiscale Mod/Sim (single or multi-physics/discipline)
   4. Multifidelity Mod/Sim (single or multi-physics/discipline)
   5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
   6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
   7. AI/ML applied to sophisticated automation, data analysis, etc.
   8. Hybrid AI/ML + traditional modeling/simulation integrated methods
   9. Other: [Request Short Answers]
4. Interoperability is most realized by the application of DE to which of the following research areas?

**[Select All That Apply]**

* 1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, CHT, FSI, etc.)
  2. Coupled Multiphysics Mod/Sim
  3. Multiscale Mod/Sim (single or multi-physics/discipline)
  4. Multifidelity Mod/Sim (single or multi-physics/discipline)
  5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
  6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
  7. AI/ML applied to sophisticated automation, data analysis, etc.
  8. Hybrid AI/ML + traditional modeling/simulation integrated methods
  9. Other: [Request Short Answers]

1. Interoperability is not/least realized by the application of DE to which of the following research areas?

**[Select All That Apply]**

* 1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, CHT, FSI, etc.)
  2. Coupled Multiphysics Mod/Sim
  3. Multiscale Mod/Sim (single or multi-physics/discipline)
  4. Multifidelity Mod/Sim (single or multi-physics/discipline)
  5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
  6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
  7. AI/ML applied to sophisticated automation, data analysis, etc.
  8. Hybrid AI/ML + traditional modeling/simulation integrated methods
  9. Other: [Request Short Answers]

1. Would it be appropriate to use digital engineering with any of these research areas?

**[Select All That Apply]**

* 1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, CHT, FSI, etc.)
  2. Coupled Multiphysics Mod/Sim
  3. Multiscale Mod/Sim (single or multi-physics/discipline)
  4. Multifidelity Mod/Sim (single or multi-physics/discipline)
  5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
  6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
  7. AI/ML applied to sophisticated automation, data analysis, etc.
  8. Hybrid AI/ML + traditional modeling/simulation integrated methods
  9. Other: [Request Short Answers]

1. Which research areas would benefit from additional guidelines for maximizing interoperability?

**[Select All That Apply]**

* 1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, CHT, FSI, etc.)
  2. Coupled Multiphysics Mod/Sim
  3. Multiscale Mod/Sim (single or multi-physics/discipline)
  4. Multifidelity Mod/Sim (single or multi-physics/discipline)
  5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
  6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
  7. AI/ML applied to sophisticated automation, data analysis, etc.
  8. Hybrid AI/ML + traditional modeling/simulation integrated methods
  9. Other: [Request Short Answers]

1. Which research areas would benefit from additional guidelines for promoting appropriate use?

**[Select All That Apply]**

* 1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, CHT, FSI, etc.)
  2. Coupled Multiphysics Mod/Sim
  3. Multiscale Mod/Sim (single or multi-physics/discipline)
  4. Multifidelity Mod/Sim (single or multi-physics/discipline)
  5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
  6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
  7. AI/ML applied to sophisticated automation, data analysis, etc.
  8. Hybrid AI/ML + traditional modeling/simulation integrated methods
  9. Other: [Request Short Answers]

1. How frequently do you plan to use the digital threads you are developing?
   1. One-off digital threads
   2. Few-repeated-use digital threads (used a finite number of times and shelved)
   3. Continuously used and operated digital threads
   4. Other: [Request Short Answers]

# Enterprise Data and Software Architecture

1. Which kinds of data do you mostly utilize in your work?

**[Select All That Apply]**

* 1. Unstructured text data
  2. Structured data
  3. Boundary conditions
  4. Geometric data
  5. Tolerances
  6. Photographs
  7. Metadata
  8. Product life cycle management (PLM) data
  9. HW/SW coupling information
  10. Simulation verification & validation data
  11. Other: [Request Short Answers]

1. Is the data you work with:
   1. Measured
   2. Simulated
   3. System Descriptive (e.g., PLM data, HW/SW data)
   4. Fusion Computational (mixed simulated and measured data)
   5. All of the above (measured, simulated, and system descriptive)
   6. Other: [Request Short Answers]
2. Which types of data would you expect to be the least challenging to manage with respect to digital thread development?

**[Select All That Apply]**

1. Unstructured text data
2. Structured data
3. Boundary conditions
4. Geometric data
5. Tolerances
6. Photographs
7. Metadata
8. Product life cycle management (PLM) data
9. HW/SW coupling information
10. Simulation verification & validation data
11. Other: [Request Short Answers]
12. Which types of data would you expect to be the most challenging to manage with respect to digital thread development?

**[Select All That Apply]**

* 1. Unstructured text data
  2. Structured data
  3. Boundary conditions
  4. Geometric data
  5. Tolerances
  6. Photographs
  7. Metadata
  8. Product life cycle management (PLM) data
  9. HW/SW coupling information
  10. Simulation verification & validation data
  11. Other: [Request Short Answers]

1. The utilization of which types of data would benefit from additional guidelines for maximizing interoperability?
   1. Unstructured text data
   2. Structured data
   3. Boundary conditions
   4. Geometric data
   5. Tolerances
   6. Photographs
   7. Metadata
   8. Product life cycle management (PLM) data
   9. HW/SW coupling information
   10. Simulation verification & validation data
   11. Other: [Request Short Answers]
2. The utilization of which types of data would benefit from additional guidelines for promoting appropriate use?
   1. Unstructured text data
   2. Structured data
   3. Boundary conditions
   4. Geometric data
   5. Tolerances
   6. Photographs
   7. Metadata
   8. Product life cycle management (PLM) data
   9. HW/SW coupling information
   10. Simulation verification & validation data
   11. Other: [Request Short Answers]

# Hardware and Software Infrastructure Co-Design

1. What research areas do you use high performance computing for? **[Select All That Apply]**
   1. Co-simulated (uncoupled) Multiphysics (e.g., aeroacoustics, conjugate heat transfer, fluid-structures interactions)
   2. Coupled Multiphysics Mod/Sim
   3. Multiscale Mod/Sim (single or multi-physics/discipline)
   4. Multifidelity Mod/Sim (single or multi-physics/discipline)
   5. Multidisciplinary Trade-off Analyses (integrated design/manufacturing, performance/lifing, etc.)
   6. Automation for labor-intensive tasks (meshing, post-processing, etc.)
   7. AI/ML applied to sophisticated automation, data analysis, etc.
   8. Hybrid AI/ML + traditional modeling/simulation integrated methods
   9. Other: [Request Short Answers]
2. What types of data do you utilize in your research areas that use high performance computing? **[Select All That Apply]**
   1. Unstructured text data
   2. Structured data
   3. Boundary conditions
   4. Geometric data
   5. Tolerances
   6. Photographs
   7. Metadata
   8. Product life cycle management (PLM) data
   9. HW/SW coupling information
   10. Simulation verification & validation data
   11. Other: [Request Short Answers]
3. What types of scaling do you anticipate your enterprise having to undergo in the future?

**[Select All That Apply]**

1. Strong scaling – Incorporate more hardware to reduce the time-to-solution for a given problem.
2. Weak scaling – Incorporate more hardware to solve larger problems than before.
3. User scaling – Add ability to support growth in concurrent users with minimal efforts.
4. Functional scaling – Add new functionality with minimal effort.
5. Horizontal scaling – Add more nodes/racks/data centers.
6. Vertical scaling – Upgrading nodes (e.g., processor, memory, interconnect)
7. Other: [Request Short Answers]
8. Which research areas would benefit the most from which kind of scaling?

**[List of Research Areas with Options to Choose Types of Scaling Next To Them]**

e.g., Research Area \_\_\_\_\_\_ {Dropdown Box With List of Scaling Options}

I envision the following research area \_\_\_\_\_\_ {Dropdown} to benefit the most from this type of scaling \_\_\_\_\_\_ {Dropdown}

1. The management of which types of data would benefit the most from which kind of scaling?

**[List of Research Areas with Options to Choose Types of Scaling Next To Them]**

e.g., Types of data \_\_\_\_\_\_ {Dropdown Box With List of Scaling Options}

I envision the following type of data \_\_\_\_\_\_ {Dropdown} to benefit the most from this type of scaling: \_\_\_\_\_\_ {Dropdown}

1. Interoperability is best realized by the use of \_\_\_\_\_\_\_ scaling.

**[Select All That Apply]**

* 1. Strong scaling – Incorporate more hardware to reduce the time-to-solution for a given problem.
  2. Weak scaling – Incorporate more hardware to solve larger problems than before.
  3. User scaling – Add ability to support growth in concurrent users with minimal efforts.
  4. Functional scaling – Add new functionality with minimal effort.
  5. Horizontal scaling – Add more nodes/racks/data centers.
  6. Vertical scaling – Upgrading nodes (e.g., processor, memory, interconnect)
  7. Other: [Request Short Answers]

1. Appropriate use of AI is best ensured/promoted by the use of \_\_\_\_\_\_\_ scaling.

**[Select All That Apply]**

* 1. Strong scaling – Incorporate more hardware to reduce the time-to-solution for a given problem.
  2. Weak scaling – Incorporate more hardware to solve larger problems than before.
  3. User scaling – Add ability to support growth in concurrent users with minimal efforts.
  4. Functional scaling – Add new functionality with minimal effort.
  5. Horizontal scaling – Add more nodes/racks/data centers.
  6. Vertical scaling – Upgrading nodes (e.g., processor, memory, interconnect)
  7. Other: [Request Short Answers]

# The Role of Organization Strategy and Culture

1. How do you interact with digital twins?

**[Select All That Apply]**

* 1. As a vendor of supporting technology
  2. As a developer / product manager of twins or twinned products
  3. As a consumer of twins / user of twinned products

1. How much progress into digital twin and digital thread development has your organization achieved?
   1. Conceptual stage (designed, but no implementation at all)
   2. Minimum viable product (basic implementation, meeting design requirements)
   3. Operational on a team-wide scale (fully implemented in a limited setting)
   4. Operational on a division-wide scale (fully implemented across engineering, manufacturing, etc.)
   5. Operational on an enterprise scale (fully implemented and “fielded” to relevant teams/efforts)
2. Who are the current stakeholders of your digital engineering efforts?

**[Select All That Apply]**

* 1. Other computational design and analysis teams
  2. Program management
  3. Direct customers
  4. End-product users
  5. Community around end-product users
  6. Tool vendors
  7. Regulatory bodies
  8. Other: [Request Short Answers]

1. Who do you believe should be considered as stakeholders of your digital engineering efforts?

**[Select All That Apply]**

* 1. Other computational design and analysis teams
  2. Program management
  3. Direct customers
  4. End-product customers
  5. Community around end-product users
  6. Tool vendors
  7. Regulatory bodies
  8. Other: [Request Short Answers]

1. Who currently has the most influence over your digital engineering efforts?

**[Select All That Apply]**

* 1. Other computational design and analysis teams
  2. Program management
  3. Direct customers
  4. End-product customers
  5. Community around end-product users
  6. Tool vendors
  7. Regulatory bodies
  8. Other: [Request Short Answers]

1. Have cost reductions impacted your digital engineering efforts?

**[Choose One Option]**

* 1. Yes
  2. No (skip to #37)
  3. Other: [Request Short Answers]

1. If you have experienced cost reductions to your digital engineering efforts, what was the impact on your enterprise as a whole?

**[Choose One Option]**

* 1. Significant impact
  2. Minor impact
  3. No impact
  4. Other: [Request Short Answers]

1. What has been the impact of the size of your organization on your ability to implement digital engineering?

**[Choose One Option]**

* 1. Significant impact
  2. Minor impact
  3. No impact
  4. Other: [Request Short Answers]

1. What has been the impact of the number of years of experience your workforce has on your ability to implement digital engineering?

**[Choose One Option]**

* 1. Significant impact
  2. Minor impact
  3. No impact
  4. Other: [Request Short Answers]

1. What has been the impact of having to integrate various tools on your ability to implement digital engineering?

**[Choose One Option]**

* 1. Significant impact
  2. Minor impact
  3. No impact
  4. Other: [Request Short Answers]

1. What has been the impact of the alignment of your organization (e.g., government, defense, commercial, academia) on your implementation of digital engineering?

**[Choose One Option]**

* 1. Significant impact
  2. Minor impact
  3. No impact
  4. Other: [Request Short Answers]

# Short Answer Questions

1. What are the fundamental challenges / major barriers to the implementation of digital engineering?

**[Short Answer: No More Than 500 Words]**

1. What advancements in tools / technologies / methods / processes are needed to realize the promise of digital engineering?

**[Short Answer: No More Than 500 Words]**

1. What advancements in strategies for data curation and life cycle management are needed to realize the promise of digital engineering?

**[Short Answer: No More Than 500 Words]**

1. If you are interested in the results of this survey, please provide your contact information below.

**[Short Answer: No More Than 500 Words]**