NASA Digital Engineering's Approach to the Incorporation of AI: All that Glitters is Not **Gold**

Terry R. Hill

NASA OCE Digital Engineering Program Manager

terry.hill-1@nasa.gov

Audience:

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AI in PLM: A Disruptive Opportunity and Challenge

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Artificial Intelligence (AI) Usage Disclosure: Images were created with assistance from NASA-approved AI tool for the purpose of creating an AI image to illustrate how AI is not always the answer. The content has been reviewed and edited by T. Hill. More information on the extent and nature of AI usage is included in the Methods or Acknowledgements sections of the document.

Bottom Line Up Front

While LLMs like Copilot and ChatGPT are powerful for language and code, NASA Engineering demands AI that is physics-aware, real-time, explainable, and deeply integrated with domain data and tools.

All That Glitters is Not Gold

b.t.w. this image was created using AI

Opening Thought:

- AI is everywhere—promises abound, but not every "golden" claim delivers value, especially in the context of NASA's mission-critical, resource-constrained environment.

The AI/ML Hype Cycle in Digital Engineering

- **Common Claims:**
  - "AI will automate all engineering decisions."
  - "Digital twins will self-optimize with AI."
  - "PLM systems will become fully autonomous."

- **Why Hype Persists:**
  - Vendor marketing, media amplification, and the allure of "revolutionary" change.

- **NASA's Perspective:**
  - Caution against "silver bullet" thinking; focus on mission safety & assurance, traceability (e.g. data pedigree/integrity or analysis verification), and incremental value

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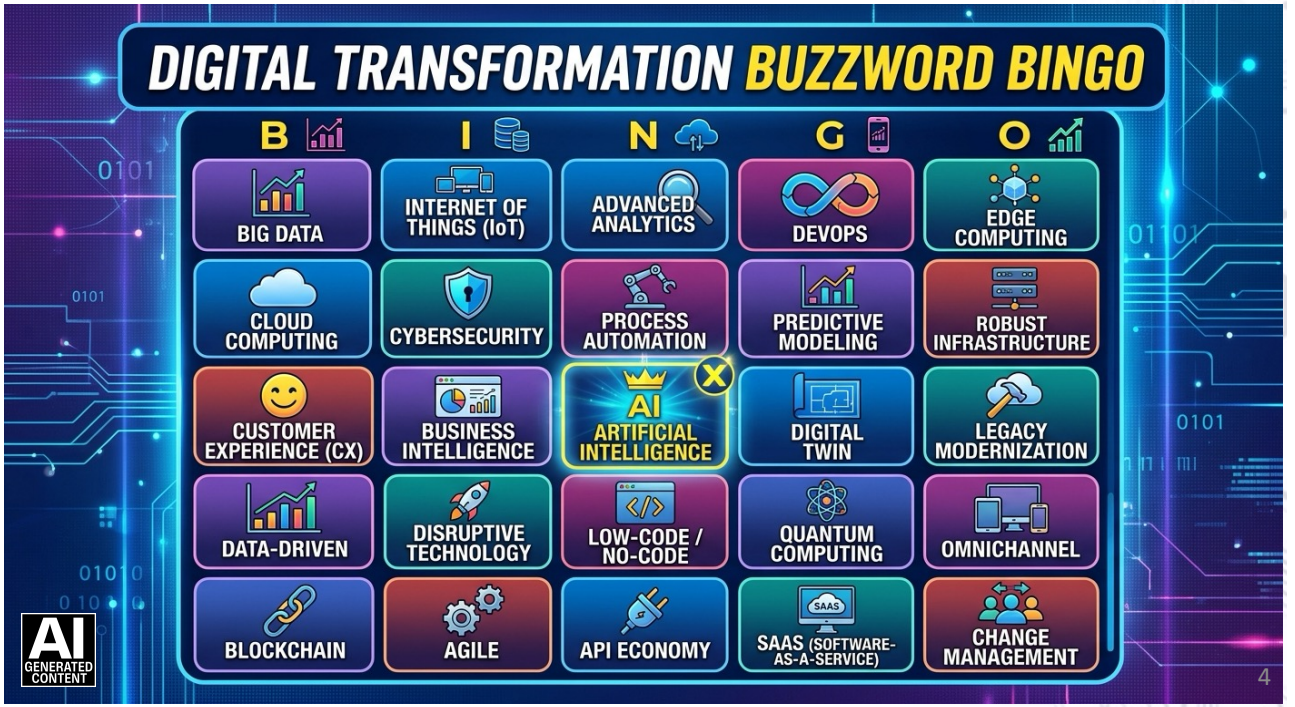


What Doesn't Work: Lessons from the Field

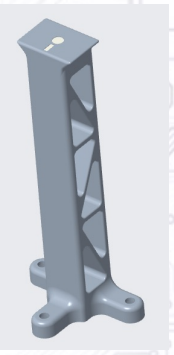
- **Unsupported Hype Examples:**
  - "Push-button" AI for design optimization—often fails due to lack of quality data, context, or explainability.
    - *Why AI Systems Fail Quietly*, IEEE Spectrum, 7 Apr. '26 – "Quiet [AI] failure is emerging as one of the defining engineering challenges of autonomous systems because correctness now depends on coordination, timing, and feedback across entire systems."
  - Autonomous digital twins without robust, validated models—risk of "garbage in, garbage out."
  - Overpromising on cost savings or speed without accounting for integration, training, and governance costs.

- **NASA's Lessons Learned:**
  - ROI must be proven with pilot projects and real mission data and verified by subject matter experts.
  - AI/ML is only as good as the underlying data quality & machine interpretability, tagging/meta data, model fidelity, and governance structures
  - "Perfect is the enemy of good"—focus on incremental, scalable improvements

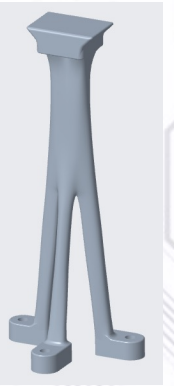
You guessed it, this image was also created using AI

What Actually Works: Where AI/ML Adds Real Value to NASA's Digital Engineering

- **Smart Standards Selection:**
  - AI/ML prototypes for recommending relevant NASA-unique standards, reducing manual review time and improving compliance (current)
- **Non-Conformance & Anomaly Detection:**
  - ML to assess non-conformance reporting to identify possible common causes (current)
  - ML models flagging outliers in simulation, test, and operational data within digital twins (future)
- **Automated Data Aggregation & Reporting:**
  - AI-driven dashboards (Power BI, DAX) for license usage (current)
  - AI-driven dashboards tool adoption, and project status—saving labor and enabling data-driven decisions (future)
- **System Maintenance and Performance Forecasting**
  - AI/ML models consume digital thread data for predictive maintenance with Condition-Based Maintenance (CBM), & performance forecasting (future)
- **Mass Optimization:**
  - ML optimization of structural element mass and performance using COTS generative topological optimization (GTO) resulting in ~30% savings in mass and meeting or exceeding performance metrics. (current)
- **Knowledge Discovery:**
  - AI assistants (e.g. ChatGSFC pulling from Agency procurement records) for rapid software inventory and resource location across NASA's complex IT landscape (current)
- **AI/ML as a Data Curation Assistant:**
  - Scripts and ML models automate metadata extraction, classification, metadata tagging recommendations of decades of corporate knowledge and synchronization across PLM, MBSE, SPDM, and requirements tools (future)
- **AI/ML for Model Validation:**
  - ML used to check consistency and completeness in SysML models and digital thread artifacts (future)
- **Human-in-the-Loop:**
  - **AI augments, not replaces, engineering judgment—NASA's approach is always to keep humans in control of critical decisions (foundational)**



Traditional Design



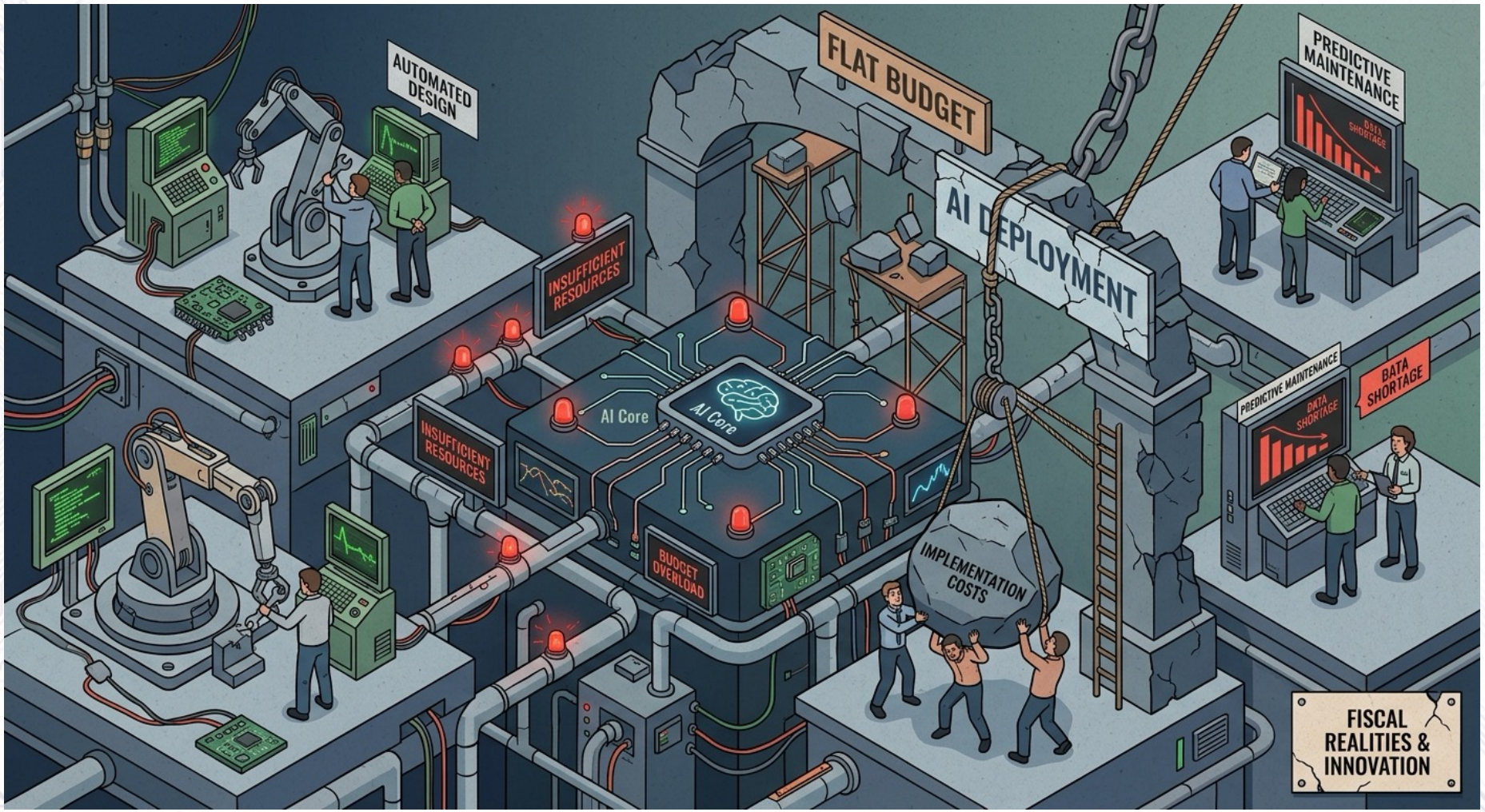
GTO Design

AI Solutions Needed for Engineering That LLMs Can't Address*

- **Physics-Based Simulation and High-Fidelity Modeling**
  - Engineering requires AI that can reason with and generate solutions based on the laws of physics, material properties, and validated simulation models—not just text or code.
  - LLMs like Copilot or ChatGPT cannot replace finite element analysis, computational fluid dynamics, or multi-physics simulation engines.
- **Real-Time, Closed-Loop Control and Embedded Systems**
  - Many engineering applications need AI that can operate in real time, interact with hardware, and make safety-critical decisions (e.g., flight control, robotics, spacecraft operations).
  - LLMs are not designed for deterministic, low-latency, or safety-certified environments.
- **Data Fusion from Heterogeneous, Non-Textual Sources**
  - Engineering AI must integrate sensor data, CAD models, telemetry, images, and time-series data—often in real time.
  - LLMs are optimized for language, not for fusing and interpreting complex, multi-modal engineering datasets.
- **Explainable, Auditable, and Certifiable AI**
  - Engineering and PLM systems demand AI whose decisions can be traced, validated, and certified for regulatory and mission assurance.
  - LLMs are "black boxes" and cannot provide the level of explainability or auditability required for safety-critical engineering.
- **Domain-Specific Knowledge Integration**
  - AI for engineering must encode and reason with standards, requirements, and domain ontologies (e.g., NASA-unique standards, material databases, system architectures).
  - LLMs lack persistent, structured integration with authoritative engineering sources of truth.
- **Secure, On-Premise, and IP-Sensitive Deployment**
  - Many engineering environments require AI that can run securely on-premises, protect intellectual property, and comply with export control—capabilities not guaranteed by commercial, cloud-based LLMs.

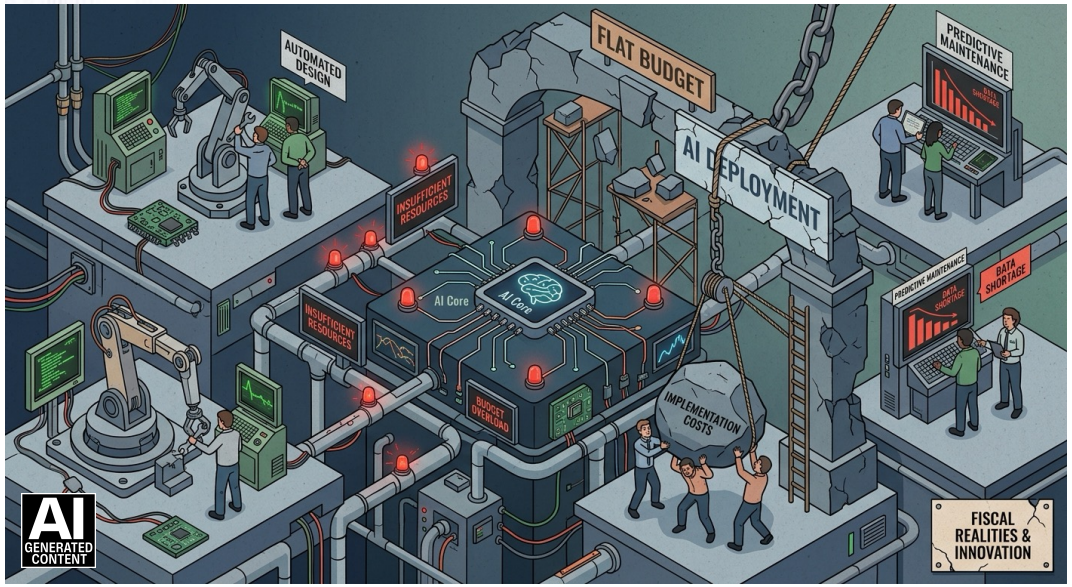
*The capabilities of LLMs are evolving rapidly so these statements are made to the best of the speaker's knowledge as of the writing of this presentation.

Deploying AI/ML in a Flat-Budget Environment



Deploying AI/ML in a Flat-Budget Environment

- **Prioritization:**
  - Target AI/ML investments where they demonstrably reduce manual labor, accelerate compliance, or improve mission assurance.
- **Leverage Existing Tools:**
  - Integrate AI/ML into current PLM, MBSE, and reporting systems (e.g., Power BI, MagicDraw, Windchill) rather than building bespoke solutions



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- **Cloud & Shared Services:**
  - Use cloud-based, centrally managed AI/ML services to avoid redundant infrastructure, unknown reliability due to dissimilar AI/ML solution deployment and inconsistent AI/ML training/modeling and maximize to ROI.
- **Workforce Upskilling:**
  - Invest in training engineers to use AI-augmented tools, not in replacing the workforce.
  - By augmenting the workforce, you widen the productivity pipeline and increase profits (or do more at the same cost per government paradigm) rather than saving labor costs by replacing workers with AI.
- **Governance & Transparency:**
  - Maintain rigorous validation, traceability, and explainability for all AI/ML outputs—no “black box” decisions in mission-critical contexts

Recommendations for Realistic AI/ML Adoption in Digital Engineering

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Start Small, Scale Wisely

- Pilot AI/ML in targeted, high-impact areas; expand only with proven ROI.


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HEIGHTS
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REVEAL
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BENEFIT
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Terry R. Hill
NASA OCE Digital Engineering
Program Manager
terry.hill-1@nasa.gov