

# Transforming Information Assurance and IT Service Management Through Digital Engineering

## Dissertation Proposal Defense

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# Dissertation Committee

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# About the Researcher

- ▶ Seven Degrees and Certifications from Dakota State University
- ▶ Program Work Environment Solution Engineer & Architect for Collins Aerospace (Part of RTX)
- ▶ Daily experience with high-compliance environments: DAAG, JSIG, CNSS, CSFC, CDS
- ▶ Research Focus: Digital Engineering for Enterprise IT and Information Assurance
- ▶ Bridging systems engineering with enterprise IT and IA practice

# Research Abstract

Digital Engineering has transformed how the Department of Defense, NASA, and the aerospace industry design, develop, and sustain complex systems. This research investigates whether IT and Information Assurance professionals recognize the potential that Digital Engineering capabilities hold for their work.

Systematic literature review documents a near-complete absence of academic research applying these proven methods to enterprise IT infrastructure or Information Assurance programs. This study employs quantitative survey methodology to establish baseline empirical data regarding professional awareness and perceived value. The findings shall inform strategic decisions regarding future research investment, industry adoption initiatives, and academic curricula development.

# Presentation Agenda

1. Problem Statement and Research Context
2. Research Questions
3. Literature Review Highlights
4. Digital Engineering Foundations
5. Research Methodology
6. Survey Design and Instrument
7. Analytical Approach and Rigor
8. Timeline and Schedule
9. Expected Contributions
10. Questions and Discussion

# The Visibility Crisis: A Real-World Scenario

## Federal Incident Response: Late 2023

When a vulnerability surfaced within federal information systems, security teams raced to identify every affected component. Weeks passed while agencies struggled to map the blast radius of potential compromise.

**The Core Problem:** Existing documentation bore no faithful resemblance to actual infrastructure configurations. Defenders challenged with tracing cascading impacts while adversaries retained the initiative.

# Current State of Information System Management

## Environmental Complexity

Organizations operate within relentless technological evolution: cloud computing, microservices, IoT devices, and operational technology have spawned intricate webs of interdependencies.

## Documentation Velocity Mismatch

Static documentation approaches designed for quarterly or annual update cycles cannot maintain accuracy when systems change hourly. The structural mismatch creates systematic failures that compound over time.

# Information Assurance Practice Challenges

## Key Frameworks

NIST SP 800-37 Rev 2: Risk Management Framework

ISO 31000: Risk Management

NIST Cybersecurity Framework

**Critical Challenge:** The RMF continuous monitoring requirement exposes limitations of document-centric approaches most directly. Organizations attempting continuous monitoring through manual processes discover the labor exceeds available resources.

# IT Service Management Practice Challenges

## ITIL Framework Dependencies

Service Strategy — Service Design — Service Transition — Service Operation — Continual Service Improvement

**Critical Challenge:** Configuration Management Database implementations depend upon accuracy and currency of underlying information—accuracy that organizations consistently fail to achieve. Change management processes suffer when impact assessments rely upon incomplete dependency information.

# Evidence: Visibility and Documentation Failures

Finding	Statistic	Source
<i>Visibility Gap Metrics</i>		
IT environment monitorable	66%	IDC/Exabeam 2023
Security teams lacking device visibility	63%	Ponemon Institute 2023
High confidence in device discovery	15%	SANS Institute 2023
Organizations with security/IT silos	55%	Ivanti 2025
<i>Configuration Management Failures</i>		
CMDB implementation failure rate	80%	Gartner Research
Outages from configuration issues	64%	Uptime Institute 2023
Misconfigurations from parameter errors	70-85%	Yin et al. 2011

# Evidence: Security Impact Metrics

Finding	Statistic	Source
<i>Shadow IT and Undocumented Assets</i>		
Shadow IT as percentage of IT spend	30-40%	Gartner Research
Cloud services vs. IT estimates	15-22x higher	Cisco 2016
Projected shadow IT usage (2027)	75%	Gartner Research
<i>Security Impact Metrics</i>		
Mean time to identify breach	204 days	IBM/Ponemon 2024
Cloud breaches from misconfigurations	82%	Check Point 2024
Organizations with cloud breaches (18 mo)	95%	CSA 2024
Projected preventable cloud breaches (2027)	99%	Gartner Research

# The Documentation-Reality Gap

The persistent gap between documentation and operational reality represents the common thread connecting failures across both domains:

- ▶ Security documentation describes control implementations that may not exist as documented
- ▶ Configuration databases contain information that no longer reflects system states
- ▶ Network diagrams depict architectures that have evolved beyond their documented form

**Key Insight:** This gap undermines every process that depends upon accurate system information—which includes nearly all Information Assurance and IT Service Management activities.

# Research Questions

## RQ1: Awareness

To what extent are information technology and information assurance professionals aware of Digital Engineering capabilities, including Model-Based Systems Engineering, digital threads, digital twin technologies, and Product Lifecycle Management principles?

## RQ2: Perceived Value

Do information technology and information assurance professionals perceive Digital Engineering capabilities as potentially valuable or important for their work in information assurance, security compliance, and IT service delivery?

## RQ3: Anticipated Benefits

Do information technology and information assurance professionals believe that Digital Engineering practices could help them in performing their jobs, meeting compliance requirements, or enhancing organizational capabilities in information assurance and IT service delivery?

# Identified Research Gap

## The Literature Gap

Systematic literature review documents a near-complete absence of academic research applying proven MBSE and Digital Engineering methodologies to enterprise IT infrastructure, IT Service Management, or Information Assurance programs.

**Academic applications exist for:** Defense systems, aerospace engineering, unmanned aircraft, military system-of-systems design.

**Academic applications absent for:** Enterprise IT infrastructure, Information Assurance programs, IT Service Management.

# Literature Review: Enterprise Architecture

## Unified Architecture Framework (UAF)

ISO/IEC 19540-1:2022 and ISO/IEC 19540-2:2022, UAF emerged as the consolidating standard. The specification asserts that 90% of concepts in military frameworks prove equally applicable in commercial domains.

## Comparative Framework Analysis (Bankauskaite 2019)

UAF achieved the highest overall rating of 2.8, surpassing TOGAF (2.3), DoDAF (1.9), MODAF (1.8), NAF (1.6), and FEAF (1.2).

# Literature Review: DoD Digital Engineering Strategy

## Five Strategic Goals (DoD DE Strategy 2018)

1. Formalize model development and integration for enterprise decisions
2. Provide an authoritative source of truth
3. Incorporate technological innovation to improve practice
4. Establish a Digital Engineering ecosystem
5. Transform culture and workforce for Digital Engineering adoption

DoD Instruction 5000.97 (December 2023) codifies Digital Engineering requirements, mandating programs leverage digital artifacts as the authoritative source of system information.

# Digital Engineering: Four Pillars

**Digital Engineering capabilities address the documentation-reality gap through four integrated pillars:**

## Model-Based Systems Engineering

Executable models as authoritative system representations

## Digital Thread

Authoritative traceability across system lifecycle

## Digital Twin

Virtual replicas for development, testing, and validation

## Product Lifecycle Management

Integrated lifecycle governance and configuration control

# Pillar 1: Model-Based Systems Engineering

## Definition

MBSE represents a fundamental shift from document-centric to model-centric approaches. Models become the authoritative representation of system architecture, requirements, behavior, and interfaces.

## Application to IA/IT:

- ▶ Models can capture security architectures with explicit relationships between controls, assets, and threats
- ▶ Authorization boundaries represented as executable models rather than static documents
- ▶ Relationships between configuration items modeled with inheritance and dependencies

## Pillar 2: Digital Thread

### Definition

The digital thread provides authoritative traceability—verified connections between requirements, implementations, test results, and operational configurations throughout the system lifecycle.

### Application to IA/IT:

- ▶ Traceability from security requirements through control implementations to assessment evidence
- ▶ Automated compliance verification through model-based queries
- ▶ Change impact analysis that traces modifications across interconnected systems

## Pillar 3: Digital Twin

### Definition

Digital twins are virtual replicas of physical systems that enable development, simulation, analysis, testing, and validation without impacting production environments. Digital twins maintain synchronization with their physical counterparts and may utilize “hardware in the loop” of physical components

### Application to IA/IT:

- ▶ Security scenario simulation and defensive measure testing
- ▶ Change validation in as-configured virtual environments before production deployment
- ▶ Capacity planning and performance analysis for IT service delivery

# Pillar 4: Product Lifecycle Management

## Definition

PLM provides frameworks and toolsets for managing information, configurations, changes, service history, processes, and resources throughout the entire system lifecycle from conception through retirement.

## Application to IA/IT:

- ▶ Configuration baseline management aligned with ITIL principles
- ▶ Change coordination across interconnected systems
- ▶ Security control maintenance throughout system operation and decommissioning
- ▶ Integration of security and IT operations through shared authoritative data

# Digital Engineering Value Proposition

## Addressing Identified Gaps

- ▶ **Authoritative Source of Truth Gap:** Single authoritative model eliminates conflicting documentation
- ▶ **Traceability Gap:** Digital thread provides verified connections across lifecycle artifacts
- ▶ **Visibility Gap:** Model-based approaches enable comprehensive system visibility
- ▶ **Simulation Gap:** Digital twins enable testing without production impact

**Key Question:** Do IT and IA professionals recognize this potential value for their work?

# Research Design Overview

## Quantitative Cross-Sectional Survey Design

- ▶ Survey methodology enables standardized data collection supporting statistical analysis
- ▶ Cross-sectional design captures professional perceptions at a single point in time
- ▶ Anonymous nature encourages candid responses about knowledge gaps

## Systems Engineering Approach

The research methodology itself follows a systems engineering lifecycle, demonstrating application of structured engineering principles to research design while ensuring rigorous traceability.

# Methodology Justification

## Why Perceptions Matter

Technology Acceptance Model research demonstrates that perceived value influences adoption decisions regardless of demonstrated actual value. Professionals who do not perceive value will not advocate for adoption.

## Why Survey Over Case Study

- ▶ Case study findings reflect particular organizational contexts
- ▶ Survey enables assessment across broad population of practitioners
- ▶ Establishes baseline awareness data before implementation research

# Systems Engineering Research Lifecycle

1. **Strategic Phase:** Hypothesis, capabilities, constraints, goals, stakeholders
2. **Requirements Phase:** Derived requirements following ISO 15288:2023 standards
3. **Architecture Phase:** High-level outline and structure for survey
4. **Design Phase:** Survey instrument with complete traceability
5. **Results Phase:** Data capture and analysis with model traceability
6. **Report Phase:** Dissertation chapters traced to requirements

# Target Population and Sampling

## Target Population

Professionals actively working in IT and Information Assurance roles: IT service delivery, infrastructure management, security operations, compliance management, security architecture.

## Sampling Strategy

Non-probability convenience sampling through multiple channels:

- ▶ Professional organizations: ISACA, (ISC)<sup>2</sup>, ITIL communities
- ▶ LinkedIn professional groups
- ▶ Industry conferences and professional development events

# Sample Size Determination

## Statistical Requirements

Target: 95% confidence level with 5% margin of error

$$n = \frac{Z^2 \times p \times (1-p)}{E^2} = \frac{1.96^2 \times 0.5 \times 0.5}{0.05^2} = 384.16$$

## Target Sample

- ▶ Minimum required: 385 completed responses
- ▶ Target with oversampling: 450 completed responses
- ▶ Oversampling accommodates 10-15% incomplete response rates
- ▶ Requires distribution to approximately 1,500–1,800 professionals

# Survey Instrument Structure

## 27 Questions Across Six Sections

1. Awareness and Familiarity with Digital Engineering (2 questions)
2. Understanding of Digital Engineering Capabilities (6 questions)
3. Applicability of Digital Engineering (6 questions)
4. Value Assessment for Information Technology (5 questions)
5. Value Assessment for Information Assurance and Cybersecurity (7 questions)
6. Interest and Demographic Information (4 questions)

**Estimated Completion Time:** Approximately 10 minutes

# Question Format and Scale Selection

## Five-Point Likert Scale

**Familiarity Scale:** Not at all familiar → Extremely familiar

**Agreement Scale:** Strongly disagree → Strongly agree

## Justification

- ▶ Likert scales validated since 1932 for measuring attitudes and perceptions
- ▶ Five-point format provides optimal discrimination while remaining cognitively manageable
- ▶ Consistent with TAM and UTAUT frameworks for technology acceptance research

# Likert Scale Analytical Treatment

## The Ordinal–Interval Debate

Longstanding methodological debate regarding whether Likert responses constitute ordinal or interval data. Norman (2010) and subsequent research demonstrate that parametric methods yield valid results with Likert data even when distributional assumptions are violated.

## Dual-Reporting Approach

- ▶ **Parametric:** Means and standard deviations reported for composite scores and cross-study comparison
- ▶ **Non-parametric:** Medians and interquartile ranges reported alongside for individual Likert items
- ▶ Enables readers holding either position to evaluate findings against their preferred framework

# Survey-to-Research Question Mapping

Section	Questions	Research Question
Section 1: Awareness	1.1, 1.2	RQ1: Awareness
Section 2: Understanding	2.1–2.6	RQ1: Awareness
Section 3: Applicability	3.1–3.6	RQ2 / RQ3
Section 4: IT Value	4.1–4.5	RQ3: Anticipated Benefits
Section 5: IA Value	5.1–5.7	RQ3: Anticipated Benefits
Section 6: Demographics	6.1–6.4	Subgroup Analysis

Each question maintains explicit traceability to research questions within the systems engineering model.

# Data Analysis: Descriptive and Comparative

## Descriptive Statistics

- ▶ Central tendency and dispersion for all Likert-scale responses
- ▶ Frequency distributions for categorical and binary responses
- ▶ Response pattern visualization across survey sections

## Comparative Analysis

- ▶ Analysis across professional subgroups (IT vs. IA professionals)
- ▶ Analysis across experience levels
- ▶ Composite score calculation with Cronbach's alpha reliability assessment

# Data Analysis: Inferential Testing and Error Management

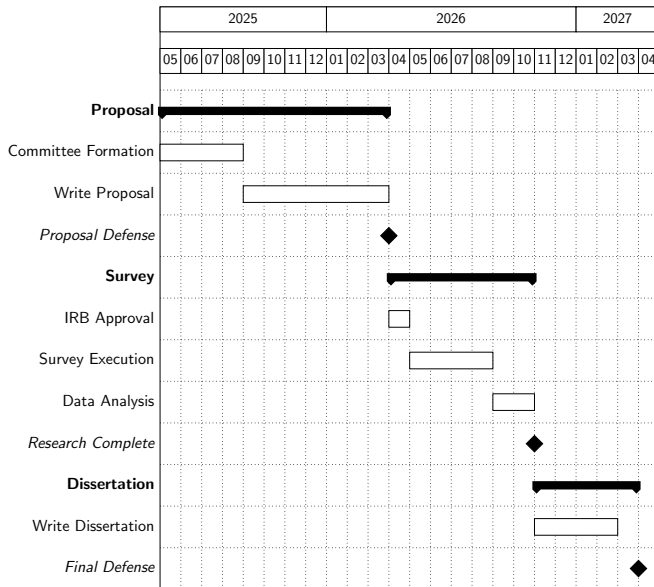
## Inferential Statistical Tests

- ▶ Parametric (t-tests, ANOVA) or non-parametric alternatives (Mann-Whitney U, Kruskal-Wallis) based on Shapiro-Wilk normality assessment
- ▶ Chi-square tests of independence for categorical associations
- ▶ Effect sizes reported: Cohen's  $d$  for group comparisons, Cramér's  $V$  for chi-square

## Multiple Comparison Correction

- ▶ Holm-Bonferroni sequential correction applied within logical families of related tests
- ▶ Effect size assessment ensures observed differences reflect practically meaningful magnitudes

# Research Timeline: 22-Month Schedule



# Timeline Phase Details

## Phase 1–2: Proposal (May 2025 – March 2026)

Committee formation, proposal development, proposal defense

## Phase 3–4: IRB and Survey Execution (April – August 2026)

IRB approval, platform configuration, recruitment through multiple professional channels, data collection targeting 450 responses

## Phase 5–6: Analysis and Writing (September 2026 – March 2027)

Data analysis, results interpretation, dissertation writing, final defense

# Validity and Reliability

## Content Validity

Systematic mapping of survey questions to research questions; alignment with established Digital Engineering frameworks from INCOSE, NASA, and DoD

## Construct Validity

Question formats and scale anchors drawn from validated TAM and UTAUT instruments

## Reliability

Internal consistency assessed through Cronbach's alpha; standardized question format supports response consistency

# Pilot Testing and Instrument Refinement

## Spring 2024 Pilot Study

An earlier version of the instrument was administered to IT and information assurance professionals during the Spring 2024 semester. The pilot study evaluated:

- ▶ Question clarity and comprehension among target population representatives
- ▶ Completion time and respondent fatigue
- ▶ Response distribution across scale points (no floor or ceiling effects observed)

## Empirical Contributions to Instrument Design

- ▶ Question wording refined to balance context with priming avoidance
- ▶ Section ordering adjusted
- ▶ Confirmed substantial variation in Digital Engineering awareness across respondents

# Response Bias Mitigation

## Proactive Mitigation Strategies

- ▶ **Self-selection bias:** Recruitment messaging encourages participation across the awareness spectrum; no prior Digital Engineering knowledge required
- ▶ **Acquiescence bias:** Neutral midpoint option and explicit “No” / “Unsure” options on investment willingness questions
- ▶ **Social desirability:** Anonymous design (no PII)

## Analytical Safeguards

- ▶ Wave analysis comparing early and late respondents to assess non-response bias
- ▶ Familiarity-stratified comparison of value perceptions to diagnose potential priming effects from contextual descriptions

# Research Limitations

- ▶ Non-probability sampling limits generalizability to broader population
- ▶ Self-selection bias may over-represent professionals with existing Digital Engineering awareness
- ▶ Social desirability bias may influence perceived value responses
- ▶ Self-reported awareness may not reflect actual knowledge
- ▶ Cross-sectional design captures single point in time
- ▶ Survey measures perceived value rather than actual experienced benefits

# Expected Contributions: Academic

## Addressing the Literature Gap

- ▶ First empirical investigation of Digital Engineering awareness among IT/IA professionals
- ▶ Establishes baseline data for future research in this nascent application domain
- ▶ Validates or challenges theoretical framework positing DE value for enterprise contexts

## Methodological Contribution

Demonstrates systems engineering approach to research design with traceability between questions, instruments, and analysis

# Expected Contributions: Industry

## Industry Benefits

- ▶ Informs tool vendor and service provider development priorities
- ▶ Guides professional development and training initiatives
- ▶ Identifies which DE capabilities professionals recognize as addressing their needs
- ▶ Indicates whether adoption initiatives would find receptive audiences

# Expected Contributions: Commonwealth and Society

## Commonwealth Benefits

- ▶ Enhances protection of government systems and critical infrastructure
- ▶ Enables rapid, accurate impact assessment for security incidents affecting federal and national security systems
- ▶ Reduces compliance verification burden while improving documentation currency

## Societal Benefits

- ▶ Potentially enable better security capabilities for organizations serving underserved populations
- ▶ Democratize sophisticated documentation capabilities beyond large enterprises
- ▶ May reduce compliance burden for resource-constrained organizations serving communities with limited resources

# Ethical Considerations

## Human Subjects Protection

- ▶ **Anonymity:** No personally identifiable information collected
- ▶ **Voluntary:** Participation voluntary with no consequences for non-participation
- ▶ **Minimal Risk:** Similar to normal daily internet activity
- ▶ **Informed Consent:** Obtained through participation notice
- ▶ **Data Protection:** Secure storage with encryption

IRB approval will proceed after successful proposal defense.

# Proposal Summary

## Research Purpose

Investigate whether IT and Information Assurance professionals recognize potential value in Digital Engineering capabilities for their work

## Approach

Quantitative survey methodology with 27 questions targeting 385–450 IT/IA professionals across multiple sectors

## Significance

Establishes empirical foundation for strategic decisions regarding Digital Engineering adoption in enterprise IT and Information Assurance domains

# Questions and Discussion

Thank you for attending.

Questions?

Proposal Presentation:

<https://github.com/jbone81/DissertationProposalPresentation>

# Thank You

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