Transforming Information Assurance and IT Service Management Through Digital Engineering

Dissertation Proposal Defense

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Spring Research Seminar 2026

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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.

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. Timeline and Schedule
8. Expected Contributions
9. 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 — NIST SP 800-53 Rev 5: Security Controls

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**
Visibility Gap Metrics		
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
Configuration Management Failures		
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
Shadow IT and Undocumented Assets		
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
Security Impact Metrics		
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 IT and Information Assurance professionals perceive Digital Engineering capabilities as potentially valuable or important for their work?

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)

Now codified as 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 simulation and testing

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 simulation, analysis, and testing without impacting production environments. Twins maintain synchronization with their physical counterparts.

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, 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, $(ISC)^2$, 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

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 (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 $\rightarrow$ Extremely familiar

Agreement Scale: Strongly disagree $\rightarrow$ 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

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: Perceived Value
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 Approach

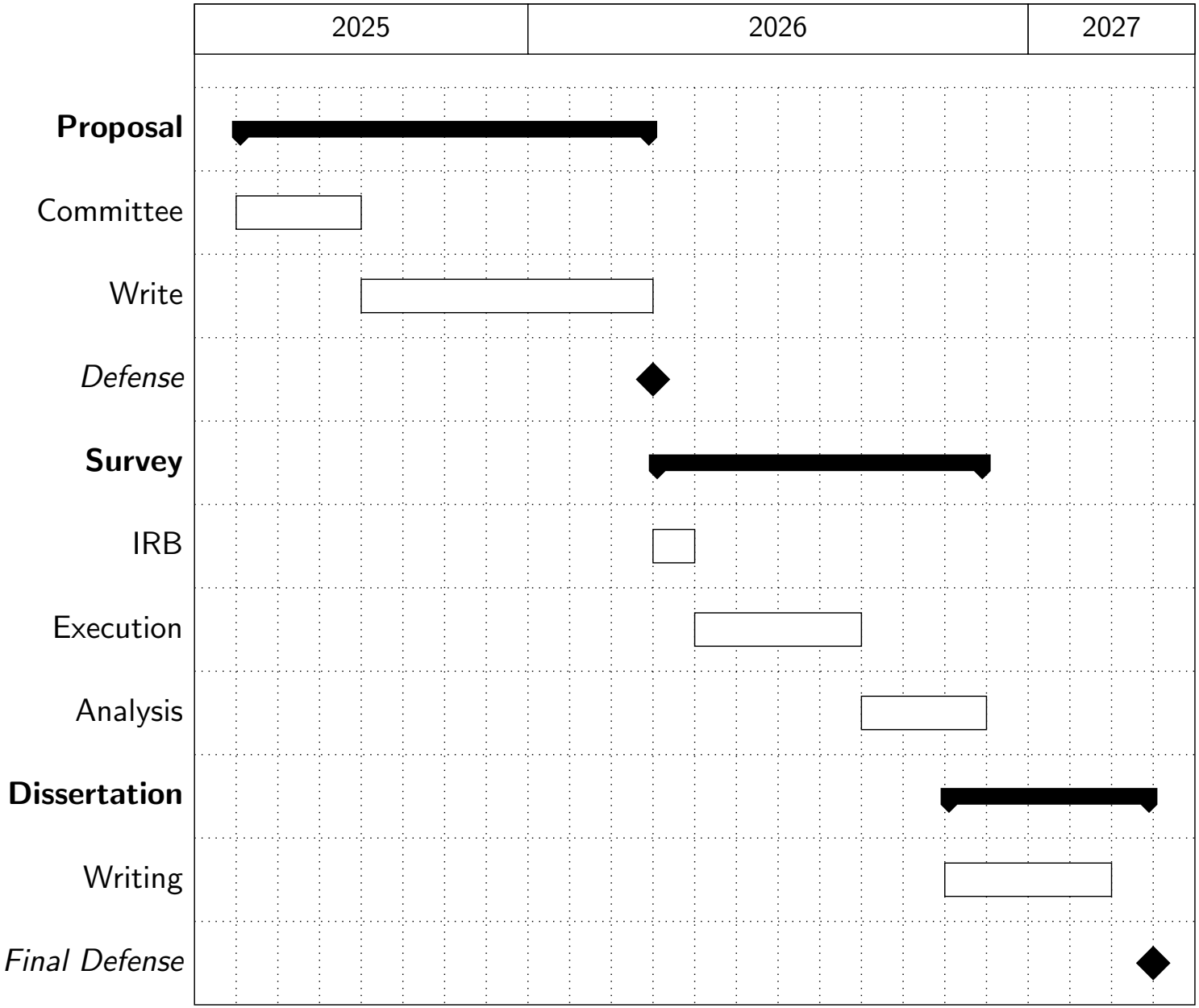
Descriptive Statistics

- 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

Research Timeline: 22-Month Schedule



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Timeline Phase Details

Phase 1–3: Proposal (May 2025 – April 2026)

Committee formation, proposal development, proposal defense, IRB approval

Phase 4: Survey Execution (May – August 2026)

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

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 and Society

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

Societal Benefits

- Enhances protection of government systems and critical infrastructure
- Potentially enables better security capabilities for organizations serving underserved populations
- Democratizes sophisticated documentation capabilities beyond large enterprises

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?

Thank You

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Committee:
Dr. Patrick Engebretson (Chair)
Dr. David Kenley
Dr. Matthew Kelso

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