JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Digital Engineering Framework

A Systematic Review of What and How to Digitalize

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Outline

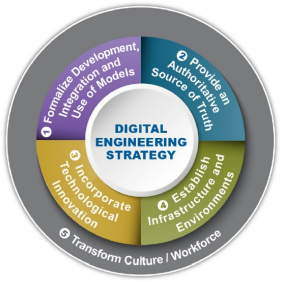
- Problem Statement
  - Digital Engineering
- Method
  - Systematic Review
- Findings
  - Input, Throughput, Output, External Force, Feedback
- Result
  - Digital Engineering Framework
- Recommendations
  - Conclusions
  - Limitations

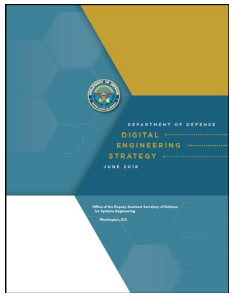
Problem Statement

Digital Engineering (DoD Strategy)

Problem

- Executing acquisition plans in a predictable, fully resourced manner is challenging (Kraft, 2015).
- Greater efficiency in procurement is a national priority (National Defense Strategy, 2018).
- Reforming the business processes is a key strategic goal (National Defense Business Operations Plan, 2018).
- DoD lags industry on digital transformation solutions (DoD Digital Engineering Strategy, 2018).





DoD Digital Engineering Strategy Goals:

- Formalize the development, integration and use of models to inform enterprise and program decision making
- Provide enduring, authoritative source of truth
- Incorporate technological innovation to improve the engineering practice
- Establish a supporting infrastructure and environments to perform activities, collaborate, and communicate across stakeholders
- Transform the culture and workforce to adopt and support digital engineering across the lifecycle

"DE is an integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support life cycle activities from concept through disposal." - DAU

Does not answer [WHAT] or [HOW] to implement digitalization

Determining a Digital Engineering Framework for Implementation

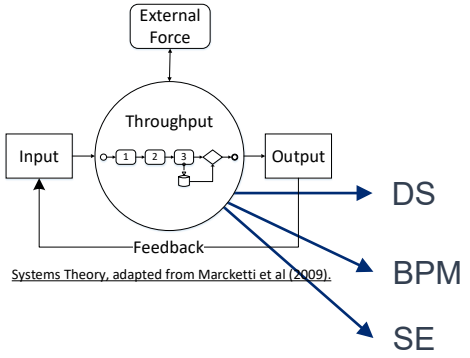
A Systematic Review

Integrating The Principles Of Decision Science (DS), Business Process Management (BPM), and Systems Engineering (SE)

Research Question: *What are the best practices for Digitalization and Industry 4.0 to inform DoD acquisition programs?*

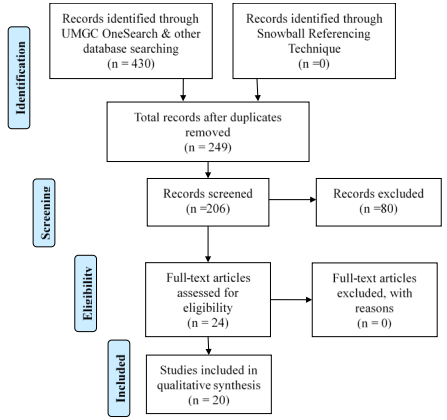
- Purpose
  - Identify the current state of Digitalization practices and methods, and to identify a conceptual framework for what and how to digitalize.
- Significance:
  - Digitalized processes would be documented and constrained, with their triggers, inputs and outputs defined.
  - Program decisions could be made with a common operating picture of the technical and managerial context around a given problem on a variety of levels, in a variety of functions, across the enterprise.
- Management Implications
  - Digitalize the processes that generate the data to make better decisions.

- Theoretical Lens
  - General Systems Theory
    - von Bertalanffy (1972)

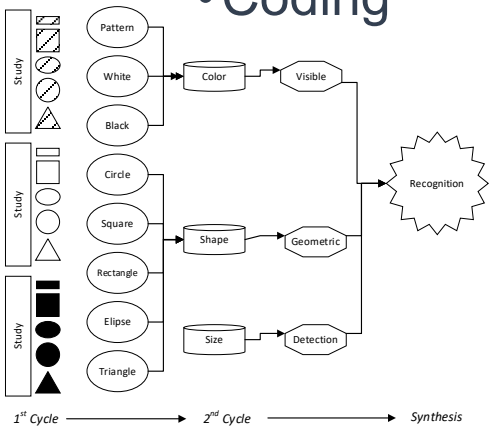


Systems Theory, adapted from Marcketti et al (2009).

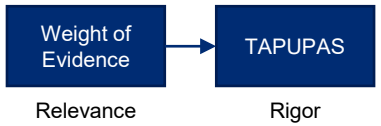
- Literature Search



- Coding

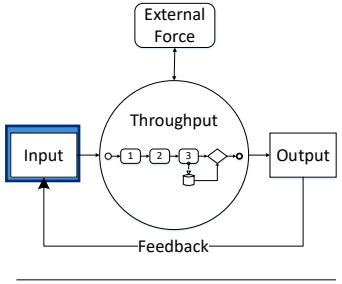


- Quality



Findings

INPUT: Strategy



1. Degree of Change
   Refine, or Innovate, or Transform
   Blackburn et al (2017)
2. Lean Impact Target
   Process, or Product & Service
   Tortorella et al (2021)
3. Smart Circular Economy Factors
   Data Transformation, Resource Optimization, Data Flow Process, Reuse
   Kristoffersen et al (2020)
4. Industry 4.0 Design Principles
   Flexibility, Real-Time Capability, Decentralization, Modularity
   Nosalska et al (2019)
5. Avoid over-digitization
   Donnelly (2019)

- Decision Tools

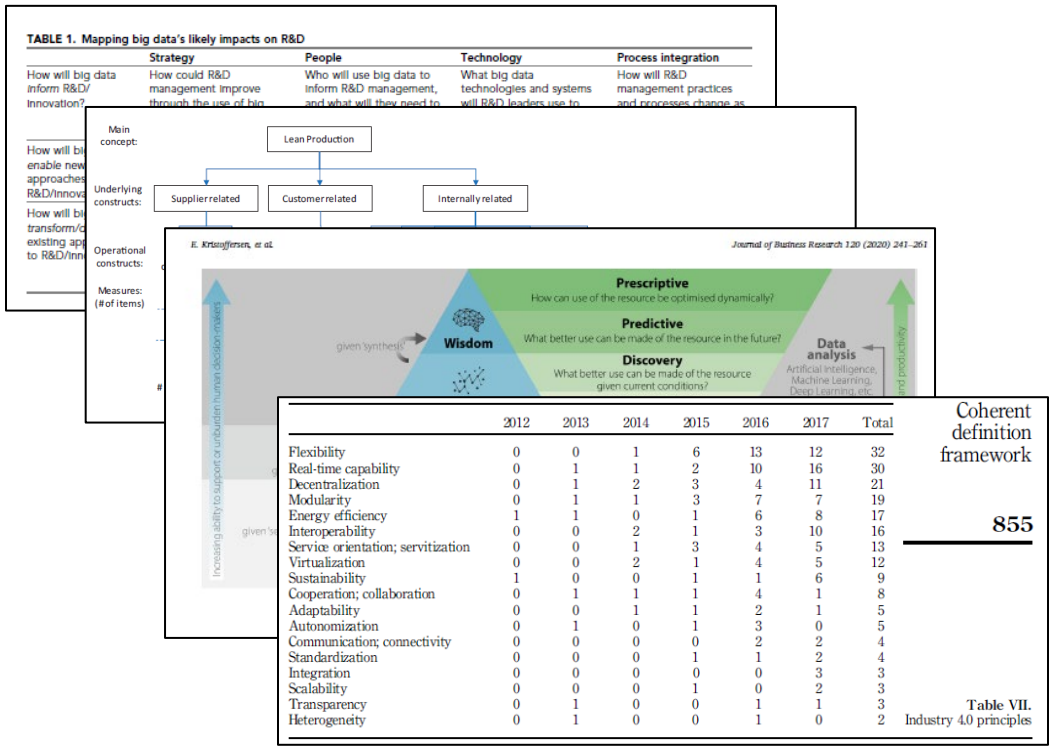


TABLE 1. Mapping big data's likely impacts on R&D

	Strategy	People	Technology	Process integration
How will big data *inform* R&D/ innovation?	How could R&D management improve	Who will use big data to inform R&D management,	What big data technologies and systems	How will R&D management practices

Main concept: Lean Production

Underlying constructs: Supplier related | Customer related | Internally related

Operational constructs:

Measures: (# of items)

E. Kristoffersen, et al. Journal of Business Research 120 (2020) 241–261

Prescriptive — How can use of the resource be optimised dynamically?

Predictive — What better use can be made of the resource in the future?

Discovery — What better use can be made of the resource given current conditions?

Wisdom

Data analysis — Artificial Intelligence, Machine Learning, Deep Learning, etc.

Increasing ability to support or unburden human decision-makers

Increasing productivity

	2012	2013	2014	2015	2016	2017	Total
Flexibility	0	0	1	6	13	12	32
Real-time capability	0	1	1	2	10	16	30
Decentralization	0	1	2	3	4	11	21
Modularity	0	1	1	3	7	7	19
Energy efficiency	1	1	0	1	6	8	17
Interoperability	0	0	2	1	3	10	16
Service orientation; servitization	0	0	1	3	4	5	13
Virtualization	0	0	2	1	4	5	12
Sustainability	1	0	0	1	1	6	9
Cooperation; collaboration	0	1	1	1	4	1	8
Adaptability	0	0	1	1	2	1	5
Autonomization	0	1	0	1	3	0	5
Communication; connectivity	0	0	0	0	2	2	4
Standardization	0	0	0	1	1	2	4
Integration	0	0	0	0	0	3	3
Scalability	0	0	0	1	0	2	3
Transparency	0	1	0	0	1	1	3
Heterogeneity	0	1	0	0	1	0	2

Coherent definition framework

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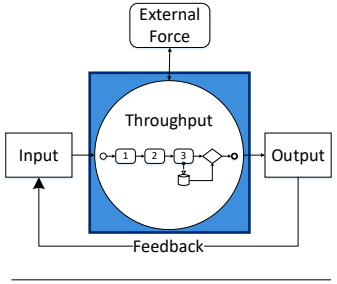
Table VII. Industry 4.0 principles

Use tools to make strategic decisions to meet DoD DE Goals.

Findings

THROUGHPUT: Process



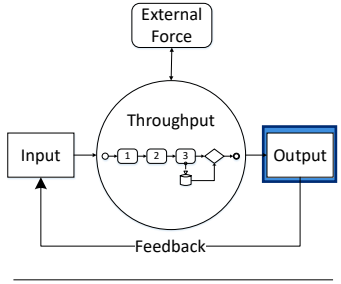
- The value of digitalization is realized through the transformed underlying business processes.
  - Antonucci et al (2021)
- Lean production most affected by process technology.
  - Tortorella et al (2021)
- Process is a critical component of Industry 4.0 implementation in supply chains.
  - Ghadge et al (2020)

- Use 6-step design science research process (Janiesch et al, 2019).
  1. Problem Identification
  2. Objectives of a Solution
  3. Design and Development
  4. Demonstration
  5. Evaluation
  6. Conclusion
- Evaluate opportunities, and avoid traps (Linde et al, 2021).
  - Assess processes, model futures, evaluate risk
  - Trap 1: Not Understanding Customer Value
  - Trap 2: Not Understanding Value Delivery Process
  - Trap 3: Not Understanding the Profit Formula

Scoping changeable processes is critical

Findings

OUTPUT: New Business Model



- Technical and business-related aspects are intertwined factors.
  - Nosalska et al (2019)
- Business model change is enabled by digitalization.
  - Laïfi & Josserand (2016)
- A business model progresses with the business modeling process.
- Public-private interaction reveals tensions that drive BPM: structural, behavioral, organizational.
- Public actor in the public network is a much more complex implementation.
  - Mattsson & Andersson (2019)

Tensions revealed in interacting Small-Medium Enterprise (SME) and public Service Provisioning Model (SPM) in Business Modelling (BM).

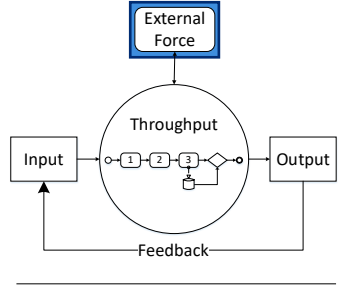
	Dominant form of interactions	Main BM – SPM interactions and tensions	
SME Business modelling phase 1	SME ⇔ Local public user interactions	BM: 1.Finding new progressive end-users, 2.Develop user interactions in order to develop the value offfering	⇔ SPM: 2. Identifying and developing new social values (from edtech)
SME Business modelling phase 2	SME ⇔ Local buying center interactions	BM: 1. Develop interactions with and an understanding of customers' buying centers. 2.Develop the value offering 3.Develop the charging and revenue model	⇔ SPM: 4.Develop local (municipal) public procurement organizations for procurment of new edtech services
SME Business modelling phase 3	SME ⇔ Multilevel, public actor network interactions	BM: 1, 2, 3, and 4: Developing all dimensions of the existing and new business models in response to increased complexity in interactions with both central and local public customers	⇔ SPM: 1, 2. Focus on new social and economic values related to new requirements for digitalization for different public actors on central regional and local levels, 3. Developing new budgets and economic frames for digitalization, 4. Coordinate internal networks for digital transformation
SME Business modelling phase 4	SME ⇔ New distributor and partner interactions	BM: In parallel to ongoing, continued BM changes started in phase 3. 1 , 4 developing new relationships with new key distribution partners (customers) among big publishing houses	⇔ SPM: 1,2,3 and 4: continued, intensified work to develop values, determinants and networks for continued digital transformation of public operations on all levels of the public system

BM= private actor's business model
SPM= public actor's service provisioning model

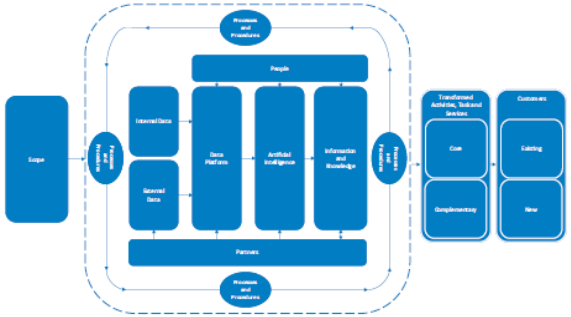
The more processes change, the more they can change internally/externally

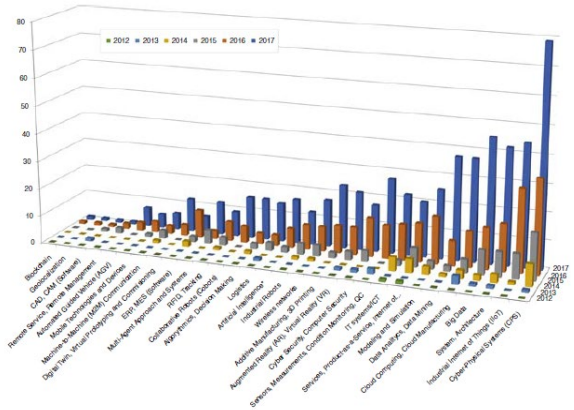
Findings

External Forces: Ecosystem & Technical



- External Forces
  - Ecosystem
    - People
    - Resources
    - Organization
    - Supply Chain
  - Technical
    - Platform
    - Technology
    - Data





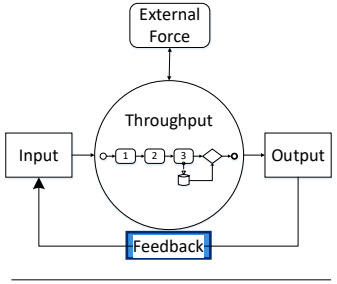
Correani et al (2020); Garay-Rondero et al (2020); Gastaldi et al (2018); Ghadge et al (2020); Ivančić et al (2019); Linde et al (2021).

- Some Industry 4.0 technologies are positively correlated with Lean Production practices, but not all
  - Tortorella et al (2021)
- Industry 4.0 key technologies:
  - Cyber-Physical Systems
  - Big Data
  - IIOT
  - Cloud Computing/Cloud Manufacturing
  - Software/Product-as-a-Service
  - Internet of Services
  - System/Architecture
    - Nosalska et al (2019)

Understand which are changeable vs. constraints

Findings

FEEDBACK: Users & Customers



- Digital Community Infrastructure
  - digital sharing platforms to share digital designs and social networks and/or blogs to discuss ideas, questions and projects
    - Rieken et al (2020)
- IoT technology and Artificial Intelligence of Things (AIoT) empowers
  - acceleration of digital transformation, and
  - real-time collection of data from customers to monitor their conditions or assets to update risk.
    - Cong et al (2021)

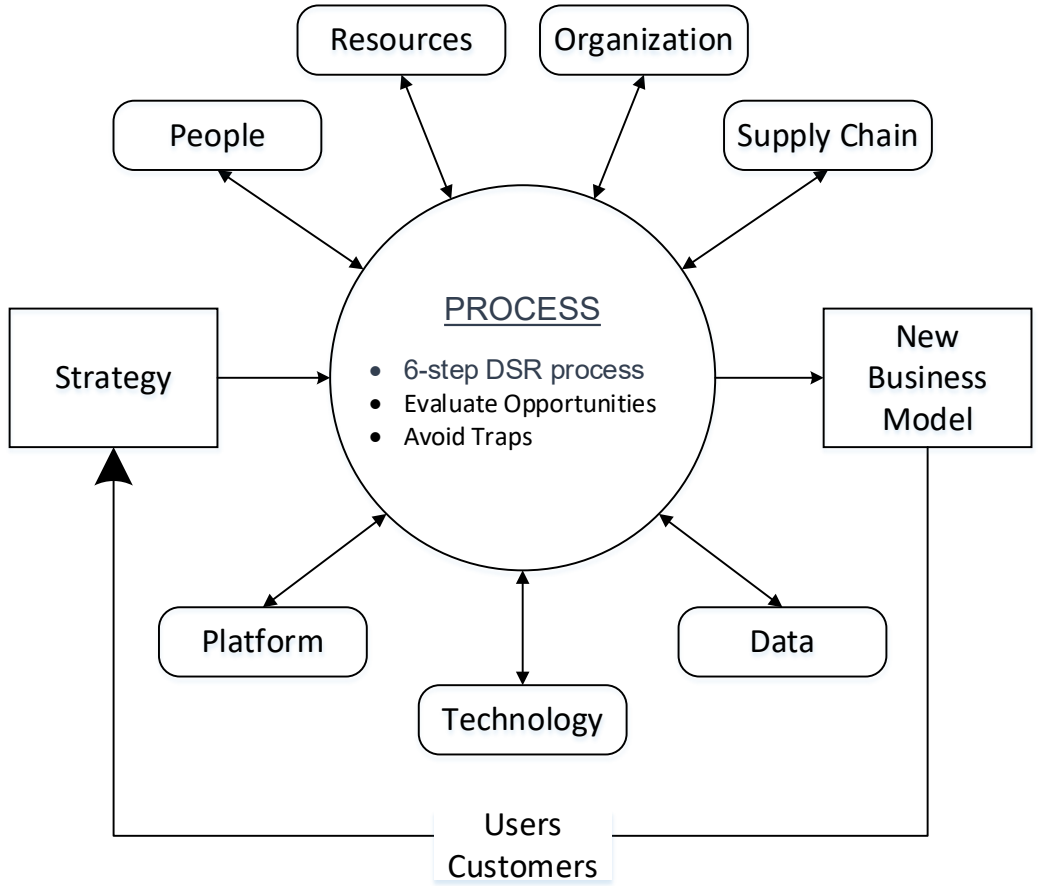
- Digitalized Supply Chain (DSC) features:
  - accelerated, adaptable, smart, real-time data gathering, transparent, globally connected, scalable and clustered, breakthrough, inventive and sustainable.
- Digitalized Supply Chain (DSC) dimensions
  1. Digital and physical SCM Components and Processes within the Cloud Computing / Robotics
  2. Digital and physical SC Network Structure interconnected through CPS
  3. Industry 4.0 technologies concepts, enablers and features
  4. Digital and physical Supply Chain Flows
  5. Virtual value chain
  6. Digital and physical world
     - Garay-Rondero et al (2020)

Within the existing organization, implementation is unlikely to succeed (Matzler et al, 2018), therefore organizational change is essential to success

Discussion

Digital Engineering Strategy, Ecosystem, Technology, & Method

1. Degree of Change:
   Refine, or Innovate, or Transform
2. Lean Impact Target:
   Process, or Product & Service
3. Circular Economy:
   Data Transformation, Resource Optimization, Data Flow Process, Reuse
4. Industry 4.0 Design Principles:
   e.g. Flexibility, Real-Time Capability, Decentralization, Modularity
5. Delimit eligible processes:
   Avoid over-digitization



Goals feed Strategy decisions, Ecosystem constrains Technology options, Process defines execution, New Business Model delivers efficiencies, Feedback informs recursion

Recommendations

Integrate Decision Science (DS), Business Process Management (BPM), and Systems Engineering (SE)

Conclusion

1. Establish the implementation framework.
2. Decide the strategy.
3. Delimit the changeable processes.
4. Model those processes as-is, to-be, and assess risk.
5. Engineer new data model.
6. Communicate with the affected users/customers/suppliers, *continuously*.
7. Monitor changes to the business model; prepare to adjust.

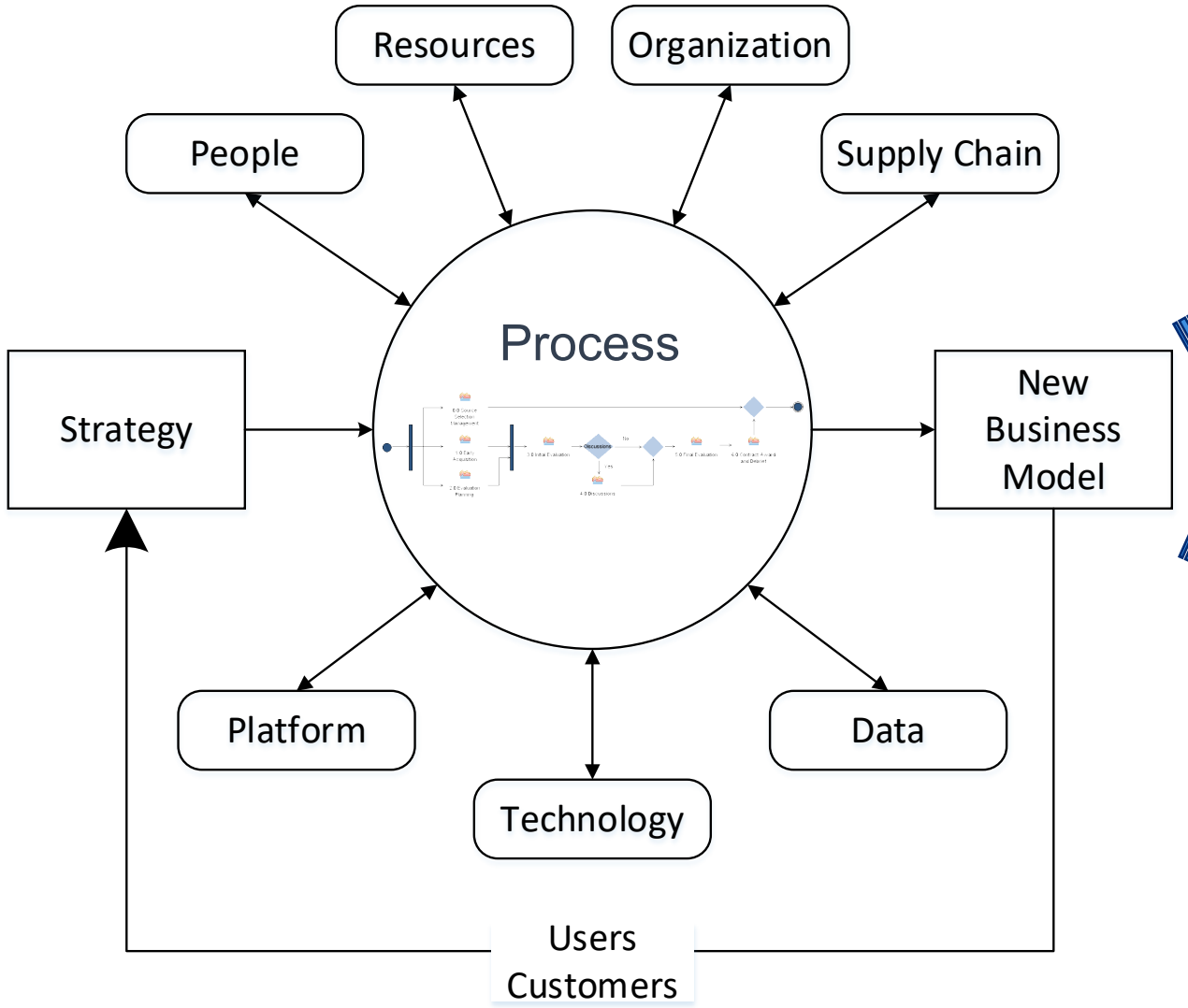
Study Limitations

- Digital Engineering is not a defined branch of engineering, therefore few journal articles reference it. ABET certifies > 3,000 programs at > 600 US institutions in > 75 engineering programs, yet none are ‘digital engineering.’ DE could be a sub-branch of SE if a distinct DE process is identified.
- Digitalization is a rapidly evolving practice with hotly competing providers who need a proprietary edge, which resists scholarly publication.
- Study may be limited by selection bias in search terms.

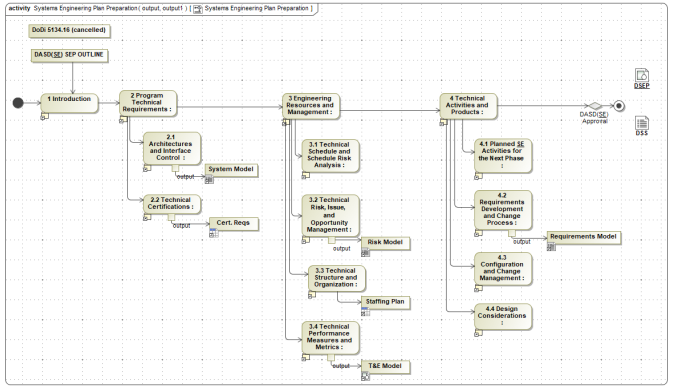
To succeed, understand the value the process creates (why we do it), the value delivery process (how we do it), and value realization (what we get out of it).

Effective Digital Engineering

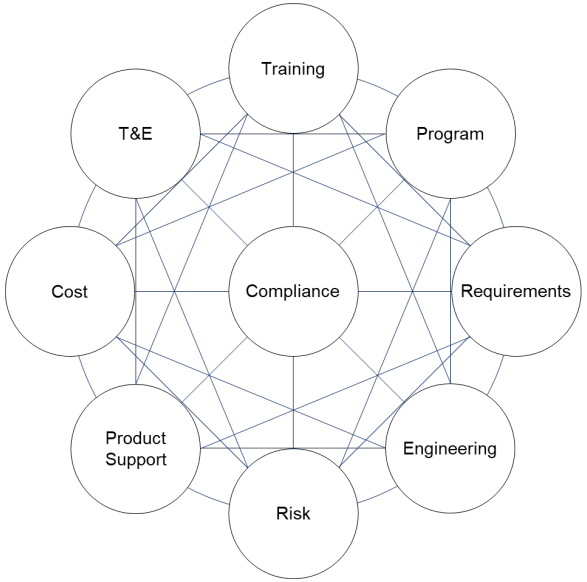
Digitalize a Process to Use Data Models for Decisions



New Digitalized Process



New Data Model



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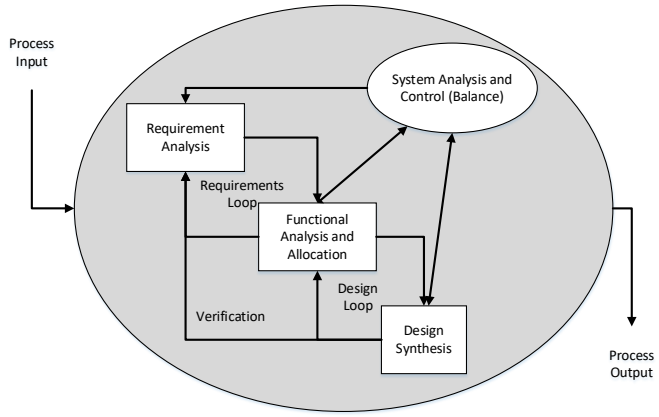
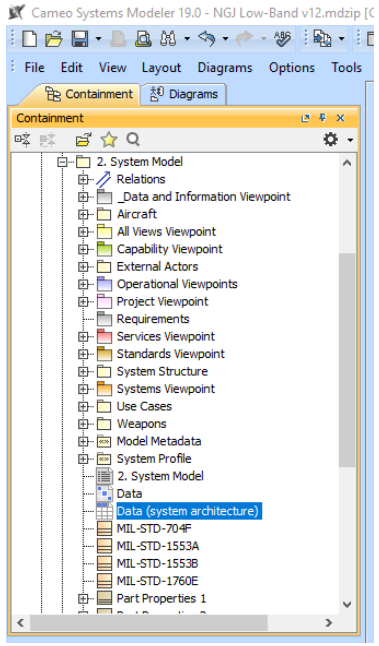
Taxonomy

MBSE – Model-Based Systems Engineering

- “Model-based systems engineering is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.”
  - INCOSE SE Vision 2020
- “In contrast to document-centric engineering, MBSE puts models at the center of system design.”
  - Shevchenko, N. (2020)





MBSE can be done in any of several languages, in many tools

Taxonomy

SysML - System Modeling Language

- “SysML® is a general-purpose graphical modeling language for specifying, analyzing, designing, and verifying complex systems that may include hardware, software, information, personnel, procedures, and facilities.”
  - Object Management Group

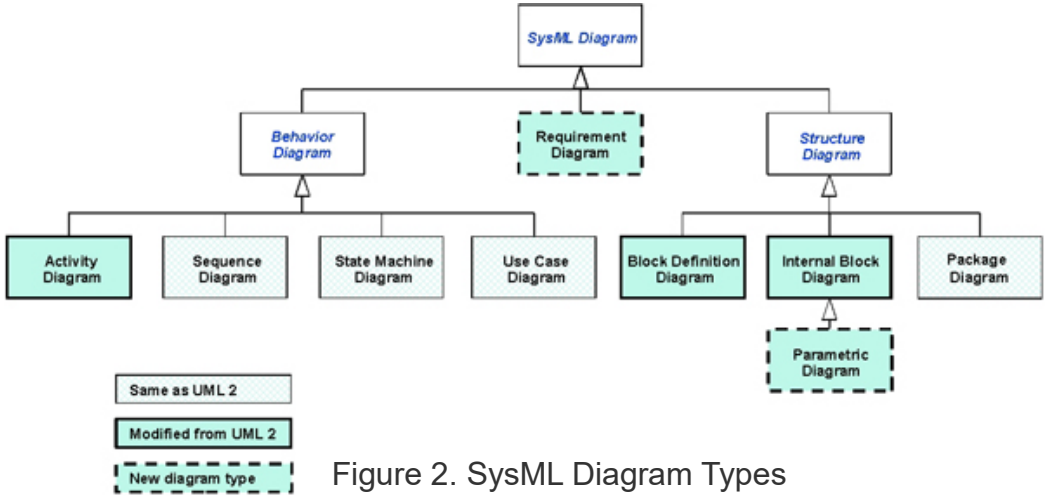


Figure 2. SysML Diagram Types

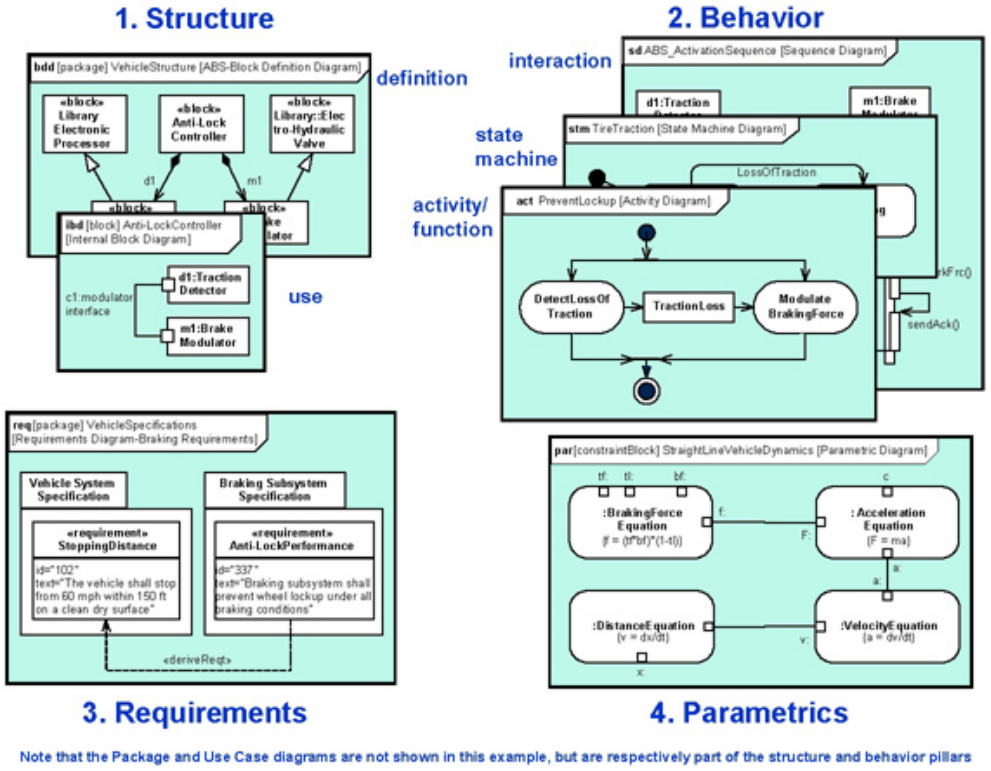


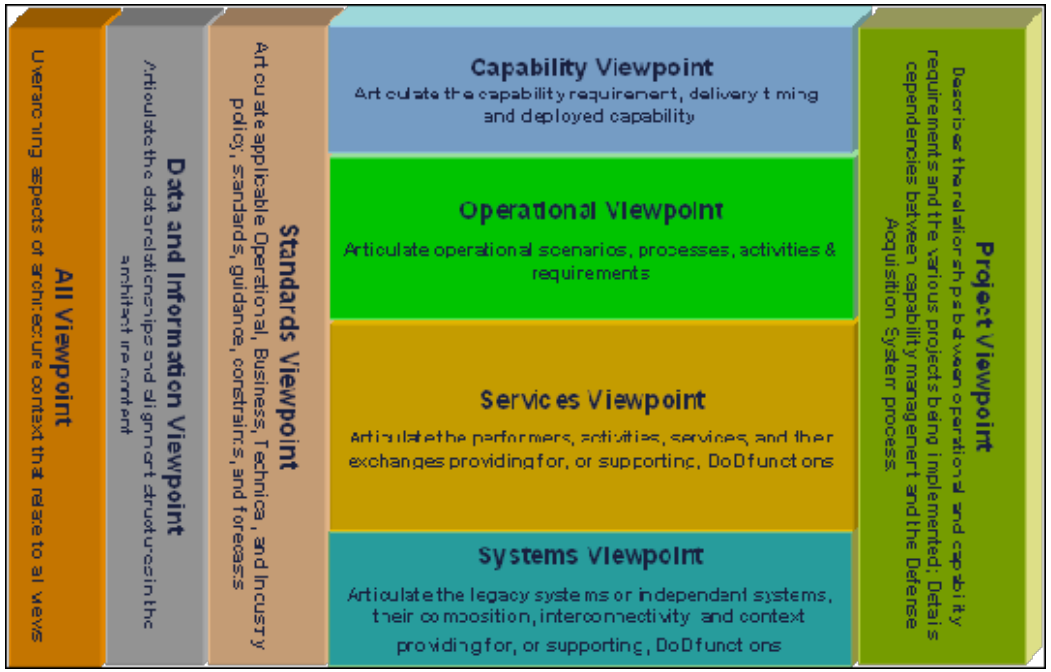
Figure 3. The Four Pillars of SysML

OMG Maintains 250 Similar Specifications, e.g. UML, UPDM, BPMN

Taxonomy

DoDAF - Department of Defense Architecture Framework, V 2.02

- "…framework and conceptual model enabling the development of architectures…"
- "Visualizing architectural data is accomplished through models…
- Models can be documents, spreadsheets, dashboards, or other graphical representations…"



DoDAF Viewpoints

CONTRAST: DoDAF has OV-5b: Operational Activity Models
SysML has Activity Diagrams

Note: NAVAIRINST 4355.19E requires certain DoDAF views for given SETR events.

Taxonomy

MDAO - Multi-Disciplinary Analysis and Optimization

Gray et al. (2019)

- Multidisciplinary design optimization is concerned with solving design problems involving coupled numerical models of complex engineering systems.

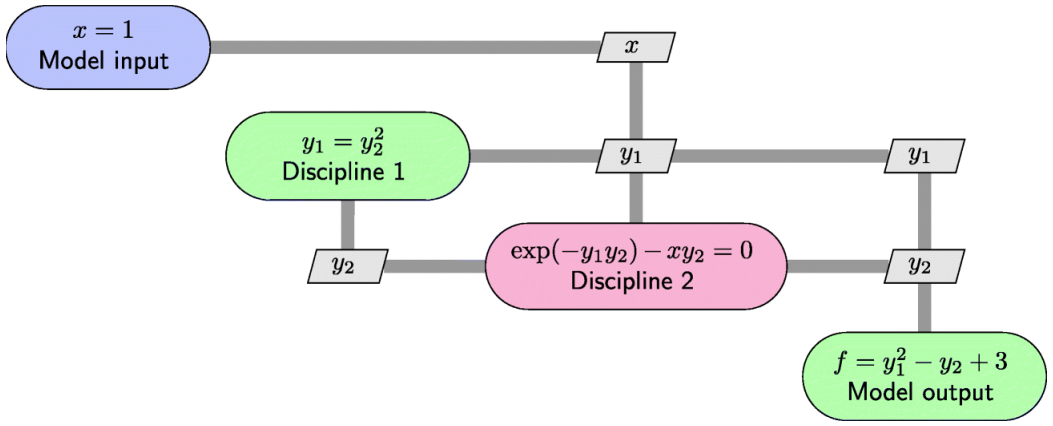


Fig. 1

Bone et al., (2018)

- SysML model generation of unmanned aircraft system (UAS) instances. Blocks define design variables and attributes, which are interlinked on parametrics diagrams, which are executed using activity diagrams and ModelCenter (not shown) to generate alternative instances.

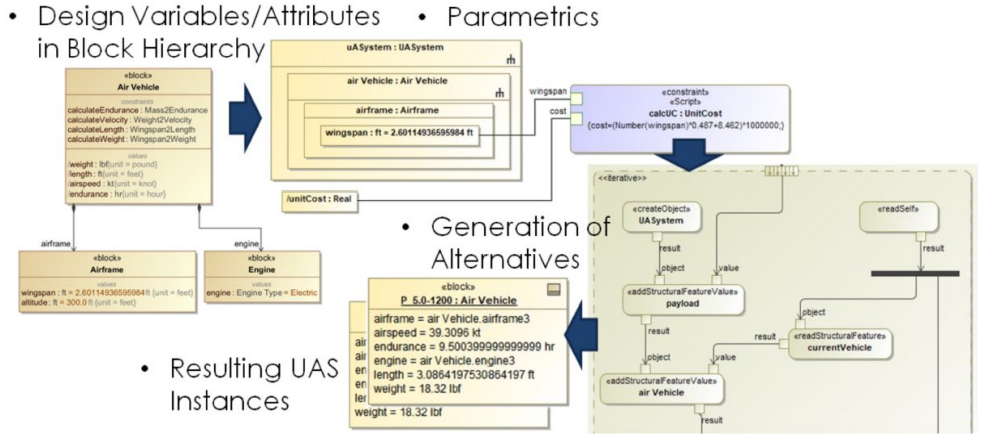


Figure 2.

Using an architecture to invoke select math models to automatically analyze alternatives

Taxonomy

Business Process Modeling (BPM)

Business Process Management (BPM)

- the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and to take advantage of improvement opportunities.

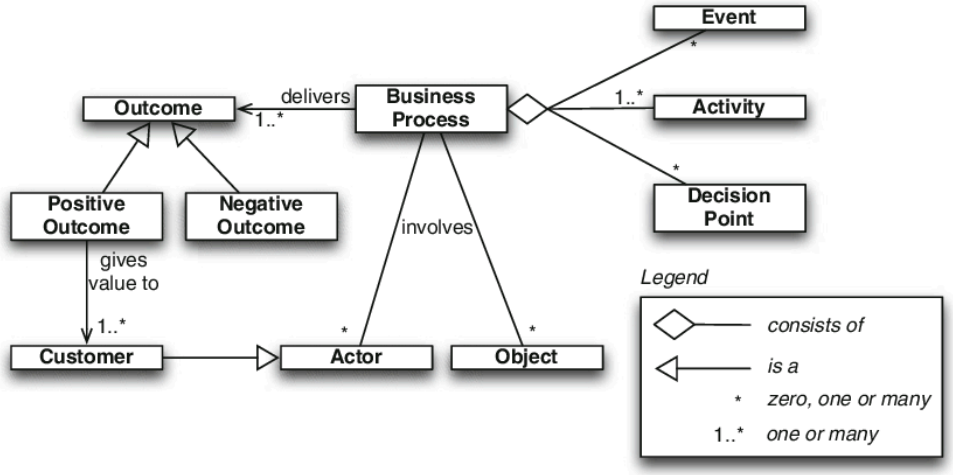
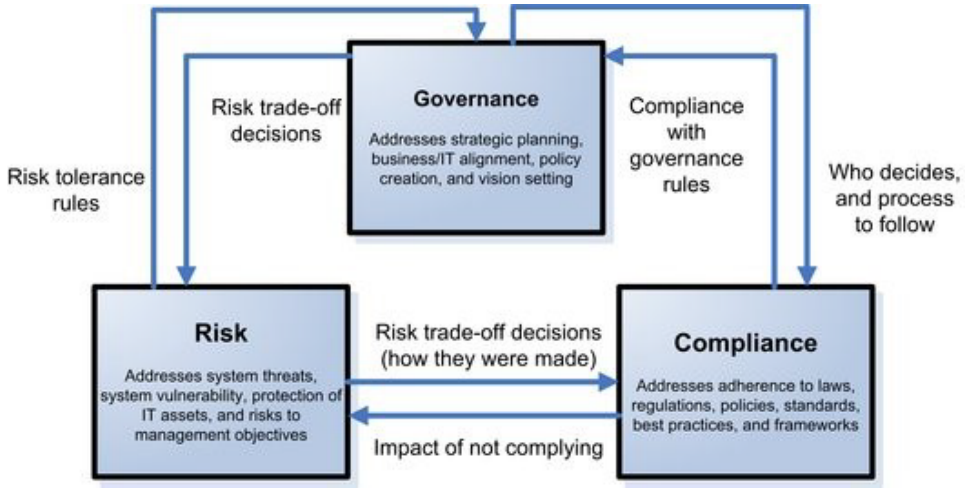


Fig. 1.1 Ingredients of a business process

Dumas M, La Rosa M, Mendling J, et al. *Fundamentals of Business Process Management*. Germany. Springer-Verlag Berlin Heidelberg, 2013

Governance, Risk, and Compliance (GRC) is a type of software that business uses to

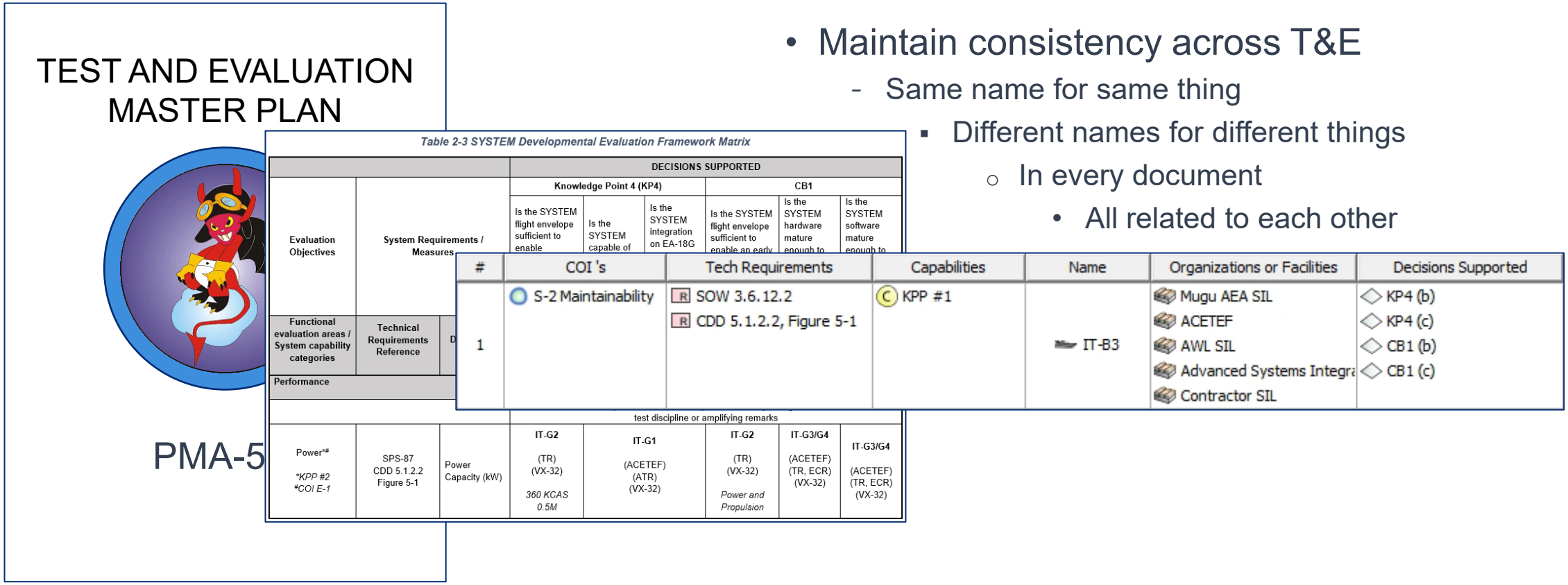
- Meet BPM goals by governing processes
- Keeps processes compliant with changing regulations
- Allow only authorized amounts of risk



Source: Microsoft

Principles

Digitalization: Capabilities-Based Test & Evaluation (CBT&E) for NGJ-LB



- Maintain consistency across T&E
  - Same name for same thing
    - Different names for different things
      - In every document
        - All related to each other

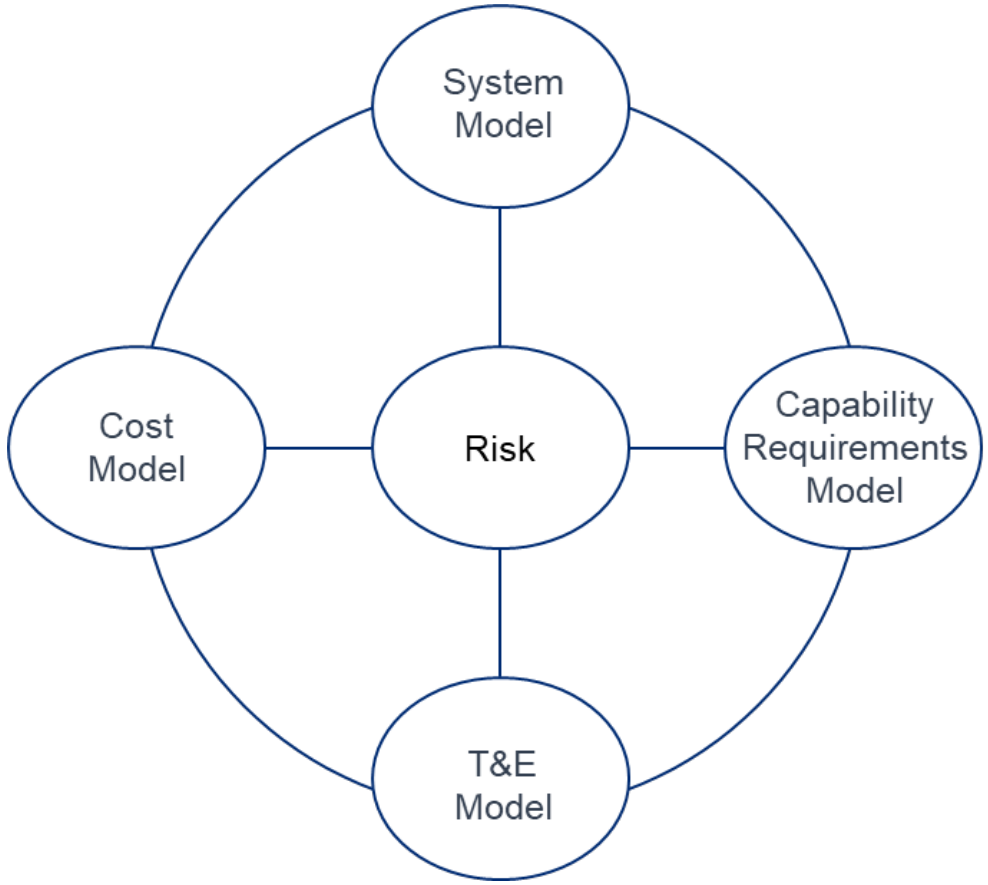
Transform Common Documents into Object-Oriented Databases
KEY: Identifying Objects, with Properties, related to other Objects

Principles

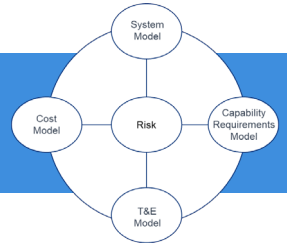
Cross-Functional Data: Decision Support System (DSS) for NGMPS

Achieved objectives:

- ✓ Decision Support System (DSS) in a single digital object-oriented environment.
- ✓ Integrated 5 component models as analytical products for alternative comparison.
  - ➢ Classic DoDAF: CV, OV, SV, etc.
  - ➢ Requirements documents and repositories
  - ➢ Cost Estimates and Items
  - ➢ Risk cube and enhanced bow ties
  - ➢ CBT&E, MBTD, IEF, Cyber
- ✓ Enabled program functions to operate independently while retaining coherence.
- ✓ Remains a queryable database for subsequent analysis.



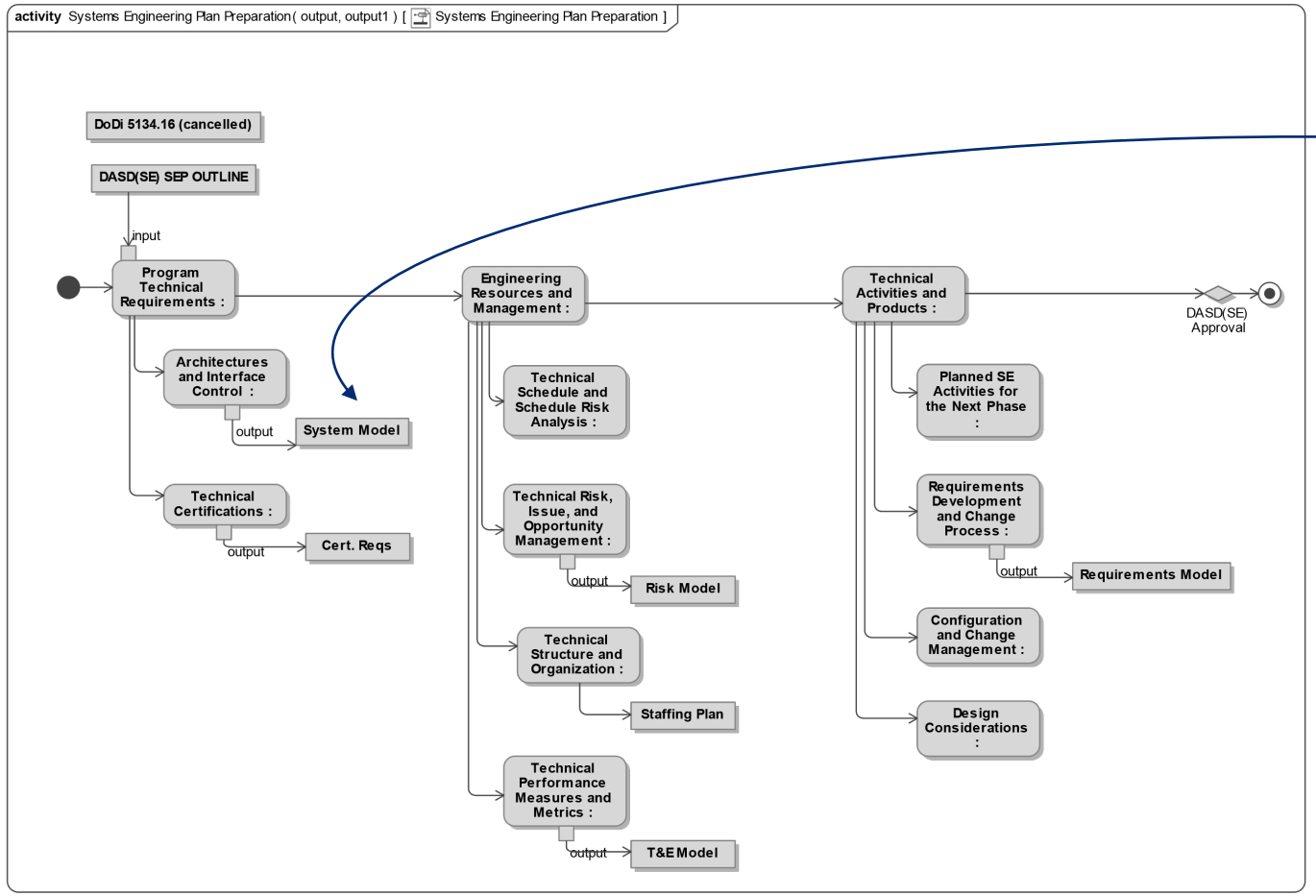
New Conceptual Framework & Exemplar

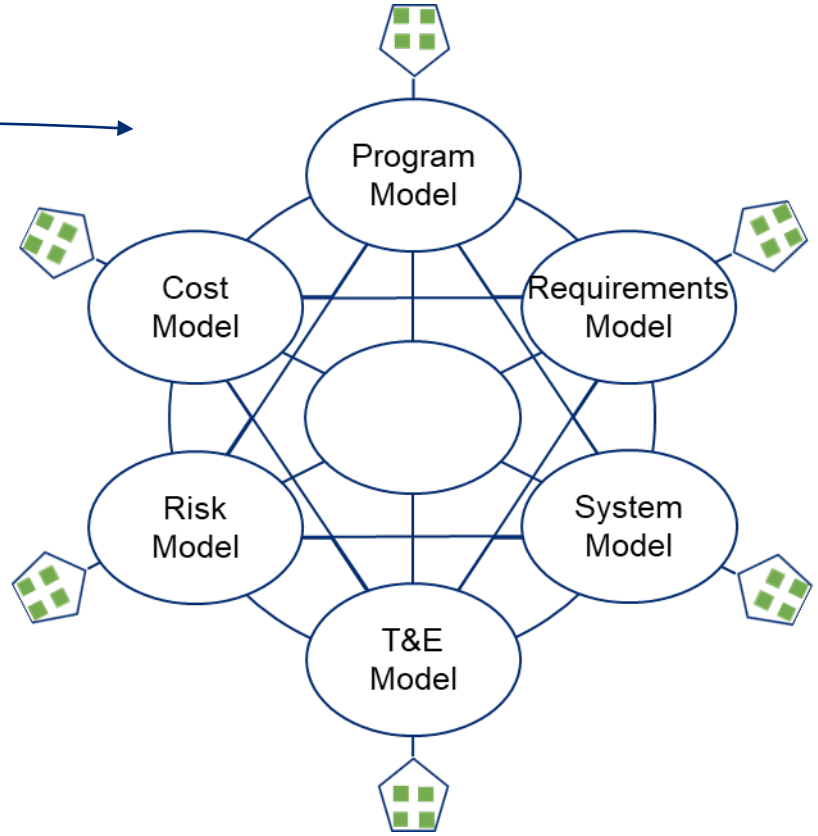


Functioning DSS

Principles

Connecting Process to Data: Digital SEP with DSS for AFRL/RW Next Gen Hypersonic Capability

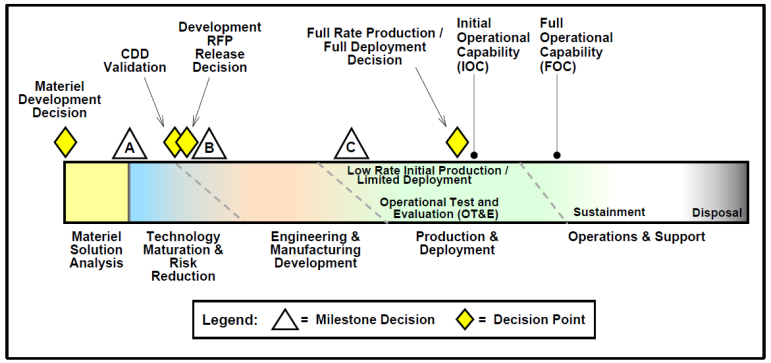


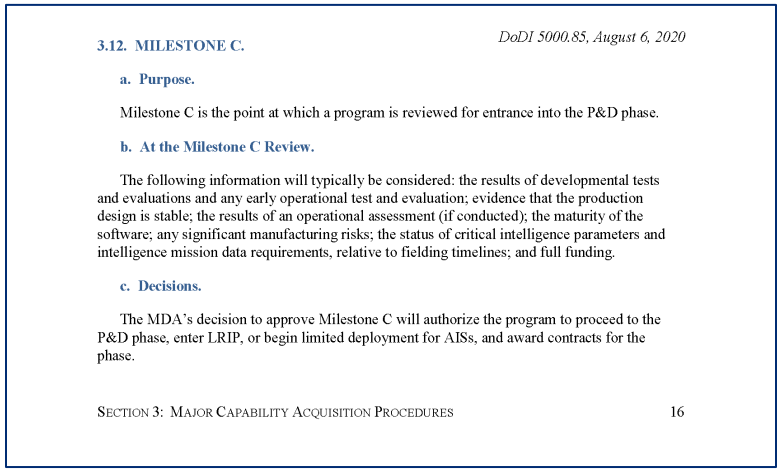


Cameo Systems Modeler, 1-1 NGHC DSEP with DSS Systems Engineering Plan Preparation Nov 5, 2020 8:13:21 AM

Solution

Model Data Required by Decisions: e.g. Milestone ‘C’ (DoDI 5000.85)





3.12. MILESTONE C.

DoDI 5000.85, August 6, 2020

a. Purpose.

Milestone C is the point at which a program is reviewed for entrance into the P&D phase.

b. At the Milestone C Review.

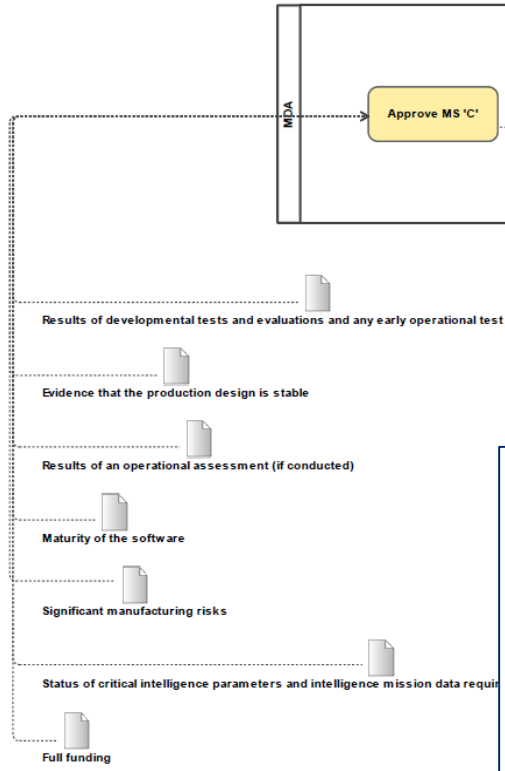
The following information will typically be considered: the results of developmental tests and evaluations and any early operational test and evaluation; evidence that the production design is stable; the results of an operational assessment (if conducted); the maturity of the software; any significant manufacturing risks; the status of critical intelligence parameters and intelligence mission data requirements, relative to fielding timelines; and full funding.

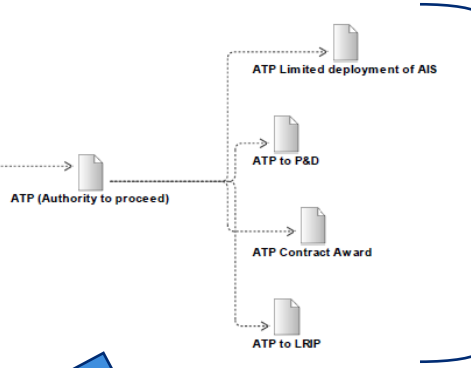
c. Decisions.

The MDA’s decision to approve Milestone C will authorize the program to proceed to the P&D phase, enter LRIP, or begin limited deployment for AISs, and award contracts for the phase.

SECTION 3: MAJOR CAPABILITY ACQUISITION PROCEDURES 16

Data Required





Data Produced

DATA OBJECTS

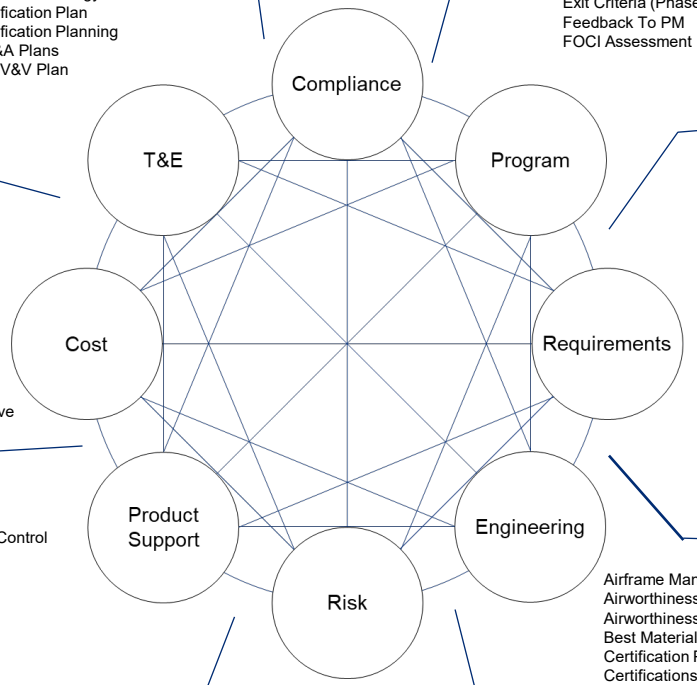
- ❑ Evidence that the production design is stable
- ❑ Full funding
- ❑ Maturity of the software
- ❑ Results of DT and early OT
- ❑ Results of an operational assessment (if conducted)
- ❑ Significant manufacturing risks
- ❑ Status of critical intelligence parameters
- ❑ ATP (Authority to proceed)
- ❑ ATP Contract Award
- ❑ ATP Limited deployment of AIS
- ❑ ATP to LRIP
- ❑ ATP to P&D

Data Objects Derived From

- DoDI 5000.85
- NAVAIRINST 4355.19E

Data Objects

1. Coded
2. Themed
3. Synthesized



Ability To Achieve KPP's
Ability To Achieve KSA's
Acceptance Test Procedures (ATP)
CSI And CSA Test Planning
CSI And CSA Testing
Data Collection, Reduction, Analysis; Test And Deficiency Reporting
Flight Test Requirements
Flight Testing Certifications
Initial Assessments Of Operational Effectiveness
Initial Assessments Of Suitability
Initial Assessments Of Survivability
Live Fire T&E (As Appropriate)
M&S Plan
M&S Role In Testing
M&S Validation
Remaining Tests Planned
Results Of OA
Results Of DT
Software Integration Testing
Software Test Plan
Sprint Testing Results
Test And Data Processing Procedures
T&E Accomplishments
T&E Master Plan (TEMP)
Test Facilities Planning
Test Planning
Test Plans
Test Procedure
Test Requirements
Test Results
Test Strategy
Test Verification Plan
V&V Methodology
Verification Plan
Verification Planning
VV&A Plans
SIL V&V Plan

Public Law
FAR
DFAR
DODI
SECNAVINST
NAVAIRINST
FAA Regulations

Acquisition Phase Of Entry
Acquisition Program Baseline (APB)
Acquisition Strategy
ADM
AoA Study Guidance
AoA Study Plan
ATP (Authority To Proceed)
Business Approach
Business Strategy
Capability Trade Space & Priorities
Contract Incentives
Entrance Criteria (Phase)
Exit Criteria (Phase)
Feedback To PM
FOCI Assessment
Framing Assumptions
Initial Review Milestone
Integrated Master Schedule (IMS)
IP Strategy
Key Government And Contractor Interfaces
LRIP Quantity
LRIP Quantity Approval
Milestone Approval Criteria
Milestone Documentation
OAG Priorities
Open Action Items
Options Matrix
Organization Structure
(Phase) Acquisition Plan
(Phase) Strategy
PM Waiver Requests
Program Decisions
Program Goals Approval Memorandum
Program Protection Implementation Plan
Program Protection Plan (PPP)
Program Security
RFP
RFP Release Approval
Senior Leader Guidance
SOO
Source Selection Criteria
SOW
Competition Strategy
Subcontract Strategy

Affordability Analysis
CARD and/or Cost Estimates
Cost Data
Current Execution Year
Earned Value Data
Fiscal Assumptions
Full Funding
Funding
Future Years Defense Program
ICE
Pending Execution Year
Planned vs. Actual Resource Curve
Should Cost Targets

Affordability Requirements And Program Goals
Capability Development Document (CDD)
Capability Production Document (CPD)
Initial Capabilities Document (ICD)
Contractor System Specification
Requirements Document
SRD
SRS
Contracts Data Requirements List (CDRL)
Technical Performance Measures (TPM)
Key Performance Parameters (KPP)
Key System Attributes (KSA)
Measures Of Effectiveness (MOE)
Measures Of Performance (MOP)
Measures of Success (MoS)
Measures Of Suitability (MOS)
Critical Intelligence Parameters
Integration Planning
Maturity Of The Software

Mission Profiles
New Mission Capability
Product's Compliance With Contractual Requirements
Requirements Baseline
Requirements Trace
Requirements Verification Matrix
Requirements, Certification
Requirements, Design And Functional
Requirements, Engineering Data
Requirements, Functional
Requirements, Manufacturing
Requirements, Performance, Safety
Requirements, Producibility
Requirements, Product Support
Requirements, Quality
Requirements, Safety Critical Software
Requirements, Security, Cybersecurity
Requirements, Software
Requirements, System Level
RFP Requirements
Threat Environments
Threat Projections

Allocated Baseline
Functional Baseline
Performance Baseline
Product Baseline
Bulletin Technical Directives
Certifications Required For Fielding
CM Procedures
CM Process
CMP
DMSMS
Evidence That The Production Design Is Stable
Fatigue Life
Fielded Systems' Status
Industrial Production Capabilities
Integrated Information Dissemination Processes
IPS Elements
LCC, TOC Evaluation Methodology
Life Cycle Sustainment Plan
Life-cycle Mission Data Plan
Logistics Footprint Assessment
Manufacturing And Production Strategy
Manufacturing Plan
Manufacturing Process Control
PCA Results

Performance And Reliability Metrics
Production Quality Deficiency Reports
Producibility, Manufacturing Process, And Process Control Analysis
Product Support Planning
Product Support Strategy (PSS)
Quality Control Plan
RCM And IMP
RCM And IMP Staffing
Release Cycles
Release Schedule
Service Bulletins And Alerts
Software Release
Software Release Plan
Software Sustainment Processes Are In Place And Functioning
Supportability Analysis
Supportability Objectives
Sustainment And Support Systems
Sustainment Metrics
System-level Producibility Analysis
Technical Directive Status Accounting Status
Technical Publication Deficiency Reports
Training Strategy
NATIP
NATOPS
NARIIP

Risk Management Process
Risk Management Plan
Risks
Causal Factors
Consequences
Mitigations
Programmatic Risk Assessment
Manufacturing Risks
System Risk Assessment
System Safety Hazard Risk Assessment

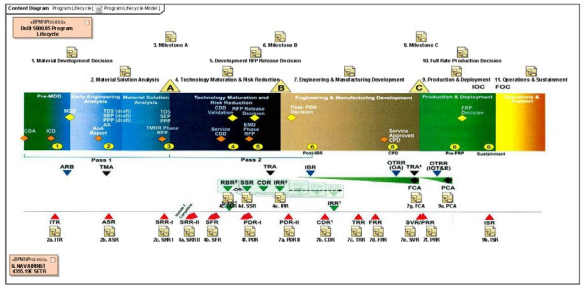
Airframe Management Board Status
Airworthiness Criteria
Airworthiness Criteria Changes
Best Material Approach(es)
Certification Plans
Certifications and/or Flight Approvals
Communication, Navigation Systems
Computer Resource Utilization Metrics
CSI And CAI
CTE
CTE Candidate
CTE Maturity
CTE TRL Verification
CTE, Software
CTE, Systems And Subsystems
Cybersecurity Controls
Cybersecurity Strategy
Design Process
Design Analysis
ECP
ECP Status
EI
Effective Combat Capability
Engineering Data Artifacts
Flight Clearance
Flight Clearance, Interim
Hazard Analysis
Hazard Material Reports
Hazard Reports
Integrated Architecture (CV, UC, OV, SV)
Integration Planning
Integration Point Complexity
Interface Design Documents
Interface Design Maturity
Interoperability
ITRA
Mishap Reports
MOSA
Physical System
Rework Quantification
Safety Assessment Reports Status
Safety Engineering Investigations
SDP
SEMP
SEP
Software Backlog Allocation
Software Backlog User Stories
Software Certification Plans
Software Development Execution Metrics
Software Development Plan
Software Development Strategy
Software Documentation
Software Integration Plan
Software Plans
Software Trouble Reports Status
Subsystem Level Analysis
Subsystem Level Safety Analysis
System Design
System Level Analysis
System Performance
System Software Interfaces
System Technical Interfaces
Systems Integration Plan
Technology Maturation Plans (TMP)

Solution

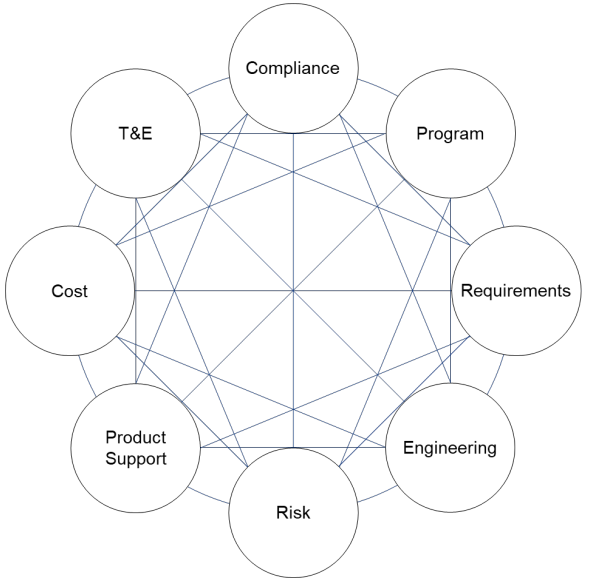
Decision Support System (DSS)

- Single repository for
  - connected cross-functional program data,
  - mapped to internal and external processes that manage or require it
  - with decision aids accessible to the enterprise

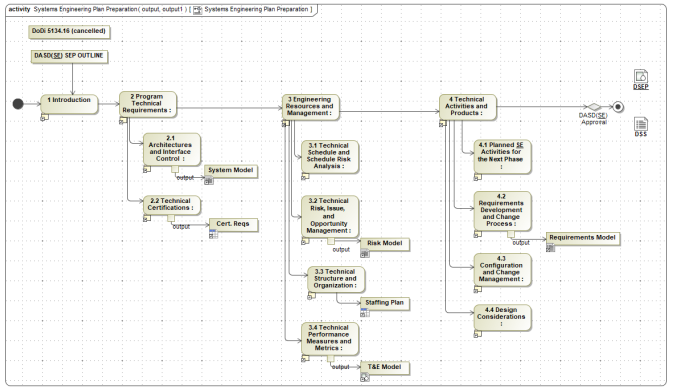
➢ Data segmented to allow internal fluidity while retaining external relevance
  - ➢ I can manage my data & process at will
  - ➢ I can see your data & relate my data to yours
  - ➢ I cannot change your data or process



New Decision Aids



New Data Model



New Digitalized Processes

Digitalization Impact

NGJ-LB - Links DT to OT, and connects T&E to Requirements & Engineering

Strategic Impacts

- Degree of Change
  - Transforms documents to database (retains process)
  - Offers data in html GUI's that mimic documents
    - EASY TO USE: accepted by VX-23
- Impact Target
  - Integrates Test (CT, DT, OT) at Mission Level
- Smart Circular Economy of Data
  - Transforms data to wisdom
    - Link T&E to Requirements to SE
  - Optimizes resources
    - Uses single source of Requirements for SE and T&E
    - Predicts path to integrated Project Data Model
  - Flows data
    - Publish changed data to all documents at once
  - Reuses Data across program

    DRM to CDD to SPS to MBTD to IEF to TEMP to DT to OT

Coordination, Efficiency, Accountability

Direct Examples

- Simplified complex requirements thru atomization
  - IRD had 126 functional requirements
    8 duplicates, 26 conjoined = *27% error rate*
- Replaced Master Objective Matrix (MOM)

  >1000 requirements with >400 attributes = >400k dependencies
- Maintain consistency across T&E, over the Lifecycle
  - Same name for same thing (e.g. test assets, support equipment)
- T&E asset management
  - Identify high value, low density equipment
  - Capability, location, ownership [eventually schedule]
- Identified critical missing Tasks in IEF
  - Creating dependency matrix [REQ] – [TASK] revealed error
- Related every DT event to OT metrics
  - Metric to Task, Task to CDD, CDD to SPS, SPS to Event
- Reconciled
  - Test Events in SPS vs TEMP
  - SPS Verification Trace vs TEMP Evaluation Framework
  - TEMP Objectives vs IEF COI
- DRM's (traceable to AoA, ISC)
  - Modeled as object interactions, become Test Use Case
  - Bound DMOT conduct, establish scenario

Conclusion

Strategy, Data Model, Decision Support System

Digitalization Strategy

1. Strategic choices
2. Ecosystem that constrains the technical options;
3. Method assesses opportunity and limits risk;
4. Result: new processes using new data models that enable better decisions;
5. Feedback will come internally from users and externally from customers

Data Model

- Eligible processes
- Necessary decision points
- Data compliance requirements

DSS is a platform to

- ingest, transform, and harmonize data,
- serve prioritized program manager needs,
- democratize the data environment using data services and business intelligence toolsets,
- scalable and sustainable data /analytics products to accelerate time to value

Know why you do work, how you do work, and what you get out it