



# **SE-DT Interactions through the Developmental Evaluation Framework**

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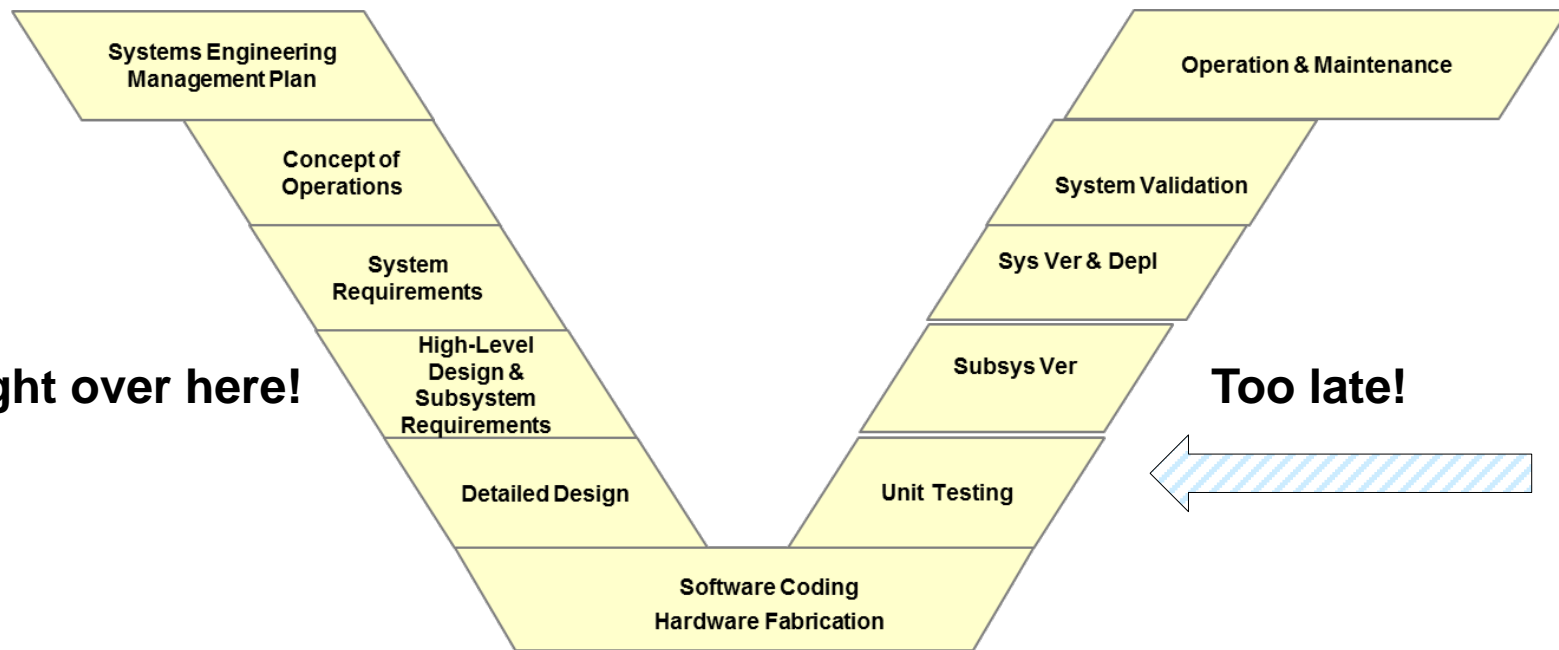
# Discussion Topics

- Why Shift Left?
- Relationship of SE-DT Roles
- Developmental Evaluation Framework (DEF)
  - Concept
  - Examples

# How Do We Solve These?



- Between FY97 and FY13, only 75 of 135 programs (56%) met their reliability thresholds at IOT&E even though too many programs optimize test strategies to deliver data/performance at IOT&E
- Fielded systems continue to experience interoperability issues and cybersecurity vulnerabilities
- Too many acquisition programs conduct significant and critical DT&E activities after the production decision



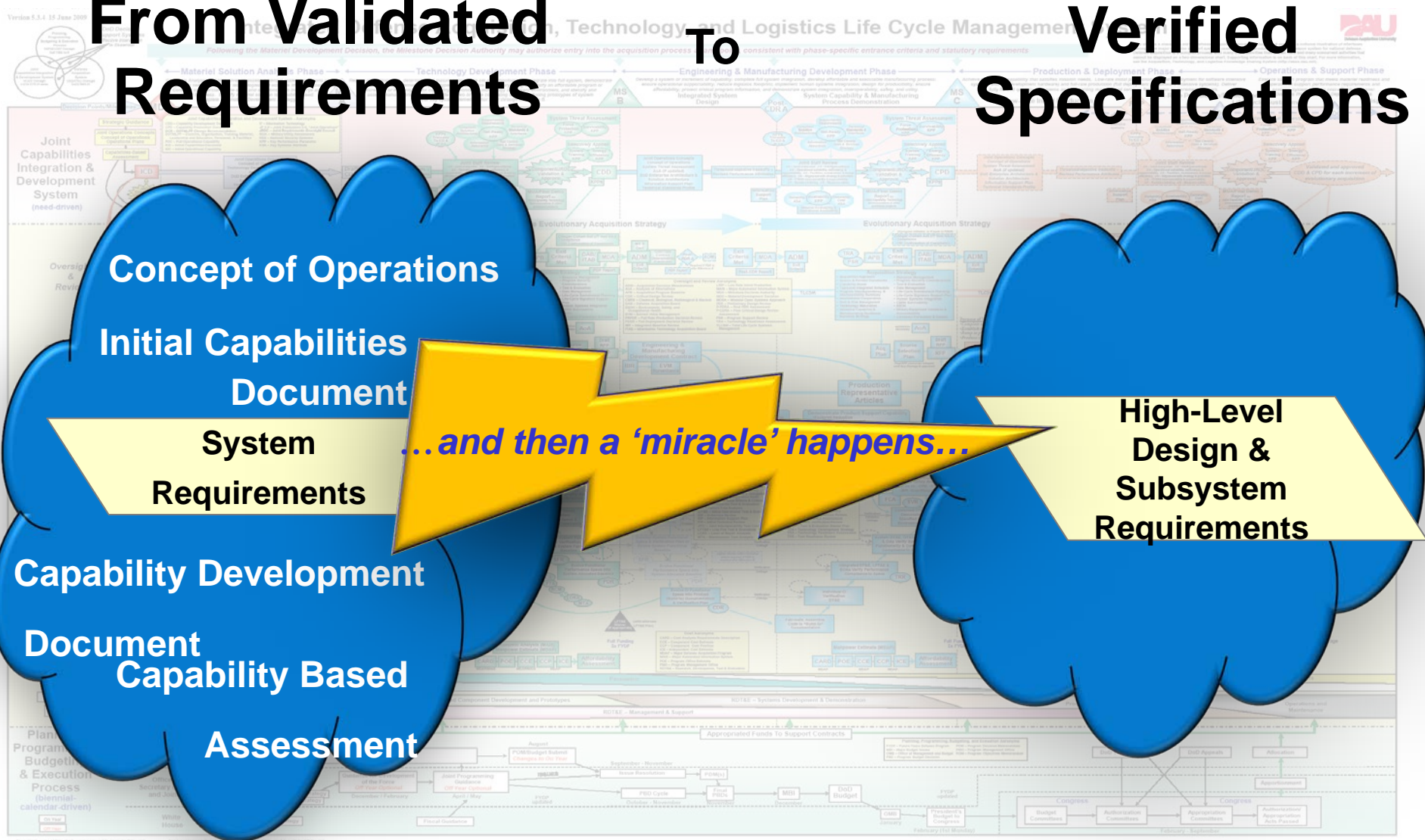


# Measurable, Testable Requirements

## From Validated Requirements

To

## Verified Specifications



**Concept of Operations**

**Initial Capabilities Document**

**System Requirements**

**Capability Development Document**

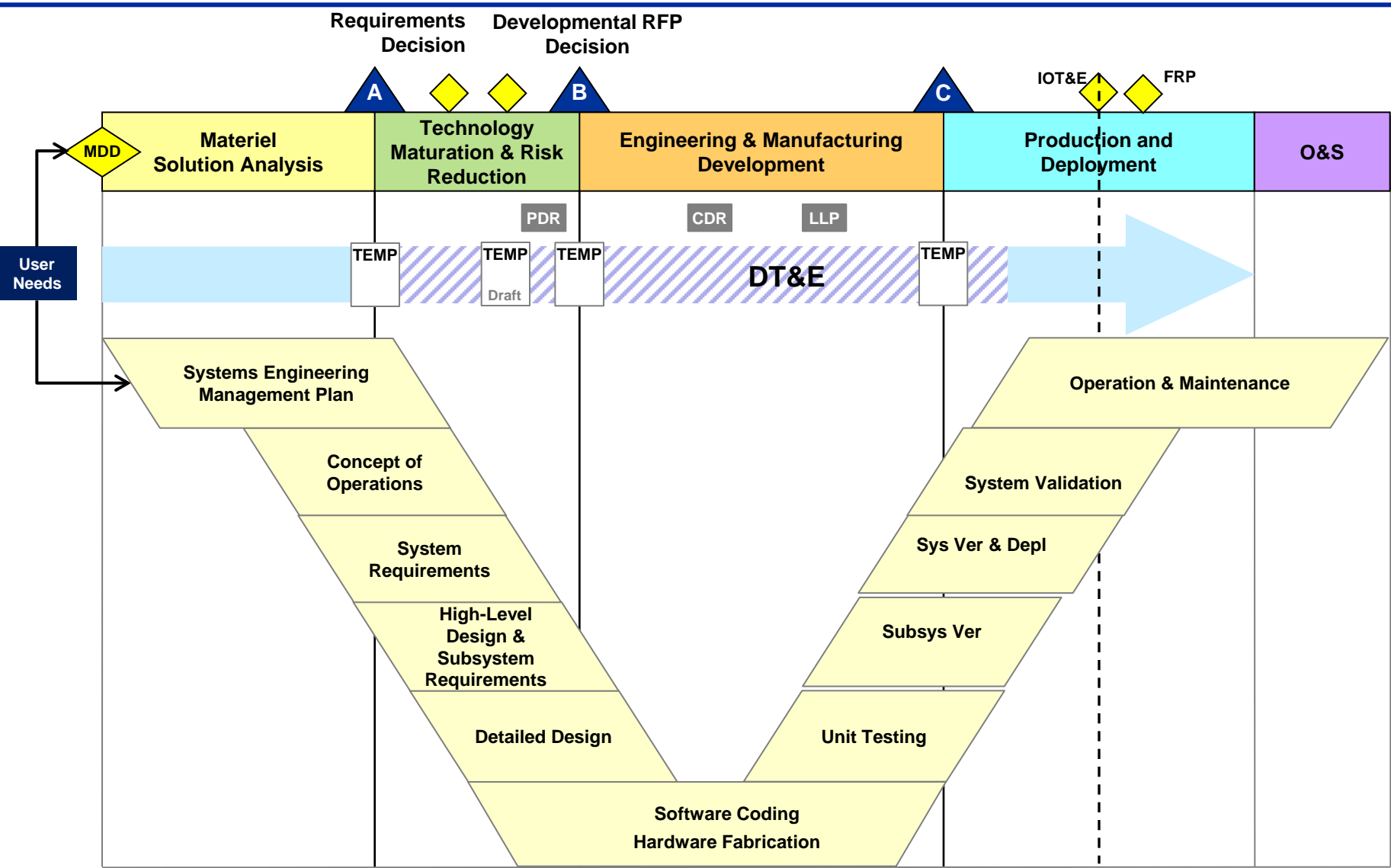
**Capability Based Assessment**

*...and then a 'miracle' happens...*

**High-Level Design & Subsystem Requirements**

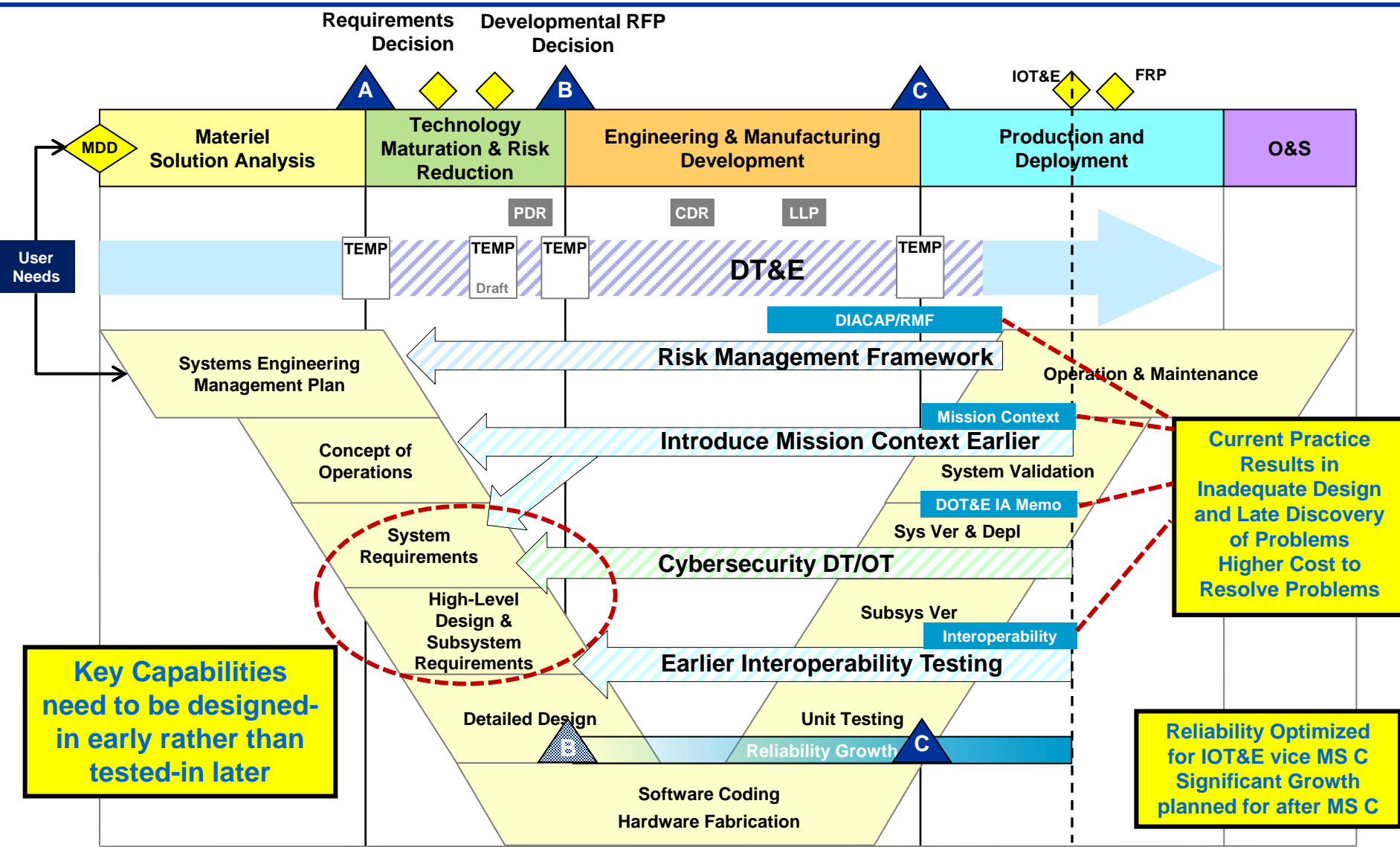


# DT and SE Role in Shift Left





# DT and SE Role in Shift Left





# What Information is Needed When and How to Get It



Requirements Decision

Developmental RFP Decision

IOT&E I FRP

A

B

C

Systems Engineering Management Plan

Concept of Operations

System Requirements

High Level Design & Specification

Functional Decomposition Allocation

Subsystem Requirements, to include the Operator

High-Level Design & Subsystem Requirements

Detailed Design

Software Coding  
Hardware Fabrication

Operation & Maintenance

System Validation

System Verification and Deployment

Subsystem Verification

Unit Testing

Reliability Growth

Developmental Evaluation Framework									
Required Information					When Required				
Performance	Sxx7	Technical Measure #3			DT93				
Capability #2	Sxx8	Technical Measure 5			MS64				
Interoperability	Sxx1	Technical			DT93				
Capability #3	Sxx2				MS64				
Capability #4	Sxx3								
Capability #4	Sxx4	Technical							
Subcontractor									
SW/System Assurance	PPP 3xx	SW Assurance Measure			SW Dev Assess				
RAMP		RAMP Control Measure #1	Assess		Cort Assess	Cort Assess	Cort Assess		
Reliability Assess		Rel Assess Measure #1			Rel Train				

Testing

Supported Decisions

RFPs

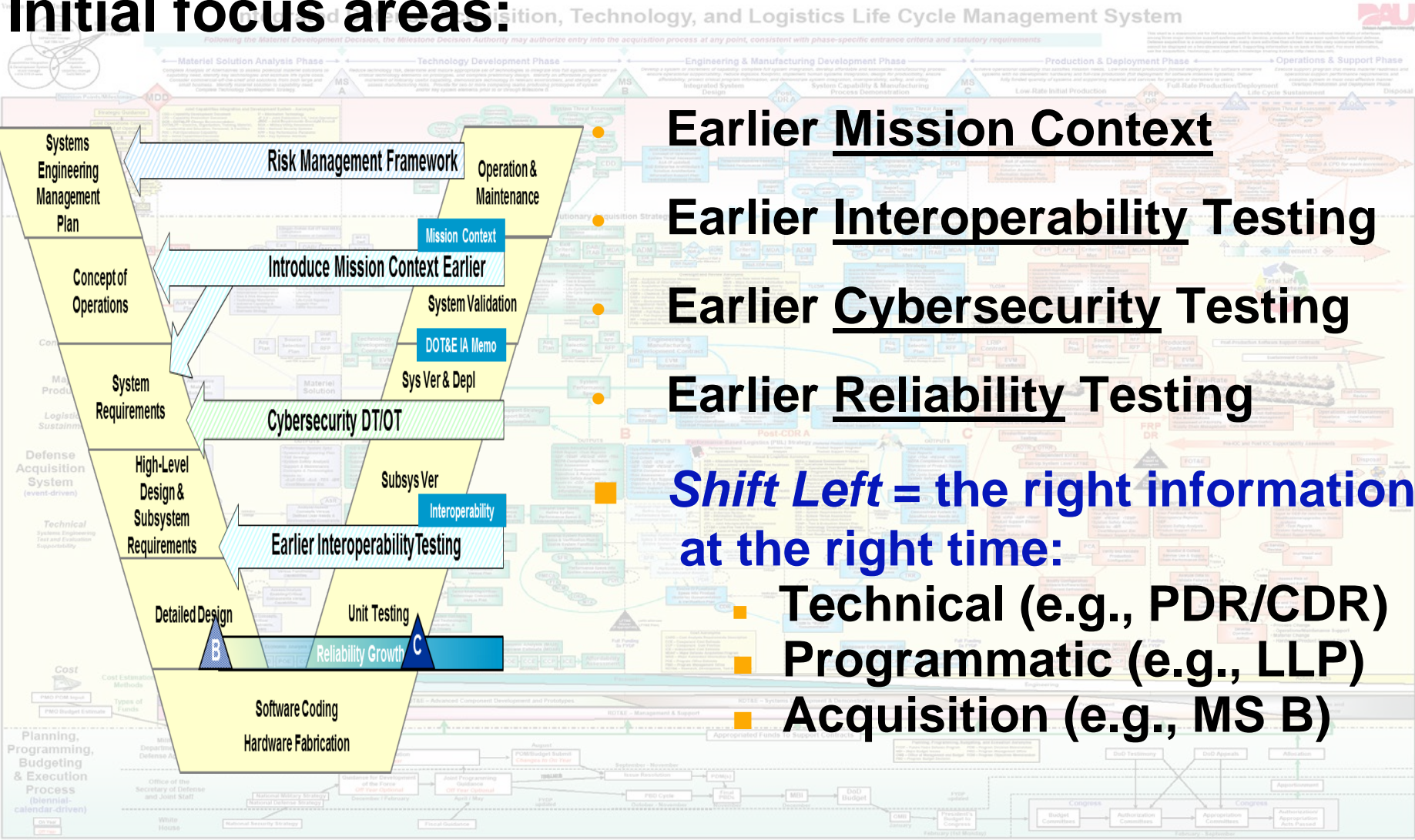
Mission & Operational Environment Decomposition

Mission Context and Operational Environment

# Shift Left



## Initial focus areas:







# Chief Developmental Tester's Role

in conjunction with

## Systems Engineering



- ***Testing and Engineering can make the 'miracle' happen!***  
CDTs and SEs, together with their staffs must:
  - Work to get the mission aspects into the specifications
  - Ensure the derived specs:
    - Represent the impact of the mission and its environment
    - Are verifiable in a mission based environment

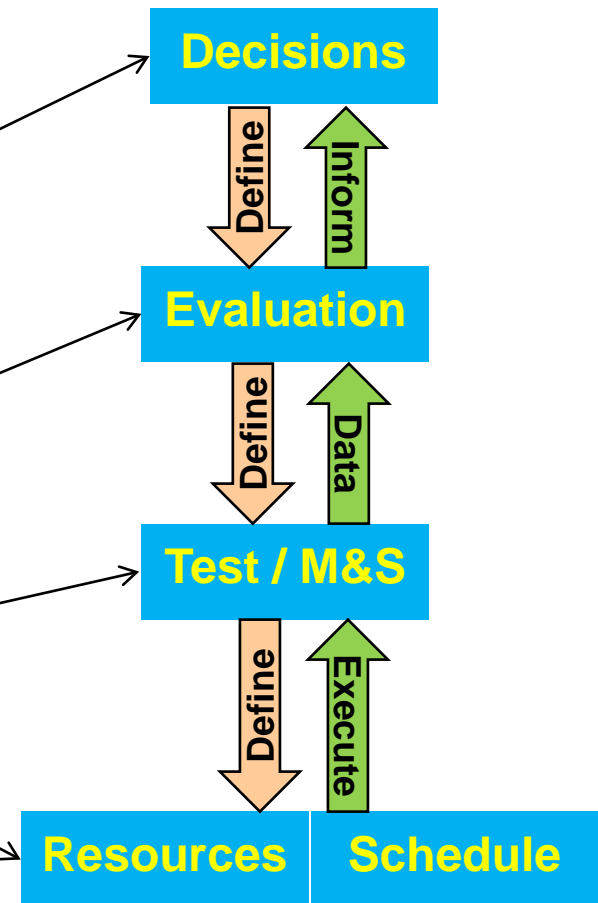
If the technical requirements and specs are informed by the mission, then verifying the technical requirements and specs is doing *testing in a mission context!*

# DEF: Articulating the DT&E Strategy



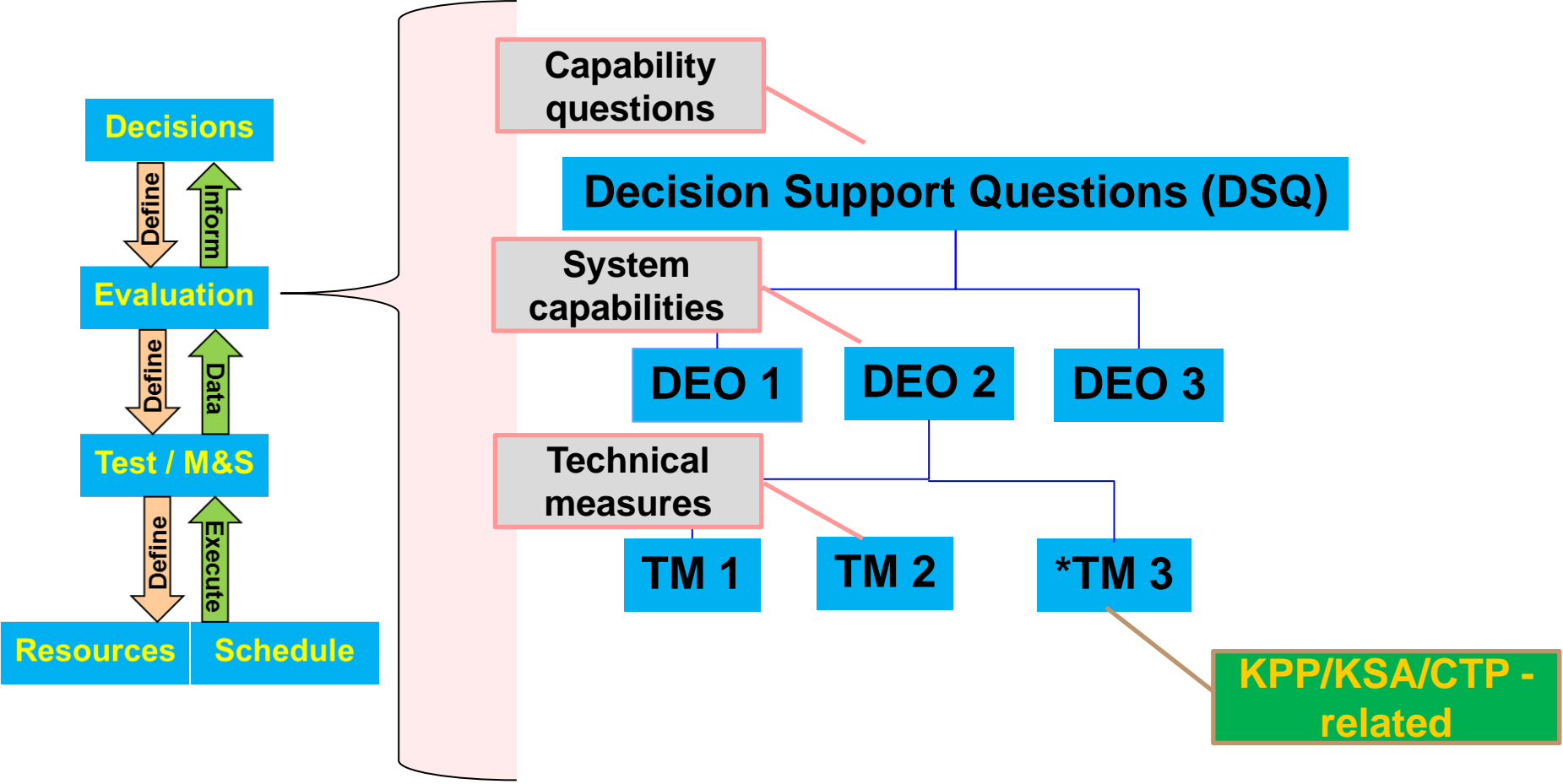
Articulate a logical *evaluation* strategy that informs decisions

- How acquisition, programmatic, technical and operational decisions will be *informed* by evaluation
- How system will be *evaluated* to generate the knowledge needed to inform decisions
- How test and M&S events will provide *data* for evaluation
- What *resources* are required to execute test, conduct evaluation, and inform decisions



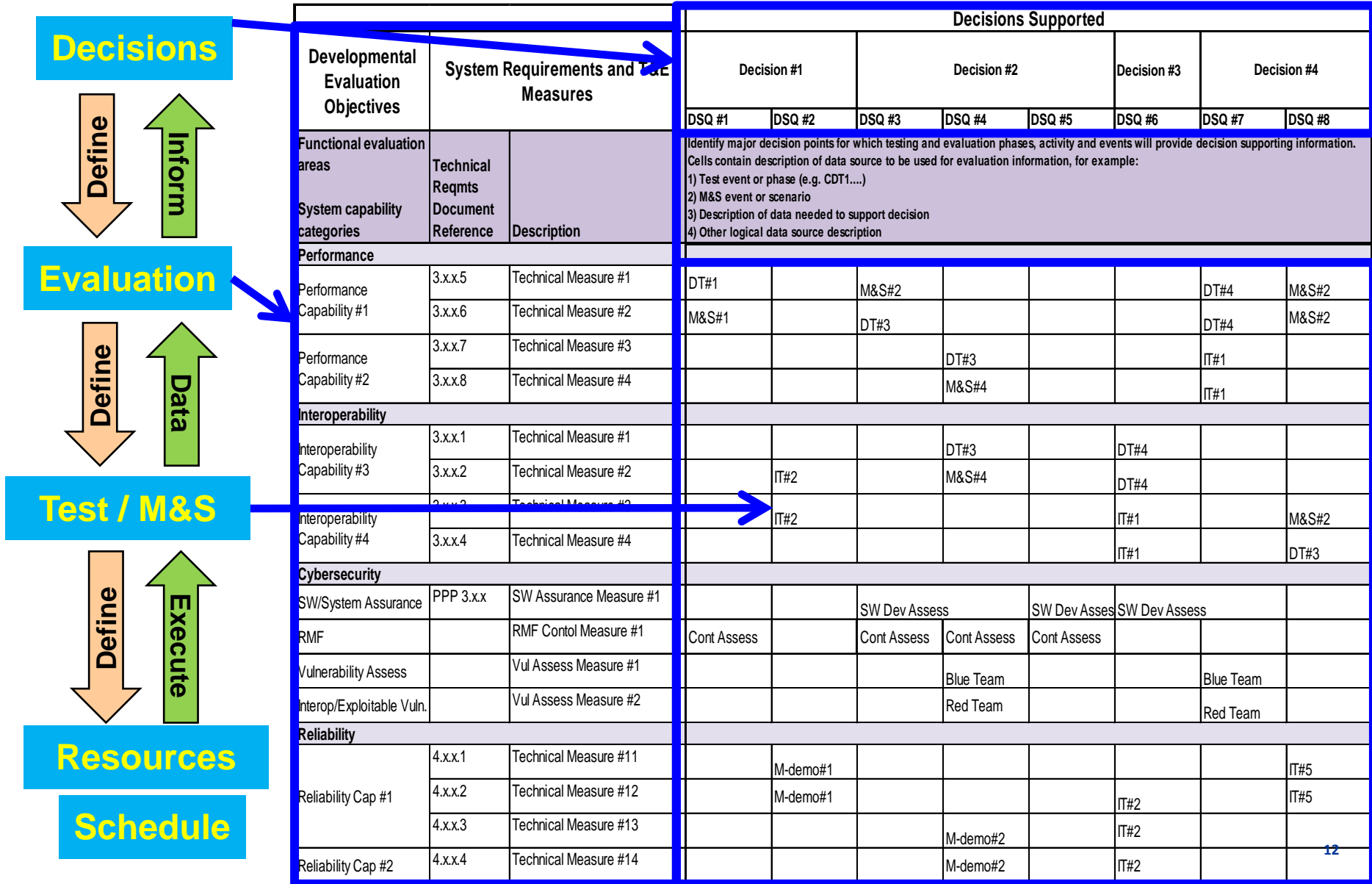
**DT&E story thread: decision – evaluation – test – resources**

# Decision Support with an Evaluation Focus



**System Engineering decomposition:  
Evaluate system capability - Inform decisions**

# Developmental Evaluation Framework





# EXAMPLES

**LRPF: Long Range Precision Fires**

**MS-A TEMP, improving requirements**

**CH-47: Improved Cargo Helicopter**

**MS-B TEMP, validating ECP content**

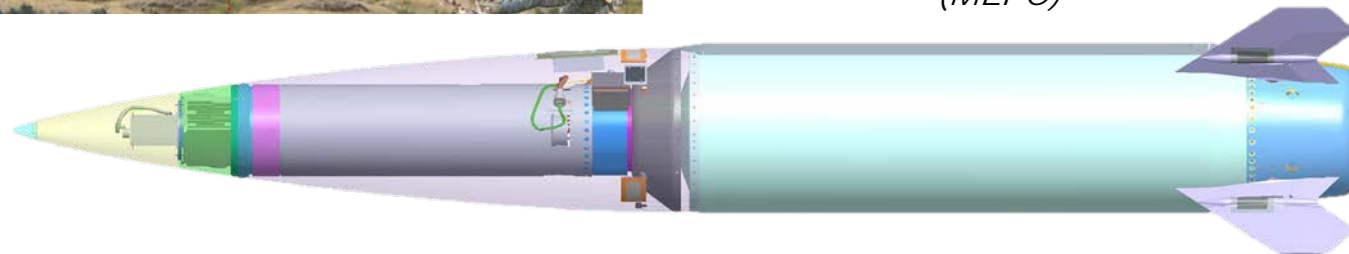
**DCGS-A: Distributed Common Ground System – Army**

**MAIS, providing benefits for cost/benefit analysis**

# Example – Long Range Precision Fires



Missile Launch Pod Container (MLPC)



*Provide responsive fire at extended ranges during full spectrum Joint operations, under all weather and/or time sensitive conditions, 24/7, in order to destroy tactical to strategic targets and provide support for decentralized operations over wide areas.*

# LRPF DEF



Developmental Evaluation Objectives			System Requirements / Measures		Decisions & DSQs				
Functional evaluation areas		Technical Documents	Component performance	Flight Test Readiness					MS-B / viselect
<b>DEO/Capabilities</b>				Component performance					system performance
Performance				Safety-related performance					
LPMC				Launcher integration					
Missile				PDR					flight test
Launcher integration				Design performance					component test
				Requirement/RFP update					analysis
Interoperability				MS-B/Downselect					
Launcher/missile interface				System performance					
C2 compatability									
GPS									
Cybersecurity				<b>Requirements/Technical Measures</b>					
System/SW assurance				TRD sub-capabilities					
Risk Management Framework									
Vulnerability Assessment									
Reliability				<b>Test events / Data sources (TBD)</b>					
Reliability				Contractor test, Ctr/govt test, M&S,					
Maintainability				analysis, CDRLs, flight test					
Environmental conditions									
Safety									
Source: Technical Requirements Document (TRD)									
Environmental Conditions	3.3.6	Natural & induced environments							
Safety	3.3.10	Flight Safety							

# Example – Improved Cargo Helicopter (CH-47F)



***Army's Improved Cargo Helicopter, providing Combat Support and Combat Service Support to forward deployed units of all services. Replacement for the Army's aging CH-47D fleet, incorporating product improvements to address operational test findings, to respond to operational needs identified during combat operations, and to accommodate component obsolescence*** <sup>16</sup>



# CH-47 DEF

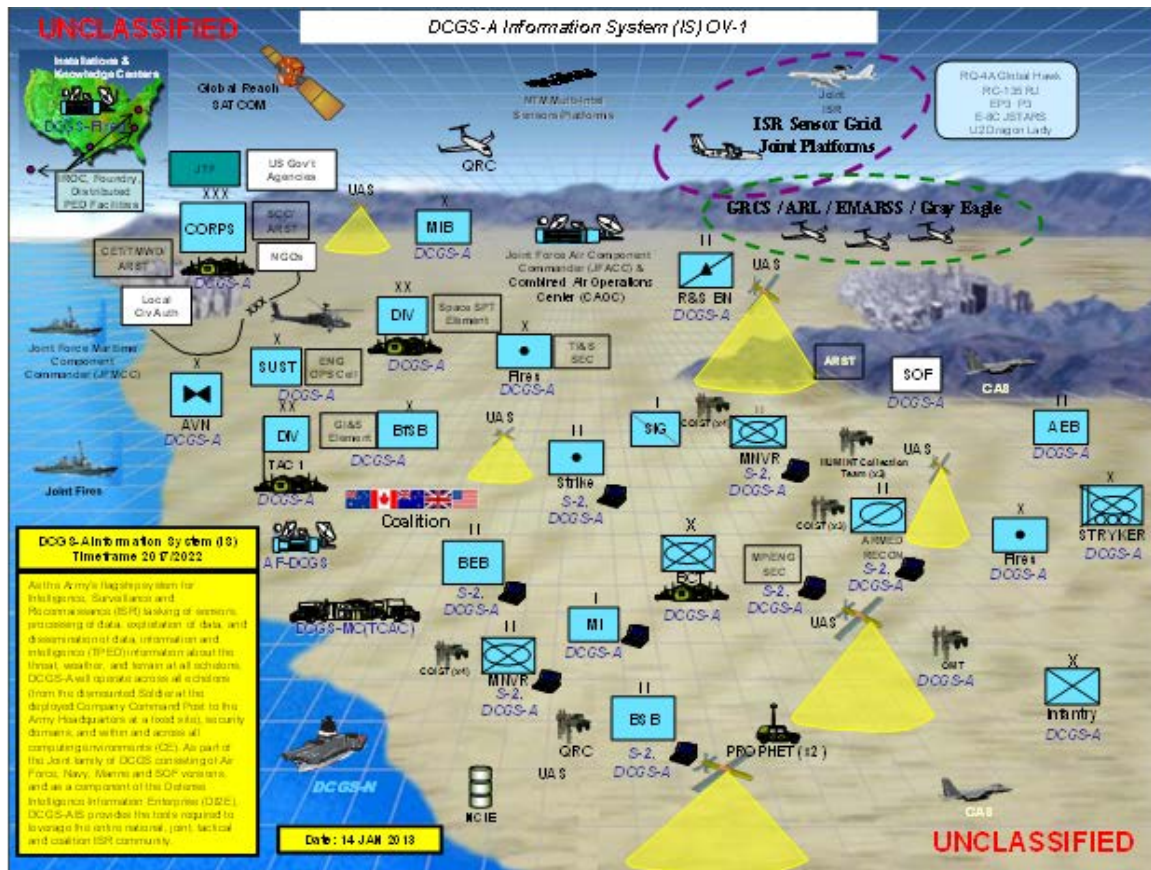


RFP Release/MS B (Block 2 ECP known)	PQA (Bench Qual Complete) (Ready for Integration)	Final TRR Integration Complete (Ready for 1st Flight)	OTRR	MS-C	
Sub System PDR Results Satisfied?	Subsystem Qual Performan	<b>Decisions / DSQs</b>			Satisfied?

Developmental Evaluation Objectives		Technical Measures									
Performance											
Airframe	Max Design Gross Weight Fatigue Life Static Structure Maneuver Load	PDR								RFP Release/MS-B (Block 2 ECP content known): Sub-system PDR results satisfactory for inclusion in Blk2	
Drive System	<b>Capabilities (Sub-systems)</b> Airframe Drive System Electrical System Rotor System Fuel System CAAS (Software) DAFCS (Control System) ACRB (Rotor blades) LCTA (Actuators)	PDR								PQA (Bench Qual Complete, Ready for Integration?): Sub-system bench qualification indicate ready to integrate?	
Electrical Sys			Component Qual Test							Final TRR (Integration Complete, Ready for 1st Flight?): Ground test demonstrate capability? Software clearance achieved?	
Rotor System			PDR							Airworthiness certification received? Contractor 1st flight assessment results/recommendation?	
Fuel System			PDR							OTRR: PM certify system ready to enter OT&E?	
CAAS		Accurate Timely A/C State Nav Comm (Digital/Voice)	PDR		CQT	Ground Test	SIL	AQS	Ctr Assessment of Grd Test, AQS, and SIL results	Govt DT Fit Test	DT Fit test and LUT Results
DAFCS		Handling Qualities	PDR		CQT	Ground Test	SIL	AQS	Ctr Assessment of Grd Test, AQS, and SIL results	Govt DT Fit Test	DT Fit test and LUT Results
ACRB	Lift Flying Quality	CDR								PDR Component Qual Test Ground Test AQS, SIL Govt DT Flight test, LUT	
LCTA	Reliability	PDR									

Interoperability										
NR-KPP										
CyberSecurity										
Sys/SW Assurance										
RMF (Compliance)										
Vulnerability Assessment										
Reliability										
RAM	MTBF MTBMA	PDR		Subsystem RAM	RAM Data Collection	SW Reliability		RAM Data Collection	RAM Data Collection	RAM Data Collection

# Example – Distributed Common Ground System – Army (DCGS-A)



*Army's system for Intelligence, Surveillance and Reconnaissance (ISR) tasking of sensors, processing of data, exploitation of data, and dissemination of data (TPED), information and intelligence. DCGS-A will operate across all echelons (from the Company-level Intelligence Support Team (ColIST) to the Army Service Component Command (ASCC)), all security and network domains (Unclassified, Secret, Top Secret (Joint Worldwide Intelligence*

# DCGS-A DEF

## Decisions & DSQs

Developmental Evaluation Objectives	System Requirements / Measures	Contract Award		Release
		Infrastructure Development	Application Integration	modern
Functional areas System categories Performance	<b>DEO/Capabilities</b>			
	Performance			
	Infrastructure			
	Fusion			
	Support to targeting			
	ISR Synchronization			
	INTs			
	Ground Station Capability			
	Interoperability			
	Interoperability			
Intra-operability				
Ground Station	Cybersecurity			
	System/SW assurance			
	Risk Management Framework			
Interoperability	Vulnerability Assessment			
Intra-System/SV Risk Management Framework Vulnerability Reliability	Reliability			
	Usability			
	Suitability			
	Training			
Source: Inc-2 Requirements Data Package (RDP) draft				

Contract Award  
Infrastructure meet technical capability requirements?  
Ability to integrate existing applications?

Release 2 Capability Drop Definition  
Benefit of modernization/emerging capability options?

Release 1 Fielding Decision  
Infrastructure capabilities meet technical requirements?  
No loss of Inc-1 capabilities?  
Infrastructure expandable/scalable?

Release 2 Fielding Decision  
Modernized capabilities performing sufficient to field?  
Capabilities to be included in future releases/increments?

**Test events / Data sources (TBD)**  
TBD (evaluation info needs defined)

**Requirements/Technical Measures**  
RDP paragraph content



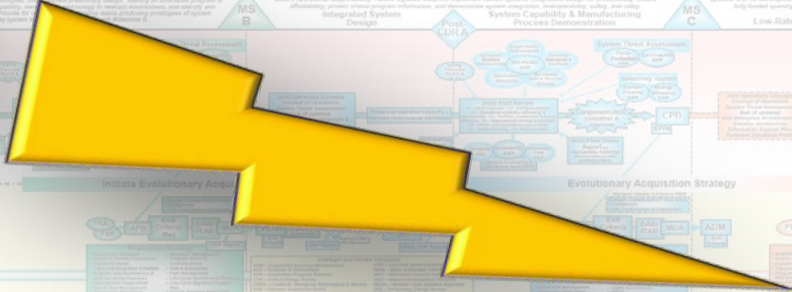
# Summary

- **DEF has identified potential DT-SE collaboration to build better warfighter systems**
  - **DT-generated knowledge helping SE**
    - Requirements refinement
    - Informing early SE-based decisions
  - **SE-generated knowledge helping DT**
    - Define technical capabilities and measures
    - Define Critical Technical Parameters
  
- **Way Ahead: Define collaboration opportunities & document in SEP & TEMP guidance**

# It's no miracle...



Decision Quality Knowledge

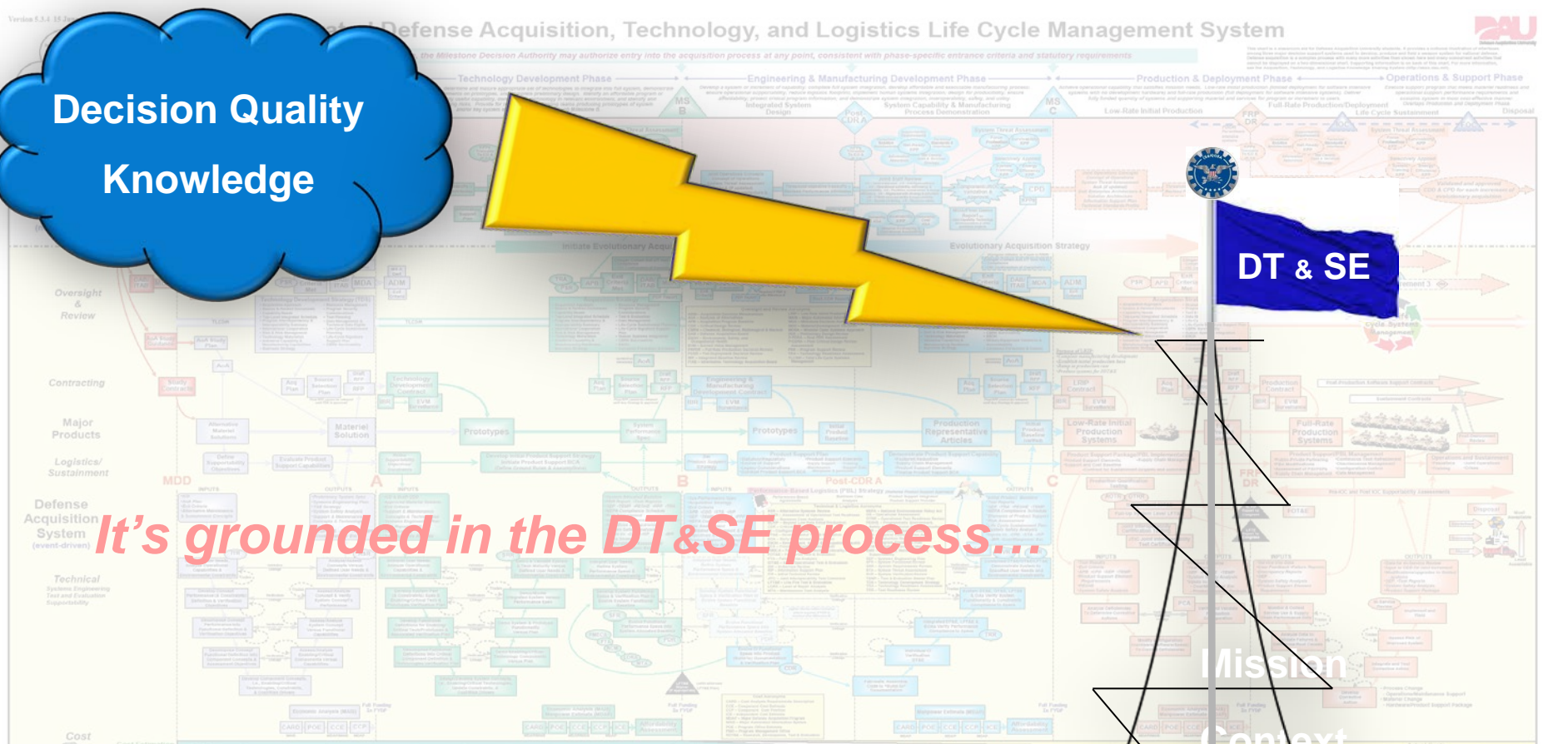


DT & SE

It's grounded in the DT&SE process...

...doing the right things, at the right time (SE).

...having the right information, at the right time (DT).





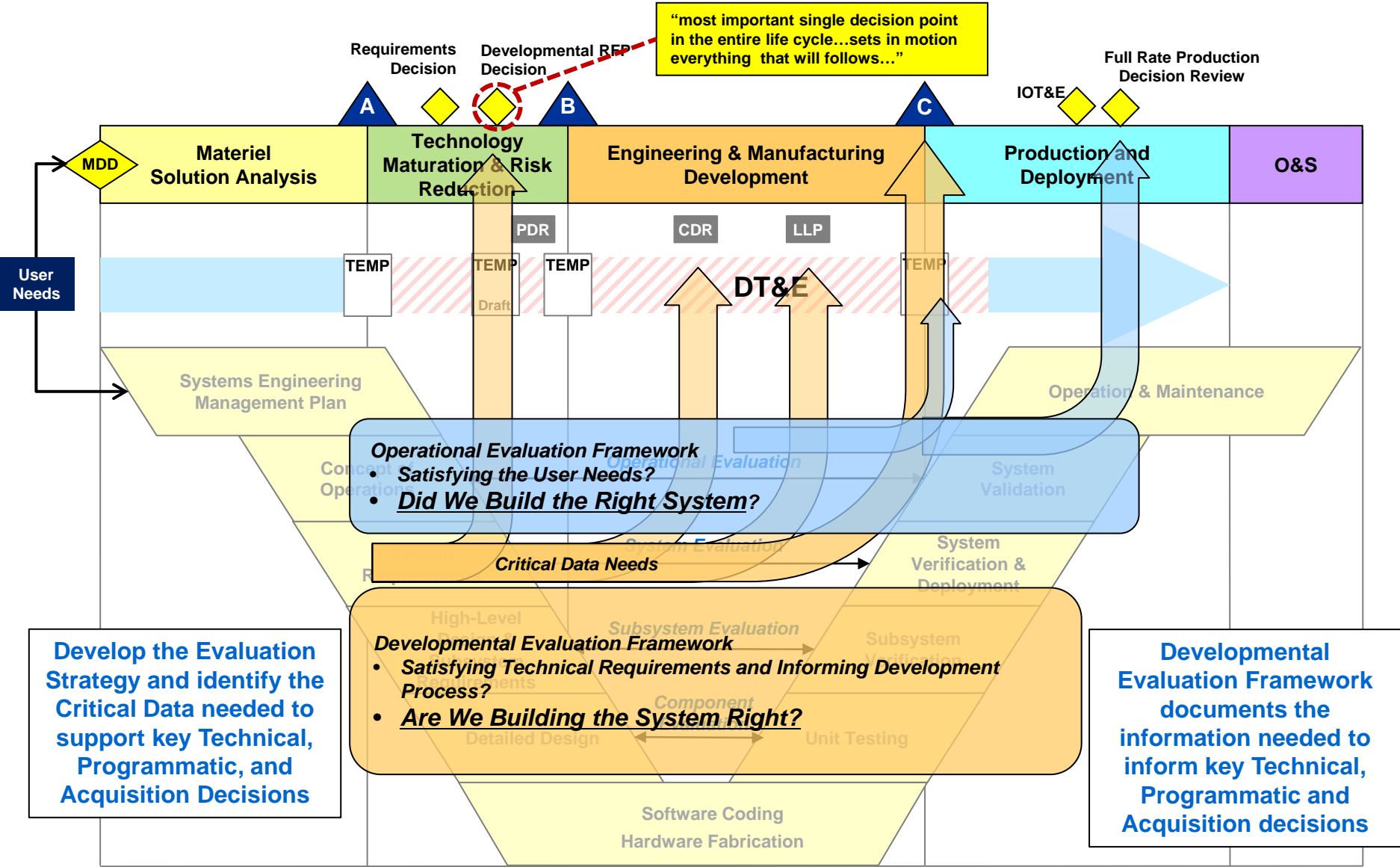
# BACK-UP

# SE, DT&E, and DoDI 5000.02

## Plan the Evaluation & Inform the Decisions



"most important single decision point in the entire life cycle...sets in motion everything that will follow..."

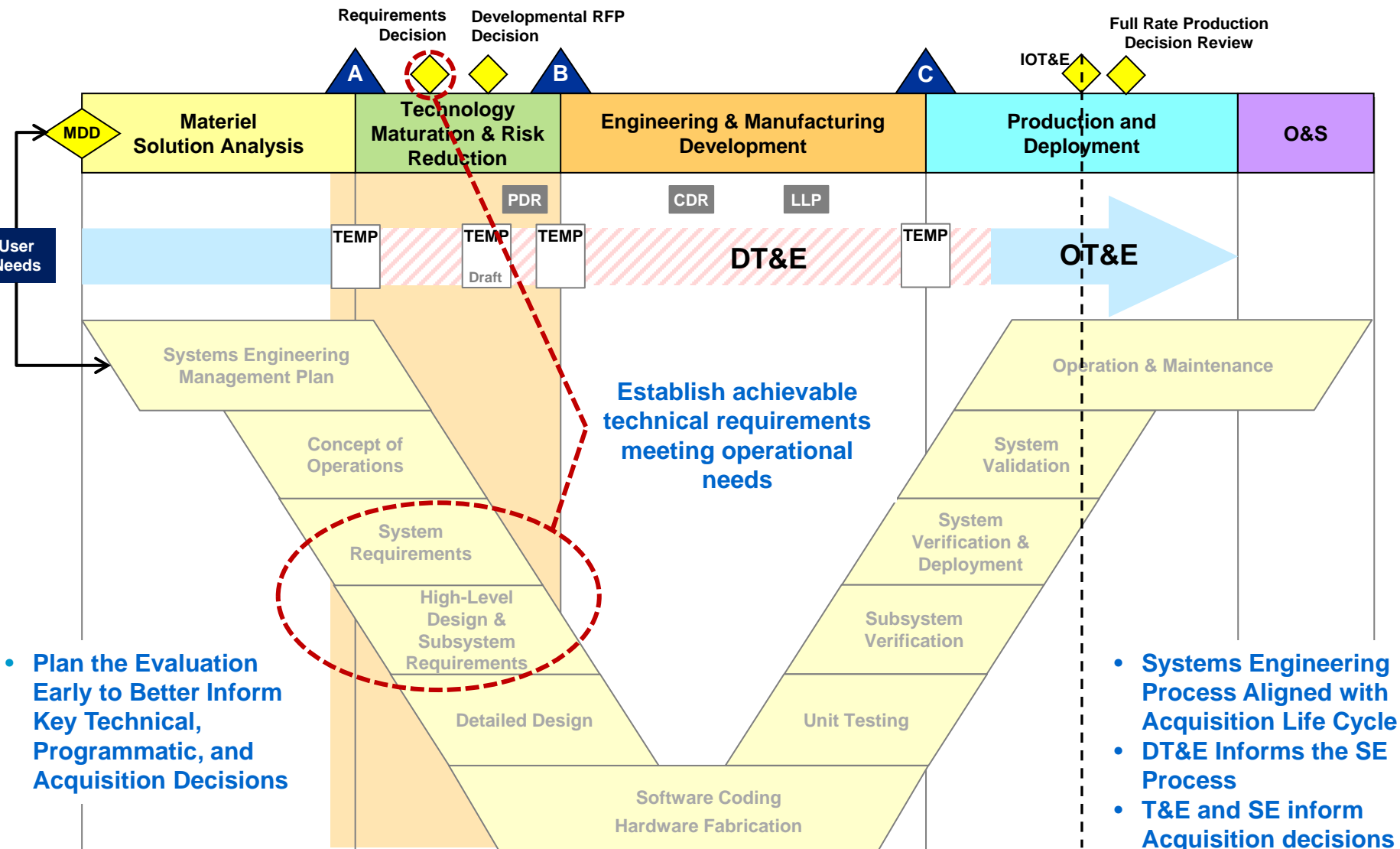


Develop the Evaluation Strategy and identify the Critical Data needed to support key Technical, Programmatic, and Acquisition Decisions

Developmental Evaluation Framework documents the information needed to inform key Technical, Programmatic and Acquisition decisions

# DT-generated knowledge as SE-assist

## Improving Requirements



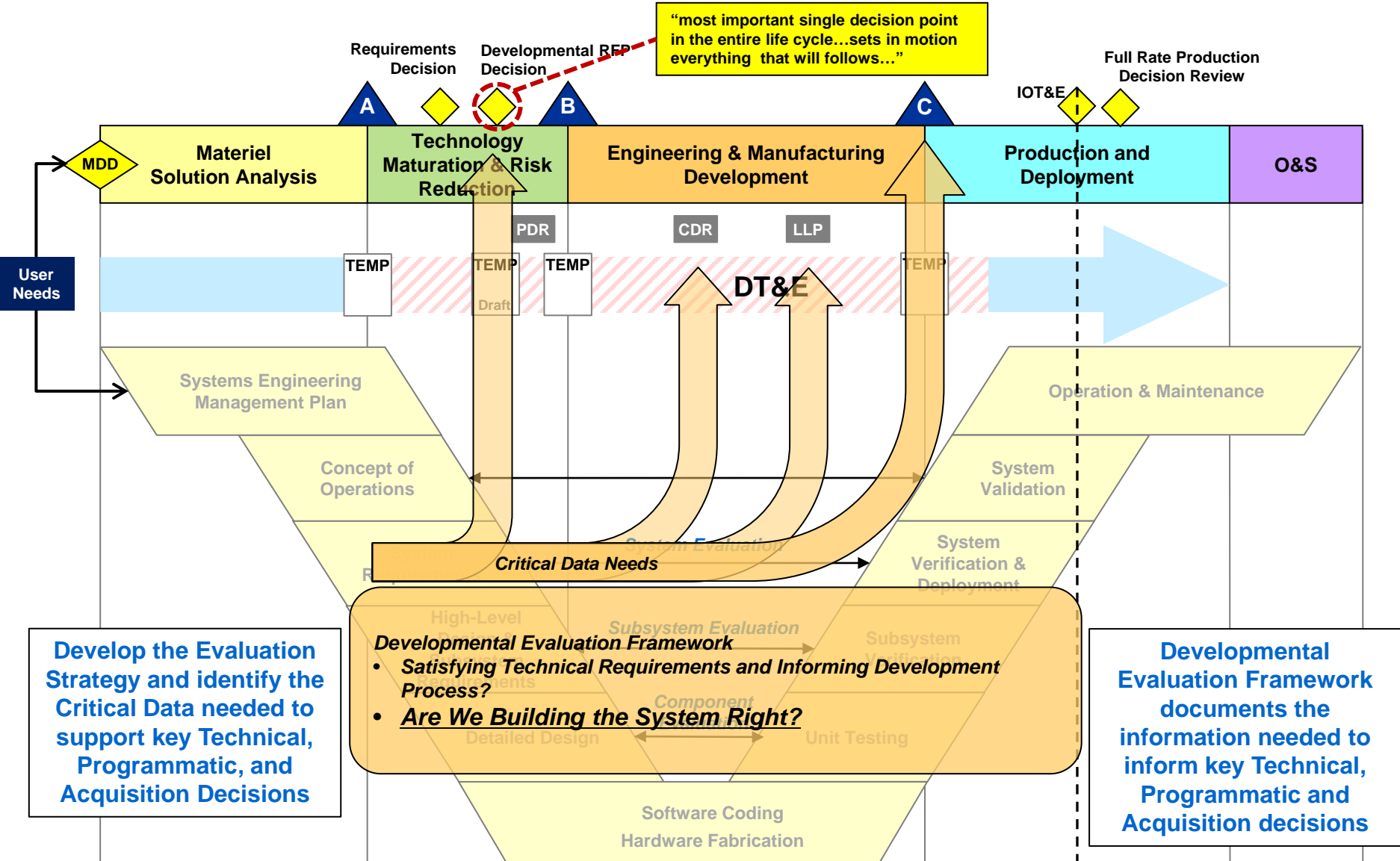


# DT-generated knowledge as SE-assist

## Inform the Decisions



"most important single decision point in the entire life cycle...sets in motion everything that will follows..."





# SE-generated knowledge as DT-assist

## Building the DEF: Defining information needs

### Identify *key decisions & information needs*

- Identify programmatic, acquisition, technical, or operational **decisions** (PM, PEO, AT&L) throughout acquisition strategy
- Articulate **essence** of decision being made
- Determine **DT&E information needed** to support decision-making in form of **Decision Support Questions (DSQ)**

			Decisions Supported							
Developmental Evaluation Objectives	System Requirements and T&E Measures		Decision #1		Decision #2			Decision #3	Decision #4	
			DSQ #1	DSQ #2	DSQ #3	DSQ #4	DSQ #5	DSQ #6	DSQ #7	DSQ #8
Functional evaluation areas	Technical Reqmts Document Reference	Description	Identify major decision points for which testing and evaluation phases, activity and events will provide decision supporting information. Cells contain description of data source to be used for evaluation information, for example: 1) Test event or phase (e.g. CDT1....) 2) M&S event or scenario 3) Description of data needed to support decision 4) Other logical data source description							
<b>Performance</b>										
Performance Capability #1	3.x.x5	Technical Measure #1	DT#1		M&S#2				DT#4	M&S#2
	3.x.x6	Technical Measure #2	M&S#1		DT#3				DT#4	M&S#2
Performance Capability #2	3.x.x7	Technical Measure #3				DT#3			IT#1	
	3.x.x8	Technical Measure #4				M&S#4			IT#1	
<b>Interoperability</b>										
Interoperability Capability #3	3.x.x1	Technical Measure #1				DT#3		DT#4		
	3.x.x2	Technical Measure #2		IT#2		M&S#4		DT#4		
Interoperability Capability #4	3.x.x3	Technical Measure #3		IT#2				IT#1		M&S#2
	3.x.x4	Technical Measure #4						IT#1		DT#3
<b>Cybersecurity</b>										
SW/System Assurance	PPP 3.x.x	SW Assurance Measure #1			SW Dev Assess		SW Dev Asses	SW Dev Assess		
RMF		RMF Contol Measure #1	Cont Assess		Cont Assess	Cont Assess	Cont Assess			
Vulnerability Assess		Vul Assess Measure #1				Blue Team			Blue Team	
Interop/Exploitable Vuln.		Vul Assess Measure #2				Red Team			Red Team	
<b>Reliability</b>										
Reliability Cap #1	4.x.x1	Technical Measure #11		M-demo#1						IT#5
	4.x.x2	Technical Measure #12		M-demo#1				IT#2		IT#5
	4.x.x3	Technical Measure #13				M-demo#2		IT#2		
Reliability Cap #2	4.x.x4	Technical Measure #14				M-demo#2		IT#2		

# SE-generated knowledge as DT-assist

## Building the DEF: Defining system capabilities



Develop Developmental Evaluation Objectives (DEO)

- **System technical capabilities**
- Binned into Functional Evaluation Areas (performance, interoperability, cybersecurity, reliability)
- Suggested starting point: major SRD paragraph headings
- Expand or contract to generate top-level listing of technical capabilities

Developmental Evaluation Objectives			System Requirements and T&E Measures			Decisions Supported								
						Decision #1		Decision #2			Decision #3		Decision #4	
Functional evaluation areas			Technical Reqrmts Document Reference		Description		D&SQ #1	D&SQ #2	D&SQ #3	D&SQ #4	D&SQ #5	D&SQ #6	D&SQ #7	D&SQ #8
Performance							Identify major decision points for which testing and evaluation phases, a ctivity and events will provide decision supporting information. Cells contain description of data source to be used for evaluation information, for example: 1) Test event or phase (e.g. CDF1...) 2) M&S event or scenario 3) Description of data needed to support decision 4) Other logical data source description							
Performance Capability#1	3xx5	Technical Measure #1			DT#1			M&S#2					DT#4	M&S#2
	3xx6	Technical Measure #2			M&S#1			DT#3					DT#4	M&S#2
Performance Capability#2	3xx7	Technical Measure #3							DT#3				IT#1	
	3xx8	Technical Measure #4						M&S#4					IT#1	
Interoperability														
Interoperability Capability#3	3xx1	Technical Measure #1							DT#3				DT#4	
	3xx2	Technical Measure #2				IT#2			M&S#4				DT#4	
Interoperability Capability#4	3xx3	Technical Measure #3				IT#2							IT#1	M&S#2
	3xx4	Technical Measure #4											IT#1	DT#3
Cybersecurity														
SWSystem Assurance	PPP 3.xx	SW Assurance Measure #1							SW Dev Assess		SW Dev Asses	SW Dev Assess		
RMF		RMF Control Measure #1			Cont Assess			Cont Assess	Cont Assess	Cont Assess	Cont Assess			
Vulnerability Assess		Vul Assess Measure #1							Blue Team				Blue Team	
Interop/Exploitable Vuln		Vul Assess Measure #2							Red Team				Red Team	
Reliability														
Reliability Cap #1	4xx1	Technical Measure #11					M-demo#1							IT#5
	4xx2	Technical Measure #12					M-demo#1					IT#2		IT#5
	4xx3	Technical Measure #13							M-demo#2			IT#2		
Reliability Cap #2	4xx4	Technical Measure #14							M-demo#2			IT#2		

# SE-generated knowledge as DT-assist

## Building the DEF: Defining technical measures



Determine appropriate level or detail for measures

- Quantify **“inch-deep & mile-wide” measures**
  - Not just KPP/KSA/CTPs
- Depending upon number of tech requirements:
  - Technical measures
  - SRD sub-paragraph (binning of several related measures)
  - DOORS hierarchy-cut
  - Binning of related measures

			Decisions Supported							
Developmental Evaluation Objectives	System Requirements and T&E Measures		Decision #1		Decision #2		Decision #3		Decision #4	
			D SQ #1	D SQ #2	D SQ #3	D SQ #4	D SQ #5	D SQ #6	D SQ #7	D SQ #8
Functional evaluation areas	Technical Reqmts	Description	Identify major decision points for which testing and evaluation phases, activity and events will provide decision supporting information. Cells contain description of data source to be used for evaluation information, for example: 1) Test event or phase (e.g. CDT1...) 2) M&S event or scenario 3) Description of data needed to support decision 4) Other logical data source description							
System capability categories	Document Reference									
<b>Performance</b>										
Performance Capability#1	3xx5	Technical Measure #1	DT#1		M&S#2				DT#4	M&S#2
	3xx6	Technical Measure #2	M&S#1		DT#3				DT#4	M&S#2
Performance Capability#2	3xx7	Technical Measure #3				DT#3			IT#1	
	3xx8	Technical Measure #4				M&S#4			IT#1	
<b>Interoperability</b>										
Interoperability Capability#3	3xx1	Technical Measure #1				DT#3			DT#4	
	3xx2	Technical Measure #2							DT#4	
Interoperability Capability#4	3xx3	Technical Measure #3							IT#1	M&S#2
	3xx4	Technical Measure #4							IT#1	DT#3
<b>Cybersecurity</b>										
SW/System Assurance	PPP 3.xx	SW Assurance Measure #1				SW Dev Assess		SW Dev Assess	SW Dev Assess	
RMF		RMF Control Measure #1	Cont Assess			Cont Assess	Cont Assess	Cont Assess		
Vulnerability Assess		Vul Assess Measure #1				Blue Team			Blue Team	
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<b>Reliability</b>										
ReliabilityCap #1	4xx1	Technical Measure #11		M-demo#1						IT#5
	4xx2	Technical Measure #12		M-demo#1				IT#2		IT#5
	4xx3	Technical Measure #13				M-demo#2		IT#2		
ReliabilityCap #2	4xx4	Technical Measure #14				M-demo#2		IT#2		

# SE-generated knowledge as DT-assist

## Building the DEF: Defining the important measures



4. Highlight **important technical measures** for additional **evaluation emphasis**

— Designate (bold & asterisk) KPP/KSA/CTP – related measures

Developmental Evaluation Objectives			System Requirements and T&E Measures			Decisions Supported								
						Decision #1		Decision #2			Decision #3		Decision #4	
						DSQ #1	DSQ #2	DSQ #3	DSQ #4	DSQ #5	DSQ #6	DSQ #7	DSQ #8	
<b>Functional evaluation areas</b>	<b>Technical Reqmts Document Reference</b>	<b>Description</b>	Identify major decision points for which testing and evaluation phases, a activity and events will provide decision supporting information. Cells contain description of data source to be used for evaluation information, for example: 1) Test event or phase (e.g. CDT1...) 2) M&S event or scenario 3) Description of data needed to support decision 4) Other logical data source description											
<b>Performance</b>														
Performance Capability#1	3xx5	Technical Measure #1	DT#1		M&S#2				DT#4	M&S#2				
	3xx6	Technical Measure #2	M&S#1		DT#3				DT#4	M&S#2				
Performance Capability#2	3xx7	Technical Measure #3				DT#3			IT#1					
	3xx8	Technical Measure #4				M&S#4			IT#1					
<b>Interoperability</b>														
Interoperability Capability#3	3xx1	Technical Measure #1				DT#3			DT#4					
	3xx2	Technical Measure #2			IT#2		M&S#4		DT#4					
Interoperability Capability#4	3xx3	Technical Measure #3			IT#2				IT#1		M&S#2			
	3xx4	Technical Measure #4							IT#1		DT#3			
<b>Cybersecurity</b>														
SW/System Assurance	PPP 3.xx	SW Assurance Measure #1				SW Dev Assess		SW Dev Assess	SW Dev Assess					
RMF		RMF Control Measure #1	Cont Assess			Cont Assess	Cont Assess	Cont Assess	Cont Assess					
Vulnerability Assess		Vul Assess Measure #1					Blue Team			Blue Team				
Interop/Exploitable Vuln.		Vul Assess Measure #2					Red Team			Red Team				
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	4xx3	Technical Measure #13					M-demo#2		IT#2					
Reliability Cap #2	4xx4	Technical Measure #14					M-demo#2		IT#2					