



# BUILDING A DIGITAL TWIN FOR NASA 'S NONDESTRUCTIVE EVALUATION CAPABILITY

Bryan Bookhart, KSC Chief Enterprise Architect

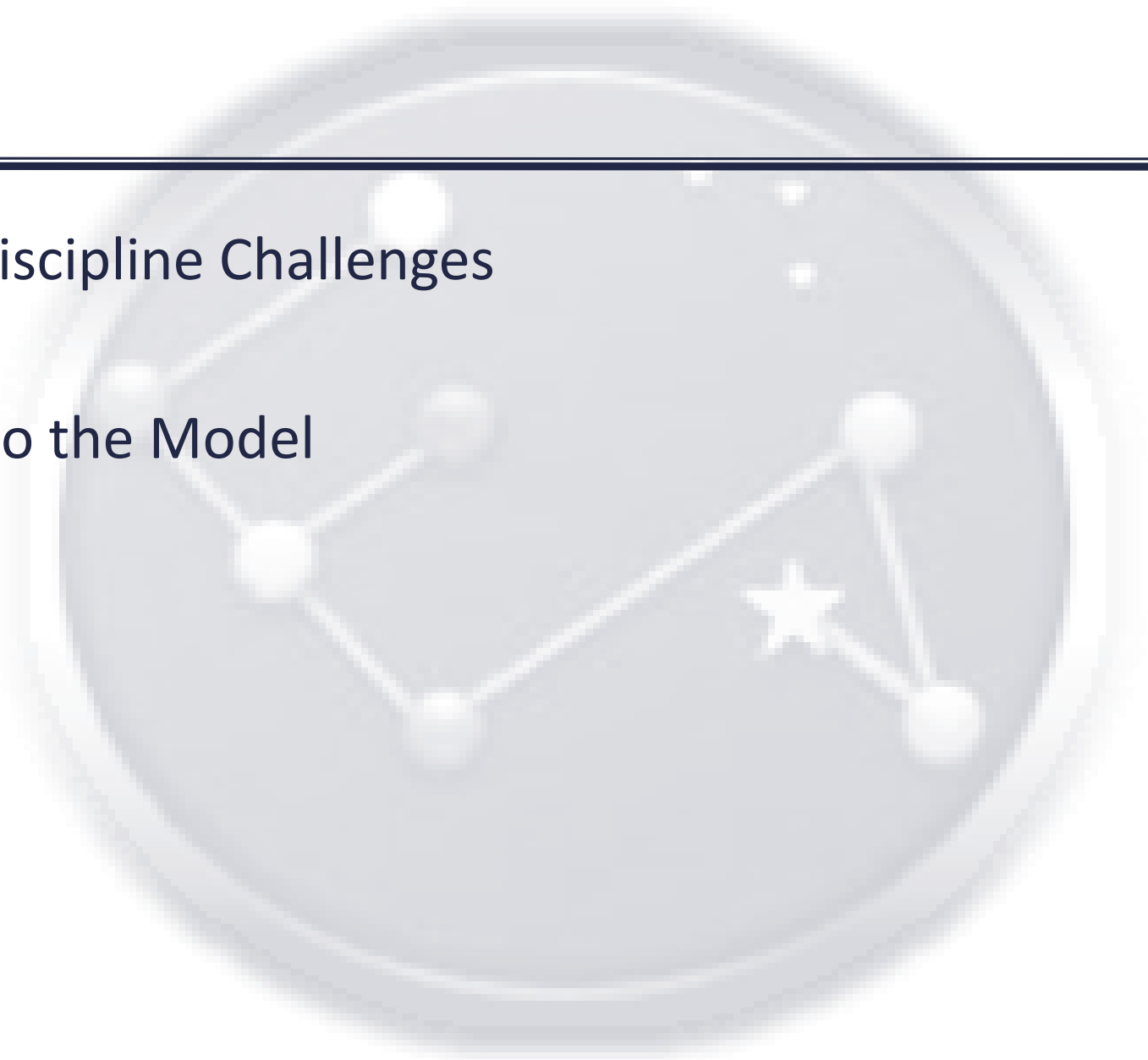
Eric Burke, NDE Program Manager

March 12, 2020

# OUTLINE



- Technical Discipline Challenges
- Approach
- Glimpse Into the Model
- Summary
- Next Steps



# TECHNICAL DISCIPLINE CHALLENGES



- Adequate insight within and across centers
  - Efforts are document based, manually updated
  - Insight into discipline interfaces and interdependencies
  - Questionable data quality and data inconsistencies
  - Ability to integrate, aggregate, analyze data
  - Sufficient insights into health, risk, and cost
  - Decision making (e.g. rationalization, modifications, addressing gaps)
  - Ability to efficiently assess Agency investment needs
  - Maintain disciplines
- 
- Objective – Demonstrate how a digital twin model of Technical Disciplines can address the above challenges and improve discipline management



# APPROACH

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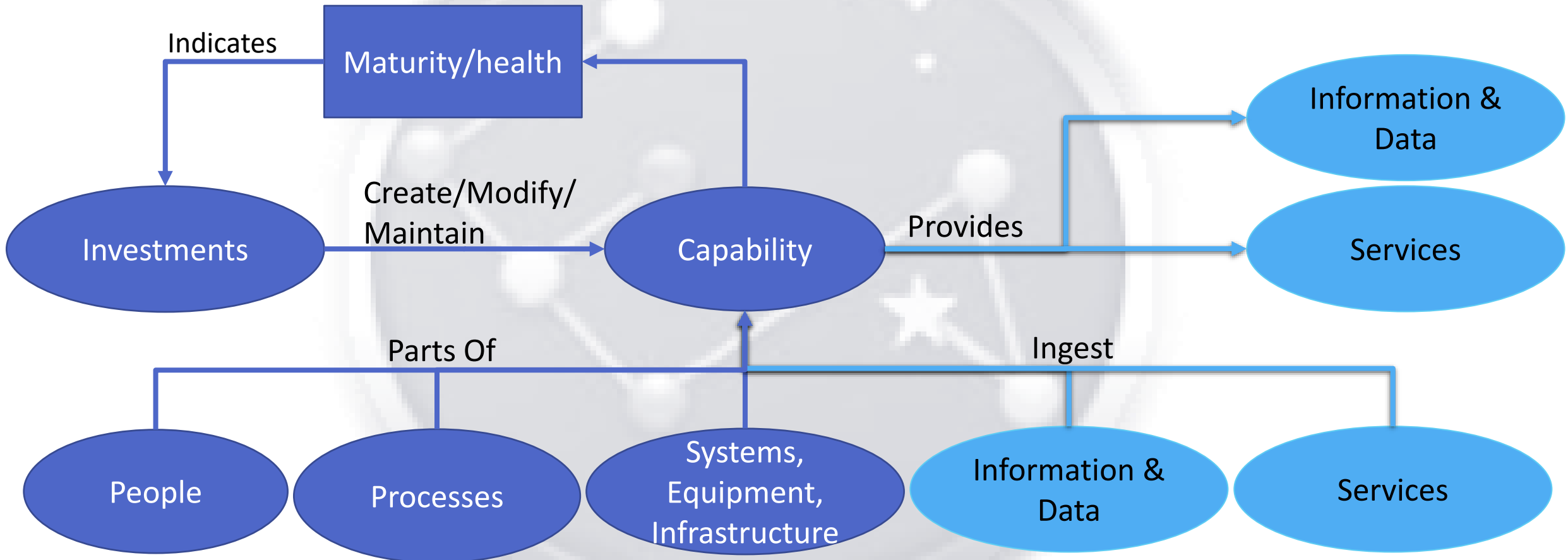
- Initial work performed as a project for OCE by Eric Burke, OSMA NDE and Bryan Bookhart, KSC Chief Enterprise Architect
- Applied the Agency's Enterprise Architecture (EA) standard processes and practices
- Utilized the NASA Agency Enterprise Architecture System (AEAS)
  - NASA EA Framework (NEAF) (Based on the DoD Architecture Framework (DoDAF))
  - Object-Based modeling
  - Repository
  - Defined Meta-Model
  - Import/Export
  - Report Development
- Roles
  - Executive Sponsor
  - Subject Matter Experts
  - Enterprise Architect/Modeler
  - Report/Query Developer

# APPROACH



- Initial proof of concept focused primarily on modeling LARC NDE; Established modeling ground-rules, patterns, and conventions for:
  - Capability decomposition
  - Current State vs. Target State
  - Gap/issue identification
  - Investment identification and road-mapping
- Added additional “threads” to highlight other modeling opportunities
  - Technical Discipline interdependencies and information/service flows
  - Agency-wide aggregations and mash-ups
  - Alignment to Agency strategy
  - Program/Project alignment and dependencies
- Partnered with WSTF/JSC SMEs to jointly capture and model core WSTF/JSC NDE content in entirety
- Expanding out to remaining Centers

# MODEL STRUCTURE & CONTENT



Capabilities describe what an enterprise does, or has the capacity to do, or needs to be able to do. It consists of people, processes, systems/equipment/infrastructure, information/data, services, and other elements.

# CAPABILITY DECOMPOSITION



## Technical Disciplines

Structures

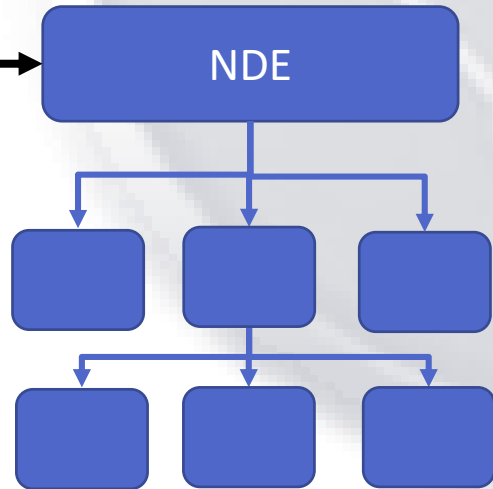
Materials

Non-Destructive  
Evaluation

Decompose

NDE

Center  
Instances



Decompose

Capability

Provides

Services,  
Info/Data

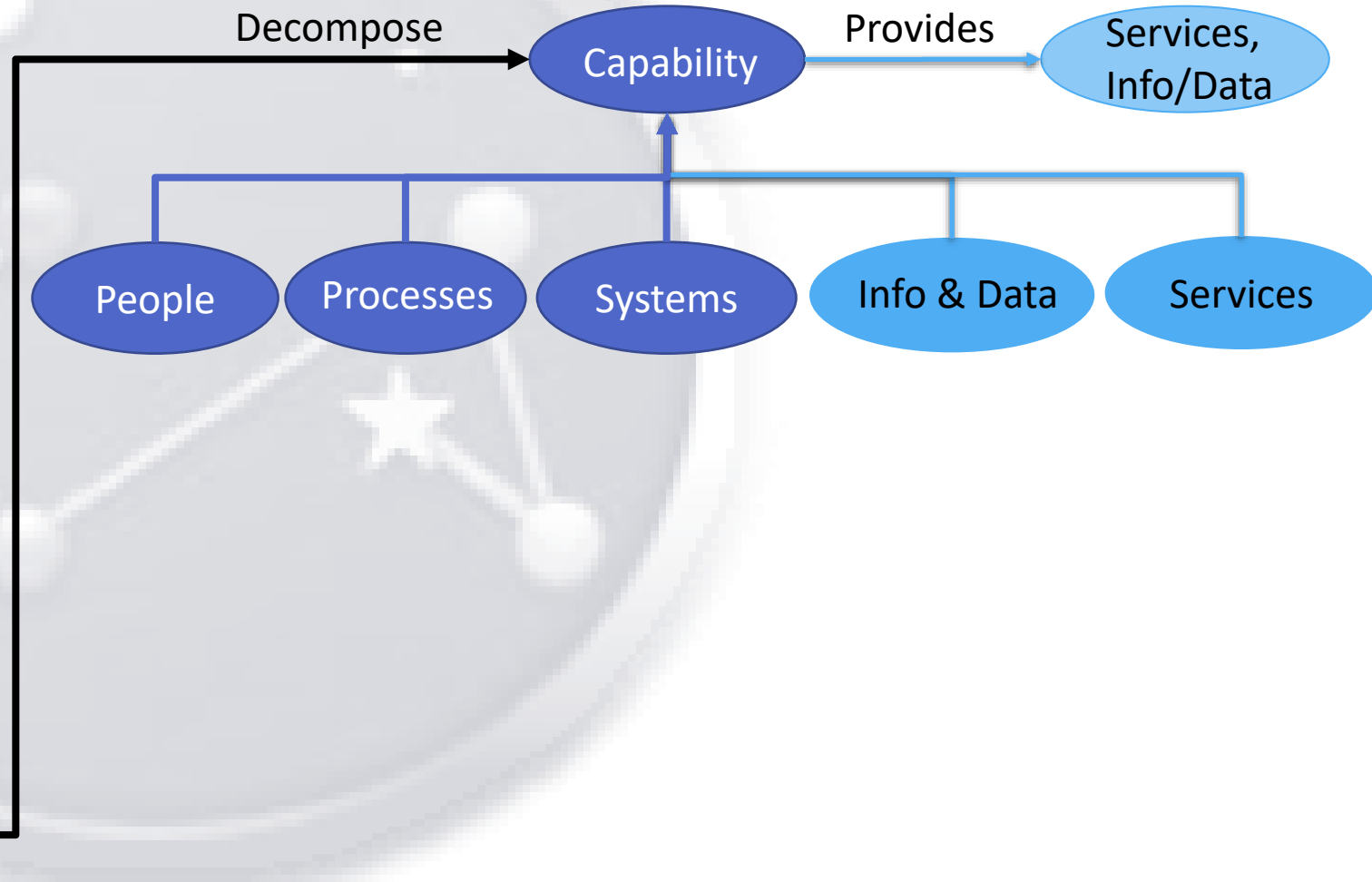
People

Processes

Systems

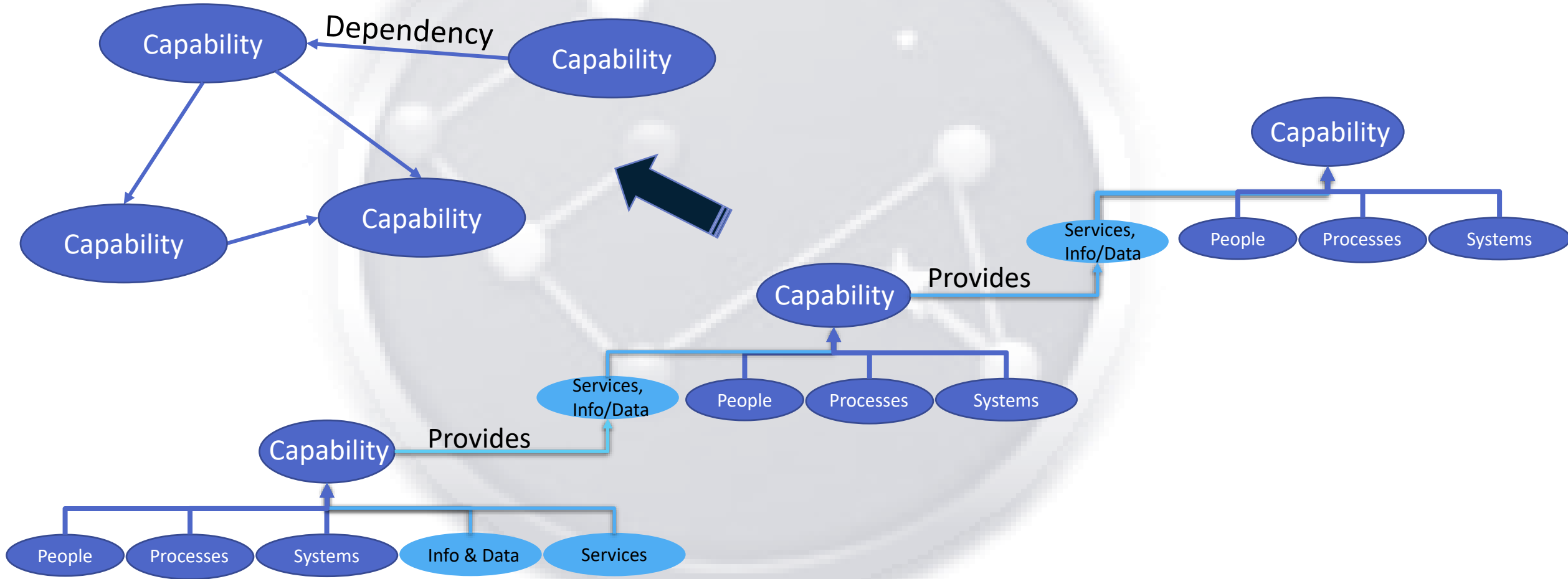
Info & Data

Services

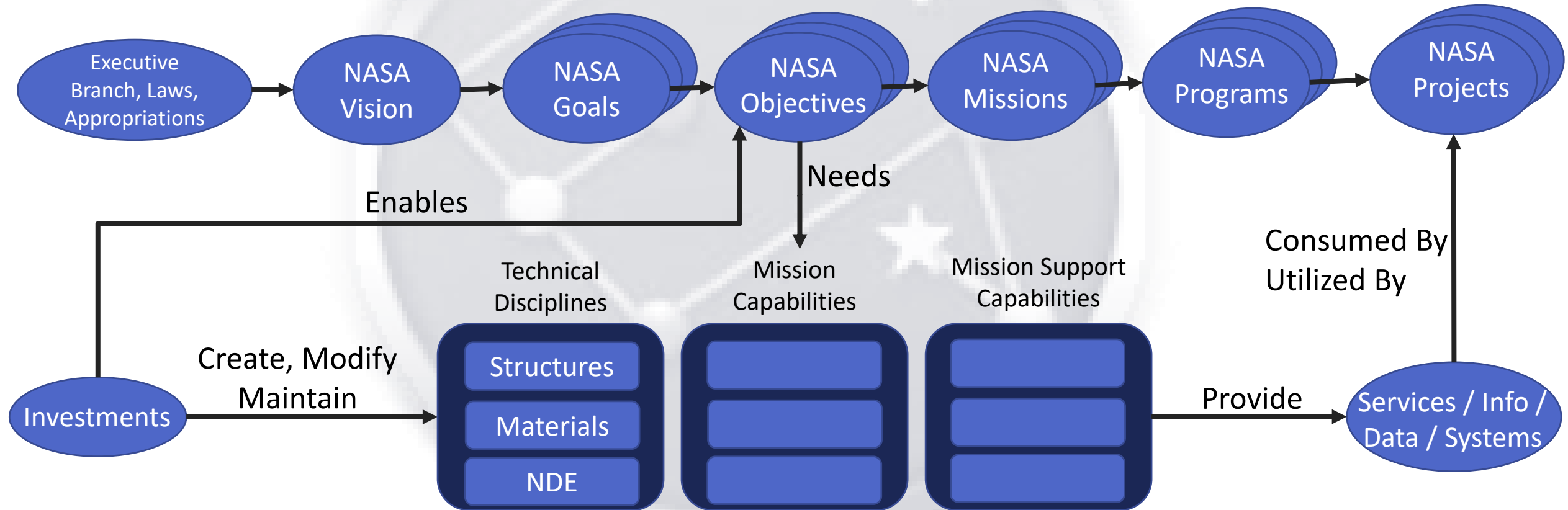




# CAPABILITY INTER-DEPENDENCIES



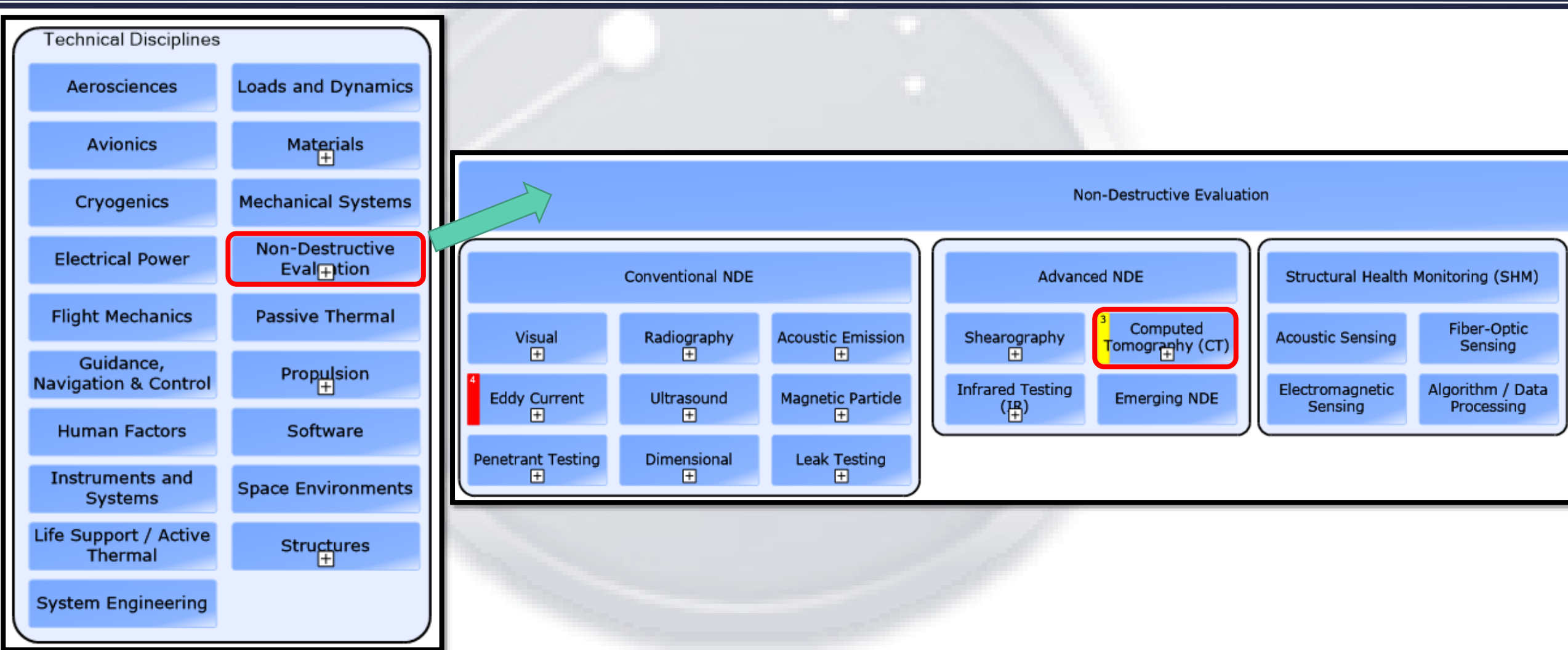
# ALIGNMENT TO AGENCY MISSION AND PROJECTS



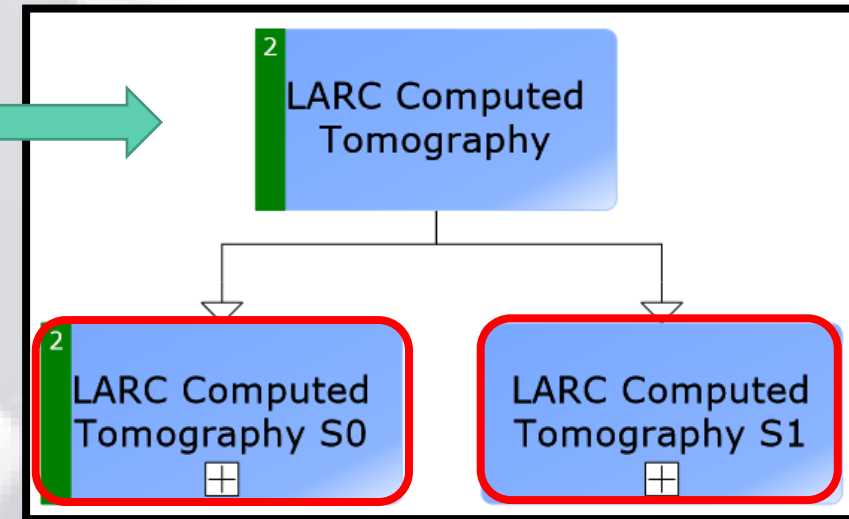
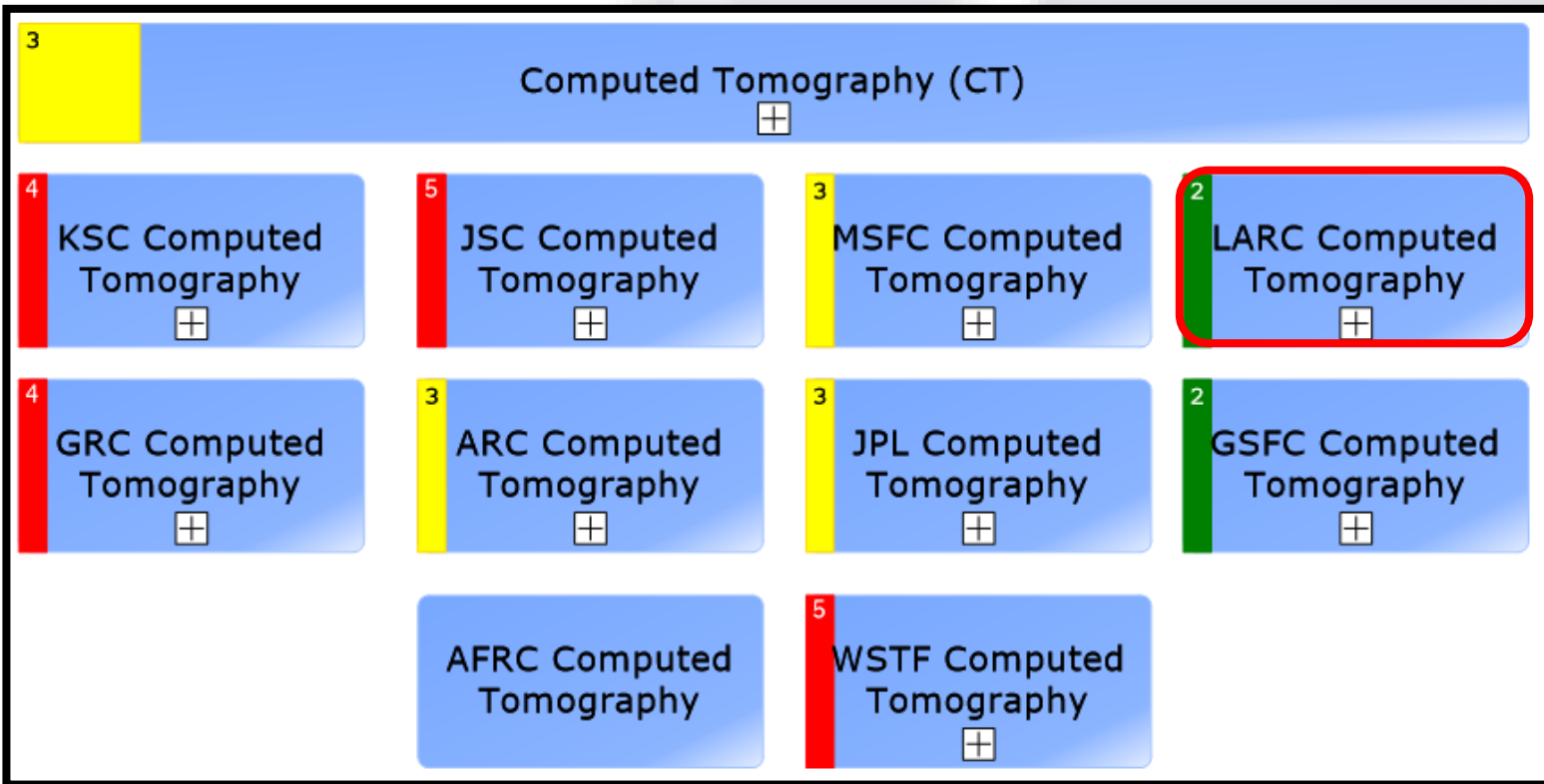


# GLIMPSE INTO THE MODEL

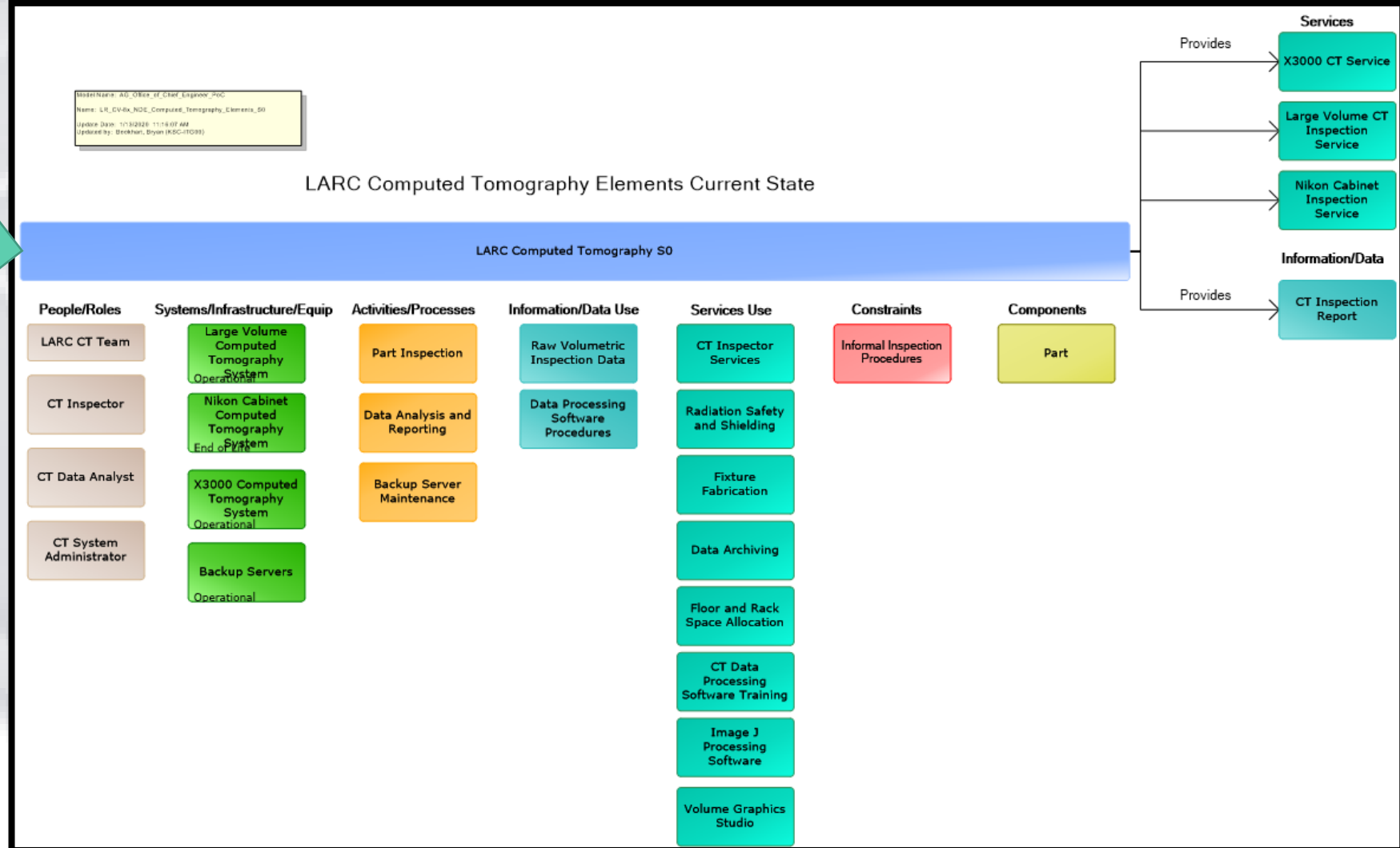
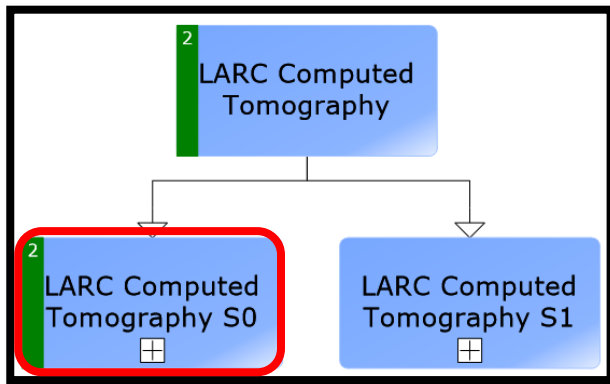
# CAPABILITY DECOMPOSITION



# CAPABILITY DECOMPOSITION



# CAPABILITY MODELING DECOMPOSITION – CURRENT STATE



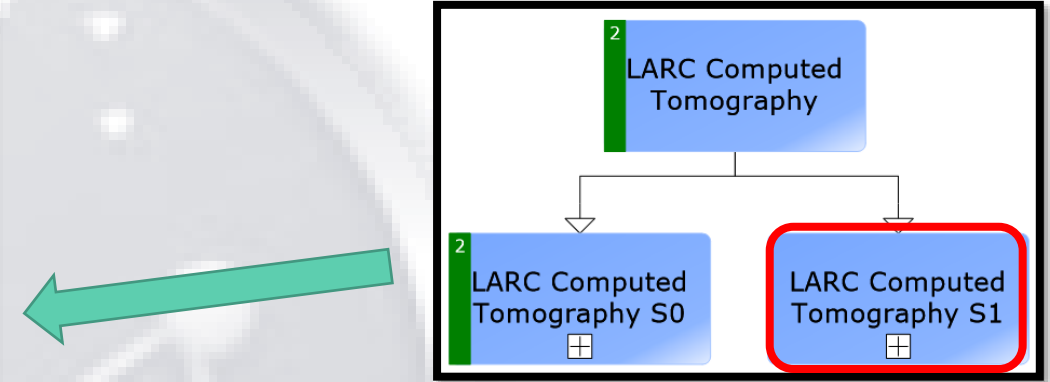
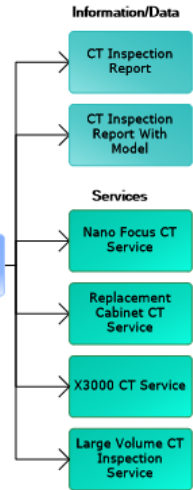
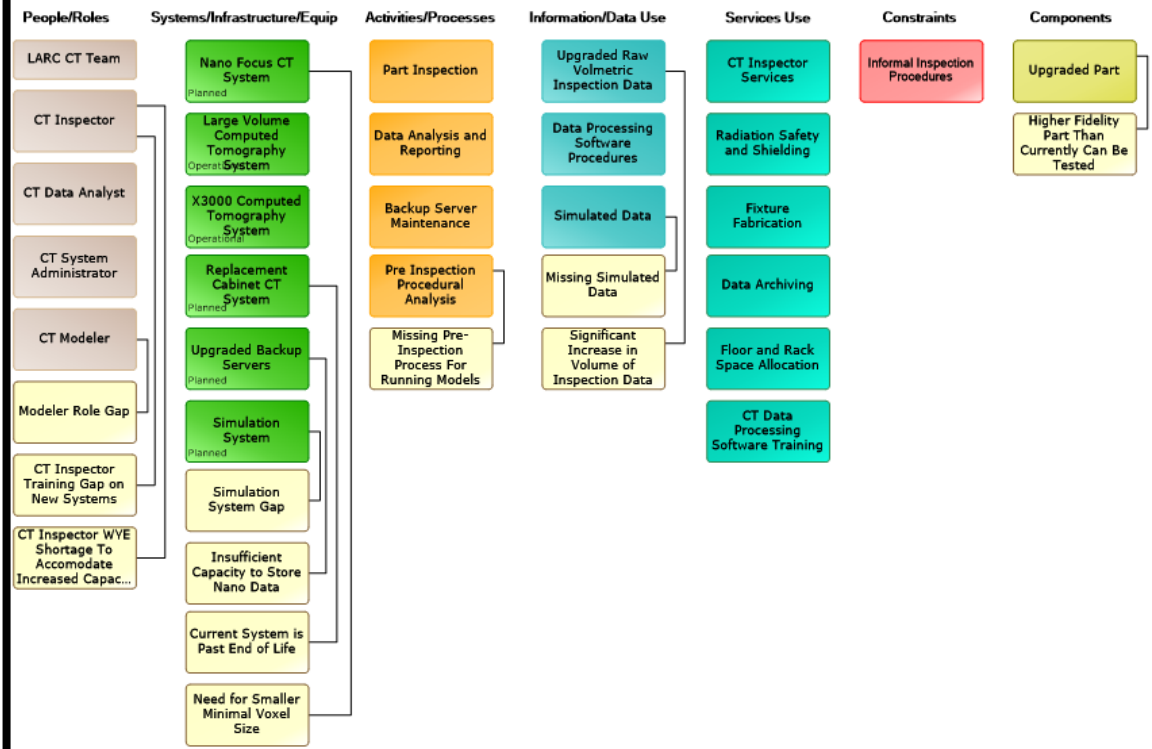
# CAPABILITY MODELING DECOMPOSITION – TARGET STATE



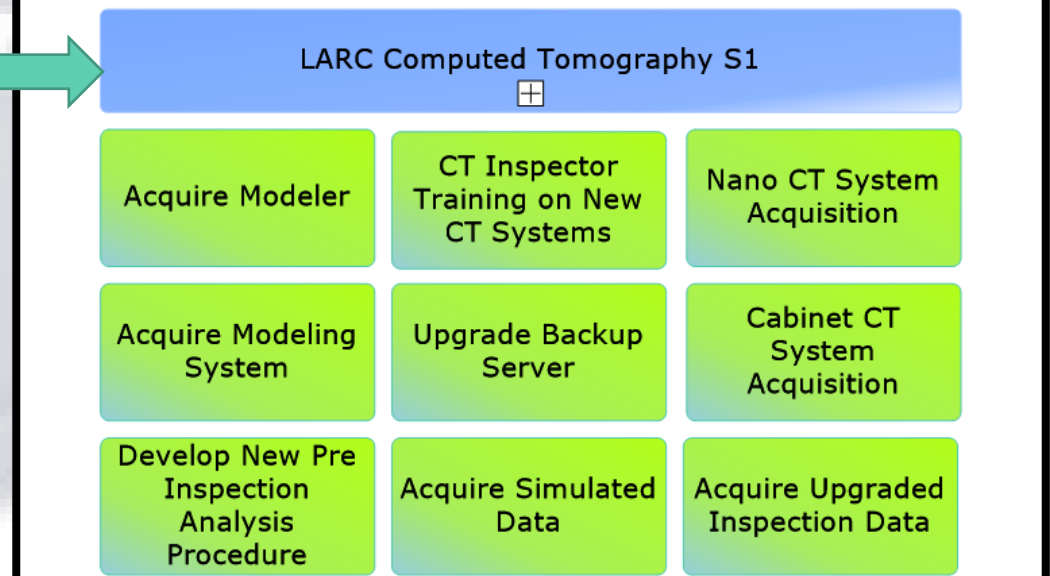
Model Name: AG\_Office\_of\_Chief\_Engineer\_POC  
 Name: LR\_Division\_Computed\_Tomography\_Element\_S1  
 Author: LAR  
 Date: 11/10/2018 12:59:21 PM  
 Location: California, Mission St. Address: 4000-1000-1000-1000  
 Generation Technology: (NOT)

## LARC Computed Tomography Elements State 1

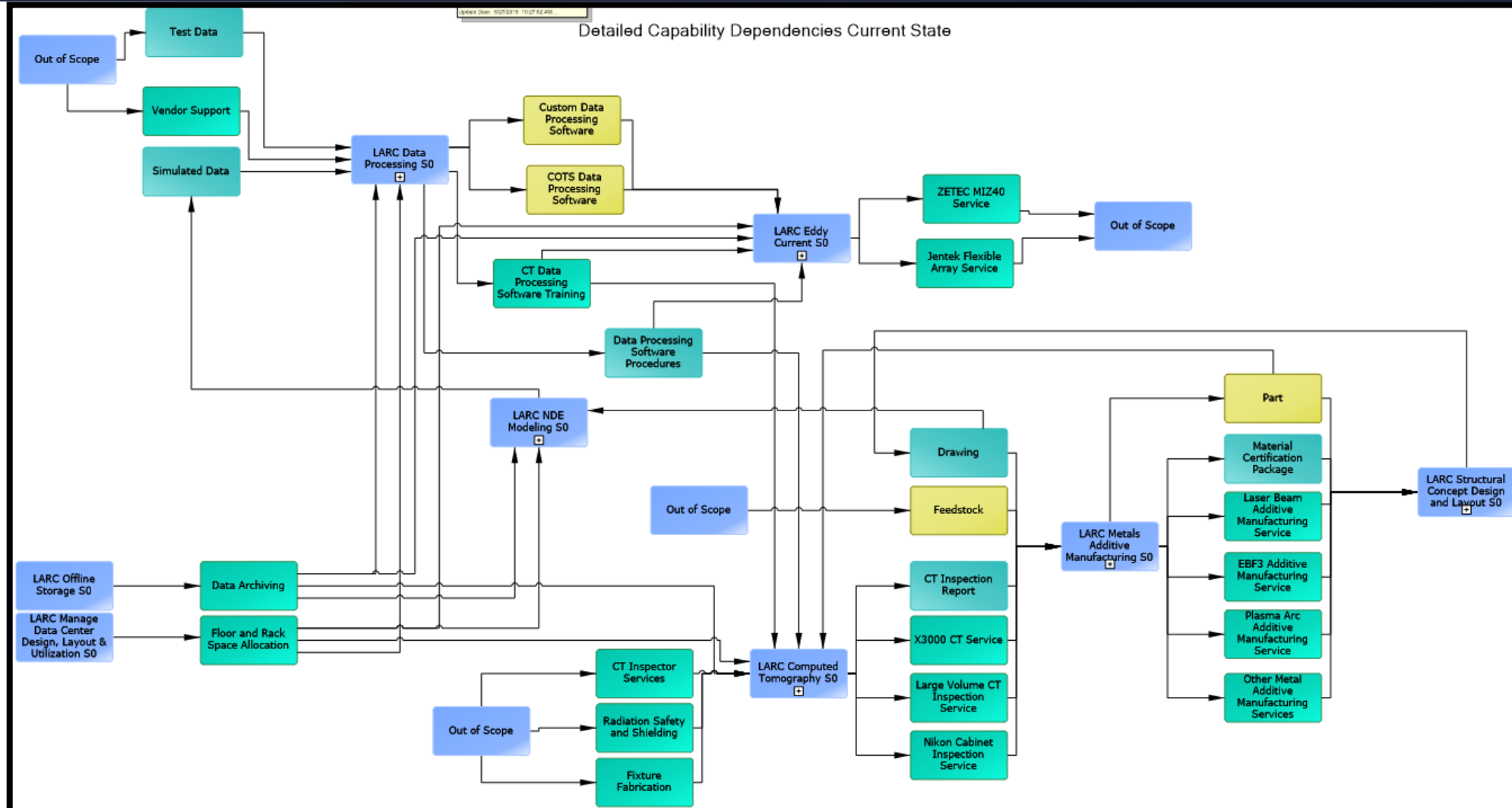
LARC Computed Tomography S1



## Computed Tomography S1 Capability-Transition Activity Map

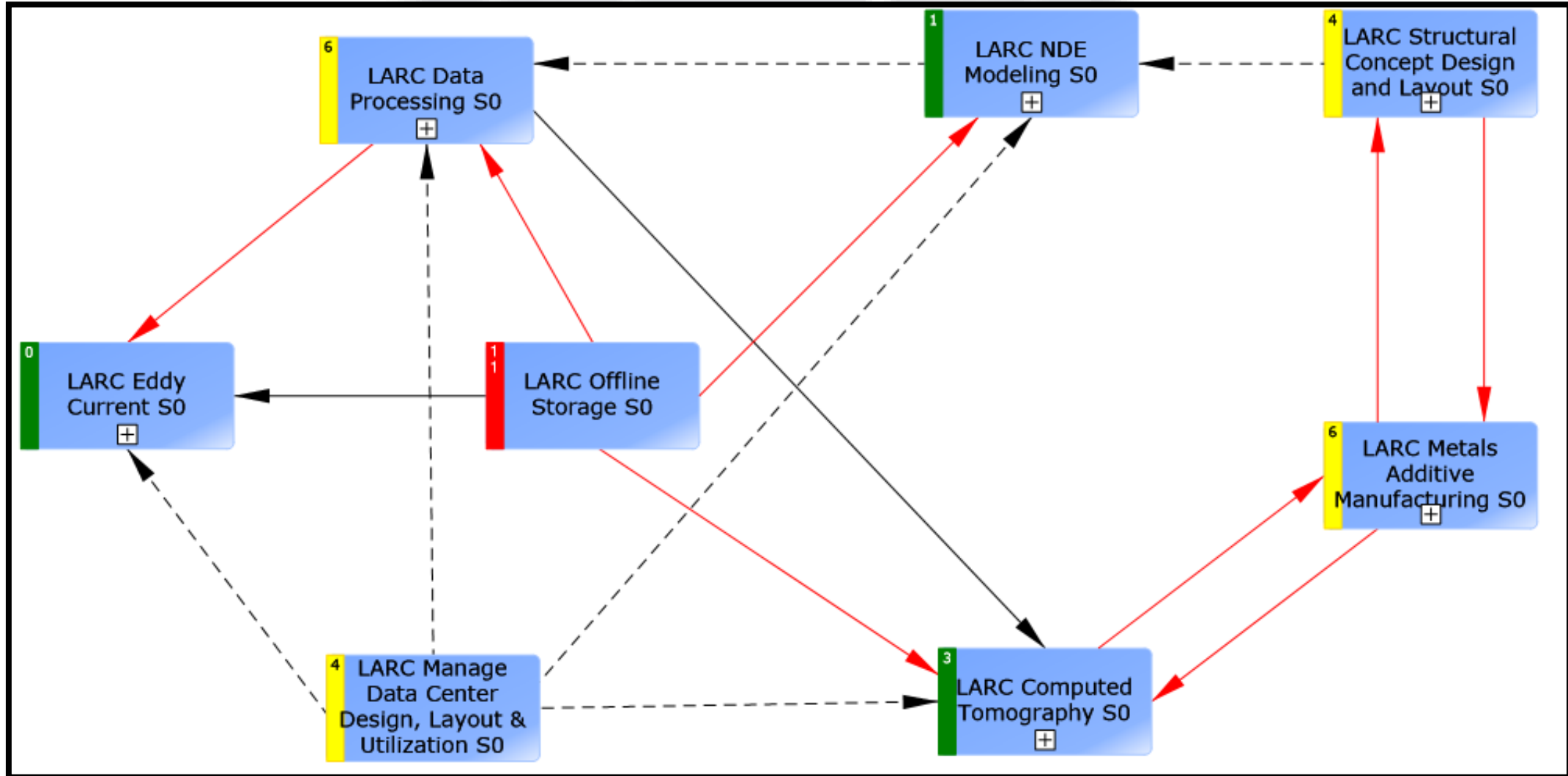


# CAPABILITY INTER-DEPENDENCY MODELING





# CAPABILITY INTER-DEPENDENCY MODELING

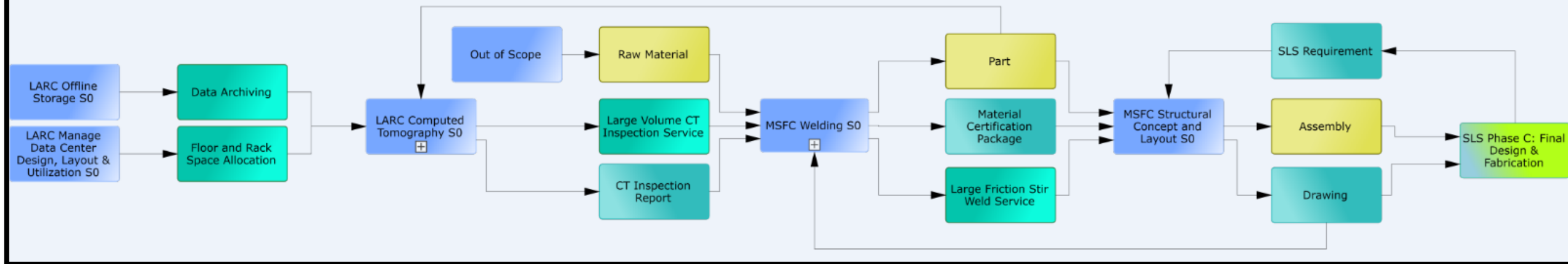


# PROJECT ALIGNMENT



Model Name: AQ\_Office\_of\_Chief\_Engineer\_PoC  
Name: AQ\_CV-4\_Detailed\_Integrated\_SLS\_Dependencies\_S0  
Update date: 10/07/2019 05:03:38  
Updated by: Backham, Bryan (6081100)

Detailed Integrated SLS Dependencies



# CAPABILITY INTERDEPENDENCY MATRIX



## Detailed Integrated SLS Dependencies Matrix

Capability Provide	LARC Computed Tomography S0	LARC Data Processing S0	LARC Eddy Current S0	LARC Metals Additive Manufacturing S0		LARC NDE Modeling S0	LARC Structural Concept Design and Layout S0			MSFC Structural Concept and Layout S0		MSFC Welding S0		
	Components Service	Service	Components Service	Info/Data	Service	Info/Data Service	Components	Info/Data	Service	Components	Info/Data	Service	Info/Data	Service
LARC Computed Tomography S0				CT Inspection Report	Large Volume CT Inspection Service								CT Inspection Report	Large Volume CT Inspection Service
					Nikon Cabinet Inspection Service									
					X3000 CT Service									
LARC Manage Data Center Design, Layout & Utilization S0	Floor and Rack Space Allocation	Floor and Rack Space Allocation	Floor and Rack Space Allocation				Floor and Rack Space Allocation							
LARC Offline Storage S0	Data Archiving	Data Archiving	Data Archiving				Data Archiving							
MSFC Structural Concept and Layout S0				Drawing		Drawing							Drawing	
MSFC Welding S0	Higher Fidelity Part Than Currently Can Be Tested Part		Higher Fidelity Part Than Currently Can Be Tested Part				Higher Fidelity Part Than Currently Can Be Tested Part	Material Certification Package	Higher Fidelity Part Than Currently Can Be Tested Part	Material Certification Package	Large Friction Stir Weld Service			



## NASA Goal 4 Strategy

NASA Vision: To discover and expand knowledge for the benefit of humanity

NASA Mission: Lead an innovative and sustainable program of exploration

NASA Goal 4 Enable: Optimize Capabilities And Operations

Strategic Objective 4.3: Assure Safety and Mission Success

NASA Strategic Objective 4.6: Sustain Infrastructure Capabilities and Operations

Target State: Build components that are structurally optimized (minimum size/weight, maximum strength), efficiently manufacturable (minimal time, cost, waste), and optimized for inspection



# STRATEGIC ALIGNMENT



## Integrated NDE, Materials, and Structures

Target State: Build components that are structurally optimized (minimum size/weight, maximum strength), efficiently manufacturable (minimal time, cost, waste), and optimized for inspection

LARC Computed Tomography S1

LARC NDE Modeling S0

LARC Data Processing S1

LARC Metals Additive Manufacturing S1

LARC Structural Concept Design and Layout S1

## NDE, Materials, and Structures Transition

Target State: Build components that are structurally optimized (minimum size/weight, maximum strength), efficiently manufacturable (minimal time, cost, waste), and optimized for inspection

Acquire EBF3 Replacement System

Acquire Modeling System

Acquire Simulated Data

Acquire Upgraded CT Inspection Report Upgrade

Acquire Upgraded CT Services

Acquire Upgraded Inspection Data

Acquire Upgraded Laser Beam System

Training on New Additive Manufacturing Systems

Cabinet CT System Acquisition

CT Inspector Training on New CT Systems

Acquire Modeler

Nano CT System Acquisition

Develop New Pre Inspection Analysis Procedure

Update AM Machine Build Instructions

Upgrade Backup Server

# AGGREGATED CAPABILITY MASH-UP



## Computed Tomography (CT) Current State

Center	Capability Level	System Utilization	Operating Mode	FTE	WYE	Risk	Cost
AF			Unknown				
AR	0		Unknown			3	3
GR	3		R&D	0.00	0.00	4	3
GS	4		R&D	0.20	0.30	2	3
JP	2		Prod		1.00	3	3
JS	3	24%	Unknown, Prod		0.50	5	3
KS	2		Prod	0.10	0.50	4	4
LR	4	35%	Prod, R&D	1.50	1.25	2	5
MS	3		Prod	0.25	2.00	3	5
WS			Unknown			5	
				<b>Totals</b>	<b>2.05</b>	<b>5.55</b>	
				<b>Averages</b>	<b>0.41</b>	<b>0.79</b>	
	<b>2.63</b>	<b>29.5%</b>					

# SERVICE AGGREGATION (CATALOG)



Select NDE Service	<input type="text" value="NDE Services"/>	Select Service Category	<input type="text" value="CT Services"/>	Select AG Operating Mode	<input type="text" value="Prod,R&amp;D"/>	<input type="button" value="View Report"/>	
MIN: AG Energy	<input type="text" value="0.0000"/>	Set MIN AG Energy	<input type="text" value="18"/> <input type="checkbox"/> NULL	Set MAX AG Energy	<input type="text" value="800"/> <input type="checkbox"/> NULL	MAX: AG Energy	<input type="text" value="2000.0000"/>
MIN: AG Min Defect Size	<input type="text" value="0.0000"/>	Set MIN AG Min Defect Size	<input type="text" value="2"/> <input type="checkbox"/> NULL	Set MAX AG Min Defect Size	<input type="text" value="1100"/> <input type="checkbox"/> NULL	MAX: AG Min Defect Size	<input type="text" value="1200.0000"/>
MIN: AG Working Envelope	<input type="text" value="0.0000"/>	Set MIN AG Working Envelope	<input type="text" value="1"/> <input type="checkbox"/> NULL	Set MAX AG Working Envelope	<input type="text" value="7.0000"/> <input type="checkbox"/> NULL	MAX: AG Working Envelope	<input type="text" value="7.0000"/>

SERVICE NAME	Energy	Minimum Defect Size	Working Envelope	Operating Mode QT	Operating Mode QL	Performer
Custom Computed Tomography Service	150.0000	15.0000	0.7620	0.0000	Prod	JSC
High Energy CT Service	2000.0000	1200.0000	1.8288	0.0000	Prod	MSFC
Hytec Cabinet CT Service	225.0000	13.0000	0.6096	0.0000	Prod	KSC
Hytec Portable CT Service	225.0000	13.0000	0.6096	0.0000	Prod	KSC
Large Volume CT Inspection Service	225.0000	3.0000	2.1300	0.0000	R&D	LaRC
Nikon Cabinet Inspection Service	225.0000	6.0000	0.6000	0.0000	R&D	LaRC
NorthStar Imaging X5000 CT Service	450.0000	6.0000	0.9652	0.0000	Prod	JPL
Northstar X5000CT Service	225.0000	3.0000	1.2190	0.0000	R&D	GSFC
Worx XWT-225Se Service	225.0000	2.0000	1.0000	0.0000	R&D	GRC
X3000 CT Service	225.0000	12.0000	0.8000	0.0000	Prod	LaRC

# SUMMARY



- Demonstrated model capabilities
  - Capability decomposition
  - Current State vs. Target State
  - Gap/issue identification
  - Investment identification and road-mapping
  - Investment alignment to Agency strategy and Programs
  - Risk/cost heat-mapping
  - Interdependencies and information/service flows
  - Reports/queries, data aggregations, rollups
- Demonstrated value of model as a catalog of services
- Demonstrated value as an alternative to managing-by-PowerPoints and spreadsheets
- Demonstrated potential to streamline PPBE submittals, and other data requests
- Can be challenging at first for SMEs to understand the model constructs
- Don't expect significant changes once baselined, so maintenance effort should be minimal



# NEXT STEPS



- Two year trial to sustain and enhance the NDE model
  - Sustain in-house capability to maintain model data (\$\$, staffing, processes, guidance)
  - Support PPBE submittals, and other data requests
  - Support State of the Discipline reviews
  - Committed to updating core content semi-annually
- Explore opportunities for where the model can be enhanced and expanded
  - NDE Target States
  - NDE Roadmaps
  - Other Technical Disciplines

# Questions?

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321.867.8366

**“All organizations are perfectly designed to get the results they get!”**

**-- Author Jones**

**“Management of a system requires knowledge of the interrelationships between all of the components within the system and of everybody that works in it.”**

**-- W. Edwards Deming**