Using Design Structure Matrix (DSM) Techniques in a Major Defense Acquisition Program (MDAP) to Define the Product Development (PD) Work Products

Abstract: A United States Department of Defense Major Defense Acquisition Program (MDAP) in the Product Development (PD) life cycle phases can employ Design Structure Matrix (DSM) techniques to more accurately identify work products by modeling entities and relationships between the System of Interest (SOI) and its life cycle data. By taking a simplified view that the MDAP is a data transformation effort resulting in the establishment of a SOI technical baseline, DSMs and Domain Mapping Matrices (DMMs) can be used to completely expose the initial and intermediate work products necessary to achieve that outcome. This is accomplished by extending the product domain to create a data subdomain to model the program Data Item Contract Data Item List (DI CDRL) entities and relationships. DI CDRLs can be thought of as the data item content requirements specifications (example: data item requirement spec for the product item requirement spec). By using these DSMs and DMMs the MDAP can produce the lists of product item-named data items (PINDI) that are needed to document the system/product design, verification, and administrative reporting activities. The PINDIs then become the work product and can be used in subsequent Process and Organizational DSMs.

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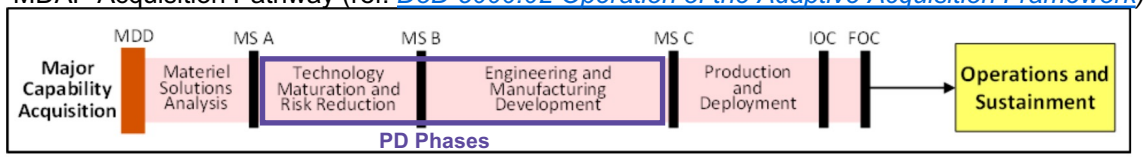
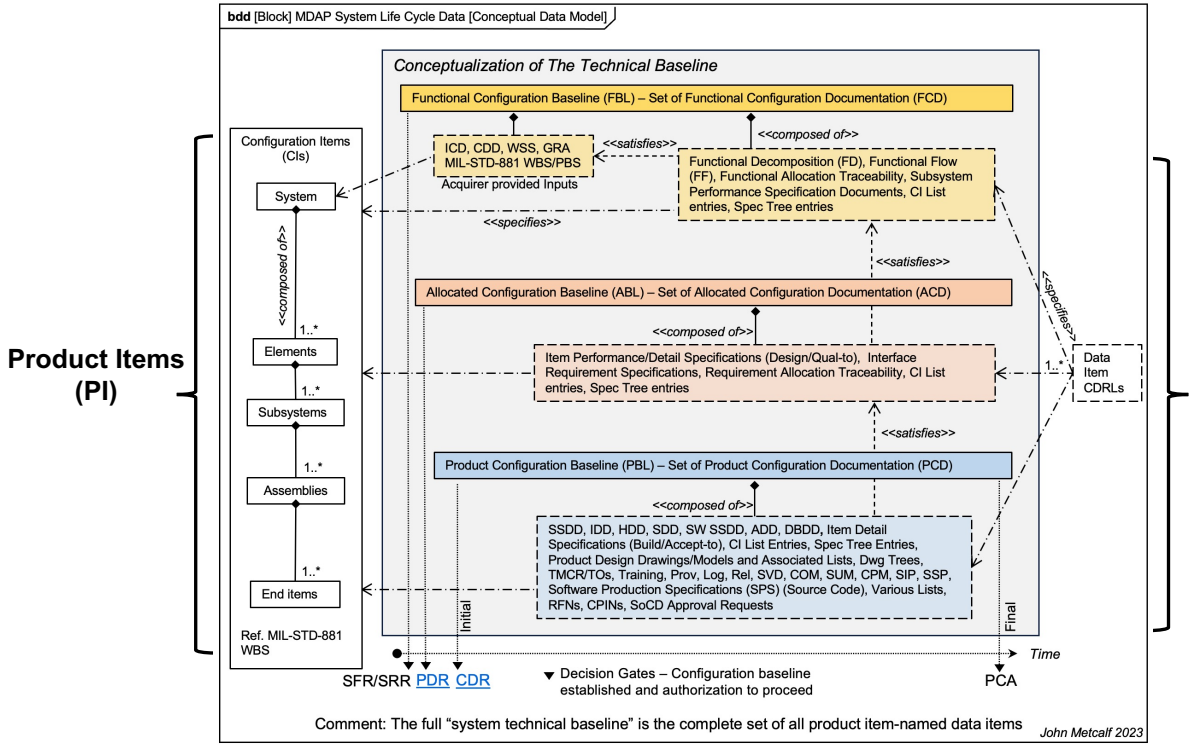
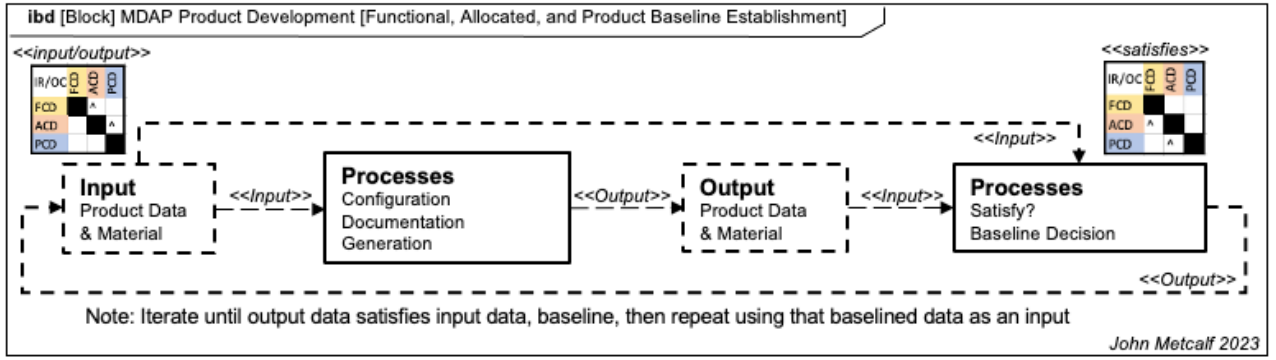
Major Defense Acquisition Program (MDAP) Overview

- Recuring theme in acquisition policy and guidance
  - The system technical baseline is established at the conclusion of the **MDAP Product Development (PD) phases**
  - The technical baseline is a composition of three configuration baselines which are compositions of sets of configuration documentation **Data Items (DI)** containing the engineering and development "recipe" for **Product Items (PI)** within the system hierarchy
    - Configuration baselines: Functional, Allocated, and Product (FBL, ABL, PBL)
    - Configuration documentation: Functional, Allocated, and Product (FCD, ACD, PCD)
- The MDAP Acquisition Pathway constrains the PD process to sequentially generate and baseline this data
- Goal – Show that DSMs can be used to set up a more suitable "work product" for the MDAP PD.

MDAP Acquisition Pathway (ref. *DoD 5000.02 Operation of the Adaptive Acquisition Framework*)



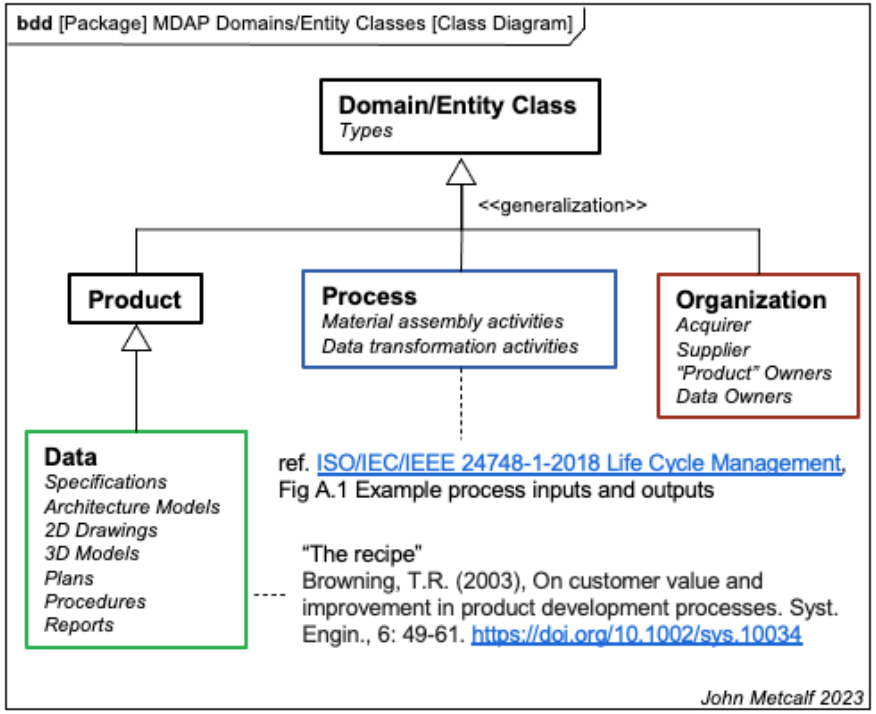


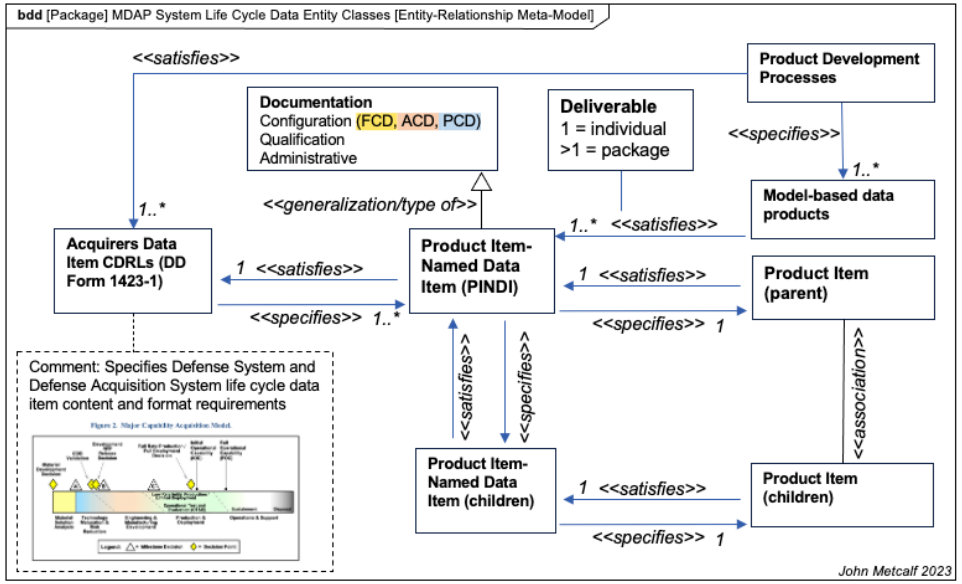


DSM Domains

- Product Domain – Provides a namespace for the data items containing the product items design and the materials required to assemble.
  - Data Domain – New domain proposed for PD projects where the customer places high value on the data. Enables modeling of the products design documentation / System Life Cycle Data. Data is transformed by processes.
- Process Domain – Transforms input materials and data into output materials and data. Major groups are data generation and data baseline decision.
- Organization Domain – Organizational resources can be allocated to perform processes, assigned ownership, and responsibility for producing and maintaining data items and product items.

- Use of DSMs from the Product and Data Domains to identify the MDAP PD work product is the focus of this briefing
  - Product Item (PI) DSM
  - Data Item (DI) DSM
  - Product Item-Data Item (PI-DI) DMM & DSM





PI DSM

- Create a PI DSM that exposes the hierarchical indenture relationship(s) of all known PIs
  - Tip: MIL-STD-881 Work Breakdown Structures (WBS) for Defense Materiel Items provides top level Product Breakdown Structures (PBSs) for typical defense materiel items and contains guidance to extend to lower levels.
  - This product item list (and the WBS) grows as the MDAP PD effort progresses
    - By FBL establishment ~ hundreds
    - By ABL establishment ~ thousands
    - By PBL establishment ~ tens of thousands
- Use that PI DSM to create an indentured product item list that represents all product items and their uses
- This indentured product item list will be one axis of the PI-DI DMM
- Optional: Create PI DSMs representing fundamental relationships such as functional allocation, flow, etc. to enrich the upcoming PI-DI DMM mapping.

Product Item Design Structure Matrix (DSM) of a partial Product Breakdown Structure (PBS) from MIL-STD-881F Appendix D.

The L relationship/dependency is for LOGICAL COMPOSITION (COMPOSED OF). The product item in the column of rows is logcally composed of the product items in the row of columns.

The P relationship/dependency is for PHYSICAL COMPOSITION (COMPOSED OF). The product item in the column of rows is physically composed of the product items in the row of columns.

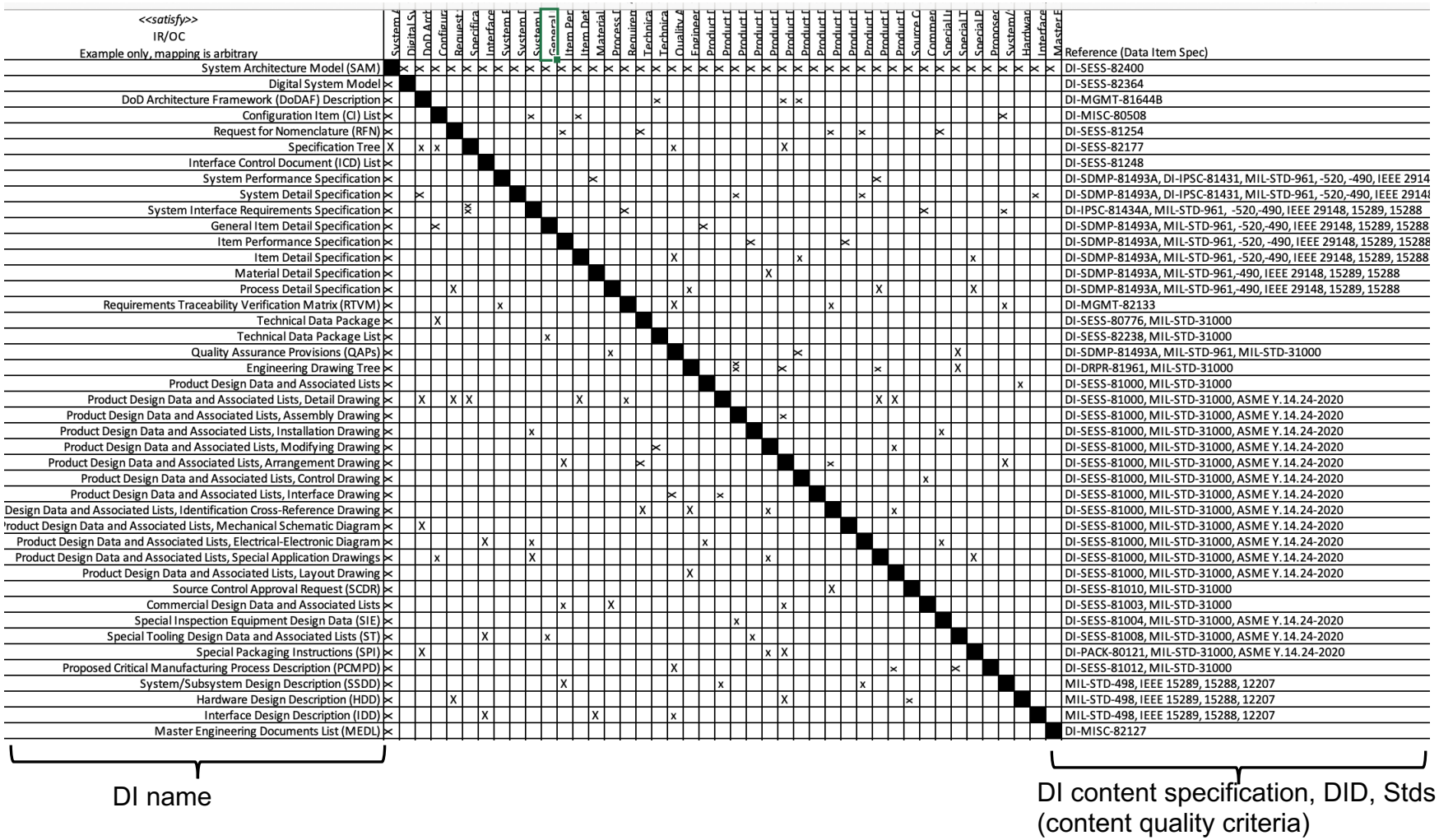
Example only, mapping is arbitrary	1.0 Strategic Missile Systems	1.4 Command and Launch	1.4.2 Launch and Guidance Control/Fire Co	1.4.3 Communications	1.4.4 Launch and Encasement Equipment	1.4.5 Auxiliary Equipment	1.4.6 Command and Launch (Ground) Softw	1.4.7 Infrastructure	1.4.8 Other Command and Launch 1…n (Sp	1.8 Training	1.8.1 Equipment	1.8.2 Services	1.8.3 Facilities	1.8.4 Training Software Release 1…n (Spec	1.10 Peculiar Support Equipment	1.10.1 Test and Measurement Equipment	1.10.2 Support and Handling Equipment	1.11 Common Support Equipment	1.11.1 Test and Measurement Equipment	1.11.2 Support and Handling Equipment
1.0 Strategic Missile Systems		L								L					L					
1.4 Command and Launch			L	L	L	L	L	L	L											
1.4.2 Launch and Guidance Control/Fire Control																				
1.4.3 Communications																				
1.4.4 Launch and Encasement Equipment																				
1.4.5 Auxiliary Equipment																				
1.4.6 Command and Launch (Ground) Software Release 1…n (Specify)																				
1.4.7 Infrastructure			P	P	P	P	P													
1.4.8 Other Command and Launch 1…n (Specify)																				
1.8 Training											L	L	L	L						
1.8.1 Equipment																				
1.8.2 Services																				
1.8.3 Facilities											P	P		P						
1.8.4 Training Software Release 1…n (Specify)																				
1.10 Peculiar Support Equipment																L	L			
1.10.1 Test and Measurement Equipment																				
1.10.2 Support and Handling Equipment																				
1.11 Common Support Equipment																			L	L
1.11.1 Test and Measurement Equipment																				
1.11.2 Support and Handling Equipment																				

	Example of a multi-indentured product item list
Lvl 2	1.4 Command and Launch
Lvl 3	1.4.2 Launch and Guidance Control/Fire Control
Lvl 4	1.4.3 Communications
Lvl 4	1.4.4 Launch and Encasement Equipment
Lvl 4	1.4.5 Auxiliary Equipment
Lvl 4	1.4.6 Command and Launch (Ground) Software Release 1…n (Specify)
Lvl 4	1.4.7 Infrastructure
Lvl 5	1.4.2 Launch and Guidance Control/Fire Control
Lvl 5	1.4.3 Communications
Lvl 5	1.4.4 Launch and Encasement Equipment
Lvl 5	1.4.5 Auxiliary Equipment
Lvl 5	1.4.6 Command and Launch (Ground) Software Release 1…n (Specify)

DI DSM

- Create a DI DSM that exposes the conceptual input/output relationship between generic DIs
  - Example: Requirement Spec DIs feed Drawing DIs
  - Tip: Relationships between DIs can be inferred by reading the DI CDRLs
  - There could be thousands of DI CDRLs
- The DI list will become an axis on the upcoming PI-DI DMM
  - Optional: Sequence the DI list to minimize feedback or group like-DIs to facilitate the upcoming PI-DI Mapping

Note: Data Item Contract Data Requirements Lists (DI CDRLs dd form 1423-1) are the data item content specifications – aka data item specs. They contain references to Statement of Work (SOW) or Performance Work Statement (PWS) paragraph numbers, industry and military standards/handbooks, and data item descriptions (DIDs). The acquirer's processes are designed to processes document or model-based data in terms of the DI CDRLs.



PI-DI DMM and DSM

- *New suggested best practice* - Create the PI-DI DMM and place marks where data items will document the product items "recipe"
  - Refer to any fundamental relationship PI DSMs
- These marks (Y's) expose the work products that need to be processed by the organization
  - Concatenate product item and data item to create a list of Product Item-Named Data Items (PINDIs), place into new PI-DI DSMs, and back-fill the I/O relationships from the DI DSM
  - Potentially millions of PINDIs
- In a Document-Centric Systems Engineering approach the solution would be generation and management of individual documents
- In a Model-Based Systems Engineering (MBSE) approach we should anticipate an innovative solution with several integrated relational databases with referential integrity that can provide the equivalent document view on-demand

Example only

		(Hypothetical) Data Items Planned for the...																
		Functional Baseline (FBL)		Allocated Baseline (ABL)				Product Baseline (PBL)										
Level	DI CDRL-> Indentured Product Item List	Sys/Item Perf Spec (Design & Qual Reqs)	Func Alloc	Sys/Item Perf Spec (Design & Qual Reqs)	QT Plan	QT Proc	QT Report	Item Detail Spec (Build & Accept Reqs)	AT Plan	AT Proc	AT Report	SSDD	IDD	Assy Dwg	Intrface Dwg	Detail Dwg	SoCD	Instl Dwg
1	1.0 Strategic Missile	Y	Y	Y	na	na	na	na	na	na	na	X	na	na	na	na	na	na
2	1.4 C&L	Y	Y	na	Y	na	na	na	na	na	na	Y	Y	na	na	na	na	na
3	1.4.3 Communications	Y	Y	na	Y	Y	Y	na	na	na	na	Y	na	na	na	na	na	na
4	1.4.3.1 Comms Subsys	na	Y	Y	Y	Y	Y	na	na	na	na	Y	na	na	na	na	na	na
5	1.4.3.1.1 Board_F	na	Y	Y	Y	Y	Y	na	na	na	na	Y	na	Y	na	na	na	na
3	1.4.2 Launch and Guidan	Y	Y	na	Y	Y	Y	na	na	na	na	Y	na	na	na	na	na	na
4	1.4.2.1 LGC/FC Subsys	na	Y	Y	Y	Y	Y	na	na	na	na	Y	na	na	na	na	na	na
5	1.4.2.1.1 Card_C	na	Y	Y	Y	Y	Y	na	na	na	na	Y	na	Y	Y	na	na	na
5	1.4.2.1.2 Software_A	na	Y	Y	Y	Y	Y	na	na	na	na	Y	na	Y	Y	na	na	na
3	1.4.7.1 Infrastructure A	na	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	na	na	na
4	1.4.7.1.1 Antenna-HF	na	na	na	^	^	^	^	^	^	^	^	na	Y	Y	na	Y	Y
4	1.4.7.1.2 Rack_A	na	na	na	^	^	^	^	^	^	^	^	na	Y	na	Y	na	Y
5	1.4.7.1.2.1 Card_D	na	na	na	^	^	^	^	^	^	^	^	na	Y	na	na	X	na
5	1.4.2.1.1 Card_C	na	^	Y	^	^	^	Y	^	Y	^	^	na	Y	na	Y	na	na
5	1.4.3.1.1 Board_F	na	^	Y	^	^	^	Y	^	Y	^	^	na	Y	na	Y	na	na
6	1.4.2.1.2 Software_A	na	^	Y	^	^	^	Y	^	Y	^	^	na	na	na	na	na	na
3	1.4.7.2 Infrastructure B	na	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	na	na	na
4	1.4.7.2.1 Antenna-LF	na	na	na	^	^	^	^	^	^	^	^	na	Y	Y	na	Y	Y
4	1.4.7.2.2 Rack_B	na	na	na	^	^	^	^	^	^	^	^	na	Y	na	Y	na	Y
5	1.4.7.2.2.1 Card_D	na	na	na	^	^	^	^	^	^	^	^	na	Y	na	na	X	na
5	1.4.2.1.1 Card_C	na	^	Y	^	^	^	Y	^	Y	^	^	na	Y	na	Y	na	na
5	1.4.3.1.1 Board_F	na	^	Y	^	^	^	Y	^	Y	^	^	na	Y	na	Y	na	na
6	1.4.2.1.2 Software_A	na	^	Y	^	^	^	Y	^	Y	^	^	na	na	na	na	na	na
	DI CD Type ->	*FCD*	*FCD*	*ACD*				*PCD*				*PCD*	*PCD*	*PCD*	*PCD*	*PCD*	*PCD*	*PCD*
	Legend: na- no data item associated with product item. Y- data item assocaited with product item. ^-Navigate upwards to the next higher data item. FCD/ACD/PCD: Functional/Allocated/Product Configuration Documenation - A Data Item appropriate for the FBL, ABL, or PBL																	

<<I/O dependency>> IR/OC Example only, mapping is arbitrary	1.4.2.1.1 C	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1	1.4.2.1.1
1.4.2.1.1 Card_C Item Detail Specification		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.4.2.1.1 Card_C Requirements Traceabiility Verification Matrix (RTVM)	x																
1.4.2.1.1 Card_C Technical Data Package	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.4.2.1.1 Card_C Technical Data Package List																	
1.4.2.1.1 Card_C Engineering Drawing Tree				x		x	x	x	x	x	x	x	x				
1.4.2.1.1 Card_C Product Design Data and Associated Lists				x													
1.4.2.1.1 Card_C Product Design Data and Associated Lists Assembly Drawing				x													
1.4.2.1.1 Card_C Product Design Data and Associated Lists Installation Drawing				x													
1.4.2.1.1 Card_C Product Design Data and Associated Lists Modifying Drawing				x													
1.4.2.1.1 Card_C Product Design Data and Associated Lists Interface Drawing				x													
1.4.2.1.1 Card_C Product Design Data and Associated Lists Identification Cross-Reference Drawing				x													
1.4.2.1.1 Card_C Special Inspection Equipment Design Data (SIE)				x													
1.4.2.1.1 Card_C Special Tooling Design Data and Associated Lists (ST)				x													
1.4.2.1.1 Card_C Special Packaging Instructions (SPI)				x													
1.4.2.1.1 Card_C Proposed Critical Manufacturing Process Description (PCMPD)				x													
1.4.2.1.1 Card_C System/Subsystem Design Description (SSDD)				x													
1.4.2.1.1 Card_C Interface Design Description (IDD)				x													
1.4.2.1.1 Card_C Master Engineering Documents List (MEDL)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

Conclusion

- A MDAP in the PD life cycle phases can be thought of as a data transformation effort that outputs a systems configuration documentation belonging to the System of Interest (SOI) technical baseline
- That output can be modeled in product and data domains to more accurately describe the work product (PINDIs) for the organization to process

✓ DSMs are well suited to expose those work product and their dependencies

References

Policy AFPD 20-1/63-1 Integrated Life Cycle Management, AFI 63-101/20-101 Integrated Life Cycle Management, AFMCI 63-1201 Integrated Life Cycle Systems Engineering and Technical Management, DoDI 5000.85_DAFI 63-151 Major Capability Acquisition, 5000.88 Engineering of Defense Systems

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