Data With A Purpose: Technical Data Initiative

Presented to ICEAA 2021 Professional Development & Training Workshop

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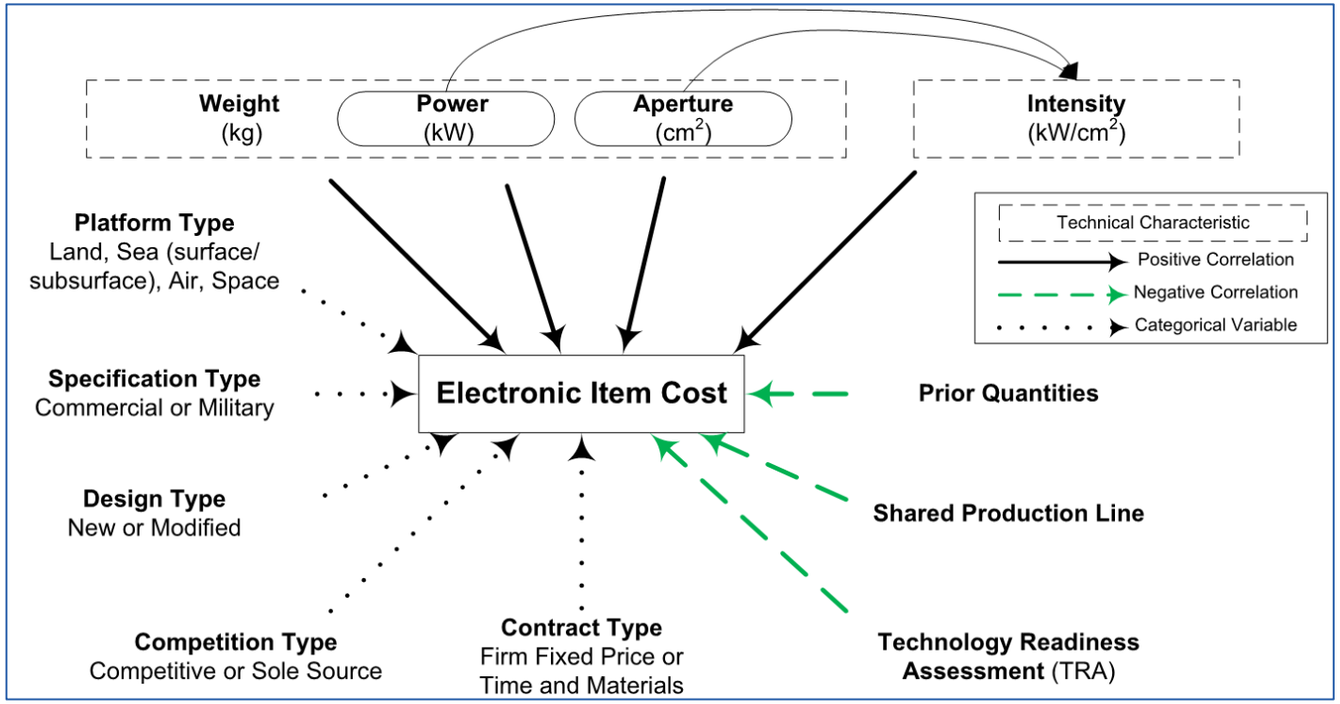
Overview

- Abstract
  - Technical characteristics are known to influence cost and as such are integral to cost estimating methods. Cost-driver data is an enduring cost community need yet is often an afterthought to cost data collection. This presentation is an overview of CADE's Technical Data Report (TDR) to systemically capture this must-needed information as part of the CSDR process. Also a sample Power BI case will illustrate the powerful analysis empowered by integrating TDR data with FlexFile cost data.

- Outline
  - The Enduring Need for Technical Data
  - Controlled Vocabulary
  - Sample Case
  - Summary and Conclusion

Performance and Technical Data as Cost Drivers



Source: NCCA, Joint Agency Cost Estimating Relationship (CER) Development Handbook, 2018

Performance data describes what the systems can/must do. Technical data describes physical and functional characteristics of the system. Speed, range, depth, survivability, and noise reduction are examples of performance characteristic data. Size, weight, and power (SWaP) are examples of technical characteristic data. Source lines of code (SLOC), function points, and story points are examples of software technical data.

Source: DoD Cost Estimating Guide, December 2020

Cost Drivers are Inseparable From Cost

Simple Rendering of a Cost Metric

$$\text{Metric} = \frac{\text{Cost}}{\text{Non-cost}}$$

We know the best sources of cost data but what are the technical data sources?

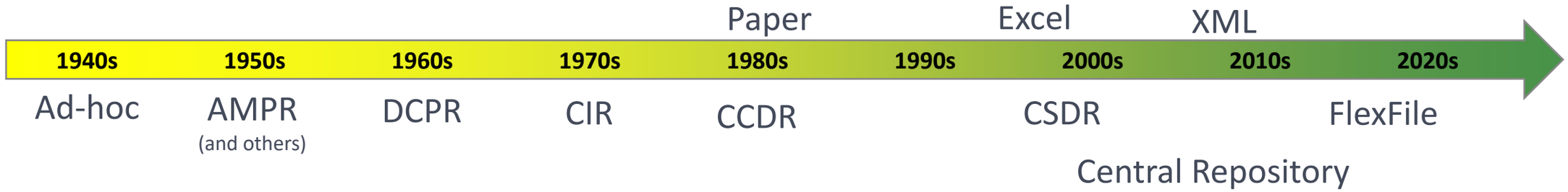
How Did We Collect Technical Data Without the Technical Data Report

Please Sir …
may I have some
technical data

Technical data collection has been ad-hoc, inefficient, and random within DoD

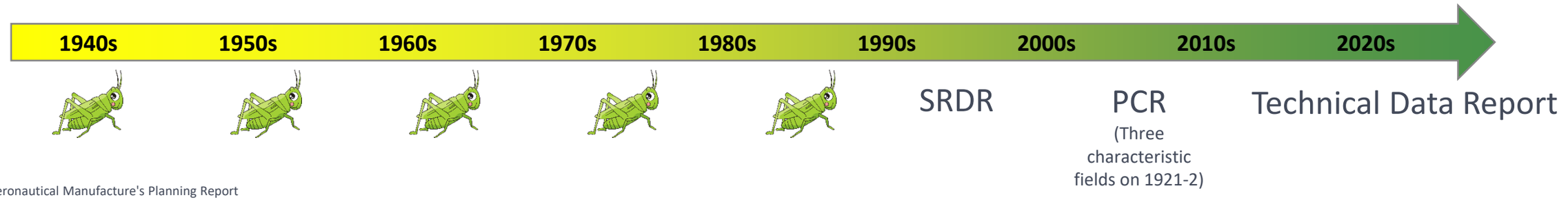
Data Collection Instrument Progress

Numerator (Cost)



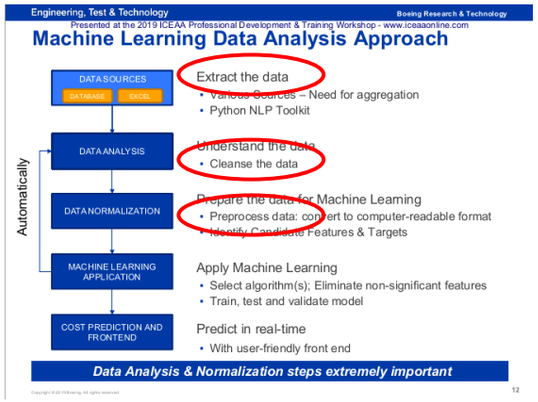
$$\frac{\text{Cost}}{\text{Non-cost}}$$

Denominator (Technical)

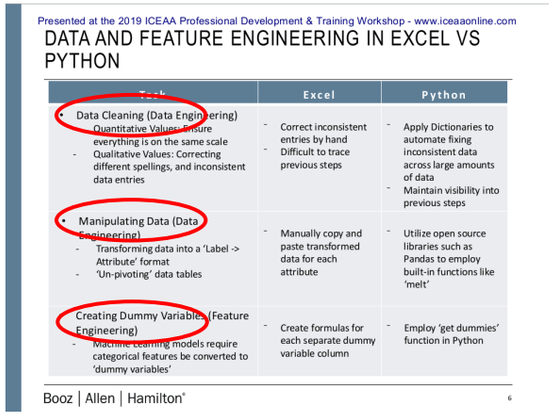


AMPR – Aeronautical Manufacture's Planning Report
DCPR – Defense Contractors' Planning Report
CIR – Cost Information Report
CCDR – Contractor Cost Data Report
CSDR – Cost and Software Data Reporting
SRDR – Software Resources Data Report
PCR – Progress Curve Report

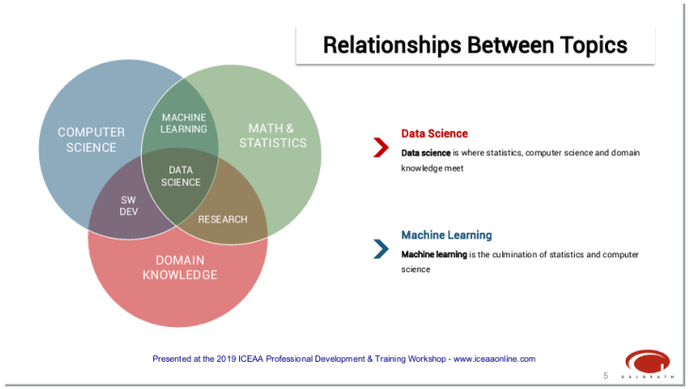
Data Preparation in Machine Learning



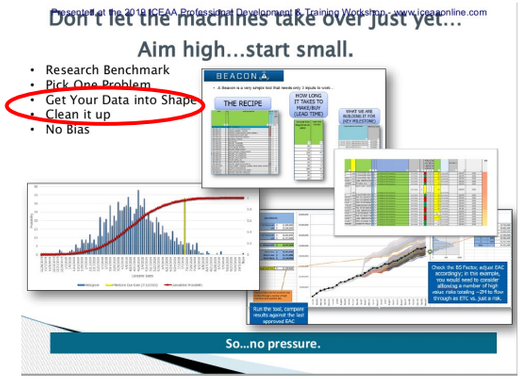
Mourikas, Machine Learning and Language Processing, Proceedings of the 2019 ICEAA Workshop



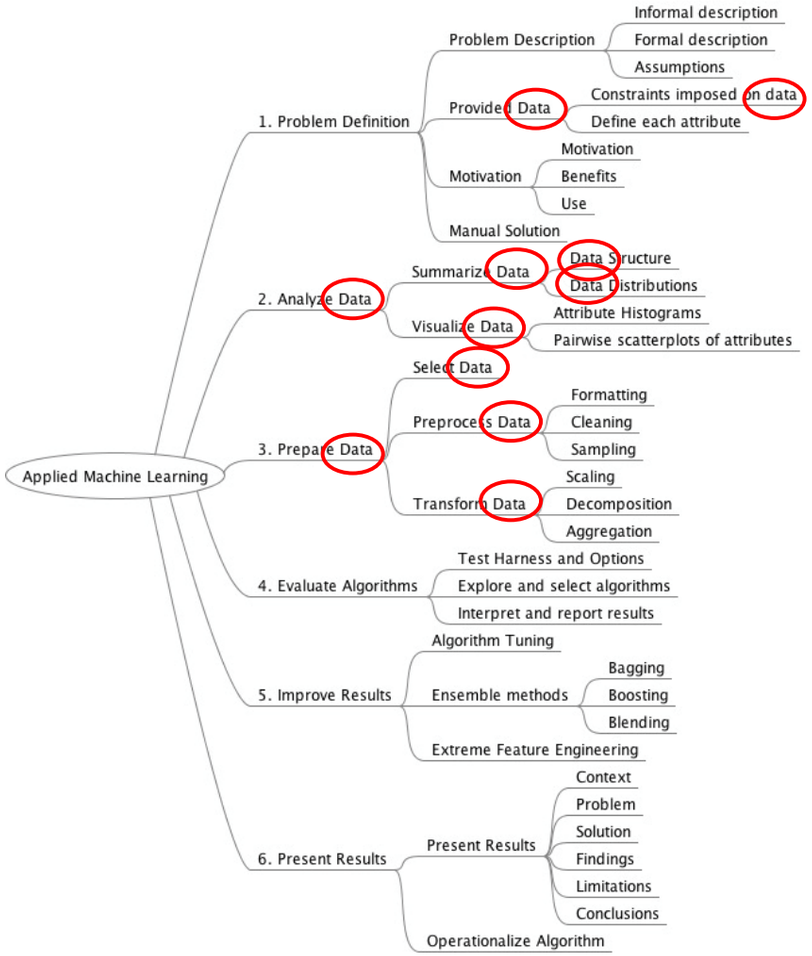
Johnson and Shafer, "Don't Be Scared, Machine Learning is Easy!", Proceedings of the 2019 ICEAA Workshop



Roye and Smart, "Beyond Regression," Proceedings of the 2019 ICEAA Conference



Eskue, "The Robot Forecaster: Our A.I. Journey – Year 2," Proceedings of the 2019 ICEAA Workshop



https://machinelearningmastery.com/4-steps-to-get-started-in-machine-learning/

Data Science, Data Engineering, Feature Engineering are ever-present in Machine Learning

A Semantic Path to Machine Learning

Increasing levels of semantic precision

(and understanding by machines)

Controlled Vocabulary	Taxonomy	Ontology
• aka glossary of terms • Natural language definitions • May include synonyms • Cannot include homonyms without further qualification, since each term should be unique • May include citations to a reference source • May include some "see also" cross references • Term definitions should not be circular	• Controlled Vocabulary plus: • Hierarchical tree(s) of broader / narrower terms • Similar to mathematical sub-setting or OO generalization / specialization • Some formal structure, but still usually represented in natural language • Can range from informal to more formal taxonomy • SKOS (Simple Knowledge Organization System, W3C standard) is an example of a more formal taxonomy specified in RDF	• Taxonomy, plus: • Terms → Concepts identified by some unique identifier as well as all relationships between them • Conforming to (some) formal logic • Machine interpretable semantics • In addition label to name each concept for human understanding • Multiple labels (aliases) supported – e.g. to support different natural languages • Homonym labels allowed, but not recommended because confusing for humans

ST4SE Update | INCOSE IW | 2019-01-27, Torrance, CA, USA 6

Expression of Domain Knowledge is a matter of semantic precision

Data Organization Considerations

Common parameters for each hardware WBS element

Size, Weight, and Power (SWAP)
- *Volume (Cubic Feet)*
- *Weight (Pounds)*
- *Max Power Consumed (Watts)*

Heritage
- *Percent New Design*
- *Predecessor System*

Unique parameters for each hardware WBS element

Varies by Item Type. Examples:
- Antenna: *Aperture, Effective Radiated Power, etc.*
- Engine: *Inlet Temperature, TSFC, etc.*
- Wing: *Area, Wingspan, Number of Movable Surfaces, etc.*

Unique parameters by end item

Varies by Commodity. Examples:
- Spacecraft: *Orbit Regime, Mission Duration, Pointing Accuracy, etc.*
- Aircraft: *Combat Radius, Max Speed, Max Useful Load, etc.*
- Missile: *Speed, Max Effective Range, Burnout Weight, etc.*

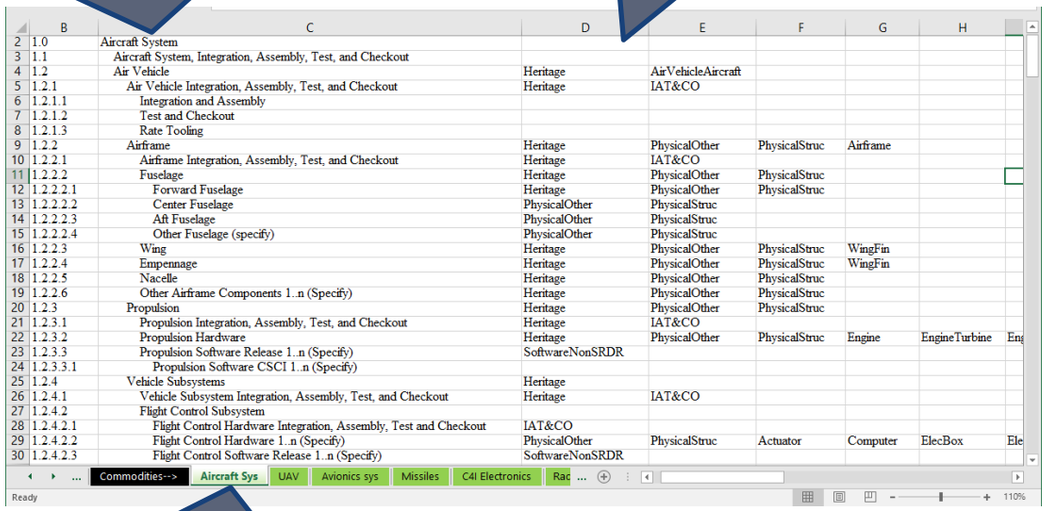
CADE Technical Vocabulary

The CADE Technical Vocabulary is comprised of two parts.

1. A glossary of parameter names, units, and definitions organized by Item Type
2. Commodity Work Breakdown Structures with associated Item Types

CSDR Standard Plan WBS

Item Types



	B	C	D	E	F	G	H
2	1.0	Aircraft System					
3	1.1	Aircraft System, Integration, Assembly, Test, and Checkout					
4	1.2	Air Vehicle	Heritage	AirVehicleAircraft			
5	1.2.1	Air Vehicle Integration, Assembly, Test, and Checkout	Heritage	IAT&CO			
6	1.2.1.1	Integration and Assembly					
7	1.2.1.2	Test and Checkout					
8	1.2.1.3	Rate Tooling					
9	1.2.2	Airframe	Heritage	PhysicalOther	PhysicalStruc	Airframe	
10	1.2.2.1	Airframe Integration, Assembly, Test, and Checkout	Heritage	IAT&CO			
11	1.2.2.2	Fuselage	Heritage	PhysicalOther	PhysicalStruc		
12	1.2.2.2.1	Forward Fuselage	Heritage	PhysicalOther	PhysicalStruc		
13	1.2.2.2.2	Center Fuselage	PhysicalOther	PhysicalStruc			
14	1.2.2.2.3	Aft Fuselage	PhysicalOther	PhysicalStruc			
15	1.2.2.2.4	Other Fuselage (specify)	PhysicalOther	PhysicalStruc			
16	1.2.2.3	Wing	Heritage	PhysicalOther	PhysicalStruc	WingFin	
17	1.2.2.4	Empennage	Heritage	PhysicalOther	PhysicalStruc	WingFin	
18	1.2.2.5	Nacelle	Heritage	PhysicalOther	PhysicalStruc		
19	1.2.2.6	Other Airframe Components 1..n (Specify)	Heritage	PhysicalOther	PhysicalStruc		
20	1.2.3	Propulsion	Heritage	PhysicalOther	PhysicalStruc		
21	1.2.3.1	Propulsion Integration, Assembly, Test, and Checkout	Heritage	IAT&CO			
22	1.2.3.2	Propulsion Hardware	Heritage	PhysicalOther	PhysicalStruc	Engine	EngineTurbine
23	1.2.3.3	Propulsion Software Release 1..n (Specify)	SoftwareNonSRDR				
24	1.2.3.3.1	Propulsion Software CSCI 1..n (Specify)					
25	1.2.4	Vehicle Subsystems	Heritage				
26	1.2.4.1	Vehicle Subsystem Integration, Assembly, Test, and Checkout	Heritage	IAT&CO			
27	1.2.4.2	Flight Control Subsystem					
28	1.2.4.2.1	Flight Control Hardware Integration, Assembly, Test and Checkout	IAT&CO				
29	1.2.4.2.2	Flight Control Hardware 1..n (Specify)	PhysicalOther	PhysicalStruc	Actuator	Computer	ElecBox
30	1.2.4.2.3	Flight Control Software Release 1..n (Specify)	SoftwareNonSRDR				

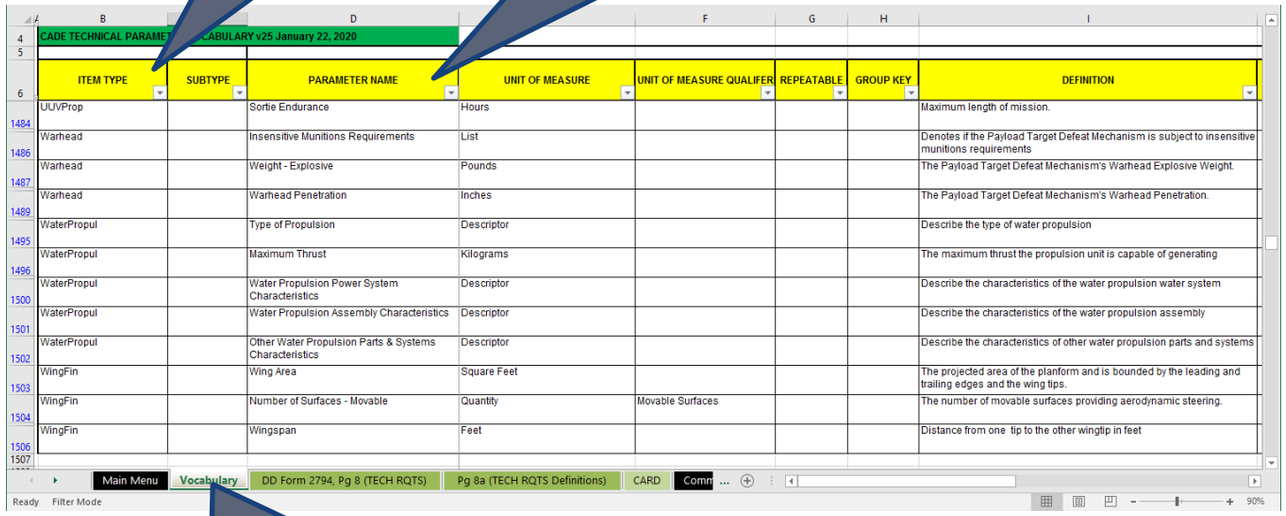
Commodities--> | Aircraft Sys | UAV | Avionics sys | Missiles | C4I Electronics | Rac ...

Ready 110%

Commodity WBS Sheets

Item Type

Parameter Name



CADE TECHNICAL PARAMET[illegible]CABULARY v25 January 22, 2020

ITEM TYPE	SUBTYPE	PARAMETER NAME	UNIT OF MEASURE	UNIT OF MEASURE QUALIFER	REPEATABLE	GROUP KEY	DEFINITION
UUVProp		Sortie Endurance	Hours				Maximum length of mission.
Warhead		Insensitive Munitions Requirements	List				Denotes if the Payload Target Defeat Mechanism is subject to insensitive munitions requirements
Warhead		Weight - Explosive	Pounds				The Payload Target Defeat Mechanism's Warhead Explosive Weight.
Warhead		Warhead Penetration	Inches				The Payload Target Defeat Mechanism's Warhead Penetration.
WaterPropul		Type of Propulsion	Descriptor				Describe the type of water propulsion
WaterPropul		Maximum Thrust	Kilograms				The maximum thrust the propulsion unit is capable of generating
WaterPropul		Water Propulsion Power System Characteristics	Descriptor				Describe the characteristics of the water propulsion water system
WaterPropul		Water Propulsion Assembly Characteristics	Descriptor				Describe the characteristics of the water propulsion assembly
WaterPropul		Other Water Propulsion Parts & Systems Characteristics	Descriptor				Describe the characteristics of other water propulsion parts and systems
WingFin		Wing Area	Square Feet				The projected area of the planform and is bounded by the leading and trailing edges and the wing tips.
WingFin		Number of Surfaces - Movable	Quantity	Movable Surfaces			The number of movable surfaces providing aerodynamic steering.
WingFin		Wingspan	Feet				Distance from one tip to the other wingtip in feet

Main Menu | Vocabulary | DD Form 2794, Pg 8 (TECH RQTS) | Pg 8a (TECH RQTS Definitions) | CARD | Comm ...

Ready Filter Mode 90%

Vocabulary Sheet

Controlled Vocabulary Exists

https://cade.osd.mil/policy/techdata

Data Best Practices
Human Readable vs Machine Readable

Weak:

WBS Element	Technical Parameter Name	Value
Subsystem n.n.n.n	Power (Avg / Peak) (W)	786.1/876.2

Better:

WBS Element	Technical Parameter Name	Value	Unit of Measure	Qualifier
Subsystem n.n.n.n	Power - Average	786.1	Watts	
Subsystem n.n.n.n	Power - Peak	876.2	Watts	

Or:

WBS Element	Technical Parameter Name	Value	Unit of Measure	Qualifier
Subsystem n.n.n.n	Power	786.1	Watts	Average
Subsystem n.n.n.n	Power	876.2	Watts	Peak

Notional Data

Data Friction

How Do We Collect Technical Data

✓ Start with WBS Structure DD2794

COST AND SOFTWARE DATA REPORTING PLAN

11. WORK BREAKDOWN STRUCTURE (WBS)			12. COST					13. TECHNICAL DATA			
								a. QUANTITY			
a. WBS CODE	b. WBS LEVEL	c. WBS ELEMENT NAME	a. ACTUALS TO DATE (ATD)	b. LEGACY 1921-1	c. LEGACY 1921-2	d. LEGACY 1921-5	e. EAC/FAC (See item 10d)	i. QUANTITY DATA	ii. GFE QUANTITY	b. SRDR FORMATS	c. MAINT. & REPAIR PARTS
1.0	1	Aircraft System					X	X			
1.1	2	Air Vehicle					X	X			
1.1.1	3	Airframe	X				X	X			
1.1.2	3	Propulsion	X				X	X			
1.1.3	3	Vehicle Subsystems					X	X			
1.1.3.1	4	Flight Control Subsystem	X				X	X			
1.1.3.2	4	Hydraulic Subsystem	X				X	X			
1.1.3.3	4	Electrical Subsystem	X				X	X			
1.1.3.4	4	Landing Gear	X				X	X			
1.1.3.5	4	Fuel Subsystem	X				X	X			
1.1.4	3	Avionics					X	X			
1.1.4.1	4	Communication/Identification	X				X	X			
1.1.4.2	4	Navigation/Guidance	X				X	X			
1.1.4.3	4	Mission Computer/Processing	X				X	X			
1.1.4.4	4	Fire Control	X				X	X			
1.2	2	Systems Engineering	X				X				
1.3	2	Program Management									
1.4	2	System Test and Evaluation									
1.5	2	Training									
1.6	2	Data									
1.7	2	Industrial Facilities									
1.8	2	Initial Spares and Repair Parts									

COST AND SOFTWARE DATA REPORTING PLAN - TECHNICAL PARAMETER REQUIREMENTS

26. WBS ELEMENT CODE	27. WBS ELEMENT NAME	28. ITEM TYPE	29. TECHNICAL PARAMETER				
			a. PARAMETER NAME	b. UNIT OF MEASURE	c. UNIT OF MEASURE QUALIFIER	d. REPEATABLE	e. REMARKS
1.1	Air Vehicle	AirVehicleAircraft	Crew Size	Quantity	Crew Members		
1.1	Air Vehicle	AirVehicleAircraft	Number of Engines	Quantity	Engines		
1.1	Air Vehicle	AirVehicleAircraft	Combat Radius	Nautical Miles			
1.1	Air Vehicle	AirVehicleAircraft	Engine Type	List			
1.1	Air Vehicle	AirVehicleAircraft	Weight - Empty	Pounds			
1.1	Air Vehicle	AirVehicleAircraft	Speed - Maximum	Knots			
1.1	Air Vehicle	AirVehicleAircraft	Stealth Features	List			
1.1	Air Vehicle	AirVehicleAircraft	Nuclear Environment Survivability	List			
1.1	Air Vehicle	AirVehicleAircraft	Supersonic Survivability	List			
1.1	Air Vehicle	AirVehicleAircraft	Combat Ceiling	Feet			
1.1	Air Vehicle	AirVehicleAircraft	Weight - Internal Fuel	Pounds			
1.1	Air Vehicle	AirVehicleAircraft	Weight - Maximum Gross	Pounds			
1.1	Air Vehicle	AirVehicleAircraft	Weight - Maximum Ordnance Gross	Pounds			
1.1	Air Vehicle	AirVehicleAircraft	Weight - Useful Load	Pounds			
1.1	Air Vehicle	AirVehicleAircraft	Airframe Unit Weight	Pounds per Cubic Meter			
1.1	Air Vehicle	AirVehicleAircraft	Empty Weight	Pounds			
1.1	Air Vehicle	AirVehicleAircraft	Structure Weight	Pounds			
1.1	Air Vehicle	AirVehicleAircraft	Crew Size	Quantity	Crew Members		
1.1	Air Vehicle	AirVehicleAircraft	Number of Engines	Quantity	Engines		
1.1	Air Vehicle	AirVehicleAircraft	Combat Radius	Nautical Miles			

- Start with WBS Structure to determine which parameters to place on contract

Examples of Parameter Selection

- Selecting Parameters
  - Development Contracts - Heritage
  - Hardware Products - SWAP
  - Hardware Products - Unique parameters

Design Heritage

- **Is this a development contract?**
  - If so, then future estimators will want design and development metrics to make full use of the CSDR's nonrecurring cost.
- **For hardware WBS elements use heritage parameters:**
  - The magnitude of nonrecurring design and development effort will be influenced by the extent to which an existing design is modified. A pair of heritage parameters, New Design and Predecessor System, are available to capture this information.
  - At what WBS level is heritage meaningful? The level at which nonrecurring engineering cost is captured is a best practice (e.g. every child element). If pressure to decrease the parameter count is present, consider placing heritage parameters on only the subsystem parent levels.

26. WBS ELEMENT CODE	27. WBS ELEMENT NAME	28. ITEM TYPE	29. TECHNICAL PARAMETER	
			a. PARAMETER NAME	b. UNIT OF MEASURE
1.1.3.2.2.1	Altimeter	Heritage	New Design	Percent
1.1.3.2.2.1	Altimeter	Heritage	Predecessor System	Descriptor
1.1.3.2.2.1	Altimeter	PhysicalElec	Weight	Pounds
1.1.3.2.2.2	Altitude Heading Reference	Heritage	New Design	Percent
1.1.3.2.2.2	Altitude Heading Reference	Heritage	Predecessor System	Descriptor
1.1.3.2.2.2	Altitude Heading Reference	PhysicalElec	Weight	Pounds
1.1.3.2.2.3	Pitot Static System	Heritage	New Design	Percent
1.1.3.2.2.3	Pitot Static System	Heritage	Predecessor System	Descriptor
1.1.3.2.2.3	Pitot Static System	PhysicalElec	Weight	Pounds

Heritage at child elements

Heritage at parent elements

26. WBS ELEMENT CODE	27. WBS ELEMENT NAME	28. ITEM TYPE	29. TECHNICAL PARAMETER	
			a. PARAMETER NAME	b. UNIT OF MEASURE
1.1.3.2.2	Navigation Sensor	Heritage	New Design	Percent
1.1.3.2.2	Navigation Sensor	Heritage	Predecessor System	Descriptor
1.1.3.2.2.1	Altimeter	PhysicalElec	Weight	Pounds
1.1.3.2.2.2	Altitude Heading Reference	PhysicalElec	Weight	Pounds
1.1.3.2.2.3	Pitot Static System	PhysicalElec	Weight	Pounds

Size, Weight, and Power for Hardware Products

- **Does this contract produce hardware (production or development prototypes)?**
  - If so, then future estimators will want product characteristics to make full use of the CSDR's recurring cost.
- **For hardware WBS elements use size, weight, and power (SWAP) parameters:**
  - Hardware costs are often influenced by SWAP parameters. Typically this is a minimum to obtain for every hardware child element. Three often-used parameters are: Use the subtype to get Weight, Volume, and Power – Maximum Consumption Rate.
  - For structural and mechanical items, Power does not of course need not be listed.
  - Structure costs are often influenced by material choices. When applicable also add Material Mix.

Unique Parameters for Hardware Products

- **Does this contract produce hardware (production or development prototypes)?**
  - If so, then future estimators will want product characteristics to make full use of the CSDR's recurring cost.
- **In addition to SWAP, many hardware production have unique characteristics**
  - Additional general-purpose parameters for specific products are available. A sample is shown below. Determine if there is a need for unique parameters for certain WBS elements. Further determine if these are most applicable at child or parent levels.

COST AND SOFTWARE DATA REPORTING PLAN - TECHNICAL PARAMETER REQUIREMENTS				
TECHNICAL PARAMETER REQUIREMENTS				
26. WBS ELEMENT	27. WBS ELEMENT NAME	28. ITEM TYPE	29. TECHNICAL PARAMETER	
1.1.2.2.2.1	Antenna 1...n (Specify)	Antenna	Frequency Band	List
1.1.2.2.2.1	Antenna 1...n (Specify)	Antenna	Aperture - Antenna	Inches
1.1.2.2.2.1	Antenna 1...n (Specify)	Antenna	Number of Sub Arrays	Quantity
1.1.2.2.2.1	Antenna 1...n (Specify)	Antenna	Tunable Bandwidth	Gigahertz
1.1.2.2.2.1	Antenna 1...n (Specify)	Antenna	Type of Steering	List
1.1.2.2.2.1	Antenna 1...n (Specify)	Antenna	Bandwidth	Gigahertz
1.1.4.2.1	Mission Computer	Computer	Simultaneous Multi-Mode Operation	List
1.1.4.2.1	Mission Computer	Computer	Processor Type	Descriptor
1.1.4.2.1	Mission Computer	Computer	Computing Performance	Millions of Instructi
1.1.8.2.1.1	Electro-optical System 1..n (Specify)	Optics	Aperture - Optics	Inches
1.1.8.2.1.1	Electro-optical System 1..n (Specify)	Optics	Number of Curved Elements	Quantity
1.1.8.2.1.1	Electro-optical System 1..n (Specify)	Optics	Number of Flat Mirrors	Quantity
1.1.8.2.1.1	Electro-optical System 1..n (Specify)	Optics	Number of Optical Components - Moving	Quantity
1.1.8.2.1.1	Electro-optical System 1..n (Specify)	Optics	Field of View	Degrees (Angle)

Antenna
Frequency Band
Aperture - Antenna
Number of Sub Arrays
Tunable Bandwidth
Type of Steering

Battery
Battery Capacity
Output Voltage
Type of Battery
Number of Battery Cells

Computer
Simultaneous Multi-Mode Operation
Processor Type
Computing Performance

ElecBox
Circuit Cards - Number of
Size of Printed Circuit Board
Circuit Cards - Number of Integrated Circuits
Integrated Circuit (IC) Part Quality

ElecBox
Circuit Cards - Number of
Size of Printed Circuit Board
Circuit Cards - Number of Integrated Circuits
Integrated Circuit (IC) Part Quality

EOIRLaser
Aperture - Optics
Number of Pixels
Pulsed or CW
Operating Band - FPA

GuidanceNav&Cntrl
Gyro Type
Stability - Inertial Reference Unit (IRU)
Redundancy
Number of Control Inputs and Outputs

LiquidEngines
Average chamber pressure
Thrust chamber length
Nozzle exit diameter

Optics
Aperture - Optics
Number of Curved Elements
Number of Flat Mirrors
Number of Optical Components - Moving
Field of View

LiquidEngines
Average chamber pressure
Thrust chamber length
Nozzle exit diameter

Optics
Aperture - Optics
Number of Curved Elements
Number of Flat Mirrors
Number of Optical Components - Moving
Field of View

RocketStage
Thrust - Maximum
Thrust - Average
Mass Fraction

TurretAssembly
Primary Material - Turret
Motorized Turret
Drive Stabilized Turret
Depression
Elevation
Traverse
Cupola Height

The Enabling Data Models: FlexFile, Quantity, and Technical

FlexFile Cost and Hour Report

Data Group A
Report Metadata
Approved Plan Number
Submission Event
Period of Performance
Reporting Organization
As of Date
Date Prepared
more in the DID…

Data Group B
DD Form 2794 Data Elements
WBS Element
Order/Lot
End Item

Data Group E
Actuals To Date (ATD)
Account
Reporting Period
Nonrecurring or Recurring
Functional Category / Overhead
Standard Functional Category
WBS Element
Order/Lot
End Item
ATD (Dollars and Labor Hours)
more in the DID…

Data Group G
Forecasts At Completion (FAC)
FAC (Dollars)
FAC (Labor Hours)

Data Group C
Definitions and Remarks
WBS Element Definitions
Remarks by WBS Element
Summary Remarks

Data Group D
Summary Elements
Order/Lot
Subtotal
General and Administrative
Undistributed Budget
Management Reserve
Facilities Capital Cost of Money
Contract Fee
Contract Price

Data Group F
Allocation Methodology
Allocation Method

Quantity Data Report

Data Group A
Report Metadata
Approved Plan Number
Submission Event
Period of Performance
Reporting Organization
As of Date
Date Prepared
more in the DID…

Data Group B
DD Form 2794 Data Elements
WBS Element
Order/Lot
End Item

Data Group C
Quantity at Completion
WBS Element
Order/Lot
End Item
Delivered Quantity At Completion
more in the DID…

Data Group D
Assessed Quantity to Date
WBS Element
Order/Lot
Quantity Completed To Date
Quantity In Process
Remarks

Data Group E
Sequencing (as required by Plan)
First Unit Number
Last Unit Number
Is Internal

Technical Data Report

Identical

Data Group A
Report Metadata
Approved Plan Number
Submission Event
Period of Performance
Reporting Organization
As of Date
Date Prepared
more in the DID…

Data Group B
DD Form 2794 Data Elements
WBS Element
Order/Lot
End Item

Data Group C
Technical Data Parameters
Mapping ID
Item Type
Technical Parameter Name
Value
Unit of Measure
Estimate/Actual
more in the DID…

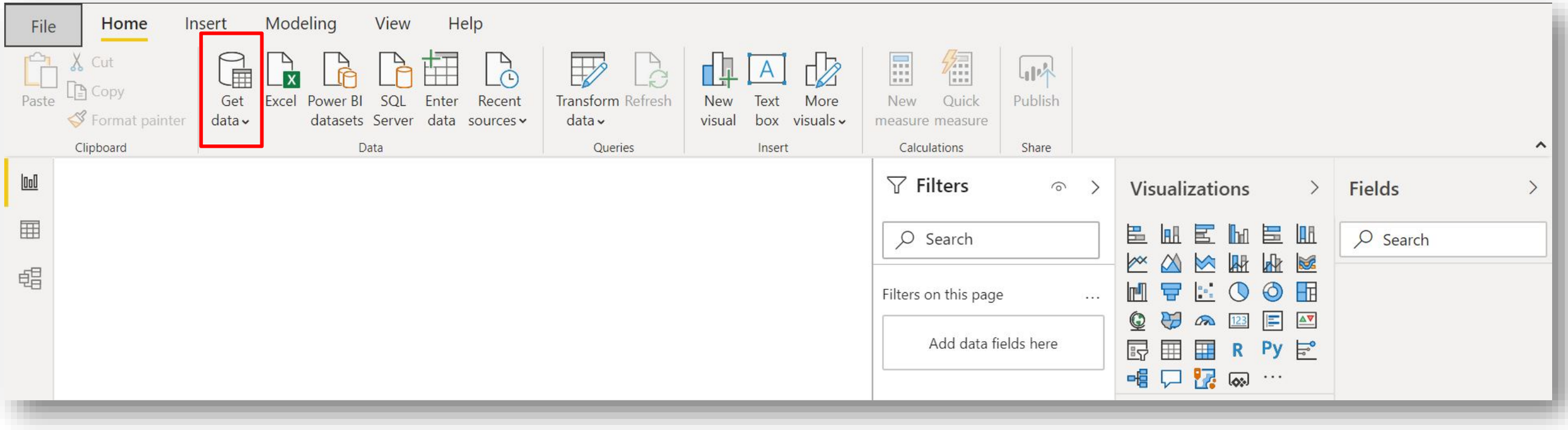
Data Group D
Technical Data WBS Mapping ID
Mapping ID
WBS Element
End Item
Order/Lot
Remarks

Power BI Sample Case Assumptions

- The Submission File has the following assumptions:
  - **File Information:**
    - The WBS Structure is based off of MIL STD 881E for Aircraft
    - The FlexFile is reporting to three Lots
    - There is a single variant (VAR A)
  - **Lifecycle of the Files:**
    - The contract is a development contract delivering the first lots in the phase Low Rate Initial Product (LRIP)
    - The Submission File is the **Final** FlexFile, Quantity File, and Technical Data Report to be submitted on the contract effort/ plan task

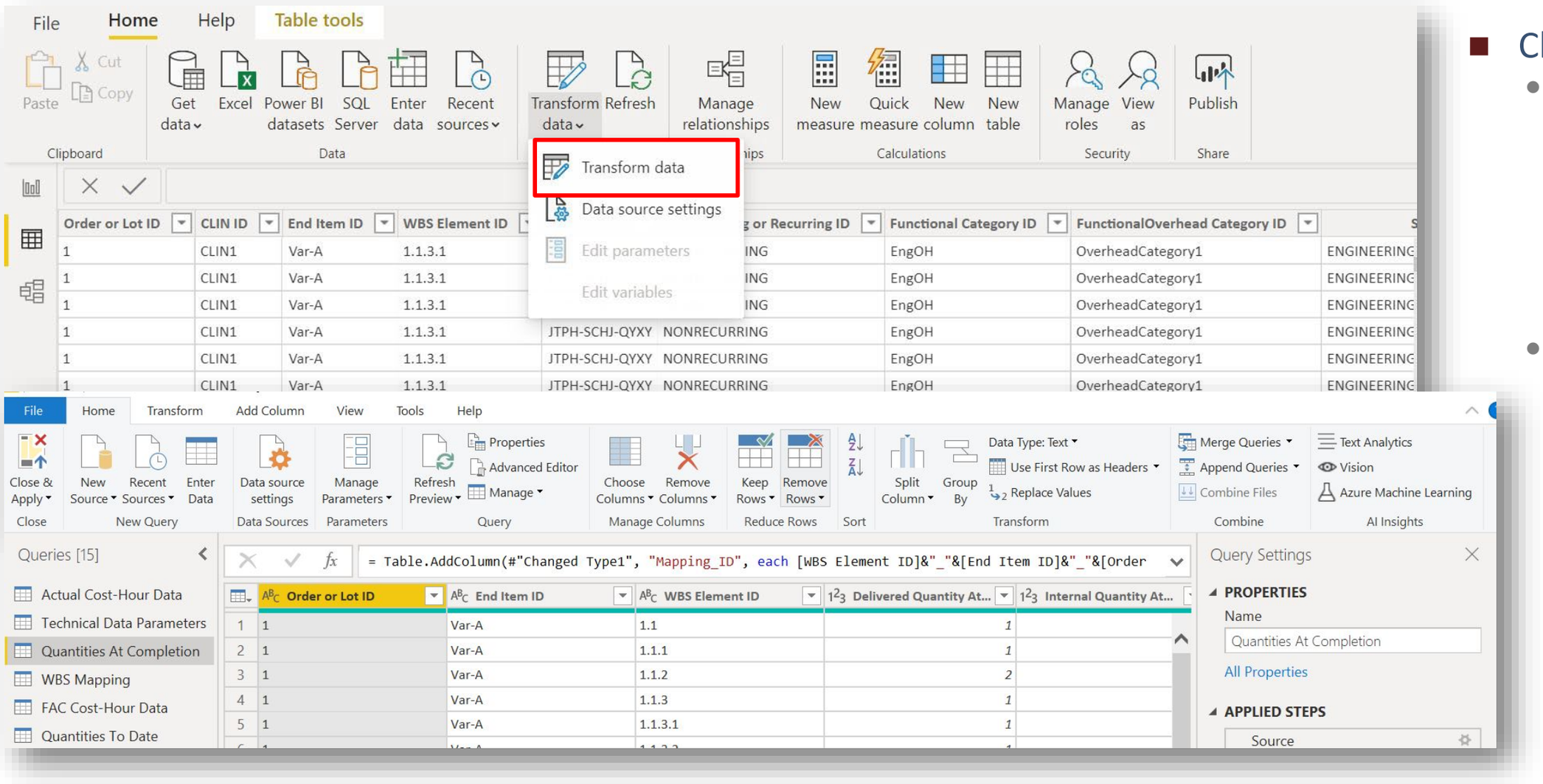
      This means that the cost To Date has to be more than 95% complete

Power BI Import Submission Data



- Import three Excel files:
  - FlexFile Cost and Hour Report
  - Quantity Data Report
  - Technical Data Report

Power BI Data Preparation



- Clean Data:
  - Create Mapping ID field for the **FlexFile** *Actual Cost-Hour Data Table* and **Quantity File** *Quantities At Completion* table
  - Combine *Technical Data Report* and **FlexFile** *Actual Cost-Hour data table* and **Quantity File** *Quantities At Completion Table* by using Mapping ID from three tables

Power BI Report: Explore Metrics

Mapping_ID	WBS Element	Technical Parameter Name	Value	Unit of Measure	Value (Dollars)	Value (Hours)	Metric in Dollars	Metric in Hours
1.1.1_Var-A_1	Airframe	Volume	700.0	Cubic Inches	$16,361,566	148,419.00	23,373.67	212.03
1.1.1_Var-A_1	Airframe	Weight	7000.0	Pounds	$16,361,566	148,419.00	2,337.37	21.20
1.1.2_Var-A_1	Propulsion	Thrust (at Sea Level, Standard Conditions)	8000.0	Pounds	$38,578,854	351,020.00	4,822.36	43.88
1.1.2_Var-A_1	Propulsion	Volume	525.0	Cubic Inches	$38,578,854	351,020.00	73,483.53	668.61
1.1.2_Var-A_1	Propulsion	Weight	1000.0	Pounds	$38,578,854	351,020.00	38,578.85	351.02
1.1.3.1_Var-A_1	Flight Control Subsystem	Volume	1225.0	Cubic Inches	$112,053,550	1,021,644.00	91,472.29	834.00
1.1.3.1_Var-A_1	Flight Control Subsystem	Weight	7000.0	Pounds	$112,053,550	1,021,644.00	16,007.65	145.95
1.1.3.2_Var-A_1	Hydraulic Subsystem	Volume	1225.0	Cubic Inches	$873,382,856	7,953,400.00	712,965.60	6,492.57
1.1.3.2_Var-A_1	Hydraulic Subsystem	Weight	8000.0	Pounds	$873,382,856	7,953,400.00	109,172.86	994.18
1.1.3.3_Var-A_1	Electrical Subsystem	Volume	175.0	Cubic Inches	$1,341,614,304	12,091,891.00	7,666,367.45	69,096.52
1.1.3.3_Var-A_1	Electrical Subsystem	Weight	4000.0	Pounds	$1,341,614,304	12,091,891.00	335,403.58	3,022.97
1.1.3.4_Var-A_1	Landing Gear	Volume	700.0	Cubic Inches	$17,165,745	156,331.00	24,522.49	223.33
1.1.3.4_Var-A_1	Landing Gear	Weight	7000.0	Pounds	$17,165,745	156,331.00	2,452.25	22.33
1.1.3.5_Var-A_1	Fuel Subsystem	Volume	1400.0	Cubic Inches	$717,183,680	6,512,547.00	512,274.06	4,651.82

Nonrecurring or Recu...
- Select all
- NONRECURRING
- RECURRING

Order or Lot ID
- Select all
- 1
- 2
- 3

Standard Category ID
- Select all
- DIRECT_ENGINEERING_LABOR
- DIRECT_MANUFACTURING_OTHER_...
- DIRECT_MANUFACTURING_TOUCH_...
- DIRECT_MATERIALS
- ENGINEERING_LABOR_OVERHEAD
- FACILITIES_CAPITAL_COST_OF_MO...
- GENERAL_AND_ADMINISTRATIVE
- MANUFACTURING_OPERATIONS_LA...
- MATERIAL_OVERHEAD
- OTHER_DIRECT_COSTS
- OTHER_OVERHEAD

Functional Categ...
- Select all
- DirEngLab1
- DirEngLab2
- DirEngLab3
- DirEngLab4
- DirEngLab5
- DirMat
- DirMfgOpsLab1
- DirMfgOpsLab2
- EngOH
- FCCM
- GA
- MatOH
- MfgOpsOH
- OtherDir
- OtherOH

Technical Parameter Name
- Power - Supply Performance Period
- Power Specific Fuel Consumption (S...
- Power-to-Weight Ratio
- Range - Radar
- Reflector Area
- Rotor Inlet Temperature
- Shaft Horsepower (SHP)
- Technology Readiness Level (TRL)
- Test Flight Points
- Test Flight Sorties
- Thrust (at Sea Level, Standard Condi...
- Thrust to Weight ratio
- Volume
- Volume of Electrical Power System
- Weight
- Weight - Electronics
- Weight - Structural

WBS
- Select all
- 1.0 Aircraft System
- 1.1 Air Vehicle
- 1.1.1 Airframe
- 1.1.2 Propulsion
- 1.1.3 Vehicle Subsystems
- 1.1.3.1 Flight Control Subsy...
- 1.1.3.2 Hydraulic Subsystem
- 1.1.3.3 Electrical Subsystem
- 1.1.3.4 Landing Gear
- 1.1.3.5 Fuel Subsystem
- 1.1.4 Avionics
- 1.1.4.1 Communication/Iden...
- 1.1.4.2 Navigation/Guidance

Notional Data

Power BI Report: Explore Unit Cost Metrics

Mapping_ID	WBS Element	Technical Parameter Name	Value	Unit of Measure	Value (Dollars)	Value (Hours)	Quantity	Unit Metric in Dollars	Unit Metric in Hours
1.1.1_Var-A_3	Airframe	Weight	7000.0	Pounds	$4,355,457	41,200.00	4	155.55	1.47
1.1.2_Var-A_3	Propulsion	Weight	1000.0	Pounds	$8,811,026	83,890.00	8	1,101.38	10.49
1.1.3.1_Var-A_3	Flight Control Subsystem	Weight	7000.0	Pounds	$26,818,236	252,874.00	4	957.79	9.03
1.1.3.2_Var-A_3	Hydraulic Subsystem	Weight	8000.0	Pounds	$224,842,149	2,120,142.00	4	7,026.32	66.25
1.1.3.3_Var-A_3	Electrical Subsystem	Weight	4000.0	Pounds	$344,035,513	3,227,799.00	4	21,502.22	201.74
1.1.3.4_Var-A_3	Landing Gear	Weight	7000.0	Pounds	$4,710,282	43,699.00	4	168.22	1.56
1.1.3.5_Var-A_3	Fuel Subsystem	Weight	3000.0	Pounds	$200,352,110	1,838,820.00	4	16,696.01	153.24
1.1.4.1_Var-A_3	Communication/Identification	Weight	8000.0	Pounds	$3,352,949	31,260.00	4	104.78	0.98
1.1.4.2_Var-A_3	Navigation/Guidance	Weight	4000.0	Pounds	$5,864,353	54,591.00	4	366.52	3.41
1.1.4.3_Var-A_3	Mission Computer/Processing	Weight	7000.0	Pounds	$6,127,445	57,520.00	4	218.84	2.05
1.1.4.4_Var-A_3	Fire Control	Weight	7000.0	Pounds	$14,983,977	140,854.00	4	535.14	5.03

Nonrecurring or Recu…
- Select all
- NONRECURRING
- RECURRING

Order or Lot ID
- Select all
- 1
- 2
- 3

Standard Category ID
- Select all
- DIRECT_ENGINEERING_LABOR
- DIRECT_MANUFACTURING_OTHER_…
- DIRECT_MANUFACTURING_TOUCH_…
- DIRECT_MATERIALS
- ENGINEERING_LABOR_OVERHEAD
- FACILITIES_CAPITAL_COST_OF_MO…
- GENERAL_AND_ADMINISTRATIVE
- MANUFACTURING_OPERATIONS_LA…
- MATERIAL_OVERHEAD
- OTHER_DIRECT_COSTS
- OTHER_OVERHEAD

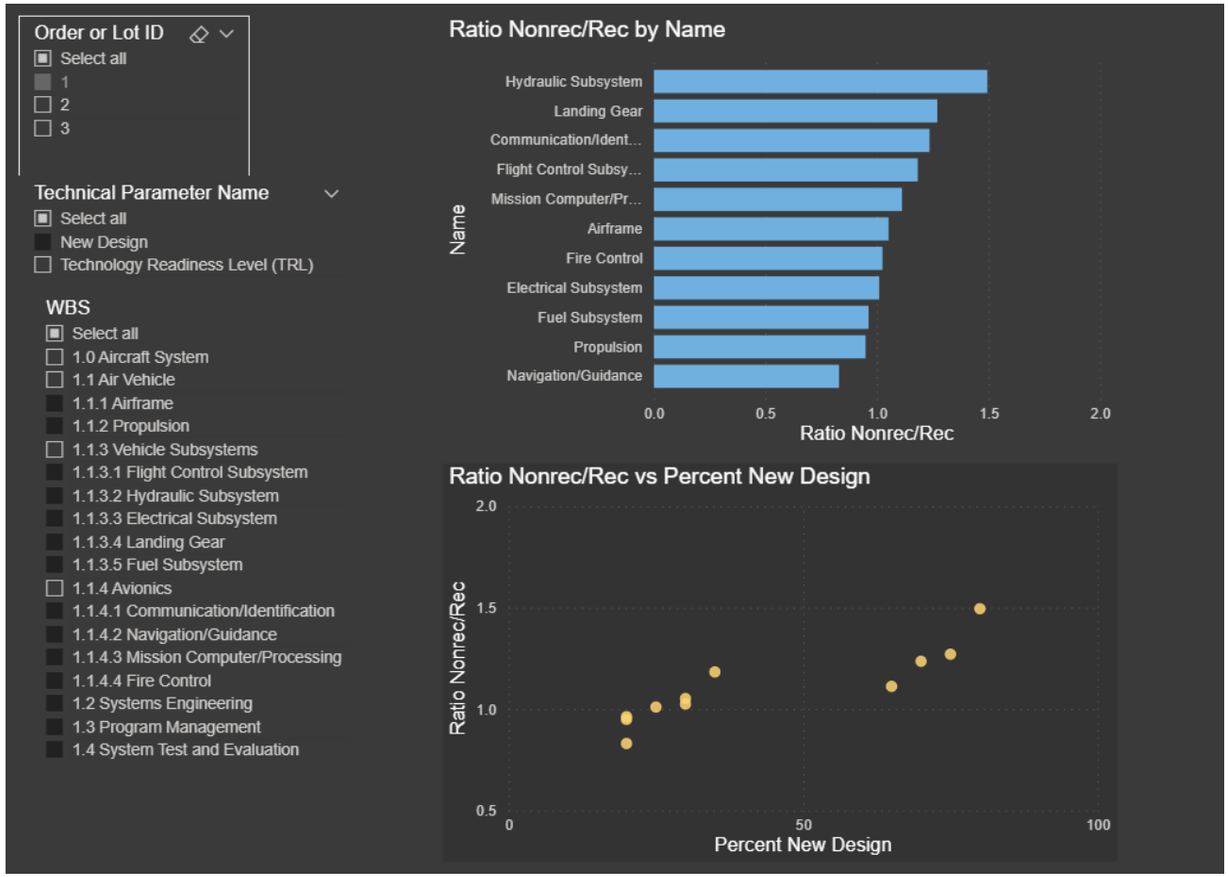
Functional Categ…
- Select all
- DirEngLab1
- DirEngLab2
- DirEngLab3
- DirEngLab4
- DirEngLab5
- DirMat
- DirMfgOpsLab1
- DirMfgOpsLab2
- EngOH
- FCCM
- GA
- MatOH
- MfgOpsOH
- OtherDir
- OtherOH

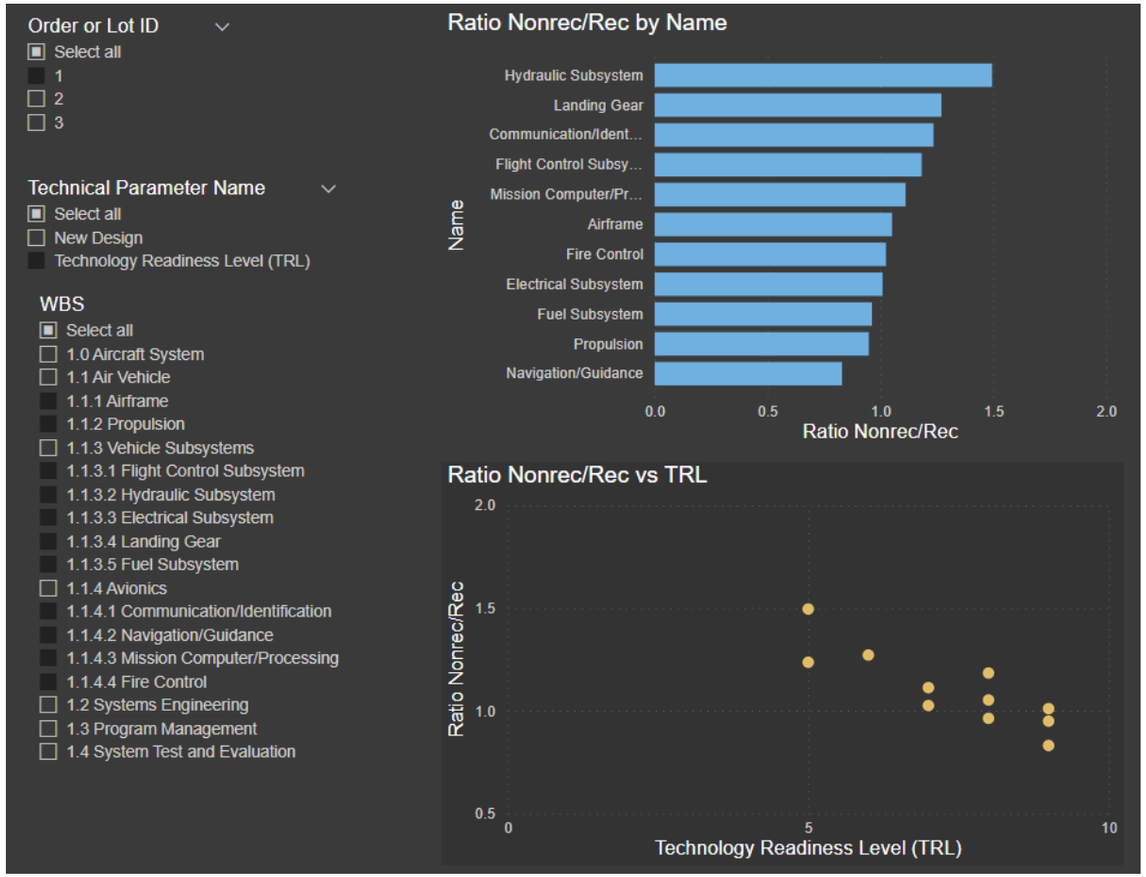
Technical Parameter Name
- Select all
- Aperture - Antenna
- Application Specific Integrated Circuit…
- Array Beams
- Bandwidth
- Battery Capacity
- Circuit Cards - Number of
- Computing Performance
- Depth of Discharge
- Field Programmable Gate Array (FPG…
- Frequency of Government Program …
- Frequency Range
- Fuel Capacity
- Fuel Consumption Rate
- Gyro Random Walk
- Inertial Measurement Unit (IMU) Drift …
- Maximum Power Density

WBS
- Select all
- 1.0 Aircraft System
- 1.1 Air Vehicle
- 1.1.1 Airframe
- 1.1.2 Propulsion
- 1.1.3 Vehicle Subsystems
- 1.1.3.1 Flight Control Subsy…
- 1.1.3.2 Hydraulic Subsystem
- 1.1.3.3 Electrical Subsystem
- 1.1.3.4 Landing Gear
- 1.1.3.5 Fuel Subsystem
- 1.1.4 Avionics
- 1.1.4.1 Communication/Iden…
- 1.1.4.2 Navigation/Guidance
- 1.1.4.3 Mission Computer/P…

Notional Data

Power BI Report: Explore Nonrecurring/Recurring Metrics





Notional Data

Repeatable Tech Data Process

Government CWIPT

- ✓ Start with Core Parameters by Commodity & Phase
- ✓ Refine Contract-Specific Parameters using Technical Data Vocabulary Database
- ✓ Review other Contractual CDRL Requirements to Minimize Duplication
- ✓ Finalize Requirements for the Contracting Process
  - Technical Data Reporting, DD 2794 Supplement & Submission Events
  - Revise generic Technical Data CDRL (DD 1423) to Program specifics
- ✓ Participate in pre / post award conferences to ensure Tech Data requirements are well understood

Industry

- ✓ Receive requirement via RFP
- ✓ Bid accordingly
- ✓ Participate in pre / post award conferences to ensure Tech Data requirements are well understood and can be effectively met
- ✓ Submit report(s) as required with cost reports

Government DCARC/TURF Team

- ✓ Validate Submission
- ✓ Place into CADE

Source: Technical Data Advocacy for Industry 6/26/2019; https://cade.osd.mil/policy/techdata

				Core by Phase		
ITEM TYPE	SUBTYPE	PARAMETER NAME	UNIT OF MEASURE	Dev	Prod	O&S
ElecBox		Clock Speed	Megahertz	X	X	
ElecBox		ASIC - Gate Count	Quantity	X	X	
ElecBox		FPGA - Gate Count	Quantity	X	X	
ElecBox		Transmitter Power Output - Peak	Watts	X	X	
ElecBox		Number of Receiver Channels	Quantity	X	X	
ElecBox		Type of Modulation	List	X	X	
ElecBox	Heritage	New Design	Percent	X		
ElecBox	Heritage	Technology Readiness Level (TRL)	List	X		
ElecBox	Identification	NSN	Name/Number		X	X
ElecBox	Operational	Maintenance Level	List		X	X
ElecBox	Operational	Mean Time Between Failure (MTBF)	Hours		X	X
ElecBox	Operational	Mean Time To Repair (MTTR)	Hours		X	X

Standard CSDR Plans and CADE Technical Vocabulary

TECHNICAL PARAMETER REQUIREMENTS

27. WBS ELEMENT CODE	28. WBS ELEMENT NAME	29. ITEM TYPE	30. TECHNICAL PARAMETER				
			a. PARAMETER NAME	b. UNIT OF MEASURE	c. UNIT OF MEASURE QUALIFIER	d. REPEATABLE	e. REMARKS
1.2	Air Vehicle	Air Vehicle	Crew Size	Quantity			
1.2	Air Vehicle	Air Vehicle	Number of Engines	Quantity			
1.2	Air Vehicle	PhysicalStruc	Volume	Cubic Inches			
1.2	Air Vehicle	PhysicalStruc	Weight	Pounds			
1.2	Air Vehicle	PhysicalOther	Material Mix 1…n	Descriptor			
1.2.2	Airframe	Heritage	Predecessor System	Year			
1.2.2.2	Fuselage	PhysicalStruc	Dimension - Description	Descriptor			
1.2.2.3	Wing	PhysicalOther	Material Mix 1…n	Descriptor			
1.2.2.3	Wing	Heritage	New Materials	List			
1.2.2.3	Wing	PhysicalStruc	Volume	Cubic Inches			
1.2.2.3	Wing	PhysicalStruc	Weight	Pounds			
1.2.2.4	Empennage	PhysicalOther	Material Mix 1…n	Descriptor			
1.2.2.4	Empennage	Heritage	New Materials	List			
1.2.2.4	Empennage	PhysicalStruc	Volume	Cubic Inches			
1.2.2.4	Empennage	PhysicalStruc	Weight	Pounds			
1.2.2.5	Nacelle	PhysicalOther	Material Mix 1…n	Descriptor			
1.2.2.5	Nacelle	Heritage	New Materials	List			
1.2.2.5	Nacelle	PhysicalStruc	Volume	Cubic Inches			
1.2.2.5	Nacelle	PhysicalStruc	Weight	Pounds			

DD FORM 2794 (Page 4),TECHNICAL PARAMETER REQUIREMENTS, JUNE 2017 — PREVIOUS EDITION IS OBSOLETE

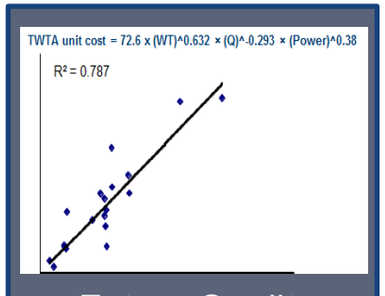
Contract CSDR Plan Technical Data Supplement

TECH: Parameters by Mapping ID

Mapping ID	Item Type	Technical Parameter Name	Group Key	Value	Unit of Measure	Unit of Measure Qualifier	Estimate/Actual	Margin	Remarks
1.1	Air Vehicle	Combat Ra							
1.1	Air Vehicle	Absolute							
1.1	Air Vehicle	Weight							
1.1.1.2	ElecBox	Clock Spe							
1.1.1.2	ElecBox	ASIC - Gat							
1.1.1.2	ElecBox	FPGA - Gate Count		245811	Quantity	Gates	Actual		
1.1.1.2	ElecBox	Volume		1	Cubic Feet		Actual		
1.1.1.2	ElecBox	Weight		20	Pounds		Actual		
1.1.1.2	ElecBox	Power - Maximum Consumption Rate		18	Watts		Actual		Bench Test Results May 2021
1.1.1.2	ElecBox	New Design		100	Percent		Actual		Abandoned reuse of prior design, TIM Jun 2021

Contractor TDR Submission

Contractor submits technical data by WBS element per plan



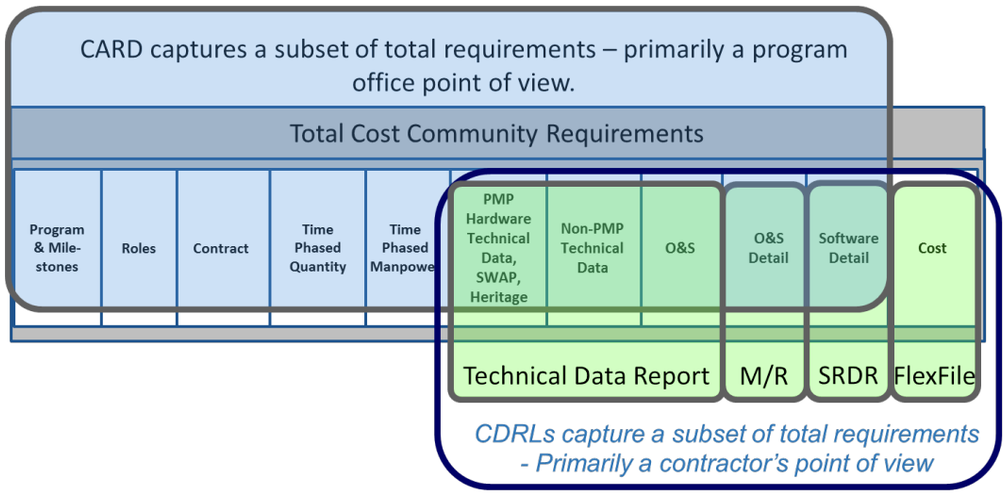
Future Quality Estimates

Data-rich CADE Repository

Technical Data Reporting enhances cost, software, quantity, and sustainment data.

CARDs Using Same Vocabulary

- Best Practice: Use the same vocabulary in the Program CARD and in the TDR
  - A Tech Data Report pertains to a contract; A CARD pertains to an entire program life cycle.
  - An early CARD will contain the Government's forecast prior to delivery of a contract Tech Data Report
  - A Program Office may use the Tech Data Report to satisfy or augment their CARD requirements after a Tech Data Report is obtained.



UNCLASSIFIED, Controlled Unclassified Information

CARD Table: PMP Hardware Technical Table

WBS/CRS Number	WBS/CRS Element	Parameter Name	Value	Unit of Measure	Unit Qualifier
1	Aircraft System				
1.1	Air Vehicle				
		Crew Size		Quantity	Crew Members
		Number of Engines		Quantity	Engines
		Combat Radius		Nautical Miles	
		Weight - Empty		Pounds	
		Speed - Maximum		Knots	
		Combat Ceiling		Feet	
		Weight - Internal Fuel		Pounds	
		Weight - Maximum Gross		Pounds	
		Weight - Maximum Ordnance Gross		Pounds	
		Weight - Useful Load		Pounds	
		Airframe Unit Weight		Pounds per Cubic Meter	
		Empty Weight		Pounds	
		Structure Weight		Pounds	
1.1.1	Airframe				
		New Design		Percent	
		Technology Readiness Level (TRL)		List	
		Volume		Cubic Inches	
		Weight		Pounds	
		Wing Chord		nches	
		Wingspan		nches	
1.1.2	Propulsion				
		New Design		Percent	

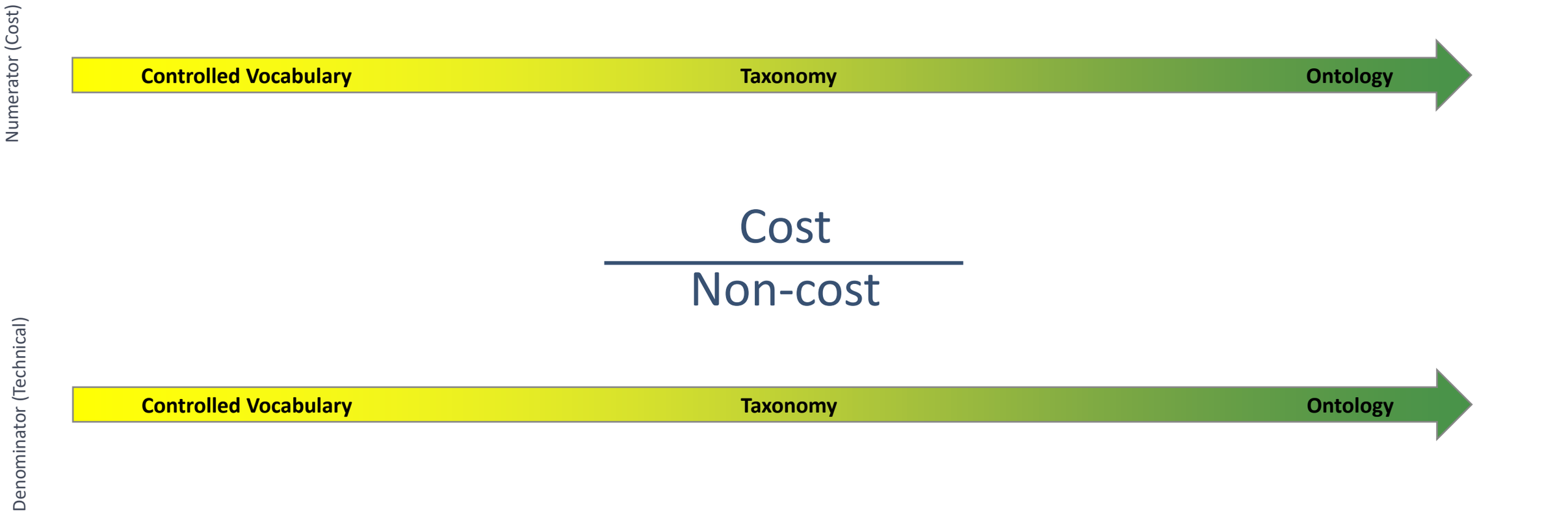
CARD

COST AND SOFTWARE DATA REPORTING PLAN - TECHNICAL PARAMETER REQUIREMENTS

26. WBS ELEMENT CODE	27. WBS ELEMENT NAME	28. ITEM TYPE	29. TECHNICAL PARAMETER		
			a. PARAMETER NAME	b. UNIT OF MEASURE	c. UNIT OF MEASURE QUALIFIER
1.1	Air Vehicle	AirVehicleAircraft	Crew Size	Quantity	Crew Members
1.1	Air Vehicle	AirVehicleAircraft	Number of Engines	Quantity	Engines
1.1	Air Vehicle	AirVehicleAircraft	Combat Radius	Nautical Miles	
1.1	Air Vehicle	AirVehicleAircraft	Engine Type	List	
1.1	Air Vehicle	AirVehicleAircraft	Weight - Empty	Pounds	
1.1	Air Vehicle	AirVehicleAircraft	Speed - Maximum	Knots	
1.1	Air Vehicle	AirVehicleAircraft	Stealth Features	List	
1.1	Air Vehicle	AirVehicleAircraft	Nuclear Environment Survivability	List	
1.1	Air Vehicle	AirVehicleAircraft	Supersonic Survivability	List	
1.1	Air Vehicle	AirVehicleAircraft	Combat Ceiling	Feet	
1.1	Air Vehicle	AirVehicleAircraft	Weight - Internal Fuel	Pounds	
1.1	Air Vehicle	AirVehicleAircraft	Weight - Maximum Gross	Pounds	
1.1	Air Vehicle	AirVehicleAircraft	Weight - Maximum Ordnance Gross	Pounds	
1.1	Air Vehicle	AirVehicleAircraft	Weight - Useful Load	Pounds	
1.1	Air Vehicle	AirVehicleAircraft	Airframe Unit Weight	Pounds per Cubic Meter	
1.1	Air Vehicle	AirVehicleAircraft	Empty Weight	Pounds	
1.1	Air Vehicle	AirVehicleAircraft	S	Pounds	
1.1	Air Vehicle	AirVehicleAircraft	C	Quantity	Crew Members
1.1	Air Vehicle	AirVehicleAircraft	N	Quantity	Engines
1.1	Air Vehicle	AirVehicleAircraft	C	Nautical Miles	

TDR Plan

Conclusion



Where is the cost community on the path to machine understanding?
Where is your organization on the path to machine understanding?
Where are you on the path to machine understanding?