Presented at the 2018 ICEAA Professional Development & Training Workshop - www.iceaaonline.com

Improved Cost and Technical Data Collection for Government Contractors

Phoenix, Arizona
June 2018

Greg Kiviat
Mgr Affordability & LCC
Sikorsky Aircraft

John Swaren
Solutions Consultant
PRICE Systems

Abstract Review

Improved Cost and Technical Data Collection for Government Contractors

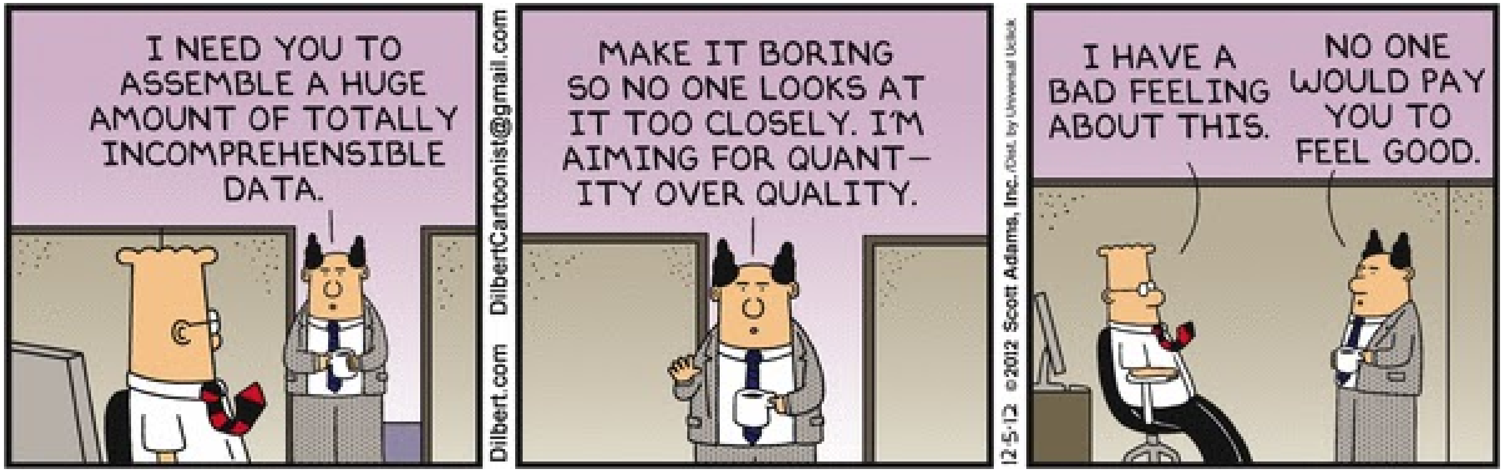
Audience feedback during the 2017 ICEAA Workshop "Lessons Learned in Leveraging Historical Cost, Schedule and Technical Data" suggested applying standardized CARD (Cost Analysis Requirements Description) structure to the presented data collection process.

Thanks to Audience members who provided feedback and insight so that OEM (Original Equipment Manufacturers)/Contractors can leverage existing government processes for data collection.

This paper provides lessons learned from adopting this enhanced approach to a large scale program. We show how contractors can leverage government standard process to improve their internal data collection and gain new insights on cost trends beyond model calibration.

We've expanded our lessons learned providing real world insight to better collect, analyze and apply historical data to future estimates … but let's hear from you too!

Contractors increasingly have the same motivation as our government customers to collect, analyze and apply historical program data …



… However, even OEM (Original Equipment Manufacturers) Contractors have limited views of all the costs associated with their own past programs due to increased outsourcing to second and third tier suppliers as well as GFE content

Cost Analysis Requirements Description (CARD)

According to the Defense Acquisition University (DAU), the CARD contains "…a description of the salient features of the acquisition program and of the system itself…" including "description of the technical and programmatic features of the program".

We found that the CARD data, while there is some overlap with our current process, adds significant additional information that would also be useful to the contractor developing estimates of their own systems.

1.1. System Characterization

Guidance: This section discusses the basic attributes of the system -- its configuration, the missions it will perform and threats it will counter, its relationship to other systems, and the major factors that will influence its cost. The presentation should be structured as follows:

1.1.1. System Description

Guidance: This paragraph provides a general description of the system, including the functions it will perform and key performance parameters. The parameters should be those most often used by cost estimators to predict system cost. Examples of key system characteristics and performance parameters are provided in Enclosure 2.

1.1.1.1. System Diagram.

Guidance: Include a diagram or picture of the system, with the major parts and subsystems appropriately labeled.

1.1.2. System Functional Relationships.
1.1.3. System Configuration.
1.1.4. Government-Furnished Equipment and Property.
1.2. System Characteristics.
1.2.1. System Performance Parameters and Characteristics.
1.2.1.1. Technical and Physical Description.
1.2.1.1.1. Physical Design Parameters.
1.2.2. Software Description.
: : : :

Microsoft Word Document

Key CARD Elements Most Relevant to our OEM Cost Analysis: Discussion

The list of relevant program attributes to enable better understanding of cost drivers continues:

- **Quality** – Reliability, Maintainability, Availability, Portability
- **Security** - Physical, information, and operations security descriptions
- **Predecessor/derivative systems** - similarity to other systems, prior problems, commonality with replaced system as well as any analogous systems
- **Risks** – Technology, TRL, MRL, test, funding, related external projects from program, manager assessment and external technology programs
- **Logistics /Support Concepts** - force structure elements associated with the operation, basing and deployment plans, deployment method, maintenance and repair levels, hardware support concept, Repair versus Replacement, Standard Support Equipment, software upgrade plans, location of system stocks and the methods of resupply, training Plans
- **Quantities** – matrix of systems developed, tested, produced, and deployed by year. This information may also include a count development or production items of other systems that are similar or common to the design under consideration.
- **Acquisition Plan** – type of contracts, suppliers and schedules to system or subsystem considered. This plan should be understood from both the customer and OEM supplier perspectives.
- **Development Plan** – DEM/VAL and EMD plans, schedules, testing during development, number, type, location, and expected duration of hardware and software tests, responsible organizations for test and operational test plans
- **Facilities** – type and number of hardware and software test and production facilities, type and number of hardware and software facilities for deployment, operation and support, and common facilities to other programs
- **Changes** – tracks changes in design, schedule and program direction (objectives)
- **Program Reporting requirements** – induces CCDR plans (e.g. 1921 reports)

Examples of Key System Technical Characteristics

These “technical” parameters may provide insight to the cost drivers when analyzed against various cost metrics including development and unit cost --

- **Aircraft:** Aircraft empty weight; weight by material type, structure/electronics weight; length; volume, wingspan; wing area; wing loading; combat weight; maximum gross weight; payload weight; internal fuel capacity; useful load; maximum speed (knots at sea level (SL)/maximum altitude); combat ceiling; combat speed; wetted area. Additionally, parametric cost analysts would use weight by Work Breakdown Structure (WBS) to define subsystem costs. For other systems like helicopters, UAVs, etc. there may be other information that might be useful including number of rotor blades, type of vertical lift and primary technologies (e.g. Single Main Rotor, Tilt Rotor, X2, pusher prop), etc.
- **Engines:** Maximum thrust at sea level; specific fuel consumption; dry weight; turbine inlet temperature at maximum value and maximum continuous value; maximum airflow.
- **Missiles:** Weight, length, width, height, type propulsion, payload, range, sensor characteristics (e.g., millimeter wavelength(s) for MMW sensors).
- **Ships:** Length overall (LOA) (ft); maximum beam (ft); displacement (full) (T); draft (full load) (ft) [Note appendages, such as sonar dome]; propulsion type (nuclear, gas turbine, conventional steam, etc.); number of screws; shaft horsepower (SHP) (HP); lift capacity (troops, vehicles, (KSqFt), cargo (KCuFt), bulk fuel, (K Gal), LCAC, AAAV, VTOL L/L and VTOL M/S).
- **Tanks and Trucks:** Weight, length, width, height, engine horsepower, and payload (i.e., ammunition loads and tonnage ratings).
- **Data Automation/ADPE (Automatic Data Processing Equipment):** Type (mainframe, mini, micro); processor (MIPS, MPLOPS, MOPS, SPECMARKS); memory (size in megabytes); architecture (monolithic, distributed).

Examples of Key Electronics Characteristics

Electronic systems naturally require a view of different characteristics and attributes from structures to best represent the drivers of development, production and support costs. The CARD outlines many of the Electronics Characteristics and Performance Parameters that at are used to estimate costs in CERs and commercial cost models.

TYPE SYSTEM	PERFORMANCE MEASURES	TECHNOLOGY	OTHER
Radar	Output Power	MIMIC	Phased Array
	Range	TWT	Type Scan
	Resolution	VHSIC	Reliability
	Classification Capable	Stealth	Waveform
	Frequency	SOS, etc	Quantity
	Number Phase	Software	
	Shifters		
	Number of Elements		
Communications	Frequency	MIMIC	Tactical/Strategic
	Power	Antenna Type	Secure
	Number Channels	SOS, etc.	ANTI-Jam
	Interoperability	Stealth	User Community
	LPI	Software	Data/Voice
	Range/LOS/NLOS		

TYPE SYSTEM	PERFORMANCE MEASURES	TECHNOLOGY	OTHER
Satellite	Quantity	Size/Weight	Purpose
	Orbit	Launch Vehicle	Coverage
	Number of Users	Processors	Design Life
	Power	Bus	
	Waveform	Software	
EW	Classification Capable	MIMIC/TWT	Purpose
	Active/Passive	On/Off Board	Expendable
	Automatic/Manual	VHSIC	Installation
	Programmable	Integration	Platforms
	Power/Frequency	Stealth	
		Packaging	
		Software	

Predecessor Data

It's important to understand predecessor or "similar to" systems that may be the foundation for the new or modified design.

Many CERs and commercial cost models account for benefits of prior work impacting factors including percent new design, experience of design team, prior production quantity (learning), design and production commonality across programs, and reliability, maintainability and logistics support.

Often OEMs will have the detail level information and understanding of "commonality" (by weight or by drawing) that the government would not normally receive in their CDRL program reports received from the contractor --

System Designation and Name

Manpower Requirements
- Flight Crew Composition

Performance
- Speed (max)
- Speed (sustained)
- Range
- Payload

Configuration
- Key technologies (lifting mechanisms, materials by subsystem
- Weight (Airframe Unit)
- Weight (empty)
- Weight (gross)
- Dimensions
- Height
- Weight
- Length

Acquisition
- Unit Cost (Prototype/100th Prod. Unit)
- Number of Systems
- Acquire(d)
- Deploy(ed)
- Operating Concept
- No. of Equipped Deployable Units (sqd/companies)
- Average No. Systems/Unit
- Operating Hours or Miles/Year/System

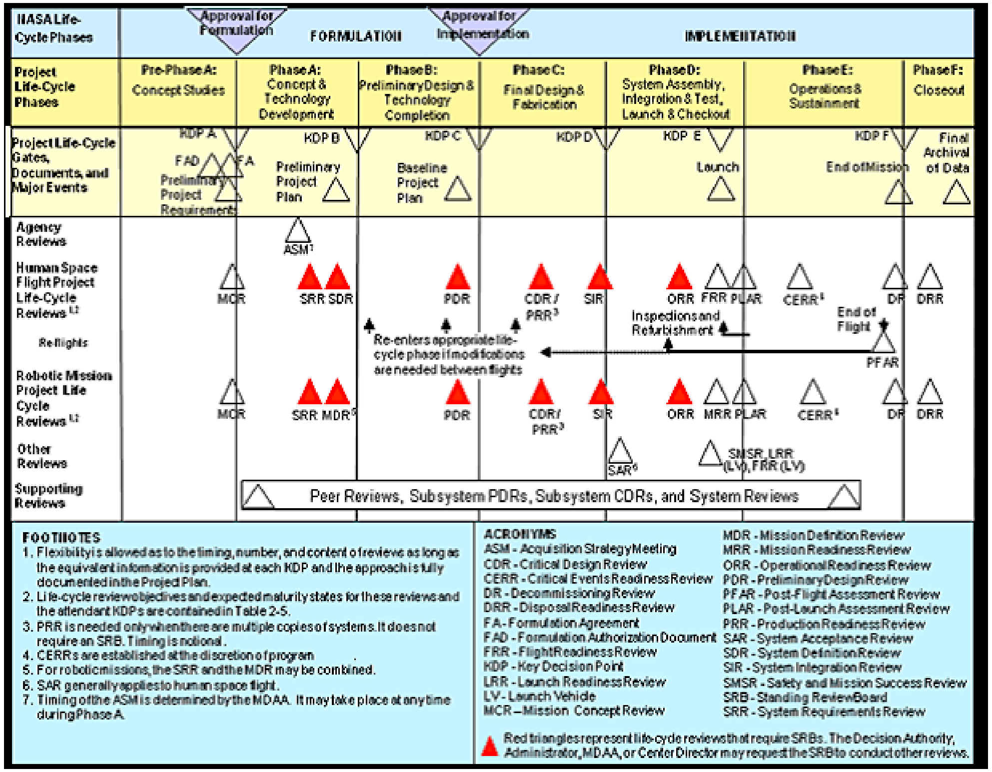
Maintenance Concept
- Interim Contractor Support
- Contractor Logistics Support
- In-House Support
- Number of Maintenance Levels

Performance Goals
- Operational Ready Rate (%)
- System Reliability (Mean Time Between Failures)
- Maintenance Manhours Per Flying/Operating Hour/Miles
- Major Overhaul Point (flying hrs/oper hrs/m/miles)

NASA's Cost Analysis Data Requirement (CADRe)

CADRe provides NASA estimators visibility to cost/schedule/technical/programmatic data, collected in a consistent and quality-enforced manner, for defendable estimating of current and future missions.

This three Part document is completed for each milestone {System Requirements Review (SRR), Preliminary Design Review (PDR), Critical Design Review (CDR), Systems Integration Review (SIR), Launch and End of Mission (EOM)} per Figure below, from the NASA Cost Estimating Handbook:



Part A, captures programmatics and narrative descriptions of significant changes .

Part B, follows an Excel template and describes technical parameters at spacecraft-bus and payload-instrument component levels, typically WBS-2 level.

Part C, also follows an Excel template and describes both project estimated and actual costs, to a WBS-2 or lower level.

Comparison of CARD to OEM Data Collection

While the objective of both government and OEMs is to develop a good preliminary estimate of proposed system costs, the focus and access to data for each group are somewhat different. For example:

- OEM focus is also primarily on the costs that they can control.
- Government teams have access to a broad set of similar programs not available to OEMs, but do not typically have data at levels below 4th level WBS that may better provide details that may better describe cost drivers in a system or subsystem.

From the perspective of the OEM, collecting and analyzing some of the characteristics that the government team requires in the CARD may provide a better understanding of government needs to meet higher level budget considerations.

Comparison of CARD to OEM Data Collection

The following provides a comparison between our current OEM data collection and those outlined in the CARD. This comparison may help to understand the differences in focus.

General Information

	In OEM	In CARD	Comments
WBS Number	Yes	Yes	OEMs may map parts to WBS
WBS Name/Description	Yes	Yes	
Alternate Name of System or Subsystem	Yes	Yes	
Part Number(s)	Yes	No	OEMs can evaluate part level costs not reported to government
Physical/Functional Description (brief descrip)	Sometimes	Yes at WBS level	Describes in general the purpose and technologies used for the part or system
If Purch - Supplier name	Yes	Yes	For subsystem – not in CARD or OEM summaries at part level.
Number of units per aircraft/assembly	Yes	No	Count of lower level parts (like rotor blades) per assembly is needed for cost evaluation and cost improvement curves
Names of Interfacing Units	Yes	Yes	For govt at system level only. OEMs may capture each level of integration
Weight of Unit (Structure)	Yes	Yes	Early design weights are parametric – mature designs are part based.
% Material Type	Yes	Yes	Available from technical mass properties data but not always captured for historical purposes – proposed CSDR report1921-T may help
Volume of Unit	No	No	May be helpful for electronics estimating— can usually be found in technical data. Cabin volume may be useful for high level CERs
WBS Weight (unit weight x # units per Aircraft/ assembly)	Yes	No	WBS weights are mapped by mass properties to the WBS standard – not generally provided to government teams
CAM Name/contact info	Yes	No	
Similar prior uses/ commonality	Not typically	Yes	Description at high level

Comparison of CARD to OEM Data Collection

Technical Information – Aircraft

Aircraft	In OEM	In CARD	Comments
Airframe unit weight (AUW)	Yes	Yes	
Breakdown of AUW by material type	Yes	Yes	
Empty weight	Yes	Yes	
Structure weight	Yes	Yes	
Common Weight or Drawing Count to prior program/product	Yes	No	Better understanding for cost impact on design and production
Length	Yes	Yes	
Wingspan	Yes	Yes	
Wing area	Yes	Yes	
Wing loading	Yes	Yes	
Combat weight	Yes	Yes	
Maximum gross weight	Yes	Yes	
Payload weight	Yes	Yes	
Internal fuel capacity	Yes	Yes	
Useful load	Yes	Yes	
Maximum speed (knots at sea level (SL)/maximum altitude)	Yes	Yes	
Combat ceiling	Yes	Yes	
Combat speed	Yes	Yes	
Wetted area.	Yes	Yes	

Comparison of CARD to OEM Data Collection

Technical Information – Engines

Engines	Yes	Yes	
Maximum thrust at sea level	Yes	Yes	
Specific fuel consumption	Yes	Yes	
Dry weight	Yes	Yes	
Turbine inlet temperature (degrees Rankine) at maximum value and maximum continuous value	Yes	Yes	
Maximum airflow	Yes	Yes	

Comparison of CARD to OEM data collection

Technical Information – Other Systems

Missiles: Weight, Length, Width, Height, type propulsion, Payload, Range, Sensor characteristics (e.g. millimeter wavelength(s) for MMW sensors).

Ships: Length overall (LOA) (ft); Maximum beam (ft); Displacement (full) (T); Draft (full load) (ft) [Note appendages, such as sonar dome]; Propulsion type (nuclear, gas turbine, conventional steam, etc.); Number of screws; shaft horsepower (SHP) (HP); Lift capacity (troops, vehicles, (KSqFt), cargo (KCuFt), bulk fuel, (K Gal), LCAC, AAAV, VTOL L/L and VTOL M/S)

Tanks and Trucks: Weight: Length; Width; Height; Engine horsepower; Payload (i.e., ammunition loads and tonnage ratings)

Software: Size, functional requirements, Product requirements, Application, Operating Environment, etc.

Conclusion

Whether aligning with DoD's CARD or NASA's CADRe (or both), the OEM has an opportunity to codify a structured data collection methodology that also solves for reporting compliance. It would stand to reason that redundant effort is eliminated if an OEM's data collection/mapping is designed up-front to satisfy both internal and external requirements.

Again, the value of standardized data collection is multi-fold. The OEMs have an opportunity to utilize the CARDs multi-dimensional views of programmatic, cost and technical data to standardize their cost analysis and modelling/calibration studies across comparable past projects.

There is government/industry support for the broader view that adds CARD/CADRe information to the OEM data set. It's clear from recent participation in government/ OEM Aviation Cost IPT meetings that new information (typically held by contractors) is being requested for new programs. These new reports using electronic "FlexFiles" and containing new data from 1921-T, Q, R and other reports provide additional detail as suggested in this paper.

Predecessor data

“Similar to” systems that may be the foundation for the new or modified design. Many CERs and commercial cost models account for benefits of prior work impacting factors including percent new design, experience of design team, prior production quantity (learning), design and production commonality across programs, and reliability, maintainability and logistics support. OEM/ contractors should ensure they include this information in their own data collection efforts that may extend beyond CARD guidance.

Examples of Predecessor or Reference System to Proposed System contained in CARD data

- System Designation and Name
- Manpower Requirements
  - Flight Crew Composition
- Performance
  - Speed (max)
  - Speed (sustained)
  - Range
  - Payload
- Configuration
  - Key technologies (lifting mechanisms, materials by subsystem
  - Weight (Airframe Unit)
  - Weight (empty)
  - Weight (gross)
  - Dimensions
  - Height
  - Weight
  - Length
- Acquisition
  - Unit Cost (Prototype/100th Prod. Unit)
  - Number of Systems
    - Acquire(d)
    - Deploy(ed)
  - Operating Concept
  - No. of Equipped Deployable Units (sqd/companies)
  - Average No. Systems/Unit
  - Operating Hours or Miles/Year/System
- Maintenance Concept
  - Interim Contractor Support
  - Contractor Logistics Support
  - In-House Support
  - Number of Maintenance Levels
- Performance Goals
  - Operational Ready Rate (%)
  - System Reliability (Mean Time Between Failures)
  - Maintenance Manhours Per Flying/Operating Hour/Miles
  - Major Overhaul Point (flying hrs/oper hrs/m/miles)