A CASE for estimate analytics at the enterprise level

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Miguel Aceves
SSC/AC FMCC

Joshua Angeo
SSC/AC FMCR

Introduction

Who we are

Space Systems Command (SSC)

Financial Management Cost & Earned Value Division (FMC)

Title: A **CASE** for estimate analytics at the enterprise level

CASE = Cost Analytics for SSC Estimates

Past SSC ICEAA workshop presentations

- 2023 Developing a Schedule Model From a Cost Modeler's Perspective
- 2022 Visual Exploration of Data – The Missing Element in CER Development
- 2021 USCM11: An Evolution of Techniques Used to Build Cost Models
- 2021 SatSim: Estimating Satellite Costs via Simulation
- 2018 A Probabilistic Method for Predicting Software Code Growth: 2018 Update
- 2018 Unmanned Space Vehicle Cost Model: Past to Present

Agenda

- Background
- A preview of CASE dashboards
- Development of CASE
- A few “case” studies
- Concluding thoughts

Description

CASE Tool - Provides users with a comprehensive analytical view of SSC program estimates

- Comprised of SSC Program estimates completed in 2017 to present day
- Various estimate types
- Provides on demand reporting for the latest approved program estimates and the impact they have on the SSC program portfolio

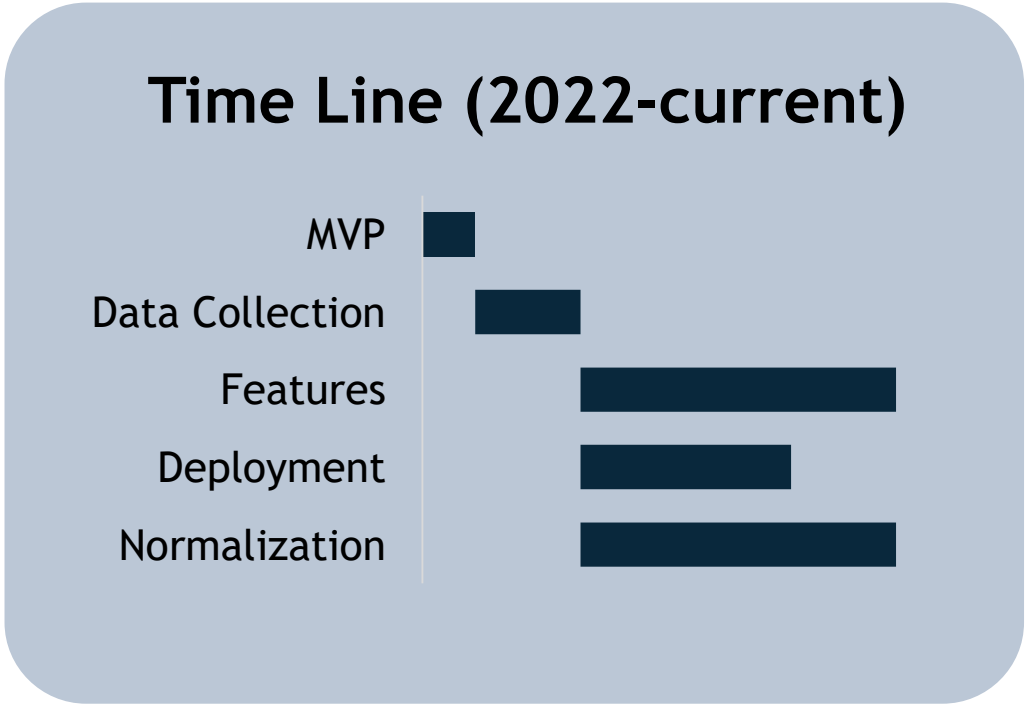
Python
Backend /
Data Pipeline

Users – SSC cost community to provide easy access to historical data and perform analysis on ad-hoc requests

PowerBI
Visualization
Platform

Background

- A central repository of historical approved SSC estimates is needed
- Developed tool that would allow for additional future growth and ease of use
- Initial objectives
  - Are our estimates improving over time?
  - What did this cost two years ago?
  - When was the last time we reviewed this estimate?
- Develop capabilities in an agile framework



Dashboard Overview

Dashboard Title	Category	Description
Current Status	Administrative	Tracks product development
Current Programs	Portfolio	High level overview of the current SSC program portfolio
Estimate Search	Portfolio	Searches for similarities among Keyword Inputs for program estimates
Estimate Frequency	Portfolio	Time series analysis of approved program estimates for SSC programs
Program Estimate History – Phasing	Programmatic	Compares selected program's estimates throughout each year submitted
Program Estimate History - WBS	Programmatic	Compares selected program's estimates throughout each year submitted focusing on the WBS level cost changes
Cost Metrics	Historical	Utilizes USCM, generates averages for SEIT/PM + SE and Hardware metrics for SSC mission areas
Schedule Metrics	Historical	Utilizing the schedule data, generates date averages

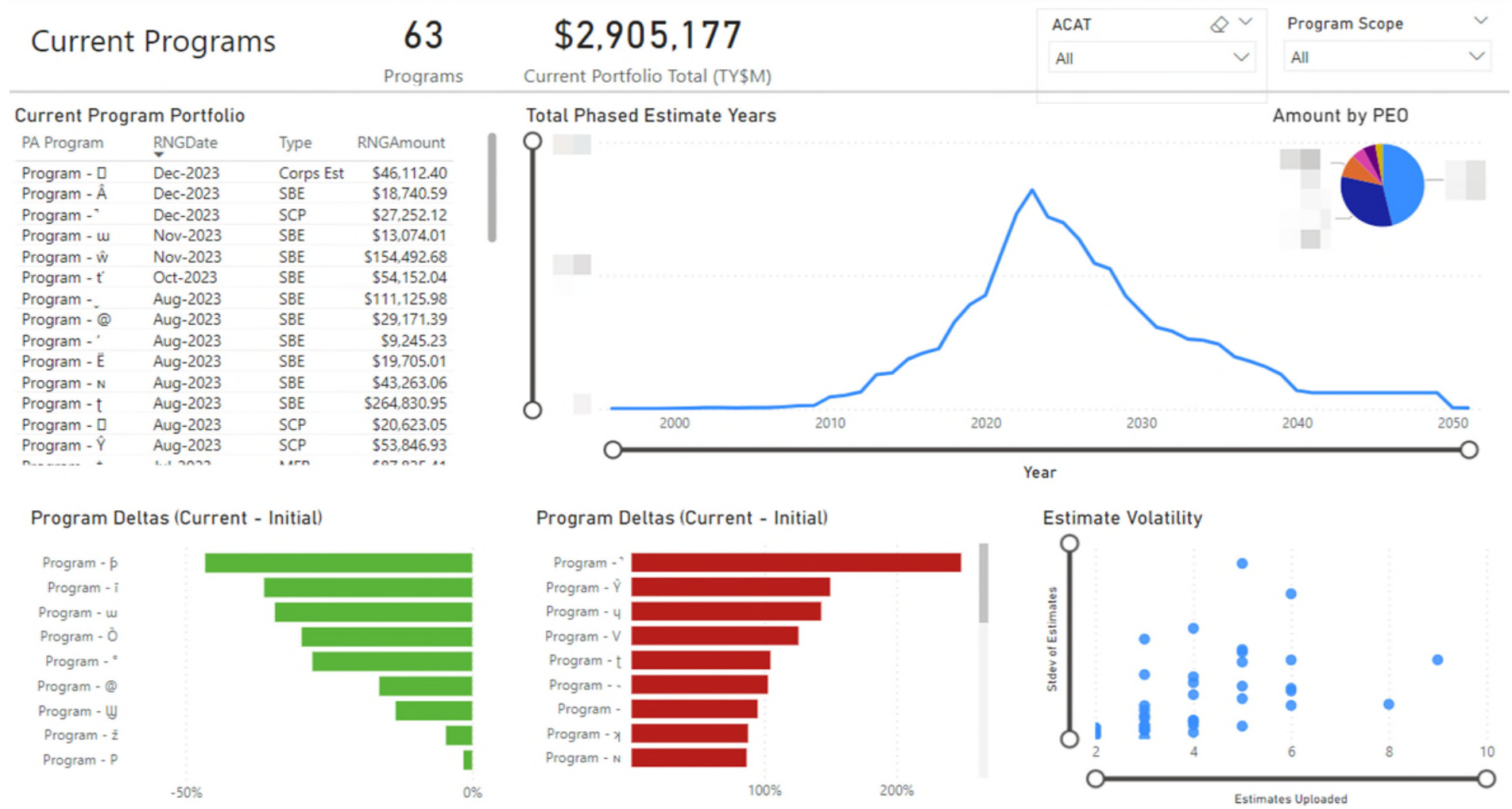
CASE currently comprises of eight different dashboards and continues to grow…

Dashboard 1: Current Programs

Quick access KPI and filter bar

Current SSC Program Portfolio

Program Health KPIs



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Dashboard 2: Prog. Est. History

Program Estimate History

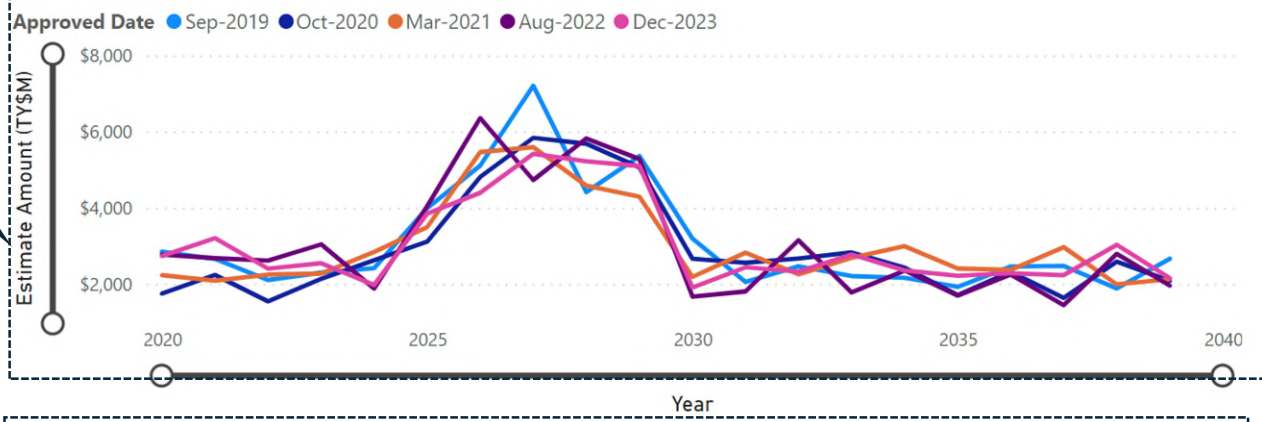
Program Example 1

Latest Approved Date	Current Total (TY$M)	Estimate History		
Dec-2023	$60,556.38 (+$437.98 +0.73%)	5	conf PEO	ACAT II ACAT
			Space/Ground Program Scope	SATCOM Mission Area

Program related KPIs

High-level estimate comparison

Phased Estimate Years



Estimate History

Approved Date	Estimate Type	Phasing Duration	Estimate Amount (TY$M)	Delta %
Dec-2023	SBE	19	$60,556.38	1%
Aug-2022	ICE	19	$60,118.40	0%
Mar-2021	SCP	19	$59,918.08	3%
Oct-2020	SBE	19	$58,276.77	-6%
Sep-2019	SBE	19	$61,896.95	

Qualitative Estimate Updates

Approved Date	Estimate Type	Annotations
Dec-2023	SBE	
Aug-2022	ICE	Added CLIN 4 to SBE
		Award fee rephased based on latest award fee plan
		Decrease in witholds due to 9% withold applied to smaller base
		Fee based on negotiated award fee, as of Feb 2017
		Implementation of SRA impacts
		O&S is not included
		OGCs increased due to new requirements and schedule extension
		PoP extended by five years, now ending in FY32

MAR Milestones

Date	Schedule Title
Nov-2021	Payload 4 Ready to Ship
Feb-2021	Required Assets Available
Dec-2020	Equipment Fielding Completion
Aug-2020	Date Funds First Obligated
Dec-2019	Equipment Fielding Complete
Jun-2019	Acquisition Program Baseline
Dec-2018	Acquisition Strategy Approved
Dec-2018	MTA Designation Date
Sep-2018	RAA Milestone
Jul-2018	RAA Milestone
Sep-2017	DT&E Completion for Single String

MAR Schedule data, adding more context to estimates

All data shown is notional

CASE Workflow

Enables

Estimate Costs

Non-Standard Data & Filtering

Enhanced Capabilities

Estimate Data

Estimate Files
- POST reports
- POM Smartsheets
- PDFs
- …

Analyst Data Validation

Meta Data

- ACAT levels
- Program Executive Offices
- Program IDs
- Annotations

Other Data Sources

- USCM
- Schedule data
- MAR
- …

- ETL
- Program POST Report Flat File
- Database
- …

python

DAX

- Data transformations, linking tables, schemas, etc.
- Build dashboards
- Upload to server

Power BI

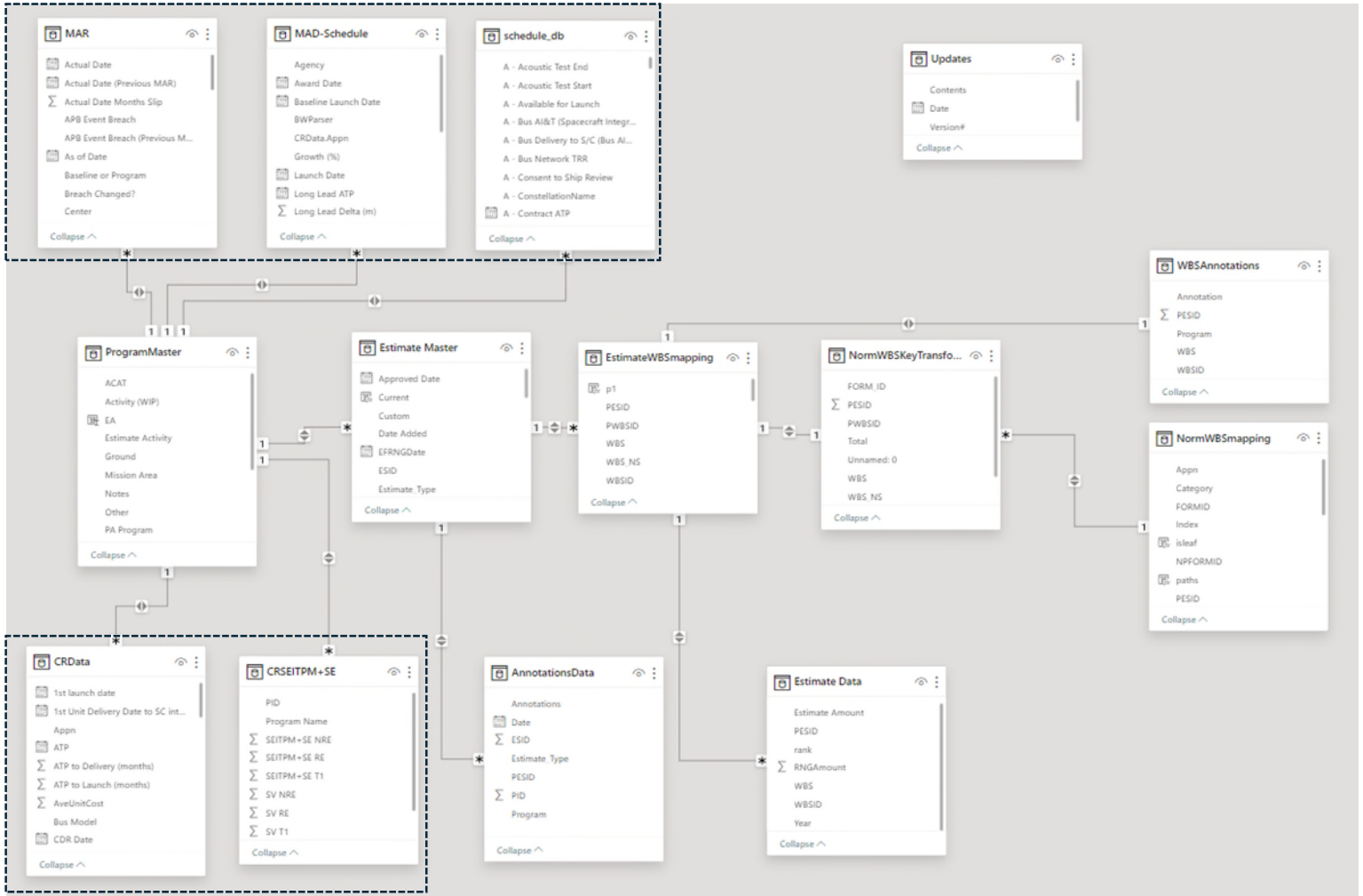
CASE Tool python code summary

- Designed to process a variety of estimate files, not specific to the POST Report
- Lowest level WBS costs available for the estimate
- Maps every estimate's WBS according to parent and children rows

Power BI Schema Design

Schedule Data Sources

Cost Data Sources

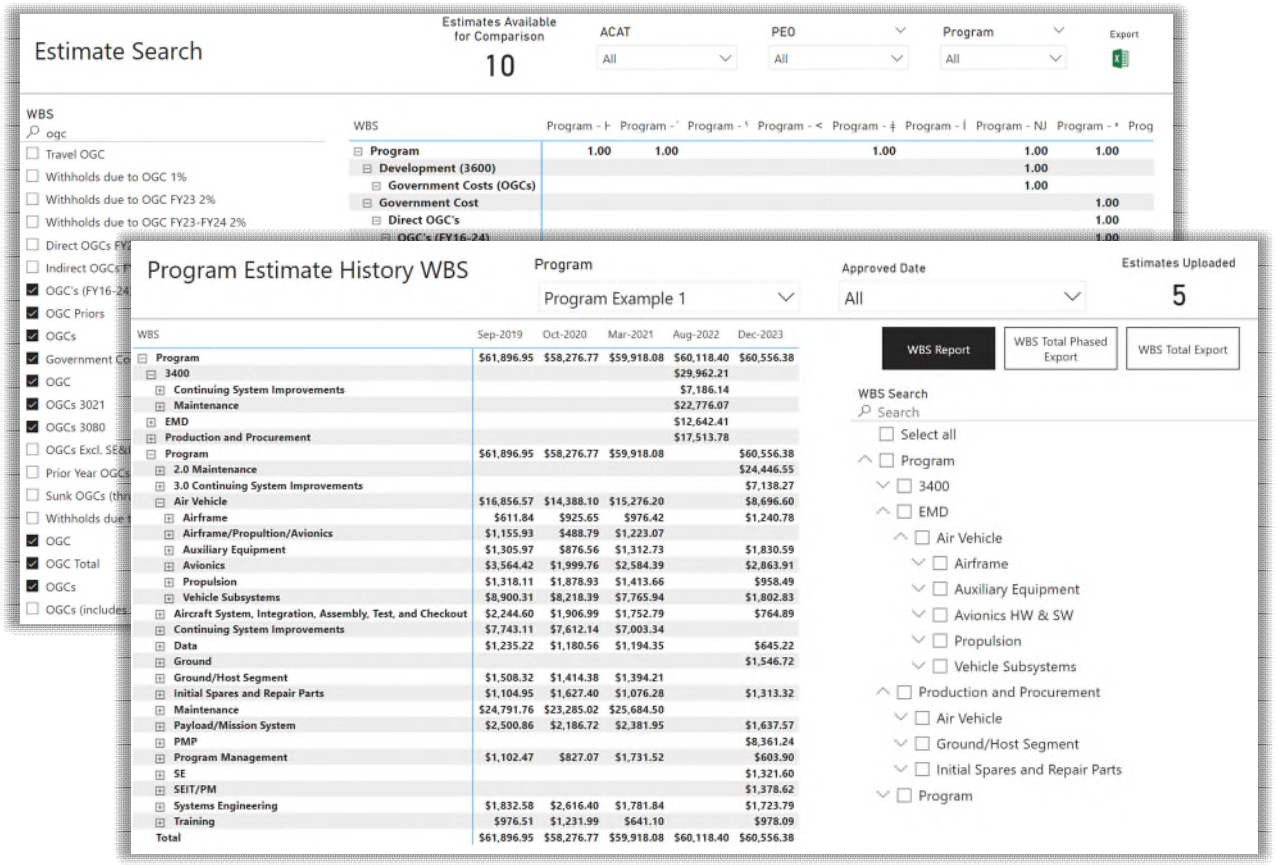


- Relates multiple data sources together (i.e. Program estimate and schedule data)
- Computes WBS hierarchy mapping for cost breakout and analysis
- Scalable

“CASE” Studies (i.e. deep dive topics, not actually case studies)

1. Estimate Search
2. Estimate Normalization
3. Estimate Frequency

CASE Study 1: Estimate Search



Search is a power feature that enables CASE to identify WBS elements…

- Within a program's estimate life cycle
- Across all programs in the portfolio

Leverages the entire POST report to produce program cost estimate dashboards

What we get: set of interactive cost dashboards that allow the user to specify costs/WBS areas of interest

All data shown is notional

CASE Study 1: Search – Program

Program Estimate History WBS

Program: Program Example 1

Approved Date: All

Estimates Uploaded: 5

WBS Report | WBS Total Phased Export | WBS Total Export

Multiple versions of exports to suit analysis needs

Interactive WBS, expand and minimize areas of focus

WBS	Sep-2019	Oct-2020	Mar-2021	Aug-2022	Dec-2023
Program	$61,896.95	$58,276.77	$59,918.08	$60,118.40	$60,556.38
3400				$29,962.21	
Continuing System Improvements				$7,186.14	
Maintenance				$22,776.07	
EMD				$12,642.41	
Production and Procurement				$17,513.78	
Program	$61,896.95	$58,276.77	$59,918.08		$60,556.38
2.0 Maintenance					$24,446.55
3.0 Continuing System Improvements					$7,138.27
Air Vehicle	$16,856.57	$14,388.10	$15,276.20		$8,696.60
Airframe	$611.84	$925.65	$976.42		$1,240.78
Airframe/Propultion/Avionics	$1,155.93	$488.79	$1,223.07		
Auxiliary Equipment	$1,305.97	$876.56	$1,312.73		$1,830.59
Avionics	$3,564.42	$1,999.76	$2,584.39		$2,863.91
Propulsion	$1,318.11	$1,878.93	$1,413.66		$958.49
Vehicle Subsystems	$8,900.31	$8,218.39	$7,765.94		$1,802.83
Aircraft System, Integration, Assembly, Test, and Checkout	$2,244.60	$1,906.99	$1,752.79		$764.89
Continuing System Improvements	$7,743.11	$7,612.14	$7,003.34		
Data	$1,235.22	$1,180.56	$1,194.35		$645.22
Ground					$1,546.72
Ground/Host Segment	$1,508.32	$1,414.38	$1,394.21		
Initial Spares and Repair Parts	$1,104.95	$1,627.40	$1,076.28		$1,313.32
Maintenance	$24,791.76	$23,285.02	$25,684.50		
Payload/Mission System	$2,500.86	$2,186.72	$2,381.95		$1,637.57
PMP					$8,361.24
Program Management	$1,102.47	$827.07	$1,731.52		$603.90
SE					$1,321.60
SEIT/PM					$1,378.62
Systems Engineering	$1,832.58	$2,616.40	$1,781.84		$1,723.79
Training	$976.51	$1,231.99	$641.10		$978.09
Total	$61,896.95	$58,276.77	$59,918.08	$60,118.40	$60,556.38

WBS Search

Search

- Select all
- Program
  - 3400
  - EMD
    - Air Vehicle
      - Airframe
      - Auxiliary Equipment
      - Avionics HW & SW
      - Propulsion
      - Vehicle Subsystems
    - Production and Procurement
      - Air Vehicle
      - Ground/Host Segment
      - Initial Spares and Repair Parts
  - Program

User defined WBS search parameter

Estimate search allows analysts more time analyzing data than finding data

All data shown is notional

CASE Study 1: Search - Portfolio

Estimate Search

Estimates Available for Comparison: 10

ACAT: All

PEO: All

Program: All

Export

Compare costs user specified categories

WBS

ogc

- [ ] Travel OGC
- [ ] Withholds due to OGC 1%
- [ ] Withholds due to OGC FY23 2%
- [ ] Withholds due to OGC FY23-FY24 2%
- [ ] Direct OGCs FY22-23 (PCOC)
- [ ] Indirect OGCs FY22-23 (PCOC)
- [x] OGC's (FY16-24)
- [x] OGC Priors
- [x] OGCs
- [x] Government Costs (OGCs)
- [x] OGC
- [x] OGCs 3021
- [x] OGCs 3080
- [ ] OGCs Excl. SE&I
- [ ] Prior Year OGCs
- [ ] Sunk OGCs (thru FY21; inferred)
- [ ] Withholds due to OGCs (withholds on FY19+ only ...
- [x] OGC
- [x] OGC Total
- [x] OGCs
- [ ] OGCs (includes SNOPC)

WBS	Program - Ⱶ	Program - ˆ	Program - ˁ	Program - <	Program - ‡	Program - İ	Program - NJ	Program - ˮ	Prog
Program	1.00	1.00			1.00		1.00	1.00	
Development (3600)							1.00		
Government Costs (OGCs)							1.00		
Government Cost								1.00	
Direct OGC's								1.00	
OGC's (FY16-24)								1.00	
OGC					1.00				
OGC Total	1.00								
Production (3021)							1.00		
Government Costs (OGCs)							1.00		
Program		1.00							
OGCs and Withholds		1.00							
OGCs		1.00							
Total program			1.00	1.00		1.00			
OGCs			1.00						
OGC									
OGCs 3021			1.00						
OGCs 3080			1.00						
Total program				1.00		1.00			
OGC						1.00			
OGCs (RDTE)				1.00					
OGC Priors				1.00					
Total SCP									
OGCs									
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Challenges

- Estimate structure inconsistency
- PowerBi search capability is limited

All data shown is notional

CASE Study 2: Estimate Normalization

Why normalize?

- Normalization of estimates alleviates some of the issues with “search” but also creates new opportunities
- Enables cost metric comparison across all programs
- A common reporting structure is required for alignment with other data

Requirements

- Low (detailed) enough to provide insight into critical items
- Account for appropriations
- Quickly implementable
- Subject Matter Expert must review each estimate

~30%

complete as of April ‘23

4 Estimate WBSs developed

Commodity	Development	Procurement
Space	✓	✓
Ground	✓	✓

CASE Study 2: Estimate WBS's Developed

RDT&E

WBS	WBS Level
Total RDT&E	2
RDT&E	3
TMRR	3
Prototype	3
System of Systems	3
Non-Recurring Space Vehicle	3
NR Space Vehicle	4
SEITPM	4
Bus	4
Payload	4
Recurring Space Vehicle 1…3	3
RE Space Vehicle 1…3	4
SEITPM	4
Bus	4
Payload	4
LOOS	3
ECOs	3
Fee	3
Ground	3
Ground	4
SEITPM	4
ICS	3
OGCs	3
OGCs	4
Direct	4
Indirect	4
Withholds	4
Other	3

Space

Procurement

WBS	WBS Level
Total Procurement	2
Procurement	3
System of Systems	3
Recurring Space Vehicle	3
RE Space Vehicle	4
SEITPM	4
Bus	4
Payload	4
LOOS	3
ECOs	3
Fee	3
Ground	3
Ground	4
SEITPM	4
ICS	3
OGCs	3
OGCs	4
Direct	4
Indirect	4
Withholds	4
Other	3

Development WBS

Total Program	1
Total RDT&E	2
RDT&E	3
TMRR	3
Prototype	3
System of Systems	3
Ground	3
Ground	4
SEITPM	4
Hardware	4
Software	4
Operations Acceptance	4
Other	4
Fee	3
ECOs	3
ICS	3
OGCs	3
OGC - NoBin	4
OGC - InDi	4
Direct	4
Indirect	4
Withholds	4
Other	3

Ground

Procurement and O&S WBS

Total Procurement	2
Procurement	3
System of Systems	3
Ground	3
Ground	4
SEITPM	4
Hardware	4
Software	4
Operations Acceptance	4
Other	4
Fee	3
ECOs	3
ICS	3
OGCs	3
OGC - NoBin	4
OGC - InDi	4
Direct	4
Indirect	4
Withholds	4
Other	3
Total O&S	2
O&S	3

CASE Study 2: Power BI Output

Pre-Normalized Estimate

WBS	Mar-2021	Aug-2022	Dec-2023
Dodo Drone Aircraft System			**$59,750.46**
Dodo Drone Engineering, Manufacturing & Development			**$12,301.24**
Systems Engineering			**$1,511.42**
Program Management			**$1,186.23**
Payload/Mission System			**$1,900.12**
Aircraft System, Integration, Assembly, Test, and Checkout			**$1,741.23**
Air Vehicle			**$5,962.23**
Vehicle Subsystems			$848.37
Propulsion			$1,559.74
Avionics			$1,519.26
Auxiliary Equipment			$827.55
Airframe			$1,207.32
Dodo Drone 3400			**$28,278.84**
Dodo Drone (DDD) Production & Deployment			**$19,170.37**
Dodo Drone (DDD) Aircraft System	**$57,447.18**	**$57,172.25**	
Production and Procurement		**$16,906.21**	
EMD		**$10,750.87**	
Dodo Drone (DDD) Production & Deployment	**$16,458.84**		
Dodo Drone (DDD) Operations & Support (O&S)	**$29,718.55**		
Dodo Drone (DDD) Engineering, Manufacturing & Development (EMD)	**$11,269.79**		
3400		**$29,515.18**	
Total	**$57,447.18**	**$57,172.25**	**$59,750.46**

Normalized Estimate

WBS	Mar-2021	Aug-2022	Dec-2023
Total Program	**$57,447.18**	**$56,181.34**	**$59,750.46**
Total RDT&E	**$11,269.79**	**$10,750.87**	**$12,301.24**
System of Systems	$2,120.54	$2,056.62	$3,252.65
Recurring Space Vehicle 2	$864.02	$977.91	$827.55
Recurring Space Vehicle 1	$4,276.03	$3,430.08	$3,419.37
OGCs	$645.78	$1,483.78	$1,186.23
Non-Recurring	$3,363.42	$2,802.48	$3,615.42
Total Procurement	**$16,458.84**	**$15,915.30**	**$19,170.37**
System of Systems	$2,524.44	$2,752.71	$3,326.93
Recurring	$1,051.09		$1,054.38
Non-Recurring	$9,604.83	$8,945.02	$10,244.01
ICS	$849.23	$1,315.86	$1,089.38
Ground	$1,532.20	$2,160.17	$2,366.58
ECOs	$897.05	$741.54	$1,089.09
Total O&S	**$29,718.55**	**$29,515.18**	**$28,278.84**
O&S	$29,718.55	$29,515.18	$28,278.84
Total	**$57,447.18**	**$56,181.34**	**$59,750.46**

Features

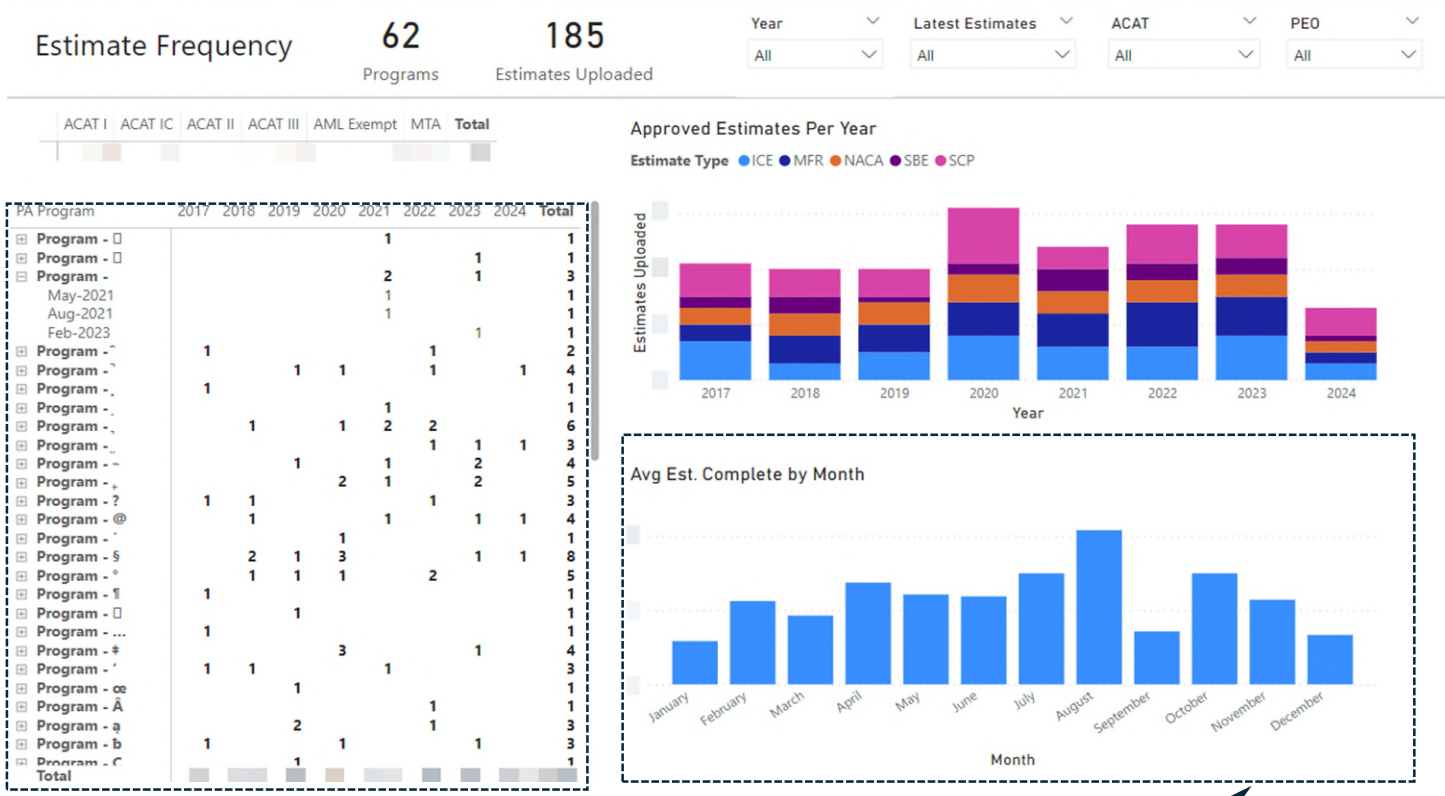
- Retain estimate WBS interactivity
- Every estimate type can utilize this WBS
- Allows for cost comparisons across many categories e.g. program scope and ACAT Level.

All data shown is notional

CASE Study 3: Estimate Frequency

CASE is more than estimate costs!

- Dashboard was originally not in MVP scope
- Leveraged approved estimate dates already in CASE
- Producing time series analysis for SSC Program estimates



Identify programs w/ upcoming estimates

Highlights FM Cost team workload per month

All data shown is notional

Lessons Learned

- Aggregating every estimate needs to address a variety of file formats and estimate structure inconsistency.
- Estimates alone are insufficient, need meta data to make analysis useful.
- Python and PowerBI DAX each have their strengths and weaknesses.
- Despite automation, data needs to be independently reviewed.

Beyond Tracking Estimates

Mission Area Dashboards
Tracks a variety of cost and schedule categories

PowerBI Server
Development vs Production comes into play…

Normalization
Necessary first step prior to add'l functionality

Integrating Budget
The most important view for decision makers

Reviewing Estimates
Leverage vast FM estimating team experience for insight

Integrating Research
Gateway for product and capability expansion

Conclusion

- Background coding well built, and streamlines import of estimate
- Dashboard provides valuable insight for user to focus in on history of a program's estimate through a variety of elements
- Proven to allow for quick and efficient resolution of ad-hoc requests
- Dashboard can continue to expand seamlessly for future efforts

Roadmap

- Incorporating cost research
- Comparing estimates against actuals
- Enhancing views for estimate evaluation
- Budget data

Acknowledgements

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