

ManTech's Distributed Integration Launch Assessment Approach

Tyler Peterson, M.S., PMP Lead Systems Architect



BLUF: ManTech-Accelerated Digital Engineering Process Technology

ManTech's prototype capability for Launch Enterprise

- MBSE (Model Based Systems Engineering) and MDAO (Multi-Disciplinary Analysis and Optimization)
 - Maximize Talent management in a workforce limited future
- Utilizes Agile methodologies to develop at the speed of relevance
 - Build a strong foundation for iterative growth towards mission integration, launch, and beyond
- Starts with Early Integration Studies (EIS)
 - Real-time adjustments and trade study results using less resources
 - Transition time and labor-intensive manual tools to automated workflows



BLUF: ManTech-ADEPT and Early Integration Studies

Mission Statement: Reduce 12-month process to a fraction of the time & cost

- Currently takes **3** years of planning & executing to procure & launch a satellite
 - One-third of this time is required to produce, prepare, and assess a launch vehicle's ability with thousands of hours of manual analysis and engineering trade studies
- MT-ADEPT develops a Digital Engineering Ecosystem that enables Launch Enterprise to assess safety & efficacy of launch vehicle and satellite compatibility
 - Incorporates off-the-shelf tools for an integrated source (digital thread & ASoT) of regulatory requirements and providers' physical characteristics (digital twin) in a secure cloud environment
- MT-ADEPT combats anticipated future Launch staffing and budget reductions
 - Enables rapid assessment of optimal launch vehicle and satellite configurations



Agenda

Digital Engineering

- Background
- What is it?
- How can we start?

Early Integration Studies (EIS): MT-ADEPT Solution

- Overarching Architecture
- Reference Model
- ModelCenter MBSE Instance Data Framework
- ModelCenter Cloud
 - ModelCenter Integrate and Explore
- User Profiles LV/PL and SV/Satellite

EIS MT-ADEPT Prototype

- LV/PL User:
 - Input, workflows, results
- SV/Satellite User
 - Input, workflows, results
- Executive User
 - Executive Dashboard
 - Launch Manifest



Digital Engineering

- Background
- What is it?
- How can we start?



Digital Engineering: Background

Culture shift has reached 'critical mass'

Momentum

Buy-in

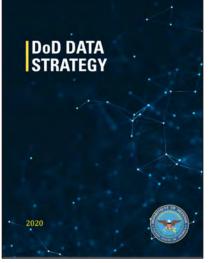
Path of Implementation



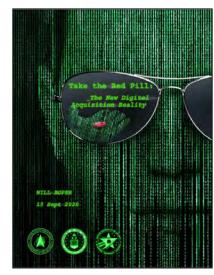
NDIA SE Conferences



DoD DE Strategy (2018)



DoD Data Strategy (2020)



The New Digital Acquisition Reality (2020)



Cloud Based -**Zero Trust Architecture**





Digital Engineering: What is it?

Definition:

"**integrated** digital approach that uses **authoritative sources** of system data and models as a continuum **across disciplines** to support lifecycle activities from **concept through disposal**"



DoD DE Strategy (2018)

Goal:

modernize how DoD "designs, develops, delivers, operates, and sustains systems"

Optimized Approach to Mission Integration:

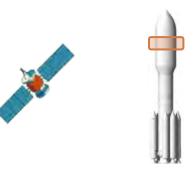
Document Supported Solution \rightarrow Model Based Systems Engineering (MBSE) Decentralized Information \rightarrow Network Centric Operations (Cloud)



Digital Engineering: How can we start?

Early Integration Studies (EIS)

- complex tests → highly automated and easily repeatable workflows
- uncomplicated viewable results





 Simple EIS Trajectory & Mission Design Analysis Coupled-Loads Analysis 	Standard EIS Draft ICD Launch Site CONOPS
Complex EIS • Integrated Thermal Analysis • Acoustic Analysis • EMI/EMC Analysis	 Contamination Analysis LV/PL Interface Analysis
Additional EIS Tasks • Vibration/Shock Analysis • Security Analysis • GN2 Purge Analysis	Other Special Studies Government Reviews Anomaly Resolution Mission Assurance Activities

Digital Engineering: How can we start?

Expand EIS Capabilities:

 assess compatibility of multi-payload mission sets

Executive Dashboard

PL Echo: Secondary PL Configurations

Secondary PL	Launch Vehicle ≑	Primary PL 🌲	Loads 🔷	Acoustics 🔷	Flight Design ≑	Thermal 🔷	Contamination 🔷
Echo	A	Alpha	•	•	•	•	•
Echo	A	Bravo	•	٠	•	۲	•
Echo	В	Alpha	•	٠	•	•	•
Echo	В	Bravo	•	٠	•	•	•
Echo	С	Alpha	•	٠	•	٠	•

Launch Verification Matrix Testing:

 tentative mission sets with refined system, big data, and machine learning

Potential Launch Manifest

Mission	Date	Launch Vehicle‡	Primary PL 👙	Secondary PL +	Hosted PL +	Status
Mission 1	2020-11-23	с	Payload Charlie	Payload Fox	Payload Hotel	٠
Mission 2	2021-01-02	А	Payload Zulu	Payload Sierra	Payload Bravo	٠
Mission 3	2021-01-18	D	Payload Dedicated			٠
Mission 4	2021-02-13	A	Payload Alpha	Payload Mike	Payload Oscar	٠
Mission 5	2021-3-28	E	Payload Delta	Payload Lima	Payload Juliet	



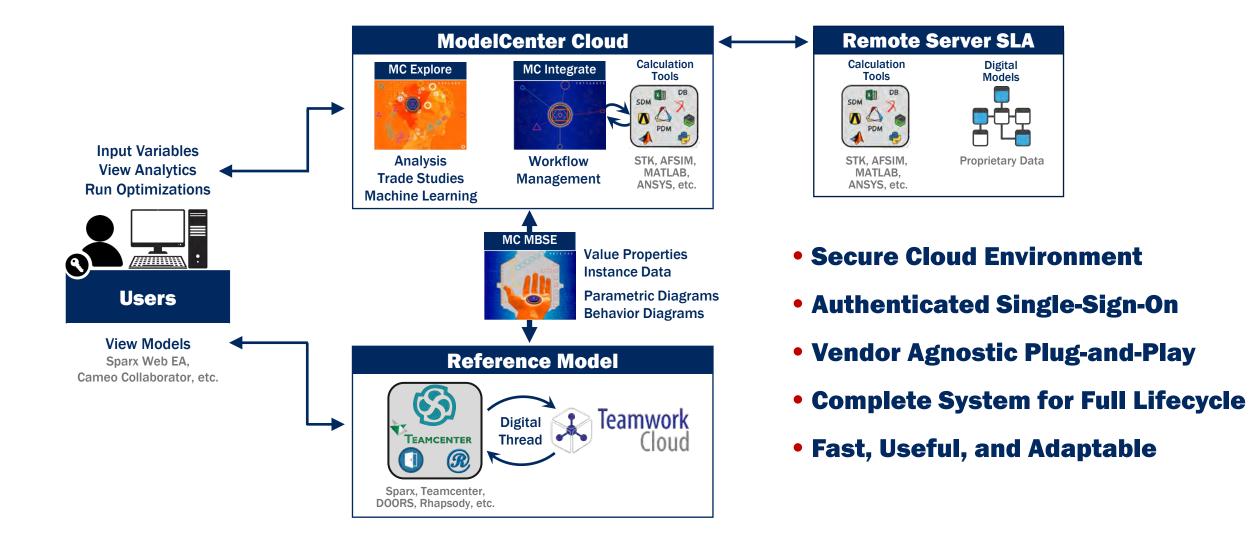
EIS: MT-ADEPT Solution

- Digital Engineering Ecosystem Architecture
- Reference Model
- ModelCenter Cloud
- User Profiles



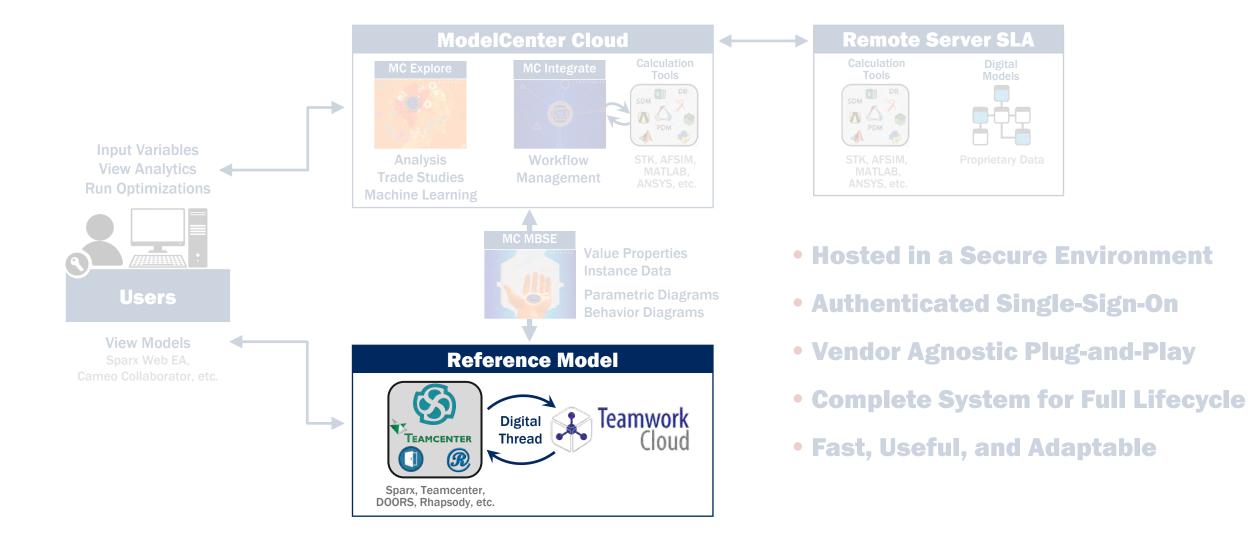


Digital Engineering Ecosystem Architecture





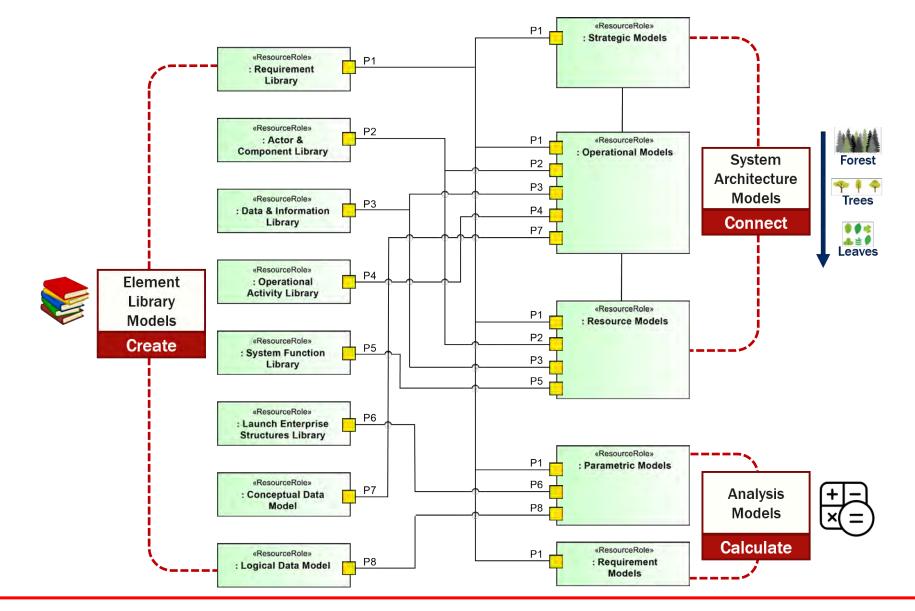
Digital Engineering Ecosystem Architecture

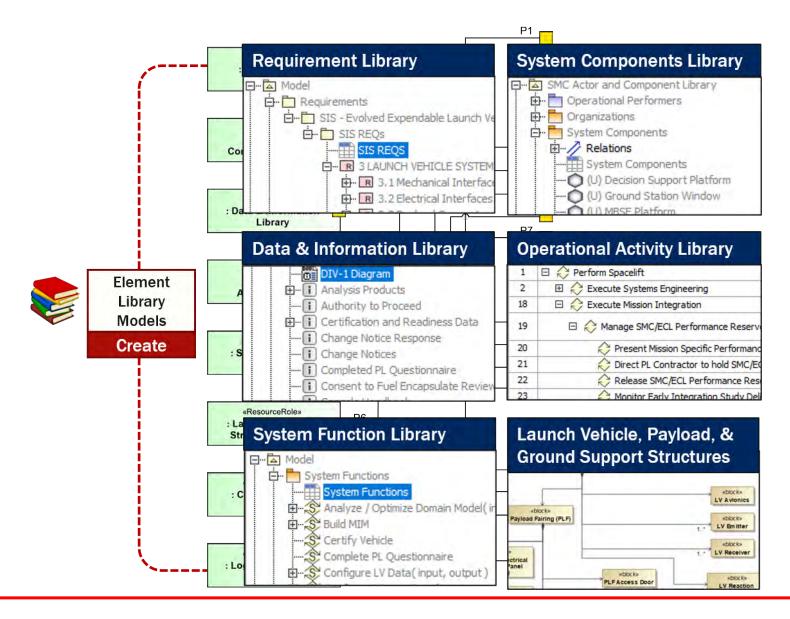


12

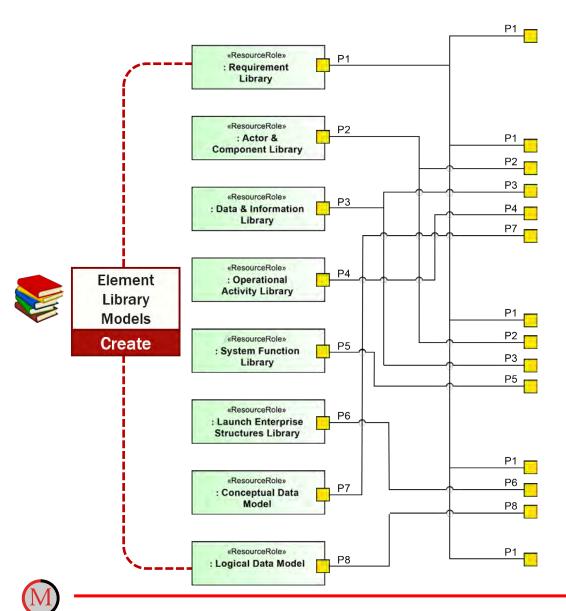
M





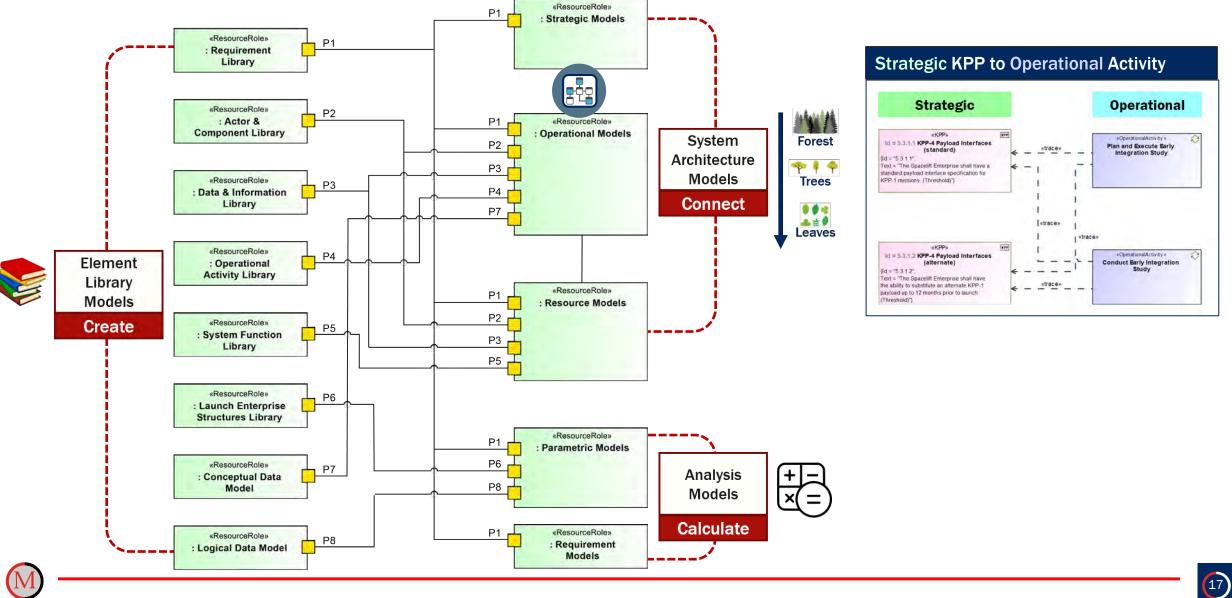


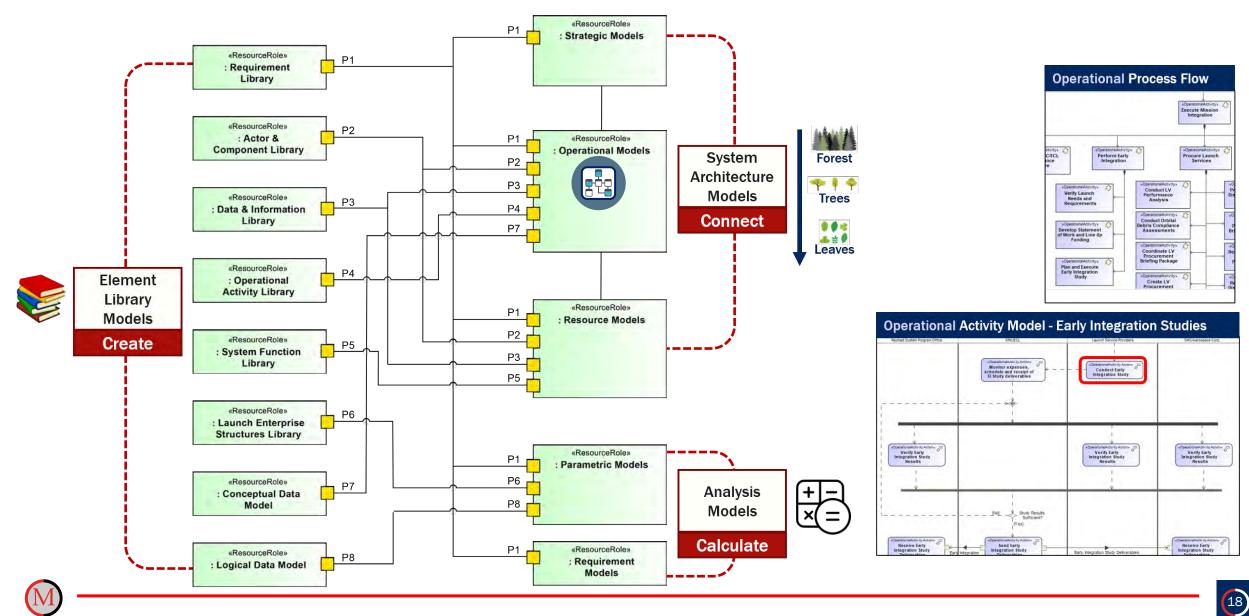


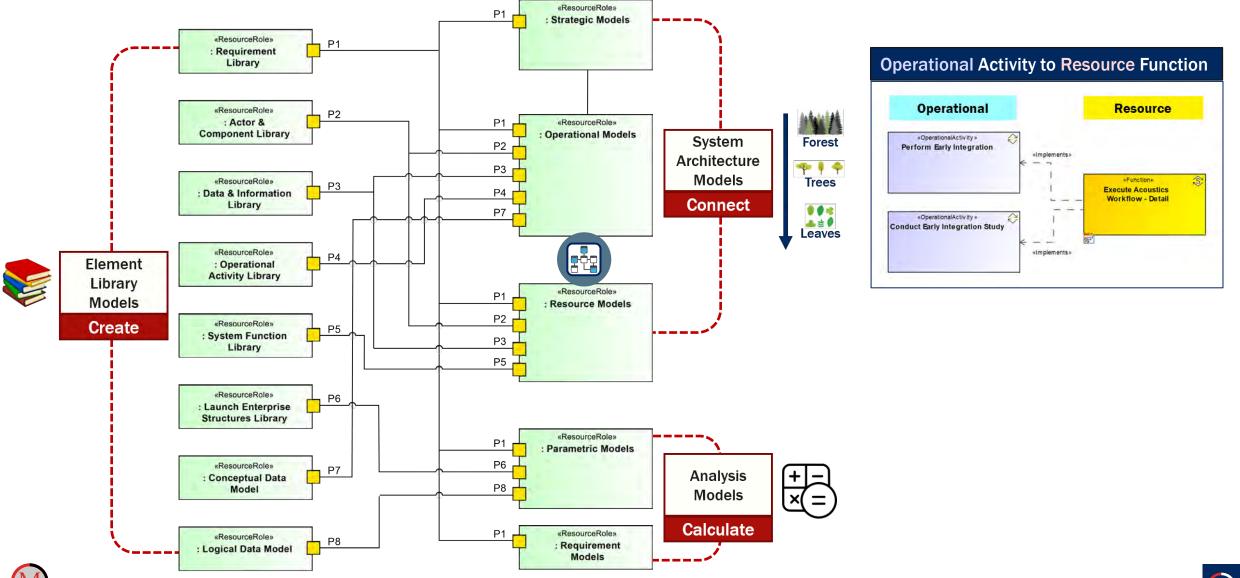


Strategic Process Flow «Capability» 0 0 C4 Data and ift Interface ns «Document Text Artifact» «Document (U) KPP-4: Payload (U) KSA-1 Interfaces «Document Text Artifact» (U) KSA-12: Payload Orientation «Document Text Artifact»

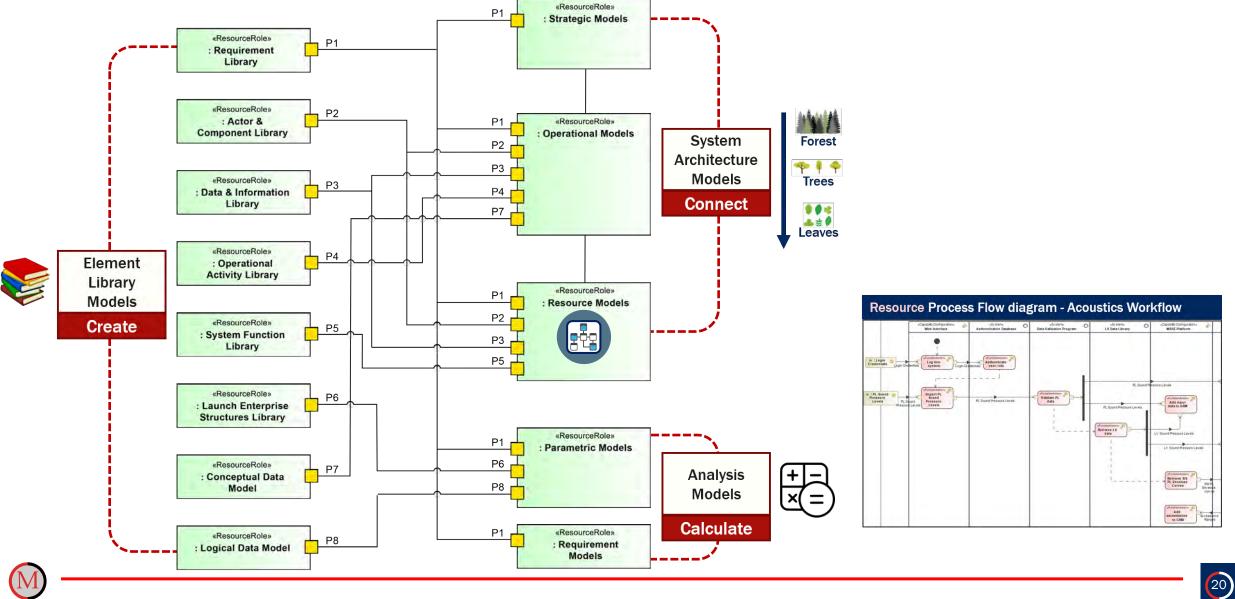


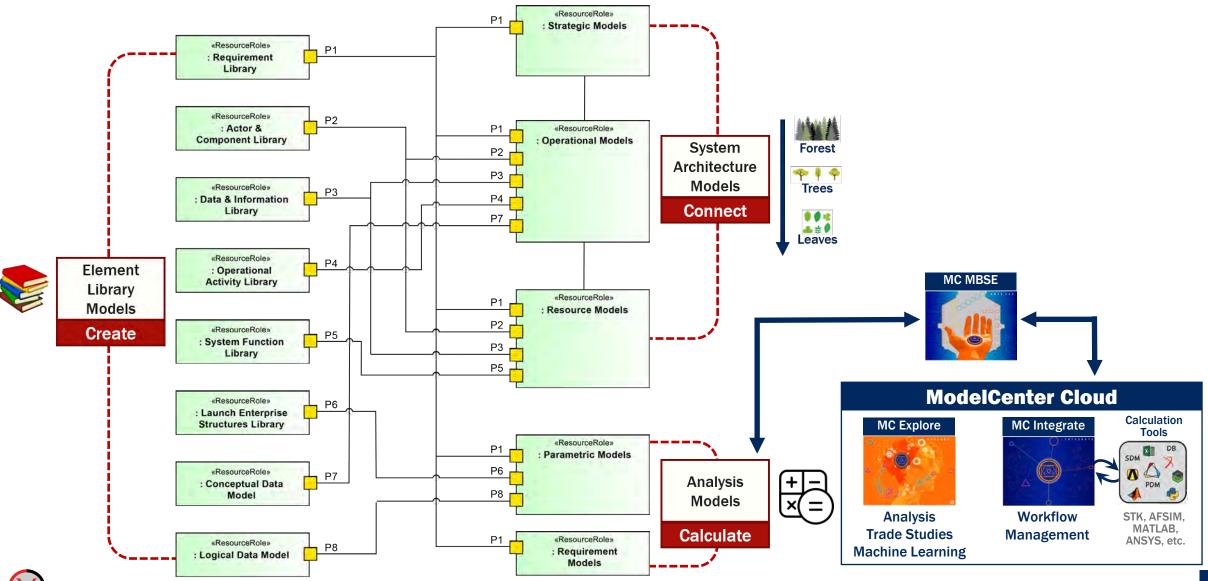


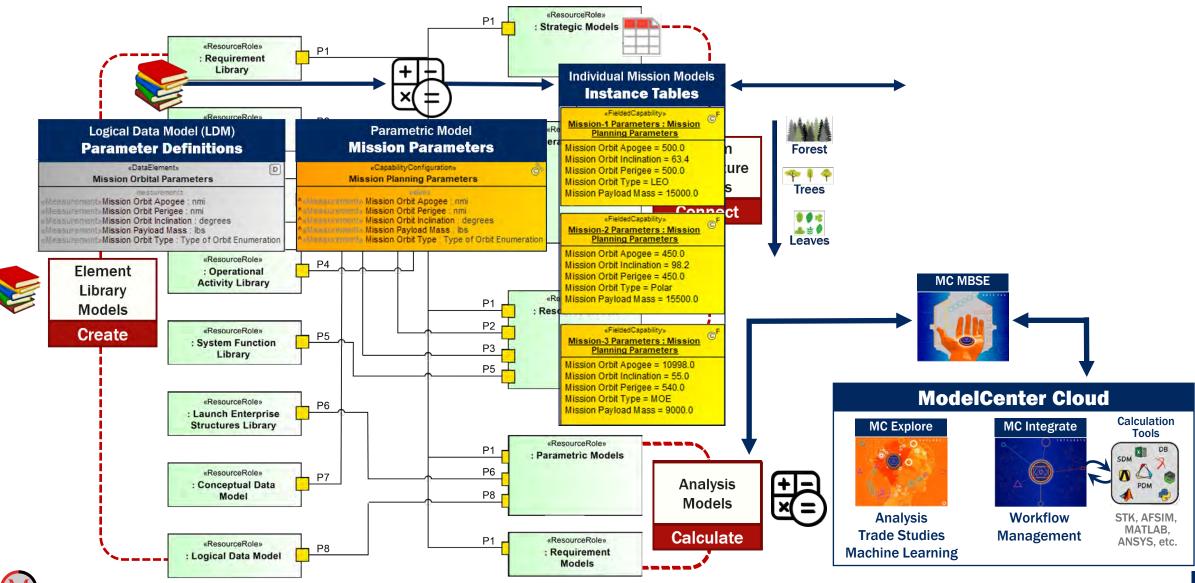




19







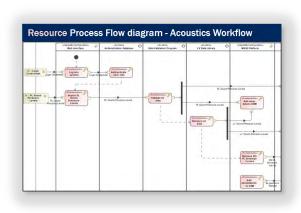
22

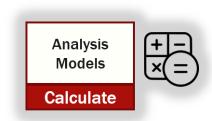
ReiterEnginetoidg Ecosystem Architecture



ModelCenter Cloud

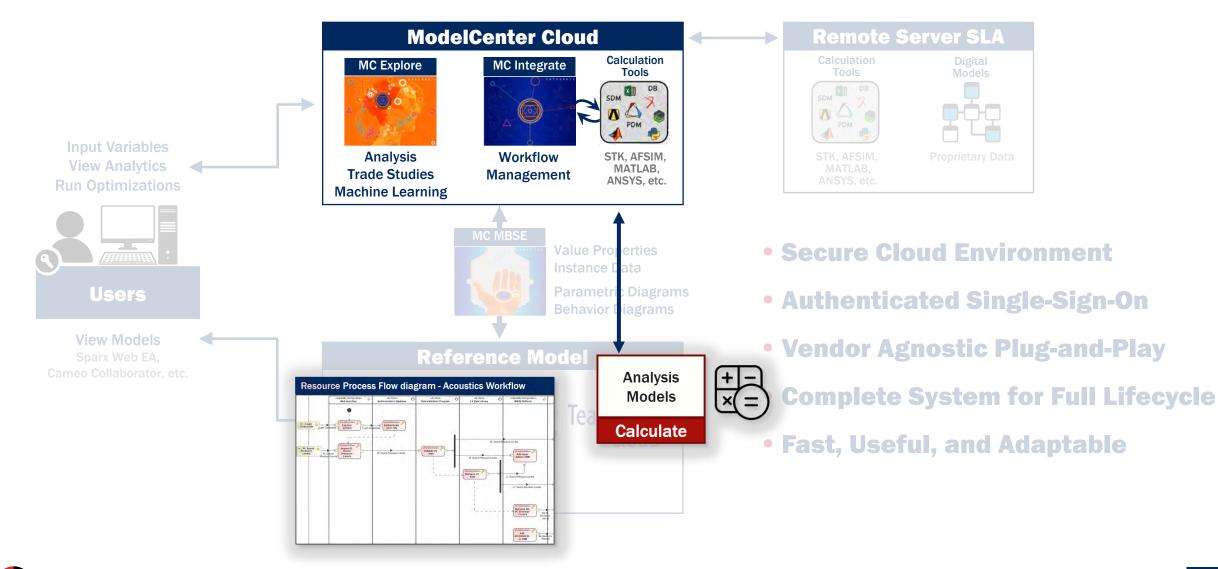






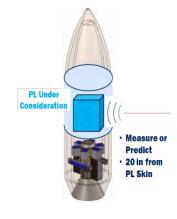


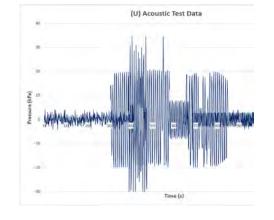
Digital Engineering Ecosystem Architecture





Acoustic Analysis Context





Data Capture

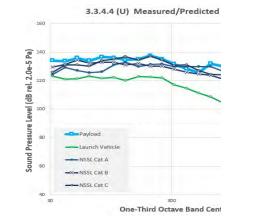


Assumptions

- P95/50 (95% Probability with 50% Confidence)
- PL shall be designed to tolerate the acoustic levels generated by LV
- From liftoff through SV separation
- Reference pressure 20 µPa

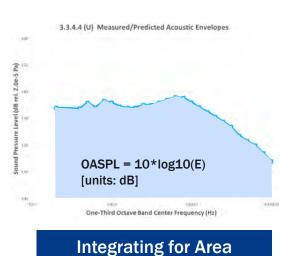
Workflow Steps

- **1.** Obtain V(t) [voltage time trace from microphone]
- 2. Calc p'(t) = mic.constant * V(t), where
 - p'(t) = pressure fluctuation
- 3. Normalize p'(t) using reference pressure 20 μ Pa
- 4. Calc S(f) using FFT, whereS(f) = spectrum of normalized p'(t)
- 5. Correct S(f) for mic response and atmospheric absorption



Threshold Crossing

Sound Pressure Level at each dB (SPL)



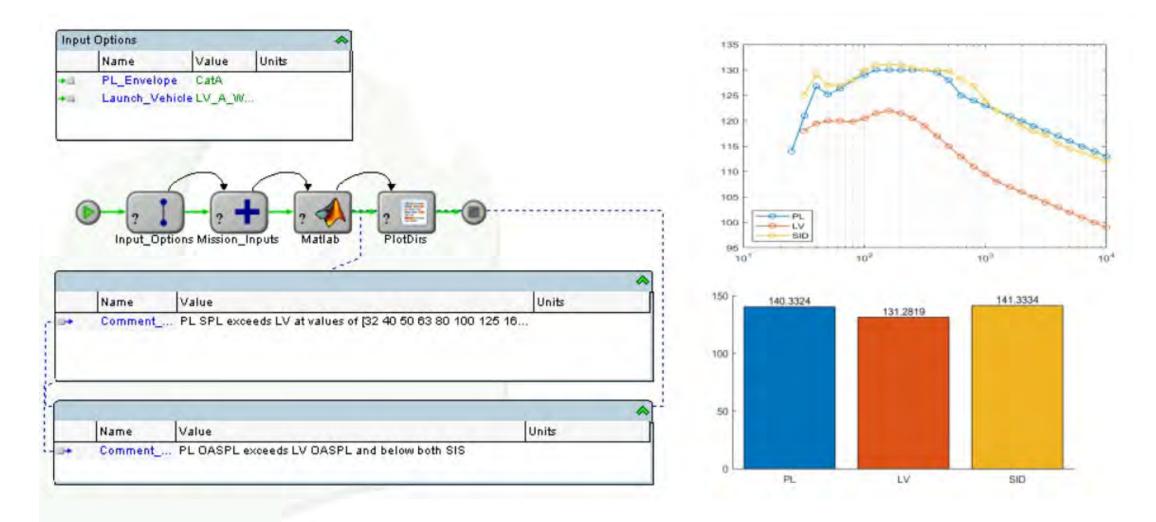
Overall Sound Pressure Level (OASPL)

- 6. Compute Sound Pressure Level (SPL) Spectrum SPL(f) = 10*log10(S(f)) [units: dB/Hz]
- 7. Compute Overall Sound Pressure Level (OASPL)

 $E = \int S(f) df$ [total energy contained in the spectrum]

- OASPL = 10*log10(E) [units: dB]
- 8. Identify SPL and OASPL exceedances

ModelCenter Integrate: Acoustics Analysis

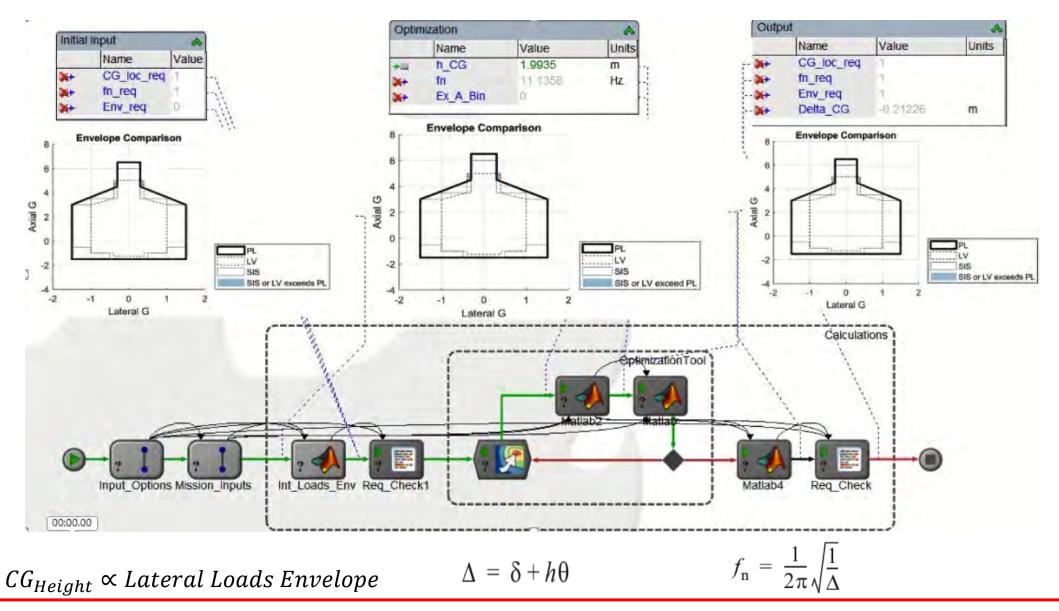


 $SPL(f) = 10 * \log 10(S(f))$

 $OASPL = 10 * \log 10 \left(\int S(f) \, df \right)$

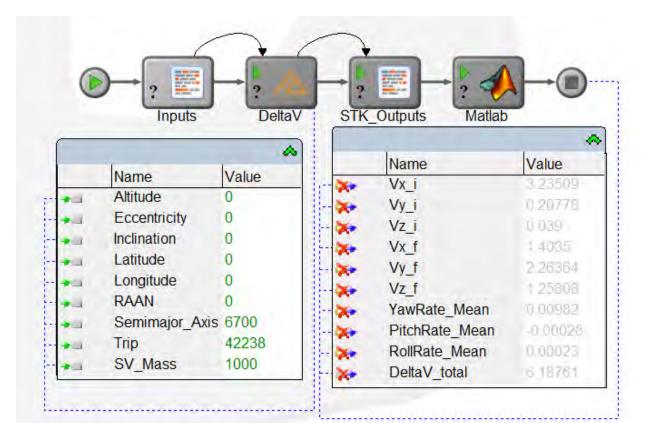


ModelCenter Explore: Load Factors Optimization





Modeling Tools: Flight Design

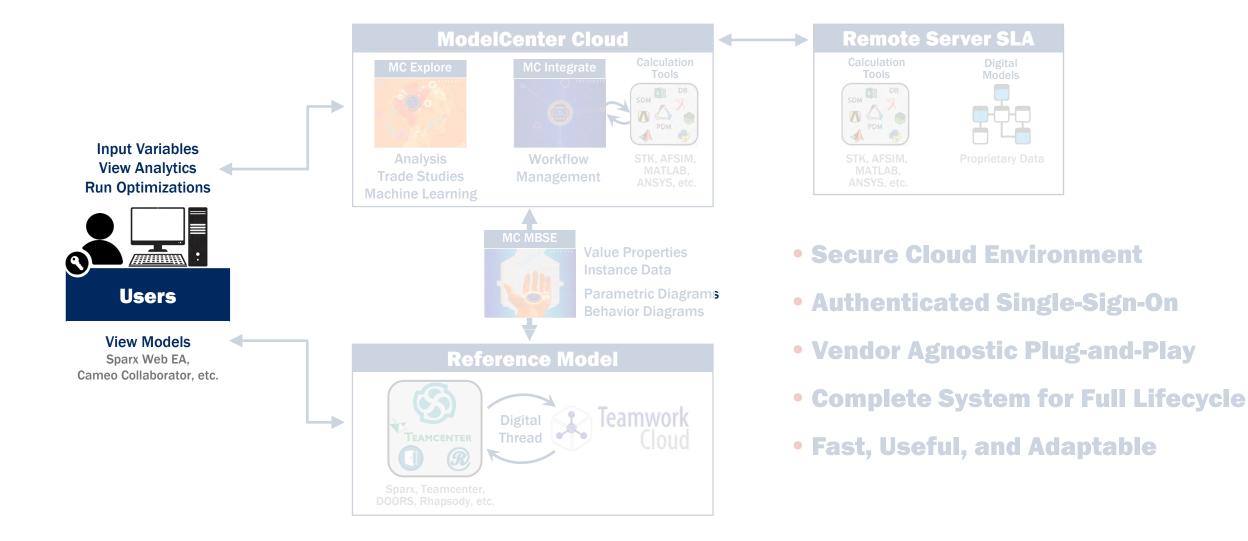


$$\Delta v = \int_{t_0}^{t_1} rac{|T(t)|}{m(t)} dt$$

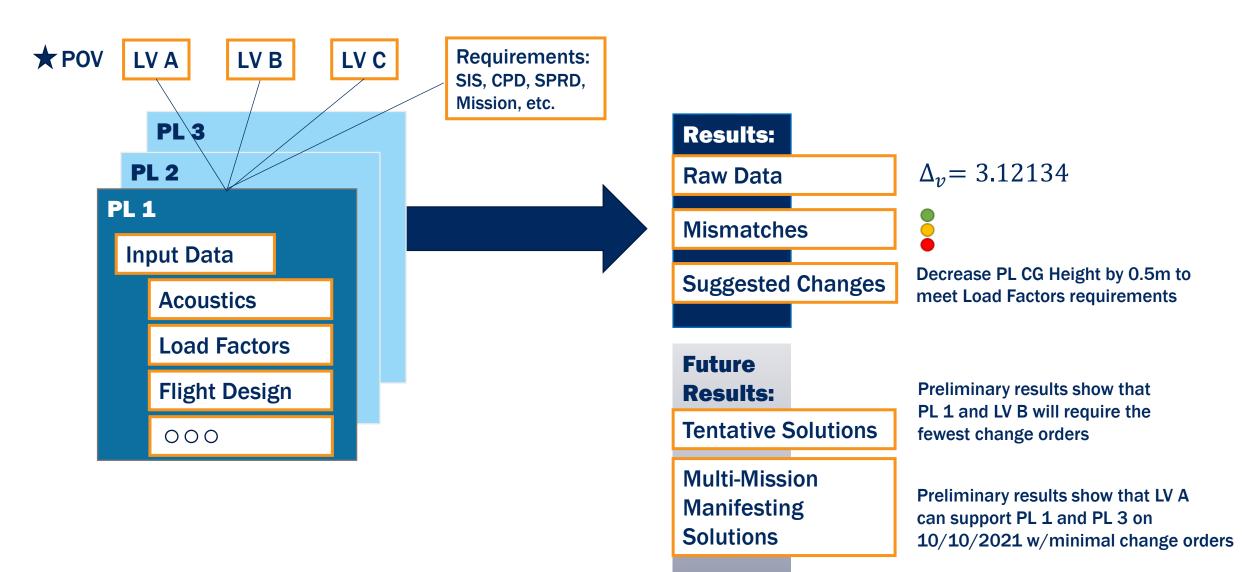
Subscher Strukturgen Subscher Strukturgen Subscher Strukturgen Subscher Strukturgen				
The WUTCD: 11 via 2029 1:123 22:00 Yun keyn 152:40 Yun keyn 152:40 Yun keyn 152:40 Yun keyn 25:53 Yun keyn Fen keyn 94:51 Yun keyn 152:40 Yun keyn 25:53 Yun keyn 25:53 Yun keyn 25:53 Yun keyn 26:60 Yun keyn 27:60 Yun keyn	LV Yaw Pitch Roll	COMPANY OF A COMPANY	LV LLA Position	
PICE (drg) 24457 401 (drg) 441 (drg)		9 18:15:02:000	Time (UTCG): 14 Jul 2	009 18:15:02.000
Rol (psp): 123.31 At ham 0000773 Sat2 LLA Position Sat2 Classical Othet Rements 0000770 Sat2 LLA Position Sat2 Classical Othet Rements Time (UTCG): 14.Jul 2009 18:15:02.000 Lat (seg): -005377 Sat2 Classical Othet Rements Time (UTCG): 14.Jul 2009 18:15:02.000 Lat (seg): -005373 Sat2 Classical Othet Rements Time (UTCG): 14.Jul 2009 18:15:02.000 Lat (seg): -005373 Sat2 Classical Othet Rements Time (UTCG): 14.Jul 2009 18:15:02.000 Lat (seg): -00533 Atte (deg): 28:43 Atte (deg): 28:43 Lon Rate (deg/sec): -006000 Atte (deg): 28:49 Time (UTCG): 19.Har 2021 20:02:11.100 Lat (seg): -29:400 SV LLA Position Time (UTCG): 10.Har 2021 20:02:11.100 Lat (seg): -29:400 SV (LA Position 19.985 Atte (deg/sec): -005377 Jat Rate (deg/sec): -0.03082 Vy (km/sec): -021.20:02:11.100 -021.20:02:11.100 Lat Rate (deg/sec): -0.03082 Vy (km/sec): -021.20:12:10 -020:20:12:10 Jat Rate (deg/sec): -0.03082 <th></th> <th></th> <th></th> <th></th>				
Unit Rate (dipperset): 0.000000 Sat2 Classical Othit Elements Sat2 Classical Othit Elements Time (UTCG): 14.0.00000 Sat2 Classical Othit Elements 11.0.00000 Seconting: 0.00000 All Rate (depsec): 0.00000 All Rate (depsec): 0.00000 All Rate (depsec): 0.00000 All Rate (depsec): 0.00000 Jun (deg): 17.9.800 SV LLA Position SV 20000 Position Velocity Time (UTCG): 10.4.0.0000 Lon (deg): -79.577 Jun (deg): -79.577				
Sat2 Sat2 Sat2 Classical Othe Biments Time (UTCG): 14 Jul 2009 15:15:02:00 Lat desj: -25:33 Lat desj: -25:33 Lat desj: -25:33 Lat desj: -0.553 Lat desj: -0.000000 Atte: (deg/sec): -0.000000 Lat (deg): -26:533 Lat (deg): -26:402 Lat deg): -27:577 Lon (Marce):	tron treats			
Sut2 Sat2 Sat2 <th< th=""><th></th><th></th><th></th><th></th></th<>				
Su2 LLA Position Su2 Classical Orbit Elements Time (UTCG): 14 Jul 2009 18:16:02.000 Lat (deg): 25.533 Att (deg): 0.002773 Lat (deg): 0.002070 All Rate (deg)sec:): 0.000000 Lon Rate (deg)sec:): 0.000000 Lat Rate (deg/sec:): 0.000001 Lat Rate (deg/sec:): 0.000001 <th></th> <th>station.</th> <th></th> <th>0.009777</th>		station.		0.009777
Su2 LLA Position Su2 Classical Orbit Elements Time (UTCG): 14 Jul 2009 18:16:02.000 Lat (deg): 25.533 Att (deg): 0.002773 Lat (deg): 0.002070 All Rate (deg)sec:): 0.000000 Lon Rate (deg)sec:): 0.000000 Lat Rate (deg/sec:): 0.000001 Lat Rate (deg/sec:): 0.000001 <th></th> <th></th> <th></th> <th></th>				
Su2 LLA Position Su2 Classical Orbit Elements Time (UTCG): 14 Jul 2009 18:16:02.000 Lat (deg): 25.533 Att (deg): 0.002773 Lat (deg): 0.002070 All Rate (deg)sec:): 0.000000 Lon Rate (deg)sec:): 0.000000 Lat Rate (deg/sec:): 0.000001 Lat Rate (deg/sec:): 0.000001 <th></th> <th></th> <th></th> <th></th>				
Sat2 LLA Position Time (UTCG): 14 Jul 2009 18:15:02.000 Lat (seg): 25.83 Lon (deg): 40.93373 Lat (Reg): 0.023773 Lat Rate (deg/sec): 0.00000 Att Rate (deg/sec): 0.00000 SV LLA Position SV 22080 Position Velocity Time (UTCG): 14 Jul 2009 18:15:02.000 SV LLA Position SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 SV LLA Position SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 SV LLA Position SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 SV LLA Position SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 Lat Rate (deg/sec): -0.003652 Vy (km/sec): -0.47400 Vy (km/sec		S	atz	
Sat2 LLA Position Time (UTCG): 14 Jul 2009 18:15:02.000 Lat (seg): 25.83 Lon (deg): 40.93373 Lat (Reg): 0.023773 Lat Rate (deg/sec): 0.00000 Att Rate (deg/sec): 0.00000 SV LLA Position SV 22080 Position Velocity Time (UTCG): 14 Jul 2009 18:15:02.000 SV LLA Position SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 SV LLA Position SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 SV LLA Position SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 SV LLA Position SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 Lat Rate (deg/sec): -0.003652 Vy (km/sec): -0.47400 Vy (km/sec				
Sat2 LLA Position Time (UTCG): 14 Jul 2009 18:15:02.000 Lat (deg): 22:583 Lon (deg): 40.633 Alt (km): 0.023773 Lan Rate (deg)sec): -0.000000 Alt Rate (deg)sec): 0.009777 Sy LLA Position SV 22668 Position Velocity Time (UTCG): 14 Jul 2009 18:15:02.000 Sy Lat Rate (deg)sec): -0.000000 Alt Rate (deg/sec): 0.009777 Sy LLA Position SV 22668 Position Velocity Time (UTCG): 14 Mar 2021 20:02:11.100 Sy LLA Position SV 22668 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.000 Sy LLA Position SV 22668 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.000 Sy Lat Rate (deg/sec): -0.003652 Vy (km/sec): -0.47400 Vy (km/sec): <			4 4	
Sat2 LLA Position Time (UTCG): 14 Jul 2009 18:15:02.000 Lat (deg): 22:583 Lon (deg): 40.633 Alt (km): 0.023773 Lan Rate (deg)sec): -0.000000 Alt Rate (deg)sec): 0.009777 Sy LLA Position SV 22668 Position Velocity Time (UTCG): 14 Jul 2009 18:15:02.000 Sy Lat Rate (deg)sec): -0.000000 Alt Rate (deg/sec): 0.009777 Sy LLA Position SV 22668 Position Velocity Time (UTCG): 14 Mar 2021 20:02:11.100 Sy LLA Position SV 22668 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.000 Sy LLA Position SV 22668 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.000 Sy Lat Rate (deg/sec): -0.003652 Vy (km/sec): -0.47400 Vy (km/sec): <			an harmonia	
Time (UTCG): 14 Jul 2000 18:1502.000 Semi-maprix Axis (km): 3190.91282 Lat (deg): 20.533 Inclination (deg): 28.453 Lat Rife (deg): 0.023773 RARM(deg): 28.453 Lat Rife (deg): 0.000000 RarM(deg): 28.453 Lat Rife (deg): 0.000000 RarM(deg): 28.453 Lat Rife (deg): 0.000000 True Anomaly (deg): 179.906 Att Rate (km/sec): 0.000000 X (hm): 29.402 SV LLA Position Time (UTCG): 10 Mar 2021 20:02:11.100 SV 22080 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 SV (km): 298.53312 Lat Rate (deg/sec): -0.003652 X (hm): 298.53312 Lat Rate (deg/sec): 0.017873 XY (MM/sec): -0.004532 Lat Rate (deg/sec): 0.017873 YY (MM/sec): -0.004532 Vi (LA Position SV 12000 Position Velocity Time (UTCG): 10 Mar 2021 20:00:58.100 Vi (MM/sec): -0.004532 Vi (LA Position SV 12000 Position Velocity Time (UTCG): 10 Mar 2021 20:00:58.100 Time (UTCG): 10 Mar 2021 20:00:58.100 Time (UTCG): 10 Mar 2021 20:00	autora and and	BANKA PA	Sat2 Classical Orbit Eler	nents
Lat (deg): 22.53 Lon (deg): 30.533 At (km): 0.023773 Lat Rate (deg/sec): -0.000000 At Rate (deg/sec): 0.000000 At Rate (deg/sec): 0.000000 SV LLA Position Time (UTCG): 10 Mar 2021 20:02:11.100 Time (UTCG): 10 Mar 2021 20:02:11.100 Time (UTCG): 10 Mar 2021 20:02:11.100 At Rate (deg/sec): -0.00577 SV LLA Position At Rate (deg/sec): -0.00577 SV LLA Position At Rate (deg/sec): -0.00577 SV LLA Position SV LLA Position At Rate (deg/sec): -0.00577 SV LLA Position SV				
Lon (deg): -80.583 Inclination (deg): 23.453 At (km): 0.022773 RAAN (deg): 35.875 Lat Rate (deg/sec): 0.000000 Ray of Perige (deg): 258.909 Lon Rate (deg/sec): 0.000000 True Anomaly (deg): 179.906 SV LLA Position SV 22000 Position Velocity 179.800 Lat Rate (deg/sec): -79.577 Y (km): 2936.327870 Alt (km): 64.400991 r (km): 995.327870 Lat Rate (deg/sec): -0.03682 VX (km/sec): -0.478507 Alt Rate (deg/sec): 0.551012 VX (km/sec): -0.478507 Alt Rate (deg/sec): 0.551012 VX (km/sec): -0.478507 SV LLA Position SV 22000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.109 Time (UTCG): 10 Mar 2021 20:10:58.109 Filme (UTCG): 10 Mar 2021 20:20:58.109 Lat Rate (deg/sec): -56.082 Y (km): 5562.234644				
Art (km): 0.023773 RAN (deg): 35.876 Lad Rate (deg/sec): 0.00000 Arg of Pengee (deg): 258.909 Lon Rate (deg/sec): 0.00000 True Anomaly (deg): 179.9800 SV LLA Position Time (UTCG): 10 Mar 2021 20:02:11.109 Time (UTCG): 10 Mar 2021 20:02:11.109 Lat (deg): : 28.402 x (km): 4046.513117 Lon (deg): : : 4946.513117 Lon (deg): : : : 4946.513117 Lon (deg): : : : : 4946.513117 Lon (deg): : : : : : 3936.347020 Lat Rate (deg/sec): : <t< th=""><th></th><th></th><th></th><th></th></t<>				
Lad Rate (deg/sec): -0.00000 Att Rate (km/sec): 0.00000 Att Rate (km/sec): 0.000777 SV LLA Position Lat (deg): -79.577 Att Rate (km/sec): -79.577 Att Rate (km/sec): -79.577 Att Rate (km/sec): -0.003682 Uvx (km/sec): -0.003682 Uvx (km/sec): -0.03682 Uvx (km/sec): -0.03482 Uvx (km/sec): -0.03484 Uvx (km): -0.034844 Uvx (km): -0.0			PAAN (dea):	
Lon Rate (deg/sec): 0 000000 All Rate (km/sec): 0 000077 SV LLA Position SV LLA Position Alt (km): 28.402 Alt (km): 28.402 Alt (km): 29.402 Alt (km): 29.577 Alt (km): 9966.327070 VX (km/scc): -0.4716047 Alt Rate (deg/sec): -0.003682 VX (km/scc): -0.4716047 VX (km/scc): -0.4716047 VX (km/scc): -0.4716047 VX (km/scc): -0.494532 VX (km/scc): -0.094832 VX (km): -0.094832 VX (km): -0.004824 VX (k				
All Rate (km/sec): 0.009777 Mean Anomaly (deg): 179.800 SV LLA Position Time (UTCG): 10 Mar 2021 20:02:11.100 Lat (deg): SV 32000 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 K (km): SV 32000 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 K (km): SV 32000 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 K (km): 10 Mar 2021 20:02:11.100 K (km/sec): 0.471404 K (km/sec): 0.471404		0.000000		
SV LLA Position SV J2000 Position Velocity Time (UTCG): 10 Mar 2021 20:02:11.100 Time (UTCG): Lat (deg): -79.577 y (km): 4046.513117 Lat (km): 64.400891 t (km): 4046.513117 Lat Rate (deg/sec): -0.003682 Vx (km/sec): -0.471604 Lon Rate (deg/sec): 0.017873 Vy (km/sec): -7.5007 Alt Rate (km/sec): 0.561012 Vx (km/sec): -0.094832 Vy (km/sec): -0.094832 -0.094832 -0.094832 Vy (km/sec): 10 Mar 2021 20:10:58.100 SV J2000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:21:8:10.00 SV LLA Position SV J2000 Position Velocity Time (UTCG): Lat (deg): 21.342 x (km): 556.2834444 Lon (deg): -56.082 y (km): 5101.960300 Lat Rate (deg/sec): -0.024424 x (km): 207.623085 Lon Rate (deg/sec): -0.024424 x (km): 5101.960300 Lon Rate (deg/sec): -0.024424 x (km): 5101.960300			Mean Anomaly (deg):	
Time (UTCG): 10 Mar 2021 20:02:11.100 Time (UTCG): 10 Mar 2021 20:02:11.100 Lat (deg): 28.402 x (km): 4046.513117 Lon (deg): -79.577 y (km): 2785.135902 Alt (km): 64.400891 t (km): 3036.327020 Lat Rate (deg/sec): -0.003662 vx (km/sec): -0.474004 Lon Rate (deg/sec): 0.017873 vy (km/sec): -7.50017 Alt Rate (km/sec): 0.561012 vz (km/sec): -0.094832 Vy (km/sec): -0.094832 -0.094832 -0.094832 Vul A Position SV J2000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 SV LLA Position SV 21:342 x (km): 556.2834424 Lon (deg): -56.082 y (km): 556.39304244 Lon (deg): 297.029085 I (km): 2407.53332 Low Rate (deg/sec): -0.024224 x (km/sec) -5.166359	A A A	and the second s	a tradi	
Time (UTCG): 10 Mar 2021 20:02:11.100 Time (UTCG): 10 Mar 2021 20:02:11.100 Lat (deg): 28.402 x (km): 4046.513117 Lon (deg): -79.577 y (km): 2785.135902 Alt (km): 64.400891 t (km): 3036.327020 Lat Rate (deg/sec): -0.003662 vx (km/sec): -0.474004 Lon Rate (deg/sec): 0.017873 vy (km/sec): -7.50017 Alt Rate (km/sec): 0.561012 vz (km/sec): -0.094832 Vy (km/sec): -0.094832 -0.094832 -0.094832 Vul A Position SV J2000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 SV LLA Position SV 21:342 x (km): 556.2834424 Lon (deg): -56.082 y (km): 556.39304244 Lon (deg): 297.029085 I (km): 2407.53332 Low Rate (deg/sec): -0.024224 x (km/sec) -5.166359				
Lat (deg): 28.482 x (km): 4946.51317 Lon (deg): -79.577 y (km): 2785.135902 Alt (km): 906362 vv (km/sec): -0.473697 Alt Rate (deg/sec): -0.017873 vy (km/sec): -0.473697 Alt Rate (km/sec): 0.561012 vz (km/sec): -0.094832 -0.09483 -0.09483 -0.09483 -0.09483 -0.09483 -0.09483 -0.09483 -0.09483 -0.	SV LLA Position		SV J2000 Position Velocity	
Lat Rate (deg/sec): -0.003682 vv (km/sec): -0.0774047 Lon Rate (deg/sec): 0.017873 vv (km/sec): -750017 Alt Rate (km/sec): 0.0561012 vz (km/sec): -8.094832 -8.094832 -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.09483 Vz (km/sec): -9.09483 Vz (km/sec): -9.0948	Time (UTCG):	10 Mar 2021 20:02:11.100	Time (UTCG): 10 Mar 2021 2	9:02:11.100
Lat Rate (deg/sec): -0.003682 vv (km/sec): -0.0774047 Lon Rate (deg/sec): 0.017873 vv (km/sec): -750017 Alt Rate (km/sec): 0.0561012 vz (km/sec): -8.094832 -8.094832 -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.09483 Vz (km/sec): -9.09483 Vz (km/sec): -9.0948	Lat (deg):	28.402	X (Rm):	4946.513117
Lat Rate (deg/sec): -0.003682 vv (km/sec): -0.0774047 Lon Rate (deg/sec): 0.017873 vv (km/sec): -750017 Alt Rate (km/sec): 0.0561012 vz (km/sec): -8.094832 -8.094832 -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.094832 Vz (km/sec): -8.09483 Vz (km/sec): -9.09483 Vz (km/sec): -9.0948	Alt (km):	64,400891	z (km):	3036.347020
Lon Rate (deg/sec): 0.017873 Alt Rate (km/sec): 0.561012 v2 (km/sec): 0.094832 V2 (km/sec): 0.0	Lat Rate (deg/sec):			-0.471494
WinMth#U5_01TR_00*652:11.100 SV LLA Position SV LLA Position Time (UTCG): 10 Mar 2021 20:10:58.100 Lon (deg): -56.002 y (km): 501.06095 Lon (deg/sec): -0.024424 x (tm*xmt) x (tm*xmt) -5.106359 x (tm*xmt) .007075	Lon Rate (deg/sec):	0.017873		2.240017
SV LAP Position SV 22800 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Par 2021 20:20:58.100 Lat (deg): 21:342 x (hm): 5562.834474 Lon (deg): -56.082 y (hm): 5101.960300 Alt (km): 297.0290805 x (km): 5101.960300 Lon Rate (deg/sec): -0.024424 x (km/sec) -5.106359 Lon Rate (deg/sec): 0.082556 x (km/sec) 5.106359	Alt Rate (km/sec):	0.561012		-0.094832
Wingiau505FR_d8382:11.100 SV J2000 Position Velocity SV LLA Position 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21.342 x (hm): 5562.834424 Lon (deg): 557.02:0005 x (hm): 5562.834424 Lon (deg): 297.02:0005 x (hm): 5101.960300 Lat (deg/sec): 0.0024424 x (hm): 5101.960300 Lor Rate (deg/sec): 0.0024255 x (hm): 5106359 Lor Rate (deg/sec): 0.0024255 x (hm): 51.06359				
Wingiau505FR_d8382:11.100 SV J2000 Position Velocity SV LLA Position 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21.342 x (hm): 5562.834424 Lon (deg): 557.02:0005 x (hm): 5562.834424 Lon (deg): 297.02:0005 x (hm): 5101.960300 Lat (deg/sec): 0.0024424 x (hm): 5101.960300 Lor Rate (deg/sec): 0.0024255 x (hm): 5106359 Lor Rate (deg/sec): 0.0024255 x (hm): 51.06359				
Wingiau505FR_d8382:11.100 SV J2000 Position Velocity SV LLA Position 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21.342 x (hm): 5562.834424 Lon (deg): 557.02:0005 x (hm): 5562.834424 Lon (deg): 297.02:0005 x (hm): 5101.960300 Lat (deg/sec): 0.0024424 x (hm): 5101.960300 Lor Rate (deg/sec): 0.0024255 x (hm): 5106359 Lor Rate (deg/sec): 0.0024255 x (hm): 51.06359				
SV LLA Position SV J20000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21:342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0005 1 (km): Lat (deg/sec): -0.024424 -5.166359 Lorn Rate (deg/sec): 0.061556 -5.166359				
SV LLA Position SV J20000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21:342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0005 1 (km): Lat (deg/sec): -0.024424 -5.166359 Lorn Rate (deg/sec): 0.061556 -5.166359				_
SV LLA Position SV J2000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:X0:58.100 Lat (deg): 21.342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lat (deg/sec): -0.024424 -5.166359 Lon Rate (deg/sec): 0.061556 -5.166359		- A -		-
SV LLA Position SV J2000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:X0:58.100 Lat (deg): 21.342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lat (deg/sec): -0.024424 -5.166359 Lon Rate (deg/sec): 0.061556 -5.166359				
SV LLA Position SV J2000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:X0:58.100 Lat (deg): 21.342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lat (deg/sec): -0.024424 -5.166359 Lon Rate (deg/sec): 0.061556 -5.166359				
SV LLA Position SV J2000 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:X0:58.100 Lat (deg): 21.342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lat (deg/sec): -0.024424 -5.166359 Lon Rate (deg/sec): 0.061556 -5.166359				
SV LLA Position SV J2800 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21.342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lon Rate (deg/sec): -0.024424 or (the sec) Lon Rate (deg/sec): 0.061556 or (the sec)				
SV LLA Position SV J2800 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21.342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lon Rate (deg/sec): -0.024424 or (the sec) Lon Rate (deg/sec): 0.061556 or (the sec)				
SV LLA Position SV J2800 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21:342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lat (deg/sec): -0:024424 or (the sec) Low Rate (deg/sec): 0.061556 or (the sec)				
SV LLA Position SV J2800 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21:342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lat (deg/sec): -0:024424 or (the sec) Low Rate (deg/sec): 0.061556 or (the sec)				
SV LLA Position SV J2800 Position Velocity Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:20:58.100 Lat (deg): 21:342 x (km): Lon (deg): -56.082 y (km): Alt (km): 207.02:0055 1 (km): Lat (deg/sec): -0:024424 or (the sec) Low Rate (deg/sec): 0.061556 or (the sec)				
Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:258.100 Lat (deg): 21.342 x (km): 3562.834424 Lon (deg): -56.082 y (km): 510.366930 Alt (km): 297.629085 r (km): 2407.593392 Lat Rate (deg/sec): -0.024424 -5.106359 -5.106359	10"Maru2021"20:02:11	.100		
Time (UTCG): 10 Mar 2021 20:10:58.100 Time (UTCG): 10 Mar 2021 20:258.100 Lat (deg): 21.342 x (km): 3562.834424 Lon (deg): -56.082 y (km): 510.366930 Alt (km): 297.629085 r (km): 2407.593392 Lat Rate (deg/sec): -0.024424 -5.106359 -5.106359				/
Lat Rate (deg/sec): -0.024424 vm (sm/sec): -5.106359 Lon Rate (deg/sec): 0.061656 vv (sm/sec): 5.170275	SV LLA Position		SV J2000 Position Velocity	/
Lat Rate (deg/sec): -0.024424 vx (sk/sec): -5.106359 Lon Rate (deg/sec): 0.061656 vy (sk/sec): 5.170275	Time (UTCG):	10 Mar 2021 20:10:58.100	Time (UTCG): 10 Mar 2021 2	0:10:58,100
Lat Rate (deg/sec): -0.024424 vx (sk/sec): -5.106359 Lon Rate (deg/sec): 0.061656 vy (sk/sec): 5.170275	Lat (deg):	21.342	x (km):	5101.960930
Lat Rate (deg/sec): -0.024424 vx (sk/sec): -5.106359 Lon Rate (deg/sec): 0.061656 vy (sk/sec): 5.170275	Alt (km):		r (kn);	2407.593392
Lon Rate (deg/sec): 0.061656 y (def sub: 5.179275 Alt Rate (km/sec): 0.322110 yz (lm/sub): 2.509309	Lat Rate (deg/sec):	-0.024424	vx (km/sec):	-5.106359
Alt Rate (km/sec): 0.322110 vz (b-fail): 2.600309	Lon Rate (deg/sec):	0.061656		5,179275
	Alt Rate (km/sec):	0.322110	vz (km/sec):	
		Se ton		
		1 maria 1		



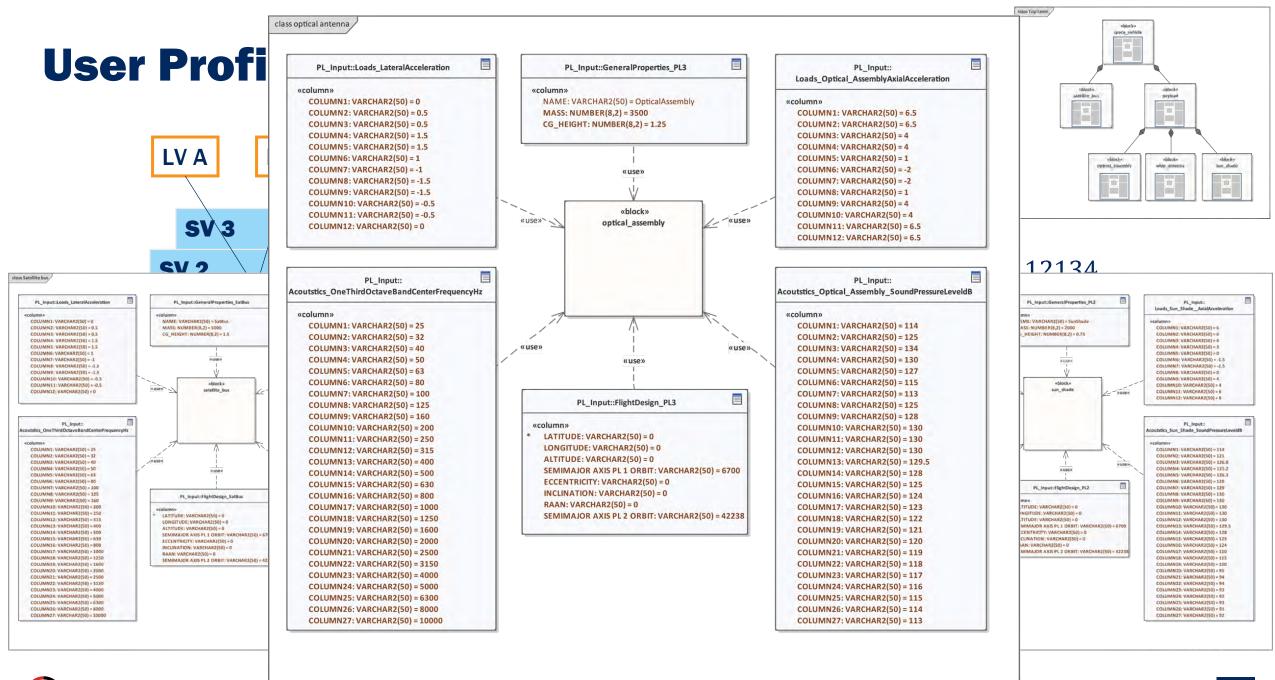
Digital Engineering Ecosystem Architecture



User Profiles: LV and PL Perspective







(M

31

Executive Profiles: Higher Perspective

Executive Dashboard:

- No PL/SV input
- Overview of results comparing "approved" or "tentative" LV/SV/PLs

Executive Dashboard

PL Echo: Secondary PL Configurations

Secondary PL	Launch Vehicle ≑	Primary PL 🔷	Loads 🔷	Acoustics 🗘	Flight Design 🔷	Thermal 🔷	Contamination 🕯
Echo	A	Alpha	٠	•	•	•	۲
Echo	A	Bravo	•	٠	•	٠	۲
Echo	В	Alpha	•	٠	•	•	۲
Echo	В	Bravo	•	٠	•	•	۲
Echo	С	Alpha	•	•	•	٠	•

Launch Manifest:

• Tentative configuration of LV/SV/PLs given complimentary cohesiveness and mission requirements

Potential Launch Manifest

Mission	Date	Launch Vehicle‡	Primary PL	Secondary PL#	Hosted PL 💠	Status
Mission 1	2020-11-23	c	Payload Charlie	Payload Fox	Payload Hotel	
Mission 2	2021-01-02	А	Payload Zulu	Payload Sierra	Payload Bravo	٠
Mission 3	2021-01-18	D	Payload Dedicated			٠
Mission 4	2021-02-13	A	Payload Alpha	Payload Mike	Payload Oscar	
Mission 5	2021-3-28	E	Payload Delta	Payload Lima	Payload Juliet	

EIS: MT-ADEPT Prototype

Cloud-Based Workflow Example









ManTech-ADEPT Benefits

Reduces Time and Labor Cost

Maintains Decision Quality Results

- Allows for real-time adjustments and resource-unconstrained studies
- Enables automated Monte Carlo experiments and other trade studies
- Eliminates error-prone and work-intensive human data exchange
- Builds a scalable foundation for future developments
- Next Steps:
 - Refining workflows, maturing analytics, including additional EIS workflows
 - Building digital twin Reference Model and exploring a model based digital thread innovation



Digital Engineering Ecosystem Architecture

