



National Aeronautics and
Space Administration



FINANCIAL MANAGEMENT DIVISION | POLICY & GRANTS DIVISION | QUALITY ASSURANCE DIVISION | BUDGET DIVISION | STRATEGIC INVESTMENTS DIVISION | AGENCY FINANCIAL SYSTEMS OFFICE | MISSION SUPPORT OFFICE



OCFO

OFFICE OF THE CHIEF FINANCIAL OFFICER

2023 Cost and Schedule Symposium

Eric Plumer | 2023



Cost Analysis Data Requirements document (CADRe)

2023 Cost and Schedule Symposium

Eric Plumer

May 2, 2023



Agenda



Section

Slide

I. Why CADRe? and CADRe Overview

*Provides overview of Cost Analysis Data Requirement
Contains information on the organization of a CADRe document*

4-15

II. CADRe Execution, Inputs, Outputs, Policy Updates

*Provides overview of CADRe execution, key document inputs and
outputs and 7120.5F related updates*

16-27

III. CADRe Recent Progress, LV, and EVM

Provides status of recently completed CADRes

28-34

IV. CADRe Resource for Analogous Missions

*Provides understanding of available CADRes to support analogous
mission comparisons.*

35-41

V. CADRe Template V8.0 Release and Summary

*Provides a clear understanding of how CADRe is a foundational
document for PP&C analysis at NASA.*

42-48





CADRe Acknowledgements

CADRe Developers

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- Michael Blandford
- Tuynhu Tran-Dam
- Valerie Rockwell
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- Paula Pool
- Drew Rice
- Rudy Rodolfo
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- Joe Deausen
- Glenn Iona
- Ryan Turner
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- Curtis Smith

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- Joe Mrozinski
- Larisa Parks
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- Allan Farrington (PM)
- Jordan Evans (PM)
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- Ethan Hopper
- Will Hopkins
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- Emma Lehnhardt

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- Andy Prince
- Robbie Holcombe
- Stanley McCaulley
- Charles Adams
- Davey Jones
- Van Strickland

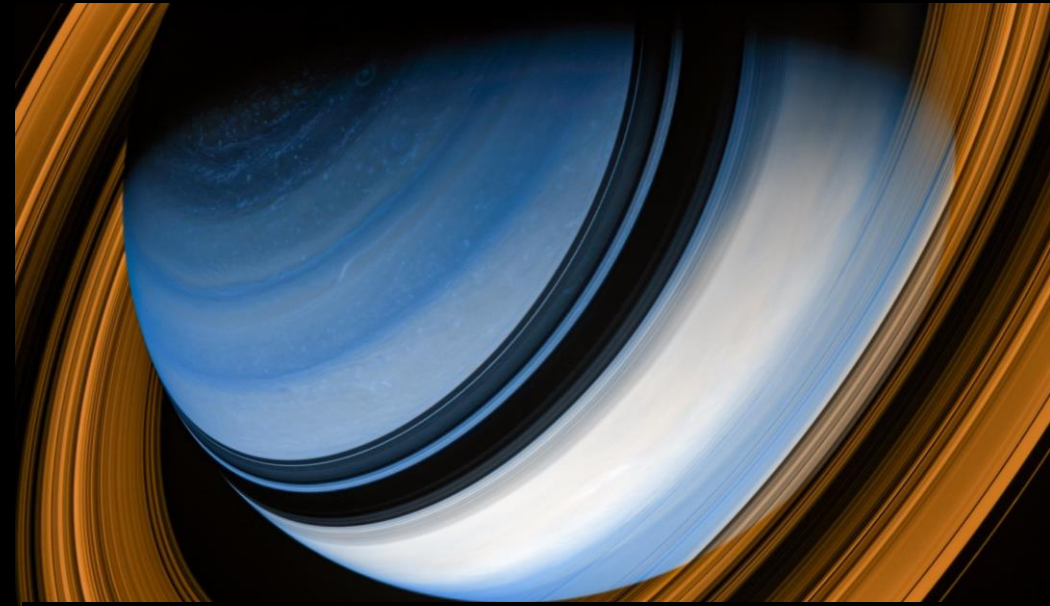
KSC

- Glenn Butts
- Jonathan Baker
- Ariel Pavlick
- Trey Reilly
- Melodie Jackson

LaRC

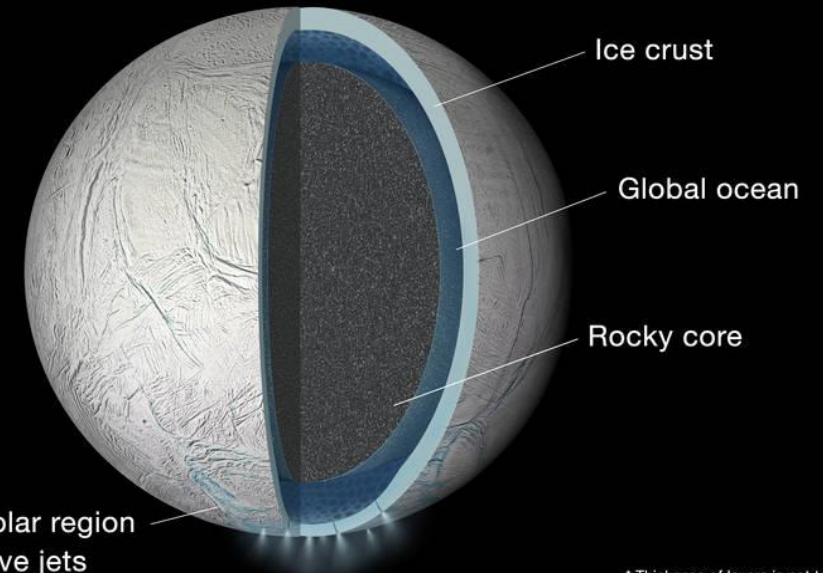
- Justin Hornback
- Sharon Seltzer
- Chad Stimson
- Gary Fleming

Image of Saturn based on near-infrared data from the Cassini spacecraft, which orbited the planet for 13 years.



Enceladus is the sixth-largest moon of Saturn. It is about 500 kilometers (310 miles) in diameter, about a tenth of that of Saturn's largest moon, Titan.

Global Ocean on
Saturn's Moon
ENCELADUS



* Thickness of layers is not to scale

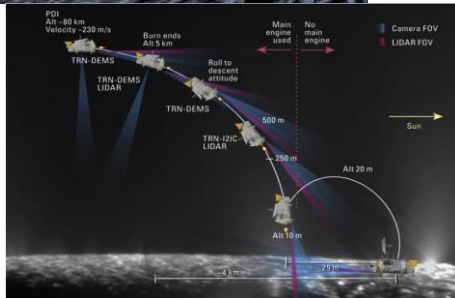
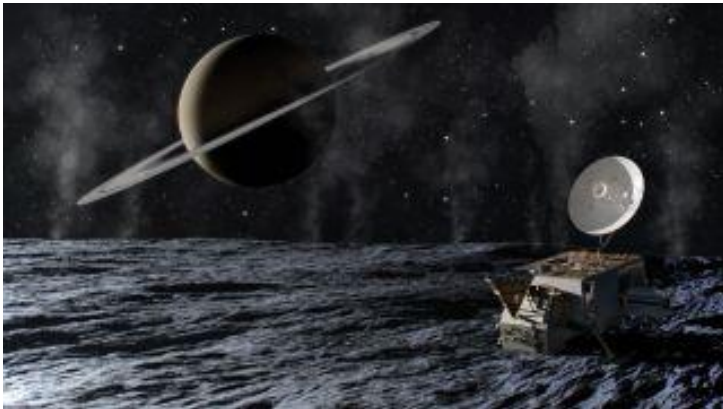


Why CADRe?

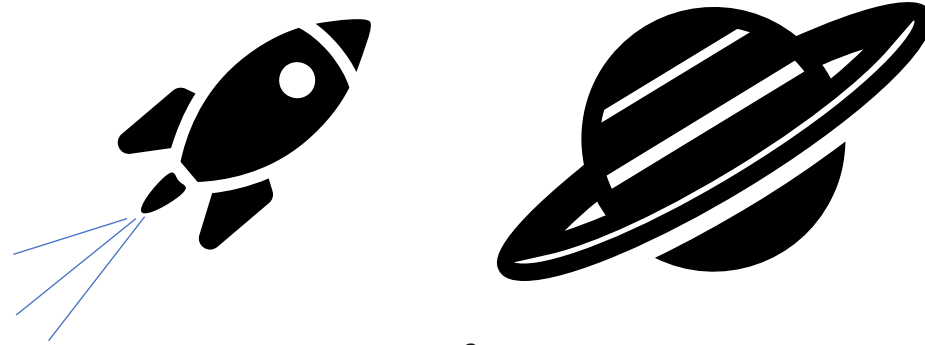


You Been Assigned To A Special Team

Objective: Programmatically Estimate a New Robotic Mission to Enceladus

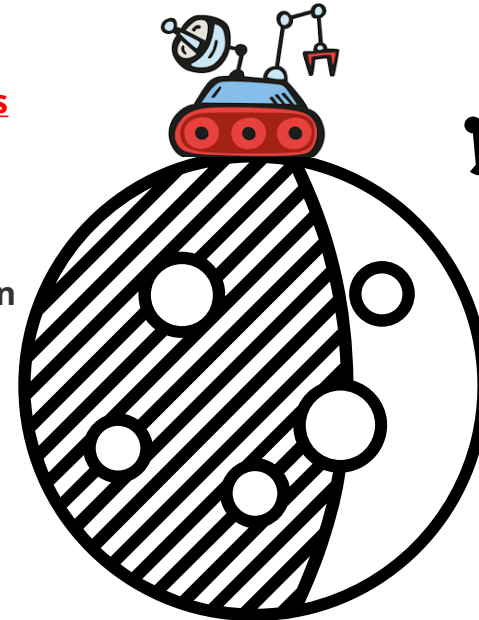


New Future Concept



Descriptions

- Structure
- Thermal
- Electrical
- G&NC
- Propulsion
- Comm
- C&DH
- Software

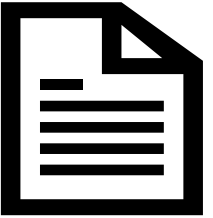


Enceladus

Early Design Parameters

- Mass
- Power
- New/Existing Tech
- RTGs
- ConOps

Life Cycle Cost Estimate



Schedule Durations

CADRe key enabler to estimate new missions

Workforce Levels

Risk Analysis

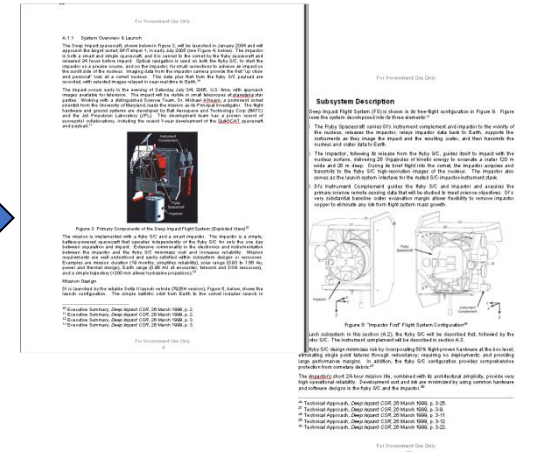
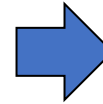


What Can I Get From CADRe?



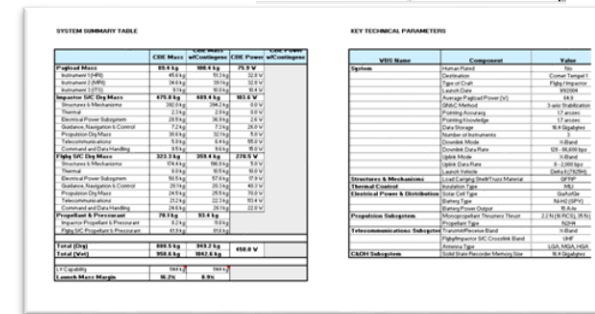
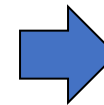
• Part A (Word Document)

- Quick understanding of the project
- Changes that occurred between milestones during development are documented
- Context on the complexity of the project and new technology



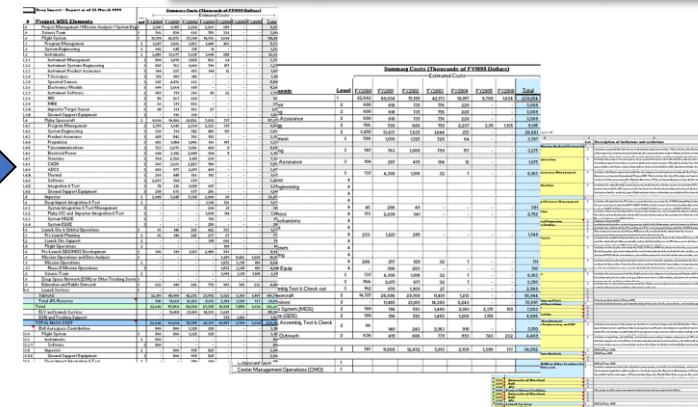
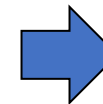
• Part B (Excel Workbook)

- Spacecraft and Payload Technical Parameters including detailed mass, power and many other parameters
- Software cost driving parameters & metrics
- Risk Class, Mission Cat, Design life, Contractor info, Heritage Ratings, Power modes



• Part C (Excel Workbook)

- Life Cycle, Cost Estimates
- Risk Posture, Risk Registers
- Summary and detailed level Schedule data
- Cost Assumptions, BOEs

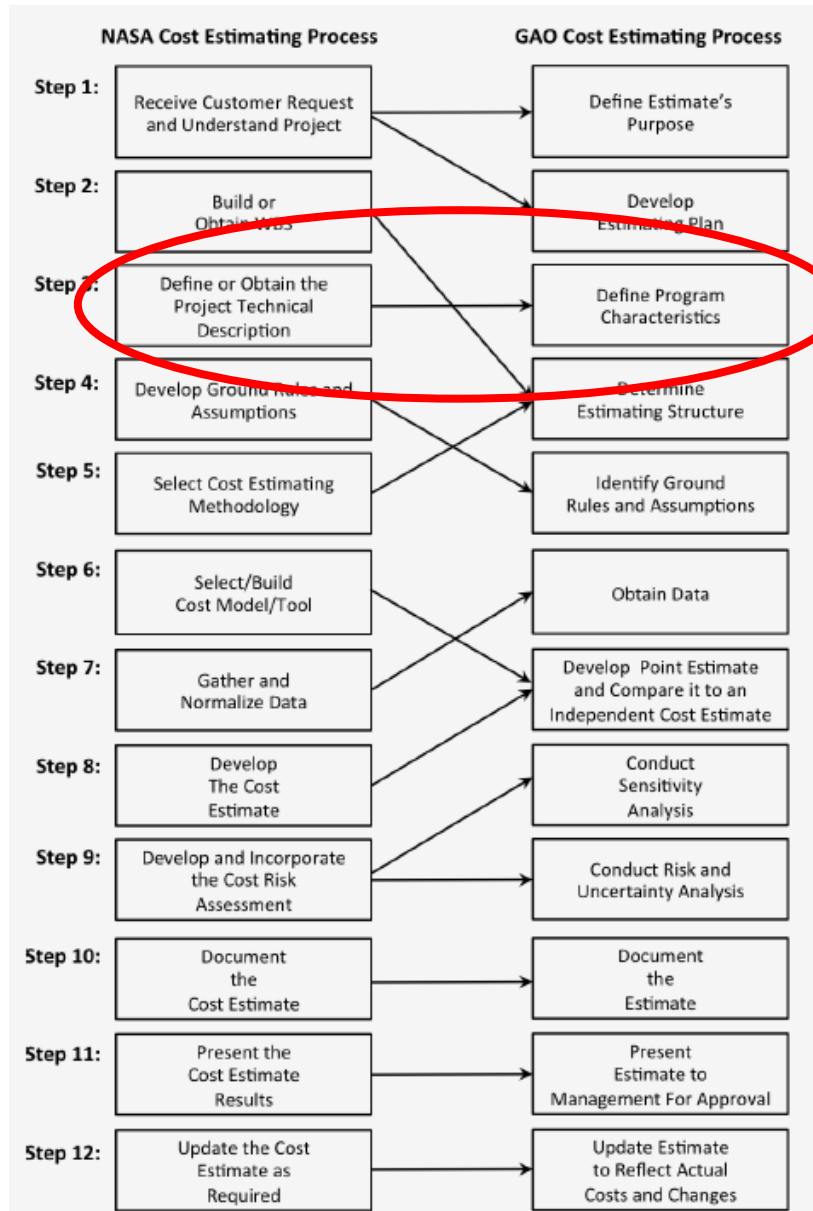




CADRe



Follows & Improves on Best Practices



Technical Baseline for Cost Analysis

- Establishment of realistic Technical Baseline is a very critical part of the estimating process.

- ➔ **NASA Cost Analysis Data Requirements (CADRe)**

NASA Procedural Requirement (NPR) 7120.5F

- ➔ **DOD Cost Analysis Requirements Description (CARD)**
DoD 5000.4M

- ➔ **Intelligence DNI, NRO Intelligence Capability Baseline Description (ICBD)** IC Policy Guidance (ICPG) 105.1

- ➔ **Homeland Security Cost Estimating Baseline Document (CEBD)** DHS Acquisition Instruction #102-02-001

- ➔ **DOE Conceptual Design Report** DOE Estimating Guide 413.3-2

Agencies use a Technical Baseline Document to perform Cost and Schedule Analysis



CADRe Part A,B,C Viewpoint from JWST CADRe





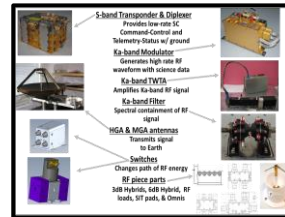
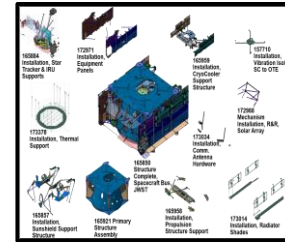
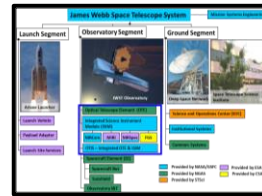
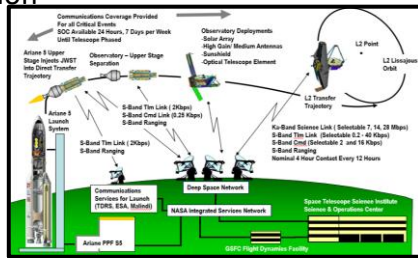
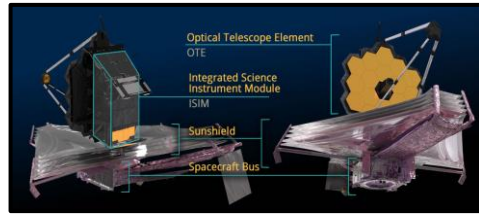
JWST LRD CADRe: Part A

Provides Descriptive Information



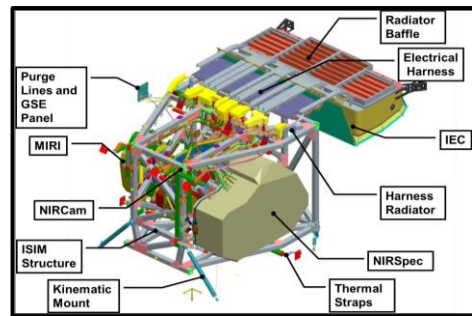
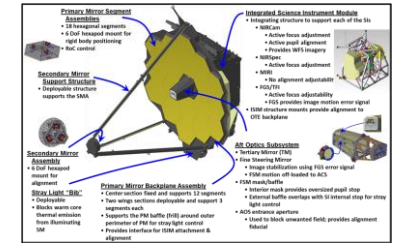
System Description

- Requirements
- Science Requirements
- System Overview
- Project Category/Risk Classification
- Technical Approach
- Launch Vehicle Description
- Cruise
- Operations
- Decommission and Disposal



Spacecraft/Observatory Details

- Structures
- Mechanisms
- Deployment Control
- Propulsion
- Thermal
- Thermal Control
- Sunshield
- Power
- Electrical
- Harness
- Avionics
- Telecom
- Attitude Control
- Software
- MOS/GDS
- Science and Operations Center
- Institutional Services
- Common Systems



Payload Details (ISIM)

- Overview of Integrated Science Instrument Module
- Integrated Science Module Design
- NIRCam
- NIRSpec
- MIRI
- FGS and NIRISS

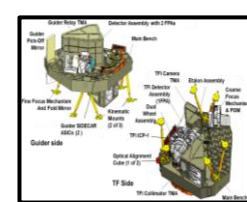
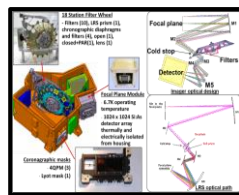
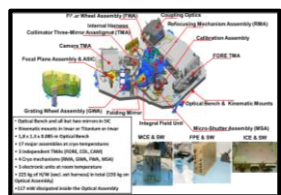
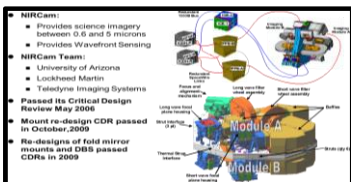
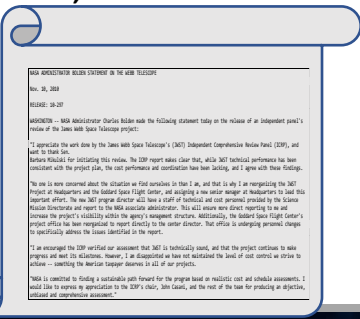
Payload Details (ISIM)

- Project Management
- Management Structure
- Partner Organizations
- Project System Engineering
- Science Team
- Mission Assurance
- Safety
- Reliability and Probabilistic Risk
- Software Assurance
- Technical Reserves
- Design Verification

Significant Changes

- Changes from JWST SDR to PDR
- Changes from PDR to CDR
- Changes from CDR to SLR
- Changes from SLR to SIR
- Changes from SIR to MPSPR

Administrator Charles Bolden Reorganization letter November 10, 2010





JWST LRD CADRe Part B

Provides Technical Parameters



System Level Parameters

- Mission Category
- Mission Class
- Design Life
- AO or Directed
- Trajectory Class
- Orbital Periapsis
- Orbital Apoapsis
- Total Dry Mass
- Total Data Return
- Launch Vehicle

B	C	D	E
MISSION KEY PARAMETERS			
Mission Project Name		James Webb Space Telescope (JWST)	
NASA Program Source		James Webb Space Telescope (JWST)	
Mission Design Life, months		126	
Num of contractors		5	
Num Govt. Organizations		9	
Cruise Duration (months)		6	
Primary Science Duration (months)		60	
Target Body		Deep Space	
Mission Reliability Class		A	
Mission Category		CAT 1	
AO or Directed			
Heritage Design Rating (see pull down)		New Design with Little Heritage	
Is there science during cruise?		No	
Trajectory Class		Lagrange Points	
Total Data Return		229	Gb
Total Dry Mass		5860.70	kg
Total Dry Mass w/Cont.		5870.82	kg
Total Average System Power			
Total Peak System Power		2073	W
Orbital Periapsis		1.06E+06	km
Orbital Apoapsis		1.06E+06	km
Inclination, degrees		4.052	
Launch Vehicle		Ariane 5 ECA	
... INSTRUCTIONS Mission & System Parm's Payload Parm's Spacecraft HW Parm's			

Spacecraft Parameters

- Top Level Parameters
- Structure Type
- Power Source type
- Solar Cell Type
- Battery Type
- Propulsion type
- Comm uplink/downlink type
- Mass (CBE) Mass (CBE + Cont)
- Avg Power (CBE) Avg Power (CBE + Cont)
- Peak Power (CBE) Peak Power (CBE + Cont)

Description	QTY	Unit	kg	kg	%	kg	kg
JWST Observatory	1		6161.05	6161.05	0.152%	9.88	6171.40
OTFE Mass OTE, ISM OTE Harness, CO	1		3610.35	3610.35		4.24	3614.60
Optical Telescope Element (OTE)	1		2338.43	2338.43	0.100%	2.307	2338.74
Primary Mirror Segment Assembly (PMISA)	1		680.31	680.31	0.155%	1.056	681.36
Secondary Mirror Assembly (SMA)	1		27.44	27.44	0.155%	0.335	27.48
AB Optics Subsystem (AOS)	1		110.44	110.44	0.155%	0.171	110.61
Primary Mirror Backplane Support Structure (PMBS)	1		311.85	311.85	0.155%	1.513	313.37
PMISA Hinges, Latches, and Mechanisms	1		48.80	48.80	0.155%	0.073	48.87
Secondary Mirror Support Structure (SMSS)	1		88.57	88.57	0.155%	0.137	88.70
Thermal Management Subsystem (TMS)	1		277.304	277.304	0.155%	0.444	277.748
Dispachable Lower Assembly (DLA)	1		60.34	60.34	0.155%	0.095	61.03
OTE Electronics	1		75.45	75.45	0.155%	0.117	75.56
OTFE Mass	1		2.95	2.95	0.155%	0.005	2.98
Mechanical Installation Hardware (MIH) - OTE	1		12.00	12.00	0.155%	0.019	12.40
Test & Fly / Discrepancy Report Hardware - OTE	1		1.35	1.35	0.155%	0.002	1.35
OTFE Measurement	1	Actual SCE CO	-13.44	-13.44		-1.701	-13.71
Integrated Science Instrument Module (ISM)	1		1245.07	1245.07	0.155%	1.932	1247.01
ISM Region 1	1		896.53	896.53	0.155%	1.702	898.23
ISM Region 2	1		299.51	299.51	0.155%	0.463	299.98
ISM Region 3 (within SC)	1		48.03	48.03	0.155%	0.075	48.11
Spacecraft Element (SCE) - Wet Mass	1		2549.47	2549.47	0.140%	3.540	2553.00
SC Element - Dry, SCE CO	1		2549.47	2549.47		-3.63	2553.10
Spacecraft (SC) Mass	1		1510.28	1510.28	0.156%	2.362	1512.64
Electrical Power Subsystem (EPS)	1		154.20	154.20	0.155%	0.250	154.45
Deployment Control Subsystem (DCS)	1		15.34	15.34	0.155%	0.019	15.36
Attitude Control Subsystem (ACS)	1		127.41	127.41	0.155%	0.190	127.60
Communications Subsystem (Comms)	1		19.87	19.87	0.155%	0.031	19.90
Command and Data Handling Subsystem (CDH)	1		38.63	38.63	0.155%	0.060	38.69
Propulsion Subsystem	461510		77.64	77.64	0.155%	0.111	77.75
Structure Subsystem (SMS)	165056.1		660.32	660.32	0.155%	1.006	661.33
Mechanical Installation Hardware (MIH) - SC	1		25.59	25.59	0.184%	0.050	25.64
Thermal Control Subsystem (TCS)	1		128.171	128.171	0.160%	0.206	128.377
Observatory Wire Harness (OWH)	1		265.62	265.62	0.155%	0.411	266.03
Scandals	165000 (Seq 149.0)		685.19	685.19	0.172%	1.10	686.30
Propulsion Fuel	1402580		388.59	388.59	0.100%	0.000	388.59
Test & Fly / Discrepancy Report Hardware - SCE	1		3.75	3.74	0.155%	0.006	3.74
SCE Measurement	1	Actual SCE CO	0.00	0.00		0.000	0.00
Cryocooler Accommodation	1		5.87	5.87	0.155%	0.009	5.88

Payload Parameters

- Top Level Parameters
- Thermal Control System
- Design Life
- Remote Sensing or In-Situ

Req ID	Req Description	Req Type	Req Category	Req Subcategory	Req Priority	Req Status	Req Date	Req Version	Req Owner	Req Assignee	Req Reviewer	Req Approver	Req Date	Req Version	Req Status	Req Date	Req Version	Req Status
1.0	CUI	INSTRUCTIONS	Mission & System Parm's	Payload Parm's	Spacecraft HW Parm's													

- Mass (CBE) Mass (CBE + Cont)
- Avg Power (CBE) Avg Power (CBE + Cont)
- Peak Power (CBE) Peak Power (CBE + Cont)

Software Parameters

- Application Environment
- Number of Requirements
- Development Methodology
- Languages used C, C++, Javascript
- SLOCs New, Modified, Reuse

Req ID	Req Description	Req Type	Req Category	Req Subcategory	Req Priority	Req Status	Req Date	Req Version	Req Owner	Req Assignee	Req Reviewer	Req Approver	Req Date	Req Version	Req Status	Req Date	Req Version	Req Status
1.0	CUI	INSTRUCTIONS	Mission & System Parm's	Payload Parm's	Spacecraft HW Parm's													

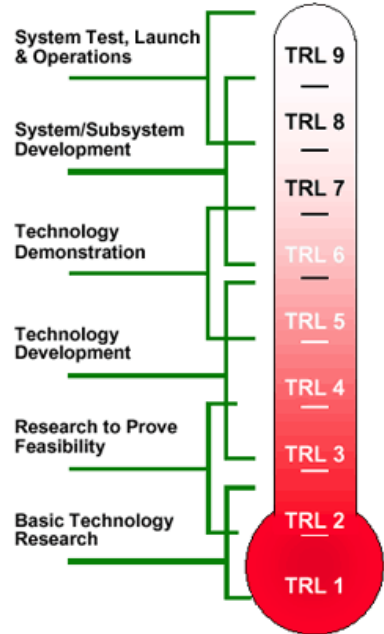


JWST LRD CADRe: Part B

Provides Technical Parameters



TRL Assessment Tracking—SRR thru final I&T

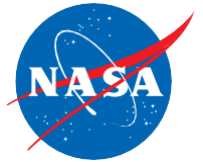


	SRR/ SDR	PDR NAR	Mission CDR											
	July-05	March- April 08	Apr-10	Sept-10	Apr-11	Apr-12	May-13	May-14	June-15	June-16	Jun-18	Jun-19	Jun-20	Jun-21
Critical Technologies -- developed by/for JWST														
Primary Mirror Segment Assembly (Optical Telescope Assembly)	5.5	6	7	7	7	8	8	8	8	8	8	8	8	8
Sunshield Membrane Material Qualification	5	6	6	6	6	6	6	6	6	6	7	8	8	8
Near Infrared Detector Focal Plane Assembly (for NIRCcam, NIRSpec, FGS, NIRISS)	5.5	6	8	8	8	8	8	8	8	8	8	8	8	8
Mid Infrared Detector Focal Plane Assembly (for MIRI)	5.5	6	8	8	8	8	8	8	8	8	8	8	8	8
Micro-shutter Array (for NIRSpec)	4	6	8	8	8	8	8	8	8	8	8	8	8	8
Cryocooler Subsystem (for MIRI)	3	6	6	6	6	6	6	6	6	8	8	8	8	8
Large Precision Cryo Structures -- Telescope Backplane (Optical Telescope Assembly)	4	6	6	6	6	6	6	7	8	8	8	8	8	8
Cryo ASIC (for NIRCcam, NIRSpec, FGS, NIRISS)	5	6	8	8	8	8	8	8	8	8	8	8	8	8
Wavefront Sensing and Control Fine Phasing (Optical Telescope Assembly)	5	6	6	6	6	6	6	6	6	6	7	7	7	7
Heritage Technologies - use by JWST														
Solar Array	5	5	6	6	6	6	6	6	6	8	8	8		
Battery	7	8	8	8	8	8	8	8	8	8	8	8		
Star Tracker	7	9	9	9	9	9	9	9	9	9	9	9		
Scalable Inertial Reference Unit (SIRU)	9	9	9	9	9	9	9	9	9	9	9	9		
Reaction Wheel Assembly (RWA)	8	8	8	8	8	8	8	8	8	8	8	8		
Coarse Sun Sensor Assembly (CSSA)	9	9	9	9	9	9	9	9	9	9	9	9		
Fine Sun Sensor Assembly (FSSA)	N/A	N/A	9	9	9	9	9	9	9	9	9	9		
Ka-Band OQPSK Modulator	6	6	7	7	7	7	7	7	7	8	8	8		
S-band Transponder	4	5	6	6	6	6	8	8	8	8	8	8		
Ka-band High Gain Antenna	N/A	N/A	6	6	6	6	6	6	6	8	8	8		
S-band Omni Antenna	9	9	9	9	9	9	9	9	9	9	9	9		
S-band Medium Gain Antenna	N/A	N/A	9	9	9	9	9	9	9	9	9	9		
Solid State Recorder	5	6	7	7	8	8	8	8	8	8	8	8		
Monopropellant Rocket Engine (MRE)	9	9	9	9	9/6*	9/6*	9/6*	9/6*	9/6*	9/8*	9/8*	9/8*		
Secondary Combustion Augmented Thruster (SCAT)	9	9	9	9	9	9	9	9	9	9	9	9		



JWST LRD CADRe: Part C

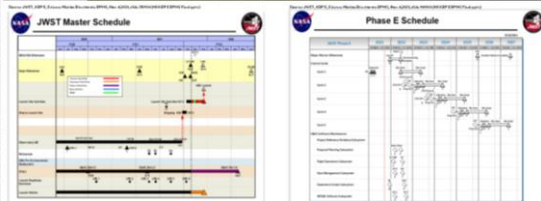
Provides Programmatic Parameters



Project Native WBS

NASA WBS Mapping

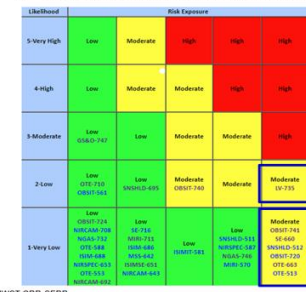
Workforce Data



Schedule Data

Risk Data (Residual Risks)

- Thirty-one risks in the Project Database
 - No Red Risk
 - 8 Yellow Risks
 - 23 Green
- Of these 6 are associated with observatory Single Point Failures (SPFs)



- **Highest Risk:**
 - OBS&T 741 Aggregate risk of latent significant anomalies in architecture performance associated with the risk of an anomalous firing separation on mission performance.
- **Next Highest Risks:**
 - OBS&T 741 Aggregate risk of latent significant anomalies in architecture performance as identified by Code 300 / Code 100 independent assessment.
 - SE-660 NEA Release Devices SPF
 - SS-512 Sunshield Membrane Release Device (MRD) SPF
 - OBS&T -720 SMSS Deployment Verification
 - OTE-663 Optical Telescope Element (OTE) Non-Structural Single Point Failure (SPF) Items
 - OTE-513 OTE SMA Actuator



Part C Example NASA Standard WBS



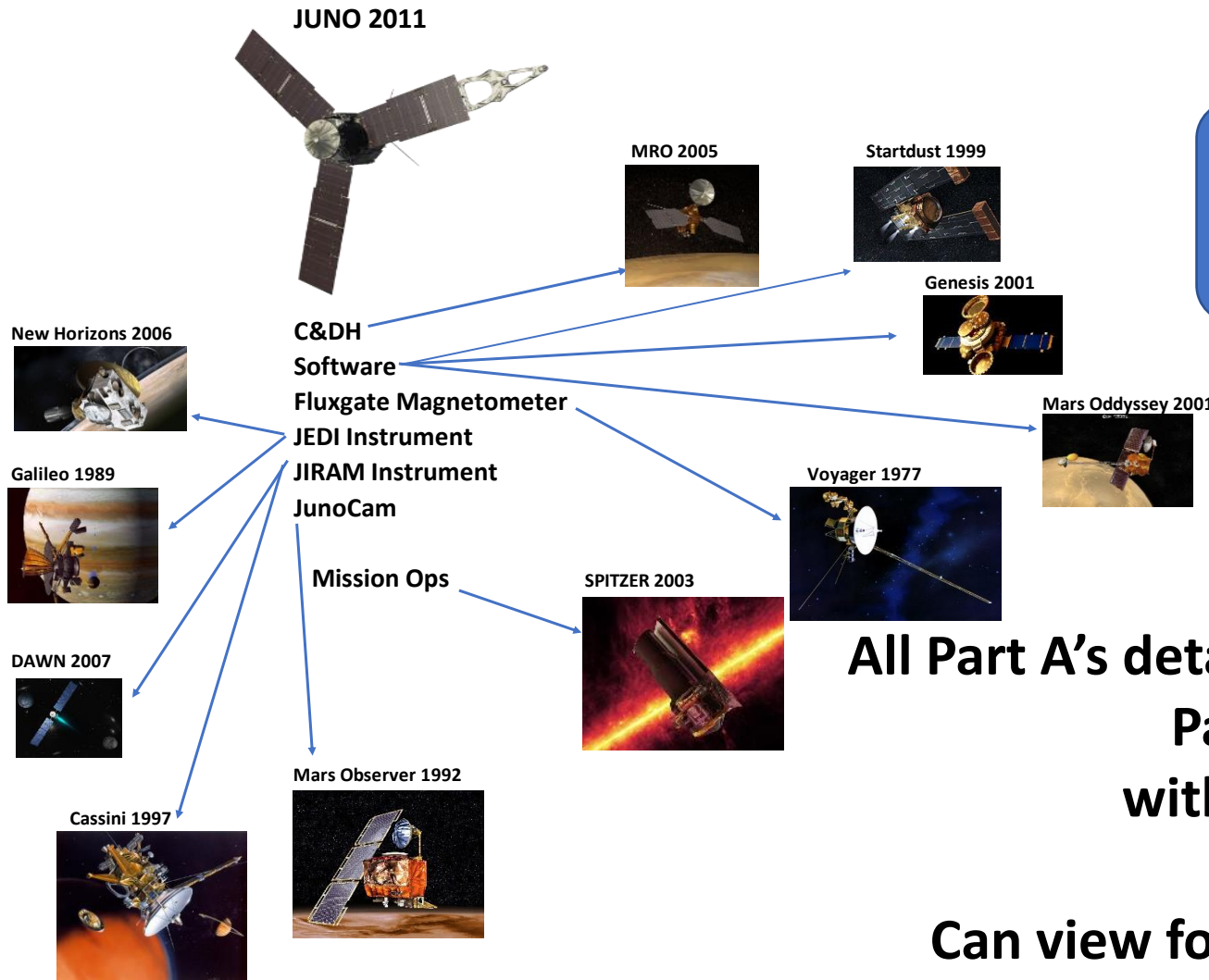
- 1.0 System Name
 - 1.1 Project Management
 - 1.2 Systems Engineering
 - 1.3 Safety and Mission Assurance
 - 1.4 Science/Technology
 - 1.5 Payload(s)
 - 1.5.1 Payload Management
 - 1.5.2 System Engineering
 - 1.5.3 Payload Product Assurance
 - 1.5.4 Instrument *n*
 - 1.5.5 Integration, Assembly Test & Check out
 - 1.6 Flight System \ Spacecraft
 - 1.6.1 Flight System Project Management
 - 1.6.2 Flight System Systems Engineering
 - 1.6.3 Flight System Product Assurance
 - 1.6.4 Spacecraft
 - 1.6.4.1 Spacecraft Management
 - 1.6.4.2 Spacecraft Systems Engineering
 - 1.6.4.3 Spacecraft Product Assurance
 - 1.6.4.4 Spacecraft Structures & Mechanisms Total
 - 1.6.4.4.1 Structures/Mech. Management
 - 1.6.4.4.2 Structures/Mech. Systems Engineering
 - 1.6.4.4.3 Primary Structures
 - 1.6.4.4.3.1 Load Carrying Shell/Truss
 - 1.6.4.4.3.2 Equipment Compartments
 - 1.6.4.4.3.3 Booms
 - 1.6.4.4.3.4 Adapters
 - 1.6.4.4.4 Secondary Structures
 - 1.6.4.4.4.1 Equipment (Instrument) Mountings
 - 1.6.4.4.4.2 Ballast Mass
 - 1.6.4.4.5 Mechanisms
 - 1.6.4.4.5.1 Positioning
 - 1.6.4.4.5.2 Deployment and Storage Equipment
 - 1.6.4.4.5.3 Docking Mechanisms
 - 1.6.4.4.6 Pyrotechnics
 - 1.6.4.4.7 Structures/Mech. Subsystem I&T
 - 1.6.4.5 Spacecraft Thermal Control
 - 1.6.4.5.1 Thermal Management
 - 1.6.4.5.2 Thermal Systems Engineering
 - 1.6.4.5.3 Active Devices
 - 1.6.4.5.3.1 Cryogenic Devices
 - 1.6.4.5.3.2 Liquid Loops
 - 1.6.4.5.3.3 Electric Cooling (Thermoelectric)
 - 1.6.4.5.3.4 Electric Heaters Thermistors & Thermostats
 - 1.6.4.5.3.5 Shutters

- 1.6.4.5.4 Passive Devices
 - 1.6.4.5.4.1 Radiator Panel/Fins
 - 1.6.4.5.4.2 Coatings
 - 1.6.4.5.4.3 Heat Pipes
 - 1.6.4.5.4.4 Insulation
 - 1.6.4.5.4.5 Conductive Structures
 - 1.6.4.5.4.6 Heat Activated louvers
 - 1.6.4.5.4.7 Sun Shields
 - 1.6.4.5.4.8 Second Surface Mirrors
- 1.6.4.5.5 Thermal Subsystem I&T
- 1.6.4.6 Spacecraft Electrical Power & Distribution
 - 1.6.4.6.1 EPS Management
 - 1.6.4.6.2 EPS Systems Engineering
 - 1.6.4.6.3 Electrical Power Generation
 - 1.6.4.6.3.1 Solar Cells
 - 1.6.4.6.3.2 Nuclear Reactor
 - 1.6.4.6.3.3 Radioisotope Thermionic Generator
 - 1.6.4.6.3.4 Chemical (Fuel Cells)
 - 1.6.4.6.3.5 Aux Power Unit(s)
 - 1.6.4.6.4 Electrical Power Conditioning
 - 1.6.4.6.4.1 Power Control Electronics
 - 1.6.4.6.4.2 Power Conversion Electronics
 - 1.6.4.6.4.3 Power Dissipation Devices
 - 1.6.4.6.4.4 Power Distribution Electronics
 - 1.6.4.6.5 Electrical Power Storage
 - 1.6.4.6.5.1 Batteries
 - 1.6.4.6.5.2 Charge Control Electronics
 - 1.6.4.6.6 Harnesses & Cables
 - 1.6.4.6.7 EPS Subsystem I&T
- 1.6.4.7 Spacecraft GN&C
 - 1.6.4.7.1 GN&C Management
 - 1.6.4.7.2 GN&C Systems Engineering
 - 1.6.4.7.3 Attitude Determination
 - 1.6.4.7.3.1 Earth (Horizon) Sensors
 - 1.6.4.7.3.2 Sun Sensors
 - 1.6.4.7.3.3 Star Tracker/Sensors
 - 1.6.4.7.3.4 GPS Receivers
 - 1.6.4.7.3.5 Imagers
 - 1.6.4.7.3.6 Magnetometers
 - 1.6.4.7.3.7 Altimeters
 - 1.6.4.7.3.8 Inertial Reference Unit
 - 1.6.4.7.3.9 Rate Gyros
 - 1.6.4.7.3.10 Accelerometers
 - 1.6.4.7.3.11 Bearings and Power Transfer Assembly
- 1.6.4.7.4 Attitude Control
 - 1.6.4.7.4.1 Reaction Wheels
 - 1.6.4.7.4.2 Momentum Wheels
 - 1.6.4.7.4.3 Control Moment Gyros
 - 1.6.4.7.4.4 Energy Storage Devices (Flywheels)
 - 1.6.4.7.4.5 Magnetic Control Devices
 - 1.6.4.7.4.6 Spin Control Devices
 - 1.6.4.7.4.7 Control Electronics
 - 1.6.4.7.5 GN&C Subsystem I&T

- 1.6.4.8 Spacecraft Propulsion
 - 1.6.4.8.1 Propulsion Management
 - 1.6.4.8.2 Propulsion Systems Engineering
 - 1.6.4.8.3 Tanks
 - 1.6.4.8.3.1 Oxidizer Tanks
 - 1.6.4.8.3.2 Fuel Tanks
 - 1.6.4.8.3.3 Propellant Tanks
 - 1.6.4.8.3.4 Pressurant Tanks
 - 1.6.4.8.4 Plumbing
 - 1.6.4.8.5 Maneuvering Thrusters
 - 1.6.4.8.5.1 Bipropellant
 - 1.6.4.8.5.2 Monopropellant
 - 1.6.4.8.5.3 Solar Electric
 - 1.6.4.8.5.4 Ion
 - 1.6.4.8.5.5 Electrostatic
 - 1.6.4.8.5.6 Electromagnetodynamic
 - 1.6.4.8.5.7 Cold Gas
 - 1.6.4.8.6 Translation Thrusters
 - 1.6.4.8.6.1 Bipropellant
 - 1.6.4.8.6.2 Monopropellant
 - 1.6.4.8.6.3 Solar Electric
 - 1.6.4.8.6.4 Ion
 - 1.6.4.8.6.5 Electrostatic
 - 1.6.4.8.6.6 Electromagnetodynamic
 - 1.6.4.8.6.7 Cold Gas
 - 1.6.4.8.7 Solid Propellant
 - 1.6.4.8.8 Liquid Propellant
 - 1.6.4.8.9 Propulsion Subsystem I&T
- 1.6.4.9 Spacecraft Communications
 - 1.6.4.9.1 Telecom Management
 - 1.6.4.9.2 Telecom Systems Engineering
 - 1.6.4.9.3 Antennas
 - 1.6.4.9.3.1 Omnidirectional
 - 1.6.4.9.3.2 Spiral
 - 1.6.4.9.3.3 Horn
 - 1.6.4.9.3.4 Patch
 - 1.6.4.9.3.5 Parabolic
 - 1.6.4.9.4 Waveguides/Routers
 - 1.6.4.9.4.1 Diplexers
 - 1.6.4.9.4.2 Triplexers
 - 1.6.4.9.4.3 Multiplexers
 - 1.6.4.9.4.4 Multicouplers
 - 1.6.4.9.4.5 Coaxial Switches
 - 1.6.4.9.4.6 RF Switches
 - 1.6.4.9.4.7 Filters
 - 1.6.4.9.4.8 Waveguide
 - 1.6.4.9.5 Radio Frequency Equipment
 - 1.6.4.9.5.1 Receivers
 - 1.6.4.9.5.2 Transmitters
 - 1.6.4.9.5.3 Transceivers
 - 1.6.4.9.5.4 Transponders
 - 1.6.4.9.5.5 Modulators
 - 1.6.4.9.5.6 Demodulators
 - 1.6.4.9.5.7 Traveling Wave Tube Assembly (TWTA)
 - 1.6.4.9.5.8 Solid State Power Amplifiers
 - 1.6.4.9.5.9 GPS Receivers
 - 1.6.4.9.5.10 Downconverters
 - 1.6.4.9.5.11 Upconverters
 - 1.6.4.9.6 Telecom Subsystem I&T

- 1.6.4.10 Spacecraft C&DH
 - 1.6.4.10.1 C&DH Management
 - 1.6.4.10.2 C&DH Systems Engineering
 - 1.6.4.10.3 Processors
 - 1.6.4.10.4 Solid State Memory
 - 1.6.4.10.5 Decoders
 - 1.6.4.10.6 Command Units
 - 1.6.4.10.7 Telemetry Units
 - 1.6.4.10.8 Command Sequencers
 - 1.6.4.10.9 Timing Units
 - 1.6.4.10.10 Frequency Generators
 - 1.6.4.10.11 Signal Conditioners
 - 1.6.4.10.12 Data Switches
 - 1.6.4.10.13 COMSEC
 - 1.6.4.10.14 Interface Units
 - 1.6.4.10.15 Tape Recorders
 - 1.6.4.10.16 Disk Recorders
 - 1.6.4.10.17 C&DH Subsystem I&T
 - 1.6.4.11 Spacecraft Software
 - 1.6.4.11.3 CSCI Name 1
 - 1.6.4.11.4 CSCI Name 2
 - 1.6.5 Entry/Descent/Lander
 - 1.6.6 Rover
 - 1.6.7 Spacecraft Retirement & Disposal
 - 1.7 Mission Operations System (MOS)
 - 1.7.1 MOS Management
 - 1.7.2 MOS Systems Engineering
 - 1.7.3 Mission Operations Center
 - 1.7.4 Science/Data Operations Center
 - 1.7.5 Data Distribution & Archival
 - 1.7.6 Communications/Network Infrastructure
 - 1.7.7 Training
 - 1.8 Launch Vehicle/Services
 - 1.9 Ground Data System (GDS)
 - 1.9.1 GDS Management
 - 1.9.2 GDS Systems Engineering
 - 1.9.3 Mission Operations Center
 - 1.9.4 Science/Data Operations Center
 - 1.9.5 Data Distribution & Archival
 - 1.9.5.1 Hardware
 - 1.9.5.2 Software
 - 1.9.5.3 Other
 - 1.9.6 Ground Stations
 - 1.9.7 Communications/Network Infrastructure
 - 1.9.7.4 GDS Integration & Test
 - 1.10 System Integration, Assembly, Test & Check Out
 - 1.11 Education & Public Outreach
 - 2.1 Reserves and Unfunded Future Expenses (UFE)

Importance of Part A's



Part A provides documented Heritages

All Part A's detail key Spacecraft Subsystems and Payload (Instruments) with documented heritage

**Can view forwards and backwards in time
Predecessors and Successors**



CADRe Execution



When are CADRes Required?

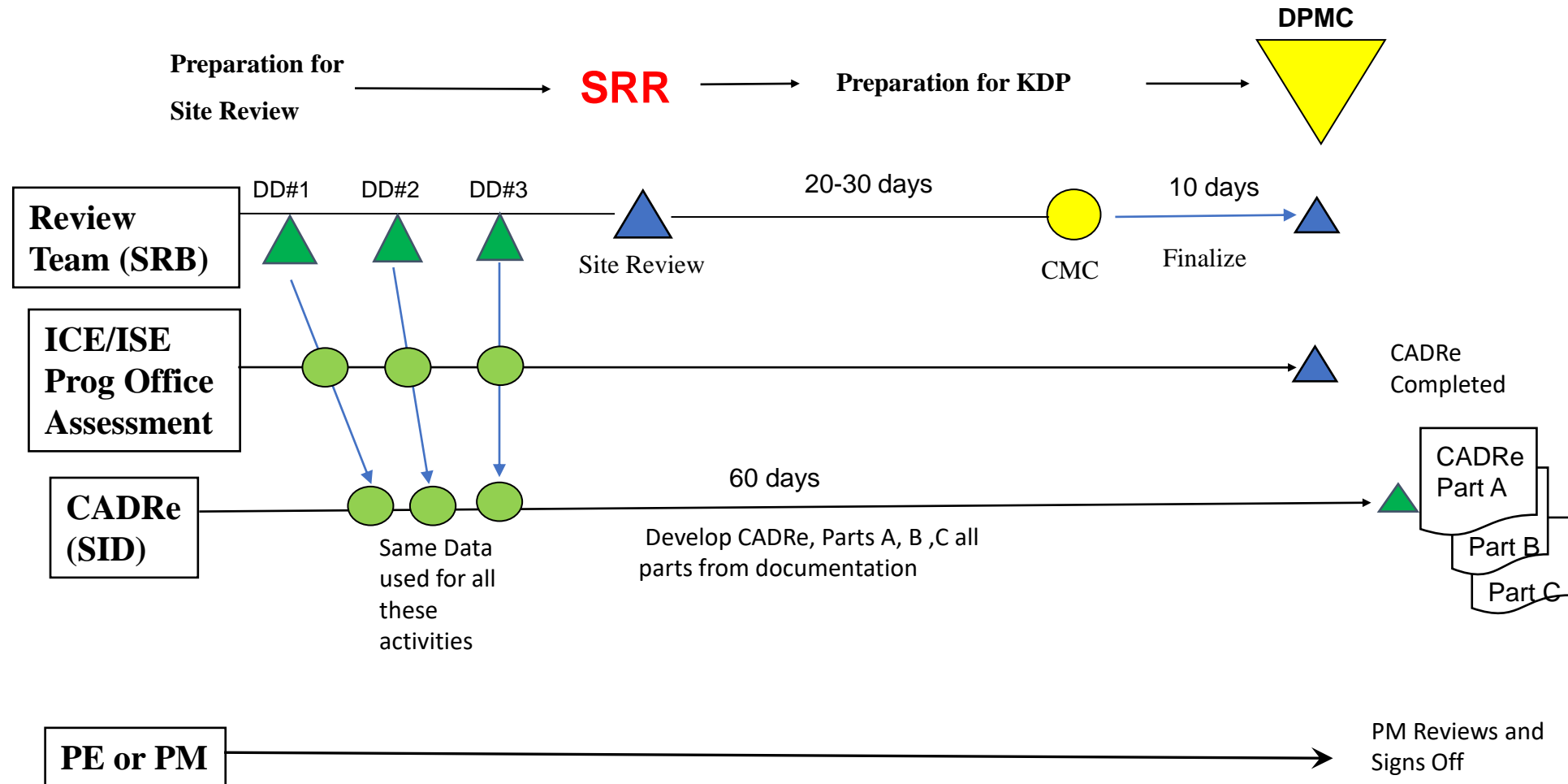
Program Phases	Formulation			Implementation			
	KDP-A	KDP-B	KDP-C	KDP-D	KDP-E		
Flight Projects Life Cycle Phases	Pre-Phase A: Concept Studies	Phase A: Concept Development SRR/MDR	Phase B: Preliminary Design PDR	Phase C: Detailed Design CDR SIR	Phase D: Fabrication, Assembly & Test Launch	Phase E: Operations & Sustainment	Phase F: Disposal EOM
Traditional Waterfall Development or Directed Missions		▼ 1	▼ 2 CR	▼ 3	4	5	6
AO-Driven Projects	Down Select Step 1 ▼	Select Step 2 ▼ 1 PMSR	▼ 2 CR	▼ 3	4	5	6

Legend

- ▼ Mission Decision Review
- 1 CADRe provided to project 30-45 days after KDP-B using SRR/MDR/PMSR material
- 2 CADRe updated to project 30-45 days after KDP-C using PDR material.
- 3 CADRe updated to project 60 days after CDR.
- 4 CADRe updated to project 30-45 days after KDP-D using SIR material.
- 5 CADRe provided to project approx. 90 days after launch using 'as built' mass and final development costs.
- 6 Update Part C only at the End of Planned Mission to capture final MOS/GDS costs.



CADRe Rhythm

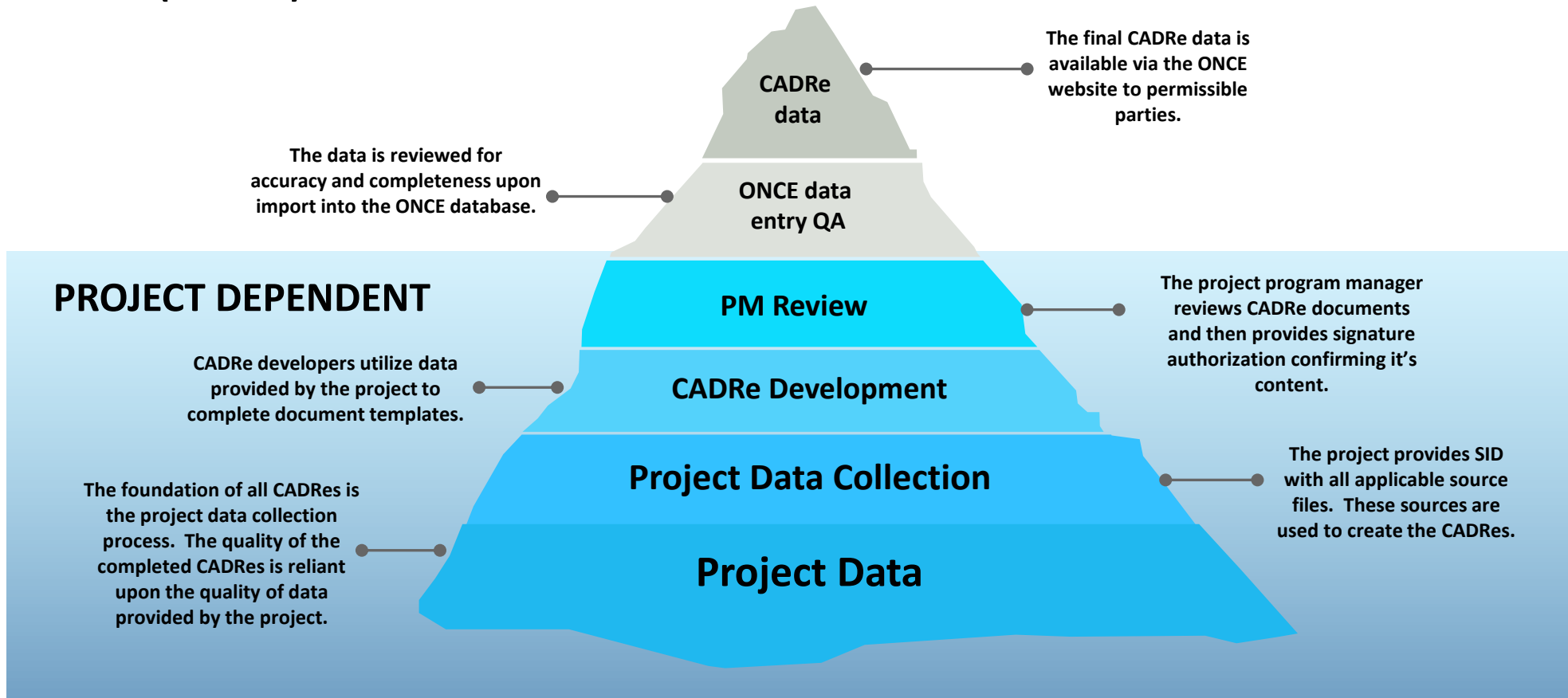


CADRe is prepared in parallel with review cycle



CADRe Dependency On Projects

SID (CADRe) DEPENDENT





CADRe Inputs and Outputs



What Is Needed to Build a CADRe (Inputs)

Part A: Descriptive Information

- Project Plan
- Acquisition Plan
- System Engineering Mgt Plan (SEMP)
- Architecture Description Document
- Risk Mitigation Plan
- Software Management Plan
- Concept of Operations
- Concept Study Proposal (if applicable)
- Milestone Briefing Packages (SRR, PDR, CDR etc)
- Subsystem Briefing Packages (SRR, PDR, CDR etc)
- Instrument Briefing Packages (SRR, PDR, CDR etc)
- Mission Assurance Implementation Plan (MAIP)
- Monthly Status Reports

Part B: Technical Data

- Master Equipment Lists (MEL)
- Power Equipment Lists (PEL)
- Other Mass Property Reports
- Software Metrics (Source Lines of Code or other)
- Technical Performance Measures (TPMs)
- Documented TRLs and assumptions

Part C: Programmatic Data

- Project Life Cycle Cost Estimate LCCE (WBS, FY, Phase)
- Risk 5X5s and Risk Registers
- WBS Dictionary
- Schedules (Gantt Charts and IMS- MS Project Files)
- Work Force (FTEs and WYEs) and Prime Workforce if avail
- Ground Rules and Assumptions

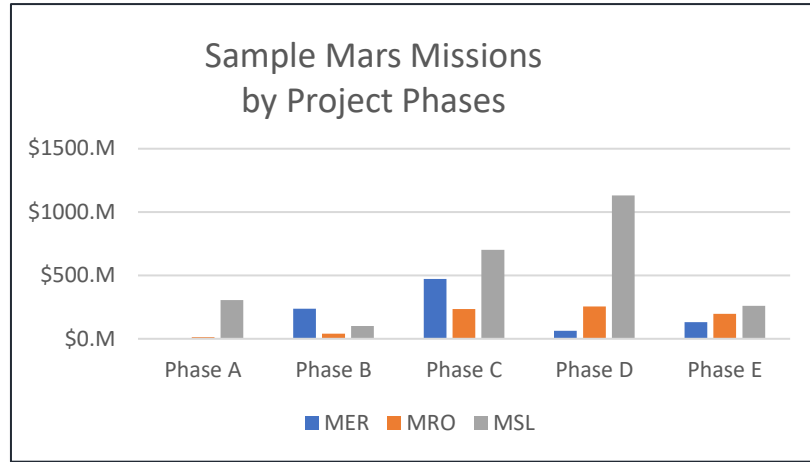
Amount of Documentation Varies with Project Size, Class, and Category



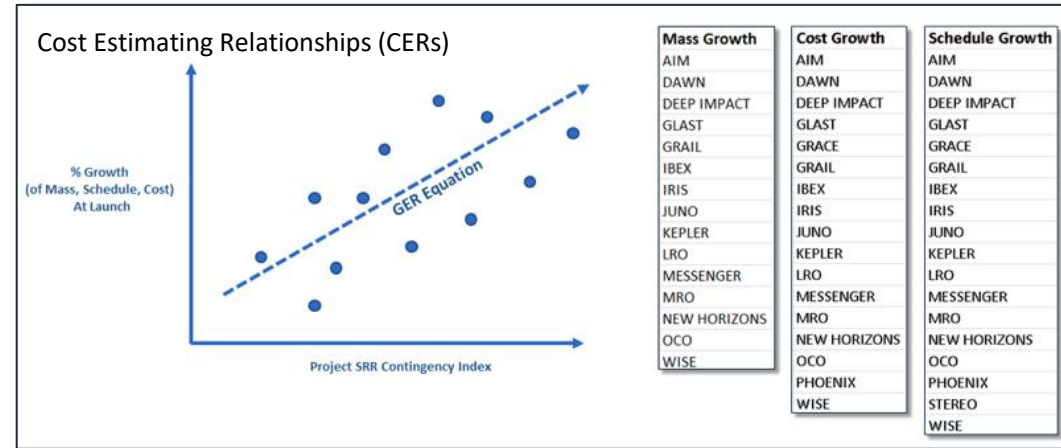
CADRe Sample of Analysis (Outputs)



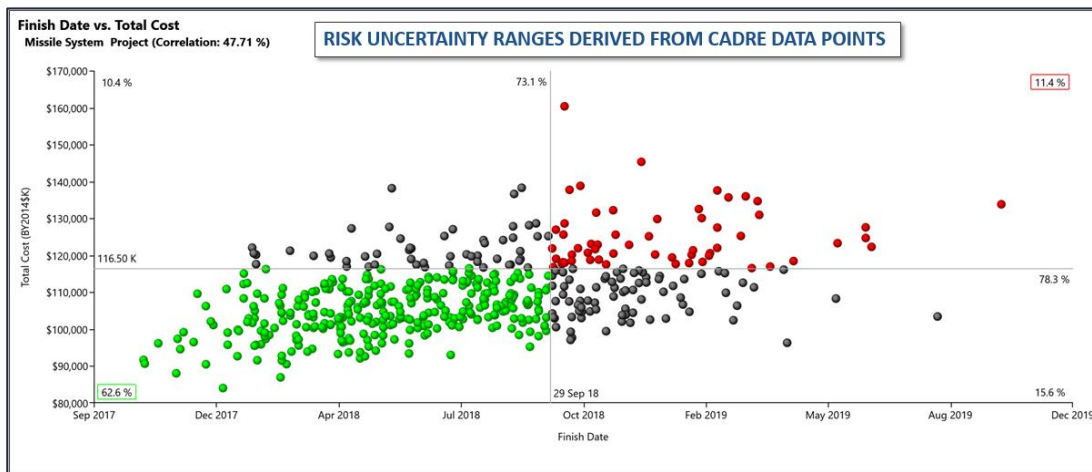
Analogy Estimating



Cost Models



Joint Confidence Level Analysis



Milestone Metrics

NASA CADRe Database	SMEX	MIDEX	Discovery	SMEX	SMEX	ESSP	MIDEX	Average Duration (all)
	NuSTAR	WISE*	Kepler*	OCO	GALEX	Cloudsat	MAP	
KDP-B to PDR (months)	12	11	12	11	3	7	7	9.0
PDR to CDR (months)	10	13	10	25	9	11	5	11.7
CDR to SIR (months)	8	17	19	19	26	14	37	20.1
SIR to Launch (months)	17	13	11	11	19	18	11	14.3
KDP-B to Launch (months)	47	54	52	66	57	50	60	55.1

* Adjusted timeline from CADRe



CADRe Policy Updates



CADRe Policy History

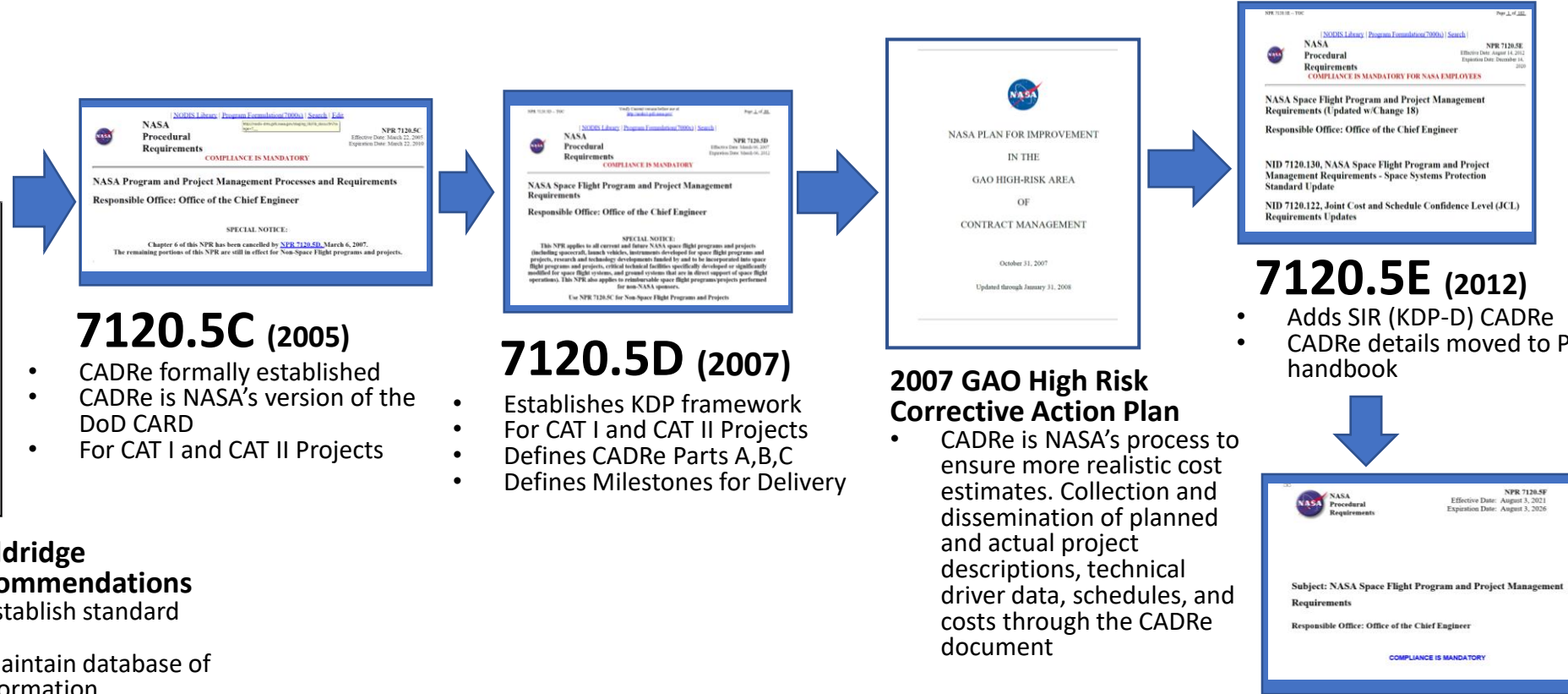


NASA Initiates Improvements for Agency Wide Cost and Schedule Estimating Practices

- 2003 CAD Established**
- Early Concepts of CADRe design
 - Early socialization of CADRe to Centers and JPL/APL

- 2004 GAO and Aldridge Commission Recommendations**
- NASA needs to establish standard LCCE framework
 - NASA needs to maintain database of historical cost information
 - NASA needs to Include cost risk analysis as part of LLC reviews
 - NASA needs Independent cost estimating activities

CADRe a NASA requirement in 7120.5



7120.5C (2005)

- CADRe formally established
- CADRe is NASA's version of the DoD CARD
- For CAT I and CAT II Projects

7120.5D (2007)

- Establishes KDP framework
- For CAT I and CAT II Projects
- Defines CADRe Parts A,B,C
- Defines Milestones for Delivery

2007 GAO High Risk Corrective Action Plan

- CADRe is NASA's process to ensure more realistic cost estimates. Collection and dissemination of planned and actual project descriptions, technical driver data, schedules, and costs through the CADRe document

7120.5E (2012)

- Adds SIR (KDP-D) CADRe
- CADRe details moved to PM handbook

7120.5F (2021)

- CADRe Req'd for all flight projects regardless of CAT or CLASS

CADRe scope increased with each release of 7120.5



Rapid Evolution of 7120.5 Project Category Definitions

NPG 7120.5B

Effective Date: November 21, 2002
Expiration Date: March 21, 2007

No Mention of Project Categories

NPR 7120.5C

Effective Date: March 22, 2005
Expiration Date: March 22, 2010

Priority	Life Cycle Cost		
	LCC < \$100M	\$100M ≤ LCC < \$500M	LCC ≥ \$500M
High	Category II	Category I	Category I
Moderate	Category III	Category II	Category I
Low	Category III	Category III	Category II

NPR 7120.5D

Effective Date: November 20, 2006
Expiration Date: November 20, 2009

Priority Level	LCC > \$1B, or use of nuclear power source, or human space flight		
	LCC < \$250M	\$250M ≤ LCC ≤ \$1B	LCC > \$1B, or use of nuclear power source, or human space flight
High	Category 2	Category 2	Category 1
Medium	Category 3	Category 2	Category 1
Low	Category 3	Category 2	Category 1

Note: The threshold values in Table 2-1 are updated annually as part of the Agency's strategic planning guidance.

NPR 7120.5E

Effective Date: August 14, 2012
Expiration Date: November 20, 2017

Priority Level	LCC < \$250M	\$250M ≤ LCC ≤ \$1B	LCC > \$1B, significant radioactive material, or human space flight
High	Category 2	Category 2	Category 1
Medium	Category 3	Category 2	Category 1
Low	Category 3	Category 2	Category 1

NPR 7120.5F

Effective Date: August 3, 2021
Expiration Date: August 3, 2026

Priority Level	LCC < \$365M	\$365M ≤ LCC ≤ \$2B	LCC > \$2B, significant radioactive material, or human space flight
High	Category 2	Category 2	Category 1
Medium	Category 3	Category 2	Category 1
Low	Category 3	Category 2	Category 1

Economic realities of inflationary growth over time



CADRe Recent Progress



New CADRe 2022-2023

Completed CADRes

AWE SIR

DART LRD

Deep Space Atomic Clock EOM

Dragonfly SRR

EPFD SRR

EMIT LRD

EscaPADE CDR

EZIE SRR, PDR

Europa Clipper SIR

FSS CDR

Gateway KPD-0

GLAST EOM

GLIDE PDR, CDR

GOES-T LRD

GPIM EOM

HST EOM

IMAP PDR

IXPE LRD

JPSS-2 SIR

Juno EOPM

JWST LRD

LCRD LRD

Libera PDR

LOFTID LRD

Lucy LRD

MEGANE CDR

ML-2 PDR

Orion SIR

PREFIRE CDR

PUNCH CDR

ROMAN-CGI SIR

SLS B1B post PDR

SPHEREx CDR

Space Weather FO- SRR

Space Weather FO - PDR

SunRise SIR

SWOT SIR

TRACERS PDR

TSIS-2 CDR

VIPER CDR

Blue= Sequential follow-on



CADRes for CAT III CLASS D Missions



AWE - Atmospheric Waves Experiment

CLARREO Path Finder - Climate Absolute Radiance and Refractivity Observatory

COSI - Compton Spectrometer and Imager

CYGNSS - Compton Spectrometer and Imager

DSAC - Deep Space Atomic Clock

DSOC - Deep Space Optical Communications (DSOC)

ECOSTRESS - Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station

EscaPADE - The Escape and Plasma Acceleration and Dynamics Explorers

EZIE - Electrojet Zeeman Imaging Explorer

GUSTO - Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory

GLIDE - Global Lyman-alpha Imagers of the Dynamic Exosphere

IRIS - Interface Region Imaging Spectrograph

IXPE - Imaging X-ray Polarimetry Explorer

LCRD - Laser Communications Relay Demonstration

LOFTID - Low-Earth Orbit Flight Test of an Inflatable Decelerator

NEA Scout - Near Earth Asteroid (NEA) Scout

NICER - Neutron star Interior Composition Explorer

NuSTAR - Nuclear Spectroscopic Telescope Array

PREFIRE - Polar Radiant Energy in the Far Infrared Experiment

PUNCH - Polarimeter to Unify the Corona and Heliosphere

SUNRISE - Sun Radio Interferometer Space Experiment

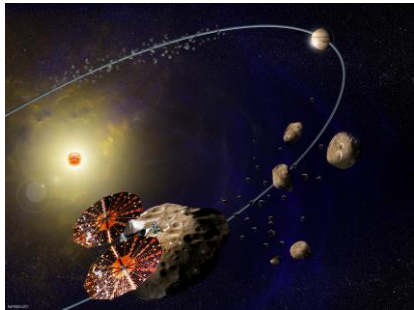
TRACERS - Transition Region and Coronal Explorer

TROPICS - Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats

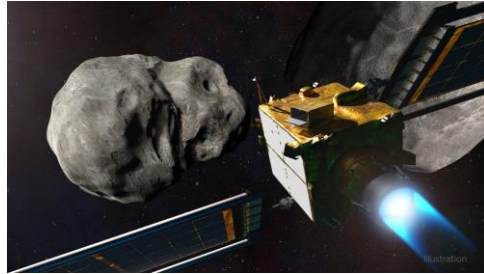
TSIS-2 Total Spectral Irradiance Sensor -2



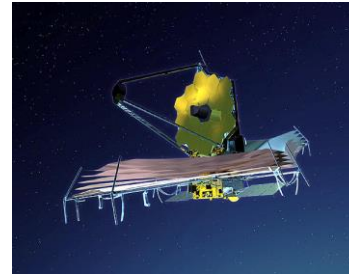
New Launch CADRes 2022-2023



Lucy LRD



DART LRD/EOM



JWST



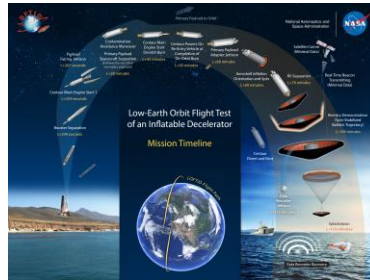
LCRD



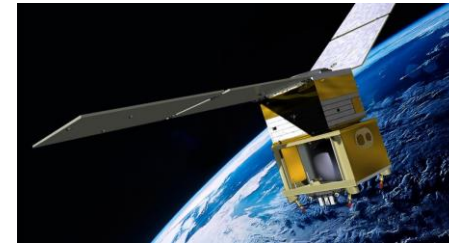
GOES-T



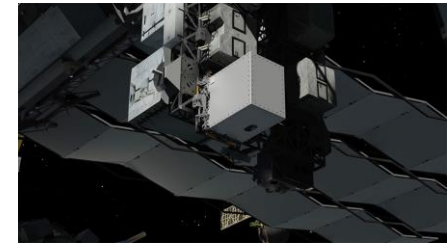
HUBBLE eEOM



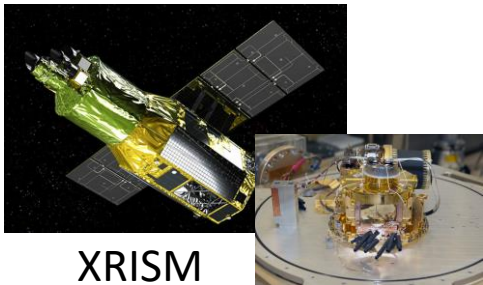
LOFTID LRD/EOM



GPIM



EMIT



XRISM



JUNO EOPM

Completed Launch and EOM CADRes

2024 LRD CADRes
TEMPO, AWE, PACE, MEGANE,
Europa, EZIE, XRISM

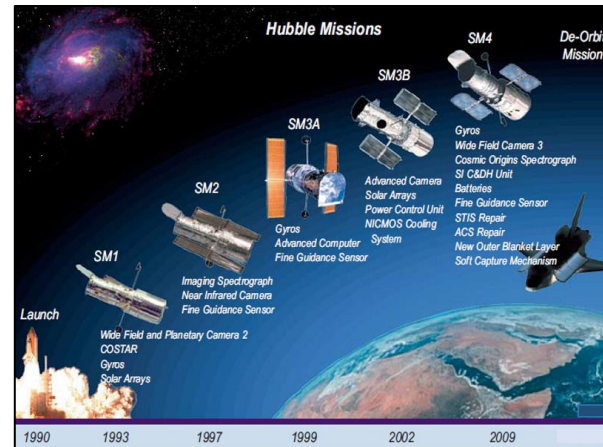


Hubble Space Telescope CADRe

Cost, Schedule, Technical, and Risks

Development History

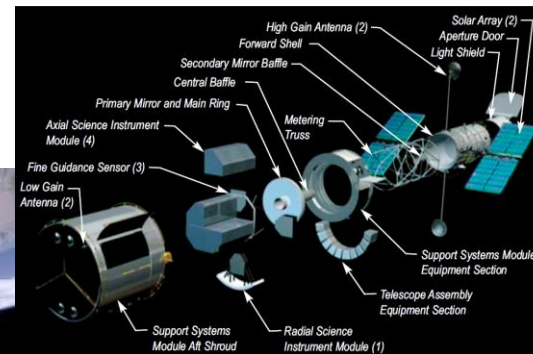
- Optical Telescope Assembly (OTA),
- Support Systems Module (SSM)
 - Solar Arrays
 - Communications
 - Computer Systems Modules
 - Electronics Boxes
 - Aperture Door
 - Shields
 - Pointing Control
- Payload five science instruments at a given time, plus the Fine Guidance Sensors



MISSION INFORMATION		PERFORMANCE CAPABILITY	
LAUNCH VEHICLE: SPACE SHUTTLE	ORBITAL ALTITUDE: 509 N MILES	SPECTRAL RANGE: 1200 - 10000 Å	POINTING RESOLUTION: 0.1"
ORBITAL PERIOD: 96.9 MIN	ORBITAL INCLINATION: 28.5°	RESOLUTION: 0.05" (FWHM)	SCIENTIFIC INSTRUMENTS:
OPERATIONAL LIFE: 5 YEARS	EXTENDED LIFE WITH GROUND REPERFRESHMENT	STABILITY: 0.01" RMS (1σ) FOR 24 HOURS	WFC/PC
TELESCOPE: 2.4 METER APERTURE	WEIGHT: 11,110 KG (24,500 LBS)	ANGULAR POSITION: 0.1°	STIS
POWER: SOLAR ARRAYS/VEHICLE	SPIN RATE: 1.0 RPM	WEIGHTED RANGE: 0.1"	ACS
SSM	SSM	SSM	SSM
WFC/PC	WFC/PC	WFC/PC	WFC/PC
STIS	STIS	STIS	STIS
ACS	ACS	ACS	ACS
TOTAL	TOTAL	TOTAL	TOTAL

CADRe captures additional data

- Challenger disaster, delays, and eventual launch in 1990
- Flawed mirror
 - Origin of the problem
 - Design of a solution
- Servicing Missions 1, 2, 3A, 3B, and 4
- Equipment failures
 - Gyroscope rotation sensors
 - Instruments and electronics



DETAIL WEIGHT STATEMENT			
4.1 Support Systems Module DSM			
ITEM	DESCRIPTION	MTL REQ'D	WEIGHT CLASS
A115	Aperture Door	1	36.1
A116	Light Shield	1	60.9
A117	Forward Shell	1	60.9
A118	Primary Mirror	1	213.2
A119	Support Systems Module	1	117.3
A120	Telescope Assembly	1	517.3
A121	Radial Science Instrument Module	1	36.6
A122	Support Systems Module Alt Shroud	1	36.6
A123	Low Gain Antenna	2	73.2
A124	Axial Science Instrument Module	4	146.4
A125	High Gain Antenna	2	73.2
A126	Solar Array	2	146.4
A127	Aperture Door	1	36.1
A128	Light Shield	1	60.9
A129	Forward Shell	1	60.9
A130	Secondary Mirror Baffle	1	213.2
A131	Central Baffle	1	213.2
A132	Primary Mirror and Main Ring	1	213.2
A133	Metering Truss	1	213.2
A134	Support Systems Module Equipment Section	1	117.3
A135	Telescope Assembly Equipment Section	1	517.3
A136	Radial Science Instrument Module	1	36.6
A137	Support Systems Module Alt Shroud	1	36.6
A138	Low Gain Antenna	2	73.2
A139	Axial Science Instrument Module	4	146.4
A140	High Gain Antenna	2	73.2
A141	Solar Array	2	146.4
A142	Aperture Door	1	36.1
A143	Light Shield	1	60.9
A144	Forward Shell	1	60.9
A145	Secondary Mirror Baffle	1	213.2
A146	Central Baffle	1	213.2
A147	Primary Mirror and Main Ring	1	213.2
A148	Metering Truss	1	213.2
A149	Support Systems Module Equipment Section	1	117.3
A150	Telescope Assembly Equipment Section	1	517.3
A151	Radial Science Instrument Module	1	36.6
A152	Support Systems Module Alt Shroud	1	36.6
A153	Low Gain Antenna	2	73.2
A154	Axial Science Instrument Module	4	146.4
A155	High Gain Antenna	2	73.2
A156	Solar Array	2	146.4
A157	Aperture Door	1	36.1
A158	Light Shield	1	60.9
A159	Forward Shell	1	60.9
A160	Secondary Mirror Baffle	1	213.2
A161	Central Baffle	1	213.2
A162	Primary Mirror and Main Ring	1	213.2
A163	Metering Truss	1	213.2
A164	Support Systems Module Equipment Section	1	117.3
A165	Telescope Assembly Equipment Section	1	517.3
A166	Radial Science Instrument Module	1	36.6
A167	Support Systems Module Alt Shroud	1	36.6
A168	Low Gain Antenna	2	73.2
A169	Axial Science Instrument Module	4	146.4
A170	High Gain Antenna	2	73.2
A171	Solar Array	2	146.4
A172	Aperture Door	1	36.1
A173	Light Shield	1	60.9
A174	Forward Shell	1	60.9
A175	Secondary Mirror Baffle	1	213.2
A176	Central Baffle	1	213.2
A177	Primary Mirror and Main Ring	1	213.2
A178	Metering Truss	1	213.2
A179	Support Systems Module Equipment Section	1	117.3
A180	Telescope Assembly Equipment Section	1	517.3
A181	Radial Science Instrument Module	1	36.6
A182	Support Systems Module Alt Shroud	1	36.6
A183	Low Gain Antenna	2	73.2
A184	Axial Science Instrument Module	4	146.4
A185	High Gain Antenna	2	73.2
A186	Solar Array	2	146.4
A187	Aperture Door	1	36.1
A188	Light Shield	1	60.9
A189	Forward Shell	1	60.9
A190	Secondary Mirror Baffle	1	213.2
A191	Central Baffle	1	213.2
A192	Primary Mirror and Main Ring	1	213.2
A193	Metering Truss	1	213.2
A194	Support Systems Module Equipment Section	1	117.3
A195	Telescope Assembly Equipment Section	1	517.3
A196	Radial Science Instrument Module	1	36.6
A197	Support Systems Module Alt Shroud	1	36.6
A198	Low Gain Antenna	2	73.2
A199	Axial Science Instrument Module	4	146.4
A200	High Gain Antenna	2	73.2



CADRe with Updated Actual Launch Vehicle Costs



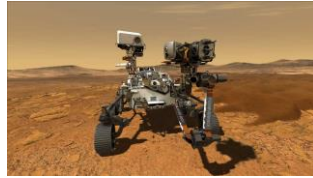
Launch Services Provider (LSP)

Launch Date

Launch Location

LV Type

M2020 Perseverance



July 30, 2020

Cape Canaveral, SLC-41

Atlas V 541

Lucy



October 16, 2021

Cape Canaveral SLC-41

Atlas V 401

Parker Probe



August 12, 2018

Cape Canaveral, SLC-37

Delta IV Heavy

DART



November 24, 2021

Vandenberg SLC- 4

SpaceX Falcon 9

IXPE



December 9, 2021

Cape Canaveral SLC 39A

SpaceX Falcon 9

L-9

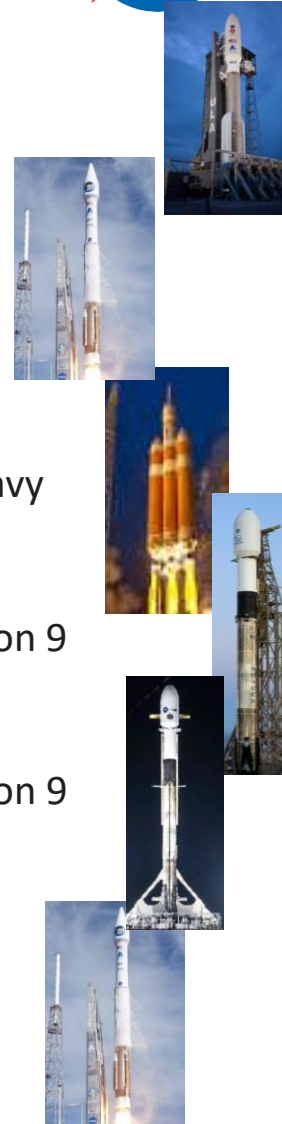


September 27, 2021

Vandenberg SLC-3E 4

Atlas V 401

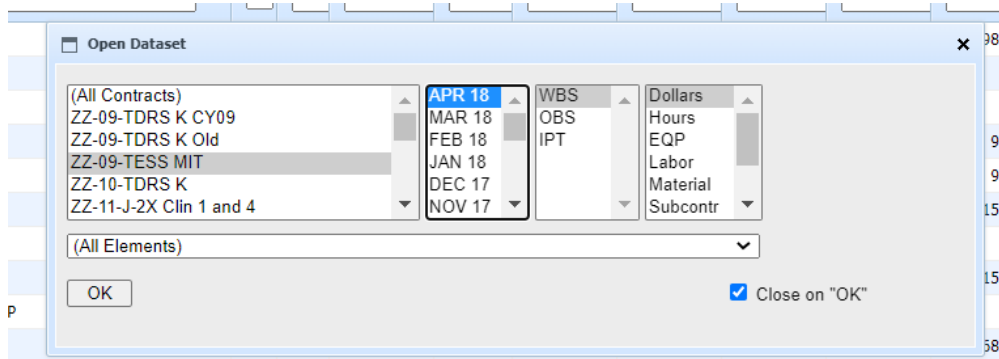
Types of Services purchased varies by mission such as long range/down range telemetry.





Incorporating EVM into CADRes

Encore Analytics



WBS NASA WBS Element	Level
1.0 System Name	1
1.1 Project Management	2
1.2 Systems Engineering	2
1.3 Safety and Mission Assurance	2
1.4 Science Technology	2
1.5 Payload(s)	2
1.5.1 Operational Land Imager-2	2
1.5.1.1 OSFC Oversight	2
1.5.1.2 Management	2
1.5.1.3 Systems Engineering	2
1.5.1.3.1 Data Analysis	2
1.5.1.3.2 Spacecraft Interfaces	2
1.5.1.3.3 Risk Management	2
1.5.1.3.4 Algorithms	2
1.5.1.4 Special Studies	2
1.5.1.5 Integration & Test	2
1.5.1.6 Inst Launch Commish Supt	2
1.5.1.7 Mission Assurance	2
1.5.1.8 Simulators	2
1.5.1.9 Instrument	2
1.5.1.7.1 Detector Subsystem	2
1.5.1.7.2 Electrical Products	2
1.5.1.7.3 Optical Products	2
1.5.1.7.4 Mechanical Products	2
1.5.1.7.5 Thermal Subsystem	2
1.5.1.7.6 Flt & Non-flt Minor Mtls	2
1.5.1.7.7 Wire Harness and Cables	2
1.5.2 Personal Infrared Sensor-2	2
1.6 Flight Systems	2
1.7 Mission Operations System (MOS)	2
1.8 Launch Vehicle/Services	2
1.9 Ground Data System (GDS)	2
1.10 System Integration, Assembly, Test & Check Out	2
1.11 Education & Public Outreach	2
2.1 Reserves and Unfunded Future Expenses (UFE)	2

Use of EMPOWER System

- Empower Administrators were able to rename all historical project dataset names to begin with “ZZ”, instead of using a separate database
- Categorization of “ZZ” projects-for completed projects open to PP&C community
- CADRe collects ACWPs by WBS totals
- Flows into by expanding lower level WBSs at total level

- Includes Lower Level Contractor Costs (ACWP)
 - Detector Subsystem
 - Electrical Product
 - Optical Products
 - Mechanical Products
 - Thermal Subsystems
 - Flt and Non Flight Materials
 - Wire Harness and Cable



Full Update of CATEGORY and CLASS for all CADRes



1	Program Name	Cent	Mission Cla	Mission Catego
2	ACE	LRD	ACE - LRD	Heliophysics Explorer Program APL C CAT 3
3	ACRIMSat	EOM	ACRIMSat - EOM	Earth Systematic Missions JPL C CAT 3
4	KDP-F	KDP-F	ACRIMSat - KDP-F	Earth Systematic Missions JPL C CAT 3
5	AIM	SRR	AIM - SRR	Heliophysics Explorer Program GSFC C CAT 2
6		PDR	AIM - PDR	Heliophysics Explorer Program GSFC C CAT 2
7		CDR	AIM - CDR	Heliophysics Explorer Program GSFC C CAT 2
8		LRD	AIM - LRD	Heliophysics Explorer Program GSFC C CAT 2
9	Aqua	LRD	Aqua - LRD	Earth Systematic Missions GSFC A CAT 1
10	Aquarius	SRR	Aquarius - SRR	Earth Science JPL C CAT 2
11		PDR	Aquarius - PDR	Earth Science JPL C CAT 2
12		LRD	Aquarius - LRD	Earth Science JPL C CAT 2
13		EOM	Aquarius - EOM	Earth Science JPL C CAT 2
14	Aquila	LRD	Aquila I - LRD	Non NASA ARC D CAT 3
15	ASTRO E II	LRD	ASTRO E II - LRD	Astrophysics Explorer GSFC C CAT 3
16	ASTRO H	SRR	ASTRO-H SRR	Astrophysics Explorer GSFC C CAT 3
17		PDR	ASTRO-H - PDR	Astrophysics Explorer GSFC C CAT 3
18		CDR	ASTRO-H - CDR	Astrophysics Explorer GSFC C CAT 3
19	PostSIR	LRD	ASTRO-H - LRD	Astrophysics Explorer GSFC C CAT 3
20	Aura	EOM	Aura - EOM	Earth Systematic Missions GSFC B CAT 1
21	AWE	SRR	AWE - SRR	Heliophysics Explorer Program GSFC D CAT 3
22		PDR	AWE - PDR	Heliophysics Explorer Program GSFC D CAT 3
23	BOPPS	LRD	BOPPS - LRD	Balloon Planetary Science APL D CAT 3
24	BRRISON	LRD	BRRISON - LRD	Balloon Planetary Science APL D CAT 3
25	CAL	LRD	CAL - LRD	International Space Station JPL D CAT 3
26	CALIPSO	CSR	CALIPSO - CSR	Earth System Science Pathfinder LaRC C CAT 2
27		PDR	CALIPSO - PDR	Earth System Science Pathfinder LaRC C CAT 2
28		CDR	CALIPSO - CDR	Earth System Science Pathfinder LaRC C CAT 2
29		LRD	CALIPSO - LRD	Earth System Science Pathfinder LaRC C CAT 2
30	Cassini	LRD	Cassini - LRD	Outer Planets Program JPL A CAT 1
31		EOM	Cassini - EOM	Outer Planets Program JPL A CAT 1
32	CHIPSAT	LRD	CHIPSAT - LRD	Astrophysics GSFC D CAT 3
33	CLARREO PF	ΔSRR	CLARREO PF - Delta SRR	Earth Science LaRC D CAT 3
34		PDR	CLARREO PF - PDR	Earth Science LaRC D CAT 3
35		CDR	CLARREO PF - CDR	Earth Science LaRC D CAT 3
36	CloudSat	CSR	CloudSat - CSR	Earth System Science Pathfinder JPL C CAT 2
37		PDR	CloudSat - PDR	Earth System Science Pathfinder JPL C CAT 2
38		CDR	CloudSat - CDR	Earth System Science Pathfinder JPL C CAT 2
39		LRD	CloudSat - LRD	Earth System Science Pathfinder JPL C CAT 2
40	COBE	EOM	COBE - EOM	Astrophysics Explorer GSFC B CAT 2
41	CONTOUR	LRD	CONTOUR - LRD	Discovery APL B CAT 3
42	CYGNSS	SRR	CYGNSS - SRR	Earth System Science Pathfinder HQ D CAT 3
43		PDR	CYGNSS - PDR	Earth System Science Pathfinder HQ D CAT 3
44		CDR	CYGNSS - CDR	Earth System Science Pathfinder HQ D CAT 3
45		SIR	CYGNSS - SIR	Earth System Science Pathfinder HQ D CAT 3
46		LRD	CYGNSS - LRD	Earth System Science Pathfinder HQ D CAT 3
47	DART	SRR	DART - SRR	Astrophysics APL D CAT 2

Program Name	Cent	Mission Cla	Mission Catego	Category	Class
ACE	LRD	ACE - LRD	Heliophysics Explorer Program	APL	C CAT 3
ACRIMSat	EOM	ACRIMSat - EOM	Earth Systematic Missions	JPL	C CAT 3
KDP-F	KDP-F	ACRIMSat - KDP-F	Earth Systematic Missions	JPL	C CAT 3
AIM	SRR	AIM - SRR	Heliophysics Explorer Program	GSFC	C CAT 2
AIM	PDR	AIM - PDR	Heliophysics Explorer Program	GSFC	C CAT 2
AIM	CDR	AIM - CDR	Heliophysics Explorer Program	GSFC	C CAT 2
AIM	LRD	AIM - LRD	Heliophysics Explorer Program	GSFC	C CAT 2
Aqua	LRD	Aqua - LRD	Earth Systematic Missions	GSFC	A CAT 1
Aquarius	SRR	Aquarius - SRR	Earth Science	JPL	C CAT 2
Aquarius	PDR	Aquarius - PDR	Earth Science	JPL	C CAT 2
Aquarius	LRD	Aquarius - LRD	Earth Science	JPL	C CAT 2
Aquarius	EOM	Aquarius - EOM	Earth Science	JPL	C CAT 2
Aquila	LRD	Aquila I - LRD	Non NASA	ARC	D CAT 3
ASTRO E II	LRD	ASTRO E II - LRD	Astrophysics Explorer	GSFC	C CAT 3
ASTRO H	SRR	ASTRO-H SRR	Astrophysics Explorer	GSFC	C CAT 3
ASTRO H	PDR	ASTRO-H - PDR	Astrophysics Explorer	GSFC	C CAT 3
ASTRO H	CDR	ASTRO-H - CDR	Astrophysics Explorer	GSFC	C CAT 3
ASTRO H	LRD	ASTRO-H - LRD	Astrophysics Explorer	GSFC	C CAT 3
Aura	EOM	Aura - EOM	Earth Systematic Missions	GSFC	B CAT 1
AWE	SRR	AWE - SRR	Heliophysics Explorer Program	GSFC	D CAT 3
AWE	PDR	AWE - PDR	Heliophysics Explorer Program	GSFC	D CAT 3
BOPPS	LRD	BOPPS - LRD	Balloon Planetary Science	APL	D CAT 3
BRRISON	LRD	BRRISON - LRD	Balloon Planetary Science	APL	D CAT 3
CAL	LRD	CAL - LRD	International Space Station	JPL	D CAT 3
CALIPSO	CSR	CALIPSO - CSR	Earth System Science Pathfinder	LaRC	C CAT 2
CALIPSO	PDR	CALIPSO - PDR	Earth System Science Pathfinder	LaRC	C CAT 2
CALIPSO	CDR	CALIPSO - CDR	Earth System Science Pathfinder	LaRC	C CAT 2
CALIPSO	LRD	CALIPSO - LRD	Earth System Science Pathfinder	LaRC	C CAT 2
Cassini	LRD	Cassini - LRD	Outer Planets Program	JPL	A CAT 1
Cassini	EOM	Cassini - EOM	Outer Planets Program	JPL	A CAT 1
CHIPSAT	LRD	CHIPSAT - LRD	Astrophysics	GSFC	D CAT 3
CLARREO PF	ΔSRR	CLARREO PF - Delta SRR	Earth Science	LaRC	D CAT 3
CLARREO PF	PDR	CLARREO PF - PDR	Earth Science	LaRC	D CAT 3
CLARREO PF	CDR	CLARREO PF - CDR	Earth Science	LaRC	D CAT 3
CloudSat	CSR	CloudSat - CSR	Earth System Science Pathfinder	JPL	C CAT 2
CloudSat	PDR	CloudSat - PDR	Earth System Science Pathfinder	JPL	C CAT 2
CloudSat	CDR	CloudSat - CDR	Earth System Science Pathfinder	JPL	C CAT 2
CloudSat	LRD	CloudSat - LRD	Earth System Science Pathfinder	JPL	C CAT 2
COBE	EOM	COBE - EOM	Astrophysics Explorer	GSFC	B CAT 2
CONTOUR	LRD	CONTOUR - LRD	Discovery	APL	B CAT 3
CYGNSS	SRR	CYGNSS - SRR	Earth System Science Pathfinder	HQ	D CAT 3
CYGNSS	PDR	CYGNSS - PDR	Earth System Science Pathfinder	HQ	D CAT 3
CYGNSS	CDR	CYGNSS - CDR	Earth System Science Pathfinder	HQ	D CAT 3
CYGNSS	SIR	CYGNSS - SIR	Earth System Science Pathfinder	HQ	D CAT 3
CYGNSS	LRD	CYGNSS - LRD	Earth System Science Pathfinder	HQ	D CAT 3
DART	SRR	DART - SRR	Astrophysics	APL	D CAT 2

- Completed review of All 500 CADRes and updated Category and Class as Necessary
- Update based on year of mission to match CAT rating provided at the time



Updated Contractor Name and Contract Type



1	Mission	Long Name	Program	Template	Spacecraft Contractor	Contract Type	Center	Contract Notes	Status	Mission Dir.
2	ACE	Advanced Composition Explorer	Heliophysics Explorer Progra	Unmanned	California Inst. of Tech.		Applied Physics Laboratory		Completed Post Launch	SMD
3	ACRIMSat	ACRIMSat	Earth Systematic Missions	Unmanned	Orbital ATK		Jet Propulsion Laboratory		Completed Post Launch	SMD
4	AIM	Aeronomy of Ice in the Mesosphere	Heliophysics Explorer Progra	Unmanned	Hampton University		Goddard Space Flight Center		Completed Post Launch	SMD
5	Apollo CSM	Apollo Command and Service Module	Explorer	Manned	Rockwell International and Na	Cost Plus (CP)	Johnson Space Center		Completed Post Launch	HEOMD
6	Apollo LM	Apollo Lunar Module	Explorer	Manned	Northrop Grumman	Cost Plus (CP)	Johnson Space Center		Completed Post Launch	HEOMD
7	Aqua	Aqua (PM-1)	Earth Systematic Missions	Unmanned	Northrop Grumman	Cost Plus Award Fee (CPAF)	Goddard Space Flight Center		Completed Post Launch	SMD
8	Aquarius	Aquarius	Earth Science	Unmanned	JPL		Jet Propulsion Laboratory		Completed Post Launch	SMD
9	Aquila	Aquila, Non-NASA	Non NASA	Unmanned	Millenium Space	Cost Plus Award Fee (CPAF)	Other		Completed Post Launch	SMD
10	ASTRO E II	Suzaku (ASTRO-E II)	Astrophysics Explorer	Unmanned	Japanese Inst of Space & As		Goddard Space Flight Center		Completed Post Launch	SMD
11	ASTRO H	ASTRO H	Astrophysics Explorer	Unmanned	GSFC		Goddard Space Flight Center		Completed Post Launch	SMD
12	Aura	Aura (Chem-1)	Earth Systematic Missions	Unmanned	Northrop Grumman	Cost Plus Award Fee (CPAF)	Goddard Space Flight Center		Completed Post Launch	SMD
13	AWE	Atmospheric Waves Experiment	Heliophysics Explorer Progra	Unmanned	GSFC	Cost Plus Fixed Fee (CPFF)	Goddard Space Flight Center		Completed Pre Launch	SMD
14	BOPPS	Balloon Observation Platform for Planetary Sci	Balloon Planetary Science	Unmanned	APL		Applied Physics Laboratory		Completed Post Launch	SMD
15	BRRISON	Balloon Rapid Response for ISON	Balloon Planetary Science	Unmanned	APL		Applied Physics Laboratory		Completed Post Launch	SMD
16	CAL	Cold Atom Laboratory	International Space Station	Unmanned	JPL		Jet Propulsion Laboratory		Completed Post Launch	SMD
17	CALIPSO	CALIPSO	Earth System Science Pathfr	Unmanned	Alcatel Alenia Space		Langley Research Center		Completed Post Launch	SMD
18	Cassini	Cassini	Outer Planets Program	Unmanned	JPL	Cost Plus Fixed Fee (CPFF)	Jet Propulsion Laboratory	1249887 Cassini Co-Investiga	Completed Post Launch	SMD
19	CEUS	Composites for Exploration Upper Stage	Technology Demonstration M	Unmanned	MSFC		Marshall Space Flight Center	Built in-house	Completed Post Launch	STMD
20	CHANDRA	CHANDRA	Physics of the Cosmo	Unmanned	TRW	Cost Plus Award Fee (CPAF)	Marshall Space Flight Center		Schedule ONLY	SMD
21	CHIPSAT	CHIPSAT	Astrophysics	Unmanned	University of California		Goddard Space Flight Center		Completed Post Launch	STMD
22	CINDI	CINDI	Heliophysics Explorer Progra	Unmanned	US AFRL		Other		Completed Post Launch	SMD
23	CLARREO PF	Climate Absolute Radiance and Refractivity Ob	Earth Science	Unmanned	Not Applicable		Langley Research Center		Work In Process Pre Launch	SMD
24	CloudSat	CloudSat	Earth System Science Pathfr	Unmanned	Ball Aerospace	Cost Plus (CP)	Jet Propulsion Laboratory		Completed Post Launch	SMD
25	COBE	COBE	Astrophysics Explorer	Unmanned	GSFC		Goddard Space Flight Center		Completed Post Launch	SMD
26	CONTOUR	Comet Nucleus Tour	Discovery	Unmanned	APL		Applied Physics Laboratory		Completed Post Launch	SMD
27	CPST	Cryogenic Propellant Storage & Transfer	Technology Demonstration M	Unmanned	GRC		Glenn Research Center		Completed Post Launch	STMD
28	CXD	CHANDRA X-RAY OBSERVATORY	Astrophysics Research	Unmanned	TRW	Cost Plus Award Fee (CPAF)	Other		Completed Post Launch	HEOMD
29	CxP Ares I	CxP Ares I	Human Exp. & Ops Mission	Manned	Lockheed Martin	Cost Plus Award Fee (CPAF)	Marshall Space Flight Center		Completed Post Launch	HEOMD
30	CxP EVA	EVA	Human Exp. & Ops Mission	Manned	JSC		Johnson Space Center		Completed Post Launch	HEOMD
31	CxP GO	Constellation (CxP) Ground Operations	Human Exp. & Ops Mission	Manned	KSC		Kennedy Space Center		Completed Post Launch	HEOMD
32	CxP Integration	Constellation Program Integration	Human Exp. & Ops Mission	Manned	JSC		Johnson Space Center		Completed Post Launch	HEOMD
33	CxP MDP	Constellation Program Mission Ops Project	Human Exp. & Ops Mission	Manned	JSC		Johnson Space Center		Completed Post Launch	HEOMD
34	CxP Orion	Constellation ORION	Human Exp. & Ops Mission	Manned	Lockheed Martin	Cost Plus Award Fee (CPAF)	Johnson Space Center		Completed Post Launch	HEOMD
35	CxP Program	Constellation Program	Human Exp. & Ops Mission	Manned	JSC		Johnson Space Center		Completed Post Launch	HEOMD
36	CYGNSS	Cyclone Global Navigation Satellite System	Earth System Science Pathfr	Unmanned	Southwest Research Institute	Firm Fixed Price (FFP)	NASA Headquarters	This spacecraft bus consists of a	Completed Post Launch	SMD
37	DART	Double Asteroid Redirection Test	Astrophysics	Unmanned	APL		Applied Physics Laboratory		Completed Post Launch	SMD
38	DAWN	DAWN	Discovery	Unmanned	Orbital ATK	Cost Plus (CP)	Jet Propulsion Laboratory		Completed Post Launch	SMD
39	Deep Impact	Deep Impact	Planetary Science Discovery	Unmanned	Ball Aerospace	Cost Plus (CP)	Jet Propulsion Laboratory		Completed Post Launch	SMD
40	Deep Space 1	Deep Space 1	Deep Space Mission System	Unmanned	Orbital ATK		Jet Propulsion Laboratory		Completed Post Launch	SMD
41	Dragonfly	Dragonfly	New Frontiers	Unmanned	APL	Cost Plus (CP)	Applied Physics Laboratory		Completed Pre Launch	SMD
42	DSAC	Deep Space Atomic Clock	Technology Demonstration M	Unmanned	JPL		Jet Propulsion Laboratory		Completed Post Launch	STMD
43	DSCOVR	Deep Space Climate Observatory	Reimbursable Projects Progr	Unmanned	GSFC		Goddard Space Flight Center		Completed Post Launch	SMD
44	DSMS	DSMS	Deep Space Mission System	Unmanned	Lockheed Martin	Cost Plus Award Fee (CPAF)	Other		Work In Process Pre Launch	SMD
45	DSOC	Deep Space Optical Communications	Space Technology	Unmanned	JPL		Jet Propulsion Laboratory		Completed Post Launch	SMD
46	ECOSTRESS	ECOSystem Spaceborne Thermal Radiometer	Earth System Science Pathfr	Unmanned	JPL		Jet Propulsion Laboratory		Completed Post Launch	SMD
47	eCryo	Evolvable Cryogenics	Technology Demonstration M	Manned	GRC		Glenn Research Center		Completed Post Launch	STMD
48	EFT-1	EFT-1	Human Exp. & Ops Mission	Manned	Lockheed Martin		Johnson Space Center		Completed Post Launch	HEOMD
49	EGS	Directorate Ground Systems Development Op	Human Exp. & Ops Mission	Manned	KSC		Kennedy Space Center		Completed Pre Launch	HEOMD

- Update based on Spacecraft Contractor
- Instrument Contractor
- Standard Report now available to pull this information



CADRe: Resource for Analogous Missions



CADRe: Resource for Analogous Missions

HELIOPHYSICS SCIENCE

Helio Missions (Sun-Pointed)

- STEREO 535 kg (2006)
- Solar Dynamics Observatory 1,542 kg (2010)
- IRIS 185 kg (2013)
- Parker Solar Probe 558 kg (2018)
- Solar Orbiter Collaboration (Insts only) (2020)
- SunRise (6-CubeSats)
- Multi-slit Solar Explorer (MUSE) (2027)



In Development

Helio Missions on ISS

- TSIS-1 257 kg (2017)
- GOLD 37 kg (2018)
- AWE 49 kg (2023 LRD)

Helio Lagrange Point Missions

- ACE 750 kg (1997)
- Genesis 350 kg (2001)
- IMAP 518 kg (2025 LRD)

Helio Missions (Earth Orbiting)

- FAST 190 kg (1996)
- TRACE 241 kg (1998) polar
- IMAGE 493 kg (2000)
- TIMED 591 kg (2001)
- RHESSI 291 kg (2002) x-rays and gamma rays
- Suzaku (ASTRO-E II) 77kg (2005)
- AIM 190 kg (2007) sun-synchronous
- THEMIS 513 kg (2007)
- MMS 928 kg (2015)
- ASTRO H 424 kg (2015)
- ICON 276 kg (2019)
- XRISM 425 kg (instrument)
- TSIS-2 256 kg (2025)
- PUNCH (2025)
- TRACERS (2024)
- GLIDE (Carruthers) (2025)
- EZIE (2024)
- EUVST (Jaxa 2026)



CADRe: Resource for Analogous Missions



PLANETARY SCIENCE

Mars Orbiters

- MGS 620 kg (1996)
- Mars Odyssey 3,539 kg (2001)
- MRO 981 kg (2005)
- MAVEN 805 kg (2013)
- ExoMars TGO (2016)
- **MEGANE 12 kg (2024)**
- **EscaPADE (2024)**

Earth Orbiting Missions

- Kepler 1,040 kg (Earth Trailing Orbit) (2009)
- TESS 311 kg (High Elliptical Orbit) (2018)

Mercury Mission

- Messenger 506 kg (2004)

Saturn Missions (incl moons)

- Cassini 2,580 kg (1997)
- **Dragonfly (TBD)**

Pluto Mission

- New Horizons 400 kg (2006)

Jupiter Missions (incl moons)

- Galileo 1,791kg (1989)
- JUNO 1,559 kg (2011)
- **Europa 2,854 kg**

Comet/Asteroid Missions

- NEAR 468 kg (1996)
- Stardust 299 kg (1999)
- Deep Space-1 369 kg (1998)
- CONTOUR 384 kg (2002)
- Deep Impact 878 kg (2005)
- DAWN 565 kg (2007)
- OSIRIS-REx 925 kg (2016)
- DART 493 kg (2021)
- LUCY 748 kg (2021)
- NEA Scout 10 kg (Cubesat)
- **Psyche 1,598 kg (2023)**
- **NEOSM 1,131 kg (2028)**
- Janus (TBD)

In Development

Mars Landers

- Mars Pathfinder 800 kg (1996)
- MER 997 kg (2003)
- Phoenix 597 kg (2007)
- MSL (Curiosity) 3,421 kg (2011)
- InSight 622 kg (2012)
- M2020 (Perseverance) 3,539 kg (2020)
- **Mars Sample Return (2027)**

Lunar Missions

- MMM 8.3 kg (instrument) (2008)
- LCROSS 2884 kg (2009)
- LRO 1,019 kg (2009)
- GRAIL 193 kg (2011)
- LADEE 243 kg (2013)
- **VIPER 386 kg (2025)**
- **Lunar Trailblazer (2025)**
- **Farside Seismic Suite (2024?)**
- **LExSO (Lunar TBD)**



CADRe: Resource for Analogous Missions

EARTH SCIENCE

Earth Orbiters (Small/Medium)

- QuikSCAT 910 kg (1999)
- ACRIMSAT 126 kg (1999)
- EO-1 556 kg (2000)
- Jason-1 472 kg (2001)
- GRACE 450 kg (2002)
- ICESAT 880 kg (2003)
- SORCE 260 kg (2003)
- CALIPSO 553 kg (2006)
- CloudSat 500 kg (2006)
- OSTM 464 kg (2008)
- OCO, OCO-2 403 kg (2009,2014)
- GLORY 487 kg (2011)
- SMAP 863 kg (2015)
- Jason-3 482 kg (2016)
- GRACE FO 568 kg (2018)
- GeoCarb 157 kg (early 2020s)
- Sentinel-6 983 kg (2020)
- TEMPO 136 kg (2023)

ISS EARTH Missions

- RBI 81 kg (canceled)
- SAGE III 521 kg (2017)
- ECOSTRESS 460 kg (2018)
- GEDI 526 kg (2018)
- OCO-3 539 kg (2019)
- MAIA 64 kg (2021)
- PREFIRE 11.96 kg
- CLARREO PF 240 kg

Meteorological Missions

- GOES I-M, N-P 2,258 kg (2001)
- POES-KLMN-N+ 1245 kg (2009)
- NPP 1792 kg (2011)
- JPSSCGS (2016)
- GOES-R, S, T, U 2,813 kg (2016)
- JPSS-1, 1868 kg (2017)
- JPSS-2 3&4 2,038 kg

Lagrange Point (Space Weather)

- DSCOVR 416 kg (2015)
- Space Weather Follow On
- SW Next

Earth System Pathfinders

- CALIPSO 553 kg (2006)
- CYGNSS 29 kg each (MicroSats) (2016)
- TROPICS 5.4 kg each (CUBESATs) (2022)
- EMIT 186 kg (2022)
- Libera

Earth Orbiters (Large)

- TRMM 2,620 kg (1997)
- Landsat-7 1,857 kg (1999)
- Terra 4,415 kg (1999)
- Aqua 2,808 kg (2002)
- Aura 2,808 kg (2004)
- Aquarius 1,088 kg (2011)
- LDCM 2,150 kg (2013)
- GPM 3,043 kg (2014)
- ICESAT II 1,354 kg (2018)
- Landsat-9 2,428 kg (2021)
- SWOT 1687 kg
- NISAR 2,110 kg
- PACE 1,224 kg
- LANDSAT Next

 In Development



CADRe: Resource for Analogous Missions

ASTROPHYSICS SCIENCE

ASTRO Observatory Missions (Large)

- COBE 2,204 kg (1989)
- Hubble Space Telescope (HST) 8,432 kg (1990)
- SPIZTER (SIRTF) 785 kg (2003)
- SIM 6,211 kg (canceled) (2006)
- SOFIA 3,244 kg (2007)
- Gamma-ray Large Space Telescope (GLAST) 3947 kg (2008)
- JWST 5,848 kg (2021)
- **ROMAN 7,090 kg**
- **CGI (ROMAN) 302 kg**

ASTRO Lagrange Point Missions

- MAP 763 kg (2001)

ASTRO MISSIONS on ISS

- NICER 262 kg (2017)

 In Development

Astro Missions Earth Orbiting

- SAMPEX 165 kg (1992)
- SWAS 282 kg (1998)
- WIRE 253 kg (1999)
- CHIPSAT 60 kg (2003)
- GALEX 287 kg (2003)
- SWIFT 1485kg (2004) gamma ray burts
- ST-8 152 kg (canceled)
- GEMS 254 kg (canceled)
- IBEX 160 kg (2008)
- WISE 645 kg (2009)
- Van Allen Probes 1,210 kg (2012)
- NuSTAR 348 kg (2012) x-ray
- ASTRO-E II 183kg (2005)
- IXPE 311 kg (2021)
- **XRISM 425 kg**
- **SPHEREx 375 kg**
- **COSI (2025)**



CADRe: Resource for Analogous Missions

Human Missions

Historical Missions

- Apollo CSM
- Apollo LM
- Saturn S-1C, S-11, S-1VB
- Skylab
- Spacelab
- Shuttle (External Tank, Booster)

International Space Station (ISS) Tier 2 Projects

- C2V2 (Communications for Visiting Vehicles)
- NORS (Nitrogen Oxygen Replenishment System)
- Li-Ion Battery Upgrade



In Development

Constellation Program

- Constellation Integration
- Constellation Ares I
- Constellation Orion
- Constellation Ground System Dev
- Constellation Mission Operations

In Development Missions

- **Orion**
- **SLS**
- **EGS**
- **Gateway**
- **Mobile Launcher - 2**
- **Human Landing System (HLS)**
- **Lunar Terrain Vehicle**



CADRe: Resource for Analogous Missions



Technology Demonstration Missions

ISS Tech Demo Missions

- Cold Atom Laboratory 319 kg

Ground Tech Demo Missions

- eCryo 34,389 lbs

Space Communication Missions

Space Communication

- TDRS K&L 1778 kg
- TDRS M 1880 kg
- SGSS Ground N/A

Aeronautics Missions

- **Low Boom Flight Demonstrator**
- **Electrified Powertrain Flight Demonstration**
- **X-57**

Earth Orbiter Tech Demo Missions

- Solar Sail Demonstrator 140 kg (canceled)
- Deep Space Optical Communications (DSOC) 38 kg
- Green Propellant Infusion (GPIM) 129 kg
- Deep Space Atomic Clock (DSAC) 40 kg
- Low-Density Supersonic Decelerator (LDSD) 1383 kg
- Laser Communications Relay Demonstration (LCRD) 180 kg
- Low-Earth Orbit Flt Test Inflatable Decelerator (LOFTID) 1,027 kg
- **OSAM-1 2,421 kg (2026)**

Balloon Missions

Planetary Balloon Missions

- BOPPS 1856 kg
- BRRISON 1864 kg

ASTRO Balloon Missions

- **GUSTO 1,171kg**

In Development





CADRe New Template Release



New CADRe Template Version Release 8.0



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All CADRe developers engaged for several months to produce final product.

Part A Updates to follow new 7120.5F

- Education & Public Outreach is now ‘STEM and Public Outreach’
- Science is now ‘Science/Technology’
- Removed ‘CADRe Plus’ terminology



CADRe Instrument Categorization

CADRe Part B (Instrument Parameters)

1. Fields	1.1. Electric Field	
	1.1.1 Double Probe	
	1.1.2 Electron Drift	
	1.2. Magnetometer	
2. Particles	1.2.1 Fluxgate	
	1.2.2 Search Coil	
	1.2.3 Ionized Gas Vapor	
	1.2.4 Magnetoresistive	
	2.1 Mass Spectrometer	
	2.1.1 Quadrupole MS	
	2.1.2 Time-of-Flight MS	
	2.1.3 Sector Field MS	
	2.1.4 Ion Cyclotron Resonance MS	
	2.2 Charge and X-ray Detector	
3. XRT	2.2.1 High Energy Partide Detector	
	2.2.2 Low Energy Partide Detector	
	2.3 Plasma Instrument	
	2.3.1 Plasma Probe	
	2.3.2 Retarding Potential Analyzer	
	2.3.3 Ion Drift Meter	
	2.4 Dust Detector	
	4. Optical	4.1 Passive Optical
		4.1.1 Cryo-cooled Passive Optical
		4.1.2 Optical Telescope Assembly
4.1.3 Radiometer		
4.1.4 Pyrheliometer		
4.1.5 Film Camera		
4.1.6 Interferometer		
4.1.7 Single-band Imager		
4.1.8 Natural Color Imager		
4.1.9 Multi-spectral Imager/Spectrometer		
4.1.10 Hyper-spectral Imager/Spectrometer		
5. MW/RF	4.2 Active Optical	
	4.2.1 Laser Ranging	
	4.2.2 Laser Velodimeter / Vibrometer	
	4.2.3 Laser Imager	
6. Support	4.2.4 Laser Scatterometer	
	5.1 Passive MW/RF	
	5.2 Active MW/RF	
	5.2.1 MW/RF Ranging	
7. Atmospheric & Surface	5.2.2 MW/RF Imager	
	5.2.3 MW/RF Scatterometer	
	6.1 Scan Platform	
	6.2 Deployment Mechanism	
	6.3 Robotic Arm	
	6.4 Data Processing Unit	
	6.5 Cryogenic Systems	
	6.5.1 Cryogenic Radiator	
	6.5.2 Expendable Cryogen Cooler	
	6.5.3 Mechanical Cryocooler	
8. Comm	6.6 Accelerometer	
	6.7 Ultra Stable Oscillator	
	6.8 Mirror Target	
	6.9 Positioning Receivers	
	7.1 Entry and Descent Sensor	
9. Other	7.2 Meteorological Station	
	7.3 Sample Collector	
7.4 Sample Analyzer		
7.5 Seismographer		
8.1 MW/RF Communications		
8.2 Laser Communications		



7	Payload	Instrument 1	Instrument 2	Instrument 3	Instrument 4	Instrument 5
8	Instrument Name					
9	Instrument Builder Name					
10	Instrument Category Level 1	1. Fields	2. Particles	4. Optical	5. MW/RF	7. Atmospheric & Surface
11	Instrument Category Level 2	1.1 Electric Field	2.2 Charge and X-ray Detector	4.2 Active Optical	5.2 Active MW/RF	7.5 Seismographer
12	Instrument Category Level 3	1.1.2 Electron Drift	2.2.2 Low Energy Particle Detector	4.2.4 Laser Scatterometer	5.2.2 MW/RF Imager	
13	Instrument Category: Additional Explanatory Comments					
14	Instrument Builder Category					

- Coordinated with Aerospace, CADRe Developers, and NICM team to refine before implementation into final CADRe templates
- Capability for unique comments for instruments that cross multiple categories
- For Historical CADRes following NICM and Aerospace lead for instrument categorization
- Next step: Build functionality into ONCE

CADRe Template Version 8.0 includes the 3-level instrument taxonomy



New CADRe Template Version Release 8.0



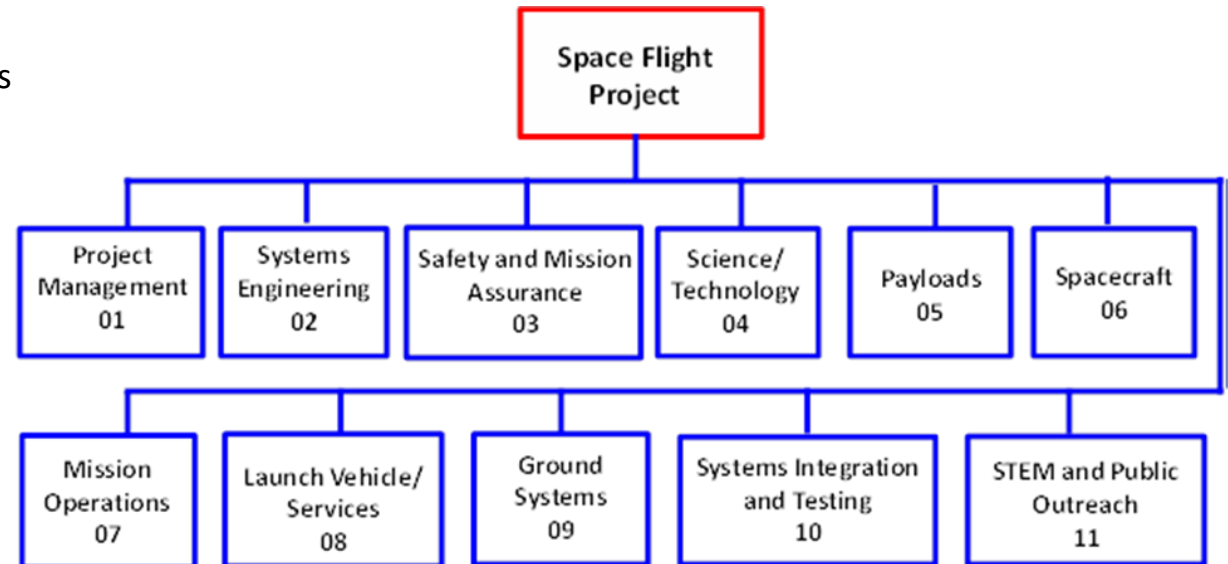
Additional Part B Updates

- Pull Harness out to subsystem level (previously under Electrical Power Subsystem) which matches how all MELs are being reported
- Aligned SC HW, EDL and ROVER tabs to all agree, (ex: moving plumbing under Tanks subsystem)
- Added Cost Plus Fixed Fee as a selection item for both Instruments and Spacecraft
- Based on 7120.5F New Mission Category definitions. Thresholds have changed. Now >\$2B threshold for CAT I
- Added Checklists to ensure completion

Priority Level	LCC < \$365M	\$365M ≤ LCC ≤ \$2B	LCC > \$2B, significant radioactive material, or human space flight
High	Category 2	Category 2	Category 1
Medium	Category 3	Category 2	Category 1
Low	Category 3	Category 2	Category 1

Part C Updates

- Follows updated Level 2 from new 7120.5F
- Updated WBS 4 to Science/Technology
- Updated WBS 11 to STEM and Public Outreach
- Added Grand Total to Work Force





CADRe Summary & Challenges

- CADRe has been a stable & uniform data collection process for the past 15+ years
- CADRes provides valuable low level cost and technical details on missions
- CADRe is experiencing budget shortfalls just like all NASA institutional offices
- Growing budgetary constraints and realized FY23 reductions having negative effects on CADRe development
 - Looking at which 2024 milestones won't have CADRe coverage
(Allow tailoring the CADRe requirement 7120.5F compliance matrix (Appendix C, Table C-1 for CADRe))
 - CADRes not being completed for projects will have long lasting effects
 - New funding options for CADRe are being explored, no clear path yet





CADRe Summary



- CADRe reports are critical for cost, schedule, and risk analysis and modeling and benefits NASA across all Centers and major offices.
- CADRe is the enabler of important programmatic policy, guidance, and estimating research, which in turn informs NASA better estimating future projects.

- ONCE website (NASA network only): <https://oncedata.hq.nasa.gov>



- How to request access:
https://www.nasa.gov/sites/default/files/atoms/files/once_user_access_request_form_tagged.pdf

- ONCE Technical Support: hq-oncesupport@mail.nasa.gov



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