NASA-JAXA Joint Management Approach for Upper Stage Engine System Development

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NASA-JAXA TIM 28 August 2013

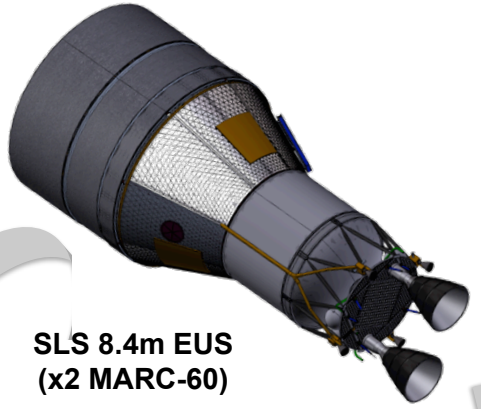
Introduction

- **Objective**
  - Define an overarching set of agreements, approaches, and assumptions to manage the NASA/JAXA collaboration in the form of a joint implementation plan

- **Approach**
  - This overarching set of agreements establishes
    - Rules of engagement and interaction
    - Common assumptions
    - Each side is expected to manage their own activities as informed by the joint implementation plan
  - Developed during Study Phase (through December 2013) and supports full implementation over element development life cycle
  - Simple, concise, focused on closing gaps between JAXA and NASA lower level plans while minimizing duplication
  - TIM Exit Criteria to include agreement on following plan elements:
    - High Level Work Breakdown System (WBS)
    - Responsibility and Authority Channels (including change authority, insight process)
    - Operating rhythm (tactical integration to accomplish near term objectives)
    - Implementation schedule (strategic milestones and reviews)
    - Definition of Study Products (requirements, qualification plans, interfaces, etc.)
    - Identification of success/performance criteria for study and implementation

Range of NASA-JAXA Upper Stage Collaboration

SLS Post Block 1
RSRMV + EUS
120t LEO
40t Earth Departure
25t Trans Mars
8t Trans Jupiter

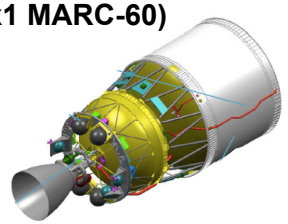


SLS 8.4m EUS
(x2 MARC-60)

NASA Integration

JAXA Integration

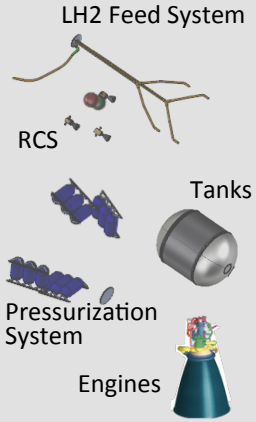
H-X 5m Upper Stage
(x1 MARC-60)



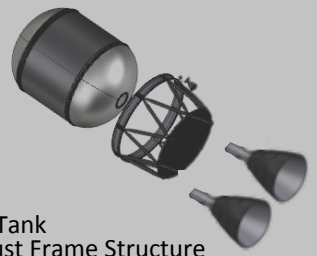
JAXA H-X
20t LEO

Potential JAXA Contributions

MARC-60 Engine Only



MARC-60 Engine & Components/Systems



- 5m Tank
- Thrust Frame Structure
- Thrust Vector Control System
- Propellant Feedline Prevalves/Screens
- Recirculation/Bleed Systems
- Pneumatic Tankage & Control Valves
- MARC-60 Engines

Co-Use Main Propulsion System (MPS)

Joint Management Plan Scope

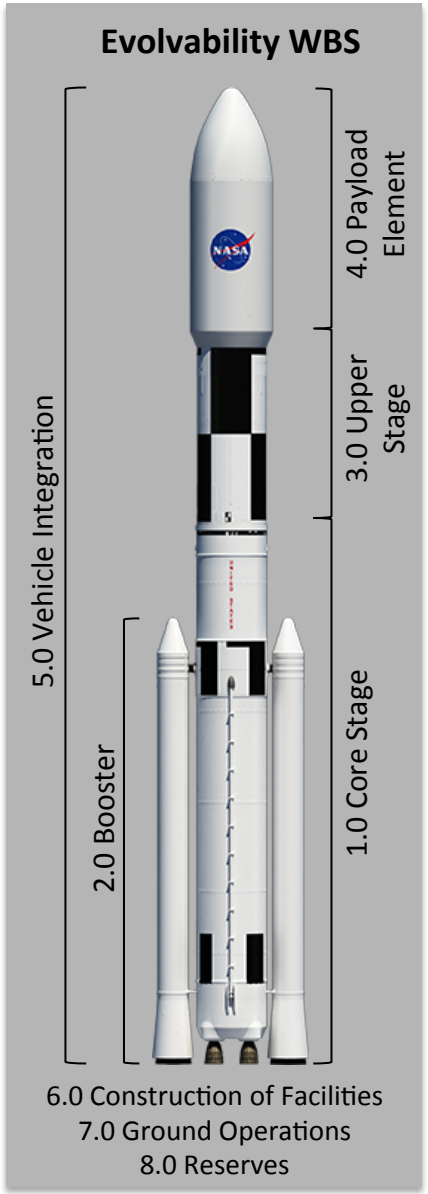
- **Scope dependent on definition of JAXA Engine System**
- **Fixed scope (Engine Only)**
  - JAXA develops MARC-60 and delivers to NASA without controller
  - NASA SLS Engines perform delta qualification test, develops controller, and delivers engine to SLS Stages (EUS) for integration
- **Increased Scope (Engine and MPS components)**
  - JAXA develops MARC-60 and delivers to NASA without controller
  - JAXA delivers TBD MPS components
  - NASA SLS Engines performs delta qualification test, develops controller, and delivers engine to NASA SLS Stages for EUS integration
  - NASA SLS Stages develops interfaces for JAXA MPS components
- **Results of Engine Definition Trade (mid-November) will determine TBD and therefore extent of scope**

SLS Evolvability WBS Dictionary

Compatible with SLS Program Element Summary WBS

SLS Evolvability Work Breakdown Structure (WBS)

- **1.0 Core Stage**
  - 1.1 Core Stage design, test and production of structures, avionics, subsystems and software
  - 1.2 Core Stage Engine: engine and associated structures, subsystems and software
- **2.0 Booster**
  - 2.1 Booster design, test and production of structures, avionics, subsystems and software
  - 2.2 Booster Engine: engine and associated structures, subsystems and software
- **3.0 Upper Stage (ascent/in-space)**
  - 3.1 Upper Stage design, test and production of structures, avionics, subsystems and software
  - 3.2 Upper Stage Engine: engine and associated structures, subsystems and software
- **4.0 Payload Element**
  - 4.1 In-space stage only (i.e., ICPS/CPS): design, test and production of structures, avionics, subsystems, software and engines
  - 4.2 Adaptor(s): design, test and production of structures and associated subsystems
  - 4.3 Payload Fairing (PLF): design, test and production of structures and associated subsystems
- **5.0 Vehicle Integration**
  - 5.1 System Engineering & Integration
  - 5.2 Insight/Oversight
  - 5.3 Program Management
  - 5.4 S&MA
- **6.0 Construction of Facilities (CoF)**
  - Construction cost of new facilities, GSE and test stands
- **7.0 Ground Operations**
  - Logistics, transportation, check-out from factory to contractor hand-over to government
- **8.0 Reserve**
  - Cost margin (based on whether an existing system, a modification of existing system, or a new system)

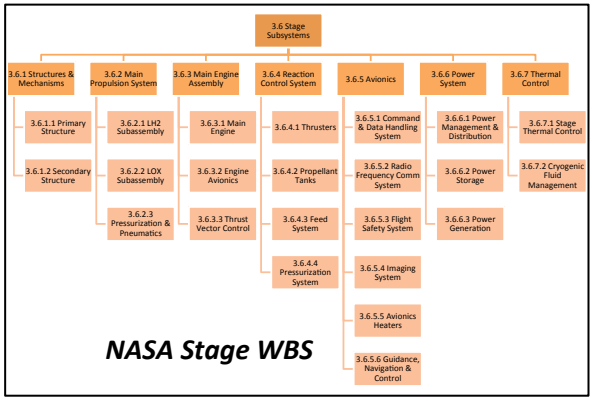


EUS WBS

Compatible with NASA Stage & JAXA Engine WBS

Upper Stage WBS Element	Responsibility	
	NASA	JAXA
3.0 Exploration Upper Stage (EUS)	X	
3.1 Stage Core	X	
3.1.1 Subsystems	X	
3.1.1.1 Avionics	X	
3.1.1.2 Structures & Mechanisms	X	
3.1.1.2.1 Fairings/Covers and System Tunnel	X	
3.1.1.2.2 LH2 Assembly (8.4m)	X	
3.1.1.2.3 Intertank/Structure	X	
3.1.1.2.4 LOX Tank Assembly (5m)	X	E
3.1.1.2.5 Engine Section (Thrust Structure)	X	E
3.1.1.2.6 Interstage/Structure	X	
3.1.1.3 Thermal Control	X	E
3.1.1.4 Main Propulsion System (less engines)	X	E
3.1.1.5 Reaction Control System	X	E
3.1.1.6 Thrust Vector Control	X	E
3.1.1.7 Range Safety	X	
3.1.2 Stage Integration	X	S
3.1.2.1 Integration, Assembly and Checkout (IACO)	X	S
3.1.2.2 System Test Operations (STO)	X	S
3.1.2.3 Ground Support Equipment (GSE)	X	
3.1.2.3.1 Tooling	X	
3.1.2.3.2 Mechanical/Electrical GSE	X	
3.1.2.4 System Engineering & Integration (SE&I)	X	
3.1.2.5 Program Management (PM)	X	
3.1.2.6 Launch & Orbital Operations Support (LOOS)	X	
3.2 Engine System	X	S
3.2.1 Engine Integration		X
3.2.2 Engine System Hardware		X
3.2.3 Engine Controller	X	

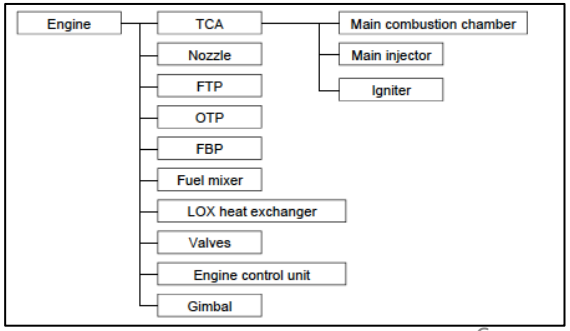
X Provider
S Support During Execution
E Evaluate During Study



NASA Stage WBS

Item		Note
Engine development	Design	
	Fundamental test	Material test, fabrication test, etc.
	Component test	Turbopump, Valve, HX, ECU, etc.
	Engine test (sea level)	3 engines for PM, 2 engines for QM 112 total firings, 19530s total duration
	Engine test (HATS)	
	Engine vibration test and cutting-inspection	
	Fabrication facility construction	
Test facility construction	Sea level engine test stand construction	New Tashiro stand
	High altitude engine test stand construction	New Kakuda stand
	Test stand maintenance	
Engine deliver for stage test	Engine fabrication and AT	1 engine
	Support for stage test operation	

JAXA April 2013 "WBS"



JAXA April 2013 "Engine Components"

Study EUS Stage WBS

Decomposed

Upper Stage WBS Element	Responsibility	
	NASA	JAXA
3.0 Exploration Upper Stage (EUS)	**X**	
3.1 Stage Core	**X**	
3.1.1 Subsystems	**X**	
3.1.1.1 Avionics	**X**	
3.1.1.1.1 Electrical Power	**X**	
3.1.1.1.2 Guidance, Navigation & Control (GN&C)	**X**	
3.1.1.1.3 Operational Flight Instrumentation	**X**	
3.1.1.1.4 C&DH (less instrumentation and inc flight SW)	**X**	
3.1.1.1.5 Development Flight Instrumentation (DFI)	**X**	
3.1.1.2 Structures & Mechanisms	**X**	
3.1.1.2.1 Fairings/Covers and System Tunnel	**X**	
3.1.1.2.2 LH2 Assembly (8.4m)	**X**	
3.1.1.2.2.1 LH2 Forward Skirt	**X**	
3.1.1.2.2.2 LH2 Tank/Structure	**X**	
3.1.1.2.2.3 LH2 Aft Skirt	**X**	
3.1.1.2.3 Intertank/Structure	**X**	
3.1.1.2.4 LOX Tank Assembly (5m)	**X**	**E**
3.1.1.2.4.1 LOX Forward Skirt	**X**	
3.1.1.2.4.2 LOX Tank/Structure	**X**	**E**
3.1.1.2.4.3 LOX Aft Skirt	**X**	**E**
3.1.1.2.5 Engine Section (Thrust Structure)	**X**	**E**
3.1.1.2.5.1 Thrust Structure	**X**	**E**
3.1.1.2.5.2 Avionics Shelf	**X**	**E**
3.1.1.2.6 Interstage/Structure	**X**	
3.1.1.3 Thermal Control	**X**	**E**
3.1.1.3.1 Induced Thermal	**X**	**E**
3.1.1.3.2 Tank Thermal	**X**	**E**
3.1.1.4 Main Propulsion System (less engines)	**X**	**E**
3.1.1.4.1 Propellant Feed Lines	**X**	**E**
3.1.1.4.2 Pressurization System	**X**	**E**
3.1.1.5 Reaction Control System	**X**	**E**
3.1.1.6 Thrust Vector Control	**X**	**E**
3.1.1.7 Range Safety	**X**	

X Provider
S Support During Execution
E Evaluate During Study

Upper Stage WBS Element	Responsibility	
	NASA	JAXA
3.0 Exploration Upper Stage (EUS)	**X**	
3.1.2 Stage Integration	**X**	
3.1.2.1 Integration, Assembly and Checkout (IACO)	**X**	**S**
3.1.2.2 System Test Operations (STO)	**X**	**S**
3.1.2.3 Ground Support Equipment (GSE)	**X**	
3.1.2.3.1 Tooling	**X**	
3.1.2.3.2 Mechanical/Electrical GSE	**X**	
3.1.2.4 System Engineering & Integration (SE&I)	**X**	
3.1.2.5 Program Management (PM)	**X**	
3.1.2.6 Launch & Orbital Operations Support (LOOS)	**X**	

X Provider
S Support During Execution
E Evaluate During Study

- **Supports Joint Baselines**
  - Technical (configuration/performance)
  - Schedule (development & production)
  - Cost (affordability estimates & budgets)
  - Risk and Opportunity
- **WBS Exit Criteria for TIM**
  - Agreed to NASA-JAXA organization
  - Agreed to NASA-JAXA decomposition
  - Agreed to NASA-JAXA responsibilities

Study EUS Engine WBS

Decomposed

Upper Stage WBS Element	Responsibility	
	NASA	JAXA
3.0 Exploration Upper Stage (EUS)	**X**	
3.2 Engine System	**X**	**S**
3.2.1 Engine Integration		**X**
3.2.1.1 Fundamental Test		**X**
3.2.1.2 Component Test		**X**
3.2.1.3 Engine Test (sea level)		**X**
3.2.1.4 Engine Test (HATS)		**X**
3.2.1.5 Engine Vibration Test and Cutting Inspection		**X**
3.2.2 Engine System Hardware		**X**
3.2.2.1 Thrust Chamber Assembly (TCA)		**X**
3.2.2.2 Nozzle		**X**
3.2.2.3 Fuel Turbopump (FTP)		**X**
3.2.2.4 Oxidizer Turbopump (OTP)		**X**
3.2.2.5 Fuel Boost Pump (FBP)		**X**
3.2.2.6 Fuel Mixer		**X**
3.2.2.7 LOX Heat Exchanger		**X**
3.2.2.8 Valves		**X**
3.2.2.9 Gimbal		**X**
3.2.2.10 Main Combustion Chamber		**X**
3.2.2.11 Main Injector		**X**
3.2.2.12 Igniter		**X**
3.2.3 Engine Controller	**X**	

X Provider
S Support During Execution
E Evaluate During Study

Proposed Change Authority and Insight

NASA-JAXA Joint Cooperation Steering Committee to coordinate joint integration activities

- **"Joint Cooperation Steering Committee" membership includes appropriate NASA and JAXA programmatic and technical personnel as well as "secretary function"**
- **Change Authority**
  - Change requires programmatic or technical integration across joint responsibilities
  - Change due to revision to established joint baseline (Technical, Schedule, Cost, Risk)
  - Change requires joint Safety/Reliability assessment
  - Changes that add significant risk necessitating joint management/mitigation or acceptance as determined during risk evaluation
  - Requests for deviations and waivers to the joint requirements
- **Insight**
  - Monthly Steering Committee coordination meetings (Study Phase and Implementation)
  - Review/decision making authority for Joint Study recommendations (December 2013)
  - Review/decision making authority at Joint Quarterly Review Meetings (Implementation)
  - Review and RID input authority at Milestone Reviews (Implementation)

Potential Leadership & Operating Rhythm

Steering Committee Leadership
- NASA, Programmatic –TBD
- JAXA, Programmatic - TBD
- NASA, Technical - TBD
- JAXA, Technical – TBD
- SC Secretary - TBD

NASA Leadership
- NASA, Programmatic –TBD
- NASA Engines, Technical - TBD
- NASA Stages, Technical - TBD

SC Operating Rhythm
- Monthly Coordination
- Quarterly Reviews
- Milestone Reviews

JAXA Leadership
- JAXA, Programmatic –TBD
- JAXA, Technical – TBD
- MHI - TBD
- AR - TBD

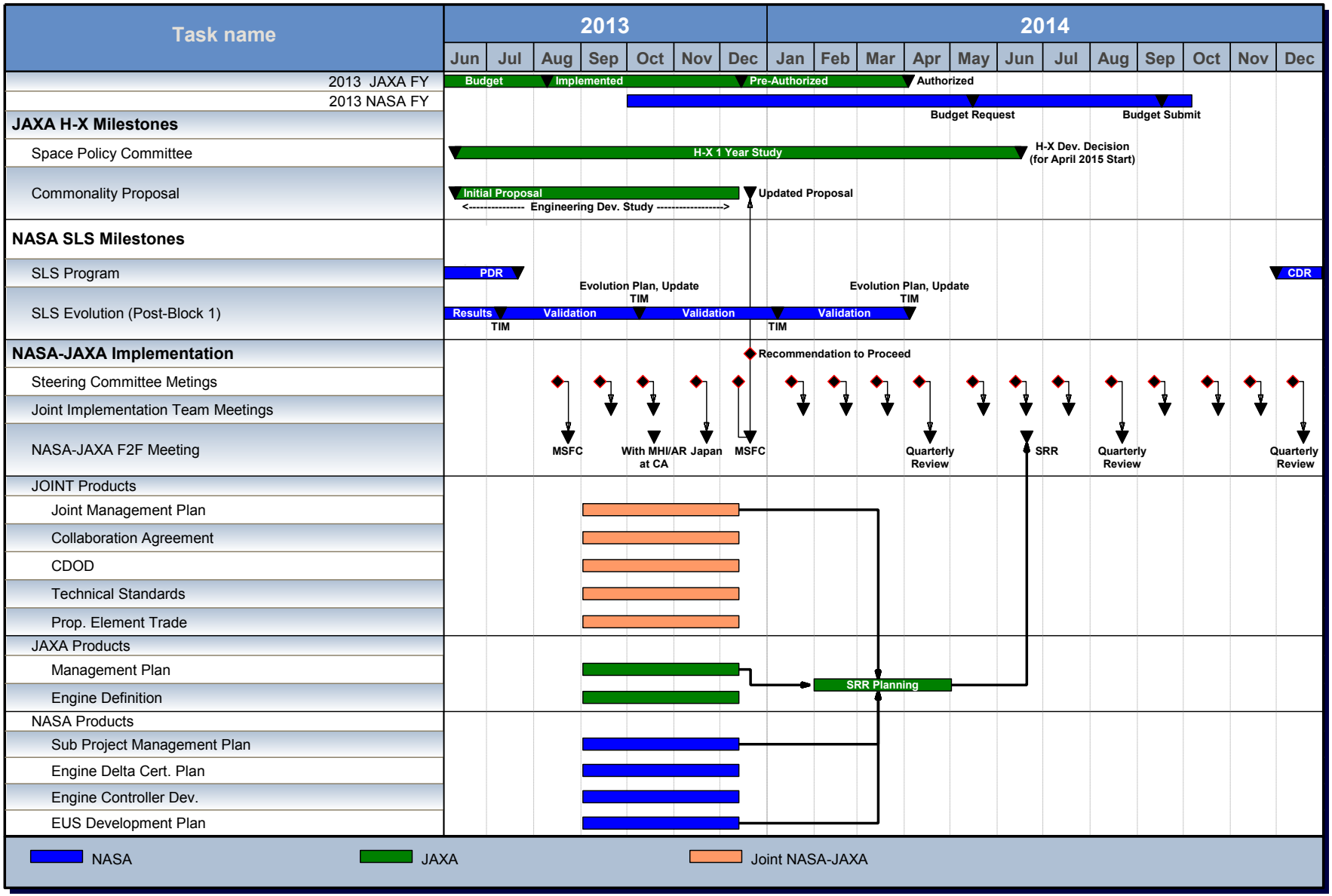
Integration Activities
- Governance
- Insight (Review/RID)
- Baseline Change Control
- Integration Management
- Joint Products
- NASA Observer Engineers

NASA SLS Management Plan
- NASA unique activities

Joint Management Plan
- Integrated activities

JAXA H-X Management Plan
- JAXA unique activities

Top Level Implementation Schedule



Potential Joint Management Plan Outline

Derived from SLS Program Plan

1.0 INTRODUCTION
- 1.1 Purpose
- 1.2 Scope
- 1.3 Change Authority/Responsibility

2.0 DOCUMENTS
- 2.1 Applicable Documents
- 2.2 Reference Documents

3.0 PROJECT OVERVIEW
- 3.1 Goals and Objectives
- 3.2 Project Architecture
- 3.3 Authority, Management and Governance Approach
  - 3.3.1 Authority
  - 3.3.2 Governance Structure
  - 3.3.3 Technical Authority
  - 3.3.4 Decision Making
  - 3.3.5 Insight Oversight

4.0 BASELINES
- 4.1 Technical/WBS
- 4.2 Schedule
- 4.4 Cost
- 4.5 Risk

5.0 INTEGRATION CONTROL
- 5.1 Technical, Schedule, and Cost Measurement
- 5.2 Margin Management
- 5.3 Safety and Mission Assurance
- 5.4 Risk and Opportunity Management
- 5.5 Systems Engineering Management
- 5.6 Verification and Validation
- 5.7 Reviews
- 5.8 Configuration Management
- 5.9 Data Management
- 5.10 Data Rights
- 5.11 Export Control
- 5.12 Product Data and Life Cycle Management
- 5.13 Human Rating Certification Package

6.0 JOINT DATA PRODUCTS

- **Should reflect minimum requirements for governance and compatibility with lower level NASA and JAXA plans**
- **TIM Exit Criteria: agree on outline approach that best meets needs**

Joint Products

- **Joint Management Plan**
- **Data Product Documents**
- **Joint Requirements Definition**
- **Consolidated Development Objectives Document (CDOD)**
- **Joint Technical Standards**
- **Collaboration Agreement**
- **Schematics and Drawings**

Joint Performance Metrics

- **Simple framework and criteria to measure performance health of joint activities**
  - Performance (engine and stage capabilities meet SLS and H-X requirements)
  - Schedule (performance capability achieved by 2021)
  - Cost (performance meets individual NASA and JAXA program cost goals)
  - Risk and Opportunity (impacts assessed and mitigation/implementation paths defined)

- **Reporting method could be concise metric Stoplight chart**