Propulsion System Elements
MSFC Options and Thoughts

8/9/2013

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Overview

- Objective: To propose a common MPS to be designed and built by JAXA, in cooperation with NASA, for applicability to the Evolvable Upper Stage for SLS.

- Approach: to keep interfaces as simple as possible

  – Keep most interfaces to mechanical joints and simple electrical connections (such as instrumentation and solenoid actuation)

  – Electrical and command/data handling are more complex to coordinate internationally unless mutual agreements can be made to ease the potential communication issue

  – Each partner is planning to use their own avionics as a ground rule

OPTIONS

There are four options MSFC would like JAXA to consider

1) A modular main propulsion system approach that includes propellant ducts, valves, RCS, and thrust structure. This excludes tanks, TVC, thermal protection, and stage load carrying members

2) A modular main propulsion system approach that includes the items listed above plus a LOX tank

3) A components approach that includes many fluid carrying components such as valves, ducts, RCS, and flexible bellows

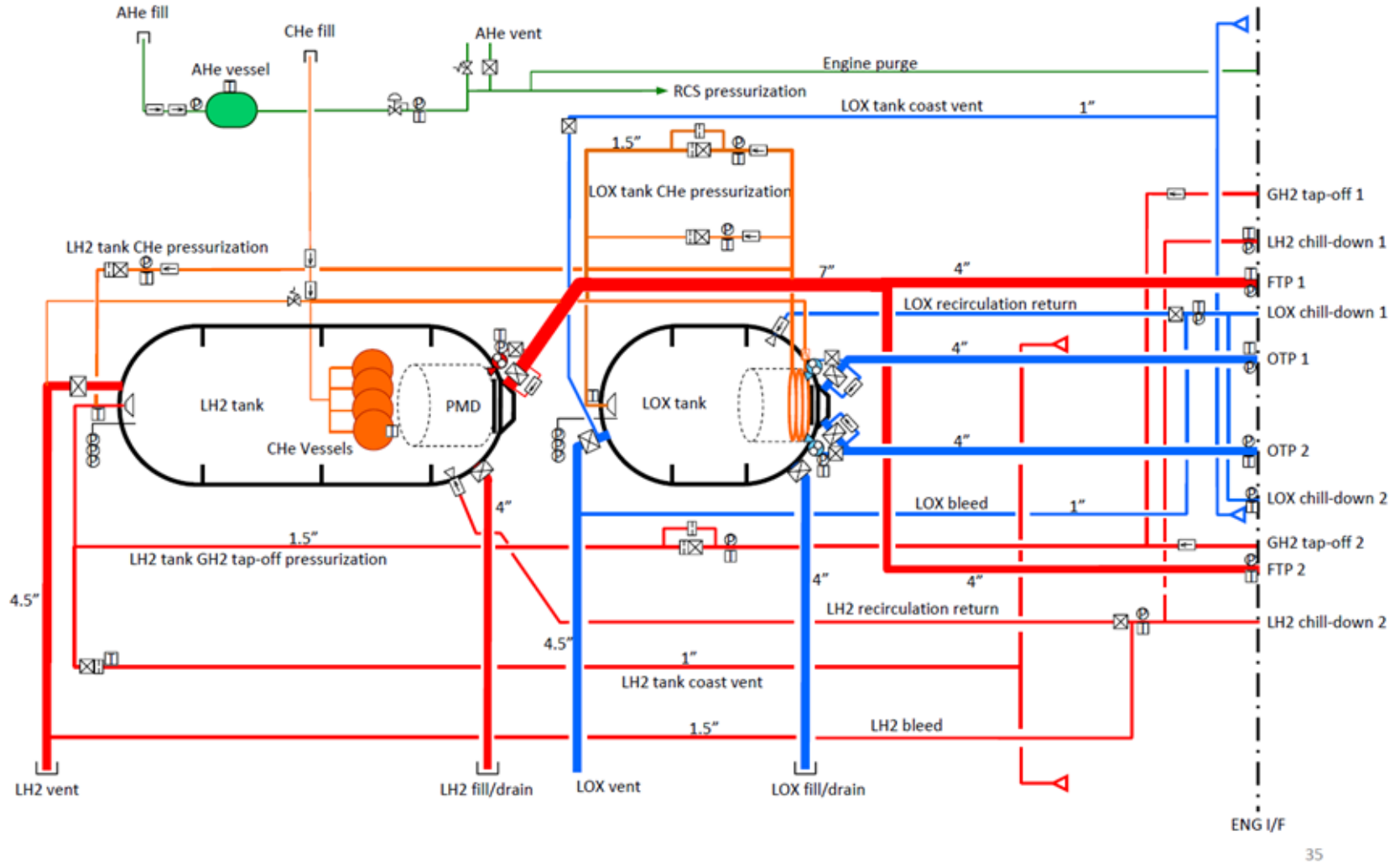
4) An extension of the engine that includes prevalves, main thrust takeout with TVC attach points

OPTION 1
Modular Main Propulsion System without a LOX tank

EUS Breakout

JAXA proposed stage

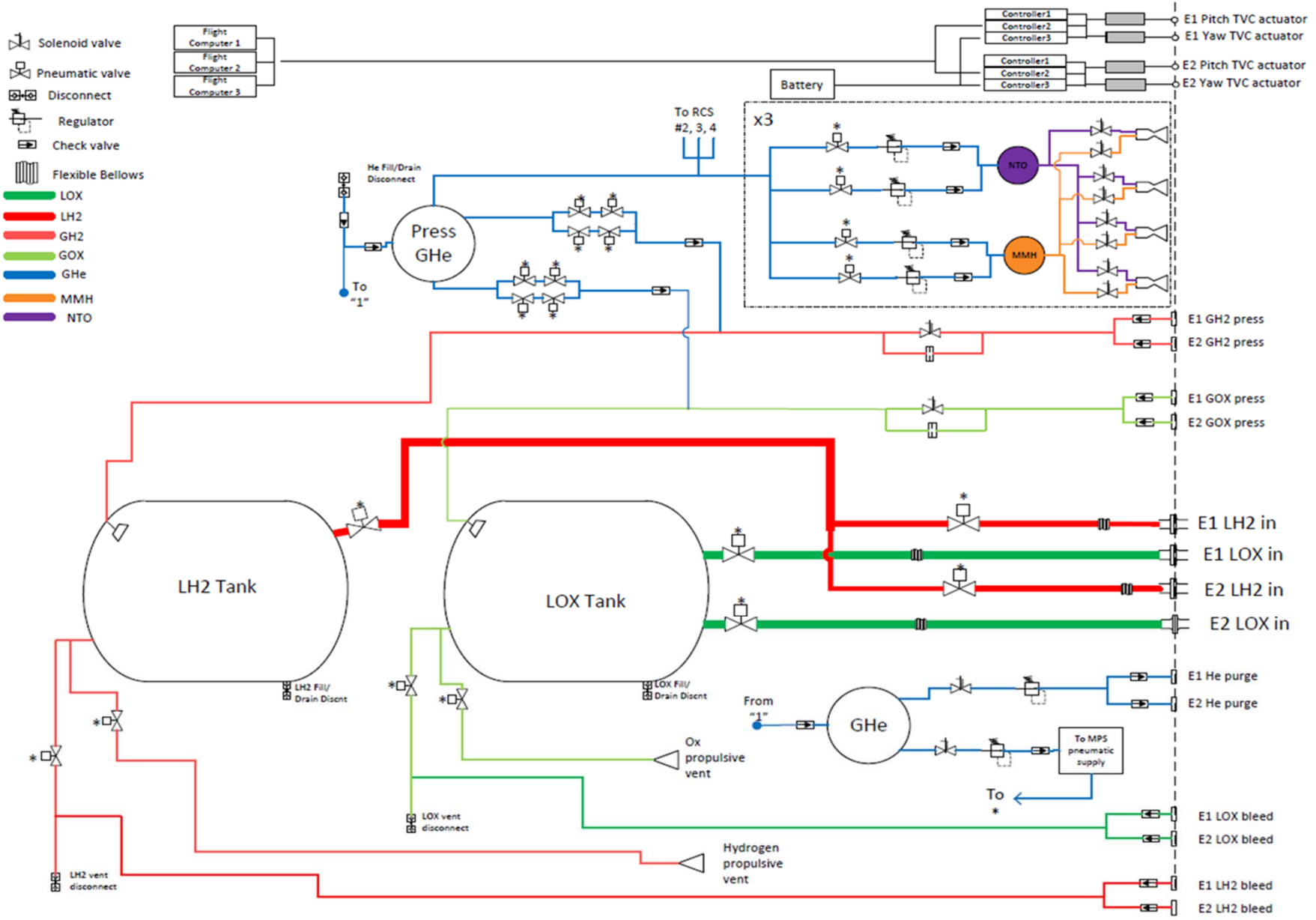
- Proposed JAXA stage from June 28, 2013 presentation



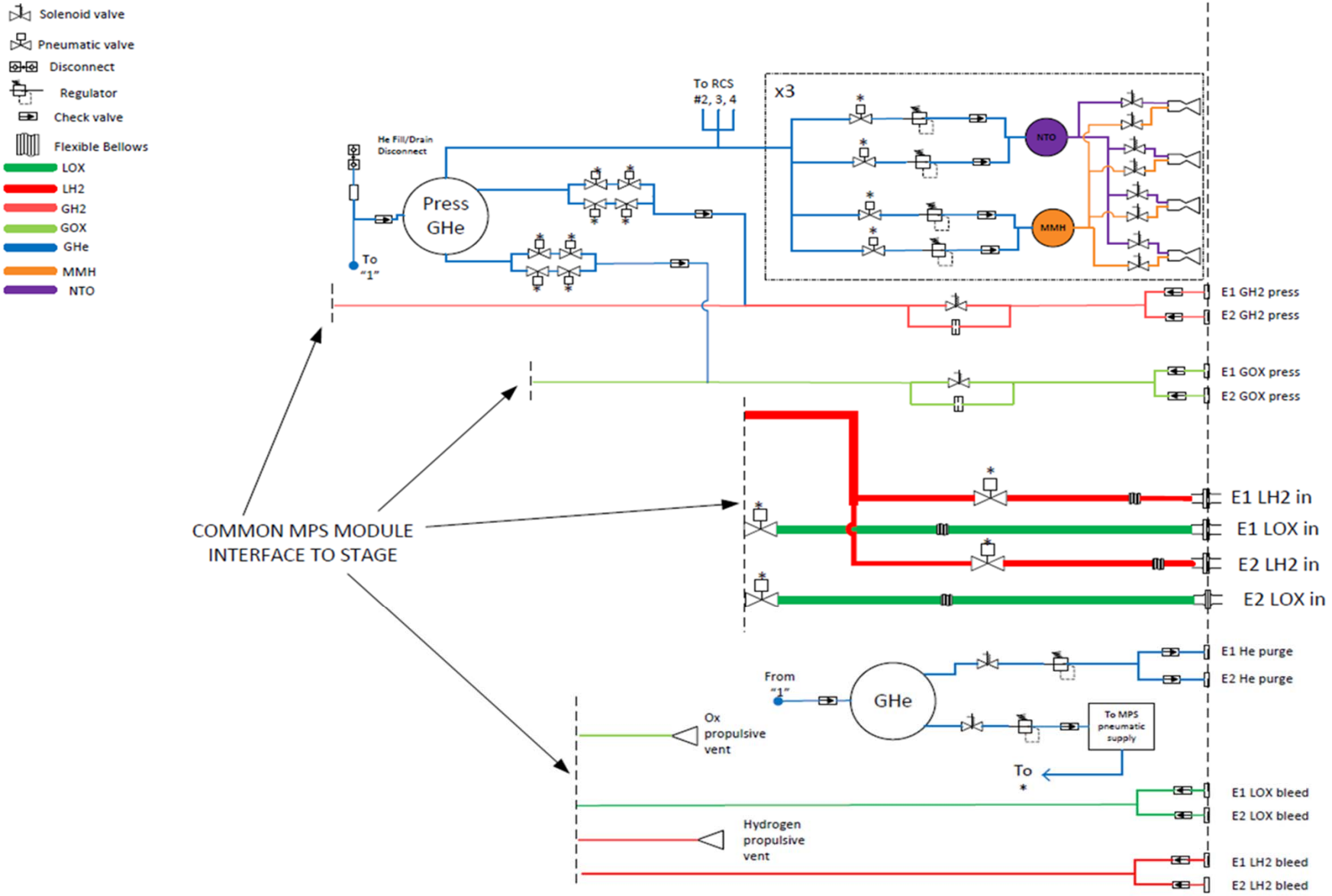
MSFC Assumptions

- Based on the information from the JAXA proposal dated June 28, the following assumptions were made
  - Both tank recirculation pumps were removed.
  - Removed cryo helium bottles since tank pressurization is done via autogenous repress
  - LH2 and LOX chill will only be active during ground operations. During flight, MARC-60 will chill the engine in idle mode and run propellant through the main chamber and overboard
  - Assume that JAXA agrees to using pneumatic and solenoid actuated valves for the MPS. EMAs would likely complicate avionics and controller integration
- Note: the following schematics are not to infer redundancy or NASA EUS schematics. They are to be used as a starting point of discussion with JAXA

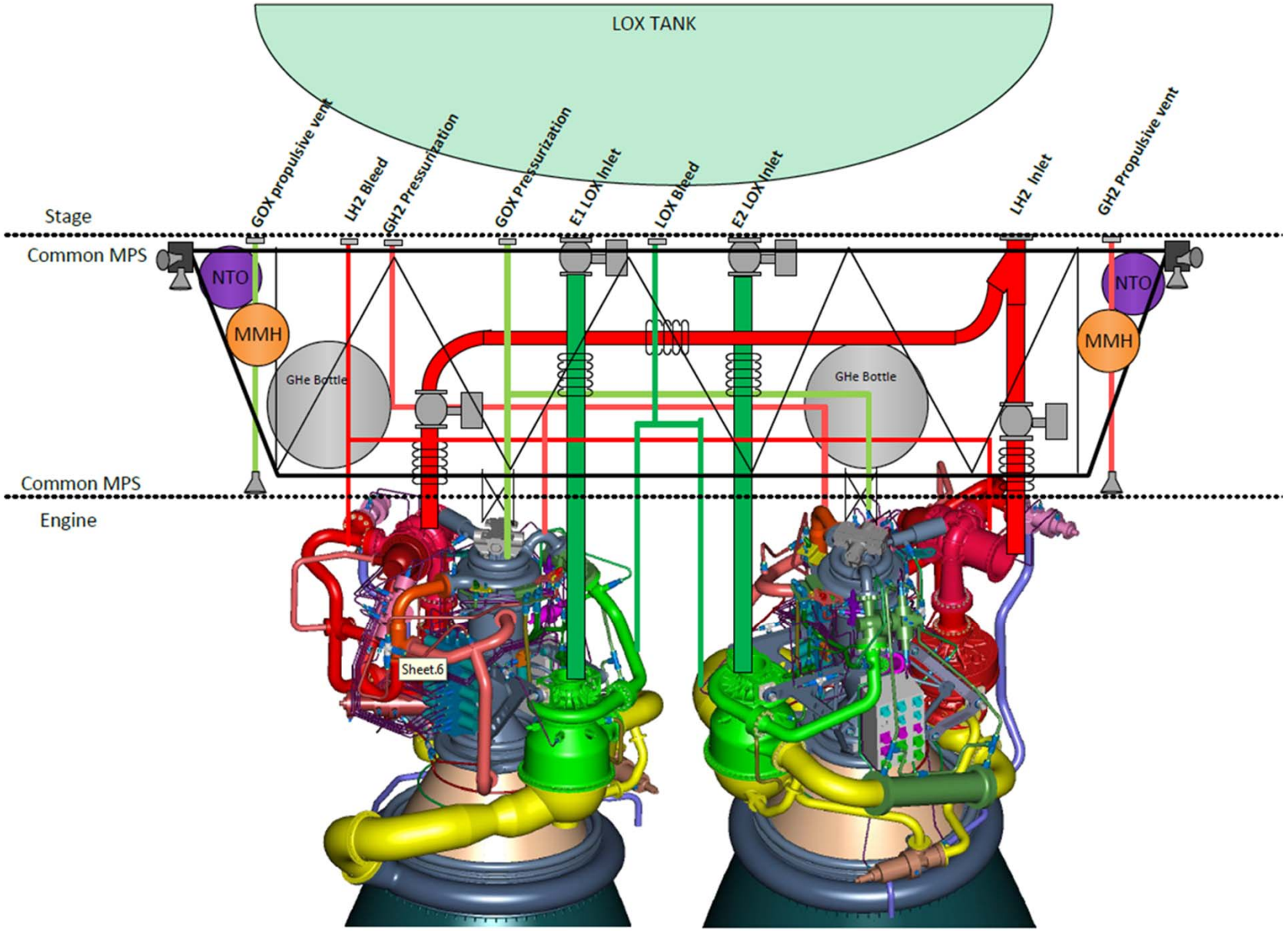
MSFC Proposed Stage Schematic



Option 1 Schematic



Option 1 Cartoon of Applicable Hardware



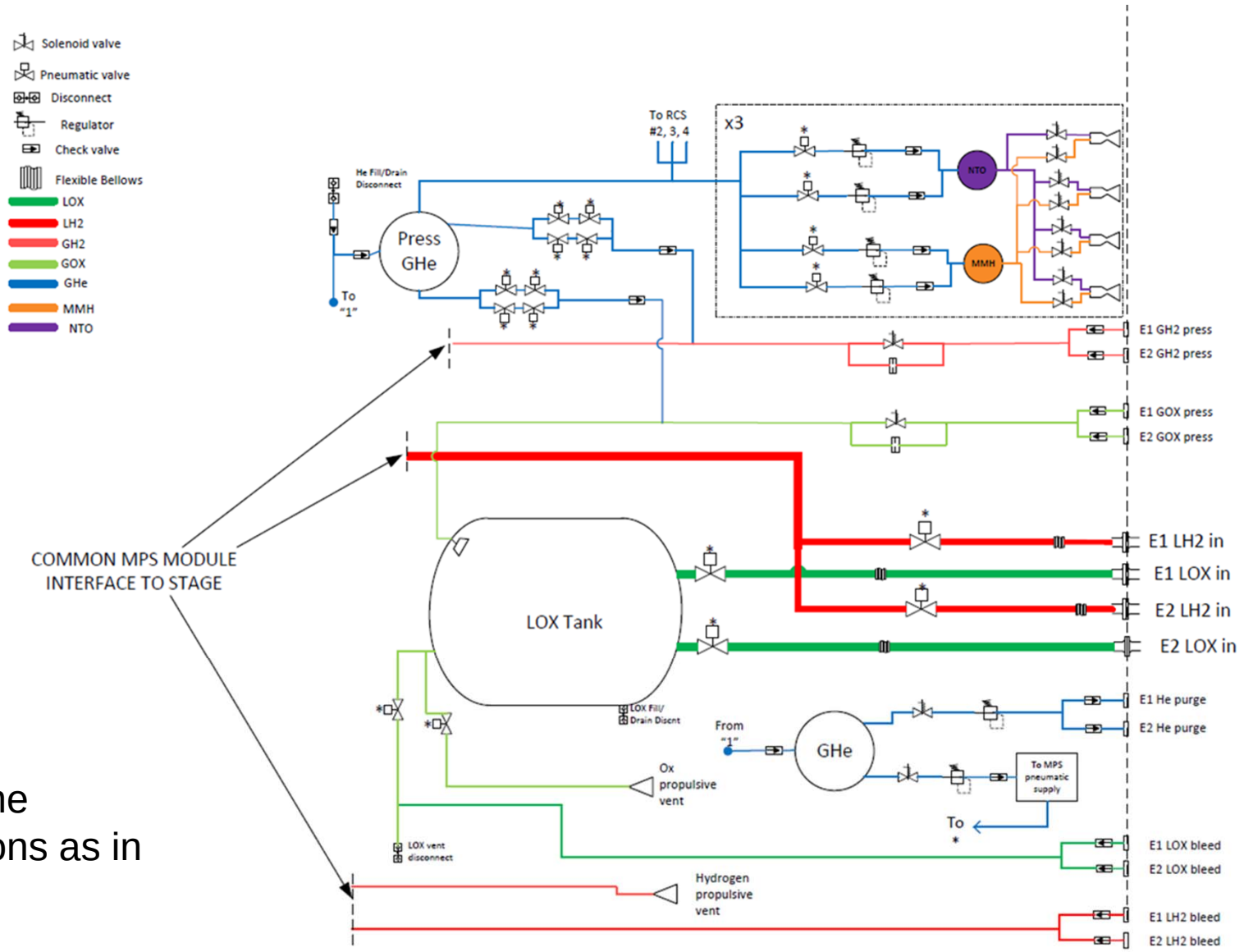
Option 1 Summary

- JAXA would provide a majority of the structure, feedlines, prevalves, helium tanks, and RCS.
- NASA would provide appropriate LOX/LH2 tanks, avionics, power, and TVC systems for the EUS
- Pros:
  - ICD can be maintained between MPS to engine and another for MPS to stage
  - Interfaces are kept clean and simple
- Cons:
  - Module is only applicable for dual engine use

OPTION 2
Modular Main Propulsion System with a LOX tank

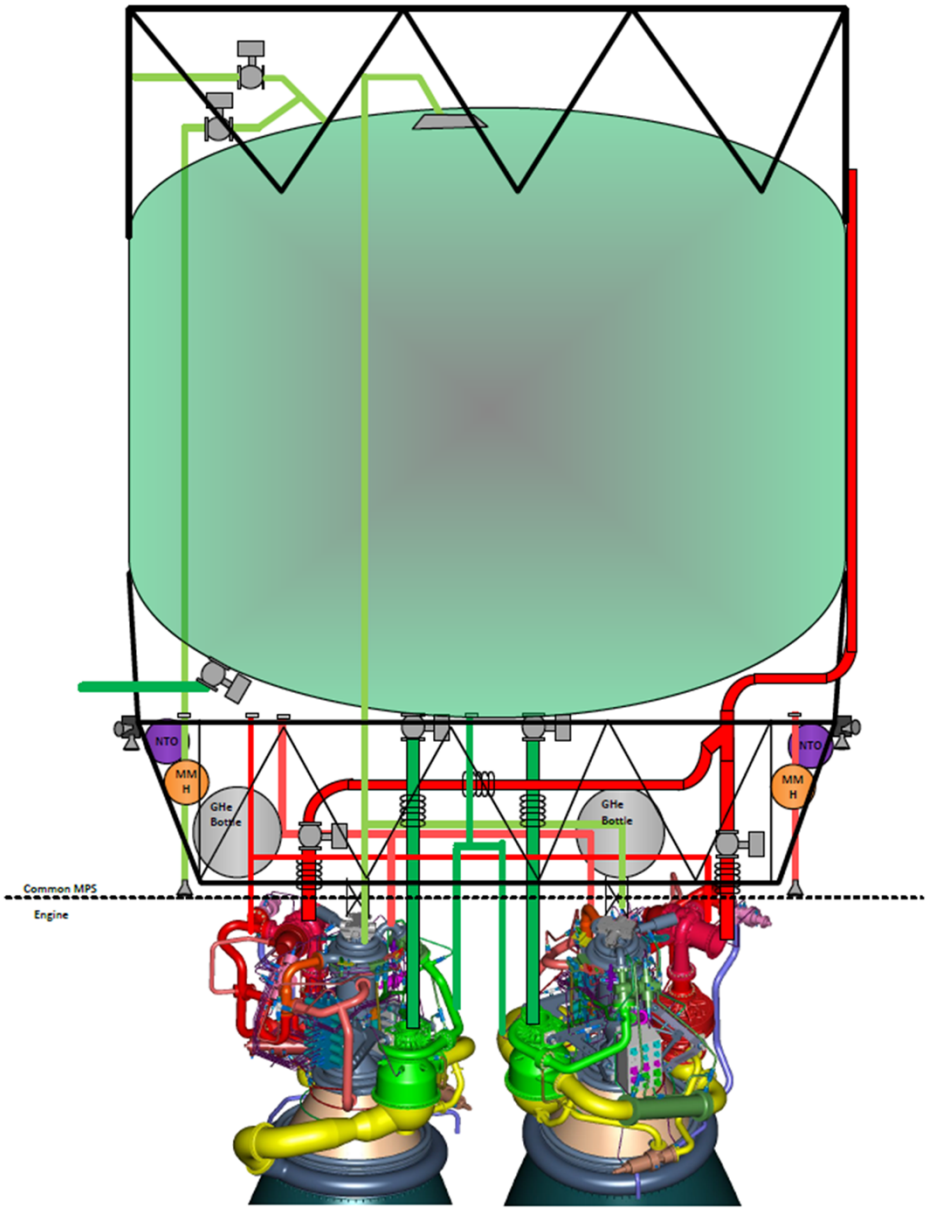
EUS Breakout

Option 2 Schematic



Note: same assumptions as in option 1

Option 2 cartoon drawing



Option 2 Summary

- JAXA would provide a majority of the structure, feedlines, prevalves, helium tanks, RCS, and structurally hung LOX tank.
- NASA would provide appropriate LH2 tank, avionics, power, and TVC systems for the EUS
- Pros:
  - ICD can be maintained between MPS to engine and another for MPS to LH2 tank
  - Interfaces are kept clean and simple
- Cons:
  - Module is only applicable for dual engine use
  - Structural interfaces will be more difficult and the design will need to be for worst case and likely carry more mass than needed

OPTION 3
Main Propulsion System Component Design and Development

JAXA provided information

- JAXA provided initial proposal on June 28, 2013 that included a Common Propulsion Components for use by NASA's EUS and JAXA's H-X.

5.4.9 CPC Definition

CPC candidates are marked X in the following table.

Category	Item		CPC	Note
Structure	PAF			
	PSS			
	LH2 tank fwd. skirt			
	LH2 tank			
	LH2 tank aft. skirt			
	Inter tank truss			
	LOX tank		(X)	Depends on safety factor, MEOP, load condition, etc. Some modification such as change of cylinder length might be required.
	Engine structure			
	Separation deices (pyrotechnic, spring)			
Propulsion	Valves	Tank vent, tank relieve	X	
		Pressurization	X	
		Fill, drain, pre-valve	X	
		CHK, relieve	X	
		Regulator	X	
		Purge	X	
	Sensors (pressure, temperature, liquid level, camera)		X	Electrical I/F to be checked
	CHe vessels (in the LH2 tank)		(X)	Depends on the volume
	AHe vessel		(X)	Depends on the volume
	RCS		X	
	EM actuator		X	
	CHe HEX (in the LOX tank)			
	Tank internal devices	LH2		
	(diffuser, baffles, seals)	LOX	(X)	Used partially for DUUS
	QD, bellows		X	
	Umbilical		(X)	Mechanical I/F to be checked
	PMD			
	Recirculation chill-down system			
	Tubing		(X)	Used partially for DUUS
Avionics				

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Option 3 Summary

- JAXA would act as vendor to NASA for most fluid carrying components such as valves, bellows, ducts, and possibly RCS
  - Partnership with upper stage prime contractor would be needed
- Each component will have its own specification and be developed and qualification tested by JAXA
- Pros:
  - Reduces NASA cost of major MPS components
  - Keeps interfaces relatively clean
- Cons:
  - Create new management structure from the proposed engine approach. JAXA would serve more as a subcontractor and possible complexities with using CSOC
  - Multiple parts and specs to control and manage

OPTION 4
Extension of MARC-60 to include thrust structure and prevalves

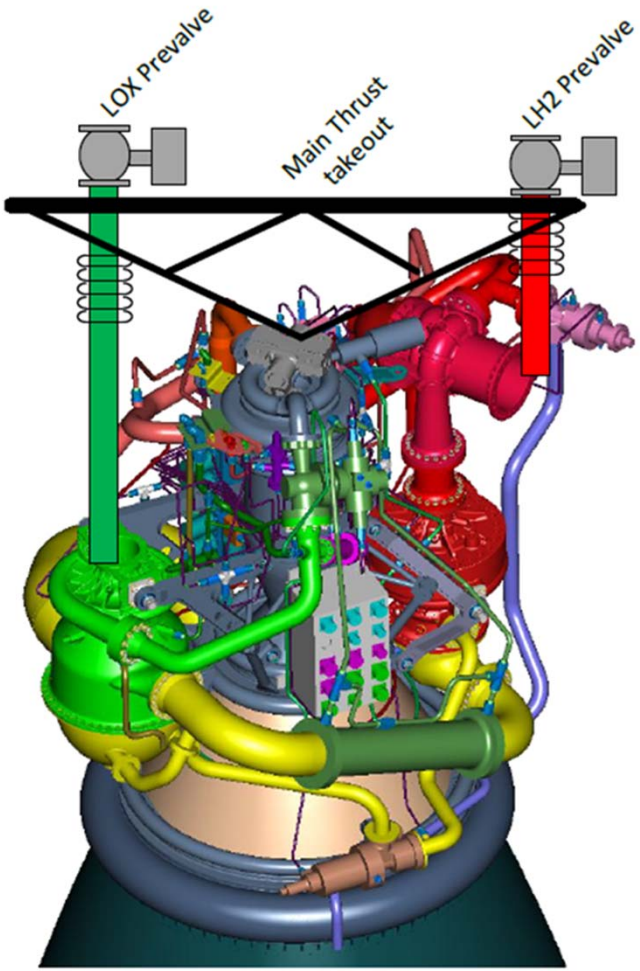
Option 4 Summary

- JAXA would include the main thrust takeout structure of the engine with TVC attach points
  - Similar to RS-68 approach
- This option would be a modification to the MARC-60 definition to include these components
- Pros:
  - Reduces some NASA cost of a few MPS components
  - Keeps interfaces relatively clean
  - Engine is still modular and can fit either 1 or 2 engine configuration
- Cons:
  - Not a large cost savings on the MPS side
  - Added weight of the thrust takeout may be sub-optimal for both EUS and H-X application

Option 4 cartoon drawing

Interfaces would essentially be brought up a few feet

Prevalves, structure, and common TVC attach points are the only items that would be relief from the MPS



Proposed Schedule

• Provide JAXA with MSFC options	Aug 12
• Obtain feedback at face to face meeting	Aug 27-29
• Formulate JAXA/NASA options	Aug 30-Sept 13
• Negotiate and assess benefits of options	Oct 14 –Nov 15
• Draft requirements as needed	Nov 25-Dec 13
• Final Proposal	End of Dec