Origins Space Telescope (OST)
Mission Concept 1
Open Issues

Face-to-Face #5

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Concept 1 Design Status/Issues

- Concept 1 mass is ~2,000 kg over the launch vehicle (Vulcan Aces 5m fairing) lift capability
  - Mass for 5 instruments is 2643 kg
    - Far-IR Imager/Polarimeter (FIP): 781 kg
    - High Resolution Spectrometer (HRS): 935 kg
    - Medium Resolution Survey Spectrometer (MRSS): 435 kg
    - Heterodyne Instrument (HI): 383 kg
    - Mid-IR Spectrometer/Imager/Coronagraph (MISC): 108 kg
- Optical ray traces for instruments are still in progress and some are near completion
  - Elimination of any of these instruments will result in rework of ray traces and packaging for remaining instruments
- Fairing volume is extremely tight and uncertain, overall packaging is uncertain and deployment is still TBD
- ***Current Concept 1 is too heavy to be launched on a 5m fairing***
  - ***Volume is tight and uncertain***

Solution: Larger Launch Vehicle (LV)

- NASA Space Launch System (SLS) has larger mass and volume capabilities to accommodate current OST Concept 1
  - **Fairing Sizes:** 8.4 x 19 m, 10 m x 31 m
- SLS will be available in 2030's when OST will be ready to launch
  - Both LUVOIR and HabEx mission concepts include SLS
- SLS is a development program and it is yet to have a first launch
  - Higher risk item in mission development
- Larger LV cost will be higher, however larger volume may allow flight system design to be less complex, resulting in lower mission cost overall

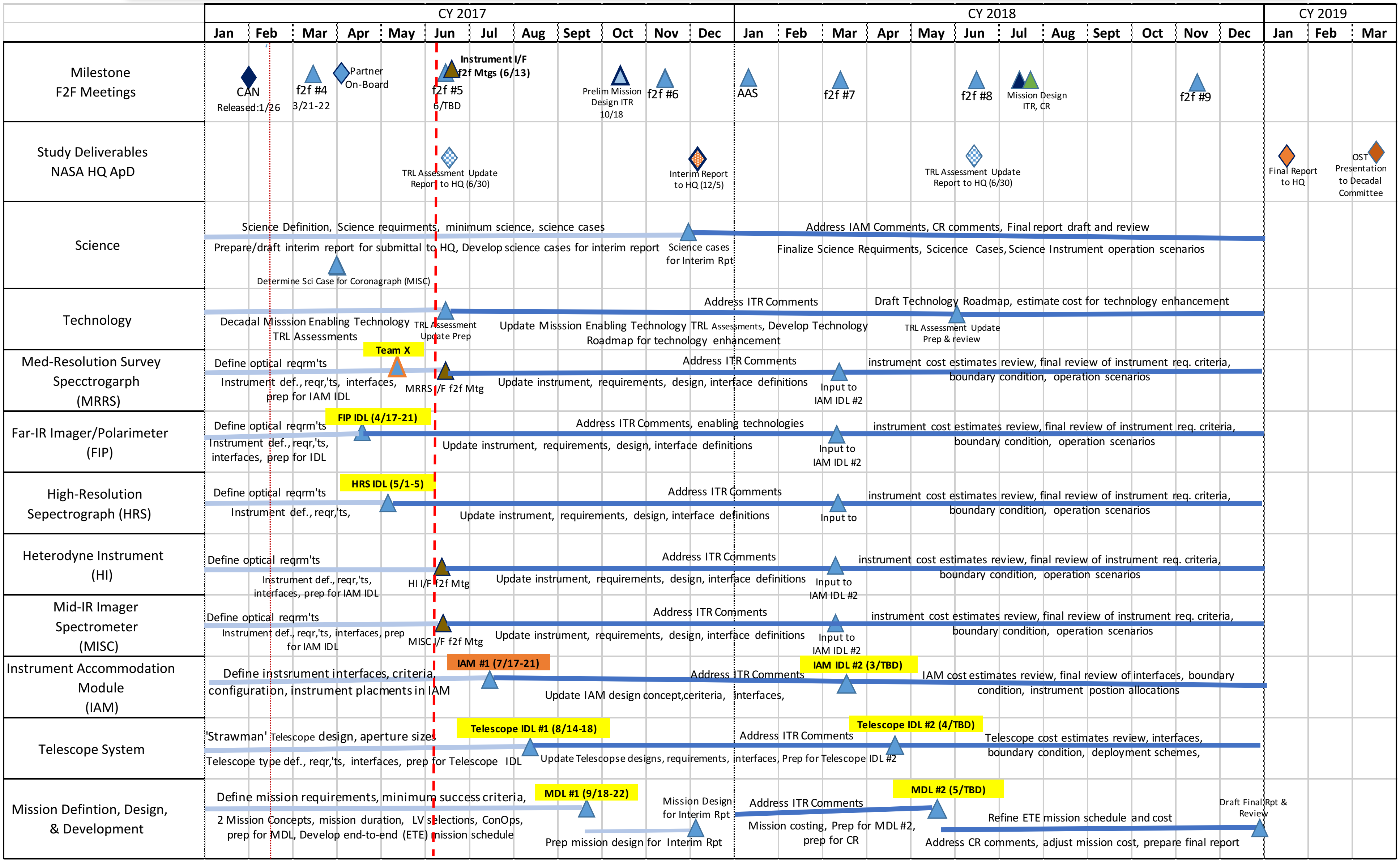
Study Office Plan and Request

- Plan to work with instrument teams to scale down instrument volume, mass and power to fit into a 5 meter fairing
- In the event that the scaled down instruments results in exceeding 5m fairing capabilities, we need design flexibility to assume a larger LV
  - In order to complete Concept 1 design by 9/30/17, we need design flexibility

- ***Study Office requests STDT permission to go to a larger launch vehicle, <u>if necessary</u>***
  - ***Need a decision by 6/15/2017, 5pm***

ORIGINS Space Telescope

Study Schedule



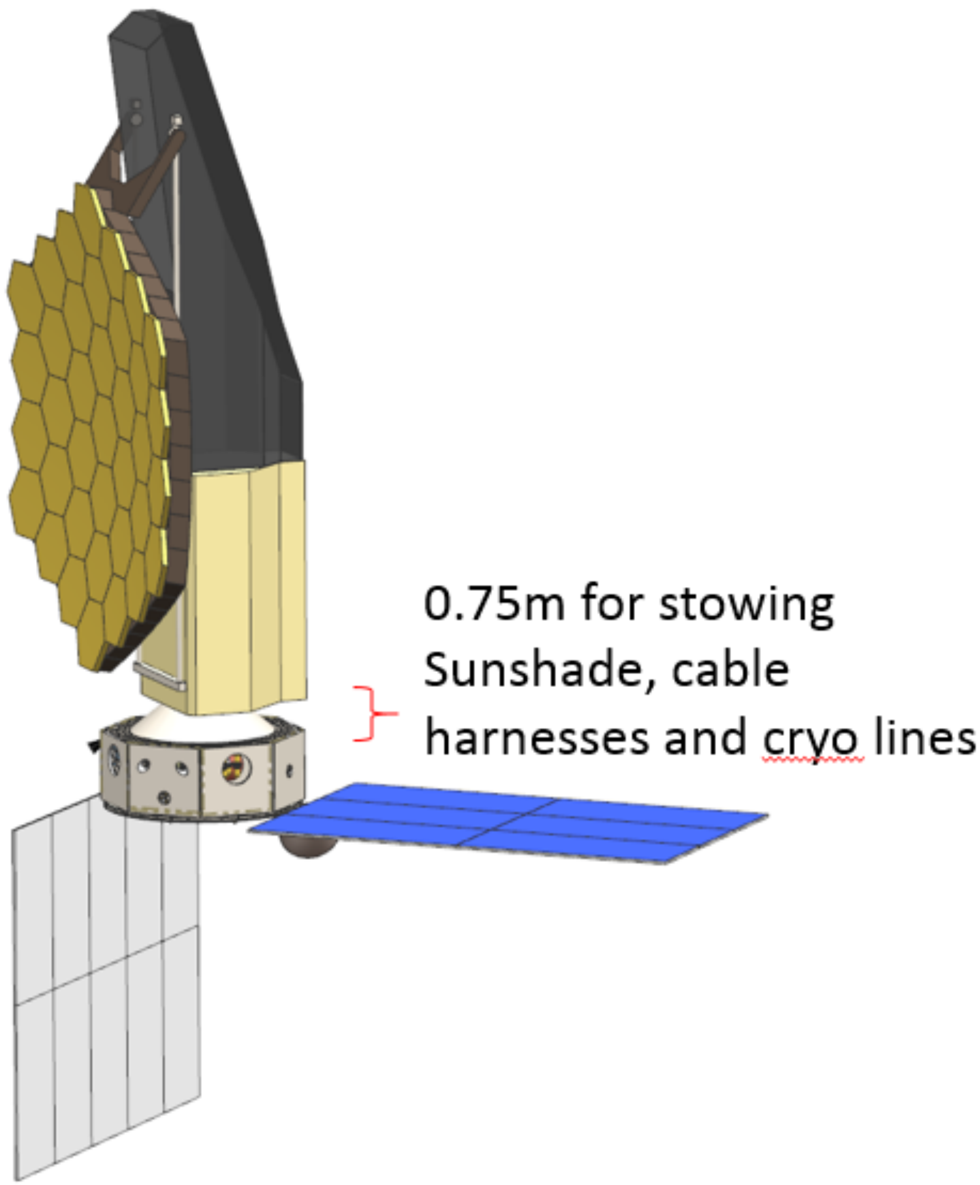
Back -Up

OST Concept 1 Design Parameters

- 9 meter diameter primary mirror
  - Segmented, Off-Axis Telescope
- 5 science instruments
  - Far-IR Imager/Polarimeter (FIP)
  - High Resolution Spectrometer (HRS)
  - Medium Resolution Survey Spectrometer (MRSS)
  - Heterodyne Instrument (HI)
  - Mid-IR Spectrometer/Imager/Coronagraph (MISC)
- Instrument Accommodation Module (IAM)
- 8 cryo-coolers to cool and maintain Telescope and IAM at 4 Kelvin
- Launch on a 5 meter fairing launch vehicle
  - Vulcan Aces assumed
- Mission Operations Orbit is Sun Earth L2

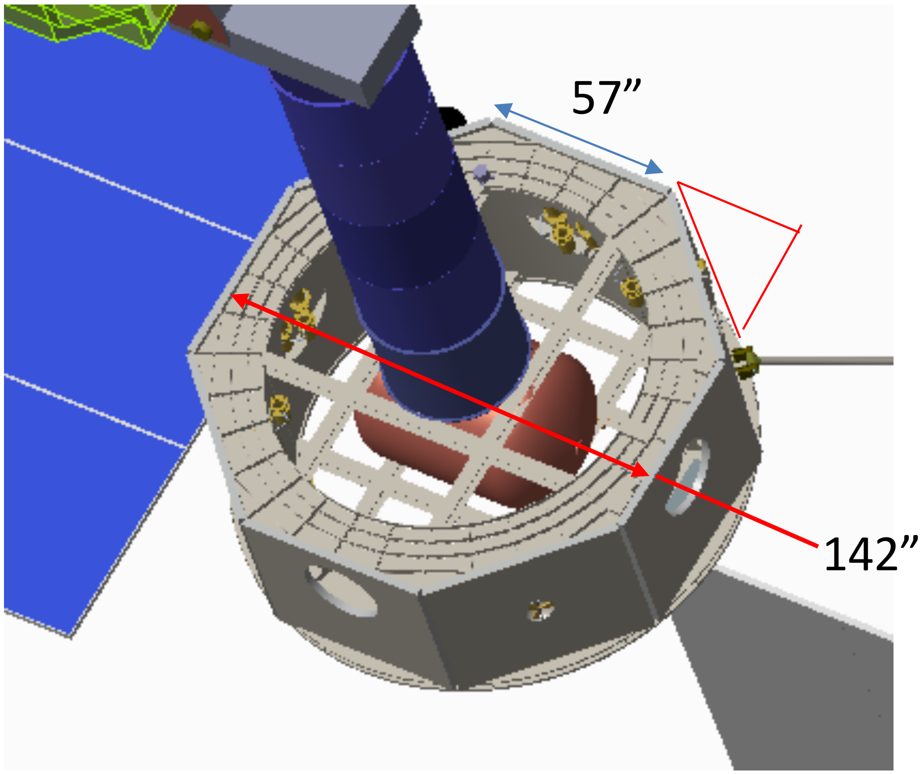
5m Fairing Design Challenges

1. Mass exceeds allowable.
2. Stowing and deploying Sunshade and Baffle:
   - Might be enough space to do it in current configuration – TBD. Stowed stack-up only allows for .75m in height for stowing Sunshade.
   - Engineer, with in-depth knowledge of JWST Sunshade design, is just starting to look at it.
   - Cable harnesses and cryo lines (volume TBD) need to stow in same area as Sun Shade. May not be enough room for it all.
   - How to deploy the cable harnesses and cryo lines AND the Sunshade when they all stow in same location may be unworkable.
   - May not be enough room in bus to store everything. Many deployment booms are needed for Sunshade. Large prop tank takes up a lot of room, as well. Layout of Bus is TBD.
3. Currently HRS instrument interferes with lower corner of stowed Primary Mirror
   - Packaging of HRS might not allow for removal of interference – TBD.
   - Removing one hex segment of PM required if HRS interference remains.
4. CG if stowed assembly will be rather high. High CG and high mass may preclude using this launch vehicle.



Layout shown is a bit obsolete, but the .75m space is accurate, given current launch vehicle fairing limitation.

Bus Volume



Area of sunshade = TBD

Area of red triangle =1/2[(142-57)/2]^2 = 903 in^2

Area of DTA = Pi x D^2/4 = Pi x 40 in^2/4 = 1256 in^2

Area of bus top shape without DTA area =
142^2 – 4(903”) – 1256 = 20,164 in^2 – 3,612 in^2 – 1256 in^2 = 15, 296 in^2 (9.8m^2)

Volume available for sunshade stowage and cable harnesses and cryo lines = 9.8 m^2 x .75 m = 7.35 m^3

Concept 1 Mass Estimates

preliminary and immature

Item	Mass Estimate (kg)	Comments
Instruments (Total of 5)	2,370	Initial allocation total of ~825 or ~165 kgs per instument
FIR Imager/Polarimeter (FIP)	508	Initial IDL mass estimate with OST Team Modifications
Hetrodyne Instrument (HI)	383	Martina's Rough Estimate
High Resolution Spectrometer (HRS)	936	Initial IDL's mass estimate
Medium Resolution Survey Spectrometer (MRSS)	435	Initial Rough Estimate provided by JPL
MID-IR Imager Spectrometer Coronograpgh (MISC)	108	Initial estimate from Itsuki Sakon, March 2017 F2F meeting
Optical Telescope Element (OTE)	2,594	Assumes 40 kgs/m^2, unknown if possible, dependant on material selected and needed OTE structural frequency. The JWST figure is ~68 kgs/m^2 all inclusive (see OTE Tab).
Cryocoolers (8 @ 66 kgs each)	528	Mike Dipirro's Mass Estimate
20 K Box		TBD, ~10's of kilograms, relatively small
Sunshield	1,000	Rajeev Sharma's mass estimate (Drew Jones' initial rough estimate was 1,861 kgs)
Baffle Assembly	350	Rajeev Sharma's mass estimate (Drew Jones's initial rough estimate was 223 kgs)
IAM (Less Instruments)	321	Greg Martin's Rough Estimate
SC Bus	2,284	Anel & Greg Martin's Rough Estimate
Deployable Tower Assemby (DTA)	149	Greg Martins Rough Estimate
Curent Best Estimate (CBE) Dry Mass	9,596	
Propellant/ Pressurant	1,360	Based on a projected ~200 m/s Delta V, Folta and Webster; or ~960 kgs; plus ~400 kgs for momentum unloading, Eric Stoneking. Assumes MPV mass of 11, 095 kgs.
Curent Best Estimate (CBE) Wet Mass	10,956	Ideally ~9,015 kgs or below
CBE Wet Mass Overweight	1,941	
Contingency (%)	23.1%	Estimated *effective* contingency needed based on CBE Dry mass only
Contingency (kgs)	2215	Estimated *effective* contingency needed based on CBE Dry mass only
Maxium Expected Value (MEV) Dry Mass	11,810	
Maxium Expected Value (MEV) Wet Mass	13,170	Needs to be below ~11,095 kgs
MEV Wet Mass overweight	2,075	

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Potential Launch Vehicles

	Launch Vehicle	Manufacturer	Country of Origin	Cost per launch	Fairing Size Dia. by Length	Payload to GTO (kg)	Payload to L2[3]	Status	Launch Sites
U.S.A./ Active	**Falcon 9 Full Thrust (FT)**[1]	SpaceX	U.S.A.	$62 Million	5.2 m x 13.1 m	8,300	3,370[4]	**FT:** Active	Cape Canaveral SLC-40 Kennedy Space Center LC-39A Vandenberg SLC-4E
	Delta IV Heavy	ULA	U.S.A	$375 Million (2014)	5 m x 19.1 m	14,220	10,695	Active	SLC-37B, Cape Canaveral SLC-6 Vandenberg AFB
	Atlas V 500 Series	ULA	U.S.A	Not Available	5.4 m x 20.7 m 5.4 m x 23.5 m	4,750 – 8,900	2125 - 6,165	Active	Cape Canaveral SLC-41 Vandenberg AFB SLC-3E
U.S.A./ In development	**Falcon Heavy**	SpaceX	U.S.A	$90 Million for up to 8,000 kg to GTO	5.2 m x 13.1 m	**(27˚)** 22,200	Not Available	In development	Kennedy LC-39A Vandenberg AFB SLC-4E
	Space Launch System	Boeing, ULA, Orbital ATK, Aeroject Rocketdyne	U.S.A	$500 Million	5 m x 19 m 8.4 m x 19 m 10 m x 31 m	Not available	Not Available	In development	LC-39B, Kennedy Space Center
Foreign/ Active	**Ariane 5**	Airbus Defense and Space	Europe	$165 - $220 Million (20 ESA member states)	5.4 m x 17 m	**(27˚)** ECA[2]: 10,500	Not Available	Active	Guiana Space Centre ELA-3, French Guiana
	H-IIB	Mitsubishi Heavy Industries	Japan	Not Available	5.1 m x 15 m	8,000	Not Available	Active	Tanegashima Space Center, Japan

Notes:

1) FT – Full Thrust is the latest version of the Falcon 9; versions v1.1 and v1.0 are retired from service.

2) ECA - The Ariane 5 ECA (*Evolution Cryotechnique type A*), first successfully flown in 2005, uses an improved Vulcain 2 first-stage engine with a longer, more efficient nozzle with a more efficient flow cycle and denser propellant ratio. The Ariane 5 ECA has a GTO launch capacity of 9,100 kg (20,100 lb.) for dual payloads or 9,600 kg (21,200 lb.) for a single payload. ES - the Ariane 5 ES (*Evolution Storable*) has an estimated LEO launch capacity of 21,000 kg (46,000 lb.). Ariane versions A5 G, A5 G+, and A5 GS are retired from service.

3) L2 - Lagrange point 2 named after Joseph Lagrange, an 18th century mathematician, who found the solution to the "three-body problem". In astrodynamics, the characteristic energy (C_3) is a measure of the excess specific energy over that required to just barely escape from a massive body. The units are $length^2/time^2$, i.e., energy per mass. In this case an initial C_3 estimate of $-0.5\ km^2/sec^2$ to L2 was assumed.

4) Assumes the Drone recovery option for the Falcon 9 FT 1st Stage and launch from SLC-41 at CCAFS.