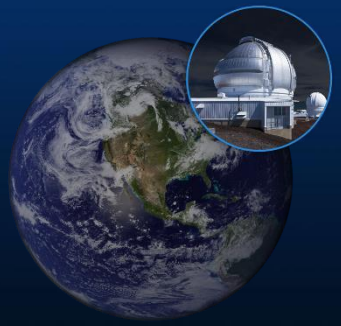
DART
Double Asteroid Redirection Test



DART Update to SMPAG

February 6, 2020

NASA
Goddard Space Flight Center
Johnson Space Center
Langley Research Center
Glenn Research Center
Marshall Space Flight Center
Planetary Defense Coordination Office

APL Johns Hopkins Applied Physics Laboratory

Jet Propulsion Laboratory
California Institute of Technology

Aerojet Rocketdyne

Lawrence Livermore National Laboratory

Auburn University

University of Colorado Boulder

University of Maryland

NAU Northern Arizona University

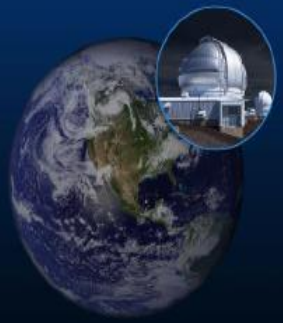
Planetary Science Institute

Launch

July 22, 2021

Falcon 9, VAFB
Ballistic Trajectory

LICIACube
(Light Italian Cubesat for Imaging of Asteroids)
ASI contribution



DART
Double Asteroid Redirection Test

IMPACT: September 30, 2022

KDP-C	Jun 2018
CDR	Jun 2019
MOR	Sep 2019
KDP-D	Apr 2020
IRR	Mar 2020
PER	Oct 2020

DART Spacecraft
650 kg arrival mass
6.65 km/s closing speed

Didymos-B
163 meters
11.92-hour orbital period

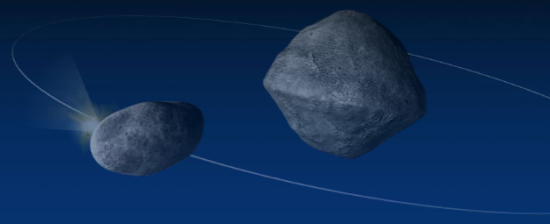
65803 Didymos (1996 GT)
1,180-meter separation between centers of A and B

Didymos-A
780 meters, S-type
2.26-hour rotation period

Earth-Based Observations
0.07 AU range at impact
Predicted ~10-minute (~1%) change in binary orbit period

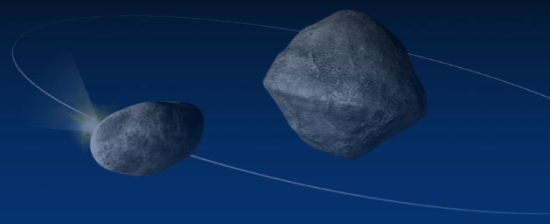
- Target the binary asteroid Didymos system
- Impact Didymos-B and change its orbital period
- Measure the period change from Earth

DART Investigation Status



- Work reported by Investigation Team member Shantanu Naidu (JPL) with preliminary analysis of Didymos B orbit based on current data.
  - Consistent with but independent of earlier work done by European colleagues.
  - Conservative analysis leads to expectation that requirement of knowing extrapolated orbit phase to ±45° (3 σ) within 180 days of launch may need observations earlier than currently baselined: Observations WG currently investigating options.
  - Analysis also shows that team expects to satisfy pre-impact requirement (±15° (3 σ) within 55 days of impact) with 2021 data, though some situations may require data taken in 2022.
  - Expect final pre-impact formal uncertainty in orbit phase of Didymos B to be < 5° (3 σ), when including simulated 2022 pre-impact measurements.
- "A Benchmarking and Sensitivity Study of the Full Two-Body Gravitational Dynamics of the DART Mission Target Binary Asteroid 65803 Didymos" by Agrusa et al. submitted to Icarus.
- Two DART abstracts submitted to LPSC (March 2020), by Stickle et al. and Cheng et al.
- Kickoff meetings held for DART planning at SxSW (March 2020) and the Investigation Team Meeting (May 2020)
- AIDA Coordination Committee meeting held on 16 January.
  - Considering formally forming joint DART-Hera working groups for Impacts, Remote Observations, Dynamics; maintain separate DART Proximity Imaging and Ejecta WGs
  - Hera Team Meeting announced for 20-22 April in Nice. Planning to support attendance by 1-2 DART team members.
- Working Group Telecons held on 3 January (Dynamics WG), 22 January (Impact Modeling WG and Joint Proximity Imaging-Ejecta WGs). All well-attended by Investigation Team members

Technical Margin Status



Spacecraft

Parameter	Margin	Trend	Threshold
Mass	15.5%	↑	=>15%
EP Power	18.6%	↔	>10%
Spacecraft Power	30.6%	↔	=>15%
Uplink	6 dB	↔	>= 6 dB
Downlink (HGA)	5 dB	↔	>= 3 dB
Downlink Latency	186%	↔	<7 s
CPU Time	51%	↑	>35%
Processor Memory	21%	↓	>35%

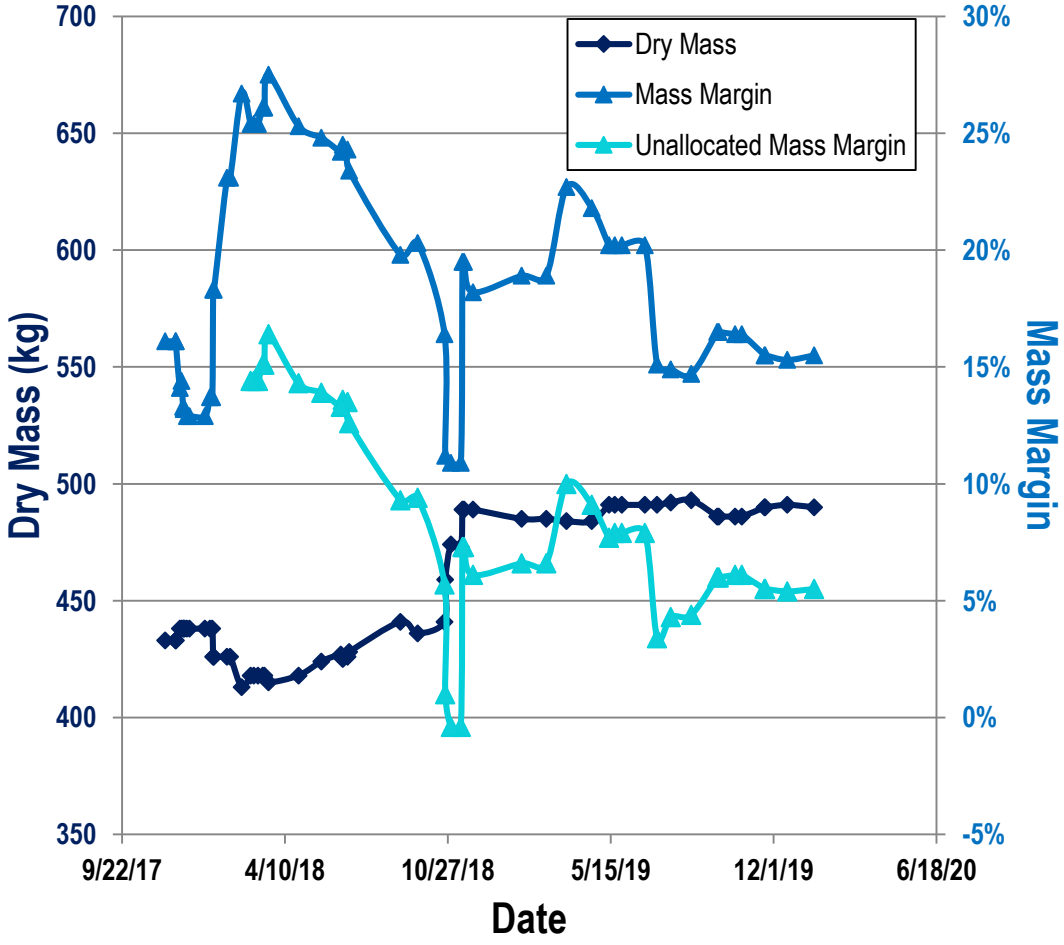
Propulsion

Parameter		Margin	Trend
Hydrazine	Allocated	8.7 kg	↑
	Unallocated	2.9 kg	↓
Xenon	Allocated	0.7 kg	↔
	Unallocated	49.1 kg	↔

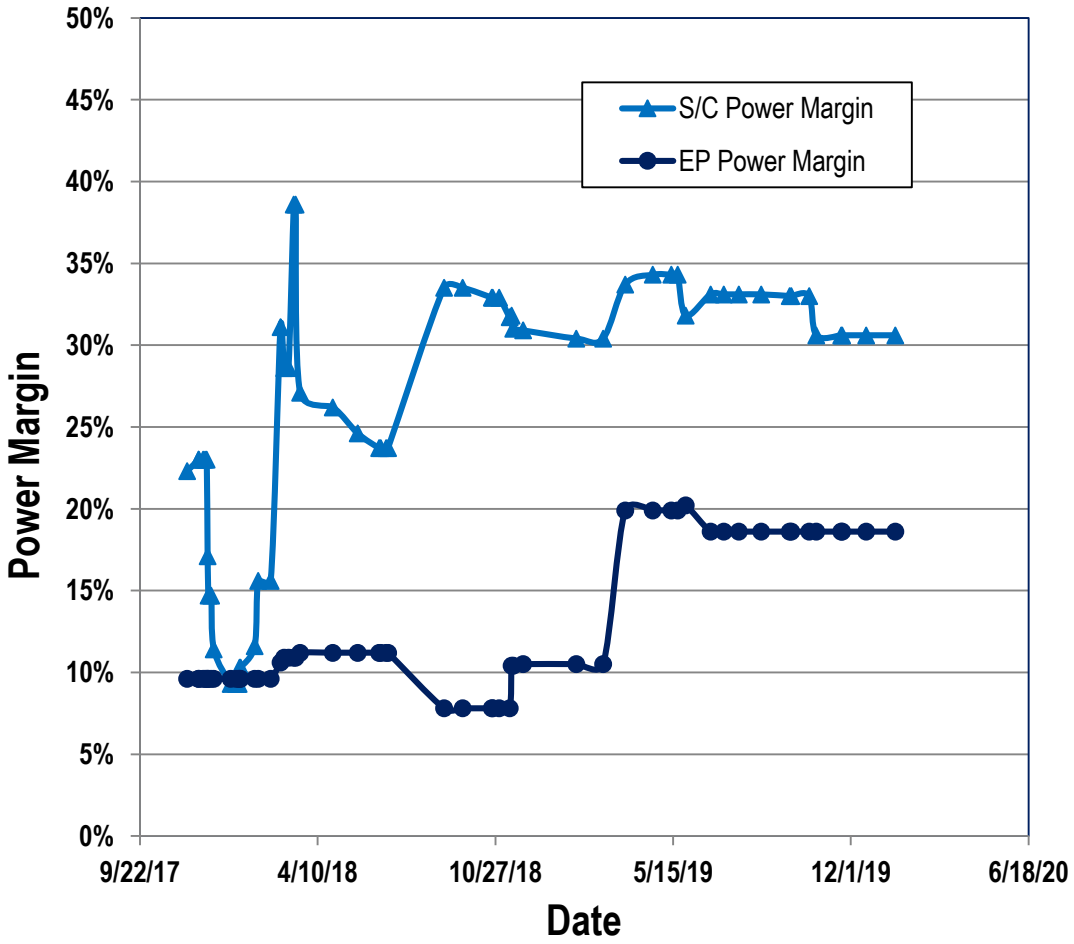
- Increase in mass margin by 0.2% (as weighed masses for a number of components)
- Spacecraft power margin unchanged
- Net propellant margins unchanged
- Decrease in processor memory is due to moving 2 MB DRACO Calibration Table from Flash memory to RAM to save development costs

Mass Trending

- Updates to as-weighed masses
  - HGA ECU
  - SADA ECU
- At this time 33% of dry mass in MEL is measured mass



DART Spacecraft and EP Power Margins



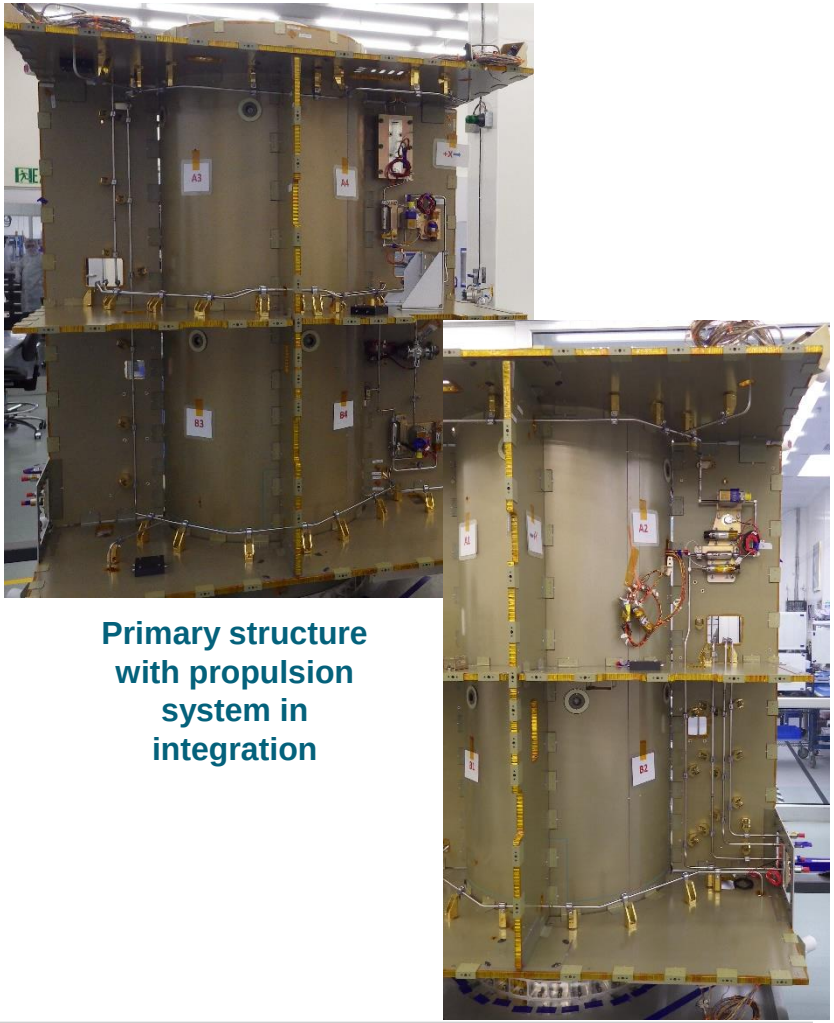
Spacecraft Margin is 30.6% during Approach/Terminal Mode.
* No change for January 2020.

EP Margin is steady at 18.6%

Total margin reported.
File “200121 DART MEL.xlsx”

Propulsion (1/3)

- Monthly Status
  - Propulsion system is continuing through the integration process on the spacecraft structure
    - Welding completed with minimal issues in the process
    - Leak and proof tests being performed and will be followed by the weld inspections
  - Remaining line heaters were delivered, completing delivery of all parts needed to complete propulsion system integration on the spacecraft structure
  - NEXT-C hardware finished component level testing and was released for the start of the system integration test (SIT)
    - Hardware data has gone through a preliminary evaluation and is acceptable
  - NEXT-C SIT began and in planned to complete no later than the beginning of February

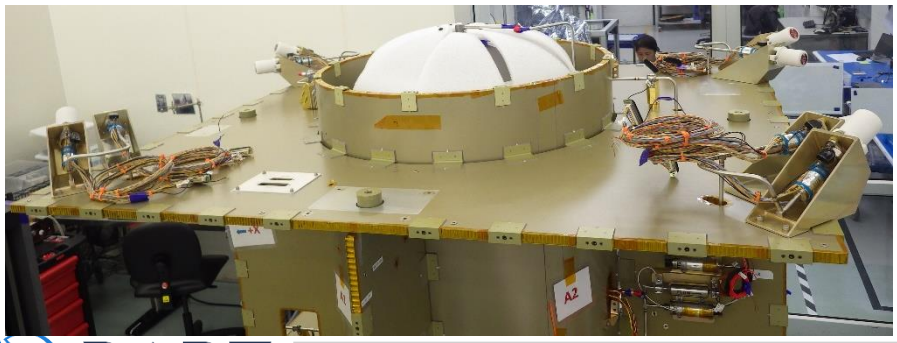


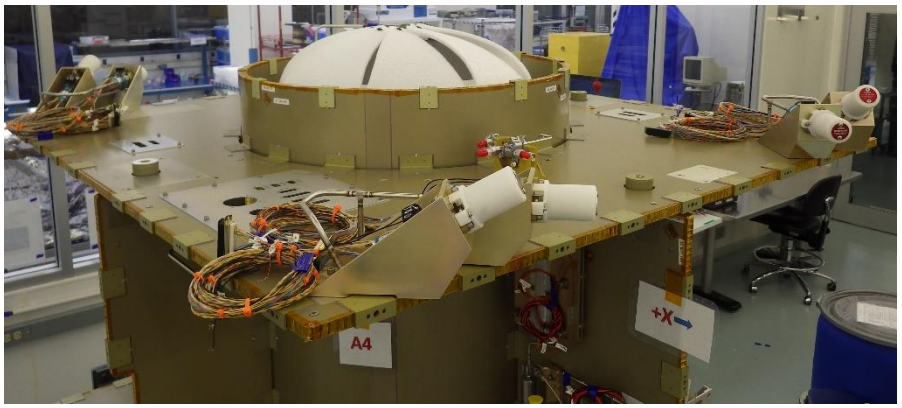
Primary structure with propulsion system in integration

Propulsion (2/3)

- Upcoming Activities
  - NEXT-C hardware acceptance review (HAR) for the thruster and PPU are planned for mid-February
    - PPU will be delivered to APL as soon as the HAR is passed
    - Thruster will be delivered in place at Aerojet to begin the installation of the flight propellant tube stubs and fittings
  - Once the PPU is delivered, it will begin the second part of an end-to-end test with the spacecraft subsystems using APL's spacecraft testbed
- Issues/Concerns
  - Schedule continues to be concern on the delivery of the spacecraft structure from Aerojet.
    - Aerojet has implemented multiple shifts and authorized overtime to ensure that the delivery to APL on April 10 is maintained

Top deck of spacecraft showing thruster placement

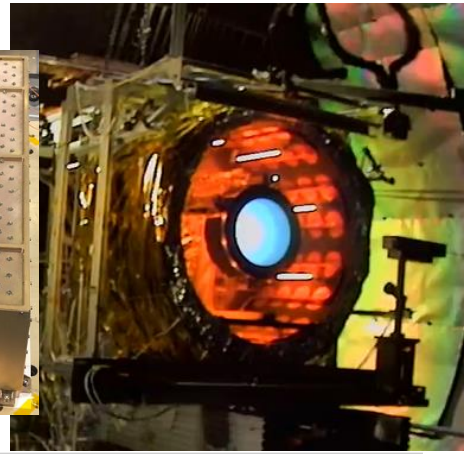


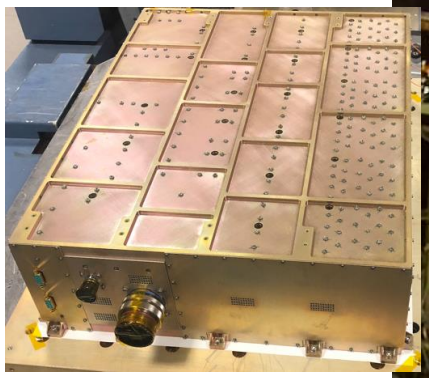


Propulsion - NASA's Evolutionary Xenon Thruster-Commercial (NEXT-C)

- **PPU**
  - Successfully completed the TVAC test on 12/6
    - The PPU's Discharge, Discharge Heater, Neutralizer, and Neutralizer Heater Current setpoint/telemetry exceeded the Setpoint Accuracy and Telemetry Accuracy specs at -29C by 10-15%.
    - DART to implement calibration corrections in software to mitigate this issue.
  - Completed the burn-in test on 12/19 with no issues noted & passed functional on 12/20.
- **Thruster**
  - Installed Flight thruster in VF-6 on 12/6; passed the post-vibe functional on 12/18.
  - On 12/20 started the TVAC test. Nominal ignition at -112C; experienced excessive recycles at ~ 15 minutes into the TL-28 dwell. A restart @ -56C yielded similar results.
    - ON 1/6 while performing resistance checks on the thruster, used the equipment "burn mode" to clear possible debris from the grids.
  - Retry TVAC cycle on 1/8. Thruster started nominally and operated successfully at -109C per the test plan.
  - Successfully completed TVAC test on 1/15.
  - Started SIT test on 1/21.

Flight Thruster

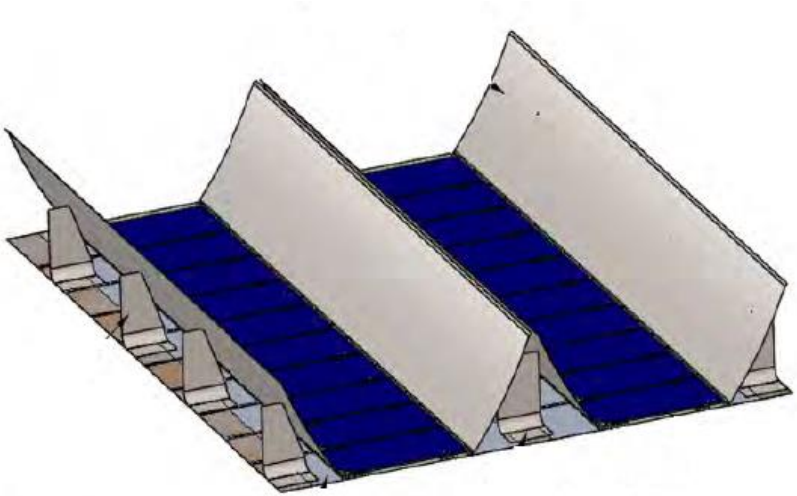




Flight PPU

Transformational Solar Array Strings Status

- **Monthly Status**
  - Successful review of Developing Transformational Solar Array for Extreme Environments.
  - The substantive work for the Transformational Array is complete
- **Upcoming Activities**
  - The Transformational Array parts for the DART array are at DSS and will be mounted to the array as soon as the array is ready for them.
- **Issues/Concerns**
  - None



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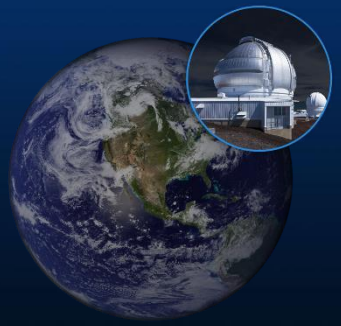
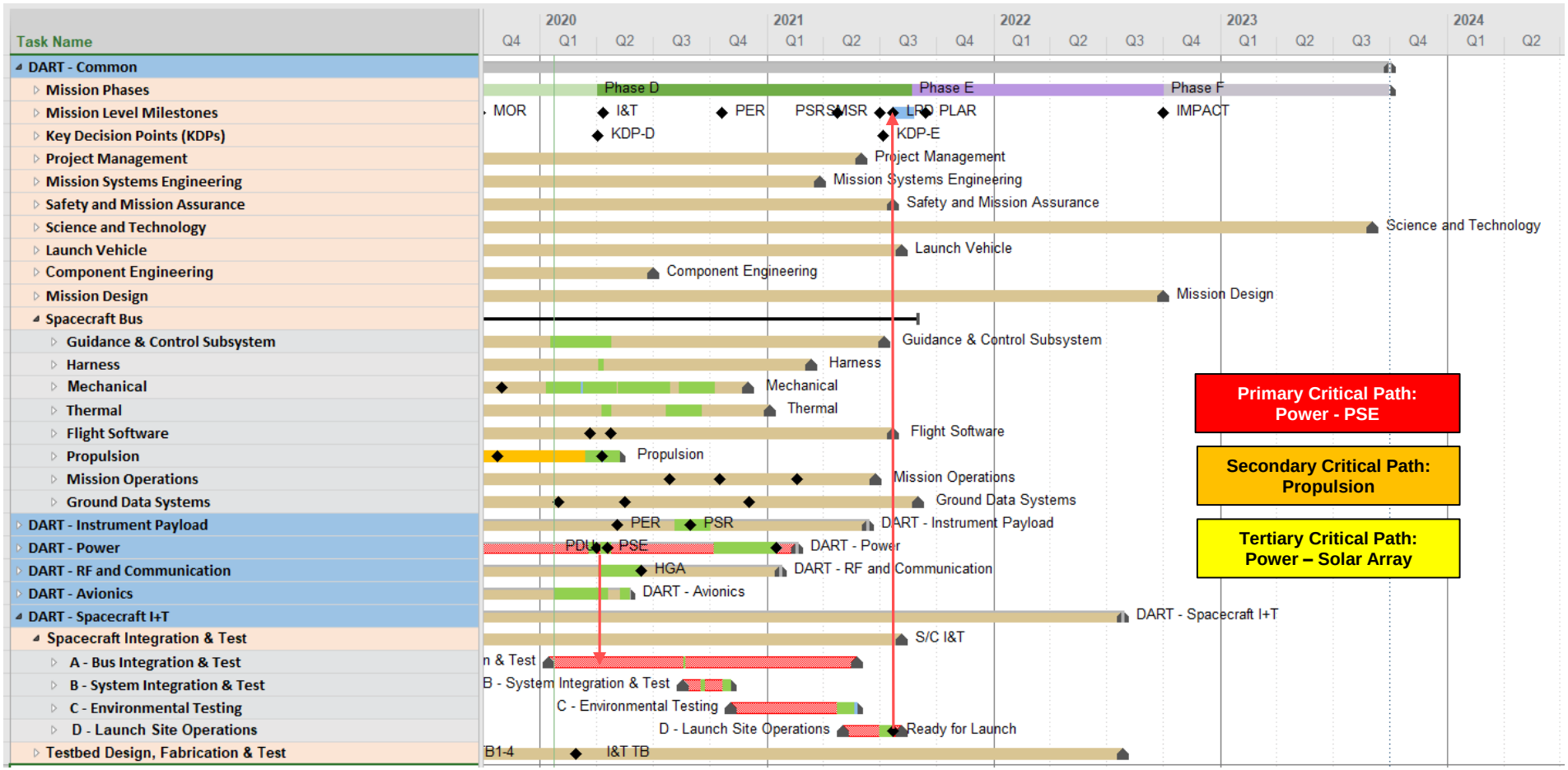


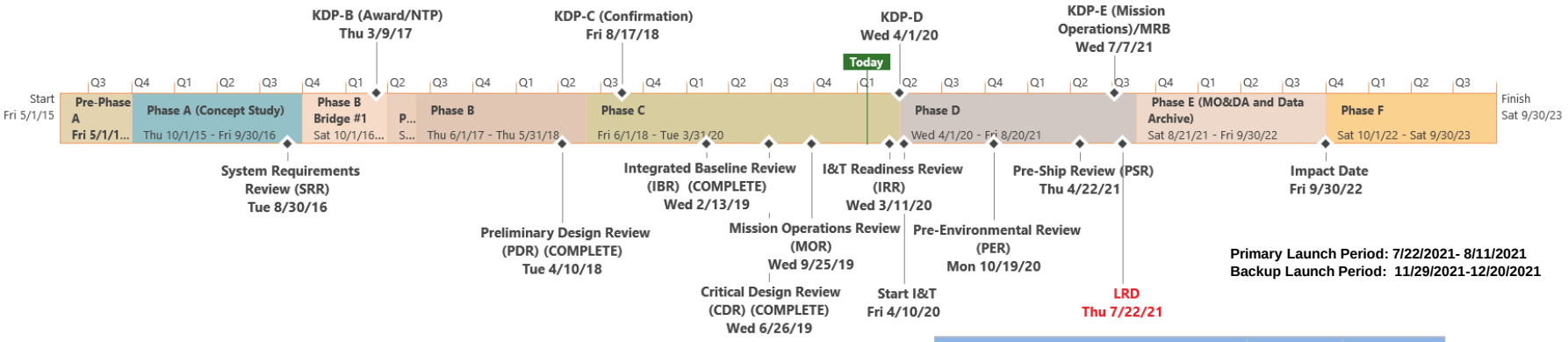
DART Schedule:

January 30, 2020

DART Mission Milestone Schedule



DART Timeline and Mission Milestones

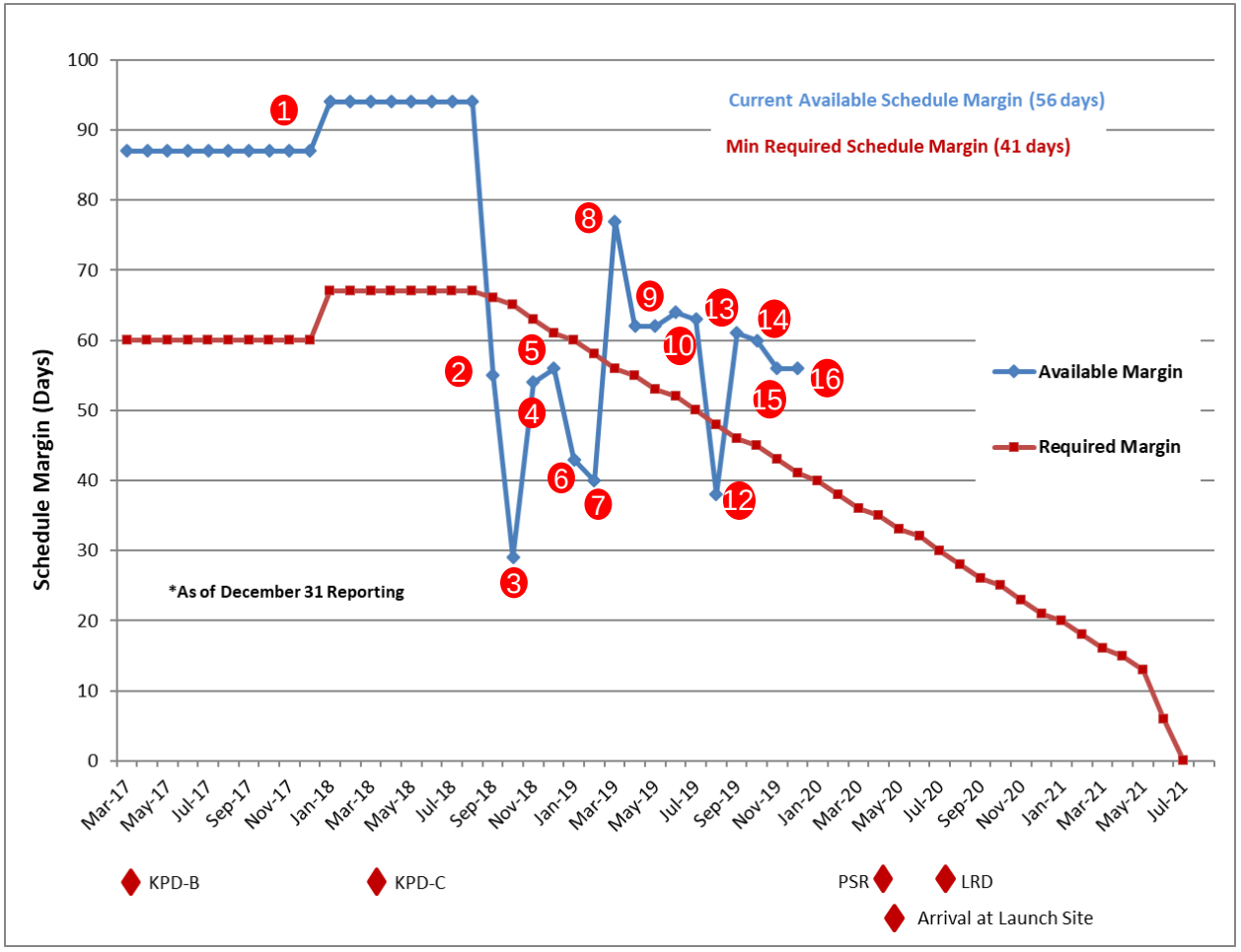


Task Name	Start	Finish
Pre-Phase A	5/1/2015	9/30/2015
Phase A (Concept Study)	10/1/2015	9/30/2016
Phase B Bridge #1	10/1/2016	3/31/2017
Phase B Bridge #2	4/1/2017	5/31/2017
Phase B	6/1/2017	5/31/2018
Phase C	6/1/2018	3/31/2020
Phase D	4/1/2020	8/20/2021
Phase E (MO&DA and Data Archive)	8/21/2021	9/30/2022
Phase F	10/1/2022	9/30/2023

Key Decision Points (KDPs)	Start	Finish
KDP-B (Award/NTP)	3/9/2017	3/9/2017
KDP-C (Confirmation)	8/17/2018	8/17/2018
KDP-D	4/1/2020	4/1/2020
KDP-E (Mission Operations)/MRB	7/7/2021	7/7/2021

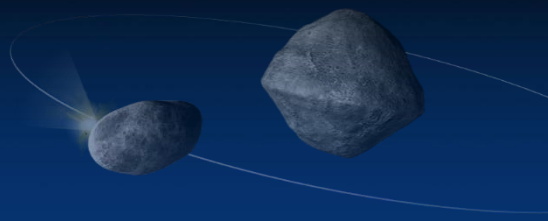
Mission Level Milestones	Start	Finish
Mission Concept Review (MCR)	5/21/2015	5/22/2015
System Requirements Review (SRR)	8/30/2016	9/1/2016
Non-Critical Systems ATP	9/1/2017	9/1/2017
Preliminary Design Review (PDR) (COMPLETE)	4/10/2018	4/12/2018
Integrated Baseline Review (IBR) (COMPLETE)	2/13/2019	2/13/2019
Critical Design Review (CDR) (COMPLETE)	6/26/2019	6/28/2019
Mission Operations Review (MOR)	9/25/2019	9/26/2019
I&T Readiness Review (IRR)	3/11/2020	3/12/2020
Start I&T	4/10/2020	4/10/2020
Terminal Phase Review	**7/15/2020**	**7/15/2020**
Pre-Environmental Review (PER)	10/19/2020	10/19/2020
Pre-Ship Review (PSR)	4/22/2021	4/22/2021
Operational Readiness Review (ORR/FOR)	6/2/2021	6/2/2021
Mission Readiness Review (MRR)	6/22/2021	6/23/2021
OSMA Safety and Mission Success Review (SMSR)	7/1/2021	7/1/2021
Launch Readiness Review (LRR)	7/15/2021	7/15/2021
LRD	7/22/2021	7/22/2021
Commissioning	7/22/2021	8/20/2021
Primary Launch Period	7/22/2021	8/24/2021
Backup Launch Period	11/29/2021	12/20/2021
Post Launch Assessment Review (PLAR)	9/11/2021	9/11/2021
Impact Date	9/30/2022	9/30/2022

DART Schedule Margin – Trend Analysis



1. Change in Launch Readiness date
2. Backlog with PDU Parts Kitting
3. Delay in Hydrazine Tank due to subcontract delay
4. Propulsion subcontract negotiations improved schedule
5. Continued improvement in propulsion Schedule
6. Added Point-of-Purity Test to propulsion schedule
7. Erosion related to Point-of-Purity duration update
8. Change in Launch readiness Date
9. Test Chamber Failure Delay / test facility change
10. Slight slack gain in PSA due to Propulsion I&T re-plan
11. Schedule erosion due to late deliveries to Propulsion
12. EM RTAX DSP Firmware impacted FM Delivery
13. Radio EM / FM Swap
14. LPS / HP EPS Panel Assemblies and Aerojet Fasteners delay due to seizure issues
15. DSN Date Change and added SSC Compatibility Test
16. Decrease in margin due to EM / FM Processor Module Swap and Increase due to resequencing of Propulsion and Harness deliveries (zero net change)

Upcoming Meetings & Events

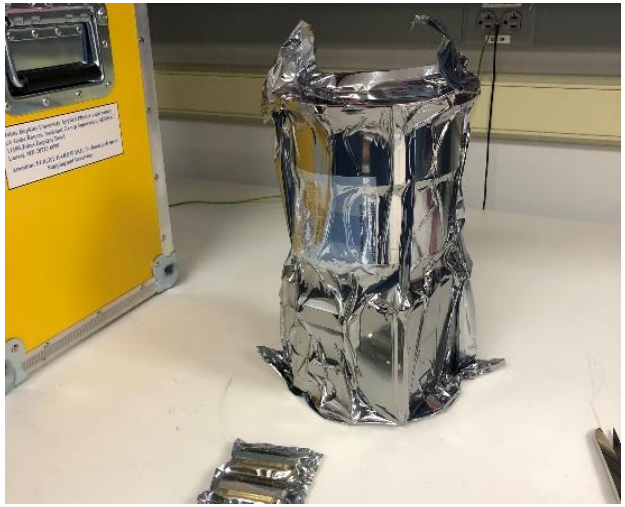


- LICIACube Accommodation Review & TIM- 3-5 Feb
- Safety Review 2.5 – 4 Feb
- Delta PMDR for LV- 13 Feb
- Launch and Early Ops (LEOPS) Review– 26 Feb
- IRR- 11-12 Mar
- KDP-D Entry April 2020

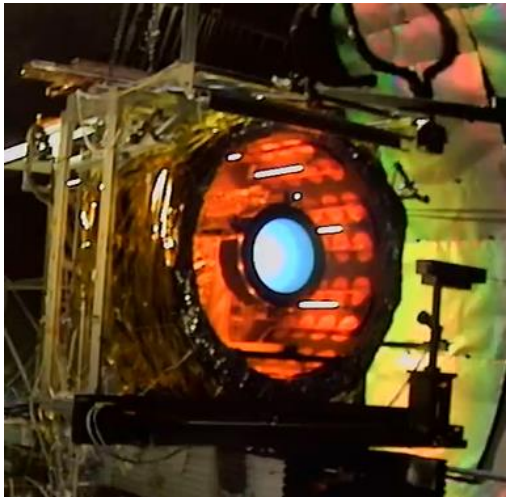
Manager's Assessment & Wrap-Up

Ed Reynolds

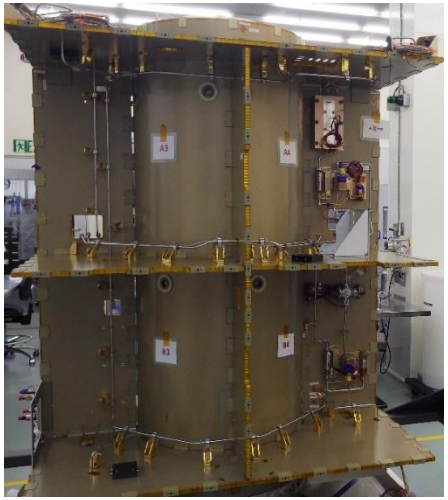
- Falcon 9 will hold onto spacecraft for 25 minutes after last 2nd stage burn, simplifying early operations.
- NEXT-C SIT began and is planned to complete no later than the beginning of February
- The critical path remains stable, well above guide line 56wd of 41wd.
- Technical Margins remain stable. Additional measured flight mass



Flight Star Tracker at APL



Electric propulsion thruster In test at GRC



Primary structure with propulsion system in integration