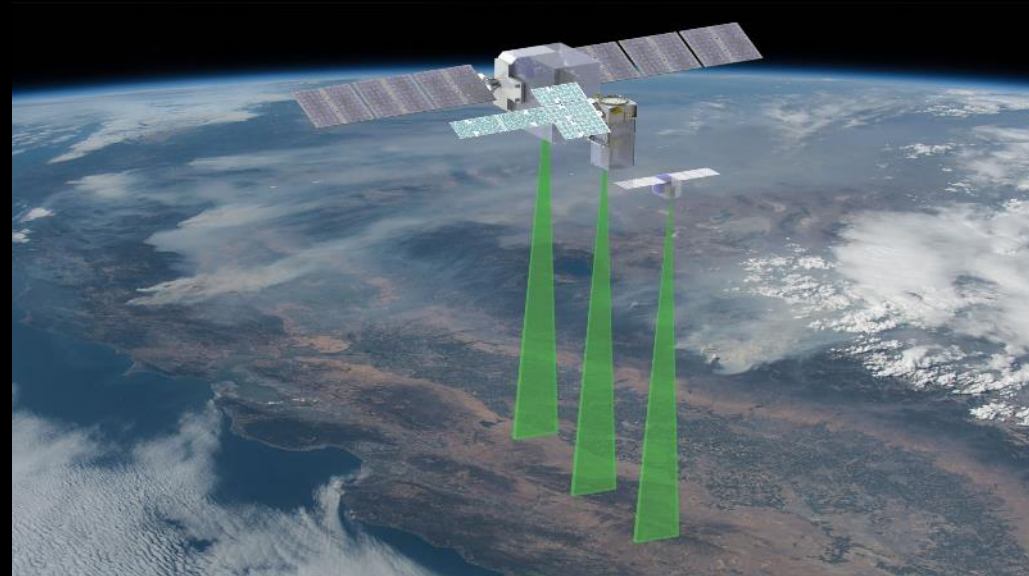
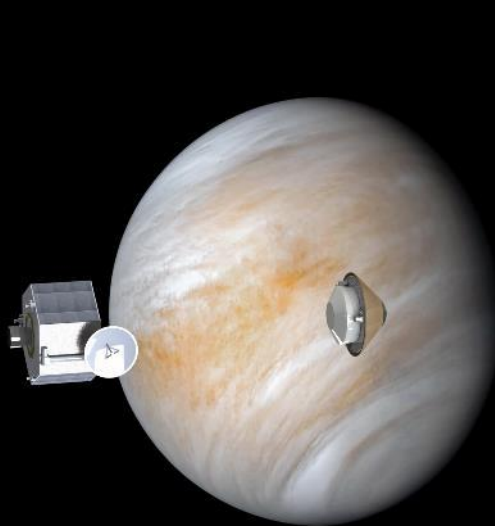
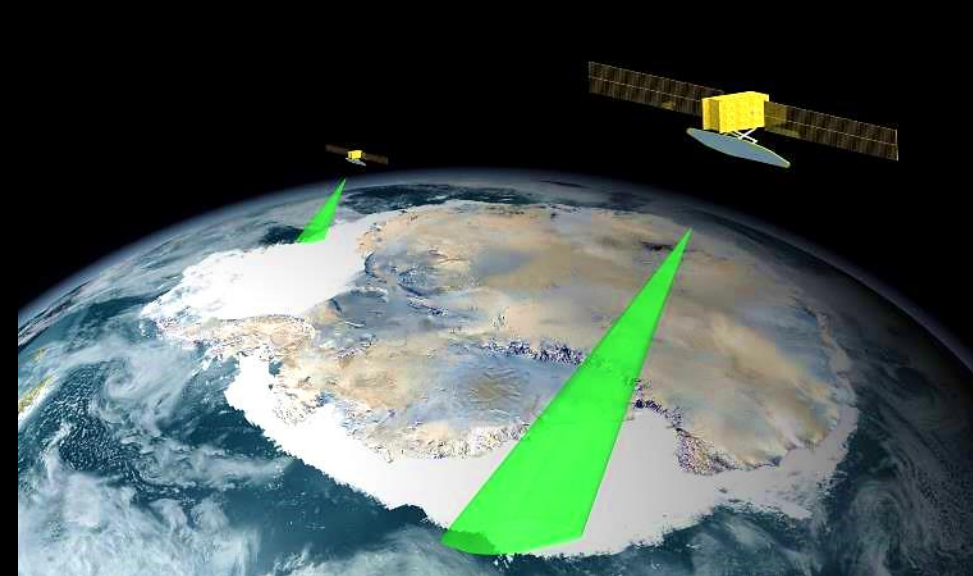




FELLOWSHIP OF THE DESIGN LABS

NASA ARC MISSION DESIGN CENTER OVERVIEW

ALAN CASSELL



Outline



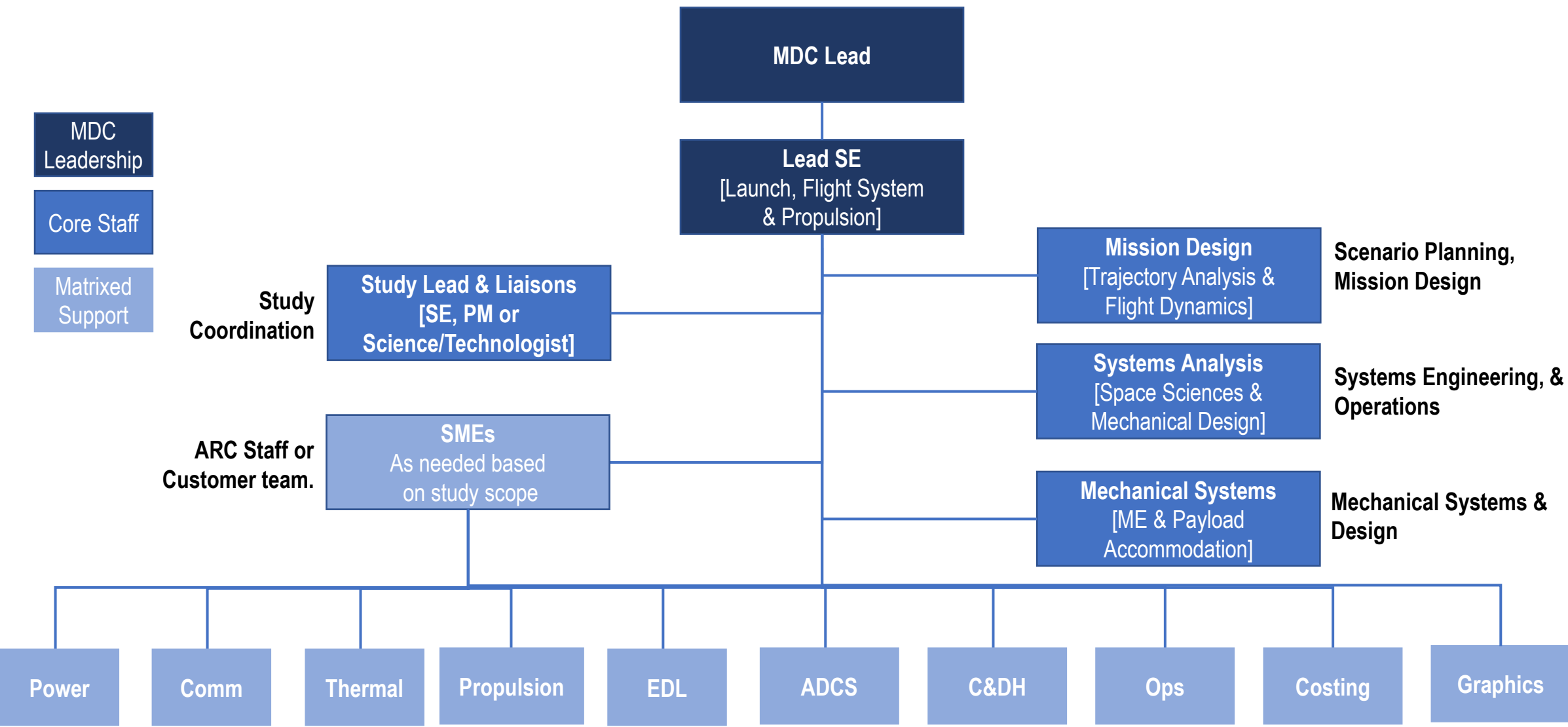
Mission Design Center Overview

- Staffing
- Services Description
- Stakeholder Engagement & Communication

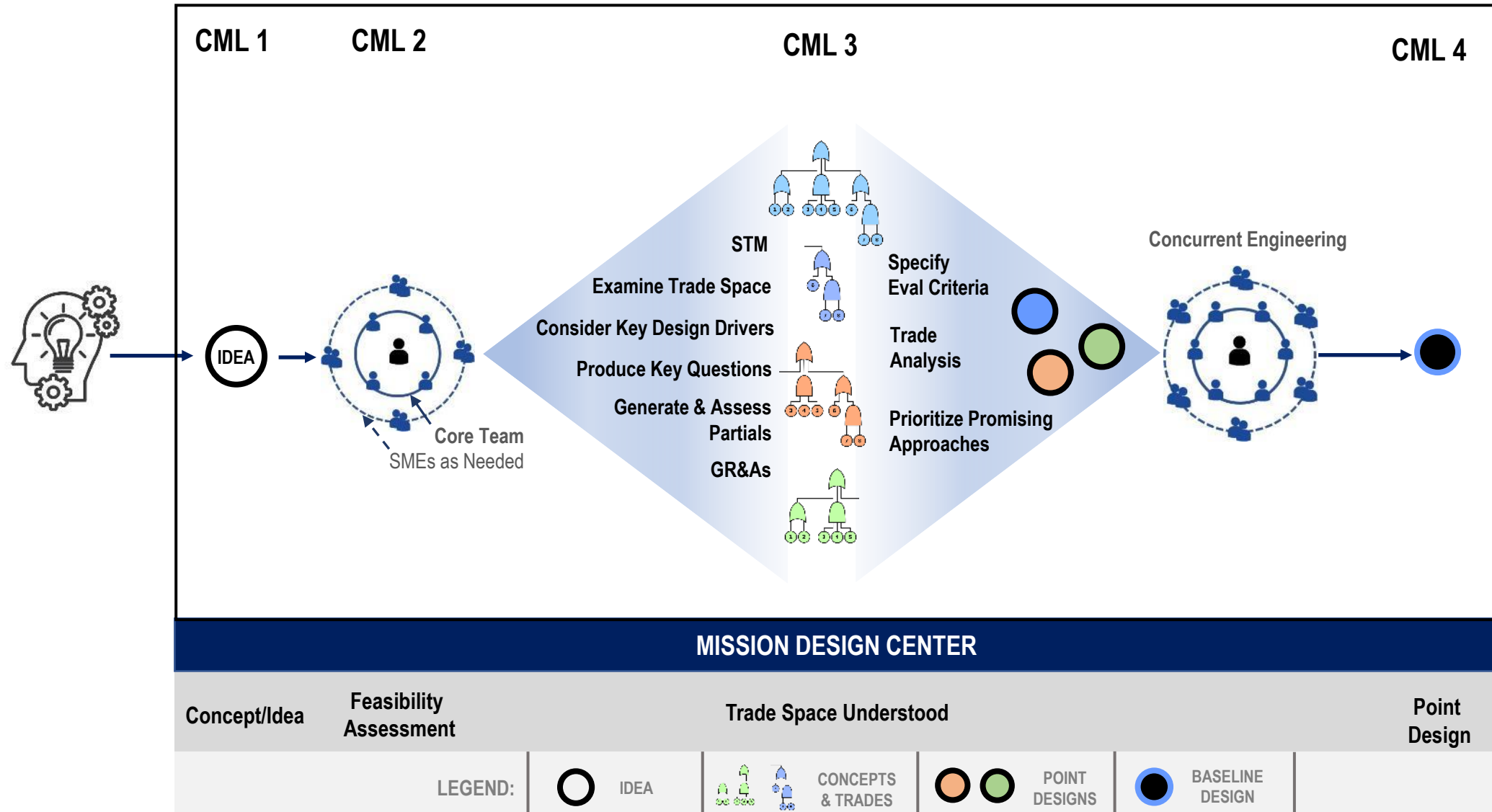
Study Products

- Case Study- Tailored Study- Technology Demonstration Mission

Staffing



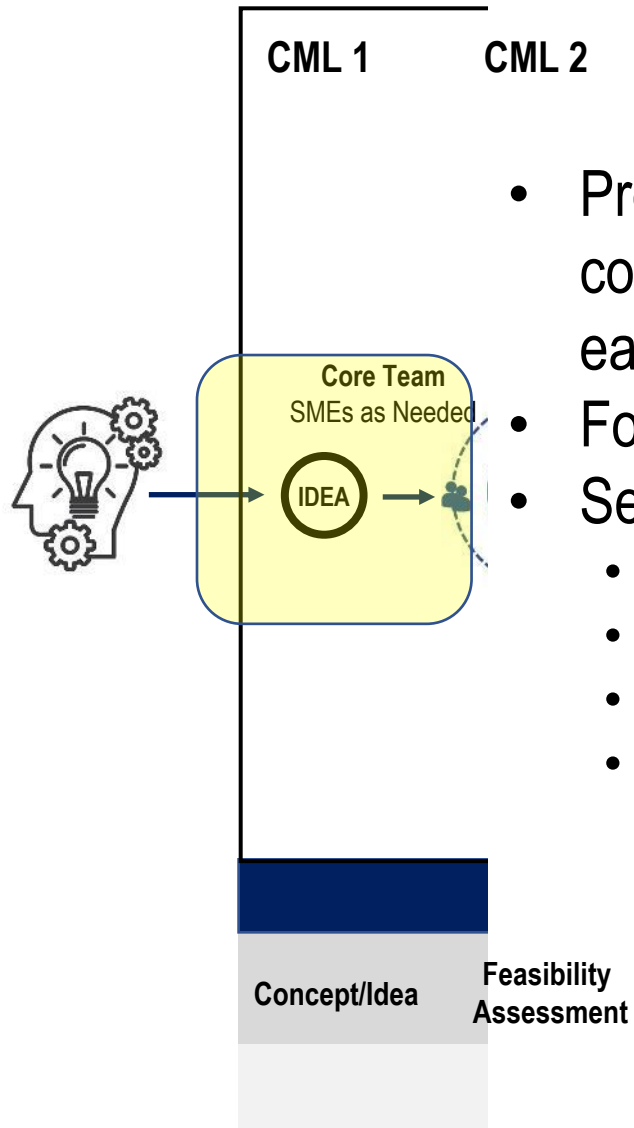
General MDC Study Process Overview



Services & Process Overview

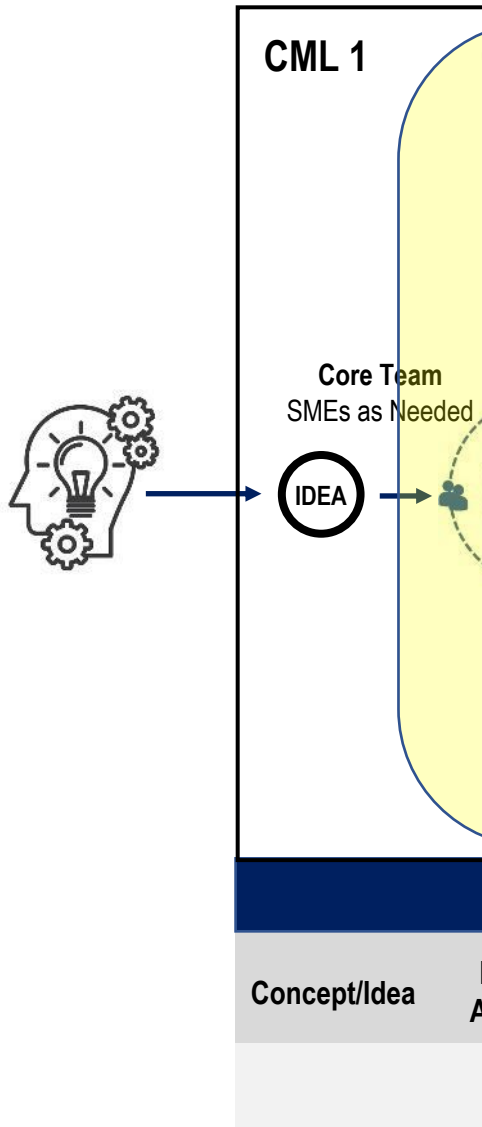
ACTIVITY	CONSULTATIONS & PRE-PLANNING	FORMULATION SUPPORT	MINI STUDIES	TAILORED STUDIES	FULL STUDIES
LEVEL of EFFORT	20-30 h	~50 h	200 h	200-500 h	>500 h
DURATION	Varies	Varies	3-4 Weeks	1-3 Months (Generally) Large Activities can be run as multiple tailored studies	1-3 Months (Generally) Longer duration for certain activities
MDC LEAD	X	X	X	X	X
LEAD SE	X	X	X	X	X
STUDY LEAD			X	X	X
CORE TEAM			X	X	X
SELECT SMEs	X	X	X	X	X
FULL SME					X
COSTING			X	X	X
GRAPHICS		LIMITED	LIMITED	X	X

Consultations & Pre-Planning



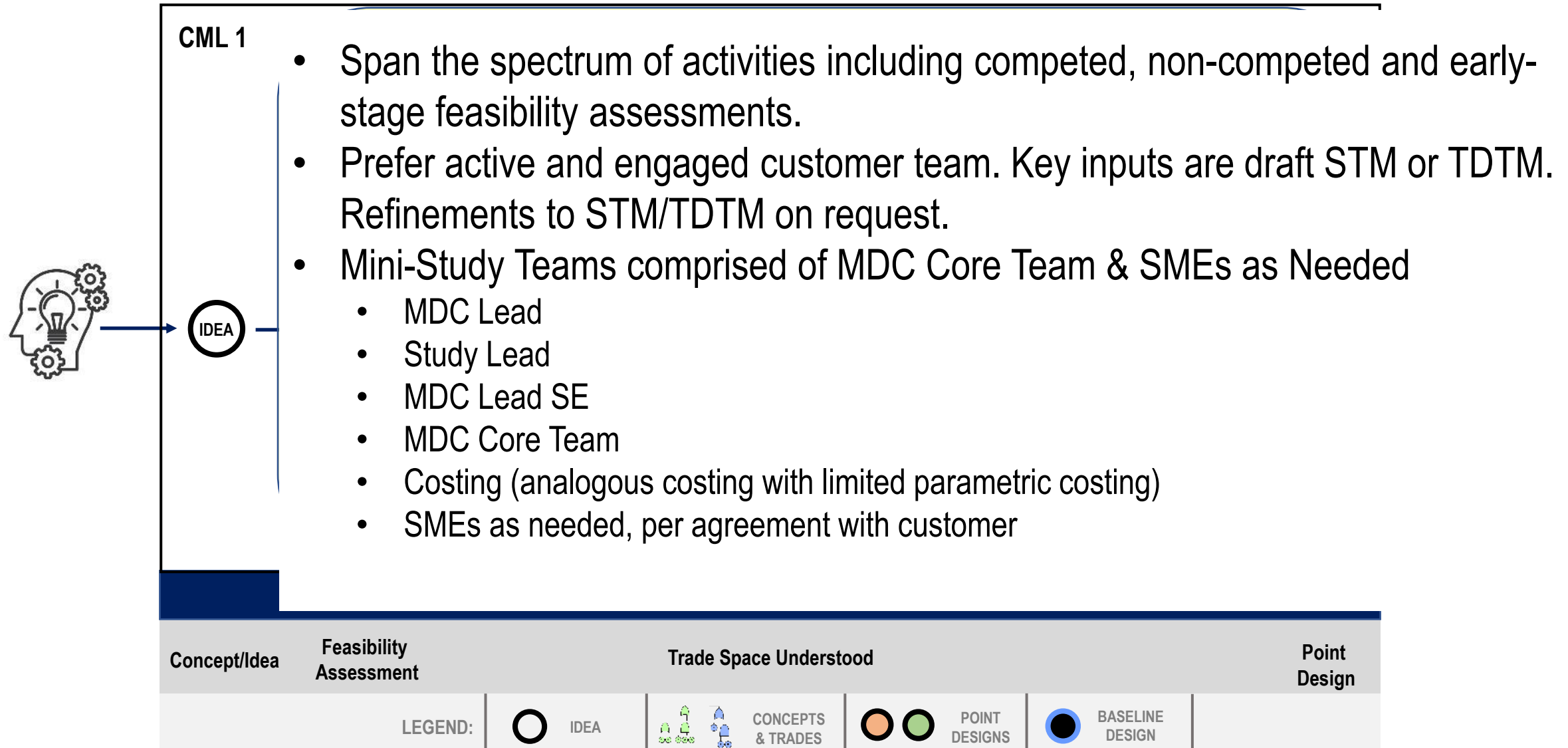
- Pre-arranged appointments to get feedback on developing mission concepts, technology demonstrations, instrumentation concepts & similar early-stage activities.
- Follow-on sessions as needed to aid in idea 'pitch' support.
- Session Team comprised of MDC Core Team & SMEs as Needed
 - MDC Lead
 - MDC Lead SE
 - MDC Mission Designer
 - SMEs as needed (SE, Technology, Flight Dynamics, Power/C&DH, Comm, ADCS, Thermal, EDL, etc.)

Formulation & New Activity Support

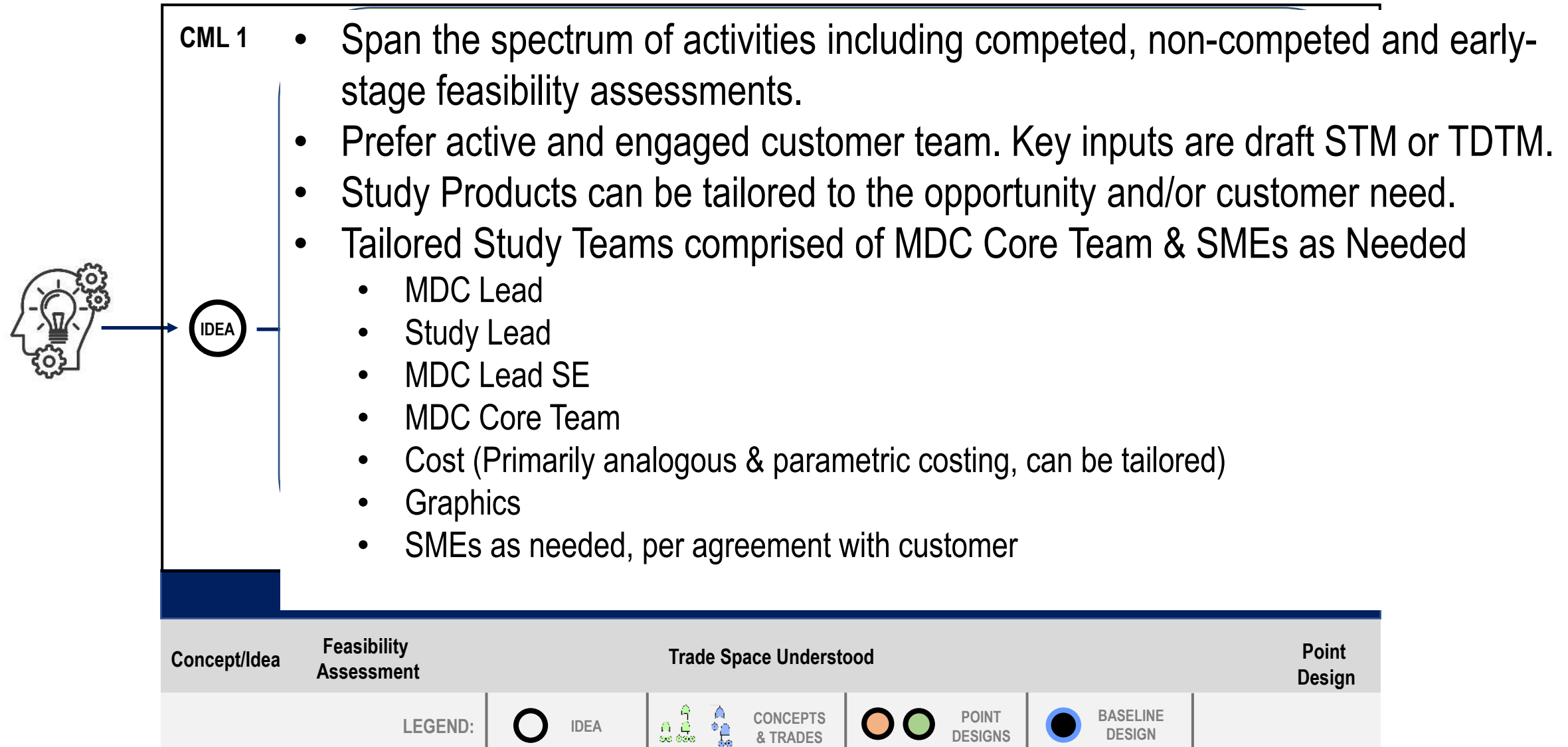


- Limited engagement with well defined expectations.
- Engagement with stakeholders as needed to provide background information and quick turn products. Key objectives & top-level draft requirements. generally needed as inputs. STM & TDTM generation on request.
- Formulation Team comprised of MDC Core Team & SMEs as Needed
 - MDC Lead
 - MDC Lead SE
 - MDC Mission Designer
 - SMEs as needed (SE, Technology, Flight Dynamics, Power/C&DH, Comm, ADCS, Thermal, EDL, etc.)

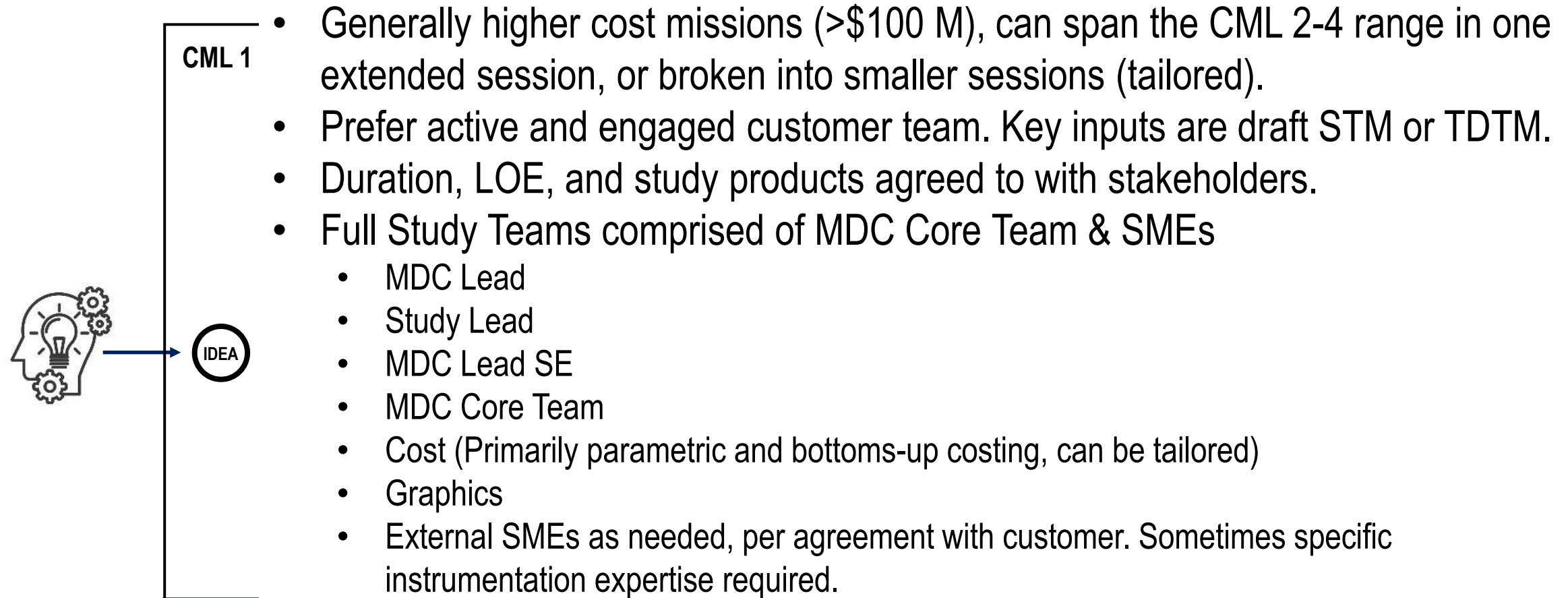
Mini-Studies



Tailored Studies



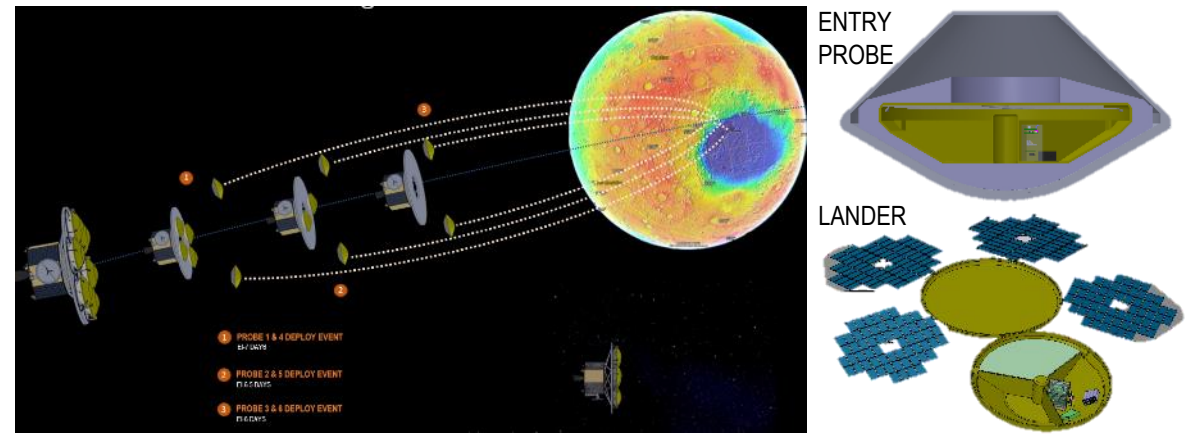
Full Studies



Concept/Idea	Feasibility Assessment	Trade Space Understood			Point Design
LEGEND:					
	IDEA	CONCEPTS & TRADES	POINT DESIGNS	BASELINE DESIGN	

STAKEHOLDER COMMUNICATION CHART

GRAPHICAL SUMMARY



DASHBOARD

ACTIVITY	STATUS	DATES	POC	MDC POC
PLANNING MEETINGS	COMPLETED	1/2023-3/2023	M. MURBACH	A. CASSELL
CML 2 MINI STUDY	COMPLETED	4/14/2023	M. MURBACH	C. PAYNE
CML 3	NOT STARTED			
NBC/PAR				
CML 4				

- COMPLETED
- IN PROGRESS
- NOT STARTED

MISSION OVERVIEW

PI- Marc Murbach (ARC-RS)

PM- Seth Schisler (ARC-P)

SE- TBD

OPPORTUNITY TYPE: Low-Cost Mars, Mars Exploration Program, Anticipated Cost Range: \$100-200 M

GOALS & OBJECTIVES:

- Measure total regional pressure gradient associated with the Hellas feature.
- Associate the concentration of water vapor with the regional climate and dynamics with the subliming southern residual polar water cap.
- Constrain the total water flux from the subliming southern cap.
- Correlate the change in radiative forcing associated with suspended dust and specific saltation and lifting events.
- Characterize the surface radiation environment.

MISSION DESCRIPTION:

Regional network of landed weather stations using Mars Orbiter Comm Relay for Telemetry.

SUMMARY

NOTES:

CML 2 Mini-Study Key Findings:

- Mature instrument concept such that detailed probe/lander requirements can be drafted
- Perform more extensive trades in Launch/Cruise/Probe Targeting segments
- More mass efficient probe design needed to enable soft landings at higher altitude landing sites. Recommend team consider low Ballistic coefficient aeroshell designs.

Study Products

ACTIVITIES

PRODUCTS	CONSULTATIONS & PRE-PLANNING	FORMULATION SUPPORT	MINI STUDIES	TAILORED STUDIES	FULL STUDIES
MISSION TRACEABILITY MATRIX	X	X	X	X	X
REQUIREMENTS DEVELOPMENT	X	X	X	X	X
GROUND RULES & ASSUMPTIONS	X	X	X	X	X
GRAPHICS/ANIMATION		LIMITED	LIMITED	X	X
ARCHITECTURE TRADES	X	X	X	X	X
FLIGHT SYSTEM TRADES	X	X	X	X	X
LAUNCH SYSTEM TRADES	LIMITED	LIMITED	X	X	X
TRAJECTORY/ORBIT ANALYSIS		X	X	X	X
SCENARIO PLANNING		LIMITED	LIMITED	X	X
POWER BUDGET			LIMITED	X	X
DATA BUDGET			LIMITED	X	X
POINTING BUDGET			LIMITED	X	X
DELTA V BUDGET			X	X	X
LINK ANALYSIS			X	X	X
MASS BUDGET/MEL			LIMITED	X	X
CAD DESIGN (CONCEPT)			X	X	X
THERMAL ANALYSIS			LIMITED	X	X
OPERATIONS PLANNING			LIMITED	X	X
EDL ANALYSIS			LIMITED	LIMITED	X
TOP RISKS			LIMITED	LIMITED	X
CML ASSESSMENT			X	X	X
INSTRUMENT(S) ASSESSMENT		LIMITED	LIMITED	LIMITED	X
COST ESTIMATION			ANALOGOUS	ANALOGOUS & PARAMETRIC	X
RECOMMENDATIONS			LIMITED	LIMITED	X

Case Study:

Tailored Study- Technology Demonstration Mission

Study Phase II Schedule

Week	Mon	Tue	Wed	Thurs	Fri
Jan 2-5			10-12 AM PST Phase II Kick-off meeting		
Jan 9-13	8:30 AM Quick Tag-Up	11-12 PM Status Meeting		8:30 AM Quick Tag-Up	11-12 PM Status Meeting
Jan 16-20	Holiday	11-12 AM Status Meeting		8:30 AM Quick Tag-Up	11-12 PM Status Meeting
Jan 23-27	8:30 AM Quick Tag-Up	11-12 PM Draft Chart Flip Thru		2-3 PM Final Chart Flip Thru	
Jan 30-Feb 2	8:30 AM Quick Tag-Up			10 AM-12 PM Final Outbrief	

- ## Draft Trades & Task List

Trade Name	Responsible SME(s)	Trade Description	Status/Findings
Launch/Phasing	Flight Dynamics	Favorable Launch Opportunities, Rideshares, Multiple launches needed to achieve required S/C spacing? Inclination alternatives.	Phase I
S/C Bus	Mechanical, Comm, Power, C&DH	Identify alternatives for S/C bus to host payload. Consider pointing. Assume COTS as a starting point.	Phase I
Ground to S/C Comm	Flight Dynamics, Comm	Explore options for downlink of tracking data and uplink of S/C commands along with transceiver hardware.	Phase I
S/C Station Keeping	Flight Dynamics	Determine dV needs and options for achieving and maintaining required S/C spacing.	Phase I (initial analysis of altitude and drag)
Ops	Flight Dynamics, Payload, Ops	How to balance drag for station keeping vs payload nadir pointing	Phase II
Tracking Data Processing	Comm, Payload, SE, Power	Explore options for science data return; higher data downlink data volume with less onboard processing vs. lower data volume with greater onboard processing.	Phase II
S/C Cost Estimate	Cost Analyst	Provide selected S/C bus plus I&T cost estimate.	Phase I
Mission Cost Estimate	Cost Analyst	Provide overall mission cost estimate.	Phase I
S/C Nomenclature	All	The NGAT spacecraft and/or constellation needs a name or acronym, if anyone has any clever ideas, please share with the project.	Ongoing

10/27/2022

NGAT 2022 Mission Feasibility Kick-Off Briefing

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Tailored Study- Technology Demonstration Mission

Phase 1- Architecture & Flight System & Operations Trades

ARCHITECTURES CONSIDERED

ARCHITECTURE 1

Rideshare to SSO

- LTAN TBD
- Time to maneuver into formation TBD
 - Aiming for as quick as possible
 - Up to 1-month acceptable (TBR)
- Assume maneuver using propulsive means
 - COTS cold gas thruster system
 - Consider other options
- Operations Phase
 - Maintain formation
 - Receive tag data 2+ times per day TBR
 - Downlink data 6+ times per day TBR
 - Command uplink 1 per day TBR
- Comm stations- Primary for SSOs; (explore other options)
 - Antennas in orbit
 - Svalbard system
- Comm Trade Assumptions:
 - S & X bands for data
 - S & X band for commanding

ARCHITECTURE 2

Rideshare to ISS orbit

- Time to maneuver into formation TBD
 - Need to wait for Cygnus primary ISS mission (60-90 days)
 - Aiming for as quick as possible
 - Up to 60 days acceptable TBR
- Assume maneuver using propulsive means
 - COTS cold gas thruster system
 - Consider other options
- Operations Phase
 - Maintain formation
 - Receive tag data 2+ times per day TBR
 - Downlink data 6+ times per day TBR
 - Command uplink 1 per day TBR
- Comm stations- Primary for ISS:
 - Near Earth Network
 - Wallops
 - White Sands
- Comm Trade Assumptions:
 - S & X bands for data
 - S & X band for commanding
- Considering deployment
 - Cygnus Nanorack
 - Nanoracks ISS De



TECH DEMO CONOPS ASSUMPTIONS

- Orbital analysis assumed a selection of existing buoys in US OCS on East, West, Gulf Coasts to facilitate concept mission design.
 - Known, constant locations on water for ToA tags
- Placing tags on animals is outside the scope of this study and would have to be worked with external partners
 - Orbit alternatives would need to be refined to reflect realities of live animal tracking
 - Resupply rates
 - Timing of passes
 - Day vs night

Phase 1 Key Trades:

- Established Architectures to be considered
- Developed ConOps & Operations Planning Scenarios.
- Compared Flight System options.

3U VERSUS 6U COMPARISON

Payload mass and volume: 6U has more than double the payload mass and volume allocation that can be used for upgraded power, propulsion, and data capability.

ADCs: Attitude knowledge and pointing capability are acceptable in both 3U and 6U cubesats.

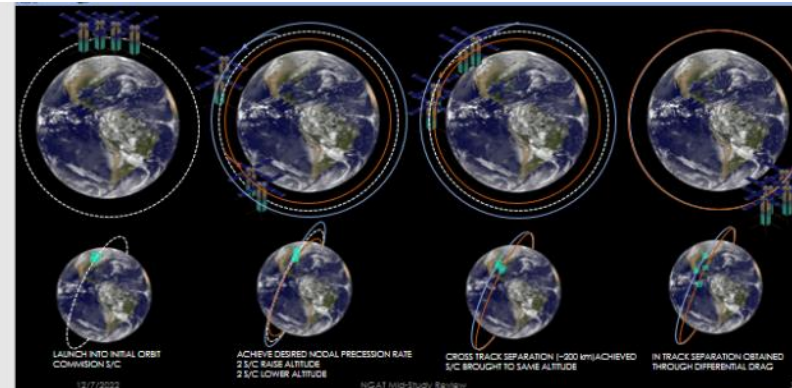
Antenna placement: 6U provides more nadir and zenith area for placing antennas.

Propulsion: Cold gas prop system takes up ~40cm (minimum) height. Expansion beyond that is additional propellant tank volume (delta-V), but it comes at the cost of allocated payload volume and mass. 6U will allow for substantially higher delta V.

Power: 3U and 6U can include deployable solar arrays to meet power needs. Battery pack size can be increased in 6U. Battery with 3-4 18650s takes up ~30cm of height. BioSentinel (6U) has 2 batteries with 3 18650 cells per brick. TBS10 (6U) has 4 batteries with 4 18650 cells per brick.

Thermal: Downlink amplifier power is high. 3U ability to dissipate the resulting heat may limit transmit time. 6U has more area to radiate heat and more room for heat transfer hardware.

	BCT XBS, 3U	BCT XBS, 6U
ALLOWABLE PAYLOAD VOLUME, "U"	1.5	4U
ALLOWABLE PAYLOAD MASS, kg	3	8
SOLAR ARRAY POWER, W	27	92-108
ENERGY STORAGE, Ah	6.8	6.8-20.4
POINTING ACCURACY	±0.003 deg (1-sigma) for 2 axes; ±0.007 deg (1-sigma) for 2nd axis	±0.002 deg (1-sigma) for 2 axes; 3 axes, 2 Trackers
POINTING STABILITY	1 arc-sec over 1 sec	1 arc-sec over 1 sec
ORBIT KNOWLEDGE	4m, 0.05m/s	4m, 0.05m/s
ONBOARD DATA STORAGE	408	408 expandable by adding high speed data recorder



TECH DEMO SCENARIO PLANNING

East Coast Max Data Collection Scenarios

	Architecture 1	Architecture 2
Target overflights/day	Sun Synchron Orbit (97.4°): 4.42	SS Orbit (97.4°): 7.43
Average overflight time	359 s	353 s
Maximum overflight time	611 s	681 s
Avg pass data (Gb)	2.84	2.82
Max pass data (Gb)	4.88	3.45
Avg data/day (Gb)	12.55	20.9

Max Data Downlink Scenarios

	Architecture 1	Architecture 2
Target overflights/day	Sun Synchron Orbit (97.4°): 13.3 (KAT-Traitor & Svalbard)	SS Orbit (97.4°): 19.3 (NEM-4 stations)
Average overflight time	240 s	190 s
Maximum overflight time	294 s	266 s
Avg D/L pass data (Gb)	1.20 (3 Mbps)	0.19 (1 Mbps)
Max D/L pass data (Gb)	1.48 (3 Mbps)	0.266 (1 Mbps)
Avg D/L data per day (Gb)	18.4 (3 Mbps downlink)	3.47 (1 Mbps downlink)

Proposed Demonstration Collection Scenarios

	Architecture 1	Architecture 2
Target overflights/day	Sun Synchron Orbit (97.4°): 2	SS Orbit (97.4°): 2
Average overflight time	359 s	353 s
Maximum overflight time	611 s	681 s
Avg pass data (Gb)	2.84	2.82
Max pass data (Gb)	4.88	3.45
Avg data/day (Gb)	5.68	5.64

Proposed Data Downlink Scenarios

	Architecture 1	Architecture 2
Target overflights/day	4 (KAT)	4 (NEM)
Average overflight time	240 s	190 s
Maximum overflight time	294 s	266 s
Avg D/L pass data (Gb)	1.20 (3 Mbps)	0.19 (1 Mbps)
Max D/L pass data (Gb)	1.48 (3 Mbps)	0.266 (1 Mbps)
Avg D/L data per day (Gb)	7.2 (3 Mbps)	3.47 (1 Mbps)

Tailored Study- Technology Demonstration Mission

Phase 2- Systems Engineering & Mission Design Trades

GROUND RULES & ASSUMPTIONS

Launch

- Falcon 9 or Cygnus Rideshare
- Single rideshare launch for all 4 S/C
- Low Earth Orbit
- Goal is for global coverage
- Primary area of interest is US Outer Continental Shelf (OCS)
- Mission calls for launch in 2025
- Mission Duration of 1 year
- Assume orbit of 400-550km altitude

Constellation

- S/C separated by 100-200km in both in-track and cross-track
- Precision station keeping is not required
- Achieve desired formation within 90 days
- Population necessary to reach desired formation

Payload

- 1-2U payload includes:
 - Processor, GPS receiver, UHF SDR
- Deployable low gain UHF turnstile antenna receives tag signals at 400MHz
- Correlates received data with timestamps and S/C positions from GPS
- Minimal onboard data processing

Flight System

- 3U or 6U S/C bus: COTS & ARC in-house
- Commercial comm network for command uplink and data downlink
- Trade-off between onboard and ground-based processing
- Payload antenna nadir pointing
- Each S/C operates independently
- Bus provides ~10W avg power to payload

Tech Demo Operations

- Collect UHF signals over US OCS
- Both static and mobile tags
- Only collect data over area of interest to minimize data volume for downlink
- Downlink to polar ground stations
- Transfer data to Mission Ops for processing

Mission Ops/Tech Demo Ops

- Downlink to ground stations over polar orbits: Command uplink
- "Raw" RF data downlink
- GPS timestamps
- Precision tag position co ground using data from of Arrival (ToA) method
- Assuming use of comm storage and processing
- Mission Ops TBD

NGAT Final Study Brief

TECHNOLOGY DEMO TRACEABILITY MATRIX

Technology Need	Current State-of-the-Art	Technology Demonstration Objectives	Technology Performance Requirements		Performance Measurement Requirements		Mission Requirements (Top Level)
			Component Involved	Performance Requirement	Performance Measurement Parameter	Measurement Requirement	
Primary needs: Provide a space-based animal tracking system		Provide tag location with a higher degree of accuracy than the current standard	Tracking standard	95% of connected tag	Ground system processed	<250m position error	

MISSION TOP-LEVEL REQUIREMENTS

Category	Requirement
Data Volume	The bus comm system shall be capable of downlinking an average of 500 MB of data per day (Baseline); 2.5 GB/day (Goal); for each of the four satellites.
Revisit Rate	The satellite constellation orbit shall average one (Baseline); five (Goal); passes per day over the defined area of interest on the US Outer Continental Shelf.
Tag Beacon	The tech demo area of interest will allow the system to determine the position of a single tag with all four S/C (Baseline); with a goal to determine the positions of multiple tags.
nadir Pointing	The instrument receive antenna shall be mounted on the S/C to provide nadir pointing during flight.
C Spacing	The S/C constellation operational in-track and cross-track satellite spacing shall be no less than 100 km.
Achievement	The S/C constellation shall achieve the required operational spacing within 90 days after launch.
Maintenance	The S/C constellation shall maintain an operational formation of 100-300 km (Baseline); 100-200 km (Goal); spacing both in-track and cross-track throughout the mission lifetime.
Position Knowledge	The NGAT instrument shall have knowledge of the position of the S/C within 10 m with a clock accuracy within 50 ns.
Position Lifetime	The orbital spacecraft will operate for one year after launch.
Position Performance	The NGAT instrument shall calculate tag locations with less than 250 m position error from ground truth for >95% of measurements.

NGAT Final Study Brief

Systems Engineering and Mission Design:

- Defined Ground Rules & Assumptions
- Refined Technology Demonstration Traceability Matrix
- Recommended changes to Top-Level Requirements.
- Provided Tech Demo Operational Scenarios.

SYSTEMS ENGINEERING OVERVIEW

Recommendations for SE from Phase I:

- Refine Tech Demonstration Objectives & Requirements to facilitate maturation of mission concept
- Consider detailing baseline and threshold mission key performance parameters

Phase II SE progress:

- TDM revised to specify baseline & goal requirements for:
 - Data volume received/day
 - Data volume downlinked/day
 - Achieving formation timing
 - Maintaining formation (altitude and in-track and cross-track spacing)
- Requirements apply for both considered orbital architectures
- Defined baseline and threshold Measures of Effectiveness (MOE) and Measures of Performance (MOP)

ARCHITECTURE 1
Rideshare to SSO

ARCHITECTURE 2
Rideshare to ISS orbit

2/9/2023 NGAT Final Study Brief

MISSION DESIGN & FLIGHT DYNAMICS

		01	02	03	04	05	06	07	08	09	10	Global
Arch1	~3.4 opportunities per day											
	Min Access [s]	299	144	141	192	22	303	70	47	33	45	32
	Max Access [s]	534	534	534	533	532	531	530	529	528	526	534
	Average Access [s]	647	611	614	626	586	654	610	578	578	602	647
Total Access (h/week)		10270	10709	10419	9787	9277	8429	8414	8370	7986	7467	10709
Arch2	~3 opportunities per day											
	Min Access [s]	245	48	285	53	221	202	201	178	11	178	11
	Max Access [s]	490	489	487	486	487	486	484	484	482	481	490
	Average Access [s]	621	426	618	548	576	558	576	572	537	574	621
Total Access (h/week)		14825	17040	17456	15842	13864	11661	10706	10207	9537	8721	17456

Higher latitudes will have increased overlap of the ground swath because the spacecraft spacing decrease.

NOTE 1: Near the poles, greater swath overlap occurs but cross track spacing is minimal (<400km) and may not be sufficient for accurate tracking.

NOTE 2: Access data should be taken over a week period (or greater) because select days will have a greater number of access opportunities than others.

Mission Design and FD Forward Work

- Detailed dive into deployment ops from rideshare
- Clarify NanoRacks deployment requirements and assess compatibility and required adjustments to maneuver sequence
- Refine timing and sequences of deployment and maneuvers to adjust in-track spacing and Local Time of Ascending Node (LTAN)

2/9/2023 NGAT Final Study Brief

MISSION OPERATIONS- SCENARIOS CONSIDERED

BASELINE SINGLE BEACON SCENARIO

- DEMONSTRATES:
 - TIME OF ARRIVAL TECHNOLOGY
 - SATELLITE OPERATION
 - UPLINK RECEIVE
 - DOWNLINK DATA
 - COMMANDING AS NEEDED
 - NOMINAL OPS

GOAL CLUSTERED MULTI-BEACON SCENARIO

- DEMONSTRATES:
 - TIME OF ARRIVAL TECHNOLOGY
 - TAG DIFFERENTIATION IN LOCALIZED AREA
 - SATELLITE OPERATION
 - UPLINK RECEIVE
 - DOWNLINK DATA
 - COMMANDING AS NEEDED
 - NOMINAL OPS

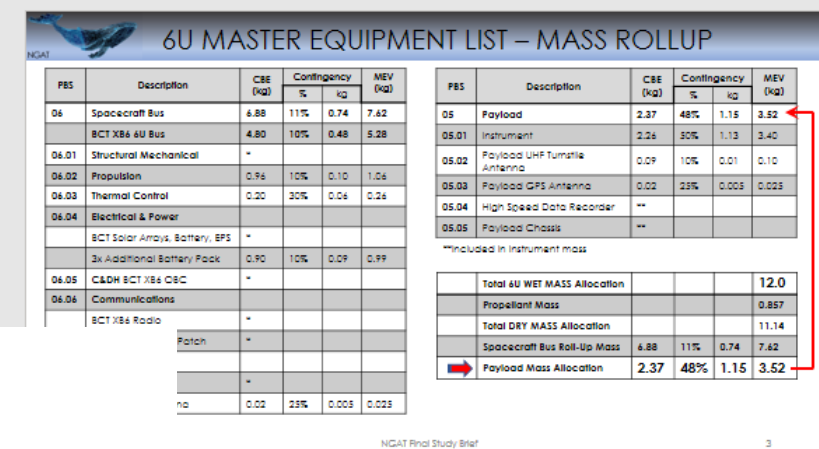
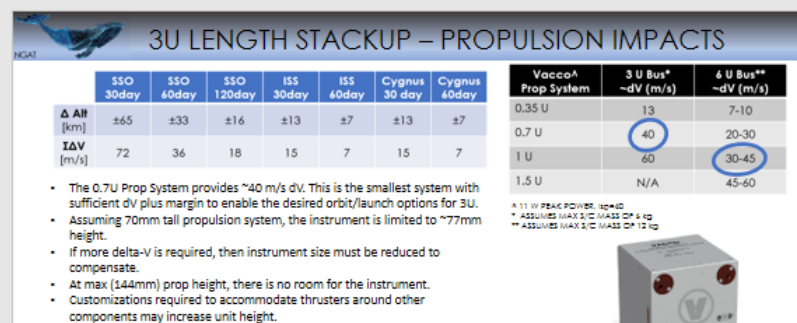
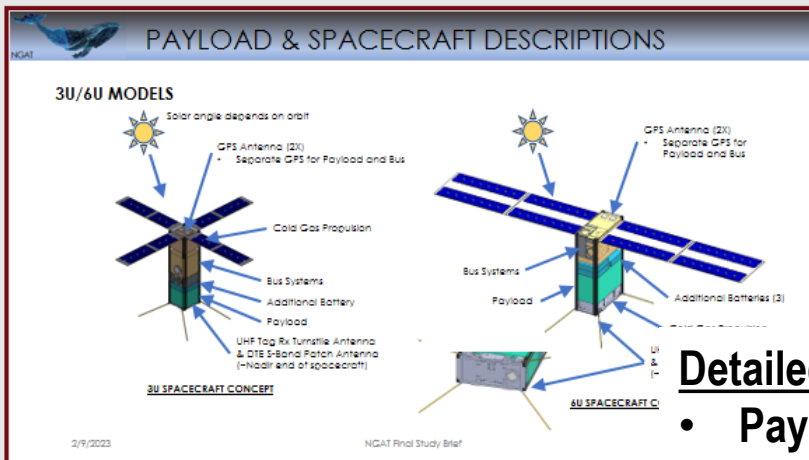
GOAL (EXAMINED IN 1st half of study) DISTRIBUTED SINGLE-BEACON SCENARIO

- DEMONSTRATES:
 - TIME OF ARRIVAL TECHNOLOGY
 - EXTENDED DATA COLLECTION PASSES ALONG COASTS
 - SATELLITE OPERATION
 - UPLINK RECEIVE
 - DOWNLINK DATA
 - COMMANDING AS NEEDED
 - NOMINAL OPS

2/9/2023 NGAT Final Study Brief

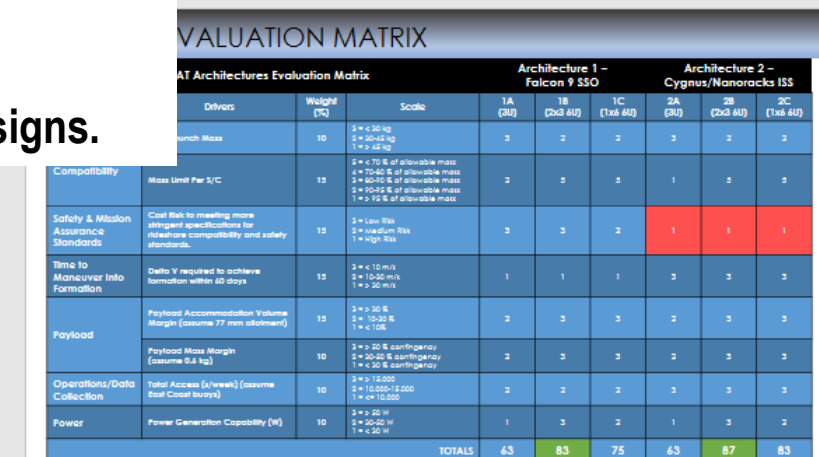
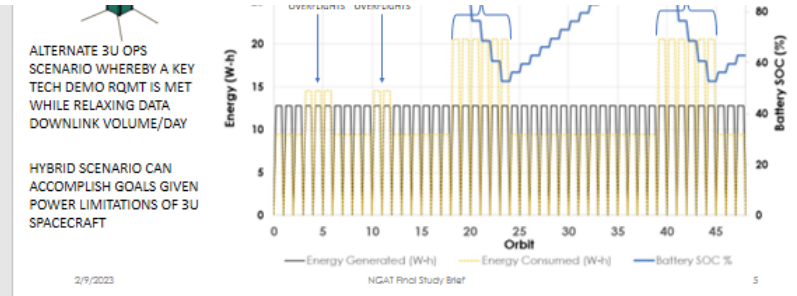
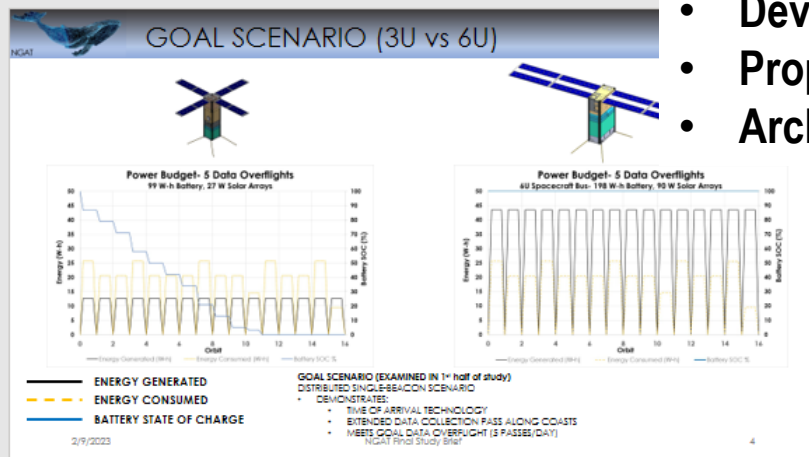
Tailored Study- Technology Demonstration Mission Study

Phase 2- Payload Accommodation, Ops Planning, Architecture Evaluation



Detailed Analysis:

- Payload volume and mass constraints
- Propulsion system trades.
- Developed Master Equipment List.
- Proposed Architecture Operational Scenarios.
- Architecture Evaluation Matrix for various point designs.



Tailored Study- Technology Demonstration Mission Study

CML=3 Assessment

Functional Area	Criteria	Status (G/Y/R)	
Objectives & System Requirements	Objectives linked to investigations and measurements		
	Science Return as a function of cost, risk and programmatic quantified		
Science Data System	Science data rates and volume included in trade space analysis		
Mission Development	Develop Figure of Merit to assess Mission Utility		
	Identify Alternative set of Mission Architectures		
	Evaluate architectures against science objectives, cost, risk		
	Quantitatively bounded hazards of space environments	N/A	Tech Demo in LEO
Spacecraft System Design	Unique features that distinguish one flight system architecture from another evaluated		
	Perform sensitivity studies to bound performance within trade space		
Instrument System Design	Key instrument performance requirements, measurement techniques and instruments selected against science / mission objectives, cost & risk	N/A	Outside scope of MDC Study
	Sensitivity studies to bound performance within trade space performed	N/A	Outside scope of MDC Study
Ground System/ Mission Operation System Design	Mission ops drivers and sensitivities assessed		
	Major flight/ground trades identified		
	New ground system capabilities identified	N/A	Outside scope of MDC Study
Technical Risk Assessment & Technology	Compare risk across the various architectures		
	Identify mitigation strategies for key risks		
Technology	Compare technologies & major developments required for design options across the trade space		
Inheritance	Early evaluation of inheritance options, benefits and risks across trade space		

2/9/2023 NGAT Final Study Brief 1

Functional Area	Criteria	Status (G/Y/R)	
Technical Margins	Use institutional margins where applicable		
	Analyze best and worst case scenarios		
System Engineering	Capture the relative merits of performance, cost and technical risk over a broad range of architectures		Tech demo- design is flexible for a narrow range of architectures
	Subsystem dependencies identified		
Launch Services	Perform trades for candidate launch vehicles demonstrating compatibility with performance and fairing size		Rideshare options considered
Verification & Validation	Identify any major or unique V&V activities	N/A	out of scope for MDC
Acquisition & Surveillance	Identification of key make-buy decisions	N/A	out of scope for MDC
	Survey international and domestic capabilities for alternate architectures		
Project Organization, Implementation Mode & Partnering	Identify partnership options		
	Implementation mode (in-house or system contract) trades performed		
Schedules	Assess variations and risks to science, development schedule and impacts to mission duration	N/A	out of scope for MDC
Work Breakdown Structure	NASA Standard WBS & Dictionary (down to level 2 and level 3 for spacecraft and payload)	N/A	out of scope for MDC
Cost Estimation and Cost Risk	Cost sensitivities explored across trade space as a function of major drivers		
	Initial estimate down to level 2 and level 3 for spacecraft and payload	N/A	out of scope for MDC
	Cost uncertainty quantified		
	System cost risk identified		

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- CML assessment categories tailored for Technology Demonstration Objectives and Stakeholder Feedback. 8 categories from primary list agreed to be out of scope for study.
- Limited cost estimation work performed per direction from project manager and key stakeholder.

Questions/Comments