SBG Community Webinar July 15, 2020
Rules of Engagement

- Turn off your video
- All will be muted
- Please use chat to ask a question to "Everyone" (Kerry Cawse-Nicholson to read)
- Following the presentations, we'll answer questions.
- Any questions we don't get to will be answered within a week in writing and the answers posted: https://sbg.jpl.nasa.gov/news-events
- Please also send questions and comments about the final architectures
- Contact Dave Schimel or Ben Poulter directly by email or to set up a phone call: dschimel@jpl.nasa.gov or benjamin.poulter@nasa.gov

SBG Program Welcome

Woody Turner, NASA HQ
HQ Program Scientist

Vote: SBG Study Logo* ***Theme***

https://tinyurl.com/SBGlogo

https://tinyurl.com/SBGlogoresults

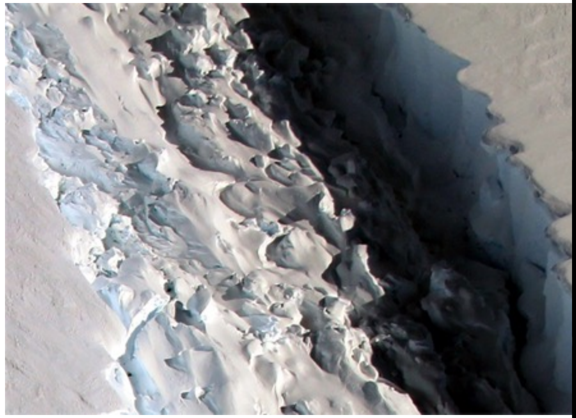
A B C D E

Closes 20 July 2020

* Subject to slight modifications

- **Logo Theme – Voting!**
- Study Overview
- Science and Applications Overview
- Science and Applications Scoring
- International Partnership Opportunities
- Architecture Study
- Science and Applications Appraisal
- NASA HQ Next Steps
- Stay Engaged

SCIENCE



SBG DO Study Overview

Jamie Nastal, JPL/Caltech

Study Lead

Outline

Previous Webinars:

1. Study status update (May 2020)
2. Study process (June 2020)

Objective for Webinar 3:

1. Community preview of recommendation for HQ on July 29th
2. Review community feedback and input
3. Solicit community perspective on final recommendation




SBG Overview

- The SBG Study has three core objectives:
  1. Identify and characterize a diverse set of high value SBG observing architectures
  2. Assess the performance and cost effectiveness of architectures against SBG research and applications objectives
  3. Perform sufficient in-depth design of one or more candidate architectures to enable near-term science return

- Decadal Survey gave clear direction on SBG Observing priorities:
  1. Terrestrial vegetation physiology, functional traits, and health
  2. Inland and coastal aquatic ecosystems physiology, functional traits, and health
  3. Snow and ice accumulation, melting, and albedo
  4. Active surface changes (eruptions, landslides, evolving landscapes, hazard risks)
  5. Effects of changing land use on surface energy, water, momentum, and C fluxes
  6. Managing agriculture, natural habitats, water use/quality, and urban development

- SBG Science and Applications Traceability Matrices (SATM)
  - Science Objectives have traceability capability categories and applications
  - Observing architectures options, with associated capability categories, are mapped back to Science Objectives

- Value Framework will assess each candidate architecture by performance, cost and risk value criteria

- Selected architectures from the Value Framework will then be further developed in preparation to support a Mission Concept Review (MCR)

SBG Study Scope

Surface Biology and Geology (SBG) Designated Observable Study Plan
2017 Earth Science Decadal Survey

1. **Candidate architectures**. Development of candidate architectures based on synthesis of Decadal Survey science and application recommendations related to SBG, surveys of community capabilities, and initial architectural designs of the options,
2. **Assessment of Architectures**. Assessment of potential observing architectures for providing cost-effective SBG observations,
3. **Architecture Design**. Design of a recommended observing system architecture and preparation of preliminary Mission Concept Review (MCR) material
4. **Deliverable Preparation**. Preparation of the End Study Report.

Observations:

- Science value assessment based on community vetted SATM and science metrics
- The team is confident that a meaningful down-select can occur in the July timeframe, resulting in one preferred architecture with alternates
- The study has significantly evolved such that the original study plan should be modified to incorporate a more focused MCR prep phase that begins in FY21.

Deliverable:

- One Recommended Architecture and two alternates
- Recommendation is to enable an MCR team in Fall 2020 to move towards a scheduled review and Key Decision Point (KDP-A)

The SBG Science Community Engagement

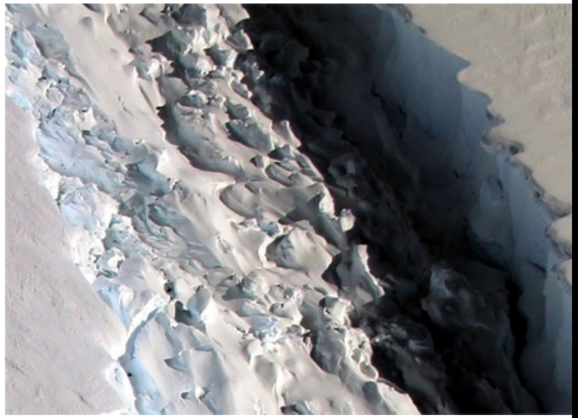
- The SBG Science Community has been actively engaged throughout the study and continues to grow through working groups, surveys and individual outreach

- The SBG Study team has been developed to integrate science focus teams and maintain transparency throughout the study process

- The architecture assessment is complete: Today we present the recommended architecture to our SBG Science Community for the first time

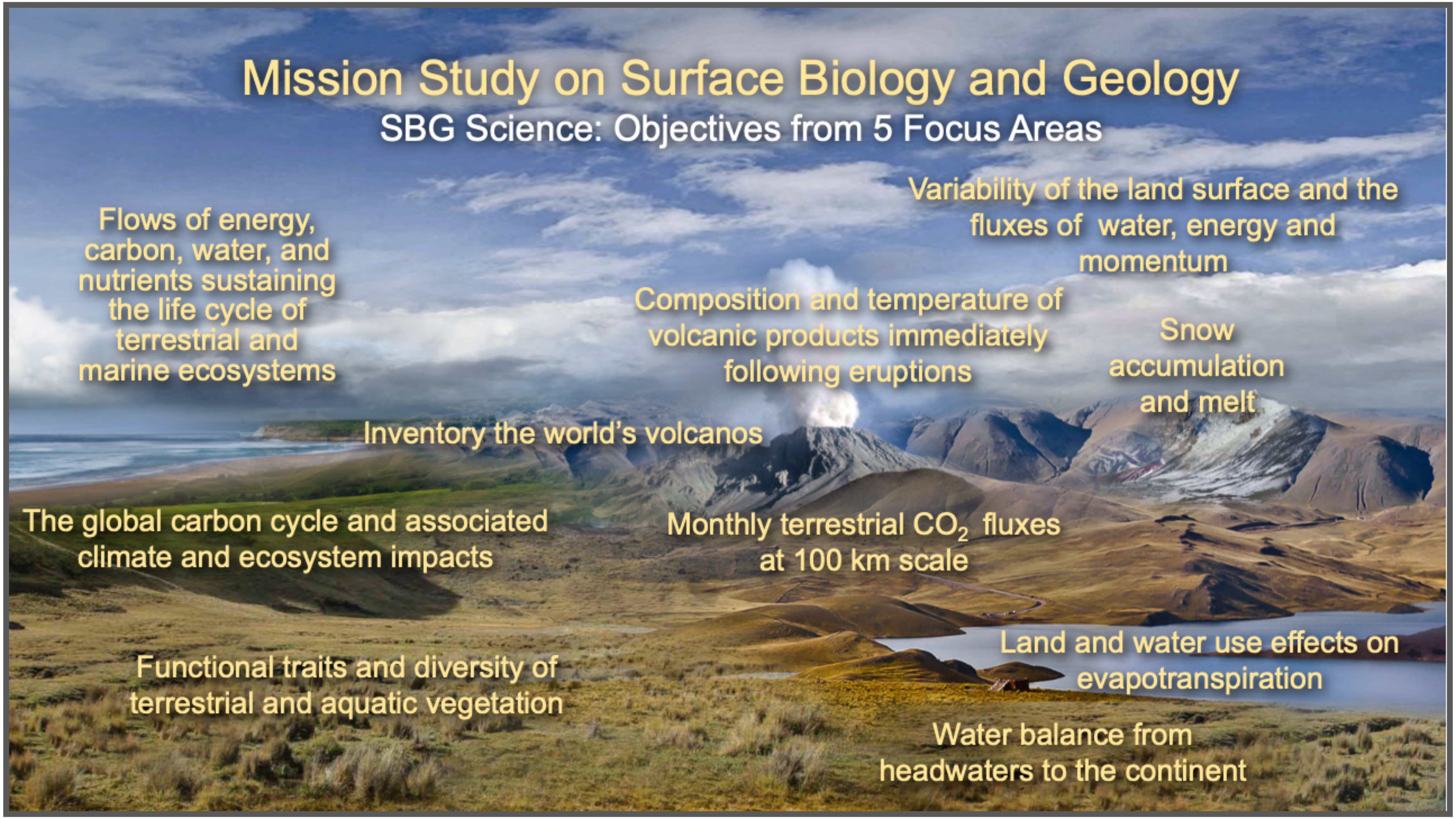
SCIENCE





Research and Applications Overview

Benjamin Poulter, GSFC, Co-Lead


Mission Study on Surface Biology and Geology
SBG Science: Objectives from 5 Focus Areas
Variability of the land surface and the fluxes of water, energy and momentum
Flows of energy, carbon, water, and nutrients sustaining the life cycle of terrestrial and marine ecosystems
Composition and temperature of volcanic products immediately following eruptions
Snow accumulation and melt
Inventory the world's volcanos
The global carbon cycle and associated climate and ecosystem impacts
Monthly terrestrial CO_2 fluxes at 100 km scale
Land and water use effects on evapotranspiration
Functional traits and diversity of terrestrial and aquatic vegetation
Water balance from headwaters to the continent

SATM Capability Codes identify measurement objectives to achieve specific science priorities

Capability Code	VSWIR Spatial	VSWIR Temporal	VSWIR Range	VSWIR Sensitivity	TIR Spatial	TIR Temporal	TIR Range	TIR Sensitivity
A	30 m	≤8 days for global coverage*	≤380 - ≥2500 nm, @ ≤10nm	SNR ≥400 VNIR, SNR ≥250 SWIR, accuracy ≤5%	60 m	≤1 day for global coverage*	≥5 bands in 8-12 um, ≥ 1 band in 3 -4.5 um	≤1K Absolute, ≤0.2K NeDT / band
B	<60 m	≤16 days for global coverage*	≤380 nm - ≥1000 nm, @ ≤10nm	≤10% Absolute accuracy	60 m – 100 m	≤3 days for global coverage*	≥5 bands in 8-12 um	≤1.5% Absolute, <1K NeDT / band
C			VNIR multiband		≥ 100 m	≤5 days for global coverage*	≥3 bands in 8-12 um	

Phase 1 Analysis of ESAS 2017 to define >70% solution, which converge on capability priorities

	VSWIR				TIR				coincidance
	spatial	Temporal	Range	Sensitivity	spatial	Temporal	Range	Sensitivity	
H1-a	A	A	A	-	A	B	B	A	-
H1-c	A	A	A	B	A	B	B	A	-
H2-a	A	A	A	-	A	B	B	A	B
H4-a	A	A	A	B	A	B	B	A	-
w-3a	-	-	-	-	B	A	B	A	-
E-1a	A	B	A	A	-	-	-	-	-
E-1c	A	B	A	A	-	-	-	-	-
E-3a	A	A	A	A	A	B	B	A	-
S1-a	A	A	A	A	A	A	B	A	-
S1-c	A	A	A	A	A	C	B	-	-
S-2b	A	A	A	A	A	A	A	-	-
Satisfier	A	A/B	A	A	A	B	B	A	B

Capability Codes Needed by SBG L3 Algorithms

Requirements per product suite

Product Suite	VSWIR spatial	VSWIR temporal	VSWIR Range	VSWIR Sensitivity	TIR spatial	TIR temporal	TIR range	TIR Sensivitity	Will be met by ABAA/ABBA?	Cliff/gradual	Science questions answered
Snow		A				A			0	Gradual	H1, H4
Water biogeochemistry			B	A					1	Cliff VNIR sensitivity; Gradual VSWIR range	E1, E3
Water biophysics			B	A					1	Steep slope with cliff at the end (sensitivity)	E1, E3
Aquatic classification			B	A					1	Steep slope with cliff at the end (sensitivity)	E3
Substrate composition	A		A				B		1	Gradual in spatial, cliff for spectral (need SWIR)	E1, S1, S2
Volcanic SO2 and ash		A			B	A	A	A	0	Gradual in time; Cliff in spectral (Need midIR)	S1, S2
High temperature features		A	A			A	A	A	0	Gradual in time; Cliff in TIR spectral (Need midIR); cliff for VSWIR range for plumes/high temperature features	S1
ET			C		B		B	A	1	Gradual; Coincidence of VNIR/TIR cliff	H1, H2
Plant functional traits	A	B	A						1	Gradual on spatial and temporal, Cliff on VSWIR range(need SWIR)	E1, E3
Proportional cover	A		A						1	Gradual	E3

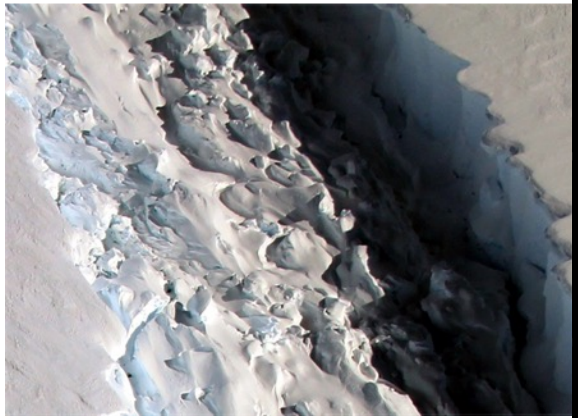
*A blank box indicates no algorithm dependency on that parameter

Optimal SATM Performance Objectives

- Derived from the Decadal Survey and shown in the SATM
- Provided in the RFI to identify all candidate observing architectures

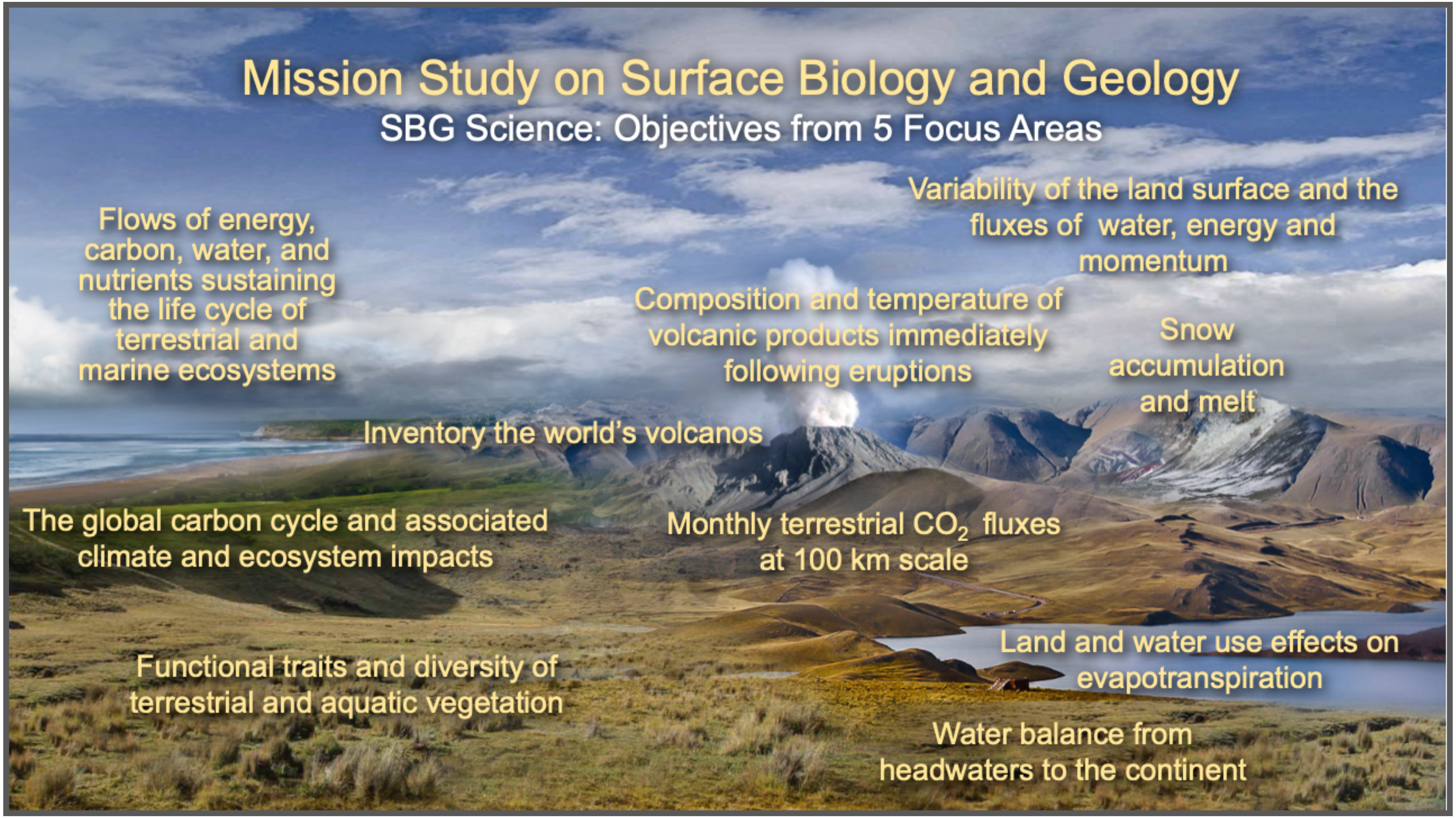
	Spectral Range	Spectral Resolution	Sensitivity	GSD	Revisit	Coverage	Local Time for Acquisition
VSWIR	0.35 or 0.4 to 2.5µm	10nm or better, Continuous coverage	VNIR >400 SWIR >250	30 m	8 days	Global	10:30-11:00
TIR	8 to 12µm 3 to 5µm	>5 Bands desired	NEdT <0.2 K	60m	1 days	Global	Afternoon

SCIENCE



SBG Research and Applications Value Scoring

Dave Schimel, JPL/Caltech Co-lead


Mission Study on Surface Biology and Geology
SBG Science: Objectives from 5 Focus Areas
Flows of energy, carbon, water, and nutrients sustaining the life cycle of terrestrial and marine ecosystems
Variability of the land surface and the fluxes of water, energy and momentum
Composition and temperature of volcanic products immediately following eruptions
Snow accumulation and melt
Inventory the world's volcanos
The global carbon cycle and associated climate and ecosystem impacts
Monthly terrestrial CO_2 fluxes at 100 km scale
Land and water use effects on evapotranspiration
Functional traits and diversity of terrestrial and aquatic vegetation
Water balance from headwaters to the continent

Scoring Approach

- Score based on capability codes $\frac{A\ Reference}{Actual}$ ratioing the actual score (except range) and the A capability code value
- Use a linear score with the A code as maximum for the NASA assets (maximum score of 1)
- Can get additional revisit value from international constellations (NASA + partner could exceed 1)
- Calibration/validation, optimal overpass, coincidence between TIR and VNIR, other features considered qualitatively
- Two international collaborations considered numerically (CHIME and TRISHNA), others, commercial collaborations less well specified or uncertain (funding, timing) noted qualitatively

Scoring

Spatial	Temporal	Sensitivity	Spectral range
$\frac{A\ Reference}{Actual}$	$\frac{A\ Reference}{Actual}$	$\frac{A\ Reference}{Actual}$	$\frac{A\ Actual}{Reference}$

eg: VSWIR

$\frac{30\ m}{30\ m}$ $\frac{8\ days}{16}$ $\frac{450/250}{450/250}$ $\frac{380-2500}{380-2500}$

1 + 0.5 + 1 + 1 = 3.5

eg: TIR

$\frac{60\ m}{60\ m}$ $\frac{1\ day}{3\ Days}$ $\frac{0.2\ NeDT}{0.2\ NeDT}$ $\frac{8\ Bands}{6\ Bands}$

1 + 0.33 + 1 + 1* = 3.33

* Maximum score is 1 (no 'extra' credit for exceeding the 'A' value)

Additional Value from International Collaboration

- Score from international collaboration for reduced revisit.
- NASA VSWIR co-orbiting with CHIME is scored as follows:

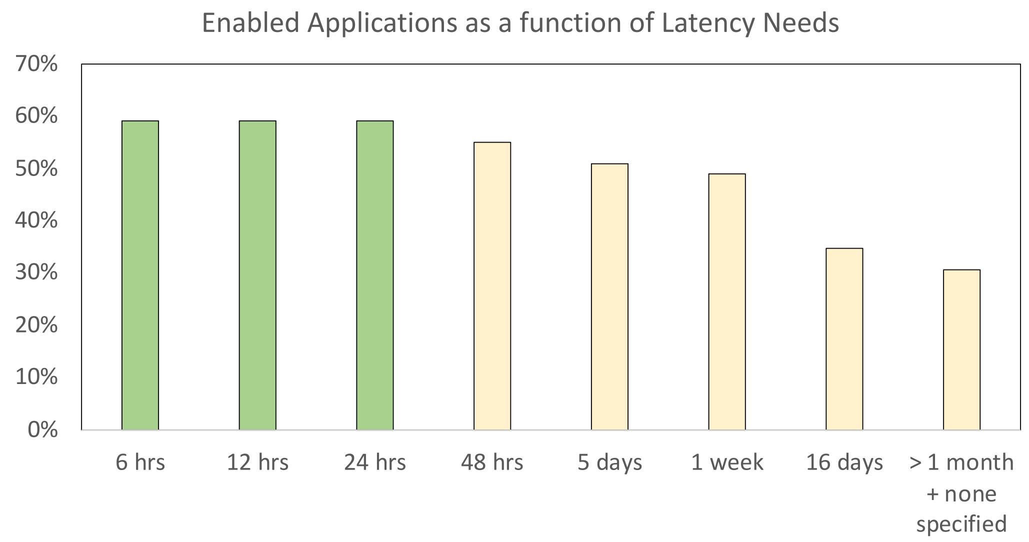
		SBG		CHIME						
$\frac{30\,m}{30\,m}$		$\frac{8\ days}{16}$	+	$\frac{8\ days}{22}$		$\frac{450/250}{450/250}$		$\frac{380-2500}{380-2500}$		
1	+	0.5	+	0.4	+	1	+	1	=	3.9 (was 3.5)

Two-platform options can get value from CHIME (ESA), 0.4 and TRISHNA (CNES/ISRO), 0.33

One platform options considered could only add value from either CHIME or TRISHNA due to conflicting overpass times.

Applications value is consistently high across architectures because needs were integrated in the Architecture design sessions

- Most applications needs captured in science value metrics (ABAA/ABBA)
- Additional, unique applications need was latency
  - 24-hour latency enables majority of applications, was a design target in engineering design sessions
- Agile spacecraft (supports early / frequent response needs for natural hazards and fast changing conditions) will be studied in phase A
- All final candidate architectures had high applications value



Applications Community

- 150+ members of AppsWG
- Contractor Community Assessment captured responses (562 survey responses /161 full responses and 41 interviews)

Community Input was fundamental to all of these assessments!

Final options were selected from high science, applications and international partnership value architectures

- All instruments were scored A for spatial resolution (30, 60 m)
- All architectures were scored B for revisit (TIR and VSWIR),
- A for revisit only obtainable with international partners (VSWIR, TIR instruments too costly to replicate)
- All instruments were scored A on sensitivity (SNR or NeDT)
- All instruments were scored A on spectral coverage (380-2500 nm VSWIR, 8 to 12µm, 3 to 5µm, thermal)
- Two-platform solutions, with instruments as above, get 0.73 points for collaboration
- Architectures scoring lower than the above were rejected once ABAA, ABBA solutions closed on cost

SCIENCE

International Partnership Opportunities

Charles Miller, JPL/Caltech

International Collaborations Are Essential to the SBG Observing System

Developing potential Contributions for the SBG flight segments

- **VSWIR**: ISRO – PSLV launch of a NASA VSWIR instrument/satellite + launch of a companion ISRO VSWIR instrument/satellite
- **TIR**: ASI – Accommodation of a NASA TIR instrument and ASI VNIR camera on an ASI PLATINO+ satellite, ASI VEGA launch

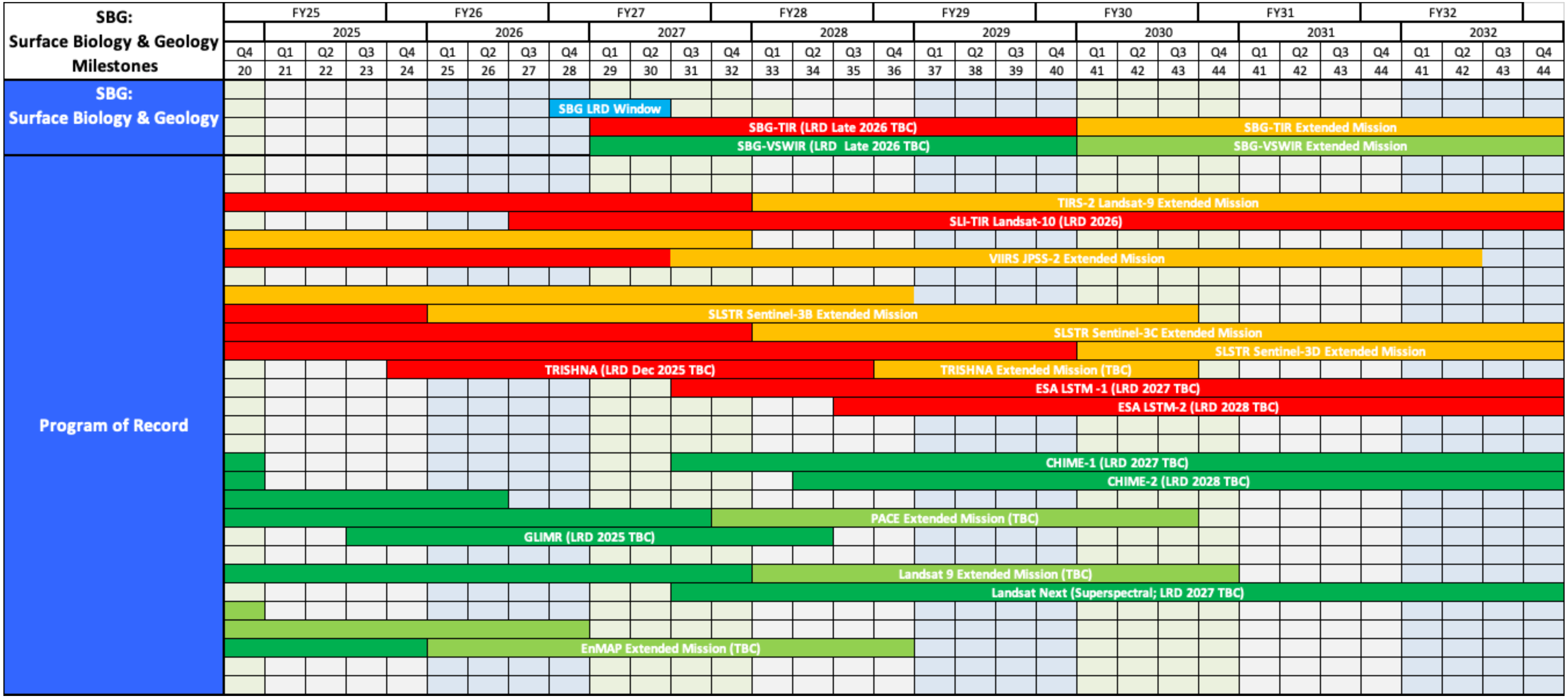
Cultivating Collaborations for coordinated on-orbit sampling strategies, product harmonization and fusion, and cal/val activities

- **VSWIR**: CHIME (ESA), Unnamed (ISRO)
- **TIR**: TRISHNA (CNES + ISRO), LSTM (ESA)
- **Cal/Val**: Australian Space Agency, ESA, TERN, STRI

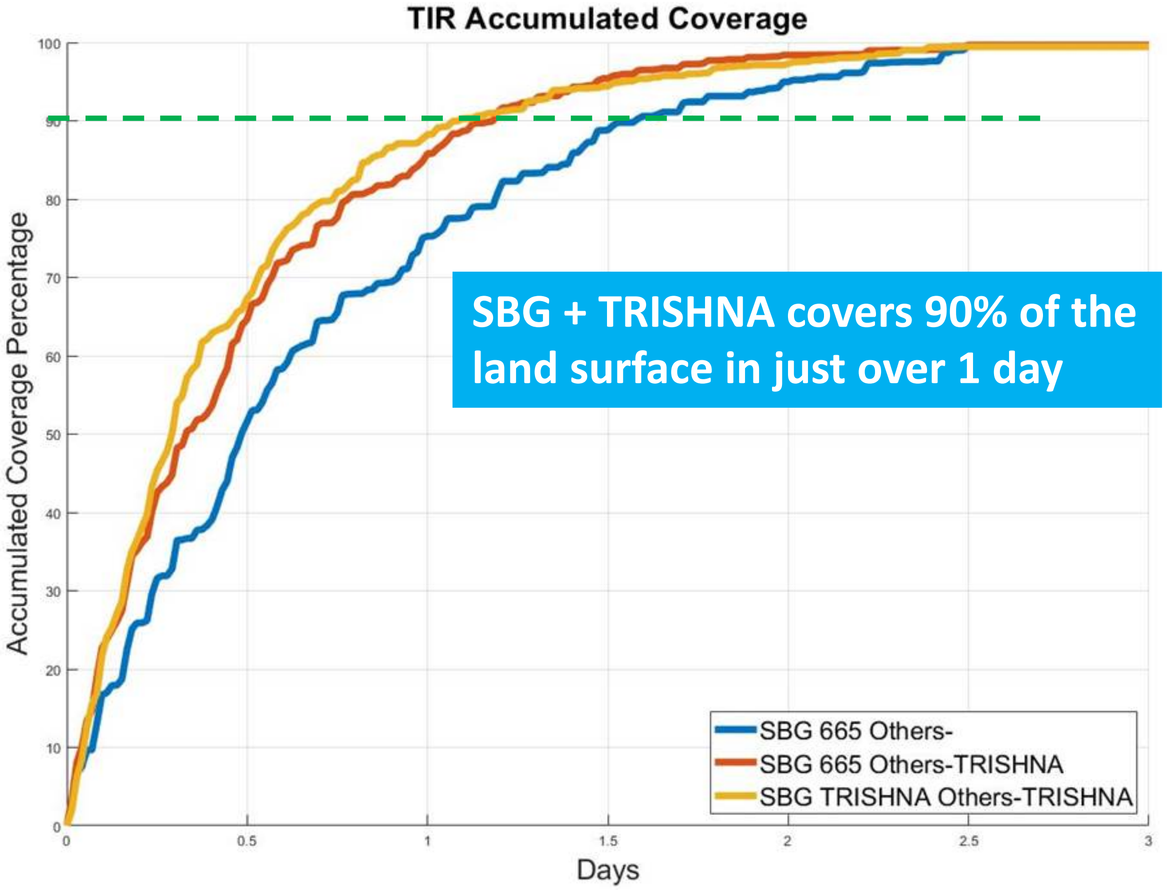
Creating pre-SBG time series through the SISTERS Pathfinder activity to better monitor Earth System change

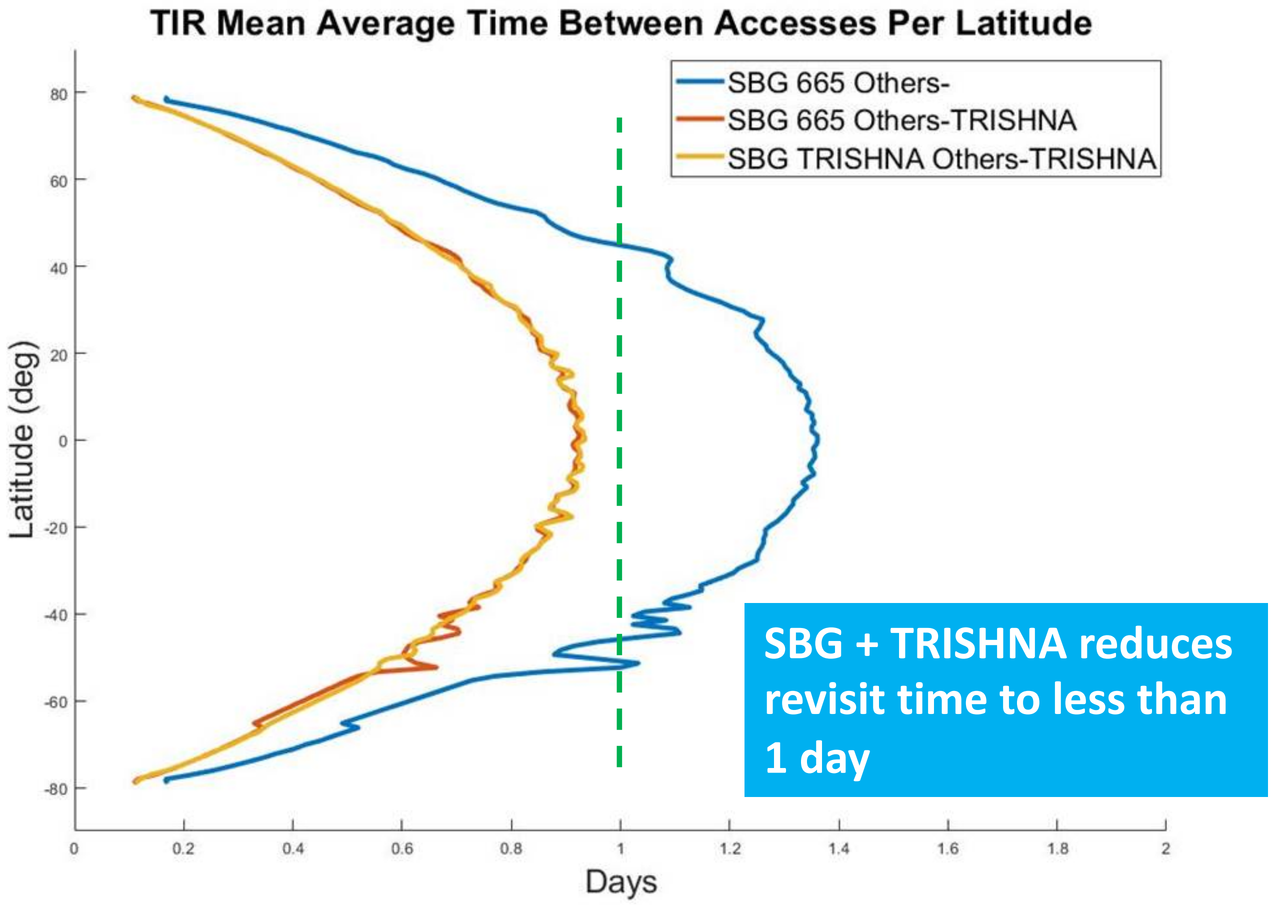
- **VSWIR**: HISUI (JSS), DESIS (DLR), PRISMA (ASI), EnMAP (DLR), Sentinel-2 (ESA)
- **TIR**: ASTER (JSS), Sentinel-3 (ESA)

Opportunities for International Collaborations and Synergies Abound in the SBG Era



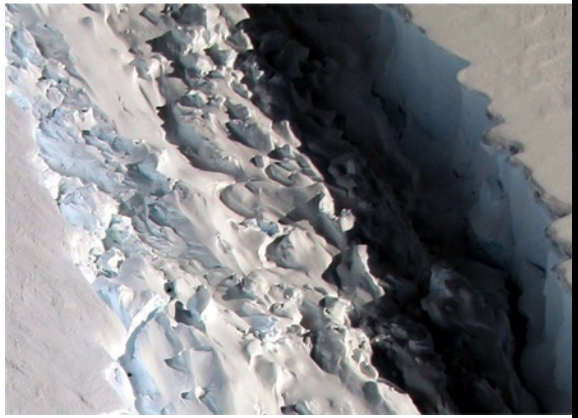
International Coordination Increases Coverage and Reduces Revisit Time for an SBG TIR Observing System





STK Simulations for SBG TIR with 665 km orbit altitude, 935 km swath, nominal 3-day orbit repeat

SCIENCE



Architecture Study

Dave Bearden, Phase 2 Lead, JPL/Caltech
Jon Chrone, SBG Phase 2 Deputy Lead, LaRC

Architecture Evaluation Objectives

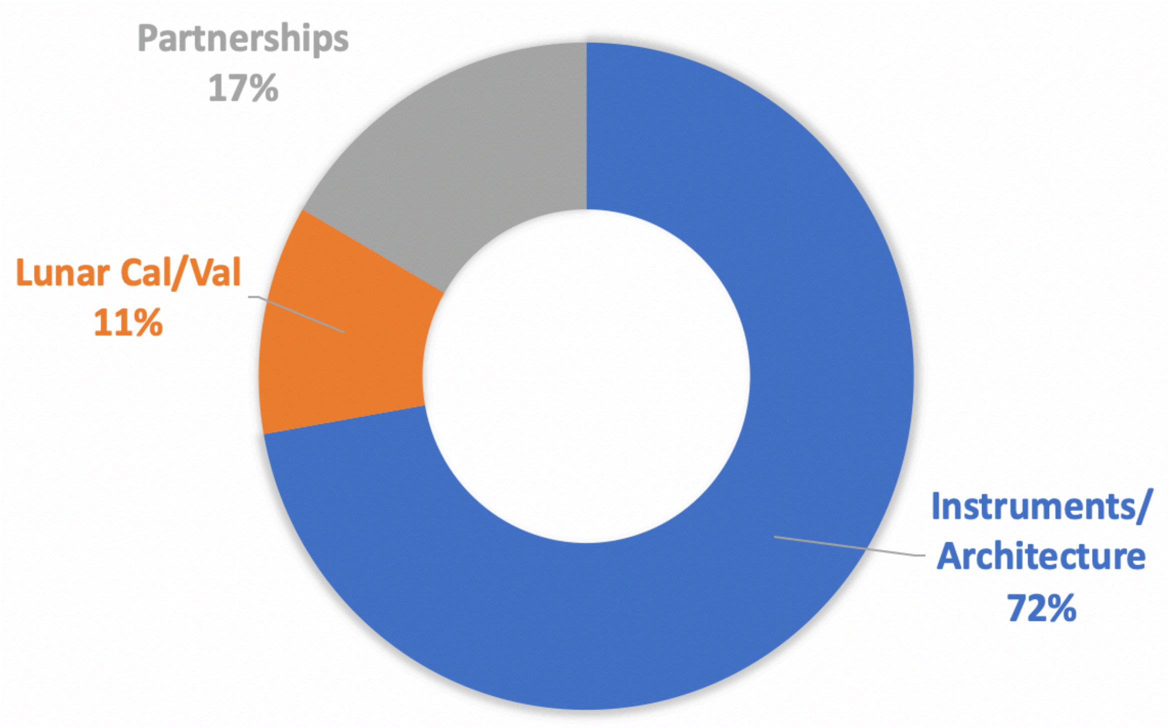
- Identify architectures to support research and applications objectives
- Develop Value Framework to evaluate architecture solutions to most/very important science and applications objectives
- Assess a diverse set of high RA value SBG observing architectures and reduce down to a few promising architectures
- Provide justification for eliminating candidate architectures

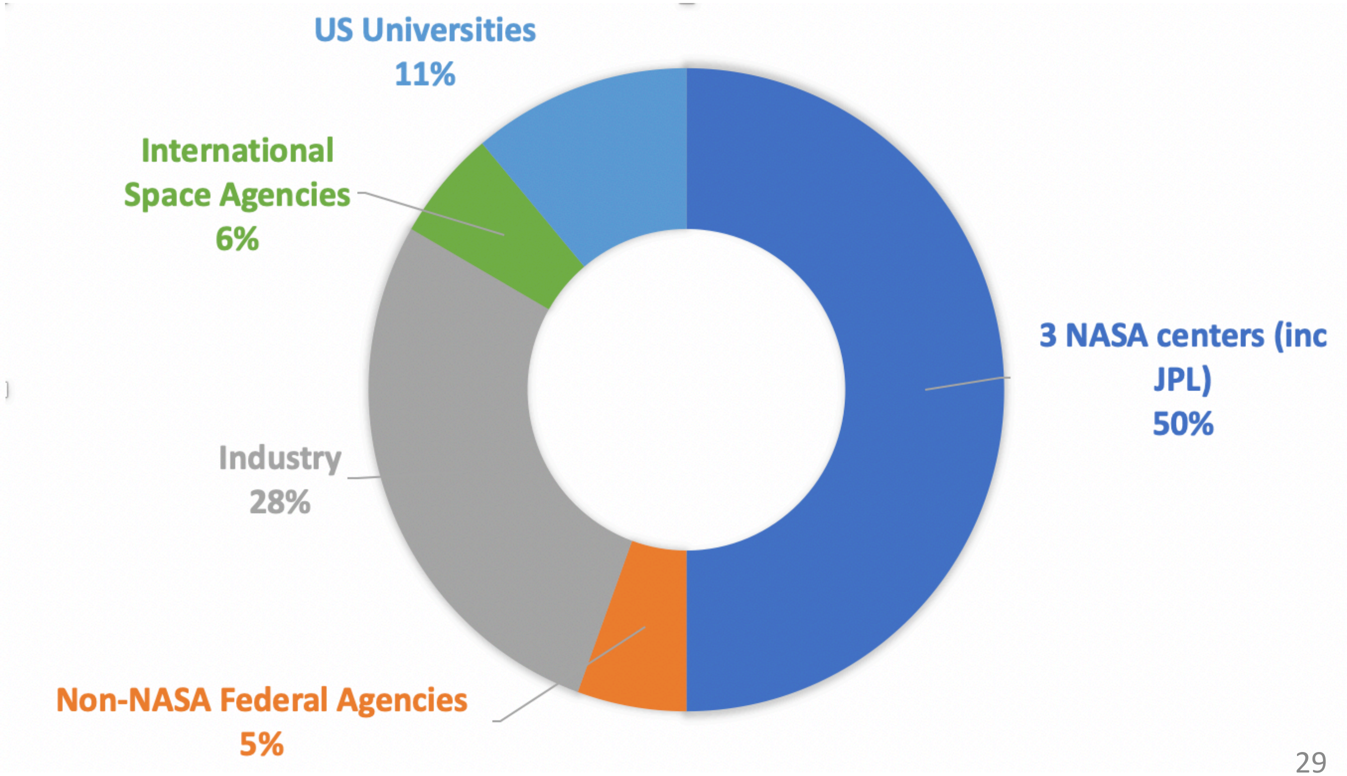
Value Framework Overview

- SBG Value Framework assesses key features relevant to decision criteria while providing the ability to discriminate between alternatives
- Quantitative features
  - Capability (Science & Applications)
  - Cost / Affordability
  - Schedule
  - Risk
- Qualitative features
  - Programmatic factors
  - International Partnerships

Summary of RFI Responses

- Two SBG RFIs seeking expertise and information from across the spectrum of Earth Science research, applications, technology, mission formulation and implementation
- Input from major stakeholder organizations in government (NASA and non-NASA), academia, industry and the international community





Funnel - from "Many" to "Few"

RFI #1 – General call for ideas and concepts

Phase 1

100s

Potential Options

- Large number of permutations
- Broad exploration of potential trade space
- Identify primary drivers and play against SATM
- High-level metrics used to consolidate and prune
- Create hybrids and combinations
- Assess using parametrics and analogy-based models

Oct 2019

Jan-Feb 2020

Filter – Cost & Value
Filter – Instrument Risk

10s

Feasible Options

- Instrument Feasibility, Science Value and Cost
- Programmatics
- Perform mission-level design center sessions (LaRC, JPL, GSFC)

Mar-May 2020

RFI #2 – Specific call for instrument technical information

few

Promising Options

- 3 with 1 recommendation
- Provide to HQ with supporting info

Programmatic Scenarios
Concept Design Center Studies
Independent Assessment

Phase 3

Jun-Jul 2020

ICE/ISE by Aerospace

Number of Observing System Architectures

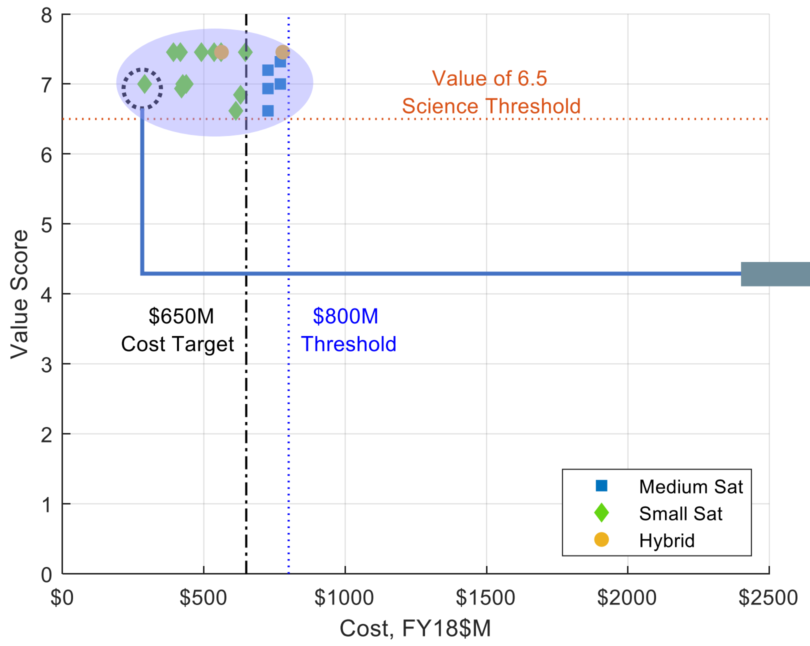
What we have learned along the way

- SBG science & applications community priorities used to assess science value
  - High spatial resolution, high SNR spectral imaging
  - Global sampling of land and coastal ocean
  - Shortest possible revisit frequency
- Cast the net wide and now have 1-3 high-value, affordable (~$650M) architectures
  - A single flagship/large VSWIR/TIR platform (HyspIRI Model) is cost challenging
  - Architectures with separate VSWIR and TIR components on smaller spacecraft provide best value and flexibility
  - “Coincidence” TIR and VNIR overlap within minutes (derived from LANDSAT) provides added value
  - Microsats may provide incremental capability/value or pathfinders to sustainable future continuity mission
  - Applications value can be assessed as a function of latency and other factors (on-board processing, downlink, etc.)
  - Airborne component may be included to provide cal/val for L2, L3 and L4 products
  - Calibration (both on-board and vicarious) can be accommodated as applicable to specific architectures
- International partnerships are <u>critical</u> to achieving objectives within the budget guideline
  - Cost sharing and launch opportunities
  - Data sharing to reduce revisit time and improve quality

Architecture Evaluation Process

Reassembled the best combination of elements into Promising Architectures

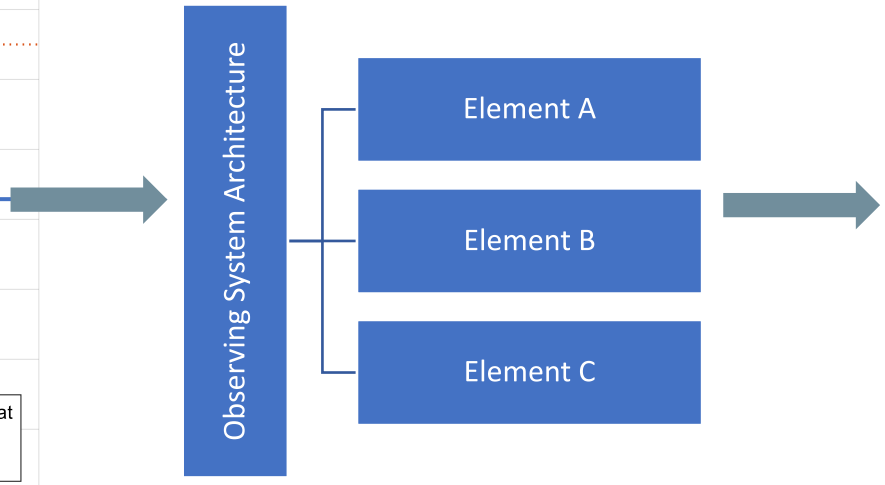
Multiple High Value, Affordable Architectures are made up of common elements



Complete February 2020

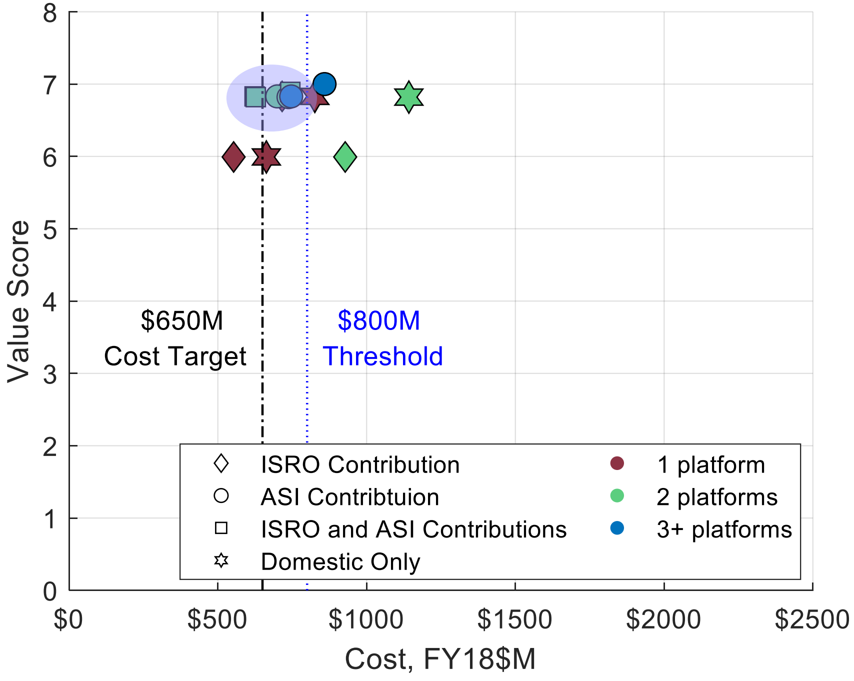
Complete May 2020

Design Center Studies focused on sizing and costing these foundational elements



- Small spacecraft with wide-swath (ws) VSWIR
- Small spacecraft with Whisk Push (W/P) TIR
- Small spacecraft with Push Broom (P/B) TIR
- Medium spacecraft with wide-swath (ws) VSWIR and W/P TIR
- Medium spacecraft with wide-swath (ws) VSWIR and P/B TIR
- Constellation spacecraft with TIR bolometer
- Constellation spacecraft with narrow-swath (ns) VSWIR/VNIR

Elements reassembled into full Architectures and Reassessed



Complete July 2020

Architecture Elements

Each element was assessed by a design center – some with deep dive design studies

Design Study	Element Description	Affordability	Feasibility	Comment
JPL	WS VSWIR FreeFlyer	Medium	High	Technically feasible, but challenging to pair with a TIR under cost target
JPL	WS VSWIR FreeFlyer w/ ISRO	High	High	Potential cost reduction with contributed launch vehicle
	NS VSWIR Constellation	Medium	High	Technically feasible, but challenging to pair with a TIR under cost target
	NS VSWIR Constellation w/ ISRO	High	Medium	Concerns about technical compatiblity with contributed LV
JPL	WP TIR FreeFlyer	Low	High	Technically feasible, but challenging to pair with a VSWIR under cost target
JPL	WP TIR FreeFlyer w/ ASI VNIR	High	Medium	Cost allows pairing with VSWIR, questions about compatibility with contributed SC/LV
LaRC	WS VSWIR & WP TIR Spacecraft	Low	High	Cost unlikely to be compatible with target
LaRC	WS VSWIR & WP TIR Spacecraft w/ ISRO	Medium	Low	Concerns about compatiblity due to mass
	PB TIR FreeFlyer	Low	High	Cost does not allow pairing with a VSWIR
	WS VSWIR FreeFlyer (Ind.)	Medium	Medium	Cost makes it challenging to pair with a TIR
	WS VSWIR FreeFlyer (Ind.) w/ ISRO	High	Medium	Data rates require further examination
	NS VSWIR & PB TIR Spacecraft	Medium	High	Cost for combined platform near the target
	WS VSWIR (Ind) & PB TIR Spacecraft	Low	High	Cost for combined platform well above the target
	NS VSWIR & WP TIR Spacecraft	Medium	High	Cost for combined platform near the target
GSFC	PB TIR FreeFlyer	Medium	High	Cost makes it challenging to pair with a VSWIR
	NS VSWIR & PB TIR Spacecraft	Medium	High	Cost for combined platform near the target
	Calibration Cubesat	High	High	Could be included as part of observing system as an ehancement
	WS VSWIR & PB TIR Spacecraft	Medium	High	Cost for combined platform near the target
	WS VSWIR & PB TIR Spacecraft w/ ISRO	High	Low	Concerns about compatibility due to mass
ARC	VNIR Cubesat	High	Medium	Concerns about pointing compatibility
ARC	TIR Cubesat	High	High	Could be included as part of observing system as an ehancement
ARC	VNIR & TIR Cubesat	High	Medium	Concerns about pointing compatibility

Architecture elements that pair well with others

Transfer function from elements to architectures

Design Study	Element Description	Affordability	Feasibility	
JPL	WS VSWIR FreeFlyer	Medium	High	
JPL	WS VSWIR FreeFlyer w/ ISRO	High	High	
	NS VSWIR Constellation	Medium	High	
	NS VSWIR Constellation w/ ISRO	High	Medium	
JPL	WP TIR FreeFlyer w/ ASI VNIR	High	Medium	
	WS VSWIR FreeFlyer (Ind.)	Medium	Medium	
	WS VSWIR FreeFlyer (Ind.) w/ ISRO	High	Medium	
	NS VSWIR & PB TIR Spacecraft	Medium	High	X low science value – small swath
	NS VSWIR & WP TIR Spacecraft	Medium	High	X low science value – small swath
GSFC	PB TIR FreeFlyer	Medium	High	X low science value – requires mult sats
	NS VSWIR & PB TIR Spacecraft	Medium	High	X low science value – small swath
	Calibration Cubesat	High	High	X no science value – adjunct
	WS VSWIR & PB TIR Spacecraft	Medium	High	
ARC	VNIR Cubesat	High	Medium	X low science value - adjunct
ARC	TIR Cubesat	High	High	X low science value - adjunct
ARC	VNIR & TIR Cubesat	High	Medium	X low science value - adjunct

Two Platform
VSWIR-ws +
TIR w/VNIR

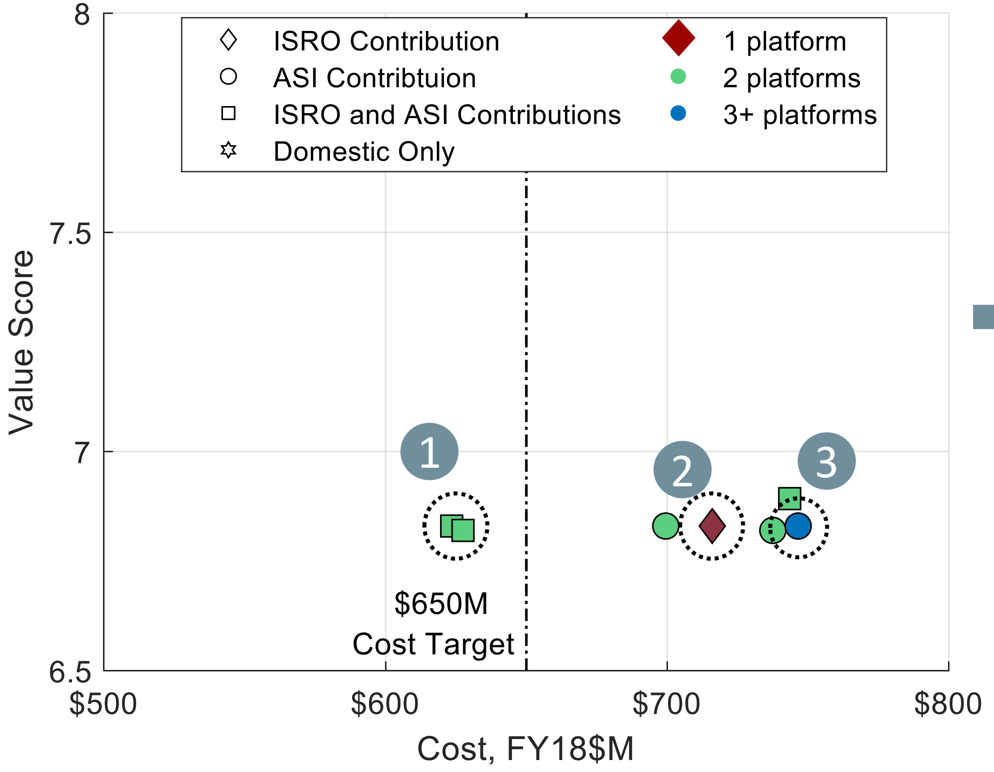
Constellation
VSWIR-ns
Constellation +
TIR w/VNIR

Single Platform
VSWIR-ws & TIR on
same SC

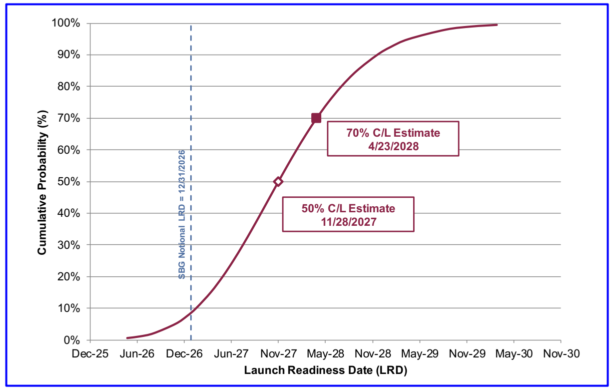
Architecture Evaluation Process

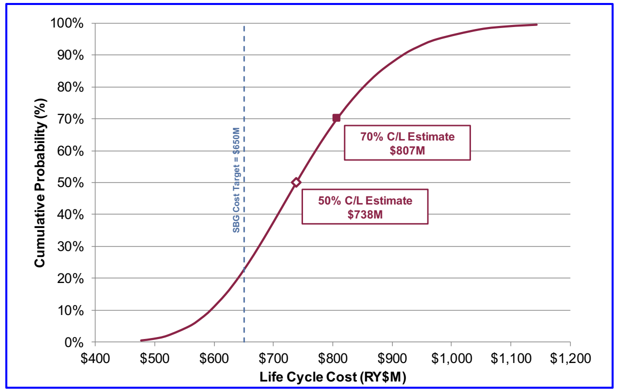
Deep Dive Design Sessions and Independent Assessment to arrive at 3 finalist Architecture Classes

Selected Final architectures for consideration maximizing science value within budget constraints



Probabilistic S-curves (notional shown) allow assessment of cost-risk and schedule-risk





Independent Cost and Schedule Evaluation by Aerospace

Recommended Architecture

1. Two Platform
VSWIR-ws +
TIR w/VNIR

2. Single Platform
VSWIR-ws & TIR on same SC

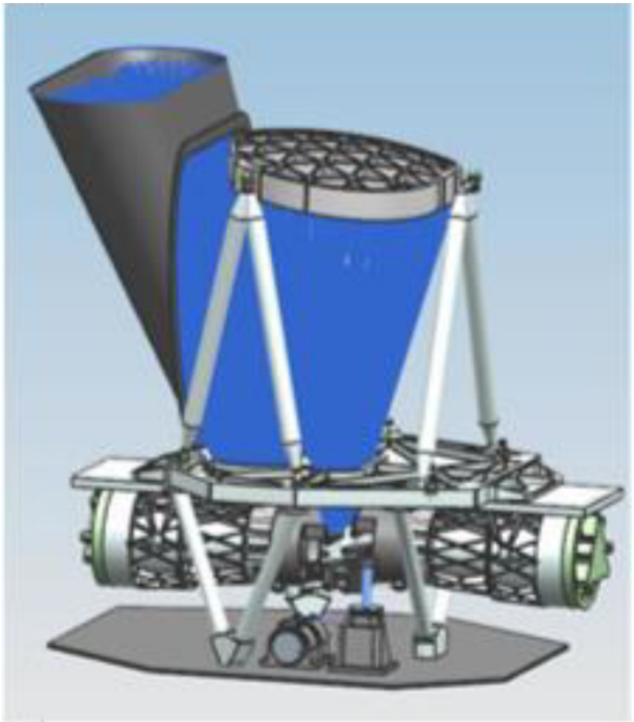
3. Constellation
VSWIR-ns Constellation +
TIR w/VNIR

Other considerations:

- Microsats for niche roles / supplement
- Smallsat-based calibration
- Airborne components
- **International Collaboration**

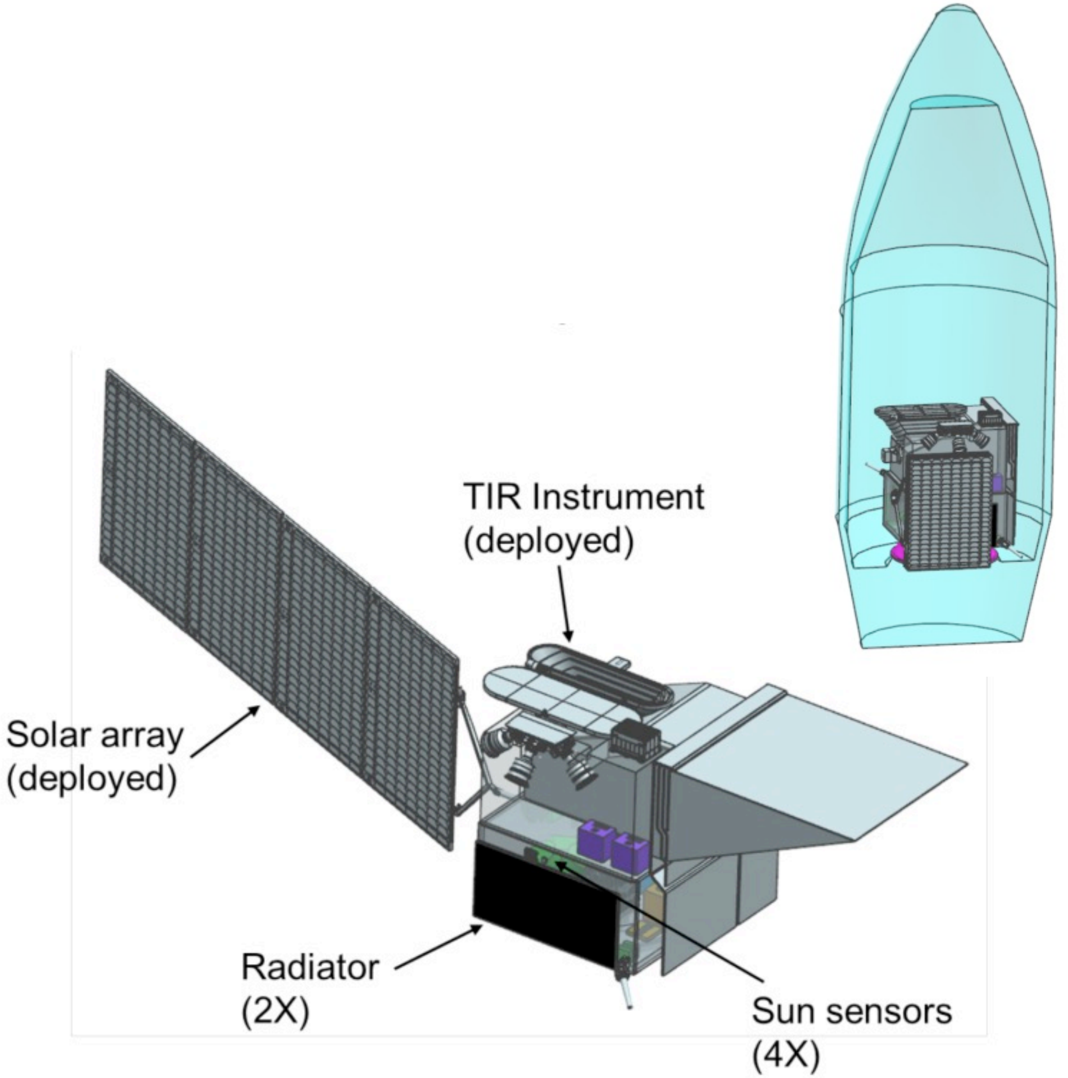
Recommended Architecture – VSWIR Freeflyer (1 of 2)

- Wide-swath VSWIR instrument accommodated on a dedicated spacecraft
- Launch into orbit compatible with ESA CHIME
- JPL Team X designed and sized spacecraft
  - Commercial spacecraft acquisition
  - Option for NASA and/or industry payload
- Compatible with potential contributed launch vehicle for cost savings
- Technically closed with costs of approximately 400-500 FY18$M (Phase A-E)
- Investigating partnerships which would reduce the cost to NASA
  - Other spacecraft is separate from a ISRO built and operated VSWIR platform
- Launch Readiness: late 2026 to mid-2027



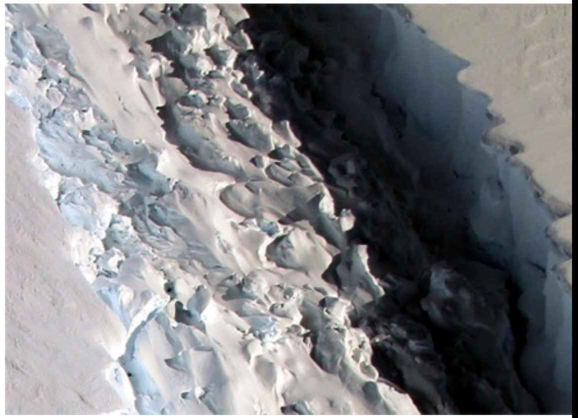
Recommended Architecture – TIR/ASI Freeflyer (2 of 2)

- Whiskpush TIR instrument and VNIR context camera on a single platform
  - VNIR camera basic performance (matched pixel, swath), provides coincidence
- This element is completely enabled by the ASI partnership
  - Spacecraft bus and VNIR instrument contributed by ASI
  - Launch on Vega vehicle, also contributed by ASI
- Five thermal IR bands, two mid-IR bands and one short-wave IR band
- JPL TeamX reviewed and confirmed compatibility with the instruments
- Orbit altitude 665-km, GSD <60m and 935-km swath provides global coverage with 3-day revisit
- Technically closed and costs of approximately 200 FY18$M (Ph.A-E)
- Launch Readiness: late 2026 to mid-2027



SCIENCE





Science and Applications Appraisal

Dave Schimel, JPL, Caltech
Co-lead

Research and Applications >20 Interviews

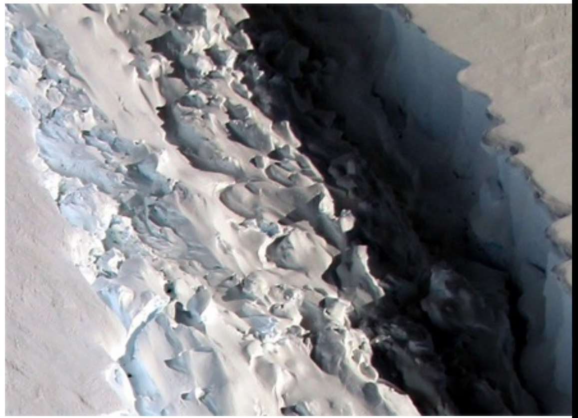
Summary

	Recommendation: Two-Platforms	Alternative 1: One-Platform	Alternative 2: Constellation
Science value	7.56 out of 8	7.23 out of 8	7.06 out of 8
Applications value	Highest – TIR coincidence with VNIR	High – non optimal crossing time for TIR	Intermediate – Challenging VSWIR multi-instrument calibration and validation
Community assessment	Provides most science value and lowest science risk	Provides high science value within constraints	Challenging VSWIR multi-instrument calibration and validation
Risk	Schedule risk depends on partners	Large mass and envelope limit potential launch contribution options	Challenging VSWIR multi-instrument calibration and validation, graceful degradation in event of on-orbit failures
NASA Cost ($M FY18)*	600-650	700-800	750-800
Schedule – Launch Year	2026-2027	2027-2028	2026-2027
Comments	ASI VNIR for coincidence, fully leverages available partnerships	Partial swath overlap, Doesn't fit well with available partnerships	Potential for flexible operations without fully impacting 'mow the lawn' operations, constellation could be expanded for sustainability
Conclusion	Highest science value, lowest cost to NASA; Fully leverages International Contributions	Meets science and applications objectives, mass and volume could prohibit contributed launch	Meets science and applications objectives, however VSWIR multi-instrument calibration and validation will be challenging

* Best-case

SCIENCE





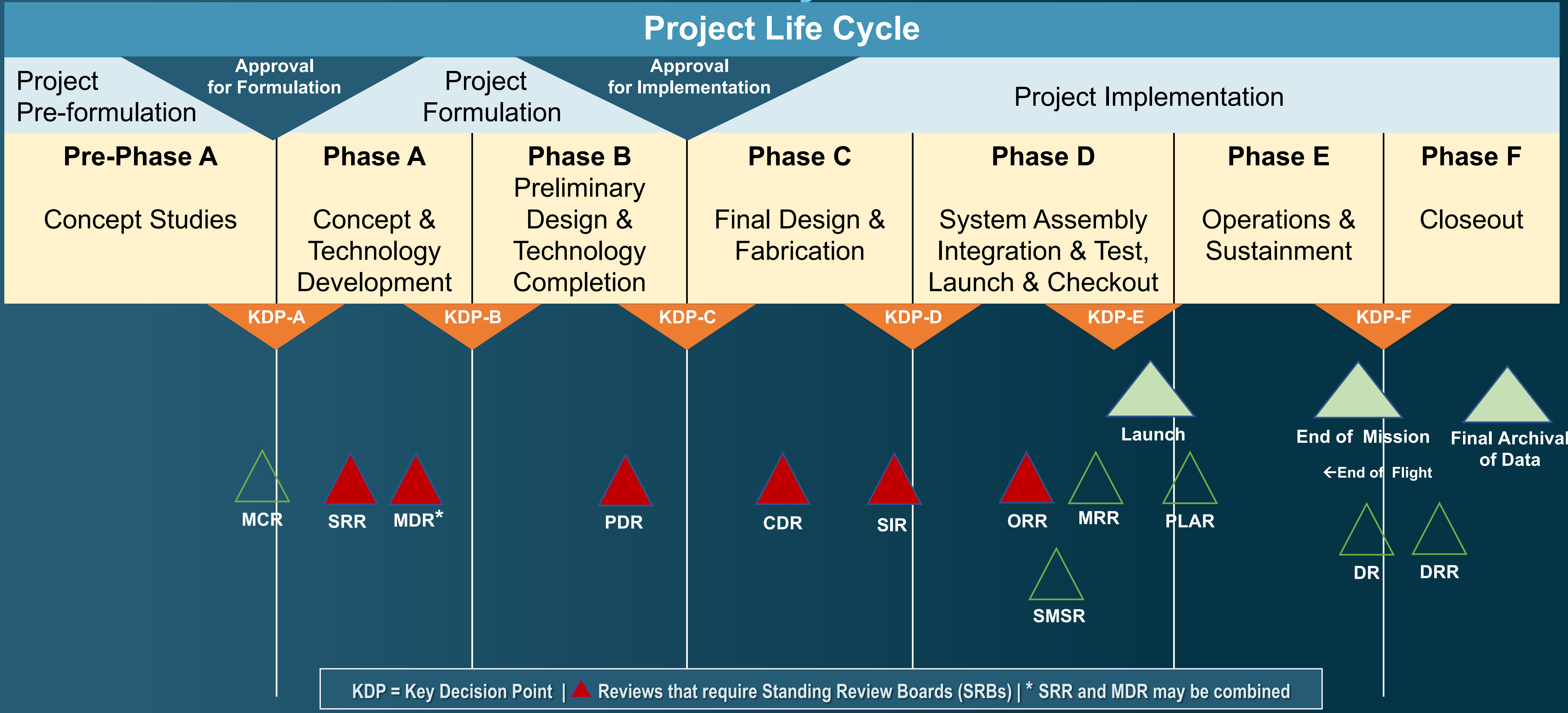
Headquarters Selection Process

Charles Webb, NASA HQ
Associate Director for Flight Programs

What's Next

- Presentation of Study Outcomes, Preferred Architectures to NASA Headquarters
- New Director of the Earth Science Division
- Independent Cost/Schedule Assessments
- Consideration of international partnerships, available budget and schedule
- Iterate with Study Team
- Select an Architecture to enter Pre-Phase A
- Goal is to hold Mission Concept Review/Key Decision Point A in late 2021, and enter Phase A

NASA Life-Cycle Phases



Stay Engaged

Website: sbg.jpl.nasa.gov

Mentimeter Logo Vote(Closes 20 July 2020):
https://tinyurl.com/SBGlogo

Slack: https://tinyurl.com/SBGslack

Twitter: @nasa_sbg and #nasasbg

Questions/Feedback please email sbg@jpl.nasa.gov, Dave Schimel (David.Schimel@jpl.nasa.gov), or Ben Poulter (benjamin.poulter@nasa.gov)

Vote: SBG Study Logo* ***Theme***

https://tinyurl.com/SBGlogo

https://tinyurl.com/SBGlogoresults

A B C D E

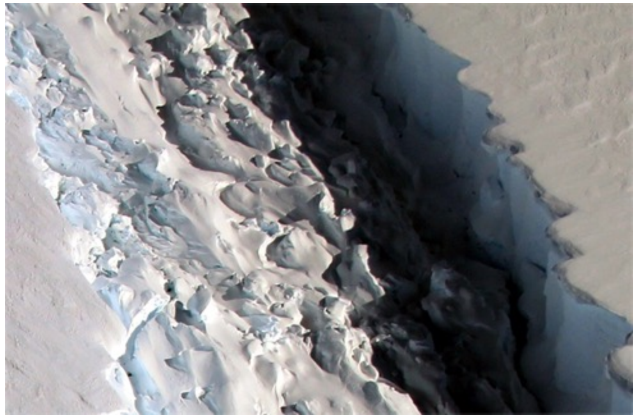
Closes 20 July 2020

* Subject to slight modifications

- **Logo Theme – Voting!**
- Study Overview
- Science and Applications Overview
- Science and Applications Scoring
- International Partnership Opportunities
- Architecture Study
- Science and Applications Appraisal
- NASA HQ Next Steps
- Stay Engaged

SCIENCE

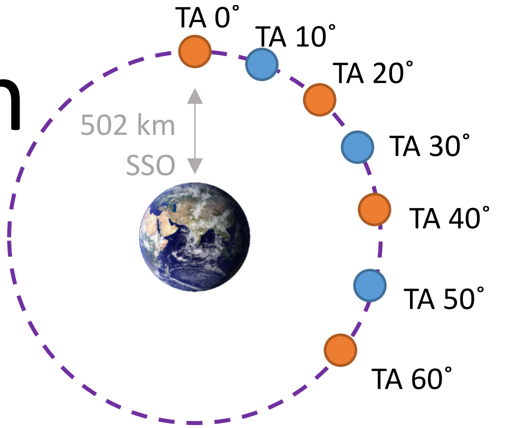


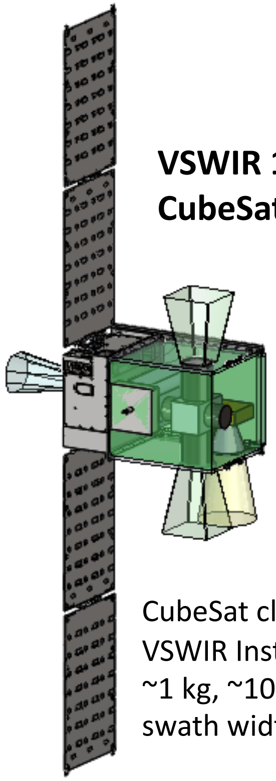


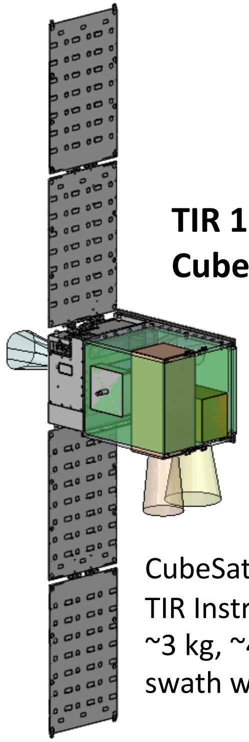

Backup

ARC Design Study – CubeSat Constellation Augmentation to Backbone Architecture

- CubeSat Constellation augmentation to SBG Backbone Architecture
- Provides greater revisit and taskable event-driven measurement opportunities
- Baseline eight spacecraft: four 12U VSWIR CubeSats and four 12U TIR spaced CubeSats spaced 10˚ in true-anomaly (TA)
- Technical report completed, cost estimates finalized
  - Mission Duration: 1-3 yrs
  - MEV each S/C ~16 kg
  - MEV launch mass ~ 128 kg
  - Single commercial rideshare launch

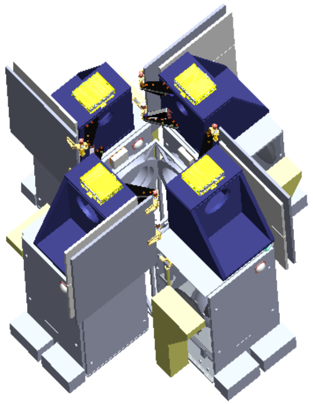


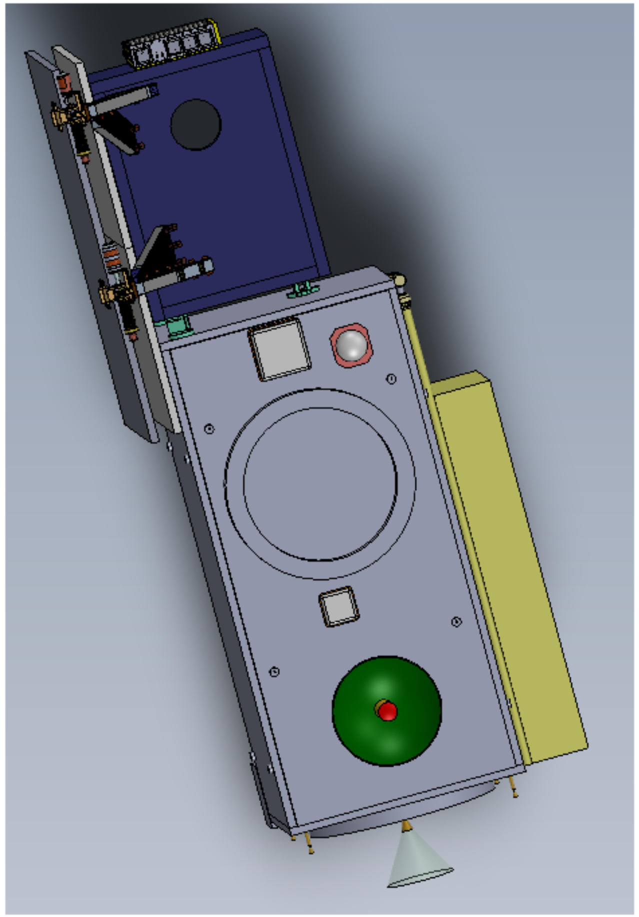




GSFC MDL Design Study – TIR Constellation

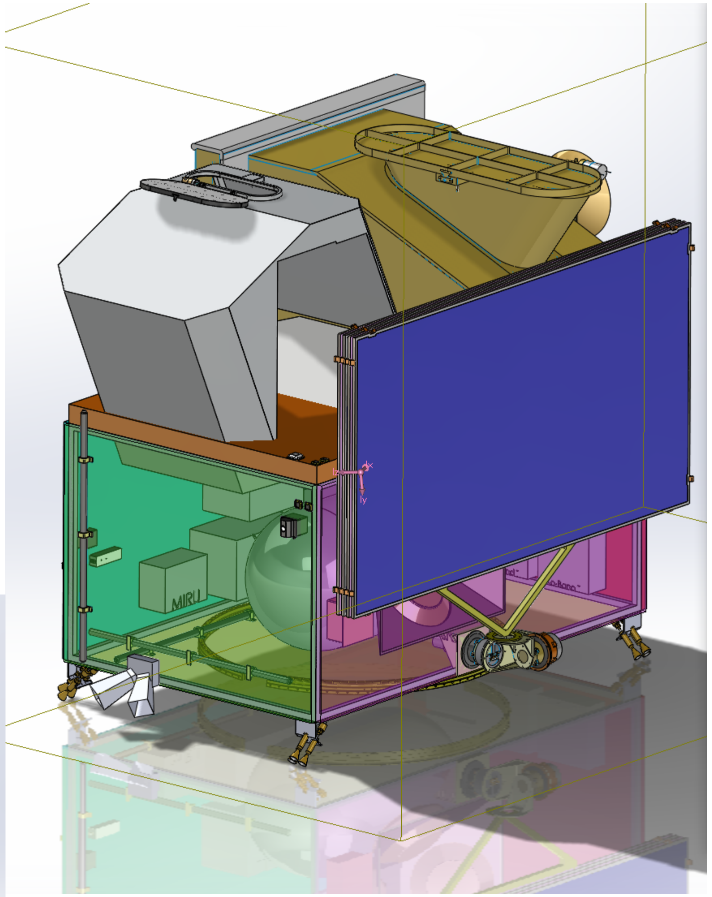
- Landsat derived TIR instrument
- Up to 4 spacecraft on a single launch
- Generic LV interface leveraging Moog Flat Plate Adapter
    - Compatible with Firefly Beta as primary payload or multiple other LVs as secondary
- Technical closed, but 4-satellite constellation cost prohibitive
    - MEV launch mass ~525 kg per spacecraft

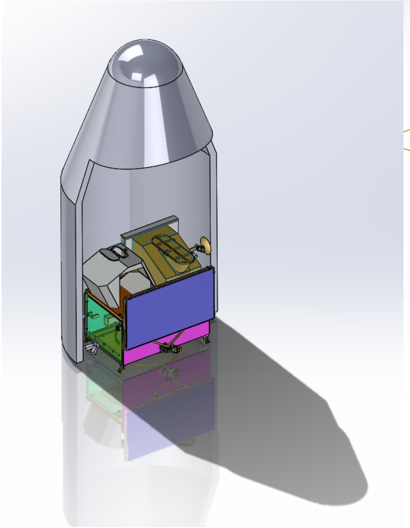


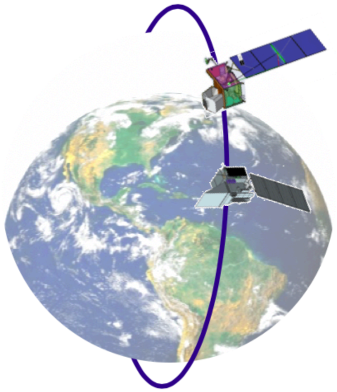


LaRC Design Study – Combined VSWIR/TIR Spacecraft

- Accommodates both a wide-swath pushbroom VSWIR and wide-swath whiskpush TIR on a single spacecraft
- Unlikely to be compatible with co-manifest on an ISRO PSLV assuming 50% mass allocation
- Technical report completed, cost estimates finalized
  - MEV launch mass ~ 1,180 kg

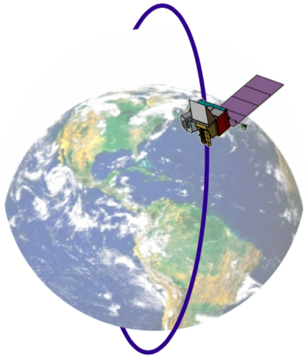






Recommended: Two Platforms

	Two Platforms (TIR + ASI VNIR + ASI LV) + (VSWIR + ISRO LV)
Capability Score-NASA assets	6.83/8
Capability score-with international constellation	7.56/8
Applications Value-NASA assets	High (low latency enabled)
Community assessment-benefits	High for revisit, performance, coincidence for ET, two platforms allow optimizing orbit and LCT
Community assessment-concerns	• Data sharing - will data system support NASA and non-NASA products? • Cal/Val
Cost (A-E), FY18$	600–650 $M (w/o PSLV 700–750 $M)
Risk posture	• TIR enabled by ASI-provided spacecraft and launch – potential schedule risk. • VSWIR enhanced by ISRO-provided LV – risk additional cost if need to procure US launch vehicle. • Ability to decouple development of the two platforms reduces development risk and interdependencies.
Industrial content	• Commercial spacecraft bus • NASA/commercial/hybrid VSWIR (make/buy prior to MCR) • Commercial downlink and data distribution. • Dependence on international contributions
Flexibility/descope	• Assuming ISRO-provided PSLV, may be able to afford adjunct microsat or pathfinder or significant airborne campaigns. • Provides flexibility to align with international collaborators.
Schedule	Date TBD – late 2026 to mid 2027
Comments	ASI partner brings VNIR simultaneity, Potential ISRO spectrometer



Alternate 1: Single-Satellite

	One Platform VSWIR + TIR
Capability Score-NASA assets	6.83/8*
Capability score-with international constellation	7.23/8
Applications Value-NASA assets	Reduced due to LCT, no coincidence for ET
Community assessment-benefits	Partial TIR/VSWIR coincidence for new science on partial swath
Community assessment-concerns	LCT, no VNIR coincidence for ET, reduced revisit for TIR because only one partner orbit
Cost (A-E), FY18$	700 – 800 $M
Risk posture	• All domestic reduces partner risk at increased cost. • Larger, coupled complex satellite with two developments
Industrial content	• Commercial spacecraft bus, • NASA/commercial/hybrid VSWIR (make/buy prior to MCR) • Commercial downlink and data distribution
Flexibility/descope	• Limited flexibility with respect to international partners • Larger, more capable spacecraft may allow hosted payload. • Less flexibility to align with international collaborators.
Schedule	Date TBD – 2027 to early 2028
Comments	Only partial swath overlap between TIR and VSWIR, TIR at suboptimal Local Crossing Time, reduced international collaboration.

Alternate 2: Constellation

	Constellation (TIR + ASI VNIR + ASI LV) + 5-satellite VSWIR narrow-swath constellation
Capability Score-NASA assets	6.83/8
Capability score-with international constellation	7.06/8
Applications Value-NASA assets	May have fewer options for rapid downlink and data sub-setting on orbit
Community assessment-benefits	Maybe sustainable model, if extra copies or parts, then launch on failure is a new sustainability model
Community assessment-concerns	• Unproven approach • May not achieve cross-sensor calibration targets without anchor flagship sensor for reference • Data inhomogeneity, instrument striping causes problems for coverage of rapidly changing phenomena
Cost (A-E), FY18$	600–650 $M (w/o PSLV 700–750 $M)
Risk posture	• TIR enabled by ASI-provided spacecraft and launch – potential schedule risk • VSWIR enhanced by ISRO-provided LV – risk additional cost if need to procure US launch vehicle. • Ability to decouple development of the two platforms reduces dev. risk and interdependencies
Industrial content	• Commercial spacecraft bus –utilize smallsat or “new space” industry • NASA TIR (based on RFI) • NASA/commercial/hybrid VSWIR (make/buy prior to MCR) • Commercial downlink and data distribution • Dependence on international contributions
Flexibility/descope	• Descope or up-scope number of spacecraft with implications for cost/ performance • Future supplemental spacecraft leading to sustainment or continuity • Provides flexibility to align with international collaborators
Schedule	Date TBD – late 2026 to mid 2027
Comments	Cal/Val a major concern, sustainability an intriguing option

Representative value proposition of an SBG observing system for 4 archetype applications

Mining	Algal Blooms Water Quality	Fire Ecology	Agriculture and Water Resources
"There is a very strong, and established expert need for SBG, particularly if it can be free.'"	"Public health is job #1, protecting industry is job #2. But I need help."	"Improved fuel and moisture maps are the biggest unmet need, and they can't come soon enough."	"I rely on scientists to develop production ready ET models, so we have defensible decision-making."
"If there were finally an HSI up there, it would be huge!"	"Monitoring for HABS is great, but not much you can do about them. But finding new sites for high growth shellfish farms will create a new industry."	"Right now most people are not great at even looking at multi-spectral maps or understanding what ET models are telling them."	"Digital agronomy is new for our business, but it is the future of business opportunities and improving farming practices"
"ASTER already gives us most of what we need, for SBG to be a game changer <10 m and high SNR HSI should be the goal."	"There have been other HSI research efforts. We need operational missions we can count on."	"Prescribed fire reduce wildfire, but without better data to support that, we can't shape better policies and oversight."	"60 bands at 5 meters, or every 2 days, could be better than 200 bands at 30m every two weeks."