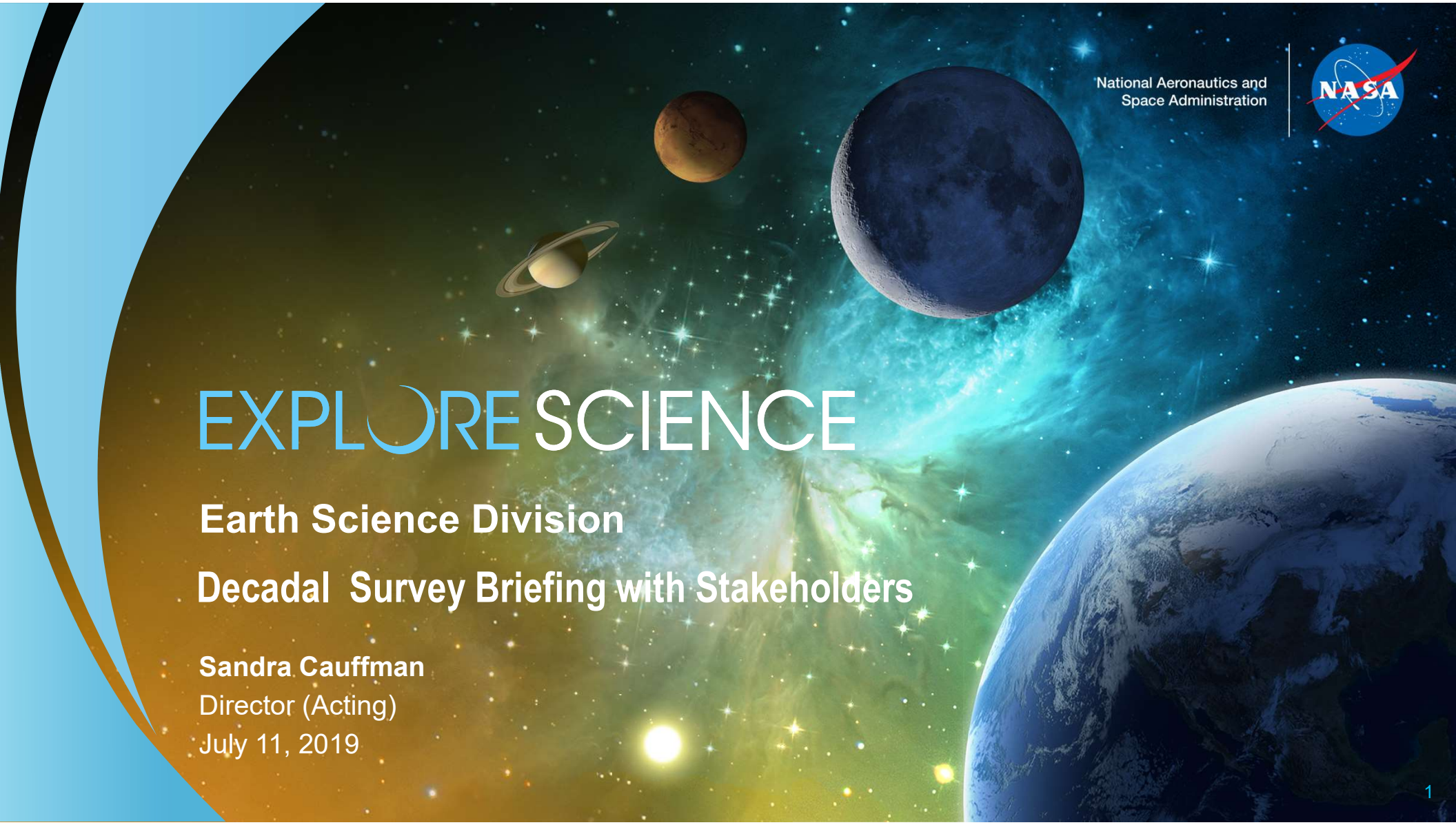
National Aeronautics and
Space Administration
NASA
EXPLORE SCIENCE
Earth Science Division
Decadal Survey Briefing with Stakeholders
Sandra Cauffman
Director (Acting)
July 11, 2019

Questions Process

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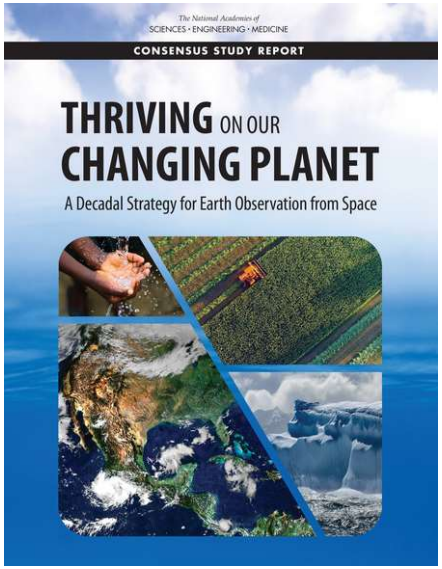
- When done, the Operator will re-mute your line and introduce the next person.
- Please also email your question to **Amy Treat at** Amy.A.Treat@nasa.gov so we can record the question and it's answer on our website.

Outline

- Update on ESAS 2017
- DO Studies - Status Report
- Updates on Industry Engagement
- Website Updates
- What’s next
- Questions

Progress on Comparison of ESAS 2017 Pre-publication and Final drafts

- The Decadal Survey Final Report was released in March 2019 https://www.nap.edu/catalog/24938/thriving-on-our-changing-planet-a-decadal-strategy-for-earth
- ESAS 2017 Recommendations contain minor wording changes, none of which affect ESD's approach to Decadal Survey implementation
- On June 18, 2019 ESAS released a free "Consensus Report" that is only 26 pages which summarizes the final report
- https://www.nap.edu/catalog/25437/thriving-on-our-changing-planet-a-decadal-strategy-for-earth-observation-from-space?utm_source=NASEM+News+and+Publications&utm_campaign=eaf6710ed2-Final_Book_2019_06_18_25437&utm_medium=email&utm_term=0_96101de015-eaf6710



Designated Observables Studies - Update

Aerosol – Cloud, Convection and Precipitation (A-CCP)

ACCP: **Architecture Construction**

Architecture Construction Workshop (ACW) #1 @JPL 14-16 May 2019

- 11 Architectures were constructed to explore trade space from more capable (1-2 spacecrafts) to less capable architectures (distributed architecture with up to 6 spacecrafts)
- **'Large' spacecraft(s)** >180kg
- Utilized Payload/Instrument Library consisting of >50 responses received from RFI
- Considered contributed instruments from potential international partners (JAXA, CNES, CSA)
- Results/Lessons Learned:
  - Costing of instruments is challenging (particularly for active radar and lidar instruments)
  - **Cost estimates in the Decadal Survey report were confirmed** on a rough order of magnitude (ROM)

Architecture Construction Workshop (ACW) #2 @JPL 18-20 June 2019

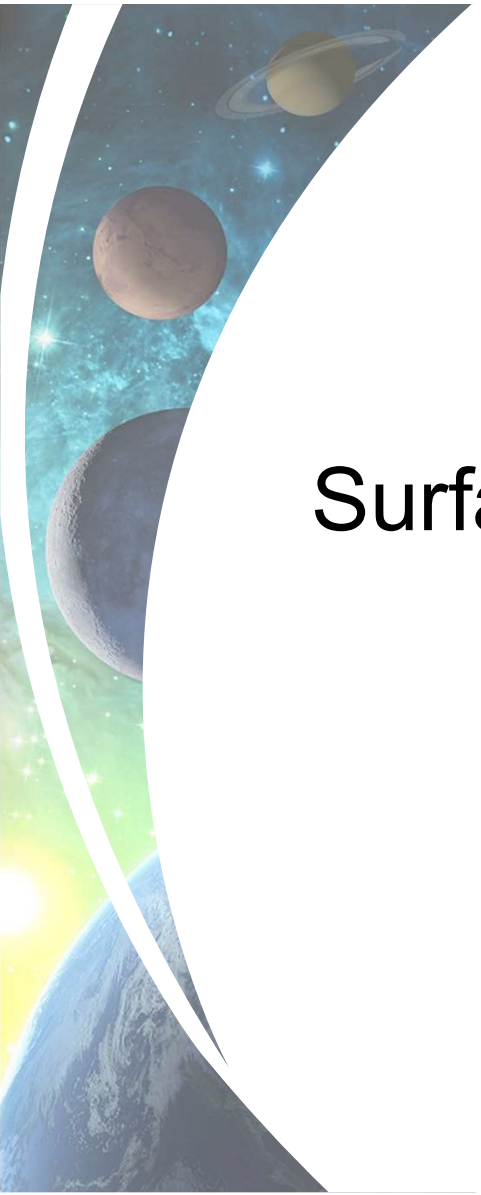
- Multiple configurations explored trade space of **SmallSats** constellations

Architecture Construction Workshop (ACW) #3 @ JPL 10-12 July 2019

- Follow up to ACWs #1 and #2

ACCP: **Study Status and Current Timeline**

Date		Milestone
2018	Oct	Study Plan Start
2019	**Apr 2-4**	**Community Workshop in Pasadena (2 month delay due to shutdown)** (SATM Rev C)
2019	Apr 19	RFI for Instrument Libraries (~50 Responses, including International Contributions)
2019	**May 7**	**Release SATM Rev D (for Architecture Construction)**
2019	**May-Aug**	**Architecture Construction Workshops I-III, Architecture Refinement, & Science Evaluation**
2019	**Aug**	**Qualitative Ranking of Science Value & Programmatics**
2019	Aug 14	Release SATM Rev E (revised post Architecture Construction refinements)
2019	Aug 19-23	Instrument Design Lab (IDL) @ Goddard (modification of Instruments)
2019	**Sept/Oct**	**Collaborative Design Center (CDC) Run #1+2 (at Goddard), Value Framework, & Costing**
2019-2020	**Nov-Mar**	**Sub-Orbital Workshops & Sub-Orbital Inclusion Into Architectures**
2020		Remaining CDCs (LaRC, ARC, MSFC, GRC, Wallops), Value Framework, & Costing
2021	**Sept**	**Final Report & Presentations**



Surface Biology and Geology (SBG)

Surface Biology and Geology (SBG) Update

- June 7 – JPL releases RFI; June 11 – RFI released in FedBizOpps with NMO as Contracting Office
  - Responses due June 28
  - Provide summary of system concept:
    1) Describe architecture concept/measurement capability and functions,
    2) How it addresses objectives/requirements in RFI, and
    3) Maturity (TRL) at present and projected at the time of implementation
  - Provide ROM estimate of cost to build the system concept with accompanying assumptions/rationale (no ROM → NICM)
- June 12-14, SBG Community Workshop, Washington, DC (details on next slide)
- July 9-11, Workshop on International Cooperation in Spaceborne Imaging Spectroscopy, Frascati, Italy
- August 20-21, SBG Leadership Meeting, NASA Ames – defining value framework
- September, Candidate Architectures Selected
- September 24-25, DO Studies Annual Review, NASA HQ
- June 2020 – Architecture Assessments Complete
- December 2020 – Conceptual Design Work Complete
- September 2021 – Final Report Delivered → October 2021 – MCR

SBG Community Workshop (June 12-14)

- 180+ attendees in room and online; remote connection okay
- Reviewed 4 phases of study (SATM/Candidate Architectures → Architecture Assessment → Architecture Design → Report Out)
- Initial Focus on Science and Applications Traceability Matrix
- Review of architecture design approach, including some sample architectures
- Sessions by each of 4 Study working groups (Algorithms, Cal/Val, Applications, and Modeling) with ample discussion after sessions
- 5-min Lightning Talks and Advocacy Statements; Posters; A-CCP presentation – good cross-study/mission synergies
- Assessing SBG architectures and next steps
- Lessons Learned:
  - Wisdom of the SBG working groups structure (thanks Dave, Betsy, et al.)
  - Engaging the youth is key
  - Temporal resolution matters a lot → need for creative architectures (probably not HyspIRI as previously construed)
  - Glint mitigation and atmospheric correction are important
  - VSWIR/TIR simultaneity
  - *Tempus fugit*: MCR in late CY2021
  - Need to harmonize across constellations of instruments (spectrometers and also multispectral radiometers: PACE, Landsats/Sentinels, ISS, etc.)
  - Pathfinder work needed (cal/val; data integration/harmonization, processing, and management; science and applications)

Surface Deformation and Change (SDC)

Surface Deformation and Change (SDC)

Events and Accomplishments

Research and Applications Workshop April 29-May 1, 2019, Caltech, Pasadena CA

- 60 participants
- Good start on SATM, including additional reflectivity-based objectives traceabilities
- Draft SATM mid-July 2019, to be refined by working groups for second R&A Workshop

Technology Workshop May 20-22, 2019 Pasadena Convention Center, Pasadena, CA

- 80 participants
- Successful engagement with a broad sector of space vendors and data providers
- Good dialog on innovations driving new space and their relevance for SDC
- Report will identify pathways for architectures that balance cost, capability, and mission risk
- Final report mid-July 2019

Generated Initial SDC Website Home Page

- Working with NASA and other DO teams to harmonize sites through NASA portal

Surface Deformation and Change (SDC)

Events and Accomplishments

International Coordination for Spaceborne Synthetic Aperture Radar Data Acquisition, Processing and Analysis for Earth Science and Applications. --- *May 2018, Caltech, California*

http://www.wmo.int/pages/prog/sat/meetings/documents/PSTG-8_Doc_11-01_SARWorkshop-GBawden.pdf

Living Planet Symposium Session on International SAR Collaboration May 12, 2019, Milan Italy

- Organized and chaired by Charles Elachi (Caltech) and Maurice Borgeaud (ESA)
- Presented SDC plans and progress amid talks about international SAR future programs
- Highlights:
  - CSA's Radarsat Constellation Mission will launch soon, with focus on Canada and maritime environs. Some capacity for additional data, no commercial tasking
  - DLR's Tandem-L continues in study phase through 2020, launch no earlier than 2027; science mission data policy
  - ESA's ROSE-L (2 L-band satellites in Sentinel-1 configuration) in competition for selection in 2020; Copernicus data policy

Ad hoc meeting of 2018 SAR Workshop participants to follow up on communications over the past year

- Participants expressed interest in continued efforts to coordinate
- Next meeting in May 27-29, 2020 at ESRIN

Surface Deformation and Change (SDC)

Events and Accomplishments

Performance Tool

- Updated the input database for backscattered power at C-band using Envisat data
- The theory for checking if an interferogram can be made with two images (taken by different satellites or one satellite) was investigated
  - The theory was tested using NISAR observation plans in polar regions to find a threshold for this function
  - The function will be implemented in performance tool
- The steerability capability is being developed and tested in mission planning tool.
- Met with ARC to discuss possible contributions to performance tool.
  - Expect that outcome of A-Team study will create meaningful assignments for centers.

A-Team Architecture Study

- A-Team prep session held June 6, 2019
- A-Team scheduled for June 19-20, 2019 – all centers represented on study team
- Focus on architectures that support the preliminary conclusions of the R&A and technology workshops.

Surface Deformation and Change (SDC)

April 29-May 1, 2019 Research and Applications Workshop Outcomes – Status

- Work is currently underway to produce a draft report of the first R&A workshop by the end June
  - Addition of traceability needs for ecosystems and applications area that take advantage of image reflectivity is a significant augmentation to the traceabilities identified from the Decadal Survey report
  - Four focus groups: Solid Earth, Geohazards, Cryosphere, Ecosystems

- General outcomes of workshop:
  - There is an emphasis on measurement continuity.
  - There is a recurrent desire of higher temporal sampling frequency (daily or better).
  - There is recurrent desire for a 10-m spatial resolution.
  - There was a strong push to add ecosystems objectives for continuity with NISAR

- Some potentially incompatible desired capabilities:
  - Solid Earth specifies capability for global coverage with less importance given to data latency and amplitude-based measurements
  - Geohazards would like more localized coverage with low data latency (1-3 hours) and a need for amplitude-based measurements for several applications.

- Input from the Ecosystems focus group includes desired capabilities both from geodetic-based and amplitude-based measurements. The latter covers several polarization arrangements.

Surface Deformation and Change (SDC)

May 20-22, 2019 Technology Workshop Outcomes

- **Work is currently underway to produce a draft report of the technology workshop by the mid July**
  - Professional documentarian generated over 60 pages of notes that need to be digested
  - Workshop covered all relevant topic areas to capture trends in new space: radar systems, antennas, spacecraft, telecom architectures, science data systems and analytics, commercial systems and plans, commercial data buys, launch vehicles, hyper-integration, thermal technologies, on-board processing, formation flying, and constellations.
- **General outcomes of workshop:**
  - *Antennas for radar continue to be hand-crafted, leading to high cost.* Current new space innovations largely are focusing on small systems that are not well-suited to SDC objectives. The driving antenna metric for the SDC application will be mass density per unit of deployed aperture area favoring reflector/reflectarray designs with either static or array feeds.
  - Harnessing Moore's Law in space could greatly reduce mass, power, and cost if:
    a. NASA is willing to transfer the risk of failure from manufacturers to projects for non-mission critical systems, enabling the use of highly integrated COTS parts such as RF SoC FPGAs.
    b. Requirements for the digital flight electronics can be set and fixed prior to Phase C without further changes. I/Os are the most power hungry components of digital electronics and minimizing those interfaces provides significant savings. But the level of customization to do this requires fixing the design requirements prior to the capital expenditure of building chips.
  - The commercial space expansion offers an array of COTS spacecraft buses, but the need for a large deployable aperture drives customization. Two options for resource savings are to over-purchase a COTS bus or custom-design a bus around an instrument. Further study is needed to determine which of the two approaches will be the most effective for SDC.
  - *Combining functions within the spacecraft or instrument can provide significant savings*, particularly as systems scale to be built in quantities of three or more. *A key area for this integration combines thermal and structural components*. Further study will seek to quantify how much mass savings might be achieved when applied to a SAR instrument.
  - Commercial space systems offer a much wider selection of telecom and launch vehicle services than has been previously available. As such, neither of those two mission systems should drive the mission architecture requirements. The approach should be to design the space segment to best suit the needs of SDC, and there should remain several possibilities to achieve the data link and access to space that can be evaluated at that point.
  - *Wireless technologies providing intra bus communications have the potential to lower the mass of harnessing and add freedom in configuration*, but this technology was not represented at the workshop. It should be explored further.

Mass Change (MC)

Mass Change (MC)

Upcoming Events

Community Engagement Workshop July 30 - August 1, 2019, Washington DC

- About 100 invitations sent out, including international partners and private sector
- Presentations by MC team and Community in plenary and breakout sessions for 2.5 days
- Registration on-going (~60) & Agenda emailed and posted on line
- Participating agencies: ESA, CNES, GFZ, DLR
- To contact the team email masschange@jpl.nasa.gov.

Classes of Architectures

1. Satellite-Satellite-Tracking (SST) (≥2 satellites)
   a. With accelerometers
   b. Without accelerometer
2. Precision Orbit Determination (POD) (constellation)
   a. With accelerometers (10-11) 0.1k/orbit/day control, gradients affect; assuming GRACE-like system
   b. Without accelerometer
3. Gradiometer
4. Clocks
5. Ground networks

Successful MC A-Team meeting :

- Identified drivers & constraints, key MC candidate architectures
- Discussion on value framework & metrics
- Deep dive on top two candidate architectures, technology readiness

MC Applications Survey released on line June 14, 2019

MC website and team email address made available.

- Information included in invitations and meeting announcement posted

Milestones - remaining of 1st year of the study

End of Phase 1: Complete SATM & Architecture List
Refine up to 3 architecture concepts (possibly through Team X/MDL/IDL)
Define science framework
Simulations and tool development to fill performance assessment gaps
Plan for value framework workshop
Cost analysis
AGU town hall

Mass Change A-Team Summary

Work flow: Architecture classes, assessment, and role of SATM

Mass Change Mission (MCM) architecture classes:

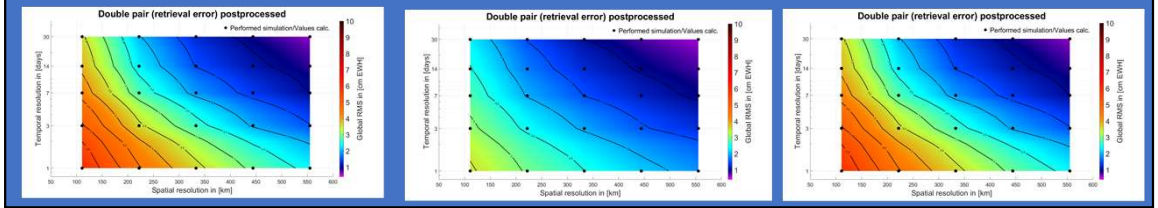
SST architectures
- GRACE-like
- N-sat pairs
- N-sat train
- LEO/MEO

Gradiometer architectures
- Single-sat
- N-sat
- Fixed or variable orientation

POD architectures
- Large GPS-receiver constellation
- With or without accelerometer?

Simulations quantify MCM architecture space-time performance:

Architecture 1 | Architecture 2 | Architecture 3



SATM – Maps Decadal Survey targets into MCM Science & Applications

Value Framework
f (Science, Applications, Programmatic, Cost, Risk)

→ Architecture Down Select

Architecture Deep Dives

N-satellite SST train

Advantages: Temporal resolution, no single point-of-failure, potentially cheaper per unit
Disadvantages: Operation/pointing challenges, likely expensive, N-satellite orbit maintenance
Key questions: Thermal control, pointing control/signal acquisition, drifting, cost, TRL

N-satellite POD (precise orbit determination)

Advantages: Low-cost per unit, fractionated design removes single point-of-failure
Disadvantages: Requires very large number of satellites, expensive with accelerometers
Key questions: Primary mission – or supplemental for reducing aliasing? Accelerometers?

Atomic Interferometer Gravity Gradiometer

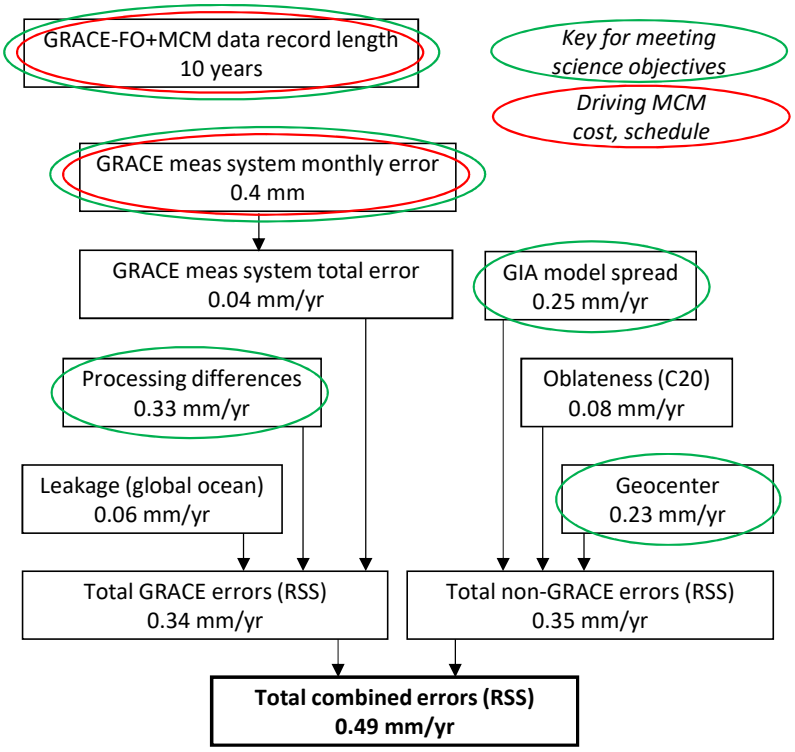
Advantages: Single satellite, inherently drag-free, higher E-W sensitivity (no stripes)
Disadvantages: Currently low TRL (3/4)
Key questions: Orientation, TRL path forward, cost, spacecraft size

Mass Change A-Team Summary

SATM: Discussion and progress

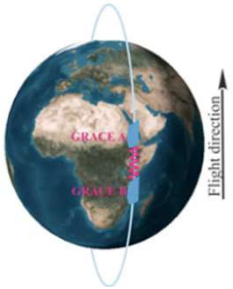
Quantifying GRACE "error tree" relative to DS

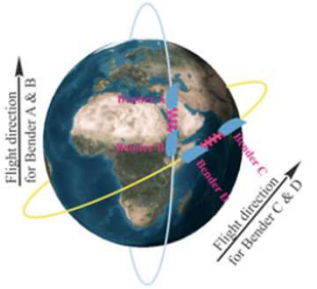
Decadal Survey science objective C1-a: Determine the global mean sea level rise to within 0.5 mm/yr over the course of a decade (RSS)

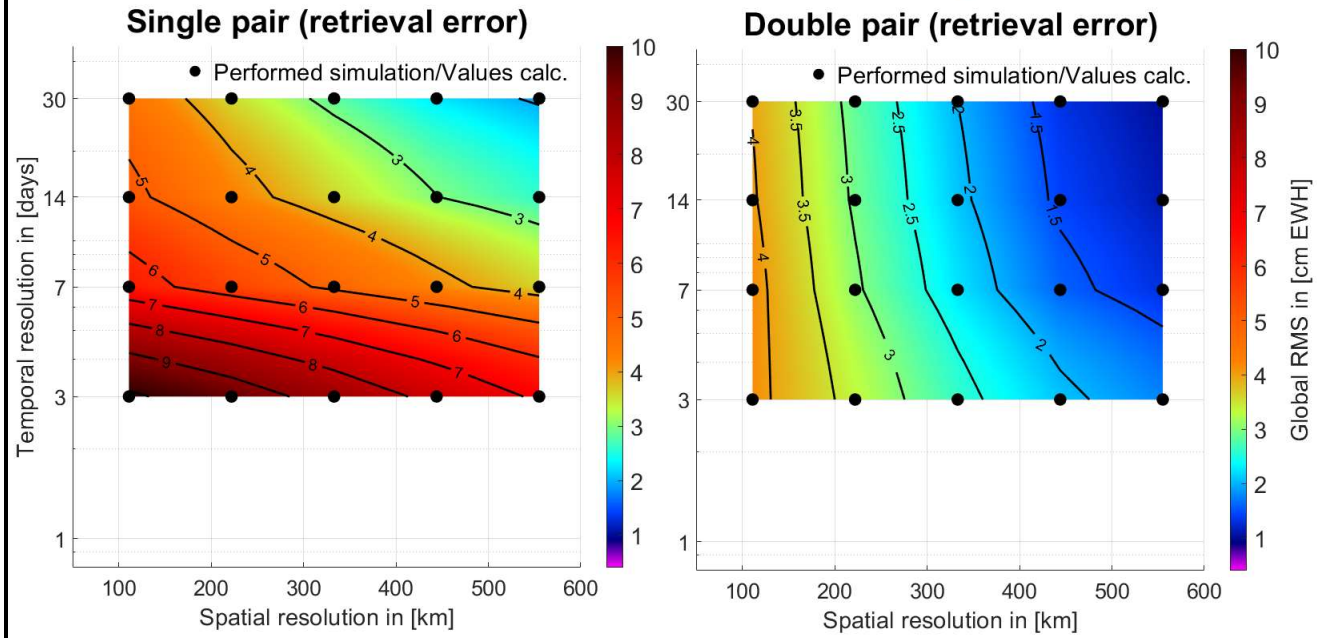


Single/double-pair SST assessment capabilities (Wiese and Hauk)

A framework to link architectures/technologies to science objectives







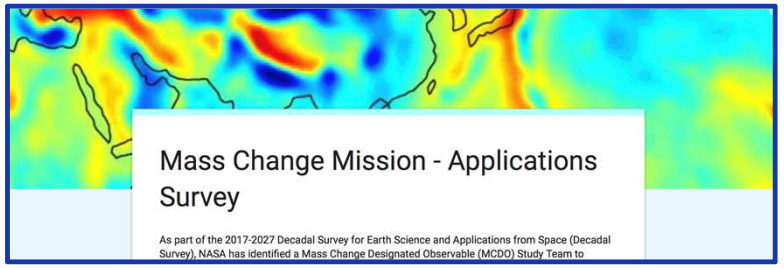
Mass Change Mission Applications Survey

Purpose – This survey is intended to provide the MCDO team with a clear understanding of the needs of the mass change applications community. The information gathered can be used to inform mission architecture design, evaluate tradeoffs, and ensure that the data products are optimized for a broad user community.

Content – The survey is comprised of two sections 1) General questions about requirements for their applications (14 questions), and 2) Data use and demographic information to help characterize aspects of the user community (7 questions).

Accessibility – The survey is in the form of a Google Document and can be accessed at this link; Mass Change Mission Survey. It has been distributed to a list, compiled by the MCAT, of people we expect to comprise part of the user community for this new mission, and also scientists and others who may have an interest in applied uses of the data, or may know people who do.

Analysis – We hope to have a representative number of responses in time to do some preliminary analysis of the data before the MC Community Meeting at the end of July.



Updates on Industry Engagement

DO Industry Engagement – Updates on Solicitations

	Description	Supported Activity	Date of solicitation
Category 1	Cross-cutting expertise in specific areas	All of the DOs	~July 2019
Category 2	Support to HQ	HQ Decadal Strategy	~Aug 2019
Category 3	Technology Demonstrations	Specific to each DO	Beginning summer 2019 (TBC)
Category 4	Applications Support	All of the DOs	~Aug 2019

Category 1 – Crosscutting support to DOs

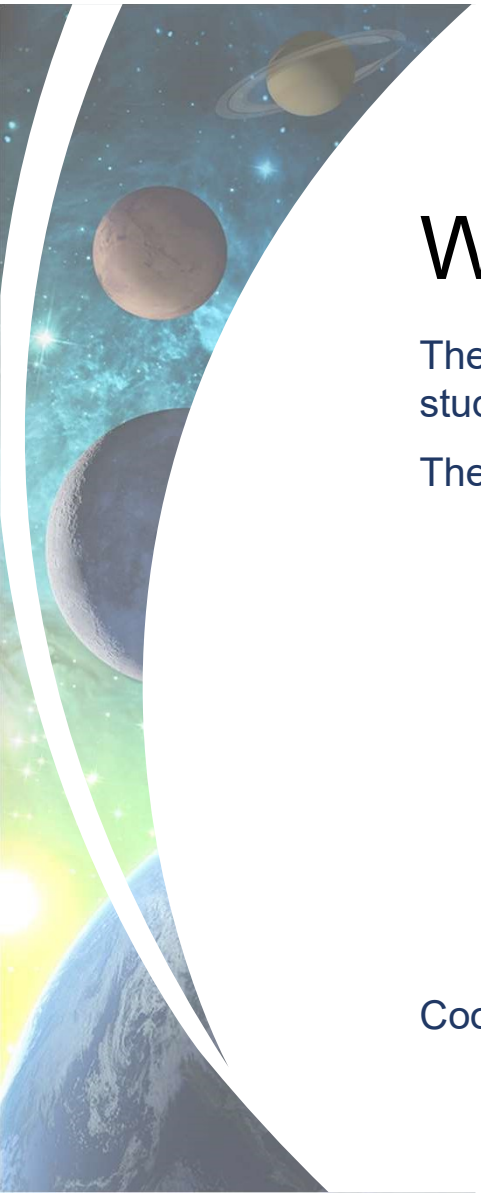
ESD is working with JPL to release the Category 1 solicitations in support of the DO Architecture Studies in cross-cutting areas (i.e. capabilities that could apply to multiple DOs) where industry has unique expertise:

- Small-Sat/CubeSat Constellations (one contract)
- Payload hosting on Commercial Satellites (one contract)
- Ground System Architectures (one contract)
- Data Processing/Data Storage/Cloud Computing (one contract)
- Market Research on out-of-the-box enabling commercial technologies (one contract)

- Research identifying and engaging non-traditional stakeholders and partnerships, such as philanthropies, and foundations (one contract)

One-year period of performance with options to renew on an annual basis

Websites Updates



Website Updates

The Decadal Survey web pages at HQ under “science.nasa.gov” for each of the DO studies require updates to include more relevant information to the community

The following are the items requested to be provided:

- A synopsis/summary of the DO
- Top-level timeline for the study(ies) underway (architecture or otherwise)
- SATMs
- Upcoming event information such as open science conferences/community workshops/dates/venues
- Advertised opportunities (RFIs)
- Instructions on how to join a Science Working Group
- Email list (if it exists) to subscribe to for upcoming events
- A study point of contact

Coordinate content updates with your DO PS and PE

What's Next?

ESD Leadership Team continues to address additional DS topics

Next Community Forum – **November 14, 2019**, 1:00-3:00pm EDT, via webex

See https://science.nasa.gov/earth-science/decadal-surveys

Check the ESD Decadal Survey web page and Inside NASA page to:

- Find meeting schedules and details
- Ask questions and see answers as they become available
- Review information in previous sets of charts
- https://science.nasa.gov/earth-science/decadal-surveys

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Want to Stay Informed

Please send an email to Amy Treat if you would like to ensure that you are informed of future Decadal Survey Community Forums.

TO: Amy.A.Treat@nasa.gov

Also, be sure to keep an eye on the website for updates.

https://science.nasa.gov/earth-science/decadal-surveys/