ACCP Aerosols, Clouds, Convection, and Precipitation Study

ACCP Programmatic Overview

Origin, Programmatic Approach and Progress in the Preformulation Study for NASA's Aerosols, Cloud, Convection and Precipitation Observing System

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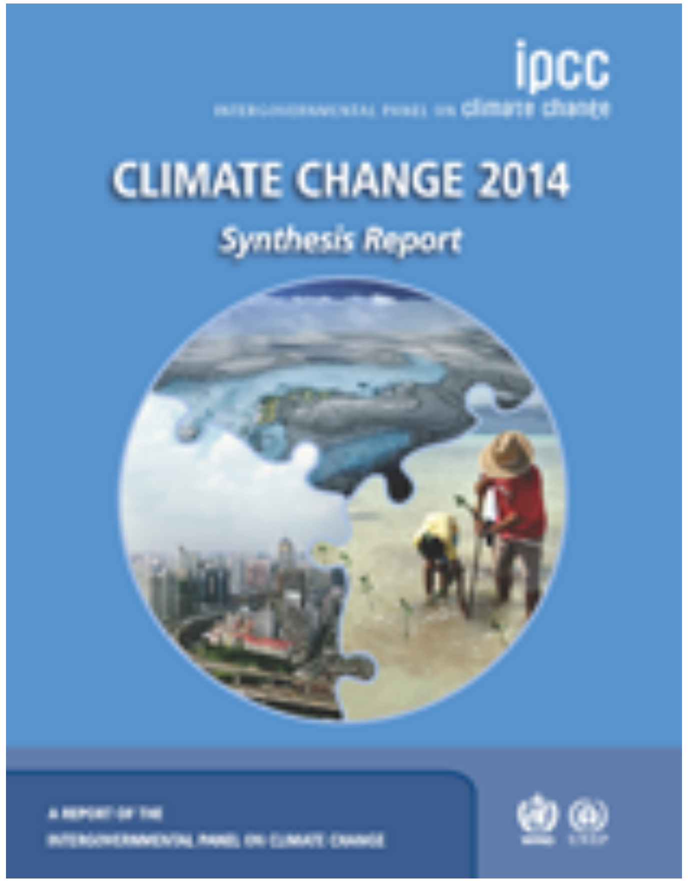
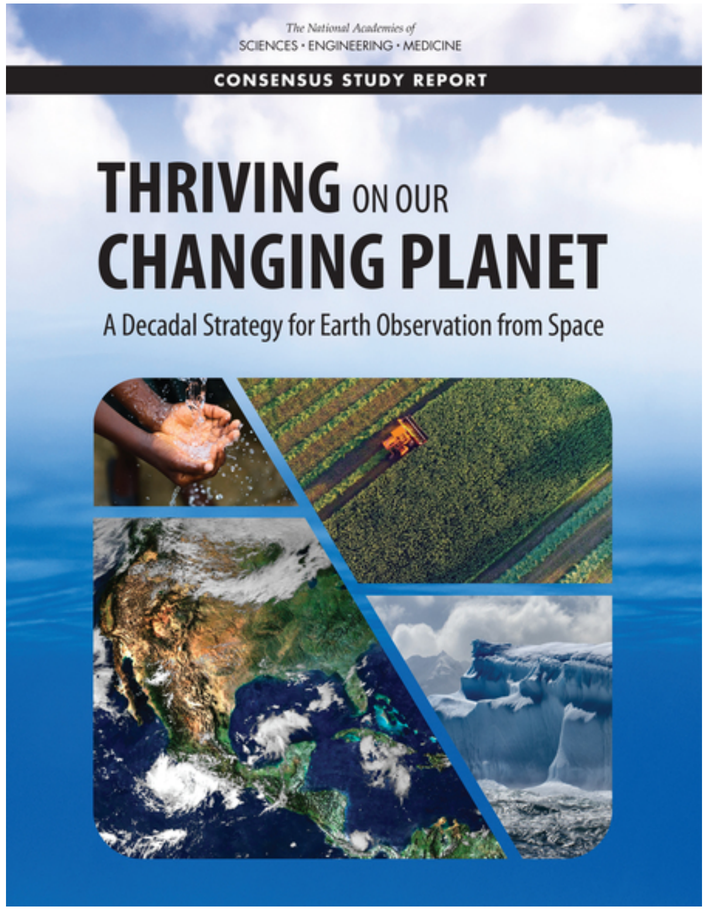
NASA Headquarters

APOLO Conference
University of Lille, France
4 – 7 November 2019

Scientific and Programmatic Basis

- Intergovernmental Panel on Climate Change – Synthesis Report (2014)
- Decadal Survey (2017-2027)
  - Scientific Questions from Science Community
    - <u>Most Important </u>(Designated Observables - DO)
    - Very Important
    - Important
- Aerosols - DO
  - Aerosol properties, aerosol vertical profiles, and cloud properties to understand their effects on climate and air quality
  - Lidar(s) HSRL and/or backscatter and multi-channel/multi-angle/imaging polarimeter flown together on the same platform
- Clouds, Convection & Precipitation - DO
  - Coupled cloud-precipitation state and Clouds, dynamics for monitoring global Convection, and hydrological cycle and understanding Precipitation contributing processes including cloud feedback
  - Radar(s), with multi-frequency passive microwave and sub-mm radiometer





ACCP Study Origin and Overview

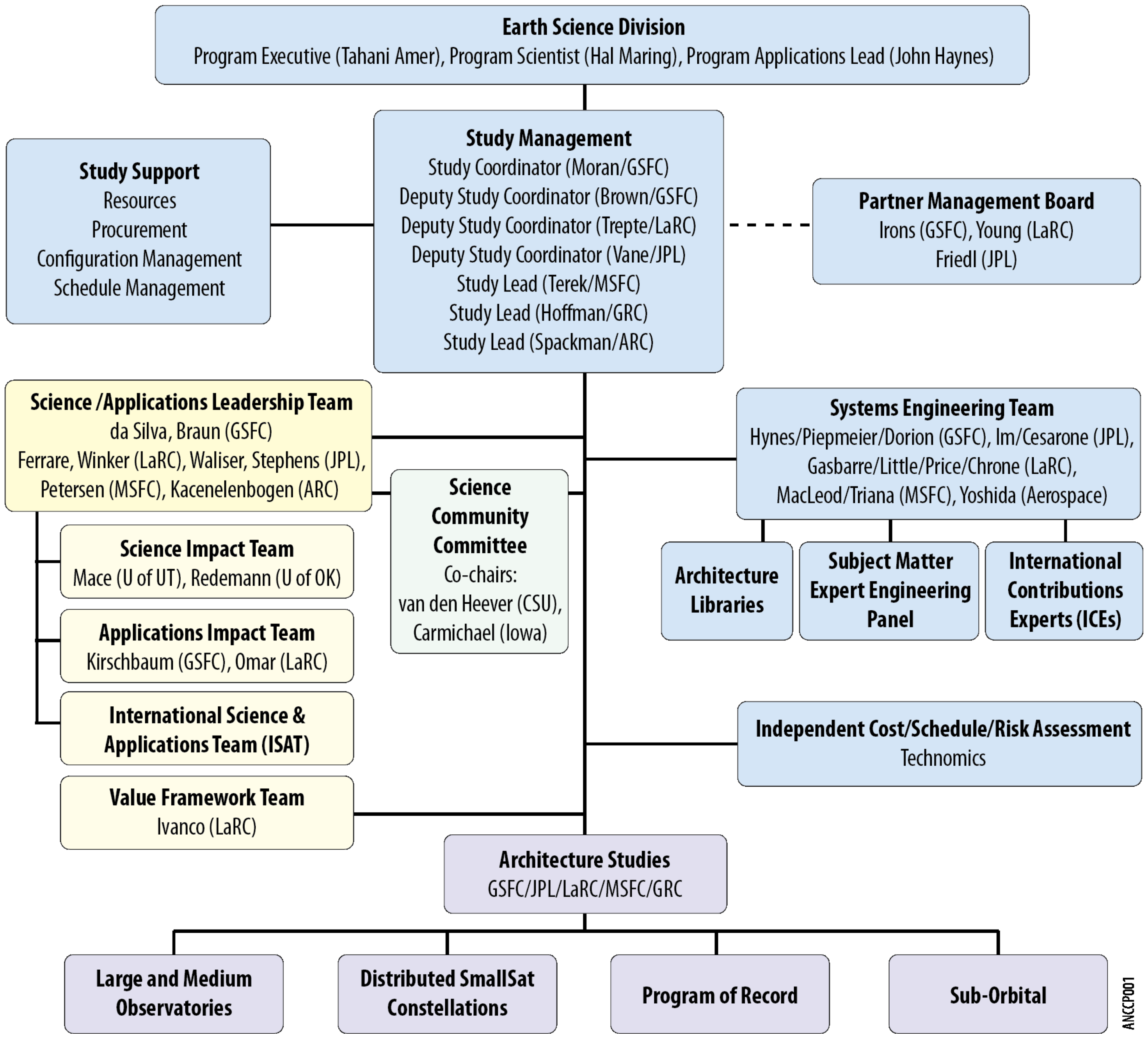
- HQ requested a Study Plan to address the Aerosol (A) and Clouds, Convection, and Precipitation (CCP) Designed Observables (DOs) called out in the 2017 Earth Science Decadal Survey (DS)
- Study Plan combining A and CCP objectives was submitted in July 2018 for a NASA HQ-sponsored, multi-center (GSFC, LaRC, JPL, MSFC, ARC, GRC, and others), 3-year pre-formulation study commencing 1 Oct 2018 and concluding with Study Report submission 30 Sept 2021
- The Study Final Report will provide Science, Technical, Management and Cost details for ~3 Candidate Observing Systems (OS)/Architectures that address the integrated A and CCP goals/objectives and are implementable
- Candidate OSs must take advantage of the Program of Record (PoR) and satellite remote sensing; they can include airborne remote sensing and in-situ observations, surface-based remote sensing and in-situ observations for science data and calibration/validation
- Implementable is defined as low risk for meeting cost cap and constraints
    - Funding assumptions: Integrated A and CCP program with initial $800M funding wedge and Phase A start at end of FY22
    - Additional funding to follow for OS elements with later start to complete A and CCP objectives
    - Candidate architectures will span a range of costs and provide funding profiles

ACCP Study Team

Study Management Team (SMT)
- Overall Leadership and Management of Study and Delivery of Study Report
- Community Engagement
- Assessment of Architectures
  - Cost Estimation & Validation
  - Programmatic Risk
  - Other Programmatic Factors

Science/Applications Leadership Team (SALT)
- Definition of Science & Applications Traceability Matrices
- Assessment of the Utility of the Geophysical Variables in Meeting Each Objective

Science & Applications Impact Teams (SIT and AIT)
- Assessing the Science & Applications Value of Architectures (Science Quality of Each Architecture with regard to Measuring Geophysical Variables)



Science Community Committee
- Independent Assessment of SATM
- Independent Assessment of Science & Applications Benefit by Community of Users

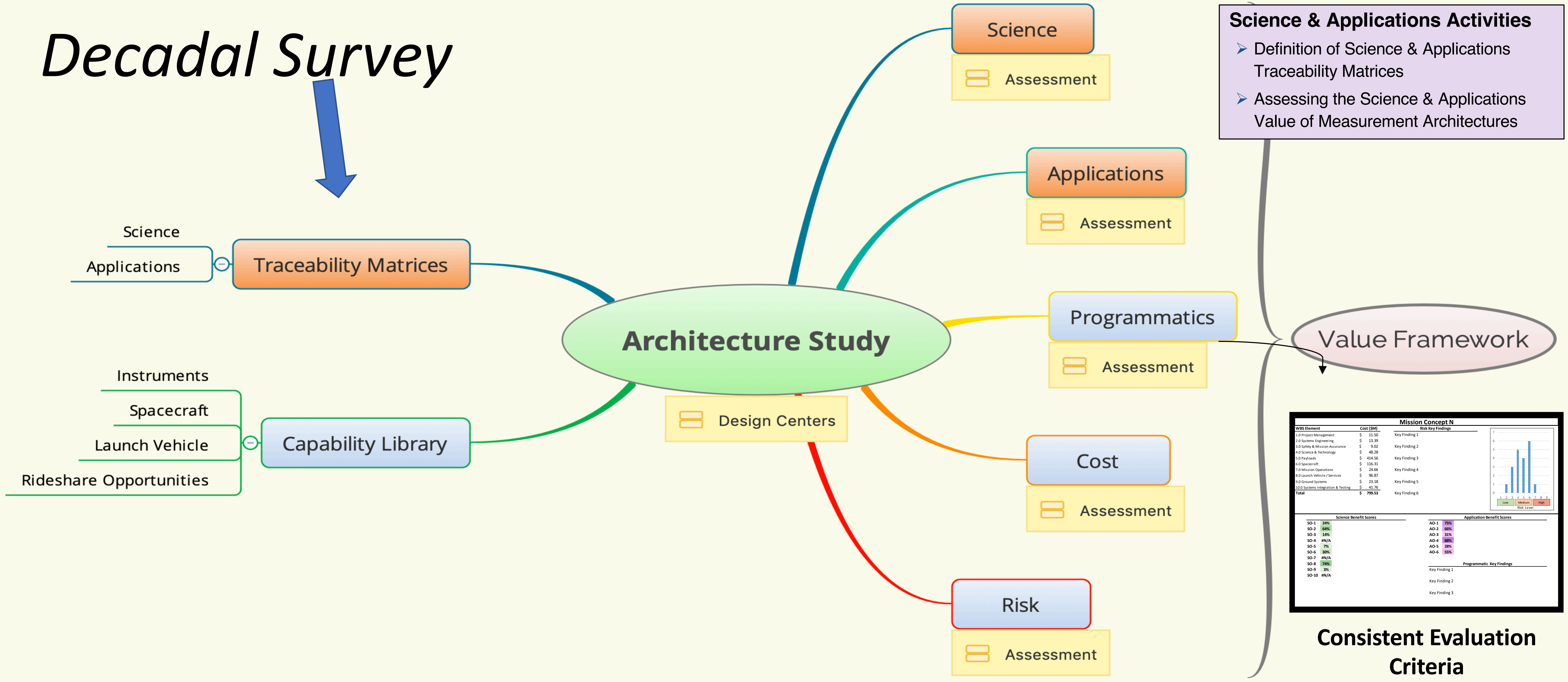
Systems Engineering Team (SET)
- Definition of Architectures
- Assessment of Architectures
  - Technology Readiness
  - Technical Risk

Value Framework Team
- Development of Standard and Systematic Approach to Science, Applications, and Programmatic Evaluations of Architectures to facilitate Down-Select Decisions

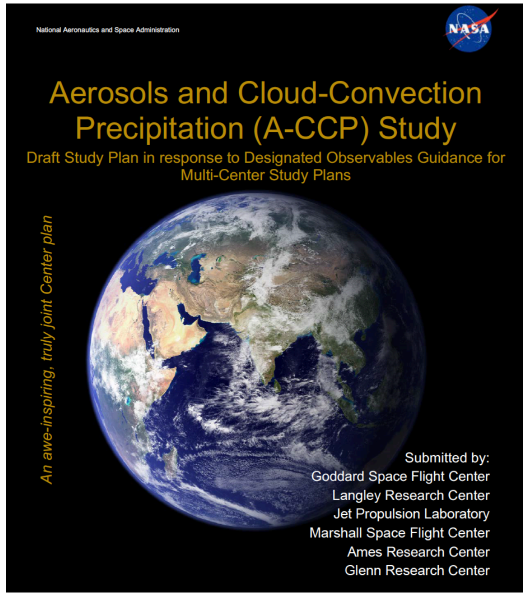
International Engagement

- Bilateral meetings began in April 2019 with:
  - JAXA
  - CNES
  - CSA
  - DLR
- JAXA, CNES, CSA and DLR have been invited to participate in SALT, SCC, SIT, AIT and engineering; and are in various stages of engagement
- Architectures considered to date have included internationally contributed instruments to the maximum extent possible
  - JAXA - precipitation radar and launch vehicle
  - CNES - lidar detector and radiometer
  - CSA - FAR IR spectrometer, limb sounder, and water vapor sensor
- DLR has expressed interest in participating in Sub-Orbital portion of the observing system and cal/val
- Continuing to investigate additional international participation (e.g. KNMI/SRON and KASI)

ACCP Study Approach



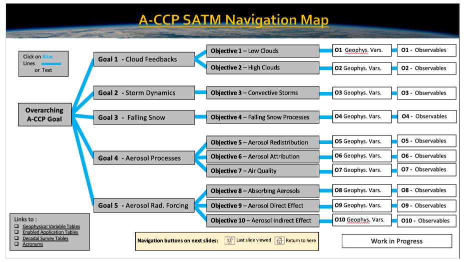
Year 1 Accomplishments



October 2018
Authorization to Proceed (ATP)
Science Workshop
Hampton, VA

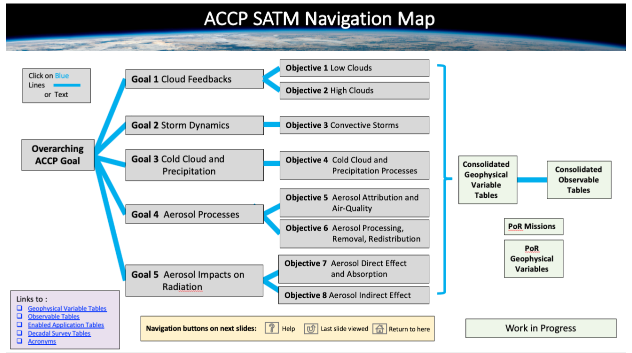
April 2019
Community Workshop
Pasadena, CA

March 2019
SATM Rel. C



May 2019
SATM Rel. D

Sept 2019
SATM Rel. E
(under CM)



Oct 2019
Community Comments
SATM Rel E

Nov 2019
Face To Face with SCC
Review All Comments

Dec 2019
SATM Rel F for Final Scoring

Year 1 Accomplishments & Year 2-3 Goals

- In Year 1, the Study Team has
  - Developed Science & Applications Traceability Matrix (SATM)
    - Held Community Workshop in Pasadena, CA with ~250 Attendees from NASA, Industry, Academia and ~5 International Participants (13 invited) to review SATM
    - Bilateral discussions with CNES, CSA, DLR and JAXA
  - Built extensive Instrument Library (>50 RFI submissions)
  - CNES, CSA, DLR and JAXA formally invited to participate in the study and engaged
  - Formulated numerous (>32) candidate Observing Systems (OS)/Architectures to address the combined DOs for A and CCP
    - 4 Architecture Construction Workshops (ACWs) completed at JPL (May, June, July) and GSFC (September)
    - Architecture Evaluation Workshop (AEW) completed at GSFC (August)
- In Year 2, the Study Team will
  - Complete more detailed designs of ~6 of the OS/Architectures
  - Evaluate science and applications benefits (via Value Framework)
  - Evaluate technical feasibility/risk of instrument capabilities (via Technology Readiness Assessments)
  - Evaluate cost and programmatic feasibility/risk (via Detailed Costing)
  - Include sub-orbital elements of Observing System (via Sub-Orbital Workshop(s))
- In Year 3, the Study Team will continue to develop ~3 OS/Architectures based on Value Framework assessments and refine the Science, Mission Implementation Technical, Management and Cost details with a recommendation to HQ for one to proceed to Mission Concept Review (MCR)/KDP-A before end of FY22

ACCP Significant Events (Near Term)

Qualitative Ranking of Science & Programmatics for ACW #1-3	Completed
Aerosol Instrument Performance Discussion	August 6, 2019 (Completed)
Architecture Evaluation Workshop (AEW) #1	August 7, 2019 (Completed)
Selection for CDC #1 (with HQ if desired)	August 7, 2019 (Completed)
DSIS #4 - Architecture Finalization for ACW #3 (Designing Sweet Instrument Suites)	August 8, 2019 (Completed)
Splinter with SBG on Architectures and measurements	Sept. 6, 2019 (Completed)
	Sept. 17, 2019 (Completed)
	October 2019 (TBS)
SATM Rev E Delivery	Sept. 16, 2019 (Completed)
ACW #4 (Refinement @ GSFC MDL)	Sept. 16-20, 2019 (Completed)
1st ACCP Quarterly Community Forum	Sept. 20, 2019 (Completed)
Annual Review DO Study Teams for HQ	Sept. 24-25, 2019
Qualitative Ranking of Science Value & Programmatic ACW #4	Due NLT Oct. 31, 2019
Community Comments SATM Rel E	Due Oct. 31, 2019
SCC Independent Assessment SATM & Qualitative Scoring for Architectures	Due Dec. 4-5, 2019
SATM Rev F (Final) Delivery	mid-Dec. 2019
AEW #2 and Selection of Architecture for CDC #2	mid-Dec. 2019
Quarterly Community Forums	Jan/Apr/July/Oct
Sub-Orbital Community Workshop #1	early March 2020

ACCP Significant Events (Longer Term)

CDC #1 GSFC MDL	Week of 30 Sept and week of 7 Oct
CDC #2 JPL Team-X	14-16 & 28-30 Jan 2020
CDC #3 MSFC	March 2020
CDC #4 LaRC	May 2020
CDC #5 GRC	July 2020
CDC #6 TBD	Sept 2020
Value Framework Assessments After Each CDC	Oct 2019-Nov 2020
Independent Costing	Oct 2019-Nov 2020
Technology Readiness Assessments	Oct 2019-Nov 2020
Down-Select To ~3 Architectures	Feb 2021
Final Recommendation	Aug 2021
Final Report & Presentations	Sept 2021

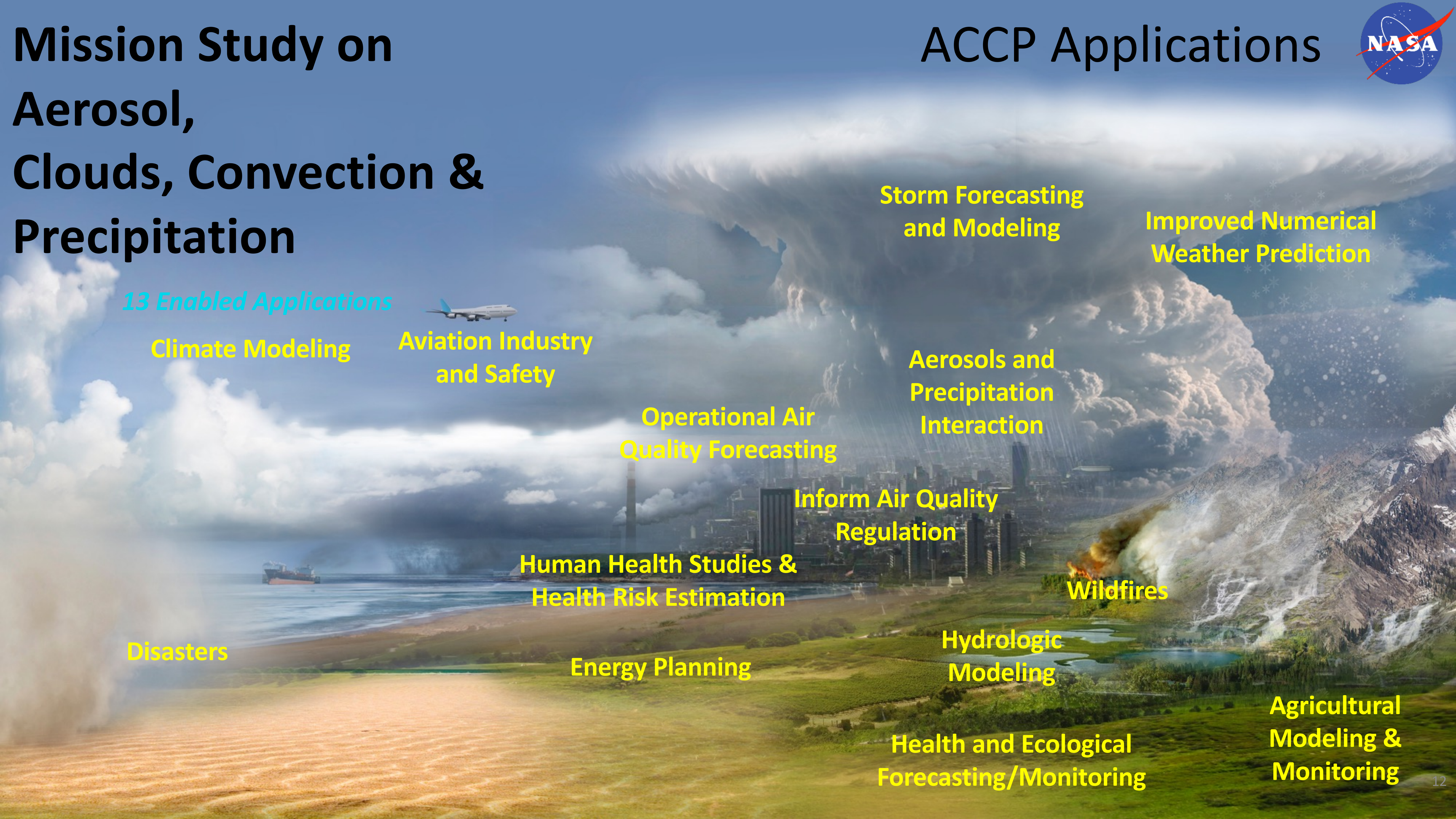
Mission Study on Aerosol and Clouds, Convection & Precipitation

ACCP Science

8 Science Objectives (see SATM for # Mapping)
Traceable to the 2017 Decadal Survey

Mission Study on Aerosol, Clouds, Convection & Precipitation

ACCP Applications



ACCP SATM Navigation Map

Click on Blue Lines or Text

Overarching ACCP Goal

- **Goal 1** Cloud Feedbacks
  - **Objective 1** Low Clouds
  - **Objective 2** High Clouds
- **Goal 2** Storm Dynamics
  - **Objective 3** Convective Storms
- **Goal 3** Cold Cloud and Precipitation
  - **Objective 4** Cold Cloud and Precipitation Processes
- **Goal 4** Aerosol Processes
  - **Objective 5** Aerosol Attribution and Air-Quality
  - **Objective 6** Aerosol Processing, Removal, Redistribution
- **Goal 5** Aerosol Impacts on Radiation
  - **Objective 7** Aerosol Direct Effect and Absorption
  - **Objective 8** Aerosol Indirect Effect

Consolidated Geophysical Variable Tables

Consolidated Observable Tables

PoR Missions

PoR Geophysical Variables

Links to :

- Geophysical Variable Tables
- Observable Tables
- Enabled Application Tables
- Decadal Survey Tables
- Acronyms

Navigation buttons on next slides: Help Last slide viewed Return to here

Work in Progress

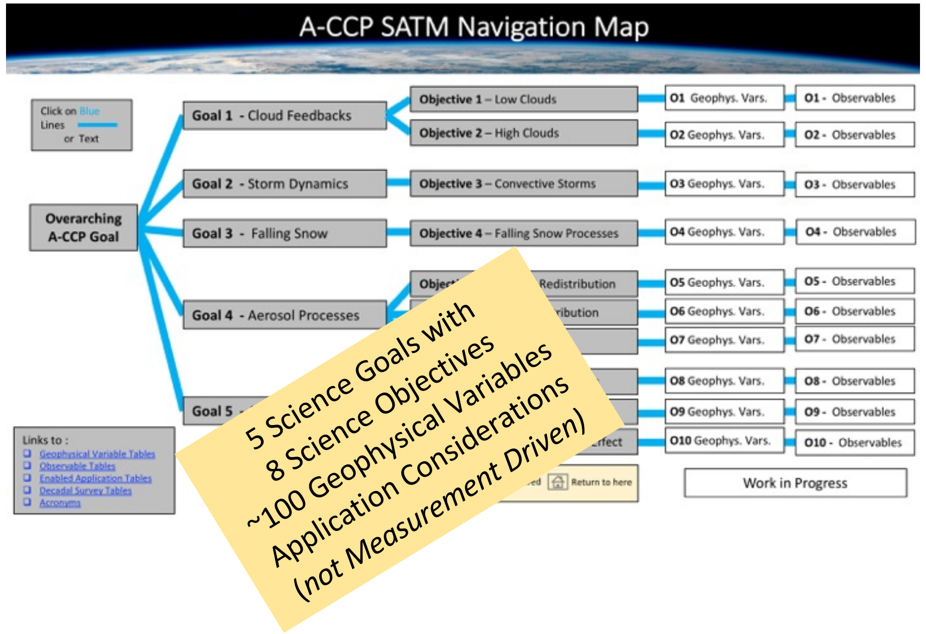
Program of Record: Examples

Mission Family	Agency	Orbit	Operating Period		Relevant Instruments		Notes
			Designed	Likely	Name	Channels	
Global Precipitation Measurement (GPM)	NASA JAXA	LEO (Non-sun synch;incline= 65°;alt=407km)	2014-2019	2014-2032+/-5	Dual-frequency Precipitation Radar (DPR)	13.6 (Ku-band), 35.55 (Ka-band) [GHz]	Electronic scanning planar array with swath width of 245 km at 13.6 GHz, 125 km at 35.55 GHz; Coverage: +/-66° latitude every 5 days Spatial resolution: 5km horizontal, 250 m vertical
					GPM Microwave Imager (GMI)	10.65(V,H), 18.7(V,H), 23.8(V), 36.5 (V,H), 89.0 (V,H), 166.0 (V,H), 183.31+/-7(V), 183.31+/-3(V) [GHz]	Conical scanning imager at 53deg zenith angle with 850 km swath width; Coverage: +/-70° latitude every 2 days Spatial resolution varies with frequency: 19x32km at 10.65 to 4.4x7.2km at 89-183.
Global Change Observation Mission-Water (GCOM-W1)	JAXA	LEO (Sun-synch, cross EQ at 1330LST; incline =98°;alt=700km)	2012-2017	2012-2027	Advanced Microwave Scanning Radiometer v2 (AMSR2)	6.925(V,H), 7.3(V,H), 10.65(V,H), 18.7(V,H), 23.8(V,H), 36.5(V,H), 89.0(V,H) [GHz]	Conical scanning imager at 55° zenith angle with 1450 km swath width; Coverage: Global once/day Spatial resolution varies with frequency: 35x62 km at 6.925 to 3x5 km at 89
Earth Clouds, Aerosol and Radiation Explorer (EarthCARE)	ESA JAXA	LEO (Sun-synch, cross EQ at 14:00LST.;incline=97°;alt=393km; 92.5min period)	~2021-2024	?	Atmospheric Lidar (ATLID)	355 [nm]	High Spectral Resolution Laser at +/-3° of along-track; Coverage: Global every 16days Spatial resolution: 30 m horizontal and 100 m vertical;
					Cloud Profiling Radar (CPR)	94.05 [GHz]	Doppler capability; Nadir only; Minimum sensitivity of –35dB; Coverage: Global every 16days Spatial resolution: 750m horizontal x 400m vertical
					Multi-Spectral Imager (MSI)	670-865 [nm] (VNIR), 1670-2210 [nm] (SWIR), 8.8-12.0 [μm] (TIR)	Pushbroom scanning; 15 km swath Coverage: Global every 8days(IR), 16days(SWIR); Spatial resolution: 500m pixel
Green-house gas Observing Satellite (GOSAT-3)	JAXA	LEO (Sun-synch; polar orbit)	2022-2027	2022-2032	Advanced Microwave Scanning Radiometer v3 (AMSR3)	6.925(V,H), 7.3(V,H), 10.65(V,H), 18.7(V,H), 23.8(V,H), 36.5(V,H), 89.0(V,H), 166(V,H), 183 [GHz]	Frequencies will be likely similar to AMSR2 with addition of 2 channels at higher microwave freq.
Weather System Follow-on-Microwave (WSF-M 1, 2)	DoD	LEO (polar orbit)	2022-?	2023-2033	Microwave Imager	10-183 [GHz]	Frequencies will be likely similar to GMI

ACCP Needs a Value Framework

Cost-Capped/Cost-Constrained

Complex Science Objective Driven Trade Space



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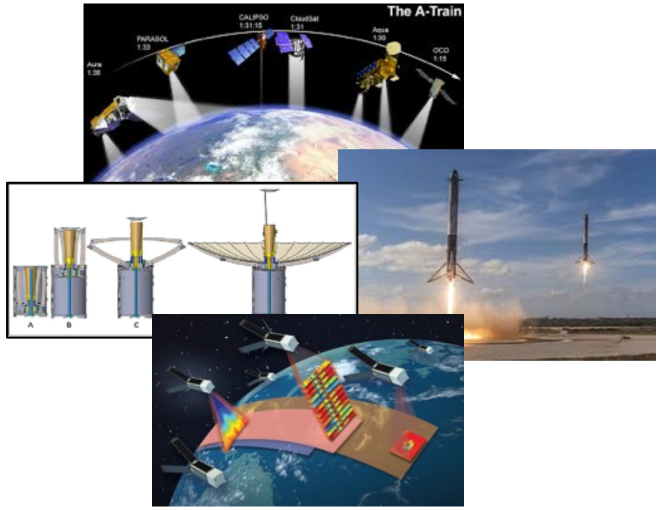
Expansive Logistical Trade Space



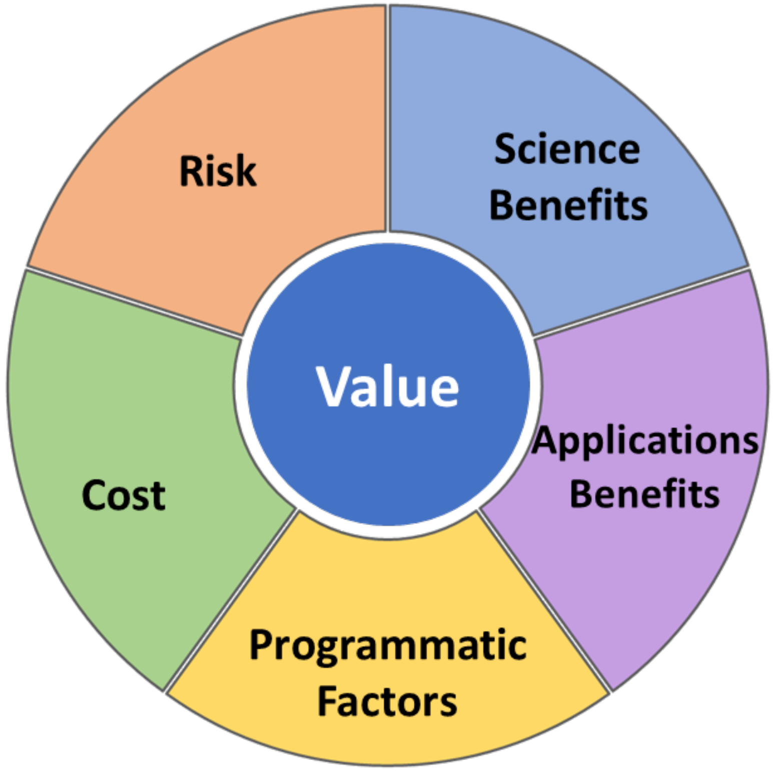
cnes CSA ASC इसरो isro JAXA DLR

ACCP –> large and complex in terms of science goals, payloads, measurement platforms, …

Requires an objective framework for assessing relevant mission architectures

Defining Value for the ACCP Study

Value: For ACCP, Value is the relative worth of science benefits, applications benefits, and programmatic factors with respect to cost and risk.

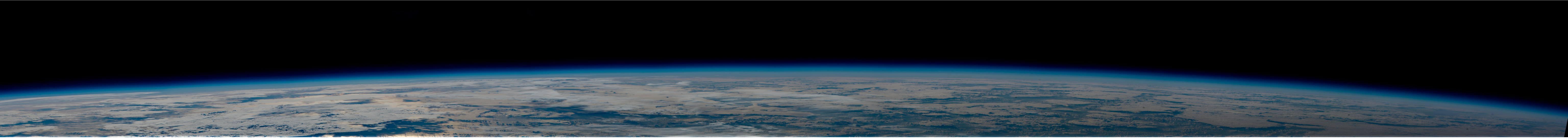


Benefits, cost, and risk are intentionally not rolled up into a single value score to avoid:

- **Losing discriminators**
- **Combining uncertainty**
- **Anchoring cognitively on an initial value**

Programmatic Anxiety

- Are we spending enough time, effort and money to do a good job, because it is unlikely we will get such another such opportunity in our professional lifetimes?
- Are we spending too much time, effort and money, because the time, effort and money spent working on ACCP is not spent doing other important tasks?
- Do we have a sufficiently diverse group of people involved to keep from missing something important?
- Do we have too many people involved such that we cannot make efficient progress?
- Can we reliably cost the ~3 recommended architectures?
- Can useful independent cost estimates be done?



Questions?