Update on the Aerosols, Clouds, Convection, and Precipitation (ACCP) Study

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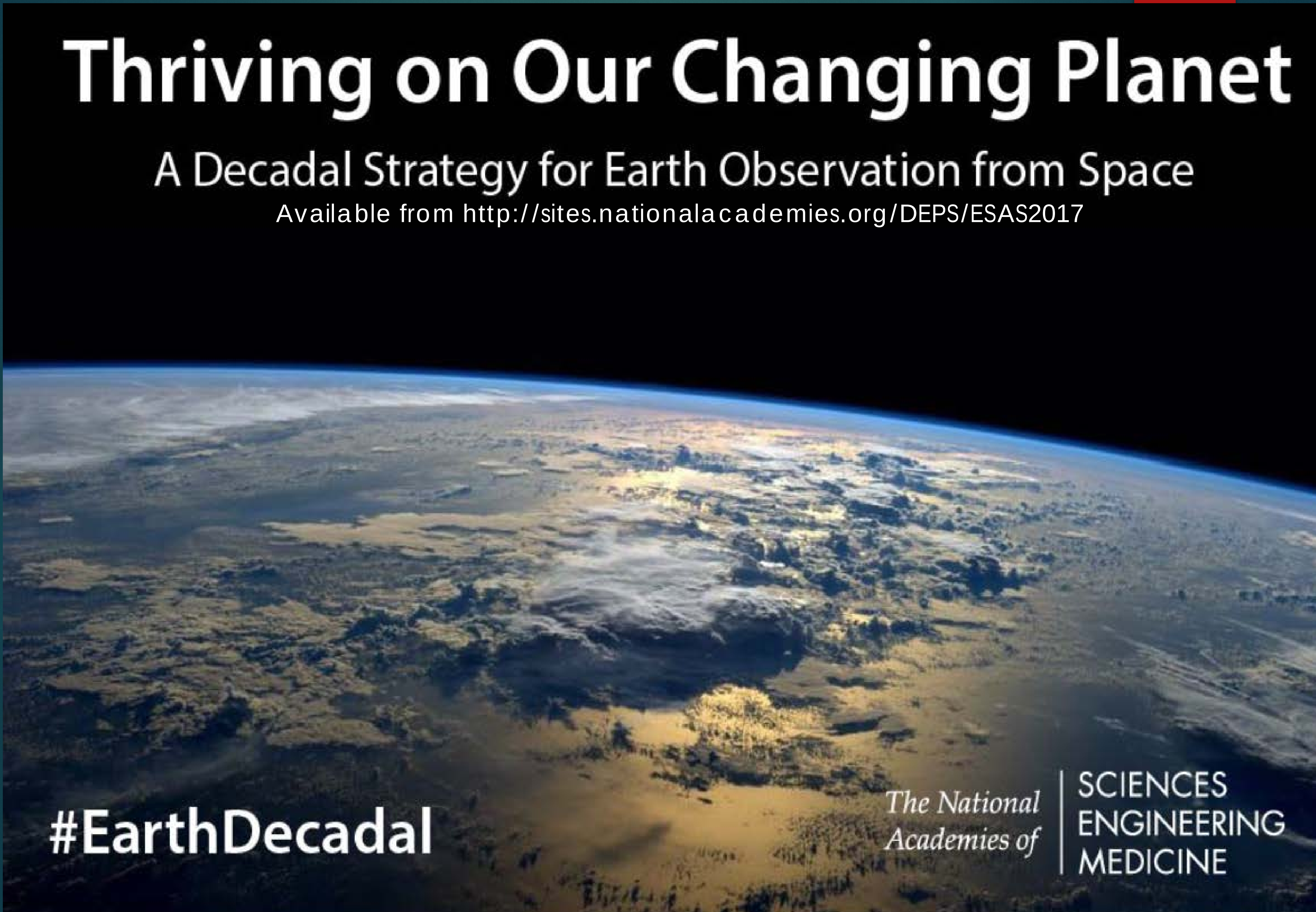
Thriving on Our Changing Planet
A Decadal Strategy for Earth Observation from Space
Available from http://sites.nationalacademies.org/DEPS/ESAS2017
#EarthDecadal
The National Academies of
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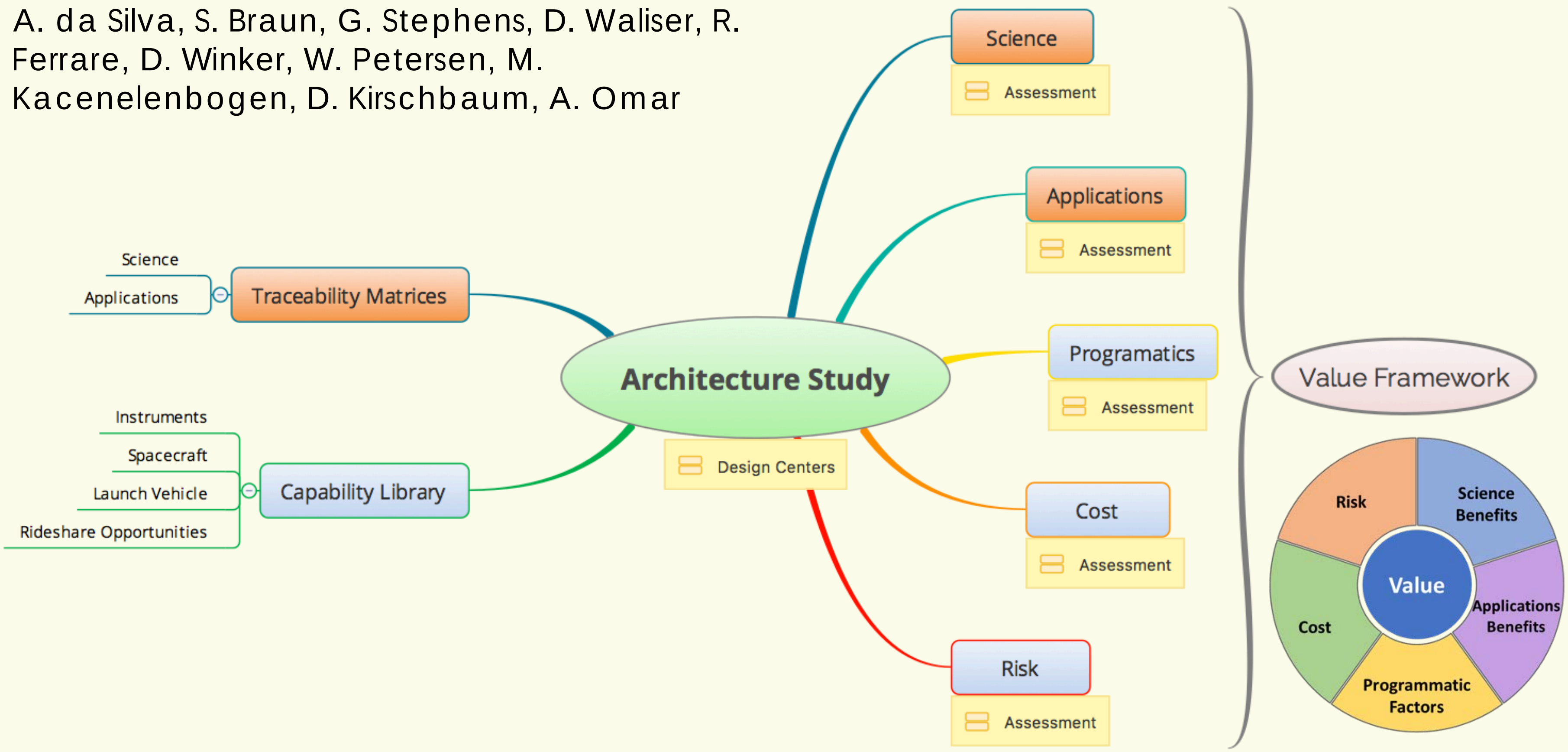
ACCP Overview

- The *2017 Decadal Survey* (DS) recommended cost-capped missions with specified caps, creating challenge for team to envision new science but ensure an implementable observing system

	Aerosols	Clouds, Convection, and Precipitation
Observable Priorities	Aerosol properties, aerosol vertical profiles, and cloud properties to understand their effects on climate and air quality	Coupled cloud-precipitation state and dynamics for monitoring global hydrological cycle and understanding contributing processes including cloud feedback
Desired Observables	Backscatter lidar and multichannel, multi-angle/polarization imaging radiometer	Radar(s), with multi-frequency passive microwave and sub-mm radiometer

ACCP Study Organization

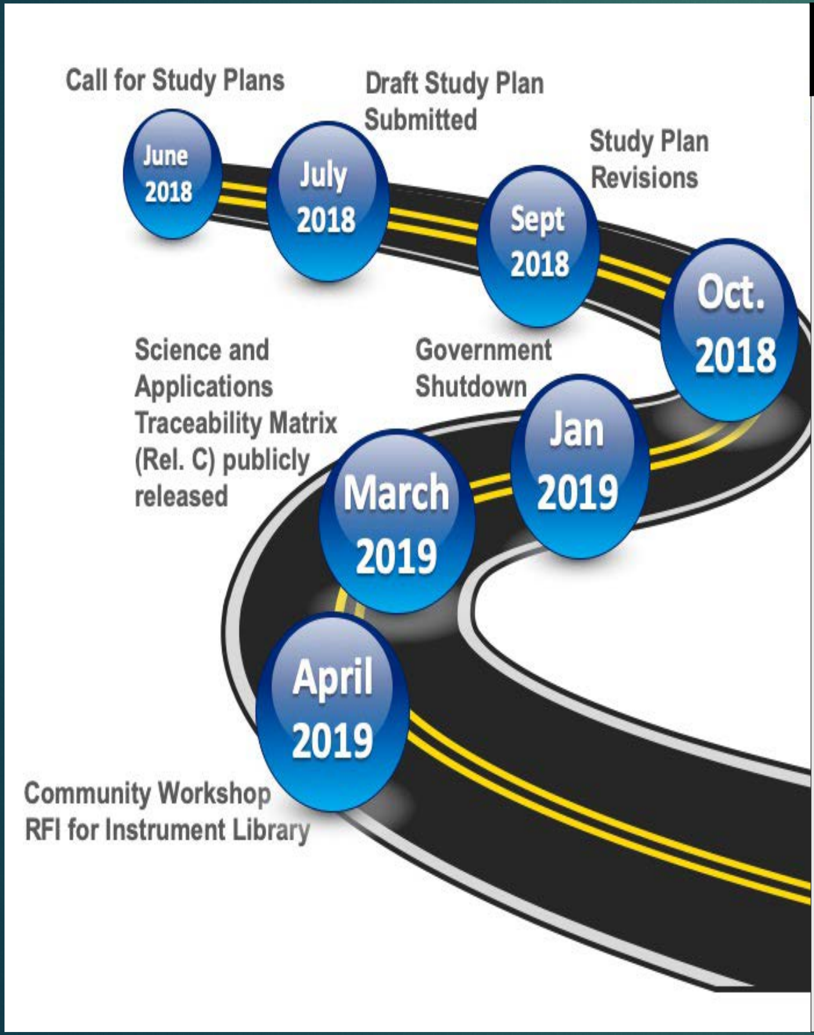
Science and Applications Leadership Team (SALT)
A. da Silva, S. Braun, G. Stephens, D. Waliser, R. Ferrare, D. Winker, W. Petersen, M. Kacenelenbogen, D. Kirschbaum, A. Omar



Science Teams:
Science Impact Team (SIT) co-chaired by G. Mace, J. Redemann
Applications Impact Team (AIT) co-chaired by D. Kirschbaum, A. Omar

Study Progress

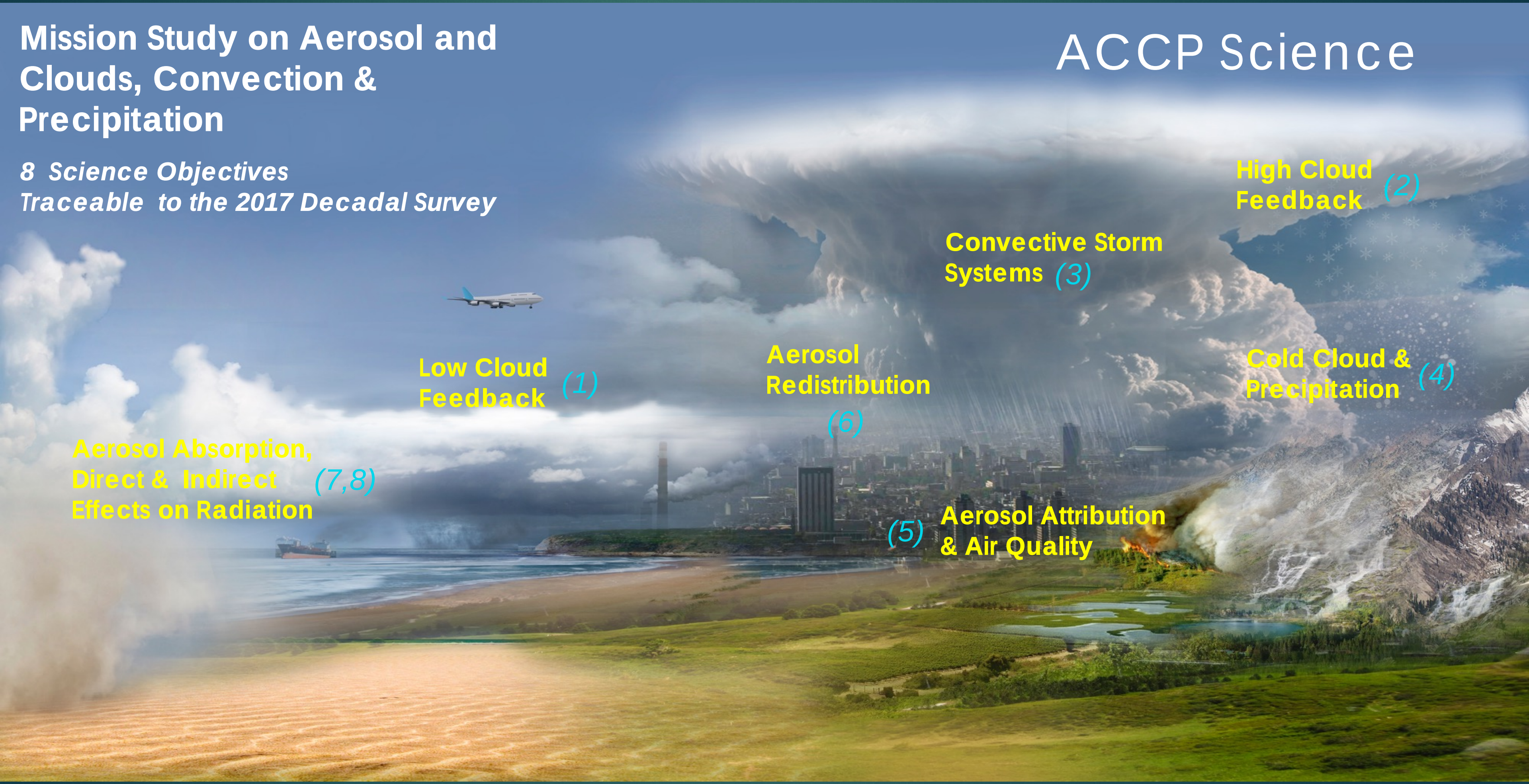
Science Definition Roadmap



Science Goals, Traceability to DS17

Overarching ACCP Goal	2017 DS Most Important Very Important	Goals
Understand the processing of water and aerosol through the atmosphere and develop the societal applications enabled from this understanding.	W-1a, W-2a, C-2a, C-2g	G1 Cloud Feedbacks Reduce the uncertainty in low- and high-cloud climate feedbacks by advancing our ability to predict the properties of low and high clouds.
	W-1a, W-2a, W-4a, C-2a, H-1b, C-2g, C-5c	G2 Storm Dynamics Improve our physical understanding and model representations of cloud, precipitation and dynamical processes within deep convective storms.
	W-1a, H-1b, S-4a, W-3a	G3 Cold Cloud and Precipitation Improve understanding of cold (supercooled liquid, ice, and mixed phase) cloud processes and associated precipitation and their coupling to the surface at mid to high latitudes and to the cryosphere.
	W-1a, W-5a, C-5a	G4 Aerosol Processes Reduce uncertainty in key processes that link aerosols to weather, climate and air quality related impacts.
	C-2a, C-2h, C-5c	G5 Aerosol Impacts on Radiation Reduce the uncertainty in Direct (D) and Indirect (I) aerosol-related radiative forcing of the climate system.

ACCP Science Objectives



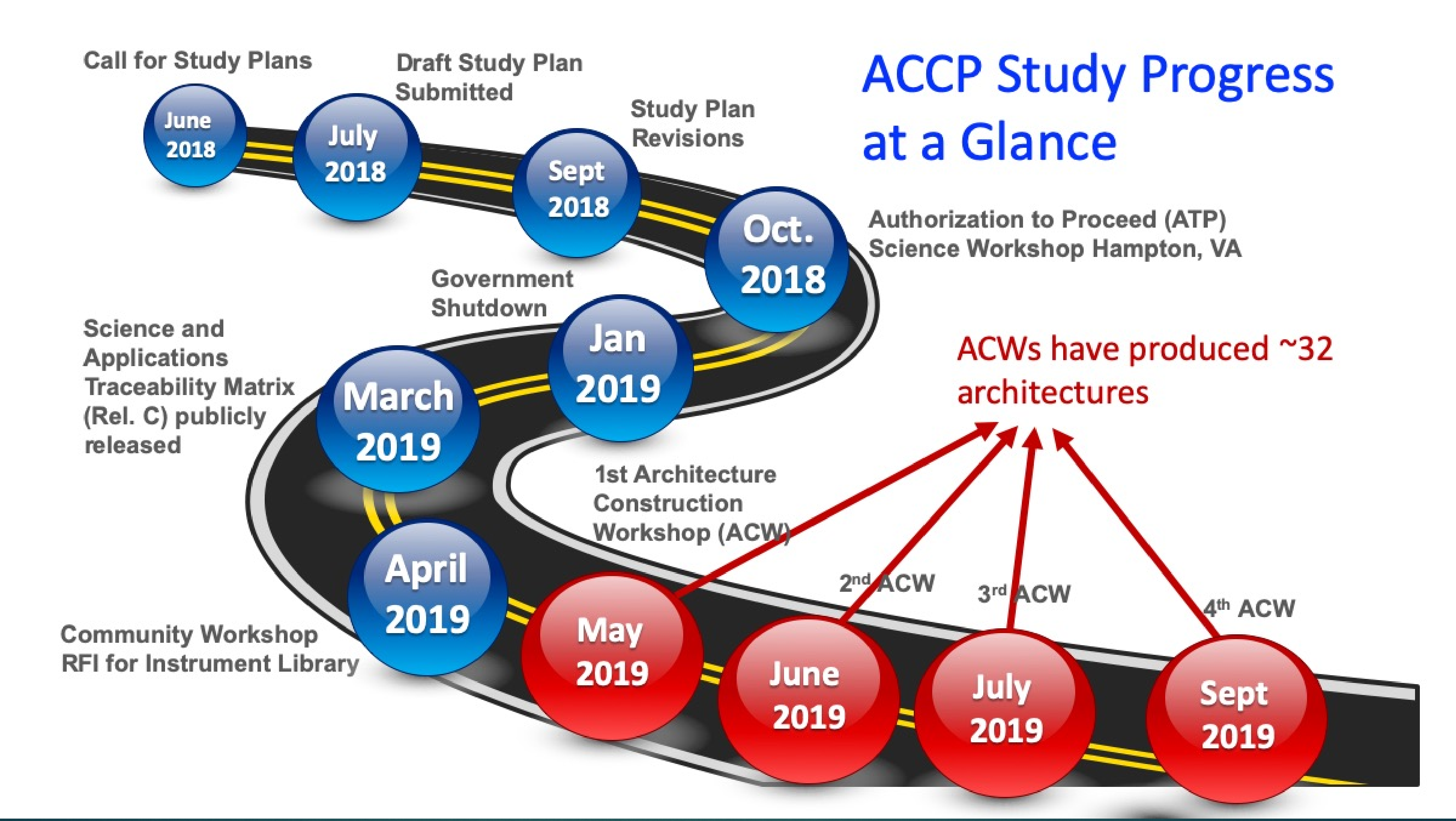
ACCP Framing Assumptions for Minimum Desired capabilities

- ACCP is a combined Aerosols and CCP process-oriented Earth Observing System, although mapping capabilities highly desired.
- Payload may consist of:
  a) Active sensors (lidars and radars)
  b) Several passive radiometers (passive MW radiometer, polarimeter, spectrometer)
- ACCP is an Earth Observing System potentially consisting of
  a) A space-based mission (payload, spacecraft, launch vehicle)
  b) A fully integrated, sustained sub-orbital component
  c) The Program of Record (existing/planned satellites/suborbital assets) at the time of ACCP operations

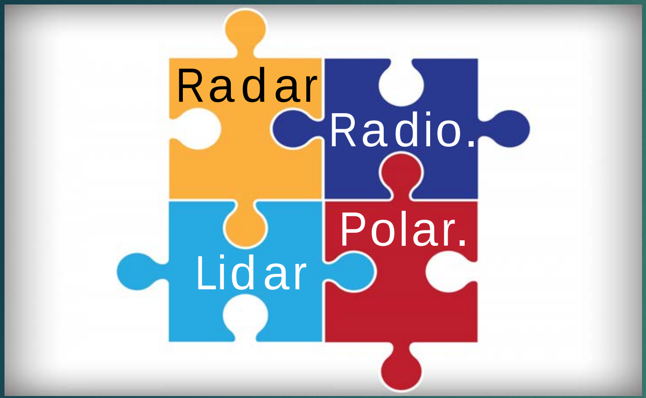
ACCP Constraints

- Define minimum and enhanced desired capabilities, not threshold and baseline requirements
- Instruments will be selected from existing capabilities rather than designed to desired science capabilities
  - Must be of sufficiently high technical readiness (TRL6) by mission preliminary design review
- Finding an observing system that meets objectives is ultimately dependent on knowledge of available capabilities (Instrument Library)

Recent Study Progress – Architecture Construction



ACCP Architecture Study



Architecture Components:

- Instruments
- Spacecraft buses
- Ground systems
- Launch vehicles
- Mission operations
- Suborbital observations/GV
- Science team

- Study instrument library includes a broad range of capabilities
- Radars include W, Ka, Ku bands, Doppler and non-Doppler, scanning and nadir only
- Radiometers include cross-track and conically scanning, frequencies ranging from 10 to 883 GHz
- Lidars include 2 and 3 frequencies, backscatter and HSRL
- Polarimeters include varying channels (5 to hyperspectral) and angles (5 to 255)
- Spectrometers include VIS, NIR, SWIT, LWIR, TIR

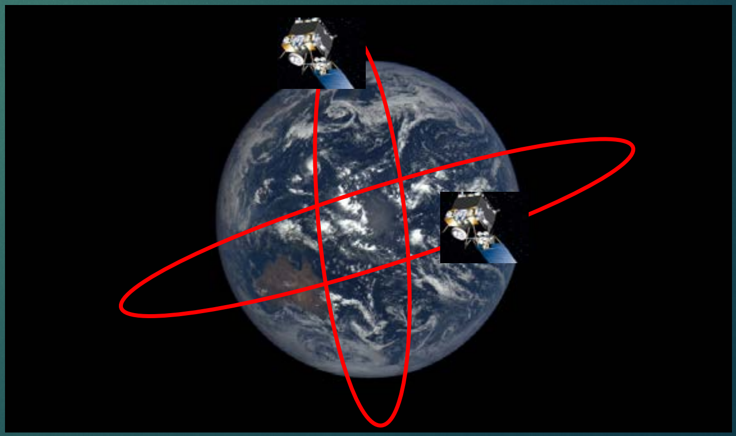
Architecture Construction Workshops (ACWs)

The ACWs explored

- Single- and dual- medium-to-large satellites
- Smallsat (<180 kg) systems
- Hybrid small/large satellite systems
- Constellations of cubesats
- Impacts of international contributions

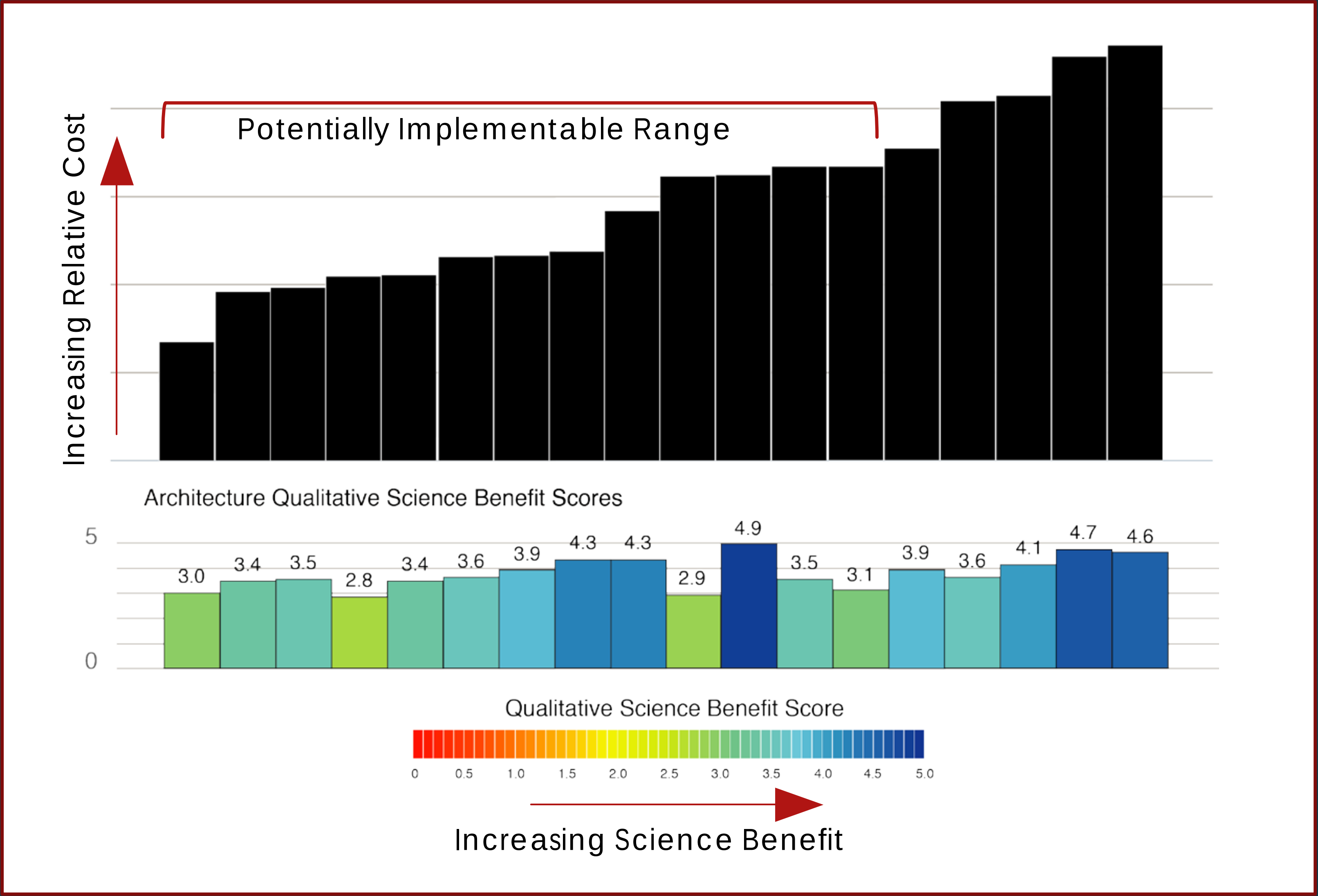
Polar orbit solutions

Inclined orbit additions



ACW General Findings

Results for first 18 architectures



Value Framework

Key parameters for assigning a science benefit score include the ***utility*** of geophysical variables for achieving the science objectives and the ***quality*** of the geophysical variables that are derived from each architecture.

The value framework will allow for a fairly objective cost-benefit assessment of the architectures considered within the observing system study.

An illustrative example of value framework scoring

$$B = \sum UQ$$

B = Family/Customer Satisfaction

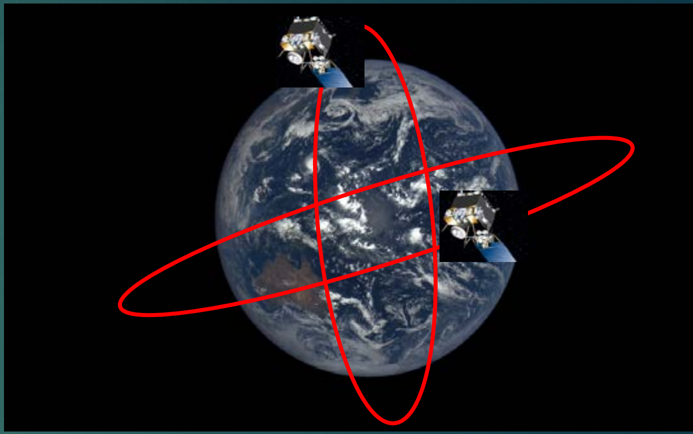
TRADITIONAL HAMBURGER RECIPE

Ingredients	Utility	Quality
Patty	0.60	1.0 = ½ lbs, 100% Angus Beef, Charbroiled 0.4 = vegan "Impossible" burger
Bun	0.20	0.8 = sesame seed topped whole wheat bun 0.4 = small, white bread bun
Cheese	0.10	0.9 = Cheddar 0.6 = American 0.3 = Mozzarella
Tomato	0.04	etc
Lettuce	0.04	etc
Onions	0.01	etc
Ketchup	0.01	etc

Utility is the importance of the Ingredient to the Recipe
Quality is the quality of the given ingredient relative to a best possible
(NOTE: Utility is probably more subjective than Quality)

CDC#1 Architecture

Dual-satellite, dual-orbit architecture with:



Polar satellite:
- W, Ka-band non-scanning radar, Ka Doppler
- Radiometer with 118, 183 GHz, and several sub-mm channels
- Dual-wavelength lidar, HSRL @ 532 nm
- Thin ice cloud spectrometer (contributed)
- 60-angle polarimeter

GPM-orbit satellite:
- W, Ka-band non-scanning radar, Ka Doppler
- Radiometers with 183/325/670 GHz
- Smallsat dual-wavelength backscatter lidar
- 60-angle polarimeter

Study Summary

- Science and Applications Traceability Matrix (SATM) is maturing, but still under development.
- Exploring international partnerships
- Conducted 4 Architecture Construction Workshops (ACWs)
  - Defined ~32 different architectures ranging from large single satellites to constellations of small satellites with a range of different instrument capabilities.
- First Collaborative Design Center study in October—deeper dive into architecture, costs, risks, etc.
- Earliest possible launch likely in late 2020s