ATMOSPHERE
Observing System

National Aeronautics and
Space Administration

AOS Community Forum—An AOS Status Update

July 13, 2022

Pre-Decisional

Overview of AOS Constellation Concept & Science

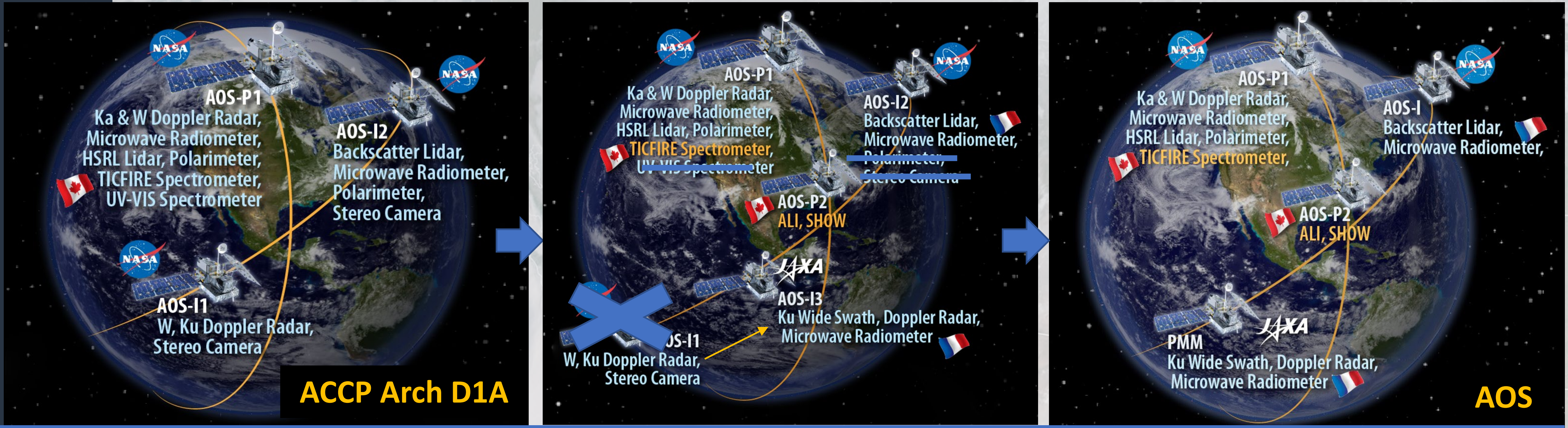
- Welcome and thank you for dialing in!
- We are very excited to have the 3rd Community Forum following Project Authorization in May 2021
- AOS recently completed the Mission Concept Review
  - Trade studies as part of pre-phase A activities resulted in adjustments to the architecture from the 2+ year Architecture Study responding to the Aerosol (A) and Cloud, Convection and Precipitation (CCP) Designated Observables called out in the 2017 Earth Science Decadal Survey
- The community forum purpose is to provide updates on the current constellation architecture and science capabilities
  - Time has been allocated for questions

Agenda

- Architecture & Instrument Overview (10 min) – Jason Hair
- Science Trades and Overview (10 min) – Scott Braun
- Applications Considerations (5 min) – Emily Berndt
- Sub-Orbital Program (5 min) – Dan Cecil
- Plan Forward for AOS (5 min) – Jason Hair
- Ways to Stay Informed (5 min)
- Questions

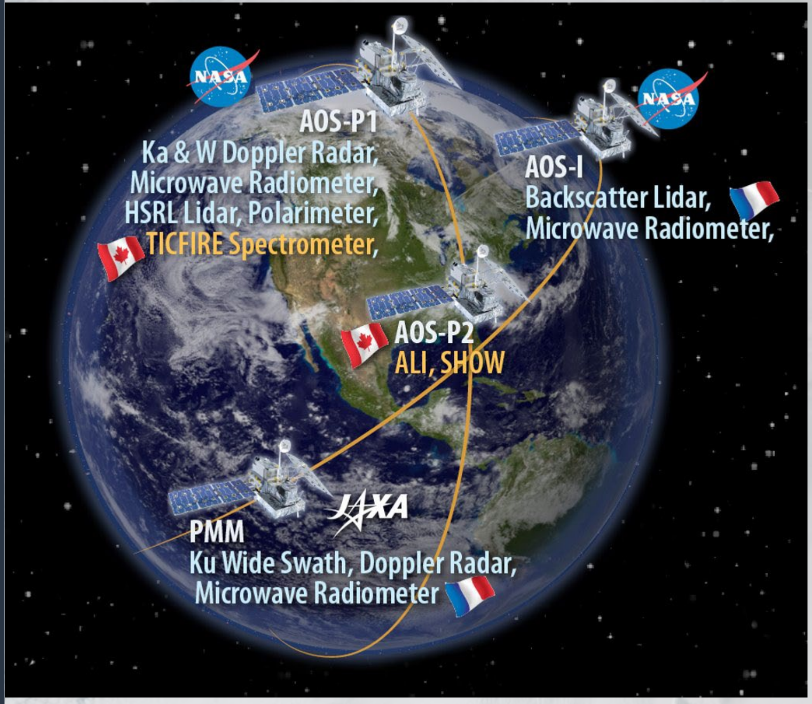
AOS Architecture from MCR

- Substantial trade efforts to enable the maximum science capability within cost constraints resulted in an updated AOS constellation architecture presented at MCR
- International contributions enable AOS science capability to be preserved at lower cost
  - Ku Band Doppler Radar shifted from JPL to JAXA Contribution
  - Inclined delta-time measurement shifted from Industry Stereo Cameras to pair of Contributed CNES Microwave Radiometers
  - Descoped JPL W Band Radar, Inclined Polarimeter, and Shortwave Spectrometer
  - CSA Contributed Longwave Spectrometer (TICFIRE)
  - CSA Observatory (AOS-P2) provides an aerosol limb sounder and water vapor sensor



Evolution of ACCP Study D1A Architecture to AOS Projects

One Constellation/ Two Projects/ Synergistic Science and Resources



- AOS-I Project launch is First in July 2028
  - NASA provides AOS-I with Backscatter Lidar and CNES contributed Microwave Radiometer
  - NASA launches AOS-I with a JAXA contributed observatory (PMM) which provides Ku Wide Swath Radar and also hosts a second CNES contributed Microwave Radiometer
- AOS-P Project launch is December 2030
  - NASA provides AOS-P1 with High Spectral Resolution Lidar, Ka/W Band Doppler Radar, Microwave Radiometer, Polarimeter and CSA contributed Thermal Infrared Spectrometer
  - NASA launches AOS-P1 with a CSA Observatory (AOS-P2, now HAWCsat) which provides an aerosol limb sounder and water vapor sensor

Agenda

- Architecture & Instrument Overview (10 min) – Jason Hair
- Science Trades and Overview (10 min) – Scott Braun
- Applications Considerations (5 min) – Emily Berndt
- Sub-Orbital Program (5 min) – Dan Cecil
- Plan Forward for AOS (5 min) – Jason Hair
- Ways to Stay Informed (5 min)
- Questions

Assumptions Guiding Architecture Modifications During Pre-Phase A

- AOS is two projects (AOS-I, AOS-P), both addressing A and CCP science
- Polar mission critical to meeting minimum desired capabilities for Aerosols and Climate
  - Preserve polar to the extent possible
- Inclined provides varying-time-of-day measurements, early science
  - Inclined project best suited to convection (O3) and associated high clouds (O2)
  - Ku radar required for threshold in inclined
- Active profiling emphasized over passives

AOS Synergy

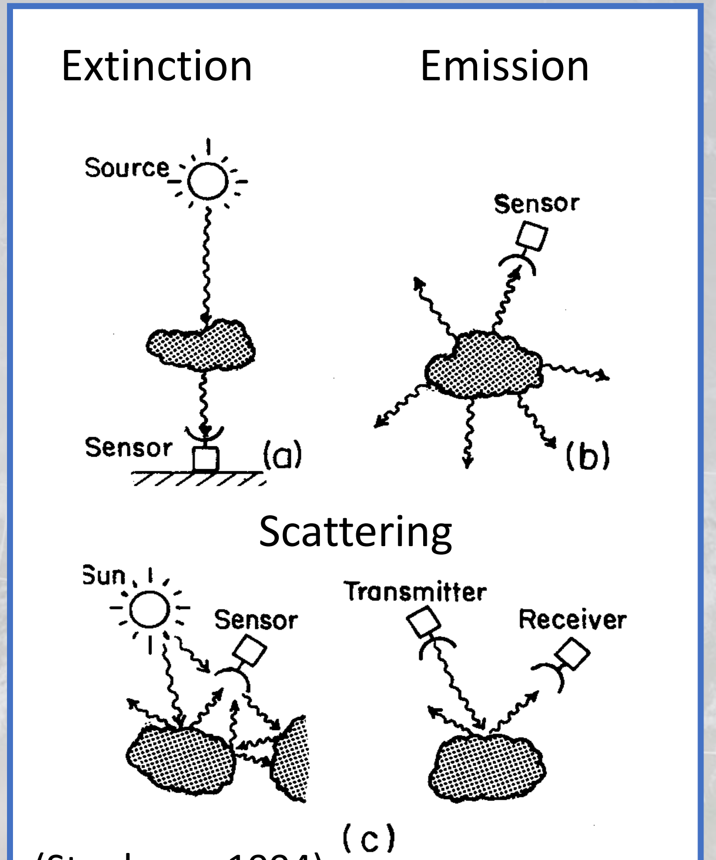
Synergy is central to the AOS observing strategy

Scientific whole>sum of scientific parts

Synergy offers:

(i) A much more integrated view of Earth than possible with single measurement
(ii) Tighter constraints on & better consistency of information retrieved
(iii) The ability to fill gaps in GVs
(iv) The possibility of extracting entirely new & refined information about ‘process’ from combinations of different observations

The compelling value of measurement ‘synergy’ has been amply demonstrated with the A-Train constellation



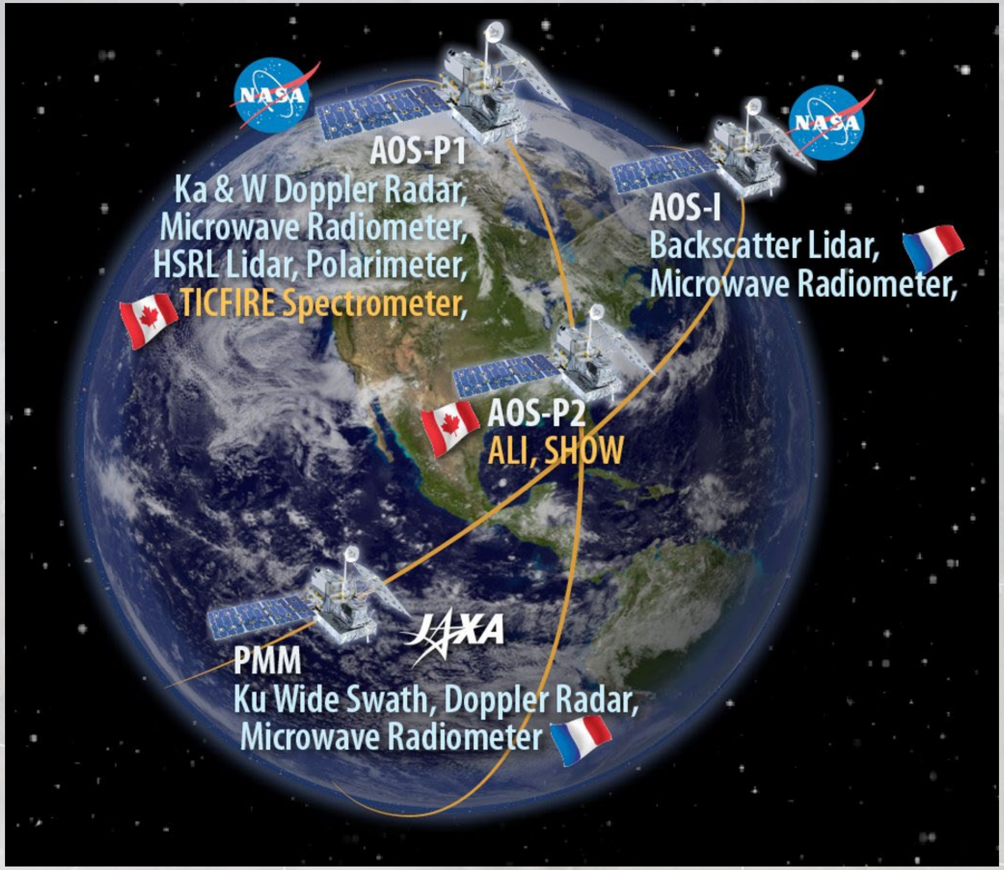
(Stephens, 1994)

Different physics offer different perspectives on processes

ATMOSPHERE
Observing System

Five First-Evers of AOS

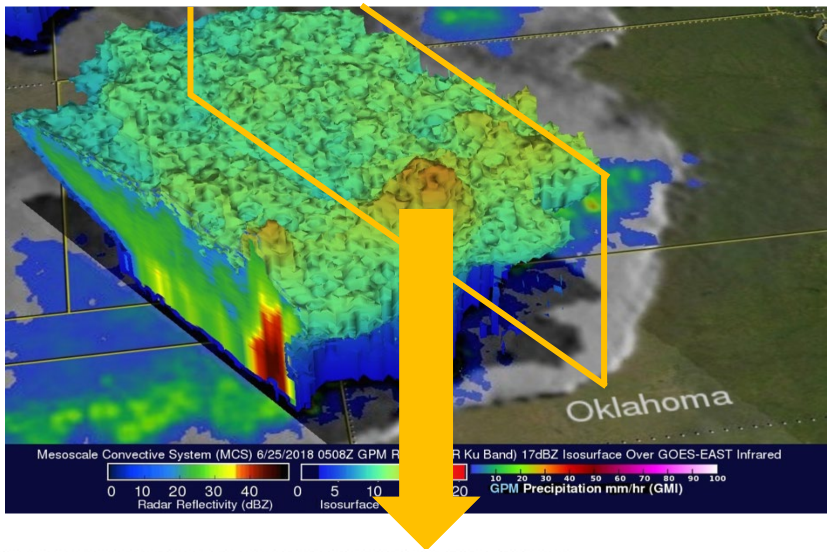
1. Global and Diurnally Varying Observations of Convective Vertical Motions
2. Global Profiles of Aerosol Properties (absorption, type, size)
3. Co-located Dynamics, Cloud and Precipitation Microphysics, Longwave Radiation, and Aerosol Characteristics
4. Short Time-Scale Evolution of Cloud and Precipitation Processes
5. Diurnal Variability of Coincident Cloud, Precipitation, and Aerosol Profiles



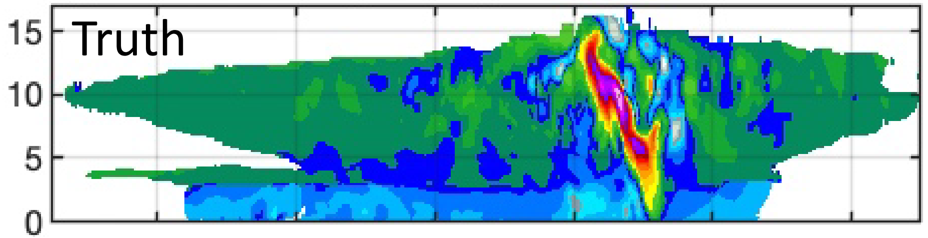
A Visual View of AOS-Inclined

Launch NET July 2028

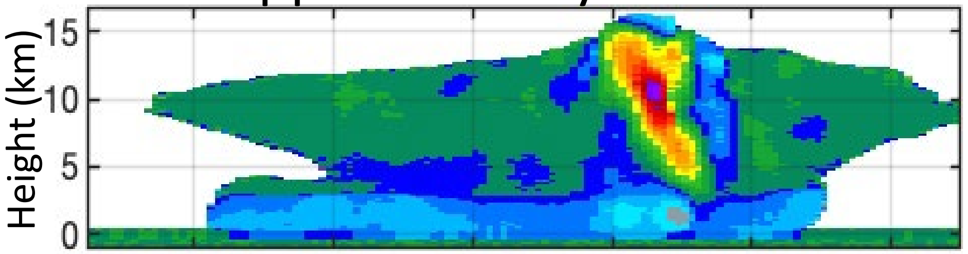
JAXA Wide Swath Ku Doppler Radar



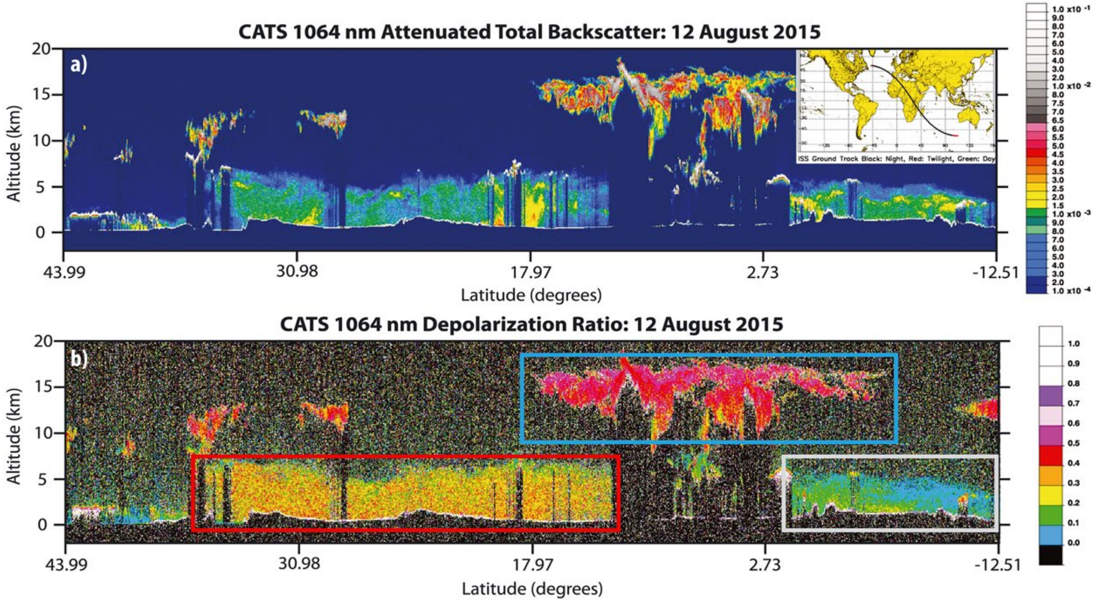
b) No radar sampling effects (13-GHz)



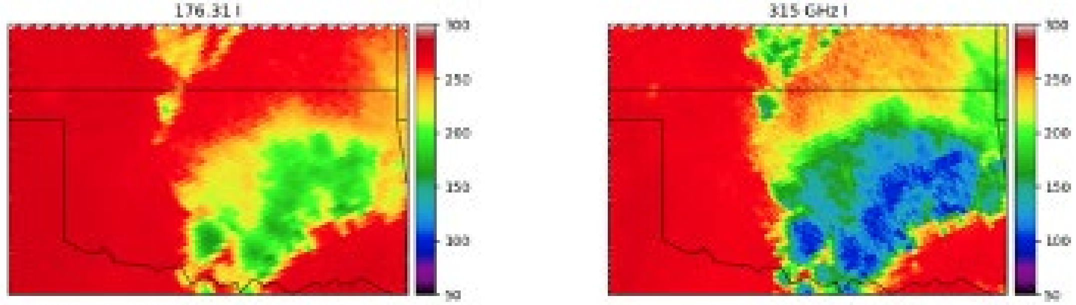
Ku Doppler Velocity



ALICAT 532-, 1064-nm Backscatter Lidar



CNES Microwave Radiometers (89, 183, 325 GHz)



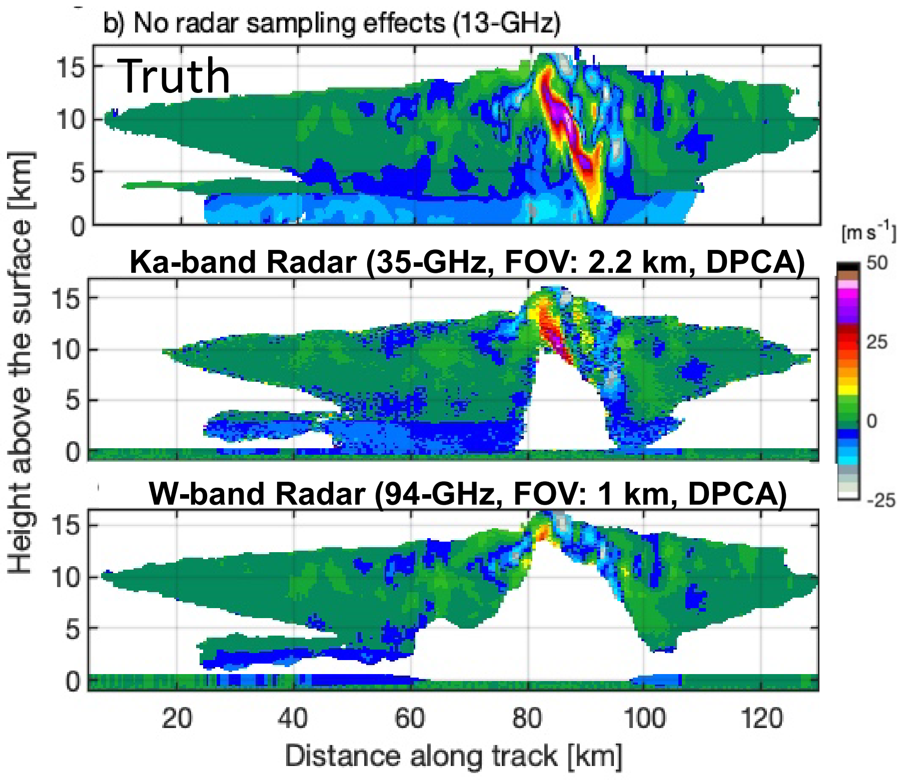
55° Inclination: Compromise between NASA, JAXA, CNES

ATMOSPHERE Observing System

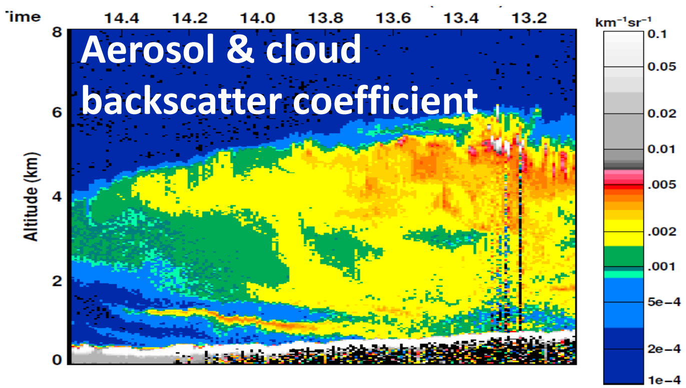
A Visual View of AOS-Polar

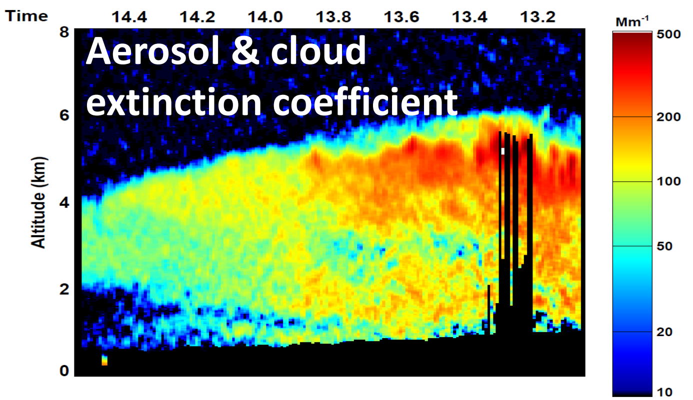
Launch NET December 2030

W-, Ka-band Doppler Radars

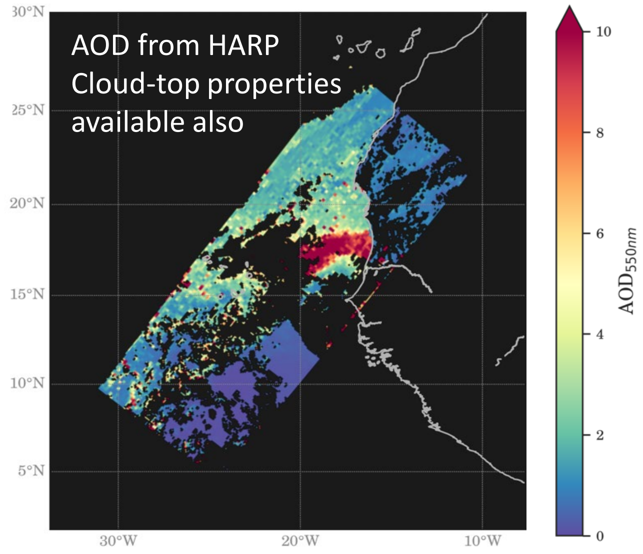


532 nm HSRL, 1064 Backscatter Lidar

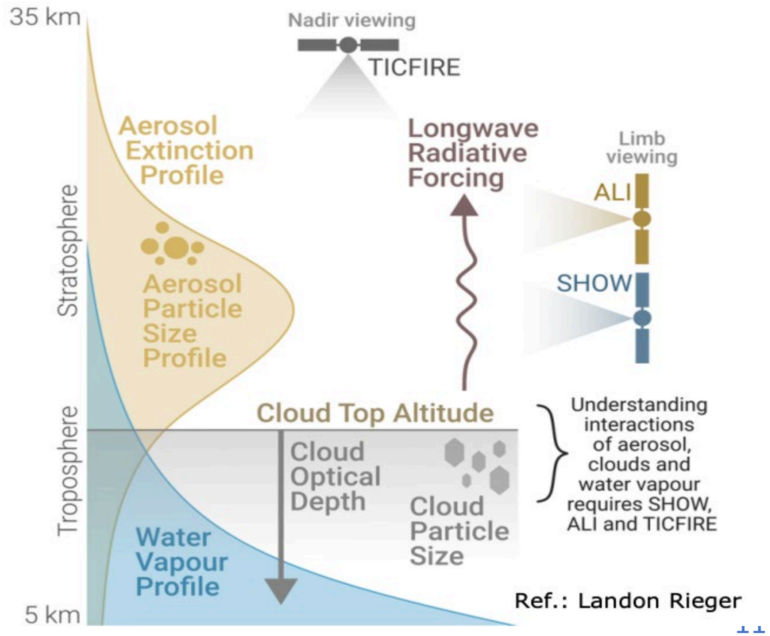




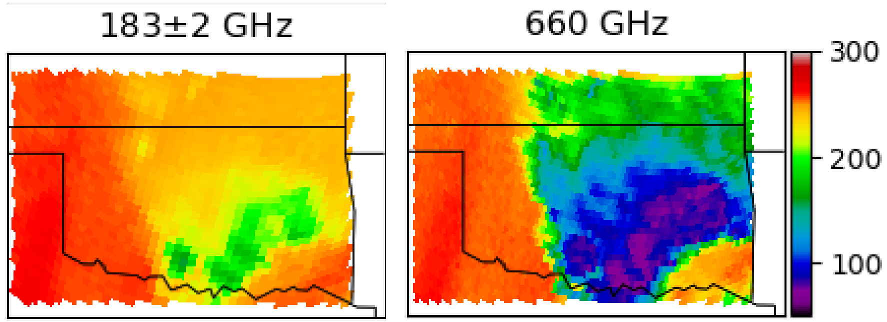
UV-VIS-NIR-SWIR Multi-angle Polarimeter



CSA LWIR-FIR Spectrometer (4-73 μm) Aerosol/Moisture Limb Sounding



Microwave Radiometer: 89-700 GHz



ATMOSPHERE
Observing System

Potential for Future Changes

- NASA HQ organized Independent Review Board (IRB)
  - Will review all Designated Observable (DO) missions of the ESO
  - Examining scope of each mission within the context of the ESO budget
  - May recommend changes to DO missions
- The “easy” descopes have been taken—painful within-instrument descopes most likely
  - Polar lidar and radar have highest cost and risk
- IRB recommendations expected in September, KDP-A review late September or mid October

Agenda

- Architecture & Instrument Overview (10 min) – Jason Hair
- Science Trades and Overview (10 min) – Scott Braun
- Applications Considerations (5 min) – Emily Berndt
- Sub-Orbital Program (5 min) – Dan Cecil
- Plan Forward for AOS (5 min) – Jason Hair
- Ways to Stay Informed (5 min)
- Questions

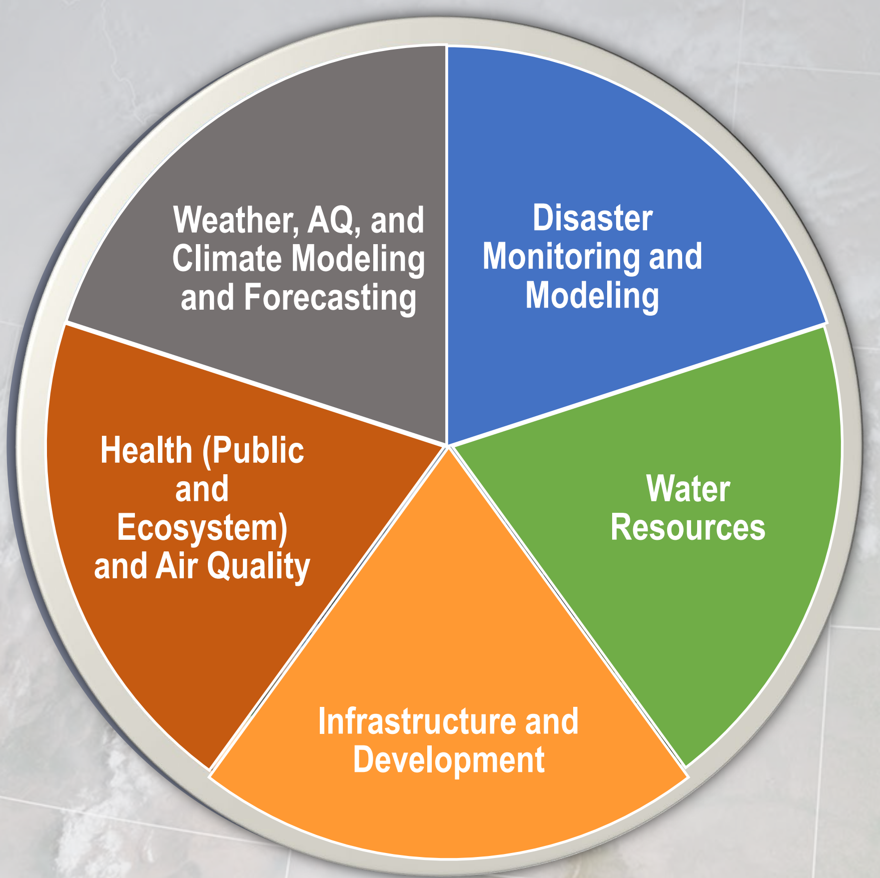
ATMOSPHERE
Observing System

AOS Applications

AOS will provide key information to support decision making at timescales from hours to decades, enabling improved weather and air quality forecasting today, seasonal to sub-seasonal changes in the near future, and societal challenges resulting from climate change in the decades to come.

The AOS Applications Team (AIT) is charged with **ensuring that applications are considered to the greatest extent possible** in mission design and implementation.

Phase-A activities focus on development of a Project Applications plan and recruitment of the earliest Early Adopters



ATMOSPHERE Observing System

AIT Team

Applications Team Lead and rep to SATT
- Emily Berndt (MSFC)

Applications Coordinator
- Andrea Portier (GSFC)

"CCP" Application Leads
- Anita LeRoy (MSFC)
- Svetla Hristova-Veleva (JPL)

"A" Application Leads
- Elizabeth Wiggins (LaRC)
- Melanie Follette Cook (GSFC)

Suborbital Application Lead
- Bryan Duncan (GSFC)

External Partners Leads
- Pierre Kirstetter (NOAA)
- James Campbell (NRL)

NASA Team Members
- Aaron Naeger (MSFC)
- Olga Kalashnikova (JPL)

International Team Members
- Danahe Paquin-Ricard (ECCC)
- Takuji Kubota (JAXA)
- Yasutaka Ikuta (JMA)

NASA Team Volunteer Participants
- Levi Goldston (ARC)
- Jonathan Jiang (JPL)
- Baijun Tian (JPL)
- Jason Tackett (LaRC)
- Kenneth Pickering (GSFC)
- Amita Mehta (GSFC)

Phase-A Activities

- *Project Studies* to enhance applications benefit
- *Collaborate with* Science Team to prioritize algorithms and identify potential near-real time products
- *Stakeholder outreach* via seminars and focus groups
- *Coordinate/Collaborate* with other DO projects and HQ

Applications Seminars

- 4 AOS Applications Seminars: lectures and thematic panels (https://aos.gsfc.nasa.gov/events.htm)

Community Assessment Report

- Deliverable: Pre-Phase A Requirement
- CAR serves to document and synthesize information and **needs from applications communities relevant to AOS t**hat include communities of practice and potential
- CAR makes recommendations and provides suggested guidelines for how **components of the AOS mission may be optimized** for enhanced applications value
- CAR is a living document that will be **maintained throughout the mission life cycle** (e.g., updates will be made as changes in the architecture could impact application opportunities)

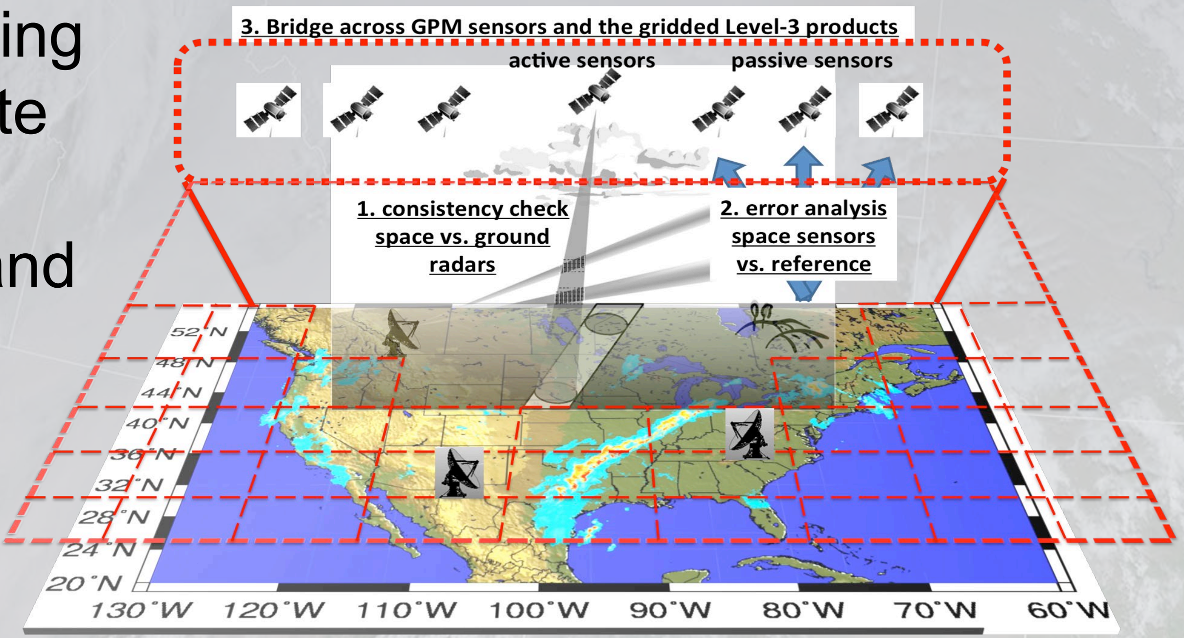
Atmosphere Observing System (AOS)
Community Assessment Report (CAR)

April 2022

The objective of this Community Assessment Report (CAR) is to provide an overview of key stakeholder communities and their needs relevant to the Atmosphere Observing System (AOS) in terms of their current use and potential application of data products for decision making. This report is based solidly on input from stakeholders and serves as a reference to articulate stakeholder needs as well as provide guidelines for how to optimize the applications benefit to communities of practice and communities of potential that may use the suite of AOS products.

AOS Suborbital Applications

- Suborbital provides early science and learning how to use the new AOS and related satellite measurements
- Bridge across a spectrum of observations and stakeholder needs
- Build from prior applications successes:



Current/Planned Examples

Synergy with spaced-based data and external field campaigns: Synergistic TEMPO Air Quality Science (STAQS) mission will integrate TEMPO satellite observations with *in situ* air quality monitoring to advance air quality estimates

Engaging Local Users: DISCOVER-AQ designed flight paths to pass over and complement air quality measurements gathered at the surface by local air quality agencies

Bridging the Gap: GPM Ground Validation provides consistency checks for inputs to NOAA Multi-Radar/Multi-Sensor System.

Filling Data Voids: GPM Ground Validation dis-drometers in Alaska and GPM precipitation are provided to the Juneau NWS forecast office for Enhanced forecasting

Agenda

- Architecture & Instrument Overview (10 min) – Jason Hair
- Science Trades and Overview (10 min) – Scott Braun
- Applications Considerations (5 min) – Emily Berndt
- Sub-Orbital Program (5 min) – Dan Cecil
- Plan Forward for AOS (5 min) – Jason Hair
- Ways to Stay Informed (5 min)
- Questions

Science Objectives flow down from overall AOS objectives to inter-related suborbital themes:

EARTH SYSTEM OBSERVATORY

O1, O4, O6, O8: Low Clouds

Characterize processes associated with cloud droplet, ice crystal, and precipitation initiation, and precipitation phase.

O2, O3, O6: Convection and High Clouds

Understand controls on convective storm processes and lifecycle, and anvil cirrus lifecycle.

O5, O6, O7, O8: Aerosol-Cloud-Radiation Interaction, Aerosol Attribution and Redistribution

Quantify vertically-resolved aerosol-cloud-radiation interaction processes, coupled with aerosol attribution and lifecycle.

ACCP Science Objectives		Key Science Focuses
O1	Low Clouds	Sensitivity of low clouds to environmental factors (thermodynamics/dynamics); solar radiative climate feedbacks
O2	High Clouds	Relationship of high cloud formation/properties to deep convection, large-scale environment; infrared radiative climate feedbacks
O3	Convective Storms	Relationship between storm vertical motions and microphysics
O4	Cold Clouds and Precipitation	Processes that govern phase partitioning and precipitation formation in cold clouds; key drivers of climate feedbacks at highlatitudes
O5	Air Quality and Aerosol Attribution	Identifying major sources of aerosols and their type/species; factors that relate aerosol microphysical/optical properties to near-surfaceair quality
O6	Aerosol Redistribution and Processing	Wet removal and processing of aerosol by clouds and precipitation; impacts of vertical and long-range transport of aerosol
O7	Aerosol Direct Effects	Role of aerosols in the Earth's energy budget; impact of absorbing aerosols on climate
O8	Aerosol Indirect Effects	Aerosol impacts on clouds and precipitation systems; modulation of climate forcing due to changes in cloud radiative properties

Timeline

Phase C | **Phase D** | **Phase E**

Augment existing surface-based networks / supersites

Leverage relevant external field campaigns

AOS-I launch NET July 2028

Large airborne campaign, mid-latitude continental?, spring-early summer (?) after AOS-I launch (~2029)

AOS-P launch NET Dec 2030

Large airborne campaigns, oceanic?, early summer (?) after AOS-P launch (~2031 and 2032)

Campaigns after launch to enable cal-val

Airborne Campaign payload concept

Two-Three aircraft, one is over-cloud top cloud/precip/aerosol/radiation remote sensors. One is mid-high remote sensor for aerosol and low cloud, with in situ probes. One is low-altitude in situ with radiation. Heritage instruments available for key needs.

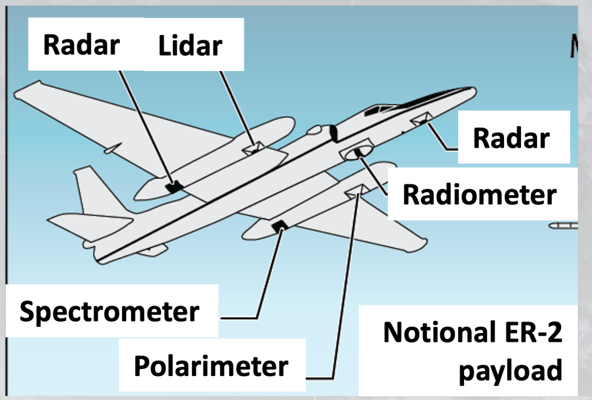
1) **High-altitude aircraft (~ER-2)** with 4-freq radar(s), microwave radiometers spanning ~ 19-700 GHz, polarimeter, lidar, radiation.

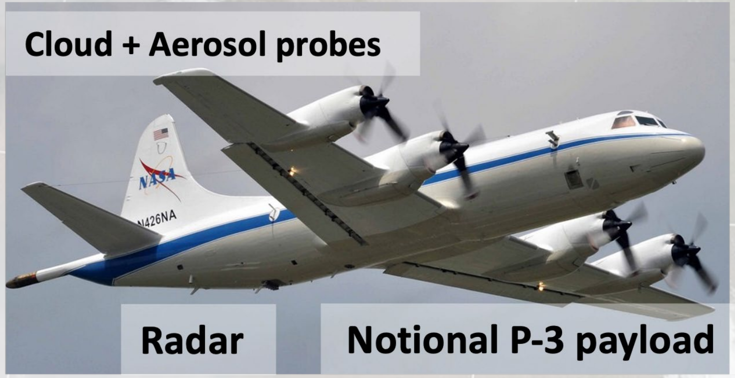
2) **~DC-8, G5, Falcon or similar**: wind lidar, polarimeter, HSRL, radar, ice microphysics, aerosol, cloud, precip in situ probes, in situ thermodynamics and wind, radiation

3) **~P-3, C130, Challenger 850 or similar** with aerosol, cloud, precipitation probes, thermodynamics and wind, radiation.

+ Surface-based instrumentation, small UAS?

Payloads depicted are notional… instruments to be prioritized / deconflicted for each campaign

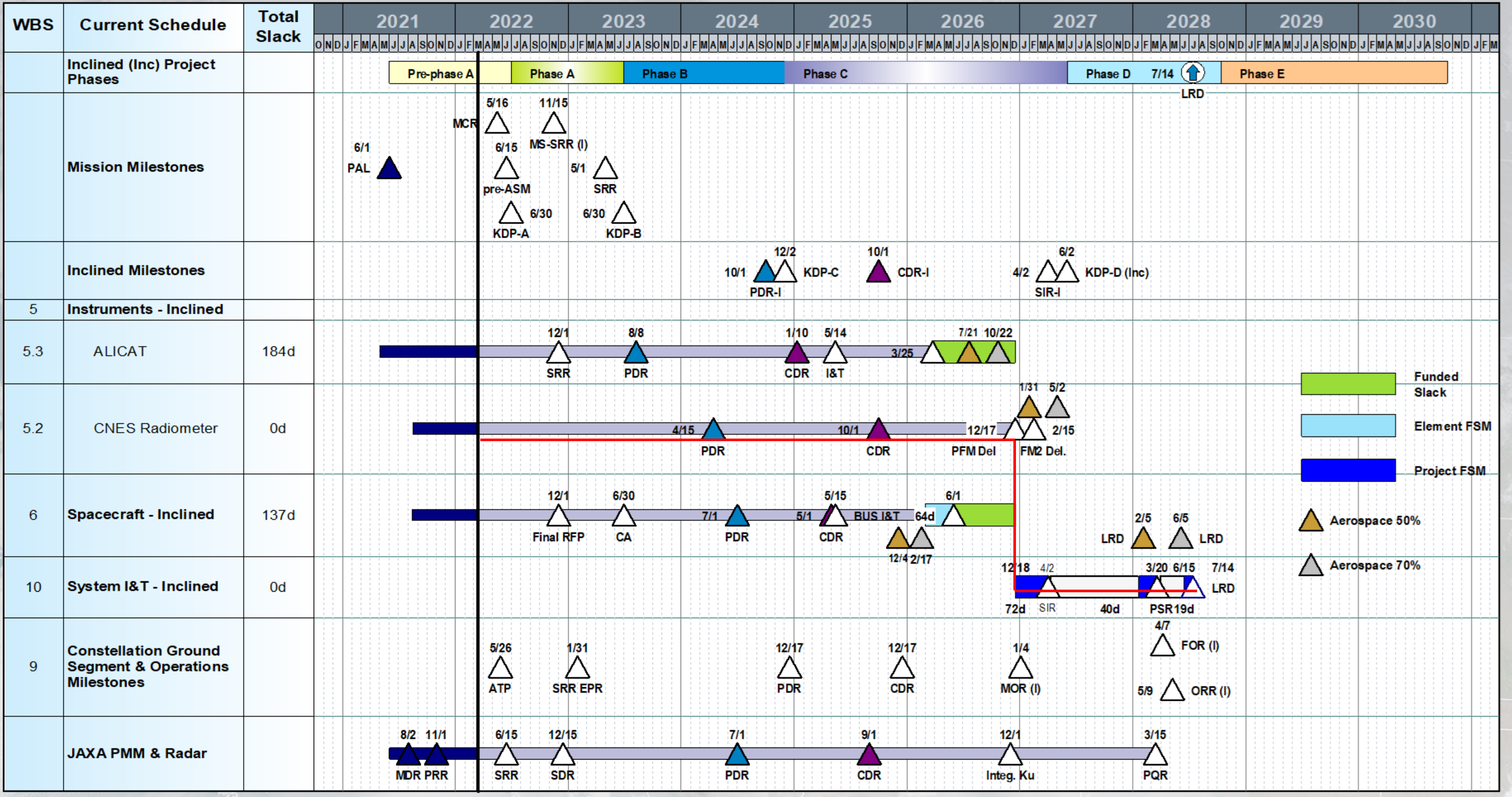




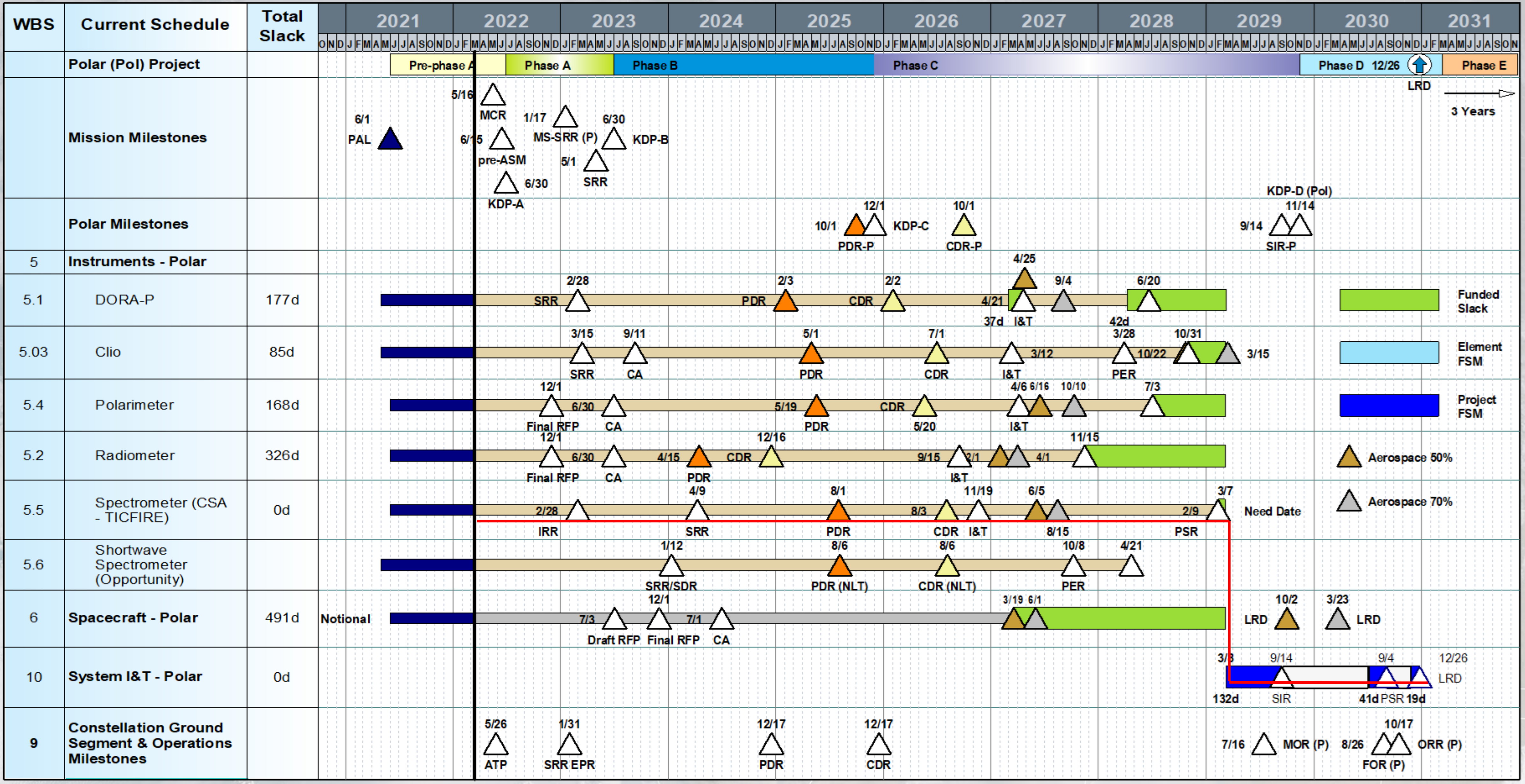
Agenda

- Architecture & Instrument Overview (10 min) – Jason Hair
- Science Trades and Overview (10 min) – Scott Braun
- Applications Considerations (5 min) – Emily Berndt
- Sub-Orbital Program (5 min) – Dan Cecil
- Plan Forward for AOS (5 min) – Jason Hair
- Ways to Stay Informed (5 min)
- Questions

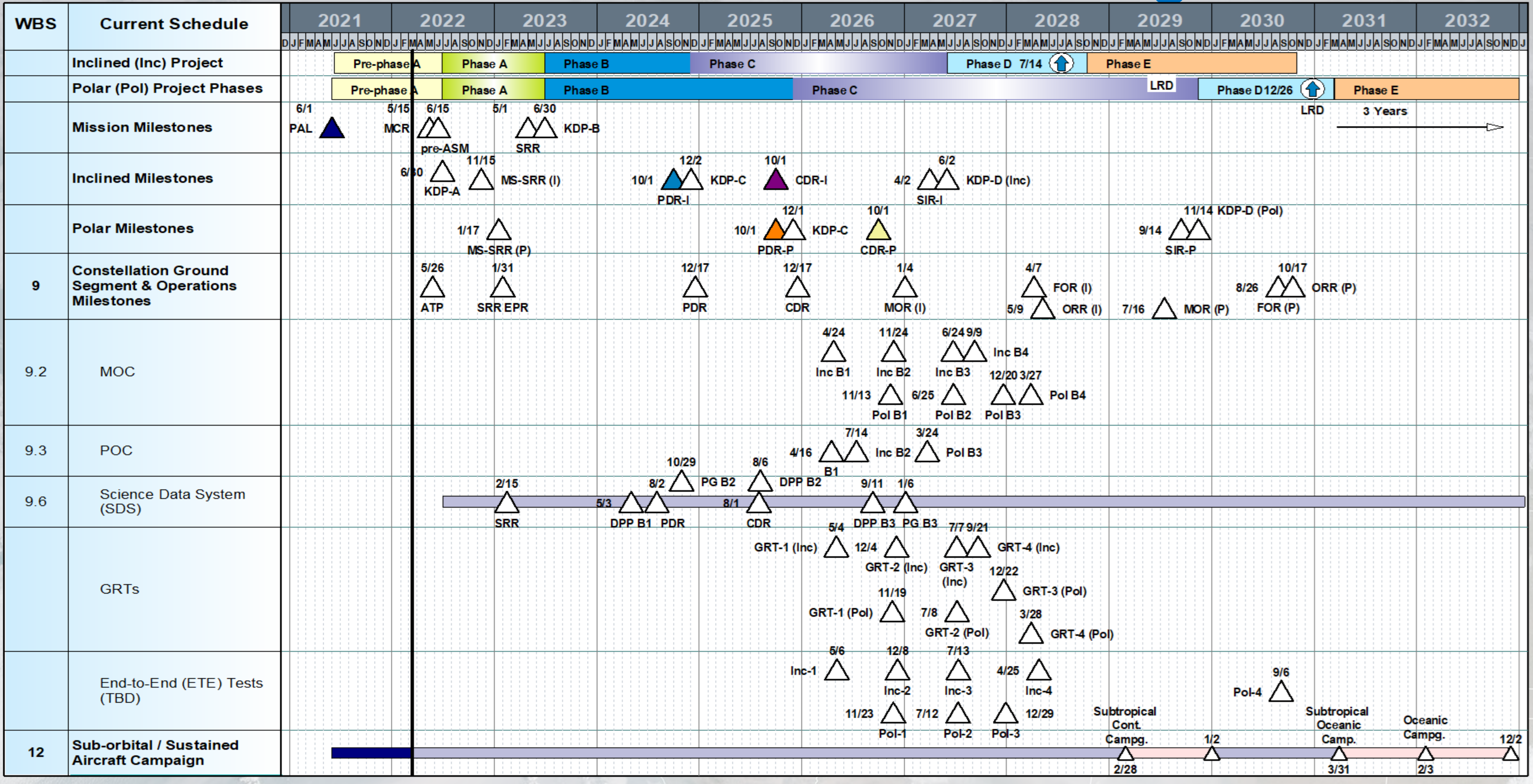
AOS Master Schedule – Inclined (July 2028 Launch)



AOS Master Schedule – Polar (December 2030 Launch)



AOS Master Schedule – Ground Segment



AOS Path Forward

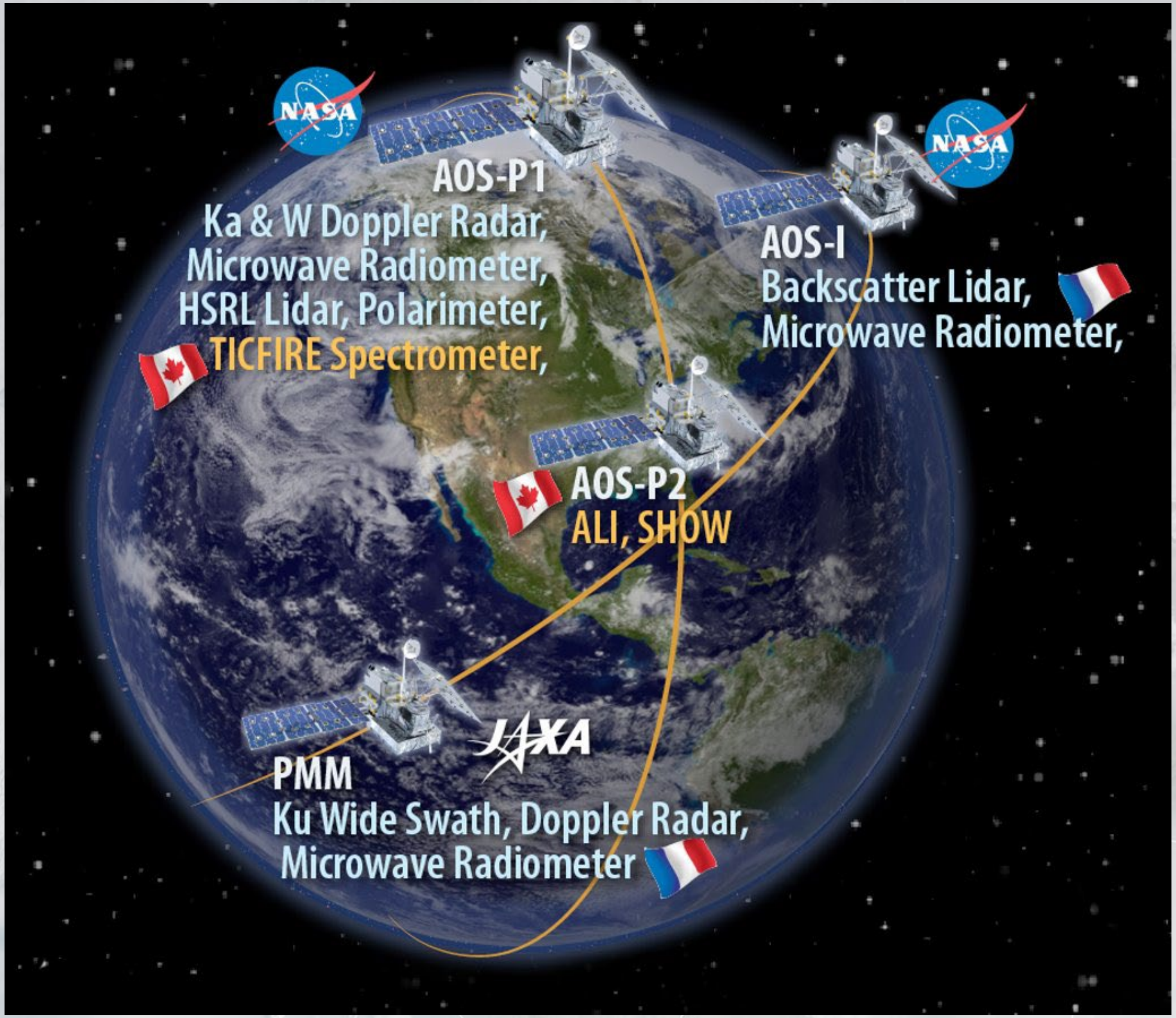
- Information presented is pre-decisional
- Mission Concept Review and pre-Acquisition Strategy Meeting (ASM) have been held
- ASM and Key Decision Point-A are planned for October 2022
- System Requirements Review / Mission Definition Review planned for late Spring 2023
- Proceed with elements (Spacecraft and/or Instruments) approved through ASM
    - Anticipated timeframes for Request for Proposal Release are Winter 2023 through Fall 2023

Ways to stay informed

- Web-Site https://aos.gsfc.nasa.gov
- Contact Sheri Smith @ aos-comments@lists.nasa.gov
- Contact Project Team Personnel (POCs on web-site)
- AGU Sessions December

ATMOSPHERE
Observing System

Questions?



Backup slides

Assumptions Guiding Architecture Modifications

- Two projects, <u>both</u> addressing A and CCP science
- Preserve polar to the extent possible
- Inclined project best suited to convection (O3) and high clouds (O2)
- Ku radar required for threshold in inclined
- Active profiling emphasized over passives

Descope Options

Orbit	Science Descope Options from ACCP D1A	Sensor Capability
Inc	Limit cloud profiling focus to high clouds	Reduce capability of W-band radar
Inc	Descope low cloud/aerosol plume dynamics	Tandem stereo cameras
Inc	Prioritize aerosol vertical profiles over swath	Polarimeter
Inc	Prioritize profiling of high clouds over swath	MW radiometer
Inc	Remove profiling of thick clouds, add back swath	W-band radar, add back radiometer
Polar	Remove cloud-scale radiative fluxes	SW spectrometer
Polar	Reduce science capabilities	Within-instrument descopes

Opportunities

Orbit	Science Opportunities	Sensor Capability
Inc	Precipitation profiling and Doppler	JAXA Ku radar
Inc	Convective mass flux,	CNES radiometers
Polar	Aerosol and moisture sounding	CSA ALI, SHOW