AOS Community Forum—An AOS Status Update

July 13, 2022
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
  o NASA provides AOS-I with Backscatter Lidar and CNES contributed Microwave Radiometer
  o 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
  o NASA provides AOS-P1 with High Spectral Resolution Lidar, Ka/W Band Doppler Radar, Microwave Radiometer, Polarimeter and CSA contributed Thermal Infrared Spectrometer
  o NASA launches AOS-P1 with a CSA Observatory (AOS-P2, now HAWCsat) which provides an aerosol limb sounder and water vapor sensor
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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
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

Different physics offer different perspectives on processes

(Stephens, 1994)
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

ALICAT 532-, 1064-nm Backscatter Lidar

CNES Microwave Radiometers (89, 183, 325 GHz)

55° Inclination: Compromise between NASA, JAXA, CNES
A Visual View of AOS-Polar

Launch NET December 2030

W-, Ka-band Doppler Radars
b) No radar sampling effects (13-GHz)

Truth

Ka-band Radar (35-GHz, FOV: 2.2 km, DPCA)

W-band Radar (94-GHz, FOV: 1 km, DPCA)

Microwave Radiometer: 89-700 GHz
183± 2 GHz
660 GHz

Truth

Aerosol & cloud backscatter coefficient

Aerosol & cloud extinction coefficient

UV-VIS-NIR-SWIR Multi-angle Polarimeter

AOD from HARP Cloud-top properties available also

532 nm HSRL, 1064 Backscatter Lidar

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

Understanding interactions of aerosol, clouds and water vapour requires SHOW, ALI and TICFIRE

Ref.: Landon Rieger
Potential for Future Changes

• NASA HQ organized Independent Review Board (IRB)
  o Will review all Designated Observable (DO) missions of the ESO
  o Examining scope of each mission within the context of the ESO budget
  o May recommend changes to DO missions

• The “easy” descopes have been taken—painful within-instrument descopes most likely
  o Polar lidar and radar have highest cost and risk

• IRB recommendations expected in September, KDP-A review late September or mid October
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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.
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** that 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)
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:** Synergestic 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 disdrometers in Alaska and GPM precipitation are provided to the Juneau NWS forecast office for Enhanced forecasting.
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Science Objectives flow down from overall AOS objectives to inter-related suborbital themes:

**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.
## Timeline

<table>
<thead>
<tr>
<th>Phase C</th>
<th>Phase D</th>
<th>Phase E</th>
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<tbody>
<tr>
<td>AOS-I launch</td>
<td>AOS-P launch</td>
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<tr>
<td>NET July 2028</td>
<td>NET Dec 2030</td>
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Augment existing surface-based networks / supersites

Leverage relevant external field campaigns

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

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
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### AOS Master Schedule – Inclined (July 2028 Launch)

<table>
<thead>
<tr>
<th>WBS</th>
<th>Current Schedule</th>
<th>Total Slack</th>
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<tr>
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<td>Inclined (Inc) Project Phases</td>
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<td>Phase A</td>
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<td>Mission Milestones</td>
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<td>Constellation Ground Segment &amp; Operations Milestones</td>
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<tr>
<td>JAXA PMM &amp; Radar</td>
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*Note: Diagram not fully transcribed here.*
## AOS Master Schedule – Polar (December 2030 Launch)

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<th>WBS</th>
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<th>Total Slack</th>
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<td>Shortwave Spectrometer (Opportunity)</td>
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### Milestone Diagram:

- **KDP-A**: 6/1
- **SRR**: 6/10
- **KDP-B**: 6/30
- **MS-SRR (P)**: 1/17
- **Pre-ASM**: 6/5
- **MCR**: 6/16
- **PDR**: 3/28
- **CDR**: 10/22
- **Funded Slack**: 3 Years
- **Element FSM**: 3 Years
- **Project FSM**: 3 Years
- **Aerospace 50%**: 3 Years
- **Aerospace 70%**: 3 Years
- **Need Date**: 3 Years
- **LRD**: 3 Years

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*Pre-Decisional*
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](https://aos.gsfc.nasa.gov)
- Contact Sheri Smith @ aos-comments@lists.nasa.gov
- Contact Project Team Personnel (POCs on web-site)
- AGU Sessions December
Questions?
Backup slides
Assumptions Guiding Architecture Modifications

- Two projects, both 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

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

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<tr>
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<th>Sensor Capability</th>
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<tbody>
<tr>
<td>Inc</td>
<td>Precipitation profiling and Doppler</td>
<td>JAXA Ku radar</td>
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<tr>
<td>Inc</td>
<td>Convective mass flux,</td>
<td>CNES radiometers</td>
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<td>Polar</td>
<td>Aerosol and moisture sounding</td>
<td>CSA ALI, SHOW</td>
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