Multi-Angle Imager for Aerosols (MAIA)

Commercial Hosting Lesson Learned from the MAIA Earth Venture Instrument Project

Instrument Development without a Host

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M A I A

Associating airborne particle types with adverse health outcomes

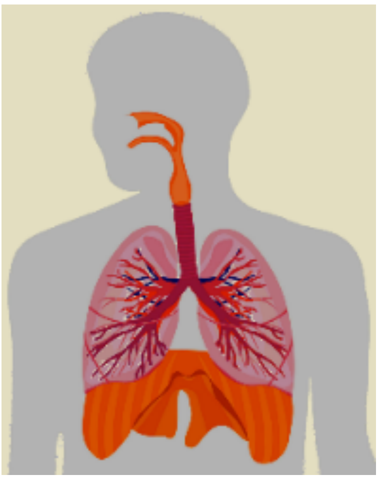


11 September 2018

MAIA
Multi-Angle Imager for Aerosols

Health Impacts of Particulate Matter (PM)

JPL



Airborne PM is a well-known cause of cardiovascular disease and mortality and has also been associated with respiratory disease, low birth weight, lung cancer, and other adverse health outcomes.

However, PM is heterogeneous in spatial and temporal distribution, size, shape, and composition, and the relative toxicity of specific **PM types** is not well understood.

Global Burden of Disease attributes > 4 million premature deaths each year to ambient PM

Coarse particles (PM_{10}-$PM_{2.5}$) are linked to respiratory irritation and cardiac death.

Fine particles ($PM_{2.5}$) penetrate deep into our lungs. Inflammation affects other organs.

The Investigation

Instrument

A pushbroom spectropolarimetric camera on a 2-axis gimbal

A bit larger than a large microwave oven

Investigation

Obtain data for globally distributed Primary Target Areas

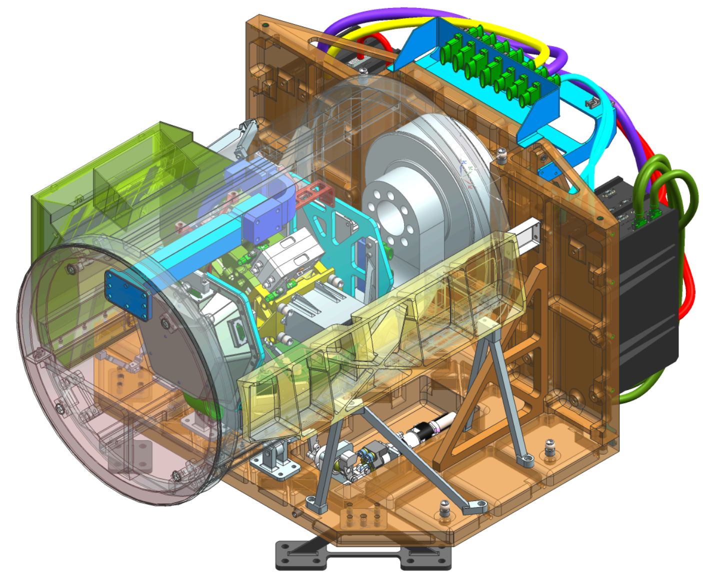
- Instrument observations
- Ground station observations
- Chemical transport model outputs
- Health records

Obtain data for globally distributed Secondary Target Areas, Calibration/Validation Target Areas, and Targets of Opportunity

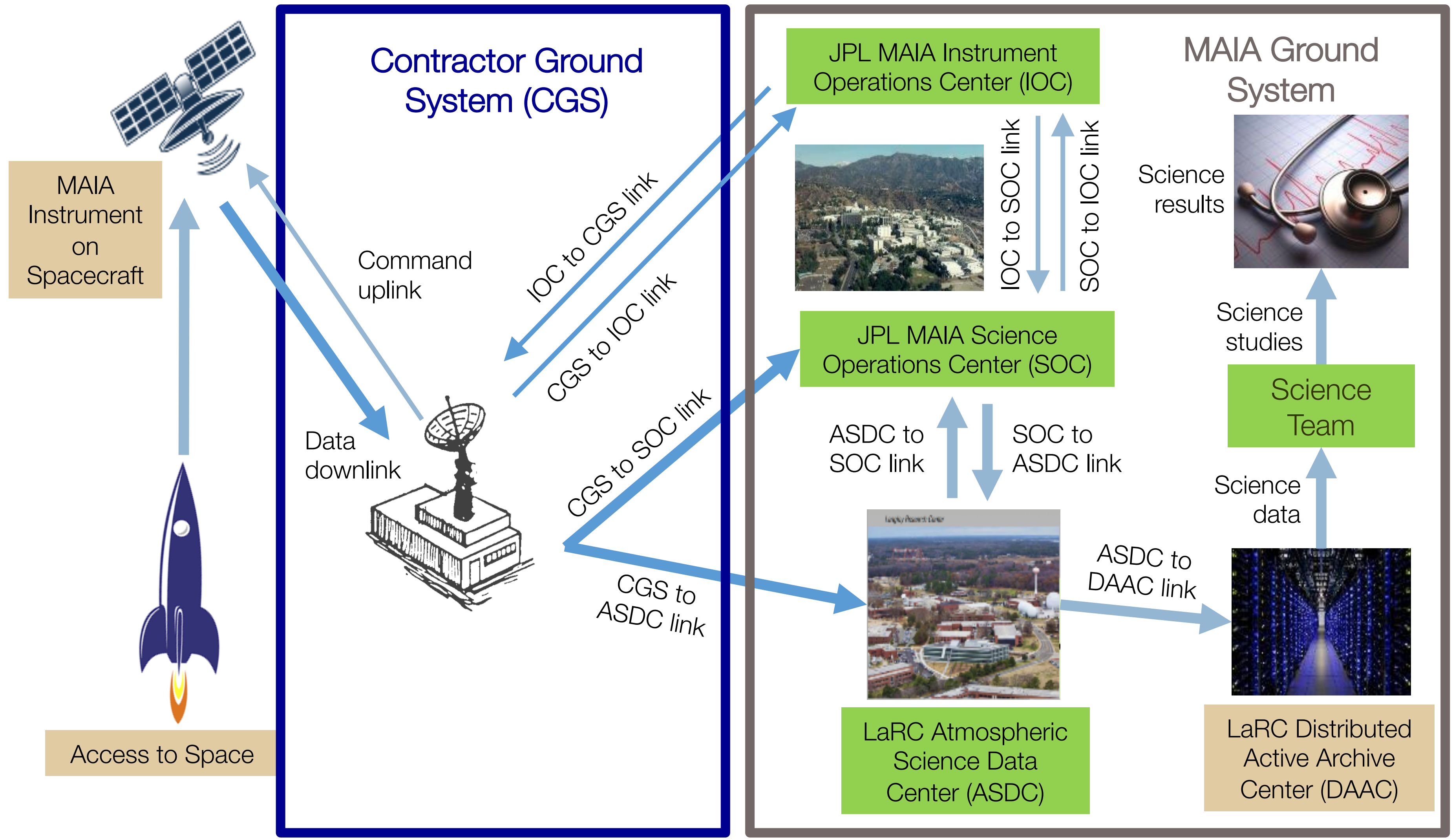
Analyses and Findings

Reporting on

- Instrument performance, calibration, and validation
- Epidemiological investigations of health impacts of particulate pollution
- Secondary mission science

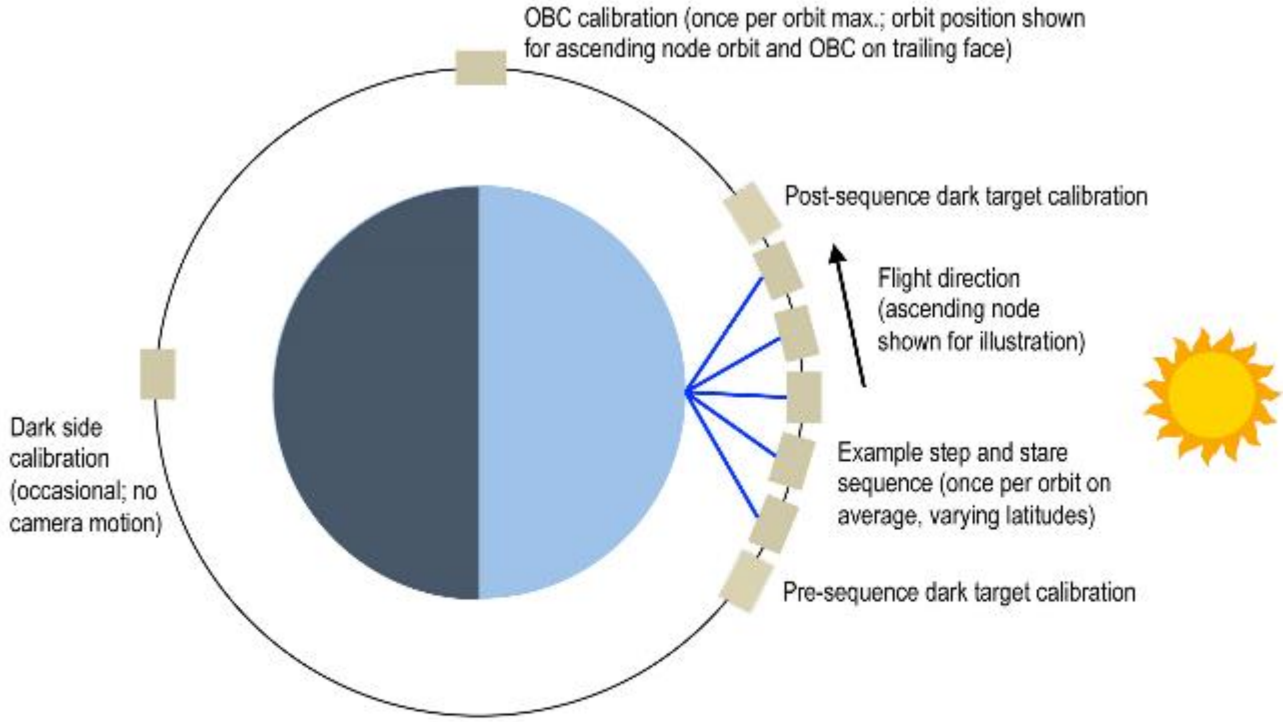


Investigation/Mission Summary



MAIA Con-Ops

- Science data collection occurs over the orbit dayside
  - Instrument measures radiance and polarization state of scattered sunlight @ angles
- Sun-synchronous orbit allows observation of targets at approximately the same local time

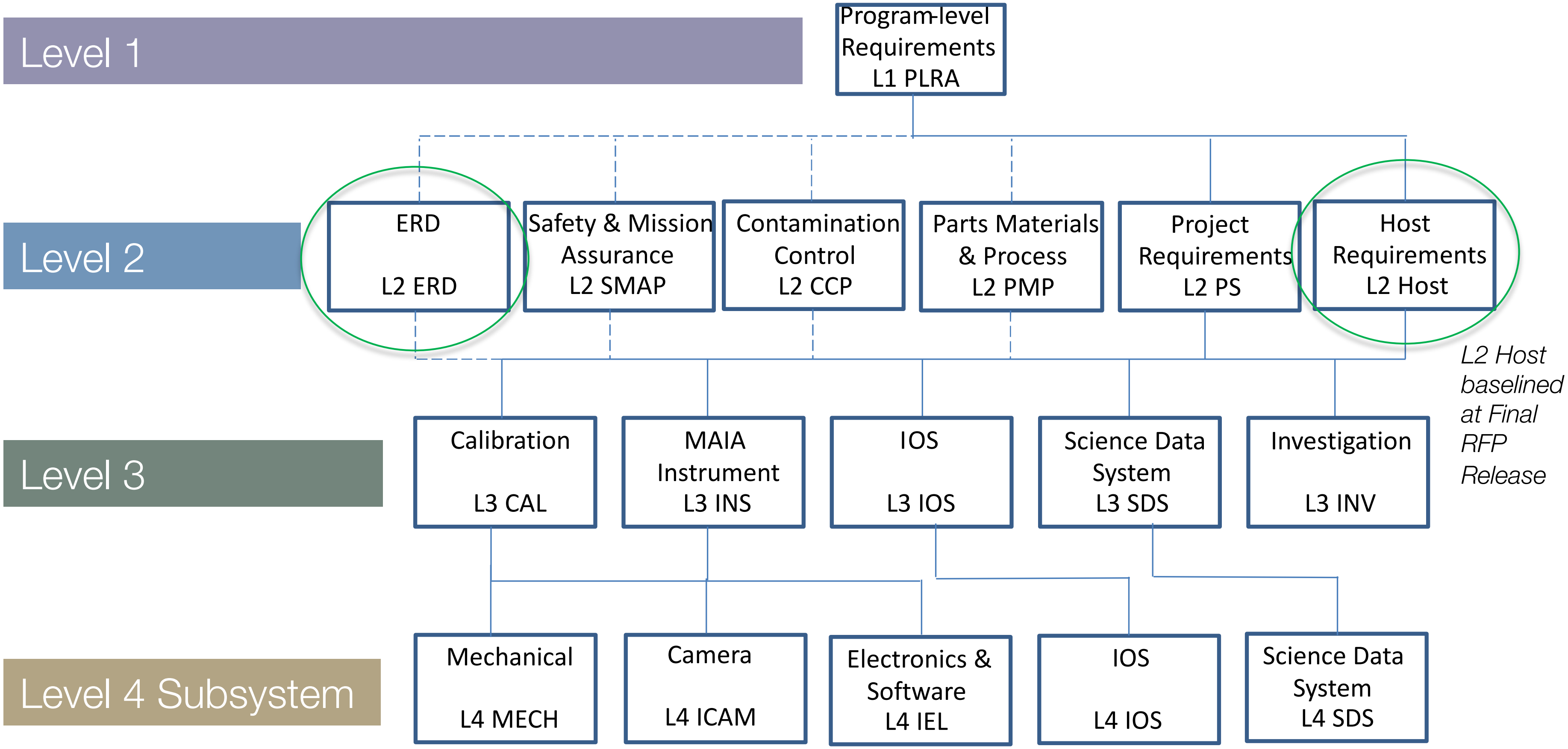


- Typical operations include an average of one Earth science target per orbit
  - Target observation lasts less than 10 minutes
    - In addition, each orbit assumes an OBC sweep of ~3 min and two dark target views of ~4 seconds each
  - Approximately 100 target acquisitions/week

Instrument Development Approach

- Define requirements!
  - Requirements on the Host (pointing, field of view, etc.)
  - Interface Control Documents (e.g. Mech/Thermal, Electrical, Operations)
- Establish Boundary Conditions
  - Environments – launch (vibration, loads), thermal, radiation, etc.
  - Allocations – Not to Exceed (NTE) mass, volume, power, data, etc.
- Common Instrument Interface (CII) Project – Hosted Payload Guidelines Document
  - Technical recommendations for LEO/GEO hosted payloads
  - Falling in family with these guidelines/parameters should make one "hostable"

Requirements Structure



Procurement Approach

- Create reference documents to describe the investigation and provide context
  - Instrument Description
  - Concept of Operations
  - Science – Orbit Considerations
- Tailor Instrument Project requirements into procurement requirements
  - Level 2 Host Requirements -> Mission Requirements Document
    - S/C pointing & stability, data management, fault response, etc.
  - Simplified Environmental Requirements Document
    - Describes the bounding conditions the instrument will be designed against
  - Interface documents
    - Provides the proposer with assumed interfaces, field of views, etc.

Mission Challenges

- Orbit parameters – large range is desired for hosting opportunities, but…
  - Instruments often need to be designed to meet field of regard and resolution requirements - great dependency on altitude
  - Investigations may have target revisit requirements that are hard to meet over a range of altitudes and crossing times
  - *Some flexibility is possible, but some parts need to be crisply defined for mission design and instrument design*
- Launch Date – flexibility is desired, but…
  - Dependency on operations, science team, external partnerships, external resources
  - Creates planning tension and difficult to coordinate

Engineering Challenges

- Bounding Requirements
  - Creates design inefficiencies, increases difficulty of meeting requirements, often costs mass, drives cost
  - Provides the most resiliency to the unknown, but overdesign is a real possibility
  - Examples – launch vehicles with most extreme dynamics, most severe radiation environment
- Interfaces – mechanical, electrical, operational – need to define blindly (w/o knowledge)
- Mechanical – decouple instrument stiffness from s/c stiffness (kinematic mount). Design to no-test factors of safety (at the expense of mass). Cautious approach – graceful degradation should loads increase
  - No opportunity for load reduction until selection (and maybe not even then)
- Thermal – design system to meet broad range of orbit altitudes and inclinations – this is a non-trivial task with many cases and time consuming analysis
  - This is a good area to narrow down (for many reasons)
- Electrical – communication interface, data flow
  - There are ready-made standards to drawn upon (e.g. Spacewire)
- Con-Ops – data storage methodology, frequency of uplink/downlink, fault response approach, …
  - Can substantially increase instrument storage requirements, capability, personnel

Process Challenges

- Out-of-the-norm development style
  - Difficult for reviewers/partners/participants/mgmt to comprehend how development is accomplished in this environment
  - Challenges typical design methodology (e.g. loads derivation and maturation as design matures)
  - Resistance to approach
- Pervasive fear of redesign – analysis paralysis

Questions to Ask Yourself

- Who will be proposing instruments? Capability?
  - University? Industry? Gov't?
- What type of hosting capability is available?
  - What is the market? Many players?
- What type of contract structure will be employed?
- How will the activities be phased with respect to another?
  - Will instrument be completed prior to or in parallel with the hosting activity?
  - Significant difference in approach, efficiency, and potentially cost and schedule
- How will gaps be adjudicated?

Discussion