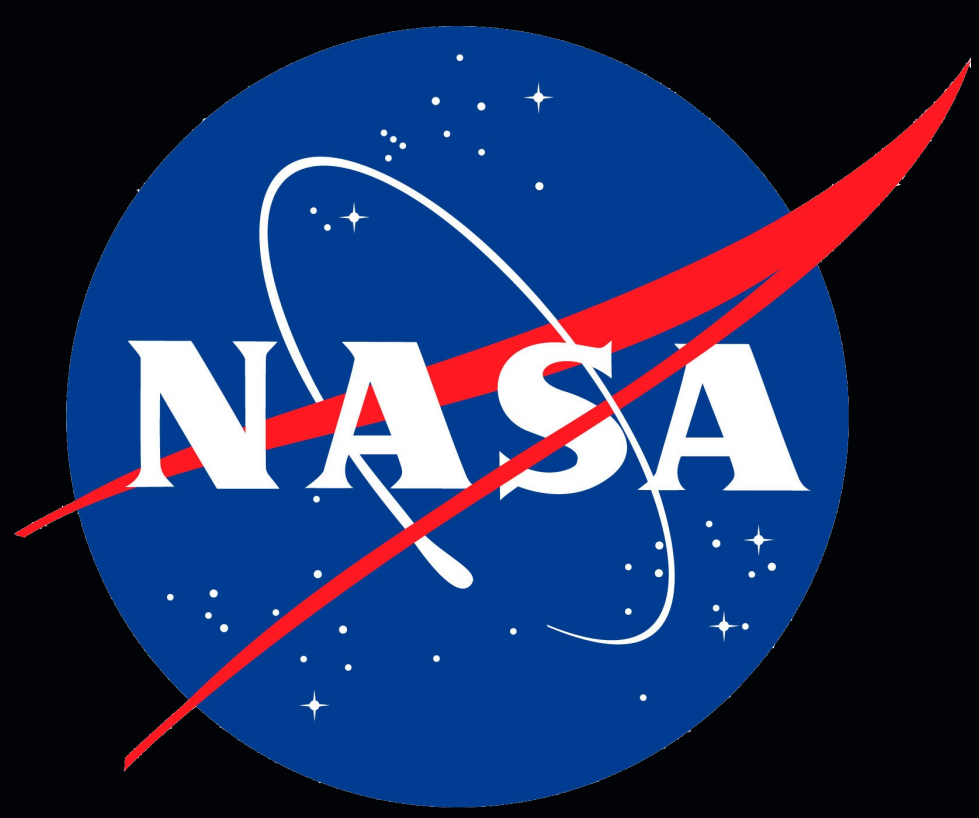




Moon Base Lunar Surface Operations Induced Environments and Integration

C.E. Soares ¹, W.A. Hoey ², C.A. Steagall ¹, N.J. Greene ¹, A.D. Dunegan ³

1) NASA Johnson Space Center, Houston, U.S., 2) Amentum, Houston, U.S., 3) The Aerospace Corporation, Houston, U.S.

E-mail (corresponding author): carlos.e.soares@nasa.gov

Introduction

NASA's Moon Base Program (MB) represents a fundamental component of the Artemis program to return humans to the Moon and explore deep space.

- Moon Base will be built through a phased, practical strategy – starting with robotic missions, early demonstrations, and technology experiments, then progressing toward semi-permanent infrastructure and ultimately continuous human presence.

Moon Base is NASA's program to develop next-generation spacesuits (xEVA), human-rated rovers, EVA tools, science payloads, and spacewalking support systems for the lunar surface and, eventually, Mars.

Moon Base Induced Environments

The Moon Base Induced Space Environments system management function manages environments induced by elements to protect crew, systems, science and equipment. Induced Space Environments develops the integration strategy and technologies to characterize and mitigate hazards including:

- **molecular and particulate contamination** caused by materials outgassing, vacuum venting, pluming, and other sources; and
- **lunar dust (regolith) erosion & deposition** effects from surface operations and landing system descent, landing and ascent.

Induced Environments Integration

The Induced Environments integration process is based on the process developed for International Space Station (ISS), with improvements from lessons learned from ISS integration and those developed for the Mars 2020 and Europa Clipper missions.

The Moon Base induced and integrated environments process characterizes [Fig. 1]:

- System sensitivities and susceptibilities to induced environment effects
- Induced contamination sources including materials outgassing, thruster plume byproducts, and vacuum venting and effects
- Molecular & particulate transport in lunar vacuum
- Contaminant deposition onto surfaces
- Contaminant effects, including degradations to systems/science performance

Deliverables support integration & requirements verification, and have direct application to lunar surface operations, integrated mission planning, science operations and Planetary Protection.

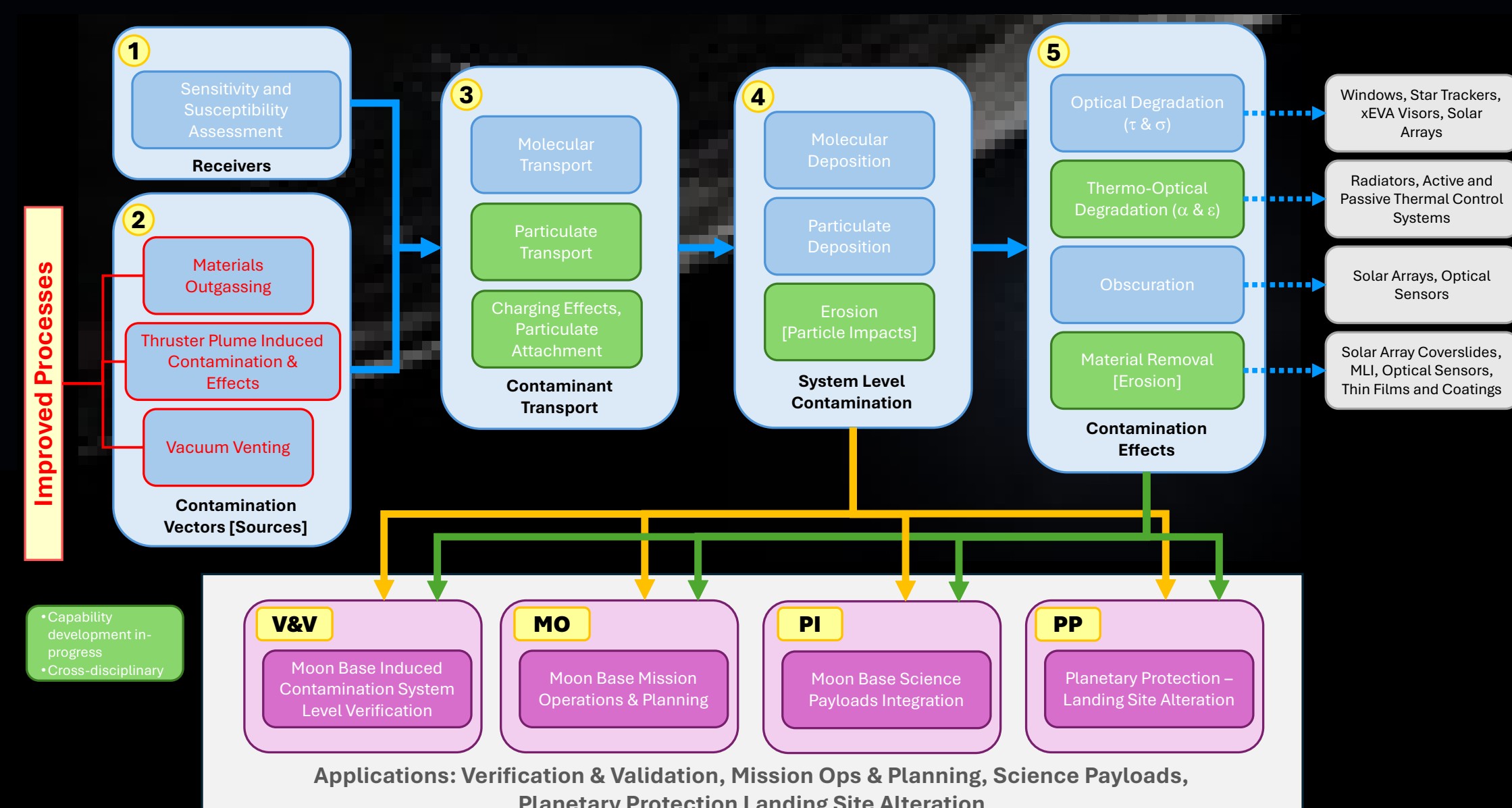


Figure 1: Moon Base Induced Environments Integration Process. [1]

Contamination Vectors

The improved process developed for characterization of **Contamination Vectors** is demonstrated in the characterization of materials outgassing sources. [Fig. 2]

Measurements taken during thermal vacuum of flight articles provide data on outgassing rates, contaminant composition, contaminant deposition and evaporation rates, and optical properties of contaminant. [Fig. 3]

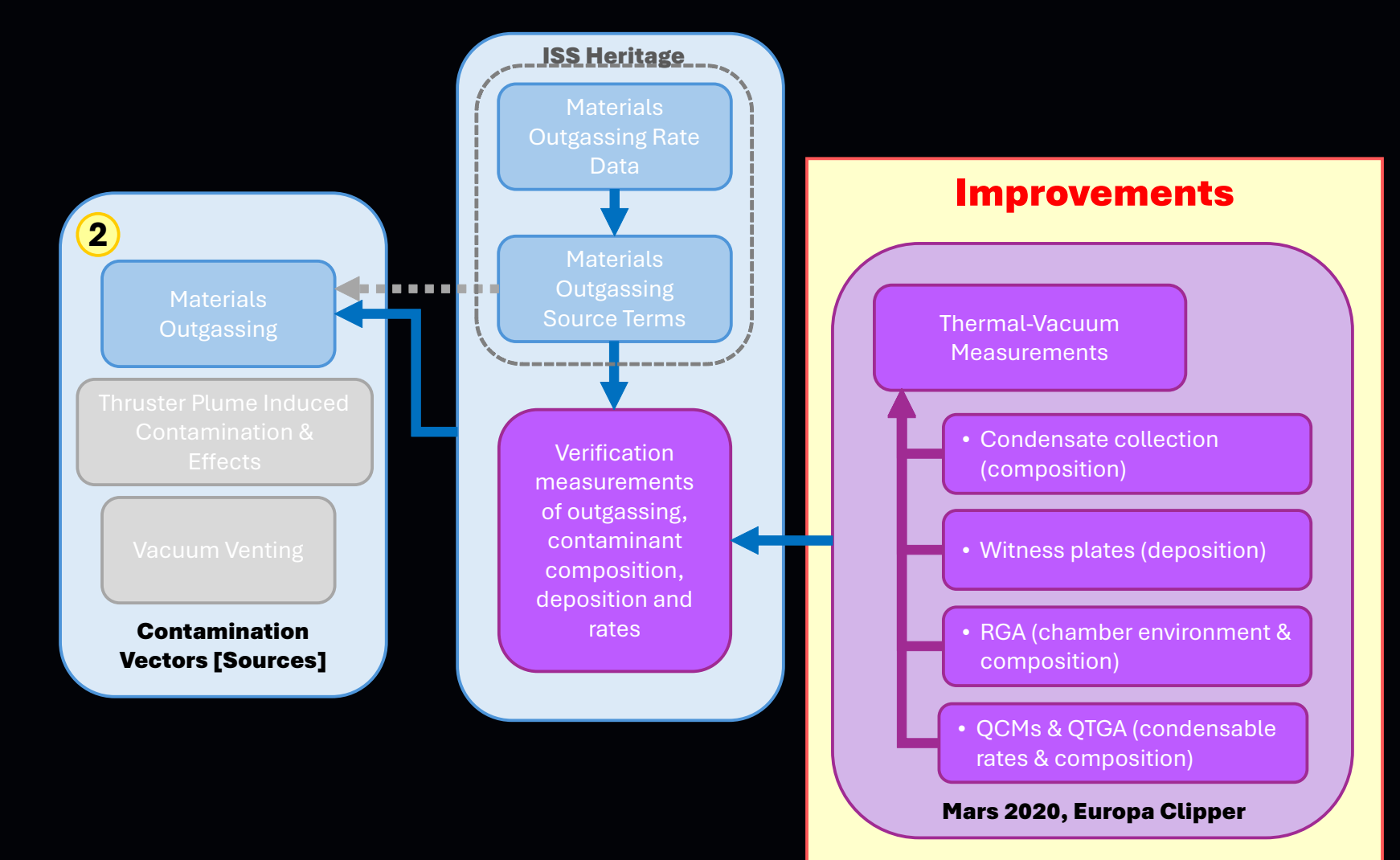


Figure 2: Improvements in the characterization of outgassing. [1]

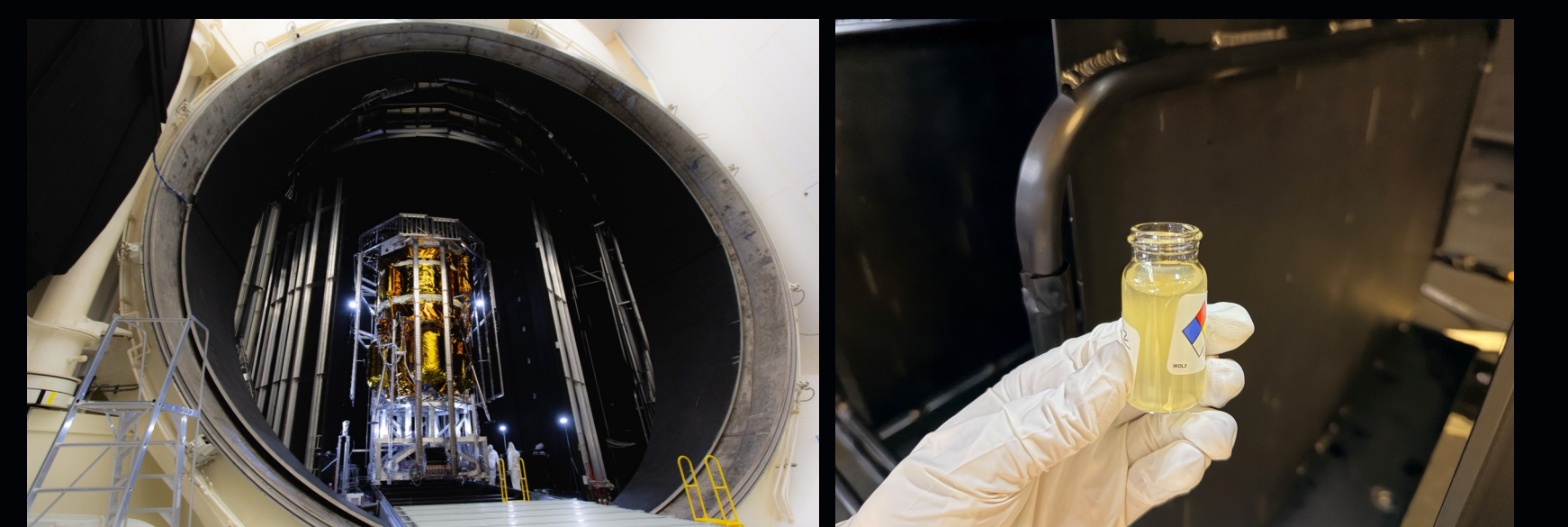


Figure 3: Condensate collected during thermal vacuum at JSC Chamber A. [1]

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References:

- [1] Hoey, W.A., Soares, C.E. et al, "Organic Inventory / The Contamination Footprint of Lunar Surface Operations," 1st Workshop on Enabling Sustainable & Responsible Lunar Activities, ECSAT, Harwell, UK, Jun. 2026.
- [2] "Moon Base Ambassador Deck 082126," NASA, Aug. 2026.

1. Establish Reliable Access to the Moon
2. Acquire Ground Truth Data
3. Demonstrate Moon Base – Enabling Technologies
4. Establish Initial Command and Control

PHASE
01

1. Establish Robust Access to the Moon
2. Establish Initial Infrastructure
3. Establish Initial Crewed Systems (Habitation & Logistics)
4. Establish Integrated Command and Control

PHASE
02

1. Establish Habitation Capability for Long Duration Missions
2. Enable Optimal Utilization of Moon Base

PHASE
03