

**The Aerial Regional-scale Environmental Surveyor (ARES): New Mars Science to Reduce Human Risk and Prepare for the Human Exploration.** Joel S. Levine<sup>1</sup> and M.A. Croom<sup>2</sup>, H.S. Wright<sup>2</sup>, B.D. Killough<sup>2</sup>, and W.C. Edwards<sup>2</sup>, <sup>1</sup>The College of William & Mary, Williamsburg, VA 23187, ajlevine1@verizon.net, <sup>2</sup>NASA Langley Research Center, Hampton, VA 23681.

**Mission Summary:** Obtaining critical measurements for eventual human Mars missions while expanding upon recent Mars scientific discoveries and deriving new scientific knowledge from a unique near-surface vantage point is the focus of the Aerial Regional-scale Environmental Surveyor (ARES) exploration mission. The key element of ARES is an instrumented, rocket-powered, well-tested robotic airplane platform, that will fly between one to two kilometers above the surface while traversing hundreds of kilometers to collect and transmit previously unobtainable high spatial measurements relevant to the NASA Mars Exploration Program and the exploration of Mars by humans. The ARES mission is uniquely designed to bridge the critical measurement gap between orbital and surface platforms [1], [2], [3], [4], and it affords an opportunity to advance several technologies useful for future Science and Human Exploration and Operations Mission Directorates' (SMD, HEOMD) missions. ARES supports the extensibility to human-scalable Entry, Descent, and Landing (EDL) by demonstrating the use of a hypersonic inflatable aerodynamic decelerator (HIAD) during the direct entry at Mars.

Having been selected to proceed into Phase A as part of the Mars Scout Mission competition in 2002 and receiving a second Category 1 science rating during the Mars Scout competition in 2006, the ARES mission concept has continued to mature technologically and scientifically, adjusting to reflect the current exploration goals for assessment of human exploration at Mars and enabling technologies for future missions.

**Challenge Areas:** Our ARES mission concept supports multiple Challenge Areas (CA) as put forth in this LPI call. CA 5 is addressed through on-board radiation sensors. CA 6 is addressed through the EDL density and wind measurements along with the density and wind measurements obtained over the regional-scale airplane flight. CA 8 is addressed through the demonstration of HIADs during the critical EDL phase. CA 16 is addressed through the demonstration of the aerial platform as a low cost regional scale exploration tool.

**Critical Measurements:** The unique perspective from an aerial platform over a regional-scale allows for in-situ measurements to aid in future mission investigations while directly resolving many questions concerning the evolution and current state of Mars.

**Radiation Safe Zones:** With the lack of a global magnetic field at Mars, the radiation levels at the surface jeopardize human habitability. Studies show that

local safe-zones could exist on the surface of Mars due to the strength of regional remnant magnetic fields.

ARES will perform an aeromagnetic survey of regions with sufficient remnant crustal magnetism to possibly offer safe havens. ARES will investigate and model the MGS-discovered regions of crustal magnetism at high spatial resolutions that are two orders of magnitude improved over the MGS mappings.

ARES radiation detectors will measure the flux of energetic solar particles across the surface of Mars and determine for the first time whether mini-magnetospheres generated by crustal magnetism shields the surface from energetic solar particles [5]. Radiation detectors on the ARES spacecraft will allow temporal and geographic correlations with the near-surface data to better understand the amelioration of the radiation fields from the remnant magnetic fields.

*Atmospheric electric field:* There are no measurements of atmospheric electric fields on Mars, which is an important environmental parameter due to the potential danger of an atmospheric electrical discharge during the descent of a massive robotic system or during human operations on the surface of Mars.

*Atmospheric dust burden:* Surface-blown electrified dust may have the potential of setting up strong atmospheric electrical fields on Mars. Simultaneous measurements of atmospheric dust burden and atmospheric electrical fields will provide important new information on this hypothesis.

*Winds and Density:* ARES will investigate the Planetary Boundary Layer (PBL) via measurements of the atmospheric state variables (e.g., pressure, temperature, density and the 3-dimensional structure of winds) along the entire ARES traverse. Our present knowledge of the Mars PBL is based on three point measurements widely separated in space and time (the Viking Landers and Mars Pathfinder).

*Environmental Toxicity:* ARES will investigate and determine the deposition rate of chemically-active (e.g., hydrogen peroxide, ozone, etc.), corrosive and potentially toxic gases from the atmosphere to the surface of Mars. ARES mass spectrometer will measure the concentration of trace atmospheric gases in the Mars PBL. These measurements, coupled with measurements of the 3-dimensional wind structure will permit calculation of the downward flux and deposition of these trace gases to the surface of Mars [6].

**Extensibility to Human-Scale EDL:** Systems analysis show HIADs provide a lower mass solution for human-scale EDL than many other technologies

[7]. HIADs have been manufactured, tested, and demonstrated at a scale consistent with the majority of SMD's Mars missions (e. g., Pathfinder, MER, Phoenix, etc.) The decelerator's ability to withstand the aerodynamic and aerothermodynamic loading consistent with robotic missions has been demonstrated. Development results show a credible path to human-scale decelerators.

**Mission Implementation:** Leveraging development of the ARES airplane spanning the previous 10 years coupled with the HIAD development over the past 5 years, and the use of high heritage measurement strategies, enable the ARES mission to demonstrate entry technologies extensible to human-scale missions while collecting and returning data critical to human exploration. Demonstrating the capabilities of EDL technologies suitable for extension to human-scale missions provides a critical opportunity.

Launching on an Atlas V-401 on 15 May 2018 with a maximum C3 of  $12.5 \text{ km}^2/\text{s}^2$ , the 1250 kg launch mass provides >30% mass margin. A 7.5 month cruise with a Type I trajectory allows for a direct entry over a wide area of interest. By using a 6 m diameter HIAD, with an entry mass of 800 kg, entry environmental levels well within the limits of the demonstrated HIAD capabilities are experienced. Transition, extraction, and deployment of the ARES aerial vehicle use proven methods demonstrated during the airplane technology development. After release, the aerial vehicle will fly a 500 km flight path to perform the aeromagnetic survey, determine local radiation levels, search for the presence and concentration of chemically active gases, measure atmospheric dust and electric fields, and measure the local density and wind. All data will be transmitted to either the carrier spacecraft as it flies by Mars or to an existing orbital asset.

**Mission Flexibility:** ARES is a strong candidate mission for simultaneously addressing additional HEOMD, SMD, and Office of Chief Technologist (OCT) goals. ARES will use optical flow to provide high-precision navigation cues to the airplane control system in a low-risk manner by not jeopardizing its controllability (addresses CA 16).

An option exists to replace the ARES flyby spacecraft with an orbiter. Instruments for an orbiter are currently being proposed by our industry and international partners, to complement the airplane instrument suite to study the atmosphere and geology. On-orbit measurements will be calibrated against in-situ truth measurements to further refine global and regional models. Deploying the entry system from orbit also addresses CA 11 to support future missions.

**Technology Maturity:** Even though some of the CAs addressed by ARES are indicated as mid-year, we

have been in development for so long that the ARES mission is ready to target the 2018 launch opportunity.

*Airplane.* The ARES airplane and deployment approach are well tested and will reach maturity for a 2018 mission. The aero and flight dynamic challenges of flying in the low density environment has been extensively studied analytically, empirically, and has been proven in a Mars-relevant condition flight test. A full-scale engineering model verifies the mass and structural properties and has served as a layout tool for the instruments and subsystems.

*HIAD:* HIADs have seen extensive development efforts from the Aeronautics Research Mission Directorate and from the OCT. A 3m scale sub-orbital demonstration flight flew in August 2009 demonstrating the critical exoatmospheric inflation phase followed by stable decelerating flight during the suborbital flight test. Maturation continues with flight tests (summer 2012) and additional developmental efforts including manufacturing, load testing and finite element model correlation of a 6 m diameter HIAD. Extensive testing of flexible insulating TPS has been performed over the previous 4 years [8]. Many material systems have been investigated via multiple arcjet tests investigating stagnation, shear, and age effects. HIADs (inflatable structure and TPS) have been demonstrated to be a technology ready for mission infusion.

**Conclusion:** ARES is a unique opportunity to address critical robotic and human-scale investigation needs at Mars through the blending of critical EDL technologies with vital environmental measurements.

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