STATEMENT OF WORK

FOR

CARBON DIOXIDE REMOVAL BY IONIC LIQUID SYSTEM FOR MOBILITY (CDRILS-M)

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CARBON DIOXIDE REMOVAL BY IONIC LIQUID SYSTEM FOR MOBILITY

1.0 GENERAL

1.1 PURPOSE

This statement of work (SOW) defines the tasks and deliverables associated with the initial feasibility for application of the Carbon Dioxide Removal by Ionic Liquid System (CDRILS) to a space suit life support system with the permutation referred to as Carbon Dioxide Removal by Ionic Liquid System for Mobility (CDRILS-M).

1.2 BACKGROUND

Carbon dioxide (CO2) and humidity control are essential features of the Extravehicular Mobility Unit (EMU) Portable Life Support Subsystem (PLSS). The PLSS for past EMUs such as the Shuttle and International Space Station (ISS) EMUs as well as the Exploration EMUs (xEMUs) have used solid adsorbents for CO2 and humidity control. Carbon Dioxide Removal by Ionic Liquid System (CDRILS) utilizes a continuously recirculated ionic liquid sorbent and hollow fiber membrane contactors for CO2 removal from spacecraft cabin air. For the vehicle Environmental Control and Life Support System (ECLSS) application, CDRILS is undergoing development for a flight demonstration on the International Space Station (ISS) in 2028. As an extension of the approach used for CDRILS in the ECLSS application, Honeywell and the NASA Space Suit & Crew Survival Systems Branch are exploring a variation of CDRILS as the CO2 and humidity removal technology for the NASA Mars Exploration EMU (mxEMU) concept referred to as Carbon Dioxide Removal by Ionic Liquid System for Mobility (CDRILS-M). The continuous removal, liquid based CO2 and humidity control approach for a Mars Exploration application such as the Mars Exploration Extravehicular Mobility Unit (mxEMU) include:

- Non-venting EVA capability in which H2O and CO2 captured in the sorbent are not vented into the environment during EVA
    - This enables recovery of these constituents back into the cabin ECLSS processing loop.
    - The environment being explored by EVA capability receives reduced contamination loading
- Inclusion of trace contaminant removal in the sorbent without need for a separate consumable component to perform that function
- Improved long duration mission serviceability
    - Liquid sorbent can be changed out or replaced as part of maintenance without the overhead that would be present for replacing an existing state of the art scrubber such as the Metal Oxide canister (~32 lbs) or Rapid Cycle Amine (~16 lbs) using smaller or more discrete components.

- The goal for convergence of the liquid sorbent with that of the vehicle ECLSS system such that sparing and maintenance could be reduced with the commonality.

In order to proceed with the feasibility for the space suit application, this effort will research alternative sorbents and operating configurations targeted to this application and characterize the forward path options for implementation to advance the state-of-the-art of carbon dioxide removal required to enable NASA's human exploration missions.

1.3 SCOPE OF EFFORT

The Contractor shall provide all materials, tooling, test equipment, test facilities, analysis tools, and labor required to complete the effort defined in this SOW.

1.3.1 Base

The contractor shall perform the following work scope as part of this effort:

1. The contractor shall analyze possible approaches to achieve the NASA mxEMU capacity and rate requirements based on literature and existing CDRILS test data.
    a. CDRILS-M Application Mini-Spec
    b. Table 0.1 – Key Performance Parameters Alignment to ESDMD Technology Gaps
    c. Table 0.2 – Abbreviated Toxicological Hazard Levels aka "Toxicity"

Table 0.1 – Key Performance Parameters Alignment to ESDMD Technology Gaps

KPP	Current Value	Task End State	Gap Performance Target
Total volumetric uptake rate (10-15°C)	---	2-4 g/L/hr	>20 g/L/hr (1)
Hollow fiber contactor unit volume uptake rate (10-15°C)	---	260-580 kg/hr/m^3	>875 kg/hr/m^3 (1)
Toxicity	---	<2	0 to 1

NOTE:

(1) This is a sizable gap from expected liquid sorbents based on market research so far however may be lowered by further evaluating the integration with the suit to enable larger storage volume usage and/or further improvements in performance with the sorbents.

Table 0.2 – Abbreviated Toxicological Hazard Levels aka "Toxicity"

Toxicity	Irritancy	Systemic Effects	Containability and Mitigation
0 Negligible	Slight irritation < 30 min	None	No PPE required

1 Critical	Slight to moderate irritation >30 min and requires therapy	Minimal	PPE required
2 Catastrophic	Moderate to Severe irritation with potential long-term issue	Minimal effects, no long term tissue damage	Can be contained/cleaned up PPE required
3 Catastrophic	Negligible to Severe irritation with systemic toxicity	Appreciable effects and long term effects	Can be contained/cleaned up PPE required
4 Catastrophic	Moderate to Severe irritation with long-term issue	Appreciable effects and long term effects	**Cannot be contained** PPE required

2. The contractor shall down-select 2-4 of the possible approaches for experiment.
3. The contractor shall experimentally evaluate the down-selected approaches and report the results to NASA.
4. The contractor shall estimate the size weight, and power (SWAP) of a mxEMU PLSS CO2 removal system using experimental data for each approach
5. The contractor shall provide a final test report summarizing the work at the completion of tasks 1 through 4.
6. The Contractor shall prepare and submit a Monthly Progress Report in accordance with DRD 1858MA-004 and conduct a brief monthly telecon with NASA to convey status and cover collaborative work with PLSS integration options.
7. The contractor shall prepare and submit Financial Management Reports (533M and 533Q) in accordance with DRD 1638MA-002.

2.0 DELIVERABLES

2.1 BASE

The contractor shall deliver data and hardware as described below:

No.	Title	Qty	Due
1	Kick-off Presentation and meeting	1	1 month post ATP
2	Monthly Status - written Summary in Word/PowerPoint of monthly activities with key activities including photos, relevant data, etc.	A/R	1st Monday each Month
3	Monthly Status - Telecon - Brief 30-60 minute telecon covering the monthly status summary and for coordination of any joint activities, etc.	A/R	Time to be established within a month of ATP
4	Final Report	1	7 months post ATP

3.0 PERIOD OF PERFORMANCE

The period of performance will be 7 months post ATP.