Statement of Work (SOW) for Yarn Procurement

Project Title: Supply of Virgin and Modified Yarns for Artemis Suit Materials Phase III

Background: The overarching goal of the NASA's Artemis Suit Materials (ASM) Project conducted by the Crew and Thermal System Division Advanced Suit Team, is to develop enabling technologies and potentially a turnkey solution for suit vendors for the outer shell fabric of a lunar suit environmental protection garment (EPG). The project asserts that no existing fabric currently meets all requirements necessitating the construction of a bespoke solution designed to withstand the harsh conditions of the lunar environment.

Virgin yarns and yarn modifications have been identified by NASA as commercially available solutions with desirable characteristics for advanced suit application. Yarn modification capabilities can potentially close identified gaps in performance such as UV degradation, abrasion resistance, dust repulsion, surface resistivity, and optical properties.

Objective:

The objective of this Statement of Work is for the vendor to collaborate with NASA in advancing the development of high-performance materials for lunar suit applications by undertaking two major tasks:

1. **Sourcing of Virgin Yarns for Weaving Preparation Trials:** The vendor will leverage its extensive inventory and procurement relationships with yarn vendors to minimize lead times and address NASA's procurement challenges. The task includes performing yarn preparation techniques, such as up-twisting or air-tacking, with twist per inch (tpi) specification set to 2 tpi Z. The vendor will source commercially available uncoated or coated yarns from agreed-upon fiber types to support fabric formation down selection.
2. **Coating Application/Development to Address Requirement Gaps:** The vendor will develop and document custom coating solutions tailored to specific yarn types to bridge gaps identified in the requirements list. The task includes a 12-week development timeline, chemistry formulation, equipment purchase or modification, documentation of process steps, quantities needed, and criteria for down selection. The vendor will conduct basic physical property testing of new coating options to evaluate their suitability for meeting NASA's requirements.

This collaboration aims to streamline material sourcing, optimize yarn preparation, and develop innovative coating solutions to meet the unique demands of NASA's fabric development project.

Period of Performance: 22 weeks after authority to proceed (ATP). Drexel (the fabric prototyping vendor) requires finished coated yarns by July 1, 2025, contingent upon the date of ATP. The work will proceed over a flexible, but defined schedule to ensure iterative feedback of meetings every 2 weeks and final sample delivery within the required timeframe. Sample deliveries and iterations will align with NASA's testing schedule to ensure timely feedback on each enhancement area.

Travel: No travel expenses are required/included in this TO.

Detailed Scope:

Task 1: Kickoff Meeting

- **Objective**: Align on project objectives, timelines, deliverables, and technical details.
- **Timeline**: Within 2 weeks of ATP
- **Details**:
    - Review project scope, identify technical challenges, and finalize yarn and coating requirements.

Task 2: Supply of Virgin or Coated Commercial-Off-The-Shelf (COTS) Yarns

- **Objective**: Source and supply specified yarns to NASA or NASA prototyping partner for initial warping/weaving trials.
- **Timeline**: Complete supply by 4 weeks after ATP.
- **Deliverables** (materials will be provided wound on paper tubes):
    - Provide quantities of the following off-the-shelf yarns uptwisted:
        1. 100d Vectran: 50,000 m
        2. 400d PTFE: 50,000 m
        3. 200d Kevlar: 50,000 m
        4. 100d UHMWPE: 50,000 m
        5. 200d Vectran: 50,000 m
        6. 200d ePTFE: 50,000 m (supply flat)
    - 2-ply twisting of 200d Vectran: 10,000m qty. Planning just incase it is needed.

Task 3: Yarn Preparation (Coating/Uptwisting)

- **Objective**: Prepare yarns to meet NASA's requirements through specialized coatings and twisting.
- **Timeline**: **10 weeks after ATP**
- **Deliverables** (materials will be provided wound on paper tubes):
    - **Uptwisting**: Strengthen Quartzel thread by applying up-twist: 50,000 m
        i. Customer supplied material
    - **Coating**: Coat the following yarns with specified materials:
        1. 100d Vectran coated in polyimide: 50,000 m
        2. 200d Kevlar coated in polyimide: 50,000 m
        3. 100d Vectran coated in resin from approved shortlist: 50,000m
        4. 250d PBO coated in resin polyimide: 50,000 m

Task 4: Prototype Coating Study and Evaluations

- **Objective**: Study and evaluation of additional coatings on yarns from Task 2 and Task 3, as deemed feasible by the vendor, with final coating configuration of yarn deliverables to be determined in collaboration with NASA.
- **Timeline**: 18 weeks after ATP
- **Deliverables**: Prototyping reports and samples; 10,000 m minimum to 50,000 m maximum of each yarn as listed to achieve properties as per properties 1-4 below, based on prioritization with and feedback to NASA (priority at start of work as listed)
    - Properties:
        1. White color: Coating to enhance the yarn's optical properties, color the white
        2. UV resistance: Coating to improve the coated yarn's UV resistance
        3. Abrasion resistance: Coating to improve the coated yarn's abrasion resistance
        4. Flame resistance: Coating to enhance flame resistance, with concerns around resin dripping
    - Proposed coated yarns:
        1. 150d PBO coated with white polyimide
        2. 100d Vectran coated with white polyimide
        3. 200d Kevlar with a white flame resistant coating from approved shortlist

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Task 5: Physical Property Testing

- **Objective**: Conduct testing to evaluate the performance of yarns and coatings from Task 3 and Task 4.
- **Timeline**: Concurrent with yarn preparation, 20 weeks after ATP
- **Details**:
    - Perform the following tests, per the vendors standards:
        - Yarn-on-same yarn abrasion (ASTM D6611-23), 10000 cycles set as test "Pass"
        - Cross-sectional analysis via optical microscopy or SEM
        - Stress-strain assessment to failure (ASTM D885)
        - Flex data based on the vendors developed test (based around ISO 5626:1993)
        - Additional tests available from the vendor as determined. (ASTM D1907, ASTM D1423)
- **Deliverables**:
    - Comprehensive test data and analysis for each prepared yarn type.

Task 6: Final Report

- **Objective**: Summarize project findings, including process details, test results, and recommendations.
- **Timeline**: Deliver 22 weeks after ATP.
- **Deliverables**:
    - Detailed documentation of:
        - Process steps and methodologies.
        - Quantities of yarns prepared and used.
        - Criteria for down-selection of materials.

        - Results of physical property testing.
    - Recommendations for next steps and potential scale-up.

Completion Date: All tasks to be completed 22 weeks after ATP, with weekly updates provided to NASA throughout the project.