STATEMENT OF WORK

Task 064 **- Unmanned Aerial System (UAS)**
Subtask A: Development and Installation of Solar Cell Power Package on the NASA Swift UAS

BACKGROUND

The Swift UAS (unmanned aerial system) is currently under development, with the goal of providing long endurance electric flight. This UAS is built on a commercial hang glider platform with unusually high performance, the Swift, originally developed by Bright Star Gliders. The concept for continuous operation of the electric aircraft will require solar panels be installed on the wings of the aircraft. This application of solar cell technology is experimental, only a small number of electric aircraft have been developed. In addition, we hope to support ongoing efforts in the industry, such as the SunSeeker 3 effort.

OBJECTIVE

The objective of the work is to design, implement, and integrate, a solar cell power package onto the NASA-Swift Electric UAS demonstrator.

REQUIREMENTS

The subcontractor's background should include significant experience in the design, installation, and testing of solar cell systems for aircraft propulsion.

SCOPE OF WORK

Because of development and funding-timing constraints related to fielding the UAS, the customer has asked that the installation of the solar cell package be separated into an Option

Develop a Solar Cell Power Package on the NASA SWIFT UAS

- Select the highest performance solar cells in the market for the UAS that meets the requirements of installation into a flight aircraft, in terms of vibration, shock, temperature, weight, form factor, maintainability, and other environment constraints. Part of this task will be to quantify these requirements.
- Develop a plan for the development **and installation** of the solar cells onto the UAS that includes the requirements. This plan will be reviewed by NASA personnel with the intention of publication, and review by an air-worthiness and flight safety review board (AFSRB).
- Provide any material required for the Flight Readiness Review (FRR) related to the development of the Solar Cell Package.

Option A. Install the SolarFlight Solar Cell Power Package on the NASA SWIFT UAS

- Prepare the UAS surfaces for mating with the solar cells.
- Perform installation of the solar cells on the UAS platform at NASA ARC including mating up to the aircraft electronics.
- Provide any material required for the Flight Readiness Review (FRR) related to the work performed to install the solar cell package on the UAS.

PERIOD OF PERFORMANCE

December 15, 2009 through September 28, 2010.

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TRAVEL REQUIREMENTS

It is expected that the kickoff meeting and general work to understand the power, functionality and safety requirements for this Solar Cell installation can be done via telecon. It is also expected that an engineer can also support the AFSRB and FRR via telecon

If Option A (installation) is selected:

1. Travel for an engineer to install and test the solar cells on the UAS platform at NASA ARC.

CUSTOMER FURNISHED DATA / EQUIPMENT

NASA will supply:

- 3D software models of NASA Swift UAV, including a description of the area on which the Solar Panels could be installed.
- Aircraft power information necessary to scope/size system.
- Access to the UAS for installation and testing of the solar panel system.

DELIVERABLES/MILESTONES

Status reports will be due the 5th working day for the prior months work.

All Demonstrations will be at NASA. All demonstrations will require delivery and integration of the system at Ames.

	Deliverable	Due Date
Solar Cell System Development		
A1	Requirements Plan delivered	12/30/2009
A2	Installation Plan delivered	2/1/2010
A3	Support AFSRB (Airworthiness and Flight Safety Review Board) Meeting	4/1/2010
A5	Support FRR (Flight Readiness Review) (limited to development of solar panels)	9/1/2010
Option A: Installation		
A4	Install and Test Solar Cell Package at NASA Ames	4/6/2010
A5	Support FRR (Flight Readiness Review) includes development and installation of solar panels)	9/1/2010

STATEMENT OF WORK

***Task 064* - Unmanned Aerial System (UAS)**
Subtask A: Development and Installation of Solar Cell Power Package on the NASA Swift UAS

ACCEPTANCE CRITERIA

	Deliverable
	Solar Cell System Development
A1	Review and Acceptance by SGT and NASA Technical Lead. The Plan should address at a minimum: Fit and Finish, Power, Interfaces, Functionality/Usability, Testing, and Reliability Requirements.
A2	Review and Acceptance by SGT and NASA Technical Lead
A3	Review NASA developed materials, participate in AFSRB via telecon
A5	Review NASA developed materials, participate in FRR via telecon
	Option A: Installation
A4	Review and Acceptance by SGT technical lead and NASA Mechanics: 1) Solar panels mate onto the wing of NASA Swift UAS (Bright Star/MLB) 2) Solar panels deliver voltage and current in full sunlight per value specified in Requirements Plan. 3) Solar panel installation must survive engine-on ground taxi testing. (Test: Solar panels must survive engine-on condition for up to 3 hours. Aircraft (with external air for cooling) will be powered on for 3 hours, and vibration will be observed.
A5	Review NASA developed materials, participate in FRR via telecon

i. Technical Approach

Describe in sufficient detail the Offeror's technical approach to accomplish the requirements as outlined in the Statement of Work.

Using a detailed and accurate plan of the SWIFT UAV, solar cell packing will be optimized, to fit as many solar cells to the aircraft as possible.

The solar cells are connected into long strings, and laminated on top of a full size plan, to assure accurate cell placement. The wing sweep of the Swift makes this crucial.

The laminate consists of fiberglass reinforced thermoplastics, and thermoset resins, and is water proof from the front, but only water resistant from the rear. Proper installation on the aircraft assures that the final solar array will be waterproof.

The laminate is manufactured at a high temperature, so that assures that there will never be problems with the solar array over-heating sitting in the sun on a windless day in the desert, on the hottest day of the year.

The entire rear area of the array will be laminated with a sacrificial polyester "peel ply" that is striped off just prior to bonding to the aircraft.

All electrical connections in the solar panels will be triple redundant, assuring full power in case of a local failure.

All end connections will be also triple redundant, and on the panel edges, never behind the panels. This allows almost instant access to the connections for testing with a handheld meter.

All contacts will terminate near the aircraft centerline, to avoid external wiring.

Preparation of the aircraft for installation will consist of trimming the edges of the solar panel if needed, then using the panel as a template to mask off the perimeter area around the panel. Then the surface needs to be sanded or abraded by some other means such as sand or grit blasting to remove most of the paint. If Bright Star engineers approve, the entire outer skin could be cut and peeled off the foam, to allow the solar panel to be recessed, for a better fit.

A layer of epoxy resin is spread on the surface, with a special "rake", to assure proper adhesive thickness.

A thixotropic filler will be added to the resin, to prevent it from running.

Alternately, a low temperature curing adhesive film could be used, or even a form of curing double stick tape.

We have good experience with all three of these processes. The best for this case is TBD based on small sample tests.

A small sample of Swift wing skin would be helpful for these tests.

In any case, a vacuum bag is taped to the outside of the aircraft, to create sufficient pressure to consolidate the lamination. In the case of the adhesive film, which is possibly the best, heat would be needed to cure the adhesive, but only 40 C, which can be obtained by simply rolling the aircraft out into the sun.

Finally, the edges are taped, to assure water proofing, after the electrical connections are made. Kapton tape is used, but some silicon or other adhesives may be used, such as hot melt glue.

ii. Work Breakdown Structure (WBS)
Show an outline of the elements of each major task to be performed

1. Solar cell packing (design cell layout)
2. Stringing cells
3. Testing strings electrically
4. Lamination
5. Electrical test
6. Shipment to NASA
7. Prep of aircraft for installation
8. Installation
9. Final wiring and testing
10. Water proofing

iii. Milestones/Deliverables
Address how the milestones/deliverables will be met.

A1 Basic study defining power and voltage available from the area coverable by solar cells

A2 Report of final tests of all installation materials

A3 Telecom with Eric Raymond and supporting engineer Dave Freund

A4 Long visit from Solar Flight engineer Dave Freund to Ames, with materials, and possible assistance from Bright Star personnel

A5 Telecom with Eric Raymond and supporting engineer Dave Freund

iv. Risk Assessment/Mitigation
Address the risks inherent in the technical approach and how that risk will be mitigated.

Fabrication of the solar panels has minimal risk, because we just built 180 square meters of these panels in Switzerland. (See www.solarimpulse.com)

The Swift wing is inherently stiff, with a carbon fiber main spar, so wing flex should not be severe enough to damage the solar panels.

Overheating the wing from the black panels will need to be investigated, but is out of scope of this contract.

Possible shadowing of solar cells need to be investigated, and diodes may be needed in certain areas to protect from high reverse voltages. These are out of scope of this contract.