R028-A: Soaring Solar Power Management (Phase III)
Submitted by Packet Digital
Principal Investigator: Andrew Paulsen
Request for $375,000; Total Project Costs $1,000,000

Technical Advisor Comments

- 2 reviewers recommended fund, 1 recommended funding may be considered through the scoring but in the final comments did not recommend funding unless certain information was provided.
- The 63% match comes from Naval Research Lab ($625,000 cash).
- All 3 reviewers had concerns regarding the achievability of the project:
    - 1 reviewer questioned the definition of the commercially viable since the design is still undergoing changes and there isn't details of what payload would be carried in the commercially viable design.
        - The applicant has responded that initially, the payload will be an optical camera and that the whole system will be available for under $100K. Numerous other payloads are possible and the payload will impact aircraft endurance due to the additional weight and required power. The payload capacity of the current airframe configuration is approximately 3.5kg. However, Packet Digital plans to work closely with customers to offer engineering services and optimization based on their specific payload needs.
    - 2 reviewers felt the solar cell/wing development is not likely to meet the objectives within the timeline.
        - The applicant agrees that the development of high efficiency (~40%) solar cells is extremely difficult and that transferring the technology from R&D to cost efficient commercial manufacturing is not a one year project. Packet Digital and NRL will continue to invest in high efficiency solar cells for UAS beyond the term of this project.
- Regarding the methodology:
    - 1 reviewer stated "…The systems engineering approach has not apportioned design attributes for a meaningful payload(s). A long endurance air vehicle that doesn't perform a function is not useful…" That reviewer also commented that "…The FAA will govern flight options of the vehicle they describe and no size, weight, power or other design attributes are apportioned."
        - The applicant responded that a long endurance UAS could have a variety of uses depending on customer needs, which would then determine the type of payload installed. They plan to work with customers to determine their payload needs and optimize the aircraft accordingly for size, weight and power.
        - The applicant also stated that they follow the FAA regulations for UAS, including the upcoming Part 107. Packet Digital's aircraft meets the FAA part 107 requirements in terms of weight (<55lbs), max ground speed (87 knots), and max altitude (400 ft).
    - 1 reviewer stated that while progress has been made in the MJ cells, solar-wing efficiencies are only at 27%, which is far short of the 40% target. The team has indicated that the MJ cells will only be viable in markets that can tolerate the high price. Discovering that the approach is not cost viable at this stage is disappointing because the resources should have been applied towards more cost effective alternatives. Additionally, the other option of solar cells (c-Si) are thick and rigid. While there are some that are partially flexible, they are not as efficient, cost effective or readily available.
        - The applicant has responded that the rigidity issue is resolved by a number of solar cell manufacturers offering Si solar cells which are thinner and more flexible than traditional Si cells. While not as flexible as thin film solar cells, they are flexible enough to conform the UAS wing without sacrificing aerodynamic efficiency.
        - Regarding the lower efficiencies of Si solar cells, Packet Digital agrees that current Si efficiencies may not enable an endless endurance UAS. However, current analysis estimates 22% efficiency will enable up to 18 hour flight times during a summer day in Fargo. While not endless, it enables UAS applications that are not feasible with current flight durations and an entire day shift UAS to fly pipelines and power lines.
        - Packet Digital states that they are not abandoning the MJ solar cells. They will still be used for any customers that require that performance, and R&D will continue to improve

production methods and ultimately decrease the purchase cost. The Si solar cells selected for Phase III along with the enabling solar electronics developed during this project will bring new levels of endurance to a broader market.

- 2 reviewers felt the PI's awareness of current research activity was limited, and the third commented that there was a lack of discussion on the deep external efforts underway in multiple locations to produce high efficiency solar technologies. However, all 3 reviewers were comfortable with team's ability to perform the work proposed.
    - In response, the applicant has cited external references.
- Regarding the management plan, 2 reviewers felt the timeline could be clearer. 1 reviewer questioned why full system integration finishes before a subcomponent. 1 reviewer noted a lack of milestones making it difficult to assess when some tasks are to be considered complete.
    - The applicant stated that the Gantt Chart was small due to page limitations and has provided additional information.
        - It should be noted that the additional details could have been provided as an appendix.
- Overall, 1 reviewer felt that the State should get some IP rights for the amount of money contributed noting that some of the interface connections were not funded by the company.
- Another reviewer felt that the FAA limit of 400 ft for UAVs has removed the possibility to implement the solar soaring algorithms which, combined with the concerns that MJ cells aren't cost viable, limits the value of the project to offsetting of non-renewable fuel sources.
    - The applicant has stated that while the current FAA limitation is 400ft for standard commercial UAS aircraft, it is expected that this limitation will be relaxed in the future. When it is relaxed, Packet Digital will be ready to offer a commercial solution. In the meantime, the military and countries other than the US will benefit from the use of the soaring algorithms.
- That same reviewer did not recommend funding unless the applicant can articulate specifically what jobs will be created and sustained beyond Phase III and what lasting economic impacts are likely if the solar cell development is limited to 20% efficiency with rigid cells.
    - The applicant has provided some additional information.

Technical Advisor Recommendations

Funding may be considered. This project features a North Dakota company that is partnering with other North Dakota companies to build a UAV. This burgeoning industry has incredible potential and North Dakota has worked hard to be at the forefront. Projects like this could be key economic success for the State.

However, the reviewers' concerns about the achievability and methodology of the project is concerning, especially when this is the third phase of the project and this program has already provided $850,000. The clarification the applicant has provided regarding the payload issue as well as the Si cells has been very beneficial.

Seeing the final report from Phase II will also help illustrate the potential economic impact and achievability of Phase III.

Suggested Contingencies If Funded

- None.