STUDENT SUSTAINABILITY COMMITTEE

Funding Application – Student-Led Projects (Under $10K)

Funding Criteria

A. General Rules

1. Students, faculty, and staff are encouraged to submit requests for funding. Student-led projects require a faculty or staff sponsor in order to have funds awarded.
2. Funding can only go to university-affiliated projects from students, faculty, staff, and departments.
3. All SSC projects must make a substantial impact on students. This may be a direct impact or an impact through education and engagement. All SSC funding is 100% from student green fees, so the projects funded by the students must benefit them.
4. SSC encourages innovation and new technologies – creative projects are encouraged to apply.
5. Unless a type of expense is specifically listed below as having restrictions, SSC can generally fund it. The items referenced below should not be taken as comprehensive list.

B. Things SSC Can Fund, On A Case-By-Case Basis

1. SSC can fund feasibility studies and design work; however, it must work toward ultimately addressing a sustainability need on campus.
2. SSC can fund staff positions that are related to improving campus sustainability. Strong preference will be given to proposals receiving matching funding from departments and/or plans for maintaining continuity of the position after the end of the initial grant.
3. SSC can fund outreach events with a central theme of sustainability, provided their primary audience is the general campus community.
4. SSC discourages funding requests for food and prizes but will consider proposals on a case by case basis that prove significant reasoning.
5. SSC can fund repairs and improvements to existing building systems as long as it works toward the goal of improving campus sustainability; however, a preference is shown to projects utilizing new or innovative ideas.
6. SSC can provide departments with loans for projects with a distinct payback on a case by case base. Loans will require a separate memorandum of understanding between SSC and departmental leadership pledging to repay the award in full and detailing the payback plan.

C. Things SSC Will Not Fund:

1. SSC will not fund projects with a primary end goal of generating revenue for non-University entities.
2. SSC will not fund personal lodging, food, beverage, and other travel expenses.
3. SSC will not fund any travel expenses.
4. SSC will not fund tuition or other forms of personal financial assistance for students beyond standard student employee wages.

Your funding application should include this application and any letters of support.

Please submit this completed application and any relevant supporting documentation by the deadline listed on the SSC website to Sustainability-Committee@Illinois.edu. The Working Group Chairs will be in contact with you regarding any questions about the application. If you have any questions about the application process, please contact the Student Sustainability Committee at Sustainability-Committee@illinois.edu.

General & Contact Information

Project Name: Illinois Space Society Hybrid Rocket Engine
Total Amount Requested from SSC: $10,000.00

Project Topic Areas: ☐ Land & Water ☐ Education ☒ Energy
☒ Transportation ☐ Food & Waste

Applicant Name: Andrew Larkey
Campus Affiliation (Unit/Department or RSO/Organization): RSO (Illinois Space Society) through the Aerospace Department
Email Address: alarkey2@illinois.edu

Check one:
☐ This project is solely my own ***OR***
☒ This project is proposed on behalf of (name of student org., campus dept., etc.): Illinois Space Society SEDS Chapter

Project Team Members

Name	Department	Email
Andrew Larkey	Illinois Space Society	alarkey2@illinois.edu
Vignesh Sella	Illinois Space Society	vsella2@illinois.edu
Avery Moore	Illinois Space Society	averykm2@illinois.edu
Connor Latham	Illinois Space Society	connorl2@illinois.edu

Student-Led Projects (Mandatory):
Name of Faculty or Staff Project Advisor: Michael Lembeck
Advisor's Email Address: mlembeck@illinois.edu

Financial Contact *(Must be a full-time University of Illinois staff member)*
Contact Name: Laura Gerhold
Unit/Department: Aerospace Engineering Department
Email Address: gerhold@illinois.edu

Project Information

Please review the proposal materials and online content carefully. It is highly recommended you visit a working group meeting sometime during the proposal submission process.

Please provide a brief background of the project, its goals, and the desired outcomes:

We want to know: What is your project? What does it concretely produce, accomplish, or solve? Why is this project needed on campus?

This project focuses on designing, building, and testing an environmentally friendly, reusable rocket on a hybrid engine. Advancements in green technology are being made in the aerospace industry on a daily basis. New materials and different propulsion methods are critical to the growing rocket industry. Commercial companies have begun to develop greener processes by designing reusable vehicles as well as implementing environmentally friendly materials and fuels. New propulsion technologies have been introduced which lower the environmental impact while retaining the technology's key capabilities. Hybrid engines are one of these technologies that are starting to be utilized in the industry as a greater amount of research is being done on them. With the uptick in companies developing new rockets and new space exploration technologies, making these kinds of engines known can help ensure that rocket technology is cleaner and more sustainable in the future.

A hybrid engine makes use of two fuels in different phases. The solid fuel, paraffin wax, is incredibly common and is used in most household candles. The liquid oxidizer is nitrous oxide, a gas used as an anesthetic for a variety of medical applications which are non-toxic as well. Hybrid rocket engines are also much safer for the students, not just the environment. Since the oxidizer and solid fuel are stored separately and cannot begin combustion without some form of ignition. Hence the storage and use of hybrid engines is safer in comparison to a solid rocket motor that could ignite at any time.

The rocket on which the hybrid engine will be flown is reusable. This entails that after each launch, with minimal overhaul, the rocket can be reused for the next launch. Such a design allows for minimum waste in materials, and therefore positively impacts the environment in comparison to other standard rocket designs. Such designs eject the rocket body into the ocean, damaging sea life and impacting the fine balance in the local ecosystem. Our rocket design parachutes safely back to us, and allows us to recollect every part used in its launch. Similar designs can be seen on rockets that large commercial companies utilize, such as SpaceX.

Furthermore, the project aims to publish a paper to the 2020 AIAA Propulsion and Energy Forum in New Orleans. This paper will encompass the design of the project, and the novel implementation of the hybrid engine. It will be an excellent experience for students to write technical documents for a science journal. If chosen, the AIAA P&E Conference would be a wonderful learning and networking experience for team members.

Seeing as how the Illinois Space Society is a student group and that our members will one day go into industry and help develop new rocket capabilities, it is important to consider sustainable solutions early on. The development of hybrid propulsion is not an area heavily focused on by either student organizations or research groups in the College of Engineering. With the development of this project, the society hopes to increase the focus on hybrid propulsion, its importance, and its capabilities. We hope that the findings uncovered from this project will help encourage future student groups on campus to consider greener alternatives in projects where they might not be seen as applicable.

Where will the project be located? Are special permissions required for this project site?

If special permission is required for this location, please explain and submit any relevant letters of support with the application. SSC cannot fund projects without prior location approval.
Work for the project will be done in the student labs at Talbot Laboratory and the Nuclear Engineering Laboratory. These are approved zones for teams to organize and store materials. No special permissions will be required to utilize these areas except that team members are students of the university. These lab spaces are monitored by the Aerospace Engineering department at Illinois. All team members working on this project are required to pass general lab, electrical safety, and compressed gas trainings in order to work in these spaces.

Other than the project team, who will have a stake in the project? Please list other individuals, groups, or departments affiliated directly or indirectly by the project. This includes any entity providing funding (immediate, future, ongoing, matching, in-kind, etc.) and any entities that benefit from this project.
Please attach letters of commitment or support at the end of the application.
Illinois Space Society, as an RSO, will have the most direct affiliation with the project. The executive board will manage the team leads and allocate funding for the project as it sees fit. It will also oversee outreach with other entities, staff, and faculty. The completion or failure of the project directly impacts the image of the society and its members. This would mean that an inability to succeed could lead to less funding, lower member counts, and a general drain of morale. There is a lot of motivation to make sure the team follows through on what is talked about here.

As an RSO in the Aerospace Department, the department has the next level of affiliation. The department wants its student projects to succeed since it reflects on the image of the department. It could also influence the number of people who come to UIUC as a result of seeing interesting projects being performed. In order to receive departmental support in the future, ISS will want to show the department that it is capable and ready to implement such a complex and multifaceted project.

ISS has the support of various private entities. They have donated various amounts of money to ISS for this project in particular. Their logos and names will be displayed on team media, as well as the final rocket. Their representation may help to increase their notoriety. Many of them are small, family-operated businesses. Even a small increase in exposure may help them profoundly. It is critical that they can show their money or materials are not wasted and go to a project that can teach students a variety of skills and disciplines.

How will this project involve and/or benefit students?
This includes both direct and indirect impact.
This project only involves students, and is student led. It has provided learning experiences for several dozen team members, and is often noted as the key item for their success in early professional events. Students have modeled the engine in Computer Aided Design softwares such as Siemens NX and have made use of simulation tools like ANSYS to model propellant flow. This allowed the team to monitor how the engine will perform before building anything and wasting precious resources. Design of the engine requires students who understand electronics, materials, programming, thermodynamics, fluid dynamics, and more, so anyone can get involved and gain valuable experience. Several students noted that the main reason they were selected for internship opportunities over past summers was in fact their time in the hybrid engine project, and the skills they accumulated.

In the process of designing the engine, students are also put in a "Propulsion School". In this school, run by the team and ISS, students are taught the basics of rocket science and propulsion. This semester, almost a hundred students have signed up and several dozen have rigorously attended. The lectures are primarily taught by a graduate student who specializes in rocket propulsion. These lectures are often regarded as the

best part of the whole project, as students will be able to directly apply what they learn in class to the engine the team is building. This opportunity is very rare in engineering organizations where more formal learning often does not occur. Furthermore, the propulsion school covers material students will often see in their classes in future semesters. This preparation provides much needed intuition and aids them to achieve better grades in the future.

Students also assist in assembly and maintenance of the engine. They get to see the components first hand and understand their importance inside the engine. They also see the ways the engine works and keep it in peak condition. Such assembly and maintenance lowers the impact on environment, by ensuring meticulous care is given to the engine personally without spending frivolously on new components. These opportunities give them a good understanding of the ways the engine works and its positive environmental impacts, essential to making sure they might consider this as an engineering solution in the future.

Lastly, students are assisting in the testing of the hybrid engine. They see what it is like, first hand, to work with the engine. Testing is major component of any field within engineering. It is quite inter-disciplinary including economics and systems, electrical, mechanical, and aerospace engineering. This increases the reach of the project to as many disciplines as possible. Furthermore, it gives them engineering intuition and a sense for what it will be like working at a real engineering job.

What are your specific outreach goals? How will this project inspire change at UIUC?
The project has maintained pre-existing outreach goals and furthered them as well. The team is still working to develop the engine to a point where it can be integrated into a rocket system. By doing this, the engine can be taken to the Intercollegiate Rocket Engineering Competition (IREC). The team in fact attended IREC this past summer, and met with dozens of teams from around the world. Contacts and friendships were made, as well as advertisements for SSC & UIUC. The attendance of the competition was well into the thousands, and a few hundred people saw the rocket (with the SSC logo) up close. The hybrid engine and the SSC are an integral part of the society, and will be presented as such at the next IREC.

Social media is a much bigger part of Illinois Space Society this year. The society has a social media director to manage Instagram, Facebook, and Twitter accounts. After attending the IREC in summer of 2019, the society nearly doubled its follower count on Instagram. With this audience, it is possible to showcase the building and testing of the hybrid engine to a much wider audience. Furthermore over 150 people attended the first meeting, where SSC's logo and the rocket motor were showcased.

The society has a new advisor for the year, Dr. Lembeck. He has many connections in the aerospace industry that might be able to help find advising sources and companies interested in learning more about the projects. This allows for better design feedback and a better functioning team. Dr. Lembeck is also highly experienced with project management and designing advanced systems. He is the leader of the CubeSat lab in the aerospace department. The team plans to leverage this experience to keep everyone safe and organized.

Last year, and continuing this year at an even larger scale a graduate student taught a "Propulsion School" to teach members and other interested students in rocket propulsion with an emphasis on hybrid rocketry. As aforementioned this Propulsion School was revamped and is being done on an even larger scale. Most interestingly is that because of this propulsion school, members of other engineering RSO's such as SSS or Illini Solar Car have attended to learn and see what hybrid rocketry is all about. Our learning opportunity has proven to be an excellent method for outreach.

Last but most not definitely least the exhibits hosted at Illinois Space Day and Engineering Open House reach a couple hundred young kids (K-12) every year. This is part of Illinois Space Society's education outreach initiative. ISS has it's own educational outreach director who handles educational events for young children and especially for female engagement in STEM to motivate their interest in space and technology. These events showcase a hybrid engine demo, where students learn the basics about hybrids and why they're special. The demo is an exciting time for children, and leaves them inspired to learn more. Such events are a perfect way to reach out and inspire the next generation of engineers and scientists.

How will the project improve environmental sustainability at the Urbana-Champaign campus?
At typical aerospace colleges, rocketry is a large part of student extracurricular activities. By introducing a project which is environmentally sustainable and friendly, it allows a pre-existing activity to become green. Currently, students at the university work mainly on projects with solid rocket engines where in as aforementioned the solid and oxidizer are often very toxic chemicals that are also quite combustible. Hybrid on other hand, due to its separate phase and distinct oxidizer/fuel components is much safer for both the environment and the students.

Students also try to source materials from as many local and recycled locations as possible. This includes making use of the stockpile of material in the machine shops instead of buying new raw materials or using what the club has used before. Reusing is often even better than recycling as it requires no extra energy or work to reuse an item! They will also work with the local shop managers to find out the most efficient, cost-wise and material-wise, ways to go about responsibly designing the engine. This allows students to think with an efficient mindset and keep in mind that they need to reduce their impact as much as possible.

From the get-go students are reminded about being environmentally conscious and cautious about waste. This project not only helps students now, but the experience and skills they develop carry with them into professional life - where change can happen on an even larger scale. The campus at Urbana-Champaign therefore now has another option, a green one, for engineering students to partake in.

If applicable, how does this project impact environmental injustice or social injustice?
In many other universities and our own in fact, international students (who are often minorities) are commonly not allowed to participate in rocketry due to ITAR (International Traffic in Arms Regulations) restrictions. These regulations prevent students who are eager or passionate about rocket science to face rejection and dismay. However, the hybrid engine project is not ITAR restricted in any sense and is therefore open to any and all who wish to join. Our project provides one of the only venues for students at the University of Illinois to participate in high power rocketry. In fact the team lead for this year's hybrid team is an international student and minority who has repeatedly stated their gratefulness for the opportunity to follow their passion.

Scope, Schedule, and Budget verification

What is the plan for project implementation? Describe the key steps of the project including the start date, target completion date, target date for submitting a final report, and any significant tasks or milestones.
Please be as detailed as possible.
The focus of the hybrid rocket engine for the Fall Semester (Aug-December 2019) is manufacturing and testing. The current plan to reach a flight-ready rocket engine by May 2020 is the following:

Aug-Sep 2019: The goals for these two months are hydrostatic testing, propulsion school, member recruitment, and hybrid awareness. A hydrostatic test has in fact already been complete. Propulsion school as aforementioned is running excellently this year, and member rates have doubled. During propulsion school hybrid awareness is also achieved. These two months have in fact met all their set out targets.

November 2019: Cold flow testing of the oxidizer feed system and hydrostatic testing of the combustion chamber. The cold flow test aims at measuring the pressure drop across the engine plumbing using an inert fluid (water). The hydrostatic test aims at ensuring that the pressure-bearing parts of the engine (here, the combustion chamber) will withstand two time their operating pressure without failure. These tests are critical to ensure that the engine will perform safely and within specification during launch operations.

December 2019: Hot fire test of the engine in ground configuration. In this test, the engine is fired while being fed from a ground tank, heavier and larger than the tank that will be implemented in the flight configuration. This test will allow the team to measure the performances of the engine (notably to measure its thrust) in a safe setting and validate the design of the oxidizer feed system and the combustion chamber.

February 2020: Assembly and hydrostatic test of the flight tank. Once the flight tank is machined and received, it must be assembled and its structural integrity tested before integrating it into the engine system. This is done with a hydrostatic testing procedure similar to the one used for the combustion chamber.

March 2020: Cold flow testing and hydrostatic testing of the engine in flight configuration. Once the flight tank is included in the engine, both cold flow and hydrostatic testing must be performed again to ensure that the engine will perform nominally.

April 2020: Hot fire of the engine in flight-ready configuration. The engine is fired with its flight tank, which constitute the ultimate validation step before the flight of the engine .

August 2020: The team presents its design at the 2020 AIAA Propulsion and Energy Forum in New Orleans in front of an international panel of experts providing feedback and orienting future design directions for the hybrid project.

List all budget items for which funding is being requested. Include cost and total amount for each item requested.
Please be as detailed as possible.

Item	*Cost*
Hybrid Engine Fabrication	*$1,000*
Test Stand Improvement	*$1,500*
Hybrid Electronics & Sensors	*$1,500*
Test Iteration Costs	*$2,000*

Machining Costs	*$2,500*
Ancillary Costs	*$1,500*
Total Amount	*$10,000*

If the project is implemented, will you require ongoing funding? What is the strategy for supporting the project in order to cover replacement, operation, or renewal costs?

SSC provides funding on a case by case basis and should not be considered as an ongoing source of funding The plan as described in the section above the budget, associated with the implementation of this project, will be covered by virtue of funding received via this application. The stated goals of this project will be successfully accomplished when the first successful flight of this hybrid engine is completed on-board a rocket at the Intercollegiate Rocket Engineering Competition (IREC). This is entirely feasible now that half the machining and testing is all that is left with leeway to complete these milestones. However, further design, development, and hot fire readiness for this engine will have costs associated with design updates as well as recurring costs such as new nozzles for every few hot fires. Presently, these costs will be covered by this one-time grant. if further funding from the SSC is necessary, a new application for a grant will be submitted while providing all deliverables for the previous year's grant allocation.

Please include any other obtained sources of funding. Have you applied for funding elsewhere?

Please attach any relevant letters of support as needed in a separate document.

Various avenues of funding have been pursued for this project. Currently, the Aerospace Department is in the process of reviewing the Illinois Space Society's annual budget request. Funding will be allocated to the society following this process. But this funding is allocated for all the society's technical, outreach as well as professional pursuits. Therefore, the funding allocated by the department will not be enough to cover the Hybrid Engine's cost for the foreseeable future.

Another source of funding is a NASA Higher Education Grant account that the society has received access to. this account has about $3,500 reserved for technical projects. But once again, this money is partially sustaining all five of the society's technical projects. ISS has also pursued and is in contact with private funding sources such as local businesses and parents of members.

Another pool of funding via reimbursement available to the society is SORF. The society is eligible for $10,000 worth of funding via SORF. But in order to receive this funding, the society must possess the money in the first place in order to acquire the necessary components of the system. Only then can the society get reimbursements on these purchases.

It is clear that if awarded, the SSC grant will be the primary source of funding for the Hybrid Engine and will enable the project for the academic year that lies ahead.

Have you applied for funding from SSC before? If so, for what project?

The Illinois Space Society applied for and received $10,000 for this same project during the Fall of 2018. The final report will be turned in along with this funding request to make the status of the project more clear. In summary, the project was able to achieve most of its goals such as teaching aerospace students about responsible design, but was unable to complete the engine due to unforeseen machining costs and scheduling issues. The team is excited to continue working on the project and would be very appreciative of continued support. With the added experience of last year, the team is more ready than ever to build a hybrid rocket engine.

How will you bring awareness and publicize the project on campus? In addition to SSC, where will information about this project be reported?

The Illinois Space Society has an expansive social presence and the project will be thoroughly covered through a variety of platforms. Some of these platforms include Facebook, Instagram, and Snapchat. Furthermore, Illinois Space Society has a website, posts on the departmental Facebook page, and through the IREC website. There have already been several posts on these pages documenting the team's progress. We have already seen a large spike in members joining the team this year from a diverse group of majors.

The team will document their progress throughout the year in many aspects. We will include information in these posts detailing the many renewable and safety-oriented aspects of the project. We will also post videos on YouTube that go over rocket parts and help to spread information about the project in a condensed form. These videos can be spread through the society and shown on personal social media pages.

A GitHub wiki, a website linked with a personal GitHub workspace, will also detail many of the critical design choices. These pages will more closely detail the technical aspects of the design. It will also describe the idea behind using products like magnesium alloys and implementing hybrid engines into a rocket. This provides a deeper look for those who want a better explanation and detailed analysis of these ideas and how they work to make for a more responsibly designed rocket.

In Summer of 2020, the team will present its design at the AIAA Propulsion and Energy Forum in New Orleans in front of an international panel of experts providing feedback and orienting future design directions for the hybrid project. This will allow us to talk about our sustainable design choices to a wider and diverse audience. At the AIAA P&E Conference several thousand aerospace professionals and media representatives alike attend to learn about the state of the industry. If selected for this conference, UIUC and our team can present our progress to aerospace professionals. Valuable feedback, press coverage, and experience is earned at such conferences.