TEXAS ENGINEERING EXPERIMENT STATION (TEES) THROUGH DR. HYLAND

A Pipeline for Creating Future Cosmic Explorers

DARPA-RA-11-70

TOTAL PROPOSED COST/TIME:
$500K/730 days

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Dr. Hyland through TEES and other individual founders are NOT providing scientific, engineering, and technical assistance (SETA) or similar support to any DARPA technical audiences through an active contract or subcontract.

I. VISION

Mankind is in a pivotal age, an age where we can flounder or soar. We can flounder through our mutual misunderstanding of each other and ensuing warfare or through rare yet significant catastrophes such as global pandemics or civilization-ending asteroid impacts. We can soar, literally and figuratively, through advancing spaceflight and colonizing other celestial bodies which will increase our survival as a species at least tenfold and provide numerous advances in science and technology that we cannot yet foresee. The visionaries of the past have not led us to this point only for us to destroy our dreams. The future is shaped by the present and we must do what we can well in advance to ensure that what we believe will be the future will indeed occur. The urgency for exploration has never been greater than now.

There are deeper reasons than the practical for why else has space graced the works of artists and poets as well as engineers and scientists so poignantly in the last century? The thought of humans on another world, even one as close to us as the moon, is so titanic that we cannot even express it fully. The Apollo era was an era of excitement and those decades hence where we relegated our exploration to sophisticated but non-human robotic probes have left us with an impressive but simultaneously mostly emotionless photos and videos of alien worlds. If we balk before the challenge of manned spaceflight and lose sight of the grand vision of interstellar flight, we become less than the people who have lifted us to the present. Though we may not be able to achieve it in one year or even ten years, with determined persistence and an unwavering vision, we can be sure that our future is ensured within this century. As the pioneer of rocketry and the first advocate for space exploration, Konstantin Tsiolkovsky, has said, “Earth is the cradle of humanity, but one cannot live in a cradle forever.”

The founder members of the 100 Year Starship (YSS) organization comes from an academic, industry, and government background. Specifically, Dr. David Hyland currently employed by Texas A&M University will serve as the Chair of the budding organization guided by his extensive professional background and through his and the other founders’ interest in space exploration. Collectively, the founders’ long-term vision is to develop technology and the human intellect that will be important for an interstellar journey in the future, hence the substantial interest in the 100 Year Starship (YSS) organization. The 100YSS organization (Org) will be a nonprofit research institution, based in Texas dedicated to creating the human intellect and the technology to aid an interstellar journey a century or less from now. The current project underway by Dr. Hyland which can be passed to the 100YSS Org is a ground-based and eventually space-based intensity interferometry telescope array which can image exosolar planets for habitability assessment. Concurrently, exploration projects will be developed in advanced propulsion research and life support system development which are the two most important areas for an extended interstellar journey to succeed.

The 100YSS Org will not be a university but a research institution conducting independent research with possible collaboration from outside industry or universities. Every year, excelling students from universities will be taken by the 100YSS Org as interns. Similarly, every year, several students who have worked at the 100YSS Org will be hired by the 100YSS Org to invigorate new energy and insights as well as to grow the organization. The 100YSS Org will initially be one complex but can later branch out to different areas around the country. The 100YSS Org's longevity is ensured through this pipeline and its topicality is ensured through this tight-knit focused approach on visionary space technology development.

During this century, the 100YSS Org will continue to develop technology for exoplanet ventures while mankind explores and settles the solar system. K. Tsiolkovsky's epitaph reads, "Man will not always stay on Earth; the pursuit of light and space will lead him to penetrate the bounds of the atmosphere, timidly at first, but in the end to conquer the whole of solar space." Even beyond what Tsiolkovsky has stated in these words, the 100YSS Org will provide the means to go beyond our planetary system.

II. OWNERSHIP

The 100YSS Org will be incorporated as a 501c3 nonprofit corporation. Though there are no shareholders, there is a Board of Directors that oversees the institution. All full-time researchers and officers of the corporation will be members giving them significant rights in regards to the direction of the organization and a check on the power of the Board of Directors. Given that the institution must last at least a century, a consensus on the direction of 100YSS Org is vital for its longevity and topicality. The five members of the Board of Directors own 50% of the corporation while the 25 full-time researchers and officers own the other 50%.

As a nonprofit corporation dedicated to research, there are a number of principles that the 100YSS follows:

1. No political or religious affiliations at any time.
2. No generation of profits within the 100YSS Org from its projects. However, spinoff companies are legal and encouraged.

See attachments for bylaws and constitution.

III. MANAGEMENT & ORGANIZATIONAL STRUCTURE

The founders of the 100YSS Org are Dr. David Hyland, Shen Ge, Ryan Goodnight, Virgiliu Pop, Neha Satak, Hyerim Kim, Darkhan Alimzhanov, and Roy Tucker. Their biographies are as follows.

Dr. David Hyland received his education at the Massachusetts Institute of technology Dr. David C. Hyland was awarded the S. B. degree in Aeronautics and Astronautics in 1969 and the M.S. and Sc.D. degrees, also in Aeronautics and Astronautics in 1971 and 1973, respectively.

During the period September 1969 through July 1983, Dr. Hyland served at the MIT Lincoln Laboratory, first was as Research Associate (until '73), then as Staff Member.

Beginning in August 1983, Dr. Hyland initially organized and subsequently led (until January 1992) the Structural Control Group within the Government Aerospace Systems Division of Harris Corporation. He has served as Principal Investigator and Chief Scientist for numerous research programs for NASA, AFRL and AFOSR. In February 1992, Dr. Hyland was promoted to Senior Scientist and assigned to the Senior Staff of the Vice President of Engineering of the Aerospace Systems Division.

Dr. Hyland joined the faculty of the University of Michigan, Ann Arbor, on May 1, 1996 and served as Professor and Chairman of the Aerospace Engineering Department until September 1, 2003.

He joined Texas A&M University on September 1, 2003 as Associate Vice Chancellor of Engineering, Associate Dean of the Dwight Look College of Engineering, holder of the Wisenbaker Chair of Engineering, Professor of Aerospace Engineering in the College of Engineering and Professor of Physics in the College of Science. Most recently, Dr. Hyland resigned from his administrative appointments to assume the position of Director of Space Science and Space Engineering Research for Texas A&M.

Dr. Hyland's current research interests include adaptive control for aerospace vehicle applications, development of formation flying control algorithms for optimal image quality and novel distributed imaging systems based on amplitude interferometry, optical heterodyne interferometry and intensity correlation interferometry.

Shen Ge is a 2011 August Masters graduate in aerospace engineering from Texas A&M University and received his undergraduate with a dual major in aerospace engineering and physics in 2008 December from Georgia Institute of Technology. His background is in space design, space simulations, and experimental design. He has great interest in manned space exploration, near earth asteroids, and space debris. His work on his Masters was on designing an innovative payload for a near earth asteroid mitigation mission. He also has interest in space entrepreneurship and public engagement of space-related endeavors. He is currently actively spearheading the establishment of the 100YSS Org and other aerospace corporations.

Ryan D. Goodnight received his education at Texas A&M University where he earned both a Bachelors and Masters in Aerospace Engineering as well as a Masters of Business

Administration. Prior to his December 2010 graduation, Ryan was heavily involved in all things aerospace related and held positions ranging from a line-boy at local airfield to the Project Leader in his senior capstone rocketry design class. As the National Director of Finance the Students for the Exploration and Development of Space (SEDS), Ryan attained non-profit recognition for the organization and helped create an endowment fund to support national space outreach activities. During graduate school, Ryan's research focused on optimal control and human interface design for micro air vehicles and he served two years as the President of the Tactical Unmanned Aerial Vehicle Laboratory. Concurrent with graduate school, Ryan co-founded an iPhone application development partnership and, based on its success, he decided to formally develop his business acumen with a business degree. Upon entering into the Mays School of Business, Ryan shifted his focus to operations management, marketing, and strategy and he became an active participant in case study competitions before winning the 2010 Texas Business Hall of Fame Scholarship. Since March of this year, Ryan has been working for the Rolls-Royce Corporation as part of its Customer Management Leadership Development Program. He is currently based in Singapore where he manages the repair and overhaul of Trent engines for Emirates, Etihad, and Qatar Airways.

Virgiliu Pop is a Researcher at the Romanian Space Agency, where he conducts research in the fields of space law, policy, and astro-sociology, and coordinates space education and outreach programs such as the World Space Week. Virgiliu studied (SSP07) and lectured (SSP11 - space and society) at the International Space University, and attended several law schools in Romania and Scotland for his undergraduate, Masters and Doctoral studies. In the field of space law, Virgiliu is one of world's specialists on the issue of space property rights, having published several refereed papers and two books, one of which - "Who Owns the Moon? Extraterrestrial Aspects of Land and Mineral Resources Ownership" was featured in the New York Times Magazine. His expertise is often sought by mass media as diverse as the BBC, Slate, New Scientist, Space.com, Astronomy Now, Science & Vie. In 2011, Virgiliu led the first Romanian crew at the Mars Desert Research Station.

Neha Satak is a final year doctoral graduate student at the Department of Aerospace Engineering at Texas A&M University. She received her Masters of Science degree in Aerospace Engineering at the Indian Institute of Science, India. There she worked on Micro Air Vehicle design, fabrication and autonomous control. She also received the best Master Thesis Award (Gold Medal) for her Master's Thesis. Her undergraduate degree is in Electronics and Communication Engineering from the Rajasthan University. She is also an Amelia Earhart Fellow for the year 2010-2011. Her interest and future goals are to become a space entrepreneur.

Hyerim Kim is a Ph. D student in Aerospace engineering at Texas A&M University and received her B.S. in Astronomy and Space science and B.E. in Mechanical informatics engineering from

Kyung Hee University, South Korea in 2009. Her research interests include optical imaging and control, space dynamics and design.

Darkhan Alimzhanov was born in Kazakhstan on May 29, 1987. He attended natural sciences oriented high school and finished it with excellence in 2004. The same year he was admitted to State University of Karaganda in Kazakhstan, receiving a governmental scholarship and majoring in Technical Physics. In 2006, Darkhan transferred to Texas A&M University Undergraduate Program to study aerospace engineering through the Kazakhstani Presidential Scholarship Program "Bolashak". He graduated from Texas A&M University with a BS in aerospace engineering in December 2009 with Magna Cum Laude. Given his contribution and cooperation with Dr. Hyland in Undergraduate Space Mission Design classes at Texas A&M, Darkhan was accepted to the graduate program in aerospace engineering, working on Dr. Hyland's asteroid mitigation mission Project. Darkhan is currently researching spacecraft dynamics and control near the asteroid Apophis during an innovative deflection technique. He is very interested in projects related spacecraft control.

Roy Tucker is employed as a CCD imaging device characterization engineer at the University of Arizona's Imaging Technology Laboratory. His Bachelor's degree in Physics was obtained from Memphis State University (now The University of Memphis) in 1978. His Master's degree in Scientific Instrumentation was granted by The University of California, Santa Barbara in 1981. He was for three years a graduate student in the Planetary Sciences at The University of Arizona (1984-1986). Roy is especially interested in the stimulating challenge of research conducted with small aperture telescopes and unmanned robotic spacecraft. In the course of his amateur astronomical endeavors, Roy has discovered several hundred Main Belt asteroids, six Near-Earth Asteroids, two comets, and is one of the three co-discoverers of the earth-threatening asteroid (99942) Apophis.

The internal organization of the 100YSS Org is divided into three tiers.

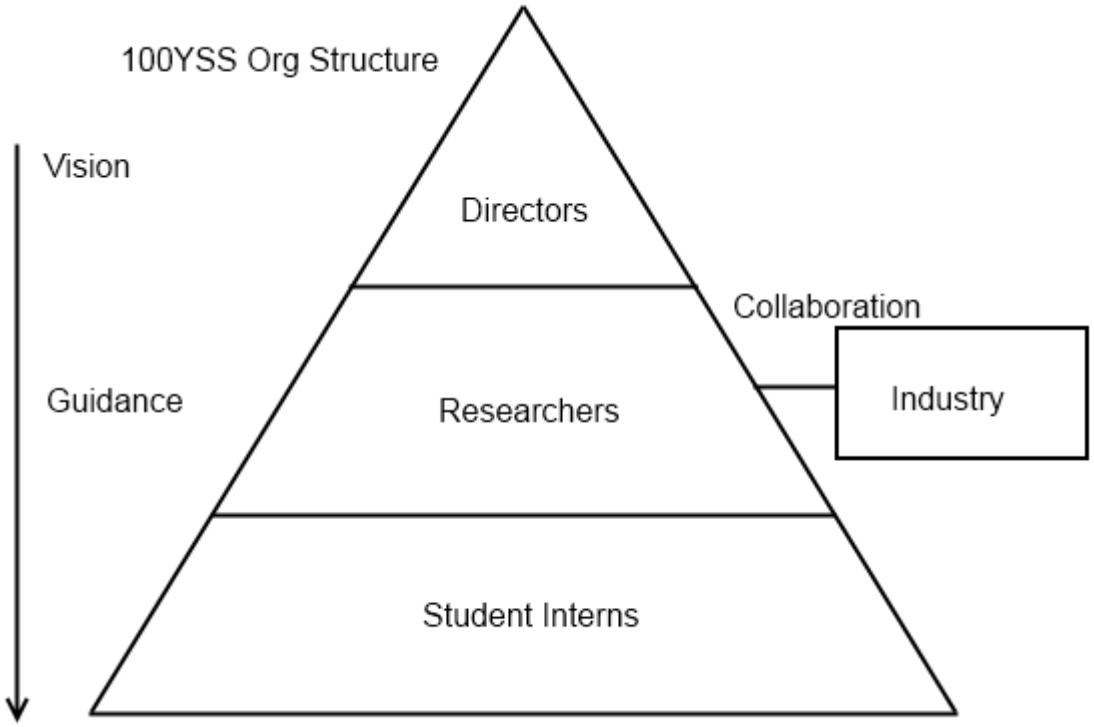

Figure 1: Diagram of the internal organizational structure of the 100YSS Org.

Through this setup, a cyclic pipeline of excellence is attained and maintained. The base rung of students can move on to the research rung hence supporting the students. The Board of Directors composed of futurists, top aerospace researchers, and space entrepreneurs will provide the broad direction for the researchers to investigate.

The 100YSS Org will collaborate with existing spaceflight advocating organizations including the Coalition for Space Exploration, British Interplanetary Society, and Icarus Interstellar. The initial commitment of the 100YSS Org will be the development of the space-based interferometry setup. Future commitments will move on to other projects including propulsion and life support systems.

See attachments for letters of commitment from individuals involved in proposing the establishment of the 100YSS Org.

IV. INCOME SOURCE & FUNDRAISING APPROACH

The initial income source of the 100YSS Org is from a combination of industry and government sponsors. The grant from DARPA via this proposal can provide the seed money to rent a facility and hire initial researchers to work on the interferometry project. This project, currently being conducted by Texas A&M University professor Dr. Hyland, has already garnered the financial support of the Air Force and Lockheed Martin on their versions of the project. However, for the

technology to be geared towards habitable exoplanet detection and not terrestrial reconnaissance, a separate system using the intensity interferometry technique must be developed and launched. This will require substantial funding but due to the civilian application, can be raised through grassroots efforts as well as government grants which can be applied through grants.gov.

Through online grassroots fundraising, small projects necessary for the overarching main project can be provided entirely through donations by the interested public. Since there are multiple crowdfunding sites, different projects can be allocated to different sites to not split the attention. The following are a number of crowdfunding platforms which 100YSS Org plans to use to reach the interested public for small individual donations:

1. **Kickstarter** collects pledges for projects and then these pledges are applied to a goal amount that the project creator sets. If the goal is not reached within a window, with the maximum being 90 days, the pledges depart and the funding does not happen.
2. **IndieGoGo** is similar to Kickstarter and actually started shortly before Kickstarter. The only major difference is that it allows the project creator to keep the funding even if the goal is not reached.
3. **RocketHub** is similar to IndieGoGo but it is newer and has a smaller community base. It has a SciFund Challenge subsection which brings scientists together to raise money.
4. **ProFounder** founded by two Stanford MBAs helps entrepreneurs and small businesses solicit and receive investments from their own network independent of banks or angel investors. Going through a lawyer to set up investment terms can also be expensive whereas ProFounder requires only $1100.

Furthermore, subprojects can be delegated to community-driven technically inclined people such as hackerspace. A hackerspace is a location where people with common technological interests can meet, socialize, and collaborate. There are hackerspaces worldwide in most major cities. A small project such as a network of cubesats with small telescopes can be developed by hackerspaces and serve as a proof of concept space test bed.

Finally, visionary blue skies research of 100YSS Org can also be funded through donations by wealthy visionaries such as the futurist Walter de Brouwer, an entrepreneur who founded several companies including Starlab, a multidisciplinary blue skies research institution conducting research in space and neuroscience. Entrepreneurs such as Walter de Brouwer have provided funding for a nonprofit organization of volunteers such as the Tau Zero Foundation. Reasonably, a full-fledged research institution will garner more interest from such individuals. Venture capitalist firms specializing in long-term science returns will also be greatly interested in the work conducted by the 100YSS Org. For instance, Marcus Venture Consulting is a company specifically founded to foster sustainable success for blue skies science research.

V. INVESTMENT APPROACH

For the 100YSS organization to plant the seeds of technological innovation and cultivate them into a vehicle for interstellar travel, it must have both foresight and focus. The group must be able to not only identify areas which are in need of attention, but also understand how it should go about properly devoting its resources to attaining the required knowledge and technology necessary to enable its vision. Furthermore, the organization must have a means to evaluate the success of its investments/research in cases where immediate commerciality may not be possible and traditional means of calculating ROI do not apply. The following section aims to indentify how the 100YSS will organize its investment approach to ensure that it can support and withstand the next century of intergalactic pursuit.

As has been previously noted, mankind is currently lacking the technology needed to reach further into the heavens in a number of different areas. For example, subject areas that will require the long-term dedicated attention of the 100YSS will include navigational systems, life-support systems, advanced high-thrust low-weight propulsion systems, regenerative food sources, enhanced communications platforms, societal buy-in, etc. It will be the primary goal of the 100YSS organization to prioritize these needs and address them through independent groups within the organization. These groups, which will consist of 100YSS employees and industry representatives, will serve two key purposes. Primarily, they will serve as the key experts in their particular area. They will evaluate the current state of technology, outline what future interstellar flight might demand, define requirements, and solicit improvements to these areas such that the needs of their fields are met. As technology is developed, these groups will serve to evaluate the impact of such improvements and reassess the need for further concentration. It will do this by defining the scope as either a short-term, intermediate-term, or long-term concern and, for each category, the 100YSS will assign a different priority level. For example, mankind has currently reached a propulsion plateau and the need for improved propulsive capabilities is paramount to the success of an intergalactic mission. This would be defined as a long-term concern as advancements are likely going to require decades of research and it would be addressed with progressive advancements leading up to an end goal. Conversely, there are currently monumental advancements being made in the field of stellar navigation, such as Dr. Hyland's current interferometry research, and these projects should be deemed as short-term concern and would receive immediate attention. As advancements are made, these categories can be re-assessed and re-scoped as necessary. All the while, the 100YSS leadership will oversee the development of all technologies from a 30,000 foot level so that the full scope of the mission is not missed.

Secondarily, these groups within 100YSS will oversee the allocation of capital to both internal and external research projects. The 100YSS envisions that it will rely on a portfolio of ways to

encourage innovation. Drawing on the success of the Nobel Group and the X-Prize Foundation, the 100YSS will set criteria for categorical improvements in various fields and incentivize innovation with monetary rewards. Award winners may come from solicited or unsolicited projects and will cover a broad range of areas ranging from technical innovations to the humanitarian results of space technology developments. A secondary method for encouraging improvements in the above-specified areas will stem from the awarding of solicited refreshing grants. A refreshing grant acts in much the same way as an endowment except that it can be removed at any time if the progress of a given project is deemed unsatisfactory. As long as progress remains in accordance with the timelines agreed upon between the two parties the grants will operate in perpetuity. The integrity of these refreshing grants will be guaranteed with a gated review process. This gated review will factor in overall progress as it aligns with the 100YSS objectives and will occur on an agreed upon timetable. The 100YSS functional groups will also actively be pursuing solutions to the space faring challenges and they will do so with both internal research efforts as well as partnerships that will redefine how society develops its space technology.

Since the 50's, the United States and other global powers have addressed these shortcomings through the allocation of tax-payer funds to research institutions and government agencies such as NASA. These investments have undeniably paid dividends, however, the greatest beneficiaries have been arguably been private industry. Quintessential discoveries such as Velcro and memory-foam have not only helped man venture deeper into space but it has also brought home improvement and mattress companies vast wealth. This relationship between space-related research and the private sector is not unidirectional. Unfortunately, examples of the corporate world developing space flight enabling technologies have been far less publicized. Going forward, it appears that this may be the most efficient and sustainable vehicle for developing the capabilities The 100YSS understands that it cannot independently fund every research initiative needed to satisfy the objectives of sending colonists to our nearest intergalactic neighbors so it will strategically pick industries that are currently or will be developing technologies with dual applications. For example, the oil and gas industry is hard at work bioengineering new forms of algae that have the ability to convert compost into consumable fossil fuels. It is speculated that these algae may also have the ability to convert carbon dioxide to oxygen at a previously unobserved rate in nature. This could create the potential for a new carbon dioxide filtration system aboard future intergalactic spaceships. The 100YSS will look to forge relationships with companies such as Exxon Mobile, one of the leaders in this field, and share the costs and responsibilities of developing these and similar technologies that might have potential applications for both parties. In taking this approach, the 100YSS will ensure that it has access to the intellectual property needed to complete its mission while at the same time, hedging some of its development risk with partners who have far more resources at their disposal.

It is anticipated that the majority of the investments and research that will take place at the 100YSS will fall into the aforementioned model. Global economies around the world are showing an increasing trend toward privatization of assets and as such the sustainable solution for the 100YSS is to partner with groups that will mutually benefit from the developments. Assuming this is the case; the problem then becomes how to determine if the 100YSS's investments are paying dividends when the investments may not come to term for an entire century. First, the success of an investment will be measured against the objectives laid out by the research teams at 100YSS. As long as the organization is moving toward its ultimate goal of satisfying the intergalactic mission requirements, then it can be said that the group is meeting a certain percentage of its objectives. However, by partnering with private industry, the 100YSS is provided a secondary means of evaluating the success of its investments, cash flow. Going back to the bioengineered algae example, it can be clearly seen that if 100YSS is successful in helping the oil and gas industry develop this technology then it will benefit financially from its partial ownership of the intellectual property associated. These cash flows clearly would aid the 100YSS as it would provide a means for increasing the endowment fund that supplies the organization with its operating capital.

It can be assumed that over the course of the next century, the 100YSS's activities would yield technology that would serve the general public, private industry, and the government. These investments would help continuously fuel the 100YSS endowment fund and support the growth that the organization must experience to make this mission a possibility. Without the assistance of government funding, it is unlikely that any approach other than industry partnerships would not likely yield the necessary cash to sustain the organization. Therefore, it is crucial that the 100YSS form these partnerships as soon as possible. Fortunately, the team that has created the 100YSS is not only diverse but has the luxury of having a close relationship with one of the world's foremost research universities, Texas A&M University in College Station. These close university ties will allow the 100YSS to immediately begin working with leading researchers on a number of projects that might aid mankind in travelling across our galaxy and into the celestial unknown.

VI. STATEMENT OF WORK

The 100YSS organization will conduct both immediately practical and blue skies research with the awarded grant. Notably, the projects entailed will be all geared towards both education and engineering development.

Exoplanet Imaging Division

Dr. David Hyland is already conducting work on the use of interferometry in detecting possible habitable worlds. The Detection Research and Implementation division will direct its focus on identifying the most likely targets for a starship in the future to travel to.

Intensity Correlation Imaging (ICI) is a technology developed by Dr. Hyland which enables the acquisition of ultra fine resolution images of space objects using an array of small, inexpensive telescopes. The technique involves breakthrough signal processing, multi-spectral receivers , and quantum correlations to achieve unprecedented image quality. With only two 16 inch telescopes, ICI has imaged a geostationary satellite to one-meter resolution from a distance of 37,000 kilometers – a task that would otherwise require a 15-meter diameter conventional telescope. It is our hope to apply ICI to non-defense, non-surveillance purposes, namely the direct imaging of exosolar planets. Such imagery would be an essential step in determining suitable destinations for the 100-year starship.

The 100 YSS organization, will collaborate with Texas A&M through expanding the existing two-observatory facility at the Texas A&M main campus to a system of 16 observatories in all the TAMU system member campuses. This array, called GAIA (Gigantic Astronomical Imaging Array) will span across the state of Texas to form an effective aperture of over 1000 kilometers in extent – sufficient to image even Earth-sized planets out to 15 parsecs.

Initial construction will require some two years of effort. Subsequent operation of GAIA will be performed by faculty and students from all of the member campuses. Viewing time and protocols will be managed by the GAIA Association, comprising both the site campuses and interested users. Once established, we anticipate operation for an indefinite period, supported by non-DARPA contributions.

Figure 2: GAIA is an intensity interferometry array of field units that will be operated at various institutions within Texas and later expanded to the US.

Advanced Propulsion Research Division

In the 1990s, NASA funded the Breakthrough Physics Propulsion (BPP) Project (1996-2003) supporting research that strove to uncover new physics leading to the development of more advanced propulsion methods. If new propulsion physics is uncovered, a new class of technologies will result, revolutionizing spaceflight and enabling humanity to learn more about the Universe. The narrower goal of breakthrough propulsion provides a different perspective for tackling the lingering mysteries of physics which can be missed if driven by only curiosity. Theoretical spacecraft propulsion research is important for it can be revolutionary.

Though NASA priorities shifted in 2003 leaving the termination of the BPP Project, the 100YSS Org's Advanced Propulsion Research will be far more long-term. Though largely theoretical, the practical implications can be enormous if reality can fit the theory. Notably, today's chemical rocketry for spaceflight was largely relegated to science fiction until early rocket pioneers showed the world their true potential. Marc Millis, the head of the BPP Project, and some other scientists who worked with him on the BPP Project, have continued to pursue this research in their spare time. They are part of the Tau Zero Foundation, which formally connects this group of researchers. The 100YSS Org plans to hire them as full-time researchers for the Advanced Propulsion Research division. We also plan to collaborate with Icarus Interstellar Inc., a nonprofit of volunteers who also has members of the Tau Zero Foundation, who is currently conducting theoretical engineering studies to design an interstellar spacecraft.

The schedule of the project will be over the span of the hundred years or until truly revolutionary propulsion mechanism is discovered. The immediate deliverables are physical simulations and theories as well as experimental tests. Some of the currently highly speculative methods that will be funded are shown in the following figure.

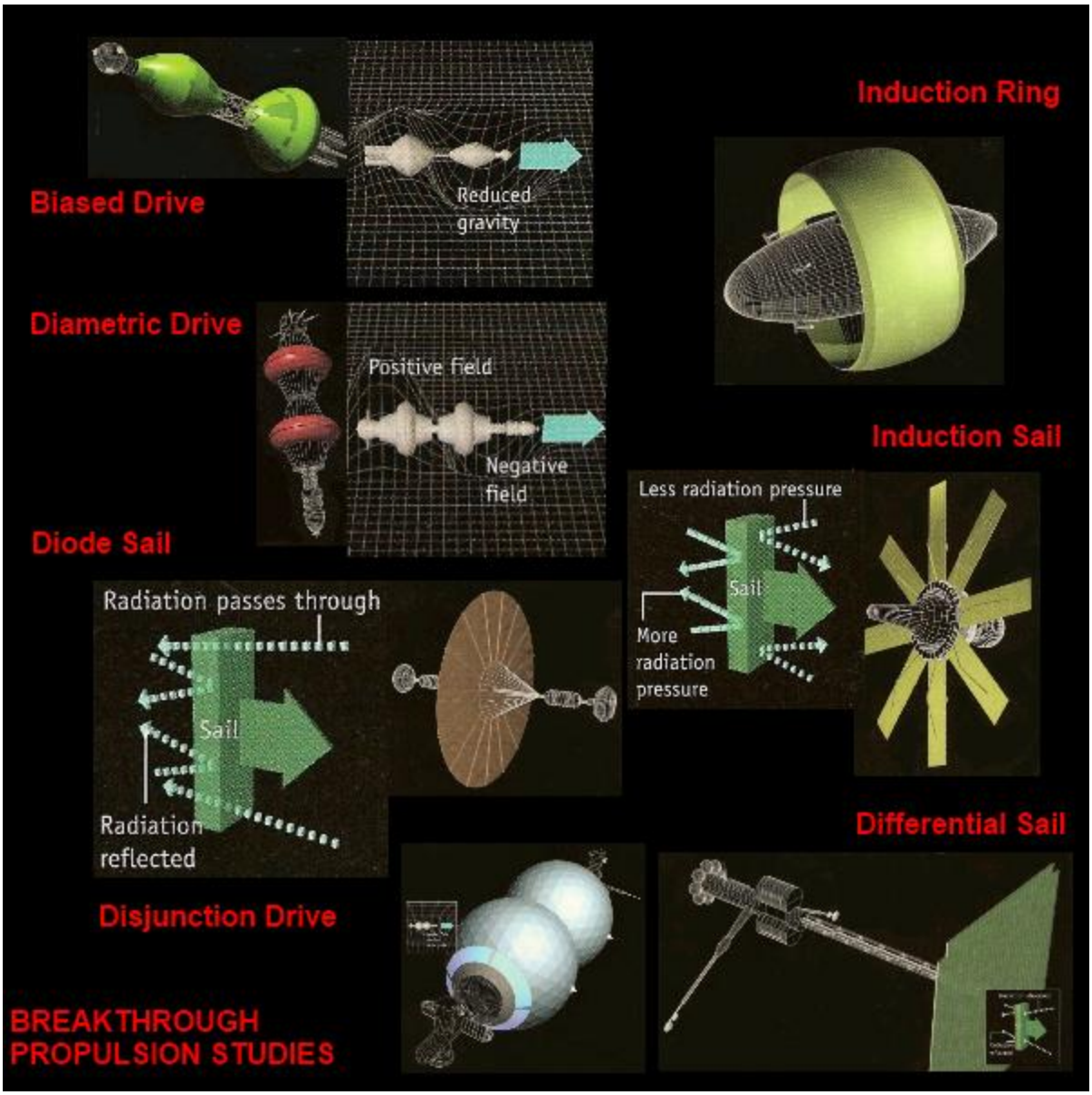

Figure 3: Breakthrough propulsion studies will continue to be funded by the 100YSS Org that the Tau Zero Foundation is currently pursuing independently without funds.

Starship Life Support Division

Unless a very revolutionary propulsion technique is discovered within the century, a regenerative life support system which can support multiple generations on a starship will be necessarily developed. The Starship Life Support division of the 100YSS Org will design the life support system from the starship macroscopic perspective as well as funding research that can be implemented quickly. For the former, a starship life support (SLS) simulator similar but grander in scope than NASA JSC's Advanced Life Support (ALS) system will be designed. This

simulator will be continually updated and upgraded with new software and engineering advancements and will eventually serve as the core control for the starship a century from its initial development. A schematic of the modules composing the simulator is shown in the following figure.

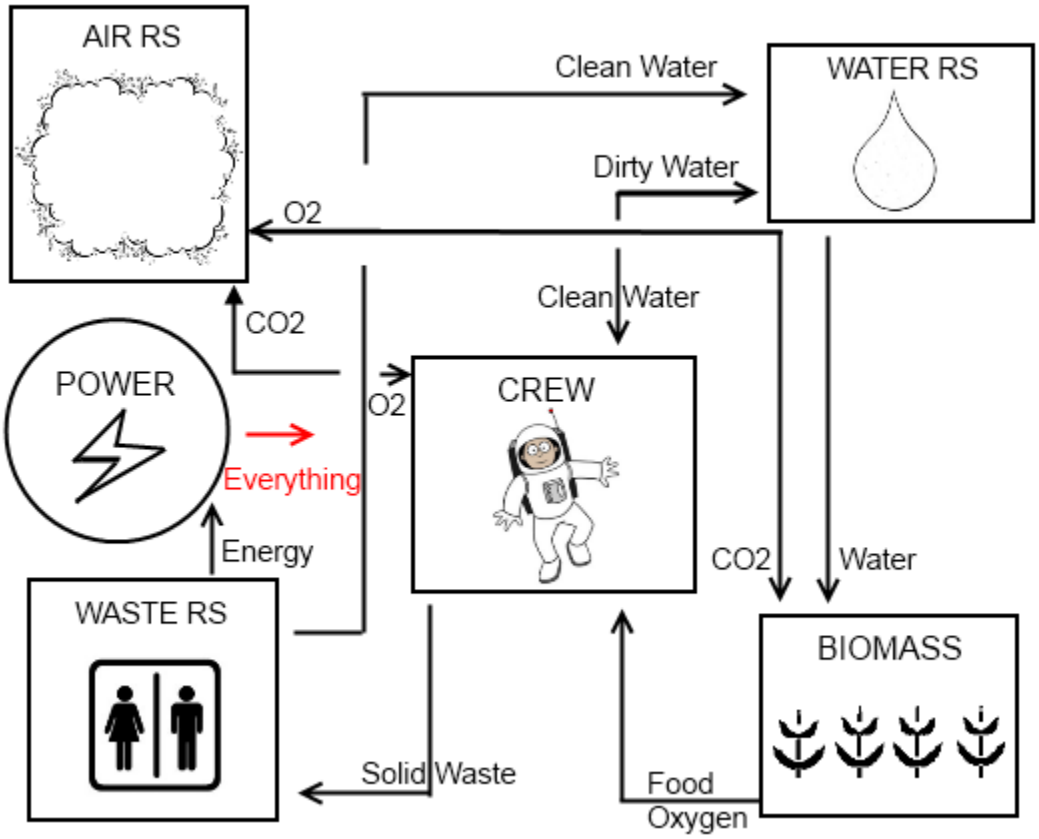

Figure 4: Schematic of the SLS simulator modules and relations between them.

Of notable importance in a regenerative life support system is the relation between mechanical and biological components in recycling air and water. Realistic regenerative complexes will rely on machinery to regulate the system, supply the plants with nutrients, and process wastes. Choosing the composition of the artificial atmosphere must take into account physiological, engineering, cost and safety factors. Investigating ideas that have not been implemented thoroughly before such as system ecology where complex high diversity biological systems are able to self-organize can revolutionize prevailing perceptions of life support systems.

After the first of the simulator is coded, the 100YSS Org will go into designing the hardware for such a closed cyclic life support system based on advancements from previous studies such as the Bios experiments in Russia, the Closed Ecological Experiment Facility in Japan, the Biosphere 2 project in Arizona, the MELiSSA program of the European Space Agency, and

several fundamental works by NASA such as the Controlled Environmental Life Support System (CELSS), the Breadboard Project, and the Advanced Life Support System Test Bed (ALSSTB).

For NASA, Kennedy Space Center provided a test bed for plant cultivation, Johnson Space Center provided the human element of food processing and diet, and Ames Research Center provided life system controls. The Starship Life Support division will be focused on two areas:

1. Investigating novel life support system ideas through incorporating new fields such as system ecology.
2. Working with government agencies in upgrading proven devices and incorporating such devices in the overall system.

For the latter, 100YSS Org will purchase life support devices already developed and incorporate it in its own system. Furthermore, 100YSS Org can collaborate with areas of space life support expertise such as NASA Ames to work on immediate relevant projects. Experts such as Dr. Harry Jones from NASA Ames can be hired as full-time employees or consultants. Currently, there are three immediate areas in life support which can be further developed through the 100YSS Org:

1. Water Recovery System
    a. Currently being developed by NASA Ames, the Vapor Phase Catalytic Ammonia Removal (VPCAR) is a single-step water recovery system that requires no consumables or maintenance for three years. As stated by NASA Ames, at TRL 6, VPCAR is a key life support subsystem technology for missions beyond the low Earth orbit. 100YSS Org can collaborate with NASA Ames to further develop this technology.
2. Air Revitalization
    a. NASA Ames is currently developing a solid-state technology for CO_2 absorption, separation, and compression which will resolve the issue of closing the air loop in the spacecraft called the Temperature Swing Absorption CO_2 compressor (TSAC). Doing so can solve substantial amounts of air in a system which for an interplanetary voyage is indispensable. Currently at TRL level 4, substantial improvement can be made here.
3. Waste Processing/Resource Recovery
    a. A solid waste processing and resource recovery technology will include both oxidation and incineration. Research into carbon nanotubes for capturing trace contaminants and converting them into usable products may result in efficient trace contaminant control capabilities for interplanetary journeys. Aside from gathering products for further usage such as water recollection, gathering energy through waste-to-energy methods will also be investigated.

As mankind ventures into the solar system and colonizes planets and asteroids in the coming decades, the likelihood of finding new technology to grow food is almost definite. The ability to clone plants has been known for centuries but the ability to grow better genetically engineered perfect replicas at lower time and cost will only increase. Furthermore, using mineral rich asteroids as soil for plant growth may also be a possibility.

VII. COST

The office and administrative setup of the 100YSS including compensating two employees, notably the Chair of the Board of Directors and the President, to manage the company is estimated to be $125 for the first year which will be covered partially ($78K) through this DARPA grant. Funding from other sources such as donations from industry and wealthy individuals or crowdfunding can cover the salaries of other personnel such as other members of the Board and administration of 100YSS. These are expected to be $500K distributed as such:

Chair of Board of Directors, $70K/year. $39K/year from DARPA, $31K/year from non-DARPA sources.

Director Member, $55K/year. $39K/year from DARPA. $16K/year from non-DARPA sources.

President, $60K/year. $39K/year from DARPA. $21K/year from non-DARPA sources.

Vice President, $50K/year. All from non-DARPA sources.

Financial Officer, $45K/year. All from non-DARPA sources.

Secretary, $40K/year. All from non-DARPA sources.

Exoplanet Imaging Division

Costs estimated here are for the initial construction of the GAIA facility and a two-year period of “shake-down” operation. Beyond this we anticipate operations support from non-DARPA sources.

Initial Construction: Two-year period

Costs are estimated directly from experience with the existing two-observatory facility. The hardware cost is $75 K per observatory (including telescope, electronics, computers, all ancillary equipment and the observatory shelter. GAIA requires the construction of 14 additional observatories which will require substantial costs and times to develop and maintain. Initially, it is assumed that sufficient funding within the two year period will be applicable for 3 new telescopes at three sites. Therefore the initial hardware cost is estimated to be $75K X 3 = $230K.

Labor over a two-year period to maintain and operate the existing facility was approximately $200K, mainly for graduate student support. The labor cost for the full GAIA facility per year would thus be approximately eight times this, or $800K per year. This labor cost would be sustained for all four years, hence the total labor cost is estimated to be $800K/yr X 4 yrs = $3.2M.

Initial projected costs for a two-year period for the construction of five new telescopes are documented here.

MONTH	ACTIVITY	AMOUNT (FROM DARPA)	AMOUNT (FROM ELSEWHERE)
1	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
2	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
3	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
4	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
5	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
6	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
7	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
8	a) Purchase of equipment. Set up one additional telescope, telescope #3 of GAIA. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
9	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
10	a) Purchase of equipment.	a) ~$9583	b) ~$9,842

	b) Salary for graduate students and other miscellaneous costs.		
11	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
12	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
13	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
14	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
15	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
16	a) Purchase of equipment. Set up one additional telescope, telescope #4 of GAIA. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
17	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
18	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
19	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
20	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
21	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
22	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
23	a) Purchase of equipment. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842

24	a) Purchase of equipment. Set up one additional telescope, telescope #5 of GAIA. b) Salary for graduate students and other miscellaneous costs.	a) ~$9583	b) ~$9,842
TOTAL		**$230K**	**$236,221**

Since this project does have commercial viability, cost-sharing from funds provided by industry such as Lockheed Martin are separately documented here:

SOURCE	**NATURE**	**AMOUNT**
Lockheed Martin	Salary for graduate students and any extraordinary equipment purchases.	$118,110
AFRL	Salary for graduate students and site maintenance.	$118,111

Additional details may be found in the appended Budget Detail for the GAIA project.

Advanced Propulsion Research Division

During NASA's six years funding of the Breakthrough Propulsion Physics program, an investment of $1.2M was distributed to a number of rocket scientists and physicists around the country. However, considering that the 100YSS Org will be funding the scientists full-time to work on innovative propulsion methods as opposed to a partial grant, an annual funding of at least $720K is required for ten scientists with an annual salary of $72K each. Any theory that can later be translated to reality will require experimentation and those costs will be higher. The projected cost for an experimental validation of a theoretical study is hard to predict and no attempt will be made here. Instead, what is presented is an initial investment in two theoretical scientists for one year.

MONTH	**ACTIVITY**	**AMOUNT (FROM DARPA)**	**AMOUNT (FROM ELSEWHERE)**
1	Scientist salary.	$6K	$6K
2	Scientist salary.	$6K	$6K
3	Scientist salary.	$6K	$6K
4	Scientist salary.	$6K	$6K
5	Scientist salary.	$6K	$6K
6	Scientist salary.	$6K	$6K
7	Scientist salary.	$6K	$6K
8	Scientist salary.	$6K	$6K
9	Scientist salary.	$6K	$6K
10	Scientist salary.	$6K	$6K
11	Scientist salary.	$6K	$6K
12	Scientist salary.	$6K	$6K
TOTAL		**$72K**	**$72K**

This project does not have immediate viability but it's expected due to its exciting nature of work, there will be interested individual donors and futurist organizations that are expected to fund such a project.

SOURCE	**NATURE**	**AMOUNT**
Wealthy individuals	Salary for renowned scientist.	$40K
Organizations such as Lifeboat Foundation	Salary for renowned scientist.	$32K

Starship Life Support Division

The SLS simulator development is expected to require at least one year and will require the expertise of at least one biologist, one biotechnologist, two life support engineers, two software engineers, and one project manager. The two life support engineers can be contracted from NASA JSC with NASA JSC handling the costs of their salary. Factoring these costs gives a rough estimate of the labor of $400K annually initially. More personnel will be hired as the 100YSS Org grows. The actual hardware test will be much more expensive. A rough ballpark estimate based on historical data is an additional $5M over a decade. The cost outline below only details the initial costs of developing the simulator program which is mainly labor costs.

MONTH	**ACTIVITY**	**AMOUNT (FROM DARPA)**	**AMOUNT (FROM ELSEWHERE)**
1	a) Software engineers. (X2) b) Biologist, biotechnologist, project manager. (X1 each) c) Life support engineers. (X2)	a) $9.6K	b) $23.3K c) N/A
2	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
3	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
4	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
5	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
6	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
7	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
8	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
9	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
10	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
11	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
12	Same as stated above.	a) $9.6K	b) $23.3K c) N/A
TOTAL		**$115K**	**$280K**

Since this project does have commercial viability, cost-sharing from funds provided by the government such as NASA or futurist organizations such as the Lifeboat Foundation may be possible. Furthermore, for individual module development, an open software platform can enable the public to participate as well through testing the software and encourage them through crowdfunding its development. The anticipated funding sources are documented here:

SOURCE	**NATURE**	**AMOUNT**
NASA JSC and/or Ames	Salary for biologist, biotechnologist, and project manager.	$140K
Organizations such as the Lifeboat Foundation	Salary as noted above.	$110K
Crowdsourcing sites	Salary as noted above.	$30K

VIII. FORM SF 424

Please see attachment for a signed copy of FORM SF 424.

Appendix A

CONSTITUTION OF THE 100 YEAR STARSHIP (100YSS) ORGANIZATION

I. Establishment

The 100 Year Starship (100YSS) Organization is established in 2011 in order to form a nonprofit research institution lasting at least 100 years to develop the technology and human resources for constructing an interplanetary spacecraft by 2111.

The principal office is located in Texas. Any designation of a change of address may be changed through a change in this constitution upon approval by a majority of the Directorate discussed in the Bylaws.

II. Mission

The 100YSS Organization's mission statement is:

"Develop scientific and technical knowledge to ensure that a manned journey to another star system a century from its foundation becomes a feasible reality."

The 100YSS Organization is split into three core areas of focus each with its own agenda but fitting together to form the whole objective.

The Exoplanet Imaging division will develop technology and missions to identify the most habitable planetary systems. Through such works as a telescope array utilizing the new technology of intensity correlation imagining, exosolar planets that may harbor water and other elements necessary for life can be identified readily. These can go into an expanding database of viable planets which will be continually updated.

The Advanced Propulsion Research division will investigate possible revolutionary breakthroughs in propulsion research. Based on studies by NASA's Breakthrough Physics Propulsion (BPP) program and the following advanced propulsion research currently conducted through the volunteered efforts of Tau Zero Foundation, a well-funded long-term investigation into advanced physics can yield promising results. New physics may be developed which will not require the tremendous mass required for conventional propulsion.

The Starship Life Support division will develop life support technology necessary for a crew to stay for a long-term in a confined area in space. Its Starship Life Simulator (SLS) and corresponding macroscopic laboratory tests of modules of air recycling system, water recycling system, water recycling system, and biomass production will be continually refined over the century.

III. Organization

The 100YSS Organization is subject to the rules of the Organization's Bylaws. The 100YSS Organization has a Board of Directors composed of five members. Due to the nonprofit status, there will be no shares. However, the Board of Directors does have substantial ownership rights and are responsible for holding

executive meetings responsible for the future direction of 100YSS. The members of the Board of Directors own 50% of 100YSS while 25 full-time researchers and officers own the other 50%. Together they compose the Directorate which makes all major decisions regarding the 100YSS.

The President of the 100YSS, appointed by majority agreement (more than half) of the Board of Directors, is the principal executive officer of the 100YSS, responsible for its overall leadership in day-to-day affairs. The Board of Directors advises the President on the major direction of the 100YSS while the President is responsible for navigating such a path through its internal governance structure described in the Bylaws. Participation in the 100YSS is open to any scientist and engineer based on their credentials and the formal criteria specified in the Bylaws.

Appendix B

BYLAWS OF THE 100 YEAR STARSHIP (100YSS) ORGANIZATION

SECTION 1
BOARD OF DIRECTORS

Section 1.1: The Board of Directors shall be consisted of at least 5 members and at most 9 members. The regular officers of the Board shall consist of a Chair, Vice Chair, and a Secretary. The regular officers of the Board shall be permanent members who will remain on the board until they resign, die, or are removed due to misconduct or physical and mental inability to fulfill the role. The other Board members shall consist of rotating members who serve 4 year terms. Any extended leave of absence by any Board member must be notified to all other Board members so that a decision can be reached on a temporary substitute. Any permanent leave of absence must also be likewise notified if possible.

Section 1.2: It shall be the duty of the Board of Directors to

- Perform any and all duties imposed on them collectively or individually by law, by the articles of incorporation, or by these bylaws;
- Appoint and remove, employ and discharge, and, except as otherwise provided in these bylaws, prescribe the duties and fix the compensation, if any, of all officers, agents, and employees of the corporation;
- Supervise all officers, agents, and employees of the corporation to assure that their duties are performed properly;
- Meet at such times and places as required by these bylaws;
- Register their addresses with the secretary of the corporation, and notices of meetings mailed or telegraphed to them at such addresses shall be valid notices thereof.

Section 1.3: Directors shall serve without compensation except that a reasonable fee may be paid to directors for attending regular and special meetings of the board. In addition, they shall be allowed reasonable advancement or reimbursement of expenses incurred in the performance of their duties. Any payments to directors shall be approved in advance in accordance with 100YSS's conflict of interest policy dictated in Section 13.

Section 1.4: **Chair:** The Chair presides over the Board and oversees the decision-making and electoral processes. The Chair is responsible for ensuring the continuing communication among Board members, advisers, and the administration. The Chair has the power to designate anyone to represent 100YSS at official functions. In the event a situation arises where an immediate decision is necessary, the Chair may make the decision on behalf of the Board, but must report all such decisions at the next regularly scheduled Board meeting, where the Board may overturn such decisions as they see fit.

Section 1.5 **Vice-Chair:** The Vice-Chair is appointed by the Chair. The Vice-Chair acts the duties that the Chair designates necessary. The Vice-Chair is also assigned to be a temporary substitute for the Chair in

the event of disability or vacancy of the Chair. In the event that the Chair resigns or is removed from office, the Vice-Chair will permanently assume the Chair's position for the remaining duration of the term, and an "unscheduled" election for a new Vice-Chair shall commence.

Section 1.6: **Secretary:** The Secretary will have two primary responsibilities. Primarily they will be in charge of recording and distributing the minutes of each Board meeting. After each meeting the secretary immediately creates a draft of the minutes for distribution to each of member of the Board. In addition, a version of these minutes will be made available to the public. The Secretary will affix a seal and attest such documents as legitimate Board decisions.

Section 1.7: The Board of Directors can hold meetings of their own to adjust their membership but they cannot change the Bylaws except at the annual Directorate Meetings where the administrative and research faculty of the Standing Committee also participate.

SECTION 2
MEETINGS

A. DIRECTORATE MEETINGS

Section 2A.1: The Directorate is composed of the top 25 positions of the administrative and research faculty of the 100YSS who make up the Standing Committee and the five members of the Board of Directors. Each Board of Director's vote is equivalent to five votes while each of the 25 positions of the administrative and research faculty is equivalent to one vote. This also applies to the Chair of the Board and the President of 100YSS.

Section 2A.2: The Directorate Meeting is held at least once every three months and will carry out any legal changes and other major responsibilities such as

- Authorizing borrowing of money, securing the repayment thereof by any appropriate hypothecation, lien, mortgage, loan, or trust deed, covering real or personal property.
- Authorizing the sale of any real estate, corporate bonds or stocks, or any other property owned by the 100YSS, and the investment of any funds in real estate, bonds, corporate stocks, or other securities it may approve.
- Authorizing the making and execution of leases of rental property of the 100YSS.
- Expending or authorizing the expenditure of all money requisite for discharges of duties imposed upon the Bylaws of the 100YSS Organization or by a special vote of the Board.
- Doing anything necessary or proper to carry out any of the foregoing powers, including employment of agents, attorneys, or employees, or to enter into contracts for any of the stated purposes.

B. INTERNAL MEETINGS

Section 2B.1: General meetings of the Standing Committee are held at least once every month. All Executive Committee members must attend and attendance by other members of the Standing Committee are strongly encouraged.

Section 2B.2: A quorum shall consist of a simple majority of the members of the Standing Committee. Motions moved and seconded for consideration in any meeting are voted on and will carry by a simple majority of the voting members present. Unless specified elsewhere in these Bylaws and under the authority of directives from the Directorate meetings, the Standing Committee may vote on any item brought before it at the general meeting.

Section 2B.3: Absent Standing Committee members may request, in advance, either a mail ballot or to be excluded from voting. Reasonable effort shall be made to contact members who will be absent in advance of votes on Bylaws and personnel matters

C. PROCEEDINGS OF MEETINGS

Section 2C.1: The Annual Meeting of the Board of Directors shall be held by default at the 100YSS or at such other place as designated by a majority of the Board at least three months before the Annual Meeting. Unless otherwise agreed on by a majority of the Board, the Annual Meeting will be held the first week of June at 3PM UTC.

Section 2C.2: Special Meetings may be held at any time if at least five members of the Board reaches consensus. In the case of the Chair's absence or disability, it is the duty of the Vice Chair to call for a special meeting.

Section 2C.3: A majority of the Board shall constitute a quorum for transaction of business in the Board.

Section 2C.4: Any member of the Board who is absent from two consecutive annual meetings without being excused by a majority will be dropped from membership on the Board.

Section 2C.5: At the appointed hour, the meeting shall be called to order by the Chair or in the case of vacancy by the Vice Chair. The order of business shall be determined by the presiding officer after consultation with the President of the 100YSS.

Section 2C.6: Written notice via email or traditional letter shall be sent to each Board member at least ten days before the date of the proposed meeting.

Section 2C.7: Any business may be transacted at any meeting of the Board whether it may be the annual meeting or a special meeting.

Section 2C.8: Action may be taken by the Board without a meeting if both a consenting decision by the majority of Board members and the full consensus of the regular officers are fulfilled.

SECTION 3
INTERNAL GOVERNANCE

Section 3.1: The 100YSS is internally governed by the Standing Committee composed of the following voting members: the President, the Vice President, the Financial Officer, the Secretary, the three division heads of the 100YSS, and other 18 members composed of either administrative positions

created at a later time or six members from each division chosen at the discretion of the respective division head.

Section 3.2: The Executive Committee is composed of seven members from the Standing Committee which are the President, the Vice President, the Financial Officer, the Secretary, and the three division heads. The Executive Committee is responsible for various important decisions including but not limited to approving the Vice President candidate, budgetary allocations, and deciding major proposals to pursue.

SECTION 4
APPOINTMENTS AND EVALUATIONS

A. APPOINTMENTS

Section 4A.1: The **President** is responsible for the overall day-to-day workings of the 100YSS Organization. The appointment is full time for a four-year term. The President is eligible for reappointment. The first President will be appointed by a majority agreement of the Board of Directors. Any future President designations will follow a more established procedure where when the selection of a President is to be made, the Board of Directors will establish a Search Committee to locate potential candidates. The Search Committee will be composed of ten members of the top faculty of the 100YSS. The Search Committee is responsible for identifying at least three likely candidates for the position of the President of the 100YSS. These three shall be presented to the Board of Directors for voting.

Section 4A.2: The **Vice President** is responsible for activities that the President designate necessary to be done. The Vice President will also take charge when the President is on extended leave due to an emergency or vacation. The appointment is renewable and full time for a two-year term. The Vice President will be proposed by the President but will be approved by a majority of the Executive Committee. The Vice President's duties include but are not limited to faculty development and discipline, research program development, evaluation and review, and strategic research planning.

Section 4A.3: The **Financial Officer** is responsible for all management of fiscal activities under the guidelines approved by the Executive Committee and the President. The appointment is renewable and full time for a four-year term. The Financial Officer will be proposed by the President but will be approved by a majority of the Executive Committee. Financial Officer keeps financial records of all 100YSS activities, controls all financial and tax matters, and monitors expenditures of all 100YSS activities. The Financial Officer is also responsible for allocating appropriate funds to general research and general maintenance under the direction of the Finance Committee of the Board. The Financial Officer must make monthly reports to the President of the 100YSS and the Finance Committee regarding the financial status of 100YSS.

Section 4A.4: **Technology Officer** may be elected by the President upon approval by the Board to act as the principal technology development officer of the 100YSS handling research contracts. The Technology Officer approves the establishment of potential technical projects with outside collaborators after reviewing any proposal submitted by faculty members. The Technology Officer

may also independently pursue space research contracts which may benefit the 100YSS and recommends appropriate faculty to conduct such projects. In the case of no present suitable faculty members, the Technology Officer can under the approval of the Executive Committee and the President of the 100YSS, create more faculty positions to conduct such projects.

Section 4A.4: The **Secretary** is responsible for documenting and distributing all meeting minutes and company procedural paperwork. The appointment is renewable and full time for a four-year term. The Secretary will be proposed by the President but will be approved by a majority of the Executive Committee.

Section 4A.5: The **Research Scientists** are responsible for the research conducted at the 100YSS. Their appointments are full-time and are permanent until termination by willing resignation or breach of the 100YSS Bylaws. The research scientists will be proposed by the Executive Committee but will be approved by a majority of the Standing Committee.

Section 4A.6: **Other Administrative Officers** may also be added. As provided in Section 1 of this article, the President shall establish, with the approval of the Directorate or its Executive Committee, such other administrative officers as the President may deem necessary for the carrying on of the work of the 100YSS, shall nominate persons to hold such offices, and shall define their duties. The President shall have authority also to appoint such committees, boards, or councils from members of the administrative staff and faculty of the 100YSS as in his or her judgment may be needed.

B. EVALUATIONS

Section 4B.1: All full-time personnel are subject to annual evaluations by the Standing Committee on their performance and a corresponding publicly available rated evaluation given. Through this, the 100YSS can encourage each of its personnel to do the utmost possible for the 100YSS and ensure that there is no breach of the Bylaws and the nonprofit status of the 100YSS.

Section 4B.2: The periodic reviews will include at the minimum the following subjects:

- Whether compensation arrangements and benefits are reasonable, based on competent survey information, and the result of arm's-length bargaining.
- Whether partnerships, joint ventures, and arrangements with management organizations conform to the corporation's written policies, are properly recorded, reflect reasonable investment or payments for goods and services, further charitable purposes, and do not result in inurement, impermissible private benefit, or in an excess benefit transaction.

SECTION 5
RESEARCH ORGANIZATION

Section 5.1: Research proposals, including budget information, are circulated for approval within the 100YSS prior to their submission to the Executive Committee and are paid to a proposal's relevance to the Institute's mission. Budgets are developed with the assistance from the 100YSS's Finance Officer and the respective staff to ensure sufficient allocation. The President is responsible for approved research proposals and related budgetary matters, including salaries proposed for outside consultants and

temporary staff. Principal Investigators are responsible for Staff and Intern appointments and their corresponding budgets.

SECTION 6
PUBLICATIONS

Section 6.1: The Interstellar Journal is a quarterly, international refereed journal published by the 100YSS. Operation of the Journal is governed by its own bylaws.

SECTION 7
FINANCES

Section 7.1: The President is responsible to the Board of Directors for all expenditures within 100YSS accounts. The Director or their designee, in a timely fashion and in consultation with the internal Executive Committee, shall prepare an annual budget for 100YSS. The Executive Committee will review the year's budget actions and report on them to the Directorate, on an annual basis. The Executive Committee and the Directorate shall approve major changes to the budget. Any member of the Directorate may bring a budget matter to the attention of the Directorate.

SECTION 8
RECORDS

Section 8.1: In order to facilitate the exchange of information between executive board members, 100YSS will maintain as many commonly used documents as possible in an electronic format.

Section 8.2: 100YSS shall maintain some type of electronic teleconferencing system for use by the Board and other committees and groups within 100YSS. A computer system accessible over the Internet is preferred.

Section 8.3: 100YSS shall maintain a File Transfer Protocol (FTP) computer site so that groups and individuals inside and outside of 100YSS may access information on 100YSS and commonly used 100YSS documents.

Section 8.4: 100YSS shall maintain electronic mail distribution lists over the Internet in order to facilitate the distribution of information. 100YSS should maintain separate distribution list for research updates, conference planning, and Board workings.

SECTION 9
SEAL OF 100YSS

Section 9.1: The Seal of 100YSS shall be a circle with an image of a blazing star on the top right quadrant and a stylized drawing of a starship at the bottom left quadrant.

SECTION 10
POLITICAL ACTIVITY

Section 10.1: 100YSS will never take a position on any political issue or candidate. 100YSS will seek to educate its members about all points of view and let each member make an individual choice. 100YSS will not spend funds supporting particular candidates, or supporting any particular side of an issue, but may spend money in order to educate the public on the issues.

SECTION 11
GENERAL INVESTIGATION

Section 11.1: Only expenses that are part of a 100YSS activity is allowable by the allocated funds approved by the Board. Any allocation of funds to a non-100YSS activity within the jurisdiction of a specific Board member or 100YSS administration will incur an investigation.

Section 11.2: Investigation will be carried out by an internal investigator appointed by the Board excluding those suspected of wrongdoing.

Section 11.3: If there is indeed a misappropriation of funds, the positions of the responsible parties will be terminated and they will be ineligible to rejoin 100YSS. Further legal action may be taken if a majority of the Board approves. If a Board position becomes vacant due to this, an unscheduled election will be held at a time voted by the remaining Board. If an administrative or faculty position becomes vacant due to this, the President of the 100YSS shall nominate a candidate to fulfill the spot.

SECTION 12
AMENDMENTS TO THE BYLAWS

Section 12.1: Changes to the Bylaws require written notice of motion to be submitted and circulated to all Directorate voting members, at least two weeks prior to the meeting at which they are to be considered. An absentee ballot will be provided for all Directorate voting members unable to attend such a meeting. Changes to the Bylaws require a two-thirds majority of all Directorate voting.

SECTION 13
CONFLICT OF INTEREST

A. PURPOSE

Section 13A.1: The purpose of this conflict of interest policy is to protect this tax-exempt corporation's interest when it is contemplating entering into a transaction or arrangement that might benefit the private interest of an officer or director of the corporation or any "disqualified person" as defined in Section 4958(f)(1) of the Internal Revenue Code and as amplified by Section 53.4958-3 of the IRS Regulations and which might result in a possible "excess benefit transaction" as defined in Section 4958(c)(1)(A) of the Internal Revenue Code and as amplified by Section 53.4958 of the IRS Regulations. This policy is intended to supplement but not replace any applicable state and federal laws governing conflict of interest applicable to nonprofit and charitable organizations.

B. DEFINITION OF INTERESTED PERSON

Section 13B.1: Any director, principal officer, member of a committee with governing board delegated powers, or any other person who is a "disqualified person" as defined in Section 4958(f)(1) of the Internal Revenue Code and as amplified by Section 53.4958-3 of the IRS Regulations, who has a direct or indirect financial interest, as defined below, is an interested person.

C. CONFLICT OF INTEREST AVOIDANCE PROCEDURES

Section 13C.1: In connection with any actual or possible conflict of interest, an interested person must disclose the existence of the financial interest and be given the opportunity to disclose all material facts to the directors and members of committees with governing board delegated powers considering the proposed transaction or arrangement.

Section 13C.2: **Determining Whether a Conflict of Interest Exists.** After disclosure of the financial interest and all material facts, and after any discussion with the interested person, he/she shall leave the governing board or committee meeting while the determination of a conflict of interest is discussed and voted upon. The remaining board or committee members shall decide if a conflict of interest exists.

Section 13C.3: **Procedures for Addressing the Conflict of Interest.** An interested person may make a presentation at the governing board or committee meeting, but after the presentation, he/she shall leave the meeting during the discussion of, and the vote on, the transaction or arrangement involving the possible conflict of interest.

The chairperson of the governing board or committee shall, if appropriate, appoint a disinterested person or committee to investigate alternatives to the proposed transaction or arrangement.

After exercising due diligence, the governing board or committee shall determine whether the corporation can obtain with reasonable efforts a more advantageous transaction or arrangement from a person or entity that would not give rise to a conflict of interest.

If a more advantageous transaction or arrangement is not reasonably possible under circumstances not producing a conflict of interest, the governing board or committee shall determine by a majority vote of the disinterested directors whether the transaction or arrangement is in the corporation's best interest, for its own benefit, and whether it is fair and reasonable. In conformity with the above determination, it shall make its decision as to whether to enter into the transaction or arrangement.

Section 13C.4: **Violations of the Conflicts of Interest Policy.** If the governing board or committee has reasonable cause to believe a member has failed to disclose actual or possible conflicts of interest, it shall inform the member of the basis for such belief and afford the member an opportunity to explain the alleged failure to disclose.

If, after hearing the member's response and after making further investigation as warranted by the circumstances, the governing board or committee determines the member has failed to disclose an actual or possible conflict of interest, it shall take appropriate disciplinary and corrective action.

SECTION 14
INDEMNIFICATION

Section 14.1 Any person made or threatened to be made a party to any action or proceeding, whether civil or criminal, by reason of the fact that the person is or was a voting or non-voting Board member, or an administrator or faculty of the 100YSS, or served another corporation, partnership, joint venture, trust, employee benefit plan or other entity in any capacity at the request of the 100YSS (any person serving in such capacity shall be referred to in this Article as a "Representative"), shall be indemnified by the 100YSS to the fullest extent allowable by law. The indemnification shall extend to all judgments, fines, amounts paid in settlement, and reasonable expenses, including attorneys' fees actually and necessarily incurred in connection with the defense or appeal of any such action or proceeding, and any other amounts, expenses and fees similarly incurred.

SECTION 15
CONSTRUCTION AND TERMS

If there is any conflict between the provisions of these bylaws and the articles of incorporation of this corporation, the provisions of the articles of incorporation shall govern. Should any of the provisions or portions of these bylaws be held unenforceable or invalid for any reason, the remaining provisions and portions of these bylaws shall be unaffected by such holding.

All references in these bylaws to the articles of incorporation shall be to the articles of incorporation, articles of organization, certificate of incorporation, organizational charter, corporate charter, or other founding document of this corporation filed with an office of this state and used to establish the legal existence of this corporation.

All references in these bylaws to a section or sections of the Internal Revenue Code shall be to such sections of the Internal Revenue Code of 1986 as amended from time to time, or to corresponding provisions of any future federal tax code.

Appendix C

Costs for GAIA is appended here.