Have Starship, Will Travel

The Newsletter of the Tennessee Valley Interstellar Workshop

Issue 16
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SAVE THE DATE FOR TVIW 2019!

WICHITA, KANSAS | NOVEMBER 10-15, 2019

The Sixth Interstellar Symposium and Advanced Interstellar Propulsion Workshop, presented by the Tennessee Valley Interstellar Workshop (TVIW) in collaboration with the National Aeronautics and Space Administration (NASA), will be held in Wichita, Kansas, on November 10-15, 2019, and will include a special two and a half day NASA Propulsion Workshop focusing on Beamed Energy Propulsion and Highly Energetic Nuclear Processes for Propulsion (Fusion and Antimatter). This workshop will be a new addition to our regular interstellar symposium, a workshop focusing on a specific aspect of interstellar exploration. It will be a part of the overall symposium and will not require special registration. We hope and expect to learn much about the current state of the art and future directions for many varied propulsion methods that may one day take us to the stars!

The symposium will be hosted by Wichita State University and Ad Astra Kansas Foundation.

We have opened the call for papers to be presented at this symposium. To submit an abstract for consideration, please do so here (tiny.cc/space2019).

Registration and Hotel information will be in the next newsletter.

2019 TVIW SCHOLARSHIP PROGRAM

The non-profit Tennessee Valley Interstellar Workshop (TVIW, Inc.) is proud to present its 2019 Scholarship Program, to provide two undergraduate scholarships and one graduate-level scholarship for qualifying students.

The $2,500 scholarships are sponsored by TVIW supporters Baen Books alongside Rob and Ruann Hampson. The scholarships are merit-based, and require all applicants to complete an essay with their application forms. **The deadline for all applications is May 15, 2019.**

Applicants for the undergraduate scholarships must be high school seniors in the southeast United States (Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, or Virginia) who plan to pursue their first undergraduate degree in a STEM related field at any accredited, four-year American college or university. Applicants for the graduate scholarship must be full-time college or university students majoring in a STEM related field, and seeking a graduate degree in science from an accredited college or university in the United States.

For more information about the new scholarships, including application guidelines, visit:

https://tviw.us/scholarships-2019

To learn more about the TVIW scholarship sponsors, visit:

http://www.baen.com

The winning essay from Crestienne DeChaine, one of the two 2018 undergraduate scholarship recipients, can be found at the end of this newsletter.

NEWSLETTER CONTENTS

TVIW POWER OF SYNERGY SYMPOSIUM EXECUTIVE SUMMARY

PROMOTING A GRAND TRANSFORMATION

The primary goal of the 2018 ***Power of Synergy*** symposium of the Tennessee Valley Interstellar Workshop (TVIW) was to generate a new vision and integrated plan for development and economic use of outer space within the decade before 2030. The resulting new jobs, infrastructure, industries, and major economic growth will insure that the United States continues and expands its traditional roles of creating great innovative futures for the world.

The symposium emphasized that inspired *multi-agency* government collaboration with private industries can greatly accelerate progress. In the 1960s, the newly formed NASA unified the best elements of existing government and business functions; and it still enjoys the greatest popularity of any government agency. Recently in March 2018, NASA announced a new cooperative technology development effort with the U.S. Department of Energy (DOE). Quickly expanding this new beginning is fundamentally important to enable major breakthrough strategies for accelerating human space development and industrialization. **An essential requirement is for clearly defined objectives for NASA and the DOE Advanced Research Projects Agency (ARPA-E) to accelerate utilization of Nuclear Thermal Propulsion (NTP) and other game-changing technologies and capabilities available from DOE National Laboratories.**

The eponomous "*Power of Synergy*" describes the vital catalytic element that must be applied. Hugely important concepts and technologies already exist that can be combined in new ways, where the sum becomes much more than the parts. Diverse not-yet-exploited technologies can be marshaled together to greatly accelerate human progress in space while – serendipitously – promoting on Earth greatly enhanced new technologies for national security, fiscal growth, infrastructure improvement, and human engagement.

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THE QUESTION OF GRAVITY
A SPECIAL ARTICLE FROM KENNETH ROY

Since the beginning of life on Earth, it has existed in a 1-g gravitational field. Life in the oceans can use buoyance to counter gravity to some extent, but once life crawled onto land it was exposed to a constant and unyielding 1-g gravity. Primate (including human) physiology and even psychology has evolved to deal with a 1-g environment.

But as we consider building bases and even settlements on distant moons, planets, and asteroids, we are faced with the question of living in a low gravity environment. A settlement on the Moon will have a gravity about 17% that of Earth. Mars has about has 38% that of Earth. So, how will that affect human health and well-being should a human spend time working out of a base on the Moon or Mars in such a low gravity environment?

We of course have a lot of experience with humans in a 1-g environment. We also have some experience with humans on the International Space Station (ISS) where they work in micro gravity, which for our purposes is effectively 0-g. And the results are not positive. Astronauts spending even a few weeks on the ISS begin to experience bone loss as calcium is re-absorbed sometimes leading to kidney stones. Muscles, because they aren't having to fight gravity, begin to waste away with studies indicating that six months on the ISS leads to a reduction in calf strength by about 32%, and that is with daily exercise. Some astronauts experience visual problems that in some cases are not full reversible upon return to Earth. The spine lengthens leading to lower back pain. It has been observed that the immune system becomes less effective. The sense of taste is affected so foods are less appetizing. And drugs seems to act different in space when compared to Earth. NASA is working to try to minimize these effects and has some progress, but long duration micro gravity is not ideal for human health.

But where does low gravity fit into this? Is Mars gravity or even the Moon's gravity enough to mitigate these health effects? We just don't know. We have no experience with humans living in gravity conditions other than 1-g or micro gravity. Astronauts did walk on the Moon for a few days, but they also spend days in micro gravity go to and coming from the Moon.

Growing children seem to need near 1-g gravity to develop bone, muscle, balance abilities, and even the ability to walk and run. How would they fare in a low gravity environment? We just don't know.

We won't know until humans live and work on the Moon and Mars. We could design a rotating space laboratory to provide low gravity environments simulating that of the Moon or Mars and then study how human subjects respond to those environments. But until then we just don't know.

Does that mean that we can't establish settlements on the Moon or Mars, or even on asteroids without risking the health and even the lives of astronauts and their family? Without some means to increase the gravitational field, the answer is probably "yes."

But, we can create artificial gravity by means of a rotating structure. Imagine a train traveling around in a circle on the Moon or even Mars. Someone on that train is subject to acceleration resulting from the circular motion as well as gravity from the moon or planet. The two acceleration vectors add up to the total acceleration experience by someone on the train. By increasing the speed of the train we can achieve any total acceleration we desire, even Earth-normal gravitational acceleration.

By example, if we establish a train track on Mars that is circular and has a radius of 825 meters and the trains runs around it completing a circuit in one minute (86 meters per second or 193 miles per hour), then the resulting acceleration experienced by any passenger on that train is equal to 1-g. The floor needs to be tilted from horizontal by about 68 degrees so that it will appear level to the passenger. If the train is 5184 meters long, its front car can connect with the last car form a complete circle. Such a train could allow humans to experience earth normal gravity for as long as they are on the train. If the train rails are located in a circular cavern composed of rock and steel, the cavern provides radiation shielding to any degree necessary.

A similar structure could be built on the Moon having slightly different parameters but with identical results with respect to gravity and radiation shielding.

A train traveling at 193 miles per hour is hard on the train wheels and tracks. But a recent Japanese magnetically levitated fast train has been clocked at over 350 miles per hour. And magnetic fields don't wear out.

In conclusion, there is much we don't know about a human's ability to work and live in low gravity environment. But using centripetal acceleration caused by rotating structures, it is possible to create Earth normal gravity on low gravity worlds and to do so in shielded caverns providing adequate radiation shielding. Humans can establish bases and settlements on low gravity worlds with some certainty that the human occupants can live long and health lives, even if we are totally dependent on living with 1-g.

TVIW POWER OF SYNERGY SYMPOSIUM EXECUTIVE SUMMARY
PROMOTING A GRAND TRANSFORMATION

Continued from page 1…

Thus, the TVIW October 2018 symposium framed a roadmap for synergy and technology superiority that will make U.S. space development the hallmark of inspired innovation leadership. Major collaboration of government agencies with emerging private space industries is the vital fructifying principle. The following three key Recommendations for Action frame the roadmap:

Recommendation 1: A Focused Program

An integrated decade-long systems and technology development program should be undertaken -- focused on the goals of **space exploration, industrial development, and human settlement**. Detailed identification and definition of novel synergistic concepts and supporting technology R&D must include plans for reprogramming resources necessary to rapidly "bridge the gap" from research to applications. This must not be random piece-work. The objectives must be concisely defined with performance requirements matched to systems objectives.

Recommendation 2: Transformative Technology Decision Process

Abundant, affordable high-energy systems (for propulsion, electric power, and industrial processing) are essential to

the large-scale exploration, development and settlement of space. High-payoff synergistic R&D investments should address the topic areas identified below to accomplish the needed objectives in 5 to 7 years maximum. Major transformations can be accomplished with reasonable funding provided these decisions are specifically governed to fit the overall systems plan.

Recommendation 3: Cooperation & Coordination

Accomplishing essential technology developments and demonstrations to realize space exploration, development and settlement **will require a variety of novel organizational arrangements** – including cooperation and coordination among government agencies, partnerships among government programs with private sector missions and programs, and possible engagement with international players. Ample support should also be given to "garage style" highly innovative startup companies inspired by the challenges. **A key element for success is for the government National Laboratories to transform their policies to bridge the current "valley of death" that is killing a large percentage of creative work** proposed by academics, small business founders, and even employees of the National Labs who are highly competent in science and engineering but not experienced in raising several million dollars to bridge to actual applications.

Transformative Technologies

Described below are several crucial technologies and concepts that can synergistically initiate transformative progress. **Most have high Technology Readiness Levels (TRLs), not requiring decades to implement.** The key materials, components, and applications (e.g., involving nuclear fuels, reactor design, and propulsion systems) will engage rapid development in existing advanced R&D facilities.

Energy Systems for Power, Propulsion, and Space Industrialization

1. **High Impulse Nuclear Propulsion & Power** – A huge step forward in compact nuclear reactor design was proved by DARPA in the $330 Million Particle Bed Reactor Program from 1988 to 1993. It remains the most advanced candidate technology for space propulsion. The reactors can also operate bi-modally to provide both propulsion and large amounts of electric power. Upper stage nuclear rockets (i.e. used only in space) can enable human trips to Mars in thirty to sixty days rather than multiple years. Nuclear propulsion is also vital for capture and engineering of small (10-meter diameter) near earth asteroids (NEA) that can facilitate construction in space of habitats safe from solar and cosmic radiation. Space solar power and other major industries will be rapidly enabled by the availability of ample nuclear energy.
2. **High Efficiency Wireless Power Transmission** – Efficient and affordable wireless power transmission is broadly applicable for space exploration and development. Proven by DARPA for near-term applications, high-efficiency fiber-optic high-energy lasers (HEL) are now very mature technology that can enable megawatt-class power beaming capabilities for space power and propulsion. Laser light sails are also a crucial application extending to interplanetary and interstellar propulsion for continuous low-cost logistics.
3. **High Temperature Superconductor (HTSC) Applications** – This technology will radically transform all types of electrical applications when fully exploited. It has been developed for thirty years and is ready for many game-changing implementations on Earth and in space having surprisingly diverse capabilities. **One crucial example is Magnetically Inflated Cable (MIC) technology that can deploy from compact payloads to form very large, very low-weight rigid space structures such as solar concentrators 100 meters in diameter.** Megawatts of 3000° C solar energy at the focus of such solar concentrators can implement near-term capture of 10-meter diameter near-earth asteroids to lunar orbits, where they can provide millions of pounds of useful materials for robotic in-space production. Examples of applications include mass-production of low-cost industrial products, completely safe radiation shielding, and artificial gravity solutions for human habitats and long-duration travel. -- **Another example of HTSC technologies is "maglev" systems**, for applications as diverse as 90% efficiency surface transportation, centrifugal artificial gravity systems, and low-cost surface-to-space electromagnetic launch from the Earth, Moon, or Mars.
4. **Solar Power Satellites (SPS)** – Formerly regarded as "pie in the sky," high-energy space solar power with microwave or laser power beaming to the Earth, our Moon, or to near-earth asteroids is now a real game-changing possibility. Persuasive concepts already exist for in-space production and deployment of all of the SPS components. Combining the notions of small asteroid capture for raw materials with robotic machines for ever-expanding production capabilities, near-term concepts are viable for beaming efficient, totally pollution-free solar energy to Earth, to space industries, and to the Moon & Mars.

Enabling & Enabled Systems (Manufacturing & Resources)

5. **Large Scale 3-D Printing for Additive Manufacturing** – Oak Ridge National Laboratory (ORNL) and its innovative manufacturing spin-offs are world leaders in this vital new technology. There are direct links to in-space manufacturing possibilities using readily available regolith materials from asteroids and on the moon.
6. **Space Resources Utilization** – The extraction, processing and utilization of space resources is both enabled-by, and enabling-for ambitious large-scale but affordable space energy systems. The resources of near-earth objects (NEOs), the Moon (particularly the detected deposits of volatiles within the permanently shadowed cold-traps at the poles) and beyond (e.g., Mars and its moons) can be utilized only with the availability of large-scale, affordable energy. And, those resources – particularly in the form of chemical feedstocks (e.g., propellants) and manufactured systems (e.g. see item 3 above) – can be readily and economically employed for advanced energy systems, such as refueling reusable transportation systems, fabricating components of Space Power Satellites, and many other applications.
7. **Lightweight Large Aperture Optics** – Various paths lead directly to the possibility of building enormous optical telescopes in space at vastly lower cost than present ground-based technology. For example, MIC (e.g. see item 3 above) enables kilometer diameter telescopes deployed in coherent interferometer arrays that will enable imaging and diagnostics of earth-like planets

around nearby stars. Diagnostics of life on exo-planets and the Search for Extraterrestrial Intelligence (SETI) would be greatly augmented. Importantly, the science of cosmology will be massively advanced toward ultimate understanding of the origin and destiny of our universe.

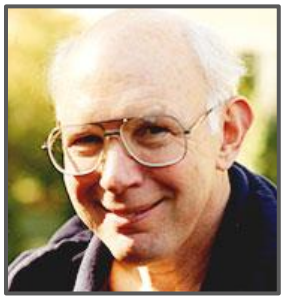
8. **Regenerative / Self-Sufficient Habitation Systems** – Affordable and abundant energy, the transformation and utilization of space resources, 3D printing of systems, etc., are essential to enable the permanent expansion of humanity beyond Earth. Today's space systems are energy-starved and as a result depend on continuous supply from Earth of consumables such as air, water and food, as well as regular waste removal. **All of the systems currently in use must be radically improved to enable humanity to move permanently beyond low Earth orbit (LEO). Megawatts of low cost energy provide the key to success.**

Executive Summary General Observations

Realization of even a fraction of these technologies and concepts by 2030 will open limitless horizons for human enterprise and accomplishment in space. This promising outcome depends upon rapid exploitation of transformative technologies focused on human development of outer-space resources, also having near-term propitious consequences for worldwide stabilization. Historically, the percentage of the US population that left the comforts of the East Coast was very small; but the effects of having an open frontier were practically, psychologically and culturally very significant: The open frontier provided vast new resources and opportunities. Historians cite the open frontier as a major factor in US fiscal and cultural development as an adventurous, individualistic, creative society. Opening space for full-scale development will provide the same advantages for our future.

High Energy synergistic technologies are at the heart of everything we might accomplish. New initiatives to combine the resources of DOE, DOD, NASA, and Private Industries are fundamental requirements for the US to lead the world in space development. Other countries will dominate if the needed synergistic capabilities are not vigorously pursued in the near term.

Figure 1. Symposium Chair Dr. John Rather (L) discusses transportation technologies with Co-Chair Dr. Dean Hartley (R) regarding travel on the Earth, Moon and Mars (globes shown to scale). John holds a model of the nuclear particle bed propulsion reactor invented by Dr. James Powell at Brookhaven National Lab and Dean considers more typical possibilities.



Dr. John D.G. Rather

Chair of the Power of Synergy Symposium

Dr. John D.G. Rather, General Chair of the Power of Synergy Symposium, is known internationally as a scientific innovator and creator of major technology programs. His experience in business and government spans defense, space, medical, and industrial communities. Dr. Rather worked in physics and space research at Oak Ridge National Lab, Lawrence Livermore National Lab and the National Radio Astronomy Observatory before moving into private business and US government senior appointments. As VP of an aerospace company, he created StarLab, which with co-contractors became the largest R&D program of the Strategic Defense Initiative. In 1990, Dr. Rather was recruited to NASA HQ to accelerate space systems development. In 1992, he served as Chairman of the NASA/DOE study of asteroid impact prevention mandated by the U.S. House of Representatives. Asteroid 7290 is named "Johnrather" in his honor. For more than twenty years he was also a contributor at the D.I.A. and the C.I.A. Dr. Rather moved back to Oak Ridge, Tennessee in 2006 and founded RCIG Inc. and Sisyphus Energy Inc. to create and develop focused revolutionary technology breakthroughs. Details are available on his websites www.RCIGinc.com and www.sisyphusenergy.com.

Dr. Dean S. Hartley III

Co-Chair of the Power of Synergy Symposium

Dr. Hartley is known internationally as a problem solver and expert in operations research (OR). He has been solving problems for customers for almost fifty years: two years while in graduate school, four years while on active duty in the Army, nine years in private industry, fifteen years at the Oak Ridge Federal Facilities, and seventeen years as Principal of Hartley Consulting. The Hartley Consulting website is http://drdeanhartley.com/HartleyConsulting/index.htm . Hartley is a Director of the Military Operations Research Society (MORS), a past Vice President of the Institute for Operations Research and Management Science (INFORMS), and past President of the Military Applications Society (MAS). Hartley has published *An Ontology for Unconventional Conflict*, *Unconventional Conflict: A Modeling Perspective*, *Predicting Combat Effects*, co-authored two other books, contributed numerous chapters to other books, and written more than 150 articles and technical documents. In 1994 he was awarded the Koopman Prize for best publication in military operations research and in 2013 he was awarded the Steinhardt Prize for lifetime achievement in operations research.

IMPRESSIONS OF THE 2018 TVIW "THE POWER OF SYNERGY" SYMPOSIUM

BY DAVID FIELDS

Genesis

The 2018 TVIW Special Symposium on The Power of Synergy (TPOS) was held October 23-25 in Oak Ridge, Tennessee. The venue chosen was the Y-12 New Hope Center, a 400-seat world-class Conference Center worthy of the U.S. Department of Energy research complex containing Oak Ridge National Laboratory and the Y-12 National Security Complex (Fig. 2).

Figure 2. Located at the Oak Ridge Y-12 National Security Complex, one of the original Manhattan Project facilities, this center houses historic displays and a 400-seat auditorium.

The 3-day Symposium started promptly on October 23, 2018. The organizers, together with TVIW staff and volunteers welcomed over 100 Symposium participants (Fig. 3) to experience inspiring presentations, waves of catered food, facility tours, and wide-ranging conversations that extended into late-evening discussions over dinner. In contrast to past TVIW Symposia, this event was supported primarily by donations and grants.

The TVIW Interstellar Mission and the Symposium Infrastructure

The TVIW Mission statement is to "facilitate interstellar research and exploration by hosting regular summit meetings, encouraging educational advances, publishing technical and scientific papers, and supporting literature and culture, all in the service of enhancing public understanding and dialogue toward interstellar exploration. TVIW will assist in building a technological, philosophical, and economic infrastructure that advances the goal of establishing outposts throughout the Solar System and, finally, achieving a pathway to the stars."

Past TVIW Symposia have focused on selected aspects of interstellar exploration. The 2018 "Special Symposium" was different, focusing primarily on rekindling the US space effort by showing how a synergistic mix of key technologies might provide the underpinnings for a grand decadal effort for space exploration. Thus, TPOS was structured to energize public enthusiasm and governmental, industrial, and educational institutional support – for a serious space initiative akin to that of the TVA hydropower initiative, the atomic weapon development effort, and the Apollo Mission.

In contrast to these past Symposia, the 2018 TPOS Symposium focused on building and jump-starting a solar system infrastructure for Space. This transformational approach would employ a synergy of technologies with components judged ready or almost ready for application. The first Symposium Theme was ***Energy Systems for Power, Propulsion, and Space Industrialization***. This category included presentations addressing High Impulse Nuclear Propulsion & Power; High Efficiency Wireless Power Transmission, High Temperature Superconductor (HTSC) Applications; and Solar Power Satellites (SPS).

The second Theme was ***Enabling & Enabled Systems (Manufacturing & Resources)***. Presentations in this category covered Large Scale 3-D Printing for Additive Manufacturing; Space Resources Utilization; Lightweight Large Aperture Optics; and Regenerative / Self-Sufficient Habitation Systems. The content of these sessions is discussed in the TVIW Power of Synergy Executive Summary article found earlier in this newsletter.

The third Theme, ***Transformative Decadal Plan***, compared the current situation, in which we are seen to be poised for a great leap into a space-based future, to a methodical approach, which may offer far fewer benefits. Our situation may be compared to past opportunities for great efforts, such as those that led to the TVA program , which engendered regional energy and cultural shift in the Tennessee Valley and spurred development of the electric power grid; the atomic energy program, which developed industrial-scale isotope-separation technology in Oak Ridge, Tennessee prompting military, electrical power, and cultural shifts of global importance; and the Apollo program, which developed the Saturn 5 rocket in Huntsville, Alabama and justified building the US space infrastructure. Each of these three important transformative projects was decadal in duration, had important focus in the Tennessee Valley region, and was global in impact.

The final Theme, ***Ultimate Paths to the Future (Science Fiction to Fact Relationships)***, offered a variety of viewpoints from diverse 'deep thinkers' as to how we might proceed with this grand transformative opportunity with which we are now presented. Initial answers as to how to chart a Decadal Plan were offered.

Figure 3. Early morning attendees on Day 1 enjoyed breakfast fare and stimulating introductory presentations.

The four Themes were each followed by an interactive 'Sagan Discussion'. The agenda proceeded as shown in the following schematic:

Day 1: Tuesday, October 23, 2018	
09:00 - 09:05	**Dean S. Hartley III, PhD** – Administrivia
09:05 - 09:13	**John D. G. Rather, PhD** - Symposium Welcome
09:13 - 09:18	**Edward "Sandy" Montgomery** - TVIW Welcome
09:18 - 09:39	**Morgan Smith** - Y-12 Keynote Address
09:39 - 10:00	**John Vonglis** - ARPA-E Keynote Address
10:00 - 10:10	**John D. G. Rather, PhD** - The Power of Synergy
Theme 1: Large-Scale Space Development	
10:10 - 10:36	**John Mankins** Realizing the Development and Settlement of Space
10:36 - 11:06	Break
11:06 - 11:31	**Franklin Chang Diaz, PhD** Living and Working in Space, an Astronaut's Perspective
11:31 - 11:56	**John Rather, PhD and John Mankins** James Powell: Creator of Particle Bed Reactors and Maglev
11:56 - 12:56	Lunch
12:56 - 13:21	**Michael Houts, PhD** Advanced Exploration with Nuclear Thermal Propulsion
13:21 - 13:46	**Joel Sercel, PhD** Capture & Uses of Small Asteroids
13:46 - 14:11	**John R. Adams** What We Know About Closed Human Ecosystems
14:11 - 14:41	Break
14:41 - 15:21	**Theme 1 Sagan Discussion**
Theme 2: Breakthrough Concepts & Technologies	
15:21 - 15:47	**Jason Derleth** NASA Innovative Advanced Concepts Program
15:47 - 16:12	**Jonathan K. Witter, PhD** Particle Bed Reactor Nuclear Thermal Propulsion Power
16:12 - 16:37	**Roger Lenard**
16:37 - 17:02	**Philip Lubin, PhD** Directed Energy Propulsion & Power Beaming
17:02 - 17:27	**Robert Bagdgian** Environmental Control & Life Support
17:27 - 18:27	Reception

Day 2: Wednesday, October 24, 2018	
08:00 - 09:00	Pre-Meeting Tour
09:00 - 09:05	**Dean S. Hartley III, PhD** – Administrivia
09:05 - 09:26	**Alan Icenhour, PhD** ORNL Keynote Address
09:26 - 09:52	**William Peter, PhD** Large-scale 3D Printing & Complex Structures
09:52 - 10:17	**Jeffrey Slostad** Persistent Space Platforms Bootstrapping Space Economy
10:17 - 10:47	Break
10:47 - 11:12	**Mark D. Carter, PhD** VASIMR Plasma Propulsion
11:12 - 11:37	**Ken Roy** Problem of Low Gravity Physiology: A Possible Solution
11:37 - 12:02	**Siefried Janson, PhD** Small Satellite Concepts at The Aerospace Corporation
12:02 - 13:02	Lunch
13:02 - 13:42	**Theme 2 Sagan Discussion**
Theme 3: Transformative Decadal Plan	
13:42 - 14:08	**Matt Hollingsworth** Making Big Ideas a Reality
14:08 - 14:33	**James T. Early, PhD** Transformative Decadal Plan
14:33 - 15:03	Break
15:03 - 15:28	**John D. G. Rather, PhD** Capture and Industrialization of Small Near Earth Asteroids
15:28 - 15:53	**John Mankins** Critical Importance of Affordable, Abundant Solar Energy
15:53 - 16:18	**A. C. Charania** Business Development Director, Blue Origin
16:18 - 16:43	**Dean S. Hartley III, PhD** How To Integrate It?
16:43 - 17:43	Reception

Day 3: Thursday, October 25, 2018	
09:00 - 09:05	**Dean S. Hartley III, PhD** – Administrivia
09:05 - 09:46	**Theme 3 Sagan Discussion**
Theme 4: Ultimate Paths to the Future Science Fiction to Fact Relationships	
09:46 - 10:12	**Catherine Asaro, PhD** Ultimate Paths to the Future
10:12 - 10:37	**Marc Millis** Sustaining Progress Beyond the Obvious
10:37 - 11:07	Break
11:07 - 11:32	**Arlan Andrews Sr. , PhD** CARPE:DIEM - Captured Asteroid Re-Purposing
11:32 - 11:57	**David Brin, PhD** Ultimate Paths to the Future
11:57 - 12:57	Lunch
12:57 - 13:22	**Ruth E. Kastner, PhD** Quantum Universe Properties
13:22 - 13:47	**Allen Steele** Science Fiction Author
13:47 - 14:27	**Theme 4 Sagan Discussion**
14:27 - 14:57	Break
14:57 - 15:07	**Catherine Asaro, PhD** – Award
Wrapup	
15:07 – 15:37	**Dean S. Hartley III, PhD** – Symposium Synthesis
15:37 – 15:47	**Edward "Sandy" Montgomery** – TVIW Futures
15:47 – 16:32	**John D. G. Rather, PhD** - Appraisal
16:32 – 17:32	Reception

Figure 4. The TPOS agenda was structured as 4 Themes, with each followed by a Sagan Discussion.

All Themes were developed with participation of the Theme Chairs: John Mankins, Jason Derleth, Matt Hollingsworth, and Catherine Asaro. Presentations were videotaped and as of mid-January, video editing is approximately half-completed. Videos will be published on-line when complete.

Symposium Organization: A Cooperative Effort

Past TVIW Symposia have been organized by the TVIW Board, advisors, and volunteers. For TPOS, the Board established a contractual relationship in which the Symposium would be structured primarily by John Rather (Chairman) and Dean Hartley (Co-Chairman). The TVIW board handled TVIW decisions. Fundraising and programmatic support was provided by a Planning Team that met weekly. Significant support was also received from volunteers. The local and extended Interstellar communities provided generous financial support and the DOE facility operators were welcoming and supportive.

The TVIW Board for 2018 consisted of David Fields, Paul Gilster, Martha Knowles (Sect./Treasurer), Doug Loss, and Sandy Montgomery (President), with advisors Les Johnson and John Rather.

The Planning Team consisted of David Fields, Martha Knowles, John Preston, Jim Rushton, D. Ray Smith, and Mark Uhran.

Volunteers included Buck Field (Symposium Video Producer), Linda Fippin (Major Domo/ Volunteer Coordinator, Rob Fowler/John Preston (Videographers), Doug Loss (Registrar), and Joe Meany (Publicity).

Measures of Success

From the standpoint of need and potential, TPOS was a much-needed Symposium. In execution, it was well conceived and focused. Presentations, tours, catered food were enjoyed by all. A scholarship was awarded to Rishi Iyer, was in support of the Chesapeake Math Program (CMP). Several articles were written by a former ORNL Review Editor, Carolyn Krause, for publication in local news media. The first, "3D printing structures in outer space", has been published. (The Oak Ridger, Dec. 27, 2018)

Figure 5. Attendees not involved in indoor conversations assembled for a group photo in front of the New Hope Center.

Participants found the Symposium stimulating, thought provoking, and energizing. They embraced the synergistic theme and evinced the spirit of the meeting as they stood under Tennessee skies for a group photo (Fig. 5). Questions about the next Symposium were answered by providing some details of the next planned TVIW Symposium, which will be held Nov. 10-15, 2019 in Wichita, Kansas. This will be the first TVIW Symposium to be held outside the Tennessee Valley.

TPOS resulted in a number of important recommendations, which are discussed in the accompanying article, The TVIW Power of Synergy Symposium Executive Summary.

As a nod to the importance of scheduling, TPOS timing was cast 10 months earlier, before recognition that the competing AAS Division of Planetary Sciences annual meeting was planned for the same date in nearby Knoxville. There was also the competing Von Braun Memorial Symposium in Huntsville. Finally, and perhaps most importantly, the event was planned without anticipation of a protracted dismal level of productivity and focus in Washington, DC. Participation nevertheless included over 100 registrants. Based on conversations with TVIW past-participants and other very interested parties, TPOS attendance would have numbered several hundred had it not been for the competing space-related meetings in Knoxville and Huntsville.

The anticipated enthusiastic national response will hopefully be heard upon publication of meeting summaries, on-line video documentation of presentations, and continuation of follow-up discussions.

UPCOMING INTERSTELLAR AND SPACE EVENTS

February (Kennedy Space Center, FL). SpaceX Crew Dragon unscrewed test flight to the International Space Station (ISS).

March (Kennedy Space Center, FL). Boeing CST-100 Starliner unpiloted Orbital Test Flight to the ISS.

March 2-9, 2019 (Big Sky, MT). IEEE Aerospace Conference.

July 9-11, 2019 (Wales, UK). UK Space Conference 2019.

October 21-25, 2019 (Washington, DC). 70th International Astronautical Congress 2019.

November 10-13, 2019 (Wichita, KS). TVIW's 6th Interstellar Symposium. Website: tviw.us/

SEEKING INPUTS FOR UPCOMING ISSUES OF HSWT

We invite your contribution to this newsletter of nominally 200-500 words, written on an Interstellar topic that you think is of compelling importance.

Please send your submissions in MSWord format to Abby Sherriff, TVIW Newsletter Editor, and to Paul Gilster, TVIW Director at Large.

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CRESTIENNE DECHAINE SCHOLARSHIP WINNING ESSAY

This essay was submitted by Crestienne DeChaine as a part of her application for the 2018 TVIW Scholarship Program for the undergraduate level scholarship.

The Great Filter

Humanity is either very special or on an irrevocable path to destruction. The Milky Way has an estimated 11 billion Earth-like planets, orbiting suns similar to our own all within the habitable zone of their sun. Why then do we not see more evidence of life? The Fermi Paradox argues that the only way to explain the apparent contradiction between the high probability of life existing, and the lack of evidence is that somewhere on the evolutionary path there is a Great Filter. It is a barrier that is nearly impossible for any intelligent species to overcome. What does this mean for humanity's future? It could mean that we are incredibly lucky and have already overcome this barrier. We are destined to colonize the galaxy. Or it could mean that the barrier stands imposing in front of us. If that is the case, then in order to overcome it, we need to be armed with information about the filter. Either way, becoming an interstellar species is either destiny or the only way for us to survive certain doom.

In order for a filter for species development to exist, it would have to be discoverable by almost every intelligent and developed species. Thus, by searching our nearby solar systems and stars we stand to gain more information. If we find alien ruins, they could be our clue to becoming the very special life that overcomes the Great Filter. Remains would indicate that life itself is not incredibly rare and neither is the ability to develop into multi-celled organisms. Knowing what caused their demise is perhaps the safest way to ensure our survival.

When the Soviet Union launched Sputnik in 1957 as a political statement, they signaled the beginning of a new age: the Space Age. For the first time humanity ventured out past the confines of our own planet, reaching the Moon and sending rovers to Mars. With each new mission we gained valuable information about our surrounding planets as well as Earth. The Gemini missions took the best photos of our planet to date. Observations of water movement finally solved why the Earth has tides. Those six missions fundamentally changed the way we viewed our tiny planet and our universe. Becoming an interstellar species will also radically change our energy production and technology as well as our understanding of the universe.

Paradoxically, living on other planets is perhaps the best way to save our own. Currently we are using up our natural resources at an alarming rate, spewing their byproducts into the atmosphere. We are destroying the only thing that is protecting us from space. With new planets we would have access to new resources. Not only that, but in order to continue to explore, new technologies must be developed that could replace our current manufacturing techniques. Solar panels, one of the cleanest ways of producing energy, were developed to aid the Apollo missions. But, solar panels were just the beginning of what was developed to aid in man's first forays into the world of space. Expanding beyond the boundaries of our solar system has fueled the creation of low power nuclear energy sources: RPG's. A drive to become an interstellar species would certainly push forward the development of reliable energy at an increased rate.

The first form of reliable clean energy was not the only thing developed from the Apollo missions. Technology from the Apollo suits is built into modern athletic sneakers, and digital image processing from lunar photos is now applied to MRI's and CT scans. A new process was also developed to remove waste from dialysis patients and technology used to control the flow of propellant is now being used to measure precise prescription doses. We have more tools to diagnose and prevent illness, from 6 lunar landings. Imagine, dozens and hundreds of forays to new planets, each one with different conditions. Each new planet would force us to adapt and thus we would need to learn more about ourselves.

Every human shares the innate urge to explore. A desire to experience the unknown pushed us out of Africa and later drove us across the Atlantic Ocean. American pioneers spreading west over the continent gave this urge the name, "Manifest Destiny" or the idea that America was destined to stretch across to both coasts. Yet, this desire is not just American, it is universal, and the the new frontier is space. Venturing out beyond our planet cannot be a national effort, the resources needed are too great, it must be a global effort. In addition to developing more technology, learning more about our universe and saving our planet, becoming an interstellar species would foster international cooperation that could help prevent developing tensions on Earth. For us to achieve this, we must ease tensions between nations. Our shared desire to explore must override international borders. This may seem like an impossible proposition for a world rife with chaos, but, in reality it is already occurring on a small scale. The International Space Station houses astronauts from various countries, all launched through coordinated efforts. In fact, the entire station is a mixture of hardware from different nations, each combined to form a cohesive living space. Our desire to explore already transcends politics; it is only a matter of time before we use that same desire to building the ships that will carry us to different stars.

Humanity is running out of room and resources on Earth, sooner or later we will continue on the evolutionary chain, and the next step is inevitably our solar system and then our galaxy. It is our human destiny to explore. We cannot remain bottled up on 196.9 million miles squared of surface area. The only question is when. The sooner we leave, the greater the chance we have of gaining the information we need to overcome the Great Filter. As Ralph Waldo Emerson said, "go not where the path may lead, go instead where there is no path and leave a trail." If there is a Great Filter before us, then our best bet is to break from the evolutionary chain, expand before humans are forced off Earth. We should forge our own trail, around the Great Filter.