



PRINCIPIUM

The Newsletter of the Initiative for Interstellar Studies™

Issue 8 | June/July 2014

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www.I4IS.org



Scientia ad sidera
— Knowledge to the Stars

A letter from Kelvin F. Long



Kelvin F. Long with newest member
Amelia Scarlett

Dear readers,

It gives me great pleasure to welcome the latest issue of *Principium*, at a time when I4IS is now an incorporated company in the United Kingdom. The Initiative for Interstellar Studies was incorporated in May and our team are now busy moving the organisation onto the next phase of development. As a part of our incorporation activities, our team spent a considerable amount of time writing our very own Articles of Association, designed to ensure sustainment and growth of the organisation in the months and years ahead. We are very excited about the next steps.

I4IS is structured around several core committees. This includes the Educational Academy Committee, chaired by Deputy Director Rob Swinney, which has the purpose of fostering educational abilities to conduct research relating to a broad set of subjects pertaining to interstellar studies, associated sciences and the arts. We also have a Technical Research Committee, chaired by Deputy Director Andreas Hein, for the purpose of conducting innovative theoretical and experimental research and development across the broad spectrum of issues relating to the starship. Our Enterprise Committee, chaired by myself, has the purpose of encouraging entrepreneurship and business innovation initiatives related to our goals. We also have a Sustainability and Development Committee, chaired by the notable Dr Rachel Armstrong, which has the purpose of seeking space-based technological solutions to solving problems on Earth and in space, human-made or environmental, and improving the human condition and harmonising cultural relations. In our quest for the stars, we do not intend to ignore the problems here on Earth. Suffice it to say,

all of our committees are already engaged in activities and external collaborations. Our Board of Directors is guided by the input from our Advisory Committee, chaired by Professor Gregory Matloff and Deputy Chairman Professor Chris Welch.

Timed with our incorporation we also have a brand new web site, which you can view at www.I4IS.org and we have extensive plans to develop this further. It is no understatement to say that our team is busy, with involvement in many events this year, including the World Science Fiction Convention in London and the Tennessee Valley Interstellar Workshop in Oakridge. We also have half a dozen Memorandums of Understanding executed with outstanding institutions that we will be announcing soon and we will be focusing our efforts on building those relationships as our priority for mutual benefit. Finally, I4IS is open for the world to get involved with. If you like what you see and what we are trying to accomplish, then please contact us and we will find a role for you. The stars are a vision that concerns us all. Let us jointly find a way, to see what is out there.

Kelvin F Long

Executive Director,
The Initiative for Interstellar Studies

New initiatives



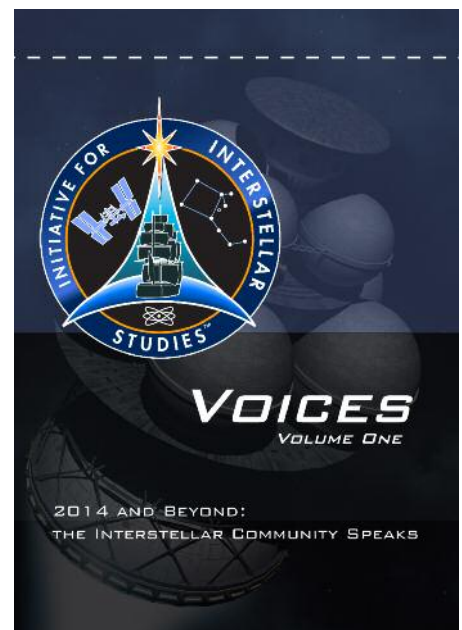
Announcing the Initiative for Interstellar Studies

I4IS is back – bigger and better than ever before! The organisation has been rebranded into the Initiative for Interstellar Studies, sporting a new website, new team members and a brand new motto: ‘building starships within our lifetime’. Now fully incorporated as a limited company in the United Kingdom, I4IS is ready to begin laying the societal, technological and cultural foundations for the path towards the stars.

Key to the rebranding effort has been the sterling work of Frank Da Silva, Mark Raimondeau and their team at DMT LAB (www.dmtlab.co/), who have built I4IS’ stunning new website that is found at the

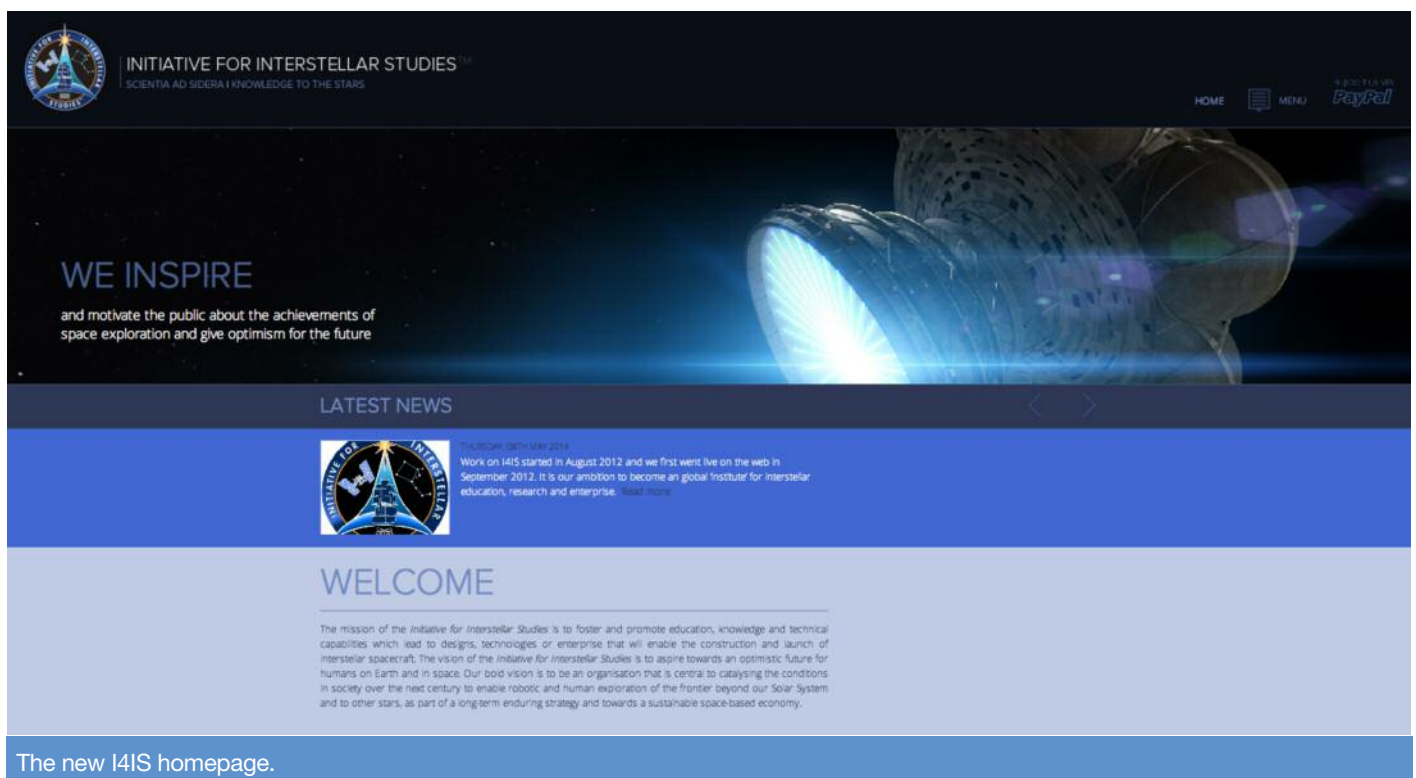
same web address as the previous site, i4is.org. On the website you will find all the latest news from I4IS on our blog, The Starship Log, the Interstellar Index that archives all starship-related articles, publications and papers, back issues of back issues of *Principium*, details of the Alpha Centauri prize, a ‘donate’ button and our brand new publication, *Voices*, a 39-page volume that is devised to give everybody in the interstellar community a voice with the opportunity to contribute a short chapter on the theme of the challenges and opportunities that the interstellar community face in 2014 and the years ahead. Eighteen authors contributed to the first volume including numerous I4IS members plus Icarus Interstellar’s Richard Obousy (interviewed in this issue of *Principium*), James and Gregory Benford, Buck Field of The Starship Vlog, Paul Gilster of Centauri Dreams and the inventor of the gravity assist manoeuvre, Michael Minovitch.

I4IS is also proud to announce some new faces to the Initiative’s roster of ‘visioneers’ (to quote a term from Princeton historian of science W Patrick McCray). Joining us are Gillian Norman, who is co-managing I4IS’ programme at the upcoming World Science Fiction convention in London (see the article in this issue) and Karen Hart, who will be



Voices is a new publication that presents a wide variety of voices from the interstellar community speaking on a common theme.

managing our social media. In addition, I4IS director Andreas Hein has stepped up to be the Initiative’s new Deputy Director, alongside fellow deputy Rob Swinney and Executive Director Kelvin F Long. He replaces George Abbey Jr, who has stepped down from the deputy position but will remain a director.



New relationships

An important facet of I4IS' involvement in the interstellar community is its relationship with other organisations. To that end we have signed memorandums of understanding, with the promise to work together, with a number of diverse organisations that we will be announcing soon. The first of those is with the International Space University, who have shown unwavering support to our Academy. Already I4IS' relationship with the International Space University has borne fruit, with four students completing Masters projects in interstellar topics, supervised by I4IS Academy members, in 2013. I4IS also received letters of support for its incorporation with Companies House from Sci-Fi London, DMTLAB and Commercial Space Technologies Ltd.

I4IS is ready to begin laying the societal, technological and cultural foundations for the path towards the stars

Going forward I4IS has plenty of projects in the work that following incorporation will now really come to fruition. Our big event this year is our exhibition and talk programme at Loncon 3, which is the World Science Fiction convention that this year is being held between 14–18 August at London's ExCeL centre in the capital's Docklands. I4IS will have a presence there for the whole four days of the convention, including a talk session on the afternoon of Sunday 17 August featuring I4IS members and some big names from the world of science fiction – you can read the details in full in John Davies' article on this page.

We also have the release of the long-awaited *Beyond the Boundary* book, the I4IS smartphone app, musical albums with interstellar themes from Alex Storer (see the advertisement this issue), more awards of the Alpha Centauri Prize and more news about Project Dragonfly, I4IS' flagship laser-sail mission. This is just the tip of the iceberg and there will be more exciting announcements later this year.

The Interstellar Space at London's greatest science fiction convention



ExCeL (Exhibition Centre London) will be the venue for August's World Science Fiction Convention.

The world of science fiction is coming to London this August and the Initiative for Interstellar Studies will be there in force to beat the drum for interstellar travel amongst science fiction aficionados. We will also be joined by some of the biggest names in sf literature, among them our special guest, award-winning author Alastair Reynolds.

The World Science Fiction convention is an annual event held in a different city in a different country every year and this August it is the turn of London. The convention, known as Worldcon for short, will be held at the ExCeL centre in the heart of London's Docklands with 9,000 fans, including around 2,000 from the United States, expected to flock to the capital for four days of science fiction between 14–18 August. The convention culminates with the prestigious Hugo Awards for the year's best sf.

So why will I4IS be there? The Initiative for Interstellar Studies is inspired not only by hard engineering and science, but also by the visionaries of science fiction. At Worldcon we will be aiming to reach out to both fans and professionals working in sf film, television, gaming and publishing.



John Davies announces the Loncon 3 I4IS film competition at Sci-Fi London in May.

“I4IS is inspired not only by science but also by the visionaries of science fiction and at Loncon 3 we will be aiming to reach out to both fans and professionals working in sf media.”

I4IS will have a half day conference session at Worldcon during the afternoon of Sunday 17 August, with presentations from our own experts and featuring one of the most distinguished current writers of interstellar fiction, Alastair Reynolds, as our keynote speaker. Reynolds is a former European Space Agency astronomer and the author of eleven novels, mostly space opera, with his latest trilogy, *Poseidon's Children*, depicting a future human society taking its first steps into a wider cosmos.



Alastair Reynolds, author of *On The Steel Breeze* and *Chasm City*.

In addition to Alastair Reynolds, Kelvin F Long will be discussing the starships presented in the work of Arthur C Clarke, Richard Osborne will examine science fiction starships as real engineering, Rachel Armstrong will look at 'living starships' and Keith Cooper will explore the motivations behind the new interstellar movement and how science fiction can help drive those motivations. The conference will end with a panel discussion featuring more big names from science fiction.

Throughout the duration of the convention I4IS will be exhibiting in an eight metre by eight metre space that we are calling 'The Interstellar Space', where visitors will be able to meet the I4IS team and learn about what we do.



Terry Regan's excellent Cassini Huygens model will be on display at Worldcon

We will also have artwork on display from our talented space and science fiction artists, Terry Regan will be exhibiting his impressive scratchbuilt models of the Voyager spacecraft and the British Interplanetary Society's Daedalus starship (see elsewhere this issue for more details), and we will be showing films on a four-metre high monolith, including clips from well known science fiction as well as specially commissioned work and films entered in our Worldcon I4IS film competition. We launched our competition at the Sci-Fi London awards on 1 May this year. There is still time to enter and you can find out how at www.i4isloncon3.co.uk.

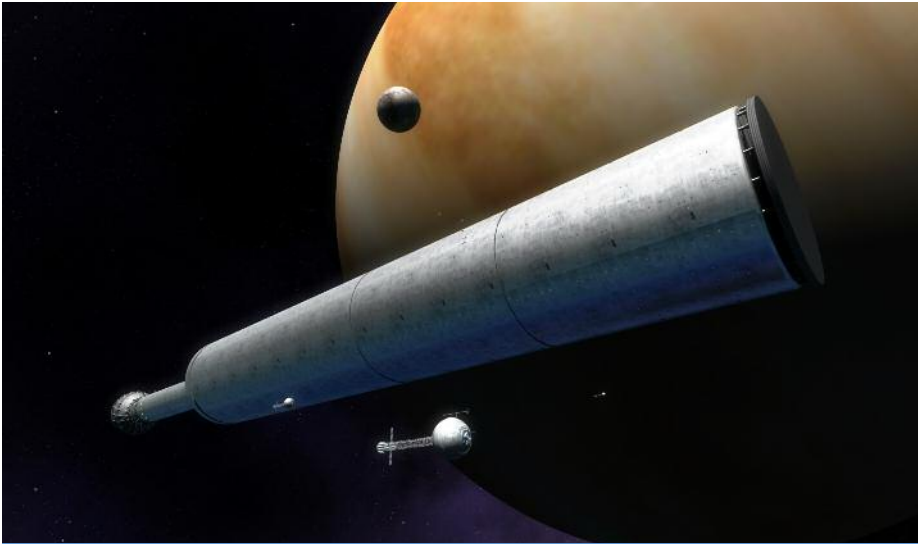
Appearing at Worldcon will be the largest outreach activity that I4IS has delivered so far, and our programme there is being expertly managed by John Davies (jjd@flying-boat.co.uk) and Gillian Norman (bargill33@yahoo.co.uk). If you would like to get involved or want to find out more information, be sure to contact them.

You can register for the WorldCon at www.loncon3.org and follow us on Twitter at @i4istellar and #i4isloncon3.

Our Loncon 3 blog can be found at www.i4isloncon3.co.uk.

Human hibernation takes a step forward

Suspended animation is ready to take a giant leap forward in medical theatres thanks to a revolutionary new technique in trauma care. However, the science is still light years away from providing suspended animation for long-duration spaceflight.



An artist's impression of a worldship. If suspended animation could become a reality, would worldships ever be built? Artwork by Adrian Mann.

A form of artificial hibernation, suspended animation has long been the dream of science fiction stories as a way of dealing with voyages that could last many years. Yet it has also been the dream of medical science, as a way of shutting down the body while conducting life-threatening emergency operations. Now scientists at the University of Pittsburgh have developed a method of essentially putting the human body on pause while surgeons work to repair it, as reported by Frank Swain in an article for *Mosaic* (<http://mosaicscience.com/story/big-sleep>).

Modern cardiac units now routinely cool the body down to 20–25 degrees, or even 15 degrees Celsius where the heart stops (body temperature is normally 37 degrees Celsius) to perform emergency surgery. This works to slow the metabolism by around five percent for every degree your body cools, reducing the rate at which oxygen is needed to be consumed, slowing the biological processes of the body, giving surgeons much needed time to work.

‘Emergency preservation and resuscitation’, as the technique is called,

takes the cooling process to its ultimate extreme, where blood is drained from the body and replaced with an ice-cold saline fluid that rapidly cools the patient to the point that brain activity, heart beats and breathing all stop and body tissues do not get the chance to deteriorate. Successful tests of the method have been conducted on animals such as pigs, with a 90 percent success rate, while in 2005 the Pittsburgh scientists led by Professor Sam Tisherman were able to revive dogs that had entered this form of hibernation for three hours. Tisherman does not dare put a human being under the process for more than an

hour at the moment, and the situation would have to be critical, with a less than seven percent chance of survival, for the procedure to be implemented. To date, it has not been used on a human being.

Freezing someone for an hour and resuscitating is one thing, but to freeze a human being for months, years, decades or centuries is a completely different ball game. The alternative is that the crew remain awake for decades onboard a cramped starship, or else we have to build enormous worldships, where generations of people will live out their entire lives as part of the journey. Suspended animation will allow the original crew to make the journey without aging. If suspended animation does become a routine procedure for emergency cases in hospitals, then the technology and the knowledge of what happens to the human body under those conditions will increase and we will gain a better insight into whether long term hibernation is possible, or whether it really is just a science fiction dream.



Are we on the brink of being able to put people into suspended animation, as in the film *2001: A Space Odyssey*?

Community News

Interstellar fever to hit Tennessee for a third time



The Tennessee Valley Interstellar Workshop (TVIW) team has been busy these last few months with their establishment as a non-profit corporation in the US State of Tennessee, as well as planning for the third TVIW to be held over 9–12 November 2014 in Oak Ridge, Tennessee, the release of their college student essay contest and the January 2014 meeting of their Interim Study Group (ISG).

TVIW is an opportunity for relaxed sharing of ideas in directions that will stimulate and encourage interstellar exploration, including propulsion, communications and research. Attendees are encouraged to not only present

intellectual concepts but to develop these concepts to suggest projects, collaboration and active research and mission planning. It should be a time for engaging discussions, thought-provoking ideas and boundless optimism contemplating a future that may one day be within the reach of humanity. The TVIW scientific committee invites the presentation of original papers and workshops that follow the theme of the conference as applied to interstellar concepts: 'Long-Term Thinking – Present-Day Action.'

The full call for papers, workshops and participation may soon be found on the TVIW website (www.TVIW.us). The deadline for entries is 1 October 2014 and students wishing to enter can do so at <http://www.tviw.us/essay-contest.shtml>. Participants who do not wish to present a paper or facilitate a workshop will also be considered and are requested to submit a short biography describing their involvement in the field of developing interstellar concepts, including interstellar-related space science and technology, and space advocacy. Submissions relating to the humanities, art and social sciences to interstellar exploration are also encouraged. Going to the stars will involve and engage most aspects of human society and innovation and all fields that may contribute are of interest. All participants (including presenters) are encouraged to bring a

freestanding poster describing their interstellar work, suitable for exhibition. The conference will kick-off on Sunday 9 November with two seminar sessions, (at additional cost). Ken Roy, P.E. will teach a course on Terraforming 101 in the morning session and Les Johnson will offer a Space Propulsion 101 course in the afternoon.

Meanwhile, the TVIW ISG held its January 2014 meeting in a Department of Energy Manhattan Project-era armoured bunker. The ISG product, to be rolled out at our fall meeting, will be submitted for journal publication.

Finally, TVIW has offered college students in the Tennessee Valley an opportunity to win a scholarship to the Third TVIW. Most of the accredited institutions with science and technology programmes of study within the Oak Ridge and Huntsville, Alabama corridor were notified of the contest, which is based around the essay topic 'Why should humanity go to the stars?' The deadline for entries was 15 May 2014 and the winner will be selected by 1 July 2014 so if you have entered, then good luck! The scholarship award will include workshop fees, room at the conference hotel, board and a travel stipend (\$550 total value).

Les Johnson



Practitioners gathered during the second Tennessee Valley Interstellar Workshop in 2013.

Paradigm Hack at TVIW Three

One of the discussion groups that will be active at TVIW will be the 'Paradigm Hack', to address new solutions to the scientific challenges of getting humans from one star system to another alive. The Paradigm Hack is the brainchild of Buck Field, of the popular Starship Video Log, and initially the group will collaborate online and candidates for the steering committee are currently being actively sought. Here Field describes his motivation behind launching this project:



Revolutionary physics will be needed if it is possible to traverse the light speed barrier. Image: NASA.

"The aforementioned risks and problems associated with interstellar flight often compound each other in both severity and complexity, and we have high confidence that unexpected challenges await that will require some new physics to solve. A century after Einstein, official, top-level strategic assessments of fundamental physics such as 2001's Quantum Universe Committee reported the need for a revolution, 'as dramatic as any in history' (<http://www.interactions.org/pdf/QuantumUniverse.pdf>). The combined power of the best minds, most advanced mathematics and by far the most accurate instrumentation ever conceived had proven inadequate for the task. The need for revolutionary physics is now shared by the scientific community, the interstellar engineers and the dreamers. Fundamental quantities in the standard model and long-standing paradoxes are well understood today within specialist maths, physics and engineering disciplines. In each, common belief is expressed that because future revolutionary models are currently unknown, they are unknowable. Such expressions are bad science, an extraordinary-sounding claim demanding extraordinary evidence.



The Paradigm Hack administrator, Buck Field. For his Starship video logs, visit <http://www.youtube.com/user/StarshipVlog>

"While physicists are properly regarded as the most reliable experts relating to physics, how can their statements about future physics be judged unreliable? The reason is that they have drifted from the technical area to the topic of knowability of a future state. Therefore, the claim is not about physics per se, but rather it is a claim about epistemology and change over time. The experts in epistemology are philosophers, academically far removed from physicists, but this is not the only defect. Revolutions in science (including physics) are similarly not within the purview of specialist experts in those sciences; instead, these are studied by historians of scientific revolutions. We need a framework or approach that will bring the right resources together for successfully delivering a future revolution.

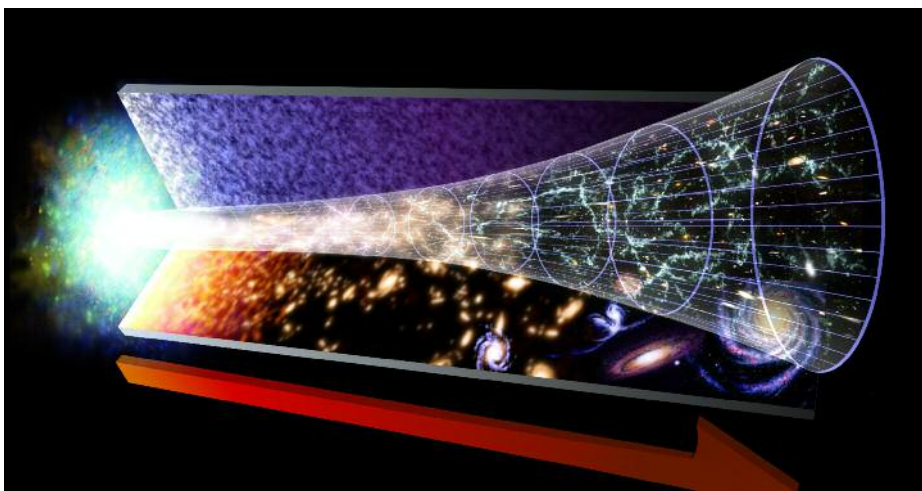
"Revolutions in physics occur at a specific time, place and within an evolving cultural environment. The specialist discipline

concerned with successful delivery of unique results is project management (PM). If successfully solving the interstellar problem by developing faster-than-light (FTL) propulsion is our goal, project management is the approach we should use. It provides a framework concerned only with success, the primary ANSI and ISO standards are discipline neutral and, like all other specialist sciences, its performance is unmatched, occasional failures notwithstanding.

"Applying PM best practices to the FTL goal suggests very different approaches than those currently in fashion. For example, it suggests historians and philosophers of science should be vital participants in planning the research. Only they can provide information about the kinds of inputs that were key to past revolutions and offer recommendations on what resources today are most similar and potentially valuable for this kind of cognitive transformation. PM experts should participate alongside interstellar enthusiasts, and so on.

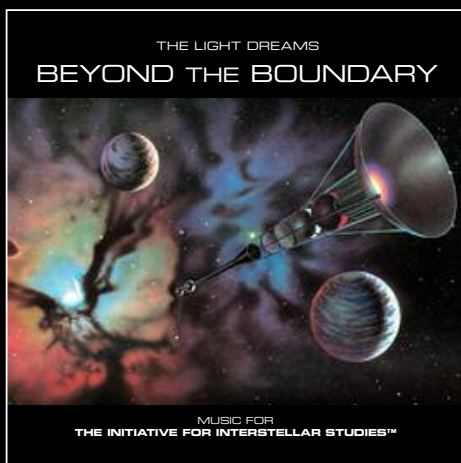
"Developing an inexpensive prototype research effort of this type will enable this first-of-its-kind team to learn how to build bridges across disciplines, planning and conducting trans-disciplinary research that has new potential to assist the interstellar community as well as the fields of history and philosophy of science, physics, project management and mathematics."

If you are interested in taking part and would like further details, contact the Paradigm Hack Project Administrator at buck.field@fieldoperative.com.



The big bang is just one aspect of the mysteries of science that will need breakthrough physics to explain. Image: NASA.

THE LIGHT DREAMS
PRESENTS
BEYOND THE BOUNDARY
A NEW INTERSTELLAR ALBUM



Beyond the Boundary is a musical voyage beyond the stars, specially composed by Alex Storer for the Initiative for Interstellar Studies™.

Powerful orchestral sounds are fused with layers of classic synths to form a distinctive interstellar soundscape. From the ambient choral sounds of the opening track through to the charged crescendo of the finalé, *Beyond the Boundary* is a starbound tour de force – belt up and enjoy the ride!

The full album download comes with a 12-page digital booklet featuring a specially-written introduction by **Keith Cooper** and artwork by **Adrian Mann, Alex Storer** and **David A. Hardy**.

“...Recommended for its blend of musical ambience with symphonic sensibilities that make repeated listens a pleasure.”

– TheInstrumentalCritic

“...A welcoming 41 minutes journey of exploring space that I’ll gladly venture through.”

– happyrage.org

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www.i4is.org

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Beyond Daedalus

We talk to Richard Obousy, one of the leading lights of Icarus Interstellar, about his vision for the future of the interstellar community and how Icarus plans to make starships a reality.



Dr Richard Obousy, a Director of Icarus Interstellar.

Icarus Interstellar was born out of the British Interplanetary Society's Project Icarus. What is the difference between the two?

Project Icarus is the successor to the immensely successful Project Daedalus in the 1970s (see issue one of *Principium*). It was initiated as a joint programme between the British Interplanetary Society and the Tau Zero Foundation (by Kelvin F. Long and myself), chiefly as a spacecraft-design exercise to evolve or re-examine Daedalus but with the additional 30-plus years of knowledge that we have gathered since then. It is very specific in its terms of reference that it has to be a fusion-based starship and has to use 'credible technology' in order to reach the target planetary system in 100 years. So it is a specific project with specific goals, specific energy and power generation.

Icarus Interstellar, on the other hand, is a non-profit foundation devoted to interstellar flight and so there are key differences there. It is far more panoramic [than Project Icarus] and it is basically an umbrella for people to gather and

undertake a number of R&D programmes of which Project Icarus is just one. We also have research programmes for worldships, for example, which would be multi-generational crewed vessels whereas Project Icarus is unmanned. We have also got a research programme looking at warp drives and wormholes and vacuum energy, we have got a beamed energy/propulsion project going on, a project called Persephone which is a living worldship, we are looking at nuclear fission-based propulsion systems and more, all of which is just the research side of things. In addition to that we have a very active public outreach committee that is really focused on getting the word out there and educating people.

That is an impressive list of projects for what is essentially a volunteer task force.

It is remarkable that we can still do all that as volunteers.

It is really a testament to how passionate people are about interstellar research. However, I'm not convinced that is something that can last into perpetuity, so I think it is very important that we embrace an entrepreneurial mindset behind what we are doing. I have always thought that if watching a bunch of guys going around and around in a circle and driving very fast can generate billions and billions of dollars – i.e. people paying to watch NASCAR – then surely we can do something to make interstellar flight exciting to the broad masses. So ultimately what we would like to do is become a very well-funded organisation so that we can ultimately pay for the brightest and the best, hopefully under one roof.

What is the biggest challenge when selling the interstellar idea to the public?

The biggest challenge is to convey our unique value proposition and why we should, as a species, invest time and money and resources into something that doesn't have an immediate return on investment. We need to be very explicit and articulate how, in the grand scheme of things, we really don't put much money into space exploration. In America people spend more on products for their dogs each year than what goes into NASA,

“Society overestimates what it can accomplish on a short timescale, but drastically underestimates what it can do on longer timescales of 30, 50, or 100 years”

which is the most well-funded space agency on the planet. If you look at the amount of money that has been spent in space since the birth of the space era, which is about \$750 billion and includes the Hubble Space Telescope, the International Space Station, the Russian space station Mir and the Apollo Moon landings, and then you compare that to the trillion dollars we gave to the banks virtually overnight to bail them out of their own mistakes, it is more than the sum total given to space exploration since its birth.

So I think the challenge is really conveying that we're really not spending that much money, and that space exploration has immense benefits to Earthly-life; you don't spend all the money on hardware and boom it is in space and gone, a lot of the money is invested in people, in research and technology development, so I think what we really need is a really broad campaign of educators conveying that message in a way that is exciting and refreshing for people and really approaching it from a twenty-first century perspective, utilising all the technology at our disposal to convey the excitement of space exploration.

Getting people's attention is one thing, but keeping it will rely on how well the community can convince them that there is a feasible plan to interstellar travel. Do you have a roadmap in mind?

We are actively working on a roadmap and that is one of the things we want to pin down in 2014. In terms of whether I think it is feasible, I absolutely do think it is feasible and that is a consequence of me





The Icarus team at the Starship Congress (left to right): Dr Richard Obousy, the current Icarus Interstellar President Dr Andreas Tziolas, Chief Editor of Discovery Space News Dr Ian O'Neill and Icarus' Creative Strategy Director Mike Mongo.

being a blatant optimist. I am very aware of the profound progress that civilisation is capable of in science and technology and my mantra – and I'm not the first to say this – is that we overestimate what we can accomplish on a short timescale, but drastically underestimate what we can do on longer timescales of 30, 50, or 100 years. I think if you look at the progression of technology and science over the past 100 years it is profound and I would think unimaginable to people a century ago. A nice example of that is the flight of the Kitty Hawk, a flimsy contraption, in 1903, but just forty-odd years later we have transatlantic jet liners transporting passengers across the ocean, then in 1957 Sputnik 1 and a few years after that man in space, then after that man on the Moon and now we have an orbiting space station that is permanently crewed. If you just picture that progression, you can see that it is just a profound reflection of what we are capable of on longer timescales.

Last year you held the Starship Congress in Houston. Did the event meet your expectations?

It was very successful. I got a lot of feedback from a lot of people who have been involved in the field for a long time and who had nothing but glowing feedback. Dr Michael Minovitch, who was the inventor of gravity assists and was nominated for the Nobel Prize, looked me in the eye and just very, very genuinely said to me that he'd been going to conferences since the 1960s and Starship Congress was the best conference he had ever attended.

What really distinguished it? Well, first of all, it was very well organised. I was privileged to work with some stunningly accomplished people who were very devoted to realising the goal of Starship

Congress, so everything went very smoothly. I think the quality of the papers accepted was very good and that was thanks to the committee that was tasked with reviewing the papers. What was also unique was this whole 'congress' angle, where there was a session that lasted for 90 minutes each day with the leaders of the various interstellar organisations articulating their viewpoints on a range of salient topics, with relevance to interstellar flight, where we are going and how we are going to get there. By being able to bring all those thought-leaders together under one roof and give them all a platform it really helped crystallise in the attendee's minds who these organisations are and who the people who are a major component in driving them forward are. It put a really important human face on interstellar flight and the

Icarus Interstellar is really a testament to how passionate people are about interstellar research

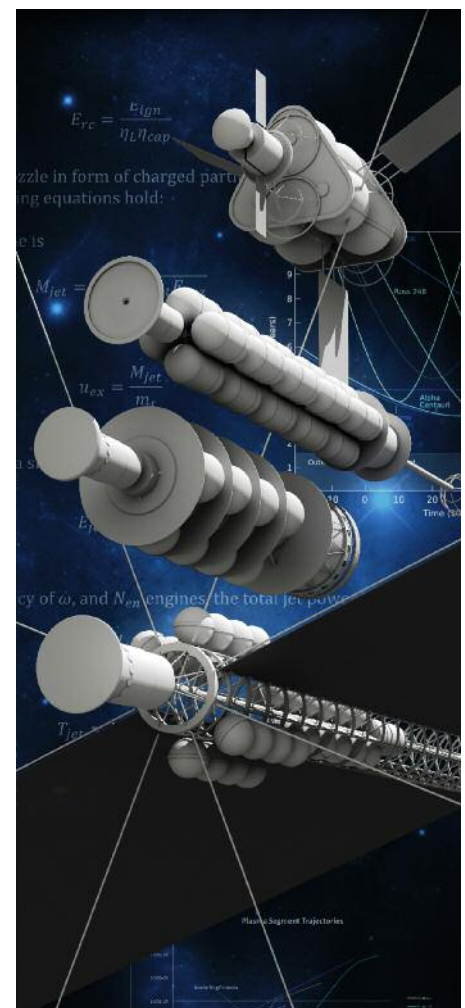
field of interstellar research.

The progression of the three days of the event, following the theme of steadily advancing into the future, helped to ground the conference in reality. Day one was about things that people are working on now that we can accomplish in the next 20 years. As we went to day two, we moved deeper into the future with things like fusion propulsion and antimatter propulsion. Then on day three there was the real deep future stuff like warp drives and wormholes and mega-engineering projects. By following that overall theme it helped us to make the Starship Congress the success that it was.

Of course such a big event costs money and you raised that via

Kickstarter, proving that there is a way to generate funding in the interstellar community.

The Kickstarter campaign was hugely important to us being able to pull off Starship Congress because we had some great invited keynote speakers and of course if you are going to invite a keynote speaker you really need to cover their expenses and travel and it would have been very hard, if not impossible, for us to raise that kind of money without a Kickstarter campaign. Once we were able to confirm that we had these great speakers I think that just helped snowball interest in the Congress. Unless I am mistaken it was the first supported campaign on Kickstarter related to the field of interstellar flight so we are thrilled on how that played out. To think that a group of dedicated people can put their idea on the internet and get it funded by people they've never met is great. Crowd-sourcing is fantastic and I think it is important that the interstellar community embrace entrepreneurship and all of the tools that are available to us and just come to the realisation that there are people out there who want to



The four candidate starship concepts from the recent Project Icarus design exercise.



Project Tin Tin is a mission profile and spacecraft design feasibility program which aims to establish the science, propulsion, communications, power and materials which will be used to build interstellar precursor missions using cubesats.

support what we are doing.

Where do you see Icarus Interstellar in the year 2024?

I think that 10 years from now I would like to see us well-funded with a physical location as well as continuing our virtual presence and galvanising volunteers. I would like to see us either having figured out a good, solid entrepreneurial plan such that we could maintain that level of funding, or have some philanthropist support us and certainly that is not beyond the realms of possibility. The Perimeter Institute in Canada, for example, is a privately-funded institute that looks at alternatives to string theory and it was funded to the tune of \$50 million by the founder of Blackberry, with no immediate return expected, just pure theoretical physics. The idea of the institute was really pushed by the dream of some physicists who were dismayed at the state of theoretical physics today with what they considered an over-focus on string theory, so it is possible that dedicated people can raise that kind of cash from philanthropists.

Finally, in a wider context, how do you see the interstellar community changing in the next decade?

I definitely believe that the community will be significantly larger by virtue of the capacity of the Internet to connect people with similar interests or, if they don't have

“I absolutely do think interstellar flight is feasible and that is a consequence of me being a blatant optimist”

those interests, to inspire them and get them interested, so I think it will be a far larger community. What will be interesting to see evolve will be the relationships between all the organisations out there and I do not know what will happen. Obviously the first one was the British Interplanetary Society and then over the last few years we have seen an explosion of interstellar organisations such as the Tau Zero Foundation, Icarus Interstellar, 100 Year Starship, I4IS, Starship Century and a couple of others more recently, so the interesting thing to look at is whether there will continue to be more and more interstellar organisations or will there be some kind of convergence, some kind of umbrella organisation? Whether they choose to work with each other or choose to compete with each other is going to be pretty interesting and will dictate the community over the next few years.

Building Daedalus: Step-by-Step

Starship-builder Terry Regan describes step-by-step how he has constructed his intricately detailed scale model of the Daedalus starship, starting with the smaller second stage.

A big job

My first job was to scale up the plans that Kelvin Long had sent to me so that I could get a better sense for what size the model was going to be. With all my scratch-built projects I use A4 plastic sheets of Styrene card but looking at the plans, I realised that I was going to require far bigger sheets. My local model shop was unable to help me, but talking to some of the lads at my model club they put me in touch with a shop in London, which is only a 20 minute walk from Liverpool Street station, so off I went to stock up with plastic styrene card in 680 by 660 mm sheets.

Payload Bay

The starship's payload consist of three parts: the top section houses the probes, the mid-section is where the telescopes are located and the bottom is the communication bay.

I cut two discs 120mm in diameter in 0.75mm (30 thousandths of an inch) thick plastic card and four tubes 50mm long that I then glued to four equidistant



Wrapping card around the payload bay structure.

points on one of the discs, before then gluing the other disc to the top of the four tubes. Next I cut a length of 0.75mm-thick card 52mm wide by 400mm long and attached it to the side of the box, working it around until it meets up and then trimming off the excess and cleaning up the joint. This created a sealed cylindrical box but with a joint line running from top to bottom that needed to be hidden. Fortunately, the surface of the starship is far from dull when finished and there is plenty of detail that will be added that will obscure any unsightly seams.



The detail added to the payload bay. The row of circles at the top are where the probes are berthed. Beneath them is the starship's telescope.

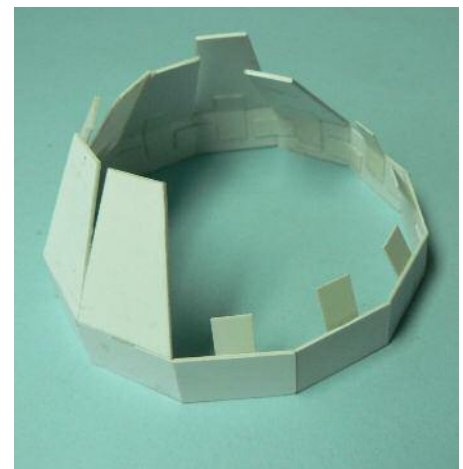
So adding that detailing was the next step. Going by the plans plus artwork from Adrian Mann (bisbos.com), the cylinder is divided into three. According to the design, the top part of the payload section houses 18 probes, so I cut a strip of card 35mm wide and again 400mm long to wrap entirely around the top of the cylinder in such a way that it hid the top of the join line. With a compass cutter I then cut out 18 round discs and drilled the centre out of each, before cleaning them up and gluing them to the top half of the body. Then, with strips of card I started adding detail to these rings, which are where the probes are launched from.

The next step was to add detail to the mid-section, including what is to be a five-metre telescope in the form of another ring. Finally, I added detail to the bottom part of the body with plastic strips and, with that, I had finished construction of the payload bay.

The Wardens' Bay

The wardens are computerised robots required to check and activate probes and carry out general maintenance and repairs to Daedalus.

Their bay is a cone-type contraption below the payload bay and is made up of twelve triangular sides. I first made a cardboard template, then laid it onto a thin sheet of aluminium on which I marked out the shape and then cut out the template. Laying the template onto a sheet of 0.75mm plastic card I cut out twelve panels and started assembling the cone. Once the glue had dried I cleaned up the joints and test fitted it to the payload bay and, happy that it all fit snugly, I put it to one side along with the payload bay.



Assembling the cone of the wardens' bay.

Internal fuel tanks.

Below the wardens' bay are two fuel tanks. The top one is the liquid hydrogen storage tank and the bottom one is the manoeuvre tank. The liquid hydrogen (LH2) tank was made from 1mm (40 thousandths of an inch) plastic card. I used a car/truck-stop light bulb that just happened to be the diameter of the fuel



The wardens' bay test-fitted on top of the payload bay.



Plunge-moulding the internal fuel tanks.

tank I wanted (they are the same size but one is 12 volt and the other is 24 volt). I drilled a hole into a piece of plywood, clamping the plastic card over the hole and, with a hot air gun, heated the plastic and pushed the bulb through to form a dome (we call this technique 'plunge moulding').

Once it had cooled down (it only takes seconds) I cut out the dome and cleaned up. As only half of the tank can be seen I only made one half of the dome. The manoeuvre fuel tank is made in the same way as the LH2 tank except that I used a tail light bulb, which is slightly smaller than the stop light bulb. With the two domes made I joined them together and then put them one side.

The engine (reaction chamber)

The Reaction Chamber is also used as an antenna dish once the fuel has run out. It is not a perfect dome as it has a slight taper to the shape and just by luck I came

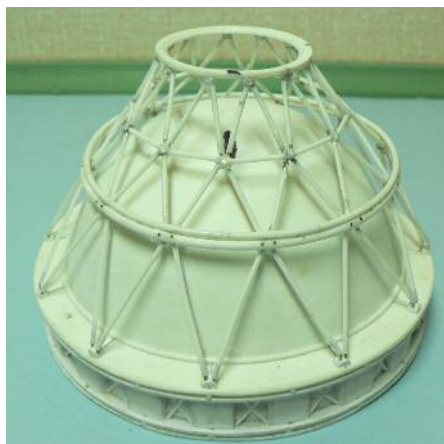


A completed fuel tank. Note the detailing on the bottom. Because only half the tank can be seen, only half the tank was made.

across an egg-shaped warehouse light bulb that had the exact shape I was looking for. Again, I made the chamber in the same way as I made the fuel tanks. I then started to build the mountings for the 18 electron guns. Two discs were cut out and test-fitted over the bottom of the dome, the top disc having a slightly smaller inner circle cut out so it was a snug fit, around 12mm above the bottom disc. Happy with it all I started to build a box section, adding detail. For the electron guns I cut plastic styrene tubes into 6mm sections, eighteen each of three different sizes of tube so that they slid inside each other and then glued them together. Once dry I spun each one up on a drill and shaped them before putting them to one side along with the other completed sections.

The engine support structure

What a pain this was! The intricate structure covers the reaction chamber and is made from 1.2mm plastic styrene rods, cut into lengths. I drilled down the centre with a 0.55mm drill and glued in 15-amp fuse wire to make locating lugs. Then I started to build the structure by interlocking the rods and I was surprised how strong the structure became. I test fitted it to the engine and put it to one side.



The engine and its surrounding support structure.

Induction loop.

This is the magnetic loop that keeps the pellet central in the reaction chamber. I cut two large round discs with 0.75mm card and a strip of 0.5mm (20 thousandths of an inch) card 12mm by 300mm long and shaped it into a circle, gluing the two rings top and bottom and adding detail. My next problem was attaching it to the bottom of the reaction chamber. There are wire supports that mount the ring to the chamber and, after a lot of trial and error, I came up with the idea of using a thin brass wire, shaped into a 'V' and soldering three of these to a locating peg on the top



The induction loop.



The induction loop attached to the engine section.

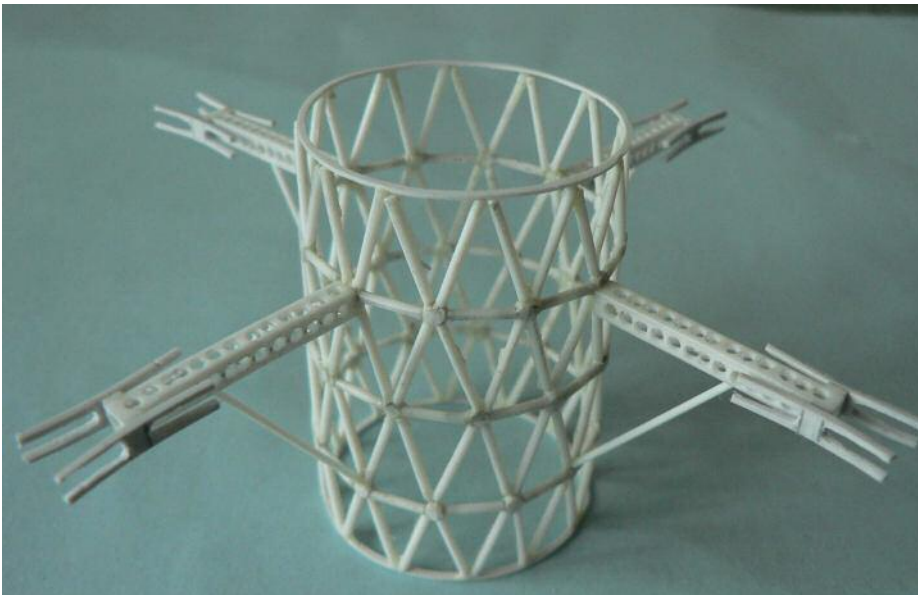
before drilling three holes in the bottom of the reaction chamber and test fitting.

Centre support structure

This was another big headache. One of Adrian Mann's pictures showed four rings mounted around a lattice cage support structure. I cut several lengths of 1.2mm plastic rod and made loads of 1.5mm round discs. I drilled through the discs and threaded 15 amp fuse wire before then drilling into the rods so as to interlock



The lattice cage cylinders around a king pin.



The completed central support structure, with four support arms that will hold the fuel tanks

them in the form of a ring. I made four of them. My next problem was to make the lattice cage and, just by luck at my workplace, I had been replacing a king pin on a 7.5 (7.5 tonnes) truck steering and I found that the rings that I made fit perfectly around the king pin. As the pin was being replaced I made use of it. I fitted the first ring over the pin and started to build the lattice cage as the glue does not stick to metal but does stick to other plastic and, eventually, I have the centre support structure built. The next parts were the four support arms, made from 3mm by 3mm square styrene rods. I drilled loads of holes to give them the appearance of a framework and then added clamps to their ends. These are to hold the fuel tanks, which I have to build next.

Fuel tanks.

The fuel tanks store frozen pellets of deuterium and helium 3 fuel for use in Daedalus' fusion engine.

To make the numerous round fuel tanks that are attached to the starship I used the plunge mould method by heating up plastic and pushing through a round object such as a lightbulb or a ball bearing. However, size was an issue – these fuel tanks are supposed to be about 78mm in diameter on my scale model so I had a problem finding a suitable round object to mould them from. Nevertheless, when I popped into my local pound shop at Christmas I found in front of me Christmas baubles of all different sizes, including four in a pack, each 70mm diameter, for £1. So I filled my basket up with them. I sanded the glitter and the shiny stuff off the baubles, added detail to them and once again put them to one side.

The parabolic reflector

This round disc holds the fuel tanks and also the pellet injector gun. From 1mm thick plastic card I cut out a round disc 170mm in diameter and then cut a 40mm diameter hole from the centre. I found a brass draw knob in a DIY store and machined the back part of it where it screws in to become the funnel and then plunge moulded it and fitted it to the round disc.



Looking down on the painted parabolic reflector, which sports panel lines and three different colours.

The support structure.

This is fitted from the bottom of the payload bay to the bottom of the wardens' bay, again made out of 1.2 mm rods drilled and pegged with 15amp fuse wire

Painting the model

All sections were painted separately before final assembly. I sprayed the support structures in gloss black then, once dried, air-brushed them in chrome silver. Every part was primed in plastic primer to take cellulose paint. The fuel tanks were sprayed in Audi Silver. The

payload and wardens' bay were sprayed in Vauxhall Polar White from a distance as I didn't want a brilliant shine. On the reaction chamber (engine) I used models paint including a metallic grey (gun metal) with a satin lacquer just to give an engineering feel to it, while the internal fuel tanks were covered in gold foil from chocolate sweet rappers (Rolos for the chocoholics amongst you!). On the



Looking down on the painted model.

parabolic reflector I wanted to show some panel lines and as part of the fun I also wanted to use paints named with a cosmic theme, so I chose three colours : Ford Moon Dust Silver, Vauxhall Starburst Silver and Nissan Cosmos Silver.

Construction

Once the paint had dried, all the sections were then glued together and a round tube inserted through the model from the payload bay right down to the engine to provide the model with some structural strength. This leaves just one



Another view of the painted, assembled Daedalus second stage.

remaining job, which is the ‘erosion shield’ that sits atop the payload bay and protects the starship from interstellar rocks. The hole in the centre shoots out bags of dust around 200 kilometres in front to smash up anything that gets in the way.

The disc was cut out of a 1.5mm (60tho) sheet of plastic card and Adrian Mann provided me with the pattern of the shield, which I printed off and enlarged before making three tracings. I airbrushed the disc in a metallic grey, marked off the sections, added a drop of silver to the metallic grey and airbrushed it. I then added a drop of black into the metallic grey and again airbrushed. Once dried I wanted to tone down the effect so I filled a glass jar with thinner, added a couple of drops of metallic grey and airbrushed over the disc until I got the desired effect.

Finishing off

I wanted to display the model and give some idea of scale so I cut a large sheet of plastic card, spayed it a grey with lines in it to give the impression of concrete to act as a base. I also found some figures that are 1:350 scale, although they are slightly on the big size: the Daedalus model is around 1:400 scale, showing just how enormous it really is!

Overall I have spent 323 hours on the model. It has been the biggest and the most complicated model I have ever built, but I have impressed myself given that when I was initially asked to build Daedalus I didn’t think I could build it.

I would like to say a very big thank you to not only Kelvin Long, but also Adrian Mann for his invaluable help throughout the project and without whom I would not have been able to build such a detailed model. I also should not forget Adam Crowl for his help as well with the technical aspects.

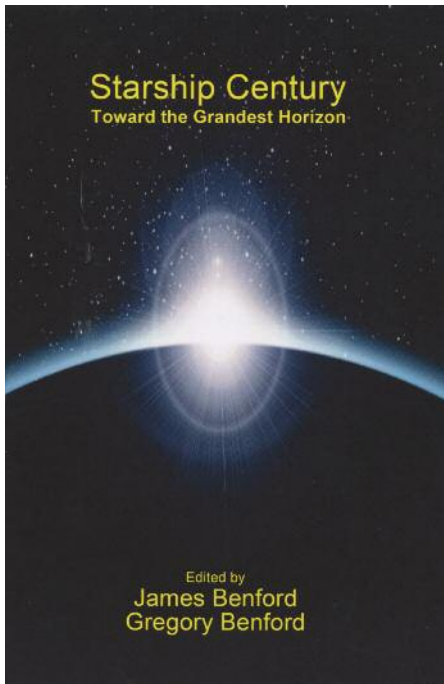


The completed first stage, along with slightly out of scale people.

Book Review

Starship Century: Toward the Grandest Horizon

Edited by James and Gregory Benford



The Benford twins' grand Starship Century project in 2013 saw two symposia, in San Diego and London, as well as the launch of this accompanying book that features as authors many of the contributors to the symposia. As a result we get essays from such esteemed personalities as Freeman Dyson, Paul Davies, Martin Rees, Geoffrey Landis and Robert Zubrin, but what makes this book special (and is in the same vein as 2012's *Going Interstellar*, reviewed in issue one of *Principium*) is that it also features numerous science fiction stories and great ones at that. Authors include top drawer writers like Neal Stephenson, Gregory Benford, Joe Haldeman and Stephen Baxter. With this kind of talent involved on both the factual and fiction sides, you would expect the book to be pretty special and, for the most part, it is.

The book is split into four sections: The Big Perspective, Pathways Towards Starships, Building Starships and The Starship Era. The first section plays host to essays from Martin Rees and Freeman Dyson. In particular Dyson's thought-provoking chapter raises the possibility that the future of space travel is actually biological, building habitats out of giant, genetically-modified trees that can survive in the vacuum of space on nutrient-rich cometary bodies. On the other hand Rees is more conservative – while he paints an

epic picture of not only the scale of the Galaxy and the Universe as a whole, but the scale of time that we have stretching before us, he sees interstellar travel as an adventure for our far future descendants rather than something we can look forward to by the end of the twenty-first century.

If there is a downside it is that the chapters from these big names in science are fairly short, only six and nine pages long respectively for Dyson and Rees' essays, and a contribution from Stephen Hawking being only four paragraphs long and taken from quotes he has made in the public domain.

Of course, any discussion of starships has to explore the economic, sociological, political and technological developments that could potentially happen in the future and pave the path towards a starship destiny. However, there is a tendency for this to morph into soothsaying about what will happen, as though the future is fait accompli. So we find statements like in Peter Schwartz's chapter where he espouses, "Several technologies of sustainability begin to transform the planet by the end of the century. The energy and industrial revolutions mean the environment and resources are no longer a barrier to the continued increase in wealth... over the next two centuries average global growth of five percent means a doubling of wealth every fifteen years... so that by the year 2200 the world is nearly a thousand times wealthier than today with half as many people." Robert Zubrin makes similar claims in his chapter 'On the Way to Starflight: The Economics of Interstellar Breakout'. While these depictions of the future sound enticing and, particularly in Zubrin's case, is backed up with at least some logical reasoning, I found myself questioning how realistic they were. The future is not a place where the best outcome is always inevitable; I would have appreciated a dose of more down-to-earth realism to sit alongside these extremely optimistic chapters (although I should point out, I hope Schwartz and Zubrin are right!).

This theme of an inevitable path towards a grand and prosperous human destiny carries over into some of the fiction, which I have to say is nevertheless the best part of the book. There are some excellent short stories and novellas, particularly Neal Stephenson's *Atmosfera Incognita*, about the construction of a 20-kilometre tower and Gregory Benford's *The Man Who Sold the*

Stars, about an entrepreneur who leads the drive to launch the first interstellar mission. There is a slight sheen of unrealism to them, partly because there is not room to flesh things out, but partly also because like Zubrin and Schwartz before them they depict a future where things are achieved almost too easily.

Possibly the best story in the book is *Knotweed and Gardenias* by Nancy Kress, which is quite different to the Stephenson and Benford epics. It is an intriguing and more down to earth tale of how what we may leave behind on Earth could be the death of any interstellar voyagers.

There are more practical chapters on starship design and engineering by Adam Crowl and Jim Benford, and a neat chapter on destinations by Stephen Baxter and Ian Crawford. There's also a nice poem by Geoffrey Landis entitled *Across the Dark: The Pioneers*. While he is at it Landis provides an interesting chapter on nuclear rockets that could take us to the edge of the Solar System.

Despite any debate or slight criticisms of the conclusions of any of the chapters, they all share the common trait of being very well-written. There are some typos and editing mistakes that are annoying but do not prevent enjoyment of the book. It is also reasonably inexpensive and available on Kindle in addition to a printed softcover edition, so there really is no excuse why any starship enthusiast, or anyone curious about what the future may hold in general, should not go ahead and buy this book.

Starship Century

Editors: James and Gregory Benford

Contributors: Stephen Baxter, David Brin, John Cramer, Ian Crawford, Adam Crowl, Paul Davies, Freeman Dyson, Joe Haldeman, Stephen Hawking, Nancy Kress, Geoffrey Landis, Richard Lovett, Martin Rees, Peter Schwartz, Allen Steele, Neal Stephenson and Robert Zubrin.

Published by Microwave Sciences/Lucky Bat Books

ISBN: 978-1-939-05129-5

Available from Amazon
(http://www.amazon.com/Starship-Century-Toward-Grandest-Horizon/dp/1939051290/ref=sr_1_1?s=books&ie=UTF8&qid=1402385756&sr=1-1&keywords=starship+century)

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The mission of the Initiative for Interstellar Studies is to foster and promote education, knowledge and technical capabilities which lead to designs, technologies or enterprise that will enable the construction and launch of interstellar spacecraft.

Vision Statement

We aspire towards an optimistic future for humans on Earth and in space. Our bold vision is to be an organisation that is central to catalysing the conditions in society over the next century to enable robotic and human exploration of the frontier beyond our Solar System and to other stars, as part of a long-term enduring strategy and towards a sustainable space-based economy.

Values Statement

To demonstrate inspiring leadership and ethical governance, to initiate visionary and bold programmes co-operating with partners inclusively, to be objective in our assessments yet keeping an open mind to alternative solutions, acting with honesty, integrity and scientific rigour.

Front cover: 'Flight Approval' by Alex Storer, thelightdream.net.

Back Cover: The Hubble Ultra Deep Field, featuring galaxies that existed 13.2 billion years ago, when the Universe was just 600 million years old. Image: NASA/ESA/H Teplitz and M Rafelski (IPAC/Caltech)/ A Koekemoer (STScI)/R Windhorst (Arizona State University)/Z Levay (STScI).

We'd love to hear from you, our readers, about your thoughts on *Principium*, the Institute or interstellar flight in general.

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Editor: Keith Cooper
Layout: Adrian Mann

The Initiative For Interstellar Studies is a pending institute in foundational start-up phase subject to incorporation in the United Kingdom

