VOICES

VOLUME ONE

2014 AND BEYOND:
THE INTERSTELLAR COMMUNITY SPEAKS

Contents

Becoming Something Better

Keith Cooper, I4IS Director,
Editor of Principium and Voices

Welcome to the first of what will hopefully be many volumes of *Voices* – think of vox pops on all manner of interstellar topics, written by researchers, directors and members of the Initiative for Interstellar Studies (I4IS), plus invited others from the wider starship community. It has been a privilege to work with so many bright and visionary people from all across the world. Our aim, with *Voices*, is to create a record for posterity of all the different ways we approach the interstellar problem. In 100 years time, when our descendants are launching the first spacecraft to voyage to another star, how will they look back on our time and the start of the journey that will take us from Earth to Alpha Centauri?

It will not be an easy journey and this volume, in part, is about identifying some of the more immediate obstacles and looking at how we can overcome them. The overriding message is one of hope for the future, a can-do attitude that will take us to a great destiny among the stars.

My colleagues writing in this volume have extolled the virtues of pursuing interstellar flight, but as we increasingly push the dream of star-flight into the public's consciousness we should expect resistance, criticism, even outright hostility from some quarters.

That is fairly natural and we shouldn't quail from it. Instead we should seize the opportunity to engage in debates with our critics about the possibility of and the motivations for interstellar flight. Some of these debates will see life as future volumes of *Voices*. Honest debates

can educate and if our answers are good enough they can also inspire. That means getting information out there into the public domain, demystifying the scientific, sociological and economical requirements of interstellar flight and being unified in voice so that the public can make balanced, educated appraisals. Key to this will be the various interstellar organisations being able to work in harmony and to that end I would like to instigate regular congresses between the groups. We should also target our allies – interstellar flight is not an all-or-nothing proposition and should not considered to be at the expense of other global problems such as combating climate change. Instead, I would also like us to forge links with environmental groups to see how we can work together, how technology developed for space can benefit the environment on Earth and vice versa. For example, I would like to see us work with the Campaign for Dark Skies, benefitting the environment but also opening up the night sky because if we cannot see the stars, how can we ever dream of travelling to them?

Nor should we pretend that interstellar flight will be a panacea for all our problems. Humans are humans – we fight and squabble but in the main we do hope for a better future and when united for a common goal we can do some amazing things. As we travel to the stars we will still be human, with all the foibles that accompany us but, like Pinocchio, we are always striving to become something better. By pursuing a better future in which space exploration, colonisation and interstellar flight plays a part, perhaps we can become something better. We may never be the perfect society depicted in *Star Trek*, but there is some truth in the idea that the journey is often more important than the destination and, as we start 2014, I hope we can begin to embark on that journey together.

Doing Our Bit

Kelvin F Long, 1415 Executive Director

Engineering and physics calculations describing interstellar fight usually lead to requirements for gigawatt (GW) to terawatt (TW) power levels, flight times of decades to centuries, velocities that are a fraction of the speed of light, vehicle masses in the range of thousands of tonnes and costs of many trillions of pounds or dollars. Although this looks prohibitive it is by no means impossible and those who claim that the stars are still many centuries from our grasp have simply not considered the weight of theoretical and experimental evidence assembled over the last century. In fact, I personally believe that interstellar flight is achievable by the end of this century, if not much sooner and I personally have chosen to dedicate my life to the fulfillment of this vision.

For me, the aspiration and vision of interstellar flight serves as a long term goal for human kind. It points the way to an optimistic future where we are living at peace with ourselves and finding more constructive ways to use our energies instead of conflict and environmental destruction. In the interstellar community pioneers like Arthur C Clarke, Les Shepherd, Robert L Forward and Carl Sagan have shown the way. They leave a legacy for us to follow and they challenge us to become greater than ourselves, to carry forward the metaphorical baton so that our species may continue to propagate among the sea of suns. We are now in a period where the ideas of imagination are fast becoming reality and it is up to us to seize the opportunity and to not waste it, working with what we have and making things better.

When we look around our planet today we see a home that has been lent to us through a process of evolution and make no mistake, nature will evict us, its caretakers, if we do not adjust. Many people among our species still live in dire poverty, surrounded by conflict, disease and in-opportunity, or

live in a country where their very human rights are denied. Yet us who live in a more developed country continue in our state of comfort and convenience and effectively live a life of luxury. We pretend we are 'doing our bit' through charity and, although this helps alleviate suffering in the short term, it does not address the fundamental problems. Science and technology, however, have the potential to set people free from the burdens of their conditions by giving them the tools to solve their own problems. This is one of the reasons why I think space technology is important, because it rushes us towards that fantastic future so dreamt of in many works of science fiction and, as we develop the technologies for Earth 2.0, it helps bring about the fruition of technologies that can help solve the problems right here on Earth 1.0. This is perhaps one of the only hopes for the less developed societies of our planet.

Indeed, I would argue this is a part of the duty of the scientific enterprise, to help improve the human condition on every level that matters; from the mind to the body, from the buildings to the environments, to energy resources and the very tools that we utilise. Only once our civilisation has reached a level of maturity such that humankind is effectively harmonised as a society at peace with itself, does the construction of starships become morally acceptable and practically achievable. It is not that we should not attempt the journey until such conditions are satisfied, but it is the attempt itself that brings this optimistic future to pass. So, when should we go? As soon as we are capable and have the moral and scientific justification for making the attempt.

Such initiatives should be attempted in parallel with the continued growth of our industrial civilisation. The road to space can be achieved from an Earth-based economy and indeed from our planet we have reached orbit and trodden boots on the surface of the Moon. The red planet Mars awaits us. If we want to take humans further, to colonise the rest of the Solar System and eventually find our way to interstellar destinations, then this clearly requires the establishment of a Solar System-wide economy. Any strategic roadmap that includes people cannot ignore this.

I have had the fortune to be personally involved with the creation of several interstellar organisations. This includes the US non-profit Icarus Interstellar, which is now growing steadily and vibrantly and I am immensely proud of that team. The latest is the Initiative for Interstellar Studies (I4IS), for which our work began in August 2012. In the first year we have achieved a lot and I am excited about the Institute's capacity to help facilitate the vision to travel to the stars. Every person who joins any of these interstellar organisations has some role to play and every person matters to us.

It should also be our task to broaden the inclusion of the interstellar community to not just include scientists, engineers and science fiction fans, but also artists, politicians, economists, philosophers, sociologists, physicians, farmers, business entrepreneurs, property developers, architects, tradesman, energy suppliers, the media, film-makers, educators, librarians, the religious community and yes – even the lawyers. I believe that every community in our society has something of value to contribute and we need to afford them the opportunity to share their viewpoints. Currently, the interstellar community is comprised 100 percent of volunteers. Where are the philanthropists and business pioneers out there with true vision to see the real benefits to humankind of our attempts to go to the stars? We need you. We need you to get behind what we are doing. Still, we are waiting for your call.

For 2014, my message is one of optimism, hope and excitement at the opportunities that are yet to come and the achievements yet to be fulfilled. The long road to the stars continues, our ambition remains steadfast and not for turning. We build on the achievements of those that came before us. Today we pick up that baton and our joint work moves us further forward. The next generation will do the same, each building on those of the past. For the challenge of the stars is a multi-generation endeavour, a multi-society problem and one that brings hope to all of humankind. The time for the stars is not just in our far future, it is now. Embrace that idea with both hands, for both the heart and the spirit of the human being is meant to fly.

Room For Us All

Sarah Margree, 1415 Executive Secretary

As a science-fiction fan from an early age, cutting my teeth on the likes of Arthur C Clarke's *Rendezvous with Rama* and Larry Niven's *Ringworld*, I have grown up with the desire to see and experience these technological, yet magical to us, worlds of the future. To be an inhabitant on a world-ship, sailing through the Galaxy to a new life, would be an experience like no other. To imagine artificial worlds built by civilisations that we deem to be advanced beyond measure, could one day be built by us.

These are exciting times and, with Harvard researchers having potentially found the key to eternal youth, we may yet get the chance to travel beyond our Solar System. The National Ignition Facility's success in generating a fusion reaction that produced more energy than it consumed gives a boost to the researchers in this field and leads to hope for the development of efficient fusion propulsion systems within an imaginable timescale. The dreams of the past are becoming a reality with increasing frequency and we have a rare opportunity to be at the forefront of the thinkers, planners, scientists and engineers who are attempting to make these future dreams a reality. Ideas are priceless and if interstellar travel and colonisation are ever to happen we are going to need every idea under the Sun(s)!

I am not yet a scientist or engineer but we all have something to offer the Initiative for Interstellar Studies. Administrative skills are just as essential as being able to use the rocket equation and for interstellar travel to become a reality we will have need of everyone with every type of skill you can imagine. Do not believe the hype that space is just for the 'right stuff'; there is room for all of us to make our contribution.

Whither Interstellar Flight, Or, How Not To Get Extinct

Andreas Hein, 1415 Director of Technical Projects

Why should we care about interstellar travel today? Common arguments include our survival and our evolution as a species. Still, why today? I will try to take up a different stance here: we should care, as Doomsday is lingering on us. By knowing more about interstellar travel, we can reduce the probability of Doomsday.

How can 'knowing' alone reduce the probability of Doomsday? The so-called Doomsday argument, or better arguments, make predictions about when humanity ceases to exist. For example, J Richard Gott's prominent prediction estimates that humanity will be extinct somewhere between the next 5,130 and 7.8 million years, with a confidence of 95 percent. This audacious prediction is based only on the observed duration of humanity's existence and the Copernican principle. The Copernican principle assumes that a random observation is likely to be an unprivileged one. Given no other information, it is better to assume that an observation is not being made at a special point in time, thus at the beginning or end of existence of an object. If I define 'beginning' with the first 2.5 percent of existence and 'end' with the last 2.5 percent of existence, there is a 95 percent probability that my observation is in between. Assuming humanity's existence up to today is 200,000 years, there is a 2.5 percent probability that my observation is at

the end and humanity will be extinct before the next 5,130 years. There is a 2.5 percent probability that my observation is at the beginning and we will exist longer than 7.8 million years. With 95 percent probability, we will be extinct in between. Given no other information, this is the best we can estimate! However, probabilities always depend on our knowledge. If I know that an asteroid will destroy Earth in a year with 99 percent probability, this knowledge certainly influences my estimate. If I know that humanity is capable of expanding its reach beyond our planet, to the stars and even other galaxies, the probability that we will be extinct is drastically reduced. It gets more likely that we are at the beginning of our existence as a special kind of species.

Knowing about the possibilities is the first step. Next, is the build-up of technological capabilities. Answering questions about how technologies and ultimately civilisation can be maintained over extended timeframes all contributes to making better predictions for how long we will exist. An alternative is SETI, the search for extraterrestrial intelligence. If we discover that the Universe is teeming with civilisations much older than ours, there is hope for us. Research in interstellar travel is thus a better way to predict our future fate and we should start today! Using Gott's approach, interstellar spaceflight will only exist for between another 1.3 and 1,950 years with 95 percent probability if we do not find out more about it.

Against the Clock

Angelo Genovese, I4IS Senior Researcher

Why interstellar manned flight? This fundamental question has two main answers for me. The first one is well summarised by the famous quotation from *Star Trek*: "To boldly go where no man has gone before". This is the same motivation that drove the ancient Polynesians who sailed their double-hulled voyaging canoes over 4,000 kilometres of the largest ocean in the world to become the first Hawaiians. They did not wait for nuclear-powered aircraft carriers, they just used the available technology (a canoe), taking huge risks until finally they succeeded. The same can be said for Roald Amundsen's expedition to the South Pole in 1911, the coldest place on Earth (down to almost –90 degrees Celsius in winter) where no plant or animal can live, using only the technological help of just skis and dog sleds for transportation.

Nowadays, the human race is challenged by its 'final frontier', "to explore strange new worlds, to seek out new life forms and new civilisations, to boldly go where no man has gone before." We at I4IS are willing to accept this fantastic challenge and are unwilling to postpone it.

The second answer is because we need it and we need it quite soon. We all know that there is plenty of time (some billion years) before the Sun becomes too luminous, heating our precious Earth to the point that life will no longer be able to survive. Unfortunately for us, several other types of events pose a much earlier risk to destroy or cripple human civilization, including asteroids, super-volcanoes, nuclear wars, nanotechnology weapons, super-intelligent AI, engineered or

natural pandemic and climate change. In fact, a major mass extinction has already happened at least five times in Earth's history. Fossils of extinct species offer ample testimony that such catastrophes do occur. The only way that humanity has to ensure its longevity is to colonise space, as Stephen Hawking has recently warned us. According to him, the human race will not survive the next millennium without establishing self-sustained colonies in space. However the funding window for space colonisation is probably much shorter than 1,000 years. A new great economic recession or the increasing destruction caused by climate change could close this window for a very long time. According to the astronomer J Richard Gott from Princeton University, the Copernican Principle tells us that there is a 50 percent chance that we have just less than 50 years in order to establish a colony in the most similar place to Earth in our Solar System, Mars. Once we succeed in this, we have just doubled our chances of survival making us a two-planet species and we have also more than doubled the chances to flying to a real habitable exoplanet in another stellar system. In fact, it looks to me more likely that an interstellar manned mission will be launched from Mars instead from Earth, with a crew who already knows how to colonise an alien planet.

Interstellar Outcomes to Growth and Progress

Stephen Ashworth, 1415 Researcher

Interstellar studies are fundamentally a project in political philosophy. These studies demonstrate that interstellar spaceflight is technically possible and sketch the outlines of a future form of civilisation in which political and economic conditions would allow that possibility to be realised. What they therefore provide is the vision of a positive outcome to the modern social paradigm of growth and progress.

This modern type of civilisation has been the dominant paradigm on Earth since the eighteenth-century Enlightenment and the accompanying industrial and scientific revolutions. It has, however, come under increasing attack since around 1970 from some environmentalist and socialist schools of thought which claim that continued growth and progress is unjust and unsustainable, and must inevitably collapse. In that view, the only possible or desirable outcome for humanity is one lived at lower levels of population, power consumption and material wealth than today, contrasting with the interstellar vision, which necessarily envisages higher levels of all of these as necessary preconditions for starship construction.

The interstellar paradigm places the human species and modern civilisation in the broadest context of which we can currently conceive, namely that of the Milky Way Galaxy. It assigns us a meaningful role in that context, whether the Galaxy is already populated by other civilisations of intelligent beings as some believe may be the case, or whether humanity is the first species to industrialise. It explores the

energy sources, transport systems and modes of living that have the potential to allow us and our post-human successors an ever-expanding future on an interstellar scale.

As early twenty-first century spaceflight in 2014 and beyond continues to make the difficult transition from reliance on special government programmes to creating economically sustainable patterns of activity, ones capable of exponential growth into our local Solar System, the interstellar community is uniquely qualified to provide the answer to the question: where is it all leading to?

The technological singularity and interstellar flight

Martin Ciupa, I4IS Researcher

We live in exciting times; none of us know how things will pan out for mankind over the next generation for sure. Existential risks are with us, some of them always have been – for example the possibility of high-energy astrophysical events such as nearby supernovae and gamma-ray bursts, not to mention impacts from massive comets and asteroids. Some of these risks we can mitigate with space technology, which is an upside to technological progression.

Technological progression, not directly related to space technology, has also given us cause to pause over ethical considerations. We have technological opportunities to remove human suffering on a massive scale, resulting in significant (if not indefinite) life extension. Yet the impact on social systems and Earth's ecology and climate, on arguably an already overpopulated planet already past a tipping point in climate change impacts, are not well modelled. We expect to see genetic, nanotech and cybernetic/AI technology continue to progress offering us better ways to manage the global economy, mitigate climate change and feed/sustain ourselves. However, impacts on geopolitics, agriculture and the working society (or an un-working one) have many sociological concerns. Whilst these future scenarios play out in terms of the 'technological singularity', existential risk analysis and transhumanism, the prophets of these future scenarios often look to space technology for resolution also. For example, the much-heralded satellite solar power, mining of asteroids and ultimately off-world colonisation.

The spirit of man looks not just for economic justification of space ventures; justification is also found from humankind's ongoing search for contact with other civilisations and the pursuit of knowledge, best scientifically examined in the cosmos. There is an expression of 'manifest destiny' that humankind will reach beyond the Solar System for its 'lebensraum'. These are loaded terms in the ethics of humankind's recent history.

Active SETI programmes that not only search for ET, but seek to invite contact have caused some to question the risks in doing so. What if ET turns out to be not so benign?

Interstellar missions also need ethical impact analysis, though it is less a technological-driven concern but rather an exo-political and ethical/regulatory consideration. As a general principle I expect from 2014 onwards that more people from outside of the scientific and technological domains will want to express their concerns and indeed demand consultative and open processes.

The Living Cosmos

Dr Rachel Armstrong, 1415 Director

At some point in the next four billion years, the planet that birthed us is no longer going to be able to support us and we will be forced to leave our home Solar System. Yet, not only do we have a moral duty to promote the lives of our successors but we also have an ethical responsibility to ensure that 'life' is also given the greatest chance of indefinite survival. To do this, in the near term we must design and launch effective directed panspermia programs. In the mid-term, we need to find ways of building living environments that support us, just as Earth's nature does. In the longer term, we need to apply those ecopoietic principles to other planets.

Twentieth-century narratives are constructed on a human-centred view of space colonisation and depict world-ship habitats that are simulacra of Earth's environment. Yet we should not assume that a life-supporting environment is inevitable, or that matter will spontaneously assemble in microgravity, or weightlessness. Rather, it is necessary to identify the fundamental ecological principles that support us and understand how to reconstruct them as dynamic exchanges in non-terrestrial environments. While we are familiar with considering these principles in the context of booting up ecosystems on dead planets, ecopoiesis – the creation of stable ecosystems that can last a long time – also needs to be applied to the design of world-ship interiors. This requires some fundamental changes in the way that we describe, imagine and design world-ship interiors. My resolution is therefore to develop philosophical, linguistic, design and engineering tactics that help open up experimental spaces on Earth, in which life-promoting methods may be discovered and applied. The most appropriate laboratory is our cities,

which are trying to find more ecologically positive ways to deal with resource shortages during a period of massive urban growth. My dream is that we begin to inhabit starship cities that are constructed according to life promoting principles of construction long before we ever seek to leave our home planet.

Interstellar Flight and the Future of Humankind

Dr Giovanni Vulpetti, 14IS Senior Researcher

In addition to my regular work in Astrodynamics at Telespazio SpA (Rome, Italy) between 1979 to 2004, I had permission from my division chief to carry out theoretical research on matter–antimatter propulsion together with my team working on space mission analysis (involved in Italian and European projects). Now at the International Academy of Astronautics (IAA), my focus is currently on solar-photon sailing (SPS) and interstellar flight with the necessary interstellar precursor missions. Indeed, SPS is one of only two propulsion modes that we at the IAA concluded may give space-probes (in the near/medium term) the capability of escaping from the Solar System with a cruise speed one order of magnitude higher than the current velocity of the Voyager spacecraft (the second mode being nuclear–electric propulsion, or NEP). Via the theory of Fast Solar Sailing and the nanotechnology, SPS could perform remarkably higher than NEP. However, it would be better to develop both propulsion modes for many reasons. The complete results of such studies will be presented at the IAA's Washington DC summit meeting over 9–10 January, which will be attended by the heads of all the world's space agencies.

The next space era, perhaps lasting 50 years, may be characterised by an evolution toward the propellant-less in-space propulsion inside the Solar System via SPS and fast NEP and SPS for going to the outer Solar System and beyond in a time comparable to or less than the mean human working lifespan. Thus, faster and faster interstellar precursor missions could be realised in the course of this century and act as the door to interstellar flight.

Interstellar flight, as a science, began when Dr Leslie Shepherd published his historical paper on the subject in the *Journal of the British Interplanetary Society* in 1952. Since then a river of studies, which involve all disciplines of human knowledge, has flooded into our culture. All this leads us to two features of interstellar flight: (i), summarising the starship with respect to every area of culture, be it science, technology, art, philosophy, or theology; and (ii) the realisation that a starship mission will result from the co-operation of many, many countries. It is not only a question of money. Above all, the first interstellar mission should be based on the widest synthesis of concepts and ideas coming from scientists, artists, philosophers and theologians, born and working in many different nations.

How can any of this be possible when we consider our current world beset with problems mainly caused by antagonistic economic and political forces? We can achieve interstellar flight if two fundamental conditions become a reality. The first is a peaceful planet; the conditions of almost no ultraistic war between economic blocks and no military war, together with the world's sustainable development, may be achieved in, say, a half century. An era of interstellar flight might have a chance if our nations came together to tackle the scandalous situations of hunger and poverty.

I reserve the last seat to what in reality should perhaps occupy the first one. Is interstellar flight, as conceived today, compliant with universal laws? Let us we restrict ourselves to enunciate the Conscious Life Expansion Principle (which the author has been working about periodically) drawn from the forthcoming I4IS book, *Beyond the Boundary*: universal laws are conscious-life oriented. They enable a conscious species, inhabiting a planet, to eventually realise systems for a progressive space exploration, including interstellar flight. A civilisation may then be motivated to either continue to live on its birth planet or to spread to other stars.

It is up to us to support the second option through features i and ii and the creation of a peaceful world.

The Outward Urge

JOHN I DAVIES, I4IS Researcher

As long as we little humans have known that the stars are other suns, we have wanted to go there. The Outward Urge, as John Wyndham called it. Some practical people argue that the engineering challenge is too great to contemplate in any foreseeable future and some philosophers believe we should 'cultivate our own garden', but I am an engineer who profoundly wishes to see the engineering challenge overcome and a student of philosophy who wishes to look into the garden next door.

So the New Interstellar Movement represented by the Initiative for Interstellar Studies, Icarus Interstellar, the Tau Zero Foundation, the British Interplanetary Society and others inspire me to contribute as well as my abilities allow to the achievement of this goal. At the age of 67 I don't expect to live to see it achieved myself but I do suspect, and hope, that my great nieces will live to see the first fulfillment of that Outward Urge.

Right now I want to ensure that the visionaries of science fiction who have inspired so many of us are made more aware of the New Interstellar Movement and the Initiative for Interstellar Studies. I aim to make our presence at the 2014 World Science Fiction convention in London in August as inspiring to them as they have been to us.

Look Up, Look Out, Reach Out

Professor Austin Tate, 1415 Senior Researcher

As a child growing up with *Eagle Comics*' Dan Dare, E C Eliott's Kemlo books and TV programmes TV like Gerry Anderson's *Fireball XL5* and watching the first human spaceflights in my teens, followed by the Apollo landings while at university, looking 'up and out' has always been a part of my life. I look up at the Moon as I walk home – so close that we can get there in similar time to reaching a remote holiday destination on Earth. I look at the bright objects that often hang in our evening sky and think of what is happening now as our early explorers like the Galileo and Cassini spacecraft continue their dance round the gas giants. I am thrilled that the Voyagers continue their mission as they enter interstellar space.

My computing, scientific and engineering career has been blessed by involvement with space scientists and spacecraft engineers in the UK, Europe and the USA with our artificial intelligence planning and autonomy systems put to use for planning Earth-orbiting and deep space missions. I am equally excited that our names and artefacts are carried on missions through the tail of a comet from the outer reaches of our Solar System, to Mars and to the surface of Titan.

The technical challenges of sending a spaceship to another star is a fantastic opportunity to consider the very many challenges that must be faced with long-lived autonomous, repairable and sustainable vehicles that can offer many insights relevant to our own environmental, medical, engineering and other issues. It offers a grand challenge that can stretch our own vision and systems.

Mars, Titan and Europa are fascinating and we will learn much as we explore with our remote sensing instruments, our robots and eventually ourselves travelling in our local area. There are also many points of light in our night sky beyond the Solar System and those take a leap of imagination, science and engineering as well as vision to reach out to. The Voyager disc is a great example of this sort of vision from folks like Carl Sagan and others seeing beyond our local area and looking beyond the short term.

So look up, look out and reach out as we work towards seeing that starship depart and overtake Voyager as it carries us on our next journey of discovery.

A Change in Mindset

Randy Chung, I4IS Researcher

I am an engineer, inventor, and the researcher in charge of I4IS' GeV project. I'm looking at ways we can use a new linear particle accelerator design for highly efficient propulsion and related applications. Ideally, we will be using this new technology within the next 20 years at the megavolt level for travel within the solar system and, after that, it might be possible to use it at the gigavolt level to travel a thousand astronomical units and even further, interstellar, distances.

The wonderful thing about I4IS and thinking about interstellar travel in general, is that it allows and encourages a different mindset about big problems and their solution. Usually, we think only about problems and solutions that might that affect us in the short term – tomorrow, or next month, or next year. Depending on where we are in life, we may think about longer term issues, like writing a will, or making a retirement plan, or setting up a college fund for our children, but we rarely think about future generations unless we are wealthy enough to fund a trust or foundation. Organisations like I4IS allow the common person, like you and me, to work toward an amazing yet very long-term goal that will benefit our descendants.

This change in mindset is liberating and can help generate new solutions for difficult problems on Earth, too, not just for interstellar travel. One of the biggest problems we face on Earth is the increasing level of carbon dioxide in our atmosphere, which seems unstoppable because the solutions are too expensive or may have serious side effects. However, if we use a terraforming approach for our own planet, new solutions can be developed that can be both low cost and low risk. For

instance, we can now read DNA using low cost DNA sequencing, generate useful new sequences using synthetic biology and edit existing DNA using CRISPR-Cas technology. We could use these techniques to modify existing plant life to absorb and sequester carbon dioxide and, if grown in the oceans, could also help reverse their acidification. The modifications can include safety features, like making the plants sterile and non-propagating thus setting a limited lifetime, and including 'suicide' triggers to make sure that the plants cannot grow out of control and can be quickly killed if necessary.

It has been estimated that the cost of reducing carbon dioxide emissions by 50 percent would reduce worldwide GDP by two percent, amounting to about $1 trillion per year. It is quite possible that a biological approach could be used for a substantial amount of the necessary emissions reduction, but at a small fraction of the cost of using conventional clean technology. If this approach proves out, it would clearly show the usefulness of our interstellar efforts and the power of long-term thinking.

Product Design in an Interstellar world

Thomas Shirley, I4IS Researcher

I grew up with television series such as *Star Trek* and *Stargate SG1*, both of which offered a utopian vision for the future of humanity and a wonderful image of interstellar travel. This has given me great enthusiasm and interest for space travel, which I see as the next step in human cultural evolution. Importantly, I am not willing to simply be a bystander as humanity realises its space faring ambitions; I want to be a contributor and a part of the story of human development.

Product designers have rarely been part of the multi-disciplinary teams assembled to develop new space hardware. I feel this is an oversight as our skill-set is particularly suited to working at the forefront of human knowledge on highly complex and interconnected problems. Before I explain why, I will briefly define what I mean by 'product design'. It is essentially a systematic process of creative problem solving, normally with the end result of producing a physical manufactured (often mass-produced) good. Designers often consider the larger system including anyone or anything that could interact with it. They consider the internal and external structure of a device, applying the same rigorous design and optimisation processes. They often take a user-centred design philosophy, meaning the user's needs are king. Finally, because of their interdisciplinary nature and ability to apply a systematic creative process to any industry, product designers can be effective far beyond their native field of consumer products. At a fundamental level the product design process can be applied to any problem and thanks to our multidisciplinary nature, we are able to communicate and discuss complex ideas with engineers, scientists and other members of a research team.

A good example of product designers working on space technology can be seen at NASA's Habitability Design Center, where designers worked closely with scientists on the SPR Pressurised Rover project. The product designers' value came from their ability to rapidly visualise information and produce iterations of quick, testable prototypes. This process of rapid idea generation and prototyping resulting in a practical and effective solution can lead to greater technological innovation within short time scales.

There are certainly challenges to bringing product designers into such a specific area of research and development and the following issues would be especially pronounced:

• Language: the terminology used in design can be quite different to that used in engineering and science.

• Culture: designers, engineers and scientists all have misconceptions about the relevance and effectiveness of the others' individual skill sets.

• Time scale: before the the first interstellar vehicle is developed, there could be very little traditional product design. However the true value of product design lays in its creative problem-solving process that could be applied at the earliest stages of research planning and system design. Product design can also help convert spin-off technologies into commercially successful products, providing short term benefits to a long term project.

Looking forward, over the next 12 months let us increase collaboration with scientists to explore commercial product opportunities that help highlight the inherent commercial benefits of investing in interstellar technology. We should also launch academic and exploratory projects designing products for deep space travel, which can have spin-off applications in extreme environments on Earth or can result in excellent solutions to everyday problems (in a similar way that designing for disability can result in much more convenient solutions for able bodied users). Finally, we should encourage brainstorming solutions to key interstellar challenges from first principles and from an outsider's (non scientist\engineers) perspective.

Interstellar Flight and the Younger Generation

Dr Michael Minovitch and Bill Cress
Member of I4IS Advisory Council
and I4IS Researcher

Any look into the long historical development of the human race will find that most important developments take place while trying to solve complicated scientific problems. When faced with a difficult scientific dilemma, human civilisation advances faster even if the problem remains unsolved. The question of achieving interstellar flight can be viewed as one of the most important gifts for the advancement of humankind because it is among the most difficult to solve. However, the concept is very easy to understand and most warmly embraced by almost everyone, especially by the younger generation who would welcome the challenge on finding a solution. This endeavor would require studying all aspects of the physical sciences and mathematics that are the underlying foundation for these fields. One can imagine the enthusiasm and inspiration a young person can find in seeing or reading about this problem in media channels while contemplating the possibility of devoting his/her life to being a part of the solution.

Educators today place far too much focus on athletics, sports and the arts as opposed to guiding their charges in directions that could profoundly affect our civilisation and humankind's quest to understand our Galaxy and eventually reach out to the stars. Our youth needs greater motivation to engage in the sciences and mathematics that will give them the basis and understanding to take on the challenges of interstellar flight.

Some professional organizations such as I4IS and Icarus Interstellar are actively trying to reverse this trend by public outreach to the younger generation in various ways. As an example Icarus Interstellar has created a short public service announcement to introduce the virtues of space exploration. Both organisations realise that through their efforts they have the ability to influence and inspire our youth to pursue a profession in high technology jobs centered on planetary and interstellar exploration and discoveries.

As we advance further into space and journey beyond our solar system, it will be the young people of today that will support the technologies of tomorrow's programmes.

Accelerating Process and Helpful Trends

Paul Gilster, Centauri Dreams
and the Tau Zero Foundation

Travel into deep space is so energising a topic that it has always inspired a sense of community, even when the problems of time and distance between researchers were profound. Johannes Kepler himself famously wrote to Galileo that the two would divide up exploration of the heavens, mapping the route for future explorers: "Let us create vessels and sails adjusted to the heavenly ether, and there will be plenty of people unafraid of the empty wastes. In the meantime, we shall prepare for the brave sky-travelers maps of the celestial bodies. I shall do it for the Moon, you Galileo, for Jupiter." Thus began incremental progress as early as 1610.

Note Kepler's reference to 'sails,' demonstrating his early interest in the tails of comets and why they always faced away from the Sun. By the 1950s such luminaries as Les Shepherd and Eugen Sänger were exploring antimatter and photon rockets and the interstellar scene we are familiar with began to take shape through the work of scientists like Robert Forward, Gregory Matloff, Freeman Dyson and many others, with a special shot of energy from the British Interplanetary Society's Project Daedalus.

Where to in 2014? Encouragingly we now have both the tools and the observations that earlier theorists lacked, bringing us the promise not only of further conceptual work but a new public engagement that may put space back on the front burner. The communications driver is, of course, the Internet, with its capability of nurturing 'virtual' organisations that otherwise would have to rely on meetings and slow postal mail. The public engagement may grow out of the ongoing exoplanet hunt, which is changing the public

view of the cosmos in directions that are very much for the better.

The process is noteworthy and accelerating. Science fiction has painted planets galore, but actually observing them – and in some few cases actually imaging them – quickens the interest and forces the question of what we would do if we found an Earth-like world. Probably everyone in the interstellar community has had the experience I've had, of being asked after some new discovery (like the small, hellish world around alpha Centauri B), how we could travel to see it up close. That sparks the conversation about advances in physics and the panoply of mission concepts that could make such a mission something beyond a mere cinematic fantasy.

The people I listen to expect to find Earth 2.0 within about a decade, but even if it is a bit longer than that, the quest is now firmly seated in the public consciousness. The James Webb Space Telescope will allow us to begin taking measurements of nearby exoplanet atmospheres, including the fascinating KOI-314c, a world of Earth-like mass but possessed of a dense atmosphere of hydrogen and helium. No Earth 2.0 here, but KOI-314c is a reminder that we will soon have the tools to study exoplanet atmospheres around such targets. We are bringing the exoplanet scale down from 'hot jupiters' to rocky worlds and it is an unstoppable trend.

I deal with the public every day on Centauri Dreams and have watched my audience change over the years, from mildly interested laymen to many people in other disciplines who have become obsessed with what we are finding in the heavens. They join an existing community that is heavy on working scientists, the interaction between whom speaks of exciting times ahead. What we need now is an infusion of interest and the funding that will flow from it. Public engagement not only from a distance but through collaborative observations and active crowd-sourced analysis of exoplanet data will lead to more accurate portrayals in films and documentaries, so critical in engaging and educating younger intellects. I expect no profound breakthroughs in 2014 but a continuation of these helpful trends.

Moving Towards Starships: Organisations and Technologies

James and Gregory Benford, Starship Century

Having produced *Starship Century* and two symposia based on it, we are thinking of tactical directions for this community. The year just past showed clearly that the interstellar community has established itself in a number of organisations with many meetings. There were six publicly open meetings, varying in length from one to four days, in a single year. I attended three of them and no one attended all of them. We need to think of consolidating the meetings because the community is spread thin at the moment. Some meetings may not occur again, which would help resolve this issue, and some could be combined.

The key community issues in the next few years are:

1. Project Icarus is our flagship and must be completed successfully with credibility. That also goes for the projects under the Icarus Interstellar banner. We urge all of them to acquire experienced spacecraft technology advice, in areas such as power systems, so that the final concepts would pass muster in the larger aerospace technical community.

2. Expand our community outward: solicit interest from other interested parties in science, engineering, biology, etc. We need to get talks into technical conferences other than our own. We must have our papers in peer-reviewed archival journals. Most of what we are doing

appears in the *Journal of the British Interplanetary Society* (*JBIS*), which at this point is not an archival journal and has a smaller readership. For example, when we did our work on SETI transmitters a few years ago, we submitted it to *Astrobiology* – a well-known journal – and went through a lengthy peer review process. When the two papers came out, they gathered a substantial number of comments from the astronomical community and a fair amount of publicity in the science press. That is an example of what we are recommending: grow outward.

3. Tone down the relentless boosterism this community is prone to. Let's stop congratulating ourselves on how forward thinking we are. "Ain't we Grand!" gets tiring quickly and begins to sound juvenile.

Meanwhile, discussing interstellar always has a tech component, so here are our preferences. Only by developing technologies to open the Solar System economically can we build infrastructure capable of deeper explorations. Among these are:

A. Space-rated robotics to service satellites and spacecraft in the burgeoning near-Earth orbital zone. This includes working around the hotels about to start business at 200 kilometres up. Later, repairing geosynchronous satellites will be quite profitable. Beyond that, asteroid mining and maybe moon mining too.

B. 3D printing of plastics and metals for advanced technology uses. Applied in space, this means making parts in orbit, out of waste materials, instead of hauling them up from Earth.

C. Nuclear thermal rockets. These exist and were tested, yielding specific impulses up to four times that of the Saturn V. Fly the nuclear core with nozzles etc into orbit, follow that with a big, loaded fuel tank and join them. Add a mission capsule atop that and you have an interplanetary craft able to manoeuvre and refuel at asteroids (mining for water), Mars and elsewhere.

Our Interstellar Community: 2014 and Beyond

Buck Field, The Starship Vlog

How do we assess the current state of the interstellar community and look forward to where we are going? Identifying who we are and what we're trying to achieve seems a sensible start, so here's a brief overview of the interstellar organisations:

• British Interplanetary Society – supporting and promoting the exploration of space and astronautics;

• Global Starship Alliance – to launch a manned starship to the nearest potentially habitable exoplanet;

• Icarus Interstellar – dedicated to achieving interstellar flight by 2100;

• Initiative for Interstellar Studies – to create a long term research strategy pulling all the other organisations together in a co-operative way;

• Planetary Society – creating a better future by exploring other worlds and understanding our own;

• SETI Institute – to explore, understand and explain the origin, nature and prevalence of life in the Universe;

• The Starship Vlog – to provide news and information on starship-related research & management;

• Tau Zero Foundation and Centauri Dreams – pioneering interstellar flight and providing news on related topics;

• 100 Year Starship – to make the capability of human travel beyond our Solar System a reality within the next 100 years.

There are also closely related communities with a strong affinity to the interstellar flight community, including academics, the space industry, governments and agencies like NASA, ESA and DARPA, plus the general

public. Finally, we all recognise the overlapping interests of the entertainment and publishing industries, from which have come the most detailed and best imagined visions of future success.

Technical and engineering challenges include energy production, propulsion and dealing with the interstellar medium. Time and distance are recurring themes in these discussions and will continue to be an engineering focus for the foreseeable future. Communications with home and the relative merits of exploring deep space are ongoing, as is the technical issue of time dilation and what it means for any mission to another star system.

Organisational obstacles are the second type of challenge we might want to address, including the most endemic: funding, the use of volunteers and the potential friction when payments and salaries enter the mix. Using volunteers limits the level of professionalism any organisation can demand and we have seen funded efforts produce marginal quality. Since I feel relatively free to beat up on my own work, The Starship Vlog is a good example of a product that is close to corporate grade material, but will forever remain all but impossible to keep defect free as a self-funded effort.

Despite these challenges, there are some brilliant, high-quality productions, especially in the area of web design, content and events that enhance the professional credibility of the producers and our community as a whole. The Tennessee Valley Interstellar Workshop, Starship Century and Starship Congress demonstrate the dedication and professionalism that we need to advance the state of the art and build productive collaborations.

The most common aspiration I have noticed is the desire for greater public engagement, influence, and awareness of our cause. The need for inspiration is widely cited within our community, with the idea that action will follow, but I think it is our job to lead. We are the thought leaders and need to develop the communications skills to not only effectively spread the word, but to provide meaning and emotion. By doing this, we can continue to grow and develop through 2014 and beyond.

Embrace our inner entrepreneur

Richard Obousy, Icarus Interstellar

To date, the amount of funding that has been injected into interstellar research is trivial and insignificant. If interstellar flight is to ever become a reality then a measurable injection of resources, funding and effort is necessary. Until that time, the dream of interstellar flight that burns within us will be carried forward by just a small handful of organisations with dedicated, but more to the point, volunteer members. It is my belief that while a volunteer effort can galvanise minds and build strong communities, that volunteerism is fundamentally unsustainable across the span of time that will take us from today to the launch our first rapid and dedicated interstellar mission.

Thus, it is crucial that our community do one, or both, of two things:

1. Convince private or public entities with significant 'pockets' to fund our work, long term.

2. Learn a high degree of self sufficiency and embrace entrepreneurship as a vehicle for realizing our collective ambition.

I favor '2'.

To put things into perspective, over the first two quarters of fiscal year 2013, Apple injected some $2.1 billion into its R&D budget (about two percent of net sales). Compare this figure to the $2.5 billion spent on NASA's Mars Science Laboratory Curiosity. We see immediately that large corporations who have developed gargantuan revenue streams easily have the capacity to fund space initiatives – if that were part of their mandate. Why can our community, the interstellar community, not put our collective brilliance together to create companies with wealth

abundance and directors and stakeholders who are passionate and devoted to space exploration.

Last year alone, over $72 trillion dollars was circulating within the global economy. Those who say "there's no money" are misguided. Money is literally raining from the sky. Our community just has to learn how to attract it and I believe that entrepreneurship, the most potent force on our planet, needs to be more broadly embraced. I believe that there is an inherent fear of entrepreneurship and many prefer 'job security'. I am amazed each time I hear that phrase. It takes only two words to take away that security: "you're fired" (or "you're sacked" if you live in the UK!). How is that, in any way, job security?

I believe that 2014 can become the year where we embrace our inner entrepreneur and find ways to become self sufficient and transform ourselves into the captains of our own fate. We will not reach the stars if it is our hobby. We will reach the stars if we can embrace our calling fully and not be held back worrying about daily subsistence.

Mission Statement

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.

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www.i4is.org