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for Space Applications**

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Innovative Technologies from Science Fiction for Space Applications

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Abstract

Ideas play an important role in science and technology, even when they do not have an immediately testable aspect, and writers have predicted satellites, spaceflight, moon landings, well before they were actually possible. Science fiction literature, artwork and films are full of descriptions of space technologies and systems – often just pure imagination, sometimes based on some semblance of fact. Early science fiction authors, artists, and illustrators described space concepts and spacecraft based on the limited scientific and technical knowledge available at the time, whereas more modern writers generally portray the same basic systems as are used in the real life space flight of today in their literature and art, even though artistic licence is often employed. Although early writings were usually wildly inaccurate in many areas, some of the predictions made did come to pass and some of the systems and technologies described have been subsequently successfully developed and used.

It is against this background that the European Space Agency (ESA) launched a specific initiative, the main objectives of which were to review the past and present science fiction literature, artwork and films in order to identify and assess innovative technologies, systems, devices, designs, configurations and concepts described therein which could be possibly developed further for space applications. The study resulted in some 250 innovative technologies and concepts mentioned in the science fiction genre being found and a preliminary assessment is currently being performed in order to identify whether any of these technologies might hold potential for a more-in-depth analysis leading to subsequent feasibility studies. The assessment is also examining the technologies described with a view to ascertaining what might be possible with today's knowledge, techniques, technologies and materials, and what new technologies and knowledge might be required to make any of the identified science fiction concepts work.

The paper discusses the background and objectives of the study, the methodology and the results, as well as the next steps to be taken in order to capitalize on the huge amount of public and media interest generated in this unusual and advanced concept study.

Introduction

Science fiction (SF) literature, artwork and films, are full of descriptions of space technologies and systems – often just pure imagination, sometimes based on some semblance of fact. Early science fiction authors, artists, and illustrators described space concepts and spacecraft based on the limited scientific knowledge available at the time, whereas more modern writers generally portray the same basic systems as used in real life space flight in their literature and art, even though artistic licence is often employed. It still gives them the opportunity to promote their ideas which may not otherwise be possible through more formal scientific evaluation processes.

The idea that perhaps such science fiction literature contained innovative technological ideas which could possibly be brought to a point of development with either today's technology or possibly technology which was just around the corner was the driving force behind a recent European Space Agency (ESA) study entitled Innovative Technologies from Science Fiction (ITSF).

The main objectives of the study were to review the past and present science fiction literature, artwork and films in order to identify and assess innovative technologies and concepts described

therein which could be possibly developed further for space applications. In addition, it was hoped to obtain imaginative ideas, potentially viable for long-term development by the European space sector, which could predict the course of future space technologies and their impact.

Given the huge amount of SF literature in many languages and going back decades, it was clearly impractical to think of covering more than a mere fraction of what was available. However, those involved in the study (scientists, engineers, SF writers, laymen) reviewed and brain-stormed the technologies in SF literature as far as they were able given the time and budget constraints and came up with a list of technologies which are being assessed as to whether they might be worthy of more in-depth evaluation. Some technologies might be judged unfeasible, some might have already been tried before and found not to work. However, new tools and techniques are being developed all the time and what was not possible several years ago, might be possible today. Indeed, the study has already suggested several promising areas for further investigation.

The genre of science fiction

Science fiction is not a genre which tries to predict the future, nor does it pretend to imagine concepts that will actually happen and only occasionally can technologies which SF describes be considered as innovative.

For some, science fiction tells a story that lies outside the current bounds of experience for the prospective readership, while constraining the setting and the character actions to obey plausible extrapolations of current understandings of the universe. Characters, for instance, may experience many things that seem unlikely to occur to the average person in the 20th century: for example, time travel, interplanetary travel, genetically optimized lifeforms, fully autonomous robots, and unlimited power sources. Each of these examples is pretty much a plausible extrapolation of current scientific and technological thought.

For others, science fiction is the art of using science to make conjectures about the future of mankind. What separates this type of writing from fantasy fiction is that there is a certain amount of plausibility evident in science fiction literature. In any discussion about the future of technology, it is difficult to determine exactly when a technology might become ubiquitous. There are numerous examples of technologies which have taken (and still do take) many years to be accepted and deployed. Equally today there are many technologies in existence which could never have been conceived even one hundred years ago. This phenomenon allows writers to put ideas down on paper which are not immediately dismissed as irrelevant either by the layman or the scientist and which may perhaps ultimately bring the seemingly fantastical inventions into reality.

Several SF authors have taken modern technology and concepts (ie of their own time) and made extrapolations about the future of humanity based upon it. While works of imagination, the writings do still contain some elements of plausibility, with the story revolving around some known facts (such as descriptions of landscapes and conditions (eg lunar, Martian, freezing nights) or current spacecraft technologies) as well as inventions and possibilities that are to all intents and purposes beyond our current technologies.

There is also some debate over hard and soft science fiction, with the former being defined as SF that does not go beyond current scientific knowledge. It can be further distinguished between near-future extrapolation of current scientific developments and the far-future projection of other developments and strange (but scientifically plausible) worlds. Hard science SF, i.e. the form of imaginative literature that uses either established or carefully extrapolated science as its backbone, according to writer Allen Steele; as opposed to "speculative fiction", which focuses mostly on social changes – may use science in a speculative way and try to extrapolate what might be done with a specific technology.

Still, science is always used as a narrative tool in science fiction: most of the time technologies are imagined in order to make the story progress or to put the characters in a given situation that

could not happen without it. For instance, the book "Dune" by Frank Herbert describes (among other things) the colonisation of a sand-covered planet. The author wants to express how the protagonists evolve in that arid environment without any contact with the outside world. Therefore, Herbert has to "invent" a piece of apparatus that allows people to live with a minimum amount of water in the desert – hence, the stillsuit: a device conceived to recycle body fluids such as sweat and urine.

Furthermore, science fiction prepares us to accept new ways of using technologies, it gives us the urge and the motivation to master them. Science fiction, as a very rational genre, is often about the beauty of science and its accomplishments. SF can then even work as an inspiration for scientists – as SF writer Charles Sheffield noted science fiction and science fact swap ideas all the time - thus a dialogue between science and fiction does indeed exist.

Science fiction is not only a literature of ideas, but also of images. From Cyrano de Bergerac to Dan Simmons, writers have – with often rich descriptions – evoked extraordinary landscapes, prodigious inventions or beings without peers. As a result drawings and engravings representing striking scenes of the text naturally came as enrichments to Science Fiction novels. From the end of the 1920s, the spread of colour printing and the appearance of pulp magazines devoted exclusively to SF (like *Amazing Stories* or *Thrilling Wonder Stories*) make illustrators play a more and more important part in the Science Fiction community. A specific tradition of pictorial art related to the genre has thus been formed. Later, illustration art went on to embellish the covers of paperbacks – while other artists such as Manchu and Hubert de Lartigue rendered on canvas their futuristic, dreamlike and startling visions. Through their works we are able to breathe the atmosphere of distant planets, live in a technological paradise, and believe in new horizons.

The exploration of space by artists and writers

Throughout history artists have traditionally accompanied explorers on many of the great voyages of scientific and geographic discovery. Space exploration is the greatest voyage of discovery ever undertaken and artists have been at the forefront from the beginning.

Before the flight of the first aeroplane, before the launch of the first rocket, both literature and art began the exploration of space and have progressed ever since. Since the first use of the telescope in 1610 astronomers recorded what they observed by making drawings. The first science fiction novel written by a scientist was by the German astronomer Johannes Kepler in 1615. Called "Somnium" it is a tale about a voyage to the Moon and acknowledged that Earth's atmosphere does not extend infinitely. In 1870, Emile Bayard illustrated Jules Verne's "Around the Moon" a sequel to his classic novel "From the Earth to the Moon" with woodcut illustrations. At about the same time, James Nasmyth's illustrations were the first space landscapes to appear in a non-fiction book "The Moon". Before Yuri Gagarin or John Glenn orbited the Earth, artist Chesley Bonestell was depicting what life would be like in orbit and which kind of space vehicles would be used. Since then, many space artists have explored places or concepts that were too distant, too technologically advanced or too dangerous for human beings to explore directly.

Art and literature about space have not only been an integral part of space exploration since its beginnings, they have also played a vital role to its development as well. The primary way of introducing the general public to ideas about space exploration have been the fictional images and scenarios created by visual artists and writers. As such, artists and writers lay the foundation which made future space activities understandable by the general public. Stimulating the public's imagination and excitement about space exploration has also helped to secure the necessary political and financial support for the national civilian space programs. Indeed, science fiction films are arguably the most popular and financially successful art forms of all times.

Many space scientists and engineers can trace the roots of their careers to the pages of a science fiction novel or to the seats of the local movie theatre. In the past 50 years of space exploration, artists have helped these space professionals to visualize their plans and projects and to give form to their developing technologies.

Ideas into reality

Ideas clearly play an important role in science and technology, even when they do not have an immediately testable aspect, and writers have predicted satellites and spaceflight well before they were actually possible. For instance, man has dreamed, and explored ways, of going to the moon for centuries (take Cyrano de Bergerac in the 1650s) - but it is only in very recent times that the technologies and infrastructure were in place to actually make it possible. It should be thus feasible to find out some new ideas in SF capable of convincing engineers to work seriously from such imagination. One has only to look at the past where concepts described by Jules Verne, for instance, or Arthur C. Clarke and many others have subsequently been developed or rediscovered.

Although early writings were often wildly inaccurate in many areas, some of the imaginary scenarios and extrapolations made did come to pass and some of the invented systems and technologies described were subsequently successfully developed further in real life. Examples include ultra-high velocity projectile launchers (1865); retro-rockets (1869); planetary landers (1928); rocket fins for aerodynamic stability (1929); vertical assembly buildings (1929); clustered rocket boosters (1929); EVA, pressure suits, life support tethers (1929); construction of orbital space station complete with living quarters using material ferried up and regular service visits (1945); satellite communication with satellites in geostationary orbit (1945); solar and light sails (1920, 1951, 1963); multiple propellant storage tanks (1954); streamlined crew modules for atmospheric entry (1954) and so on.

Some twenty or so years ago, a NASA engineer analyzed the apparent eye-witness description of a spaceship as written up in the Bible's Book of Ezekiel (the description was necessarily constrained by the limits of technology understanding at the time) and showed that a similar spherical spacecraft could be constructed, but was outside the scope of the day's (ie 1970s) technology. More recently, it has been shown that faster-than-light propulsion systems (such as used in the starship Enterprise) may not be so ludicrous as first thought and research is currently being undertaken into the concept of space warps. It has also been reported in the press that scientists working independently in the USA, Europe as well as Australia have carried out some form of particle teleportation. And NASA engineers are working on a "spacecraft on a chip".

Another example of a technology mentioned in the SF literature is that of the space elevator. This concept was first mooted in 1895 by a Russian scientist, looked at again some 60 years later by another Soviet scientist, studied further by an American physicist in 1970, and became the subject of an SF book by Arthur C. Clarke in 1979 which served to popularize the device. Now NASA has recently completed a detailed study of the concept of space elevators and concluded that in possibly 50 years or so, this method of cheap transportation to geostationary orbit could become a reality. An even more recent US study on the same topic thinks that it might be possible within 10-15 years. And both NASA and ESA are looking at quite a few concepts in the advanced propulsion area some of which have been described to a greater or lesser extent in the SF literature.

In any discussion about the future of technology, it is difficult to determine exactly when a technology might be taken up and become ubiquitous. There are plenty of technologies which have taken (and still do take) many years to be accepted and deployed. Equally today there are many technologies in existence which could never have been conceived of one hundred years ago or even fifty. This phenomenon allows writers to put ideas or dreams down on paper which are not immediately dismissed as irrelevant either by the layman or the scientist and which may perhaps ultimately bring the seemingly fantastical inventions into reality.

Science fiction can thus be used to stimulate thoughts and ideas which could perhaps be turned into a more realistic scenario with the eventual development of new innovative technologies which are not as conservative as those being currently used in the space field. In fact, Hugo Gernsback, founder of *Amazing Stories* magazine in 1926, noted that science fiction was socially useful precisely because it inspired research and inventions.

On the other hand, we also have it in ourselves to develop technologies for their own sake, as well as for some ultimately useful purpose, including exploration. Inventors often invent things or come up with concepts that have no immediate or obvious application or a use outside a narrow specific domain and it requires a leap of imagination by someone else to make that invention into a useful product elsewhere. This is where spin-off from space technologies comes into its own, and why it can take so long for some ideas or technologies to hit the marketplace.

A pioneer or dreamer will still have his dream regardless of whether technology is actually available to make it a reality (take Dick Tracy and his two-way wrist watch radio for instance in the 1940s - that has only become a reality today, 60 years later with miniaturization); and equally an engineer or inventor will still create a machine regardless of whether there is a defined use for it or not (take some of the developments in the robotics field, for instance). The application and selling of that idea often comes much later. On the other hand, innovative engineers can certainly take a dream or imaginative idea and bring them to reality.

The ITSF study – methodology and results

With this as background, the Innovative Technologies from Science Fiction (ITSF) study, conducted for the European Space Agency by the Maison d'Ailleurs and the OURS Foundation, reviewed past and present science fiction literature, artwork and films in order to identify and assess innovative technologies and concepts described therein which could be possibly developed further for space applications, and to obtain imaginative ideas which might hold potential for long-term development by the European space sector. It should be noted that the study was not exhaustive and that it barely scratched the surface of the vast amount of science fiction literature and films. Nevertheless, the study has covered many of the major concepts mentioned in the literature.

In order to reach the largest possible group of science fiction experts it was decided to utilize various Internet technologies. An initial Web site was created at <http://itsf.spaceart.net> with the domain pointer <http://www.itsf.org>. In addition a listserv discussion forum was also set up. With these facilities in place various science fiction and space interest groups were contacted and invited to participate in the study.

The Web site provided a gateway to the ITSF study and contained an introduction and background to the study and its goals, contact points, a resources collection of SF references and online sources, an area for the submission and publication of factsheets, and an ITSF Imagebank - an interface which provided the opportunity for artists to post their images on the site under several categories.

The listserv was heavily used as a discussion list, mostly about technologies and their feasibility. The discussion related not only to science fiction, but also to current ideas, where SF only served as a trigger to the debate. In addition, the listserv was used by the participants as a way to find other contributors and sub-contractors. The listserv attracted a good deal of attention: since the launch of the study over 200 people subscribed to the forum. The intense media interest in the study helped to motivate new (serious) subscribers to join the discussion. A digest was archived at <http://itsf.spaceart.net/forum/digest.html>. The listserv was also used to conduct a survey about ITSF contributors. It turned out that most of these were highly qualified and experienced scientists and engineers working in a variety of aerospace companies and research establishments as well as universities.

Participants on the listserv were asked to submit factsheets in various categories to assist in the development of the study. These factsheets were available as a form on the Web site and when a participant came across a technology or innovative concept in the literature, then a factsheet form was completed which gave descriptive details of the technology, the source reference, an indication of how and why the technology was applied, and a preliminary assessment or evaluation if possible. Factsheets were posted via the Web site by anyone interested in the project (after approval by the study conductors). Some 60 factsheets were posted during the study.

In addition to having factsheets posted on the ITSF Web site and the accompanying discussion on the listserv, it was decided to hire sub-contractors to study specific technologies found in SF works. The specific technological areas to be looked for were defined with the help of ESA's "European Space Technologies Catalogue", as well as its "Dossier o". A few topics were also proposed directly by sub-contractors. In order to assist them further, a secondary bibliography of SF literature was compiled as a preliminary guideline. It was also considered that secondary literature would be a good way to start collecting information about space technologies applied in science fiction.

Altogether some 50 fact sheets and 35 technical dossiers covering some 250 concepts and technologies were generated as a result of the study in the areas of propulsion techniques, colonization of space, energy and power, computers and communications, robotics and cyborgs, launch systems, and resources and materials. Specific topics looked at included ram scoop devices, solar and light sails, warp drives, ion drives, anti-matter, fusion drives, pellet propulsion, biospheres, long duration spaceflight, instantaneous communication, wearable computers, orbital towers, space elevators, orbital loops, terraforming, nano-technology, virtual reality, space tehers and personal transportation devices amongst others. In addition artists submitted over 50 images on space art which they believed encapsulated the essence of many of the ideas found in science fiction.

The ITSF study has only scratched the surface of the vast amount of available SF resources, especially if one takes non-Anglo Saxon resources into account. The extensive media coverage of the project was an unexpected and extremely positive by-product of the ITSF study and provides a certain impetus to go further. The dossiers emanating from the study have been synthesized into brochure (1) which contains much original artwork by SF artists. Already several topics have been proposed for further study and a follow-up study covering areas outside the scope of the present study is under consideration. In addition, it is planned to develop the ITSF Web site further to include a database engine integrating the current results as well as a public forum.

Conclusion

Science fiction literature, artwork and films, then, are full of descriptions of space technologies and systems – often just pure imagination, sometimes based on some semblance of fact. Early science fiction authors, artists, and illustrators described space concepts and spacecraft based on the limited scientific knowledge available at the time, whereas more modern writers generally portray the same basic systems as used in real life space flight in their literature and art, even though artistic licence is often employed. These basic systems and technologies relate to propulsion, attitude and orbit control, navigation and guidance, life support, thermal protection, communications, instruments and payloads, robotics, materials and components, cabin quarters, and weaponry.

There is a wealth of innovative ideas, including technological ideas, to be found in the literature and art of science fiction and the genre is a proven means to bring these ideas to the public awareness and, in fact, science fiction has stimulated the public's appetite for technological development.

The study on innovative technologies for space applications emanating from science fiction literature, art and films is something that is new and original for the European Space Agency and it could have important consequences for the use of existing technologies and the development of new technologies. It is an in-depth look beyond the actual borders of science and techniques, and it deals with exciting concepts which might be worthy of eventual consideration for ESA's long-term space programmes and explored in the decades to come. Quite apart from the potential contribution to future technological progress in space activities, the study and its description, categorization and evaluation of technologies should offer a stimulating perspective to the science fiction community at large, and provide science fiction authors with fresh ideas and trends.

There have always been explorers and pioneers - it is a basic instinct (and not necessarily a human instinct) - from animals in search of new pastures, from prehistoric man who crossed continental divides in pursuit of food and to find new places to live, and to people in our own times who have sailed the oceans and traversed the land in search of adventure. Where would we be today without the great explorers of the past?

So we have an in-built need to explore new places - especially the tiny pinpricks of stars in the night sky - simply because they are there and we are curious. And for the purposes of such exploration then we have a need for new or improved technologies. Given that we have this built-in desire to explore, then we will eventually develop the technologies to do this when the real need is there and when other enabling technologies and materials become cheap enough or feasible enough to do so. This may take years or centuries to achieve – but looking at the ideas and concepts of the past which may have been forgotten or overlooked because they were not in mainstream science and technology is certainly a worthwhile investigation and they just may give us a kick-start.

Reference

- 1) Raitt, D. et al. Innovative Technologies from Science Fiction. European Space Agency, 2001. ESA-BR-176

1 publications esa publications Innovative Technologies from Science Fiction for Space Applications By D. Raitt, P. Gyger & A. Woods

The idea that perhaps science-fiction (SF) literature contained innovative technological ideas that could possibly be brought to the point of development with either today's technology or technology that is just around the corner was the driving force behind a recent European Space Agency (ESA) study entitled Innovative Technologies from Science Fiction (ITSF). The main objectives of the study were to review the past and present science-fiction literature and take a look at some of the most innovative technologies that space exploration has invented to help us on our quest to learn as much as we can about the universe. Space exploration, although very fascinating, is extremely costly. Did you know that NASA's fiscal year budget is \$21.6 billion this year? With a budget this high, imagine the advances in technology the agency is able to achieve. Our everyday use of technology like cell phones and smart speakers may already seem advanced to you, but this is nothing compared to the intricacies of space technology. Let's take a look at some of the most innovative technologies that space exploration has invented to help us on our quest to learn as much as we can about the universe. The Hubble Space Telescope.

ITSF stands for Innovative Technologies from Science Fiction for Space Applications (research study). Suggest new definition. This definition appears somewhat frequently and is found in the following Acronym Finder categories: Science, medicine, engineering, etc. Organizations, NGOs, schools, universities, etc. See other definitions of ITSF. In true sci-fi fashion, the upcoming space technologies responsible for our ascension to the stars range from wacky to downright suicidal. They began by reviewing popular science fiction films, including Gravity and 2001: A Space Odyssey, for architectural inspiration. Ultimately, they decided on a humanizing, doughnut-shaped domicile. It inflates like a bounce house and uses a novel printing method that alleviates stress lines, allowing it to withstand the much higher air pressure inside. Every piece is made from materials extracted from Martian sand or the gases within Mars' atmosphere. However, the grand prize was awarded to Team Space Exploration Architecture and Clouds Architecture Office for their psychedelic Mars Ice House ITSF - Innovative Technologies From Science Fiction For Space Applications. Take a chance to write the future - ESA Portal - Nov.4.02. NESFA Science Fiction & Fantasy Short Story Contest. Science Fiction Submissions Forum at Space Uplink. Sci-Fi / Space Technology at Space Educator - NASA Johnson Space Center's Space Educator Handbook provides this page that uses science fiction to teach about space technology. Planet Designer by John Bray- online program to create plausible planet environments. Space Tourism in Science Fiction at Spacefuture - reviews several stories that involve space tourism.