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INTERSTELLAR SPACE EXPLORATION: WHAT'S GOING ON?

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1 INTRODUCTION

The IAA Symposiums on Realistic, Near Term, Advanced Space Missions, organised by the Interstellar Space Exploration Committee (ISEC) of the International Academy of Astronautics, with the title Missions to the Outer Solar System and Beyond, have now reached their third edition.

This fact (and also the date 2000) ask from the organisers to make a point of the situation.

The first symposium was held in 1996. The total number of papers presented and included in the proceedings was 29. The second symposium was held in 1998, with a total of 27 paper presented and included in the proceedings. The present edition of year 2000 has a total of 15 papers.

The decrease of the number of papers presented to a symposium can be caused by conflicting reasons spanning from a fading interest on the subject, which causes lesser researcher to be involved in the related topics, to an increase of the interest, which causes a larger number of initiatives being prepared, with the result of decreasing the number of papers presented to each one of them. In particular, the presence of specialised meetings on subtopics strengthen this tendency.

This last situation seems to be the general cause of the decrease of papers to both the present symposium and the Interstellar Space exploration Symposium at the IAF Conference in Rio: the latter meeting had to be cancelled for lack of participation.

The cancellation of the IAF Symposium has, in the view of the author, two more direct causes: the yearly sequence (not many researchers have something new to present every year!) and the location which seems to have discouraged many would-be participants. Note that these considerations have caused a cyclic pattern of the participation to the IAF symposium, with a maximum touched with last year symposium in Amsterdam.

Generally speaking it can be safely stated that there is no decrease of interest in interstellar space exploration, particularly if it is remembered that the ISEC of the Academy deals with the exploration of the outer solar system and the near interstellar space, and not only with interstellar exploration in due sense.

In the opening of the two previous symposiums the opening lecture dealt with the history and the evolution of the ISEC. In the present opening I will try to give a look to the future to see whether some evolution lines can be forecast. The ideas here expressed reflect only the opinion of the author and do not imply that the Committee shares or endorses such views.

2 THE MISSION OF ISEC

To quote from the Terms of Reference of the ISEC, as set out by its chairman and co-chairman in the 1992 Status and Planning Report to the Academy [1]

The purpose of the Interstellar Space Exploration Committee (ISEC) is to study and assess the problems and issues involved in the manned and unmanned exploration of interstellar space. The subject will be pursued not only in its scientific, technical and economic aspects, but also in terms of its philosophical and anthropological implications.

The title of the present symposium (and of the previous ones), missions to outer solar system and beyond, falls very short if compared with the mission of the committee, and the stress on the realistic, near-term missions, aimed also to discourage the presentation of science-fiction-type papers, perhaps

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discouraged also the presentation of more advanced ideas. It is however true that the scienti¯c committee never rejected a sound paper only because it dealt with non near-term issues.

Actually, these symposiums aimed to evaluate the possibility of pursuing some of the aims of the ISEC within a short term timeframe and to propose to the space agencies one or two missions which can be worked on starting from now. Vulpetti [2] suggested that the term realistic should mean

1) using present-day Physics;
2) requiring current or near-term technology;
3) requiring as low cost as possible (compatibly with feasibility);
4) entailing data return times well less than a normal job lifetime;
5) involving truly international co-operation.

However, the areas of interest for the activities of the Committee (and consequently for the topics of its symposiums) are wider than those strictly linked with near-term exploration. They can be identi¯ed as follows:

- general, long terms, topics related to interstellar travel;
- mission de¯nition;
- deep space propulsion;
- payload, communications, control;
- SETI;
- medical aspects of interstellar travel.

3 LONG-TERM ITERSTELLAR TRAVEL

This area did show little participation at the symposiums, even if the committee was, even recently, present in the cultural elaboration on the subject, thanks to its Chairman. In particular he introduced the hypothetical Conscious Life Expansion Principle and wrote an interesting classi¯cation of possible forms of unmanned and manned interstellar travel [3].

No doubt that the realistic, near term in the title discouraged papers under this heading, and the paper by Vulpetti was not presented at these symposiums. However the mission of the Committee is clear due space should be given to this area in the future.

A ¯rst proposal is than that of reserving a session in future symposiums for a discussion on long term perspectives of true interstellar travel, unmanned and manned, open also to contributions related to human sciences and not only to physical sciences or technology.

4 MISSION DEFINITION

The call for papers of the three symposiums explicitly stated that one of the aims was to discuss proposals for realistic missions to be forwarded to space agencies and to the scienti¯c community in general. And actually it worked as expected, as many practical ideas were forwarded, mainly regarding the solar sail mission, named Aurora, and a number of missions to the gravitational lens of the Sun.

Time seem to be ripe for a precursor interstellar mission and this item was deeply discussed.

A wide range of missions which fall within the aims of the ISEC was however less represented: robotic missions toward the outer planets of our solar system. A very important mission is at present on its way to Saturn and Titan, but very few papers on this subject have been presented in these symposiums. Much activity is going to develop in this ¯eld in the near future, with objectives like Europa, Titan and Pluto, just to name the three which at present are, for di®erent reasons, the most important.

A wider participation in this area should be encouraged for the future.

Another topic which is worth discussing under the heading of mission de¯nition is the extent of international cooperation. To state that interstellar exploration is an endeavour of the whole human species and then humankind must participate to it at the widest possible level is a political statement, which has little to do with science, technology or economics. Some recent experiences have shown that international cooperation may lead to an increase of the cost and of the time needed to develop a mission (slower, more costly, worse?) and in practice that political goals of international better understanding and collaboration have been pursued using funding which were allocated for space exploration. To ignore this issue and the ways to make international cooperation e®ective also to pursue scienti¯c and technological goals may lead to severe consequences.

5 DEEP SPACE PROPULSION

Since its beginning the ISEC realised that this is its fundamental area of activity: no interstellar space exploration can be performed without improvements in propulsion. This must be said, not to deny that a lot of good work in the outer solar system and the near interstellar space can be performed using chemical propulsion, aided by gravitational assist (the success of the Voyager and Pioneer probes is there to testify it) but to stress that if we want to do missions of this type within a reasonable mission time and if we want to enter deeply the Kuiper belt we need new propulsion devices.

But it is the whole ¯eld of space exploration which needs them: the search for new propulsion devices is a primary need for all astronautic e®orts.

A good deals of papers was devoted to propulsion in the past symposiums, mainly in the areas of solar sails, electric propulsion (nuclear and solar) and nuclear propulsion (fission and fusion).

Here I want to express clearly my views (which do not involve the ISEC as such): at the present stage of scientific knowledge nuclear propulsion, either thermal or electric, is the only way for deep space exploration. With this I do not mean that other alternatives, such as solar sails or solar electric (or even solar thermal) propulsion are not important and that we must not try to see solar sails at last deployed in space. I mean that they represent \bridge" solutions, to achieve the goals of deep space exploration while nuclear propulsion is not yet ready.

What I want to state clearly is that if humankind wants to become an actual space faring species, it needs to pursue nuclear propulsion.

And this is not only true for the goals of the ISEC but also for reaching destinations which are closer to the Earth. It is true that man can travel to Mars with chemical rockets, but I believe that Mars will never become terra cognita if we do not develop a viable nuclear propulsion system. And this seems to have been also the opinion of the missions planners of the Mars Reference Mission of NASA.

In a sense, it could be paradoxically stated that nuclear propulsion is more important to travel within the boundaries of the solar system than to achieve the primary goals of ISEC, as it falls short for the latter. But this is a paradox and the development of nuclear propulsion will stimulate those studies which will in the future lead to newer ways of moving in space, perhaps without propellant or in ways which at present cannot be forecast.

For this a breakthrough in propulsion physics is needed, and it is actually needed if what has been seen under the heading of long term interstellar travel will be implemented.

After all, it seems to me that it makes not much sense to discuss about faster than light travel, warp drive, wormholes and the like when we are not able to send a probe to Jupiter without spending years to perform gravity assist or to produce a decent amount of energy on board of a spacecraft and we put larger and larger solar panels to get farther and farther from the Sun.

A breakthrough may arrive, but in the meantime there is a large space for improvement in propulsion: solar sails can be built with current technology and quite cheap too; electric propulsion has already given a good proof of its feasibility and its applications can be extended with NEP and nuclear propulsion can represent a medium term viable solution.

In these areas the ISEC symposiums have, without doubt, made a good job. A proposal is to proceed devoting a good deal of attention on the issue of propulsion and to try to bridge the gap which exists in this area between Europe and America. In Europe very little is going on in the field of nuclear propulsion and action should be taken to revive old project and to start new ones. Project 242 of the Italian Space Agency should be given due priority, at least to reach a reasonably definite statement on its feasibility.

6 PAYLOADS, COMMUNICATIONS, CONTROL

The design of the payload for a mission is something which is undertaken when at least a number of mission parameters have been decided and so it may seem premature to speak about payload for interstellar missions.

However there are general aspects which must be studied independently from the details of the mission design and can influence the setting up of missions of different kind.

One of them is miniaturisation. No doubt that this is a key aspect for deep space missions, as everything gets simpler with the reduction of the payload mass. Microtechnologies and nanotechnologies here will play a very important role; the point seems to be mostly a problem of development cost, which in space applications may be forbidding owing to the small scale production. A backward technology transfer, e.g. from automotive of biomedical field, may be worth considering: the complexity and performance of the solutions used in many automotive applications are astounding.

Another aspect is artificial intelligence, or perhaps the lack of it displayed by many interplanetary robots. In the context of the exploration of the outer solar system and beyond it is no matter of discussing about the comparative merits of manned and robotic exploration: at least in the near and medium term future no one can think of manned exploration in this area and also telepresence becomes increasingly difficult. To put a man in the control loop of a distant probe is increasingly ineffective with increasing distance.

Progress in the area of artificial intelligence seems to be very slow, particularly if compared with that in the area of computer hardware: computers are increasingly fast and powerful, but hardly smarter.

Research in the field of robotic probes has undoubtedly practical aspects, which are reflected in the design of mission, but also general aspects, which are relevant for the issues regarding the future of interstellar space exploration and even those philosophical and anthropological implications quoted in the mission of the ISEC. The long debate on Von Neumann probes is an aspect of this; however a point can be made that no credible progress toward the implementation of such probes has been made, notwithstanding the prediction that by the year 2000 intelligent machines (in the sense implied by Von Neumann probes, not in the sense of the intelligent suspensions of motor cars) would have been around. Perhaps concerns about ethical and philo-

sophical aspects are greatly exaggerated, as man may be unable for ever (or at least for a long time) to build them. But in this case the whole strategy for interstellar space exploration has to be rethought.

What about the ultimate problem of deep space exploration may not be propulsion but artificial intelligence (again, the lack of it)? It is true that here the solution deals again with propulsion, as if robots able to undertake this task will not be available, humans will have to go themselves, and this will require further, perhaps now unimaginable, progress in the propulsion field.

A final point which is important for deep space exploration, but which has received little attention in these symposiums, is the on-board power generation. As by definition an interstellar probe (but also a probe in the outer solar system) must work at a large distance from the Sun or other stars, it cannot rely on solar panels. Up to now the use of RTGs has been widespread, but there have been political pressures against them, to the point of using solar panels on the Rosetta spacecraft.

The situation here can become a very severe one, particularly in Europe: what about having the probe, the propulsion system and everything but not having the possibility of powering it?

We should encourage the presentation of papers dealing with more advanced (and, why not?, safer) power systems for deep space probes, but I also state clearly the opinion that without nuclear power there are little chances of exploring deep space also from this viewpoint.

7 SETI

SETI is not a primary concern of ISEC, as the Academy has a Committee designed to deal with this subject. However there are good reasons, and there is a long tradition too, for the two committees to work in close contact.

Deep space missions may be involved in SETI in an active way, with bioastronomy experiments (e.g. a mission to Europa, but there have been very interesting proposals of bioastromical work in the Kuiper belt [4]) or directly with SETI as one of the goals, primary or secondary, of the mission (e.g. missions to the gravitational lens of the Sun). At any rate all deep space missions are involved in passive SETI, in the sense that they may be found ultimately by some ETI.

The Fermi question still waits for an answer, and this answer, whatever it is, may come from both the SETI and the interstellar space exploration communities. Recent suggestions that actually there may be alien probes somewhere in the solar system waiting for us to discover [5] them cannot be dismissed lightly, even if we may think that this is a remote possibility. Actually a negative result of this search will never prove that such probes do not exist, exactly in the same way as the absence of alien radio messages will never be a prove that ETIs do not exist.

The subject of SETI is then relevant in the present symposiums from three viewpoints: missions linked with SETI, general philosophical and methodological aspects and the issue of discussing which records of terrestrial life shall be included in the next probes which will get out of the solar system. A proposal of holding a show of artworks aimed to constitute a message from planet Earth was forwarded, with the ultimate aim of showing at least a selection of them to the people at NASA who will be entrusted with the duty of taking care of this aspect of the first precursor interstellar mission.

8 MEDICAL ASPECTS OF INTERSTELLAR TRAVEL

An important issue was raised by Kondo [6] in the Special Issue Modern Views on Interstellar Flight and Related Key Disciplines of the Journal of the British Interplanetary Society: will it be possible to hybernate astronauts for long space travels? Although certainly not a short term issue, particularly if seen in the context of interstellar space exploration (no manned exploration of the outer solar system is planned for the foreseeable future), the subject is, in my view, particularly important.

Apart from the medical applications of hybernation, which well justify the efforts in this direction, the applications to manned spaceflight in general are so important that the subject should attract much attention. It is enough to consider what could mean for the manned exploration of Mars to dispense with all the problems linked with the consequences of prolonged exposure to the space environment (in hybernation likely the consequences of microgravity are avoided and it is far easier to protect from radiation an hybernated astronaut than one in normal conditions) and the possibility of increasing the number of people carried to the Red Planet without the need of a larger spacecraft.

There are many species on Earth which exploit hybernation to deal with hostile environments, as in winter; what if humans will become a species which exploits hybernation to deal with the most hostile environment of all, space? A discussion of this subject, which has been long associated with manned interstellar travel, could be beneficial to the whole astronautical community and in this the ISEC could fulfil the task of encouraging the debate on the most advanced aspects of spaceflight that is implied by its mission.

9 CONCLUSIONS

With an increasing number of workshops and symposiums on deep space exploration, advanced propulsion and long-range space missions, the symposiums organised by ISEC need to find a line which

can allow to attract a wider participation and to be most e®ective in pursuing the tasks the Committee has been established for.

From an organisational viewpoint, it can be important to discuss the periodicity, to allow the interested persons to bring original contributions and to enhance the quality of the papers presented.

An e®ort should be done to attract papers on the general aspects of interstellar space exploration, to discuss perspectives involving a larger timeframe, including those related to manned exploration and colonisation beyond the solar system. Here the scienti¯c committee must make an e®ort to select sound papers, but care must be given not to discourage interesting contributions only because they are not dealing with near term technology or feasibility.

The presentation of mission proposals to be forwarded to space agencies must be encouraged, as it had been done in the past with solar sail missions aimed to the near interstellar space. In the same way, the presence of papers on missions to the outer planets presently under way or planned for the near future should be promoted.

Discussion on controversial aspects, as the extent of arti¯cial intelligence which can be embodied in robotic probes in a foreseeable future or of the future of nuclear propulsion, should also be encouraged. The circulation of the proceedings, which was in the past good, and the publication of selected papers on Acta Astronautica ensures that the topics discussed in these meetings will have a large audience. For the issue on nuclear propulsion, I believe that a strong statement by those who believe that this matter is a crucial one for the future of long range space exploration, and action in this sense toward the space agencies are important steps.

After all, no committee of the academy deals with issues which are placed in the long term future like the ISEC. Its symposiums are actually speaking to the future and, to use the word of an ancient egyptian writer who lived in the Middle Kingdom about four thousands year ago, It is good to speak to the future: it shall listen.

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