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## PROGRESS WITH REVISION OF THE NPS SAFETY PRINCIPLES

**Working paper submitted by the United Kingdom of Great Britain and Northern Ireland**

## INTRODUCTION

The unsatisfactory features of the Principles Relevant to the Use of Nuclear Power Sources in Outer Space[1] were recognised at the time of their adoption by the General Assembly on 14 December 1992 by the inclusion of a decision to begin a process of revision within two years. That this situation should arise was perhaps inevitable. There was no internationally agreed basis for a space nuclear power sources (NPS) safety regime despite the quite detailed nuclear regulatory framework many countries, particularly those with nuclear power programmes, had in place at the national level. When the structure of the Principles adopted in 1992 was formulated in the early 1980's, the 1977 recommendations of ICRP were the only related guidance available at the international level and since these did not address the prevention of accidents it was not surprising that the structure proved to be unsatisfactory.

It was also difficult to gain acceptance for Principles which had not been in place when current space programmes involving NPS were conceived. Inconsistencies inevitably arise between new statements of best safety practice and current programmes based on past safety practice. It was perhaps this problem that led to the formulation of the Principles in terms of particular technologies where consistency could be assured whilst excluding applications of NPS in space where inconsistencies might arise. As a result, the Principles are not formed in terms which are generally applicable to all uses of NPS in space.

* This document has not been formally edited.

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This potential for conflict between current programmes and new or revised safety principles cannot be totally avoided. However, the late 1990's may be an opportune time to revise the Principles as existing programmes involving NPS, particularly Earth surveillance and planetary exploration, come to an end whilst new advances, perhaps manned missions and exploration to Mars and beyond, are at a formative stage where new safety requirements may be incorporated more easily.

The level of safety achieved by the existing Principles is also unsatisfactory. For example, they accept that boosting space reactors into a so-called 'safe' orbit provides an adequate degree of protection. At present 44 missions involving nuclear power sources have been dealt with in that manner, with orbital lifetimes varying from 60 to 600 years. The current population is made up of 10 radioisotope thermoelectric generators (RTGs) still in orbit, 20 reactors with cores still in Earth orbit, together with 14 reactors without cores and 13 separated cores. This is a total of 57 nuclear-related objects still in Earth orbit. At present several of these will re-enter on the territories of Canada and the Russian Federation and there is a probability of greater than 10% that some re-entries will impact on the territories of Algeria, Argentina, Australia, Brazil, China, Denmark (Greenland), India, Kazakstan, Mongolia, Saudi Arabia, Sudan, Sweden, the United States of America and Zaire.[2] Allowing the spent fuel from a fast reactor to disperse in the atmosphere after a decay period of 600 years or less is seriously inconsistent with current standards of radiological safety, even if highly enriched U-235 is used for the initial fuel.

Moreover, collision with debris could reduce the orbital lifetimes of space reactors. At present space debris density an item of about 1 cm diameter or less is likely to impact one of the 57 nuclear-related items in orbit before the re-entry of this constellation is complete.[3] Such an impact can be expected to be absorbed without causing significant additional debris. However, modelling of the growth in cumulative debris flux at the relevant altitude indicates a doubling every 35 years.[3] Thus after 600 years the impact rate could be increased by a factor of a million, giving high probabilities of collisions with much larger debris items, perhaps causing a severe reduction in the orbital lifetime of the impacted space reactor.

From these considerations it is evident that a revised basis for ensuring the safety of space nuclear power sources is needed.

## PROGRESS

It is no longer the case that there is a lack of international consensus on the basis for nuclear safety. Since the early 1980's the International Atomic Energy Agency (IAEA) has made substantial progress in generating a hierarchy of Safety Series publications. At the highest level, Safety Fundamentals publications have included an issue on the safety of nuclear installations.[4] The 1990 recommendations of ICRP included some consideration of potential exposures.[5] And the detailed consideration given to the causes and consequences of the Chernobyl accident by IAEA identified an important new concept in nuclear safety.[6]

These developments provided the basis for a series of papers submitted to the Scientific and Technical Subcommittee by the United Kingdom of Great Britain and Northern Ireland and other countries.[2, 7, 8, 9, 10] They enabled revisions to the Principles to be formulated in terms of the process rather than the means of achieving safety, making the approach to safety general rather than specific and thereby enabling the designer of space missions to consider quite new ways of meeting the safety objective without the constraint of prescriptive principles.

The new approach identified six Supplementary Principles[9] intended to add to the Principles the later developments concerning safety culture, risk justification, risk limitation, risk reduction, safeguards and pollution. The comments they generated in the Scientific and Technical Subcommittee in Vienna, in February 1996 and in the discussions at the Committee on the Peaceful Uses of Outer Space in June 1996[11] indicate that some of the ideas could form the basis of a consensus on the revision of the Principles.

## NEXT STEP

Further progress towards a consensus could be made by constructive discussions on the issues already identified.[9] There are complex problems to resolve in areas such as risk, safeguards and pollution which need the type of technical discussions better suited to the Working Group than the full Subcommittee. That forum has not operated effectively since the Principles were adopted by the General Assembly.

Previously presented papers[2, 7, 8, 9] have identified potential agenda topics for the Working Group and text which could provide a starting point for discussions as indicated below.

### Topic A: Safety Culture

A starting point could be text quoted directly from the relevant IAEA reports.[6, 12] *The use of nuclear power sources in outer space should be carried out within a safety culture, that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear safety issues receive the attention warranted by their significance.*

### Topic B: Risk Justification

A starting point for discussion could be based on the recommendations of ICRP.[5] *The benefit for space missions utilising NPS should be demonstrably sufficient to justify the risks to individuals or to society.*

### Topic C: Risk Limitation

As a starting point, the ICRP philosophy[5] of dose limitation could be generalised. *The risk to an individual or to a coherent group of individuals should be limited to a maximum tolerable level above which risks are considered unacceptable except in extraordinary circumstances such as saving life.*

### Topic D: Risk Reduction

Both the IAEA Safety Fundamentals publication[4] and the ICRP recommendations[5] place strong emphasis on reducing risk below the maximum permitted to a level as low as reasonably achievable. *Risks should be reduced below the maximum tolerable level as far as reasonably achievable, whilst recognising that reduction below a de minimis level may not deserve consideration.*

### Topic E: Safeguards

As a starting point for discussion, it is appropriate to recognise the pre-eminence of IAEA in non-proliferation matters.[9] *Nuclear materials used for nuclear power sources in space objects should be subject to safeguards endorsed by IAEA.*

### Topic F: Pollution

The problem of pollution in space is perhaps the least well-developed topic so far identified both in terms of its threat to future missions and of its potential to enhance the risk from NPS in orbit. It may be difficult at the present stage of technical understanding to do more than express good intentions in respect of the risk to NPS. *Space missions should not give rise to enhanced risks to NPS in orbit to an extent which vitiates their basis for safety.*

### Topic G: Other Aspects of Safety

Topics A to F above are not intended to be exclusive. Other aspects of safety of concern could be added to the agenda for Working Group discussions.

## CONCLUSION

The developments in the international consensus on nuclear safety relevant to the revision of the Principles adopted by the General Assembly in 1992 have been briefly reviewed and the aspects of the Principles where some updating is appropriate have been identified. It is suggested that the complexity of the safety issues involved could be addressed more conveniently in the Working Group. Agenda topics for the Working Group are suggested, together with text which could provide a starting point for discussion on each topic.

## References

[1] General Assembly resolution 47/68 of 14 December 1992.

[2] Reply received from the United Kingdom to the invitation from the Secretary-General of the United Nations to communicate information on national research on space debris, safety of nuclear-powered satellites and problems of collisions of nuclear-power sources with space debris (A/AC.105/593/Add.3, 7 February 1995).

[3] Dr. Richard Crowther, DERA Farnborough, private communication.

[4] The safety of nuclear installations, Safety Series No. 110, IAEA Safety Fundamentals publication, Vienna, 1993.

[5] 1990 recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Annals of the ICRP, Vol. 21, No. 1-3, Pergamon Press, 1991.

[6] Safety culture, a report by the International Nuclear Safety Advisory Group, Safety Series No. 75 - INSAG-4, IAEA Safety Reports, Vienna, 1991.

[7] Safety principles for nuclear power sources in space revisited: working paper submitted by the United Kingdom to the thirtieth session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space (A/AC.105/C.1/L.187, 16 February 1993).

[8] Revising the safety principles for nuclear power sources in space: working paper submitted by the United Kingdom to the thirty-first session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space (A/AC.105/C.1/L.192, 21 February 1994).

[9] Interpretation and development of the safety principles for nuclear power sources in space: working paper submitted by the United Kingdom to the thirty-third session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space (A/AC.105/C.1/L.203, 9 February 1996).

[10] Application of the ICRP system of radiological protection to the use of nuclear power sources in outer space: working paper submitted by Sweden to the thirty-first session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space (A/AC.105/C.1/L.197, 22 February 1994).

[11] Committee on the Peaceful Uses of Outer Space, report of meetings in June 1996.

[12] International basic safety standards for protection against ionising radiation and for the safety of radiation sources, Safety Series No. 115, IAEA Safety Standards report (jointly sponsored by FAO, IAEA, ILO, OECD/NEA, PAHO, WHO), Vienna ,1996.