Implementing the International Safety Framework for Space Nuclear Power Sources at ESA

Options and Open Questions

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European Space Agency (ESA)

International Intergovernmental Organisation

19 Member States

- Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Norway, the Netherlands, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom.

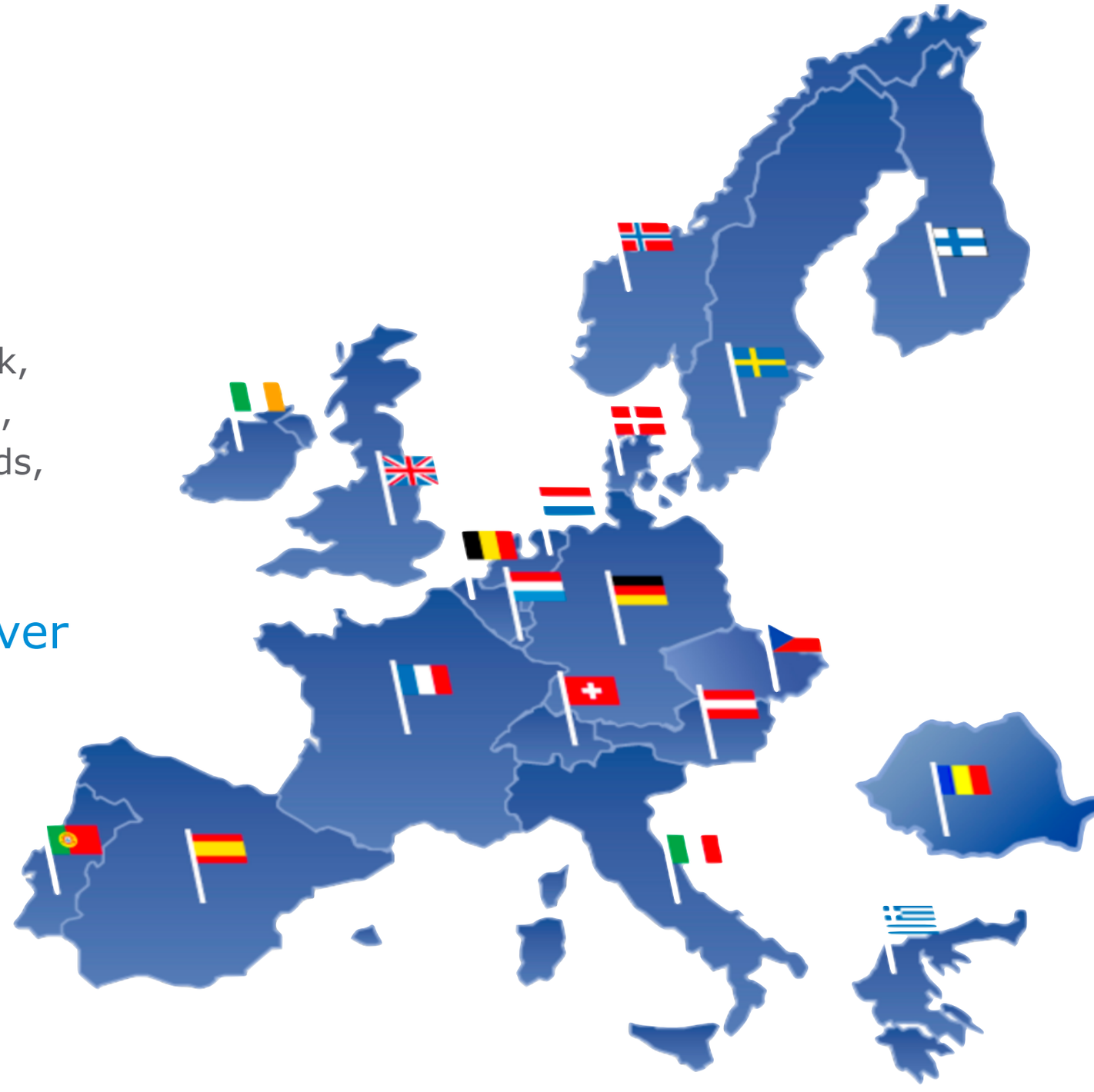
Canada:Cooperation Agreement over 30 years

European Cooperating States

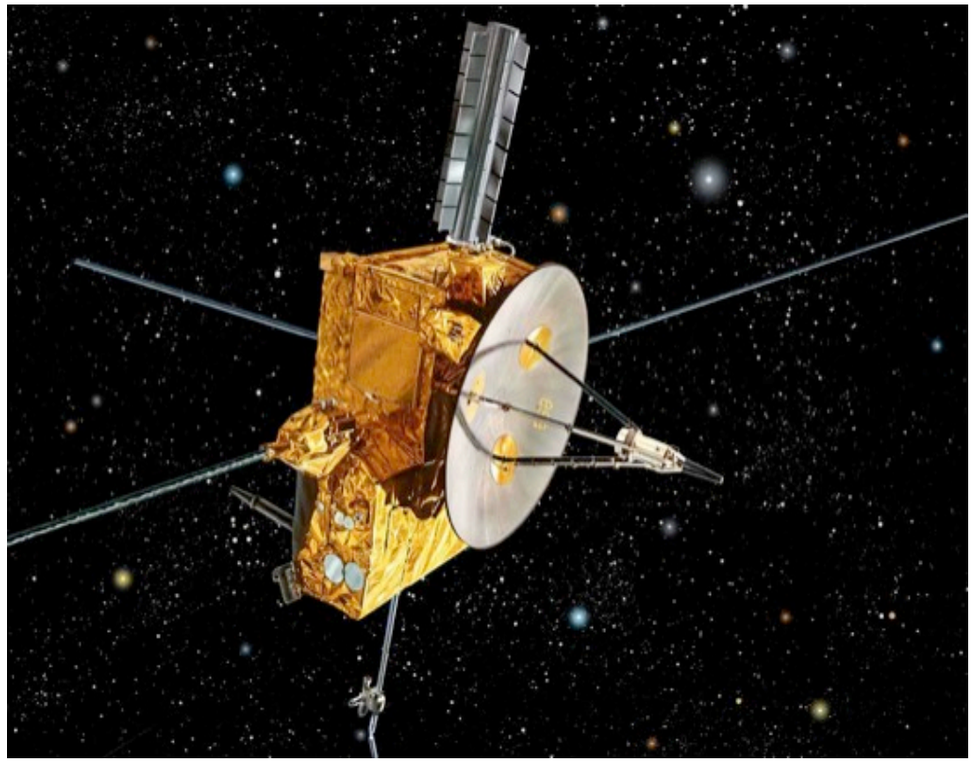
- Estonia, Hungary, Poland, and Slovenia

Cooperation Agreements

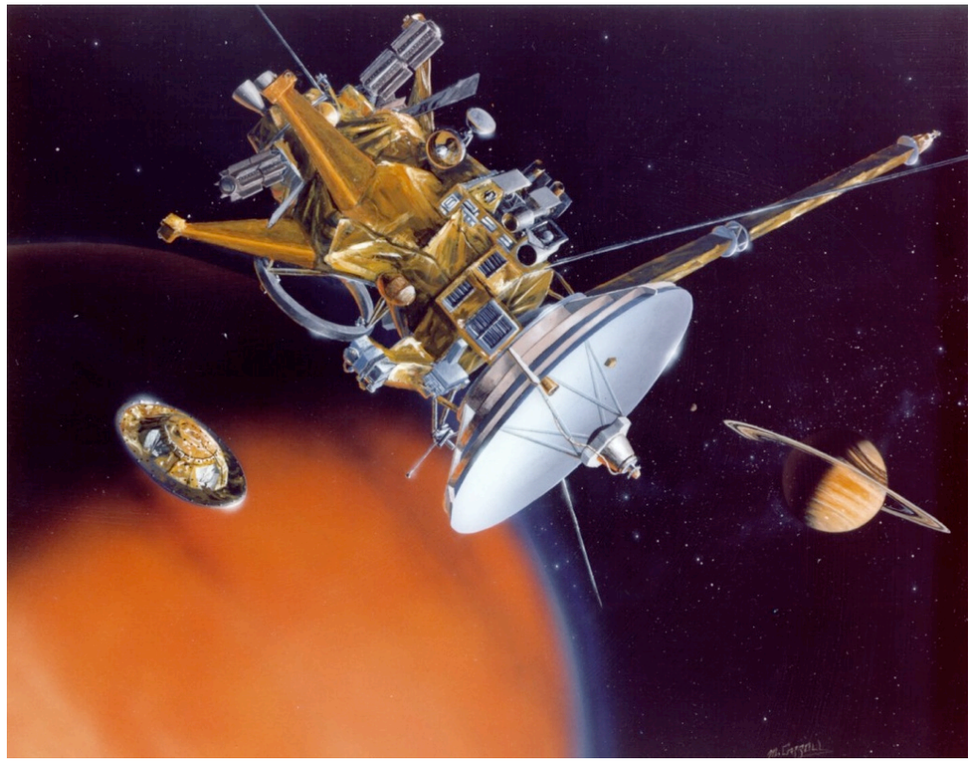
- Cyprus, Latvia, Lithuania, Slovakia, Israel



ESA missions involving nuclear power sources



Ulysses
1990, 1 RTG, solar polar orbit



Cassini / Huygens
1997, 3 RTG, RHUs, Saturn / Titan

ESA has used the energy provided by nuclear power sources in two of its science missions. Both missions were done in cooperation with NASA, using US nuclear power sources and US launcher vehicles. ESA will need the energy provided by NPS also in future missions.

ESA and International Safety Framework for Space NPS Applications

ESA has been supporting the preparation and development of the International Safety Framework for Space NPS Applications during the entire workplan period of the STSC-IAEA Joint Expert Group, based on the facts that

- space NPS are the only viable energy option to power some space missions and significantly enhance others; ESA has been using space NPS in the past and is likely to need them for planned and future space missions
- NPS applications in outer space have unique safety considerations compared with terrestrial applications that are not addressed in safety guidance for terrestrial nuclear applications
- it is important to promote the safety of NPS applications in outer space via an international safety framework that reflects a broad international consensus on the on measures needed to achieve safety of all space NPS applications
- such a broad international consensus and the implementation of the framework provides assurance to the global public that space NPS applications would be launched and used in a safe manner, and facilitates bilateral and multilateral cooperation on space missions using NPS

ESA has accompanied this process internally with study activities in preparation of a European Nuclear Safety Framework (ENSaF).

ESA and International Safety Framework for Space NPS Applications

Considerations concerning the implementation of the safety framework within ESA

Safety framework already used as reference document for some statements of works / contracts

Two-phases implementation process:

1. ESA-internal procedures
2. Coordination with ESA MS, especially France for launches from CSG

Implementation of

- Guidance for governments and relevant international intergovernmental organisations related to safety policies, requirements and processes, to the justification process and to emergency preparedness and response
- Guidance for management of the organisation that conducts the mission, related to its prime responsibility for safety and its leadership and safety management
- Guidance for the technical implementation within ESA related to the core competence in nuclear safety, to the design and development process integrating safety in the entire NPS application from the earliest stages

Identified open questions regarding the Frameworks' Guidance for Governments

Open questions regarding the Frameworks' Guidance for Governments

- In the spirit of the OST and the Liability Convention, the recommendations in the safety framework specify special responsibilities for safety of involved governments due to the potentially global risk associated with space NPS applications.
- Three of the recommendations for governments deal with regulatory aspects
  1. establishing of and ensuring compliance with safety policies, requirements and processes
  2. the verification of the justification and
  3. the establishment of a dedicated, supplementary nuclear launch authorisation process,

  while the fourth recommendation involves direct governmental activities, particularly the preparation for emergency preparedness and response.
- guidance is addressed to "*governments and relevant international intergovernmental organisations*", except for the recommendations related to the mission launch authorisation process for space NPS applications (addressed only to the governments that oversee and authorise the launch operations for such missions).

Identified open questions regarding the Frameworks' Guidance for Governments

mission launch authorisation process

- Applying this recommendation to the case of an international intergovernmental organisation, such as ESA, implies that:
  - the regular launch authorisation process, which is ideally taken care of by one State for any given launch, would need to be complemented by a dedicated "*mission launch authorisation process focused on nuclear safety aspects*" (sect. 3.3) organised by the "*government that oversees and authorises the launch operations*", e.g. France in the case of a launch from the European Space Port the Guiana Space Centre (French Guiana).
  - The international intergovernmental organisation could then be considered as one of the "*participating organisations*", from which "*all relevant information and considerations*" need to be evaluated by the government in question. (sect. 3.3)

Identified open questions regarding the Frameworks' Guidance for Governments

"independent safety evaluation"

- The article related to the authorisation process further recommends the establishment of "*an independent safety evaluation*" as "*an integral part of the authorisation process*". The framework also specifies what is meant by 'independent', by giving the example of "*a review, independent of the management organisation conducting the mission*".
  - question whether ESA, in case it were the "*management organisation conducting mission*" could also be conducting the "*independent safety evaluation*" ?
  - question whether organisations such as national agencies, which are substantially involved in ESA (e.g. regarding the choices and decisions related to the goals, scope and sometimes even technical choices made for ESA missions) could be considered as "*independent of the organisation conducting the mission"*?
- Guidance of framework is modelled after the Russian and US processes
  - US national level: administrative independence of involved organisations, even though these are part of the same executive branch of government, funded via the same federal budget and ultimately reporting to the US President.
  - Independence could be therefore interpreted as contingent on the hierarchical level at which interactions occur. Therefore
    - It seems appropriate to consider national agencies, despite their involvement in ESA, to be independent enough from the organisation conducting the mission, to qualify for conducting such a review?
    - To what degree the internal structure of ESA, and particularly its independent safety office, might qualify as being sufficiently independent of the internal organisational unit conducting the mission?

Identified open questions regarding the Frameworks' Guidance for Governments

Potentially multiple authorisation and approval processes

- Recommendation to "*governments and relevant international intergovernmental organisations that authorise or approve space NPS missions*, [..] *to establish and ensure compliance with their respective safety policies, requirements.*"
- The terms 'authorisation' and 'approval' are defined in the global IAEA Safety Glossary, to which reference is made in the glossary of the Safety Framework. Both terms mean the granting of consent by a regulatory body with 'approval' standing for a more formal process.
- Both definitions give room for interpretations. The possibility that a multilateral approval might be required for a specific activity is already anticipated in the IAEA Safety Glossary. Similarly, more than one State or international organisation may be approving or authorising a space NPS mission.
- Such a space NPS mission could therefore be submitted to a number of potentially conflicting jurisdictions and consequently to multiple procedures of technical scrutiny.
- For these cases as well as for the case of a space NPS mission carried out by an international intergovernmental organisation, that will certainly necessitate an additional authorisation or approval from the respective launching State, it would be preferable to develop common, integrated, joint safety policies, requirements and processes or at least strive for a harmonisation of existing ones.
- Concerning the organisations conducting the 'independent safety assessment', the technical work could be done by an ad-hoc panel composed of experts from all those governmental entities involved in the authorisation or approval of the space NPS application. Existing Technical Nuclear Safety Organisations appear as natural candidates for this task.

Identified open questions regarding the Frameworks' Guidance for Management

Understanding of "prime responsibility for safety"

- The notion of "prime responsibility for safety" in the Safety Framework needs to be understood as aiming at an internal distribution of tasks among the relevant participants and at avoiding any bickering over competences in the pursuit of optimised safety levels in the preparation and the conduct of the mission. It is not to be confounded with the "international responsibility" as described in Principle 8 of the 1992 Principles and Article VI of the OST.
- While chapter 4 of the safety framework deals with all organisations involved in space NPS applications (the larger definition) in general, section 4.1 specifically addresses only one organisation and only the space NPS mission. It recommends that "*the organisation that conducts the space NPS mission has the prime responsibility for safety*."

Identified open questions regarding the Frameworks' Guidance for Management

"organisation that conducts the space NPS mission"

- No entry in the Framework glossary, nor the IAEA Safety Glossary are defining the "*organisation that conducts a mission"*. The terms of the Outer Space Treaty or the Liability Convention are not of help to answer this question, since their main focus are the actions, responsibilities and liabilities of States.
- In section 4.1, the safety framework specifies the type of relationship such an organisation needs to have: "*That organisation should include, or have formal arrangements with, all relevant participants in the mission (spacecraft provider, launch vehicle provider, NPS provider, launch site provider etc.) for satisfying the safety requirements established for the space NPS application*."
- All three main entities (launch service provider, prime contractor, international intergovernmental organisation) *could* have, in principle, such formal arrangements (e.g. development or purchase contracts with the provider of the space NPS). In practice, especially in relation to the required interface management, the *technically* most straight-forward approach to integrate space NPS into the spacecraft would be dealt with in the same way as other subsystems and therefore in the frame of subcontracts between the prime contractor and the NPS provider.

Identified open questions regarding the Frameworks' Guidance for Management

"organisation that conducts the space NPS mission" (cont[d])

- The purpose of the central role of the organisation (assuming 'prime responsibility') is to be able to enforce all necessary safety-relevant provisions and changes during the entire development and operation phases of the mission.
- Since nuclear safety needs to be addressed holistically, it is important that the organisation assuming prime responsibility is involved from the very early design phases of missions.
- Following current practice, launch service provider contracts are however rarely signed at early phases of missions. Therefore, out of the three potential organisations, the launch service provider appears to be the least suitable regarding the spirit in which the safety framework has been drafted.

Identified open questions regarding the Frameworks' Technical Guidance

- Most of the technical guidance is relatively straight-forward in their application also to missions conducted by international intergovernmental organisations. However, in detail some open questions remain.

establishment and maintenance of adequate technical competence

- Concerning the establishment and maintenance of adequate technical competence, the safety framework recommends organisations to "*establish, consistent with their responsibilities, nuclear safety design, test and analysis capabilities, including qualified individuals and facilities, as appropriate*".
- The definition of accident scenarios, their estimated probabilities, the characteristics of the physical conditions to which the space NPS and its components could be exposed in normal operations, as well as potential accident conditions, they all require the launch service provider, the manufacturing industries for the launch system and potentially of the spacecraft as well as mission operations expertise;
- the assessment of potential impact of accidents on people and the environment requires the providers of the NPS, the developer(s) of the main elements of the space NPS as well as launch safety authorities;
- the competence related to the identification and assessment of inherent and engineered safety features to reduce the risk of potential accidents requires, in addition to the prime contractor, the launch service provider and the provider of the NPS.

Identified open questions regarding the Frameworks' Technical Guidance

- The mission launch authorisation process relies on specific competence regarding the evaluation of radiation risks for people and the environment from potential accidents. The choice of the organisation that is required to establish and maintain the core competence in this area depends strongly on the organisation that authorises the mission launch and needs to rely on this input for its decisions. Thus, in the case of ESA missions, this would depend on answers found to the questions raised related to chapter 3 and 4.
- The choice of the organisations required to establish and maintain the necessary competence to mitigate the consequences of accidents with the potential to release radioactive material into Earth's environment depends mainly on location (the location of the launch site and secondarily potential accidental re-entry locations along the launch path). In the case of ESA missions from French Guiana, French authorities would therefore play a central role for accident mitigation competence at and near the launch site.
- For accident mitigation competence further down the launcher trajectory, the situation still requires further analysis.
- Concerning the preparation of relevant information about the accident for dissemination to the appropriate governments, international organisations and non-governmental entities and to the general public, the best suited organisation to set up and maintain the competence to perform these tasks efficiently would also need to be established between ESA and French authorities, including a clear and prior understanding on which organisation would be leading for what type of accident and at what locations.

Conclusions

Based on the current state of the analysis of the Safety Framework and its implementation option at ESA, it appears that

- the Safety Framework provides useful and valuable guidance also for the complex case of ESA with its large spectrum of potential cooperative mission types and configurations
- most of the guidance is directly implementable and some is already partially covered by existing processes and structures
- open questions and different implementation options have so far been identified regarding
  - role(s) of international organisations in the (complementary?) mission launch authorisation process focused on nuclear safety aspects for space NPS application missions
  - details of the "independent safety evaluation" as an integral part of the authorisation process, specifically its "independence" of the management organisation conducting the mission
  - how to best avoid the risk of multiple, potentially contradicting authorisation and approval processes
  - the interpretation and implementation options of "prime responsibility for safety" for the "organisation that conducts the space NPS mission"
  - the chosen option for the above questions will determine the most appropriate implementation paths for the technical guidance and especially the required maintenance of competence will follow logically

Information sharing within the frame of the NPS Working Group is very valuable to benefit from existing experience in conducting space NPS missions in a safe manner