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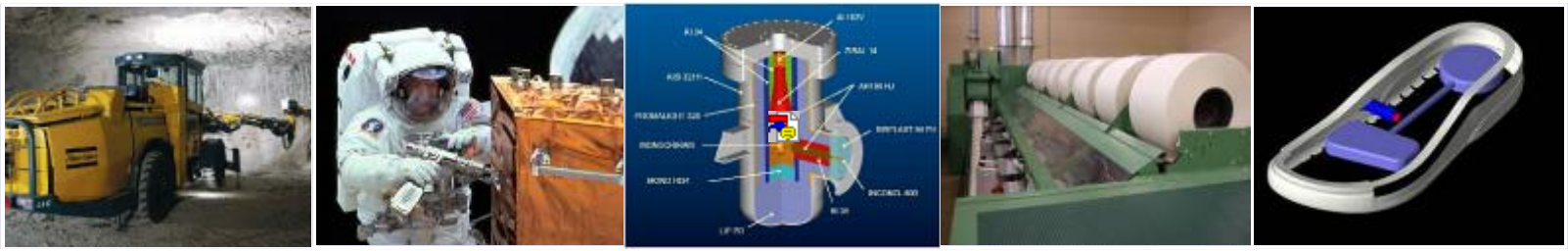


NANOSPACE – NANOTECHNOLOGIES FOR SPACE TRANSPORTATION SYSTEMS

Aims of the Project

The Italian Space Agency promoted a Call for Ideas on nanotechnologies.

Main aims of this study are:

1. Assessment of the State-of-the-Art of Nanotechnologies at National and International level
2. Details on State-of-the-Art of nanotechnologies within the space transportation systems
3. Analysis of cost/benefit and development plan for the most innovative key nanotechnologies (structural components, propulsion systems, etc…)

Working Team

Italian district with specific expertise in the creation and dissemination of nanotechnology knowledge and in strengthening the Italian competitivity in this field. Through its NanoFab facilities it is able to use various laboratories for nanotechnologies applications in the industrial field.

D'APPOLONIA

Research & Innovation Division: Methodology of Analysis, technology scouting and market analysis

Expert in space applications for space transportation. Development, production, testing and commercialisation of advanced space propulsion systems, particularly for electric and plasma propulsion systems

Methodology

The project follows two parallel paths:

PATH 1

- ✓ WHAT ?
  QFD
- ✓ WHO?
  Internal Working Team
- ✓ HOW?
  definition of a matrix in which a detailed description of all ASI's space transportation unit needs were identified..

PATH 2

- ✓ WHAT?
  Delphi Study
- ✓ WHO ?
  International Expert Group
- ✓ HOW?
  two steps questionnaire was submitted to a group of sixtytwo (62) International experts in both nanotechnology and space transport fields

Methodology – Path 1

- Definition of ASI space transportation unit needs → translation into requirements
- The starting point was the European Space Agency technology tree: the internal team, with ASI's support, operated the selection of the technologies related to space transportation
- Allocation of a weight (1 – 5) to each requirement. The weight was assigned basing on the Technology Readiness Level according to ESA's definition
- The nanotechnologies able to achieve the requirements were identified with an increasing level of detail. (In total, two macro areas and sixty (60) detailed nanotechnologies)
- For each cf the nanotechnologies identified, a relation with all space transportation requirements was attributed, taking into account the development duration and costs
- The final matrix contains all possible nanotechnologies that can be crossed-analysed with space transportation requirements
- A Pareto chart was developed as final result of the matrix construction. It helps establishing which are the major factors that influence a phenomenon (in this case the nanotechnologies with stronger influence in the space transportation field) and, therefore, it is a very useful instrument for the analysis and support for the following decision making process

Methodology – Path 2 - Delphi Study

OBJECTIVE OF THE DELPHI STUDY

Aim of the Delphi study was to identify the most promising nanotechnologies for space transportation applications.

For this Delphi study 62 International experts were identified by the Internal working group and were approved by ASI (Italian Space Agency)

WHY THE DELPHI METHOD?

The Delphi method is a systematic, interactive forecasting method which relies on a panel of independent experts. Delphi is based on the principle that forecasts from a structured group of experts are more accurate than those from unstructured groups or individuals.

In this specific Delphi study, the experts answered two rounds of questionnaires.

In the second round experts were encouraged to revise their earlier answers in light of the replies of other members of their panel. It is believed that during this process the range of the answers decreases and the group converges towards a shared answer.

Methodology – Path 2 - Delphi Study

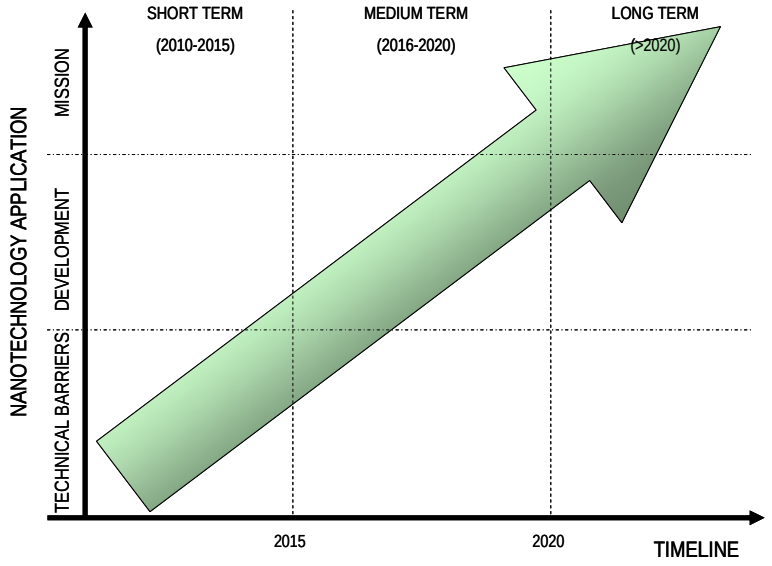
- **STRUCTURING OF INFORMATION FLOW** : The initial contributions from the experts were collected in the form of answers to open questions and their comments to these answers. This avoids the negative effects of face-to-face panel discussions and solves the usual problems of group dynamics
- **REGULAR FEEDBACK**: Participants comment on their own forecasts, the responses of others and on the progress of the panel as a whole and they can revise their earlier statements
- **ANONYMITY OF THE PARTICIPANTS**: all participants maintain their anonymity. This stops them from dominating others in the process using their authority or personality and allows them expressing their opinions also admitting errors by revising earlier judgments.

- As a result of the first step of the questionnaire, which was focused on open questions, a synthesis table of the most promising nanotechnologies applications in the space transportation field on a short (2010-2015), medium (2016-2020) and long (>2020) term basis were identified
- In the second step, the experts were asked to rank, among the solutions proposed by them in the previous step, which of the solutions are the best on a short, medium and long term

Technology Roadmap Process

1. Identification of the “nano-product” that will be the focus of the roadmap
2. Identification of the critical system requirements and their targets
3. Specification of the major technology areas
4. Specification of the technology drivers and their targets
5. Identification of the technology alternatives and their time lines
6. Recommendation of technology alternatives that should be pursued
7. Creation of the technology roadmap report

Follow-up activities include a critical validation of the roadmap and the development of an implementation plan, with an evaluation of the economic impact and update



Conclusions

- ASI considers highly strategic to initiate in Italy actions that help valorising and developing in a coordinated way the strong competences already existing in both the nanotechnological and space transportation fields

- Particular emphasis is given to those nanotechnologies able to support future development for applications in launchers and highly strategic structural devices

- Technology roadmapping is considered by ASI as a valuable process if carried out in a systematic and coordinated way and is results as useful to coordinate the development of multiple technologies, especially across multiple projects

Thank you for your attention !

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