First Workshop on Fusion Technologies and the Contribution of TECHNOFUSIÓN

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Strategy and Standards in Remote Handling for Fusion Energy from TECHNOFUSION

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The authors discuss the importance of the TECHNOFUSIÓN facility from the standpoint of Remote Handling and its special features with regard to the other laboratories. This arises to the interest of developing a long-term integrated approach, which covers research, training, exploitation and dissemination of results. Standardization activity is also closely related to long-term strategy. It is shown the actual situation of standardization in Remote Handling for the nuclear industry and the evolution that is currently taking place in this field.

11.1 Introduction

Remote Handling techniques are a key factor for nuclear power plant in the maintenance and exploitation operations. Their role increases, if possible, when the facility availability becomes a critical issue since it affects the investment return. They are clear rules regarding safety that prohibit access to activated areas for interventions such as repairs or preventive maintenance. All tasks and interventions in activated places or with components of such kind should be performed by automated or remotely guided equipment. Moreover, it is relevant to consider at the very initial design of the installation and all its components that the intervention of remote manipulation could be required (UKAEA 2003). The bigger and more complex the installation is, the more critical will it be to consider remote manipulation from the initial stage of its conception and design.

In addition to the above, Remote Handling has some peculiarities compared to the other laboratories that make up TechnoFusion (TF). While the TF Remote Handling Lab focuses primarily on testing of robots under irradiation, the solutions that future fusion facilities will demand, have to be developed in a completely new manner with major technological challenges (managing huge loads over long distances, remote working considerable precision) but also scientific ones (haptic devices, radiation-resistant sensors, etc.)

Considering the high investment that TF creation and existence require, this should be an opportunity not to miss out since it will be able to address the needed developments by joining the existing research groups and empowering them to the extent that they would need. Moreover, the collaboration that must be generated to address this should not stay in a facility but has to include all of an operating plan and evolution. With Remote Handling, this is special because we have to continue with the development of solutions for facilities that are being designed or that has to be designed in the future. Furthermore these solutions, as foreseen by those responsible for the facilities, have to be tested in real models of the sites where they are meant.

A particular aspect closely related to long-term strategy is the standardization activity. It is used for establishing the characteristics that have to be complied for this kind of works. Even when standardization activity starts in a field the first requirement is to develop a *standard* vocabulary in order to establish proper definitions to facilitate communication between experts. Standard is used to establish common language in the features of any equipment and to ease comparison of technical specifications or characteristics, important issue when, e.g., launching procurement activities. Standard use is done by customers when they require equipment to comply with a certain standard, which may be an entry barrier to reduce competition.

Currently ISO (International Standard Organization) have just agreed whit developing a new Standard for telerobotics in the nuclear field and we have decided to participate, with the AENOR support, in the ISO Working Group to which has charge of it, cooperating with all actors involved.

11.2 Strategy in Remote Handling

The Remote Handling Area of TF is supported by relevant robotics research groups (CAR-CSIC, CAR-UPM, UC3M) and 'Laboratorio Nacional de Fusión' from CIEMAT. This circumstance offers an opportunity to reflect on what role a centre of knowledge and high technology industrial activity focused on Remote Handling should be. In other words, it has to think strategically with an action plan that will propose objectives in the short, medium and long term. An efficient strategy firstly requires a long-term vision and secondly a comprehensive approach to the situation.

To work on this approach and develop a proposal of a strategically oriented action plan, research groups supporting the TF Remote Handling Area formed a working group "RMRT" (Robótica y Manipulación Remota paraTechnoFusion), although its scope may include any fusion facility (ITER, IFMIF ..).

The long-term approach means recognizing that the goal is not only developing equipment for ITER (which is interesting) whose characteristics will be determined by current dominated technologies. Furthermore proven technologies shall be required in the facilities now under design. The ultimate goal for this long-term strategy would be on how TF could prepare solutions to be applied in future fusion power plant, starting from ITER and followed by all the plants that will be built in the future such as DEMO.

The development of long-term projects, such as DEMO, requires to take into account and to incorporate the advances that could be reached at every moment in whatever discipline that could be of interest for remote manipulation. For this reason in a long-term approach is necessary to determine what will be such technologies and to guess if possible, lines of evolution that they will have and to what extent their progress could be incorporated to the robots.

A long-term strategy with an integral focus has to consider at least four different aspects:

- Research
- Training
- Industrial exploitation of results
- Dissemination

Let look at them in some detail.

Research: The long-term strategy should focus on identifying unsolved topics and support research on them. This research does not have to be open but totally directed. And the results should be integrated and proven with available models in different installations. The strategy should not consider Remote Handling itself as its only research fields. Otherwise it should encourage research on any technology or field of knowledge whose results may affect manipulators and Remote Handling systems as well as any of their components.

Training: Qualified personnel are a must to adequately advance in technological topics. Then the strategy has to include clear plans to prepare all levels of technical personnel. It covers training of TF employees, master and pre-doctorate courses, postdoc contracts and sabbatical leaves for professors in Spain or abroad. The applicants for training would be personnel of research groups and professors, as well as technical staff of companies that develop and exploit TF results.

Industry and exploitation of results: Regarding exploitation of results, experience of other countries can be followed. The American and European nuclear programs show special attention in gathering and explaining new businesses that have emerged upon exploiting technologies developed from the research carried out in its nuclear programs, similar to what they do in other kinds of programs. It is a way to justify to the society the research effort made. In order to reach this goal, support and adequate resources should be provided. In this line, a structure of detection of exploitable results and opportunity for exploitation has to be established, not only in Remote Handling but also in other related fields. It is also advisable to set up a network of contacts and structures for these types of activities such as Technology Transfer Offices, and create a structure similar to Industrial Liaison Program with companies in order to maintain a stable relationship. Considering this point, an approach to companies and to organizations in charge of supporting industrial R&D has already been done.

Dissemination: We must take advantage of TF facility in general and of RH Area in particular, to inform society about benefits of the nuclear fusion and of the technologies that it implies. This must be done at least two ways: through the elaboration and dissemination of information material and through teacher training and activities for students and general public. Considering the first issue, the effort can be focused on

elaborating printed informative leaflet and audiovisual material, establishing communications line with the media and meeting with journalists and maintaining an exposition area. The second issue, aside from didactic visits for students, training for trainers and professors have to be considered. And together elaborate education material and collaborate in doing exercise with students. This movement can also be extended to university students in an adequate level.

Since strategy is focused on long term, the first element to take on is the detection of key technologies wherein actions can be concentrated on. These technologies mark the fields where research should be based on and boost training. Moreover, it serves as a platform in monitoring evolution in order to detect advancement of interest. As previously mentioned, these technologies have to take into account all topics about Remote Handling but also any part of its components.

In searches and analysis carried out as of today, some fields of knowledge considered critical have been identified. The work of the "Agenda Estratégica de Investigación" elaborated by "Plataforma Tecnologica Española de Robotica", HISPAROB, (HISPAROB 2010) can be identified as general fields of knowledge to be promoted. The following list mentions the most relevant topics related to Remote Handling field:

- Perception systems
- Simulation and off-line programming.
- Haptic devices
- Motors and its controllers
- Materials
- Communications
- IHM-man-machine interface
- Control architecture
- Communications
- Artificial Intelligence
- Teleoperation
- Calibration
- Modelling of the environment

A more detailed analysis adds up more specialized fields such as the following:

- Virtual Reality and Augmented Reality

- Fault Tolerance.
- Detection and Recovery of Failure.
- Water Hydraulic Motors
- Light and resistant structural materials. Composite materials.
- Radiation Protection Materials, Coating
- Radiation Sensors
- CAE-Structural Analysis of Finite Elements

All these activities of research, and especially planning, cannot be carried out separately. Nonetheless, it has to take advantage on it to establish collaboration links in an international level and participate in joint projects.

Upon having decided to lead this research activity in this field, the need of act on a particular topic such as the elaboration of standards has been seen. Standards have at the same time industrial and technological aspects and it is decided to participate in the development of Remote Handling Standards, supporting AENOR assuming the representation of Spain and in the interest of industry.

11.3 Standardization

As commonly known, standardization is an activity whose objective is the improvement of quality in products and services. Nevertheless, it can also be applied to the industry and in industrial policies for more strategic goals. Undoubtedly, standardization eases the acceptance of innovation on behalf of clients and end consumers, but it also builds barriers to possible competitors through delimiting future requirements. Standardization is boarded on three basic levels as can be observed in Table 1. The organizations that work in the standardization in the industry are also indicated.

Table 1: Levels of Standardization and Entities

Level	Responsibility	Entity of Standardization	
		General	Electrical
International	WTO	ISO	IEC
Regional	Europe	CEN	CENELEC
National	Spain	AENOR	

The different organizations are mutually dependent to each other since different national institutions form the International Standard Organisation (ISO) designated by administrations in every country. Their activities are carried out by committees that have been set up by national representatives and experts appointed by their corresponding national organizations. The activities of standardization (setting up and revision of standard) are carried out by Technical Committees (TC according to ISO and CTN according to AENOR terminology).

In the Nuclear sector, there is an important activity of standardization carried out at international level by ISO/TC 85 "Nuclear Energy, Nuclear Technologies and Radiological Protection", but until its 2010 Annual Meeting it was referred to as "Nuclear Energy". This committee corresponds to CTN 73 of AENOR. ISO/TC 85 has 3 Subcommittees (SC), 2 Working Groups (WG) and an Ad Hoc Group. Each of the SC has various Working Groups. Standardization of Remote Handling is under ISO/TC 85/SC 2/WG 24 which is called Remote Handling for Nuclear Applications. As observed, it can be found inside SC 2 framework: Radiological Protection. As of today, ISO has approved a standard about Remote Handling with 4 parts published and one (ISO/DIS) in stage of final vote, that can be summarized as follows:

- ISO 17874: Remote Handling Devices for Radioactive Materials
    - Part 1: General Requirements: ISO 17874-1: 2010
    - Part 2: Mechanical Master-Slave Manipulators: ISO 17874-2: 2004
    - Part 3: Electrical master–slave manipulators: ISO/DIS 17874-3.
    - Part 4: Power Manipulators: ISO 17874-4: 2006
    - Part 5: Remote Handling Tongs: ISO 17874-5: 2007

Part 3 has just been submitted for voting of its approval, which is expected by the end of 2011.

At this crucial moment, when the design and development of ITER is being done, ISO TC 85/SC 2, in their last meeting in Korea, upon the proposition of AFNOR and WG 24 Convenor, have decided setting up a proposal of standard (NPI- New Preliminary Item) about Telerobotics.

Spain decided to participate in the elaboration of the standard. Its main objective is to contribute in the basket of knowledge and focus on the vision that can be acquired in the elaboration of strategy in the long term.

Moreover, it is also a manner of being able to connect companies with the standards that will be applied in the future.

The proposal has been well accepted by AENOR that has appointed the two first authors of this chapter as experts to represent the interest of Spain in WG 24 that is in charge of elaborating the standard. The representative experts of every country have to interact with the actors (companies and research groups) of this field in order to inform them about the work being carried out, gather their proposals and present them in the meetings. Developments and decisions carried out will then be reported back. When the WG has a proposal of a standard, it will be voted on by National representatives, AENOR for Spain, in order to be definitely approved.

11.3.1 Approved Standards

ISO 17874 deals mainly with multipurpose remote handling devices for nuclear applications, used to replace personnel to do tasks in areas inaccessible to them. ISO 17874 is like an umbrella for the standards related to this topic. Remote handling devices are sometimes used for non-nuclear applications and designers of those fields can take advantage of standardized components for the nuclear sector or of the information and designs included in these standards, where appropriate. The approved standards are detailed in the following paragraphs.

ISO 17874 Part 1: General Requirements, revised in 2010, starts defining the different categories of remote handling devices and establishing generally the characteristics of each. It has also a section dedicated to tongs: tools, manually operated and its characteristics. It also indicates basic criteria for the selection of multipurpose remote handling devices. It includes an annex about movements of devices and the symbols of motions for schematic diagrams.

ISO 17874 Part 2: Mechanical master-slave manipulators, revised in 2004,is focused on the mechanical systems. It firstly presents its general characteristics and existing types. Later it takes on the basic considerations for selecting a manipulator. Then it presents different manipulator mounting methods and the associated requirements for each. It also presents the accessories and in an annex, it describes measurement methods of some fundamental characteristics.

ISO 17874 Part 4: Power manipulators, revised in 2006, is one of the parts devoted to manipulators driven by electrical motors. This part is centered on the slave arm of the system. It exposes their requirements – materials, design features, electrical equipment-, operating devices and control systems, transport vehicles and special tongs. A special section is devoted to testing. And in Annex the electrical equipment is considered.

ISO 17874 Part 5: Remote handling tongs, revised in 2007, is focused on tools to be used by the manipulators. Main covered aspects are: General features and classification, Basic selection criteria, examples of special handling tongs, and Accessories.

As common in any type of standards, they all start with normative references, terms and definitions.

11.3.2 The elaboration of the standard in telerobotics

The development of technology has boosted the evolution of remote manipulators in such a way that the connection between the master and the slave is carried out through computers. This means that any of the two arms may be replaced by any other. In case both arms come from different suppliers, after the connection of a new arm, it has to be guaranteed that it will work without any problem giving orders intelligibly and correctly either performing as the master or interpreting orders and responding adequately when performing as the slave. At the same time, the equipment can be set with more advanced properties in which more complex tasks can be carried out and performed efficiently. This situation has made WG 24 and its leaders consider the need for elaborating a new standard that covers these new aspects. The approval of elaborating such standard has firstly been done in Working Group 24, of Remote Handling, and was ratified by ISO/TC 85/ SC 2 in the following Resolution (ISO 2010):

Resolution JEJU 31/2010 –PWI- "TELEROBOTICS SYSTEMS FOR NUCLEAR APPLICATIONS".

> *"ISO/TC 85/SC2 agreed to the proposal from WG24 convenor to register the Project "Telerobotics Systems for Nuclear Applications" as a preliminary work item (Project leader is Philippe GARREC from France) and recommended to the WG to take into account existing work within prepared by ISO/TC 184 "Automation systems and integration".*

It should be noted the recommendation included in the resolution of taking into account the standardization work already existing in other committees, particularly ISO/TC 184, "Automation systems and integration", with several standards on industrial robots. These are some of them:

- ISO 8373-1994: Manipulating industrial robots – Vocabulary
- ISO 8373:1994/Amd 1:1996. Annex B: Multilingual annex.
- ISO 9283:1998: Manipulating industrial robots – Performance criteria and related test methods.
- ISO 9409-1:2004: Manipulating industrial robots – Mechanical interfaces – Part 1: Plates.
- ISO 9409-2:2004: Manipulating industrial robots – Mechanical interfaces – Part 2: Shafts.
- ISO 9787:1999: Manipulating industrial robots – Coordinate systems and motion nomenclatures.
- ISO 11593:1996: Manipulating industrial robots – Automatic end-effector exchange systems – Vocabulary and presentation of characteristics.

WG 24 has already started to hold meetings and a document is to be drafted at the end of 2012. It is addressing industrial demands and cooperation of ITER as one of the most active user has been welcomed. Its needs during the coming years may be determinant for the activity of the Working Group.

11.4 Conclusions

TechnoFusión should be an opportunity not to be missed to raise and make a long term strategy that places the Spanish research groups and industry in a leading position worldwide in the field of Remote Handling for nuclear fusion.

Robotic research groups involved in the Remote Handling Area of Technofusión are working in developing such a strategy and are establishing contacts with industry to strength cooperation links.

In the international arena representatives are participating in the development of ISO standard on telerobotics, aspect that can be decisive in the future.

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