THE CHALLENGES OF DIVERSIFICATION OF TECHNOLOGIES AND MARKETS

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For several years, Tecnatom has been developing a technology and market diversification strategy based on its corporate vision of technological leadership in the services and products it supplies on the national and international nuclear market. Starting with the historical development of these technologies, this article describes how diversification in the global market is initiated and identifies the industrial market segments where the provision of services and the supply of high-tech products can be expanded. It also includes the diversification strategies in these new markets, and presents some of the results obtained in the aeronautical and aerospace market, the transportation market, the industrial processes market, etc. Finally, it provides some examples of the development of new virtual reality and enhanced reality technologies and how these new capabilities are fed back to the nuclear market.

INTRODUCTION

Tecnatom is an engineering firm that has been providing its services in the nuclear sector since it was created in 1957. Its current owners are the Spanish electric utilities with assets in national nuclear power plants. At present, it has more than 500 employees, of which approximately 50% are university degree holders, which is warranted by the complex technologies associated with the services provided.

Since the mid-90s, the national and international nuclear industry has been affected by major changes in both the electric utilities and in the engineering firms that provide services to them.

Corporate concentration is one of the most significant factors that is modifying the nuclear market in general. This concentration is occurring in Tecnatom's customers and competitors alike. The result is, on one hand, a decrease in the number of potential clients, which also require more global service contracts, and on the other that competitor firms are increasing their size and specific weight in the market. In short, this means a smaller, more competitive market.

In the mid-90s, in order to maintain and increase its volume of business, Tecnatom began a new strategy of market and technology diversification that builds on the strategy initiated some years earlier in what were considered our company's regular activities. To understand the potential of this new diversification of Tecnatom, it is necessary to understand the historical evolution of the company's technological development and markets, which is described below.

TECHNOLOGICAL DEVELOPMENT

When the new construction plan of second-generation nuclear power plans was launched in Spain in the mid-70s, Tecnatom made a large economic investment to acquire two full-scope simulators, one of PWR and the other of BWR technology, to train and instruct operators of the new nuclear power plants, as well as the mechanized in-service inspection systems for the main components of the nuclear island, such as the reactor vessel and steam generators. A major part of this technology was acquired in the U.S. and another part in Europe. However, in the early 80s, it became necessary to upgrade these technologies.

On one hand, in the case of the full-scope simulators, the simulation computer programs had to be adapted to the design modifications in plant systems, stemming in part from the accident in the Three Mile Island power plant in the U.S. and also from the new requirements of Spanish nuclear regulators. The options available at that time were: depend on the main suppliers of these technologies, or develop in-house groups of specialists in Tecnatom to implement these modifications. The decision was made to achieve technological independence and strive for a position of leadership in the field. Thus began the development of the technology of systems simulation in the enterprise. On the other hand, it should be noted that simulator operation requires an in-depth knowledge of all plant systems and how they operate in any of the possible situations associated with nuclear power plant operation. This also called for the development of groups specializing in operations engineering of these plants.

On the other hand, in the case of mechanized in-service inspection systems, important issues concerning electrical, electronic and mechanical maintenance had to be resolved, as well as how to use new mechanized equipment for the inspection of other components in nuclear power plants. Dependence on the main suppliers of this equipment, the diversity of equipment spare parts, and training in operation and maintenance are some of the reasons that led to the decision to create groups of specialists in these areas. Thus, in the early 80s, the electronic and mechanical design groups were set up, and early development activities commenced for the data acquisition and signal processing systems for the ultrasound technique.

One of the first products that was designed and built is an electronic inspection system controller called SIROCO, which can be applied to any mechanized equipment thanks to the characteristics of its interface that takes into account the operating peculiarities of the mechanical part. New inspection equipment began to be designed and manufactured in Tecnatom for a diversity of nuclear components: piping, turbines, all kinds of bolts, penetrations of the control rod mechanisms in BWR pressure vessels and later in PWR vessels as well, etc. Thus, year after year, the technological expertise in robotics became increasingly consolidated.

On the other hand, a significant part of inspection systems are data acquisition and signal processing equipment for evaluation of inspection results. As mentioned above, Tecnatom also began to design and build its first ultrasound equipment, in parallel with the early development stages of robotics. In the early 80s, Tecnatom achieved its first ultrasound data acquisition system, which allowed it to become independent of the foreign suppliers of this technology. The hiring of electronic and computer experts was encouraged to extend these developments, and by the mid-80s Tecnatom had a new ultrasound data acquisition system, SUMIAD, and an induced current system, TEDDY, the technical features of which were equivalent to or in some cases superior to those available on the international market. This completed the inspection system technology, from the mechanical equipment and associated controllers to data acquisition and processing systems, and finally to the non-destructive inspection techniques that not only permitted Tecnatom to be self-sufficient in carrying out any kind of in-service inspection in Spanish nuclear power plants, but also to compete on the international market.

THE GLOBAL MARKET

Penetration of the international market is consistent with the company's vision of a global services company. In-service inspections and the supply of complete inspection systems were the first stage of new market development in Tecnatom. Although the first international experience was in 1979 in the ISI of the Garigliano Nuclear Power Plant in Italy, it was not until the mid-80s that Tecnatom, with its own inspection technology, launched its venture on the international market for the supply of inspection services and systems, which has continued until today. At the beginning of this stage, inspection services and equipment were supplied to Pakistan, later to Brazil, Switzerland and Argentina, and subsequently, with the opening up of the Eastern European countries, to the Czech Republic, Hungary, Ukraine and Russia. From the mid- to the late 90s, inspection work and the supply of inspection equipment on the international market accounted for 40% of Tecnatom's volume of business and included countries such as South Korea, Finland, United States, Japan, Sweden, Tunisia, etc., in addition to those mentioned above.

The cornerstone of this significant result obtained on the extremely competitive international market for in-service inspection, equipment supply and service provision is the fact that the company can rely on its own technology, which is on an equal or, in some cases, higher level than the existing market level. This has represented an important added value to the products offered by Tecnatom, and it has also permitted technological independence from the main suppliers of inspection equipment.

On the other hand, in the field of full-scope simulators, the company's in-house developments of simulation programs, its operating experience in nuclear power plants, and its knowledge of control rooms and operator functions have allowed Tecnatom to take part in several international projects related to the design of advanced control rooms, advanced instrumentation & control systems, etc. This international experience and recognition has led to Tecnatom's participation in the General Electric project for the Lungmen Nuclear Power Plant in Taiwan, in the design of advanced control rooms for the two project units. In addition, the company has won international tenders, such as the upgrading and modernization of the full-scope simulators in the training center of KSG KRAFTWERKS-SIMULATOR-GESELLSCHAFT MBH in Germany. On the national level, it modernized and adapted the Tecnatom PWR simulator to the Almaraz Nuclear Power Plant, and subsequently contracted the construction of three full-scope simulators for the Asco and Vandellós Nuclear Power Plants, in Tecnatom's new building in Tarragona, and for the Trillo Nuclear Power Plant, in the Madrid offices. These latter simulators are under construction and should be completed and validated in 2003.

As in the case of its experience in the field of in-service inspection, in the area of full-scope simulators Tecnatom has developed the technology required to be a leader in the field and achieve projects in the international market.

DIVERSIFICATION

This technological base developed over so many years and with significant investments in human and material means is what has allowed Tecnatom to begin to analyze the possibility of applying it to other markets that share a significant synergy with nuclear applications. But it is also possible to apply it to the development of new technologies that require the experience and expertise gained over those years. However, the strategies to be followed in both cases differ significantly, even though the goal is basically the same: achieve new competitive products and expand the target market.

In the first of the above mentioned cases, i.e. applying the developed technologies to other synergic markets, the problem lies in identifying the industrial segment where new activities can be developed and analyzing whether Tecnatom can provide a different added value than what is already available; it must then identify potential customers, assess their needs, ascertain the technical requirements and applicable regulations, and above all understand the capabilities of competitors, their implementation and their recognition in that market. It must be understood that the competitors may have been operating in that market for many years with a series of already consolidated customers, and that a company that begins to take its first steps in that market may encounter only difficulties. It is at this time when the acquired technology begins to open doors to new customers. When technological recognition has been achieved, then all efforts should be devoted to fulfilling the commitments made, leveraging commercial aspects, extending references, and feeding back the experience gained to new technological actions that will help to maintain the leadership position over other competing companies.

When the goal is to embark on new technologies for developing new products and services for the nuclear or other markets, it should be remembered that this is a mid-term strategy, although there is also the possibility of following a strategy combined with the short term. The new technologies to be developed should be compatible with the company's technical expertise and its technological bases, in order to reduce the investment costs involved in these developments. In this respect, it is necessary to identify what these new technologies are and the markets in

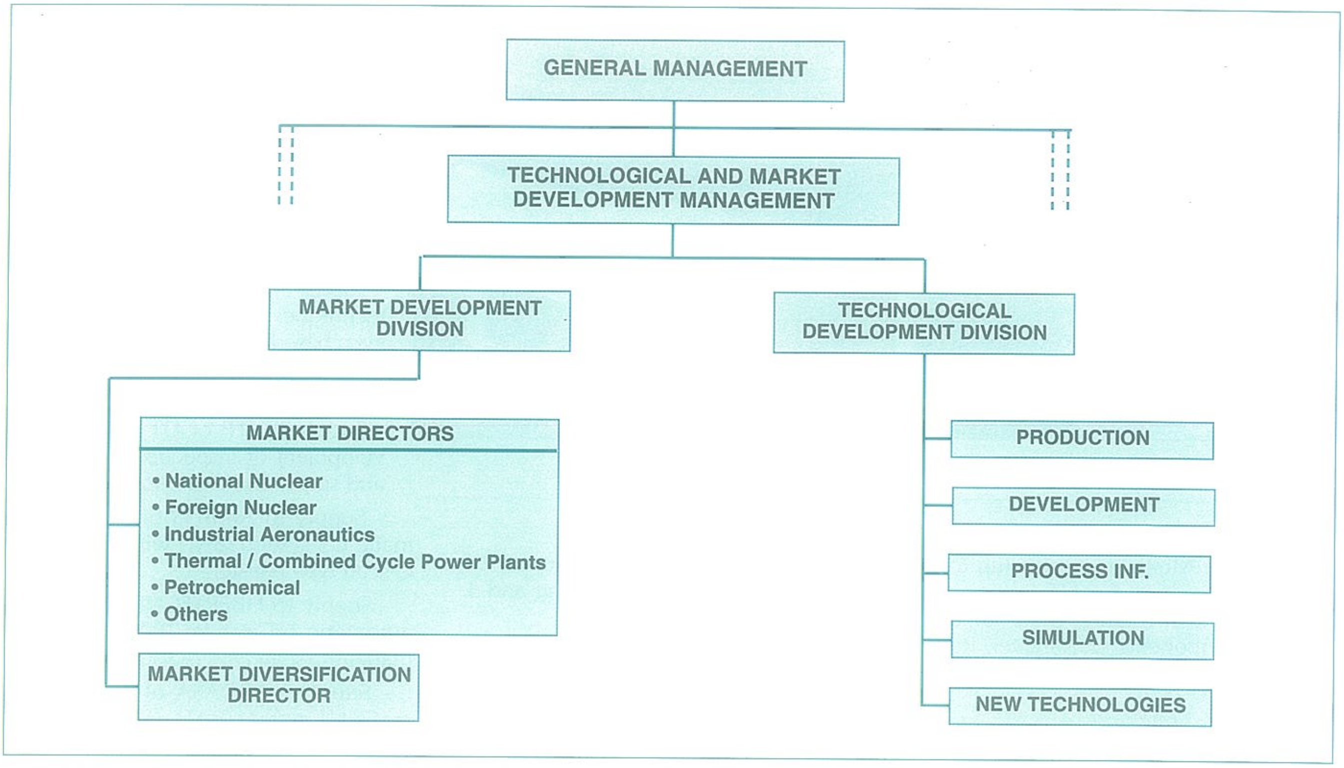


Figure 1: Organization of the Technological and Market Development Management

which they will be offered. In order to ensure the success of this initiative, and especially of a short-term strategy, it is advisable to identify a technological partner that complements Tecnatom's technical capabilities, to be able to penetrate markets with a high degree of trust. On the other hand, it is necessary to seek the support of research institutions, universities, laboratories, etc. that, as experts in new technologies, allow a gradual transfer of technical expertise to the enterprise. In this way, the company's groups of experts can be consolidated in the mid-term, and they are able to carry on with sustainable development of the new technologies.

In parallel with the definition of these strategies of technology and market diversification, the support of an internal structure in the company is required to manage the technical resources allotted to these activities, and also to perform viability and market analyses and carry out the associated commercial activities.

ORGANIZATION

In order to ensure that the diversification objectives are achieved, the company has in the last few years carried out an internal reorganization, aimed on one hand at optimizing the human and material technical resources assigned to technological development and on the other at consolidating market management activities, opportunities and customers. Thus, in the Technological and Market Development Management (see Figure 1), there are now two divisions, one devoted to Technological Development and the other to Market Development. Although both divisions have fully defined functions and responsibilities, there is an interrelationship between the two to undertake viability and market studies, strategic plans, commercial actions, etc.

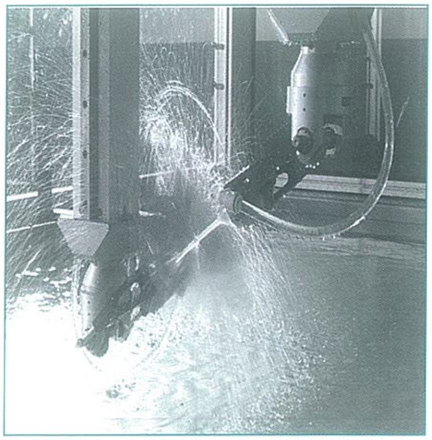
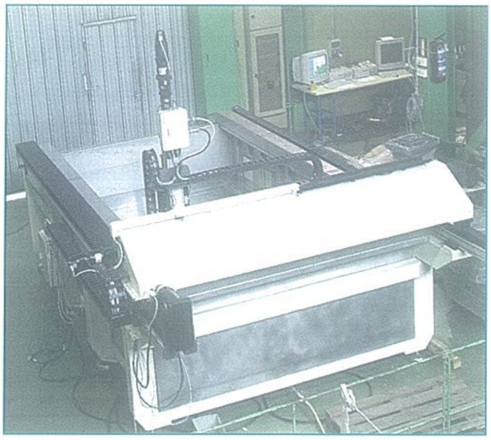
Based on these diversification analyses of new markets and technologies, a conclusion has been reached regarding which ones show the greatest synergy with Tecnatom's technical capabilities, and short-, mid- and long-term strategies have been defined. A summary of the results of these activities is included below.

RESULTS

The aeronautical/aerospace market has been identified as one of the markets having the strongest synergies, as a result of the demanding levels of inspection and quality control required by the different components contained in aircraft or space transports, which are similar to or even higher than those required in the nuclear industry. The Spanish aeronautical/aerospace industry has participated significantly in the most important European projects, having manufactured and assembled different components for the different Airbus models, the Eurofighter and the Arianne missile. The structural integrity requirements of the different manufactured components and their quality control determine the non-destructive test inspections that must be performed during the different phases of manufacturing. This requires mechanized ultrasound and induced current inspection systems, which conceptually correspond to the same structure as those used in the in-service inspection of nuclear power plant components, i.e. mechanized equipment and motion control system (robotics), programming of complex trajectories owing to the component geometry, data acquisition and processing systems, and inspection procedures.

The different projects and products executed in the aeronautical market are as follows:

a) Immersion inspection systems for metallic and non-metallic components of complex geometry (TEMUS Family – See Figures 2 and 3):

Figures 2 & 3: TEMUS Inspection System

TEMUS-1: Multiaxis system (up to 6 simultaneous axes) for UT immersion inspection with rotating plate for turboprop components (Eurofighter, Rolls Royce), supplied to ITP.

TEMUS-2: Multiaxis system (up to 5 simultaneous axes) for UT immersion inspection for structural components such as D-noses, Slats, etc. (Eurofighter, Airbus, etc.), supplied to EADS-CASA (Seville).

TEMUS-3: Multiaxis system (up to 9 axes) for UT immersion inspection, contact and transmission for development of advanced quality control procedures for metallic and non-metallic components, supplied to EADS-CASA-AIRBUS.

b) Water jet inspection systems for carbon fiber components (COMPOSITE Family – See Figures 4 and 5):

COMPOSITE-1: for inspection of large flat panels up to 16 mm long and 2.5 mm wide, supplied to SACESA.

COMPOSITE-2: for inspection of large flat panels up to 9 m. long and 3 m. wide, supplied to SACESA.

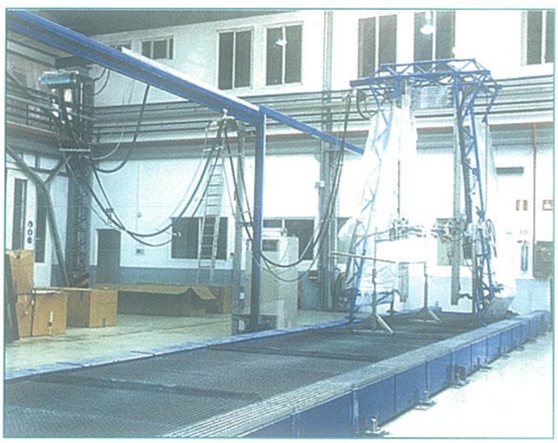
COMPOSITE-3: for inspection of large flat panels up to 14 m. long and 3 m. wide, with up to 7 simultaneous axes, supplied to COMPOSYSTEM.

COMPOSITE-4: for inspection of large flat panels up to 14 m. long and 3 m. wide. Up to 7 simultaneous axes, supplied to COASA.

COMPOSITE-5: for inspection of large flat panels up to 9 m. long and 3 m. wide, supplied to FIBERTECNIC.

c) Inspection systems for geometrically complex carbon fiber components (customized systems).

SICCO: for ultrasound inspection of Arianne missile components (cylinders and cones of 5 m. in diameter and 4 m. high), with dry coupling, supplied to EADS-CASA-ESPACIO (see Figure 6).

Figures 4 & 5: COMPOSITE Inspection System

TTPs: for geometrically complex carbon fiber panels, supplied to FIBERTECNIC.

- Inspection system for carbon fiber panels, tubes and parabolas, supplied to ALCATEL Space.

d) Other inspection systems and services:

- Supply to GAMESA of inspection techniques and control methodologies, based on CI, to be implemented in manufacturing processes, sensors and training.
- Supply to ITP of UT training, development of inspection procedures and specific software tools.
- Supply to AIRBUS of a semiautomatic UT system (BAT) with permanent C-scan type register.
- Supply to FIBERTECNIC of a semiautomatic UT system (BAT) with permanent C-scan type register.
- Supply to COASA of a semiautomatic UT system (BAT) with permanent C-scan type register.
- Certification in GENERAL ELECTRIC AIRCRAFT ENGINES of Tecnatom's ultrasound data acquisition system "MIDAS", for ultrasound inspections at high frequencies.

These developments for the aeronautical/aerospace market have in turned opened up other markets such as the Iron and Steel market, where similar inspection systems have been supplied, e.g. the TEMUS inspection system for SIDENOR, which is a multiaxis system (up to 4 simultaneous axes) for UT immersion inspection for quality control (inclusions) of special steel bars.

On the other hand, developments in new technologies have been identified, such as the case of the UT-Laser System for inspection of high-speed aeronautical components, which is a collaboration project between the main European manufacturers: Aerospatial, Dassault, DASA, BA, Alenia and AIRBUS, among others.

As regards the other technological cornerstone of Tecnatom, i.e. simulator development, a viability analysis and market study were carried out, followed by a strategic diversification plan. The conclusion was reached that, among others, the industrial transportation market requires the use of simulators for training drivers of the different means of transportation, e.g. railroads, metros and trams. Since in this case the market demand is short-term, a technological partner has been

Figure 6: SICCO Inspection System

identified to complement Tecnatom's capabilities and which meets the requirements of experience and solvency in this market. Universities and laboratories have also been included in this venture, to help increase technological expertise in the mid-term (see Figures 7 and 8).

Other markets identified as potentially needing the use of simulators for operator training include the industrial processes market, including the sugar industry, petrochemical industry, etc. (see Figure 9).

In the field of personnel training, not only are simulators a support tool for increasing the performance and know-how of personnel in training, but there are also a series of technologies that have lately been used to develop new instruction tools, such as the case of Virtual Reality and Enhanced Reality techniques. Tecnatom has been involved in the development of these tools together with other technological and industrial partners. Some examples are: the VIRMAN, which is a virtual reality maintenance course based on animation of virtual three-dimensional images for equipment assembly, disassembly and maneuvering (see Figure 10) – it models equipment, rooms, buildings or equipment parts in three dimensions and animates them; and the STARMATE, based on enhanced reality techniques (virtual reality supported by additional information). In this case, the student or technician in training uses special goggles to see the series of real objects and interact with them, but the system provides additional virtual information in the goggles, which act as a computer screen with instruction guidelines, sequences, sounds, etc., that the student requests by using headphones and a microphone (see Figure 11). Issue 211 of the Spanish Nuclear Society's Magazine has an article by Francisco Gonzalez Áñez on both tools.

Tecnatom has also targeted the nuclear field for use of these new virtual reality and enhanced reality technologies, both for training and for applications to radioactive environments. These products include the following, developed with the collaboration of technological and industrial partners:

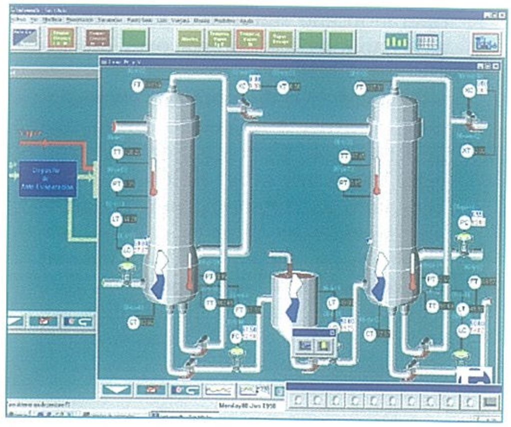


Figure 9: Industrial Process Simulator-Sugar Industry. Courtesy of the University of Valladolid.

- VIRMAN: virtual reality tool for training nuclear power plant component and equipment maintenance personnel, through a 3D display of these components in an interactive, navigable environment.

- SIMU2: virtual simulation tool for planning interventions in radioactive environments, which establishes the working conditions by estimating doses and required maneuvering times, with identification of relevant materials and types of radioactive sources for dose calculation.

- PRVIR: virtual reality tool applied to personnel training in radiological protection in nuclear power plants.

- VRIMOR: virtual reality tool for inspection, maintenance, operation and repair of components in nuclear power plants.

- SIROCO 3D: virtual reality system of the remote controller SIROCO for nuclear component robotic inspection equipment, with graphic display of both, to ascertain their actual location,

figures 7 & 8: Railroad transportation simulator. Courtesy of Corys.

operation and status and with interactive capacity for control over the inspection system.

This article only mentions some significant aspects related to the market and technology diversification strategy. There are other fields in which Tecnatom is developing new products and services in order to continue diversifying in nuclear and non-nuclear markets and in new technologies. Due to space limitations, these fields are not all covered in this article. These include the following:

- Diagnostic and control systems for gas turbines, power-operated valves, etc.
- Advanced control systems.
- Hydraulic loop flow monitor.
- Advanced control rooms.
- Advanced alarm systems.
- Etc.

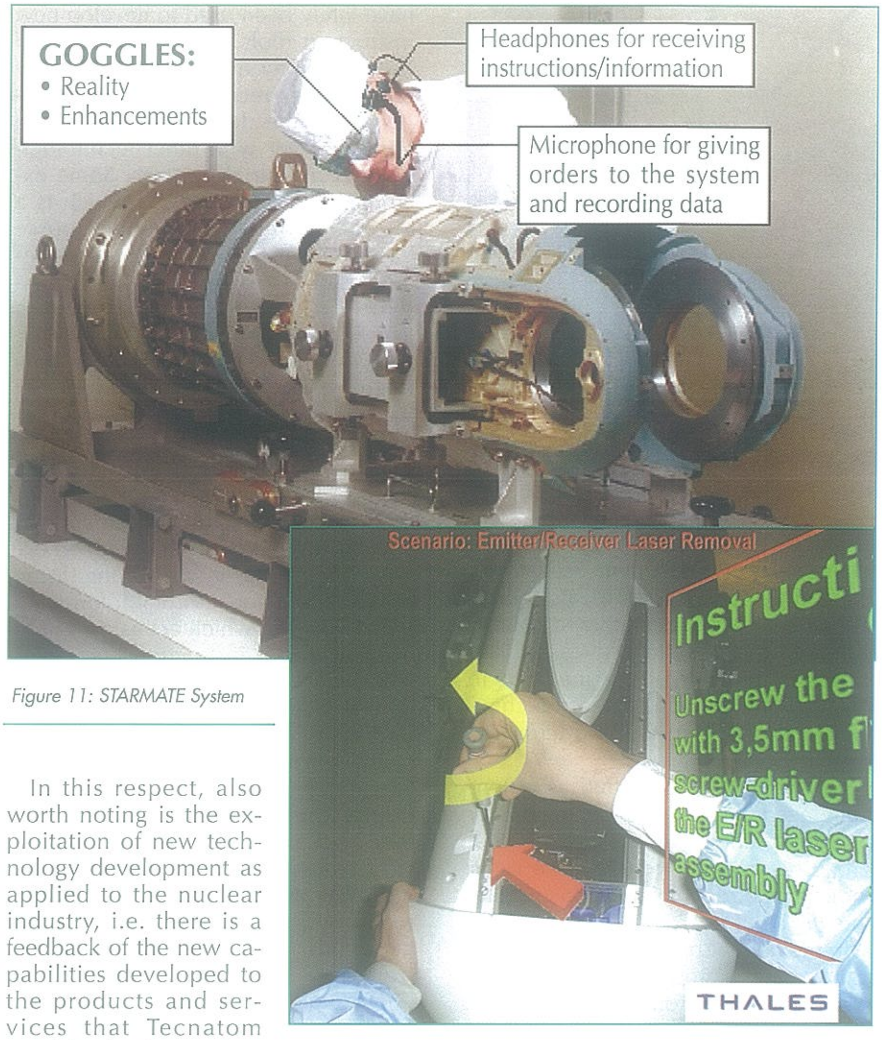


Figure 11: STARMATE System

CONCLUSIONS

The technological capabilities that Tecnatom has developed over many years for the national and international nuclear industry have made it possible to open up new industrial markets where, with the necessary adaptations, a series of high-tech products demanded by these markets have been developed, thus consolidating the proposed diversification strategy.

In addition, these capabilities are used to undertake the development of new technologies that lead to the creation of new technological products, which enhance the market diversification potential.

In this respect, also worth noting is the exploitation of new technology development as applied to the nuclear industry, i.e. there is a feedback of the new capabilities developed to the products and services that Tecnatom provides in the nuclear market, thus enhancing the effectiveness of processes and the ability to respond to the different problems existing in nuclear power plants.

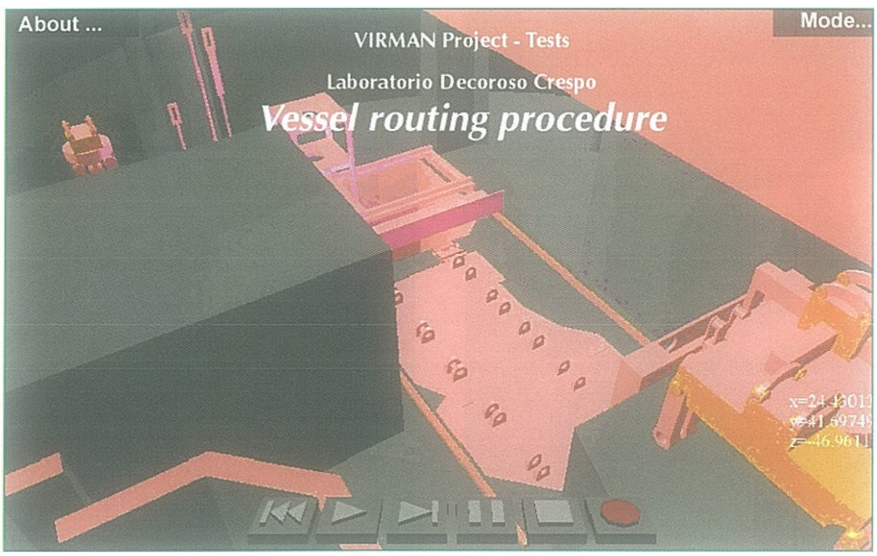


FIGURE 10: VIRMAN System

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