THE OYSTER EXPERIENCE

REINVENTING OUR REACTOR INSTITUTE DELFT RESEARCH INFRASTRUCTURE

R.J. LINSSEN

REACTOR INSTITUTE DELFT (RID), DELFT UNIVERSITY OF TECHNOLOGY (TU DELFT)

MEKELWEG 15, 2629JB DELFT – NETHERLANDS

ABSTRACT

Executing the OYSTER program at our research reactor showed the need to consider all 19 infrastructure issues identified by the IAEA for a research reactor to be newly built.
The TU Delft Reactor Institute Delft (RID) is a nuclear knowledge centre. It operates a 2MW pool type research reactor, the irradiation facilities and laboratories, as well as its neutron- and positron instruments.
In 2005, the RID management launched the OYSTER program enabling the continuation of our excellent scientific research, focused on energy, health and instrument development. The need for funding was laid down in a business plan supported by the board of the TU Delft. After extensive communication with the stakeholders the government awarded us in 2012 a 38M€ grant based on our excellent safety and security record and proven excellence in research. This consolidated our national position.
The organization of the CNS installation project is based on an integrated team approach with a team of in-house and external specialists. In all aspects of the development of the project this is a basic necessity to rightly assess the quality of the engineering, procurement and construction contract (EPC) with the supplier. The choice of a Korean consortium including KAERI has been fruitful in using a creative approach to the execution of the OYSTER project bridging cultural differences.
Our Regulator demanded a renewal of our 1996 nuclear and environmental license including a new license for the installation of a cold neutron source (CNS) based on new rules launched simultaneously in a new legislative framework. This added significantly to the workload, the time needed and the cost to execute the project.
In the meantime, many other infrastructure issues were being addressed, like upgrading physical and cyber security, improving emergency preparedness and response, installing ageing management, installing an integrated management system, securing financing of dismantling and renewing the waste disposal contract.
All 19 infrastructure issues have been touched upon. Studying them for similar size research reactor upgrade projects is recommended. Creative solutions are still necessary for the unforeseen.

1. Introduction

The Reactor Institute Delft [1] (RID) is a knowledge centre on nuclear topics, operating the reactor (HOR), irradiation facilities, and neutron- and positron instruments. In conjunction with the scientific Department of Radiation Science and Technology [2] (RST) of the Faculty of Applied Sciences, RID accommodates resident and visiting scientists from a variety of scientific disciplines, educates students, professionals and scientists, and serves as an independent source of information for society on radiation- and nuclear-related issues. Over the years, the scientists around the reactor have gained a strong reputation in developing and using new and often unique instruments, irradiation facilities and methods.

In 2005, the decision was taken to upgrade the 2MW open pool research reactor. 12 years later we can clearly see that the 19 infrastructure issues defined by the IAEA for new built research reactors [3] hold also for a major upgrade. For our project OYSTER, (i.e. Optimized Yield - for Science, Technology and Education – of Radiation) [4], we have touched upon all 19. In the following text, some specific experiences are explained dealing with the 19 infrastructure issues.

The program OYSTER will lead to an expected significant increase of the utilization of our research reactor by Dutch and international scientists from 2020 onward. RID will be fully prepared for innovative scientific developments with a safe and reliable reactor.

Fig 1. The 19 infrastructure issues according to the IAEA
(for research reactors “Utilization” instead of “Electrical Grid”) [5]

2. RID National position

In 2005, the HOR had 42 years of operation with an excellent safety and security record. Also, the research showed scientific excellence in:

- building neutron instruments with a speciality in Larmor precession based designs
- building the strongest continuous positron beam worldwide
- having developed the world’s most efficient radiation detector based on luminescence
- being in the forefront developing radioisotopes
- developing innovative reactors e.g. by being part of the Gen IV initiative
- having developed the world’s most sophisticated Neutron Activation Analyses (NAA) interpretation software

However, the reactor utilization could be improved. Neutron sources worldwide keep on improving of course, so the gap between our reactor’s capability towards the top ones became unacceptable. It became clear that a major improvement was needed for the reactor to stay competitive. Co-funding from the government had to be organized. A business plan was developed with full support of the board of the TU Delft. This resulted in the plan OYSTER. The main objective of OYSTER is facilitating excellent scientific research by

- installing a Cold Neutron Source (CNS)
- improving existing and developing new instruments for neutron and positron research
- developing new instruments for irradiation related research
- enabling the next 10 years’ operation of the HOR

To view more details of the OYSTER project, see ref. [6]

2.1 Funding OYSTER

In 2005, RID was a well-respected scientific research institute, mostly within the nuclear community in the Netherlands and abroad. RID is financed by public funds. In an environment with a fluctuating opinion about nuclear issues, a clear, nationally recognized position became a necessity. It took 7 years to increase the visibility of our institute so much that OYSTER was finally granted 38M€ on the 20th of January 2012. This grant was sponsored by three Ministries: primarily by the Ministry of Education, Culture and Science (OCW) and furthermore by the ministry of Health, Welfare and Sports and (VWS) by the

Ministry of Economic Affairs (EZ). Interesting to note is that the government at that time consisted for the first time in 7 years of parties which were all in favour of nuclear power.

2.2 Communicating OYSTER

We increased our visibility by promoting active communication with stakeholders. Among them was, besides the above-mentioned ministries, the Ministry of Foreign Affairs (BuZa), which needs our knowledge and education for e.g. strong anti-proliferation position of the Netherlands in the international debate and IAEA relations. Also by influencing the parliament it was reaffirmed by the government that the knowledge and education of RID is a necessity in view of the nuclear industry and institutes present in the Netherlands, the power plant (EPZ), the Nuclear Research and consulting Group(NRG), the uranium enrichment facility (URENCO) and the centralized waste disposal facility (COVRA). We also organized the support of scientists, universities and other big neutron sources (ISIS, ILL, and ESS). The industry was approached from two sides: by the regular contacts of our scientists and by the contacts for those who used our Neutron Activation Analyses (NAA). Several NGO's supported our request also. Another activity which helped was attracting the building of the first proton therapy clinic in the Netherlands (HollandPTC) on our premises. Finally, we also teamed up for the government grant with PALLAS, the plan of NRG for a new reactor.

RID has a long history of collaboration with the IAEA for educating NAA, reactor utilization and quality control. This resulted since 2009 in being a IAEA Collaborating Centre as one of the few research reactors in the world [7]. The stakeholders appreciate these efforts.

3. OYSTER Project management

The first activity after receiving the grant, was hiring an experienced project leader who was acquainted with the management of complex (nuclear) projects nationally and internationally. His first action was performing a cold eye review, to make clear what was needed as follow-up steps. On the basis of this review we decided to work with an integrated team approach, meaning that we would not make a separate project team with dedicated members. With the limited knowledgeable manpower available, this could introduce a communication barrier and would spread the knowledge inefficiently. Within the first year our regulator was involved in the developments. This will be explained further in section 4.

3.1 Creativity

Creativity is a basic skill for a scientist. At a university, the scientist is not the sole keeper of this skill. Due to the creative environment, a lot of the supporting personnel is also open for it. We took advantage of this situation. Creativity has become an integral part of the project approach for our RID team as well as for the executing contractors. This should not be confused with flexibility to change to another already existing proven possibility. To reduce the risk of creative technical design solutions we have planned two mock-ups to test the solutions and we consult our external expert team, which consists of specialists in:

- cold neutrons equipment design,
- multiphase flow
- CNS process technology
- CNS performance calculations
- operations and safety
- licensing issues including CNS

The HOR research reactor is a one-of-a-kind design. Just copying or downsizing an existing CNS design is therefore not an option. So we are assisting the consortium to change the design to get a creative optimized result. Combining efforts is beneficial for both. The vendor can increase his knowledge and sell a better product now and in the future, and we will also get a better result.

An example of this collaboration is the decision to use six Stirling motors instead of one conventional cooling compressor. This allows much more flexibility for load sharing and for maintenance redundancy.

3.2 Procurement

A Request For Proposal (RFP) was made. Next, in 2013 we decided to award the public Engineering, Procurement and Construction (EPC) contract for the CNS according to the EU Procurement Competitive Dialogue procedure [8]. Besides using the knowledge of the suppliers to optimize the design, the following extra advantages of this procedure have been recognized:

- the work method of each supplier has become clear
- the communication with each supplier has been tested
- the attitude of consortium members towards each other could be evaluated
- openness towards creativity was assessed

The disadvantage is of course the longer procedure because of the dialogue. However, the gain is much higher, taking into account that the result has to last for decades in an ever-changing environment. The South Korean consortium KHC (KAERI, Hyundai Engineering and Hyundai Engineering and Construction) finally received most credits and was granted the contract.

3.3 Cultural differences

Being aware of cultural differences from the beginning is also important. Western approaches and the way of saying things clearly differs from those of the Far East. We made this clear to all the project members of both RID and KHC from the early start of our working relation. As an example, this sensitivity resulted in an early stage in the recognition that the detailed design according to KHC was much more detailed than necessary to enter the Dutch construction market. We changed to the higher-level approach. As a result, we both benefited from reduced cost and a clear relation towards Dutch subcontractors.

The legal framework has also to be considered. The legal basis can differ in approach, either based on the Code Civil, like in the Netherlands, where the intent is leading, or based on the Anglo-Saxon approach where the exact description in the contract counts. The South Korean law is based on the Code Civil, however, many of the Korean lawyers are educated in the US.

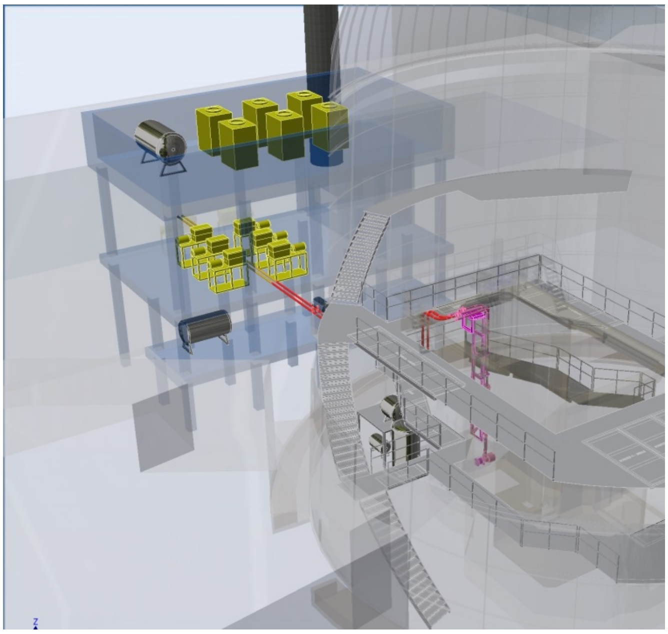
4. Nuclear safety, nuclear security and radiation protection

The Dutch Regulator (ANVS) decided that, with OYSTER, we shall renew our existing nuclear licence including the environmental licence, which both date from 1996. A complete Safety Analysis Report (SAR) is being prepared. In developing OYSTER from 2005 onwards, our safety and security operations have been continuously improved. Our standing organization of nuclear safety, nuclear security and radiation protection has been significantly challenged to be improved due to new insights. The overall improvement increased cost for operation and increased required manpower significantly.

4.1 Renewal of the licence

The ANVS made clear, from the first contacts in 2012, that modernization of the Dutch nuclear law based on the latest IAEA standards, lessons learned from Fukushima accident and on the WENRA safety reference levels, was under development. This new legislation, Dutch Safety Regulations (DSR), would be applicable for our licence renewal. These new Dutch Safety Regulations, in its final version became available only in October 2015. This leads to two complicating factors which are still impacting the project.

First of all, during the preparation of the SAR all three parties involved, RID, ANVS and GRS have to establish the approach to the new regulation. For example, “grading” is based on the interpretation of the rules, so this has to be established using the new rules. Another interpretation factor is due to the old design of the reactor. The new demands are based on providing modern design and engineering details. Although the safe operation of the HOR has been adequately proven over time, the engineering and design details are not always available. Reverse engineering is sometimes the only solution. A lot of extra communication is needed.



Secondly, this complicated the tendering which started with an incomplete DSR in 2013. Again, an advantage of the Competitive Dialogue tendering is the involvement of the suppliers in proposing solutions for the increased safety demands. However, the financial impact of the full DSR could not be incorporated in the EPC contract. The DSR items became additional scope. Creativity was needed also during this process.

To save time the project was split in two parts: the non-nuclear part which comprises the building with the cooling equipment and control, and the nuclear part which essentially is all the equipment inside the containment of the HOR. RID will get the licence to build the non-nuclear part about one and a half year earlier than the final licence, which allows to test the cooling equipment extensively with a mock-up of the in-pool part connected.

4.2 10 years’ periodic safety assessment (10EVA)

In our 10EVA analysis of 2009 ageing management was added as follow-up item for the regular management of our reactor. After detailed analysis, renewal of the primary and secondary cooling loop piping was found to be necessary. The OYSTER project construction time is an excellent moment to do this job thereby avoiding unnecessary downtime of the reactor. This work was added to the scope of the OYSTER project. The ageing management will become an integral part of our licence.

The second main item was the necessity to set up an Integrated Management System (IMS). This is a time consuming long term project. In a university environment, a system which is strictly procedural is not going to work smoothly, although the necessity for it is clear to everybody. Therefore, RID aims to develop the system such that the users will appreciate the quick overview and step by step explanation of all procedures to master, and all the approvals to get a licence for work where risk is involved. Modern IT systems will enable a low-barrier approach to this.

4.3 Stress test

Soon after the accident at Fukushima in 2011, the Dutch Regulator, ANVS, asked for a stress test of our reactor according to the agreement made by the European Regulators. Beyond-design cases were introduced, new countermeasures were developed. Earth quake resistance reassessment has taken quite some time because of non-availability of accurate data. The emergency planning has been improved especially in relation to the local authorities. Increasing our visibility by e.g. radiation protection training for fire brigades helped.

4.4 Security update and cyber security

Security has been improved based on design based threats. Cyber security is a continuous effort nowadays.

4.5 Decommissioning

In 2011, the first decommissioning plan, based on OECD/NEA rules, was accepted by the Regulator for the HOR. In the meantime, we have renewed this decommissioning plan and have included the OYSTER CNS according to the wish of our Regulator.

5. Conclusions

During the 12 years of the OYSTER project all 19 infrastructure issues, defined by the IAEA for a new built research reactor, have been addressed. Several changes to the project, which resulted from changes external to the project, have heavily influenced the planning and the budget of OYSTER. Using the 19 infrastructure issues for careful analyses of the actual situation at the beginning of similar-size projects like OYSTER will help defining all parameters to be considered. Nevertheless, major changes will occur during project execution time. What helps most then, according to our experience, is the creative approach by which you are able to find alternative routes while aiming for a win-win situation for all parties involved.

6. References

[1] Reactor Institute Delft (RID)
http://www.tnw.tudelft.nl/en/cooperation/facilities/reactor-instituut-delft/

[2] Radiation Science and Technology (RST)
http://www.tnw.tudelft.nl/over-faculteit/afdelingen/radiation-science-technology/

[3] Specific Considerations and Milestones for a Research Reactor Project, IAEA Nuclear Energy Series No. NP-T-5.1

[4] Optimised Yield – for Science Technology and Education – of Radiation (OYSTER)
http://www.tnw.tudelft.nl/en/cooperation/facilities/reactor-instituut-delft/oyster/

[5] https://www.iaea.org/NuclearPower/Infrastructure/milestone/index.html

[6] A.E. Molag, C.N.J. Kaaijk: “OYSTER Reactor Upgrade Project: Cold neutrons for cool science” Conference Proceedings RRFM European Research Reactor Conference 2015, Bucharest, Romania 19-23 April 2015

[7] Active IAEA Collaborating Centres sorted by topic
https://www.iaea.org/sites/default/files/16/12/collaborating-centres.pdf

[8] Explanatory note – competitive dialogue – classic directive, European Commission, Ares(2016)810094 – 16/02/2016
http://ec.europa.eu/DocsRoom/documents/15473/attachments/1/translations/