Joint Industrial Projects: a study of cooperative efforts in the oil industry

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Abstract

This paper focuses on a successful case of R&D co-operation effort in the form of a Joint Industrial Project (JIP) with the leadership of Petrobras to develop and upgrade a system of production using Electrical Submersible Pump (ESP) in Subsea Well. In October 1994, for the first time in the world an ESP, located 82 meters water depth was installed in Campos Basin - Brazil, and in 1997 it completed almost three years of operation without failure.

Although major players in the upstream segment of the oil industry have been trying to accelerate innovation through R&D alliances, still an organizational culture based on market incentives characterize contracts in the industry with little effort on R&D integration between suppliers and clients (Wardt, 1997). Petrobras’ experience exemplifies the transition already in place in the industry and highlights the capability of an enterprise to define objectives, coordinate and manage a project involving the participation of different suppliers to built a complex system.

The paper presents in section I a summary of the main characteristics of the JIPs. Section II analyses the importance of PROCAP, Petrobras technological program on deep-water technology and the role played by the JIPs in this process. Section III focuses on how the JIP was motivated and organized. Section IV discusses the management of the project. Finally, the conclusion highlights the factors that affected its performance, and the mechanisms used to diffuse the benefits of the project development among participants.

I. Basic Characteristics of JIPs

R&D Consortia, in general, and JIPs specifically, are self-governing, usually non-profit organizations run for the benefit of their members. The owners are the customers, and their purpose is to develop new technology and put it into practice. Funded largely by members companies, with additional support often from government sources, they are vehicles for R&D cost-sharing in areas of common interest. They may be defined in terms of their membership policies, industrial organization, the nature of R&D missions, their intended duration, and their R&D sourcing modes.

JIPs have the objectives the following objectives:

✓ Technological upgrading of the industry at human resources and infrastructure level;
✓ Better links between suppliers and customers;
✓ Competitive advantage of its members;
Industry standard-setting as a way to organize competition or to build specific strategies (life-cycles, compatibility among components, safety requirements)

**The Rationale for Collaboration**

The economic rationale for the formation of a collaborative group is the anticipation of gain by some members or core group - a greater gain than if the members core group were to undertake the same mission independently, Olsen (1968). Potential gains from collaboration may emanate from cost sharing, the sharing of complementary technology, and reduction of risks. Cost-sharing opportunities are prime motivation in the formation of JIPs for the development of collective R&D products in non-competitive domains. Sharing complementary technical knowledge is often the purpose of JIPs that are formed to develop technology to advance competitive interests. Such alliances provide opportunities for firms moving into new fields of technology or diversifying into new business.

Risk reduction opportunities provide an incentive for collaboration on large scale projects with a relatively high degree of uncertainty. Examples of that are IBM-Toshiba- Siemens joint-venture, Business Week, 27/7/92, and Boeing partnership with four leading European aerospace firms in design and construction of large capacity passenger planes, New York Times, 28/1/93. Another form of risk reduction that a collaborative venture provides is the opportunity to monitor technological advances in competitors' R&D programs, specially on Government funded R&D consortia.

The potential for economic gains tends to augment by noneconomic motivations, particularly on the part of the core group, Hardin (1992). Core-group leaders are likely to have a sense of responsibility for the JIP success, and to value the opportunity to direct a non-profit enterprise of importance to the nation or industry. Noneconomic motives seem to have particular weight in the development of basic technologies and upgrading of national enterprises. However, in the absence of an economic reasoning, a consortium in general, or a JIP in a more specific organizational form, does not have sustainability.

**II. The Importance of Deepwater Production to Brazil**

At the end of 1993, the total volume of both exploitable and non-exploitable crude oil reserves in Brazil came up to 7.04 billion barrels and about 285 billion cubic meters of natural gas. From that total, the oil reserves located onshore represent 14.1%; the ones located in shallow waters, below 400m, account for 22.5% and the ones in deep water, between 400 and 1000m, for 43.8%. The oil reserves situated in depths over 1000 meters, classified as ultra-deep waters, represent 19.6%, but in this case, it is now necessary to develop technology to produce in such water depths. Summarizing, the oil reserves located in both deep and ultra-deep waters stand for about 64% of the Brazilian exploitable and non-exploitable total reserves while the natural gas reserves placed in these water depths account for 26% of the total. The importance of deepwater technology can be also emphasized by the fact that according to Petrobras Exploration staff over 65% of the potential oil and gas discoveries, that is, new fields where favorable characteristics indicate the existence of hydrocarbons, will be in deep and ultra deepwaters. These figures reveal that Brazil’s future regarding oil production is strongly related to offshore fields located over 400m water depths.
During 1994, Petrobras achieved an accumulated oil production of 253 million barrels, corresponding an average daily production of 693,000 barrels. This production is not enough to meet the Brazilian market demand which is nowadays of 1,3 million bpd. From the total produced, 27,0% came from onshore fields, 48,4% belonged to shallow waters and 24,6% was produced in deep waters, Assayag et. al. (1995).

*The First PROCAP*

The economic significance of the deep water reserves determined the creation, in 1986, of Petrobras Technological Development Program on Deep Water Productions Systems - PROCAP. The main objective of this program was to improve the Nation’s technological expertise in oil and natural gas production in waters as deep as 1000 meters, aiming at the Albacora and Marlim field developments.

The program also aimed at:

- Consolidating Petrobras operational experience, mainly in floating production systems (FPS), to achieve cost reduction and reliability improvements.
- Extending shallow waters offshore technology to deeper waters.
- Developing new alternatives to improve deep water oil exploitation.

The PROCAP was carried out in 6 years, from 1986 to 1991, and undertook 109 interdisciplinary projects.

In addition to the developed projects related to technology extension, the first PROCAP dedicated about 20% of its total human resources to the study of Innovative Systems. These systems were the ones Petrobras has not used yet, but they were considered attractive alternatives for our deep water oil fields.

During the whole program, ended by December 1991, PROCAP expenditures came up to US$ 70 million. A total of 400 Petrobras’s experts and over 1000 staff members from other institutions were involved, representing around 200,000 man/hours per year. As a major result, full technological capability through the floating production system based on semi-submersible at water depths up to 1000 meters was acquired, Petrobras(1986). Petrobras won international recognition for its work in deepwater oil production technology, when was honored by the Offshore Technology Conference (OTC) with the 1992 Distinguished Achievement Award for Companies, Organizations and Institutions. The first PROCAP represented a major contribution to this technology development and played an important role in helping Petrobras to get that award.
PROCAP-2000

Petrobras started by the end of 1992, a new program called PROCAP-2000 - Technological Innovation Program on Deepwater Exploitation Systems - which has been implemented to give continuity to the efforts of the first program to improve Brazilian technological skills in deep waters. The new program has got the following goals, Petrobras(1992).

✓ Development of technologically innovative projects aiming at reducing investment and operational costs related deepwater production systems operating between 300 and 1000 meters, and enhancing final recovery of oil and gas, besides extending the useful life of wells located in waters over 300 meters deep.

✓ Development of offshore drilling and production technologies, enabling Petrobras to produce oil and gas from fields situated in ultra-deepwaters (1000 - 2000 meters).

PROCAP-2000 Strategies

According to the same document, Petrobras (1992), the strategies chosen for PROCAP-2000 reflected not only the level of oil prices - expected to hold steady or climb only slightly in the near future - but also Brazil’s current situation, particularly the constant difficulties in the balance-of-payments. The program aimed to optimize reliance on know-how and resources available locally and abroad, and reduce the costs of the development of deepwater technology. This strategy stressed:

1. Links with the Brazilian Technological Community (Sharing Efforts)
2. Links with the International Technological Community (Complementation)
3. Focus on Essential Technologies (Selectivity)
4. Links with Governmental Funding Agencies (Financial Resources)

PROCAP-2000 Portfolio of Projects

After a wide discussion with the major actors of the process, involving 200 Petrobras and local universities experts, 12 systemic projects were chosen to be developed throughout 4 years by PROCAP-2000, from 1992 to 1996. These projects represented the essential technologies for Petrobras to come up to the goals of that program, that is, reduction on production costs, increase in productivity at deep water fields by enabling oil production in water depth over 1000 meters.

A brief overview of each one of those 12 projects:

1. Stability in Horizontal and Highly Deviated Wells;
2. Drilling Highly Deviated Wells in Unconsolidated Sandstones and Unstable Shales;
3. Kick and Blowout Control in Deep Water Wells;
4. Electrical Submersible Pumps in Subsea Wells (BCS);
5. Subsea Separation Systems (SSS);
6. Subsea Multiphase Pumping System;
7. Flow Assurance in Deep Water Conditions;
8. Reduction of Rig Downtime Due to BOP (Blowwater Preventer) Handling;
9. Stationary Production Units with Dry Completion;
10. Stationary Production Units with Subsea Completion;
11. Acquisition and Treatment of Geotechnical, Geophysical, Geological and Environmental Data;
12. Deepwater Subsea Pipelines (Gathering, Export and Control)

The Brazilian technological community - universities, engineering consultants, industries, science and technology centers - came up with important contributions to these projects. The international community also played a key role through Joint Industry Projects, service contracts, technology transfer programs, cooperative agreements, consultancy and in-service training.

Table 1 illustrates the participation of the different institutions in the process of implementation of Petrobras technological strategy in the PROCAP 2000.

<table>
<thead>
<tr>
<th>Institutions</th>
<th>National (units)</th>
<th>International (units)</th>
</tr>
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<tbody>
<tr>
<td>R&amp;D Centers</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Engineering Firms</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Equipment Producers (suppliers)</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>Operators (other oil co.)</td>
<td>-</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: 4ª Avaliação do Procap, p.95-99

III. The Petrobras' JIP: Technological Problem and Process of Negotiation

The Background of the Initial JIP

The project was initially financed by a grant of the European Union, in the period 1988-90, with the leadership of Subsea Intervention System Ltd., a joint-venture formed between Vetco and another English company. Several oil companies participated in this phase of the JIP including British Petroleum, Shell, Texaco and Amoco.

Although this multi-client JIP was very successful in developing basic technology in subsea connectors, the continuity of the JIP was questioned. Participants argued that further development of this new technology was not profitability for most of their scenarios given the short durability of the pumps. Only Amoco was interested in developing further applications in its fields in China, and decided to develop in-house their technology.
Another factor that may have affected negatively the continuity of the JIP, it was the way the negotiation was set. It seemed to the oil companies that suppliers would benefit more than clients from the new phase of the JIP given that both Lassale and Vetco, that initiated the negotiation, were willing to sell end products, instead of developing a joint-co-operation effort.

Despite the fact that Petrobras did not participate in this JIP, the implementation of the PROCAP 2000 was a great incentive to develop further technology in this area. Others factors greatly worked in favour of a renewal of interest in this technology. First, the North Sea needed to increase production in idle fields. It was already observed that as production increased over time, the productivity of most wells were decreasing. Therefore, there was a need to pump fields located far from the platforms in order to increase the profitability of this fields without further capital investment. This technology could allow a better production system. Secondly, both Tronic and Remote Marine System (RMS) had developed the wet connectors, one of the key components of the new production system, and their product had been already tested, being the technology available in the market.

**Negotiation of the JIP with Petrobras’ Leadership**

The initial process of forming the JIP, organized in a vertical structure, that is, one client and multi-suppliers, was informal. Petrobras project manager of BCS starts contact with Lassale to have the company participation in the supply of the components of the pumping system. Lassale was offered to participate in the joint-effort, benefiting from the information of real field performance, and the market reputation of participating on a new technological concept. Lassale refused to participate because did not agree with the terms of co-operation, and as a Joint-venture with Rheda, found that the corporate strategy did not fit this type of co-operation proposed by Petrobras. Instead, Petrobras invited Tronic, a small English enterprise. However, to convince the company to join the JIP was not an easy target given that the Brazilian manager had a very immediate view of the potential gains of this effort, and delayed the answer to see if other enterprises would be interested in Petrobras’ project.

Pirelli do Brazil, interested in expanding its share in the Brazilian market is the first enterprise to accept to form the JIP. Its first contribution was restricted to supply the subsea cable, but later the company expands its participation in the JIP to supply also the interior cable of the well.

Meanwhile, Petrobras as part of its strategy to develop the national industry, invited several producers of wet trees. Two immediately refused to supply services in a project of technological development. Sade-Vigesa, a national company, not a major supplier of Petrobras, having its technology licensed from Cameron (English), was interested in get closer to Petrobras and accepts to join the JIP. Finally, Tronic decides to join also the JIP, and Petrobras finds a substitute for Lassalle technology by inviting the enterprise Centrelift.

When the JIP seemed near to be completed, this later enterprise demanded a reserve of the Brazilian market to participate in the JIP, and Petrobras could not satisfy this condition given her own legislation of a Brazilian public enterprise. Meanwhile, Rheda took acquaintance that Centelift had left the JIP, and decides to accept the participation of Lassalle, motivated by the fact that being out of the JIP might have negative competitive effects in the future.
Negotiations that started in 1992 are only completed in 1994 when all the participants of the JIP formally agreed to sign a Co-operation Agreement. The agreement basically defined that Petrobras was responsible for the coordination, implementation and testing of the technology, whereas each partner would be responsible to supply components of the new production system. Table 2 below specify the division of targets of each participant.

Table 2 - Attribution Matrix of the JIP - First Stage

<table>
<thead>
<tr>
<th>Participant</th>
<th>Responsibility</th>
</tr>
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<tbody>
<tr>
<td>- Tronic (United Kingdom)</td>
<td>Develop and supply the subsea power connectors;</td>
</tr>
<tr>
<td>- Reda (USA) and Lasalle (UK)</td>
<td>Adequate and supply the ESP components (pump, motor, ...);</td>
</tr>
<tr>
<td>- Pirelli (Brazil)</td>
<td>Develop and supply the subsea and downhole power cables;</td>
</tr>
<tr>
<td>- Cameron (USA) and Sade-Vigesa (Brazil)</td>
<td>Adapt an available subsea tree to receive power connectors;</td>
</tr>
<tr>
<td>- Petrobras (Brazil)</td>
<td>Coordinate the project and integrate the subsystems, provide all other materials and vessels, responsible for the completion and logistics.</td>
</tr>
</tbody>
</table>

Source: Mendonca J.E., SPE 38533

Criteria used by Petrobras to choose its Partners in the JIP

The choice of participants was partly the willingness of suppliers to participate in a collaborative effort and partly the complementarity of expertise of the participants. Petrobras was not willing to follow the traditional rules of buying equipment and services on a contractual (market) base. Instead, the enterprise wanted to share a process of technological development and upgrading of a system of components based on loyalty and trust among members. Another important criterion, reflected in the main lines of Petrobras technological strategy, was to incorporate national enterprises once they showed similar technological capability that it could be found in the international frontier.

Besides those criteria, clearly the vision of the managers of the respective enterprises that entered or refused the JIP was extremely important. Those people were responsible to sell the JIP to their enterprise or group and convince them of the future benefits of the joint-effort. Nevertheless, as it will be discussed above, a JIP only works if all partners have strategic interest in be a participant of the technological outcome and the network of relations that are established as a result of the JIP functioning.

IV. The Management of the JIP

The role of the leader is fundamental to the success of a JIP. In this case, Petrobras before starting the JIP was well informed about the economic and technical feasibility of the new technology and the expertise available in the international frontier. Therefore, it was able to define clear targets to its collaborators and able to manage teams and schedules. According to interview with participants of the JIP, another fundamental factor is the believe that the project is feasible. Problems did occur along the several stages, from conception to testing in the field. But the believe that the system will work was fundamental to keep the spirit of the team. Participation in field tests and Petrobras disclosure of the results led to a process of increasing co-operation.
The co-ordination of the JIP was located in Petrobras Research Centre - Cenpes, within the area of subsea engineering given that the main objective of Petrobras was to develop the applications of the new technology. Petrobras co-ordinator of the JIP was responsible to all technical aspects, and the team was formed by five full-time technicians that belonged, functionally, to other areas of the Research Centre. Great interface was always present with the Operational Area of Campos Basin, and, on average, 32 technicians from Petrobras were directly involved in the project.

According to the co-ordinator of the JIP, overlaps between a matrix organization and a functional structure leads to several problems of internal organization of the team. Problems were better solved in an informal way, with lots of efforts devoted to assure that human resources were effectively allocated to the project. The cost of the JIP is not well quantified by Petrobras. Since in the Co-operation Agreement only man-hours are accounted by Cenpes, all costs of operation are internalised by the cost centre of Campos Basin. In fact, there is not a clear idea of the amount spent, although this project only represented 3% of the total of the Protocap 2000 budget.

As we saw above, firms are moved by their own strategic interest to enter in a JIP. In the case of a vertical JIP, complementarity of expertise is the major drive and given this aspect, much less room is left to disagreement and conflicts in cases of property rights disputes. Nevertheless, Petrobras, as the client/user of the new technology had the comprise to give all the feedbacks in terms of equipment performance, and all types of improvements and technological upgrading of the equipment are property of the supplier. However, they all agreed that end-products would be available to the market. In other words, Petrobras assured to all suppliers that the know-why did not have to be transferred to the client, only the know-how at the operational level.

Besides, Petrobras offered to give all marketing support to suppliers, and Petrobras certification of quality after the equipment had been tested during one year. Despite all the possibilities though to avoid conflict, Pirelli and Lassalle became competitors along the JIP, and it was necessary to write a special agreement. It became clear in this case, that participants in a vertical JIP can not have areas of technological overlapping and clear strategic motives.

This certification usually means that the product will continue to be supplied to Petrobras afterwards, a way to assure market reserve, but also Petrobras certification of an equipment gives to suppliers of the JIP competitive advantage over competitors since the technology is hardly known in the market. In fact, benefits of each participant of the JIP can be qualitatively measured in terms that Tronic was able to test connectors in real fields, Seda-Vigesa gained market visibility on an international scale, and Lassalle is already selling its services to Amoco in the Chinese field.

The JIP was divided in two stages. The first stage, January 1993 up to December 1994, the operational system was develop to shallow water, and able to operate up to 300 meters. The second stage starts in January 1995, when Petrobras starts buying the equipment from the suppliers of the first phase, and much less technological cooperation exist among members.

*Actual Stage of the JIP*
The JIP is in its final stage and showed that the technology to deep water is already available. Several field tests were performed in different conditions. It was considered, among the 12 projects of the Procap 2000, the project that had the best performance in terms of fulfilling objectives. Recently it was decided that the project should continue until the end of 1988 with the objective to better diffuse the technology within the enterprise. Also, Petrobras is thinking on developing infrastructure to use the system in any type of well by increasing the pump capacity.

V. Conclusion

Petrobras' successful experience can be attributed to the following factors:

The JIP was conceived in increasing stages of complexity. First, the system was designed to operate up to 300 meters, and on a second phase the target was to develop the system to ultra-deep water. This gave to the suppliers the possibility to apply the technology to a greater number of potential clients.

Basic knowledge for the development of the project was already known, and the JIP could define its economic objective with greater precision, as well as Petrobras could specify better its demands to participants of the JIP.

Several economic and technical visibility studies were performed before the implementation of the JIP what allowed Petrobras to have greater knowledge of alternative scenarios, and able to choose the best technological strategy to be followed.

The terms of the agreement helped to create a process of co-operation and mutual sharing of experience. Also the complementary of expertise of members of the JIP helped to avoid areas of common interest were disputes could more easily arise.

Petrobras showed capacity to coordinate the tests, and assure partners of disclosure of information.

Project managers in the participants firms were able to maintain a constant process of feedback of information, a factor that contributed to the scheduling of the stages of the JIP an environment of mutual exchange of experience, specially in the first phase.

The participants contribution to the JIP was defined in terms of technological services develop by joint-efforts. Therefore, the organizational culture of "contractor", willing to obtain benefits by selling products, was not present, specially in the first phase of the JIP.

Finally, vertical JIPs in which the client implicitly gives market reserves to participants, have a grater tendency to work once future gain are less risky. Other types of gains are related to a better visibility of suppliers in the international market, specially if they were before a minor player in the industry.
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