A PROJECT MANAGEMENT APPROACH TO THE DESIGN, CONSTRUCTION, COMMISSIONING AND TURN OVER OF THE OPAL REACTOR

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With the OPAL Reactor reaching conclusion and ready for the start of hot commissioning, it becomes mandatory to turn our minds to the challenging Project Management (PM) requirements it posed and the way they were tackled. INVAP was, back in 2000, selected by the Australian Nuclear Science and Technology Organization (ANSTO) as the Prime Contractor for a project which would become the biggest single investment in Science & Technology in Australian history.

INVAP’s operations are built based on 3 main factors. The most recognized is related to the technological capabilities INVAP keeps developing towards leadership and ultimately, for the satisfaction of our customer’s requirements. The second important factor is the strategic objective of providing first of a kind customer oriented solutions. The less obvious factor in this trilogy is the continuous strive for improved up to date, cost effective, “nuclear” suited PM techniques and methods.

This paper provides a description, review and discussion on the PM methods and practices being applied to the OPAL Project. It also presents a description of the main challenges faced during these years and how the PM team and tools worked. It detail outlines the achievements after 6 years of Project execution:

a) All milestones contractually agreed, reached,
b) Timely completion of project phases,
c) Quality requirements from the top all the way down to the supply chain of subcontractors and services providers, met,
d) Environmental requirements in Australia and Argentina, fulfilled,
e) Risky situations like the economical crisis of 2001 in Argentina, successfully overcame without jeopardizing any of the Contractual commitments,
f) The setting of a benchmark for future reference in similar complex projects.

Finally and briefly we present a set of conclusions and recommendations being fed back into today’s PM approach prevailing at INVAP.

Key word: Research Reactor, Project Management

I. INTRODUCTION

After an exemplar tendering process for the world community, back in June 2000, INVAP was awarded by the Australian Science and Technology Organization (ANSTO) with a turn key contract for the design, construction, commissioning and turn over of the Replacement Research Reactor for the existing HIFAR. The contract was signed and activities immediately began in July 13, 2000.

Being this, the biggest single investment so far accomplished in Science & Technology by Australia, and the biggest turn key technological export for Argentina, the project is indeed important and strategic for both countries. In a very short time frame since Contract award many issues had to be worked out with a just in time approach in order to satisfy all the requirements. Among them: warranties, different types of bonds, subcontractors commitments and their formalizations, etc..
This type of contract for a first of a kind facility by itself poses a tremendous challenge: technological views and solutions never tried before, extremely tough performance parameters for a very compact core, truly multipurpose applications, manufacturing of very complex components, are examples just to mention a few. Aside, on the organizational side, the handling of a worldwide network to meet the quality and timely delivery of components and supplies was another source of risk.

Nonetheless, INVAP has been successful in projecting itself into domestic and overseas operations. We have done so in such diverse areas and projects like research reactors, enrichment plants, fuel manufacturing plants, radioisotope plants, radiotherapy products, nuclear power plants solutions and services, space scientific satellites and many more.

Several factors have been key ingredients to our results. Of these, the most recognized is related to the technological capabilities and associated quality that INVAP and the Argentinean nuclear sector keep developing and improving in order to satisfy our customer's requirements. A second thought brings to our mind the important strategic Company objective of providing specific purpose customer oriented solutions.

Less obvious for many people and the third important factor in this trilogy is the successful implementation an application of PROJECT MANAGEMENT (PM)[1] techniques and methods.

For INVAP, the concept of Project Management and its application has evolved over the past 30 years, reaching with the actual execution of the Replacement Research Reactor (RRR) Project, today the OPAL Reactor, its latest ‘state of the art’ version (but still another step in a continuous evolution).

In the following, it will be presented an schematic view of project management as INVAP applies it in all its projects with brief explanations on:

- Project view, its organization and implementation,
- Programmatic Complexity: project overall management and phase oriented management,
- Application of the integrated management approach,
- Integration of risk management into the overall process,
- Effective coordination and integration of multiple subcontractors worldwide dispersed,
- Customer integration into project execution,
- Technology Transfer,
- Project planning, target schedule,
- Quality assurance and effective cost reporting and control,
- Configuration Management and tools,
- Integrated Logistic Support.

II. STRATEGIC VIEW AND PROJECT VIEW

INVAP bases its strategy in three key factors:
- Own proven and innovative technology plus capabilities and developments through extensive cooperative efforts, principally with the Comisión Nacional de Energía Atómica (CNEA-National Atomic Energy Commission) in Argentina and a case by case specific network of other key partners
- Development of customer oriented specific purpose solutions to meet clients needs
- Efficient Project Management.

Effective Project Management has traditionally implied for INVAP from the very beginning of Company activities:
- Integrated management approach,
- Proactive solutions and attitude,
- Meeting technical and performance requirements
- Highest achievable quality assurance program (INVAP is a certified ISO 9001 Company and its QA program also meets NQA-1 requirements in the US as well as IAEA guidelines)
- Full licensing support
- Environmental management
- Cost control and reporting and,
• Design and handling of program schedules and target schedules

In the past recent years, this traditional approach to project’s view has been reinforced through:
• Improved and faster cost control and reporting
• Improved program schedule and target schedule handling
• Improved Environmental Management (INVAP is also certified as per ISO 14000)
• Configuration Management
• Integrated Logistic Support
• Risk Management

Company capabilities have reached a stage in which above elements are all together effectively applied and carried on.

III. GOALS OF INVAP’s PROJECT MANAGEMENT

Common sense and experience dictates that any ‘project view’ has to focus in three key elements: projected duration versus actual execution, budgeted cost versus actual expenditures, and the resultant versus the specified (demanded) product.

Project success relies on the success in those 3 dimensions: cost within budget, schedule accomplishment and meeting performance (and therefore quality) requirements.

The most single factor contributing to the fulfillment of above quoted success is intensive planning at all levels.

Planning starts at the very early tendering stage, continues and gets feedback during the pre-contractual negotiations and its subsequent updating and improvement is of critical importance during the actual execution.

Planning is not a simple task and is intimately related to the project vision and to the customer’s requirements. INVAP has developed a common and systematic approach to planning which is applicable to projects very different in their nature. This approach is described in the following section.

IV. THE RRR PROJECT IN AUSTRALIA

For us, Projects are envisaged in a sort of a matrix form. Particularly, the RRR Project has been viewed and executed that way.

Under this matrix approach we distinguish project activities that are called ‘general’ from those that are ‘specific’ to the project stage.

General project activities are therefore those that exist due to the mere existence of the project regardless of project status, progress or phase under execution. They begin with the project beginning and last until the project is formally closed.

As an example of these types of activities and areas we can quote: general management, contractual relations, legal affairs, financial and administration, safety and licensing / relations with the regulator, quality assurance, local content, continuous improvement, risk management, non market and political issues, overall security, environmental management, configuration management and integrated logistics support.

Specific project activities are on the contrary, strictly associated to the project phase under execution. They therefore do begin and finish within the time limits of the phase, unless for particular reasons, the activity is transferred to a different phase.

Examples of the project phases are Basic Design, Detail Design, Manufacturing and Procurement, Construction, Integration and Installation, Pre-operational Testing, Commissioning, Initial Support Period and In service Operation.

Activities that are phase related or phase specific might well be: construction – inspection and testing, industrial relations / unions, construction environmental issues, occupational health and safety, procurement – shipping and storage, community relations during construction, disruptions to the community during construction, construction security, commissioning.

V. INTEGRATED MANAGEMENT APPROACH
The matrix approach, the planning needs and the integrated management concept get all real in practice, through different concatenated plans.

The Master plan that sets the frame for Project Management is called the Project Management Plan (PMP)[2]. It acts as an umbrella and serves to the following purposes:

- Defines project organization, functions and roles
- Identifies main managers, group coordinators and persons in charge
- Defines relationships among the different functions and reporting ways
- Defines general structure for the works
- Nominates and assigns responsibilities to important subcontractors
- Defines the update frequency for the master schedule and the target schedule
- Defines the software and tools for planning and control
- Defines status report contents and, frequency for their issuance
- Defines project controls, audits and responsibilities, and frequencies for follow up.

The ultimate responsible for the PMP is the project maximum authority, the Project Director. But its application is carried on by all the managers and coordinators within it defined, all agglutinated in what it is called the Project Management Team (PMT).

The integrated management approach is therefore obtained through:

- The multi-disciplinary participation of managers in different specific purpose task groups, as well as with
- Periodical coordination meetings of the PMT.

From the PMP, a set of General Management Plans (GMPs) and Phase Specific Management Plans (PSMPs) hang down. As their names indicate the GMPs basically deal with project general activities and the PSMPs are related to project specific activities.

VI. QUALITY ASSURANCE AND ENVIRONMENTAL MANAGEMENT

As part of the nuclear complex in Argentina, INVAP has been one of the precursors in such matters as Quality Assurance and Environmental Management.

Quality Assurance is a well-established practice within the Company and demanded all along the chain of partners, subcontractors and suppliers. INVAP has a comprehensive manual applicable to the whole of the company and usually a project specific manual, procedures and the associated practices are defined for cases like the RRR. INVAP is fully certified to ISO 9001: 2000 revision. INVAP QA Program has been found in full compliance with all the requirements for all the quality levels as defined and demanded by NQA-1 in the USA. It also complies with the guidelines mandated by the IAEA and of course, with the local regulations in place in Argentina.

Environmental Management has been also part of the Company goals from the very beginning. The difference is that today, every project stage or phase has to address environmental facts using a systematic and explicit approach from design to in service operation, through construction, assembly and commissioning.

INVAP has defined an environmental policy that relies in well know principles of sustainable development, life cycle assessment and environmentally friendly solutions.

Environmental Management is considered an activity of the general type. Nonetheless environmental issues are handled through project phases paying attention to the associated peculiarities. That’s why almost every project phase has associated its own specific phase environmental plan.

In this regard, during Design, guides and recommendations are applied within INVAP groups in order to explicitly address environmental issues for every system and subsystem associated to the product.

The Construction stage also deals with Environmental issues, which not only covers classical pollution avoidance, recycling and minimization of waste. Sound and light pollution to the neighborhood, traffic management and congestion, dust control, storm water handling, fire protection zone and even conservation of
archeological deposits during excavation are all addressed.

This approach is substantiated in the fact that INVAP has an environmental management system and the whole Company is also certified to ISO 14000.

VII. EARNED VALUE METHOD AND THE CONCEPT OF WORK PACKAGE

As stated before, the 3 key “dimensions” for PM are: costs, schedule and quality / performance.

A practical way to integrate above 3 elements into a single understandable scheme is the Earned Value Method (EV)[1].

The EV compares the amount of work that was planned with what was actually earned and with was actually spent. The aim is to determine if schedule and cost performance are as planned.

For this purpose, a baseline is designed, integrating:
- A Work Breakdown Structure (WBS),
- A Contract Master Schedule (CMS)
- A Price - Cost Reference.
- A Project Dictionary containing the main definitions, scope and deliverables for each Work Package

A Work Package is the basic structure with which the work to accomplish the project, is organized and therefore the project is breakdown by Work Packages (WPs). A WP comprises a series of activities concentrating workforce, materials, and services, singled out for the full implementation of all necessary tasks to complete the contract.

A WP is therefore:
- The Project implementation and control unit;
- A reference for the application of resources (workforce, supplies and services);
- A reference for expenditure allocation;
- A reference for the exchange of information with the Owner and suppliers;
- A reference for project progress certifications to the Owner

The main characteristics sought when defining of a WP are:
- It is a work unit at the level in which the work is carried out;
- It is clearly recognizable from other WPs;
- Overall, only one entity (person or subcontractor) is in charge of its execution;
- It is the unit for the assigned value or budget; in monetary terms, man hours or other measure units;
- It has clearly defined start and finish dates and, when it corresponds, representative milestones of specific and verifiable progress that are used as basis for progress certification to the Owner;
- It has a limited duration.
- Each WP has assigned a clearly recognizable set of deliverables as it product.

VIII. SCHEDULES AND TARGET SCHEDULES

Aside from the tooling adopted for project planning and scheduling, the basic fact is that the whole project management team plans and executes its activities on the basis of target (stretched) schedules.

A general project target schedule and internal or partial target sub-schedules are a matter of project management judgment. On a continuous basis, such target schedules are addressed, evaluated and adjusted as necessary.

When performing above gaming and balance, an important issue is the ownership of overall project and individual activities float. INVAP policy is that the float ownership relies in the Main Contractor and any use of the float to the benefit of the Customer should be the subject of a case by case negotiation.

Target schedules are not cost free and their implementation is the result of a delicate balance between risk and opportunities.

IX. COST CONTROL AND REPORTING

Project Control and reporting has been a tool long present in every INVAP project. Nonetheless, it has recently achieved a high level of efficiency feeding back the PM team with accurate and up to date information.
Generically, Project Control is carried out at the WPs level, through costs and progress indicators that may allow a simple and accurate evaluation of the state of every WP at a certain moment. These indicators allow the calculation of the status of the Main Activities and Phases, to which a WP belongs, as well as of the status of the Project’s integrity.

Under this methodology, two different monthly reports are normally issued. The Contract Status Reports summarizes the progress of the projects and the status of the Project Management Plan and is shared with the Customer. The internal Cost Report contains related information to cost and resource use and is intended for internal purposes only.

Based on this reporting and frequency, the PMT can assess project status on a two week basis and introduce proactive and effective contingency and/or corrective measures in due time whenever necessary.

X. CONFIGURATION MANAGEMENT

As per the respective standard, Configuration Management (CM)[3] is a management discipline that applies technical and administrative direction to the development, production and support life cycle of a configuration item. This discipline is applicable to all the systems of the product (reactor), its components, hardware, software, processed materials, services, and related technical documentation.

The main objectives of Configuration Management are:
- To document and provide full visibility of the reactor's current configuration and its physical and functional status.
- To ensure that everyone working on the RRRP at any time in its life cycle uses the correct and accurate documentation.
- To define which is the scope of each Configuration Item (i.e. System, Subsystem, Components or Parts).

The starting point for the successful application of CM, is the definition of Configuration Items (CIs). CIs are progressively defined as long as the design evolves. At the end of the detail engineering, the CI set is completely defined.

Once that set is defined, there is a committee that addresses the need for changes in any CI. Each time a parameter, property or characteristic of the CI is changed; a process for notification to all the parties interested is started.

To such effects, INVAP has developed and put in place a set of software tools based on the management of the following databases:
- Project General Data or Design Database
- Equipment Database
- Documentation Database
- Drawing Database
- Spare parts database

These databases are all interconnected in such a way, that if a design parameter is changed, an automatic instruction is generated to all the interested parties— including subcontractors— in order to actualize the corresponding equipment database— identified by its tag-, the project documentation and drawings database and the spare parts database.

This process on goes during construction reflecting construction modifications, non conformances or design change notices, and ends up at the end of the project with a set of project documents completely coherent and ‘as built and commissioned’.

XI. INTEGRATED LOGISTIC SUPPORT

The purpose of implementing an Integrated Logistic Support (ILS)[4,5] for a reactor facility is to guarantee reactor availability and the implementation of a safe and cost-effective support system.

ILS is intended to cover management and implementation requirements for the relevant equipment affecting reactor facility availability and radiological and industrial safety during:
- Design
- Procurement
- Construction
- Commissioning
- Initial support period
- Follow-on support period
INVAP presently design facilities with a target availability factor of 90% throughout the facility life cycle. Planned and unplanned maintenance activities can not go over the remaining 10%, number which is really low, even for production facilities.

To such effects, the dedicated ILS groups stages its work in 3 main different areas:
- ILS Requirements in the Design Phase (which includes specification, assessment and analysis on Reliability, Maintainability, Supportability, Availability).

ILS relies in and shares, many tools developed for Configuration Management – databases and processing utilities and interfaces-. That way, the duplication of effort is aborted, and again the management approach is based on the integrated concept.

**XII. RISK MANAGEMENT**

Risk Management (RM)[6,7] has been an implicit task within project management groups. Project Managers, Discipline Managers and Group Managers, in the performance of their duties, implicitly evaluated risks and therefore implemented contingency measures.

INVAP has developed and applies a policy, a plan, a method and the procedures to perform explicit Risk Management from the tendering stage, through pre-contract negotiations up to project execution and completion.

The main goal of RM is to serve as a proactive tool in order to:
- Identify, prioritize and track events for risks, regardless of their nature or origin (internal or external to the project, technical or non-technical)
- Analyze their impact and probability
- Evaluate and rank above events based on their resulting risk
- Treat the events ranked as major, high or extreme risk with its corresponding mitigation plans
- Generate special contingency plans and countermeasures to mitigate adverse risk effects, and
- Plan for the availability of adequate resources to handle risk.

INVAP handles 5 levels of risk: from negligible, to extreme through low, medium and high. Negligible and low risks are handled through normal company procedures. Medium and high risks require senior management attention and the implementation of a contingency plan. Extreme risks require immediate top management action.

When required –due to the importance in the area, the subcontract or project phase-, explicit risk management is required from our subcontractors.

INVAP handles project risks through a simple in house developed tool called the ‘GDR’ (acronym for ‘Gestión de Riesgos’) fully integrated with the risk management software. In this GDR tool, the risks events, their evaluation and the contingency / mitigation plans are depicted, followed up and updated.

When a risk is identified and evaluated, the course of action is very simple: either we accept it, we avoid it, we control it or we try to transfer it to a qualified subcontractor or consultant.

All the Risk Management process is designed to be fully auditable.

**XII. SAFETY & LICENSING**

Usually the Safety and Licensing effort and the way it is tackled by INVAP deserves a full paper
and a presentation by itself. Just for the purposes of clarity let us briefly mention that:
- safety and licensing issues are one the main sources for schedule delays if not properly handled,
- therefore, effective safety and licensing is one of the highest single factors for contract risk,
- again, the best way to proactively work in this arena is with an up front comprehensive Safety and Licensing Plan, proposed and acknowledged between the main three (and regulated) parties: the Installation Owner or Licensee, the Main Contractor and the Regulator itself.

When putting in place and agreeing on such a plan, the preparation and submission of safety reports, design and quality assurance documentation and, inspection and test documentation, is the best way to reduce uncertainties and schedule risks to a minimum.

XIII. TECHNOLOGY TRANSFER

INVAP truly believes in technology transfer as the key for a successful and efficient use of the installations we design and built. After all, they should last and perform for 40 years. For every project and for the Australian case too, we seek the participation of the Customer personnel in every stage of the effort, especially basic design, detail design and construction activities. This also applies to subcontractors in order to have a very efficient interface control and good results. Again, at the very beginning of the project, a Technology Transfer Management Plan is outlined and subsequently implemented and updated depending on the dynamics of the project, detail project needs for each phase and customer preferences. For the case of Australia thousands of man hours have dedicated to this task and as always it paid the effort: it also helped in overcoming any natural language, idiosyncrasy and cultural barrier.

XIV. PROJECT EVENTS: EXPERIENCE

Compared to the big traditional players of the nuclear industry INVAP is a medium to small size Company. This, rather than being a detriment makes us more efficient, transparent and diligent. Company values and vision are much easily permeated to our structure and to our people and also, to our chain of suppliers too.

INVAP in all these years had always to overcome (just to mention a few) important factors:
- not having a subsidy of any kind like a local captive market, not to mention direct subsidies of other kind
- difficult access to credit and government financing
- non tariff barriers and restrictions to compete in certain markets.

Despite above, in the last 20 years we have exported 6 Research Reactors, 3 Radioisotope processing plants and many more small facilities and high tech supplies. We have accumulated close to 500 MUSD in exports and in doing so, always adhered to non proliferation (for example designing always for high performance but based on LEU use).

Effective, efficient Project Management (or the way to do it) has been a key ingredient to above.

XV. RESULTS

Project RRR has been under effective contractual execution for 6 years. Previously, the tendering process took for INVAP another 2 years of related work. Aside, from pure technical matters, our Customer (ANSTO) has been and is constantly monitoring, project management capabilities, skills and results in order to be sure the ‘Contractor’ (us) can deliver. For the past 8 years, in house adapted (and adopted) PM methods and techniques, Management structure and, organization and procedures, have allowed INVAP, its many important subcontractors and ANSTO to:

- Reach all the milestones contractually agreed.
- Accomplish with the all the project phases, in time, within budget and with the highest quality from basic engineering through detail engineering, up to Cold Commissioning and installation turn over, phases which have all been accomplished.
• Prepare and deliver to the Australian regulatory body one of the most comprehensive safety reports ever assembled for installations of this type, which on top went through the review of many external consultants and experts, plus the scrutiny of public in general and its discussion on public hearings. All this process, which involved the community, has been particularly exemplar and transparent. No flaws to the design have been found by any one of the reviewers and advisors, nor even by the opposing anti nuclear groups.

• Design, manufacture and test several of the key technological concepts in specifically built mock ups in order to reduce risk exposure and assure the contracted facility performance through its life time, as well as develop and prove well in advance, construction techniques to save time and commissioning effort.

• Confront and overcome many risky situations like the economical and financial panorama in Argentina without jeopardizing any of the Contractual commitments.

• Confront the pressure from anti nuclear groups that constantly opposed the project and our Company (with of course ‘active’ actions).

• All along this process, to maintain a very good relationship with ANSTO and our subcontractors, with all the parties involved not ever claudicating in their objectives and goals but aligning them into the ultimate achievement: to make of the OPAL a first of kind world reference Research Reactor.

XIV. CONCLUSIONS

The overall conclusions are that:

• Every single Customer in the world not only seeks for better – high quality, cheaper and effective solutions, but for a Contractor that ‘can deliver’.

• The equation to satisfy such requirement implies that aside from pure technical and economical considerations, effective Project Management is a must in every project.

• The up front effort invested by INVAP in the generation of accurate project views and their ‘state of the art’ PM approach is well paid off by project results: it is cost effective, meets quality and performance requirements and timely delivers a high quality product as per planned schedule.

• INVAP’s view and organization well suits worldwide standards (ISO 9001:2000, ISO 14000, NQA-1, IAEA, others) as well as almost any local standard with a very minor adapting effort.

• INVAP can fulfill and meet any market requirement for local content through extensive partnering agreements and real technology transfer programs.

• INVAP Project Management organization and operative principles are applicable to projects with a very different nature by themselves: from nuclear to space oriented projects, going through industrial, environmental, medical, or even military, domestic or for overseas markets, in well developed or in under development countries,

• INVAP strategy allows for the effective handling and integration of many local and overseas subcontractors meeting integrated logistic support requirements and applying configuration management control.

• INVAP present PM organization routinely employs simple but very effective Risk Management techniques for risk control and mitigation during every stage: from tendering preparation through contract negotiations and well into project execution.

It is INVAP intention and goal to project ahead these effectively developed and integrated Project Management techniques in conjunction with its technical capabilities in the nuclear, industrial and space arena, in such a way that could and should benefit new high tech projects, new and ‘old’ customers and their home countries.

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