NUCLEAR POWER PLANT ANGRA 3
INTEGRATED ENTERPRISE MANAGEMENT SYSTEM

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ABSTRACT

The characteristics and peculiarities of the Nuclear Power Plant ANGRA 3 enterprise, amongst which its technical complexity, the size of the project and of the supplies of goods and services contracted for for the Brazilian and foreign scopes, the variety of contractors and participants involved in the implementation, associated with the need of integrated management of all the activities of the enterprise, requires the setting of standardized criteria and procedures to be adopted by the enterprise Project Management Team and by all involved Eletronuclear (ETN) Units, Suppliers and Contractors for Brazilian and foreign goods and services for the execution of the activities related to overall enterprise planning. These criteria and procedures aim at covering the five Project Management Process Groups: Initiating Process Group, Planning Process Group, Execution Process Group, Monitoring and Controlling Process Group and Closing Process Group. For the ANGRA 3 enterprise, ETN developed the Integrated Enterprise Management System - INTEGRA, being the software “Primavera Enterprise Project Management” a fundamental part of this system. The aim of this paper is to describe the main concepts involving the ANGRA 3 enterprise management, and the integration between the processes, including all disciplines in all phases of the enterprise life cycle, such as: Nuclear and Environmental Licensing, Infrastructure, National and Foreign Engineering, National and Import Supplies, Civil Works, Electromechanical Erection, Commissioning.

1. INTRODUCTION

In parallel with the countless economic and financial viability studies performed for the enterprise ANGRA 3 in the past [1][2], cost estimation, cost budgeting, tariff calculation, formal approval by the Brazilian Government, preparation of the documentation (Environmental Impact Study – EIA and Environmental Impact Report - RIMA) for obtainment of the Installation License (LI) from the Brazilian Institute of the Environmental and Renewable Resources - IBAMA and the documentation (Preliminary Safety Analysis Report - PSAR) for the Construction License (LC) from the Brazilian National Nuclear Power Commission - CNEN, the ANGRA 3 Project Management Team has set up the Planning, Monitoring and Controlling Process Groups for the enterprise, using as a tool the Primavera Enterprise Project Management for the physical planning, monitoring and controlling and the SAP/R3 system for monitoring and controlling of the economic and financial aspects (planned budget versus realized budget).

At present, this concept is being implemented by the Project Management Team for the life cycle of the enterprise: Licensing, Infrastructure, Engineering, Supplies, Civil Works, Electromechanical Erection, Commissioning etc. The directives established by the ANGRA 3 Project Manager are described in detail in a manual: INTEGRA – Integrated Enterprise Management System – Primavera Enterprise Planning Manual [3]. This paper intends to give a brief description of this concept.
2. STRATEGY FOR ENTERPRISE PLANNING AND CONDUCT

The planning system for the ANGRA 3 enterprise and for its characteristics, was defined on the basis of the premises below [3]:

- Planning and controlling in decentralized projects (e.g. Infrastructure, Nuclear and Environmental Licensing, National and Foreign Engineering, National and Import Supplies, Civil Works, Electromechanical Erection, Commissioning and Demonstration Tests of the Plant etc)
- Full integration of all decentralized projects.
- Project updating in a decentralized manner.
- Ease of communication between the Project Manager, Project Management Team, Project Sponsor, Project Team and Project Stakeholders.

For these reasons, was chosen the Primavera Enterprise Project Management, a multi-project system, as the fundamental part of the INTEGRA.

The ANGRA 3 Project Manager sets the strategy, deadlines and goals deemed as fundamental to the enterprise for each one of its projects based on the prevailing ANGRA 3 General Project Schedule. The structures related to the projects and deadlines are included in a macro project that is provided to the responsible for the detailing.

The Project Management Team in charge detail the projects, at least down to the minimum level of monitoring and controlling set in each specific Contract between ETN and Suppliers and Contractors (level of contractual measurement/payment conditions), according to its own criteria, but respecting the limitations and rules set by the Project Manager. Modifications to any of the restrictions may be accepted, following analysis and agreement by the Project Manager.

After the detailing for each Project, the Project Management Team, supported by the respective Project Team, sets the interrelations with other enterprise projects, so as to promote the needed integration. This integration is marked by interconnections between the activities of different projects.

It is the responsibility of the Project Manager to promote meetings between all of those involved for a perfect and correct definition of the interconnections needed between the several projects from different areas. After the definition and insertion of the agreed interconnections, the resulting project is considered as Schedule Baseline (Baseline Plan 01) for each responsible party.

Due to the fact that the full integration of the projects occurs in a single ETN database (ANGRA 3 Primavera / SQL database), the interconnections between the projects are preserved, minimizing change of files among the involved parts. The SQL database server is located in the ETN headquarters (Rio de Janeiro, RJ) and is the official data repository of all online information coming from Site (Angra dos Reis, RJ) and from Areva (Germany).

3. STRUCTURES

The global structures, defined by the Project Management Team, are used for the whole ANGRA 3 enterprise. The use of the Primavera Enterprise Project Management permits among other things the definition of the following main structures [3]:

- Enterprise Project Structure (EPS).
- Work Breakdown Structure (WBS).
- Organizational Breakdown Structure (OBS).
- Resource Structure.
- Project Codes Structure.
- Resources Codes Structure.
- Activity Codes Structure (Global, EPS, Project).
- Cost Account Structure.

Figure 1 below shows the Enterprise Project Structure (EPS levels 1, 2 and 3) of the ANGRA 3 enterprise. All detailed projects for the life cycle of the enterprise are incorporated in such structure. For instance, only in the branch Supplies (EPS level 2), for National Supplies there are more than 230 projects with a total of approximately 16500 activities, each project representing an individual Contract between ETN and a Supplier. Another example is the projects for the Civil Works/Concrete Structures, each project representing a main Building of the plant such as the Reactor Building Annulus (UJB), Reactor Building (UJA), Reactor Auxiliary Building (UKA), Switchgear Building (UBA), Turbine Building (UMA), etc. For instance, the ANGRA 3 Civil Works Contractor, only for the branch Civil Works (EPS level 2), has developed approximately 45 projects with a total of approximately 18000 activities.

Figure 1 - ANGRA 3 Enterprise Project Structure (EPS)

According to the definition given in the PMBOK® Guide [5], the Work Breakdown Structure (WBS) represents the hierarchical decomposition oriented towards the delivery of the work to be executed by the team involved for attaining the objectives of the enterprise. The WBS organizes and defines the full scope of the enterprise. The WBS subdivides the work of the enterprise into smaller parts, which are more easily managed. Each descending level
represents an increasingly more detailed definition of the work in the enterprise. The
structuring of the ANGRA 3 enterprise was defined with 3 levels in the EPS, where the other
levels for each Project are part of its WBS. The WBS for each Project is specific. Its first
level (WBS level 1) is immediately below the last level of the EPS (EPS level 3).

The Organizational Breakdown Structure (OBS) of the Primavera Enterprise aims at defining
the responsibilities of each ETN Organizational Unit in the conducting of the Projects that
form the ANGRA 3 enterprise. It is not necessarily equal to the company Organizational
Chart, but to the functional chart from the point-of-view of the enterprise management.

Resources can be of three types: Labor, Non-Labor and Material in the Primavera Enterprise
Project Management. The Non-Labor resource type was reserved to build the S_Curve for the
ANGRA 3 Enterprise. In ANGRA 3 contracts, based on unit prices, the Material resource
type is used (e.g. Contracts for Civil Works and Electromechanical Erection). Figure 2 below
shows a Material resource type (Resource ID: MOE03M – Medium Voltage Switchgear >
1kV) and a Non-Labor resource type (Resource ID: CURVA_S => S_Curve) used in the
activity Erection of Medium-Voltage Switchgears 13.8 kV – BBA (Activity ID:
ME01BA0110) in the Project of the Electrical Erection (Project ID: ME01), under Electrical
(EPS level 3) in the branch Erection (EPS level 2).

Figure 2 – Example of a Material (MOE03M) and a Non-Labor resource (S_Curve)

Project Codes are used to organize and group projects in the EPS, to meet the different needs
of the Project Management Team in the enterprise. According to specific Project Code
categories, it is possible to filter, to sort or group projects after the requirements. For instance,
for ANGRA 3 the following Project Codes are used, among others:
• ELEMPEP - interface element between Primavera Enterprise Project Management and
SAP/R3 system (EPS levels 1, 2 and 3).
• ORGEXEC - identifies the organization that executes each Project.
• GERPROJ - identifies the person in the organization in charge for the respective Project.
• PLANRESP - identifies the person in the organization in charge for planning, updating
and controlling the respective Project.
MOEDA – identifies the currency adopted in budgets and in payments (the official currency adopted for ANGRA 3 enterprise was Brazilian Real).

Resource Codes are used to allow better identification of their source, enabling the use of filters, data organization and sorting. For ANGRA 3 the following Resource Codes are used:

- ORGEXEC(R) - identifies the Resources of the Organization that execute each Project.
- GRSUBGR(R) - identifies the Resources for each group of equipment or material.
- PACCPMP(R) - identifies the Resources for each Supply Package.

Activity Codes are a very simple, powerful and efficient way to make easier filter, organize, sort and find an activity or a group of activities in the Primavera Enterprise Management System, which allows the creation of 3 types of Activity Codes:

- Global Activity Code - Standardized global codes, defined by the Project Management Team and applicable to all Projects of the ANGRA 3 enterprise.
- EPS Activity Code - Standardized codes, applicable to all Projects of a particular EPS branch (node) in the ANGRA 3 enterprise (e.g. EPS level 2 – Civil Works)
- Project Activity Code - Standardized codes applicable only to a specific Project.

Figure 3 shows twelve Global Activity Codes associated with the activity ID: ME01BA0110 - Erection of Medium-Voltage Switchgears 13.8 kV – BBA. For instance, Activity Code EAEUSALA shows that the Switchgear referred to is located in the elevation 03, room nr. 26 of the Switchgear Building (UBA).

![Figure 3 - Example of use of Global Activity Codes in the Electromechanical Erection.](image-url)
The Cost Account Structure showed in figure 4 in the Primavera Enterprise Project Management is the same as the one adopted for the SAP/R3 system of ANGRA 3.

![Cost Accounts Table]

Figure 4 - Cost Account Structure (EPS Levels 1 and 2)

The use of Structures and Codes for Resources, Projects, Activities for an enterprise like ANGRA 3, facilitate the issue of reports, filtering, sorting and organizing information with the use of Primavera Enterprise Project Management.

4. EXECUTING, MONITORING AND CONTROLLING PROCESS

All the execution of the ANGRA 3 enterprise should be duly monitored and controlled through a specific monitoring and controlling process, so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary [3].

The Monitoring and Controlling Process Group not only monitors and controls the work being done within a Process Group, but also monitors and controls the entire enterprise effort. It provides feedback between enterprise phases, in order to implement the necessary corrective or preventive actions. The continuous monitoring allows the ANGRA 3 enterprise Project Management Team to have a clear vision of the health of the enterprise and to identify the areas that demand special attention.

The Monitoring and Controlling Process for the ANGRA 3 enterprise is related to:

- Comparison of the enterprise activities carried out to its management plan;
- Performance evaluation to determine if preventive or corrective actions are advisable, and recommend such actions as needed;
- Analysis, tracking and monitoring of enterprise risks (pending development) to ensure that risks are identified, that the progress is reported and that adequate risk response plans are in execution;
- Having an information base that is precise and correct, as related to the product(s) of the enterprise and its associated documentation until its completion;
- Supplying of information to provide support to progress reports, progress measurements and forecast;
- Forecasting to update the present cost and the information on the present schedule; and
- Monitoring of the implementation of approved changes when, and as they occur.
In order to attain the objectives described above, for the monitoring and controlling of the execution in the ANGRA 3 enterprise, the following actions are planned:

- On a monthly basis, the responsible for each project should make the measurements and afterwards they will be duly verified and approved by the respective ETN inspection(s), recording the progress logged in and other data in each activity into the ETN Primavera/SQL database.

- The Project Management Team integrates all projects that have already been duly updated and cleared by the respective ETN inspection(s), and re-calculates, on a monthly basis, the entire set, obtaining the global, updated and integrated, vision of the enterprise. In the applicable cases, the recalculated projects should be analyzed by each responsible, so that they may prepare the scheduling and planned sequence for the service execution. Naturally, each project, individually and as it is required, can be updated with a higher frequency (e.g. weekly). However, its integration by the ANGRA 3 Project Management Team into all the other projects will be done on a monthly basis.

- Should the integrated enterprise calculation show important deviations from the planned goals, the ANGRA 3 Project Management Team, after analysis, and along with the parties directly involved with the deviations, should meet and establish the actions needed to correct or mitigate.

- After the corrections have been implemented, the reviewed projects shall again be evaluated by the responsible and the modified points analysed. The scheduling and the sequence of service execution shall be changed according to these corrections. The modifications mentioned above should be made in the shortest timeframe possible.

- After the corrections, the reports contained in the Communication System, printed and made available in the Intranet/Internet, are issued again for the general cognizance of the ETN and its Suppliers and Contractors.

The definitions of the physical and financial progress measurement criteria to be adopted for the ANGRA 3 enterprise are diverse, based on the phases (Licensing, Engineering, Supplies, Civil Works, Erection, Commissioning etc) and on the disciplines (Systems, Mechanical Components, Civil, Piping, HVAC, Electrical, I&C, etc).

The measurement criteria for physical (in the Primavera Enterprise Project Management) and financial (in the SAP/R3 system) progress to be adopted for the enterprise should faithfully portray the criteria set in the contracts for Engineering, for Supplies, for Civil Works, for Electromechanical Erection, for Commissioning. These contracts are already in place, in re-negotiation or to be executed for ANGRA 3.

The consolidation of the global physical progress of the enterprise, taking into account all the phases and disciplines, is made on a monthly basis via Primavera Enterprise Project Management by the ANGRA 3 Project Management Team. Similarly, the same criteria apply to the consolidation of the global financial progress, on a monthly basis, via the SAP/R3 system.

For the calculation of the global physical progress of the ANGRA 3 enterprise, a weight is given to each EPS branch (node) in the Primavera Enterprise Project Management for the S_Curve, totalling 100% for the whole enterprise. These weights should be constant in the entire life cycle of the ANGRA 3 enterprise, provided no relevant variations occur in its original scope. Only in the case of relevant variations in the original scope, may the weights be carefully re-assessed by the ANGRA 3 Project Manager. Weights may have particular and specific criteria for each Project, with the maintenance of the total value for each Project unchanged, that is, according to the original S_Curve weight.
As the Enterprise Project Structure (EPS) for the ANGRA 3 is assembled in a harmonic manner in the Primavera Enterprise Project Management and SAP/R3 system, the Primavera Enterprise generates reports comparing the physical and financial progress, via importing data, on the same basis, from the SAP/R3 system (EPS levels 1, 2 and 3).

5. COMMUNICATION SYSTEMS

The Communication System for the ANGRA 3 enterprise aims at ensuring the generation, collection, distribution, storage, recovery and final destination of the information in the enterprise in a timely and adequate manner. For that, the Communication System relies on Standardized Scheduling and Analysis and Reports to be issued, distributed and stored on a monthly basis by the ANGRA 3 Project Management Team, in printed or electronic form, as well as material for internal and external disclosure via Intranet and Internet [3].

![Diagram](image.png)

**Figure 5 - Time Schedules hierarchy of the ANGRA 3 enterprise**

The Standardized Scheduling Reports for the ANGRA 3 enterprise are listed below.

- Activity Scheduling for the next Quarter
- Purchase Plan for Equipment and Materials
- Plan for Service Contracting
- Cash Flow for the next Quarter
- Production Plan for the next Quarter

The Standardized Analysis Reports for the ANGRA 3 enterprise are listed below.

- Summarized Enterprise Overview
- Critical Variables in the next Quarter
- Overdue Activities
- Productivity Report
- $S_C$ Curve Global (for EPS Levels 1 and 2)
- Cost Report
6. AUXILIARY TOOLS

As already mentioned, the basic tool used by ETN for planning, scheduling, monitoring and controlling of the ANGRA 3 enterprise is the module Primavera Enterprise Project Management that forms the Primavera Enterprise Suite by Primavera Systems, Inc. This module is the heart of the INTEGRA. The module Methodology Management of the Primavera Enterprise Suite is also used by the Project Management Team for the standardization of work methods in the planning area [3].

The ETN Intranet, through standardized reports published at regular intervals (e.g. monthly) by the ANGRA 3 Project Manager, via the Project Web Site Publisher, is used as an additional source of information by the Project Management Team, Project Sponsor, Project Team, Project Stakeholders and by all other collaborators of ETN, who need to obtain summarized and updated information on the progress of the projects. Similarly, the module Primavera Web Access is also aimed at management, to allow verification and monitoring of the enterprise, but with the possibility of Web Access use.

The main engineering and auxiliary tools used for the ANGRA 3 enterprise, specific for each area that belongs to INTEGRA are listed below.

- For the management of all the Engineering Documentation (approximately 200000 documents) the Electronic Document Management System - SINGED - will be used, a proprietary system now under development by ETN.
- As already mentioned, the SAP/R3 system is the tool used by ETN for the economic and financial control, up to level 3 of the Enterprise Project Structure (EPS).
- The source of data for the Technological Systems of the plant is the object-oriented Computer-Aided Engineering - CAE - engineering system, the COMOS® PT system used for the interdisciplinary preparation of projects for basic end executive engineering. This tool allows the smart preparation of the flowcharts, from Technological Systems to the electrical, mechanical, piping and I&C areas, containing a database with the main technical features (e.g. weight, dimensions, place of installation and other technical data) for these components, or those in piping lines such as valves, special components etc.
- For the design of Electrical Systems and Components the Electrical Systems Design and Documentation System - DESY - are used. For the design, monitoring and control of the cable laying (calculation of the routes for power and control cables, estimates of planned numbers and recording of the numbers executed, documentation on cable laying) the Cabling System - KADIS - will be used. The DESY and KADIS systems are supplementary to each other and were developed by Siemens, specifically for use in electrical system design for thermal or nuclear plants.
- For the design of the Digital Instrumentation and Control (I&C) System, TEC4 system is used as developed by Siemens (Technology Editor-TEC4function; TEC4VT; and Tool for Hardware and Field Engineering - TEC4fde).
• In the civil engineering area, ETN is using the proprietary systems: System for the Preparation of Civil Engineering Form Drawings - FORMAS A3 - and 3D Civil Engineering Project Modelling for ANGRA 3 - FORMAS CIVIL 3D.
• Similarly, ETN is updating for the ANGRA 3 Piping and Supports project the following proprietary systems: Issuing System for lists of materials and project data for Piping isometrics - PC87; Issuing System for Lists of Materials and Project data for Piping Support - SC86; CAD Preparation System for Fabrication Isometrics with the respective Lists of Materials - SIMPLEISO; CAD Preparation System for Piping Support with the respective Lists of Materials - BQCAD; Control System for Documentation, Engineering Services for Piping and Support - FUP - and Non-Destructive Assay Control System for Piping and Supports - TESP, to be used during the project, erection and testing of the piping and support systems, based on the system used during the engineering and erection phase of ANGRA 2 Nuclear Power Plant.
• For Warehouse Control in the ANGRA 3 Site, ETN is also perfecting the proprietary system named Warehouse Handling System for Materials Controlling and Requisition System - WHS.

All these auxiliary tools are part of the INTEGRA system. If necessary, other auxiliary tools can also be incorporated, in future, into this system.

7. CONCLUSIONS

The aim of developing the Integrated Enterprise Management System - INTEGRA - was to standardize criteria and procedures to be adopted by the ANGRA 3 Project Management Team, by all involved ETN Units, Suppliers and Contractors for Brazilian and Foreign Goods and Services for the execution of the activities related to overall enterprise planning, scheduling, execution, monitoring and controlling.

The Project Management Team intended main goal is the mitigation of the risks of an overrun of time and cost, maintaining the quality and improving the integration of the Project Team and all involved organizations during enterprise life cycle, such as: Nuclear and Environmental Licensing, National and Foreign Engineering, National and Import Supplies, Civil Works, Electromechanical Erection, Commissioning and Demonstration Tests of the Plant.

In order to achieve this goal for the ANGRA 3 enterprise, not only a good Integrated Enterprise Management System available but, mainly a great effort and positive engagement of all involved parts and organizations such as Project Manager, Project Management Team, Project Sponsor, Project Team and Project Stakeholders will be necessary.

REFERENCES