Introducing an ILS methodology into research reactors

Néstor De Lorenzo[1] *– Roberto Cervieri Borsani*[2]

Abstract:

Integrated Logistics Support (ILS) is the managerial organisation that co-ordinates the activities of many disciplines to develop the supporting resources (training, staffing, designing aids, equipment removal routes, etc) required by technologically complex systems. The application of an ILS methodology in defence projects is described in several places, but it is infrequently illustrated for other areas; therefore the present paper deals with applying this approach to research reactors under design or already in operation. Although better results are obtained when applied since the very beginning of a project, it can be applied successfully in facilities already in operation to improve their capability in a cost-effective way.

In applying this methodology, the key objectives shall be previously identified in order to tailor the whole approach. Generally in high power multipurpose reactors, obtaining maximum profit at the lowest possible cost without reducing the safety levels are key issues, while in others the goal is to minimise drawbacks like spurious shutdowns, low quality experimental results or even to reduce staff dose to ALARA values. These items need to be quantified for establishing a system status base line in order to trace the process evolution.

Thereafter, specific logistics analyses should be performed in the different areas composing the system. RAMS (Reliability, Availability, Maintainability and Supportability), Manning, Training Needs, Supplying Needs are some examples of these special logistic assessments. The following paragraphs summarise the different areas, encompassed by this ILS methodology.

Plant design is influenced focussing the designers' attention on the objectives already identified. Careful design reviews are performed only in an early design stage, being useless a later application. In this paper is presented a methodology including appropriate tools for ensuring the designers abide to ILS issues and key objectives through the subsequent design stages.

Staff should be allocated to operate the system after assessments based on the workload and safety issues. A methodology for a Plant Tasks Analysis (used as the input for a Manning Analysis Assessment) to define a cost-effective organisational structure is presented.

Training is a key issue to support a well-designed plant. This paper describes general training aspects to be considered in the ILS approach. General considerations to tailor a Training Plan are presented as well as for developing training tools such as Plant Simulators and 3D Electronic Models.

Manuals, procedures and instructions (relevant for system operation and maintenance) are generally developed by designers or operators focussing on technical characteristics rather than considering the documentation framework and training needs. Methodology and general recommendations regarding documents structure and scope to achieve world class plant documents are also presented.

Plant Maintenance should be consistent with in house capabilities regarding the appropriate Level of Repair of each plant item. Reliability, Availability, Maintainability and Supportability assessment methodology is presented in order to focus maintenance activities on relevant issues. Spare parts management is a critical issue and hence is also included in this logistical approach. References regarding optimisation of these and related issues are included.

All the mentioned factors are optimally integrated from the beginning of the process application in order to achieve the major outcomes with the available resources.

[1] Centro Atomico Bariloche – Bustillo 9500 – (8400) Bariloche – Argentina (presenting author)
[2] INVAP S.E. – Moreno 1089 – (8400) Bariloche - Argentina

Introducing the Integrated Logistics Support concept

The ILS is defined as the managerial organisation that co-ordinates the activities of many disciplines to develop the supporting resources (training, staffing, designing aids, etc.) required by technologically complex systems. Although the techniques employed in its application have been used since many years ago, the systematisation of an integral approach in the defence area just begins in the earliest sixties.

The process starts with the issuing of some DoD guidelines, followed by a spin off process ruled by standards and recommendations produced by the US DoD and UK MoD. Some of the documents cited bellow deals with the integral approach and with particular applications and were developed to support the military applications:

- UK MoD Defence Standard 00-60
- US DoD MIL-HDBK-502 and MIL-PRF-49506
- Reliability Prediction MIL-STD 756 and MIL-HDBK 217
- Failure Mode Effects & Criticality Analysis MIL-STD 1629A
- Level of Repair Analysis MIL-STD 1390D
- Logistic Support Analysis Record MIL-STD 1388-2B
- Reliability by Design MIL-HDBK 338
- Requirements for Reliability and Maintainability Def Stan 00-40
- R&M Mod Guide to Practices and Procedures Def Stan 00-41

If the techniques defined in these and other documents are analysed as a whole, it will be clear that the key issue hidden behind them is as follow. “To design or procure equipment guarantying that it will be supportable once fielded and the supporting infrastructure will be in place at an optimal life cycle cost”.

Moving away from the defence area, the whole approach ruled can be compared with the “client satisfaction programs” implemented in several commercial areas. In the same way they pretend to provide a product and the associated supporting structure to satisfy the client requirements at the optimum cost.

With this context in mind our ILS group started the development of a suitable ILS structure to be applied in the Research Reactor Area.

Many differences were clear from the very beginning and required a major adaptation as is explained in the following paragraph:

- The regulatory framework of nuclear facilities is extremely more complex than in other fields. Although a regulatory framework is always present in the development of a project in every area, in the nuclear field a Regulatory Body is always present keeping special attention to the project evolution. Moreover, the regulations and standards to be considered exceed the national framework and abide to international recommendations should also be demonstrated as well.
- The amount of technical documentation produced in a nuclear project is much bigger than in other fields and should be analysed to determine which logistics issues need to be addressed.
- Some physical phenomena (e.g. Xe poisoning) affect the availability in a non-linear way. Regulatory issues sometimes require longer shutdowns than technical considerations.
- Research Reactors (RR) are “One of a kind” products: almost all RR are tailored to the customer needs so they could barely be considered as a base for future projects. Analysis and development costs are afforded by this single unit increasing the cost associated with modifications in the design.
- Many analyses are safety oriented rather than reliability focused.

Nevertheless, some techniques and methodologies are directly applicable or adaptable for using in a nuclear project as it is shown in the following sections.

Starting up the application

The starting point is the identification of the main goals to be achieved by the reactor. Every reactor is generally a plant specially designed to satisfy specific requirements. Within these requirements there is always a mixture between quantitative factors (power, neutron fluxes, etc) and non-directly measurable topics (e.g. supportability).

The technical specifications represent these quantitative factors and are generally taken by design groups to develop or improve the plant systems in order to comply with them disregarding the relevance of the others requirements. The ILS group responsibility is to determine the additional requirements, quantify them and later to induce the design team about their relevance.

As a matter of fact, it is not unusual that many designers minimise the influence of the future cost to be afforded by the customer in spare parts during the components purchasing considering only the technical specifications as the leading parameters to be analysed.

In the application of an ILS approach through different projects, two major “goals” have been identified as relevant for clients:
- to reach a high degree of availability
- to reduce the operation cost to optimum values.

Together with these two paramount objectives (that are surely relevant for all customers), particular interest have been assigned to other issues like: reducing spurious trips, enhancing the readability of plant documents and increase the staff efficiency.

Once the objectives are determined, a clarification of the real meaning of them and a prioritisation should be performed. For example, to define the plant availability when several “products” can be produced simultaneously.

Resembling the military application of ILS where for a “system” is generally requested to:
- produce damage to the enemy
- elude an enemy “attack” and
- survive to this possible attack

A similar list of priorities should be developed for the reactor. For example in a multipurpose production reactor, it will be requested to:
- support full scale production of RI and beam ports.
- keep the reactor at power to carry out some activities although the RI is discontinued and
- guarantee a safe shutdown status for as long as necessary with a minimum maintenance cost.

This prioritisation of outcomes plus certain quantification define the key points to base the ILS implementation and later measuring of the effective application.

The second step is determined by the project itself. For example, if the development will start from the very beginning of reactor design or will be applied to a plant already in operation. In both cases, the tools to be used are different as well as the strategies to implement them.

These two initial steps are enough to develop a management plan where the implementation of further steps are scheduled and defined.

ILS Management Plan

The ILS Management Plan (ILSMP) is the master plan to which abide in order to achieve a cost-effective project without loose ends regarding logistics issues. In other words, the ILSMP shall adapt the ILS theory tailoring it to the real specific needs of the project clarifying objectives, deliverables, dates and involvement.

This plan has to cover the following main topics:

a) Manning (manpower and organisation) to operate the reactor
b) Training of reactor staff and possible users
c) Reactor Operation support (special tools, manuals, procedures, drawings, etc)
d) Reactor Maintenance infrastructure (workshops equipped in agreement with components
e) Spares parts, support equipment and other logistic issues (handling devices, packaging and transportation, etc).

The policies to apply in the development of the projects are also included together with a description of the Managerial Organisation that will implement it. The following items are also assessed:
- Human Resources to implement the ILS related activities
- Main Milestones and deliverables
- Activities Scheduling
- Meetings Agenda

As it has been explained in the previous section, the key objectives are also defined in the Plan and they generally include:
- Target Availability
- Target Reliability
- Assessed Maintainability
- Assessed Supportability
- Other Human and Logistics factors to be met.

Finally, the ILS Tools ready available and those that need to be specifically tailored for the project are referenced in the plan. The following paragraphs list some of them:
- ILS System/Subsystem Classification: in order to graduate the effort efficiently, the system/subsystems are classified in agreement with their relation with the objectives identified.
- General purchasing strategy procedure: to define the logistics aspects to be considered in the procurement of equipment parts, supplies, etc.
- Manuals structure and issuing process: procedures to define from the very beginning the style of document required for achieving the project objectives.
- Spare parts allocation: to capture during the design and further project stages the spare parts required to fulfil the objectives defined.
- Assessments strategy: it identifies the necessary analysis to calculate the required parameters (e.g. global availability, components reliability, etc). The databases used as data sources are also identified and procured if not available (e.g. MTBF, etc).
- Training requirements: an outline of the training plan for reactor staff as well as internal training (e.g. for manual issuing, ILS procedure application, etc)

ILS procedures during Design Stages

The traditional approach when designing a nuclear facility is to complete all design issues prior attempting to solve the logistic aspects concerning training, operation and maintenance. In this approach the logistic support issues are included early enough in the design stage rather than evaluating them in the final project stages when will not be cost effective.

Plant Design is subjected to assessments in order to determine if the design meets the ILS requirements expected by the customer. These assessments will have a positive feedback in the design producing modifications in the same way than technical reasons (e.g. results from prototypes). It should be noted that these are only assessments and the designers are responsible for providing the appropriate solution. Some of these assessments are:

ILS Checklists
ILS organisation supplies to each design group a project tailored questionnaire regarding those details beyond the technical aspects that need special attention from designers in order to satisfy completely the final user requirements. These details involve to check the designer involvement in provide a “product” with an adequate HMI, all addressed maintainability and supportability issues as well as appropriate documentation. The ILS Group executes an

adequate follow up of the information retrieved with these checklists tracking the advance in the design process. This information is also used to verify the degree of standardisation and to predict the special tools and spare parts requirements.

Reliability, Availability, Maintainability and Supportability Assessment (RAMS). The processes are analysed using the Blocks Diagram technique in order to determine the overall Mean Time Between Failure and to verify that the Availability requirement is met. This assessment not only considers the plant reliability but also the maintenance and support features that permit to resume operation as soon as possible in case that a failure conducting to an Availability loss occurred. The data set used in this assessment is obtained from the sources (databases) identified in the ILSMP and used by the project team. The values used should be consistent with those requested in the purchasing process and verified in the fielded component.

Specific Questionnaire on Systems and Subsystems affecting availability
ILS group analyses the design focusing attention in those features regarding operation and maintenance in order to detect potential difficulties that may degrade availability or maintainability. Disassembly routes for heavy or big equipment are thoroughly analysed in order to determine if all the sequential steps to remove a component from the plant are possible and which extra resources are needed to accomplish the task.

Manning
Manning consists on defining a suitable organisational schedule in order to accomplish the duties during plant operation and to manage minor emergencies, i.e. those which are limited up to the plant perimeter. The output of a Manning Analysis is the organisational schedule and the required input is a Tasks Analysis Assessment to determine which the expected tasks in plant will be. Then, the quantity of personnel in each position as well as qualifications and skills are defined based on experience and engineering judgement among other facts.

Training
Training is a key issue for obtaining all the profit from a well designed plant. Once the tasks are identified this constitutes the input for the Training Needs Analysis Report, whose output shall be the training needs for each position defined in the Manning Analysis as well as the required skills and background for receiving specific training. Then, a Training Plan is developed in order to meet the training objectives.

Training aids are specifically developed and tailored to the project needs such as a Plant Simulator to train operators safely prior allowing them to operate the plant. Another example is a virtual 3D model that with the technologies available presently can be easily navigated allowing queries and links to all kind of documents at a mouse click distance.

Documentation describing the plant as well as the one for operation and maintenance purposes is issued bearing in mind that they shall also meet the training requirements. In this way it is ensured that plant documentation and training documentation is coherent and continually updated.

Equipment database
The plant components are permanently fed in an equipment database during design stage. The relevant characteristics can be retrieved at any moment from this database, facilitating the standardisation process since every designer is in knowledge of the components being used in other system. This database is also useful in the tagging process since validation rules prevent from TAGs duplication.

ILS procedure during procurement and installation

The components being purchased shall be specified from the logistic point of view with the same strength as from technical aspects. Moreover, the logistic issues shall be considered to select an option between different tenders. Among the requirements included in a quotation are: Life Cycle Cost (LCC) assessment, special tools and recommended spare parts, supporting technical documentation, delivery time, after-sale support, etc.

During the installation and commissioning stage the ILS major activities are:

- Labels verification
- Documents accuracy (as-built)
- Final training support to initial plant staff
- Stocks and inventories verification
- Hand over process

Plant documentation: Manuals, Procedures and Instructions

Plant documentation needed to train, operate and maintain is grouped within a hierarchical structure, whose main groups are QA, Engineering Procedures, Design, Licensing, Health Physics, Training, Operation, Emergencies, and Maintenance.

An exhaustive Preliminary List of documents is defined from the early stage. The objective is to avoid that a system or subsystem could have defective associated documentation or no documentation at all. At later stages, some documents could be merged or eliminated if necessary, since a list too long difficult to manage. On the other hand if it is too short, whenever a part of a document needs updating, the whole document shall need the same.

Since manuals are key for training, operation and maintenance they not only need to contain accurate and complete information but must also be written in a comprehensive style as well. It worth to focus enough effort on developing adequate manuals structures and expected content summarised in guidelines in order to achieve standard documents with high quality content.

Manuals should include as much graphical aid as possible, i.e. procedures should be accompanied with flow diagrams, simplified P&ID's, tables, etc.

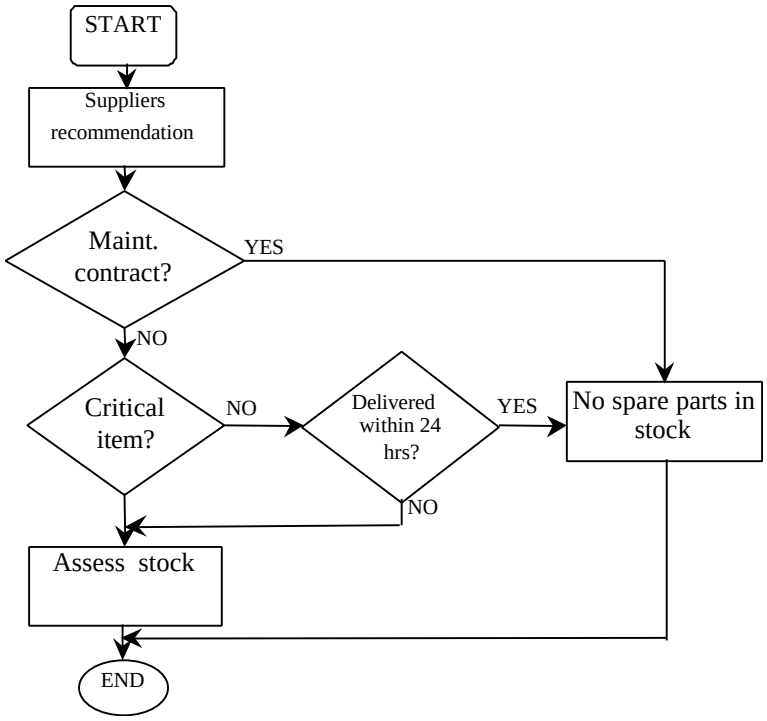
ILS issues the integrated plant manuals (higher level documents in the already mentioned hierarchical structure): Plant Operation Manual, Plant Maintenance Manual and Plan Design Manual

Plant Maintenance and Spare Parts

The maintenance policy to be used during the reactor lifetime is already defined at the beginning of the project in the ILSMP. In this way the designers are in knowledge of the degree of support that their systems will be able to receive in-situ. At the same time this policy allows the addressing of workshops equipment and the manpower required for keeping the plant maintainability in the required values. Both thinks are later used in the level of repair analysis (LORA) which shall be applied to every system to detect the minimum replaceable unit. This shall be a needed input for the spare parts stock calculations.

The Plant Maintenance Plan summarises in an unique schedule all maintenance schedules and needs for all plant systems and components identified with the above-mentioned analysis. Mean Time Between Failures, Mean Time to Repair and other statistical estimators help to allocate the frequency of scheduled maintenance tasks and also the expected spare parts demand in order to define the corresponding stocks levels.

In order to achieve cost-effectiveness, i.e. not too large stocks nor to run out of critical items, a careful analysis has to be performed. The starting point is the spare parts list suggested by suppliers. Procurement time is also a very important issue. If an item presents a procurement time, which is incompatible with availability requirements, this shall be a stock item and the stored quantity shall be assessed. The Spare Parts allocation procedure used in ILS approaches is depicted bellow.



Conclusions

The ILS methodology applied systematically in the design or refurbishment of research reactors allows tailoring the plant in an effective way to achieve the customer needs. The integration of logistics considerations and technical issues early enough in the project is worthwhile since will facilitates the future plant utilisation at a minimum LCC.

The tools developed for other fields could be adapted to work with the peculiarities of nuclear projects if the project objectives are clearly defined from the very beginning. An ILSMP is the document that summarises and integrates the application of these tools in order to follow the project evolution and to trigger timely corrective actions if project objectives are being disregarded.

The induction of the project staff (managers, designers, etc) in the advantages of an integrated approach between logistics issues and project requirements needs to be addressed at early stages. This is implemented as “induction meetings” that should include a variety of examples to demonstrate that the final goal is to facilitate the staff activities providing adequate and useful tools which when applied, will ensure complete satisfaction for the client.