A Software Factory for the Canadian Government Year 2000 Conversion Program

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Abstract

A Year 2000 software Factory has been established, in Canada, to re-engineer major systems of the Canadian Government mainly for real-time embedded systems. This paper is divided in three sections. In the first section the elements of a software factory and its implementation in the Factory are described. In section two the Year 2000 conversion process is described. Finally, lessons learned are presented.

Elements of a Software Factory

As described by Cusumano [1], the main elements of a software factory are: strategic management and integration and planned economies of scope, commitment to process improvement, product-process focus and segmentation, process-quality analysis and control, tailored and centralized process R&D, skills standardization and leverage, dynamic standardization, systematic reusability, computer-aided tools and integration, and incremental product and variety improvement. In the following paragraphs, each element will be described, and its application to the Year 2000 software conversion factory will be discussed.

Strategic Management and Integration and Planned Economies of Scope

Economies of scope require sharing of resources such as processes, methods and training programs across different projects. Also, economies could be realized when work products, such as specifications, plans and executable software components are properly developed.

In the software factory, the application domain has been selected especially to maximize economies of scope. The expertise developed, by one factory member when developing and improving its main product over the years, has been selected as the factory application domain: i.e. real-time embedded systems.

Commitment to Process Improvement

Commitment from top management is essential to ensure time and engineering resource allocation. Also, top management support is essential for long term investments necessary in any process improvement initiative.

In one factory member, top management has committed since 1992 necessary resources for the development, implementation, integration and deployment of processes. Top management commitment is also demonstrated by the approval of organizational policies regarding process improvement activities.

Product-Process Focus and Segmentation

One criterion for a successful factory is to focus on specific products. Processes can then be tailored to selected products.

The software factory decided to focus on real-time embedded products. Processes, methods and tools supported by appropriate training have been developed or acquired to address this domain.

Process-Quality Analysis and Control

The development, selection and acquisition of processes, methods and tools require a careful study of data in a specific application domain. This data should foster a greater predictability in quality, cost and schedule.

In the software factory data has been collected, on real-time embedded systems projects. Data collected is used to prepare software development plans where quality levels, cost and schedule are estimated within an expected range of accuracy.

Tailored and Centralized Process Research & Development (R&D)
Process R&D, methodology and tool selection, when centralized at a level above individual projects, raise the potential of optimization for a specific application domain. Being centralized just above individual projects, tailoring approaches can accommodate a wide range of projects.

By focusing the software conversion factory on real-time embedded applications, knowledge captured by one project could easily be incorporated in processes and methods such that future projects would benefit from previous experiences.

Skills Standardization and Leverage
Training on common processes, methods and tools is mandatory in an era when industry is short of experienced software engineers and software managers. Also, standardized training greatly facilitates the development of a common culture amongst different projects.

In the software factory, every new employee has to go through a set of courses covering broad software engineering concepts as well as training on specialized processes such as the Year 2000 conversion process for real-time embedded systems. Also, some team training is provided in order to accelerate the collaboration and communication required in any complex project. In the factory, expertise from local universities is used either to teach or develop training material on selected topics.

Dynamic Standardization
A formal process to periodically review and update processes, methods, tools and training is needed in a world of moving technology.

In the software factory, a process has been developed to capture, at major milestones, lessons learned. Once validated, the lessons are used to modify the process asset library of the conversion factory. Similarly, root cause analysis sessions are held to make sure that problems are resolved once for all.

Systematic Reusability
Reusability is one way of increasing quality and decreasing cost and schedule. However, reusability does not happen by itself. It has to be planned and formalized in a process. Methods and tools have to be developed. Training sessions and reward mechanisms have to be developed in order to promote a culture where projects will produce and use reusable artifacts. In other words, developing means by which individuals will move from a “not invented here” culture to a “not reinvented here” culture.

In the software factory, a process asset library captures, as they are developed and approved, work products such as project plans and tailored processes.

Computer-Aided Tools and Integration
Like many industrial factories, tool standardization, work mechanization and automation are essential to increase effectiveness. Also method and tool integration are important ingredients.

In the software factory, the process asset library stores the conversion tool suite. No project managers are allowed to acquire tools unless project requirements cannot be fulfilled with existing Factory tools.

Incremental Product and Variety Improvement
Once processes are deployed and used consistently, when a product achieves a certain maturity level, incremental improvements to both process and product could bring substantial gains.

In the software factory, at least for the next few years, the focus will be on Year 2000 conversion. Therefore, new products will not be developed. The factory will convert, from different customers, similar systems such as radars and communication systems. By concentrating processes, methods and tools in one application domain such as real-time embedded systems, expertise gained on a particular system will be transferred on future projects. Additionally, identical systems from different customers will be converted. Therefore, the expertise gained on the first system will be used for the others.

Year 2000 Software Factory Process

To solve the Y2K problem for any level (system of systems, system, sub-system, or components of a system), a global system engineering approach is necessary, supported by other processes when applicable. Rigorous planning must be done at all levels and all work products must be submitted through disciplined formal peer reviews (inspection) in order to detect and address the maximum number of issues.

The Factory has adopted an integrated discipline approach for management and execution of all software-systems engineering activities of the company. To that effect, various inter-related processes have been developed and documented which now serve as a basis for all projects requiring engineering participation. Those processes, fully compliant to ISO 9001, Project Management Institute [2], Software Engineering Institute (SEI) Software Engineering Capability Maturity Model [3], and Electronic Industry Association Standard 731 on Systems Engineering Capability Model [4], consists of the following:

- Systems Engineering Process;
- Software Maintenance Process;
- Software Development Process;
- Software Re-engineering Process;
- Software Quality Assurance Process;
- Software Configuration Management Process;
- Documentation Management Process;
- Document Inspection Process;
- Project Management Process;
- Procurement Management Process; and
- Staffing Management Process.

Management of Year 2000 Activities

The Factory Project Management Process

The Project Management Process (PMP) is organized into five groups (i.e. PMP 100 to PMP 500) of one or more processes each:

- PMP 100 - Initiate project — recognizing that a project or phase should begin and committing to do so.
- PMP 200 - Plan project — devising and maintaining a workable scheme to accomplish the business need that the project was undertaken to address.
- PMP 300 - Execute project — coordinating people and other resources to carry out the plan.
- PMP 400 - Control project — ensuring that project objectives are met by monitoring and measuring progress and taking corrective action when necessary.
- PMP 500 - Close project — formalizing acceptance of the project or phase and bringing it to an orderly end.

The five process groups are linked by the results they produce—the result or outcome of one becomes an input to another. Among the process groups, the links are iterated—planning provides executing with a documented project plan early on, and then provides documented updates to the plan as the project progresses. These connections are illustrated in Figure 1. In addition, the project management process groups are not discrete, one-time events; they are overlapping activities which occur at varying levels of intensity throughout each phase of the project.

Description of the Year 2000 Conversion Process

Overview of the Conversion Process

The Year 2000 Process is divided into five major phases: Phase 0: Awareness; Phase 1: Assessment; Phase 2 Conversion; Phase 3 Test & Validation; and Phase 4: Deployment. In addition to the activities performed in those phases, there are activities related to Program/Project Management and Engineering that are performed continuously as background activities.

The Awareness phase main objective is to distribute information about the Y2K problem and its potential solutions and insure awareness/commitment from stakeholders. The Assessment phase, phase 1, evaluates the scope of the Y2K problem for a specific system and recommends solutions through a business case. The Conversion Phase, phase 2, executes the solution proposed as the result of the Assessment phase up to the point where the solution must be tested and validated, which is done in the Test & Validation phase, i.e. phase 3. At last, phase 4 ensures that the tested and validated system is correctly deployed in its final environment, including all the required training to the users, when applicable. Figure 2 gives an overview of the Y2K conversion process.

Phase 0 - Awareness.

The Awareness Phase is performed to support the customer in preparing, maintaining and disseminating Y2K information. The Awareness Phase is shown in Figure 3.

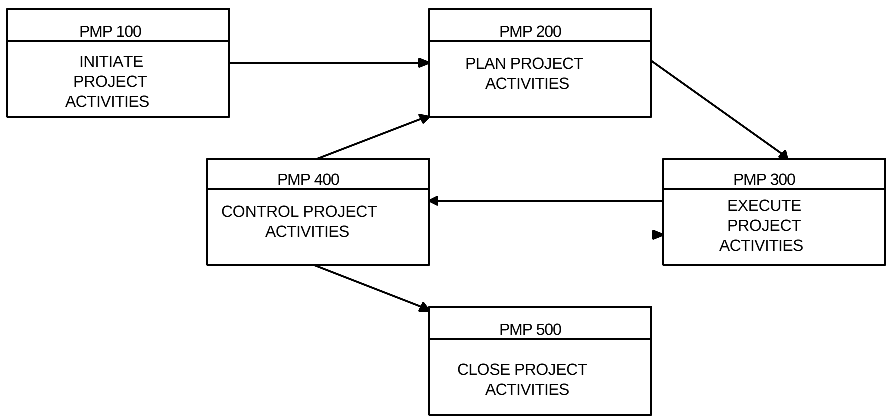

Figure 1. Factory Project Management Process

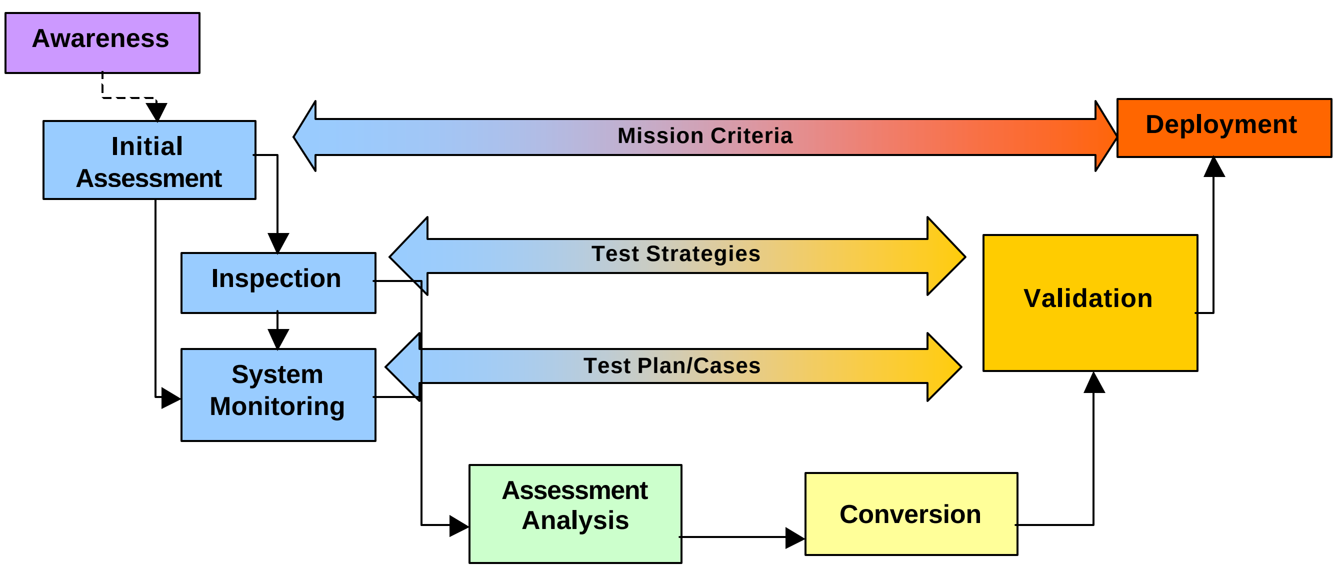

Figure 2. Overview of Year 2000 Conversion Process

The Awareness Phase is composed of the following major activities:

- **Obtain Stakeholders Support**
  To be successful in addressing Y2K, the Team will endeavor to provide the critical information so that the customer's senior leadership can understand and vigorously support efforts to resolve Y2K. Without buy-in from the top, all Y2K efforts will be difficult and the acquisition of required resources, all but impossible.

- **Establish the Project Team**
  The first step of the Team approach in attacking Y2K is to establish a full time Project Team (possibly several Project Teams: for example, one in each application domain category).

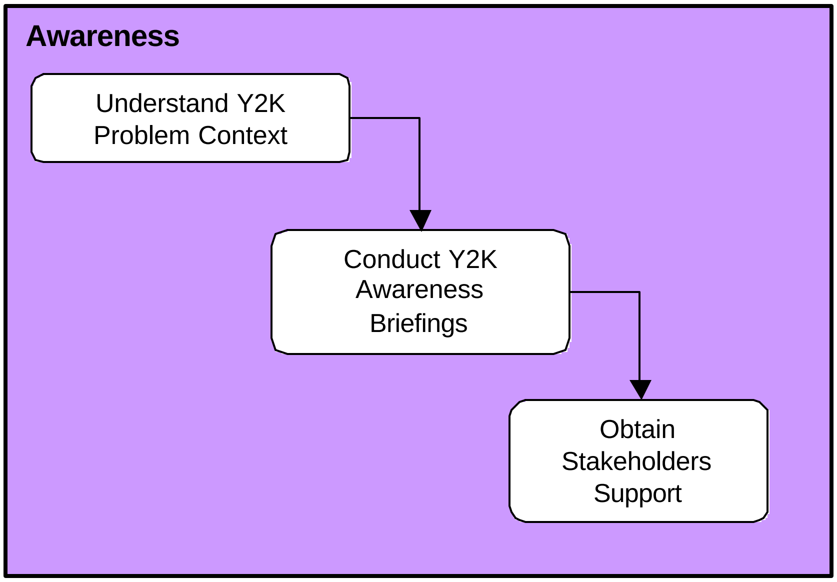

Figure 3. Awareness Phase

- **Customize Year 2000 Process to Customer's needs**
  The Year 2000 Project Team must decide early on an overall approach, which must be publicized throughout the customer organization.

- **Make Oral and Written Presentations**
  To successfully promote awareness throughout an organization, the Team proposes that the Y2K project team establishes a presence by providing oral presentations to personnel at every level.

- **Identify Technical and Management Representatives**
  The Team fully understands that identification of all technical and management points of contact (POCs) is critical to successful Y2K resolution. This includes system managers, budgeting and resource personnel, legal representatives, senior management, and of course contractors and other external contacts.

- **Make a Business Case**
  A business case must be developed for each system as well as for the organization as a whole. The organization's entire inventory of systems will need to be examined and a decision made on the importance of each one to the business. Some systems may be terminated at this point because of their low relative importance to the organization.

- **Train on Y2K Problems/Solutions**
  The Factory Team will identify and educate as soon as possible the customer Information Technology (IT) community. They need to know what Y2K is and how it can potentially affect them.

- **Start Preparation of a Global Project Plan**
  Even with incomplete knowledge of Y2K costs and schedules, it is important that meaningful work begins as soon as possible. It is advantageous to have a high-level organizational management plan which includes things such as: a brief statement of the situation, Y2K objectives, Y2K management strategy, and assignment of responsibilities.

Phase 1 - Assessment

The assessment Phase is composed of four major tasks: Initial Assessment, Inspection, System Monitoring and Assessment Analysis.

Task 1: Initial Assessment

There are two objectives for executing this task. First, inform the Customer on his potential Year 2000 problems by analyzing the information gathered in order to classify every system/component's compliance, assess the risk and define contingency plans. Second, estimate the effort needed to perform the next step which is the Year 2000 Inspection task for systems components that are not Year 2000 compliant. This task is illustrated in figure 4.

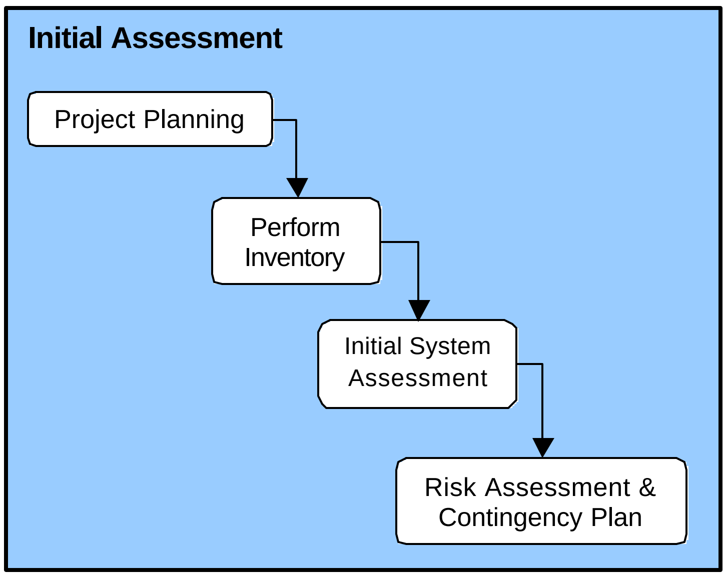

Figure 4. Initial Assessment

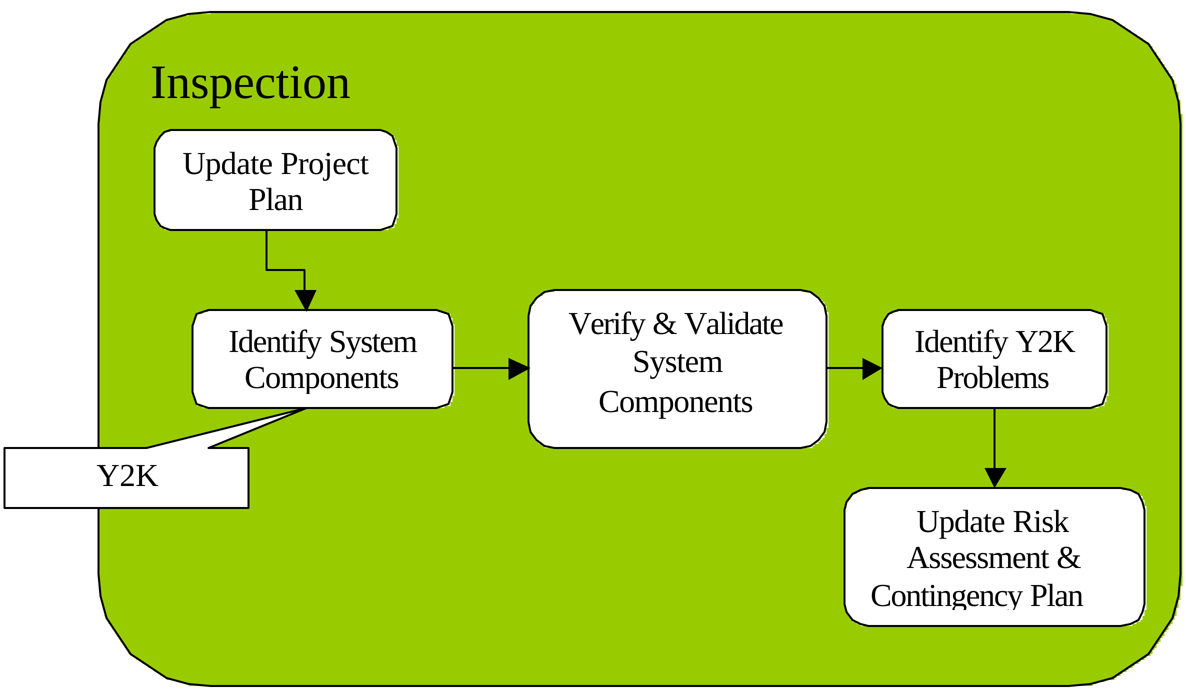

Figure 5. Inspection Task

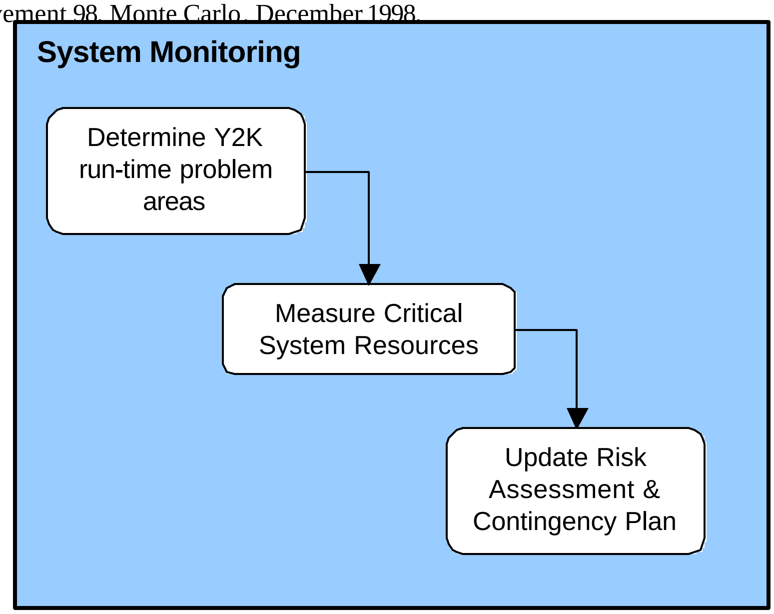

Figure 6. System Monitoring Task

Task 2: Inspection

Whereas the Initial Analysis task on a system is made at a high level, the inspection of the system consists of lower level analysis: the Inspection task analyses, in details, the system to identify Y2K problem areas. Figure 5 below shows the Inspection Task

Task 3: System Monitoring

The System Monitoring task, as illustrated in figure 6, applies generally to real-time systems, which can be found in real-time embedded systems such as: Systems & Battlefield Surveillance Systems and Command, Control, Communications and Intelligence Systems. Since some Management Information Systems (MIS) are not real-time, this task may be skipped for these systems.

Real-time systems generate some action in response to external events. To accomplish this function, they perform high-speed data acquisition and control under severe time and reliability constraints. Because these constraints are so stringent, real-time systems are frequently dedicated to a single application. Since those systems are usually very dedicated and specific, the Team proposed a case-by-case monitoring strategy to address the customer needs (no silver-bullet solution).

Task 4: Assessment Analysis

The main objective of the Assessment Analysis task, as illustrated in figure 7, is to analyze the results of the previous tasks (Initial Analysis, Inspection and System Monitoring), identify if there are Y2K problems and recommend a solution for fixing the Y2K problem. Based on this recommendation, the customer will have to make a critical decision at the end of this task (convert/modify, replace or retire system). The appropriate Y2K solution strategy is determined at this stage with the help of a business case.

Assessment analysis task is one of the most critical task of the project, as it builds the foundation for all the remaining work. The assessment analysis task uses all the detailed information received from the inspection phase to upgrade the Y2K global strategy defined during the Initial Assessment phase. The planning includes technical aspects such as partitioning, conversion, bridging, testing, retrofit and implementation strategies. It indicates tools used in the process, needed human resources and facilities. The partitioning insures that all interrelations between partitions and needed bridges are identified. The bridging strategy then explains how the needed bridges will be implemented and managed. During this stage, a business case analysis is performed. The business case will give you the opportunity to be able to analyze any issue in a fair, logical and rational way to improve decision making.

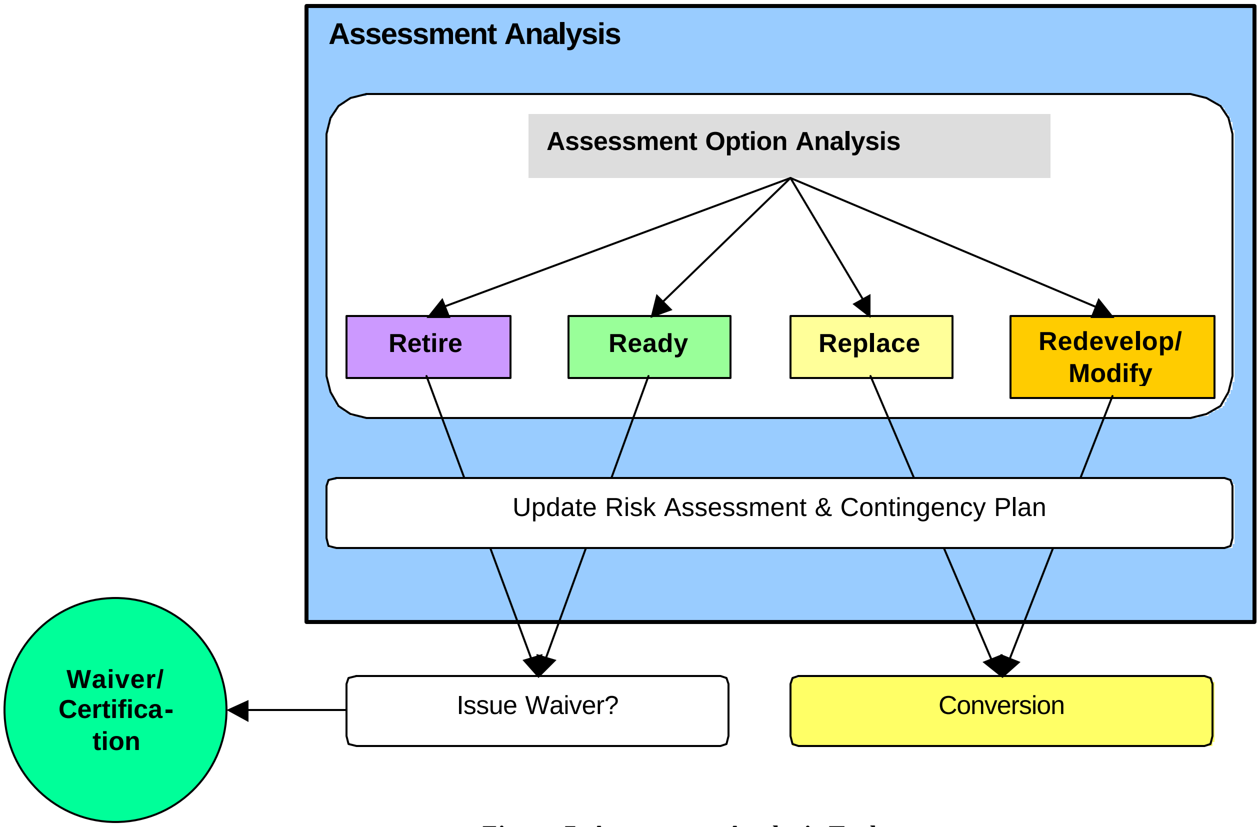

Figure 7. Assessment Analysis Task

This task prepares all the necessary information and configuration for tools to convert components, identifies the unsupported components and plans recipes to handle them. Test scenarios and expected output are also defined in order to verify that converted component behavior after the conversion reflects the expected results.

Phase 2 - Conversion Phase

The conversion activities follow the completion of the Assessment Analysis, that is, once a customer has decided a course of action based on a business case approach. In a nut shell, the conversion, illustrated in figure 8, could be performed as follows, depending on the results of the Assessment Analysis Phase:

- Modify existing code to make it compliant using automated tools and/or manual effort. Once modification will be identified and their impact validated, the Factory maintenance process will be executed;
- Redevelop non-compliant source code using the Factory systems engineering process and the software reverse engineering process;
- Replace some or all elements of a deficient program/system because the costs of modifying and/or reengineering exceed the cost of replacement. In this case a decision will be made to either engineer a component, purchase a custom-built component, or purchase a COTS and modify it to suit the requirements. If a component is purchased, the Factory Procurement Management Process will be performed; and
- The combination of any of the three approaches listed above

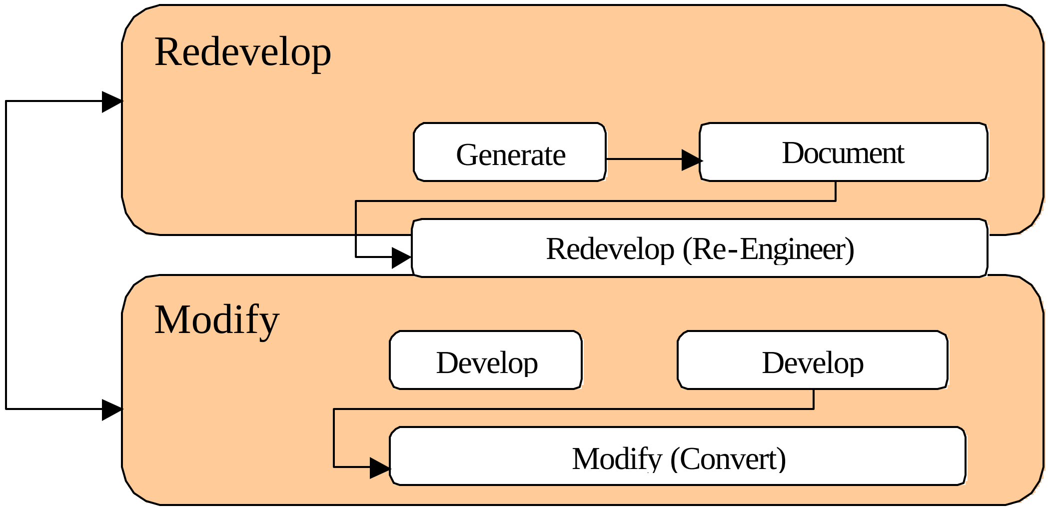

Figure 8. Conversion Phase

The rigorous adherence to configuration management and data management processes is essential to the success of conversion. Furthermore, a proven and mature software engineering process will reduce risk of cost overrun and/or schedule slippage.

Phase 3 - Validation Phase

Once a system has been converted, testing in a controlled environment is required prior to placing it in operation. This phase is always conducted independently of the conversion strategy used. Testing is complicated by the fact that the system may have been upgraded in more than one area. For example, hardware, software, input file and interface formats may have been changed at the same time. This phase requires the largest percentage of time of the whole Year 2000 conversion process. As illustrated in figure 9, the main activities of this phase are:

- Verify system requirements
- Perform functional configuration audit

Phase 4 - Deployment Phase

It is during this phase, as illustrated in figure 10, that Year 2000 compliant systems are actually put back into operation. Depending on the system, the complexity of the deployment may vary widely. For example, it is anticipated that systems such as Command, Control and Communication and Intelligence will be more complex than ones pertaining to stand-alone management information systems. Typically, this phase will be composed of the following main activities:

- Generate a deployment plan
- Install system in the field
- Perform system tests
- Train users (if applicable)

Lessons Learned
We offer the following lessons for those who will be involved in either year 2000 conversion programs or similar projects such as the Euro Conversion Initiatives.

Awareness is Difficult
It was found that organizations and their managers are in a denial mode, i.e. they do not believe that their organization may suffer damages due to the year 2000 problem. In other cases, i.e. when some managers are aware of the potential problems, they have great difficulties in acquiring the resources necessary to address the problems.

Year 2000 is a Major Maintenance Project
The process is indeed similar to a regular maintenance process: identifying the problem, validating the problem, assessing the impact of the corrected module. The main difference with normal system maintenance is that year 2000 problems may affect dozens if not hundreds of modules at the same time. Configuration management and project management disciplines are critical to the success of year 2000 conversion.

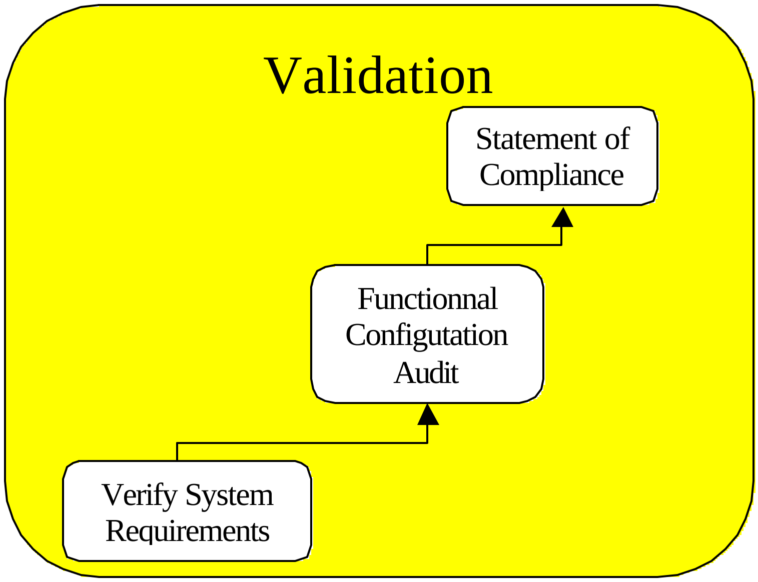

Figure 9. Validation Phase

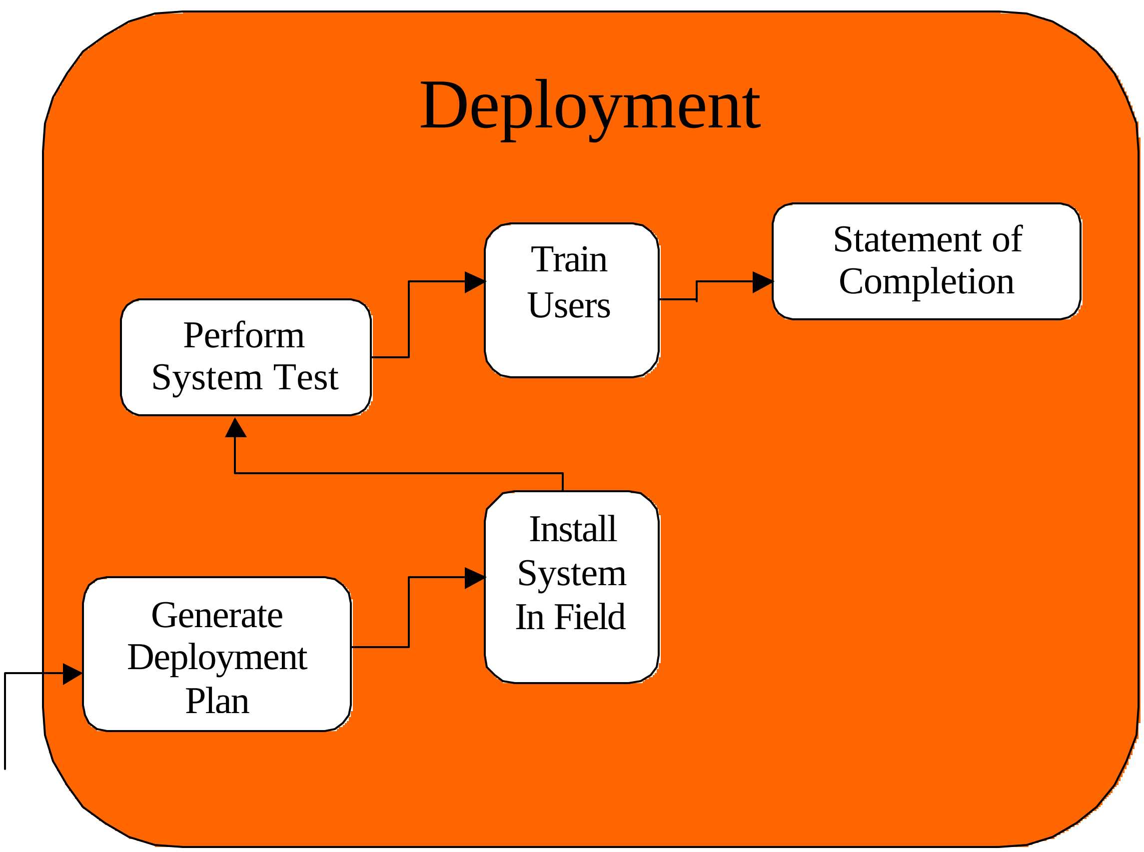

Figure 10. Deployment Phase

Issues of Interoperability and Interconnectivity are Difficult to Assess Globally

When many systems have to collaborate together, i.e. mainly through communications links, it becomes very difficult to first fix each system and second to test the communications between them. If one system fails, it may impact the operation of many systems that have to exc hange data.

Infrastructures are the Poor Children

When managers assess the impact of year 2000 on their operations, they very often forget the invisible components of their organization such as heating and ventilation, lifts, lights, instrumentation. If these infrastructures fail to operate properly, the whole organization may be impacted for days or even weeks before these systems are brought to normal operation.

Use "Fear Tactics" if Necessary – Time is the Essence

When organizations stay in denial mode, it is time to use tactics to wake them up. One fear tactic for executives is to explain their responsibilities in front of shareholders and customers if their organization do not address the year 2000 issues. Executives could be formally accused of negligence by their board of directors. No executives can claim ignorance of the potential problems resulting of year 2000 issues.

Shareholders should be made aware of the potential risks that face their investments if firms do not address year 2000 issues promptly. Similarly, citizens should exert pressure on their public servants to make sure that adequate resources are dedicated to public systems such as utilities, hospitals and transports.

We are Past Awareness – We are now in Contingency Mode

With even less than 12 months to go before January 1, 2000, it is very likely that some systems will not be converted in time. In this case, it is time to prepare contingency plans. These plans should describe, in details the following issues: what, why, when, who, how. Because, when systems will start to fail, it will not be the time to sit down and prepare recovery plans. People may start to panic and more damages can be done under those circumstances.

An overall communications plan should also be developed in order to communicate to all stakeholders, their roles when systems fail to operate normally. Again, when "things" start to stop, it won't be the proper time to quietly sit down and ask ourselves what to do; it will be time to react effectively.

Conclusion

A Factory has been established to help the Canadian government in addressing the Year 2000 issues. The Factory has developed and integrated a suite of processes, methods and tools mainly for real-time embedded systems. As new projects are completed, the Factory Asset Library is enriched with expertise and lessons learned.

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