THE CANADIAN ISTAR INFORMATION-CENTRIC COLLABORATIVE WORKSPACE CONCEPT

PAPER FOUR
The Info-Centric Collaborative Workspace From an Implementation Perspective

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Abstract

1. Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) is an evolving information operations (IO) concept in the Canadian Land Force. ISTAR provides the commander with a system to collect and process required information for producing intelligence on the threat and knowledge on the environment during operations, as well as knowledge needed to identify, acquire and engage targets. The various processes used to collect and analyze the information are the result of numerous individual systems some of which have only been recently introduced in the field while many others are still in development as a result of advances in the information age. This compendium of systems makes ISTAR a “System of systems”, as opposed to a single system. These four papers present the new Canadian information centric collaborative workspace concept that provides a more coherent information management approach to better support the Commander in both its tactical intelligence and operations activities at brigade level. The info-centric collaborative workspace concept aims at offering a seamless collaborative environment enabling the ISTAR staff to perform their tasks using different applications / services through a standardized Human Computer Interface (HCI).

Introduction

2. As presented in the previous three papers, if the Canadian Land Force is to be successful in fielding an efficient Information Centric Collaborative Workspace (ICCW) ISTAR “System of systems”, many ingredients have to work together. We thus need to address many factors. As with any other system, the ISTAR System encompasses the three main perspectives explained earlier: the systems, the users and the processes by which these users use the systems. These three perspectives have to be addressed concurrently by the Canadian Land Forces for a successful implementation.

3. Many armies have by now learned that when introducing Command and Control (C2) information technologies (IT) to their organization, a series of changes occur in a number of areas and if these changes are not properly taken into consideration in the planning stages of the transformation process, then these changes will become hindrance in the accomplishment of the missions thus planting the seeds for the overall rejection of the system. The areas that will be affected and need to be considered in the transition have been regrouped into three main perspectives as illustrated in Figure 1 and are: a) Systems, b) Users, and c) Processes. What is meant by “systems” are the hardware and software components related to Information

Technologies (IT) that, when put together according to a set of requirements and specifications, make up IT systems. The term "users" refers to the people and their skills, education, training, experience and Organizations. The term "processes" refers to the Doctrine, Standard Operating Procedures (SOP), and Techniques, Tactics and Procedures (TTP). The successful business solution will be the one achieving best harmony between the three perspectives: Users - Processes - Systems. In this series of papers, the authors will be presenting one by one, each apex of this harmony triangle and the achieved business solution. The first paper covers the Canadian military organization and the transformation needed to exploit the new emerging Command Support environment from an information centric collaborative environment perspective. The second paper presents the ISTAR context and its inherent imbedded processes while introducing the adaptation needed for an organization to become more effective as an information driven organization. The third paper covers the System of systems Service Architecture perspective and describes the approach taken to develop an information centric collaborative workspace solution. The fourth paper brings forward an approach and some techniques to implement the three previous perspectives and keep a global system harmony. It also includes some of the lessons learned in developing and implementing the Canadian Command Support Info-Centric Collaborative Workspace (ICCW) using a value management approach.

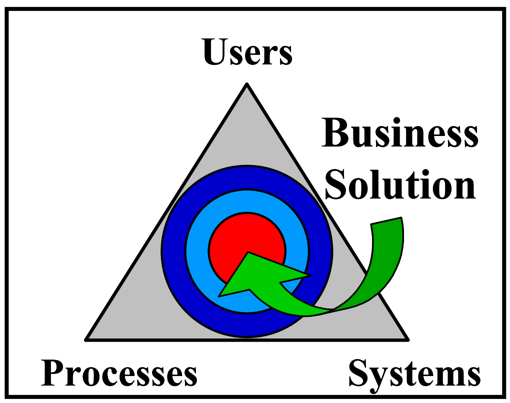

Figure 1: System of Systems Harmony Triangle:
Users - Processes – Systems

4. Experience shows that the introduction of new information technologies and their capabilities into organizations is potentially risky unless accompanied by a planned change transition in a number of key areas. Keeping in balance those three different perspectives throughout the realization of the system is a real challenge. Especially when trying to provide a coherent and continuous transition plan for deployment of the new capabilities provided by a System of systems supporting an Info-Centric Workspace.

5. When introducing new technologies into an organization, one of the aspects very often overlooked by project teams is the Users perspective. They also represent the most difficult perspective to manage. So very often during the life of a project when trying to simplify the many problems at stake and to avoid incurring extra costs, project teams tend to diminish the users implication and therefore the requirements capture. Most of the time, this leads the teams to develop systems from a limited to a bad comprehension of the users way of doing business and leaving to the user community the problem to figure out how to absorb the changes brought about by the new systems dumped on them. The result of such an approach is often a weak system design that either does not provide the expected organizational benefits, or that results in over schedule and over budget system delivery. Only 25% of the software projects are delivered within time and budget, and no improvement have been made over the last decade. [NASA 2002] One

must keep in mind that the organizational benefits are directly related to the capacity, not to say the desire and willingness, of the Users to use the systems efficiently once delivered to them. Therefore we believe that a continuous user implication throughout the development and implementation of the system is mandatory and has the benefit to increase stakeholder confidence that the system will meet all expected requirements.

6. As defined in the Larousse dictionary [Larousse 1996], engineering is defined as the study of an industrial project under all its aspects (technical, economic, financial, budget and social) and that necessitate a synthesized view to co-ordinate the work performed by many specialized teams. Traditionally in engineering we try to simplify the problem. Simplifying does not mean to eliminate some aspects. We believe that more emphasis should be put on these overlooked aspects of software engineering. The other aspects are well understood and modeled. However taking into consideration the social perspective or user perspective to a project, it raises the level of difficulty and very often the cost of the architecture phase of the project. On the other hand experience had demonstrated to us that in many cases users have developed simple solutions based on their experience when dealing with their daily business problems, thus potentially saving cost during the development phase of the project. It can be seen that by having continuous user involvement has is benefits even though it raises the project implementation complexity.

7. As presented in a previous paper, in order to render the ISTAR "System of systems" more efficient as a whole, the authors have found that new ISTAR functions need to be created. [Thibault 2004] These new functions combined with the introduction of technology to support users in their task execution will require adjustments to the procedures. This will therefore require adjustment to the force generation namely with regards to users training curriculum, which has an impact on their capability to use the system. We can also observe that these new functionality will have a direct impact on the procedures which in turn will have an impact on the training issues that will impact on the capacity of the users to use the system appropriately and, finally will impact on the system requirements capture and definition. At the end, all of this is reinforcing the circular reference to the three perspectives described earlier. This circular reference makes the use of a top down waterfall approach to system design and implementation impossible to use in order to provide the expected organizational benefits. The evolutionary prototyping technique described in paper three, has so far proven to be a more appropriate technique.

8. It is very often forgotten in system design that technology is there to help users to perform a process. Very often the "what needs" to be produced by the military from a doctrinal perspective is correct but it is the "how" they produce it that requires adjustments. The main purpose of technology should be to facilitate task execution. This is one of the main reasons why user involvement is important, because they know what they have to do and they have the experience of doing it. Technology should be a support not necessarily a replacement.

9. A "System of systems" Architecture based on a service approach [Cantin 2004] will in fact provide the flexibility for a gradual user adaptation, gradual procedure adjustments and incremental system implementation through a prototyping technique. It is to be noted that in order to build a coherent design, the architecture must consider the ensemble of the technologies involved. Thus the physical architecture must take into consideration the characteristics of sensors, deployed computers, radio communications, platforms, etc.

10. Thus the challenge of building a "System of systems" is to keep an equilibrium between the interrelated different perspectives. This is not possible through a pure "Top Down" neither through a "Bottom Up" approach, but rather by an iterative approach navigating between the

global and the detailed system views. This is what has been called the complementary top-down and bottom-up approach introduced in paper three. This will be explained in this paper, at each level between the top and the bottom views, the three perspectives must be looked at simultaneously and analyzed to make sure the balance between the three perspectives at each level is respected. To enable the keeping of this equilibrium, the composition of the architecture and development teams requires the matching of specific skills from the individuals.

11. This paper is about how different existing methods and techniques and technologies were put together to provide an adaptive system development and implementation of a new Canadian ISTAR information centric collaborative workspace (ICCW) concept that aims to offer a seamless collaborative environment enabling the users to perform their tasks using different applications through a unified Human Computer Interface (HCI). The overall project approach to the "System of systems" implementation takes into account and makes great use of the three main perspectives identified above along with a configuration management plan and a project value management approach. It is believed believe that this approach when applied at the brigade command level and below will provide an information driven approach that better supports the Commander in both its tactical intelligence and tactical operations activities.

12. This paper discusses the project management experience at implementing the Canadian ICCW. This experience is regrouped under the following sections: a) the project context providing an historical overview of the project and the companies that were involved; b) the vision and the architecture to be implemented; c) the team and organization that were put in place to realize the project; d) the methodology and quality procedures developed to structure the work; e) the development effort estimates we used to plan the work; f) the risk management strategy; g) and a brief discussion and conclusion.

Project Context

13. At the time this paper was being written the project had started its Phase II. Therefore, only Phase I of the project is covered in this paper. The project started in June 2002 and Phase I was completed in March 2004. It started with a preliminary study providing an idea of the vision that was to be implemented. The ISTAR TD project is a Risk Reduction Unit (RRU) for a larger project. In the Canadian environment, this type of project is called a Technology Demonstrator (TD). Their purpose is to provide enough insight into a specific subject area before starting the bigger project. Their focus is to look at research results and experiment how these can be transited into deployable systems. Thus, the output of a TD should be transitionable to a fielded system baseline and should provide information on the user and organization impact.

14. During the preliminary study activity the vision was established. Because of the nature of the business to be supported, it was decided to go with a Service Architecture enabling the implementation the Info-Centric Collaborative Workspace (ICCW) where the benefits of such an architecture have been demonstrated in many research projects over the last ten years. [Cantin 2004] This service architecture aims at developing information processing tools that are a natural consequence of implementing a data centric concept over a network centric infrastructure technology. [Thibault 2003]

15. Even though the project was essentially to develop software tools to support the information requirements of the commander, it had to take into consideration the actual army baseline namely in terms of hardware and software capabilities and constraints. This lead to a multidisciplinary implementation team involving eight different companies (figure 2). Each company team coming with different skills and background and having different ways of

performing software development and documentation. In summary they were coming with the following background: Air Defence, Network Communications, Fusion tools, Planning tools, Monitoring tools, Intelligence tools, Electronic Warfare tools, and Battlefield Visualization tools. All these companies had to be aligned with the vision, the baseline and the information management new way of thinking. As an example an air defence weapons system from an information management perspective became a source of information. This change in role for an air defence asset towards an information provider role required a certain amount of time to sink in.

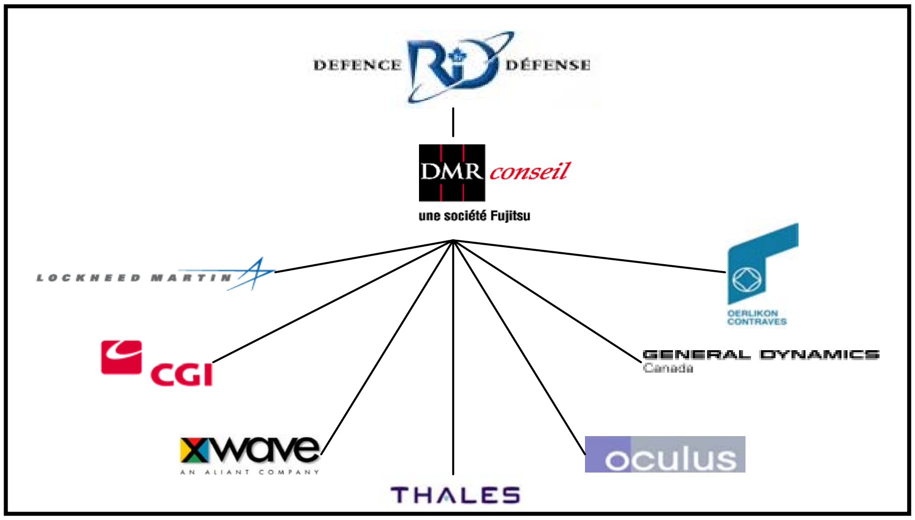

Figure 2: Partners Involved in the realization of the ISTAR TD Project

16. Another element of context is to be mentioned. The Canadian Land Forces has decided to retain Total System Responsibility (TSR) over any fielded capabilities. This was reflected by the fact that specifications and tasks for realizing portions of the System of systems are provided to the contractors by this TSR team. This resulted in the need to properly integrate any capability developed into the overall System of systems. This approach is only possible through a well-articulated architecture, rules and methods to guide any development effort. In this way, the supplying companies develop a common understanding and are forced to adopt the client language.

The vision and the architecture

17. The first step in starting a project is to acquire a good understanding of the current system, defining the vision and build a plan to attain the vision. A good understanding of the mission and objectives of the System will ensure the System of systems architecture is properly focused to meet the requirements and expectations of the user community. [Thibault 2003]. This means that the organization must have a clear vision of where the transformation process will lead it [Guide 1996]. If one is not rigorous during this phase where System Principles and Orientations are covered, the system design activity can lead to a lot of wasted effort [Macroscope]. For example, if an organization has specific requirements and an approach for managing security access to data, it must therefore be considered in the architecture activity since it is more than likely that these will impact on the software development effort. This means that in order to properly address a problem, one has to adopt the right perspective [de Rosnay, 1979].

18. When the project started, there were no architecture or vision documented. This lead to a preliminary study to model current and future systems in order to depict a transition plan. The

results of the study produced a clear target vision for the environment and a clear path to achieve it. It was recommended that this path be evolutionary instead of revolutionary in order for the solution to consider as many of the current operational and future systems as possible including their limitations. The main challenge faced during this part of the project was that the best System of systems capabilities did not always equate to the integration of all the best tools. So selection and recommendations had to be done considering the global perspective and taking into consideration the three System of systems perspectives described earlier.

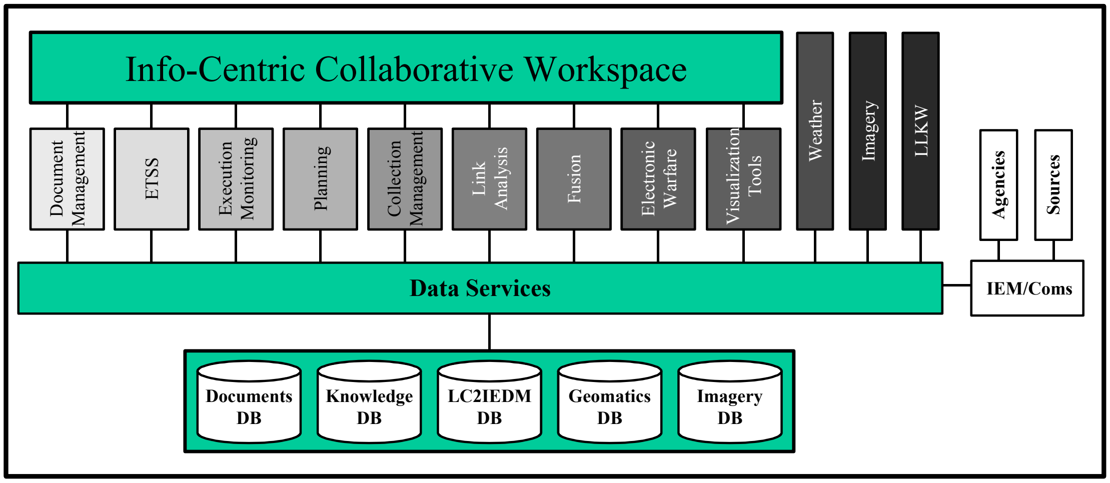

Figure 3: The proposed ISTAR Information Centric Workspace System of Systems Vision

19. Eventually, a "System of systems" architecture was developed as shown in Figure 3. It portrays the high level view of the Canadian ISTAR Info-Centric Collaborative Workspace concept supported by nine groups of services and a data service layer regulating the access to five types of databases for non-structured, structured and special data formats [Thibault 2003] and [Cantin 2004]. It must be noted that one of the databases is based on the NATO agreed C2IEDM that provides a data centric environment [NATO C2IEDM]. Once the architecture formulated, it was provided to the different companies involved along with information concerning the baseline and the methodology to be used such as for management procedures and document templates. This phase took eight months and 1,500 person-days of effort.

Team organization

20. In the Phase I of the project, two different team organizations were used. Initially because the project was a TD and because two partners were involved in the Architecture activity, we used a relatively light project organization as depicted in Figure 4.

21. One of the main aspects of this organization chart reflects the fact that sub-contractors were loosely coupled with the main project team. This organization was assuming that specification could be transmitted to sub-contractor and the work would be executed as a module and being returned and integrated within the baseline infrastructure respecting the TSR approach taken by the Land Force. Furthermore, the main core team because of its size and because of the TD project context started to use X-Programming techniques [Plaulck 2001] (discussed later in this paper). Soon enough, the results obtained were not very good. The lack of common understanding and global co-ordination resulted in software applications that were not compatible. The incompatibility was mainly related to the lack of understanding of the use of the C2IEDM database. Developing applications based on C2IEDM is not an obvious endeavor.

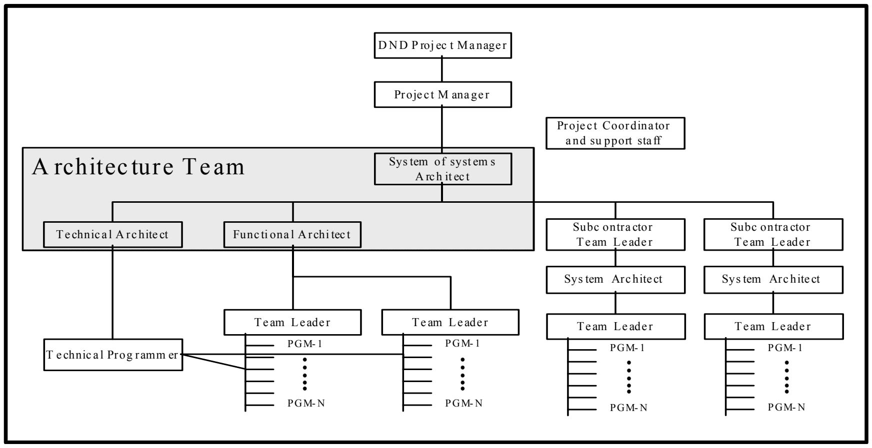

Figure 4: Initial team organization

22. In consequence, we adopted an organization more aligned with a program management model where the project manager has full authority and the teams are 100% dedicated to the project from the programmers to the managers [Guide 1996]. One of the main findings in implementing a database such as the NATO C2IEDM is that this model provides an embedded ontology and thus enforces a common language. This brought engineering constraints that forced the implementation of a different project organization that was more directive.

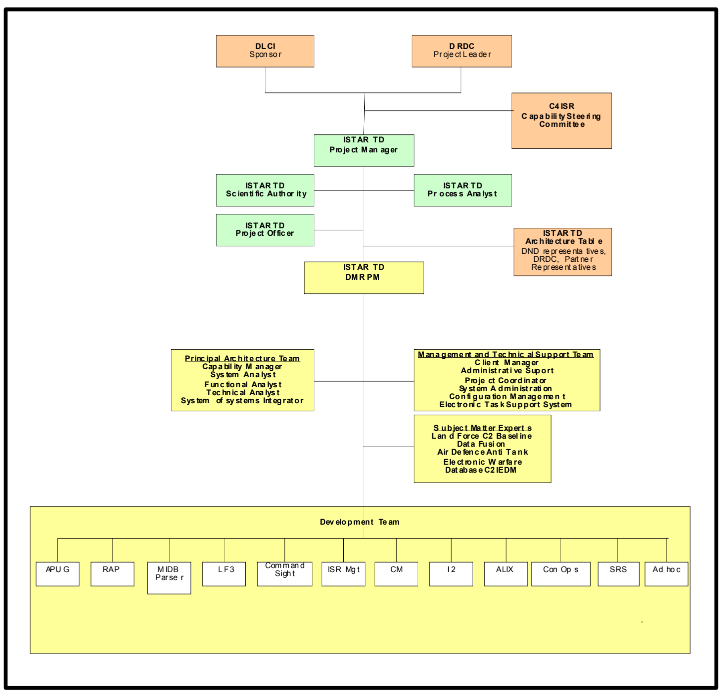

Figure 5: Restructured Team Organization

23. Figure 5 depicts the project organization that was put in place to augment the rigor within the project implementation team. The main characteristics of this project organization are:

a) It is more oriented towards a program management approach so the architects supervise all the work being executed on a regular basis to ensure cohesiveness and integration of the modules;

b) A Capability Manager was identified in the architecture team with the responsibility to ensure that what the users had to do is either covered by a procedure or a tool ensuring completeness of the solution from a System of systems approach; and

c) A configuration management team and a system administration team were put in place and centralized to supervise the global project test bed environment where the different components of the total System of systems can be integrated and tested by user representatives.

24. This organization forced the different partners to acquire a common understanding of the procedures (CMM-3, IEEE 12207, etc.), of the Land Force C2 system baseline and of the C2IEDM database implemented. It takes discipline, dedication, and some time before the different teams could be aligned on the right target. In the case of this project the alignment or realignment for some of the partners took close to six months. A good analogy would be: "you hire eight companies geographically dispersed and having different backgrounds to write a novel, 15 chapters long, on a subject that most of the companies think they have knowledge of but to discover later to the contrary that they did not have it when they tried to assemble their chapters together". More specifically, with a prime contractor who harnessed a core team of nine persons possessing an average of 15 years of experience in software system development in general and with an average of eight years in doing DND software system development, it took for that team four months before they were able to properly design applications based on the C2IEDM. We now know by experience that if the contractual partners are properly mentored, the learning time taken can be brought down to about two months. The organization depicted in figure 5 represents a more rigid, centralized and directive project management approach that proved to be more efficient in this kind of projects where exist a higher level of complexity and where all of the partners are geographically dispersed.

Methodology and Quality Control

25. In the case of the Canadian Land Forces, the main objective of the Defence R&D Canada Technology Demonstration (TD) Program in the C4ISR domain is to propose R&D solutions for defence problems and validate or demonstrate their viability on the existing Land Force C2 System baseline. This TD project is about halfway between pure R&D and engineering project implementation. This implies a trial and error realization mode. Guarantying at the end that the findings will be effectively transition able to the field even though the solution is not yet complete requires a lot of discipline and a solid methodology.

26. As mentioned previously in this paper, Xtreme Programming technique [Plaulk 2001] was tried at the beginning of the project and it was found not suitable for this type of project size and complexity. In large and complex project, the architects are creative and focus their attention at answering user requirements. The programmers seldom have the global view or global understanding required to measure the impact of design decisions. Furthermore Xtreme Programming technique lacks the aspect of architecture documentation that is a mandatory requirement to synchronize efforts between many companies not being co-located in the same facility. Furthermore, programmers' creativity must be controlled very well. XP teams are typically collocated and have fewer than ten members. It is confirmed based on the ISTAR TD

experience that Xtreme Programming (XP) is typically targeted at small to medium-sized teams building software with vague or rapidly changing requirements directly supported by ever-present user representatives. Should organization use XP for critical military complex applications? Probably not especially since it aims at pure software development projects only. XP lacks of design and architecture documentation is very risky. Finally XP is an intensely social activity and it is not given to every one to like it. XP was therefore excluded because it also lacks two other crucial elements and it is that the resulting software products can only with greater difficulty be brought up to Computer Maturity Model (CMM) level 3 standards.

27. The project management rapidly adopted a much more structured methodology based on "Macroscope™" [Macroscope]. Understanding that standards are not sufficient by themselves, a suitable methodology is mandatory to provide for proper synchronization and harmonization amongst team members through the use of a common language and agreed checklists that are especially useful to manage large projects distributed over different physical locations. Nevertheless, success rests upon the core team of selected people that must be knowledgeable in that kind of military business. Methods and methodology ensure the quality of the products, hence their transition ability into the field but the validity of the solutions found is based on the team's expertise with its capacity to solve complex problems. However, adaptation to a particular context requires people knowledgeable about the specific operational requirements in order to document the right kind of information. Composing with all these factors is the science of project management.

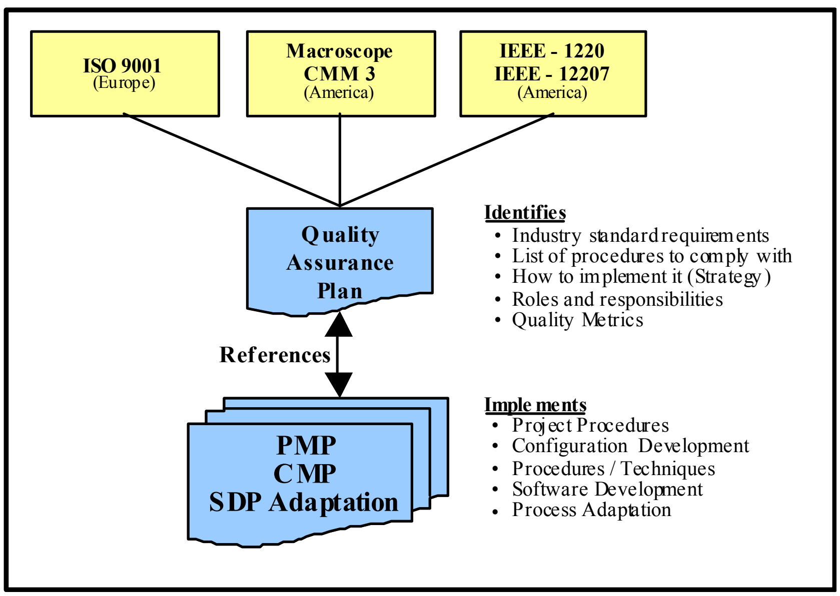

Figure 6: Canadian ISTAR Project Adopted Methodology

28. In view of the particular complexity of the System of systems Architecture and of the nature of the work to be performed, a methodology was thus chosen and adapted to the Canadian Department of National Defence (DND) context. Figure 6 illustrates the different references that were used in order to build the ISTAR final methodology. The selected methodology was based on "Macroscope™" [Macroscope] from Fujitsu Consulting, which is one recommended by Gartner's Group [Light 2002], and the Computer Maturity Model (CMM) level 3. Some adaptations were done to take into consideration different standards such as IEEE-12207 (software development life-cycle) [IEEE 12207] and IEEE-1220 ("System of Systems") [IEEE 1220]. From this adapted methodology, the software development and implementation

techniques were developed including a Quality Assurance Plan (QAP), a Project Management Plan (PMP), a Configuration Management Plan (CMP) and an adapted Software Development Plan (SDP).

29. Figure 7 illustrates the evolutionary prototyping approach that has been retained. This evolutionary prototyping technique combined with a rigorous Configuration Management Plan (CMP) (including validation tests throughout the development process using test beds in appropriate context) provides a formal incremental system release approach that is better than the traditional waterfall model. This technique allowed all the different perspectives to evolve at the same time and to provide a balanced "System of systems" phased delivery that had periods of 12 to 18 months instead of multi years. This aspect of system delivery becomes a very important issue when fielding complex command and control systems.

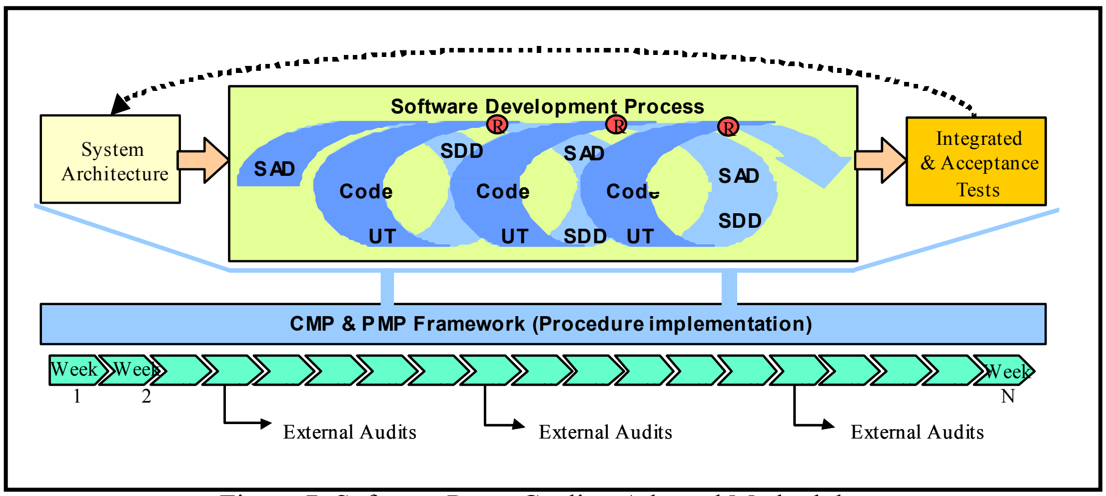

Figure 7: Software Proto-Cycling Adopted Methodology

30. One of the most interesting features of "Macroscope™" [Macroscope] is the use of Joint Application Development (JAD) sessions with subject matter experts as introduced in Paper Three of this series [Cantin 2004]. The JAD technique also had to be adapted to a context of limited user availability. This JAD approach had the benefit of providing a continuous training environment for the users, of facilitating user acceptance, and of tailoring the system to user needs. This technique enabled all the different perspectives to evolve at the same time providing a balanced "System of systems". By performing JAD sessions in this fashion, it provided two additional benefits: a) the means to do effective and efficient requirements capture, and b) a value rating for the different requirements was possible thus reinforcing the capacity to perform true value management [PMBOK 2000] [Value 2003] during the project.

31. Thus in a JAD session users describe in their own language about their own experience. System Engineers must understand and reverse engineer these user requirements, the system procedures and the system specifications. They are responsible to understand and evaluate the impact the new ways of doing things may have on an organization. System engineers will have to first go from bottom-up in designing the system and then they will have to go top-down to understand the big picture, and then start cycling from top to bottom and bottom to top in an evolutionary prototyping environment (Figure 7). This process requires a fairly good understanding of the organization and a lot of intellectual agility. The challenge of managing change is that it generates dislocation, conflict, and confusion [Ferguson, 1987]. What the

ISTAR TD experience demonstrated is that methodologies and standards to perform this kind of work exist and are available providing they are properly adapted to each particular developmental effort.

32. Finally, more emphasis should be put on the fact that IT technology is there to support people. So in a JAD session, listening to and learning from experienced users will more often than not provide insights for finding simple solutions to complex problems. Technology has been for too many years used as a simple way to replace people. As suggested in Figure 8, the knowledge of the situation required to command in military operations is supported by the technology. So far computers are not capable of performing the "understanding" function done by humans. Systems should be designed to support and raise the processing speed and its usability while allowing for greater information fluidity [Thibault, 2003].

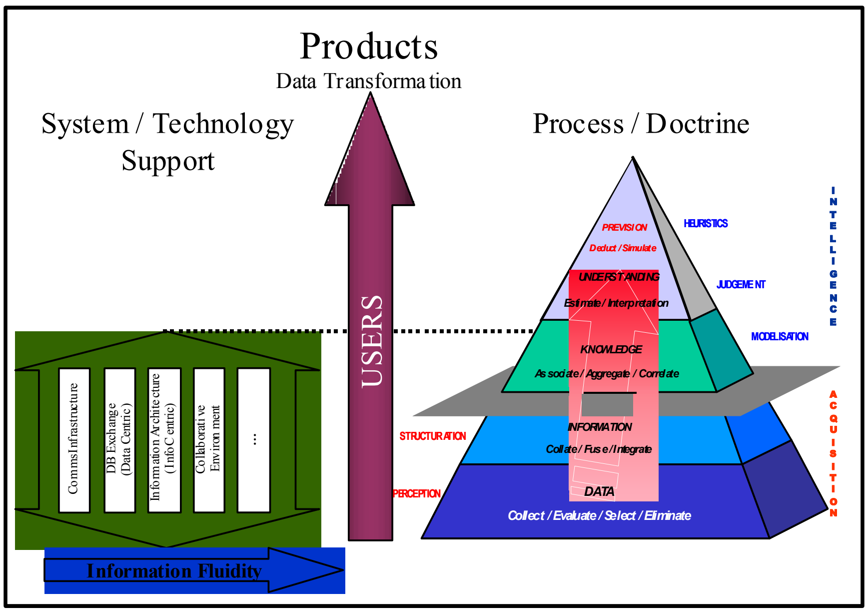

Figure 8: Enabling Technology and User Support

Development Effort Estimation

33. As described in the NASA Cost Estimate Handbook [NASA 2002], many techniques and software vendors exist. However the software development industry, as a whole, does not have a good track record when it comes to completing a project on time and within budget. Recent studies have shown that only 25% percent of the software development projects are completed successfully within the estimated schedule and budget. This statistics has shown no significant improvement over the past decade. Initial project estimates are typically over optimistic and inaccurate [NASA 2002, p. 72]. Most of the time, estimates cover only the development effort while ignoring the other factors. When the implementation environment is complex or some parts of the System of systems are simultaneously under development, it becomes difficult to properly estimate efforts. Furthermore, most of the estimation methods available do not take into consideration the human factors such as usability and the capability of the organization to absorb the change. In military environment, we could say that force employment is relatively simple but when it comes to measuring the impact on force generation it becomes much more difficult.

34. Manually driven and tool driven methods exit for estimating developmental effort. Very often a combination of both methods is recommended. According to NASA [NASA 2002], the

accuracy of manual methods has not proven sufficient for mission critical applications, larger development efforts, and contracted software development projects. Software size evaluation can be performed through two main techniques: Software Line of Code (SLOC) and Function Point Aanalysis. SLOC is mostly irrelevant to some modern programming environments (e.g. visual languages or code generators) [Park 1997] [Jones 1998]. On the other hand Function Point Analysis is gaining more attention. The standards are maintained through the International Function Point User Group (IFPUG). This technique has the advantage of being more platforms independent. However it is still relying on some human understanding of the standards and manual processes.

35. Another approach was adopted by the ISTAR TD project. The approach is based on Software Unit Task Complexity Estimate (SUTCE) and had the advantage of being quick and readily understood by all. It proved to be a suitable approach for this project. It is understood that SUTCE relies heavily on expert judgment and on the architects capacity to properly de-compose the system into sub-systems, sub-system into functions, and finally from function to unit tasks. Even though this technique relies heavily on expert opinions and therefore stays relatively subjective, it was found reliable in respect to the overall experience possessed by the system architecture team (Table 1). In fact, the team had a long experience of deriving estimates from their past experience in software development.

Table 1: Average core team member experience

	Numbers of years in IT projects (Average)	**Numbers of years in DND IT projects (Average)**
Architecture Team (9 persons)	15,3	8,0
Development Team (12 persons)	6,5	3,7

36. The estimation technique is basically done in two steps. The first step consists in the architects defining a level of complexity to a unit task identified during the architecture activity through the system de-composition into small pieces of software development. This step represents the most subjective activity in the project evaluation. During this step the architects must document how they define the level of complexity and why a certain level was given to specific software units. Being a CMM-3 project all of these estimates were validated by a formal and documented peer review. When the first level of estimation is completed then the second step consists in applying macro estimates. The macro estimates will be explained further below after the micro estimates have been introduced.

Table 2: Micro Estimates

Micro Estimates	**Days**
Very Simple	12
Simple	25
Medium	39
Complex	66
Very Complex	101

37. The Micro estimates [Macroscope] are given in Table 2 and include activities such as the detailed functional analysis with one revision cycle by users; the detailed technical analysis; the coding activity; the unit tests; and the functional and integrated tests. A rule of tomb frequently used is that the software unit task <u>average</u> complexity should be somewhere around the medium level. The higher is the resulting average level of complexity, the more inaccurate will be the

evaluation because the software units (at the task level) are not detailed enough and therefore not well understood. In general, in order to attain an average level of complexity ranking at medium, a relatively detailed architecture is required.

38. The Macro estimates [Macroscope] illustrated in Table 3 exclude efforts relating to user support during the system development or JAD sessions; deployment in the field; user training; and the efforts relating to processes analysis and modification. So they are focused on the software development activity. These excluded efforts must be evaluated carefully since they are more subjective than the development ones and typically, they vary from 50% to 100% of the software system development efforts depending on the type of organization and the core business criticality of the deployed system. Knowing from experience that the software coding represents about 55% of the software development activities, the other efforts are calculated in a linear extrapolation fashion. It is to be noted that these macro estimates are revised on a per project basis to take into consideration the specific context of each project. This latter activity is performed by a group of very senior architects at the beginning of the project.

Table 3: Macro Estimates

Macro Estimates	Effort %
Functional Architecture	10%
Technical Architecture	10%
Components development	55%
Development support (Functional, Technical, DBA)	8%
Components implementation	2%
Project Management	15%
Total	100%

39. Table 4 illustrates the results after completion of phase one of the project. One can observe that the values demonstrate that the estimates were totally off track. This deviation can be explained by numerous reasons. One reason is that the Land Forces did not possess a global system architecture at the beginning of the project and eventually asked the project to produce one for them. That is why a System of systems architecture was developed by the team. In performing this task the team began to really comprehend the extent of the complexity brought by the C2IEDM model. Depending on how the model is implemented, it could generate important constraints at the functional design level. In a very summarized fashion, this model carries an embedded ontology that forces all the partners to talk a common language. Another reason is that during the time the project team was developing an ISTAR software module, there was another team (independent of the ISTAR TD team) that was developing the Database Service Layer (DSL), a common service to access the central database. Being under continuous development newer versions of the DSL were provided regularly to the other development teams. So even though the project had a good approved System of systems architecture, when the time came to perform the detailed design, the ISTAR TD team was building functionality on a moving foundation. The project was well advanced in its delivery Phase II when the team was finally able to connect the existing functionality to a stabilized DSL foundation. Towards the end of Phase II delivery, the initial estimates seemed to be confirmed. So, in general, when the foundation is stable and the development team is knowledgeable about the context in a broad fashion, the provided estimates relying on expert judgment are trustable most of the time.

Table 4: Project phase one results

	Efforts in Days (Excluding Sub-Contractors)	% Budget Effort
Architecture	36%	42%
Development	35%	29%
Product Integration	2%	2%
System Administration	8%	8%
Project Management	19%	19%

40. Another example is that at the end of Phase I, a sub-contractor was tasked to develop an air defence functionality. Although, this task was relatively small when compared to the overall project, the provided estimates for the efforts were reasonable and in accordance with the overall project estimates. The sub-contractor succeeded in delivering the functionality within time and budget according to the estimates. This was possible because the air defence team, even though it started late in Phase I, benefited from the new project organization and from the knowledge acquired by the core architecture team.

Table 5: Air defense task efforts

	Effort in Days	% Budget Effort
Project Management	4%	7%
Architecture	18%	18%
Development	78%	75%

41. In conclusion, cost estimation is by definition a subjective analysis. One must seek as much independent input and review as time and circumstances allow in order to counteract any particular biases. Cost models are at best a fuzzy predictor of the future and it is difficult to remain on target with cost estimation only.

Risk Management

42. Risk management is an important activity in any project. In highly complex R&D environment, it is probably the most important factor for obtaining success. Risk Management is about managing all of the 'unexpected', which seems to be a natural occurrence in R&D project. As mentioned earlier, it is related to our confidence level that is often much too optimistic. We like to believe that we are experts in some domains but in reality, the real experts are those who always maintain a reasonable doubt about what they are doing. Risk management is questioning everything all the time during the project realization [NASA 2002, Annex O]. Like every task performed by human beings, risk assessment in the evaluation phase must be performed. Risk is also partially related to the capacity of the team and of its decision makers to face the unknown.

43. During the course of the project, risk management has become a critical activity in view of the possible cost overrun. When referring to risk management, we believe that the People are THE most important critical factors. Generally, project managers understand the easy part of projects. But o the other hand, they often tend to push in the future those things that are complex to grasp and understand. How many times have we heard statements like this one: "We do not have the luxury to do too much detail analysis now, we will see when we will get there". In very simplistic terms, a project is composed of people trying to accomplish tasks in a coordinated way. From experience, in this kind of TD project, having the right skilled people understanding the same project scope, aiming at the same objectives and working as one team represents one of the most challenging aspect of project management. Knowledge Management is often presented in

terms of tools where in fact one should be talking about KM in terms of people management. It has been demonstrated that 90% of the knowledge resides in people's mind. This is where resides the knowledge to be managed in project. As mentioned by Elaine Hall in her book [Hall, 1998], we rarely resolve risk in isolation. It could be added to this statement that we rarely identify risk in isolation. Identifying risk requires a lot of knowledge. Even thought tools exist to help managing the risks, knowledgeable and creative people are required to manage risks and resolve issues.

44. Quality augments productivity; it should not be a trade off. [Hall, 1998, page 22]. Trying to fit square people into round jobs reduce the effectiveness of both the individual and the organization. A project manager should ensure to have the right people at the right place. As long as people will engineer software systems, they will be a critical factor in communicating the issues, concerns, and uncertainties in their work that always translate to risk. Again, people are THE critical factors. Detailing the specifications is still strongly related to the requirements capture made by the analyst who listened to the users whom very often did not express the requirements properly because they had problems transposing their current situation into the future way of doing things with the new envisioned systems. Literature provides plenty examples of many high quality software development projects that failed to provide the expected benefits because at the very end the users for whatever reason refused to use the delivered system. Therefore, an IT project will always be a flat failure if at the end the users reject the system. How can you measure the risk that such a situation will not occur? There exist ways to evaluate and manage risks.

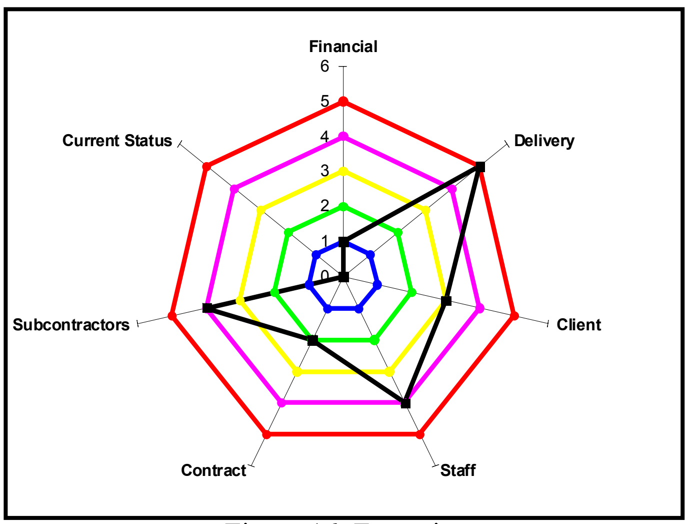

Figure 16: Footprint

45. Even though risk evaluation has a subjective side based on the input estimates provided by the people involved in the project (project manager, architects, analysts…), it is important to combine the different perspectives into one common project view since all of the topics are inter-related. For managing risk in software development projects we use the footprint technique as shown in figure 16 [Macroscope]. This tool helps to cover the different project aspects. The tool is also described in the Software Risk Taxonomy chapter of Elaine Hall's book [Hall, 1998, page 76]. Over the regular risk management discussions happening within the management team many times a week, more formal monthly internal project reviews are held under supervision of independent experienced software development managers external to the project. This tool is used to measure the risk on 47 different aspects and is presented to these senior managers. The

tool uses non-linear function calculus to take into consideration previous project experience in creating the footprint. Figure 16 illustrates one of these footprint output. In this “Bull eyes” view, the 47 topics are regrouped under seven main subjects. There are seven risk levels in the gradation from 0 to 6. For example, the blue inner circle of the diagram indicates a low risk while the red outer circle indicates a very high risk. With respect to trying to anticipate problems, every time a subject is identified as having a yellow risk (level 3) or higher, the project manager is requested to present to the senior managers an action plan. This plan must include an impact assessment on the different subjects. So, if to solve a technical problem, the project manager requests to bring in experts at high costs which will push the financial aspect of the project over the red circle (level 5+), then this solution is likely to be rejected.

46. Good risk management is a key factor to the success of a project. Since risk has been described as being partly related to the unknown or unforeseen, when properly managed, it will generate opportunities but at the condition that the right people with the proper body of knowledge is in place to manage that risk. Many success stories in the business world relate to people that turned risks into opportunities for success [Hall, 1998].

Discussion

47. As mentioned in the book called “Paradigm Shift” [Tapscott, 1993], the computer technology over the last few years changed from a back office tool to a front office tool, from few initiated users to million of users and from a personnel success to an organizational success. To some extent, the Personal Computers have disabled the capability to work in a collaborative mode. ICCW is about re-enabling the workgroup collaborative working. The military were doing collaborative work before the computer age came about, they had to, and it was a matter of survival that was well understood and documented in their doctrine.

48. In the 80’s software engineers were asked to build system to reduce the number of employees in organizations, it was called “rationalization”. Today, many organizations rehire these employees because they do possess the knowledge of the business, not the machines. Now they ask software engineers to build systems that raise the level of productivity. Well the army understood from ages that to succeed it must work as a coordinated team. So the next generation of systems should focus at putting the people back together. The benefit sought by the Canadian Land Force in implementing technology is to augment the speed of the decision-action cycle in operations.

49. A few examples that this goal is achievable already exit. Organizations that have succeeded in implementing workgroups have demonstrated a raise in speed by orders of magnitude in their decision-action cycle. A first example is the Citibank Corporate Real Estate marketing personnel that were able to save many hours a day thus freeing them to spend more time in direct customer contacts. This was achieved through redesign of work processes, the implementation of workgroup computing, and the building of high-performance work teams. The result was a dramatic increase in revenue and profit, and, interestingly, quality of work life for the employees [Tapscott 1993]. One author personally designed two Case File Management systems for the Worker’s Compensation Board of Nova Scotia in Canada and a similar system for AXA Royale Belge in Brussels, Belgium. When the organization was revisited after a year of system deployment, the same results as in the City Bank were verified. So, when they are well-conceived and implemented, workgroup systems can be a focal point for the redesign of business processes and jobs. This can result in spectacular improvements in productivity and responsiveness. Rather than improving the efficiency of a task such as writing a report or preparing a budget, the goal should be to improve the effectiveness and performance of the group.

50. Because computers are now the basic delivery systems for products and services, companies need new computer applications in days or weeks, rather than months or years. The Canadian Land Force is no different, however, most of the organization does not understand the organizational impact of introducing new systems and many organizations can only sustain a given rhythm of change. Based on ISTAR TD experience, it can be mentioned that the coding activity represents only 15% to 20% of the total project efforts even though the software applications in System of systems are becoming more and more complex.

51. Over is the time where computers were designed by computer specialists to be used solely by computer specialists. Because of new GUI approaches (pronounced "gooey" for graphical user interface) were introduced to make them more usable such as the GUI popularized by Apple, computers have become usable by the general population. However, the problem remains complete when it comes to measuring organizational benefits. Very often one hears about technology push versus business push. To achieve the latter one must start to understand the business problem and start being able to measure and anticipate benefits out of computer implementation. The fundamental changes in today's business environment coupled with the rise of the new technology paradigm are beginning to represent a major challenge to organizations. While many complex and significant technical issues must be overcome, ISTAR TD experience showed that the main difficulties were not in the area of technology but rather in the organizational structures for managing computers, along with the knowledge, skills, resource base, approaches to systems planning, and even organizational culture.

52. As software Engineers, we worked a lot on the software aspect. It is now time to address the real difficult problems: understanding the user requirements, user acceptance of the system, and usability of the system in the context of how the work will be performed in the future with the new system.

Conclusion

53. One of the main challenges when embracing a new technological environment is for the team to acquire a common semantic to the level where all the requests and the specifications do not need to be explained anymore in thorough details. Thus bringing the team to a level of acceptable productivity. This will be obtained in our own experience by adopting a very rigorous process that sometimes may limit the creativity needed to solve complex problems. Referring to knowledge transfer principles, tacit and explicit knowledge, the latter is by far the easiest and most common way of transferring it. However, to transform tacit knowledge into explicit knowledge requires a lot of effort.

54. The necessity to choose a suitable methodology supported by recognized standards coupled with a project team composed of knowledgeable people are the cornerstones for success. ISTAR TD project team has selected a methodology for evolutionary prototyping software development based on a phase delivery approach. This approach had the benefit to enable on going user training, user acceptance, and system's tailoring all at the same time during the validation testing sessions. This technique allowed all the different perspectives to evolve at the same time and to provide a balanced “System of systems” phased delivery that had periods of 12 to 18 months instead of multi years.

55. Building the body of knowledge to run a project such as implementing the Information Centric Collaborative Workspace (ICCW) requires a non negligible effort to assemble a team with the right skilled people and to have them act with cohesiveness under standardized project

management rules. Once the team is assembled, one should think about keeping that 'whole system production capability' to further support the system throughout its life cycle.

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