THE CANADIAN ISTAR INFORMATION-CENTRIC COLLABORATIVE WORKSPACE CONCEPT

PAPER THREE
The Info-Centric Collaborative Workspace From a Systems 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. The explosion of information technologies has set in motion a virtual tidal wave of change that is in the process of profoundly affecting both organizations and individuals in different aspects. This means that military organizations also face a tidal wave of transformation of an irresistible force that, at the same time, offers unprecedented challenges. The military does not have much choice. Resisting transformation is futile. However, accepting transformation in only the technological aspect is also not a valid option. Today, improvements in processing power and communications means make information technologies even more attractive and cost-effective for organizations to implement. Willingly or not, we have entered the information age. As Owens puts it, for a long time, information has been inseparable from commanders, command structures, and command systems [Owens 95]. Information is no longer the prerogative of commanders and command structures but has become necessary to all participants in a mission.

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.

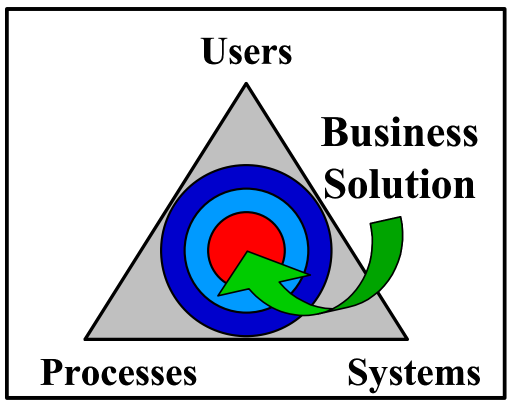

Figure 1: System of Systems Harmony Triangle:
Users - Processes - Systems

The Ingredients for "Systems" Transformation

4. The concept of system of systems is generally accepted to describe ways of designing and building information systems. The main challenge for a system of systems is to integrate into a coherent and homogenous infrastructure environment different systems that were individually designed and developed to support specific requirements at the outset. The system of systems approach must maximize the individuality and availability of functionality without regards to reuse of components. This approach is the one proposed by Information Technology (IT) Infrastructure. It gives to the organization a coherent framework of systems. This framework guarantees to the organization that every requirement is met by one of the sub-systems. The approach taken by the ISTAR-TD project is the development of an architecture of services associated to a System of Systems (SoS). This approach helps deliver the services necessary to support user requirements and business processes while maximizing reuse of components. It also guarantees the individuality of functionality and the encapsulation of services as well as giving a

better view of the global enterprise capability. The Services Architecture helps to identify the capabilities that are not supported in the current systems architecture.

5. The Canadian Land Force System Architecture was developed to support the requirements of specific user communities. This resulted in duplication of functionality, duplication of data entry in multiple systems, heterogeneous and incompatible infrastructure environment, and complex and costly system integration. With this approach, it was almost impossible for the organization to have rationalized requirements as well as a global view of its capability and thus, the capabilities that were not supported or at least not sufficiently supported. In addition, each system was built with a different development environment and with different functional standards. This proliferation of systems puts users in the awkward position to access a suite of heterogeneous applications and systems with different data and user interfaces to accomplish their day-to-day activities. This could result in misinterpretation of information and in errors in the manipulation of data.

6. The SoS architecture definition is relatively simple to accomplish if the mission and objectives of the System are clearly defined a priori. This means that the organization must have a clear vision of where the transformation process will lead it. If one is not rigorous during this phase, System Principles and Orientations for system design can translate into a lot of wasted effort [MPC 2004]. So building a "System of systems" represents a challenge in determining the necessary and appropriate Principles and Orientation to the problem. In the domain of science and engineering the notion of "System of systems" has always existed. In biology, for example, a human cell is a system in the human body that itself is a system in the animal kingdom. Then that animal kingdom can be considered a system of systems. That is to say that in order to properly address a problem, one has to adopt the right perspective [de Rosnay 1979]. Once identified, the next step consists in a de-composition into complementary components and services that make up the different parts of the "System of systems". Even though this represents a classical and well-known approach to system design, its success is still an art rather than a science and is the purview of a few dedicated professionals who have refined their art through years of experience.

Architecture of Services and the Info-Centric Collaborative Workspace

7. The Info-Centric Collaborative Workspace (ICCW) offers a new dimension to the System of Systems approach and provides an ideal environment for the implementation of an architecture of services. The availability of different functionality as services within an integrated and seamless user interface environment coupled with a common underlying data structure provides the users with a complete toolkit to support the planning and control of military operations and tactical intelligence. The user is also provided with the necessary support to share and visualize pertinent HQ data through the use of views to provide seamless access to Situation Awareness (SA). In the ICCW, this common look and feel is the responsibility of the information services that provide the users with the necessary accesses to data. Furthermore, when a user interacts with the services through the ICCW to access the underlying common data, all the services access the data with the same functional mechanisms and standards. This significantly reduces the risk of possible misinterpretation of the data and errors in the manipulation of data. It also eliminates induced errors and overhead associated with data conversion from one system to another.

8. The services approach requires the development of an architecture for the technology infrastructure. This architecture describes the different capabilities using: Application Services, Application Software Resources and Technology Infrastructure.

9. Application Services describe the specific services required from application software. They are organized by business solution. Their purpose is to illustrate the different ways in which application software is used. Traditional application software supports specific sets of business processes. In other words, application software was traditionally developed for a single and unique purpose. This has evolved to the current reality where access to numerous systems is required during the course of a typical business process. Interfaces to existing applications or databases are created specifically to support specific tasks in a business process. From the standpoint of the user, the identity of the application software is less important than the services provided in support of a specific business solution. Figure 2 presents one example of the ISTAR TD service architecture.

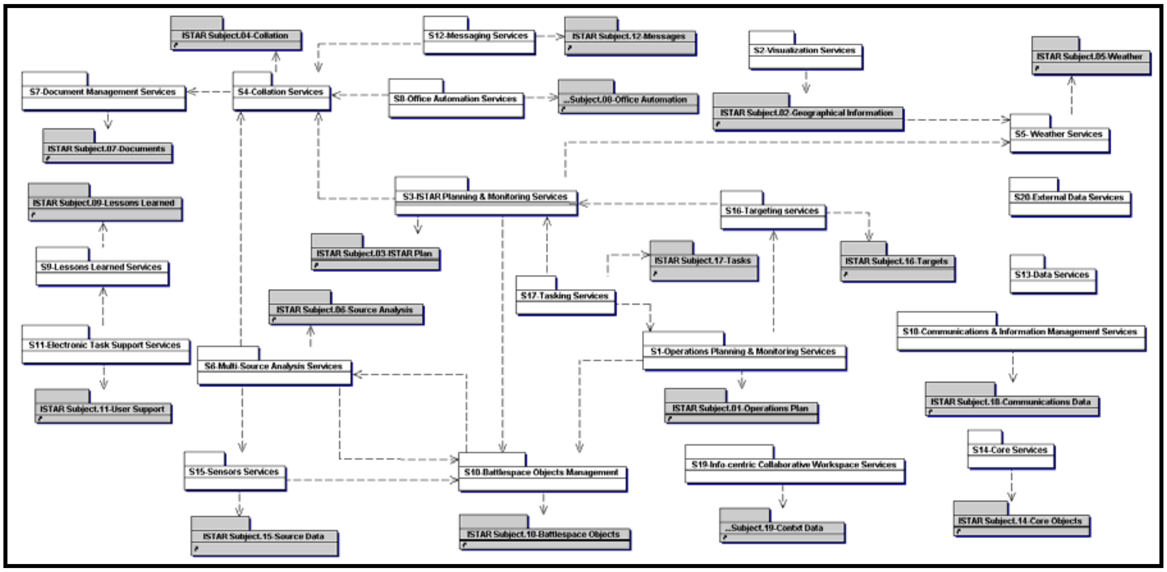

Figure 2: ISTAR TD Services

10. Application Software Resources describe application software in terms of the generic functions it is providing. It focuses on uniquely identifying and associating physical applications to facilitate reuse and eliminate redundancy. It emphasizes the ability of the application software resources to support the business operations. The proposed architecture represents trade-offs between affordability, performance, flexibility and supporting business operations, and combines new capabilities with legacy environments. It defines the structure and management of software component repositories. It also addresses assembly processes. Figure 3 depicts the application software resource architecture of ISTAR TD.

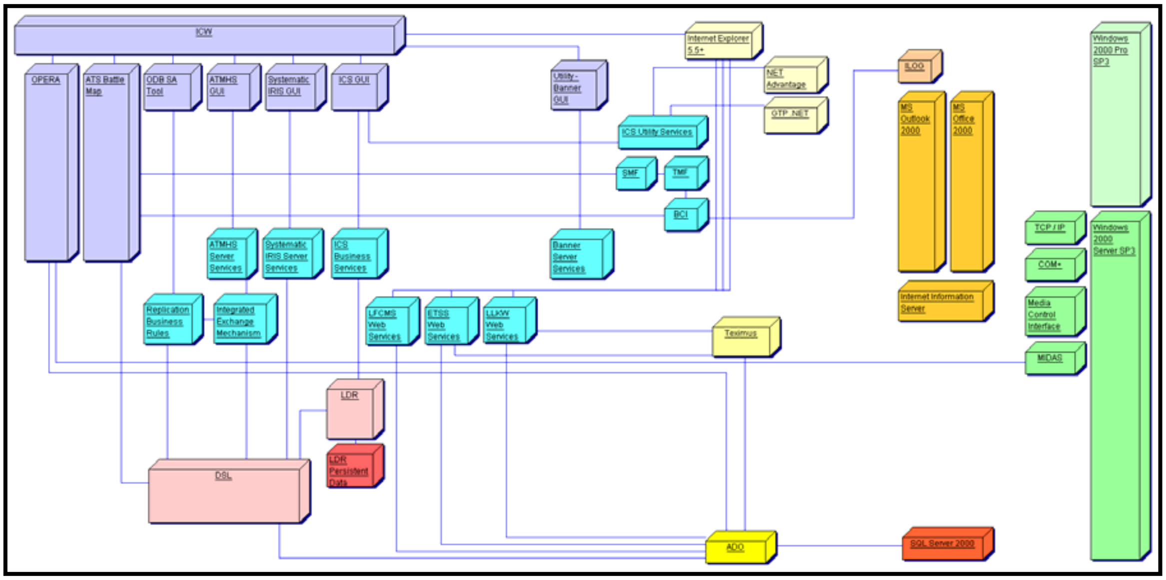

Figure 3: ISTAR TD Application Software Resources

11. Technology Infrastructure describes the technology infrastructure services to the extent required to ensure that the necessary components are available to deliver the application services. It addresses the sources of the technology infrastructure services, e.g. within the enterprise, outsourcing vendors, hosting services or through public services. Figure 4 presents the ISTAR TD Technology Infrastructure Model.

12. The result of this architecture is the identification of:

a) Services that are common to different business processes. These will form the basis of reusable system for the organization;
b) Services that are not covered by existing systems. This may result in the development of new system;
c) Systems that are redundant. These may possibly be rationalized single systems;
d) Systems that are partially redundant. These may become the subject of further enhancement to eliminate the redundancy, or be rationalized into reusable systems; and
e) Incapacity or Inability of the infrastructure to support the systems necessary to deliver the services. This results in the migration of the technology infrastructure.

Complementary Top-Down and Bottom-Up Solution

13. The approach taken by the ISTAR TD project in the development of an architecture of services in view of the complexity of the LFC2IS environment was to adopt both a top-down and a bottom-up complementary solution. The top-down approach was used to describe the services necessary to support the user requirements as it describes a high level architecture and details specific functions, tasks, and components. The bottom-up approach was used to describe the existing systems in term of functionality as illustrated in Figure 5. This approach describes the specifics of a system and fuses them into more global/general/high level functions. The result of both approaches was used to identify the services that were supported by the existing systems, the services that were not supported and the systems functionality that were found redundant.

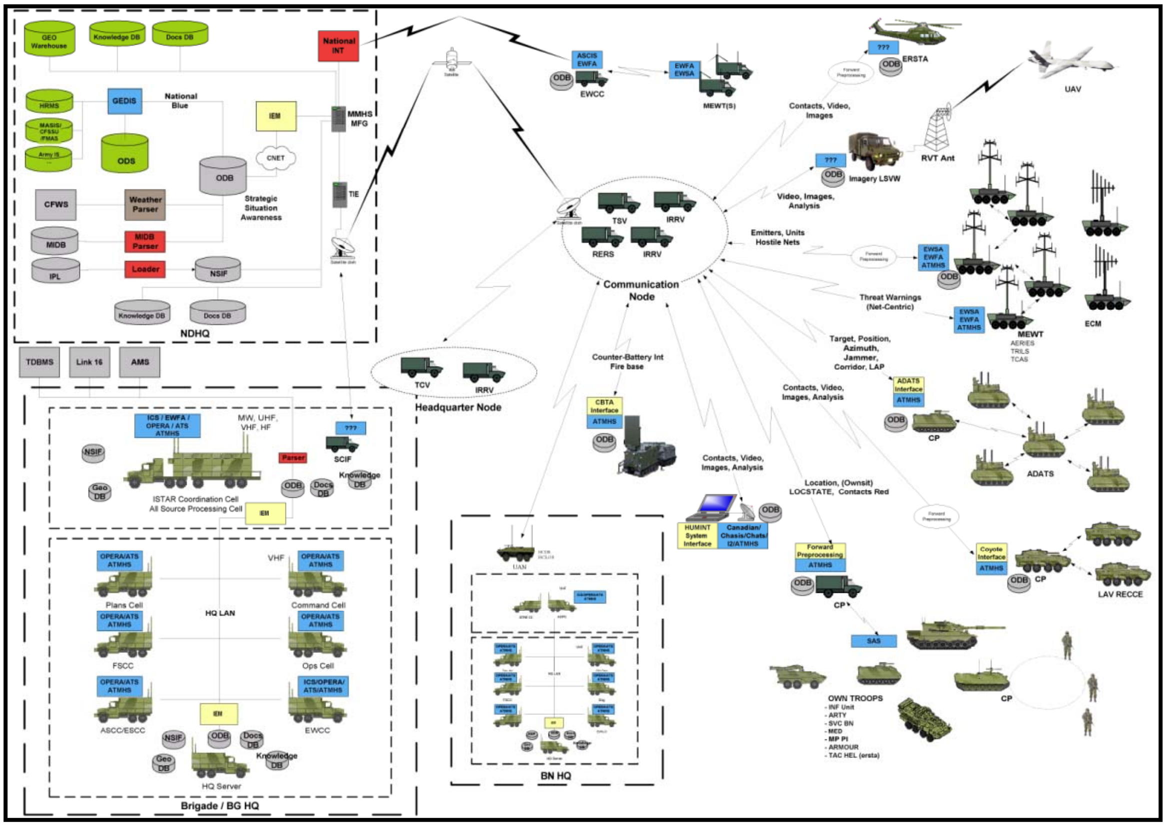

Figure 4: ISTAR TD Technology Infrastructure Model

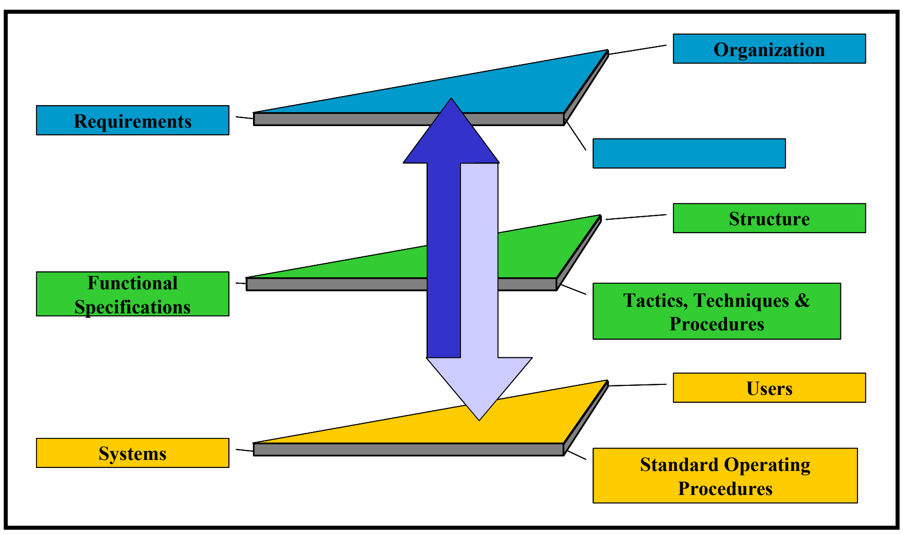

Figure 5: Complementary Top Down and Bottom Up approach

14. The Services Architecture is an enabler of the ICCW concept. This architecture focuses on the services provided instead of the business systems. By doing so it helps to define a common information model. This model is required to achieve information centricity. This model must result in a common and generic Business Object model that is shared by all the systems/services. It then becomes possible to exchange business information between the services/systems in a collaborative way. The information could be exchanged without the

necessity of contextual persistence. Further, a common ontology (information model) is mandatory to enable information centricity. Without it, conversion must take place between the different systems/services that could induce misinterpretation and bad translation of the data.

15. This further evolution of the Services Architecture is nevertheless facing one major constraint in that the workspace must work in a distributed environment while being flexible enough to support different decision making processes in different combat situations. The ICCW will contain a set of tools that will be used as necessary and appropriate depending upon the role and the level of command of the user in the information production chain. A difficult objective to achieve will be to deliver the ICCW at all levels in the information chain so that the same set of tools is available to perform fusion and analysis in support of the intelligence and SA. In order to improve the commander's ability to understand and conduct operations, he must be better informed just not more informed. This is the difference between “too much” and “just enough” information to enable the creation of the right knowledge about and sufficient understanding of the situation [Thorp 2003]. A shift to an intelligent pull approach, where the users get to shape their information space, clearly reduces the probability that users will be overwhelmed with information of little or no relevance. On the other hand, producers of information cannot possibly know all of the uses of the information they collect, nor the importance of the various details or lack of details, so posting before processing is not a solution. Perhaps, giving the possibility to information workers to obtain on-demand underlying data details may alleviate the danger of information bottlenecks.

16. The first step in the project was to develop a System of systems architecture. The results produced a clear vision for the environment and a clear path to achieve it. It was recommended that this path be evolutionary instead of being revolutionary so the design of the solution had to take into consideration as many of the current operational and future systems as possible including their limitations. Figure 6 presents 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.

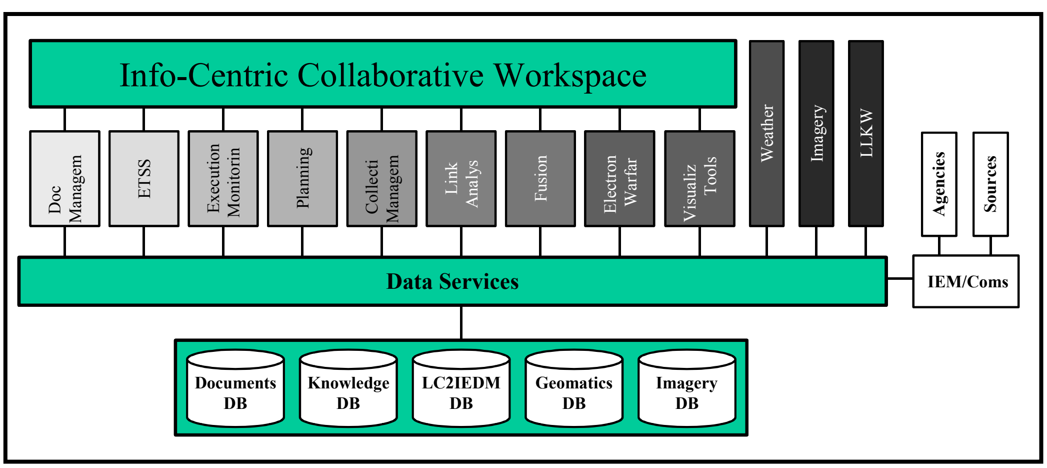

Figure 6: The proposed ICCW System of Systems Vision

17. The ICCW concept will allow all functions comprising ISTAR to work together and enable the different analysts to perform their tasks and extract information using different applications through a standardized Human Computer Interface (HCI). This ICCW concept also assumes that core application components will plug into the workspace environment in a similar

fashion irrespective of the military functions being integrated. The ICCW will contain a set of tools that will be used as necessary and appropriate depending upon the role and the level of command of the user in the information production chain. A difficult objective to achieve will be to deliver the info-centric collaborative workspace at all levels in the information chain so that the same set of tools is available to perform fusion and analysis in support of ISTAR. In order to improve the commander's ability to understand and conduct operations, he must be better informed just not more informed. This is the difference between “too much” and “just enough” information to enable the creation of the right knowledge about and sufficient understanding of the situation Figure 7 provides an example of the user interface provided by the ICCW under construction. It has been developed in accordance with the all the precepts described in this paper.

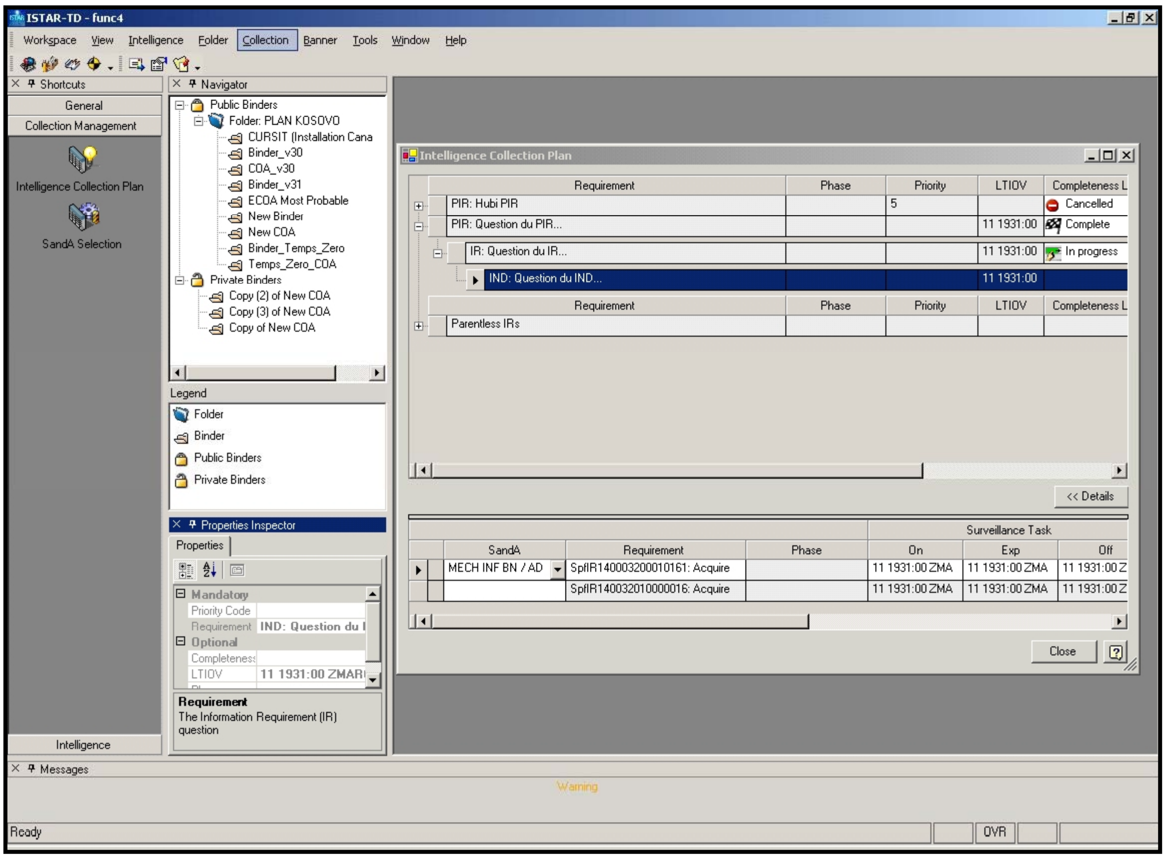

Figure 7: The ICCW System of Systems under development

Evolutionary Prototyping and the Release Strategy

18. The complexity and degree of uncertainty associated with system design results is inherently tied with the human factor. In other words, the diversity of characteristics, aptitudes, preferences, behaviors, and work methods specific to each user or user group makes it difficult to define useful and usable systems on a purely theoretical basis. To design, measure, and ensure intended functionality before completing the product, user evaluation of the proposed design must be used. A prototype technique can be used to mange these risks. It is well known that as a project progresses and work is accomplished, it becomes more and more expensive to make changes. However, the prototyping technique essentially tends to foster:

a) Early discovery of the organization's latent needs, by means of experimentation with a real system; and
b) Continued evolution of the system, during development, and after it enters production.

19. The prototyping technique aims at evaluating the appropriateness of the proposed system objectives, such as its principles, standards and models with the assistance of the users and the developers. This helps to ensure that the proposed system components design and construction will meet users' and developers' expectations. Consequently, using prototypes in each phase of the delivery process can significantly increase the quality of the final product. In many situations, it is possible to adopt an evolutionary prototyping strategy where subsequent prototypes converge towards becoming the actual final product delivered. The prototype development process is iterative and requires frequent evaluations by subject-matter experts and users. No matter the amount of attention applied to development, the first version of a software unit will never be satisfactory. This is why the development should follow an iterative process where each prototype is evaluated by the users and enhanced in regards to issues encountered during tests. The complete system is built progressively by successive iterations. In fact, each iteration is a prototype.

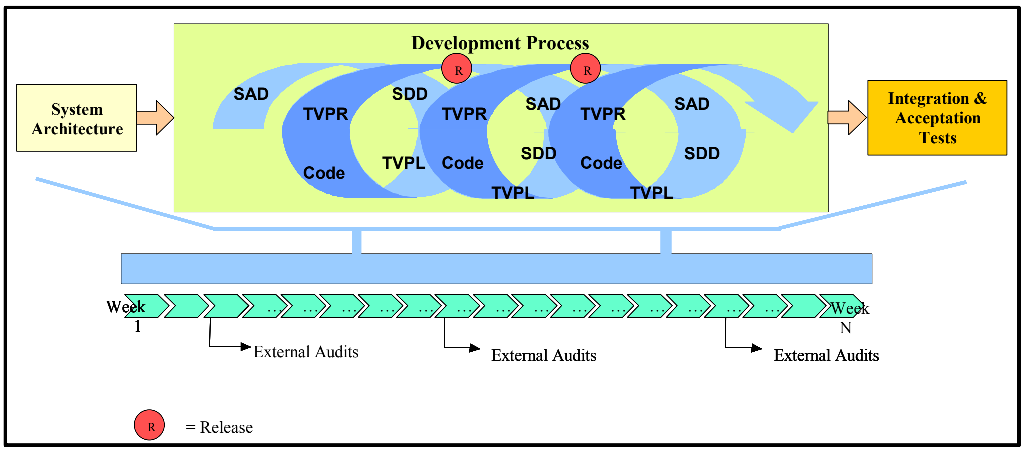

Figure 8: Software Evolutionary Prototyping Methodology

20. Figure 8 illustrates the evolutionary prototyping approach that has been retained. This 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.

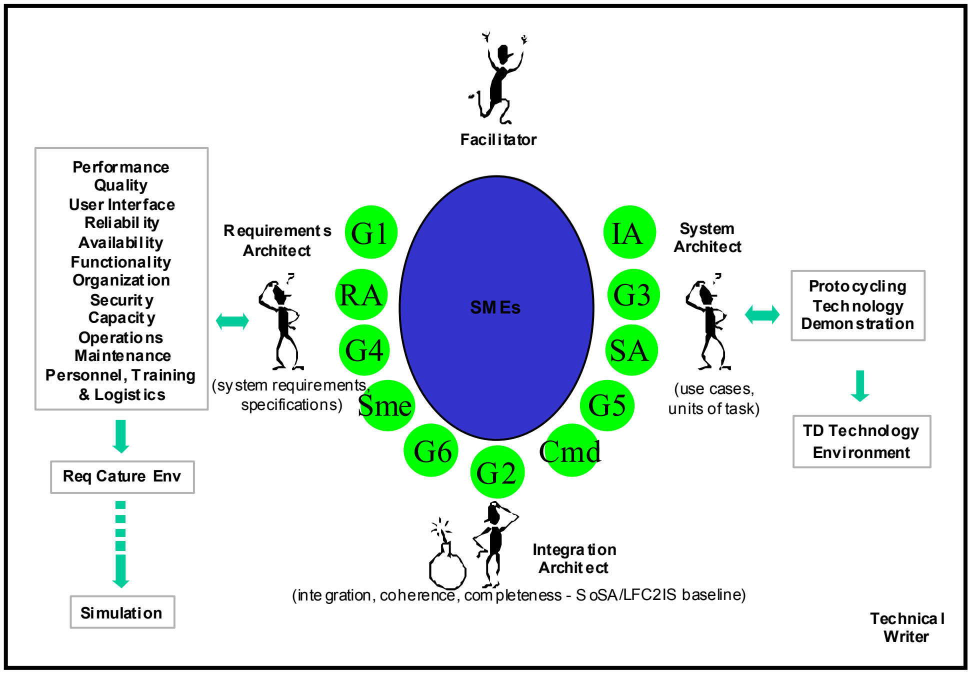

Figure 9: Joint Application Development (JAD) Set up

21. In the ISTAR TD project, the capture of User Requirements was done using the Joint Application Design (JAD) technique. The JAD workshops are deliberations during which the user representatives and the delivery group jointly review and complete the principles and design of one or more system components. The process is interactive and a workshop facilitator moderates the discussions. The results are recorded in predefined deliverables. One of the most interesting features of "Macroscope™" [Macroscope] in this context is the use of Joint Application Design (JAD) sessions with subject matter experts [JDWT] shown in Figure 9. The JAD technique also had to be adapted to a context of limited user availability. During the JAD sessions, the three main perspectives illustrated in Figure 1 had to be considered and weighed: the users and their capability to absorb the new technology, the procedures and processes that need to be adapted and the diverse required functionality of the systems.

22. When 'JADing' the challenge is to have a multidisciplinary team that through a comprehensive methodology understood by the different members can be used to document the different facets of the system. The goal is not to create a lot of documentation that only the editors will understand. The goal is to grasp and put the necessary information and knowledge in an explicit format to be reused by other team members. The challenge is to have a coherent set of documentation permitting to go from the top to the details.

23. In JAD sessions, a basic principle to remember is that Users are the main focus. They are those who will use or will not use the developed system. So the users are those people that will make a difference between delivering benefits to the organization or just wasting money and valuable resources. 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. As depicted in Figure 5, 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. During the JAD session, changes are addressed by all involved parties. This process requires a fairly good understanding of the organization and a lot of intellectual agility.

Viewpoints on the Enterprise and Information Systems

24. In order to produce a system that meets the Enterprise (Organization) Objectives, the Users Requirements and that is understandable by the developers, ISTAR TD is using the approach of different viewpoints. This achieves a solution satisfying the needs of all participants, the delivery of information systems considers enterprises and information systems from three points of view: owner, user, and developer. These three viewpoints correspond to those defined for software quality characteristics according to the ISO 9126 standard.

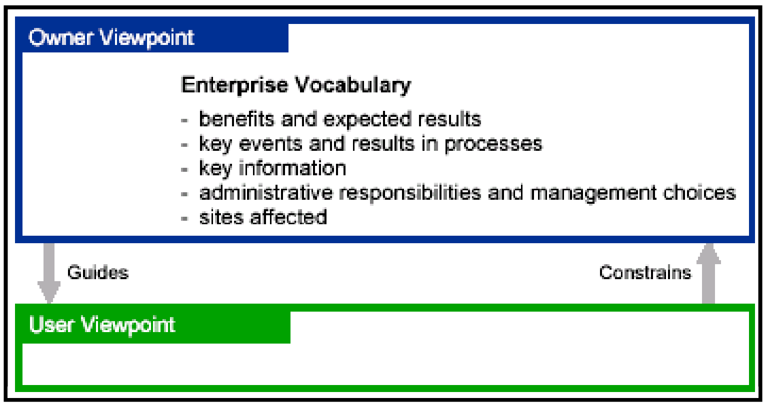

Figure 10: The System from the Owner's Point of View

- Improve the awareness of the battlefield by automating the link between some Sources, the ISTAR CC and the ASPC;
- Support the ISTAR Collection Management function

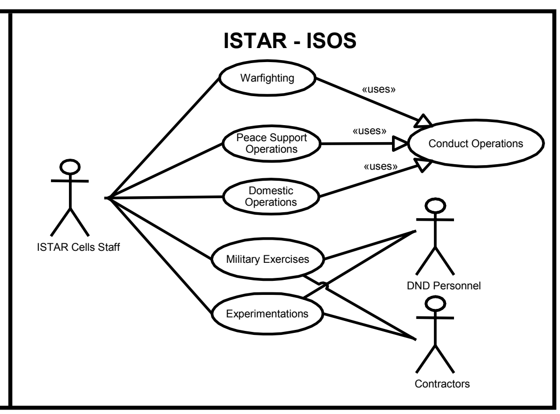

Figure 11: Owner's Point of View Examples

25. <u>Owner Viewpoint</u>. The owner viewpoint represents the enterprise practices and management options capable of supporting the organization's mission, supporting its ability to supply products and services, and ensuring its success. It is invariant with respect to the specific modes of operation or the physical resources used. It represents an "idealized" definition of the enterprise and of its processes that does not consider the functional constraints. From the owner viewpoint, the goal of the delivery process is a business or enterprise solution. For information systems, the emphasis of the owner viewpoint is more on questions defining the problem than on the solution (Figure 10): What are the needs? What do the systems do and why? What activities do they support? What information do they provide? What are the business principles? To find

the answer to these questions, the project team must consider the owner viewpoint both from a general and a detailed perspective, not limiting themselves to a high-level view or only to items destined for the owner. Figure 11 illustrates one example of ISTAR TD Owner's Point of View.

26. User Viewpoint. The user viewpoint describes the user-perceivable aspects: this perception can be direct, through the senses, or indirect, through an understanding of the operations. It involves a definition of the enterprise and its processes that considers the functional constraints. From the user viewpoint, the goal of the delivery process is to create a usable solution. For information systems, the user viewpoint emphasizes functional questions concerning the adopted solution (Figure 12): What is the behavior of the systems? Which parts are automated? What support is offered to the user? Where does data flow? Who is responsible for what? What are the system principles? The user viewpoint represents the functional choices adopted to support a productive work organization; it includes the automation choices and interaction with the user, and the behavior of the information systems. It is invariant with respect to the non-perceivable aspects and construction techniques. Figure 13 illustrates one example of ISTAR TD User's Point of View.

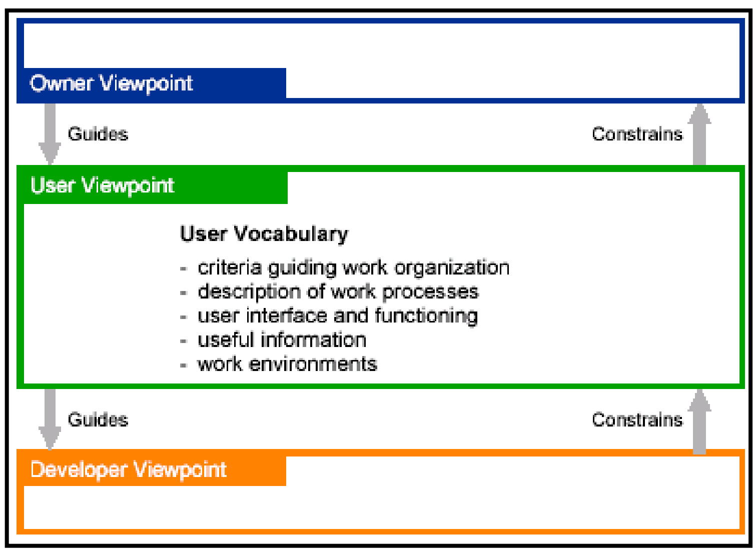

Figure 12: The System from the User's Point of View

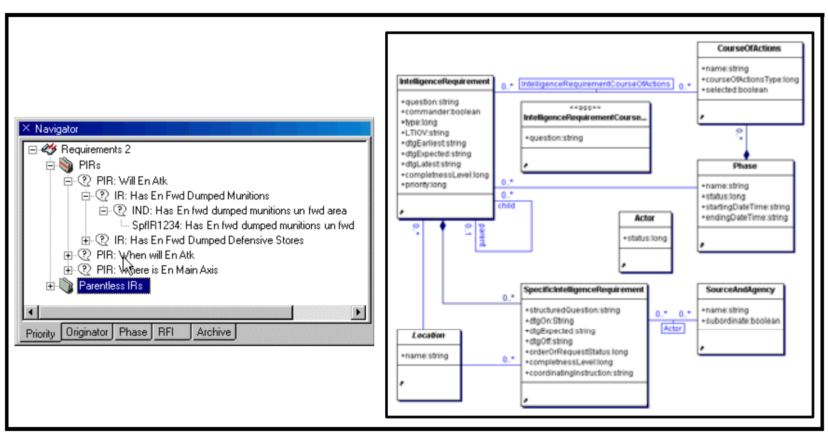

Figure 13: User's Point of View Example

27. Developer Viewpoint. The developer viewpoint is concerned with the implementation of the functional choices defined in the user viewpoint. It completes this viewpoint by adding aspects considered by the developer, but not perceivable to the user. From the developer viewpoint, the goal of the delivery process is to arrive at a well-crafted solution. For information systems, the developer viewpoint emphasizes questions of physical organization related to the technical construction of the solution (Figure 14): How is a specific process constructed? What hardware and software are required? How to adapt to their constraints? How to address the specialized ergonomic aspects? The developer viewpoint describes the internal structures used to construct the information systems and adapt them to the enabling computer hardware and basic software. It represents the physical organization of systems. One example of ISTAR TD Developer's Point of View is illustrated in Figure 15.

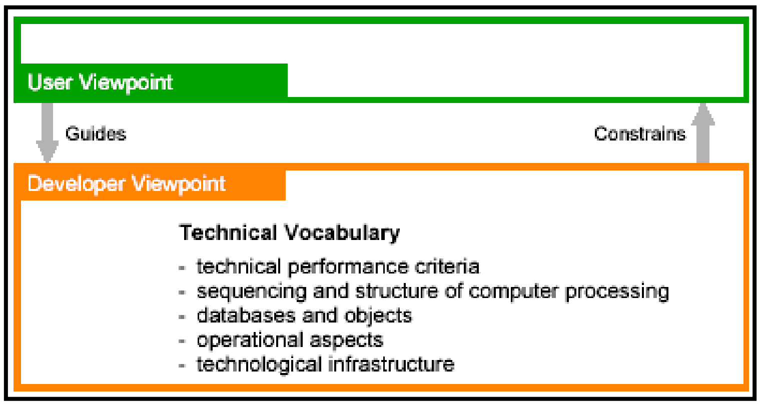

Figure 14: The System from the Developer's Point of View

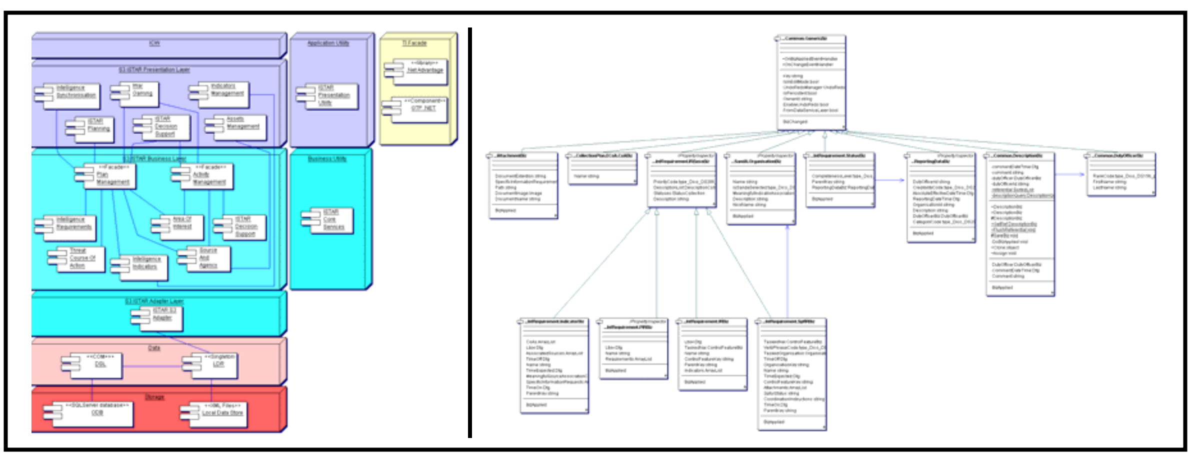
Figure 15: Developer's Point of View Examples

28. These different viewpoints are documented into different deliverables of IEEE 12207 [IEEE 12207] (Figure 16). A deliverable could contain more than one point of view. The different views of a document are added as the architecture and the analysis progress. In the figure 16, SARAD is system and requirements analysis document, SAD is system architecture document, SDD is software design document, and SIDD is software implementation design document.

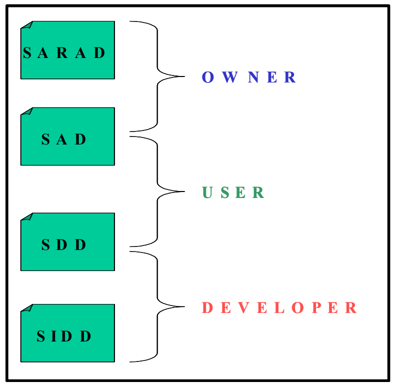

Figure 16: Point of View in IEEE 12207 Documents

Conclusion

23. We have seen so far that the project took a top-down approach, it identified a vision, it adopted a methodology, methods and standards, it designed a solution that took into consideration the current and selected future system components, articulated a SoS architecture, and finally, through its evolutionary prototyping methodology had taken a phased delivery approach. 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. We have 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.

28. The definition of a perfect "information centric collaborative workspace" is when all of the services existing in a "System of systems" are all working on the same distributed network in a manner as to offer a seamless collaborative environment. This enables the different analysts to perform their tasks and to extract information using different services through a standardized Human Computer Interface (HCI). The ICCW approach also provides major improvements in facilitating system's component integration from user training and a maintenance point of view.

REFERENCES

[IEEE 12207] Institute of Electrical and Electronics Engineers, Standard 12207 – IEEE standard for Industry Implementation of International Standard ISO/IEC 12207;ISBN 1-5593-7999-5; Product No.: SH94603-TBR; IEEE Standard No.: 12207-1997 SET, (WWW.ieee.org), 236 pages; 1997, Unclassified

[JDWT] Fujitsu Consulting Macroscope, Joint Development Workshop Technique (JDWT): Macroscope Productivity Center Reference: (http://us.fujitsu.com/services/Consulting/Methodology/Macroscope/) Unclassified

[Macroscope] Macroscope from Fujitsu Consulting: (http://us.fujitsu.com/services/Consulting/Methodology/Macroscope/) Unclassified

[MPC 2004] Defining System Principles and Orientations, Macroscope Productivity Center, deliverables P140S – Owner Requirements, P230S – User Alternatives, and P240S - User Principles; Fujitsu Consulting, Unclassified (http://us.fujitsu.com/services/Consulting/Methodology/Macroscope/)

[Owens 95] Owens, William, A., "Introduction to Dominant Battle-Space Knowledge: the Winning Edge"; edited by Stuart E. Johnson and Martin C. Libicki, National Defence University Press, Washington, 1995, Unclassified

[Thorp 2003] Thorp, John, "The information paradox: Realizing the business benefits of information technology"; McGraw-Hill, New-York, 1999-2003, Unclassified