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Lessons Learned from Establishing the IDF C4I Architecture

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In 2004, the Israeli Defense Forces (IDF) C4I Branch began an effort to build a C4I architecture. The goal of this effort is to enable the realization of the "e-IDF" vision ("air, sea and ground forces – fight as a single force"), and to take it step by step from idea to practice. This article describes the process of building the architecture for a large and complex organization as the IDF, focusing on the lessons learned, recommendations for other organizations trying to undertake a similar effort and planned activities for keeping the Israeli Defense Forces C4I architecture up to-date in years to come.

Background

Many organizations build their information systems as a response to specific business problems, and not as part of an enterprise wide solution. This approach usually results in a painstaking effort to integrate different business systems to achieve a common picture of the enterprise required to manage an agile and efficient organization. The Israeli Defense Forces (IDF) has also built some of its C4I systems in response to local requirements. Each service and branch asked for operational requirements suiting the different problems it faced and received the finest tailored solution that the IT units could come up with. The different IT units worked hard in order to supply the best solution to the needs raised by their different customers. Each IT project chose its own architecture and technology standards. This led to a fractured organization containing C4I systems built in a variety of architectures and technologies. In similarity to what happens in large business organizations, each C4I system is best suited to specific operational domain but lacks the capability to seamlessly integrate to the other C4I systems surrounding it.

Throughout 2004 the IDF general headquarters formed a new conceptual template for how the IDF will achieve better effectiveness in a rapidly changing environment. The need for updating the current operational concept rose from changes in the environment: the need to answer a variety of conflicts (LIC, HIC, and Terror), the change in the nature of conflicts (a-symmetric conflicts), the advances in technology (especially in information technologies), the decrease in the freedom of land maneuver and the continuing resource crisis. The new operational concept is a vision of a joint and simultaneous war fighting force, which will reduce the length of the war and the number of casualties suffered.

One of the fundamental abilities defined as the base of the new operational concept is "Information Superiority". The shared understanding in the IDF was that building local C4I systems will not allow the enterprise to maximize the potential hidden in these systems in order to achieve information superiority. The need to integrate the war fighters and the organization supporting them, stresses the need for highly connected C4I systems serving these joint efforts.

As part of the process of clarifying the new operational concept the need for a new branch as part of the general headquarters arose. The Command, Control, Computers, Communication and Information (C4I) branch was established on March 2003. The mission of the C4I branch is: "to enhance the effectiveness of the IDF". In order to fulfill its mission the C4I branch has conceived the "e-IDF" vision. This vision depicts an army fighting as one force at air, sea and land, one which handles a variety of tasks ranging from policing, LIC to full scale war. The "e-IDF" vision includes the guidelines for each layer of the required C4I system-of-systems. To enable this vision, an appropriate architecture is essential. The information and communication technology (ICT) architecture should synchronize all buildup efforts taking place in the services, in order to allow jointness[1] between fighting forces from different services on the battlefield. In 2004, the C4I Branch began to establish the "e-IDF" architecture in order to bring "e-IDF" from vision to fact.

The remainder of the article will describe the process of building the architecture for a large and complex organization as the IDF, focusing on the lessons learned, recommendations for other organizations trying to undertake a similar effort and planned activities for keeping the Israeli Defense Forces C4I architecture up to-date in years to come.

[1] Connectivity, information sharing, situational awareness, common battlefield understanding, etc.

Problem Statement

When we inspect C4I systems in the IDF today we find a variety of C4I architectures: each system was built according to a specially fitted architecture. The thing missing is an enterprise architecture showing the interfaces and dependencies between the different C4I systems serving the different organizational components. In order to view the collection of C4I systems as a system-of-systems we must define an enterprise wide architecture to help us define the tasks and limits of each system. In the current situation we do not have an enterprise architecture which leads to inconsistencies between our C4I efforts. The lack of an enterprise architecture leads to:

- Inflexibility in answering changing operational demands – unsynchronized C4I efforts leads to difficulties in adapting our C4I solutions to changing operational requirements.
- No senior management planning tools – an inability to examine the suitability of new C4I efforts to the IDF objectives. An inability to simulate scenarios of competing C4I efforts and how they will influence the IDF.
- Inventing the wheel – each project solves architectural problems from scratch. Each project chooses its own technological standards, creating a growing integration problem.

The Process

In order to repair this situation the C4I branch began to learn the topic of enterprise architecture and how it is implemented in the business world. We interviewed the leading companies in various Israeli industries. One of the lessons learned was that enterprise an architecture has the advantage of establishing organizational standards. Converging into standards reduces cost – preventing duplicate efforts, easier integration between enterprise systems and easier operations. These benefits result in higher operational effectiveness. We understood that building enterprise architectures is an organizational effort; requiring the involvement of the entire enterprise. This effort affects the enterprise work plan and requires integration of people and systems (not necessarily part of the same organizational unit).

The resulting enterprise architecture is a strategic tool helping in the inspection of new or current C4I efforts done by the IDF. Another major lesson we learned was the

need to treat the enterprise architecture effort as a project in itself: set-up phase, assimilation and enforcement phase, and a continuing maintenance phase.

Several methodologies for building C4I architectures were studied before beginning the effort: Unified Modeling Language (UML) artifacts used with the Rational Unified Process (RUP) methodology, Zachman Framework for describing enterprise architectures, and the DoD Architectural Framework (AF) used by the US Department of Defense.

The C4I Branch has chosen DoD AF as the methodology for describing its C4I architecture for number of reasons:

- It is a methodology that describes an enterprise; it is suitable for describing a collection of systems in an organization and their relations as opposed to a methodology suitable for describing a single system.
- The methodology is appropriate for a military organization; it starts with an "Operational View" (the equivalent to business processes and requirements) in other methodologies.
- It is an iterative methodology; it allows one to build some products before completing all preceding products. This feature is crucial when building architecture for a large and complex organization in a reasonable time .

DoD AF defines architecture as the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time. The framework defines three related views of architecture:

- Operational View – identifies what needs to be accomplished and who does it.
- Systems View – relates systems and characteristics to operational needs.
- Technical standards View – prescribes standards and conventions.

Each view defines the format for a number of products, building the architecture is done by completing these products. The framework defines 26 different products. The IDF has chosen half of them to describe the IDF enterprise architecture. The selected products were chosen according to the frameworks recommendation usage for building a modernization plan for the organization (see Figure 1).

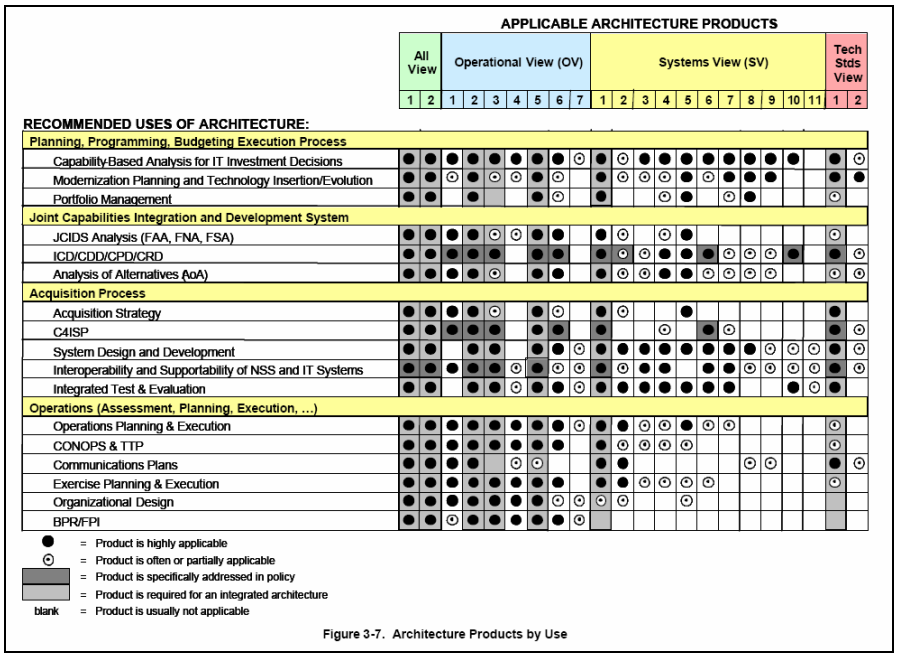

Figure 3-7. Architecture Products by Use

Figure 1 – Recommended architecture products by usage scenarios

As we started the architecture project we defined the work's level of resolution and the phases for the entire process. The focus for the architecture was defined as the network – capabilities, services, and the network structure – how a system connects to the network in order to expose or consume services. The architecture does not deal with the inner structure of any specific C4I system.

The work process phases were defined as follows:

- Phase A: current (As-Is) architecture for the C4I systems in the IDF – describing existing C4I systems, the relationships between them and the dilemmas of the current situation, blocking the advancement towards the vision. Phase A did not include analysis of the operational view (OV) due to its low relevance in light of the doctrinal change in the operational concept.
- Phase B: future (To-Be) architecture – describing the C4I systems and the relationships between them that will be needed in a future desirable architecture, including solutions to the dilemmas raised in the previous step. This phase was implemented in two steps: step 1 – a three to four years framework (tagged as increment 1) and a vision framework looking ten years ahead.
- Phase C: transformation plan – explains the required steps to get from the current to the desired (increment 1) architecture, including resources needed for the transformation.

Figure 2 summarizes the list of products and the process of building the IDF enterprise architecture.

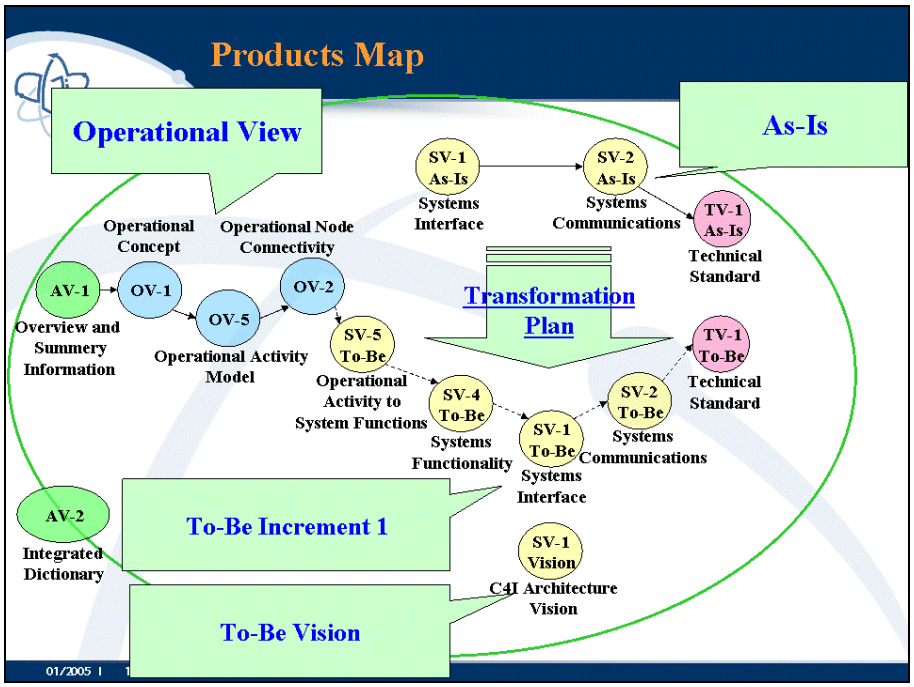

Figure 2 – Products map for the IDF enterprise architecture

Systems and Technical Views Building Process

In this section we will focus on the work done in describing the systems (SV) and technical standards (TV) views of the architecture. When building an architecture for a large and complex organization as the IDF, the process must be tackled from a number of aspects. We decided to split the work between four teams, each responsible for delivering the architecture of a certain architectural layer. The four work teams were:

- Network and communications infrastructure team – analysis of the network and communications systems and the interfaces between them (including: transmission infrastructure, data networks architecture, voice networks architecture, multimedia applications architecture and monitoring architecture).
- Systems infrastructure team – analysis of the systems infrastructure systems and the interfaces between them (including: data centers architecture, infrastructure services architecture, and mobile user connectivity architecture).
- Application architecture team – analysis of the applications and the interfaces between them (including: application layers concept and data warehouses architecture).

- Connectivity architecture team – analysis of the connectivity systems required to achieve joitness in the IDF and the interfaces between them (including: operational connectivity architecture, tactical connectivity architecture, and support systems connectivity architecture).

The relationship between the teams can be seen in Figure 3.

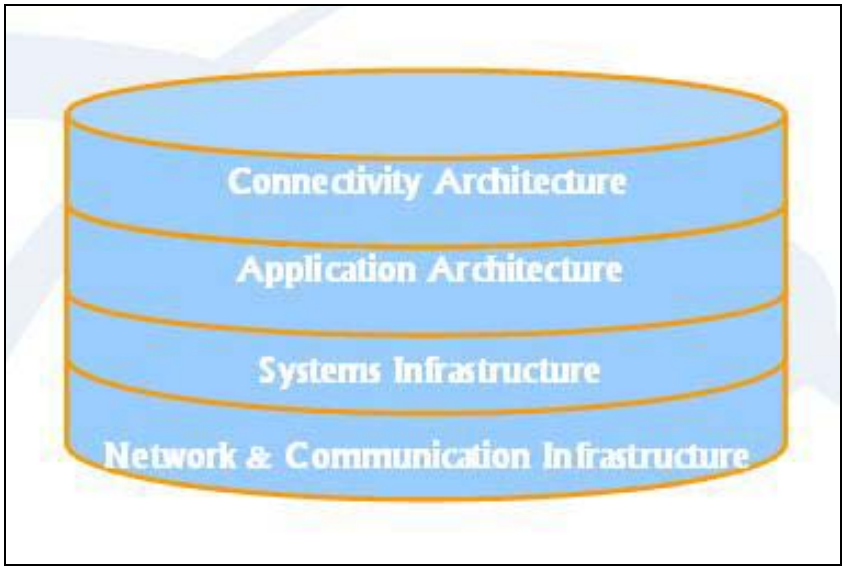

Figure 3 – The relationships between the architectural working teams

To complete the architecture in a reasonable time frame, the teams had to work in parallel. The dependencies between the different teams caused a few problems. First, dilemmas raised in one team often required a solution by another. Second, a concept one team proposed usually required a concept change in another team. Third, common dilemmas incorporated experts from different layers. An integration team, led by the CTO of the C4I Branch, has been nominated to guide the teams, design the process templates, and workout the dependencies between the teams. The integration team worked in parallel to the other team's work and included representatives from all teams. Its final task was to create the integrative desired "e-IDF" architecture, and overall transformation plan. Furthermore an automated tool to manage and synchronize the architecture creation process was chosen: System Architect® by Popkin software.

In order to allow the distributed and parallel work of the different teams the integration team created a common joint template. As can be seen in Figure 4 the

template includes the systems interface description product (SV-1) depicting only systems nodes. After reaching a common view of the system nodes each team could now fill in the system elements, relevant to the layer it is analyzing, inside the system nodes. The integration team work typically included defining the interfaces between systems from different architectural layers.

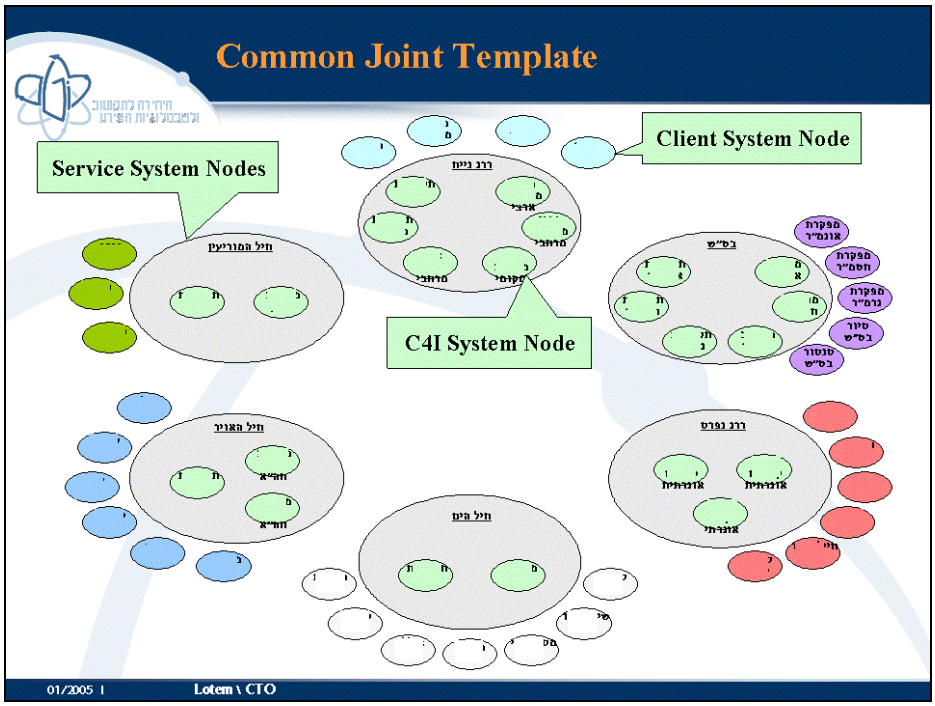

Figure 4 – The common joint template created by the integration team

We will show here a short description of one of the team's products: the application architecture team. The team's responsibility was to analyze the As-Is architecture of applications in the IDF, raise dilemmas and suggest an appropriate To-Be architecture according to the dilemmas and the operational requirements. The team started with describing the current As-Is architecture. Figure 5 shows some of the team's work. All existing applications in the IDF and their interfaces were mapped. The diagram shows a graphic description of the systems mapped.

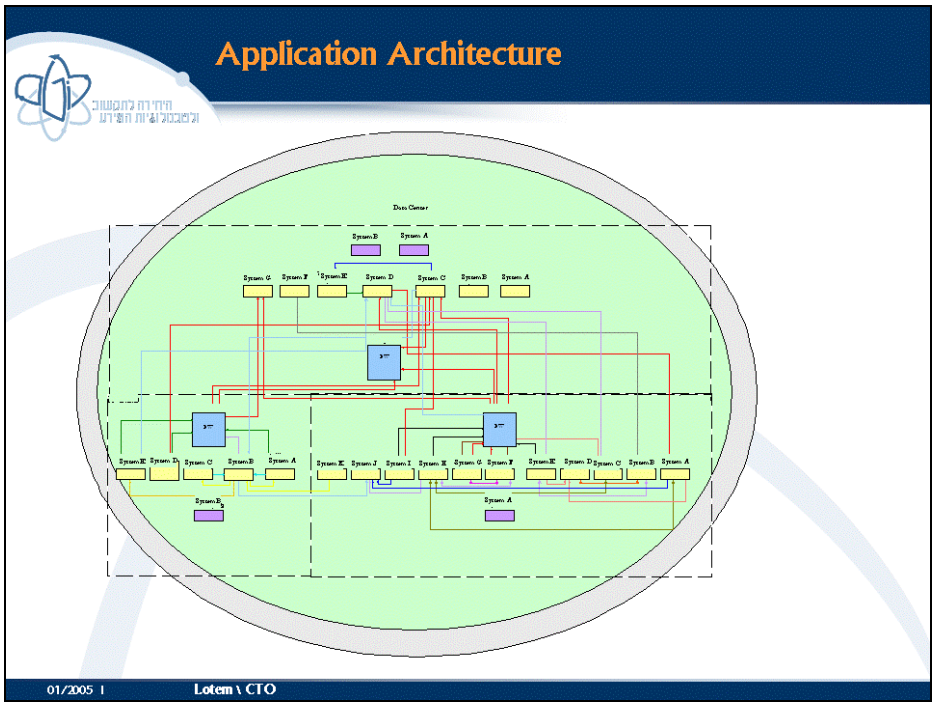

Figure 5 – Application's team as-is architecture

Following are the dilemmas in the current architecture, the team identified:

- Partial/non existing "common language" across the organization.
- Duplicate data, managed again and again in different systems.
- Many different data replication mechanisms.
- No re-use of functionality.

The team has also identified two organizational dilemmas:

- Client oriented and not process oriented requirements, especially problematic when managing enterprise wide resources.
- Partial synchronization of development efforts, and a variety of bodies representing the end client.

After analyzing the current As-Is situation the team suggested a To-Be architecture in two steps: a vision architecture (10 years ahead) and increment 1 architecture (3-4 years ahead). Figure 6 shows the applications architecture team To-Be vision architecture, depicting an enterprise service bus, with all applications exposed through it as services. Connectivity between the systems is also achieved through the service bus.

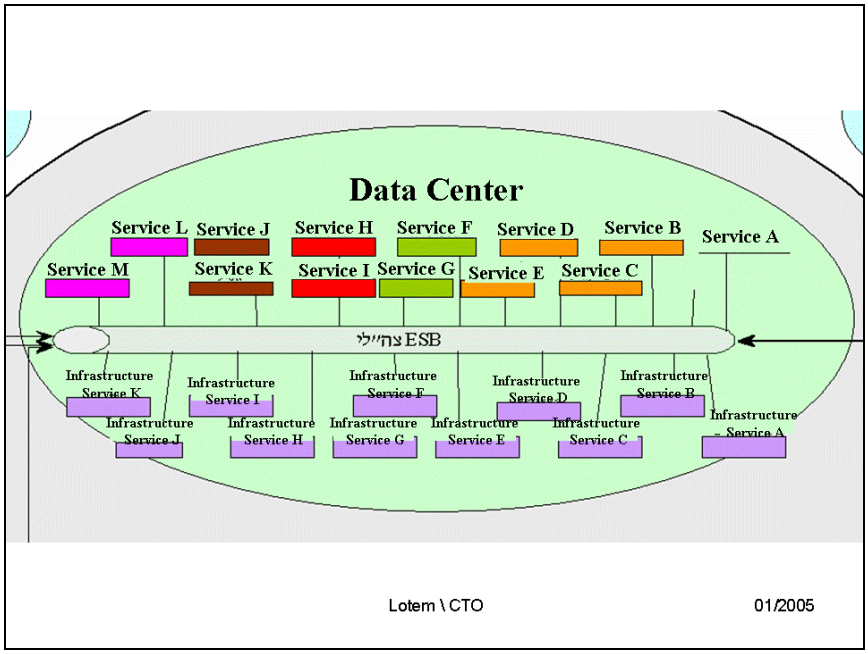

Figure 6 – Application team to-be vision architecture

Lessons Learned

In this section we will present the lessons learned by the C4I Branch while going through the parallel work process described above. The lessons will focus on two aspects: lessons learned from the *content* of the work and lessons learned from the work *process*.

- Lessons learned from the *content* of the work:
  - "Common language" – since building an enterprise architecture is an enterprise wide effort executed by a number of teams working in parallel, each mapping a single viewpoint of the C4I architecture, a unifying template must be supplied in advanced. The template is the "glue" that holds all the viewpoints together creating a single enterprise architecture.
    The lesson is to define in advance a "common language" template that enables us to combine all products into a single coherent architecture.
  - Modeling hundreds of systems into one coherent architecture using representative systems – an enterprise architecture for a large and complex organization like the IDF contains hundreds of systems and thousands of interfaces between them. To maintain a reasonable level of complexity when modeling such a large system-of-systems representative systems have been chosen according to their typical characteristics. These representative systems were analyzed and used to portray a complete picture of the architecture with out hurting clarity.
    The lesson is to use representative systems in places where analyzing large numbers of systems clutter the resulting architectural picture.
  - Focus on current architecture dilemmas – one of the problems we had moving to the second phase of our work was giving the working teams a clear focus for their work. Each team had a large number of dilemmas he wanted to deal with. In order to focus the work on the To-Be architecture, all the dilemmas discussed in phase A were analyzed; but only a few of them were confirmed for the next phase.
    The lesson is focusing the work of the teams working on the To-Be architecture using a small number of dilemmas from the As-Is architecture.
  - Automated products integration – in order to perform an integration of the different working team's products a computerized tool was used. This tool allowed the management of a common dictionary containing the terms and definitions used by the entire working group. Each team sketched the diagrams suitable to their viewpoint of the architecture. Existing tools (including the tool we used) do not know how to automatically integrate the different viewpoints of the architecture into one architectural picture and we had to do this integration manually.

The lesson is to experiment with developing a tool for automated integration of the architectural picture.

- Lessons learned from the work *process*:
  - Separating the As-Is products from the operational view – as described above, due to its complexity the architecture was built by a number of teams working in parallel. To allow the systems view teams to move on, the process of mapping the As-Is architecture was based on the operational high level concept product (OV-1) with out waiting for the completion of the entire operational view products.
    The lesson is to use an iterative methodology allowing work on some products before preceding products have been completed. To-Be systems architecture can be built with out detailed operational processes, especially when constructing the network and communication infrastructures architecture.
  - "Common language" – as mentioned above a common data base used by all teams was set up. This data base accompanied the process of building the architecture and enabled the parallel work of the teams.
    The lesson is maximum transparency and constant information sharing between the teams.
  - Resolution – as part of the effort to create a common language between the working teams, the efforts resolution level was defined beforehand. This was done in order to prevent a situation were each team describes the architecture in a different detail level (system-of-systems, systems, sub-systems, inner interfaces). We determined the single "system" (C4I system or interfacing systems, like a weapons or sensor systems) as the "atom" upon which the entire architecture was built. There was no "drill down" to the level of the sub-system. The focus was on the relationships between the systems.
    The lesson is to set one common level of detail for the entire architectural effort, and to focus the teams on the interfaces between systems.
  - Difficulty in defining the architectural effort client – during the work process the question of who are the clients of the architecture was repeatedly asked. Is it intended for senior command or for the project officers? Although no one simple answer exists, it is important to define – as part of the process – different usage scenarios, so each potential client can associate with the process.
    The lesson is to define beforehand the clients that will be using the architecture products and how they will be using them.
  - Accompanying integration process – during the work process we discovered that many topics are dependent on more then one team. The integration team we appointed held weekly meetings in order to expose and solve all the conflicting topics. Selecting the right panel for the integration team is crucial; we assembled representatives from each of the teams.
    The lesson is to closely direct the process with an integration team in order to maintain a holistic view of the architecture.

Recommendations

Our recommendations for organizations undertaking a similar process of C4I architecture establishment are:

- In most cases an enterprise architecture (at least a first version of it) should be built in a relatively short period of time (6-12 months). This means working in parallel on the operational and systems views. In order to keep the focus of the working teams, a small number of representing operational processes should be analyzed. The systems view teams should broadly analyze these operational processes and suggest a suitable infrastructure supporting these and similar operational processes.
  Our recommendation is to analyze a small number of representative operational processes and to suggest a broad solution, able to support a variety of operational needs.
- Our work suggested the need for defining many technical standards. In order to focus the teams work we started with standards concerning connecting systems and only after defining them we proceeded to deal with standards of building systems.
  Our recommendation is to focus on connectivity standards first.

Future activities

The C4I Branch continues the effort to define the "e-IDF" architecture for years to come. In order to direct future efforts two additional products are being prepared:

- A transformation plan – a gradual plan setting the path from current architecture to the To-Be increment 1 architecture. This plan will be updated according to new C4I efforts completed each year.
- Standards definition work plan – a perennial work plan for defining the various standards for building C4I systems. These standards will become mandated within the IDF from now on. The work plan focuses on connectivity standards.

There is a growing understanding in the IDF, that the architectural effort is a continues one. We plan to revise it yearly, update the changes, and direct ongoing and future C4I projects accordingly.