Chapter 2 – BACKGROUND

2.1 PROBLEM FRAMEWORK

Analysis for formulating the Task Group Programme of Work was initiated during two meetings of Exploratory Team 014 and was completed during the first and second meetings of TG-012. A summary of that analysis follows:

Four different frameworks for analyzing the problem being addressed by the Task Group were considered:

1) Architectural

   Adaptive information management strategies would be classified according to the level in a system architecture where they are applied, namely:

   - Application or application database;
   - Middleware layer; and
   - Communications network layers.

2) Command Level

   Adaptive information management strategies would be classified according to the command level in the tactical domain where they are applied:

   - Brigade;
   - Battalion;
   - Company; and
   - Section.

3) Conflict Intensity

   Adaptive information management strategies would be classified according to the different intensities of conflict where they would be used, namely:

   - High intensity;
   - Medium intensity;
   - Low intensity; and
   - Operations other than war.

4) Tactical Radio Characteristics

   Adaptive information management strategies would be classified according to the nature of the radio systems over which the data is being passed, namely:

   - Data only; and
   - Integrated voice and data.

The Task Group concluded that the architectural framework provided the most logical framework for analyzing the problem. The factors of command level, conflict intensity and radio characteristics can each influence the nature of information strategies that are employed and the effectiveness of those strategies. However, it was felt that the level in a system architecture where the techniques are applied has the most direct bearing on the nature of techniques selected, the way in which the techniques are implemented, and their ultimate effectiveness.

The Task Group decided that it should limit its attention to national (as opposed to coalition) forces employing land-based tactical radio systems (Army, Marines)[1] deployed in mobile nodes. Further, it was agreed that attention would be restricted to battalion level and below, in particular:

a) A battalion command net employing vehicle-mounted radios; and

b) A small dismounted unit (for example, a section of infantry) employing man-portable radios.

The Task Group further concluded that its attention should be focused on scenarios of high-intensity conflict, since that is the environment in which the demand on the communication system is most intense and is therefore the environment in which adaptive information management strategies can provide the most added value for the military user.

2.2 PROGRAMME OF WORK

It was decided that the programme of work which best served the Task Group goals would comprise the following key components:

1) A series of three workshops. Each workshop would:
   - Address a key issue in information management at a different level of C2IS architecture (application, middleware, communications network);
   - Be associated with a Task Group meeting;
   - Be of one – two day duration; and
   - Be open to all NATO (but not PfP) nations and involve, where possible, invited experts on the issue.

2) Sharing and analysis of results from one or more national experiments.

2.3 OVERVIEW OF WORKSHOPS

As part of its programme of work, the Task Group undertook to organize three workshops, each addressing a key issue in information management at a different level of C2IS architecture (application, middleware, communications network). The first workshop was held at DRDC – Valcartier in Canada in September 2002 on the topic of 'Data Replication over Disadvantaged Tactical Communication Links'. The second workshop was held at FGAN/FKIE in Germany in August 2003 on the topic of 'Role of Middleware in Systems Functioning over Mobile Wireless Networks'. The third workshop was held at Naval Research Laboratory in the United States in June 2004 on the topic of 'Cross-Layer Issues in the Design of Tactical Mobile Ad Hoc

[1] In this document, the general term Land Force will be used to refer to either Army or Marine elements employing land-based tactical radios.

Wireless Networks: Integration of Communication and Networking Functions to Support Optimal Information Management'.

A summary of the objective of each workshop is provided in the following three sections.

2.3.1 Data Replication over Disadvantaged Tactical Communication Links

The objective of this workshop was to address the problem of replicating data among distributed databases over disadvantaged (unreliable, low bandwidth or energy-constrained) mobile wireless military communication networks. Links in such networks are generally characterized by extremely limited and highly variable data throughput. For the foreseeable future, tactical data communications networks are unlikely to be able to distribute all of the timely information required to support global situation awareness. One consequence is that the data in adjacent databases on the battlefield will not be fully consistent much of the time. The challenge was to find ways for the military user in the tactical domain to exploit the information in databases effectively when traditional consistency expectations are unrealistic.

Application layer information exchange issues are discussed in Chapter 4. A copy of the technical programme for the data replication workshop can be found at Annex A.

2.3.2 Role of Middleware in Systems Functioning over Mobile Wireless Networks

The objective of this workshop was to address the role of middleware in disadvantaged military communication networks. In contrast to the cellular networks that are the standard for commercial applications, these military networks will typically be of an ad hoc or infrastructureless nature. The challenge was to find ways to use middleware effectively to enable and support intelligent information distribution in such communications environments.

Issues associated with the role of middleware are discussed in Chapter 5. A copy of the technical programme for the workshop on role of middleware can be found at Annex B.

2.3.3 Cross-Layer Issues in the Design of Tactical Mobile Ad Hoc Wireless Networks: Integration of Communication and Networking Functions to Support Optimal Information Management

The objective of this workshop was to address the challenge of 'top-to-bottom' information management in tactical command and control systems functioning over mobile ad hoc networks. Crucial issues relating to communication and networking in hostile environments include the characteristics of the physical channel, media-access mechanisms, routing, network control structures, and data structures. These issues span the entire layered structure from the physical layer up through the application layer. The conventional way to implement networks is to use a strictly layered structure, in which these issues are addressed separately, while defining interfaces to higher and lower layer functions. Although such an approach may be appropriate for wired networks, the characteristics of wireless networks suggest that improved performance may be obtained by addressing these issues in a coordinated fashion. This workshop addressed alternative approaches to various aspects of the communication/networking problem, and assessed the potential benefits that may be achieved through the vertical integration of layer functionality. Employing results obtained from the first two workshops, this workshop also addressed how these changes can support improved collaboration with business applications residing on the network to achieve information exchange that is sensitive to, and constantly optimized for, the changing needs of the military user in the tactical domain.

Networking issues associated with mobile ad hoc networks are discussed in Chapter 6. A copy of the technical programme for the workshop on cross-layer issues can be found at Annex C.

2.4 OVERVIEW OF CONTRIBUTIONS FROM NATIONAL EXPERIMENTS

The Task Group sought to organize one or more experiments, or to analyze available results of one or more experiments, that would validate and demonstrate the potential for adaptive information management schemes, implemented at the application/database layer within tactical C2 nodes, to minimize the impact of the low and variable throughput and unreliable connectivity of a mobile wireless military communications grid. After studying several options, the Task Group decided that it would focus its efforts on exploiting the low-bandwidth test bed being installed at DRDC Valcartier in Canada. The test bed was designed to support a set of national experiments planned under the Canadian High Capacity Tactical Communications Network Technology Demonstration project. The objectives of these experiments were very closely aligned with the overall objective of RTG-012. Canada offered to make some of its experimental results available to the Task Group.

At the Task Group's first meeting, the possibility was discussed of having the Task Group members observe experiments to be conducted using Poland's 'Wide Area Network for Operational Data Exchange' (WANODE). WANODE is a prototype system for tactical data exchange that uses a data replication mechanism to replicate data changes between mobile or fixed tactical nodes. The data replication mechanism is a custom mechanism that is not based on the ATCCIS Replication Mechanism (see Annex D). It was subsequently decided that observation of WANODE experiments would not be possible for security reasons. In October 2003, Poland offered the possibility of contributing some results from WANODE to support the Task Group's work. However, in late 2004, it was learned that performance metrics obtained using WANODE would not be available in time for inclusion in the Task Group's final report.

Similarly, a German simulation tool called FIT was considered but it was concluded that it did not provide the level of functionality required for Task Group work.

Experiments conducted using the Canadian Low Bandwidth Test Bed, and lessons learned from those experiments, are discussed in Chapter 7.