NATO RTG SAS-045
on
Computer Based Decision Support Tool for Helicopter Mission Planning in Disaster Relief and Military Operations

Annex D – TECHNICAL REPORT 4: OVERVIEW OF RESEARCH ON MODELS, DATA AND KNOWLEDGE MANAGEMENT REPOSITORIES AND PLANNING PROCESS IN NATO ORGANISATIONS

Marcel Smit
TNO-FEL, P.O. Box 96864, 2509 JG The Hague, The Netherlands
Tel: +31 70 374 0175; Fax: +31 70 374 0642

Email: M.C.Smit@fel.tno.nl

D.1 INTRODUCTION

This document is prepared to fulfil the requirements of the Programme of Work (POW) of NATO SAS-045 RTG on "Computer Based Decision Support Tool for Helicopter Mission Planning in Disaster Relief and Military Operations".

The POW dictates to provide an a-priori analysis of the model, data, and knowledge management repositories (which are available in NATO nations and which can be made available for this study) and that are anticipated to support the development of NATO SAS-045 project. As it is stated in the Terms of Reference (TOR) of the aforementioned project, the main goal of the research is to provide the basis for developing a generic and flexible decision support tool for effective management of helicopter missions by conducting the problem analysis, investigating the concept of solutions and determining relevant technical requirements.

It is foreseen that different models, technologies and solution approaches will be utilised concurrently, and integration and interfacing will pose itself as an important technical issue within the scope of maintaining interoperability and standardisation in NATO practices.

Thus, the POW states that during the Analysis Phase of the project technology surveys should be carried out on modelling, computer and software engineering and data collection technologies; geographical information systems, digital maps, mission data compilation systems; model, data, and knowledge management repositories in NATO nations. Then, the technology mapping and capability matrix can be developed using the identified current needs and capability gaps.

In this document, it is intended to provide a broad overview that will guide any potential research dealing with the design and development of a generic decision support tool within a similar NATO context, not limited to helicopter operations.

In this document an overview is given of the models that are being used to support the planning process of operations and helicopter operations more specific. The planning models described in this report refer only to planning models that are being used in a military environment. SAS-045 also looks at planning of helicopter operations in disaster relief operations. However, in disaster relief operations military helicopters will be used and in this case planning of the helicopters will always be performed by military personnel using military planning models. Another point to address is that in this research no helicopter planning models have been found that are being used by civil organisations in disaster relief operations. So it is sufficient to describe the helicopter planning models that are being used in a military environment.

First the planning process inside NATO is described (Chapter 2). In Chapter 3 an overview is given of the models that exist inside NATO to support the planning process of operations. Then in Chapter 4 an overview is given of the models that exist in the nations. It is very well possible that this overview is not complete. Only the models known by one the members of SAS-045 are described here. This report will be closed with some conclusions (Chapter 5).

D.2 NATO PLANNING PROCESS

Operational planning in NATO (see also ref. [1]) can be conducted under a wide range of conditions, from routine exercises to immediate reaction to an attack on NATO territory. The main categories of planning situations are:

- The response to an emerging crisis situation that NATO might become involved in- typically a peace support operation where NATO become involved as the result of a UN resolution/mandate and request for intervention; and
- Prudent military planning for potential future operations that are not linked to any expressed threat or an actual crisis situation, but which nevertheless require advance planning to ensure NATO's ability to respond should it be called upon to do so.

The ultimate responsibility for initiating planning under any of these headings rests with NATO's political leadership – the North Atlantic Council (NAC) although military commanders are, of course, expected to conduct prudent military planning within their terms of reference. In either case, the planning procedures that NATO has adopted are the same although the urgency and time pressure will of course differ. The basic steps of the planning process are also the same for the different command levels of planning – the military strategic, the operational and the tactical/component levels. In NATO, the planning at all levels is typically conducted in parallel with close interactions throughout the command hierarchy. The basic military concepts used in the NATO Operational Planning Process (OPP) (see Figure D.1) are the same or similar to those found in national military doctrines. However, certain key aspects of the planning process will be different for the obvious reasons that NATO is an alliance of 19 sovereign nations and that military forces only become available to the NATO commanders through the contributions from the nations in the force generation and activation process.

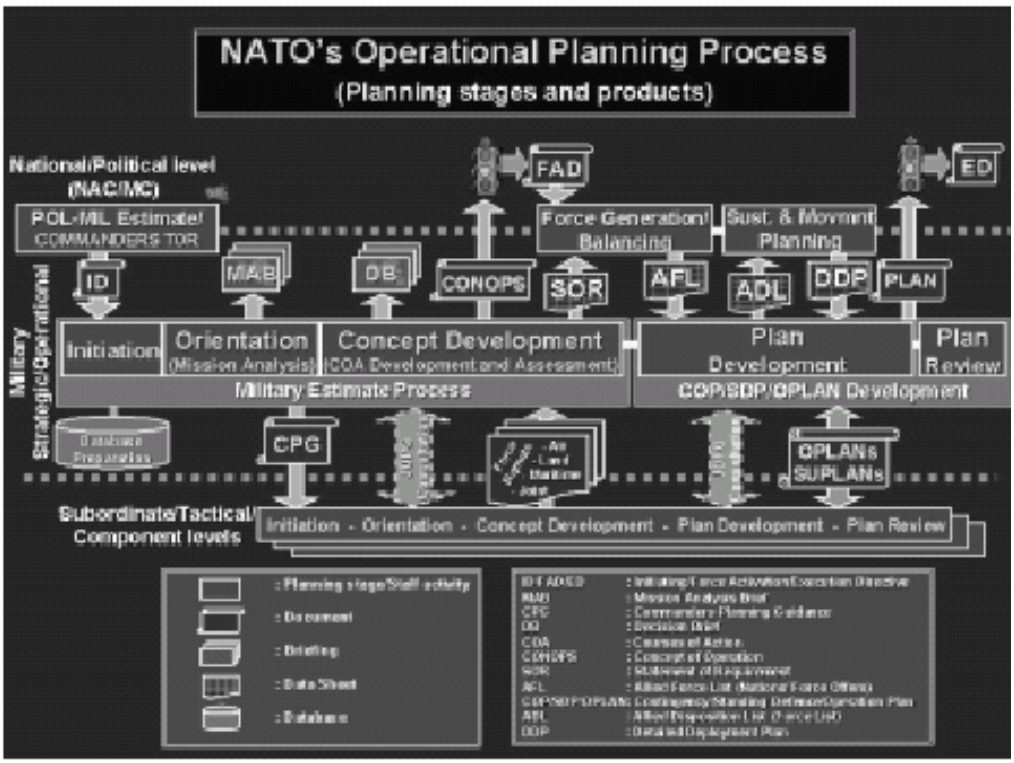


Figure D.1: Overview of NATO's Operational Planning Process.

The explicit directives from the political level are required at three critical junctures:

1) Initiation of the planning process through the Initiating Directive (ID);

2) Authorization to proceed to the force generation process with the nations through the Force Activation Directive (FAD); and
3) Authorisation to commence the execution of the operation through the Execution Directive (ED).

Planning may, of course, stop at any point in the process when the appropriate planning product for the situation at hand has been produced.

From the receipt of the Initiating Directive until approval of the Concept of Operation (CONOPS) the OPP is largely conducted within and among the NATO military headquarters with only ad hoc interaction with national military authorities. The key planning products from the strategic level military level are the CONOPS and the Statement of Requirements (SOR).

The SOR is the detailed estimate of the forces and capabilities required to conduct the operation and perform the tasks spelled out in the Initiating Directive. The SOR is expressed in terms of generic units and/or equipment.

Once the force generation process starts, the interactions between the NATO and national military headquarters expand greatly. These interactions continue throughout the force generation and the deployment planning process. At the end of the force generation process the generic requirements of the SOR have been replaced by the real and specific force contributions of the nations. For NATO-lead peace support, disaster relief or humanitarian aid operations the participation of Partnership-for-Peace nations and others will normally be invited.

The force contributing nations are ultimately responsible for the movement and transportation of their units, equipment and sustainment to the theatre destinations although the national planning is, of course, subject to close co-ordination by the appropriate NATO functional area authorities.

The key steps and tasks of the NATO OPP are further described in Figure D.2. The text also includes references to important military concepts in the planning process and should allow comparison to the concepts found in national doctrine.

OPERATIONAL PLANNING PROCESS (OPP)

Planning Stages	Steps	Tasks		Output
INITIATION	1. Receive or recognize task(s).	•Receive (or develop) Initiating Directive •Provide Strategic Military Assessment •Form the Planning Group and gather necessary information		Possible MROs
ORIENTATION	1. Conduct Mission Analysis 2. Deliver Mission Analysis Briefing 3. Develop Commander's Planning Guidance	•Review the Situation •Review Superior's Mission, Intent, Objectives & End-state •Identify/review Constraints & Restraints •Identify/determine Assumptions and Factors •Identify the Strengths and Weaknesses (OPFOR & Own) •Identify/Determine the Centre(s) of Gravity (Strategic & Operational) •Determine Decisive Points	•Identify/ determine Tasks (Assigned and Implied) •Determine Own Objectives, Desired End-state and Criteria for Success •Develop Mission Statement •Conduct Initial Force Structure Analysis •Prepare/deliver the Mission Analysis Briefing •Develop the Commander's Planning Guidance	Commander's Planning Guidance (may serve as an Initiating Directive to subordinates)
CONCEPT DEVELOPMENT	1. Staff analysis 2. Develop COAs 3. Deliver Decision Brief 4. Develop a Concept of Operations	•Analyse Situation/Make Deductions (Theatre Situation, Opposing Forces, Time and Space, Assessment of Tasks, C2, CIS) •Develop COAs •Analyse COAs (Test, War Game, Compare)	•Prepare/Deliver Decision Brief •Select Preferred COA •Develop Concept of Operations and forward for approval •Develop Statement of Requirements	Concept of Operations; SOR
PLAN DEVELOPMENT	1. Develop 2. Co-ordinate 3. Seek approval 4. Issue plan	•Refine Commander's Intent and Concept of Operations •Complete synchronisation of the plan •Confirm and identify forces through Force Generation Process •Co-ordinate and write OPLAN	•Write SUPLANS •Write Branch Plans •Seek OPLAN Approval •Issue OPLANs and SUPLANs	Family of Plans; Allied Disposition List (ADL)
PLAN REVIEW	1. Plan Review 2. Plan Evaluation 3. Revised Decision Brief	•Conduct Progress Review for on-going operations •Conduct Periodic Review •Conduct exercises and/or war games	•Conduct Revised Decision Briefing as required •Update/Issue amendments as required •Prepare and Issue plans as required	Updates and/or develop new plans

Figure D.2: Key Steps and Tasks in NATO OPP.

Helicopter operations are part of air operations. The planning of air operations is done by CAOC (Combined Air Operations Centre), but the CAOC does not task the helicopters. CAOC is the theatre command and control centre that plans, executes and assesses joint, allied and coalition aerospace operations during a contingency or conflict. See for a more detailed description of the tasks of the CAOC the report on Air Space Management that resulted from SAS-045 (ref. [14]), e.g. in 1993 a CAOC was established to manage 50 aircraft enforcing a no-fly zone over Bosnia. To support the planning of air operations, several models are available within NATO and will be described shortly in the following sections.

D.3 NATO-MODELS

Inside NATO several models exist to support an operation. In this chapter an overview is given of the models that exist inside NATO in order to support operations. Each of the models is described and an indication is given of the possible application of the model in support of the helicopter planning model that will be developed.

D.3.1 ICC (Integrated Command and Control)

D.3.1.1 Overview

ICC is an integrated C3I environment that provides information management and decision support to NATO Combined Air Operations Center (CAOC) level air operation activities during peacetime, exercise and wartime. ICC supports the most critical Air Command and Control functions, such as Planning and Tasking, Air Task Order Generation, Current Offensive and Defensive Operations, and Recognized Air Picture

Display. In addition, ICC supports the dissemination of orders, reports and imagery between the CAOC and the Headquarters above and below the CAOC.

ICC has been developed at NC3A (NATO Consultation, Command, and Control Agency) in The Hague, The Netherlands. ICC is being used to investigate requirements of the future NATO ACCS (Air Command and Control System). ICC has evolved into NATO's interim operational capability in several ICAOC's in the NATO Northern, Central and Southern region as part of their AOPTS (Air Operations Planning and Tasking System) initiatives, and is being interfaced with national systems. Various other sites and NATO nations have decided to adopt Integrated Command and Control as their interim capability for national Air Operations Centers.

ICC (see also ref. [2]) integrates planning, tasking, intelligence, operations and airspace management modules. It is an interim solution until ACCS (Air Command and Control System) is fielded. It is expected that ACCS will be ready in 2005.

ICC consists of many modules:

- **SALTO**: The SALTO (STC Air Logic Tool) application aims at assisting the planners in both building and generating the ATO by offering a number of useful functions, like bookkeeping (usage and availability), choice enumeration and automatic constraints checking. Graphical support is offered as well in order to better present to the user functions like unit utilisation and sortie flow checks. The SALTO approach is to let the user control the planning process, rather than to provide a complete plan. SALTO assists the planner in completing this task by carrying out a number of activities that are difficult, or time-consuming of error-prone for human operators. According to the CAOC team-approach, SALTO supports co-operative planning, by automatically co-ordinating the activities of different planners who are developing the same ATO. SALTO supports OAS, OCA, AI, RECCE, AAR, EW, SAR, AEW and NATO Composite Air Operations (COMAO) Planning. The ATO can be generated according to the mission type or entirely in AIRCENT and USMTF ATO formats.
- **ASMAN**: Air Space Management procedures are basically defined in the Airspace Control Order (ACO). The ASMAN (Air Space MANagement) module (see Figure D.3) consists of automated tools for maintaining Airspace Coordination Orders. It allows the user to graphically enter airspace objects into the CAOC database and to display the ACO on the map in order to make it available for the planning and tasking activities. The ACO can be generated in AIRCENT or USMTF formats. ASMAN allows a flexible input and modifications (e.g. ASMs can be drawn on the and it allows transformations of co-ordinates).

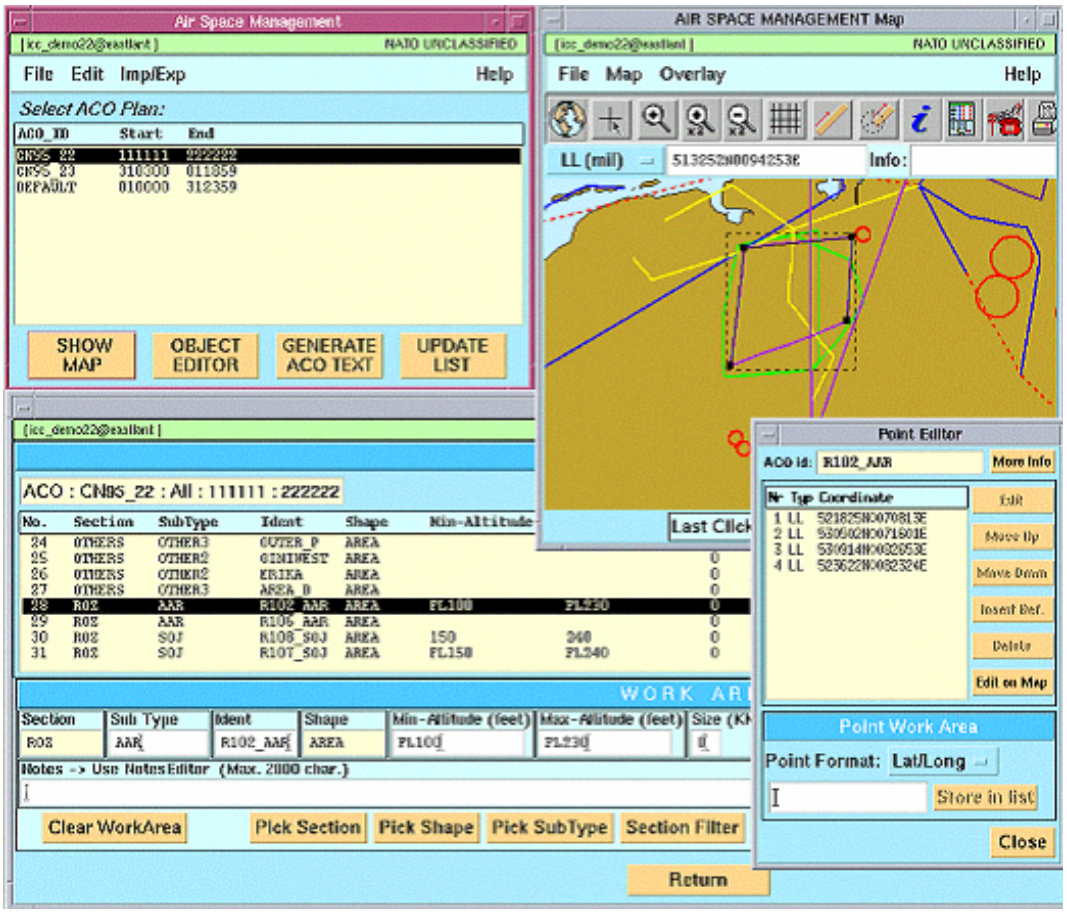


Figure D.3: Graphical Overview of ASMAN Module.

- **RESOURCE ALLOCATION**: Resource Allocation is the module assisting in the allocation of units to CAOCs. Based on the daily Air Operations Directive (AOD), Operations Order (DOO) or Master Attack Plan, it allows the planner to specify resource allocation plans, in which unit assignments and available systems are defined. These resource plans are then available for the other planning applications.
- **TGTNOM**: The TGTNOM (Target Nomination) module allows the Plans or Intel section to define a Target Nomination Plan, based on the target database and according to the specifications in the Air Operations Directive (AOD) or Daily Operations Order (DOO). This target plan is then made available for everybody in the network.
- **ADEPT**: The ADEPT (Air Defence Planning Tool) module provides the planners with automated tools to build and maintain the Air Defence posture. The graphical map provides the display of cartographic information overlaid with radar coverage, SAM coverage, the ACO and current own-force and enemy situations. ADEPT gives the planners the tools to define graphically and display AORs, BMAs, FEZs, FAORs, MEZs and other user-defined areas. The module provides a user-friendly interface for the input and modification of all elements of the OPTASKAAW/ ATOANNEXAD and automatically generates this message in the AIRCENT format for inclusion in the ACO.

- **ASVIEW**: The ASVIEW module (see Figure D.4) allows the planners to quickly and effectively check the developed ACO by providing the means of previewing the ACO execution. The module visualizes an ACO in a tabular form, graphically on a map background (2D View) and graphically in 3 dimensions (3D View). It presents a graphical simulation on a map of mission execution in the specified scenario. This tool allows the planners to quickly verify and deconflict the correctness of their plan. (automatic deconfliction of ASMs). Typical checks are the correct use or corridors, the critical timing over a target and of coordinated support missions. The module can be used for briefing the command group on future activities and can be used by Current Operations to see where their missions are supposed to be by previewing the ACO in real-time and synchronised to the exercise clock.

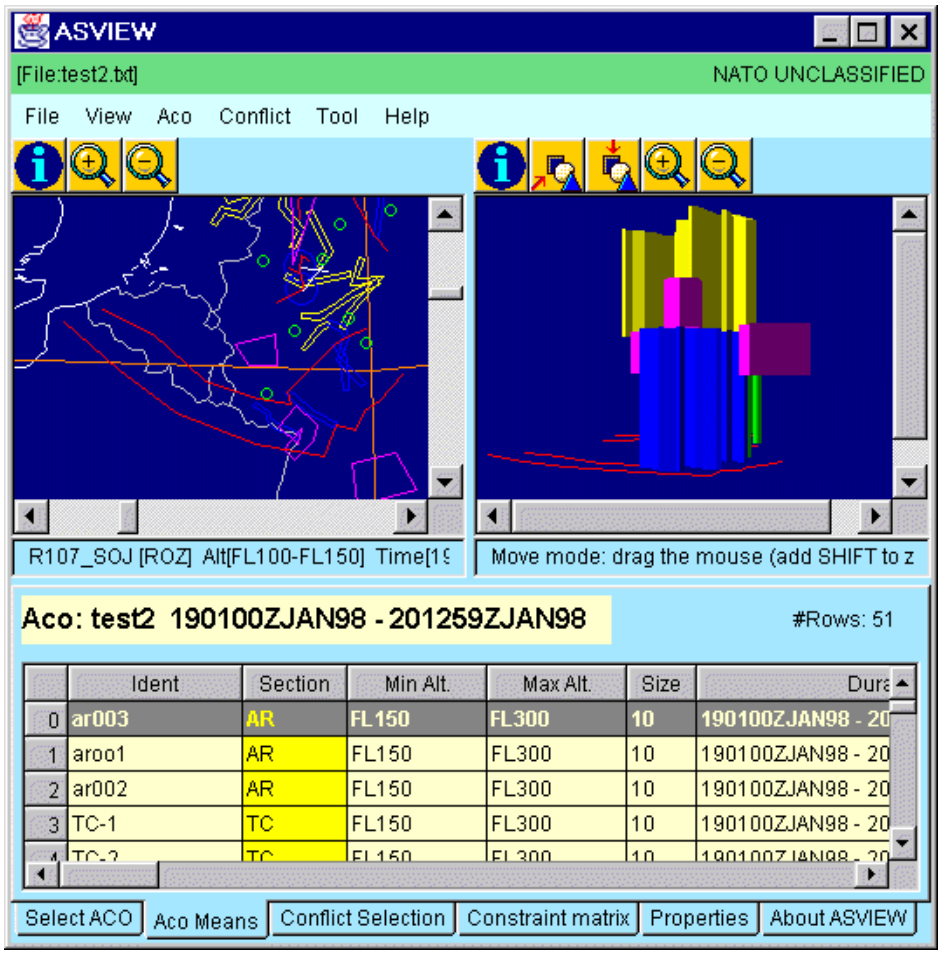


Figure D.4: Graphical Overview of the Module ASVIEW.

- **Mission Tote**: The Mission Tote module allows the operator to easily monitor the tasked missions by listing all the missions or show them on a sortie flow graph. Mission status is automatically changed as soon as the mission report is received, or as a consequence of automatic checks. Different colours are used to represent status and to give warnings about critical situations. Several summary reports can be generated automatically. This tool can also be used to monitor the status of on going air operations from a remote site on a non-interference basis. MAP: This module does not provide

sufficiently detailed maps of the world, including borders, rivers, roads, etc. A new version of this module should include the use of digital maps.

- **ADAPI (COP)** Command Operational Picture (see Figure D.5): This displays recognised air pictures. (i.e. Pictures from AWACS or CRC). All sorts of overlays can also be displayed, using ARC Digitised Raster Graphic (ADRG) visualisation.

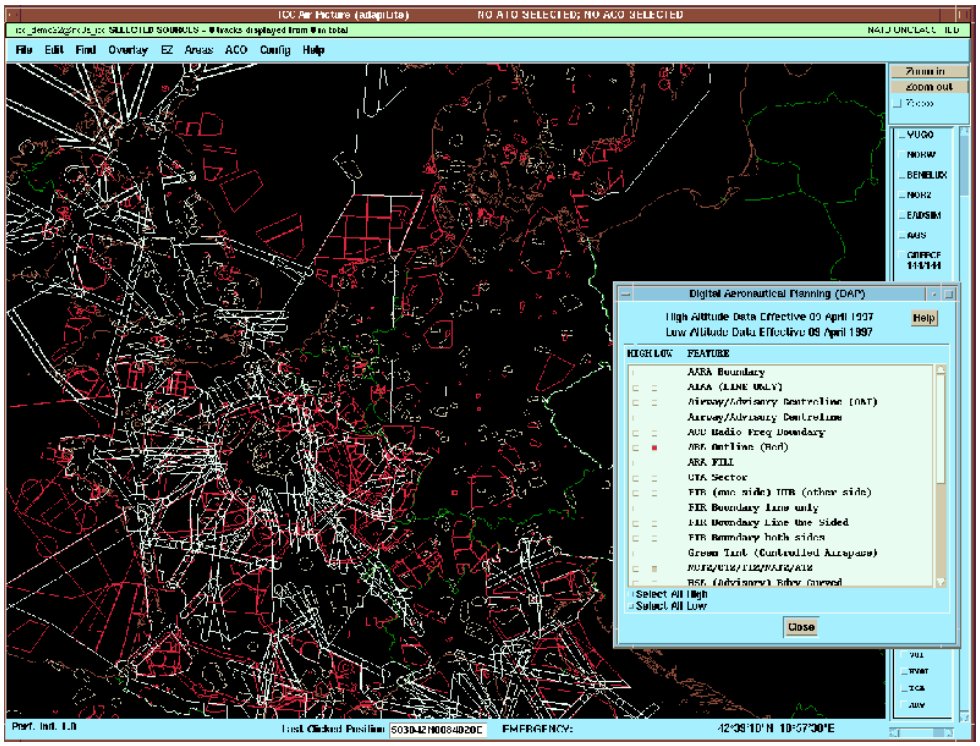


Figure D.5: Graphical Overview of Module ADAPI.

D.3.1.2 Summary

It can be concluded that ICC is mainly used for planning at higher level command and control and airspace management issues. Although ICC can be used to plan both future and current operations, it seems ICC is more focusing on current operations rather than on future operations. Nevertheless, the helicopter model that will be developed should have the capability for interfacing with ICC, as it might be necessary to use information from ICC in the helicopter model.

A two-way communication is required between the models in order to get approval for the planning. ICC is only a temporary solution. In the near future, ACCS will be replaced by ACCS.

D.3.2 ACCS (Air Command and Control System)

D.3.2.1 Overview

The ACCS programme (see also ref. [3]) is intended to combine, and automate, at the tactical level the planning, tasking and task execution of all air defensive, offensive air and air support operations in a single

system operations. Although it was originally designed to be used in an air defence environment, Its scope is much broader than just air defence. The system will be composed of a balanced mix of static and deployable entities.

When operational, the ACCS will provide a unified air command and control system, enabling NATO's European nations (including new Alliance members) to seamlessly manage all types of air operations over their territory, and beyond. NATO members will be able to integrate their air traffic control, surveillance, air mission control, airspace management and force management functions.

ACCS will incorporate the most modern technologies, and will make full use of up-to-date data link communications. Through its open architecture, the system is already evolving to meet emerging operational requirements such as those associated with theatre missile defence, and it will be able to adapt to a changing operational environment such as network centric warfare.

ACCS will be fielded at the planning and tasking level in Combined Air Operations Centres (CAOC), supporting the Joint Force Air Component Commander in exercising OPCON over his subordinate forces. ACCS will be fielded at the execution level in control centres (using the generic acronym ARS) that will provide facilities for aircraft control and production and dissemination of the Joint Environment Picture. At present, NATO and the nations have requirements for 5 static and 2 deployable CAOCs, while 18 static and 2 deployable ARS are also planned.

The added value of ACCS is that it is a modern architecture for all entities, but also it can provide real-time air picture enhancements. Figure D.6 gives an overview of the ACCS architecture (see also ref. [4]).

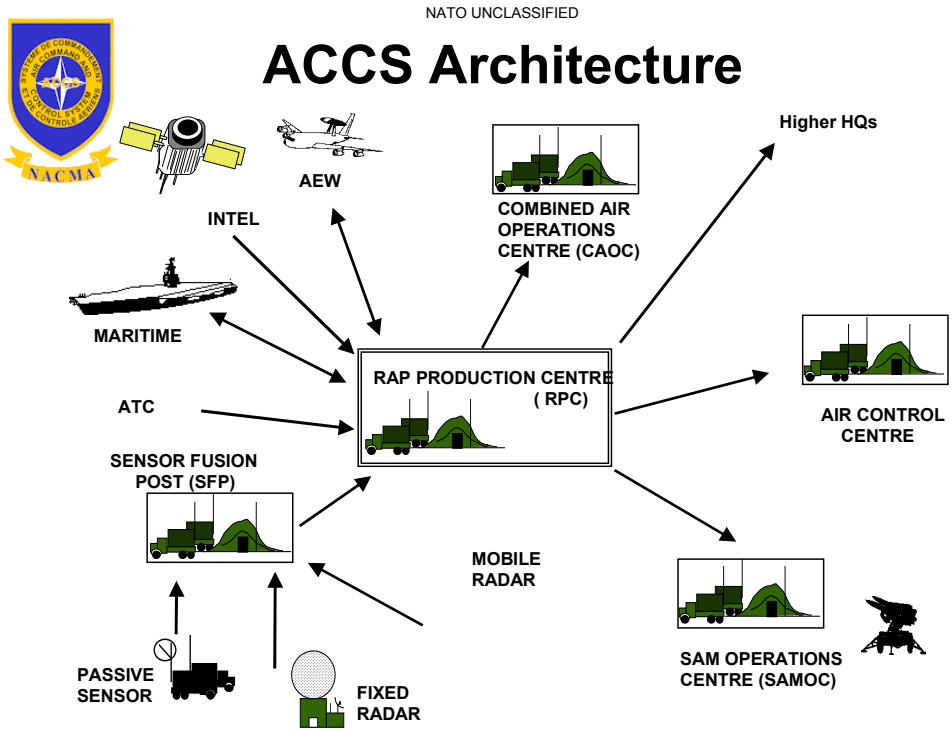


Figure D.6: Overview of ACCS Architecture.

Additional requirements in the areas of Theatre Missile Defence and Ground Surveillance are already being addressed. ACCS follows an incremental approach, and the software development should be ready in 2005.

D.3.2.2 Summary

ACCS is not a planning model, but it is an operational command and control system. Here also, an interface should exist between ACCS and the helicopter model. ACCS does not provide two ways of communications.

D.3.3 ADAMS (Allied Deployment and Movement System)

D.3.3.1 Overview

ADAMS has been developed in support of multinational force movement planning (strategic deployment). This system is in wide use throughout NATO and NATO nations for analysis, generation and co-ordination of movement plans. ADAMS provides the users with the tools to plan and manage deployment operations. The software also includes conversion modules for interfacing between ADAMS and national mobility management systems.

ADAMS is a program developed by NC3A. (see also refs. [5] and [6]). The purpose of this model is to provide the theatre commander with strategic deployment information on the dates, times, locations and equipment of arriving forces. It was designed for planning and monitoring strategic deployments within NATO's area of responsibility.

It is a system for analysis, planning and executing deployments at strategic level, it is primarily about a system of exchange of information between combined forces on the intentions of movement. The responsibility for the movements remains national. The system makes it possible however to mutually exchange in a common format the plans of movement and to detect the inconsistencies (like, the simultaneous use exceeding the capacities of a port) on the level of the SHAPE to make their resolution possible. The developments in hand are directed towards the assistance with the analysis and the co-ordination of the plans. In particular, the system is not currently regarded as a system of "command and control". ADAMS is not a movement control program. It cannot manage the movement of forces past their final destination. ADAMS provides visibility of movements projected or reported over time rather than real-time.

D.3.3.2 Modules

ADAMS is divided into seven specific components shown in Figure D.7.

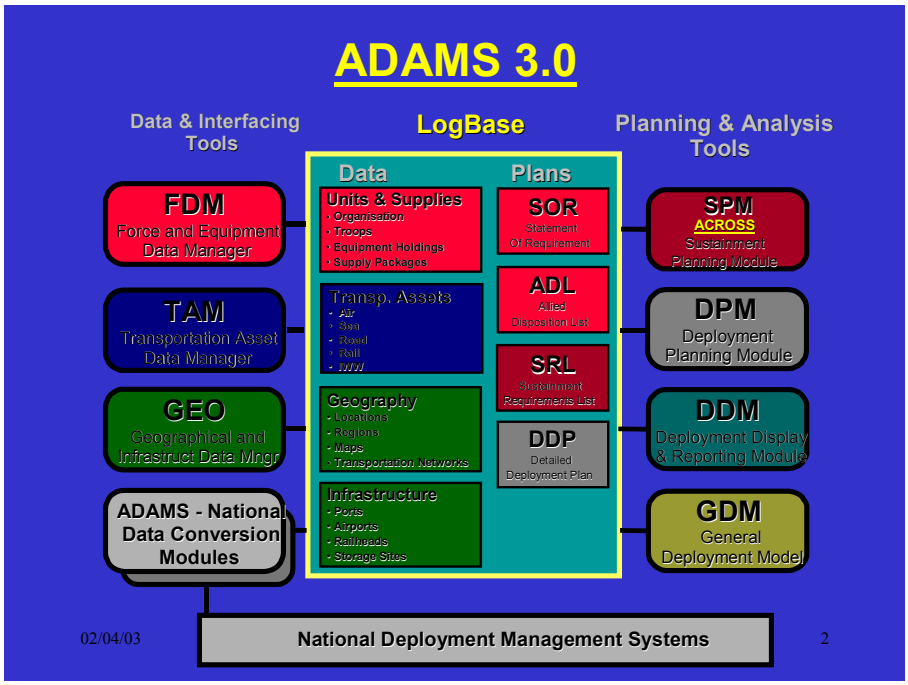


Figure D.7: Modules in ADAMS.

- **FDM**: the force data management module for the selection of the forces.
- **TAM**: the transportation asset data manager for the planning/management of the means of transport which allows, for example, to analyse the additional means of transport necessary for a given planning.
- **GEO**: the geographical and infrastructure data manager.
- **DPM** (the Deployment Planning Module): This module, the forces are organised based on the method of deployment and matched to their mode of transport. The module facilitates planning of movements by all modes from all available facilities. Decisions are made on transportability and height and width restrictions, which influence the type of assets that will be sent and the routes they will follow into the theatre.
- **SPM** (The Sustainment Planning Module): this module determines the sustainment requirement for forces. This module also determines the transportation requirements for supplies based on the consumption factors stored in the database.
- **DDM** (The Deployment Display Module): this module is used to perform major analysis and deconfliction of the proposed movements in accordance with the detailed deployment plans. ADAMS examines the DDP and uses the system to deconflict national movements.
- **GDM** (The General Deployment Module: this module is a simulation model that uses many "what-if" scenario's to develop various options to the basic plan. This model evaluates the "what-if" of possible changes to deployment assets, infrastructure, and timelines based on the existing plan. After these scenarios are run, the results can be analysed to determine the effects of changes to the basic plan. This is a valuable tool for planners to use because of the constant changes that normally occur before a deployment.

D.3.3.3 Data

Data is organised in a relational database with a separate Database Management Module. Three databases are accessible by the user:

- Forces (units and supplies);
- Means of transport (transport assets); and
- Facilities (infrastructure: ports, airports, railheads, storage sites).

Data concerning force descriptions are nationally seized by the national HQ. Only the characteristics of obstruction of the major hardware (dimensions, weight) remain to be seized.

The majority of the sealift data are ensured by the LLOYD COMPANY who provided his descriptive files to the NC3A. Thus 2 600 civil ships appear in the base of the NC3A. It remains to describe the trains, the civil aircraft and military as well as the commercial barges. Facilities should not be the subject of a systematic data entry. It is advised to seize them progressively whenever there is a need.

D.3.3.4 Operations of Planning and Movement

The following operations constitute the core of ADAMS.

A graphic help makes it possible to the user to carry out the first planning. The user has the possibility of bursting the units (while transporting the personnel by aircraft and the hardware either by airlift according to the type of aircraft available or per sea) and assigns them to different means, then amalgamates them near their destination.

After having chosen the means of transport and taking account of the operational availability of the unit, fine planning can be carried out. As an example, consider the units which do not have a resource allocation of transport and which must use the maritime way without knowing the name of the RORO. Then the planner selects them and determines the resource allocation of transport for them.

Taking into account the speed of the means of transport which appear in the data base, the arrival time of the unit can easily be deducted. Thus very simplified calculations of duration of movement are possible in the system, but the user can replace them by his own estimates as well. Figure D.8 and Figure D.9 give an overview of the deployments display view and deployment display report, respectively.

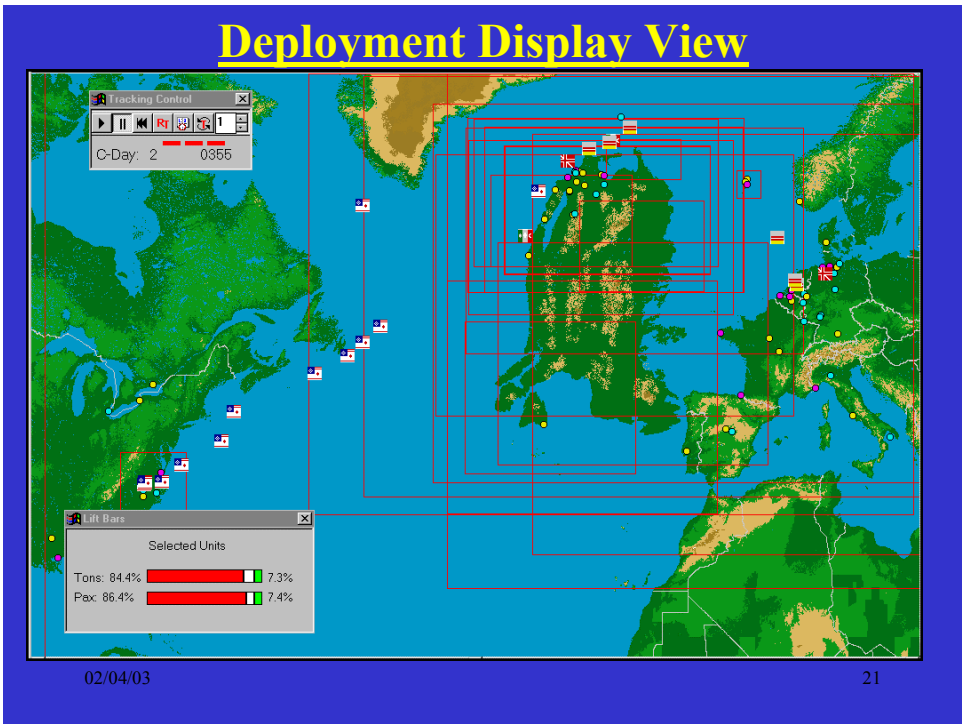


Figure D.8: Deployment Display View of ADAMS.

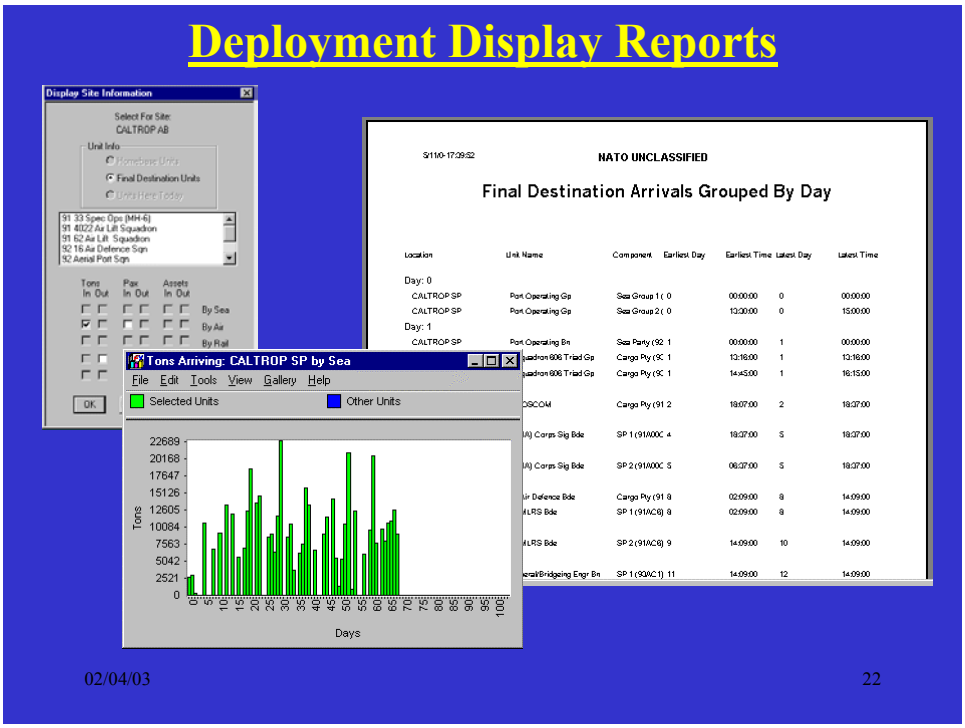


Figure D.9: Deployment Display Reports of ADAMS.

D.3.3.5 Summary

ADAMS is a planning system for planning of deployment and re-deployment at strategic level. The helicopter model to be developed will not take into account planning at strategic level. However ADAMS may plan the strategic deployment and re-deployment of helicopters. So considering the possibility that the output of ADAMS be used in the helicopter planning model, it may be useful to have an interface between ADAMS and the helicopter model.

D.3.4 LOGBASE

D.3.4.1 Overview

ADAMS uses the LogBase logistics database which has been developed over the last decade. LogBase is common to all the logistics functional area sub-systems (LogFASS), which are being developed as a part of the ACE Alliance Command Communication and Information System (ACCIS). ADAMS therefore shares this common database with both the ACROSS stockpile planning system and the Logistics Reporting Tool (LogRep). This in turn means that such features as database security, auditing and integrity controls are shared by all three systems. Other related NATO operational and logistic systems such as the Force Identification System (FIDS) are planned to share LogBase. A schematic outline of the relationship between the various LogFASS systems is shown in Figure D.10.

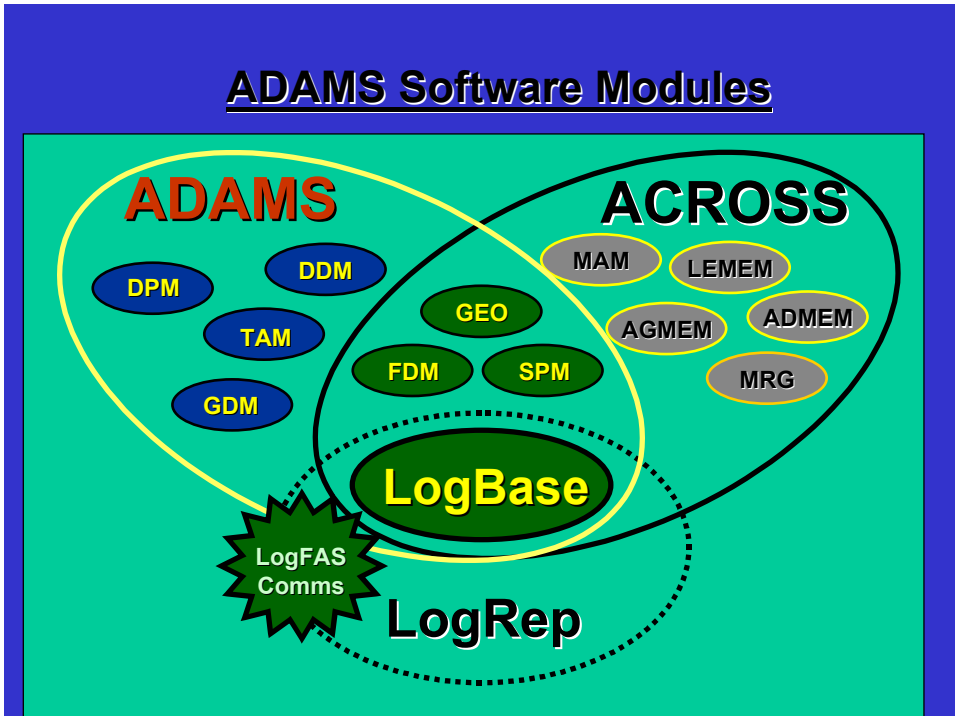


Figure D.10: Software Modules ADAMS.

Information can be exchanged within other external NATO planning systems by means of intermediate formats such as ASCII files or spreadsheets. NATO standards are used in LogBase reference data such as unit types, country codes, etc., whenever possible to facilitate interoperability.

Reportable Items Codes: LogBase includes the BI-SC Reportable Items Codes (RICs) for ACE and SACLANT. RICs have been introduced into LogBase to allow capability based queries to be carried out. The RIC system allows equipment and munitions to be classified and reported using a common set of values which transcend language, national nomenclature and coding systems. The RIC system has been developed using service expertise from both SCs and their subordinate Headquarters. The system represents a significant step forward in the exchange of information between allies and is used not only in LogRep, but also in the various modules within FIDS, ACROSS and ADAMS.

D.3.4.2 Summary

LOGBASE is a core database related to assets, forces, geography, infrastructure, medical, movements, supply and targets. From the information available on LOGBASE it seems this database provides less detailed to be of any use of the helicopter planning model.

D.3.5 TOPFAS (Tool for Operational Planning, Force Activation and Simulation)

D.3.5.1 Introduction

TOPFAS is designed to speed and improve the fidelity of the NATO operational planning process. This system will pervade all levels of operational planning from strategic/operational level through to the tactical level.

TOPFAS (see also ref. [1] and [7]) is the data and planning support system for the operational planning and force activation in accordance with the NATO Operational Planning Process (OPP). It will provide a common database and tools for the planning process as well as a common repository of the operational plans and the audit trail for the Force Generation Process. TOPFAS supports the planning process with graphical tools to the greatest possible extent; i.e. graphical lay-out of the operational design, phases and tasks, geographical mapping tools for the specification of operational planning factors and environmental conditions; and for the disposition of the forces. Troop-to-task rules, combined with military expertise, are the basis for the identification of force requirements.

D.3.5.2 Scope

The scope and aim of the TOPFAS development is to provide software and data support for all stages and activities of the OPP. The operational planning process consists of the following stages:

1) **Initiation** based on the initiating directive and including the receipt of planning inputs and preparation of the database.
2) **Orientation** with focus on the mission analysis, operational design and the identification of assigned and implied tasks and planning factors.
3) **Concept Development** with identification of the preferred course of action (COA) to be developed into the concept of operations (CONOPS) including force requirements.
4) **Plan Development** with the refinement of the CONOPS and detailed planning based on the actual forces and capabilities provided by the nations.
5) **Plan Review** for further assessment, large-scale war-gaming and exercising, including the adaptation of the force requirements to the changing operational environment.

However, the sustainment and deployment planning are handled by other special-purpose logistics management systems. The TOPFAS functionality required for this is limited to the interfacing with these. For the rest, the stages and steps of the NATO OPP are built into the TOPFAS software in the form of a Planning Wizard that guides the planner through the process and the associated TOPFAS functionality. TOPFAS is a joint planning tool. This means that the air, land, maritime and other service specific issues are all addressed within a common framework.

D.3.5.3 Users

The primary users of TOPFAS will be the NATO Strategic Commands, Combined Joint Planning Staff, Regional Commands and other NATO military headquarters with designated operational planning tasks.

D.3.5.4 Database

TOPFAS interfaces indirectly with the NATO Defence Planning Process through the planning situations and generic force definitions. In actual planning it will interface directly with Intelligence Information Systems for the preparation of the battlefield, and with the Logistics Management Systems for sustainment and deployment planning. OpsBase is the relational database for the family of TOPFAS applications. It is fully harmonised with LogBase, the relational database for the family of NATO Logistics Management Systems, and holds the relevant information about military tasks and planning factors as well as the generic and real forces and equipment that may be expected to participate in or impact on NATO-lead operations.

The planning functionality in TOPFAS requires that the database include extensive data on the military units that nations may contribute in a NATO-lead operation. Although the initial planning results are expressed in terms of requirements for generic units and capabilities, it is clear that the planning from the outset needs to take into account the limitations of real capabilities. Once the planning has progressed to the force generation and balancing, the real unit operational data requirements become obvious. By itself, the need for data management functionality within TOPFAS for the operational data on national units, their organisation and equipment makes the tool useful beyond the operational planning requirements.

D.3.5.5 Summary

The TOPFAS planning module tool is a module that helps the user go through the OPP and prepare an operational plan. It also plans at strategic level. Although TOPFAS does not concern the planning of helicopters, the model may be useful, as it guides the user through the OPP. The OPP is also one of the starting points for the helicopter model. Together with ACROSS and ADAMS, TOPFAS becomes the basis for further logistical planning of sustainment and transportation by the NATO Logistics Management Systems. Furthermore TOPFAS may provide output that may be used as input for the helicopter model.

D.3.6 PATHFINDER

D.3.6.1 Overview

The PATHFINDER programme is the flagship programme of the NATO Modelling and Simulation Group (NMSG), which is investigating advanced technology and capability for assembling federations of national models and simulations that can support the exercising and training of high level commanders and their component commands. This programme is tied to the original M&S Master Plan (MSMP) which is the base plan underpinning PATHFINDER activities. Essentially, the agreed MSMP stated that NATO should conduct a PATHFINDER development of an HLA-based federation of national simulations building on the experience

base established during NATO's Distributed Multi-National Defence Simulation (DiMuNDS) project. PATHFINDER is also connected to the Defence Capability Initiative (DCI); an activity launched at the 99 NATO Washington Summit with the objective to improve relevant military capabilities with focus on improving interoperability. DCI item Effective Engagement 9 (EE9) states that NATO nations should support the development and implementation of operational simulation devices in order to enhance interoperability in training and the decision-making process. Finally, PATHFINDER is also linked to SACLANT Concept Development and Experimentation (CDE) initiative being part now of the CDE database. The CDE initiative is a process to match concepts that meet national, multi-national or NATO-wide military requirements helping to explore innovative approaches and "leap-ahead" capabilities, exploiting opportunities for transforming NATO defence forces.

As stated in the NATO Modelling and Simulation Master Plan (MSMP), «exercising the CJTF» has been identified by the Major NATO Commands (MNC)s as the top priority requirement to steer M&S activities in the Alliance. As an answer to this requirement, the PATHFINDER Programme, considered by SACLANT as the most important NMSG Programme, is to provide federations of national simulations and decision support tools integrated and linked to NATO operational C3I systems, to exercise and train the CJTF HQ Staff on the conduct of Crisis Response Operations (CRO). The federations would be planned, integrated and tested in common, but the individual national simulation developments would be executed by the participating nations. Advantages of this approach are that each simulation would meet both national and NATO requirements, the cost of development being shared between both sides.

D.3.6.2 Summary

The PATHFINDER model is not a planning model, but is a software solution that supports exercises and training of high level commanders and their component commands. At the moment it does not look really necessary that the helicopter model takes into account the techniques that are being used in the PATHFINDER programme.

D.3.7 NATO Data Models

The helicopter planning tool that will be developed will make use of a data model or database. Inside NATO, a number of data models are being accepted and being used. This section describes the NATO data models that are available and also the applicability of the NATO data model to the helicopter planning tool. The following NATO data models are considered:

- NATO Product Data Model (NPDM);
- LogBase;
- ATCCIS;
- NATO Corporate Data Model; and
- NATO Directory Data Model.

D.3.7.1 NATO Product Data Model

The NATO Product Data Model (NPDM) is a conceptual data model. It defines a common set of data definitions and data structures to support Defence System technical information management, throughout the system life cycle, in the context of NATO nations and NATO industries.

The NPDM addresses the NATO requirement for data interoperability between different Information Systems by delivering a common data semantic and thus enabling consistency of interfaces at the information level without requiring standardization of hardware or software. The NPDM uses EXPRESS, ISO 10303-11, as the modeling language to enable both human understanding and computer processing of these semantics.

NPDM has been developed by the NATO CALS Office (NCO) under the guidance of the NATO CALS Management Board (NCMB) with contributions from Association GOSET, France, Daimler Chrysler Aerospace (former DASA), Germany, Eurostep Limited, United Kingdom and Metasistemi S.p.A, Italy.

The NATO Product Data Model consists of data that is not directly necessary for the helicopter planning model. NPDM describes logistic information related to a product. It can be concluded that the helicopter planning model is not dependent on information in the NPDM or that the helicopter planning model will feed NPDM.

D.3.7.2 ATCCIS (Army Tactical Command and Control Information System)

The ATCCIS specification is a managed interface between C2 information systems. When incorporated into a system, it enables interoperability of information between any other system that also incorporates the specification. Battle space data is transferred as information. The meaning and context of the information is preserved across national and system boundaries precisely and without any ambiguity. By 2002, 18 nations and NATO agencies had incorporated these specifications into their programmes and systems.

One of the two main components of the ATCCIS specifications is a data model, The Land C2 Information Exchange Data Model (LC2IEDM). It is a product of the analysis of a wide spectrum of allied information exchange requirements by 16 nations. It models the information that allied land component commanders need to exchange (both vertically and horizontally). It serves as the common interface specification for the exchange of essential battle space information. The function, implementation and the display of the host C2 application is not the concern of ATCCIS. System developers incorporate the ATCCIS specification and include a single interface to it. Thereafter no further interfaces are required to interoperate with any other ATCCIS enabled system. The LC2IEDM is in its 5th generation (version 5). The previous version, LC2IEDM v2, is the core of the NATO Reference Model and is also a view model of NATO Corporate Data Model (STANAG 5523 / AdatP-32).

ATCCIS itself is not a specification that should be considered when developing the helicopter model. However, one of the main components of the ATCCIS specifications is the LC2IEDM data model. This data model is widely accepted inside NATO and should be considered as a basis for definitions and a guideline when developing the helicopter planning model.

D.3.7.3 NATO Corporate Data Model

The NATO Corporate Data Model has been developed by the NATO Data Administration Group (NDAG). The NDAG is a multi-national working group, responsible to the Information Systems Sub-Committee (ISSC) for the development and maintenance of NATO data management policies for recommendation to the NC3B, together with guidance on the coherent implementation of data management and administration across NATO.

The prime purpose of the NATO Corporate Data Model is to provide a source for Standard Data Elements (SDE), in direct support of NATO s Policy for Data Management. The use of SDEs enhances interoperability among NATO C3 systems, facilitates increased data sharing, reduces data handling costs and leads to better data accuracy, consistency and timeliness. It is a Joint Data Model and comprises:

- A Reference Model, which contains the semantic definitions of the SDEs, their inter-relationships and necessary information about data structures (e.g.: maximum field length, data types);
- View Models, which are project-centric data views encapsulating specific examples and combinations of the generic SDEs as well as project specific data elements that can not be found in the Reference Model; and
- Semantics and structure of meta data.

ATCCIS itself is not a specification that should be considered when developing the helicopter model. However, one of the main components of the ATCCIS specifications is the LC2IEDM data model. This data model is widely accepted inside NATO and should be considered as a basis for definitions and a guideline when developing the helicopter planning model.

D.3.7.4 NATO Directory Data Model

The NATO Directory Data Model has been developed by the ACP 133 Task Force within the ACP 133 B and has been adopted by the NATO Directory Services Working Group (DSWG). The DSWG is a multi-national group responsible to the Information Systems Sub Committee (ISSC) for the development, review and harmonization of policies, requirements and procedures concerning directories for use by NATO. The aim is to ensure interoperable electronic directory services across the tactical/strategic, SC, RC, GSRC and national boundaries within NATO.

The purpose of the NATO Directory Data Model is to maintain the NATO Directory Schema that encompasses the directory entry types, object classes, attributes, matching rules, name forms, and structure rules that are necessary for specifying the information that is stored in the Allied Directory System. Components of the NATO Directory System shall implement all of the standard object classes, attributes, and name forms defined in X.501, X.509, X.520, X.521, and X.402, as profiled in Annex D of ACP 133 B and the relevant NATO supplements. The NATO Directory Schema, called Common Content, employs the standard schema elements and also includes object classes, attributes, and name forms defined in ACP 133 B especially to meet NATO requirements. The NATO Directory Schema is specified in Annex B of ACP 133 B and is profiled in Annex D of ACP 133 B.

The NATO Directory Data Model is a Joint Data Model and comprises:

- A Reference Model, which contains the semantic definitions of the used object classes, their inter-relationships and necessary information about data structures (e.g.: maximum field length, data types); and
- View Models, which are project-centric data views, through the project specific selection of the necessary object classes from the general repository.

The NATO Directory Data Model should be considered as a basis for developing software models. The definitions mentioned in this model should be taken into account when developing the helicopter planning model.

D.3.8 Summary of NATO-Models

In Figure D.11, an overview is given of the NATO models discussed in this section and their application. As the focus of SAS-045 is on the planning of helicopter operations at operational and tactical level, only TOPFAS is of interest. However, only TOPFAS does not take into account helicopter operations. Thus,

at this moment there is no NATO-model available for planning helicopter operations at operational and tactical level.

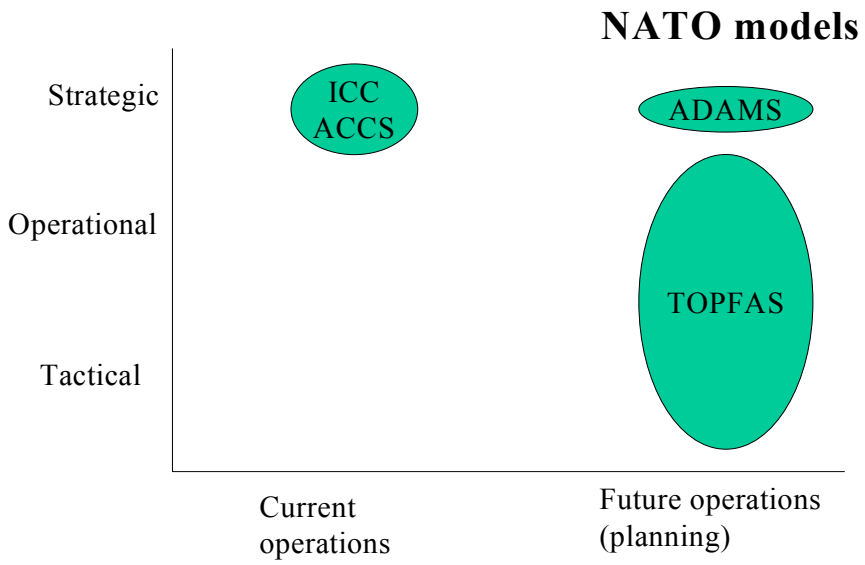


Figure D.11: Overview of NATO-Models.

D.4 PLANNING MODELS WITHIN NATO NATIONS

Among the planning models within NATO nations, there exists only one model (FELPATH) that considers solely helicopter planning. The available US models are being used mainly for planning air mobility. A short description of these models follows. Turkey possesses a planning an information system for the air force, but this system cannot be used for planning helicopter operations. Although some information (1998) has been obtained about a German model called Daedalus, this model has not been developed any further since then. At the first SAS-045 meeting, France presented information on the PROFORCE model. PROFORCE can be used for aircraft transportation and more specifically for the strategic move. France is also preparing the development of a helicopter tool to be used for airmobile studies. Furthermore, according to the Netherlands Army, the Spanish army should possess a planning model available, but further details on this model could not be found.

Other existing planning models mainly focus on aircraft and not on helicopters, e.g. Military Airlift Command (MAC) in the US has developed some models and heuristics in this area. See refs [8], [9] and [10]. CAMPS is an example of such a model.

D.4.1 CAMPS (USA)

The Consolidated Air Mobility Planning System (CAMPS) (see also ref. [11]) is Air Mobility Command's (AMC) command and control migration system that will combine the functionality of legacy systems, AMC Deployment Analysis System (ADANS) and Combined Mating and Ranging Planning System (CMARPS), into a single, integrated AMC planning and scheduling system for both airlift and air refuelling missions. Currently, AMC uses CAMPS and ADANS for planning and scheduling airlift missions, and CMARPS for planning and scheduling air-refuelling missions.

CAMPS provides the mission planner with an integrated view for planning and scheduling AMC air mobility resources to support peacetime, contingency, humanitarian, and wartime operations. CAMPS consolidates the baseline functionality of ADANS and CMARPS into a new, integrated architecture that will be Defence Information Infrastructure Common Operating Environment (DII COE) Level 5 compliant (eventually Level 7) and will conform to the U.S. Transportation Command (USTRANSCOM) and AMC enterprise environments.

CAMPS provides advanced user capabilities for operational planning and allocation management. Deliberate planning, contingency or crisis action planning, and support functions have been added in February 2002. A single Oracle database provides one-time data entry and is consistent with Department of Defence (DoD) standard data definitions and the AMC Corporate Database architecture. CAMPS uses Windows NT 4 and Windows 2000 in a client-server environment and will take advantage of DII COE software components to provide administration and support services.

CAMPS is a powerful, deployable planning tool that presents an integrated view of planning and scheduling mobility resources (airlift and tanker aircraft) while lowering life cycle costs. It provides one-time data entry and Department of Defence (DoD) standard data elements. CAMPS enhances usability and minimises training requirements for users and systems personnel, utilising several industry standard Commercial Off The Shelf (COTS) products.

As the Program/Systems Overview, CAMPS will provide a complete, integrated view of mobility requirements, resources, and commitments; and status of air mobility planning and scheduling activities at each stage from concept initiation through mission closure. It will facilitate development and presentation of alternative resource options to permit more efficient use of available assets. CAMPS replaces the legacy AMC Deployment Analysis System (ADANS) and Combined Mating and Ranging Planning System (CMARPS). It is easiest to understand the functionality of CAMPS by understanding the functionality of the legacy systems.

D.4.2 ADANS (USA)

ADANS stands for the Air Mobility Command (AMC) Deployment Analysis System (ADANS) (see also ref. [12]). ADANS contains five main software components supporting Headquarters (HQ) AMC and the TACC (including the Alternate TACC (ATACC)). It provides automated support for air mobility deliberate planning, crisis/contingency planning, peacetime and wartime scheduling, and analysis of the air mobility system.

The five major components are as follows:

- **Airlift Flow Planning:** Supports deliberate, contingency, and exercise planning from peacetime through crisis/contingency to wartime.
- **Barrelmaster:** Allows AMCs Tanker Airlift Control Center (TACC) to allocate aircraft to specific missions (migrated to CAMPS).
- **Channels:** Plans regularly scheduled airlift missions (migrated to CAMPS).
- **Special Assignment Airlift Missions (SAAMs):** Plans one-time unique missions (migrated to CAMPS).
- **Air Refueling:** Plans and schedules air refueling missions (migrated to CAMPS).

ADANS is AMC's primary headquarters-level computer system supporting Department of Defence (DoD) airlift planning and scheduling. It is an AMC Command and Control legacy program supporting airlift and

tanker planning, scheduling, and analysis during peacetime, crisis, contingency, and wartime. ADANS provides planners and schedulers automated tools necessary to plan and schedule the extensive number of air mobility mission flown by AMC during peacetime, contingency, and humanitarian missions. ADANS schedules airlift and air refuelling missions under all scenarios: routine channel missions; special assignment airlift missions; field training exercises; and contingency, crisis, and humanitarian missions.

ADANS has a narrowing customer base. After 1 Oct 2000, only the TACC and HQ AMC/DOX use the airlift flow planning component of ADANS. The other ADANS component functionality has been migrated to CAMPS. HQ USAFE also uses ADANS to support theater airlift planning and scheduling. ADANS runs on Sun Solaris workstations and utilizes a Sybase Database. ADANS has been replaced by the Consolidated Air Mobility Planning System (CAMPS) in February 2002.

In addition to the essential tools for editing, managing and analysing data, ADANS provides three optimisation models developed by CTA Operations Research experts. A linear programming based model estimates the capability of the airlift system to support a large movement. A second model supports schedulers who plan the regularly scheduled peacetime movement of aircraft from the U.S. to overseas locations. By combining linear and integer programming techniques, this model suggests how often each route should be flown to satisfy the projected demand. The largest of the models is a dynamic programming based scheduler, which generates detailed aircraft itineraries automatically based on the planner's constraints.

ADANS was made operational in early 1990 and has been used daily, 24 hours a day, since that time to schedule over 100,000 operational missions and millions of potential wartime scenario missions. During late 1990 and early 1991, ADANS was used to plan and schedule the largest airlift in history – Operations DESERT SHIELD/DESERT STORM – to support the Persian Gulf war.

D.4.3 CMARPS (USA)

The Combined Mating and Ranging Planning System (CMARPS) is the system used by AMC to schedule air refuelling for deployments from the continental U.S. to other parts of the world. The CMARPS model has been replaced by the CAMPS model in 2002.

D.4.4 TUAFIS (Turkey)

D.4.4.1 Vision and Goals

Vision of TUAFIS is to provide a comprehensive information system; including custom built Intelligence, Operations and Flight Training modules, integrated with Resource Management modules implementing "best practices", and in this manner ensure that TuAF becomes an exemplary air force setting standards for other air forces. Two goals of TUAFIS are explained as follows:

- **Functionally**
  - All core TuAF functional processes must be implemented by TIS in a manner responsive to the strategic, tactical and operational dynamics of TuAF; and
  - Where desirable, promoting the improvement of these processes by the introduction of best-practices and standard procedures.
- **Technically**
  - Survivability in peace, crisis and war conditions;

- High availability (>99.98%); and
- Ease of maintenance and development through open standards and platform independence.

D.4.4.2 Architecture

Figure D.12 illustrates the architecture of TUAFIS. It basically consists of two main modules: custom-built Battle management and ERP based Resource Management modules.

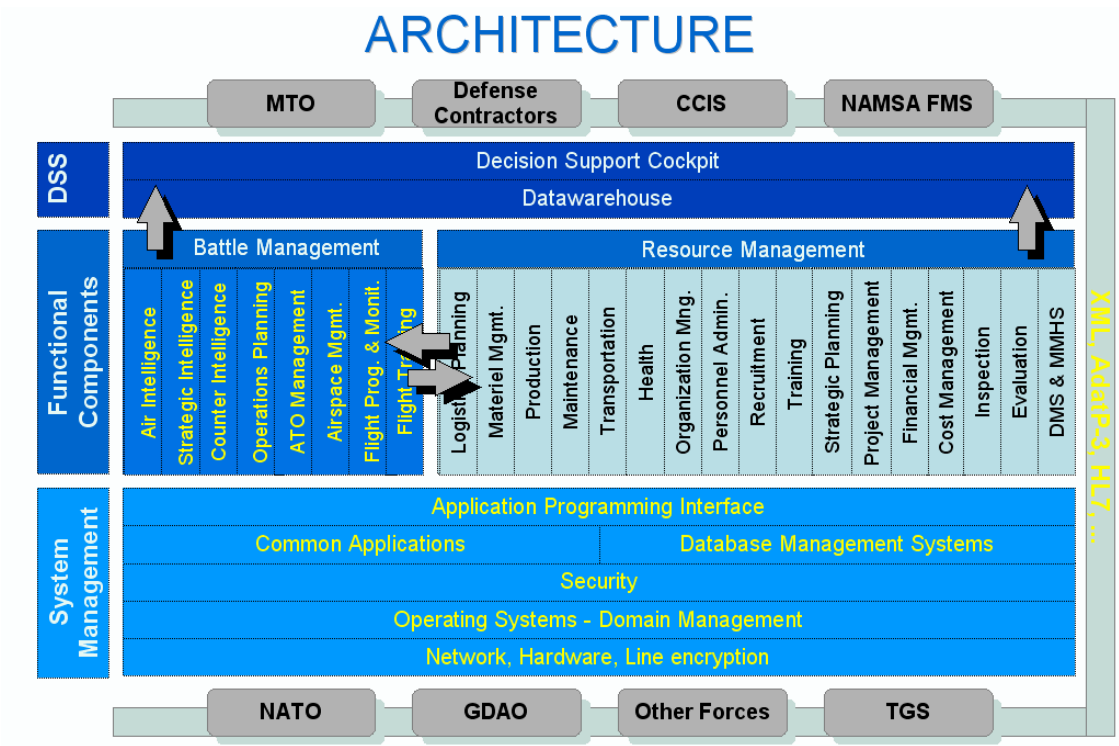


Figure D.12: Illustration of Architecture TUAFIS.

D.4.5 DAEDALUS (Germany)

Daedalus (see also ref. [13]) is a model that uses simulation to plan the deployment of aircraft and helicopters in Air Mobile operations (Luftlandeoperationen). It supports transport from the staging area to the deployment area including refuelling at a FARP. Input is the available fleet of aircraft and helicopters, personnel and material to be transported and operational restrictions.

The following elements are calculated:

- Number of aircraft and helicopters required;
- Time required for each wave;
- Time that transport resources are used; and
- Use of fuel.

The output of this model should also be an Air Movement Table.

A prototype and demonstrator of this model has been developed by IABG in 1998. After 1998 the model has not been further developed, neither has is it been used.

D.4.6 PROFORCE LEOPAR (France)

D.4.6.1 Description

PROFORCE LEOPAR can be used for aircraft transportation and more specifically it aims to simulate a force projection on one or more theatres of operation to assess the effectiveness of a fleet of aircraft or other means of transport for a given scenario.

Using data describing the force to be transported and the means of transport to be used, PROFORCE LEOPAR provides the precise loading plans of each means of transport required to realise of the transport plan.

The transport plan can start from one or several points on one or several theatres of operation. PROFORCE LEOPAR

The model is divided in three major parts:

- The reference frame;
- The loading module; and
- The planning module.

The reference frame manages all the general concepts which will be used in the various scenarios of loading and planning. In particular, it enables to store information:

- At the air bases, of which distances between bases;
- With the vectors of transport, of which speeds and seats;
- With the equipment to be transported; and
- With the pax to transport.

The loading module manages scenarios corresponding to various transport plans. To build a scenario, useful information from the reference frame for this projection is used to define the quantities of equipment and pax to be deployed. Optimisation proposes the loading of the compartments in order to minimise the number of sorties necessary to the transportation.

The planning module manages scenarios corresponding to various transportation plans. To build a planning scenario, information related to this transportation can be imported from the scenario of the corresponding loading. Optimisation is used to the plan of sorties in order to determine the earliest arrival date for both the materials and the PAX taking into account the deployment and the priorities.

D.4.6.2 Technologies Used

PROFORCE LEOPAR was developed without any optimisation engine. The established algorithms allow the tool to be used without any software package and can be used on all the operating systems. The languages

used are the Java language for the User interface and C++ for the coding the algorithms. The data base management system is MySQL. The export files are in HTML format.

The ADAMS database is used to define elements to be transported, and also geographical data is taken from this database. The model is not operationally used, but only for study purposes, mainly acquisition projects. In the future France would like to link ADAMS with PROFORCE LEOPAR.

D.4.7 Helicopter Tool Project (France)

France (DGA) has decided to develop a tool to be used to study Air Mobile studies. The model will be developed in two stages:

- Stage 1 (2003 – 2004): To make a demonstration model (prototype); and
- Stage 2 (2004 – 2005): To make a helicopter model for an air mobile mission.

The development of the model will focus on the following objectives:

- Study purposes: The tool is not intended to be used as an operational tool;
- Helicopter characteristics;
- GIS data;
- Optimization of loadings; and
- Planning and scheduling.

The model will use the following technologies and techniques:

- **Operations research techniques**
  - Algorithms;
  - Heuristics;
  - Linear programming; and
  - Constraint Satisfaction problem.
- **Programming languages**
  - JAVA;
  - C++; and
  - OPL Studio (mathematical language).
- **Database system**
  - Relational databases (Access, MySQL, Interbase, …)

D.4.8 FELPATH (The Netherlands)

FELPATH (FEL Planning Aid for Transport helicopters) is an operationally used decision support system, supporting the combined planning cell of the 11 Air Maneuvre Brigade (consisting of the Tactical Helicopter

Group of the Royal Netherlands Air Force and the 11 Airmobile Brigade of the Royal Netherlands Army) in planning tactical transport helicopter operations.

FELPATH is developed by TNO Physics and Electronics Laboratory (TNO FEL) and includes routeplanning, tasking of transport helicopters and scheduling of air moves. The latest version of FELPATH is V3.2, completed mid 2003.

FELPATH consists of main two modules:

- Routeplanner; and
- Initial Fleet Allocation (IFA).

Before the main modules are entered FELPATH opens with a main screen in order to start an operation. Here general information for a certain operation can be defined, like Air Control Points and Helicopter types. Figure D.13 gives an overview of the helicopter related information that can be defined.

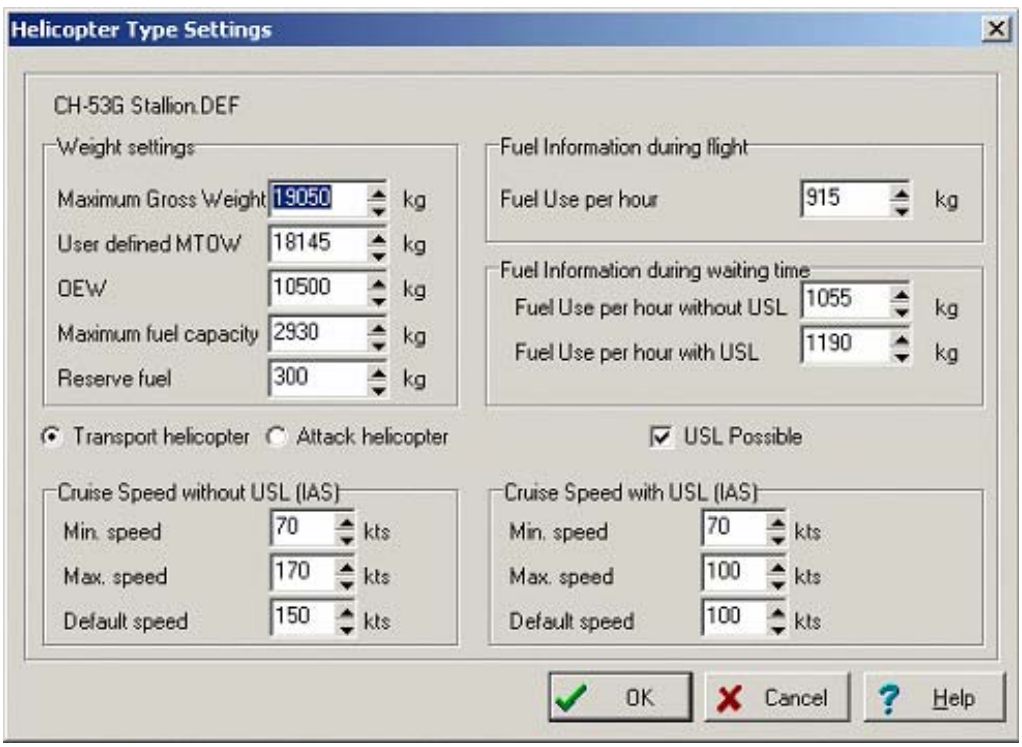


Figure D.13: Helicopter Type Settings Screen.

D.4.8.1 Routeplanner

Figure D.14 shows the main screen of the **Routeplanner** of FELPATH. Using this main screen Routes to be flown by the various types of helicopters can be defined and edited in a digital terrain. A route consists of different types of points, such as Take-off Point, Way Points, Pick-up Points, Landing Points, Fuelling Points and an End Point. Also the area of operation can be defined, zooms can be defined or selected and scanned maps can be used as an overlay.

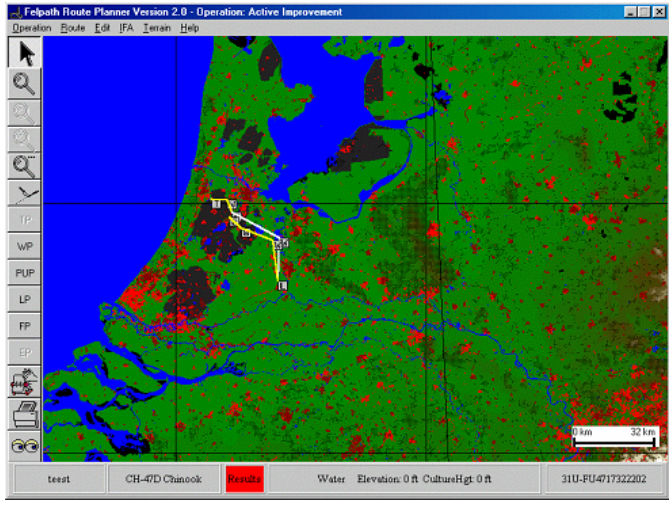


Figure D.14: Main Screen of Routeplanner.

From the route menu the route settings can be defined. This concerns the definition of the route for a certain type of helicopter. Data to be entered ate: flying altitude, atmospheric conditions, like temperature and pressure, but also wind properties as direction and velocity. Then, the route points need to be defined. The general route data may be varied for certain point(s), so for each route point the atmospheric conditions can be changed and a delay time a point may be entered. Some information can also be changed for multiple legs on the route, like flying altitude and speed (IAS or ground speed) and the wind properties. Figure D.15 gives an overview of the dialog.

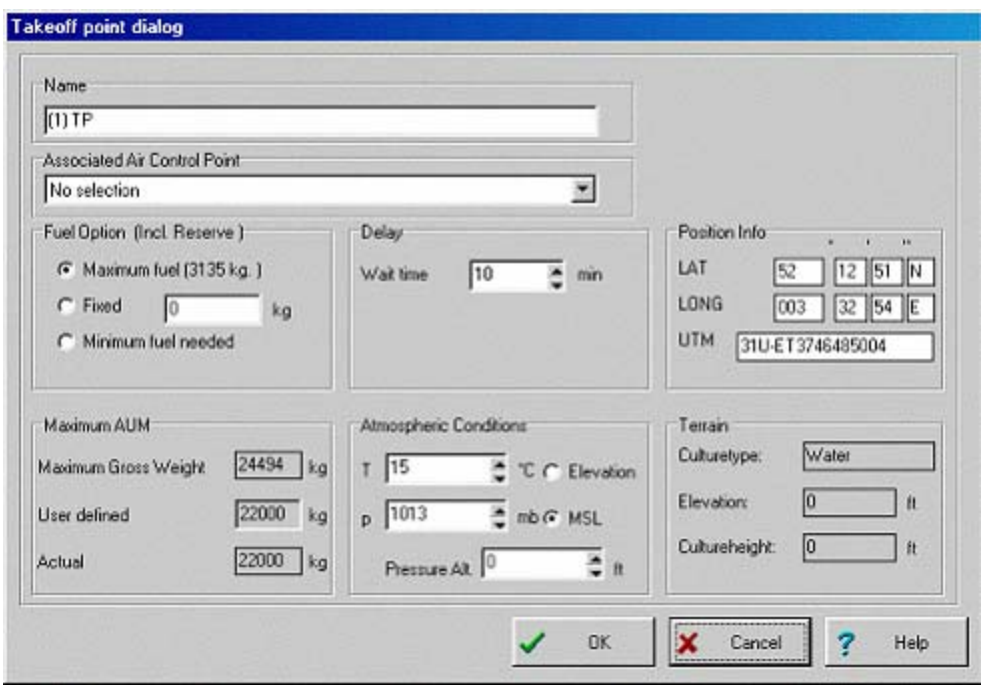


Figure D.15: Take Off Point Dialog.

Once a route has been defined a cross section of the route can be displayed. Figure D.16 gives on overview of the cross section screen.

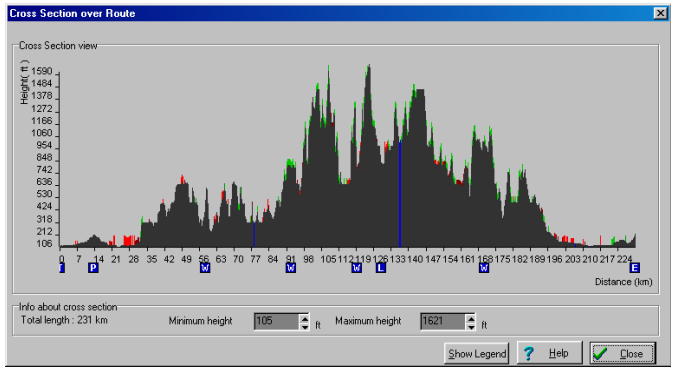
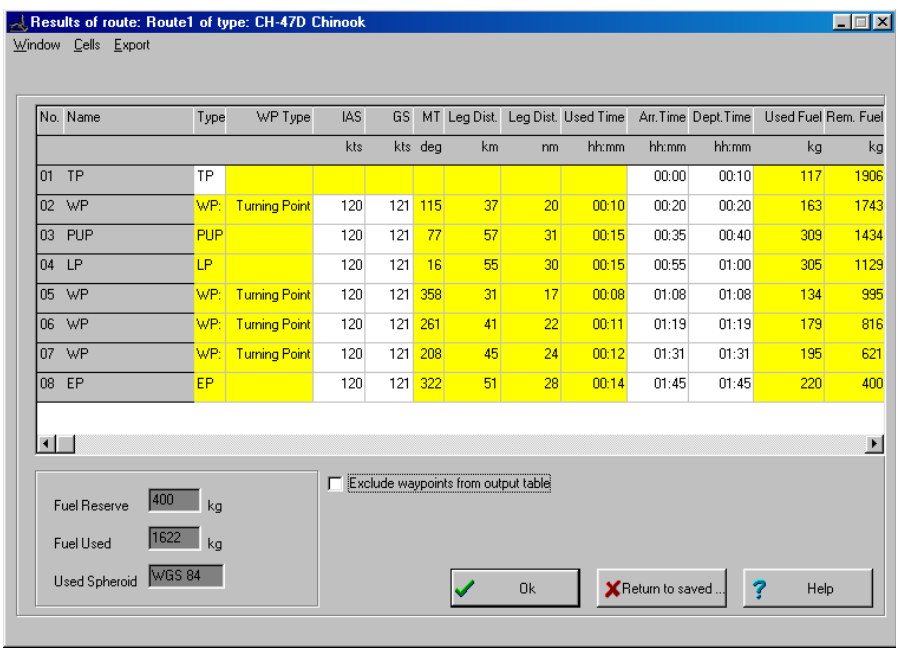


Figure D.16: Cross Section Screen.

The Routeplanner determines the total distance that has to be flown, the time needed, the fuel consumption during the route and the maximum payload that can be transported. Figure D.17 gives an overview of (a part of) the screen showing the results of the route.



No.	Name	Type	WP Type	IAS	GS	MT	Leg Dist.	Leg Dist.	Used Time	Arr.Time	Dept.Time	Used Fuel	Rem. Fuel
				kts	kts	deg	km	nm	hh:mm	hh:mm	hh:mm	kg	kg
01	TP	TP								00:00	00:10	117	1906
02	WP	WP:	Turning Point	120	121	115	37	20	00:10	00:20	00:20	163	1743
03	PUP	PUP		120	121	77	57	31	00:15	00:35	00:40	309	1434
04	LP	LP		120	121	16	55	30	00:15	00:55	01:00	305	1129
05	WP	WP:	Turning Point	120	121	358	31	17	00:08	01:08	01:08	134	995
06	WP	WP:	Turning Point	120	121	261	41	22	00:11	01:19	01:19	179	816
07	WP	WP:	Turning Point	120	121	208	45	24	00:12	01:31	01:31	195	621
08	EP	EP		120	121	322	51	28	00:14	01:45	01:45	220	400

Figure D.17: Results of Route.

The output of the Routeplanner can be exported to a number of files:

- **An Excel file**: all results are exported to an EXCEL document,
  - **A Flight log**: flight log information is exported to an EXCEL document, ready to be printed.

FLIGHTLOG			CH-47D Chinook									
		Date		Time	Z/A/B	dtg L-Hour		dtg F-Hour				
		24-7-2001		13:36					Fuel		Wind	
Nr.	Name	IAS	GS	MT	KM	NM	Time	Run	Burned	Rem.	Direction	Speed
1	TP							0:00		3018		
2	WP	120	121	208	5	3	0:01	0:11	24	2995	0	0
3	WP	120	121	208	5	3	0:01	0:23	24	2854	0	0
4	PUP	120	121	101	28	15	0:07	0:40	124	2613	0	0
5	WP	120	121	229	14	7	0:04	0:49	77	2478	0	0
6	LP	120	121	270	11	6	0:03	0:52	63	2414	0	0
7	WP	120	121	53	14	8	0:04	1:01	65	2291	0	0
8	EP	120	121	88	10	6	0:03	1:03	46	2245	0	0
TOTALS					87	47	1:03		Reserve	400		

N.B. De gegevens uit de Flightlog mogen niet gebruikt worden als vervanging van de planning door de vlieger.

Speed in	kts
Direction in	deg
Time in	hh:mm
Fuel in	kg

Figure D.18: Example of a Flight Log.

- **A Co-ordinates sheet**: all information on co-ordinates is exported to an EXCEL document, ready to be printed in a kneepad format (see also Figure D.19).

COORDINATES			CH-47D Chinook						
Spheroid		Date	Time	Z/A/B	dtg L-Hour		dtg F-Hour		
WGS 84		24-7-2001	13:37				Wind		
Nr.	Name	Zone	Lat	Long	Var	Pa	Temp	Speed	Direction
1	TP	31U-FT2038493208	52°16'34'N	004°45'52'E					
2	WP	31U-FT1795688622	52°14'07'N	004°43'38'E	0	489	15	0	0
3	WP	31U-FT1552884037	52°11'41'N	004°41'25'E	0	486	15	0	0
4	PUP	31U-FT4250178642	52°08'24'N	005°04'56'E	0	491	15	0	0
5	WP	31U-FT3225169830	52°03'48'N	004°55'45'E	0	499	15	0	0
6	LP	31U-FT2110169830	52°03'57'N	004°46'00'E	0	496	15	0	0
7	WP	31U-FT3261078461	52°08'27'N	004°56'16'E	0	495	15	0	0
8	EP	31U-FT4285978821	52°08'29'N	005°05'16'E	0	498	15	0	0

N.B. De gegevens uit de Coordinates mogen niet gebruikt worden als vervanging van de planning door de vlieger.

Pressure in	ft
Speed in	kts
Direction in	deg
Temperature in	°C
Variance in	deg

Figure D.19: Example of a Coordinates Sheet.

- **An Air Routes file**: a combination of all information concerning flight-times and co-ordinates is exported to an EXCEL document (see also Figure D.20).

NATO RESTRICTED
EXERCISE <EXERCISE NAME>
EXERCISE CLASSIFICATION: <EXERCISE CLASSIFICATION>

Appendix 1A (AIR ROUTES) to Annex H (HELI OPS) to OPORDER <oporder no.> (<oporder title>) of CDR-11(NL)AMB
Version: DTG <version>

ISSUE: MAY 2002

DATE: <date>			AIR ROUTES									HHI / UNIT:	
Waypoint Information						Information of leg preceding current waypoint							
No.	Name	UTM Coordinate	LAT-LONG Coordinate		Holdup	IAS	GS	MT	km	nm	Time	Run	Remarks
1	TP	31U-FT9736891228	52°14'10'N	005°53'26'E								0:00	
2	PUP	31U-FT7982568421	52°02'14'N	005°37'19'E	0.10	120	121	218	29	16	0.08	0:18	
3	WP	31U-FT4122887719	52°13'18'N	005°04'03'E	0.05	120	121	297	43	23	0.12	0:34	
4	WP	31U-FT1842150877	51°53'46'N	004°43'16'E	0.00	120	121	212	43	23	0.12	0:46	
5	LP	31U-FS1666794737	51°23'31'N	004°40'37'E	0.00	120	121	182	56	30	0.15	1:01	
6	WP	31U-FT3070240351	51°47'55'N	004°53'44'E	0.05	120	121	17	48	26	0.13	1:19	
7	WP	31U-FT5701894737	52°16'50'N	005°18'06'E	0.00	120	121	26	60	33	0.16	1:35	
8	EP	31U-FT8333366667	52°01'13'N	005°40'19'E	0.00	120	121	137	38	21	0.10	1:45	
									318	172	1:45		

Remarks
01. This form was generated by FELPATH, use for planning only
02. IAS and GS in kts; MT in *; Holdup, Time and Run in hh:mm
03. Spheroid: WGS 84
04.
05.
06.
07.

Figure D.20: Example of Air Routes Output.

- **File**: all results are exported to a semicolon-delimited text-file.

The results are also used by the Initial Fleet Allocation (IFA) module. These results can be transferred to the IFA module. Figure D.21 gives an overview of the screen that allows to transfer the results to the IFA.

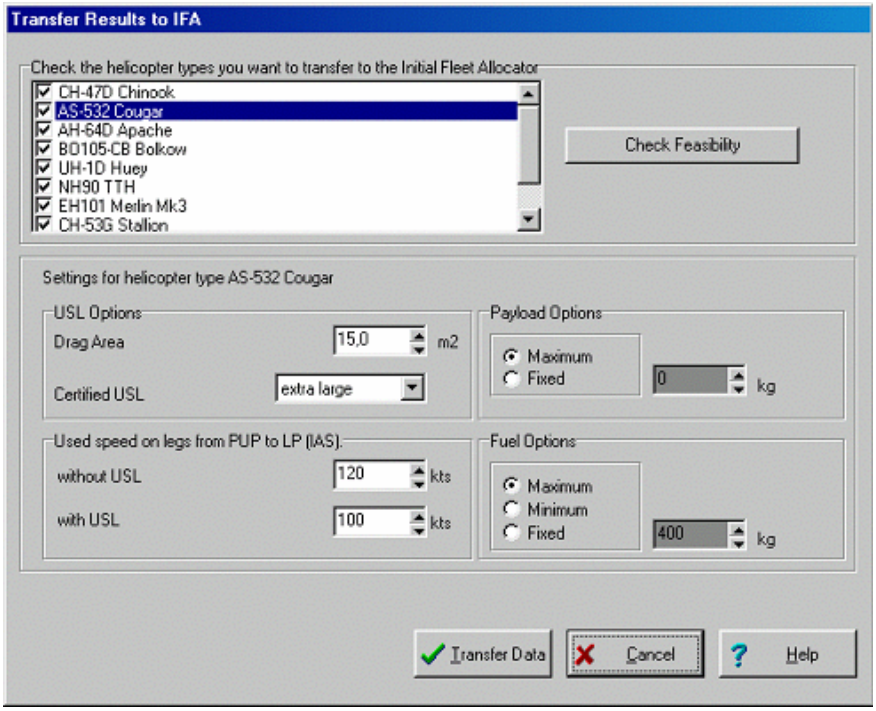


Figure D.21: Transfer Results to IFA.

As the route is planned only for one helicopter type, the route should also be checked for other helicopter types to be used in the IFA. The "check feasibility" button allows this. Clicking the button "Transfer data" will transfer all relevant data to the second module "IFA".

D.4.8.2 Initial Fleet Allocation

The module **Initial Fleet Allocation (IFA)** can be used to make a first estimation, in a quick, simple and rough way, of the number of persons, vehicles and pallets to be transported during an air mobile move. A planning is made of the number of sorties to flown and the number of flights required. Thus this module is used to allocate helicopters from the available fleet to the transport tasks that need to be performed.

The user can easily define the transport task by choosing the units to be transported and the helicopter types to be used. Using this information and the remaining maximum payload, the program produces the number of helicopter sorties required to perform the transport task and schedules them in air moves. The ultimate output of FELPATH is an Air Movement Table.

The AMT consists of information on the movement of the helicopters, like start- and end points and routing times for each flight. Figure D.22 shows the navigation screen of the IFA. It gives on overview of all the elements inside the IFA.

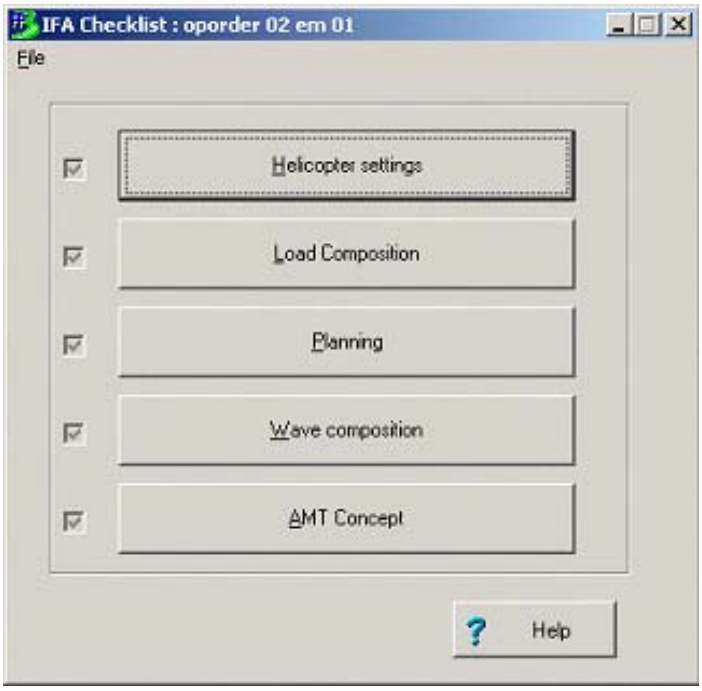


Figure D.22: Navigation Screen IFA.

Helicopter settings: The helicopter settings screen allows the user to enter all the helicopter types that are available to be planned in the IFA. Figure D.23 shows the helicopter settings screen. In this screen the available number of helicopters need to be filled in, Fuel data, loading and unloading times and the load configurations for this helicopter type.

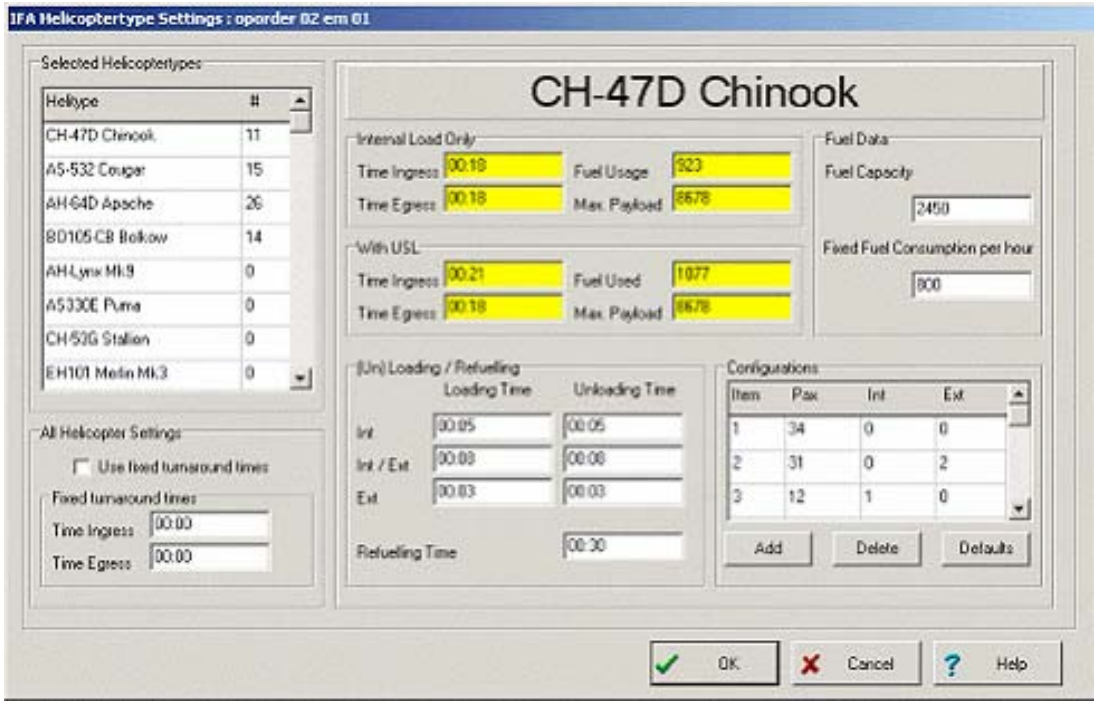


Figure D.23: Helicopter Settings Screen.

Load composition: The load configuration screen is simple, as shown in Figure D.24. Here the number of pax, the pax weight and the number of vehicles and pallets need to be filled in.

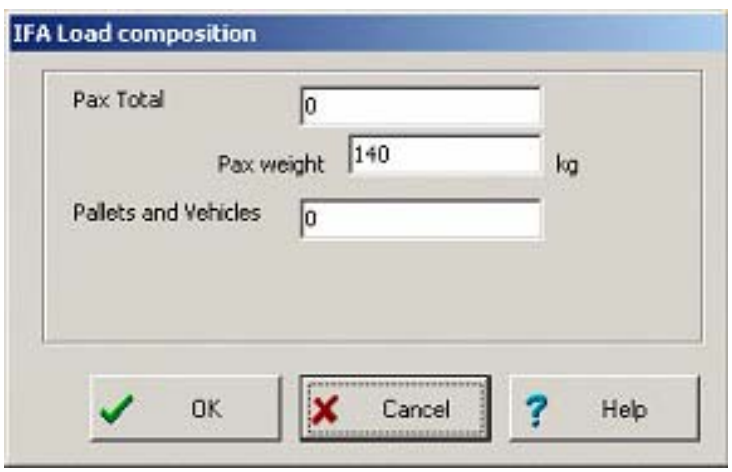


Figure D.24: Load Composition Screen.

Planning: The planning screen is the 'heart' of the IFA. Here the loads are assigned to waves. The user can either do this manually or let the model do this. Figure D.25 gives an overview of this screen after a planning has been done.

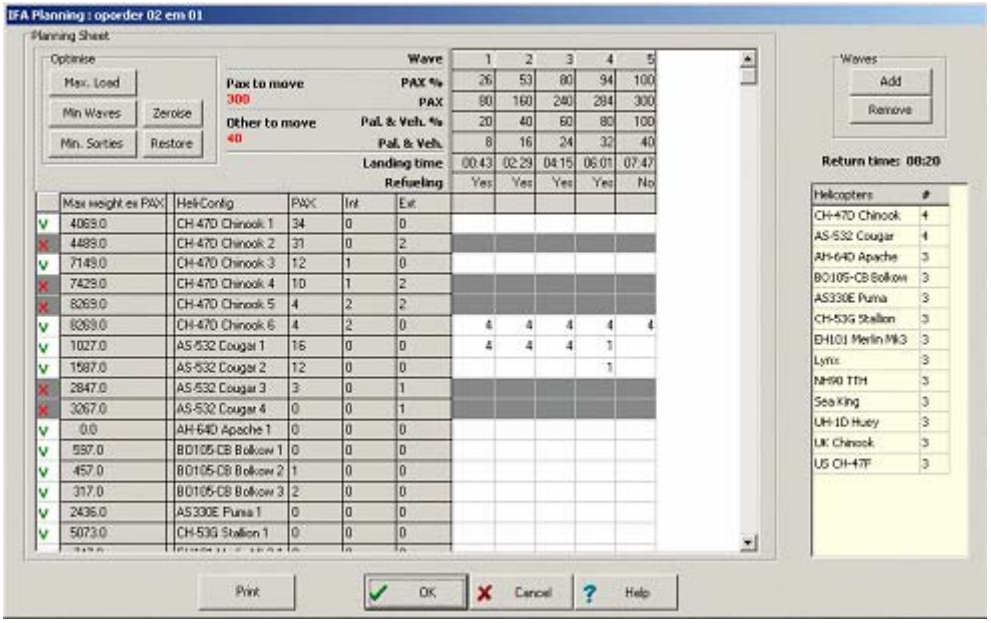


Figure D.25: Planning Screen.

Wave composition: When a planning has been made in sorties, these sorties need to be subdivided in waves. The wave composition screen allows this.

The screen shows the number of sorties for each helicopter and user can manually assign sorties to waves. Figure D.26 gives an overview of the wave composition screen.

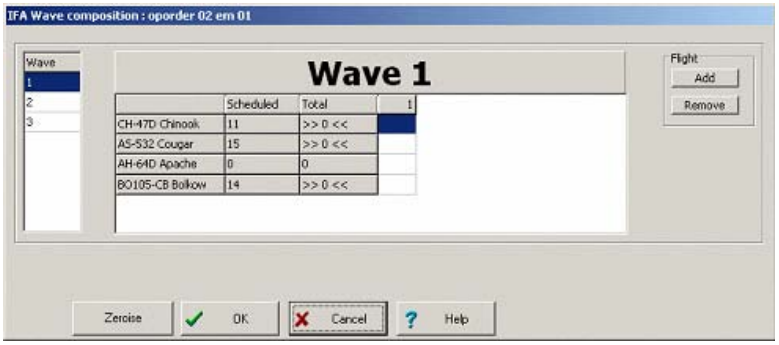


Figure D.26: Wave Composition Screen.

AMT concept: after filling in the first four screens, the planning is almost complete. Now, only some extra data need to be filled in. The AMT-concept screen allows this.

First, the landing times of the wave need to be defined, this can be done related to L-hour or in real time. Figure D.27 shows the results for a landing time in real time. Other data to be filled in, are some delay times like: Time between flights, Time for PUP to WP, Time from WP to LP. Furthermore, some reference data concerning the operation can be filled in, like exercise name, OPORDER nr., version, date, etc.

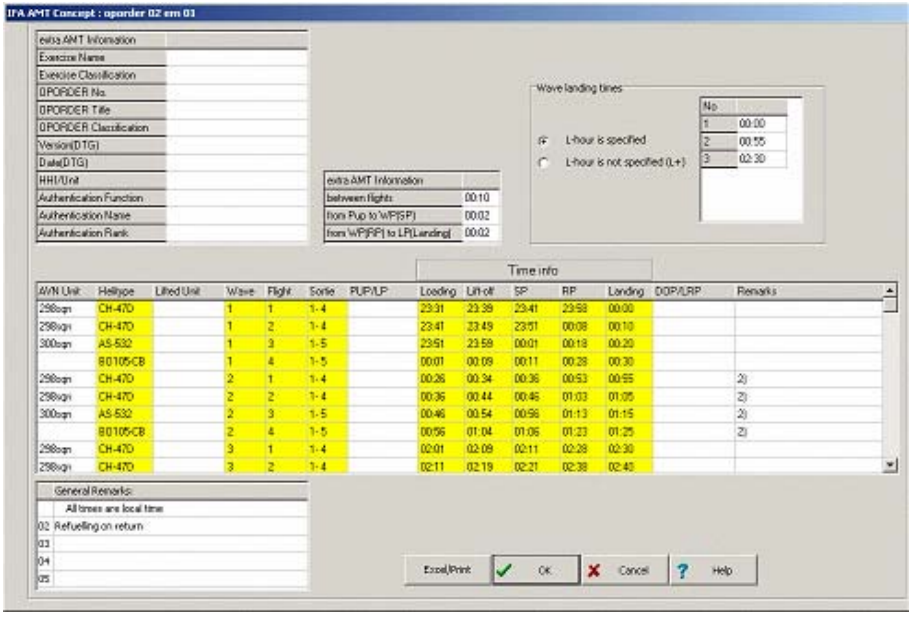
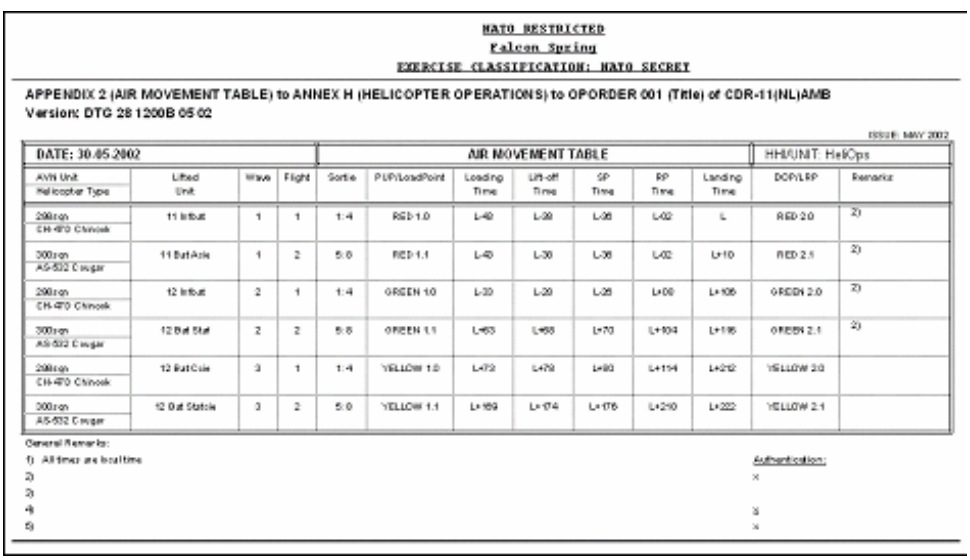


Figure D.27: AMT Concept Screen.

From this screen the final output of FELPATH can be generated. After clicking the Excel/Print button, an Air Movement Table as shown in Figure D.28 will be produced.



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EXERCISE CLASSIFICATION: NATO SECRET

APPENDIX 2 (AIR MOVEMENT TABLE) to ANNEX H (HELICOPTER OPERATIONS) to OPORDER 001 (Title) of CDR-11(NL)AMB
Version: DTG 28 1200B 05 02

ISSUE: MAY 2002

DATE: 30.05.2002				AIR MOVEMENT TABLE								HHI/UNIT: HelOps	
AVN Unit / Helicopter Type	Lifted Unit	Wave	Flight	Sortie	PUP/LoadPoint	Loading Time	Lift-off Time	SP Time	RP Time	Landing Time	DOP/LRP	Remarks
298sqn / CH-47D Chinook	11 Infbat	1	1	1-4	RED 1.0	L-40	L-30	L-26	L-02	L	RED 2.0	2)
300sqn / AS-532 Cougar	11 Bat Aste	1	2	5-8	RED 1.1	L-40	L-30	L-26	L-02	L+10	RED 2.1	2)
298sqn / CH-47D Chinook	12 Infbat	2	1	1-4	GREEN 1.0	L-20	L-20	L-26	L+08	L+106	GREEN 2.0	2)
300sqn / AS-532 Cougar	12 Bat Stat	2	2	5-8	GREEN 1.1	L+63	L+68	L+70	L+104	L+196	GREEN 2.1	2)
298sqn / CH-47D Chinook	12 Bat Cole	3	1	1-4	YELLOW 1.0	L+72	L+79	L+80	L+114	L+212	YELLOW 2.0	
300sqn / AS-532 Cougar	12 Bat Statole	3	2	5-8	YELLOW 1.1	L+169	L+174	L+176	L+210	L+222	YELLOW 2.1	

General Remarks:
1) All times are local time
2)
3)
4)
5)

Authentication:
x
x
x

Figure D.28: Air Movement Table in Excel.

D.4.8.3 System Requirements

FELPATH can be installed on a stand-alone PC. For the Dutch Armed Forces also a LAN-version has been developed. Using FELPATH v3.2 requires the following minimum system description:

- Processor: Pentium II 200 MHz
- RAM: 64 MB RAM
- Hard disk: 325 MB free space
- Display resolution: 1024 x 768 pixels
- Peripheral equipment: CD-ROM player
- Operating system: MS Windows 95/98/NT
- Required software: MS Office 97

D.4.9 OTHELLO (The Netherlands)

OTHELLO (Operational Transport HELicopter LOadplanner) is an optimisation tool, supporting at battalion and company level of the 11 Air Mobile Brigade (11LMB) of the Royal Netherlands Army (RNLA) in planning tactical helicopter movements.

One of the results of the brigade-level planning is an Air Movement Table (AMT), which gives an overview of the number of sorties (i.e. movements of one single helicopter) per helicopter type that is required to perform the transport task. The battalions, part of 11LMB, have to work out the brigade plan in more detail. OTHELLO is a software tool that helps the battalion planners to make this detailed plan. The final output of OTHELLO is an Air Loading Table (ALT), as shown in Figure D.29.

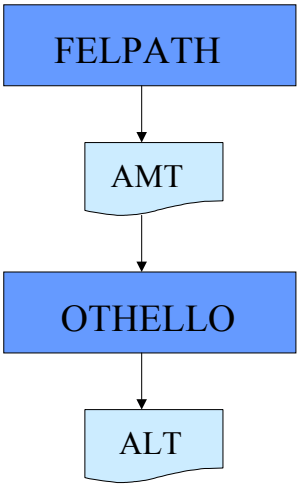

Figure D.29: Relationship between FELPATH and OTHELLO.

OTHELLO produces an ALT, taking into account the following:

- The preferred order in which the load must arrive at the drop off point (priorities of the load);
- Which loads must be transported in the same helicopter sortie (or successive sorties); and
- Which loads have to be transported separately (crossloads).

Data originating from FELPATH, needed to produce an ALT, can be imported automatically.

OTHELLO performs single helicopter planning and for this purpose it only uses certified loads for both internal and external loads. Figure D.30 gives a general overview of the first part of OTHELLO. It uses a PAX and equipment list and a list of internal and external load to produce a list of load configurations.

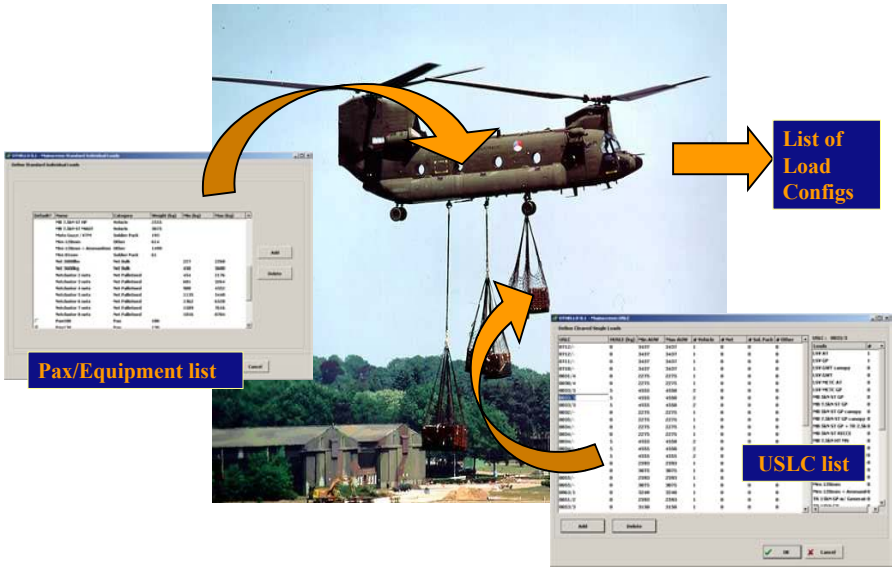

Figure D.30: Overview Determination List of Load Configurations.

Figure D.31 gives an overview of how the load configurations are determined in OTHELLO.

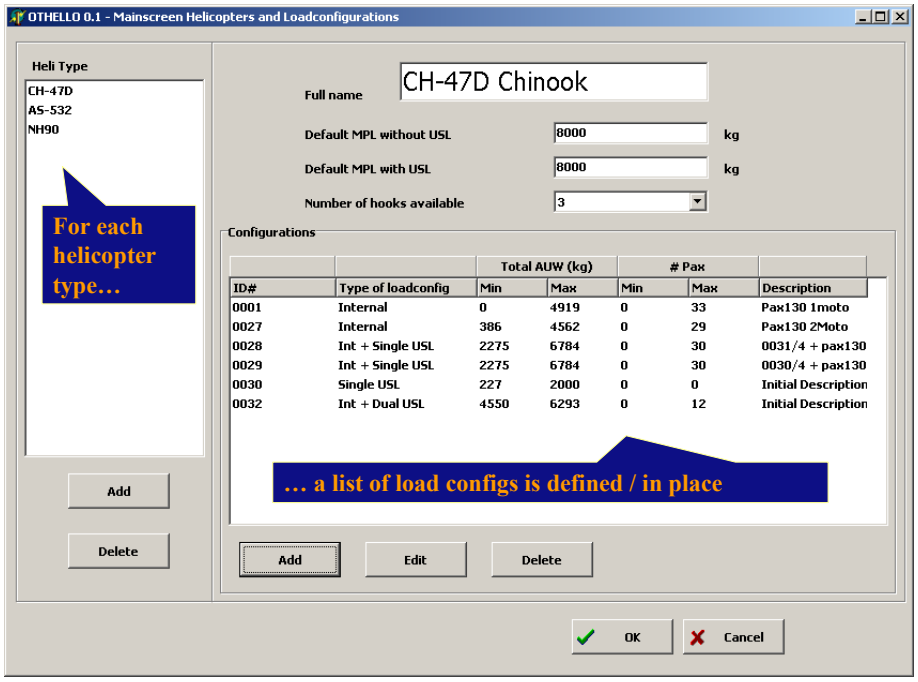

Figure D.31: Determination of Load Configurations in OTHELLO.

OTHELLO enables the planner to easily select the load to be transported by using an electronic database of all units of the 11LMB. The number of vehicles and pax can be modified per group and task forces can be added to the organisation. An overview is given in Figure D.32.

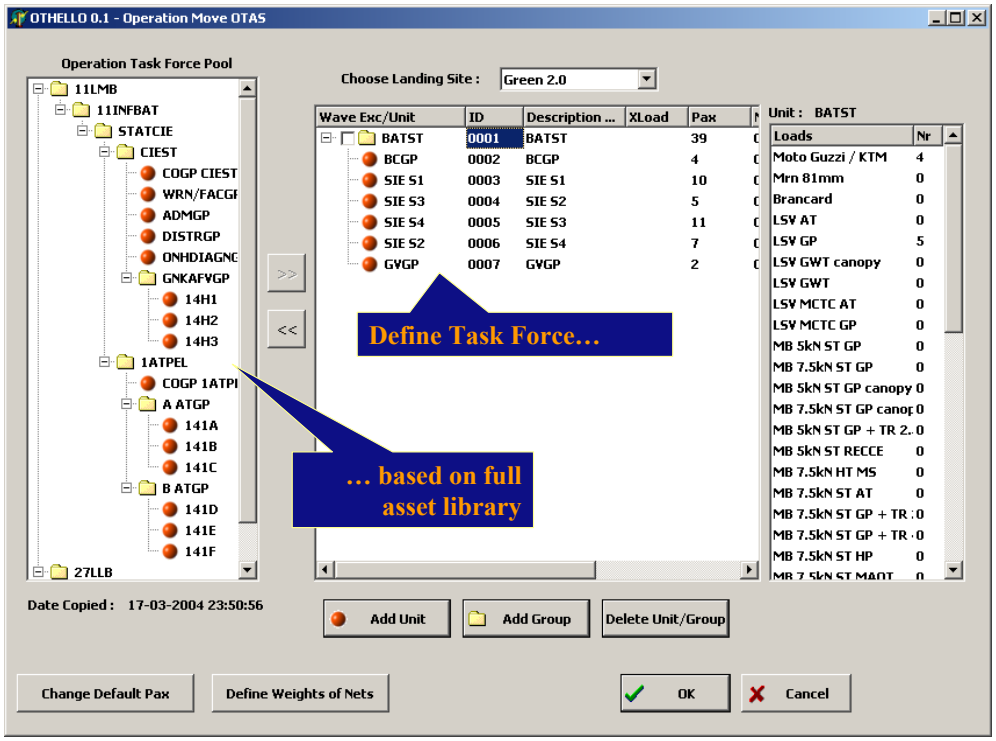

Figure D.32: Definition of Task Force.

Figure D.33 shows the next step, where the actual planning takes place, at single helicopter level.

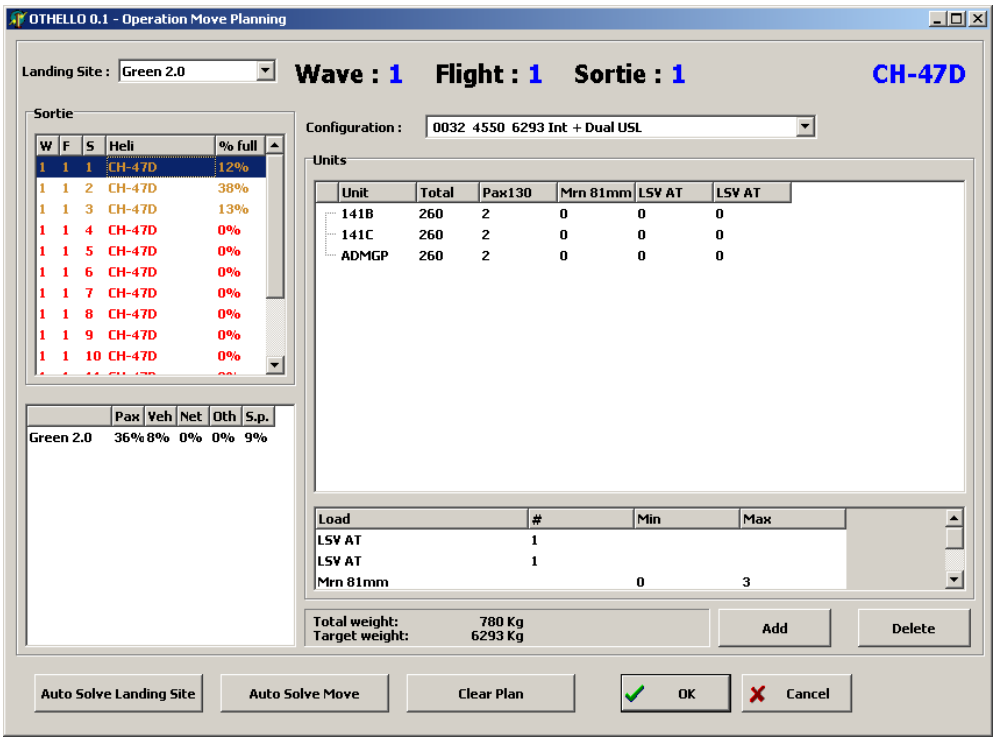

Figure D.33: The Planning in OTHELLO.

The result of the planning is an Air Loading Table (ALT) (see Figure D.34), which gives a detailed description of the exact load that will be transported per sortie, the exact locations where the load will be picked up by the helicopters and the exact arrival and loading times. TNO Physics and Electronics Laboratory (TNO-FEL) has developed a demonstrator version of OTHELLO in 2002. The development of an operational version of the software started in 2003. This leads to a first operational version of the model at the end of 2004.

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Page.....of.....Pages

ISSUE 6

DATE:				AIRLOADING TABLE						HH/UNIT:
AVN- Unit/ Type	Wave	Flight	Sortie	Sub-Unit/ Usl	No of Pax/ Usls	AUW (kg)	PUP/ Load point	Arrival time	Loading time	Remarks
(A)	(B)	(B)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(J)
Voorbeeld 1:										
300/AS	-	-	1	8 pax A/- 8 pax B/-	16/-	1920	FT 12345678	H - 100	H - 55	1)
300/AS	-	-	2	8 pax C/- 8 pax B/-	16/-	1920	FT 12345678	H - 100	H - 55	1)
Voorbeeld 2:										
298/CH	1	1	1	1e pel A/ MB 7.5 kN	25/5410	6075	Red 10	1210	1255	2)
298/CH	1	1	2	2e pel A/ MB 7.5 kN	25/5410	6075	Red 10	1210	1255	2)
298/CH	1	1	3	3e pel A	30	3600	Red 10	1210	1255	
298/CH	1	1	4	Overigen A - coy	30	3600	Red 10	1210	1255	

General Remarks: All times are local times
1) Receiparty
2) 2 mtr extension strop mandatory for Usl

01 jul 000

Figure D.34: Air Loading Table.

Using OTHELLO increases the speed in planning helicopter movements on battalion level. Alternative ALTs can be generated quickly. Also, the possibility of human errors is significantly reduced. Another advantage of OTHELLO is that the optimisation tool only works with certified load configurations for the different types of transport helicopters, which ensures a feasible ALT.

D.4.10 SYNCHROMATRIX (The Netherlands)

As part of the planning process, the 11 Air Manoeuvre Brigade of the Netherlands armed forces build a time schedule for each operation. This time schedule is referred to as the synchronisation matrix, or synchromatrix. The synchromatrix provides a visual representation of all tasks that have to be performed throughout an operation, including when they start and how long they take. This way the people in the planning cell can quickly see if any of the tasks coincide and whether or not all actions are taking place in the right order.

In the past, this synchromatrix was used to be hand-drawn on a white board, which was a very tedious, time-consuming job. Also, changes to the schedule could result in a good part of the synchromatix having to be redrawn. As a result – even though it was acknowledged that the synchromatrix has a clear added value for the operation – drawing up the synchromatrix was often omitted, due to time constraints.

To solve this problem, it was suggested to investigate the feasibility of having a software tool that could ‘do the job’. Currently, TNO is developing a software tool that makes it possible to create a synchromatrix electronically. This adds a number of powerful features to the original concept:

- **Convincing visual presentation**. By using the full range of colours available on a computer (instead of the four colours of the white board markers) and presenting the synchromatrix in a recognizable format known in many scheduling programs (i.e. a Gantt-chart), the different tasks and events in an operation can be easily comprehended and communicated.
- **Added intelligence**. The SYNCHROMATRIX software will allow for different tasks and events to be dependent on each other. For example, the task of refueling a helicopter will have to coincide with the event of an activated and open FRP/FARP location. Other dependencies include day/night patterns, weather, and crew availability.
- **Monitoring the operation**. The SYNCHROMATRIX software incorporates a 'time bar' that shows the current time, and also provides pop-up messages whenever an important event is about to start. This way the synchromatrix that is constructed by the PLANS cell can then be used by the CURRENT cell to monitor the operation as it takes place.

The SYNCHROMATRIX software will be the core of an integrated planning system for the 11 Air Manoeuvre Brigade (see also Figure D.35). Other models in this integrated planning system are:

- **FELPATH**. This Brigade-level planning tool for transport helicopters has been used in an operational context for several years. It combines route planning on a geographical map with transport planning. For transport planning, cargo and passengers to be transported within an operation can be distributed over the available helicopters, resulting in a number of moves (*waves*) that have to be flown. Future developments of FELPATH may include planning attack operations and enhancements to digital terrain capabilities.
- **OTHELLO**. The Brigade-level plan for transport helicopters needs to be worked out in detail at Battalion-level. This is the job of OTHELLO. The result is a detailed loading plan for each helicopter sortie in the operation. OTHELLO will be developed in the near future.
- **Squadron planning system**. The last part of the integrated planning system is a squadron-level planning system. FELPATH plans are based on rough helicopter routing estimates. The squadron planning system will verify these routes and specify the routes in more detail. The result would be detailed mission plans, which directly feed into the helicopter-specific mission planning systems. The squadron planning system would be developed by the National Aerospace Laboratory NLR.

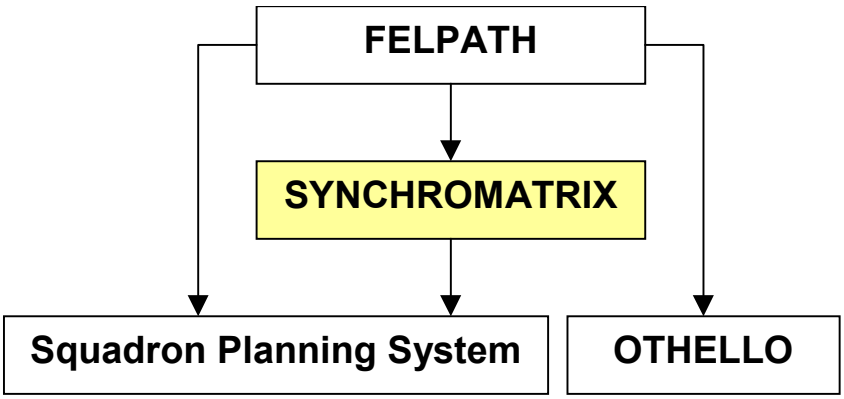

Figure D.35: Overview of Integrated Planning System RNLAF.

TNO has developed a first demonstrator version of the SYNCHROMATRIX software in 2002 (see Figure D.36), which has shown that it will be feasible to build an electronic version of the synchromatrix. A fully operational version of the software will be developed by TNO in the near future.

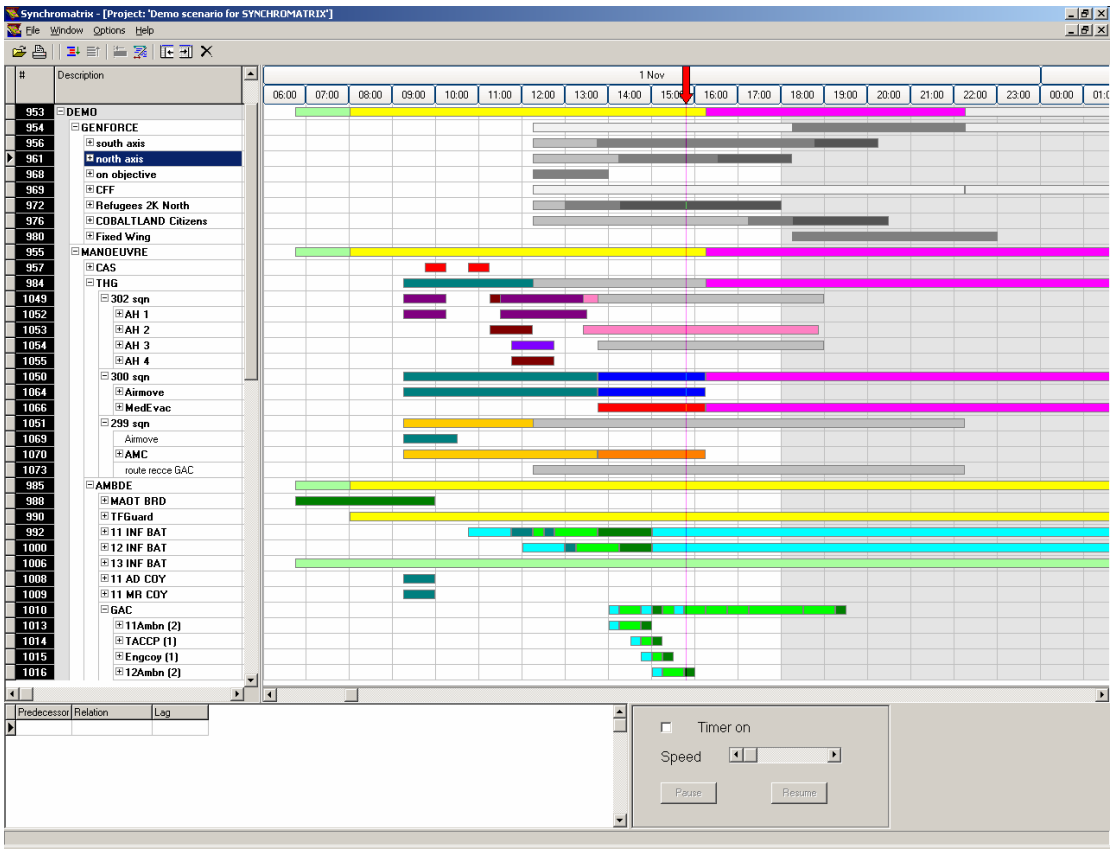

Figure D.36: Demonstration Version of Synchromatrix.

D.4.11 Summary of National Models

In Figure D.37 an overview is given of the national models discussed in this section and their application. For the current operations more national models exist than discussed here. TUAFIS from Turkey is just one example.

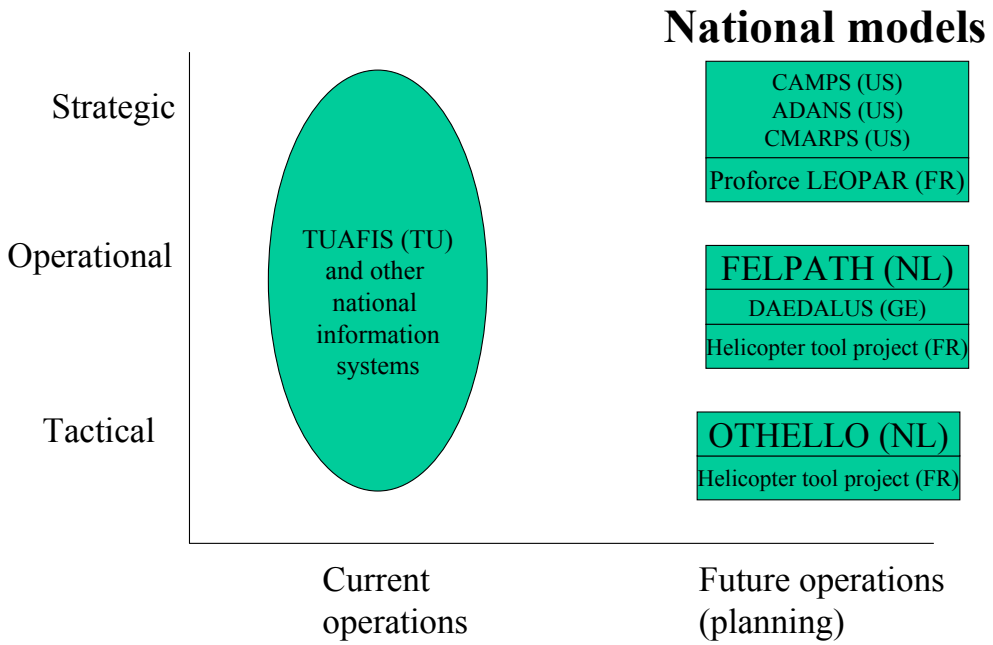

Figure D.37: Overview of National Models.

As the focus of SAS-045 is on the planning of helicopter operations at operational level, only FELPATH, DAEDALUS, the French helicopter tool and OTHELLO are of interest. However, only FELPATH is a operationally used tool. DAEDALUS has not been developed, The French helicopter tool is still to be developed and OTHELLO is under development.

D.5 CONCLUSION

NATO developed several models for planning purposes, but none of them has specifically been developed to support helicopter operations. However, it seems to be sensible that the helicopter model that will be developed within SAS-045 scope will need to use similar software platforms and database that are being used in NATO models like ADAMS.

Within the nations some planning models have been developed. Most of them are developed to support the planning of aircraft. So far only The Netherlands have developed a model called FELPATH that supports the operational planning of helicopters. FELPATH, however supports only a limited number of the functionalities that are required for the new NATO helicopter planning model. That being said, it is rational to use the lessons learned from The Netherlands, when developing the model, and probably use FELPATH as a starting point for developing the decision support tool for planning helicopter operations.

D.6 REFERENCES

[1] TOPFAS Tool for Operational Planning, Force Activation and Simulation, Hakon Thuve, presented at the 6th International Command and Control Research and Technology Symposium, United States Naval Academy (USNA) Annapolis, Maryland, June 19-21, 2001, www.dodccrp.org/6thICCRTS/Cd/Tracks/%20Papers/Track4/127_tr4.pdf

[2] Fanti, L., Airspace Management in the Initial CAOC Capability (ICC), Air C2 Branch NC3A, http://uav.navair.navy.mil/nato/brief/z)%20IV-1/index.htm

[3] Press Statement 22 July 1999, The ACCS Programme & NACMA (NATO Air Command And Control System Management Agency), http://www.nato.int/docu/pr/1999/p990722e.htm

[4] NATO ACCS Overview & Update, Keith Maxwell, NACMA, Briefing for TMD PG 24-25 February 2003.

[5] Jones, Lieutenant Colonel F.K., ADAMS: Can You Get There From Here Without It?, http://www.almc.army.mil/alog/issues/SepOct99/MS470.htm

[6] Heal, G.N., ADAMS System Overview and support to exercises and operations.

[7] TOPFAS Planning Module version 1.1 User's reference Guide.

[8] Solanski, R. and Southworth, F., An execution planning algorithm of military aircraft, Interfaces Vol. 21, No. 4, pp. 121-131.

[9] Rappoport, H., Levy, L., Golden, B. and Feshbach, D., Estimating Loads of Aircraft in Planning for the Military Airlift Command, Interfaces Vol. 21, No. 4, pp. 63-78.

[10] Rappoport, H., Levy, L., Golden, B. and Toussaint, K., A Planning Heuristic for Military Aircraft, Interfaces Vol. 22, No. 3, pp. 73-87.

[11] Global Command and Control System Consolidated Air Mobility Planning System (CAMPS) – system description, http://jitc.fhu.disa.mil/gccsiop/interfaces/camps.htm

[12] Global Command and Control System Air Mobility Command (AMC) Deployment Analysis System (ADANS) – system description, http://jitc.fhu.disa.mil/gccsiop/interfaces/adans.htm

[13] Entwicklung/Bereistelung von planungshilfen für die Einsatzunterstützung luftbeweglichrer Kräfte im Rahmen der Studie Luftbeweglichter Grossverband, Dr. Hättig, R. Hagen, IABG, January 1998.

[14] SAS-045 report on Airspace Management, to be published in 2004.