MILITARY OPERATIONS RESEARCH IN A CHANGING ENVIRONMENT

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September, 1993

Military Operations Research in a Changing Environment

History of OR

Operations Research in the military area as we understand it today was initiated during World War II in both the US and the UK armed forces in order to analyse and to support military operations. The definition used by Morse/Kimbal [1] is:

> "Operations Research is a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control".

Although the instruments for the quantitative work have improved considerable since that time, the principles of OR as stated remain the same today and are even more valid, as the requirement for new and challenging operations in the NATO environment leads to increased analysis in the original context of OR.

On the other hand, OR is much older in its principle content. The 'Art of War' by Sun Tzu, written more than two thousand years ago, is still the most prestigious book about strategy in the world. Sun Tzu stated [2]:

> "The rules of the military are five:
>
> - measurement
> - assessment
> - calculation
> - comparison and
> - victory
>
> The ground gives rise to measurements, measurements give rise to assessments, assessments give rise to calculations, calculations give rise to comparisons and comparisons give rise to victories".
>
> This ancient statement translated into modern language could read:
>
> "Based on the perceived realities the natural sciences such as mathematics and physics give the toolbox to create models, which represent the reality under consideration. The application of models, eg the simulation are then the basis for the analysis of operations" (see Fig. 1).

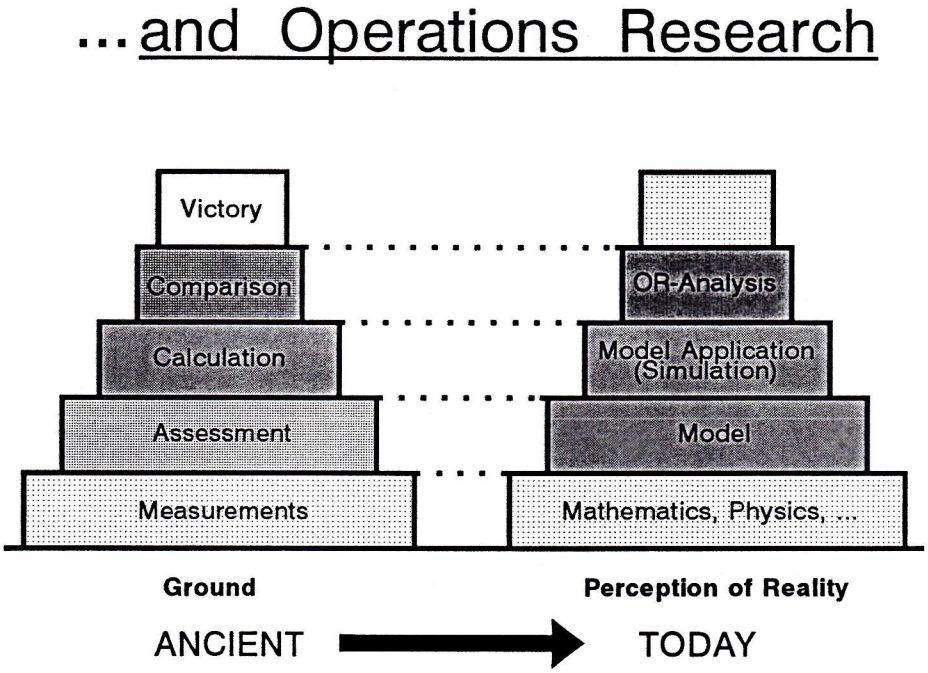


Figure 1

Sun Tzu also stated: [2]:

"To win without fighting is best". Today we would say it is better to think first, or it is preferable to calculate the likely results of actions before the actions are started, again related to Operations Analysis. Since Sun Tzu many strategists, war philosophers and analysts have worked in this area. During the last 30-40 years a huge amount of data, models and theories have been created in support of the operations analysis, unfortunately, also a great deal of misperception of the potential of the methods and misuse thereof. The latter led to critical thoughts as stated by Ackoff [3] about the future of operational research. Ackoff strongly recommended not to forget the old rules for planning:

- Participation. The principal benefit of planning comes from engaging in it. The creation of a plan is more important than the plan itself.

- Continuity. Plans should be continuously revised. The creation of the plan is never finished, it is important to learn from the process and to keep a (corporate) memory of mistakes and failures.

- Holistic. All units at the same level of an organisation and every level should be planned for simultaneously and independently. The system under consideration should be seen in its hierarchial structure in the top-down and bottom-up approach at the same time.

OR in support of SHAPE

In general the OR problems in the military area can be addressed by two typical questions: (Fig. 2).

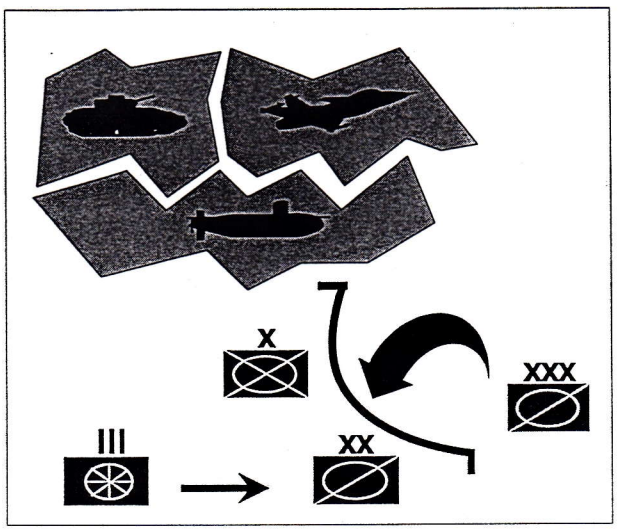


Figure 2

a. Structure:

What is the best mix or composition of forces in all categories in order to meet given requirements and objectives and to minimize resources, or to develop the best mix for given resources and to maximise the effectiveness. The requirements and objectives are eg to maintain strategic force balance or a certain probability of success in predefined planning situations.

b. Operations:

What is the best employment of forces in defined contingencies and for operational objectives in order to minimize casualties or operational costs.

Whilst the first problem area is focusing on relatively long term planning frames in time, the latter problem area is focusing on short term oriented questions.

The work of the OR division in the SHAPE Technical Centre (STC) is correlated to these problem areas and integrated with the respective divisions in SHAPE. (Fig. 3).

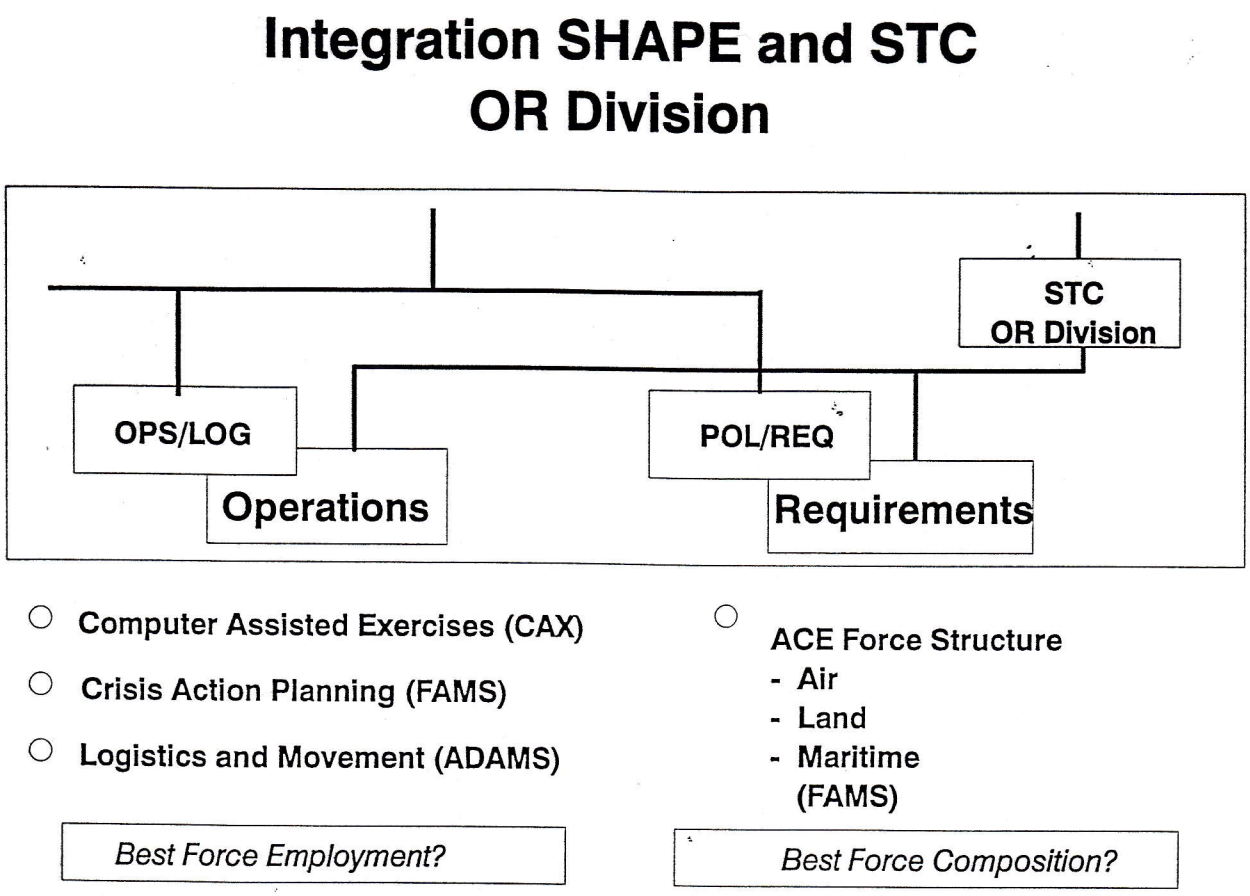


Figure 3

These SHAPE divisions are OPS/LOG and POL/REQ. OPS/LOG is responsible for short term operational and logistical planning, including crisis management and exercises while POL/REQ is responsible for long term force structures and force planning. The branches in the OR Division are related to these areas as well. The Operations Branch presently works primarily with OPS/LOG in SHAPE on the following projects:

- Computer Assisted Exercises (CAX)
- Crisis Action Planning (FAMS)
- Logistics and Movement (ADAMS)

The Requirements Branch currently works primarily with POL/REQ in SHAPE on the service related projects focussing on the review of the ACE-force structure for the late 90s.

Crisis Action Planning:

The topic of crisis response serves as a good example for the typical work of the OR Division and its integration into the needs of the customers in SHAPE. During Summer 1992, an internal OR Division crisis response exercise was planned with the following objectives: (Fig. 4).

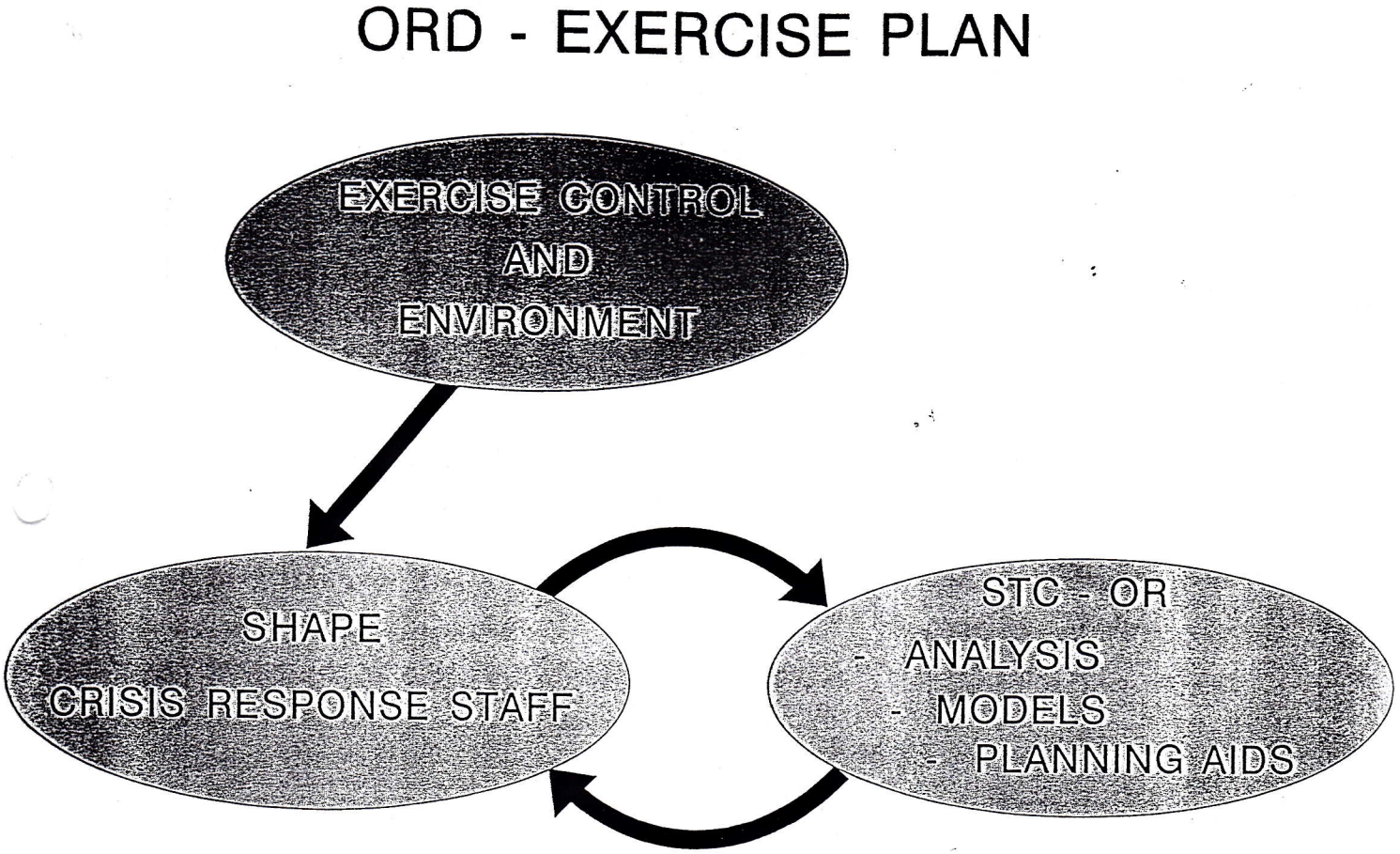


Figure 4

- Mutual understanding of the roles and actions of the key factors in a crisis and the flow of events, in other words, the process of a crisis. This would generate parameters relevant for a crisis watch system.

- Testing the gaming approach as a method for exercising crisis management staff groups as an input to a planned SHAPE exercise.

- Identify potential decision and planning aids, models, methods and data bases, which could be applied in a significant way in crisis management, in other words, OR contributions to SHAPE.

- Creation of scenarios as a basis for several projects.

The plan for the composition of the exercise groups was as follows: (Fig. 4).

- Group A (top circle) should represent the exercise control group and should provide the environment.

- Group B (left circle) should act as a crisis response staff group in SHAPE, responsible for the preparation of potential military response options in the given crisis situation.

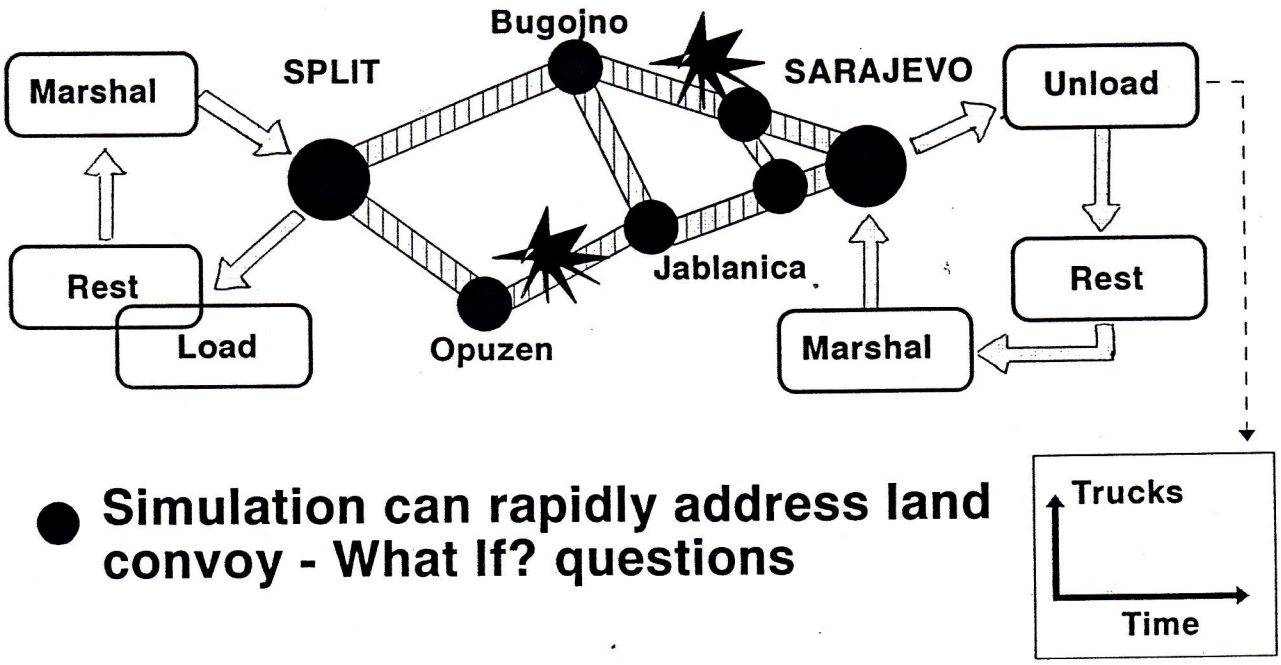
- Group C (right circle) should act as a scientific advisory group such as STC, responsible for contributions to force structures, situation assessments, planning aids, databases and responding to the request of Group B as indicated by the arrows.

After this set-up was established the STC OR Division was asked by SHAPE to prepare contributions to military response options in the Yugoslavia crisis. The set-up of the work team turned out to be almost as planned in the internal crisis exercise. The virtual exercise situation became reality sooner than expected.

The contributions to SHAPE were:

- historical analysis
- logistical analysis
- risk assessments for convoys
- air support calculations
- terrain analysis
- communication analysis
- radar coverage analysis

Within a few days it was possible to create a rapid prototype simulation model for convoy land opeations on the basis of the systems dynamics technique (Fig. 5). In this simulation model, although relatively straightforward, it was possible to represent different routes, different activities at departure and destination points as well as stops caused by whatever reason. It can be used to analyse first 'what if' questions and to compare several route options.



- **Simulation can rapidly address land convoy - What If? questions**

- **Basic elements can be re-arranged to adapt to any other set of routes**

Figure 5

Combat Air Patrol by Helicopter or Fixed Wing aircraft for the protection of the land based convoys seemed to be mandatory. For these options many parameter combinations and trade-offs have been tested and analysed using spreadsheet techniques on a PC. (Fig. 6).

km

HELICOPTER CAP REQUIREMENTS

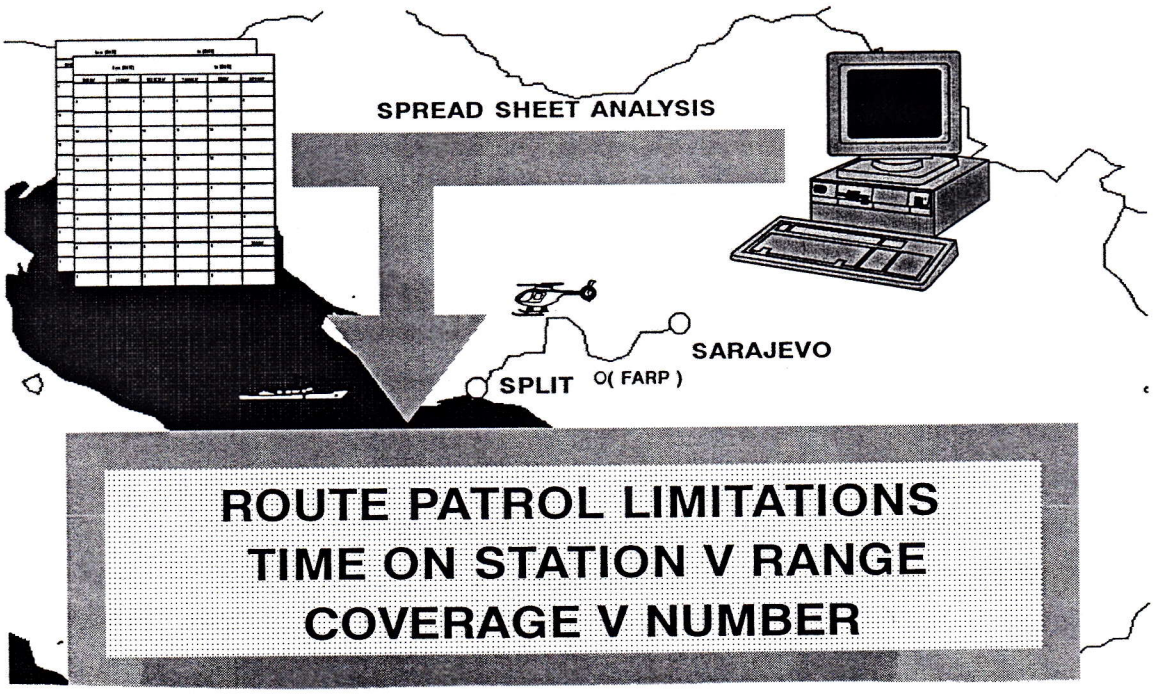


Figure 6

In the Logistics area a huge amount of contributions have been prepared for input to OPS/LOG over a period of several months. Here, many options of force compositions and the corresponding transport requirements have been assessed and compared. Different transport routes and assets have been considered to estimate unit arrival in the deployment area. (Fig. 7).

ANALYSIS INPUTS TO OPS/LOG DIVISION

- **Transport Requirements for Force Composition Alternatives:**

  - **Heavy Options : 3 Division Corps**
  - **Medium Options : Reinforced Bde Group**
  - **Light Options : Reduced Bde Group**

- **Unit Arrival/Closure Profiles for Alternative Development Routes:**

  - **Road/Rail Directly**
  - **Road/Rail to Italy + Adriatic Ro-Ro Shuttle**
  - **Direct Sea Transport from North Sea Ports**

Figure 7

In a similar way the Air Transport capabilities and required fleet size have been calculated based on transport rates, available crews, loading factors etc.

In Figure 3 the acronym FAMS was introduced. FAMS stands for Force Assessment and Management System (FAMS) (Figure 8).

FAMS represents methods and procedures to be capable of initiating the planning immediately and with the highest possible state-of-the-art when a crisis arises. A key element of a crises is surprise which leads to the need for quick reaction. Therefore, we have to develop generic building blocks for planning, which are to be used in the Headquarters on the desk of the planning officer.

FORCE ASSESSMENT & MANAGEMENT SYSTEM
(FAMS)

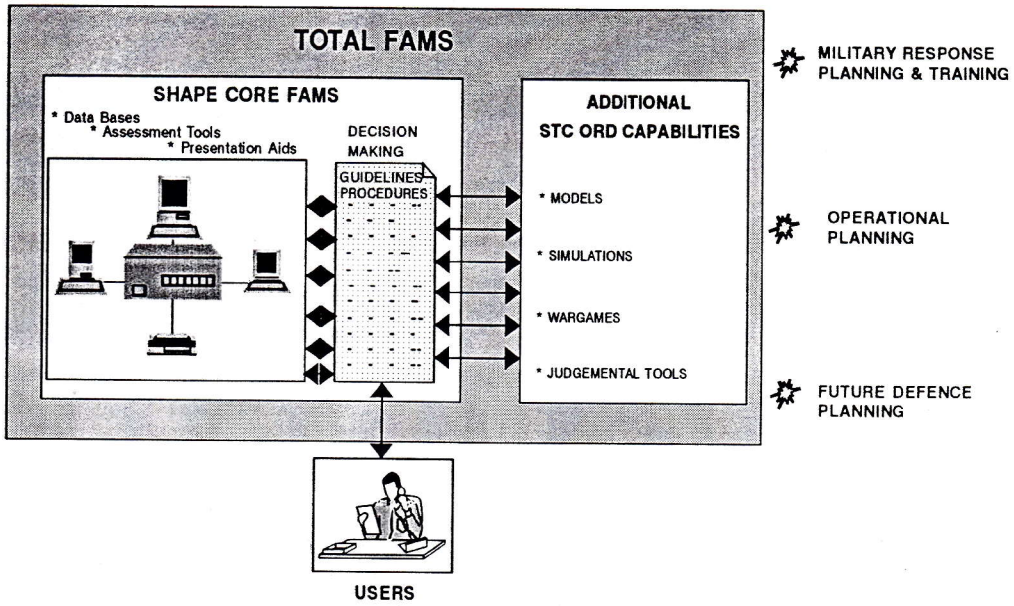


Figure 8

FAMS is intended to assist SHAPE with their operational and future defence planning activities in peacetime, crisis and/or for wartime tasks. The total system is composed of a core element comprising a computer network containing data, analysis and presentation tools. This will be supplemented by more complex models resident at STC. The military user calls upon either the core element or the additional STC systems dependent on the task to be performed. In peacetime, planning situations or contingencies will be examined by FAMS to devise the capabilities and deficiencies of NATO-forces for the

various planning situations. This information can assist in devising new contingency plans or the updating of existing ones. It can also be an input to the Defence Planning Process in the form of force proposals. If these studies indicate major deficiencies, military concepts could also be updated. In a crisis, FAMS will enable the military to play a more active role in the crisis management process. It will allow rapidly produced response options to be fed into the political decision process. If action is required, the same system will facilitate the production of an implementation plan.

Force Structure Planning

The ACE Force Structure Review is another example of successful support work. The objectives of the review relate directly to the principle elements of SACEUR's mission:

(a) To preserve the strategic balance in Europe.

(b) To deter and defend against any threat of aggression against the territory of any NATO member state, and

(c) To support activities for peacekeeping and humanitarian aid operations.

The first two elements have the highest priority. It is assumed that the support of peacekeeping and humanitarian aid operations is possible with less forces than needed for the first two mission elements. In other words the requirements for the force balance and defence mission will cover the peacekeeping requirements. Therefore the two first elements will determine the force structure, while specific peacekeeping requirements have to be added if necessary. It is further assumed that qualitative characteristics of force structure will be assessed after the quantitative force elements have been determined. These qualitative factors mainly stem from C3I and related issues. There is much evidence based on history, wargaming and operations research that the operational art can be the most determining factor in the outcome of a specific battle, campaign or conflict.

The issues of balance of forces and defence against an aggression, are quantifiable to a certain degree and can be assessed by modelling methods of operation research.

Assessment of strategic balance needs the consideration of many combinations of NATO force deployment, NATO forces composition and NATO force levels as well as combinations of opponent's forces, which should be balanced. This leads to the requirement for the calculation of many force structure options. At the same time the balance issue needs only to take into consideration the numbers, the performance and the deployment factors which can be analysed by static-score based methods. (Fig. 9). On the other hand, the dynamic method needs to include factors related to the situational defence issue. Here only a few options can be analysed in a given time. These planning situations are based on many specific assumptions to the possible aggressor, his intentions and objectives. The planning situations serve as an experimental frame for the verification/falsification of the results obtained from the static approach (refinement). Based on the simulation approach which considers many assessment factors explicitly, a statistical

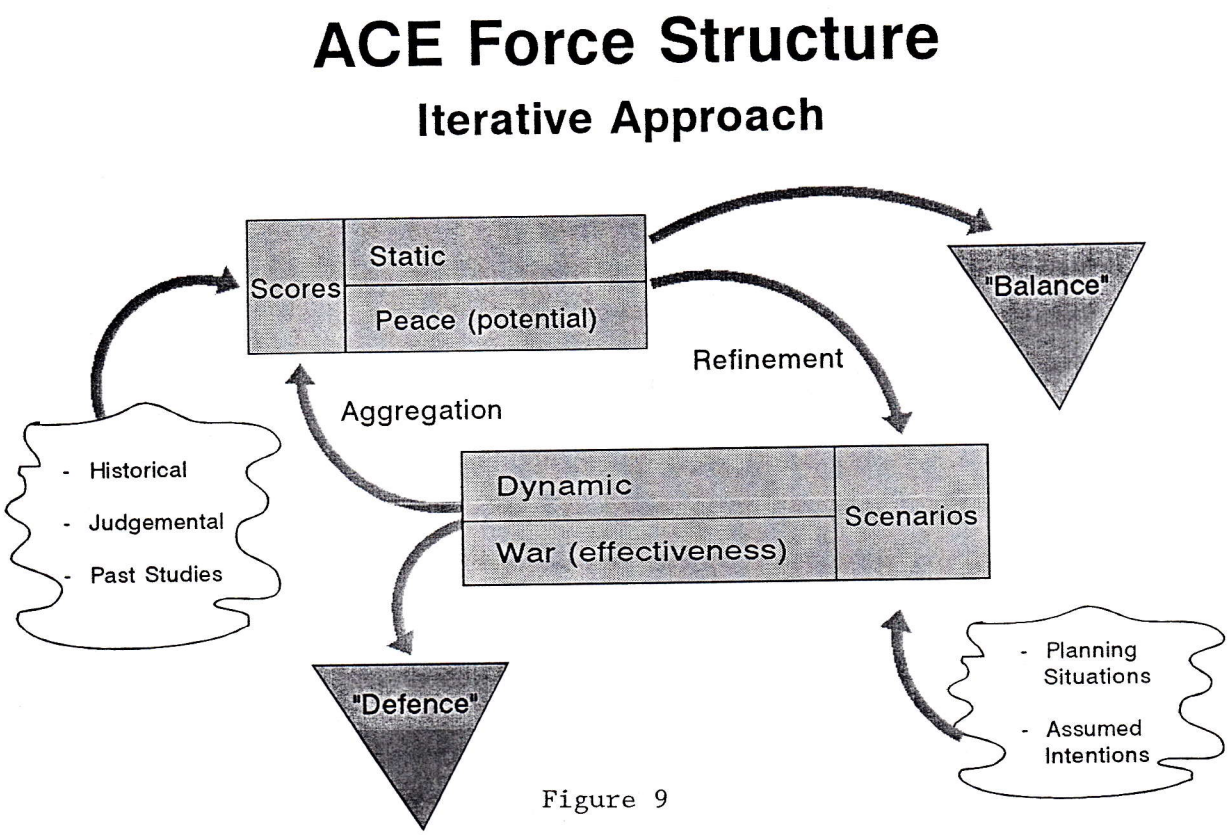


Figure 9

evaluation of the results for the generation of scores is possible (aggregation). These scores can be used together with historically and judgementally derived scores from other sources. This circular flow of analysis forms an iterative approach to the problem of force structuring covering the magnitude of options related to the balance issue and the

necessary fidelity of assessment factors related to the defence issue at the same time. In the ACE force structure review the static balance issue and the dynamic defence issue are analysed simultaneously based on available inputs. In the static analysis, historical, judgemental or past studies provide input for the calculation and comparison of scores. At the same time a few planning situations based on intelligence assessments, political constraints and projected NATO-forces are analysed.

Future of OR

In the future the OR community in NATO will be influenced by the general approach of how to do research, development and planning. In the past forty years the force postures can be characterized by large standing forces poised to attack or defend within days or weeks. Today the defence system moves towards a mobilization posture with much smaller standing forces, most of them less ready In the future this might be a 'rearmament posture', with even smaller standing forces and years required to build equipment and mobilize the forces needed to mount sizable military operations. For the past, the defence planning was based, sometimes explicitly, on the view that the future would be much like the recent past. This perspective of the defense acquisition process can be seen as a 'pipeline'. (See Fig. 10). Research and development are poured into one end and eventually their results appear as fully deployed systems at the other end. A common perception has been that the value of research and development accrues only if and when fully deployed systems materialize. On the other hand, research and development afford value in and of themselves before any production or deployment. A developed and demonstrated potential to produce or deploy certain systems is a product in its own right and can provide options and hedges against an unknown future and mitigate the consequences of surprise. Also, the potential of future deployment can influence possible adversaries behaviour. In effect, research and development cast a 'long shadow' forward, its influence felt long before any deployment. In addition there is a growing difference between what is technologically available and technologies actually embodied in deployed force structures. In any case, these effects should be of interest for future NATO planning and detailed quantitative analysis. The increased emphasis on strategies to deal with greater uncertainty of the future, the need for projecting military potential and the growing technology gap lead to concepts, which could be labelled as virtual deployment of forces and artificial experience. The virtual deployment can be perceived as capability within some

PERSPECTIVES ON RESEARCH, DEVELOPMENT AND PLANNING

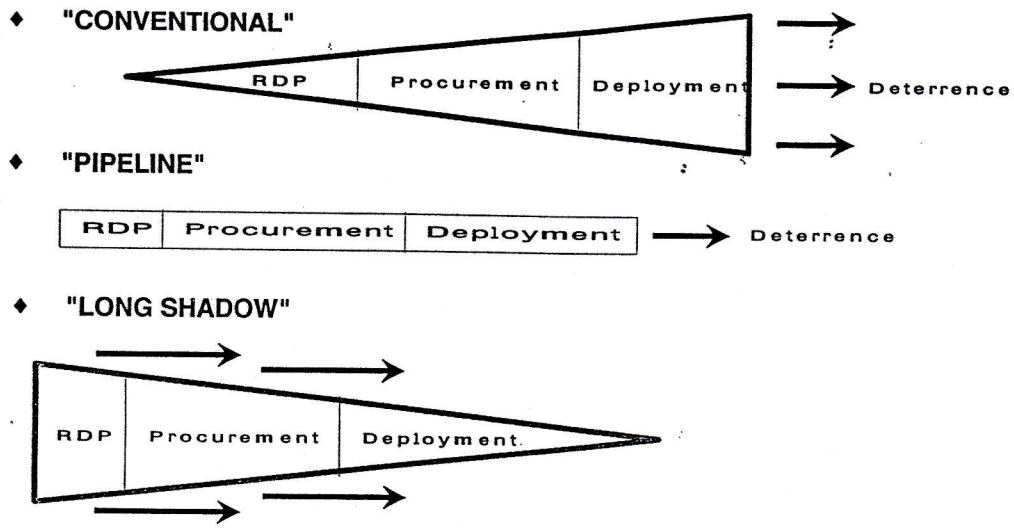
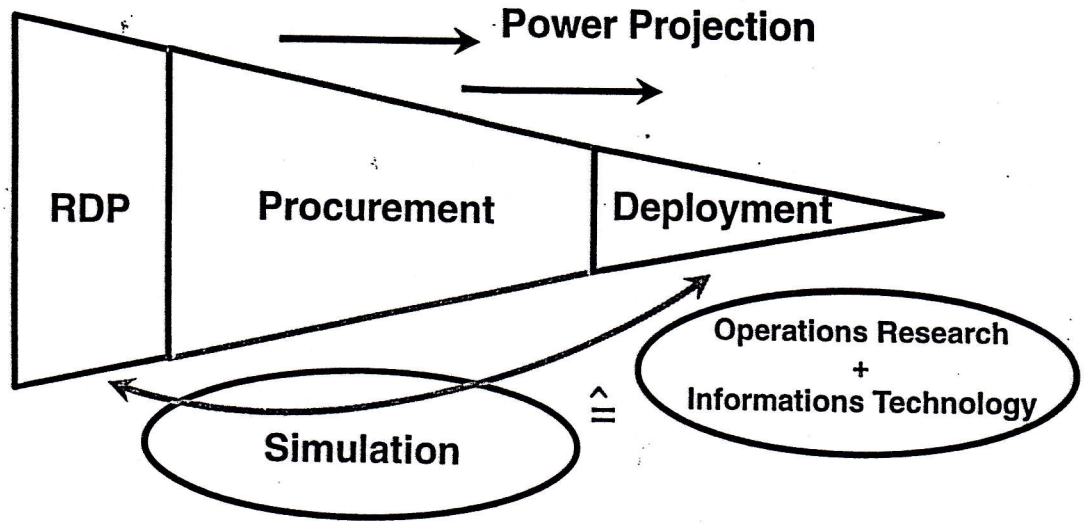


Figure 10

time before actual deployment. It includes various stages of development, demonstration, prototyping and limited production. In the future, military competitions may be characterized more by development and by maintenance of such un-deployed options, than by deployed systems. The virtual deployment in close relation to the growing gap between civil technology and deployed military technology will magnify an already existing trend, the reliance on and need for artificial experience. Increased environmental concerns, smaller budgets and resource constraints have already motivated great interest in simulation techniques and capabilities. (Fig. 11). The interactions of new technologies embedded in future forces and out of their counter- and counter-counter measures, will not be well understood. Virtual deployments cannot be actually tested on the field. High fidelity simulation and training techniques used not only for deployed systems but to assess the interplays of potential developments and virtual deployments, will increasingly become the tools of military planning and education. Since simulation is equivalent to operations research based on the information technology, operations research becomes an essential element and discipline in the context of this new research and development process.



- Virtual Realities
- Plan the Planning
- "Just in Time"
- New Acquisition Strategies

Figure 11

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[2] The Art of War, Sun Tzu (translated by T Cleary] Shamblala, Boston, 1988

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