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TECHNIQUES OF DEFENCE ANALYSIS

by

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TECHNIQUES OF DEFENCE ANALYSIS

I. LEVELS OF DEFENCE PROBLEMS FOR WHICH ANALYSIS MAY BE REQUIRED

CHART 1 ON

- operational, tactical, managerial, "low level"
  - e.g., What range is required for the next AS torpedo?
- procurement planning, "medium level"
  - e.g., Is a torpedo the right choice for the next AS weapon?

OFF

- strategic, policy, "high level"
  - e.g., Should Canada continue in the AS role?

II. FORECASTING

- most medium and high level problems deal with the medium and long-term future
  - need forecasts of the situation some months or years hence
- attempt to establish a science of "futurology"

CHART 2 ON

- two types of forecasting:

EXPLORATORY	- based on today's capabilities,
	- opportunity-oriented, "technology push"
NORMATIVE	- based on future goals, mission-oriented,
	- "requirements pull"

Techniques

consensus forecasting (polls, Delphi)

cross-impact analysis, input-output

time-series (cycles, precursors) indicators

regression, trend extrapolation

growth curves, envelopes, limits

models, global, macro-economic

- example of solar system: simple model highly successful - for forecasting positions of planets, eclipses, sunrise, moonrise, tides,... - misused for astrology

- Limits to Growth (Forrester/Meadows)
  (Mesarović/Pestel, Bariloche,....)

OFF

  Leontief
    - industrialization
    - food production — level of aggregation
    - resource depletion
    - population
    - pollution

CHART 3

ON

- expanding uncertainty, example of world population to year 2100, confidence intervals

OFF

- surprises and discontinuities

III. OPERATIONAL, TACTICAL, MANAGERIAL PROBLEMS

- tend to be well-defined, amenable to systematic quantitative (often rigorously mathematical) treatment
- necessary to identify suitable measures of effectiveness
- excluding "management analysis" (planning techniques like PPBS, PERT; MBO, performance evaluation, auditing,....)
  - also excluding standard techniques of production control (acceptance sampling, quality control,....)

CHART 4

ON

Techniques

models

simulation (deterministic, Monte Carlo)

(war) games, high level/low level
manual/computer
research/training
limitations

detection theory; visual, radar, sonar

theory of search and evasion

Lanchester theory

queuing theory, inventories

reliability and maintenance

scheduling, transportation, networks

.../3

mathematical programming, linear
quadratic
stochastic
dynamic
goal

mathematical optimization

theory of games

- two person, n-person
- 0-sum, non-0-sum
- discrete, continuous (Differential Games)
- perfect or incomplete information
- OFF Minimax principle - relationship to linear programming

<u>Examples</u>

AS screens

SAR patterns

CASTRO

initial provisioning and stocking policy for spare parts

vehicle replacement

computer-assisted posting of personnel

promotion quotas: results of present policies on future rank (force) structure

<u>Limitations</u>

suboptimization

overconcentration of the model (difficulties with operational data)

IV. SYSTEMS ANALYSIS

- problems often ill-structured and less clear-cut than for operational research
- usually much more difficult to find appropriate measures of effectiveness
  - often multiple objectives, which may be incompatible

- temptations to emphasize the aspects that are amenable to quantitative analysis
- often applied to problems of allocating resources
- conditions may be (1) known with certainty
  (2) uncertain, but with known probability distribution
  (3) uncertain with no assignable probability
- NOP estimates
- incremental vs total planning (short term/long term)

CHART 5 ON

Techniques

mathematical models
computer simulations, Monte Carlo replications
cost-benefit analysis (problems of costing: life cycle, discounting, sunk costs, attribution)
marginal analysis, tradeoffs, isoquants
utility
satisficing
weighting of objectives
presentation of options

Examples

LRPA
NFA
CPF
OFF FSS Future Ship Study

LRPA Program

The first simulation concerned the operation of an LRPA base to determine how many aircraft would be needed on squadron service to conduct a required flying program. The inputs to the simulation were:

- a detailed flying schedule (like an airline timetable) derived from a total flying program needed to accomplish all tasks assigned to the fleet (including operational flights, training flights, exercise participation, sovereignty surveillance, etc.)

- a detailed maintenance schedule (number of maintenance crews, shifts worked, coffee breaks, etc.)
- number of repair channels available
- probability that an aircraft is unserviceable on landing (expressed as a function of mean time between failures, MTBF)
- repair time distribution (expressed as a function of mean time to repair, MTTR)
- fixed delays such as post flight servicing and pre-flight checkout
- an assumed number of aircraft assigned to operations.

The output of the simulation was

- the probability that an aircraft would be available to fly a mission when required.

The simulation was re-run for different assumed numbers of aircraft assigned to operations in order to obtain a plot of the probability of aircraft availability vs number of aircraft. The decision maker chooses the level of probability that he is prepared to accept and the number of squadron aircraft is read off. This process was repeated for all bases to determine the total number of squadron aircraft required. The fleet size to support this number was then deduced. Fleet size calculations were done for each of the four contending aircraft in the LRPA competition. Two of the four contenders were eliminated at this point on the grounds of cost of acquiring the required fleet size.

The second simulation was developed to evaluate the effectiveness of the aircraft weapons system in submarine detection and tracking. The ratio of effectiveness to cost provided the basis for choosing the best aircraft.

NFA Program

A series of computer simulations were developed to evaluate the effectiveness of contending aircraft in multi-role operations. The main simulations were:

- FLIEM, a flight estimation model developed to permit the derivation of flight profiles for any aircraft, given its basic aerodynamic characteristics (lift and drag coefficients, thrust, weight, etc.)

- BIEM, a basic intercept evaluation model developed to compare the basic abilities of the aircraft to intercept bomber aircraft

- FISCHER, a simulation of N. American air defence developed by NORAD and modified to model the intercept problem in more detail

- Air Sovereignty, a model for examining the intercept capabilities required for the control of Canadian air space

- AIRGND, a model to compare aircraft effectiveness in the tactical role of support for land forces in Europe (air bombardment of enemy ground targets).

These were used along with a lot of other information to assess the capability of the various contending aircraft to fulfil roles

N. America - sovereignty, air defence

Europe - air/ground (close support, interdiction
air/sea

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CPF Program

Unlike the LRPA or NFA programs, the CPF program will involve ships that are designed and built in Canada. Further, both the number of ships and the amount of money in the program are pre-determined. The only room for manoeuvre in this program lies in the types of sensors, navigation aids, communications equipment, weapon systems, etc., which may be fitted to give the ship its fighting capability.

Eight different operations, in which the CPF could become involved, have been identified. From the analysis point of view, each operation requires separate treatment, which could result in eight simulations. To date, five of the eight simulations have been developed. These are:

- offensive operations against surface ships
- protective operations to defend convoys against submarine attack
- protective operations to defend convoys against air attack
- self defence against ASSM and aircraft attack
- self defence against torpedo attack.

The remaining three operations are of lesser priority and may not be analysed. They are:

- hunter-killer operations against submarines
- protection of geographical areas from submarine penetration
- protection of fixed offshore installations from submarine attack.

Future Ship Study

Advanced Destroyer

Slender Ship

Semi-Planning Ship

Planning Craft

SWATH ship
hydrofoil: foils fully submerged
foils surface piercing
Air Cushion Vehicle
Surface Effect Ship

Options

- multi-helo	DHH	5000-8000 tons	conventional or SWATH
- minimum GP	DDG	5000-8000	" "
- CPF type	FFH	3000-5000	" or slender lengthene
- air defence	FFG	3000-5000	conventional or slender length
AAW		2000-5000	SWATH
- fast-light frigate	FLF	1000-2000	slender planning
ASW ASuW		<1000	hydrofoil

Limitations
overconcentration on the model
sensitivity to assumptions, flexibility, off-design performance
search for robust solutions

V. STRATEGIC ANALYSIS

- The Ideal Problem: Who is the enemy?
  How strong are his forces? How are they equipped?
  How is he likely to attack us?

  Determine what forces we need
- the real Canadian problem
- interdisciplinary approach needed
- more subjective, less quantitative than SA or OR

CHART 6 ON

Techniques
scenarios (e.g., books on WW II; Close, Hackett, Bidwell)
historical analysis

gaming (incl. political)
forecasting, futures research
systems analysis

OFF

Examples

deterrence

LIGHTS ON

the strategic balance
arms control, verification, SALT, MBFR
implications of nuclear proliferation
the strategic significance of energy shortages
the strategic significance of demographic trends
the strategic significance of the Arctic
the strategic significance of new weapons technology
the importance of the North Atlantic sea lines of communication
North American air defence
the role of civil defence
international terrorism
circumstances for peacekeeping

Limitations

perceptions and values of decision makers
questioning the scenarios
disagreement over assumptions
adequate scope

SYSTEMS ANALYSIS

The basic technique of systems analysis is computer simulation. It was the advent of the digital computer which made systems analysis practicable, thus the history of systems analysis began with the computer. The history of OR began with WW II at RAF Fighter Command.

Computer simulation depends on the development of a model, or models, to describe a simplified representation of an operation. The model is usually in mathematical form where formulae are used to represent the various functions and actions which take place. Mathematics is used because this is the most precise way of manipulating the quantitative input data in order to obtain quantitative output describing the result of performing a given operation.

The simplification referred to is a relative term. All mathematical representations of operations are simplifications of what happens in the real world. The degree of simplification depends on the complexity of the operation to be simulated and is normally carried to the point of keeping the simulations manageable and useable. Because of the simplification, it is necessary to conduct experiments to ensure that reasonable agreement occurs between experimental results and model (or simulation) results. Any disagreement in such results requires that the model be changed until it produces results in reasonable agreement with experiment.

In military operations, the experiment is called war. We seldom have such results at hand with which to test our models for validity. In systems analysis, we are often concerned with evaluating concepts, where the hardware is not available, for one reason or another, to allow an experiment to be conducted. This difficulty of not being able to validate theoretical models as reasonable representations of real life means that we cannot place much faith in the absolute values of results predicted by the models. These values are nevertheless calculated in order to determine how they change when the input data are changed. Thus, we can only <u>compare</u> results for different systems, tactics, courses of action, etc.

In addition to the systems analysis in support of capital equipment replacement, simulation has been used as an operational research technique to assist in the planning of an operation. A typical example is the Canadian Air/Sea Simulation of Strategic Transport Operations (CASSTRO) which was developed several years ago and is still in use as an aid in planning the deployment overseas of a force by combined air and sealift.

All the foregoing simulations have been developed for computer analysis. They are all essentially equipment-intensive operations.

Yet another type of simulation is the war game which represents the land battle. Land operations are usually manpower intensive and subject to frequent human intervention to control the course of the battle. In addition, when a war game is played in the detail required to assess the effectiveness of individual weapon types, the technique does not lend itself to large scale computerization. Our war game is essentially a manual simulation, assisted by computer assessments of the outcome of specific engagements which take place during the course of game play.

Systems analysis based on computer simulation is a very powerful technique. The modern computer allows one to simulate almost any military operation one could think of and evaluate it in a few seconds or minutes. The simulation can be repeated either exactly or with parametric changes to discover the advantages of doing things differently. This can be done quickly and much more cheaply than the real life

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operation, and it can be done without risking life or limb. Especially with regard to major capital replacement programs, where we are now getting used to talking about one or two billion dollar programs, this type of analysis serves to give much greater confidence that the money will be spent wisely (at least this is true in theory).

One of the chief limitations is the fact that, in spite of much effort expended on developing the analysis technique; the method cannot be used with confidence to predict the absolute result of an operation. This is because we don't know, and there is no way of finding out, how close the mathematical representation is to real life. The implicit assumption is usually made that man will perform exactly as he should in his interface with the machine. He is no doubt trained to do this and probably will perform as he should in trials and exercises. But man may not do this when in a real operational environment, especially if there are bullets flying.

STRATEGIC ANALYSIS

SCENARIOS

HISTORICAL ANALYSIS

GAMING

FORECASTING   FUTURES RESEARCH

SYSTEMS ANALYSIS

SYSTEMS ANALYSIS

MATHEMATICAL MODELS

COMPUTER SIMULATION

COST-BENEFIT ANALYSIS

MARGINAL ANALYSIS   TRADEOFFS

UTILITY

SATISFICING

WEIGHTING OF OBJECTIVES

OPTIONS

FORECASTING

DELPHI

CROSS IMPACT

TIME SERIES

TREND EXTRAPOLATION

GROWTH CURVES   ENVELOPES

(GLOBAL) MODELS

EXPLORATORY   "TECHNOLOGY PUSH"

NORMATIVE   "REQUIREMENTS PULL"

OPERATIONAL, TACTICAL, MANAGERIAL

MODELS

SIMULATION

(WAR) GAMES

DETECTION THEORY

THEORY OF SEARCH & EVASION

LANCHESTER THEORY

QUEUEING THEORY

RELIABILITY & MAINTENANCE

SCHEDULING, TRANSPORTATION

MATHEMATICAL PROGRAMMING

THEORY OF GAMES

LEVELS OF DEFENCE PROBLEMS

OPERATIONAL, TACTICAL, MANAGERIAL

"LOW LEVEL"

PROCUREMENT PLANNING

"MEDIUM LEVEL"

STRATEGIC, POLICY

"HIGH LEVEL"

ESTIMATE OF WORLD POPULATION

2000-2100