Developments in Air Targeting: The Military Resources Model

Robert W. Leavitt

The basic objective for air targeting is to present measurements of the ability of the enemy to take actions which threaten our national security. These measurements must be presented in such a way as to guide our action against the enemy's strengths. This objective is usually broken down into subobjectives which illustrate clearly its breadth and complexity. Expressed in terms of courses of enemy action which are unacceptable to the US, these subobjectives are, in descending order of importance:

1. To deliver atomic weapons against the US, our forces abroad, and our allies.
2. To resist the penetration of his airspace by our air forces.
3. To develop and produce potentially decisive weapons or weapons systems.
4. To conduct large-scale land and naval operations against our forces and our allies.
5. To develop and maintain the economic, political, and psychological strengths necessary to support prolonged military operations.

With the development of new weapons and weapons systems, however, and the resultant capability of a single aircraft or missile to deliver the equivalent of millions of tons of TNT on one mission, the analysis and presentation of the strengths supporting the first three subobjectives have assumed ever increasing importance and urgency. This compression of firepower in time brings the realization that the decision in future wars may be reached in a matter of hours or days at most. Old problems have been accentuated and many new ones created by these developments. For example, selection of target systems to achieve the subobjectives time-phased in the order shown above is no longer sufficient. Analysis must produce not only a priority of targets within each subobjective and target system, but also an indication of how many of them must be attacked to achieve the objective. Thus analysis by increments in time and space is becoming an essential element in the targeting process.

The complexity of these problems and the speed with which they must be solved have led to the introduction of new statistical methods and of new machine computing techniques into the targeting analysis process. For example, immediate assessment of the damage and contamination effect of a given attack will be necessary in order to determine the destruction required of succeeding attacks. This involves a continuing evaluation of target priorities and of net offensive strengths throughout an air offensive until a decision is reached. Twosided war-gaming offers the best possibility for providing the answers needed for this and similar problems. Because of the time element and the great volume of data required by the new statistical techniques, high-speed electronic computing is essential. By this process hypothetical but highly probable military situations in both peace and war can be examined and tested for the types of detailed targeting information needed by the analyst to guide and evaluate target selections. Only in this way can the total targeting effort truly be said to present measurements of the enemy's strengths in such a way as to facilitate action against them.

During the last several years it has become increasingly apparent that mathematical "Monte Carlo" and "input-output" type models offer a new and promising technique for "war-gaming" and for analyzing a nation's economic and military resources for targeting purposes. The rapid advances in the speed and data handling capacity of modem electronic computers have now made these models feasible for application to many air targets problems.

The purpose of the mathematical models is the selection of targets for optimum forestalling of enemy courses of action. This requires the models to answer the following questions in order.

1. *Present situation*

    a. What is the size and composition of the enemy military establishment (military resources)?

    b. What is the size, composition, and productive ability of the enemy economy (economic resources)?

    c. What levels of military action will these resources support?

2. *Mobilization capability*

    a. What would be the size and composition of enemy military resources and economic resources after an all-out mobilization period of x months?

    b. What levels of military action would these resources support?

3. *Evaluation of damage*

    a. For any specified bombing attack what would be the yield and location of all exploding weapons?

    b. Given these explosions what would be the size and composition of the post attack military and economic resources (including population)?

c. Given the post attack resources what level of enemy military action could be maintained?

4. *Recuperation*

What would be the size and composition of enemy military and economic resources y months (or days) after the specified attack, taking into account repair, rebuilding, conversion of other facilities, and new construction?

For "war-gaming," that is, estimating net offensive capabilities, the above questions must be asked about our own country as well as about the enemy country.

The system of mathematical models which would answer these questions is shown schematically in Figure 1.

The air battle, the damage, and the contamination models would answer questions 3a and b above. Discussions of these models are planned in subsequent issues. The remaining questions concerning the present, post mobilization, post attack, and post recuperation capabilities of the military and the economy are the province of the military resources model, which includes economic resources.

Procedurally, the military resources models determine the number and size of missions, both offensive and defensive of various types, which each country can carry out in a given span of time. This information is fed to the air battle model which together with the damage and contamination models determines the military, economic, and population resources remaining in each country after a period of air battle. The damage information is in turn fed back to the military resources model which determines the number, type, and size of missions which each country can carry out *after the first phase of air battle*. The process is then repeated for later phases of the air battle.

If the models can, as is believed possible, answer the questions posed we have an exceedingly powerful tool not only for target selection, but also for estimating the capability of a country to carry out military action now and in the future under various conditions and assumptions. The testing of alternative target systems in the first and succeeding phases can lead to the choice of the optimum target system for any of several different strategic situations.

When then, is the military resources model and how is it designed to answer the questions put to it?

The military resources model is an input-output model. This is a kind of mathematical model about which it has been said, it is much easier to understand what it is expected to do than how it does it. What the military resources model is expected to do is to estimate the capabilities of a military establishment and its supporting economy to carry out military action. The essential problem of making this estimate is that everything must be considered simultaneously.

It is not enough to know that the capacity of the aeroengine industry is so many engines per month. One must also know whether there is enough steel (or electric power, copper, petroleum, ball bearings, and so on) to produce these engines while at the same time the tank, gun, shipbuilding, ammunition, and many other key industries (including reconstruction in a post attack period) are also requiring steel. Furthermore, not only the direct demand for steel must be considered. The aeroengine industry consumes not only steel but also aluminum, electric power, transportation, and many other inputs, the production of which also requires some steel. In short, to know the capabilities of one industry we must account for requirements of all industries for a vast range of raw materials, labor, capital equipment, components, goods in process, transportation, and communications. Input-output models are a technique for doing just this. An input-output model shows for each industry (or military activity) the requirements for supdies from each other industry.[1]

The military resources model consists of three sub-models or grids; the military grid, the economic grid, and the transportation grid. The economic grid is in turn broken down into geographical regions which are related to each other by the transportation grid. The military resources model can be illustrated schematically.

Each of these grids consists of an inventory of resources and a table of coefficients in the form of inputs required per unit of output. For the economic grid the inventory of resources is the capacities of all producing industries. The table of coefficients shows material, labor, and capital inputs per unit of industrial output; for example, kilowatt hours of electricity per ton of aluminum and tons of aluminum per heavy bomber aircraft. The military grid shows labor, equipment, and supplies required per unit of military activity; for example, tons of fuel per flying hour, number of aircraft per wing, tons of ammunition (by type) per division month, and so on. Its inventory of resources is the number of military units of each kind and their associated equipment. The transportation grid has as its output units of transportation capacity on a regional basis. This grid acts as a restraint on both the economic grid and the military grid as transportation can be a bottleneck or restraint both in the economy and within the military structure itself.

Without knowing the full complexity of the statistical and computational procedures (which is awe-inspiring) the reader can now visualize the operation of these grids in answering our initial questions. The military grid shows for a given set of military forces the level of combat actions that could be maintained if the economy provides all the supplies the military requires. The coefficients of the military grid determine the requirements of the given level of combat actions from the economy. The economic and transportation grids determine how much of these supplies can be forthcoming from the existing inventory of economic resources.

At the present time the economic grid of the Soviet Bloc has been largely completed. It has been constructed in two parts - one covering the USSR and European Satellites and the other the Peoples Republic of China. For the European Bloc the grid distinguishes 240 producing industries or sectors and their materials, components, capital equipment, and labor inputs. Five test runs have been made and evaluated.[2] On the basis of the evaluation of these test runs, application of this grid to certain types of live air targets problems is now being undertaken. However, a substantial data improvement research program is going concurrently.

The military grid has been under development for about nine months. It is expected that test runs of this grid will be made in the summer of 1958.

The transportation grid has been under development for about six months, and it is expected that test runs of this grid will be made in the summer of 1958. The construction of this grid is being undertaken on two fronts. The first involves the geographic disaggregation of the economic grids in terms of local regions. The second consists of the development of a transportation grid based on these regions. To date, 159 regions covering the USSR have been designated, outlined, and coded. The transportation net has been divided according to these regions and the terminals and links within each region coded and catalogued. The 159 regions correspond to Soviet oblasts wherever possible in order to take advantage of the data on production and transportation published by the Russians. The effort to gather Soviet source information for the grid is linked to a concerted effort to gather applicable data, both classified and unclassified, from all other available sources.

The enormous complexity of the computations involved in model analysis makes hand calculation completely unthinkable. In the economic grid for the European Soviet Bloc, for example, there are per unit of output of each of the 240 sectors the commodity input requirements from each of the other 239 sectors. This will be further broken down into 159 geographical regions. Thus the number of coefficients to be simultaneously processed theoretically could be of the order of 240 x 240 x 159, or about 9 million.[3] For any major problem millions of individual arithmetic steps may be involved. Modern electronic computers, however, can perform this job. The revolutionary aspect of these computers is the speed with which they can file, sort, recall, and manipulate large masses of data. These partially routine steps in arriving at intelligence estimates on large areas, such as the Soviet Bloc, have always been time-consuming and cumbersome. For the more difficult analytical problems, electronic computers together with mathematical models provide the analyst with a tool for considering and holding in juxtaposition a great many more of the elements of the analysis than formerly was possible. This technique does not, by any means, eliminate the human judgment factor. Rather it is believed that it will prove to be a powerful tool in assisting intelligence analysts and planners to make better judgments, and to be able to make them more rapidly.

Some of the more specific applications of the military resources model to air targets problems are presented below.

1. *Enemy Capabilities*

The military resources model can be used to assess the capability of the economy of the Soviet Bloc to mount and sustain elements of military strength during a pre-attack period under varying Bloc objectives, policies, and assumptions. The government is constrained to work its available resources and within technological relationships. If it wants a jet medium bomber regiment it must provide planes, bombs, crews, airbases from which to operate, and so on, in specific quantities. If a ton of steel is needed the government must see that steel mill capacity, pig iron, scrap, coal, labor, and so on, are available in the correct amounts. If more steel capacity is needed it must provide the steel, concrete, machinery, and so on, in the right quantities and types to construct a new steel mill. These resource restraints and technological relationships are set out comprehensively and in detail by the military resources model. The ability of the economy to support the mobilization of desired combinations or "mixes" of air, land, and sea forces can be measured. A typical problem would be a determination of the maximum "balanced" air, land, and sea forces which could be activated in a specified mobilization period with specified stockpiling and capital expansion policies. In addition to measuring the maximum activation of combat units, the economic grid can be used to determine under a variety of Bloc policies and objectives the maximum capability to produce specific weapons such as guided missiles and H-bombs at specified times.

However, the economic-industrial grid does not take into account any restraints or bottlenecks that might develop within the military structure itself. Therefore, the outputs of the economic grid are fed into the military grid as inputs. The military grid is then used to assess the capability of the Soviet Bloc military structure to mount and sustain, during a pre-attack period, elements of military strength fully prepared to engage in combat activities required by given strategies. The ability of the military structure to support desired combinations or "mixes" of air, land, and sea combat activities can be measured under varying Bloc mobilization objectives, policies, and assumptions. In addition to measuring the maximum combat capabilities that can be sustained, the military model can be used to determine the capability of the military structure to put into operation specific weapons, such as guided missiles, within the available military resources, that is, trained personnel, missile sites, logistics, and repair facilities.

The transportation grid would then be used to establish any transportation restraints or bottlenecks which might develop within the economy or military structure itself.

2. *Effects Analysis*

Following their use in pre-attack situations, the three grids of the military resources model can be used to determine the capability of the Bloc economy, military structure, and transportation system to re-mount various types of military strength in the post-attack period after air attacks of different scope and intensity. The analysis can be applied to various time periods after the air attack. In very short periods of time only the military, or possibly the military and transportation grids might come into play, as the answers needed would be the availabilities within the immediate military structure of the Soviet Bloc to re-cycle air attacks and to sustain ground and naval action. These answers would be in terms of availabilities of aircraft, runways, fuel, men, and ammunition to produce flying hours, and the needed inputs to produce ground division months and units of naval action. The longer the time period involved the more industrial and economic resources must be analyzed and brought into play as supporting military resources. In the analyses of recuperation periods of over a few months the economic-industrial grid is heavily drawn upon. However, the model as a whole is designed to cope with immediate post-attack military assessment, as well as long range economic and industrial recuperation assessment.

3. *Selection of Air Targets*

One of the outstanding advances of the model-computer technique is the possibility of rapidly testing a great variety of simulated air targets problems, using various assumptions, and considering air attacks of varying magnitude and scope. Optimum air target systems can be developed for a variety of circumstances as a result of repeated running of both pre-attack capabilities problems and post-attack air target effects problems (a. and b. above). The resources such as airfields, missile sites, storage, supply, repair facilities, and industrial and transportation installations which prove to be limiting factors or bottlenecks in pre-attack mobilization problems and in the re-mounting of combat activities in the post-attack period become the air targets. The same techniques applied in simulated problems would, of course, be applied to actual hot war problems.

4. *Feasibility Testing*

The necessity for balancing the internal flows within the matrix of an input-output model make this type of model particularly suitable for testing the internal consistency of either announced Soviet Bloc plans or of US intelligence estimates of Soviet Bloc military or economic growth patterns. For example, the internal consistency of either Soviet Bloc plans to mount military strength or US intelligence estimates of Soviet Bloc military growth plans can be tested. Estimates independently projected for various types of air combat strength can be tested one against the other in order to determine whether or not the total projected strength estimate is internally consistent and whether or not such total strength can be supported by the Soviet Bloc military structure. The economic grid can be used to check production estimates independently arrived at for various military end products to determine whether or not the production pattern so established is economically feasible. The transportation grid should be of great help in checking estimates of Soviet Bloc transportation patterns and capability.

5. *Mobilization Indicators*

The military resources model can be used to establish indicators of mobilization build-up. By testing the model under various assumed mobilization conditions certain economic changes as well as changes within the military structure can be identified as indicators of partial or complete mobilization. Specific changes in the use of resources can be identified as indicating specific types of mobilization.

6. *Intelligence Collection Indicators*

In using the military resources model to solve a series of simulated air targets problems, certain areas of economic and military activity will be shown to be of critical significance to the capability of the Soviet Bloc to mount and maintain military strength. These critical sectors are those on which it is most important to obtain accurate, current data for targeting purposes. Thus the priority list of air targets intelligence requirements can be sharpened, and emphasis can be placed on the collection of certain key military and economic data.

7. *Inputs for Operational Models*

The military resources model is to be used to translate any given overall military strategy into requirements upon the economic-industrial, transportation, and military structure for the creation of military formations and military resource elements together with the necessary military supporting activities in both pre- and post-attack situations. Operational models such as the air battle model, currently being tested, serve to indicate these requirements in a realistic manner. The military resources model is designed to provide appropriate inputs for these operational models in the form of units of combat capability and to reflect the output of operational models in changing requirements upon the military structure. Thus the military resources model can define the maximum levels of combat activity possible within the limitations of the Bloc military and economic structure at any specified time.

8. *Data Requirements*

The validity of problem solutions provided by the military resources model is dependent upon the accuracy of the data inputs as well as the logic of the mathematical design of the model. Each of the component parts of the model - the economic grid, the military grid, and the transportation grid - has its own data requirements which must be initially assembled and subsequently kept up to date.

The economic grid contains a classification of economic activity in the Soviet Bloc in the form of three submatrices or grids; the commodity input grid, the capital input grid, and the capital expansion grid. The data requirements of the commodity input grid or matrix consist of the commodity inputs per unit of production for each of the 240 sectors of the matrix. These sectors cover most of the commodities produced in the Bloc. The data requirements of the capital input matrix consist of the inputs of capital equipment and labor per unit of production of each of these same commodities. The data required by the capital expansion matrix consist of the commodity and capital inputs necessary to increase available capital by one unit. The data described above are in the form of technological coefficients which reflect the technological relationships currently operating as the economic restraints in any desired mobilization or recuperation by the Soviet Bloc. In order to reflect fully the flexibility of the Soviet Bloc economy in meeting mobilization or wartime requirements the data inputs must reflect not only production processes currently in use but also the alternative processes which could be used to break bottlenecks, or stoppages resulting from air attack. Thus the economic grid requires the introduction of all practical alternate input coefficients in order to establish realistic technological restraints. Because production technology changes with the passage of time, these coefficients must be continually scrutinized to insure that they reflect current technology. In addition, changes are necessitated in the classification of commodities and capital equipment in the light of experience gained in using the model for various types of problems. Those economic sectors which prove to be the most sensitive to mobilization or recuperation demands may require a more detailed or disaggregated classification in the model, whereas less vital sectors may be further aggregated.

The running of a simulation on the economic model requires, in addition to the technological coefficients, data on the economic resources available to the Soviet Bloc for the time period being considered. Thus for each of the 240 commodity groups in the grid, current data on Bloc capacity, inventory, and foreign trade must be assembled.

The data requirements of the military grid of the model parallel those of the economic grid, but pertain to military activities rather than economic activities. As previously mentioned, the output of the military grid, equivalent to commodity outputs in the economic grid, is in units of frontline activity, for example, flying hours of a specific type of bomber. For each such military activity data on inputs of other military activities as well as inputs of industrial commodities must be determined. In addition, for each unit of military activity the requirements of military capital aggregated in the form of "resource elements" such as airstrips, naval bases, and repair facilities must be determined together with the inputs necessary to expand a military "resource element" by one unit. As in the case of the economic grid, input data for alternative processes of producing a unit of military activity must be assembled and all coefficients in the grid must be kept in accord with the most modern logistical processes used by the Soviet Bloc. In the running of simulations on the military grid, data on total Soviet Bloc capacity, inventories, and possible increments from foreign trade for each of the military activities in the grid should be available for the time period under consideration.

The introduction of transportation factors into the military sources model requires an analysis of the Soviet Bloc economic and military commodity flow structure in terms of geographic regions, thus greatly increasing the data needs. For each region the types and amounts of transportation facilities available must be determined in order to establish the freight handling capabilities of each region. For example, the analysis the USSR railroad system, currently underway, requires for each terminal, link, and region estimates of the terminal motive power and freight-car handling capacities, rail-link capacities, and regional car-day requirements. In addition to these transportation data requirements, the Soviet Bloc production and consumption pattern must be established by geographic region. This task requires the identification of the types and amounts economic and military capital facilities, or "resource elements," available in each region. In addition, the Soviet Bloc bill of goods," or final demand for military and civilian goods, must be determined by geographic region. The regional consumption of goods for military, government, and civilian use as well as the regional consumption of construction materials and producer durables must be estimated. Only when all these data are introduced into the military resources model can the transportation restraints, or "bottlenecks" under specified mobilization and recuperation conditions be identified.

The data problem is formidable, but considerable progress as been made, and new sources of data are being found and exploited. The data requirements for the model-machine technique do not represent a marked change from the requirements of traditional methods of analysis. However, the rigorous analysis made possible by this technique or method simply makes existing data deficiencies more apparent. Moreover, its technique has the additional advantage of enabling the analyst to identify those specific data requirements which are the most crucial in target analysis by subjecting the data to various types of sensitivity testing, e.g., the variation of coefficients, and data aggregations. The model also offers a means of testing the reliability of coefficients in the light of known output patterns of past years. It is believed that these various testing techniques will contribute to a sharpening of the priority list of intelligence collection requirements.

---

1 See Studies in Intelligence, Vol. 1, No. 4, "The Role of Interindustry Studies in Economic Intelligence," Robert Loring Allen, p. 97.

2 Distribution of these runs has been made throughout the intelligence community. A few copies are still available for interested readers.

3 The number is actually smaller since many of the coefficients are zero. Only a machine, however, could remember which ones are zero.

Posted: May 08, 2007 06:58 AM