TACWAR # 61
2 May 72

INTERFACES BETWEEN MILITARY FUNCTIONS

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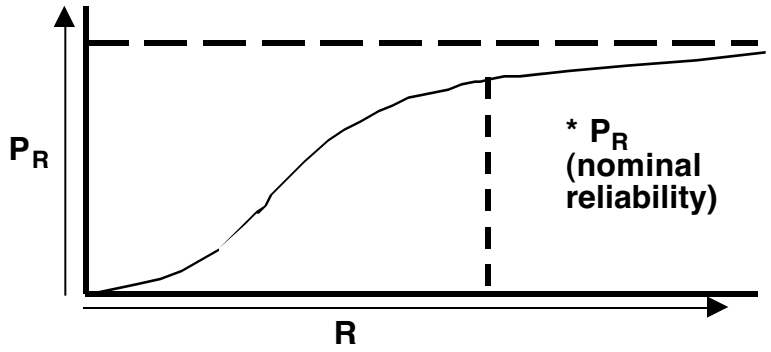
1. The nine military functions defined for battle analysis are Command (D), Intelligence (I), Fire (F), Maneuver (M), Supply (S), Maintenance (R), Transportation (T), Construction (E), and Signal (X). We have previously made the statement that performance of these functions by an element or unit results in change of functional potential of some other element or unit. This paper describes the interfaces between functional elements in terms of interface variables. The interface variable is an output of modeling of performance of any single function which can serve as an input for the potential of some other function.

2. FIRE -- the interface variable for Fire performance is a probability of "kill". "Kill" is to be interpreted as a partial or total degradation of the functional capability K of the target element. if the element has more than one function, the kill may be specialized, e.g., a "mobility" kill or a "fire" kill. It is possible to define more than one level of kill within any given function. In addition, it may be useful in analyses involving the



Maintenance function to specify the repair effort in man-days required to restore a damaged element to some nominal (probably original) state of reliability. Thus the complete interface variable for the Fire function potential is expressed as:

$$\pi_{F,B_i} = \left\{ ....., \left(p_{R_j}, K_{\ell_j R_j}, R_{D,R_j} \right), ... \right\}$$

In describing actual performance, the triplets in the set are mutually exclusive. K specifies a defined level and type of capability of R_j, and R specifies the repair effort required to restore original reliability ($R = \infty$ for an irreparable element). This formulation permits study of target damage to any desired depth; simplifications by means of approximation will be required for analysis of any significant breadth.

Fire potential, π_F, may have a suppressive effect on the performance of any enemy element. This, however, is reflected in the Command function of the opponent, where a decision based on the assigned objective function may reveal it to be unprofitable for the element to perform a function (or move) in the face of a certain risk Φ imposed by Blue π_F. If human factors are ignored, the decision is rational; if the human factor of Motivation is considered (by change of objective function inputs), the suppressive effect will probably be greater.

"Suppressive fire" is primarily an intentional input to enemy Intelligence, which relays it to enemy Command. The information imparted is that Blue has a certain current destructive capability which should be considered in the selection of Red courses of action.

"Suppressive fire" may have some destructive effect, expressed as above for π_{F,B_i}, and destructive fire reveals further capability. If both aspects of fire are considered at all times, there is not much need to distinguish between "suppressive" and "destructive " fire as long as it is recognized that a sizable fraction of the available fire is usually used for suppressive effect.

3. MANEUVER -- Movement is a process; maneuver is an adversary function based on <u>position</u> and <u>movement</u>. All mobile elements have a capability for movement K_M, modified by current state and environment to a π_M. K_M is merely an average speed of movement under standard conditions with unlimited fuel. π_M is a set $\{\ldots\ldots\ldots\ldots, t_{M,\Delta_\ell}, \ldots\ldots\ldots\}$ of times required for movement from current position to alternative positions. The interface variable for movement is t_M.

The designation "maneuver" is reserved for a type of movement which alters the terrain distribution of friendly π_F and π_I. Maneuver, at this point in the analysis , is not studied separately, but only in terms of its contribution to the combat function (see Paragraph 4).

It is recognized that maneuver may be affected by two somewhat different considerations, "strategic", which seek favorable positioning with respect to final or intermediate terrain objectives derived from war aims, and "tactical" which seek favorable position with respect to enemy elements.

These considerations are reflected in the values Q_S, Q_I, and Q_T introduced into the objective function (Paragraph 4).

Transportation (Paragraph 6) may of course temporarily increase π_M.

4. COMBAT is a composite function which expresses the combined effect on the battle of all of the nine above-listed functions. Combat potential (K_C) is measured by objective function expectation expressed in man-days. The type objective function for Blue is $\sum_{\ell} Q^B_{\Delta_\ell} \Delta t_\ell + \sum_j p_{R_j} V^B_{R_j} - \sum_i p_{B_i} V^B_{B_i}$. Three of the variables involved are probabilistic -- p_{R_j}, p_{B_i} and Δt_ℓ -- the latter being probable duration of functional time on the objective for some combat element or unit (type may be specified in orders). Combat potential is released as combat performance P_C by orders from Command elements; we express the interrelated timing of these orders by $\tau_{C,B}$ and $\tau_{C,R}$ which can be expressed in terms of progress of the line of contact. It is not yet clear that these concepts are necessary; the τ's applying to individual functions may be adequate..

Combat performance determines success in application of a strategy designed to attain military objectives. The soundness of the strategy also has an effect on military success, and military success does not achieve war aims unless military objectives have been correctly defined (in some cases there may be no military objectives which will actually achieve the national war aims). The questions of soundness of strategy and interrelation of strategy with war aims cannot at present be examined quantitatively; therefore, we assume the inputs Q, V_B, and V_R, as being based on sound strategy -- objective function value realized will contribute directly to a successful resolution of conflict.

The above-stated general objective function is designed to accommodate the effects of Fire and Maneuver elements or units; it is not yet known whether additional terms must be incorporated for other functions.

5. SUPPLY -- For analysis purposes we desire to generalize and simplify the concept of Supply as much as possible, in doing so we depart somewhat from accepted military terminology. Traditionally, Supply deals with expendable and non-expendable materiel items, and not with personnel which are handled by the "Replacement" system.

In our analysis we speak of Elements, Components and Consumables. Elements are indivisible functional entities; they normally include people although some, such as an unmanned signal relay equipment, may not. Components are the constituent non-expendable pieces of an Element (including people). Consumables are those materials such as ammunition, fuel, construction supplies, expended by Elements in the performance of their functions.

To create new Elements is the function of Procurement; this function is preponderantly performed in the Z.I. If necessary to model its in-theater performance, we view Supply as delivering (probably through Transportation) components to some Procurement element, which then generates new elements.

To restore damaged or non-functional elements is the Repair sub-function of Maintenance. Again Supply merely furnishes components. Thus Supply does not handle Elements, and Components may be regarded as Consumables furnished to either Procurement or Maintenance elements for the performance of their function.

The interface variable from Supply to all other functional elements is a quantity of supply (S_m), where the m is some stock number listing identifying the type of consumable. (For some types of analysis we may elect to use a flow (ds/dt) of supplies rather than discrete deliveries.) Each delivery reduces the supply potential of the delivering element and enhances the functional potential of the receiving element. In the case of Transportation, a distinction must be made between the provision of consumable (fuel) for Transportation, and Transportation furnished for the delivery of Supply. In the latter case, the Transportation is regarded as temporarily converted to a mobile Supply element.

6. TRANSPORTATION -- Transportation elements "lift" elements, components or consumables point-to-point; they are also used to increase the movement potential (by substituting their own π_M) of other elements.

Some transportation components -- rail cars, trailers, gliders -- have no self-contained motive power. These are not considered as transportation elements until a prime mover is added. Transportation elements are characterized by capacity, maximum load dimensions, daily range, and effect on functional capability of cargo (usually $K = 0$ while transportation is going on).

The interface variable for transportation "lift" of materiel is ton-miles per day, subject to the above restrictions on loading and range. K_T is modified to π_T by loading and unloading times and return trips unloaded. π_T is further modified to P_T by Traffic Control; a limited network of routes or faulty scheduling may involve considerable lost time for transportation.

When transportation elements are used to enhance mobility of tactical elements, there is no interface variable as such. The transportation element is viewed as merging temporarily with the transported element and imparting to it its own π_M, together with any limitations on function of the transported element.

7. MAINTENANCE -- The performance of maintenance on any element is viewed as increasing the functional reliability of that element. Reliability is expressed by a curve asymptotic to 1 and probably of a shape similar to that shown in the figure. Reliability may decay with time or be reduced by enemy fire; in both cases the current reliability point on the curve moves left. It may be moved back to the right by some investment of man-days.

All elements and components other than humans are viewed as always reparable given the proper skilled maintenance labor and either the proper components or the necessary tools and raw materials for their fabrication. Whether an element is repaired or replaced is a question of the cooperative effect involved in the two different operations, including that of evacuation of the damaged element to a qualified maintenance facility. The situational value of a functioning element may also affect the decision. Field repairs, even at greater manpower investment, may put the damaged element back in action sooner, and the situational value gained may outweigh the extra manpower investment.

Medical service is viewed as maintenance of personnel, with the difference that some are irreparable. The interface variable for the maintenance function is effective man-days.

The type of maintenance man-days required for different elements, and for different components of the same element, may be specified for any detailed consideration of maintenance operations. For the element to be maintained, $P_R(R)$ is stated for some defined, reasonably high-order skills, facilities, equipment and repair parts. Maintenance operations done under more adverse conditions impose a series of multipliers on K_R which convert it to π_R.

8. CONSTRUCTION -- The symbol construction (E) represents the military Engineers, but not all traditional engineer roles are incorporated in the definition of construction. For example, mining is considered as a Fire function and water purification as a Supply function.

Construction includes all activities which modify the terrain in regard to Routes, Obstacles, Cover, Concealment, and Environmental Protection. "Routes" include the provision of terminals for air and sea routes and the installation of pipe-lines. Demolition of bridges, tunnels, and dams, as well as actual construction, create obstacles. Provision of Cover ranges from fox-hole digging to elaborate protective shelters. Man-made concealment is camouflage. Environmental protection includes all buildings, hard-stands, etc.

These activities can include a great variety of construction elements, ranging from a single soldier with an entrenching tool to large and specialized construction machinery, with operator.

As with Maintenance the interface variable is effective man-days of some specified one of the above five types of construction. Route construction improves trafficability between features, Obstacles construction adds to delay time for enemy movement, Cover in effect reduces vulnerable area of friendly elements, Camouflage reduces signature, and Environmental Protection reduces the rate of decay of reliability. Each of these results are expressed as a function of input construction man-days. Again as with maintenance, K_E is set for some specified high standard of skill, equipment and construction supplies; deficiencies from this standard change K_E to π_E.

9. SIGNAL -- Signal is concerned with the point-to-point transfer of information, but <u>not</u> with the generation or translation of information. The latter processes, labeled "communication", are considered within the Command function and its staff sub-functions including Intelligence (Paragraph 11).

Signal elements are transmitters, receivers, or most commonly transmitter-receivers. They are characterized by number of channels, range, bit rate, and error rate. Every command element has a signal capability (voice or computer readout); in many cases this is reinforced by signal equipment, which substitutes its signal performance characteristics for those of the command element. Dependent on the analysis, the signal equipment may be included in the definition of a command element, or may be treated as a separate element typically collocated with a command element but sometimes transferred to another. In addition, signal elements may be internetted to provide a "lift"

of information between points; this "lift" being available to any authorized customer. This is typified by the grid network of signal facilities planned for the field army.

Signal actually increases command potential by increasing the range, and possibly the speed, at which items of information can be communicated between command elements. The interface variable for signal potential is a set $\left\{\ldots\ldots, v_{X,\Delta_i-\Delta_j}, e_{X,\Delta_i-\Delta_j}, \ldots\ldots\right\}$ expressing the bit rate and error rate between any two points. Signal "lift" is somewhat analogous to transportation "lift", with the vital difference that the information is broadcast rather than delivered to a specific point, and can be picked up by any suitable receiver (cipher may be used, of course). Signal thus may increase the information content of the files of any command element within range (including enemy), with a Δt_X delay time and a possible reduction of credibility due to signal error.

10. COMMAND -- Any element containing a human being or a computer "intelligence" is regarded as having a command capability K_D. Each human being is regarded as making decisions concerning at least his own actions. Dependent on his own motivation, expressed by his degree of acceptance of the values assigned to objective function variables by higher echelons, he carries out orders more or less as given. Skill in planning and estimation also affects the performance of all command elements. If a command element fails to visualize the course of action actually adopted by the opponent (faulty planning), the result can be deadly.

Although the results of faulty motivation and inadequate command skill can be reflected in analysis of the command function, we have insufficient information on gradations of skill and motivation, on their interrelation, and on group phenomena such as morale to make it profitable to model these "human factors" at this time. Therefore, we assume perfect skill and motivation for all command elements.

This assumption makes the performance of command elements dependent on file content and speed of manipulation. The interface variable between command and all other functions (including other command) is measured in rate of flow of items of directive information. An item of directive information can be rather simply defined in our system of analysis -- it is the assignment of a value to one of the directive variables, such as Q_I, V_B, and others to be identified as components of tactical or functional orders.

One can picture the file structure of any command element as consisting of a definable number of cells to be filled with items of information used in the processes of Planning, Estimation and Inference. The flow of information affects the completeness and credibility of the files, and the probability of sound decision. At present, prior to some approach to human factor evaluation, our analysis of command must be limited to the subject of delay times, because a study of optimum file content is too dependent on human intellectual performance to be reasonably approached at this stage.

11. INTELLIGENCE -- The conduct of tactical and support operations requires the processing of many types of information; each of the nine listed functions contributes to the content of the files and in addition there are many others which we are presently ignoring as not particularly vital to the outcome of combat.

Of these "staff" specialties, Intelligence has a unique position in that it "communicates" with the enemy. Whereas the information used by other staff sections is freely furnished in the form of Status Reports, that used by Intelligence must either be extracted from the Natural Environment, which does not cooperate, or from the Enemy, who practices Concealment and Deception. (Deception consists of the furnishing of false items of information, or the selective release of true items of information intended to lead to false Inference, or a combination of the two.)

Intelligence has two interface variables. The first interfaces with enemy assets, terrain, and weather, and is measured in items of sensor information. These are readings of various facets of the "signature" of an object, which must be subjected to an Inference process before being converted to items of intelligence information. The latter form the interface with friendly Command, and with enemy Intelligence in the case of active deception.