TACWAR # 70
21 Aug 72

SUPPORT FUNCTIONS - ANATOMY OF COMBAT CONTEXT

WHPease

1.0 INTRODUCTION

The analyses of combat to date have the goal of logically and mathematically describing the phenomena of tactical operations. The initial analyses have concentrated upon the command and combat functions as their descriptions are basic references for the remaining functions. The sound value descriptions of the command and combat functions are derived from the interrelationships among themselves, the environment, an objective, and enemy potential. In similar fashion value descriptions for the support functions, Signal, Supply, Maintenance, Transportation, and Construction, are derived. However, unlike the command and combat functions, support functions do not directly interface with enemy potential. Thus their value descriptions are derived from interrelationships among themselves, the command and combat functions, and the environment. The discussion that follows transmits descriptions of the support functions derived in the aforementioned manner.

The discussion assumes knowledge of The Anatomy Of Combat, Theory of Value of Military Elements [1], and the Interdependence of Command, Fire, and Maneuver [2].

As the discussion develops it is necessary to amplify the details and definitions in the aforementioned documents. These amplifications in no way change basic concept even though new aspects are introduced. Further, as a convenience to the writer's inadequacy in discussing dimensionless things, functions are often referred to as functional elements. This convenience does not imply any variation in function attribute or characteristics.

---

1 Chapter 5, *The Anatomy of Combat*

2 TACWAR #52

2.0 DISCUSSION ORIENTATION

Each support function exhibits qualities and characteristics unique to the others. As a consequence a simple approach to their descriptions is denied. Instead it is necessary to describe a special universe that puts command, combat, and support functions into an interface context first before going into their detailed descriptions.

The organization of the discussion that follows observes the above complication. First, the functional universe of tactical operation is described in terms of interface characteristics. Next, the command and combat functions are described according to those interfaces that pertain to the support functions. With these preparations in hand, it is possible to proceed into the descriptions of the support functions. These are presented in the following order: Signal, Supply, Maintenance, Transportation, and lastly, Construction.

3.0 THE SUPPORT UNIVERSE

The concept for modeling or describing combat phenomena is based upon the premise that the battle is decided by the performance of nine functions. These functions are readily grouped into three categories, Command, Combat, and Support as depicted in Figure 1. The performance of each affects the potential of one or more of the others [3].The combined performances of all these functions are stated in terms of combat effects which mathematically are expressed by the expectancy value of the objective function.

---

[3] See descriptive phrases in Figure 1.

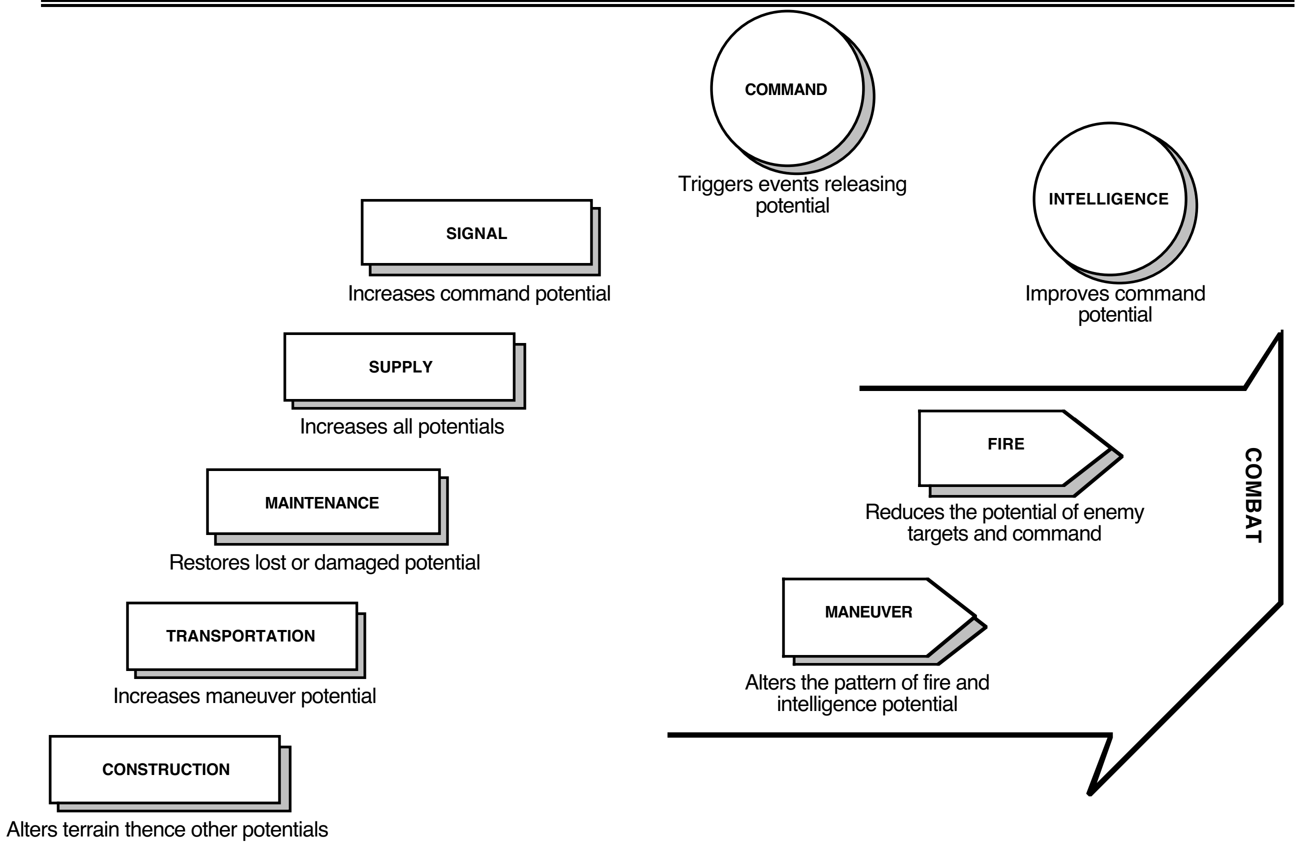


Figure 1 - Tactical War Functions and Effects

In order to use these affect relationships or interfaces in some modeling context of support function, it is necessary that they, the interfaces, be first described according to two criteria:

1) That descriptions be in terms for which acceptable units of measurement are available or can be obtained, and

2) That the descriptions enable audit tracking of complex functional interfaces, and relationships from input through output.

These criteria are met by describing the relationships as the effect of one functional element upon another as changes in the potentials of both, as the functional output being transferred, the time(s) when transfer may be transferred, and the interface(s) of potential transfer.

3.1 <u>Functional Outputs</u>

Support functions are unique in that they not only interface directly with other combat and support function, but they also interface with the interface between two other functions. It is therefore appropriate to identify, as categories, the nature of support function interfaces. These are identified according to category of support function output.

Three categories of functional output are ascribed to support functions. One, Information, is the common functional output not only of all support functions, but also of the command and combat functions. The other two, Resource and Service, are limited to the support function only. The information output includes such things as items of fact, directive, request, etc., transmitted between command element and any other functional element. A Resource output is the provisioning of items of materiel and individual personnel from one functional element to another. The provisioning is performed by a supply element to another element. The materiel and personnel involved are those normally consumed by the receiving element in course of performing its function. A Service output is a helpful or enabling activity of personnel and materiel provided by one functional element to another. Signal, Maintenance, Supply, Transportation, and Construction functions provide Service category outputs. The identities of the above outputs with the several functions are summarized in Figure 2. Descriptions of the output interfaces thus identified are discussed according to function later.

It is appropriate to note at this time the modeling content of this functional output -- the output of a functional element to another functional element is an event in which the performance of the former changes the potential of the latter. This event relationship is called an interface and is expressed as an interface variable of the functional element's output. The description of a functional element's interface with another functional element is in terms of the former's output. This output, depending upon the function, is stated as an item, quantity of resource, or task effort with some time or rate reference.

FROM \ TO	MANEUVER	FIRE	INTELLIGENCE	COMMAND	SIGNAL	SUPPLY	MAINTENANCE	TRANSPORTATION	CONSTRUCTION
MANEUVER				1					
FIRE				1					
INTELLIGENCE				1					
COMMAND	1	1	1	1	1	1	1	1	1
SIGNAL	3	3	3	1 3	3	3	3	3	3
SUPPLY	2	2	2	1 2	2	2	2	2	2
MAINTENANCE	3	3	3	1 3	3	3	3	3	3
TRANSPORTATION	3	3	3	1 3	3	3	3	3	3
CONSTRUCTION	3			1				3	

(1 – Information; 2 – Resource; 3 – Service)

Figure 2 - Support Function Outputs

3.2 Time of Functional Output.

When referring to the time of functional output the concern is with the latter of two time increments that comprise the operating cycle that consists of two increments. The first increment, t_0 to t_1, is the time available for the preparation for the execution of a course of action, or the time a functional element has to mass its potential and select the course of action for its release. The second time increment t_1 to t_2, is the time description for the release of functional elements performance.

The time description of a functional element output references these increments to those of other functional elements with which a support or supported interface exists. The prime reference for the time increments of all functional elements is that of the "Combat" course of action. Thus it is possible for any particular or situational instance to describe the processes and events of a support functional element in either of two ways as shown in Figure 3. Though the time relationships illustrated are situational, it should be noted that they are typical of an echelon. To be particularly noted is that the "t_2" of the command function of the echelon precedes or is concurrent with the "t_0" of the function that should be initiated first, in this case Supply. The impact of this condition may be readily visualized if, instead of supporting Maneuver, Transportation supported Supply. If the times available to Command and Supply were as shown, there would not be time available for the Transportation operation. This time characteristic of support function interface to the command and combat functions may be one of the sources for criteria to be used when defining echelons in detail.

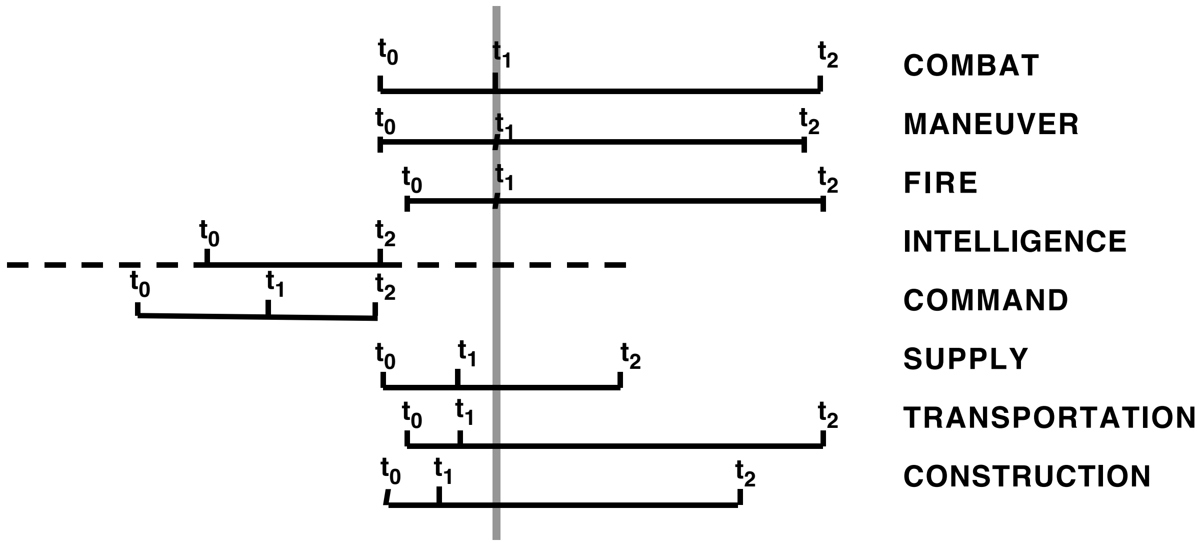


Figure 3 - Support function Interface Times (Situational)

4.0 COMMAND AND COMBAT FUNCTIONS

Though this discussion is addressed to the task of describing the support functions, it is necessary to touch upon the combat and command functions as they singly and collectively become the arbiters of values which are being described. Therefore, what follows are descriptors of these non-support functions considered important to the descriptions of the support functions.

4.1 Command

It was noted earlier that the Command function interfaces with all other functions and that this interface is information. The derived thesis of this condition is that all combat and support functional elements have selected command function attributes in order to interface with a command element. This attribute is designated a "functional" command to distinguish it from "combat" command and "tactical" command, the other two types (categories) of command.

The information interfaces among these three levels are significant from two standpoints. First, the Signal function derives part of its value description from the information values transmitted among the three levels of command. And second, each support element has a "functional" command, the output of which is information, defining an interface which is part of the support function description. Figure 4 schematically illustrates the three levels of command under discussion. The command processes at each level are similar. However, at the "functional" level the functional processes are the source of and terminals for information relating to functional state, events and environment. The "tactical" level has as sources and terminals for information at the lower level the "functional "commands of two or more functional elements. The sources and terminals for information coming from higher level into "functional" and "tactical" commands are command elements. The categories of information interfaces among these commands are the same -- directive, state, environmental, and event. Individual descriptions of these categories of information at the functional element level are derived from the situational values of the functional processes and events involved. Descriptions of information categories at the "tactical" and above levels are the product of aggregation as two or more "functional" commands' information categories are involved. This aggregation may or may not be in the direct context of the processes and events of the included functional elements. It is possible that aggregated information is among other things the consequence of a situational integration of the functional element processes and events involved. For this discussion it is sufficient when dealing with signal to refer to the category of information and the source.

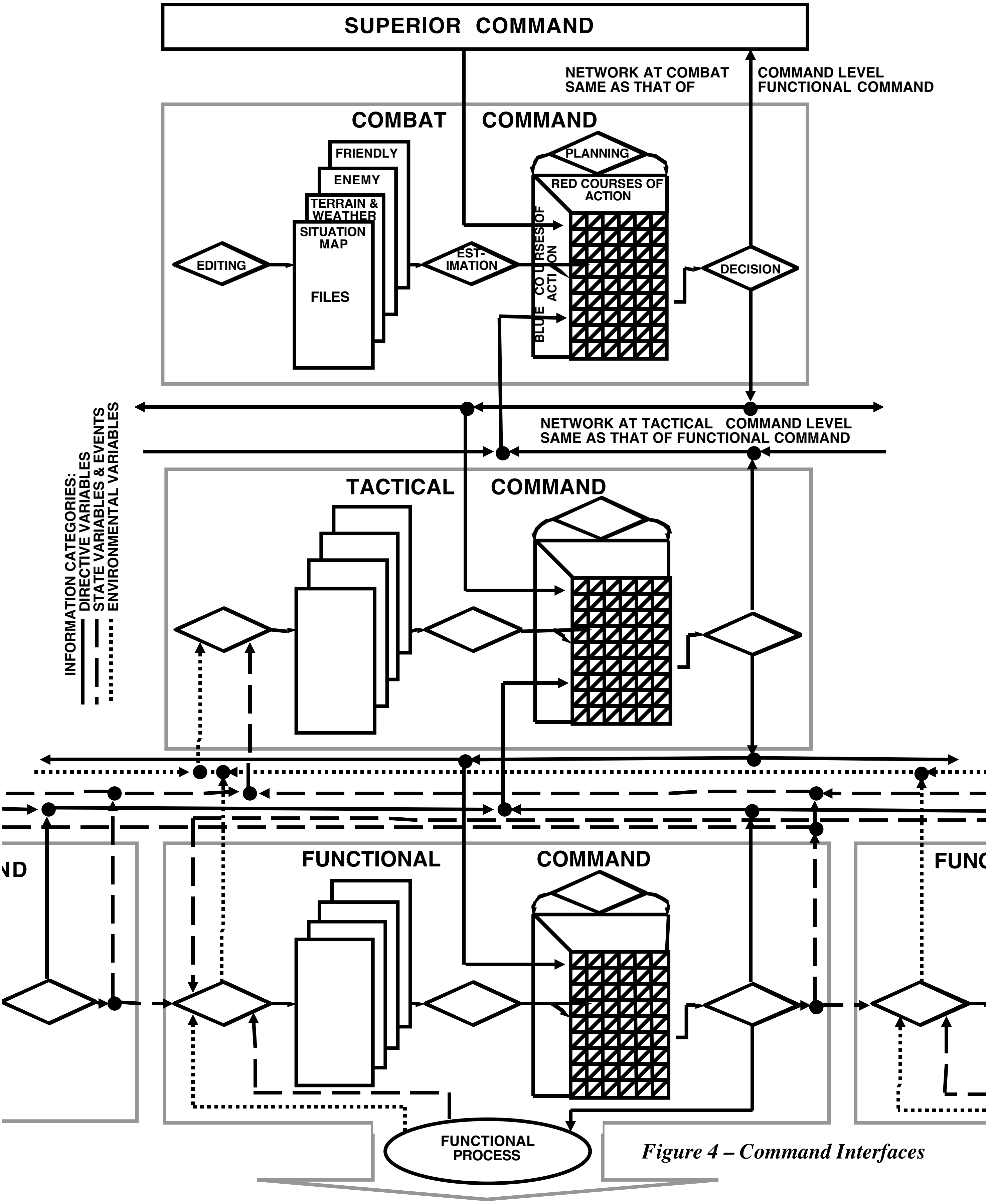


Figure 4 – Command Interfaces

4.2 Combat

Support function outputs are either direct or indirect interfaces with combat functions. A direct interface means the functional output goes directly to the combat function with no other intervening function, such as a maintenance element providing repair services to a fire element. An indirect interface involves an intervening function as a construction element alters terrain to enable transportation to provide a higher degree of maneuver to a fire element. Both direct and indirect interfaces of support function outputs alter the potentials of the combat functions. The intent of alteration is the increase of potential. The event altering potential and its effect upon the release of combat potential, the supported functions, are the characteristics of interest in describing support functions.

There are two typical interfaces that illustrate the event of altering combat function potential. The first involves support functions resource and information outputs. The interface with the combat function and in the case of information, with the command function, does not normally interrupt the release of potential and the alteration is the normal outcome of the receiving functions processes and events. The combat functions have certain support function attributes similar to that described for information earlier which enable this type of interface.

The second type is generally associated with a service output. A service interface normally interrupts the receiving combat function's normal cycle of processes and events. Service interfaces take on importance when combat function configuration attempts to ameliorate the impact of this service interface interruption. Making an artillery weapon self-propelled is a classic example of a configuration to accommodate service interface.

Each type of interface with combat functions is unique to the support function involved and is described in more detail below.

5.0 SUPPORT FUNCTIONS

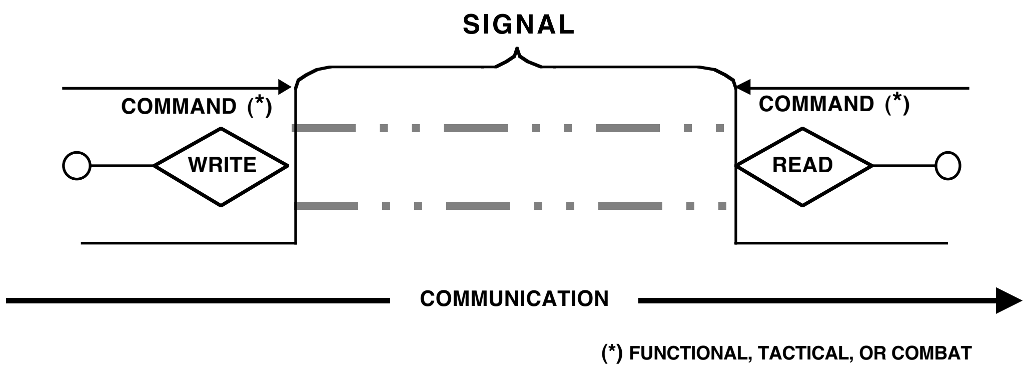
There is no orderly arrangement of the support functions that facilitates their discussion and description in a step-by-step progression. Some order and logic is obtained by describing first the support functions that have some of their attributes included in the combat functions. With these out of the way, descriptions of the service support functions appear in order. This organization does not eliminate references to functions yet to be described, but it does minimize these references.

The description of each support function includes the following:

1) The basic functional element
2) Functional effect upon supported function
3) Significant processes and events involved
4) Classification of function, if any
5) Performance characteristics
6) Interface description

5.1 Signal

The signal function enables the flow of information, the effect of which increases command potential. Schematically the signal function is depicted as the information interface between two command elements as shown below.



Sketch A

The information flows from an originating command element to a destination command element. To the processes and events of the originating command element, is added "write". To those of the destination element, "read". These two events avoid the interruptions of normal command processes by the receipt or release of information. The signal function carries information over one or more channels between the "write" of the releasing command element, and the "read" of the receiving command element. The information is carried in a transmission form or context. Only command and coordinating information is transmitted by the signal function. The performance of the signal function involves the accomplishment of several processes and events which for convenience are summarized as follows:

1) "Transform" information from "write" to a transmission format and context,
2) "Route" information when two or more channels are available,

3) "Hold" information when input exceeds situational performance,
4) "Transmit" (lift or carry) the transformed information, and
5) "Transform" information from transmission format and context to "read".

The basic signal element is a runner carrying information from one command element to another. He is a two-channel element as information may be carried in a written format or in his memory. His performance, capability, potential, and performance are measured in the volume rate of written matter carried in hand and/or memory and in the error rate, loss in the case of written matter and that which is forgotten or transposed in the case of memory.

The runner is rather rudimentary serving only to illustrate the basics of performance. It is more appropriate to consider a signal element that transmits information electronically in which condition the element consists of two operators, one with a transmitter and the other with a receiver. The former is located at "write". The latter at "read". The performance of this signal element is in the same terms, bit rate and error rate. Two or more of these signal elements comprise a signal unit associated with the transmission of information among the functional commands and command of an echelon.

The signal element's functional performance is stated as an information bit rate and an error rate. For modeling descriptive purposes the error rate increases with the bit rate as shown in Figure 5.

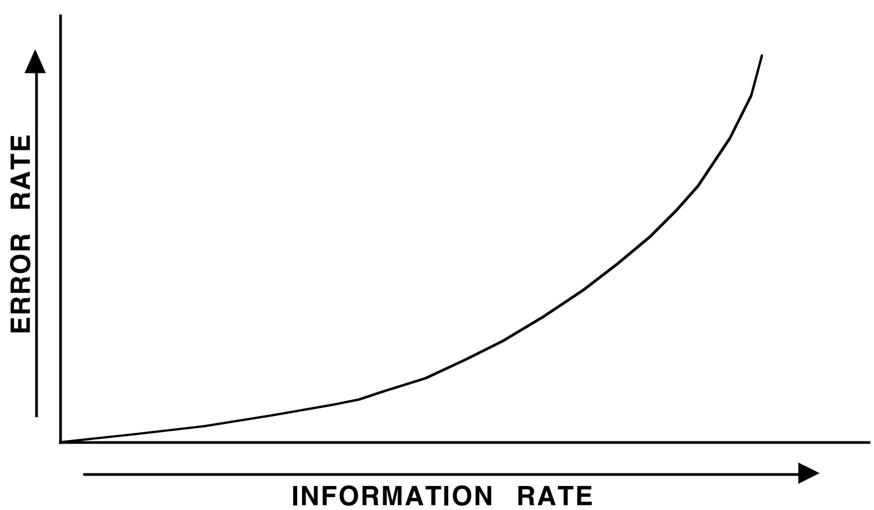


Figure 5

Further, there is a unique error rate-bit rate function for each signal means which is the basis for describing capability (K) of the particular element. The functional performance (P) or other interfacing support and command elements determine a signal element's potential (π). Command releases the potential obtaining signal performance (P). There are two aspects of command noted herein, one affecting π's and the other affecting P's. The former refers to the "write" and "read" characteristics of the information flow, intervening distances, mobility of the command element, etc. The latter refers to the "directive variable" from tactical command to the signal element "functional" command that releases the element's potential.

The signal element's potential is released between the times t_1 and t_2 during which time interval a course of action is executed. This signal course of action supports the courses of action of command and another functional element by transmitting the information from command to the other functional element. Command issues orders to the signal element to plan and prepare for a signal operation.

This time for planning and preparation, t_0 to t_1, is the second time increment of the element's time profile. The preparation aspect can be likened to massing potential enabling the performance to be available during the time t_1 to t_2. These two time increments provide a time description of the element as shown in Figure 6 below.

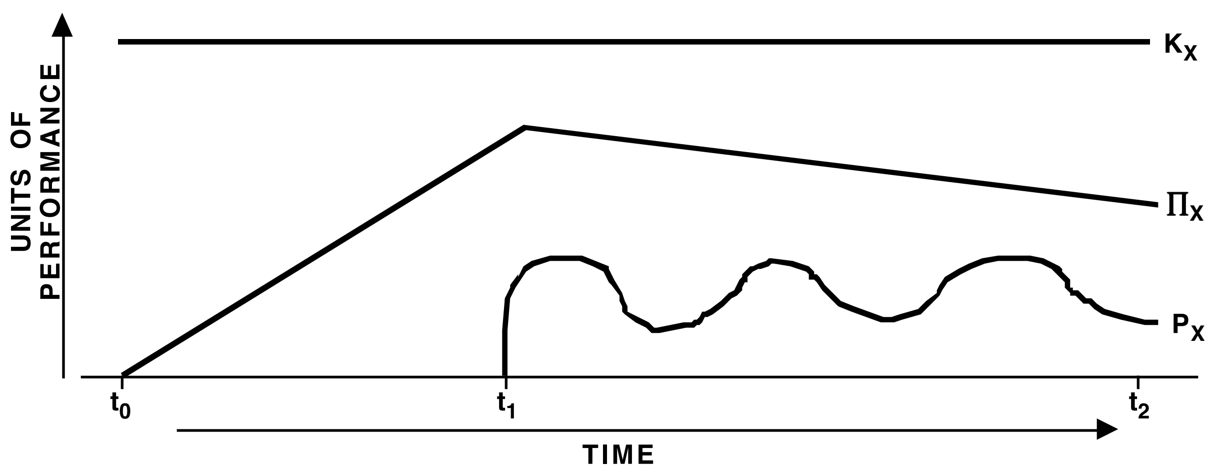


Figure 6

The fact that a signal element transmits information between command and another functional element and that this information is pertinent to the planning for, preparation for, and execution of a course of action places the signal element's time profile, t_0 through t_2, in a discrete relationship with both command's and the other functional element's time profiles.

This discrete relationship is depicted in Figure 7. An operational course of action for some

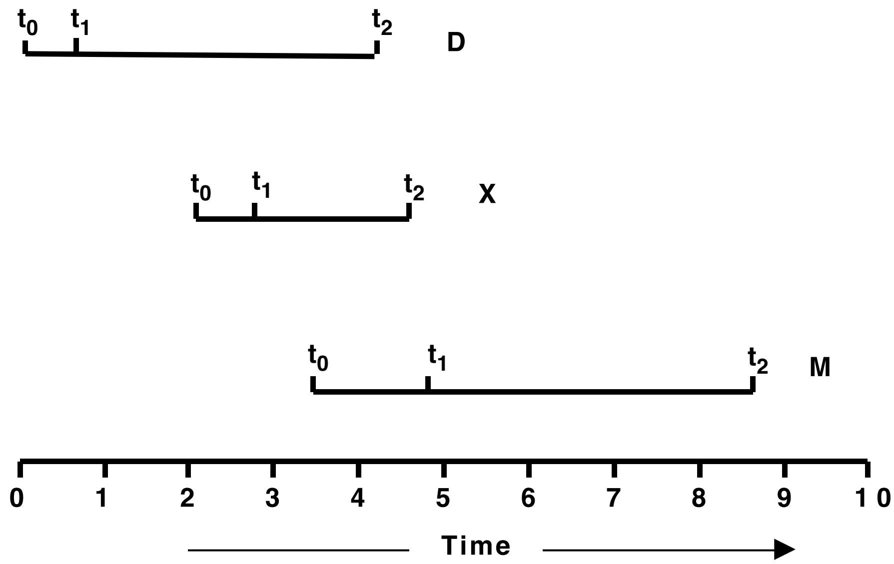


Figure 7

functional element other than signal, in this case, maneuver, is shown from time 5.0 through 10.0 on an arbitrary time scale. Maneuver is estimated to require 1.5 time units, t_{o_M} through t_{1_M}, to plan and prepare for the execution of the course of action. A time, t_{1_X} to t_{o_M}, is required to transmit directive information from the combat or tactical command to the maneuver functional command. Therefore, combat or tactical command has the time t_{1_D} to t_{1_X} to prepare initial directive information and the time t_{1_X} through t_{2_X} to complete the preparation of directive information. Combat or tactical command receives a directive from higher command at time 0, uses one time unit to plan and prepare to issue orders, and three time units to conduct its estimate, arrive at a decision and write the directive. The signal unit uses one time unit to plan and prepare for its course of action and is allowed two time units for its execution.

The signal element obtains functional importance (the transmission of directive information) from t_{1_X} through t_{2_X}. During this time the element contributes to the effectiveness of command. The value description of this contribution references the time $t_{1_M} - t_{1_D}$ and a yet to be defined command measurement, the quality of the decision.

The foregoing functionally describes a sequence of decision (combat or tactical command) to transmission (signal) to decision (functional command of maneuver). The flow of directive information is common among all three. The effectiveness of this sequence is stated in terms of its duration t_{1_D} through t_{1_M}, the time available for making decisions at the combat or tactical command level, t_{1_D} through t_{2_D}, and the time available for making decisions at the functional command level, t_{1_M} through t_{2_M}. The performances of the commands involved are in terms of the quality of decisions developed. The quality of decision is determined by the time available in which to make the decision and the amount of pertinent information available upon which the decision is based. The signal element's rate of transmission influences the time available for making decision and its error rate affects the amount of pertinent information available. As the signal element's performance during t_{1_X} through t_{2_X} is in a discrete included time relationship with the total command sequence t_{1_D} through t_{1_M} the value of the signal function is stated as some matrix involving two variables, command sequence time and quality of decision. The quality of decision is believed to be a commander's estimate so values are either in figures of merit or in terms of the functional element output, in this case maneuver. Thus the value description of a signal element may be indicated as some time value of the command sequence, t_{1_D} through t_{1_M}, in time for a quality of decision, either as a figure of merit or as a functional output, for a given information and error rate. Given the appropriate time relationship of the times t_{1_X} through t_{2_X} with t_{1_D} through t_{1_M}.

The foregoing discussion was limited to directive information for convenience. The other categories of information, environment, event, and state have time relationships to the command process and the quality of decision similar to those of directive information. Therefore the signal value description concept described above applies to the other information categories as well.

5.2 Supply

Supply is the function of providing materiel and personnel resources that are normally consumed, expended, or issued in the course of tactical operations. "Normally" means that the resource, expenditure, or issue does not interrupt the processes and events of the provisioned function's normal operation. This distinction is made to delineate "supply" from certain techniques of "maintenance" which involve provisioning materiel but interrupt the provisioned functions' normal operation.

Supply has a resource relationship or interface with command and all combat and support functions. The effect of this interface is the increase of potential. Schematically, this resource interface is depicted as a discontinuous flow from the "receive" of a supply element to, but not including, the "use" of another functional element as shown in Figure 8 below.

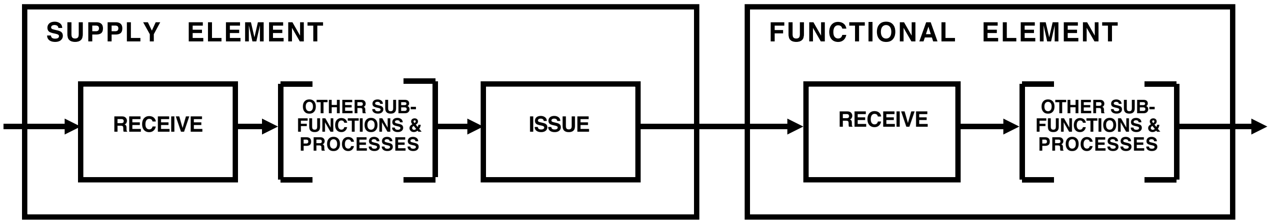


Figure 8

The other functional element may be any one of the other elements, including another supply element.

In addition to provisioning user functions, the supply function physically adjusts the flow of resources as received from source to the use rates of consumption, expenditure, or issue. Rates from sources are measured and not subject too short term changes. Use rates change markedly and use of some resources is frequently intermittent. The supply function accomplishes this physical adjustment to the discontinuities between the rates of resource input and output by holding resources in temporary "storage". There are two kinds of storage, Portable and Transit. Portable storage places the resource in some temporary facility. Transit storage places the resources in or on some vehicle (transportation) moving from one point to another. The physical management of the flow of resources from "receive" to "storage" to "issue" to "receive" is by the process of "inventory control". Inventory control includes the physical sorting of materiel by lot for both storage and issue, inspection for state of readiness, and accounting for receipts, issues, and on-hand (storage) amounts. Immediate command of the physical processes of supply is exercised by "functional" command.

For tactical war analysis purposes a supply element is schematically depicted as shown in Figure 9. This supply element has three resource flow paths from input "receive" to output "issue". These are representative. In practice, other flow path options are used and can be similarly described on situational bases. The supply element's interface with another element is a back-to-back "issue" to "receive" events for which no options exist. The input to the supply element is linearly always the interface of another supply element. The supply element interface, output, is with another supply element or the "elemental" supply of another functional element. Elemental supply will be described later in this discussion. To be noted are the service interfaces of Transportation and Construction functions with the supply function. The former is with "portable" and "transit" storage while the latter is normally associated with the facility aspects of "portable" storage. Both these functions figure prominently in the potential of performance of a supply element.

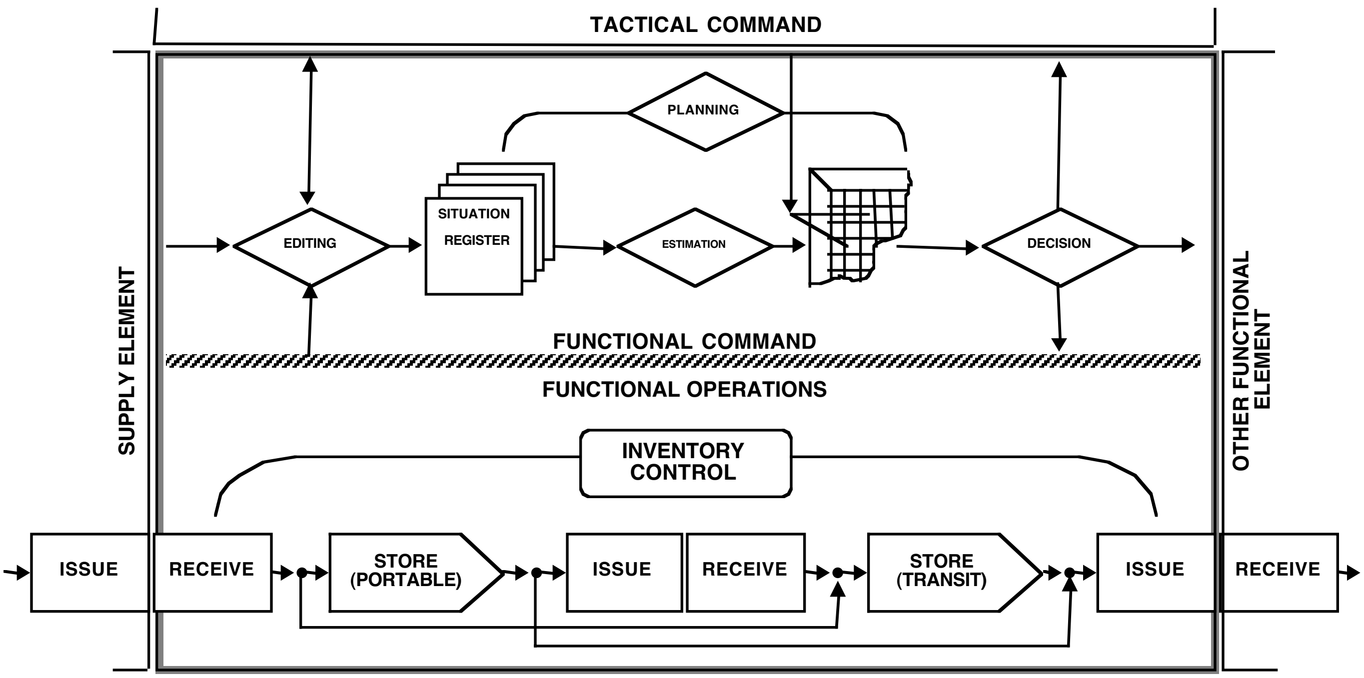


Figure 9 - Supply Element

The components of a supply element are the personnel and equipment to perform the above processes and a quantity of resource being processed. The quantity of resource may be all or portions of two amounts, an "operating" level and a "safety" level. These levels are described later in connection with the value descriptions of supply.

The variety of resources in process encompasses the full spectrum of consumables. However, to facilitate analyses and description, two simplifications are adopted. Resources are grouped in categories that approximately correlate with functional element consumption or expenditure and a supply element process as only one category of resource. This establishes the primary category associations shown below.

Resource Category	Consuming or Expending Functional Element
Fuel	Maneuver, Transportation, Signal
Ammunition	Fire
Repair Parts & End Items	Maintenance
Engineer	Construction
Personnel	All
Rations	All

A supply element, in common with the other functional elements, has three levels of performance: Capability ($K_{(S)}$) Potential ($\pi_{(S)}$) and Performance ($P_{(S)}$). Performance $P_{(S)}$ is expressed mathematically as $W\eta\,\tau$ (see Ref. 1). The units used to express performance are quantities of resource issued (output) during a specified time period, a supply rate. A situational relationship among these three levels of performance and the primary interfacing function may be depicted as shown in Figure 10.

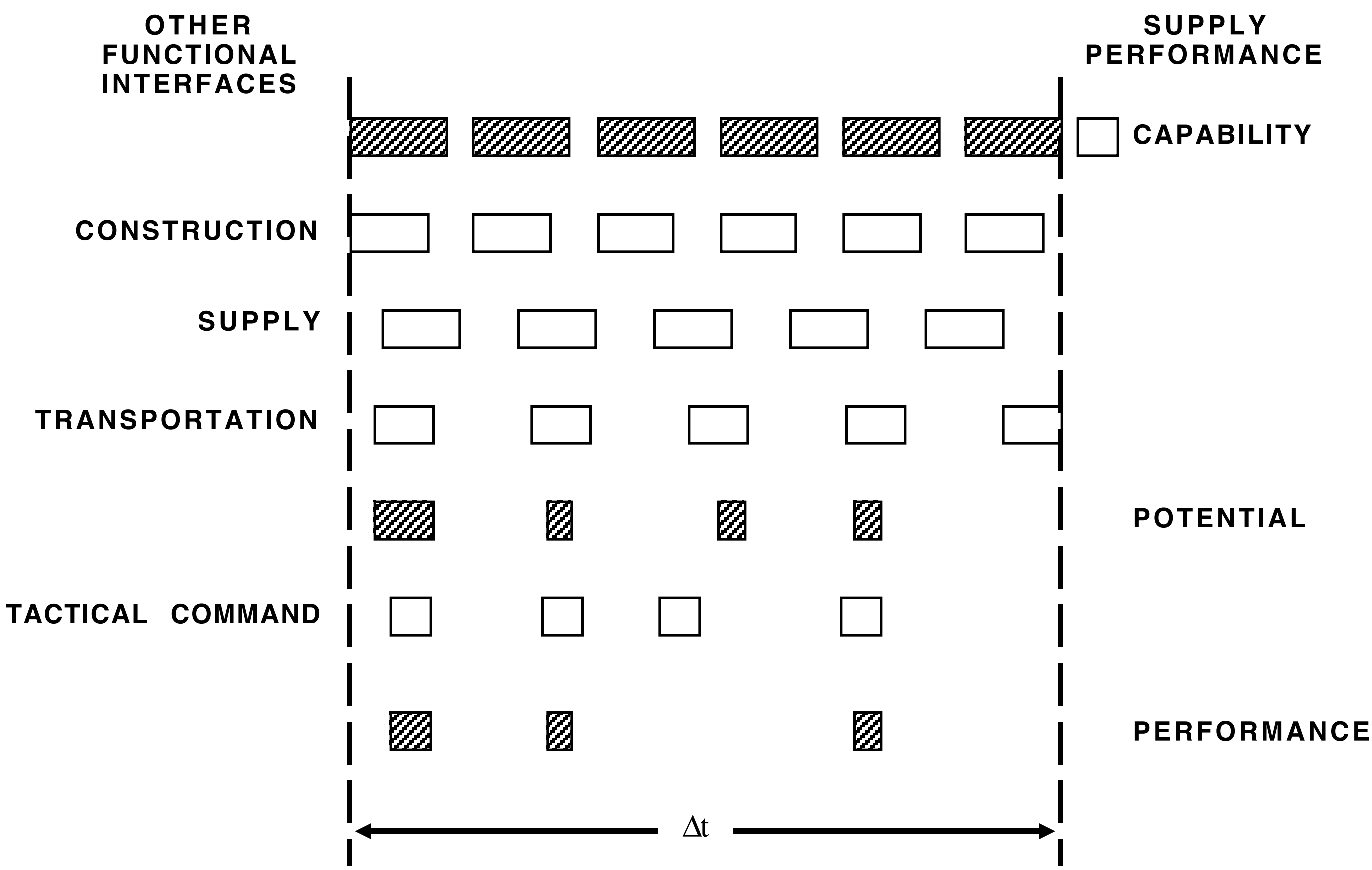
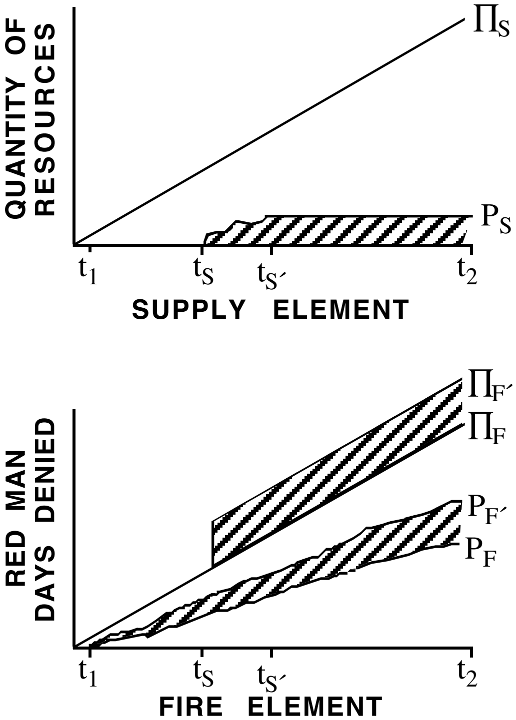


Figure 10

The result of a supply element's interfacing with another functional element is an increase in the latter's functional performance. Thus the value of P_S is expressed as a $\Delta\pi$ of the receiving element in terms of the receiving element's output. In this manner, P_S eventually obtains a $\Delta\pi_F$ or a $\Delta\pi_M$ which is used in calculating an expected objective functional value entered into decision matrix process. The decision matrix process expresses P_S as an increment (Δ) of two expected objective function values. Figure 11 is a simplified illustration of establishing the value of ammunition supply function to a fire element. There is missing in this chain of values the effect of command upon Potential (π_S) to realize performance P_S. Command interface has been identified as the "quality of decision (P_D) in the earlier description of the Signal function.



- **C/A 1 –**
  FIRE ELEMENT P_F t_1 TO t_2 WITH
  SUPPLY t_S TO $t_{S'}$
  SUPPLY ELEMENT P_S t_{1_S} TO t_{2_S} =
  t_S TO $t_{S'}$

- **C/A 2 –**
  FIRE ELEMENT P_F t_1 TO t_2 WITHOUT
  SUPPLY t_S TO $t_{S'}$

- **VALUE OF SUPPLY =** $\int_{t_{1S}}^{t_{2S}} P_S$

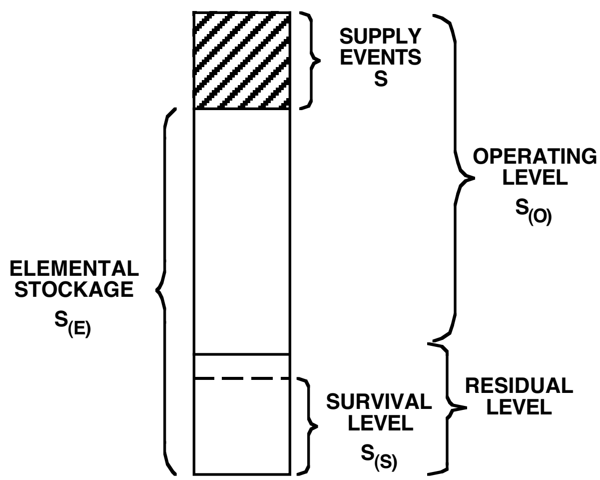
$$\int_{t_s}^{t_{s'}} P_S = f \int_{t_1}^{t_2} \Pi_F - \int_{t_1}^{t_2} \Pi_{F'}$$

$$= f\, P_D \int_{t_1}^{t_2} P_F - \int_{t_1}^{t_2} P_{F'}$$

Figure 11

The foregoing describes the value of the supply function but does not describe the value of the supply event. The descriptive value of the supply event is associated with the "how" supply performance interfaces with other functional element's potential. Description of the supply event is actually two descriptions, one for the interface with a non-supply element, and another for the interface with another supply element.

A supply element interfaces with the "elemental" stockage level of a non-supply functional element. The riflemen's cartridge belts and bandoleers of ammunition constitutes a typical elemental stockage element for a squad. The description of this interface event is obtained by considering a C/A (Course of Action) involving resupply. The order directing the squad to execute a combat C/A allocates the ammunition to be used during its execution and to be remaining at the completion of the C/A. In addition, the order for the C/A the squad leader selects to implement as his command decision directs a "survival" level. The three amounts or levels derived from the order and squad leader's C/A relate to "elemental" stockage and a supply event as shown in Figure 12. The operating, residual, and survival levels are the result of the planning and decision of the next higher command level, the platoon. Their descriptions are derived by examination of portions of the planning made at that level. For simplicity only one squad is considered even though at the platoon echelon more than one squad is involved.



FOR A GIVEN C/A

- **OPERATING LEVEL AND RESIDUAL LEVEL SPECIFIED BY ORDER FROM HIGHER COMMAND**
- **SUPPLY EVENT(S) t_S (OPERATING + RESIDUAL LEVELS) – ELEMENTAL STOCKAGE**
- **SURVIVAL LEVEL**
  FROM t_1 TO $t_S \leq$ ELEMENTAL STOCKAGE
  FROM t_S TO $t_1 \leq$ RESIDUAL LEVEL

Figure 12

The platoon leader has received an order similar to the one eventually issued the squad but for the platoon. As a result of planning and estimation, he selects a course of action for the squad that to obtain an acceptable expected objective function value results in a resource expenditure, operating level, plus residual level exceeding the squad's "elemental" stockage level, indicating the need for one or more resupply events. (A supply element or portions of a supply element's performance together with the authorized platoon operating level are allocated to the platoon in the order received from higher command.) The platoon leader must decide what is the minimum storage, "survival" stockage, the squad may have before it is resupplied. The survival stockage is that amount allocated to assure squad functional potential when, for the failure of some process or event in the planned friendly (platoon) course of action and/or in the estimated enemy course of action, the friendly expected objective function value becomes no longer acceptable and a new course of action must be planned and implemented. The plans and estimates and tentative decision of the selected course of action include the results of an analysis that entertains the consequences of failure and its effect upon the expected objective function value. The course of action and the results may be depicted as shown in Figure 13, which indicates that if there is a need for a "survival" stockage, it occurs between $t_{1,4}$ and $t_{1,6}$.

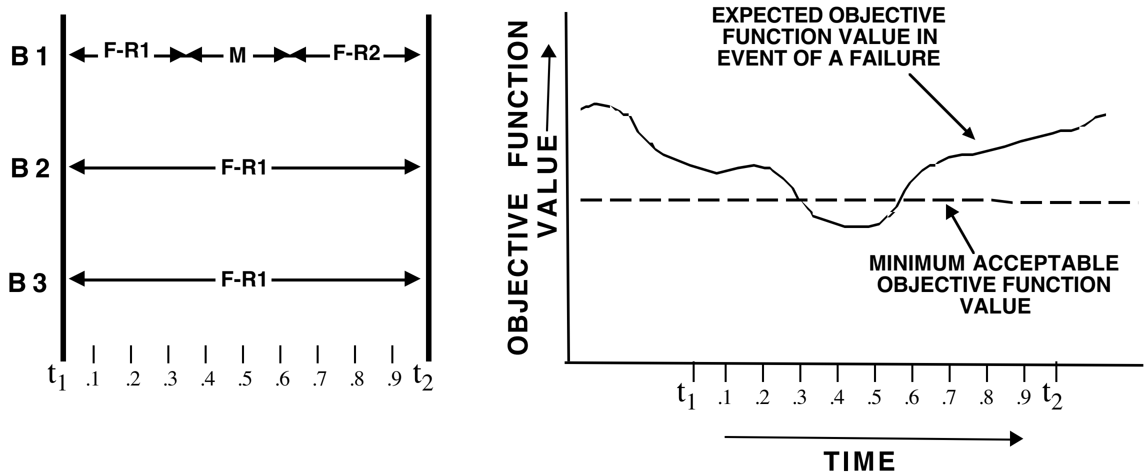


Figure 13

A resource expenditure time profile provides the other information necessary for the resupply event. In Figure 14 the platoon leader's estimate is depicted with two possible resupply C/A's; one at t_s , the earliest; the other at $t_{s'}$, the latest. An expected objective function value is computed for the success and failure of each. The value of each resupply event is the difference between success and failure value. The value of one resupply event relative to another is the difference between their respective success values.

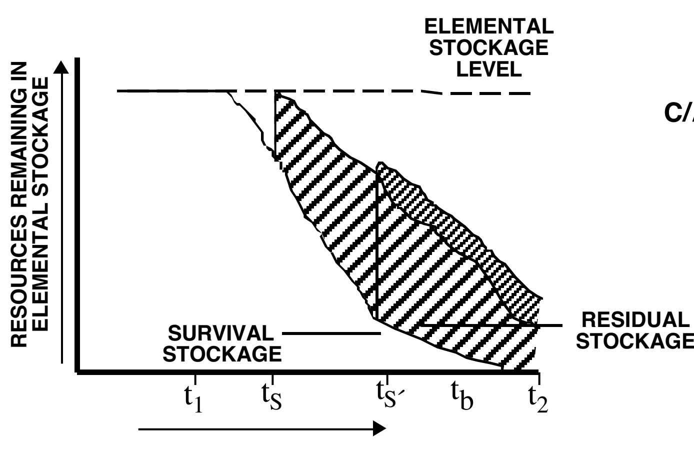


Figure 14

C/A 1 – RESUPPLY AT t_S = pA

FAILED RESUPPLY AT t_S = 1 – pA

C/A 2 – RESUPPLY AT $t_{S'}$ = pB

FAILED RESUPPLY AT t_S = 1 – pB

VALUE OF SUPPLY:
C/A 1 < C/A 2

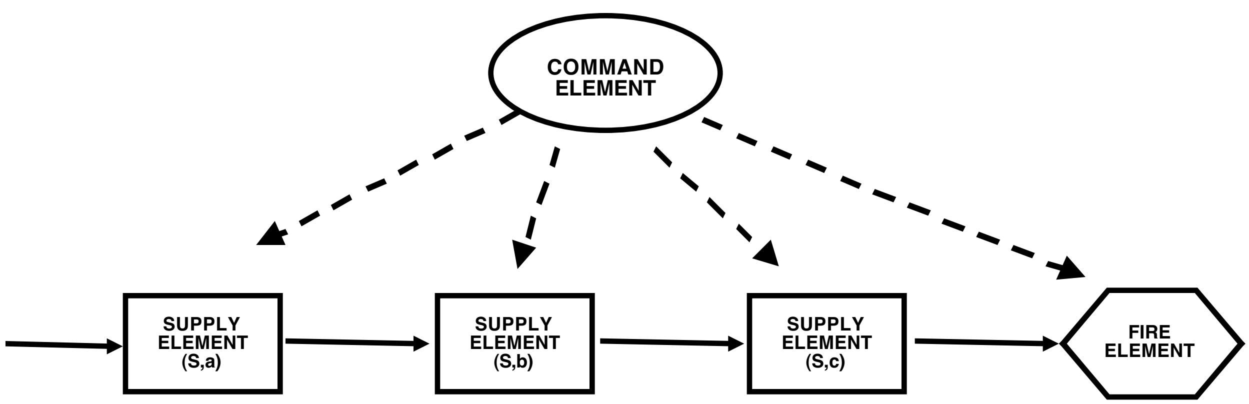
VALUE OF SUPPLY EVENT:

PA > pB

DECISION:
C/A 1 > C/A 2

The description of the supply event refers to three stockage levels or amounts, one of which, the "survival" level, is described. The other two, "residual" and "elemental" , levels lack both description and rationale. The rationale for "residual" stockage has not been established as it is involved in the planning sub-functions of higher command, yet to be analyzed and described. However, insofar as the "residual " level is identified with a time increment t_b to t_2, the quantity so allocated assures continued potential during the preparation for and implementation of the next course of action. The suggested rationale for the "elemental" stockage is considerably more complex and requires analyses of Transportation and the characteristics of mobility for substantiation. The premise is advanced that degrees of mobility are, in part, functions of weights and sizes of things that are to be mobile. As "elemental" stockage contributes both weight and size to the element, the amount of stockage is in some way a function of mobility.

The foregoing descriptions for the values of the supply function and the supply event (interface) for convenience are illustrated with a supply element, the potential of which is renewed during neither the supply course of action nor the fire course of action, but after its completion. However, the supply element function's complete definition includes enabling the flow of resources from source to use. This aspect of the definition requires further description of supply element interfacing with supply element. The description is obtained from analysis of the characteristics of a hierarchy of supply elements approximating current doctrine.



FIRE ELEMENT C/A

DELIVER FIRES FROM t_1 TO t_2 WITH Π_F INCREASED

WITH P_S OF S_a, S_b AND S_c

$S_{(o)i}|_{t_2} \geq S_{(o)i}|_{t_1}$

Figure 15

A simplified supply system of several supply elements serving a fire element and all under one command element (see Figure 15) is the vehicle of analysis. The system is single cycle, releasing no potential until directed by command and only for the next combat C/A. In accordance with higher authority, command selects a C/A for the fire element during a specified time $t_1 \rightarrow t_2$, for which performances of three supply elements are allocated. A series relationship among the three supply elements impose the time regime shown in Figure 16. The Command Element performs the planning, estimating, decision, and order subfunctions prior to $t_{0,s,a}$ incurring the command lead time shown. With this "command lead time" the operating levels of all supply elements are restored. If the combined performances of the three supply elements were available in supply element S_c during the time Δt_F , the command function can be performed in an earlier time increment, shown by a dashed line, obtaining a lesser command lead time.

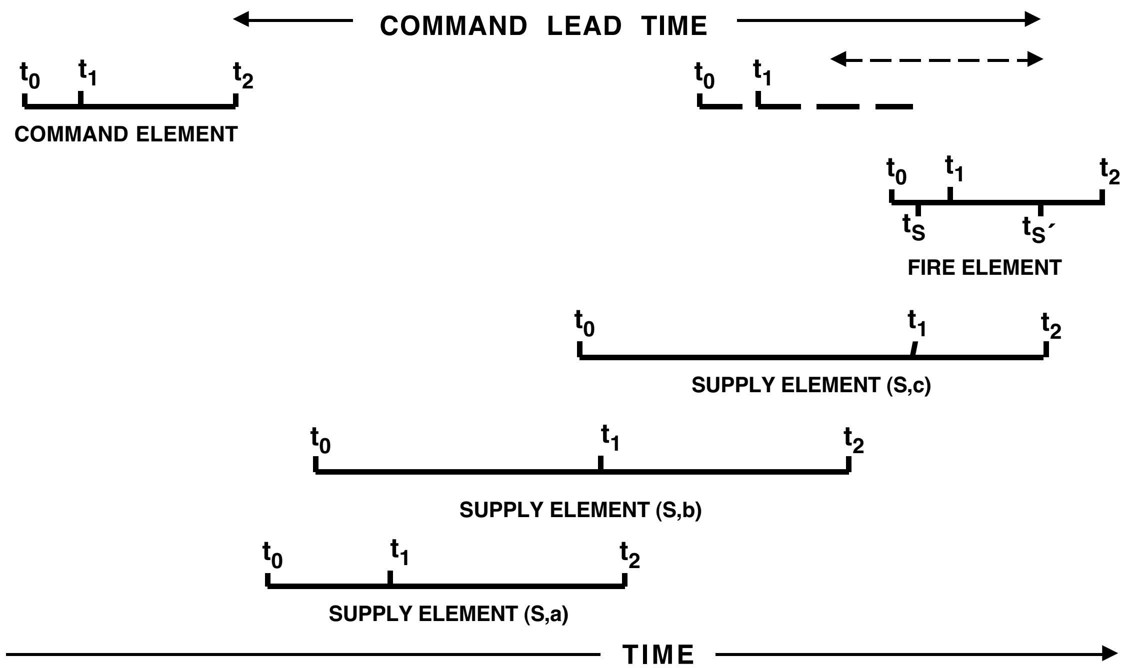


Figure 16

This second and lesser command lead time is introduced because of an assumed improvement in the release of fire potential thereby obtained. It may be argued that the "quality of decision" does not improve with time. However, the extreme, a very short command lead time, implies a "quality of decision" using an incomplete situation register and foreshortened planning and estimation processes -- an undesired condition. There are probably upper and lower limits for command lead time, the characteristics and rationales of which are yet to be defined. Therefore, for this discussion of supply, it is assumed a shorter command lead time is desired without the concomitant limitation upon supply potential.

The description of a lesser "command lead time" implements command directed resource flow approximating U.S. military doctrine of "continuous refill". Figure 17 illustrates the time regime of lesser "command lead time". The C/A for the fire element is the same as stated before except for $S_{(o)_i}\big|_{t_2} \leq S_{(o)_i}\big|_{t_1}$. The value of supply obtained under this time regime is a function of the operational stockage of the supply elements and the time relationship of the Δt's of two interfacing supply elements.

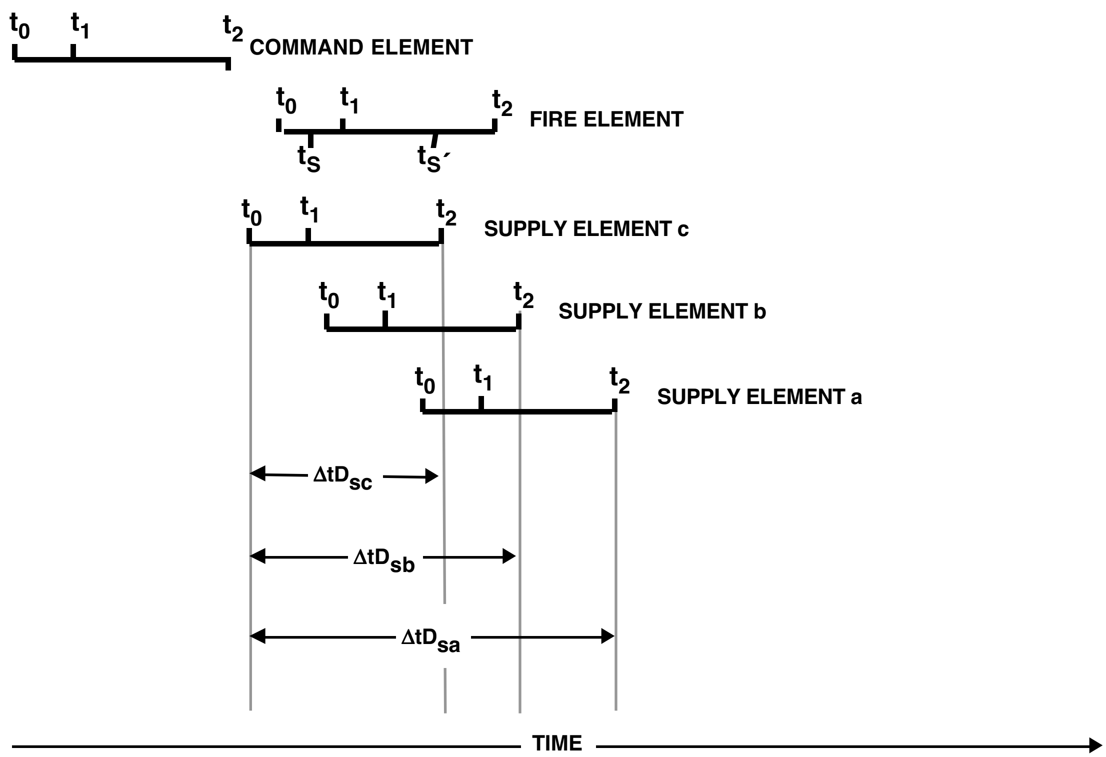


Figure 17

Two interfacing element's ($S_b \rightarrow S_c$) time relationship is described as follows:

$$\Delta t\ D_{S,c} > \Delta t\ D_{S,b} - \Delta t_{S,b}$$

(Note: $\Delta t\ D_{S,c} \geq \Delta t\ D_{S,b}$ .... for $\pi_{S,b}$ or $P_{S,b}$, to have value in terms of P_F.)

During this time of interface $\Delta t_{S,b\rightarrow c}$ the $\pi_{S,c}$ is increased by the released increment of $\pi_{S,b}$, $(\Delta t_{S,b})(P_{S,c})$. This interface is illustrated on a performance time basis in Figure 17. The comparisons between the two concepts of "command lead time" other than the time differences are in the distribution of the operating level occurring with the passage of time and the "command lead time" for varying the rates of π_{S_i} increase or decrease. Assuming the Δt's for each supply element remain the same and in the same time relationships, the $S_{(0)}$ and the resulting π_S of the three element system, given there is a steady input to S_a, are the same. However, the operating level for each successive fire element C/A assumes a distribution among the three supply elements different from the preceding C/A. This is illustrated in Figure 18. At time t_{oF} the $S_{(o)}$ for the C/A is in S_c and S_b in the amounts shown, involving two supply events $S_c \to F$ and $S_b \to S_c$ and a preponderance of the resource in S_c. At time t_2 the $S_{(o)}$ for the next C/A is distributed among the three elements and the release of π_s for the system involves three events $S_c \to F$ and $S_b \to S_c$ and $S_a \to S_b$. This event dependency is one of the bases for allocating a survival level $S_{(s)}$ among the supply elements in a series relationship. The other basis for allocating $S_{(s)}$ among the elements is an application of the rationale and logic discussed earlier in connection with elemental stockage.

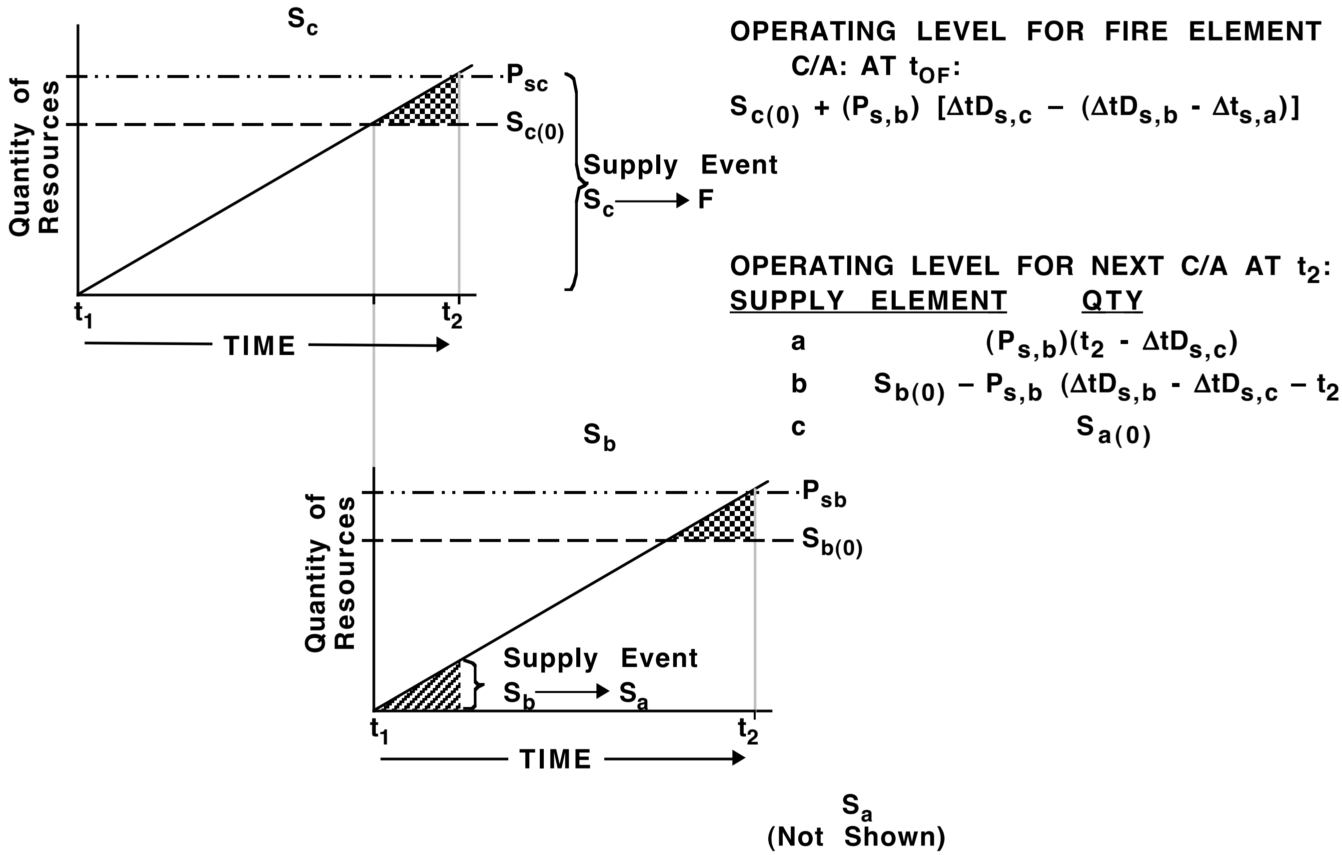


Figure 18