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TANK CREWS AND PLATOONS AS LIVING SYSTEMS

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CHAPTER 1 - INTRODUCTION

The purpose of this paper is to assess the applicability and utility of living systems theory (LST), as developed by James G. Miller (1978), for analyzing the operations of small military combat units. General systems theories have been developed in recent years to provide interdisciplinary approaches for the discovery of identities (isomorphisms) among various levels of systems and for developing general theories of systems behavior (e.g., Bertalanffy, 1968). In such theories a system is generally defined as a functionally related set of elements which together form a whole. Systems in today's world are innumerable, ranging from the abstract (e.g.; systems of justice, management systems) to the concrete (e.g.; computer systems, weapons systems). LST provides a framework for the study of the behavior of living systems, which are defined as concrete open systems having identifiable inputs, throughputs, and outputs in the forms of matter-energy and information. Living systems which have been studied under the rubric of LST include a modern city (Vandevelde and Miller, 1975), health delivery systems (Pierce, 1972), and industrial organizations (Duncan, 1972). Small combat units certainly fit the definition of a living system; it thus appears worthwhile to examine LST as an integrated framework for analyzing the complex man-machine interactions ongoing within them.

LST is basically a simple theory which is made complex by the great variety of systems to which it applies. The theory is described in some detail in Chapter 2. LST addresses the total spectrum of living systems, from single cells to the complex international level. Its central postulate is that a minimum set of 19 subsystems can be identified at any level of living system, and that these subsystems are critical for system survival. The first step in applying LST is thus the description of the structure and processes of the system under study within the framework of the 19 subsystems. This is accomplished for particular types of combat units, tank crews and platoons, in Chapter 3.

A question of prime concern for LST is whether it provides a tool only for describing systems or can move beyond that stage to provide prescriptions for systems design and predictions of systems behavior. The theory attempts to take this step by categorizing variables which influence subsystems' behavior and by proposing a set of 173 cross-level hypotheses or generalizations about the structure and processes of systems across various levels. These variables and hypotheses are discussed within the context of tank crews and platoons in Chapters 4 and 5, in order to provide general suggestions for future military research within the framework of LST. As will be further argued later, tank crews and platoons may represent two levels of living systems, the group and the organization, and they thus provide a context for limited applications of cross-level hypotheses.

Why should systems science in general and LST in particular be of interest to the US Army? This question is addressed in detail in Chapter 6, but some preliminary points can be made here. The Army is one of the more complex systems in our society, and it is influenced by a host of interacting factors, such as political, technical, and motivational considerations. An integrated way of examining the effects of complex, interrelated factors is needed in today's Army; for example, training and doctrine development must be integrated with equipment development. Systems science and LST offer such integrated approaches, but their application must be carefully developed and their utility carefully assessed. It would be easy to perceive LST as a panacea and to pay lip service to it without fully developing and applying its concepts. Such a thing has occurred numerous times in the history of the Army. To avoid this, LST must initially be applied at levels which allow objective, manageable research. An exploratory analysis of the utility of LST for examining the functioning of a large Army organization (the armor battalion) is currently being conducted by the University of Louisville Systems Science Institute, under contract to the US Army Research Institute. A logical follow-on to this initial step would be the application of LST to more manageable-sized units for research, the tank crew and platoon. One of the primary goals of the present paper is to offer recommendations along this line.

A crucial aspect of the systems perspective is recognition of the need for interdependence of components, or the synergistic interaction of the parts of a system. Prime examples of the parts working together for the survival of the whole can be found in systems involving teamwork, such as the Dallas Cowboys or Washington Bullets. Such teamwork is of great importance to the US Army, particularly in combat units where individuals must risk their lives for the survival of the system. Tank crews consist of four individuals who must communicate and work together effectively and rapidly as a group or team during times of great stress. Tank platoons are small organizations of five tanks with echelons of decision-making responsibility contributing to the survival of their system. In addition to personnel interactions, these units must effectively process complex man-machine interactions under a variety of environmental stresses. Anything that LST can add to integrating and optimizing the performance of such units will be well worth the effort.

CHAPTER 2 - OVERVIEW OF LIVING SYSTEMS THEORY

Living systems theory (LST) is a part of general systems theory dealing with particular types of concrete (made up of matter and energy) systems. The theory as published by Miller (1978) represents over 20 years of developmental work. While LST's basic concepts are generally straightforward and simple, the theory's generality and potentially wide range of applications lead to a need to develop a clear understanding of its central postulates. The most important definitions and concepts are presented in this chapter, using a variety of examples. The theory is then further expounded in the following chapters using a specific group (the tank crew) and organization (the tank platoon) as examples.

Living systems. Living systems are a subset of all concrete or real systems, including all forms of life. A critical attribute of living systems is that they are open; that is, their boundaries are at least somewhat permeable, allowing the input, processing, and output of matter-energy and information. Matter-energy is used in its usual sense here, with the prime example being food or other sustenance. Information is used here in its formal information theory sense (Shannon, 1948) of patterning or reduction of uncertainty; i.e., the type of information that is measured by bits. Information is thus not the same as meaning, which can be thought of as the effect of information upon its receiver. Meaning is an important variable in LST, and it will be further discussed in Chapter 4. The above distinctions are not intended to imply that matter-energy and information are separable entities; they always occur together (matter-energy is ordered by information). Information is always transmitted on matter-energy markers; for example, the marks on this sheet of paper. However, systems' inputs and outputs can be categorized as to whether their prime importance is based upon their matter-energy or information content.

Another critical attribute of living systems, and one dependent upon their openness, is their ability to combat entropy. Entropy can be conceived of as the negative of information, or the state of disorder, lack of patterning, or randomness. According to the second law of thermodynamics, a system tends to increase in entropy over time. Nonliving systems cannot battle the increase of entropy (e.g., rotted flesh cannot rejuvenate), but living systems can, at least for a short period of time. The processes by which they do this are an important part of LST. Living systems can grow rather than decline by taking in matter-energy and information. They can also maintain steady states (or homeostasis) of their critical variables by achieving orderly balances among their parts and with other systems. For example, a growing forest takes in energy from the earth and the sun and a balance is maintained among the many living systems in it. The multitude of variables in a living system have a range of stability, or a range within which a steady state can be maintained. Inputs or outputs which move variables out of stability ranges are stresses, and they are countered by various adjustment processes to reinstitute the steady state. The human body's mechanisms for monitoring its state and combatting diseases are examples of these processes. In order to maintain steady states, lviing systems use feedback, or output monitors. Negative feedback maintains steady states in systems by correcting deviations from the stability range; a common example is a thermostat. Living systems thus combat entropy or decay by using feedback and adjustment processes to control variables within established ranges of normality.

Other general attributes, too numerous to cover in detail here, can be used to describe living systems. They have a template or charter delineating their structure and process. They have specific critical subsystems which must be integrated together to perform the necessary processes (these are described in detail in a later section of this chapter). They can exist only in certain types of environments, and cannot adjust to extreme environmental stresses. This list could be extended, but a more important distinction for present purposes is that between the structure and process of living systems. The structure of a system is the physical arrangement of its parts at any given point in time. Structure is thus defined in terms of three-dimensional space. Components are discrete physical parts of the structure, which may or may not be systems in themselves. An example of the structure of components is the typical hierarchical organization chart. Process, on the other hand, is defined in terms of the dimension of time. It is change in the system over time, which includes growth and decline. An example of process is a computer flow chart laying out functions to be accomplished sequentially. Study of systems has often concentrated upon the study of structure rather than process. For example, at our present state of knowledge, describing the structure of a human body standing still can be accomplished in great detail, but describing all the processes involved in that body's walking across a room is another matter. One of the strengths of LST is that it allows for the integration of both structure and process. This will be further delineated in later sections.

Levels of living systems. Living systems can be classified in a hierarchy of levels, with systems at each being composed of systems at lower levels. Seven basic levels are proposed in LST: cell, organ, organism, group, organization, society, and supranational systems. The identification of these levels is based primarily upon an evolutionary perspective. All higher levels of living systems developed from early unicellular forms of life. As living systems became more complex through evolution, system processes were shredded out to multiple components, leading to the need for increased integration. A free-living cell carries out all its essential processes, but in an organism processes are shredded out to various organs. Beyond the level of individual organisms, LST views the development of groups, organizations, etc. as products of natural evolutionary growth.

All systems within our purview are parts of larger systems. Cells join together into organs, and organs make up organisms. Groups are composed of organisms, and organizations have groups and perhaps individual organisms as components. Societies and organizations have in recent times joined together to form supranational systems. The larger system of which the system being addressed is a part is called its suprasystem. The immediate environment of a system can then be defined as the suprasystem minus the system itself.

Miller and Miller (1979) point out that the levels of living systems are not completely distinct. Organizations sometimes resemble face-to-face groups. Communities or regions sometimes function between the organization and society levels (Bolman, 1967). Arguments for distinctions between various levels are generally not worth pursuing here. The important concern for LST is whether formal identities or isomorphisms can be identified between different levels and types of living systems. However, before this question can be addressed it is necessary to refine one interlevel distinction of LST of particular concern in this paper; i.e., the difference between groups and organizations.

The fundamental distinction between groups and organizations in LST is that organizations have formal echelons of decision-making responsibility, while groups do not. An echelon is not the same as a level. Echelon is defined only with respect to decision-making, and is used in the sense of military chain of command. That is, echelons are components within a system which make different types of decisions or different parts of an overall decision. A tank crew can thus be classified as a group since there is only one formally recognized primary decision-maker, the tank commander. A tank platoon, on the other hand, can be considered a small organization since the platoon leader, platoon sergeant, and tank commanders all have formally recognized decision-making responsibilities.

Subsystems. One of the central postulates of LST is that 19 subsystems are essential for the survival of a living system at any level. A subsystem is a component or group of components that carry out a particular process in a system. It differs from a component in that it is a system in itself, whereas a component may not be (i.e., a subsystem has 19 critical subsystems). The processes carried out are those which keep system variables within their steady state ranges. In complex systems, one or more subsystem processes may be carried out for a system by another system which is not part of it; such subsystems are said to be dispersed either upwardly to a higher level system or downwardly to a level below a system's own subsystems. For example, organs disperse the process of reproduction upwardly to the level of the organism. The only process which cannot be dispersed to another system is decision-making; a living system ceases to independently exist if it cannot make decisions. Subsystem processes can also be laterally dispersed, if they are accomplished by several components of the system, which together make up the subsystem. A subsystem may thus consist of a group of components, and components may be involved in more than one subsystem. As systems become more complex their subsystems are more difficult to identify, but they are critical and identifiable at all levels according to the LST framework.

The 19 subsystems are listed and briefly described below, using variations of definitions provided by Miller (1978). The first two process both matter-energy and information, the next eight process matter-energy, and the last nine process information. Examples of components involved in each subsystem are provided from the group or organization level of living systems. Further examples and descriptions of subsystems can be found in Chapter 3.

1. Reproducer - the subsystem which can produce another system similar to the one it is in. It differs from all other subsystems in that it is critical for the continuance of the species or type of living system rather than for the individual systems involved in the process. The most common example at the group level is a male and female joining in a mating dyad. At larger group and organization levels, this process is generally accomplished by development of a charter or other type of template. It is important to note that this subsystem accomplishes the reproduction of an entire system, and not the replacement of individual components within a system.

2. Boundary - the physical (and perhaps psychological in some cases, see Baker and O'Brien, 1971) perimeter which defines the system. It holds together the components of the system, protects them from environmental stress, and excludes or permits entry of matter-energy and information (serves as a filter). Examples are a sergeant at arms and guards patrolling the fences and gates of an organization's property.

3. Ingestor - the subsystem which brings matter-energy (resources and materials) across the system boundary from the environment. In a group this may be accomplished by an individual bringing coffee or supplies. Most organizations have ingesting components designated as procurement or receiving departments.

4. Distributor - the subsystem which carries matter-energy inputs from outside the system or outputs from other subsystems around the system to each component. This involves the distribution of supplies and resources that have been ingested or produced by the system. Truck drivers and supply clerks are components involved in this activity at the organization level.

5. Convertor - the subsystem which changes matter-energy inputs into forms more useful to other parts of the system. The prime example of this at the group level is components involved in the pre-cooking preparation of food (e.g., butchering). For organizations this process may be accomplished by subsidiary groups operating oil refineries, electric generating plants, slaughter houses, etc.

6. Producer - the subsystem which makes products or artifacts (man-made inclusions in a system) needed by the system itself or other systems. Matter-energy is taken from the ingestor or distributor and used to synthesize lasting materials for growth, damage repair, or replacement of the system's components. This subsystem also provides the energy for moving the system's outputs of products or information markers out of the system. Examples include components involved in cooking of food, factory production, maintenance and repair of equipment, and permanent buildings construction.

7. Matter-energy storage - the subsystem which retains deposits of matter-energy for future use by the system. A member of a group may use a refrigerator or locker for this function, and organizations have components who maintain stock rooms, fuel storage tanks, etc.

8. Extruder - the subsystem which removes matter-energy, either as products or waste, from the system. A system has purposes or goals to transmit over its boundaries sorts or matter-energy which the supra-system lacks; these are products. Wastes are sorts of matter-energy which are excess to the system and do not contribute to the accomplishment of its purposes or goals. Examples of extruding are cleaning crews, sewage disposal units, delivery trucks and drivers, and crews manning trains, barges, or other delivery systems.

9. Motor - the subsystem which moves the total system or parts of it. This may be accomplished by moving crews and may be dispersed in organizations so that individuals or groups (car pools) use their own independent motor subsystems.

10. Supporter - the subsystem which gives structure to the system and maintains the proper spatial relationships among its parts. This allows the components to interact without crowding or weighting down each other. Components involved in this process include building managers and designers, using artifacts such as walls, tables, chairs, etc.

11. Input transducer - the subsystem which brings information markers across the boundary into the system and changes them into forms suitable for transmission within it. This process may change the form of the matter-energy marker bearing information (for example, a phone conversation may be written down on paper), but does not change the code or language of the information. Examples include military scouts, telephone operators, personnel distributing mail, and intelligence gathering units.

12. Internal transducer - the subsystem which monitors information markers received from subsystems or components within the system and changes them into forms transmittable within it. This subsystem performs the same function upon markers from internal sources that the previous one does upon markers from external sources. This process may be accomplished by a group ombudsman or sensor of group changes, and by an internal inspection or auditing unit in an organization.

13. Channel and net - the subsystem which transmits markers bearing information to all parts of the system, without changing the information. This may be accomplished over a single route (channel), or may require a set of routes interconnected at nodes to form a net. In groups communications are usually conducted through the air using the propagation of light and sound, but telephones, radios, etc. may be involved.

14. Decoder - the subsystem which changes the code or language of information from the input transducer or internal transducer into a code usable internally by the system. That is, the public code is transformed into a private code (if necessary). This may involve consulting some sort of thesaurus or other translation guides. Examples at the group and organization level are components which translate languages, decipher secret messages, interpret intelligence data, and interpret directives and regulations.

15. Associator - the subsystem which forms enduring associations, patterns, or relationships among items of information in the system. This is the first stage in the learning process, in which private organizations of knowledge are formed. The information used in associating may

come from the input transducer, the internal transducer, or the memory (see below). In this process relationships are perceived and alternatives are developed for input into decision-making. According to LST, associating does not occur at group or organization levels, but is dispersed to individual members.

16. Memory - the subsystem which stores information in the system for various periods of time. This represents the second stage of the learning process, and includes the capability to retrieve stored information. Examples include filing sections, librarians, and computer operators.

17. Decider - the executive subsystem which receives information inputs from all other subsystems and transmits information outputs that control the system. As mentioned earlier, this is the only subsystem which cannot be dispersed to another system; if another system did the deciding, then the system controlled would be a subsystem of it, by definition. However, this process can be laterally dispersed within a system; i.e., decision-making can be decentralized. A decider differs from a node in a channel and net in that the former reduces the amount of (or degrees of freedom in) information, whereas the latter just passes information on. Examples of components performing the decider process are a group leader and the headquarters or executive office of an organization.

18. Encoder - the subsystem which changes information from the system's internal code to a public code understandable by other systems. This process is thus the inverse of decoding. Examples of organizational

components involved in this process include speech writers, lobbyists, and advertising departments.

19. Output transducer - the subsystem which outputs information markers from the system in a form transmittable in the environment. It thus transmits information in the opposite direction from that transmitted by the input transducer. Components which may be involved include radio operators, public relations departments, and news-releasing agencies.

The interactions of the 19 subsystems are not adequately described in the above unidimensional discussion; obviously, a great deal of integration among subsystems is required. The subsystems' descriptions indicate that certain pairs of subsystems are functionally equivalent; that is, one performs essentially the same process upon matter-energy that the other does upon information. The functionally equivalent sets are ingestor and input transducer, distributor and channel and net, convertor and decoder, producer and associator, matter-energy storage and memory, and extruder and motor combined with output transducer.

The 19 subsystems proposed by LST represent a biologically-based model. The subsystems are relatively easy to conceptualize at the level of the human organism, but this is more difficult at higher levels, such as the organization. The basic assumption or assertion of LST is that the same biologically - based processes must occur at all levels of living systems. The extent to which different types of open systems maintain the same organization of structure and process has been a previous subject of study in general systems theory (for example;

Laszlo, 1972). LST makes a strong assertion in this regard which can only be tested by careful research across levels. Basic questions which must be addressed include whether the 19 subsystems can be identified and are critical for various types of living systems, and whether other critical subsystems exist. Miller (1978) states that the 19 subsystems are a minimal set and others may exist, but it is doubtful that they are critical. Other subsystems can be conceptualized, such as an information processing equivalent of the supporter which might be considered a motivator, and may be critical for certain types of systems. Considerations such as these are further addressed in Chapter 6.

Variables and hypotheses. In every living system a large number of subsystem and system-wide variables fluctuate continuously. As described above, adjustment processes work to keep one or more variables in a steady state within a normal range of stability. Approximately one dozen variables per subsystem are suggested by Miller (1978), and they can be categorized into six classes: matter-energy input, internal, and output variables and information input, internal, and output variables. Examples of representative variables within the LST framework include meaning of information processed, sorts of matter-energy processed, changes in matter-energy or information processing over time, lag or delay in matter-energy or information processing, distortion (systematic change) in information processing, rate of matter-energy processing, and cost (time and effort) of information processing. Most of the variables can be measured by some instrument or technique, called an indicator.

Variables can be measured via indicators at each of the levels of living systems, and variations in single variables or interactions of two or more variables can be compared across levels to identify cross-level formal identities.

An important part of LST is the development of cross-level hypotheses concerning identities between various levels of living systems. Such hypotheses give the theory predictive in addition to descriptive power. The central cross-level hypothesis of LST has been described above; i.e., that 19 subsystems are critical for survival at each level of living system. Miller (1978) has provided an additional set of 173 cross-level hypotheses which are supported to varying degrees by experimental evidence. The hypotheses are categorized either as systemwide or as having applicability to specific subsystems, and each is proposed as being true for at least two levels of living systems. Example hypotheses paraphrased from Miller (1978) are that higher level systems have a higher cost per correct information unit processed, two or more systems which interact become alike in storing and processing common information, association is slower for higher level systems, and conflict is more likely among subsystems or components as resources become less available.

The measurement of the effects of variables by use of indicators and the development of cross-level hypotheses provides a means for moving from observation to generalization in LST. Research on cross-level hypotheses is badly needed, since many of the ones suggested by Miller (1978) are supported with only a small amount of evidence, and numerous additional hypotheses can be developed (see Gall, 1975). Suggestions on moving in this direction are provided in the present paper; variables and indicators for tank crews and platoons are discussed in Chapter 4, and cross-level hypotheses having relevance to these types of systems are discussed in Chapter 5.

Application of LST. LST will not have real value unless it can generally be understood and applied. Using any general systems theory it is easy to develop and espouse vague general principles, but developing specific applications is another matter. Miller (1978) has provided a start in this direction by outlining a general strategy for application of LST which closely parallels the approach to medical diagnosis and treatment. First, it is necessary to identify the 19 critical subsystems in whatever level of system that is being analyzed. Then the important variables, both system-wide and within each subsystem, are identified and indicators are found or developed to measure the states of those variables over time. These measurements are used to determine the normal steady-state ranges for each variable and the interrelationships of variables. A systematic diagnosis is then performed, looking at the pattern of normal and abnormal findings, to discover what is pathological or malfunctioning in the system. Examination of all the abnormal variables together may lead to conclusions about the state of the system and the reasons for it. Then the structure or process of the system can be modified to bring it back to a healthy or normal state. A general preventive model for applying LST can also be outlined. The indicator readings can be used to design systems so that environmental stresses do not move important variables outside their normal ranges for long periods of time. Living systems can thus be optimized in terms of subsystem structure and processes and adjustment processes.

Several general applications of LST have been considered, and these are discussed in detail in Chapter 6. Not a good deal of cross-level research has been conducted, with the most extensive effort being information input overload research described by Miller (1978). The present paper does not represent a search for and summary of cross-level systems research in the Army, but rather represents an attempt to carry out some of the steps in the application of LST within a specific military context. The 19 critical subsystems are identified in tank crews and platoons, and important variables and corresponding indicators are discussed. In addition, selected cross-level hypotheses which appear to have particular relevance to these types of systems are discussed, in order to provide an initial assessment of the potential payoff of LST for the Army.

CHAPTER 3 - TANK CREW AND PLATOON SUBSYSTEMS

The US Army is a large organization made up of numerous echelons. With respect to armor units, these echelons include individual soldiers, crews, platoons, companies, battalions, brigades, and divisions. For purposes of the present paper, tank crews and platoons are analyzed as living systems at the group and organization levels (as defined in Chapter 2), rather than as echelons in the larger, more complex system. One of the higher echelons (the armor battalion) is currently being analyzed within the LST framework by the University of Louisville's Systems Science Institute. Results of that project in combination with the present paper will provide a comprehensive view of the application of LST within the context of armor units. The initial step in the application of LST, the identification of the 19 critical subsystems in terms of the structures and processes of crews and platoons, is undertaken in the present chapter following brief descriptions of the units and situations being addressed.

Tank crews consist of four individuals whose basic mission, as described in Field Manual (FM) 17-12, is to engage and destroy targets quickly with a minimum expenditure of ammunition. Tank platoons consist of five tanks whose crews are to accomplish this mission in a coordinated manner using platoon operating procedures and fire plans. Since opportunities to engage and destroy targets do not arise frequently in peacetime, crews and platoons have many related missions to accomplish. Primary among these are training and maintenance, but a variety of administrative and support missions (which may, unfortunately, distract from training) also frequently arise. The scope of the present paper does not allow description and analysis of all the missions and situations in which crews and platoons may be involved in peacetime. Therefore, the analysis is limited primarily to those processes occurring during target engagement training and qualification exercises, such as gunnery qualification on Tank Tables VIII and IX. The analysis is also limited to M60 series tanks, the currently most common type in the field.

As described in the most current version of FM 17-12, the tank gunnery qualification program is designed to develop and test proficiency of tank crewmen in individual, crew, and platoon gunnery techniques used to destroy all types of targets, under as realistic battlefield conditions as possible. Tank tables are a progression of gunnery training exercises using devices such as scaled ranges and subcaliber firing, eventually leading to firing of live ammunition in the main gun (105 mm) for qualification. Tables I-VII prepare the crew for Table VIII (crew qualification) and the platoon for Table IX (platoon battle run). While it is recognized that training is a continuous activity, range and ammunition availabilities generally restrict the firing of qualification tables to an annual basis. Other tables and gunnery training devices are used throughout the year to hopefully provide for the training and retention of skills. Table VIII is fired on a tank combat course using machinegun and main gun ammunition, and in order to qualify crews must perform seven of ten engagement tasks satisfactorily. The tasks involve the engagement of single and multiple tank, tank-like, and other targets using appropriate ammunition within specified time limits (for example, hitting three stationary tank-like targets within 30 seconds). Crews are rated on target hits, engagement times, and ammunition conservation (hitting some targets on first round, thus saving allotted second round), and are critiqued on use of terrain. Tank platoons fire Table IX using main gun and machinegun ammunition, and in order to qualify they must hit 70% of the targets within specified time limits and must perform satisfactorily in several subjectively evaluated areas, including control of fire, reporting procedures, movement techniques, and ammunition conservation. Processes occurring during Tables VIII and IX are further delineated in subsystems' descriptions below, following brief descriptions of the structures and duties of tank crews and platoons.

A tank crew is a team of four individuals: the tank commander (TC), gunner, loader, and driver. The TC is the senior man in the tank (usually a staff sergeant, E6), and he controls its movement and the firing of its guns. He is, in general, a first-line supervisor directly responsible for the training of his crew and the maintenance of his tank, but his target engagement duties are of prime interest here. These include target acquisition and designation, determination of ranges to targets, issuance of fire commands, and observation and adjustment of fire. He may also fire and adjust the main gun from his position if the gunner cannot identify the target, and fire the machinegun mounted at his station (in the tank turret). The gunner fires and adjusts fire of the main gun and coax machinegun, and he is also responsible for tank turret maintenance. During target engagement he turns on necessary switches, indexes appropriate ammunition into the fire control system, identifies targets, takes appropriate sight pictures, and fires and adjusts as appropriate. The loader selects and loads ammunition announced by the TC in initial fire commands. He is also responsible for servicing the main gun, coax machinegun, and ammunition. He stows ammunition in the tank according to the stowage plan, loads the main gun and coax machinegun, applies misfire procedures to the main gun when necessary, and corrects malfunctions in the coax machinegun. The driver maneuvers the tank in the engagement area and is responsible for its automotive maintenance. He finds routes and firing positions which use terrain features to provide maximum protection from enemy fire, and he starts and stops smoothly on command. The importance of a tank crew functioning as a team cannot be overemphasized. Crew members must perform their own duties automatically, and they must be familiar enough with other members' duties so that they can perform them, if necessary. All members of the crew must also assist the TC in acquiring targets and in observing and sensing rounds fired. The integration of man-machine components is crucial to the survival of this living system.

The tank platoon provides an example of the critical need for teamwork at the level of a small organization. A platoon consists of five tanks, each with four crew members as described above. The TC in one of the tanks is a lieutenant serving as platoon leader, and the TC in another tank is an E7 platoon sergeant. The movement and firing of each tank is controlled by its TC, and the platoon leader distributes fire and controls movement of the entire platoon. The leader is thus faced with the double duties of controlling the platoon while commanding his own tank (he also has other duties, such as serving as a forward observer for the artillery system). Platoon operations must be well rehearsed so that firing can be initiated before the platoon is fired upon, and so that most dangerous targets can be engaged first while others are being suppressed. Platoon offensive and defensive fire plans provide the platoon leader with the necessary information to distribute and control platoon firing. Platoon fire commands must be brief and concise; communications among the platoon's echelons are very important, but procedures must be rehearsed well enough to allow fast reaction times to engage targets accurately in the absence of orders. The platoon must function as a team, with members capable of anticipating the actions of others.

The target engagement processes of tank crews and platoons are further described below, in the context of the 19 critical subsystems prescribed by LST. The descriptions are necessarily brief, and do not cover all contingencies and details which might arise. However, they do provide an initial framework for understanding all structures and processes of tank crews and platoons; the utility of this framework for guiding research and improving operations is assessed in later chapters.

1. Reproducer. This subsystem does not exist at the levels of tanks crews and platoons; neither a crew or platoon can reproduce itself.

Individual crew members and equipment components can be replaced (as part of the ingestor or producer subsystems), but intact crews and tanks cannot be created. During gunnery qualification tables, crews and platoons which cannot complete the course are rated unqualified. Qualified units cannot be obtained, except through continued training of existing crews and platoons. The reproducer subsystem is upwardly dispersed, at least to the level of division replacement. In the event of war, during the early stages of which it is anticipated that many crews and platoons would be lost, the reproducer process must be performed by the reserve system. It seems probable that a currently significant pathology of the overall military system is the lack of an adequately responsive reserve force. The reproducer process of military units is ultimately upwardly dispersed to the level of society, since Congress and the public provide the manpower and funds for replacement and reserve units. The bureaucracy involved in dispersal to this level probably prohibits the effective performance of such a reproducer process within the timeframes of modern warfare. The fact that this subsystem is critical for survival of the species sufficiently emphasizes the severity of this problem.

2. Boundary. The boundary of a tank crew is easily defined as the hull, turret, and cupola of the tank occupied. During Table VIII, all crew operations are performed within this perimeter. During wartime operations, this boundary may be somewhat extended, since individual crew members may leave the tank to scout, detect targets, or prepare firing

positions (the possibility of components leaving the boundary of a system is not specifically addressed by LST). The importance of this subsystem during wartime is obvious, since penetration of the boundary by hostile fire usually means the death of the system. The boundary is maintained by keeping hatches closed, by using terrain features for protection during movement, and by firing from hull-down or turret-down (partially exposed) positions. For platoons, the boundary can be considered as downwardly dispersed to individual tanks. It could also be defined in a less precise physical sense as the platoon sectors of fire or area of responsibility but the former definition seems to be more appropriate within the strict LST framework.

3. Ingestor. The matter-energy ingested by tank crews and platoons includes ammunition, fuel, water, food, and maintenance items (firing pins, flashlights, cleaning kits, etc.). These items are provided by the battalion supply system (S4) and are ingested (brought across the boundary) by various means. Fuel is ingested through hoses, ammunition is ingested through a hatch by the loader and other personnel, and food and water are brought in by individuals in canteens and rations. This process is thus to a large extent downwardly dispersed to individuals or outwardly dispersed to other personnel. During Tables VIII and IX, ingestion is accomplished prior to the exercise.

4. Distributor. The best example of the distributor process in tank crews and platoons is the stowage of ammunition in racks and the loading of the main gun and coax machinegun by loaders. The type of

target anticipated may dictate a type of ammunition to be preloaded in the main gun (termed battlesight ammunition), and, at the platoon level, anticipation of a variety of targets may dictate the preloading of different types of ammunition in different tanks. During target engagement the types of ammunition to be loaded are specified as an element of fire commands. Ammunition is placed in racks by loaders as directed in anticipation of the types of targets to be encountered. Other examples of the distributor subsystem in tanks include the distribution of matter-energy via fuel lines and electrical circuits.

5. Convertor. This process does not occur extensively in tank crews and platoons, since it is largely outwardly dispersed; i.e., matter-energy is provided to these systems in a useable form. Components to which conversion is dispersed include ammunition manufacturers, ration preparers, fuel refineries, etc. Examples of the occasional occurrence of this process at the tank crew level include the setting of detonation time on a certain type of anti-personnel ammunition (BEEHIVE) by the loader, and the heating of rations.

6. Producer. The primary product of tank crews and platoons is fire-power (steel on target). This is generally produced using the main gun by the TC issuing fire commands, the gunner laying on target and firing, and accomplishment of the firing sequence by the weapons system (detonation of ammunition charge in the breech). Firepower may also be produced by the TC or gunner firing their machineguns. Other products of tank crews and platoons include smoke for masking movement, and illumination

of targets by use of searchlights or flares. Maintenance processes are also included in the producer subsystem; prepare-to-fire checks (sight purging check, computer check, rangefinder check, etc.), misfire procedures, and light maintenance tasks are performed by tank crews, while heavier maintenance tasks are dispersed to full-time maintenance personnel. Individual personnel replacement can also be considered as part of the producer subsystem, and it is upwardly dispersed from the crew and platoon levels, ultimately to the personnel assignment system (Military Personnel Center). The important role of crew and platoon personnel in incorporating and training new members should not be overlooked, however. The producer processes of tank crews and platoons are thus largely either outwardly dispersed or accomplished at the crew level; platoons disperse producing to crews in a coordinated fashion (e.g., one tank may provide illumination while others fire).

7. Matter-energy storage. Matter-energy is stored at the level of tank crews in ammunition racks, fuel tanks, batteries, water cans, etc. No matter-energy storage per se takes place at platoon level; the process is downwardly dispersed to individual tanks and crews, or outwardly dispersed to other units in the battalion. Components involved here include the supply, mess, and transportation sections of the battalion support platoon.

8. Extruder. The principal products of tank crews and platoons are removed from these systems thorugh the main gun tube and machine gun barrels. Extruding for platoons is thus downwardly dispersed to individual

tanks and crews (TC's, gunners, and loaders). Empty shell casings and other waste materials are kept on tanks during exercises such as Tables VIII and IX and are disposed of through hatches at appropriate later times. Cleaning of tanks is accomplished by individual crew members.

9. Motor. At the crew level this subsystem obviously includes the tank driver, engine, track, and other parts responsible for the movement of the tank. The TC may also be included, since he provides direction to the driver. The turret and gun elevation system are also parts of the motor subsystem, since they are involved in movement of parts of the tank. Thus all crew members, except perhaps the loader, are involved in the motor process. The motor subsystem for platoons is downwardly dispersed to the level of crews, since there are no platoon vehicles or movement independent of the five tanks. In Tables VIII and IX the primary motor function may be simplified to following a well-worn pathway; in actual combat it is a complex process, involving the use of terrain features for protection and the selection of optimal firing positions. In platoons the motor process must be coordinated among five tanks; for example, bounding overwatch techniques may be used, in which part of the platoon moves while the rest provides protection.

10. Supporter. In a physical sense the supporter process is governed by the interior design of the tank. Each crew member has an assigned position within the tank, and movement is restricted by the limited space available. For example, the loader has a limited operating area and he must stay clear of the recoil pathway of the main gun. This

supporter process for platoons is downwardly dispersed to individual tanks. In a more abstract sense, the supporter subsystem is provided by command or leadership. The TC commands crew members to remain at their positions and accomplish specific tasks. One of the most important roles of the platoon leader is to maintain the proper spatial relationships among five tanks. Terrain features also play a role here. In LST the supporter subsystem is described in a physical sense; whether command or motivational support belongs here or elsewhere is a subject of later discussion.

11. Input transducer. Information is brought across the boundaries of crews and platoons in various ways. The TC receives instructions from higher echelons through the tank's radio, as does the platoon leader. These communications are primarily received from the next higher echelon (platoon leader or sergeant to TC, company personnel to platoon leader), but other radio frequencies may be monitored to provide additional information. During Tables VIII and IX, instructions are received from exercise controllers or scorers. Crew members acquire information used to detect, locate, and identify targets by observing the environment, with or without using sights. Each crew member has a clearly delineated sector of observation responsibility whether on a lone tank or as part of a platoon. Scanning is done continuously, first with unaided vision, then with magnified optics, searching strips 50 meters deep from right to left. Target acquisition information may also be obtained from dismounted observers equipped with binoculars and communications to the crew or platoon. The sense of hearing, as well as vision, is important in this process.

Targets can be located at night using night vision devices or indirect illumination. The range to located targets can be determined by the TC using a rangefinder or other range estimation techniques. During target engagement, all crew members assist the TC in observing and sensing the effects of rounds fired. Information markers may also be brought onto tanks by individual crew members carrying training aids, checklists, etc. For example, the driver may post a card detailing starting and stopping procedures in the tank where he can easily see it. All crew members are thus involved in the input transduction process, and this process for platoons is largely dispersed to crews and individuals.

12. Internal transducer. The TC has primary responsibility for the process of monitoring information from within a tank crew, but all crew members are involved to some extent. The driver monitors gauge and instrument readings and changes them into verbal form for communication to other crew members or written form for recording in the vehicle logbook, as necessary. The gunner monitors the state of various switches, sights, and other parts of the fire control system. The loader selects appropriate types of ammunition based on shape and color, and observes for weapons' misfires or stoppages. The TC monitors the performance of the other crew members; for example, he observes the route selection and starting and stopping procedures of the driver, the ammunition selection and response of "up" by the loader, and the target acquisition by the gunner. If he observes that the gunner cannot identify and acquire a target or adjust fire correctly, he takes appropriate action to correct him or override

his controls. All crew members thus continuously observe the state of each other and the tank and change their observations into appropriate verbal communications or actions. The same sorts of internal monitoring are carried out at individual and crew levels within a platoon. In addition, the platoon leader and platoon sergeant must monitor the states and positions of the other four tanks by visual observation and radio communications.

13. Channel and net. The primary communications channels in a tank crew are verbal ones using the intercom system; similarly, in a tank platoon FM radios are used. Flares, flag sets, arm signals, or other prearranged communications may also be used in a platoon in particular circumstances. In future warfare it is anticipated that jamming may lead to effective elimination of the channel and net subsystem. Since all subsystems are critical for system survival in the LST framework, alternative means of communication must be found. Platoons cannot be trained to perform satisfactorily in all situations without communications.

14. Decoder. Information is changed into internal codes or language in tank crews and platoons primarily through the issuance of fire commands by the TC or platoon leader. In general, the initial fire command issued by the TC consists of six elements (in practice, only four elements are frequently used). The first element alerts the crew of an immediate engagement (e.g., "gunner"). The second element informs the crew what ammunition and weapon is to be employed, and if the searchlight will be used (e.g, "HEAT"). The loader loads the specified ammunition in the main

gun, if necessary, and responds "up". The third element describes the type of target to be engaged (e.g., "tank"), and the next two elements specify the direction and range of the target (e.g., "direct front, one thousand"). After the gunner has indicated that he sees the target (announced "identified"), the TC gives the execution element ("fire") and the gunner announces "on the way" and fires. The TC may delay firing by announcing "at my command", and he may override the gunner and fire the round himself by announcing "from my position". The gunner continues to fire and the loader continues to load until the TC announces "cease fire". Subsequent fire commands may include standardized announcements of sensings of rounds (where round went in relation to target) and corrections of the sight picture (where gunner is aiming). There are many other details and considerations in fire commands that cannot be listed here; the important point is that a tank crew has an extensive internal language primarily controlled by the TC. The platoon leader issues similar fire commands to all tanks in the platoon, with appropriate designations for individual tanks and the entire platoon, and elements for control of the pattern of fire. There are many instances, other than fire commands, of decoding in crews and platoons; for example, the TC decodes information into instructions for the driver, and the platoon leader provides movement instructions to TC's. Crew members other than the TC may perform decoding by announcing observations of targets, sensings of rounds, etc. Similarly, at the platoon level, TC's may decode information and provide it to the platoon leader in a standard format. Decoding is a frequently occurring process in tank crews and platoons, and it must be well enough practiced to occur rapidly (automatically) during target engagement. TC's and platoon leaders have a prime responsibility for decoding, but all crew and platoon members are involved to some extent.

15. Associator. This process of forming associations as input to problem-solving does not occur at crew and platoon levels, but is downwardly dispersed to individuals. Hopefully, during exercises such as Tables VIII and IX individuals are learning (developing associations) to perform their duties better and more rapidly. They are also learning to function together as a team, but from the LST perspective this represents individuals learning to work with other individuals, and not group learning per se. The extensive personnel turbulence ongoing in crews and platoons would seem to be a great inhibitor of this associating process. An example of associating during target engagement is target recognition by the TC or gunner; i.e., an object of a particular size and shape is observed and recognized as a dangerous enemy target to be fired upon. The incoming sensory information is thus associated with information stored in the individual's memory, and appropriate responses are made. Other examples include the TC's or platoon leader's assessment of the situation by evaluating target threats, routes, etc.

16. Memory. Information storage in crews and platoons is largely dispersed to the level of individuals; i.e., members bring information into the crew or platoon based upon their past training or experience.

Examples of information storage by the crew are the entering of items (zero readings, gun tube wear, vehicle mileage, etc.) in the vehicle logbook and the preparation of range cards. An example of memory at the platoon level is the writing and use of platoon standing operating procedures (SOP's) and platoon fire plans. The platoon leader retrieves the necessary information for distributing and controlling fire from the fire plan. During Tables VIII and IX part of the memory process is outwardly dispersed to an observer or scorer, who records the results of the crew's or platoon's target engagements. Of course, a large portion of crew and platoon information storage is outwardly dispersed to preparers of technical manauals, field manuals, and other documents. Use of such institutional memory hopefully prevents units from having to reinvent the wheel too many times.

17. Decider. While all crew and platoon personnel are involved in making decisions to some extent, primary responsibility for this process resides with the TC and platoon leader. During Table VIII the TC decides which targets to engage in what order. During Table IX the platoon leader decides how to distribute the tanks and how to distribute and control their fire. Gunners may make decisions about adjustment of fire and drivers may make decisions between routes to be taken, but they do so under the direction of the TC. Decision making in these military units (as in most) is thus highly centralized within the component formally recognized as leader. As discussed earlier, the TC's and platoon leader represent echelons of decision making in a platoon, thus leading to its categorization as an organization.

18. Encoder. Information is normally prepared for external transmission from the crew by the TC and from the platoon by the platoon leader. This may involve some consolidation of information, but normally little encoding is necessary since higher Army echelons generally use the same codes as crews or platoons. In combat situations TC's or platoon leaders may encode information on fuel status, ammunition status, enemy movements, targets destroyed, etc. In Tables VIII and IX the encoding process is to some extent outwardly dispersed to observers.

19. Output transducer. The TC and the platoon leader normally use radios to output information from the crew and platoon, respectively. The types of information output in combat situations are generally those listed under encoding above. Output transducing is not an important process during Table VIII, but reporting procedures are evaluated during Table IX.

The above descriptions of subsystems' structure and process in tank crews and platoons are short and simplistic, and are intended only as a start toward a complete living systems analysis. A thorough description of tank crew and platoon operations from an LST perspective is not an easy task to accomplish; it requires a basic understanding of LST and a thorough knowledge of the duties of the units being described. Many of the distinctions made in LST (e.g., that between the internal transducer and the decoder) are difficult to maintain when one moves beyond the physiological (organism) level to group and organization levels. Many of the activities of crews and platoons are complex and involve the interaction of several LST processes, making it difficult to break them apart into clearly delineated subsystems. One must often relate a component or an activity to the subsystem it involves the most, realizing that other subsystems are involved to some extent (e.g., the loader is primarily a distributor, but he also makes decisions, decodes, etc.). Each subsystem has 19 subsystems; the living systems analyst must keep clearly in mind the level of system he is describing, or he will be describing subsystems ad infinitum. Despite these difficulties, the above initial attempt indicates that tank crews and platoons can be described within the LST framework. The 19 subsystems are identifiable, and readers familiar with the operations of crews and platoons could add more detail and accuracy to these descriptions.

Several general observations about tank crews and platoons can be made from the above analysis. Many of the subsystems of crews and platoons are outwardly dispersed, particularly in restricted contexts such as Tables VIII and IX. Examples of this include the reproducer, converter, and memory to some extent. The ramifications of such dispersal need to be further considered from a living systems point of view. The degree of dispersal demonstrates the complexity and interdependence of the total military system. Some subsystems of crews and platoons are downwardly dispersed to the level of the individual organism (e.g., the associator). This points out the great need for teamwork and coordination of the activities of individuals in these units. Most of the processes of platoons are downwardly dispersed to the level of crews;

the platoon thus serves primarily as a coordinating organization. These initial observations perhaps point out subsystems to be emphasized in initial living systems research at the levels of crews and platoons. It might be wise to concentrate on subsystems of prime importance and not widely dispersed at these levels, such as the decoder and decider. This initial analysis also highlights the importance of TC's and platoon leaders to their units; they are involved in almost all subsystems, and are the primary deciders. These components are prime targets for initial living systems research; one might expect to find certain pathologies, such as information input overload (decrease in performance as a result of more information than can be assimilated being available), evident in them.

Now that initial descriptions have been accomplished, the next steps in the application of LST will be undertaken in the next two chapters, in terms of discussion of specific variables and hypotheses. The utility of LST for the military will then be further addressed in Chapter 6.

CHAPTER 4 - VARIABLES AND INDICATORS

As briefly discussed in Chapter 2, the application of living systems analysis requires the identification of variables of interest in the system being studied. Variables of concrete systems are observable properties or relationships which can potentially change over time. This change is potentially measurable by use of an instrument or technique called an indicator. Miller (1978) has listed a large number of variables which have relevance to each of the 19 critical subsystems, along with a general discussion of and examples of indicators. Since space does not allow for detailed discussion of variables in each subsystem here, the most common variables which apply to several or all subsystems are briefly described below, followed by discussion of them and their corresponding indicators in the context of tank crews and platoons.

Variables listed by Miller (1978) which are important in all subsystems include sorts or kinds of matter-energy or information processed, changes in processing over time, changes in processing with different circumstances, rate of processing, lag in processing (time between input into system and output from it), and cost (time and effort) of processing. Another variable that is relevant to most subsystems is the percentage of available matter-energy or information that is processed. Variables which relate to all information processing subsystems include the following: meaning of information, distortion (systematic alteration of information, as opposed to noise), threshold (minimal information intensity that will elicit a process), channel capacity (maximum amount of information a physical route can transmit in a specified period of time), and number of information channels. Many other variables which relate to specific subsystems cannot be discussed in the space available here. Examples of these include permeability of the boundary, storage capacity for matter-energy or information, retrieval rate for stored matter-energy or information, information code utilized, and redundancy in information processed. Most of these variables are general and somewhat vague, and they need to be further operationalized in terms of the specific system being studied. This is initiated below for tank crews and platoons, following a brief discussion of indicators.

It is difficult to develop indicators for many of the variables listed above at the group and organization levels. Miller (1978) states that there are few generally accepted indicators which measure group variables. The most commonly studied group variables, such as cohesion, do not have accepted measures with established ranges of normality. More traditionally accepted indicators exist at the level of organizations, but these do not always have established ranges of normality (or relationships to job performance). Included here are personnel indicators (turnover rate, employee satisfaction, etc.), product or service indicators (production time per unit, rate of sales, etc.), financial indicators (profit or loss, indebtedness, etc.), and other indicators (amount of information processed per unit of time, geographic distribution of components, etc.). The development of measures of group and organizational variables is a matter of great importance to the military, and such indicators are discussed below in the context of specific variables. For further discussion of objective indicators in the context of Table IX, see Wheaton, Allen, Drucker, and Boycan (1979). At its present stage of development, LST does not prescribe specific indicators to be utilized, but rather provides a framework guiding their development.

Sort of matter-energy processed. Tank crews and platoons process many sorts of matter-energy, such as fuel, ammunition, repair parts, etc. It is very important to know the sorts which will be processed on various types of missions, so that the appropriate types can be ingested (units can be properly supplied). For example, types of ammunition must be ingested and distributed among the tanks in a platoon in anticipation of the types of targets to be encountered. It is also important to know the sorts of products (combat power) which will be output by various crews and platoons, so that they can be optimally distributed to meet the enemy. Such types of knowledge are largely based upon previous experience and the use of reference manuals. Ranges of normality for sorts of matter-energy to be processed can be established by analyzing missions to be accomplished and drawing upon historical experience to determine success or failure rates of units given various sorts of supplies. However, such institutional memory may be faulty or incomplete in the Army, due to high personnel turnover rates. Indicators are very difficult to develop for Army units, since they never actually perform their primary duties except in time of war. Indicators must be developed for variables in peacetime, with the assumption that these measures can be made to approximate what would happen in a war. For the present variable, an appropriate indicator might be a checklist measurement of whether components responsible for supplying crews and platoons have done so. Such an indicator would be of little value in standardized situations such as Tables VIII and IX, but might be important in exercises or ARTEPs having various missions. The effects of pathologies (indicators out of range) on this variable are obvious; units cannot fight without appropriate matter-energy supplied and produced.

Sorts of information processed. Various sorts of information are processed by tank crews and platoons, including verbal communications coming in and going out over radio or intercom channels, environmental stimuli (target and terrain information) received by the visual and auditory senses, information recorded in logbooks, etc. Some types of information are processed and others are not; for example, targets may be identified when in the open but not when partially masked by terrain features, or targets may be identified at near but not far ranges. An indicator of whether or not a particular type of information is processed would be an appropriate behavioral response measure. For example, does the loader perform the appropriate action in response to an element of the fire command? The pathology of failure to process certain sorts of information is critical; for example, failure to recognize targets or respond to fire commands may mean the death of the system.

Changes in processing over time. This is an extremely general variable since, by definition, variables are relationships which change over time. However, in certain situations change in performance as a function of time may be of prime importance. For example, it is anticipated that future wars will involve intense battles lasting hours or days. Being a member of a crew or platoon should thus not be viewed as an 8-hour a day job, since it may require long periods of continuous performance. Ranges of normality need to be established for the time periods over which crews and platoons can effectively process matter-energy and information. Indicators such as target hit probability, firing rate, and reporting procedures should be examined over long continuous periods of time. Other variables would also be of interest here, such as sleep schedules, drug usage, etc. Pathologies here could lead to failure to sustain combat operations and loss of intense central battles.

Changes in processing with different circumstances. There are many cases where this variable is important to performance of tank crews and platoons. These units must be flexible and adaptable to the dynamics of future battlefields. Situations which may change include the loss of components of crews and platoons, changing tactics on the part of the enemy, and changes in mission priorities. Units are accustomed to changing training mission priorities in peacetime, but current training exercises do not, in general, incorporate the dynamics of modern warfare. The use of engagement simulations and more realistic training exercises, such as those planned for the National Training Center, will help establish ranges of normality for indicators of crew and platoon performance in a variety of changing situations.

Rate of processing. This variable has many important implications for crews and platoons in modern warfare. At what rate can these units process matter-energy to service targets which are arriving rapidly in large numbers? At what rate can they process information without suffering from overload? Such questions must be answered with regard to anticipated future battle situations. Again, ranges of normality can be established by looking at performance indicators (firing rates, speed of decision making) in simulations and realistic training exercises. Obvious pathologies exist if the rate of destroying targets does not exceed their anticipated arrival rate.

Lag in processing. A currently available indicator which is relevant to this variable is opening times for target engagement. Other relevant measures which can be obtained include speed of issuing orders, time to arrive at designated positions, and time to retrieve information from various types of memory storage. Processing lags must be minimized on future battlefields, and this can be accomplished through training crews and platoons to the point where processes are virtually automatic. This variable is intimately related to the previous one; that is, rate of processing per unit of time depends upon lag in individual processes.

Cost of processing. Within the current restricted budget environment, the cost of tank and platoon processing must be minimized. For example, a prime objective of these units in exercises such as Tables VIII and IX is to hit targets with a minimal expenditure of ammunition. Conservation of ammunition is an indicator currently used here. Cost must be minimized on future battlefields, since resources are not limitless. Cost must also be minimized in training programs, which will be difficult if realistic training is conducted considering all the variables described herein. This points out an increased need for reliance upon cost-effective simulators for training. Ranges of normality for the cost of successfully waging modern warfare need to be precisely established for use in budget defense. Costs must also be minimized in terms of the time and effort devoted to processes by crews and platoons, in order to maximize rates and minimize lags.

Percentage processed. The variables of sorts of matter-energy and information processed have been discussed previously. These are all-or-none variables, indicating whether something has been processed or not. In concrete systems such as tank crews and platoons, sorts of matter-energy and information are processed to varying degrees. A more meaningful variable is thus the percentage that is processed. For example, one might examine the percentage of matter-energy that is used for training in target engagement versus that used for support or administrative activities. Or the percentage of information that is processed from various types of target displays or formats of orders might be analyzed. The percentage of rounds expended that hit the target is an indicator that can be used in conjunction with many of the variables discussed herein.

Information processing variables. All the information processing variables discussed earlier have application within the context of tank crews and platoons. Meaning of information is an important variable, but it is difficult to measure within LST or any other framework. It is perhaps best conceived in terms of its effect upon the information's receiver, rather than in terms of anything inherent in the information itself. That is, various types of information are presented to tank crews, and that which affects their behavior, given that it is processed, is meaningful. It is important to determine the most meaningful types of information, in order to improve the efficiency of communications and decision making. Distortion is certainly a relevant variable, since communications interference and deception are anticipated on future battlefields. Distortion in information input to or output from crews or platoons could have disastrous consequences. It is important to know the information processing threshold in many instances; for example, how much of a target must be exposed before it can be recognized and fired upon? Knowledge of the capacity and number of information channels available is also critical to optimizing communications. For example, what is the channel capacity of the platoon leader? Can he effectively pass communications to his own crew and the rest of the platoon during the stress of battle? Can he serve as forward observer for the artillery and efficiently report to higher command? Even this preliminary examination of information processing variables indicates that there are many questions to be answered about crew and platoon processes.

The above discussions illustrate that all the major variables of LST have relevance to the processes of tank crews and platoons. Other variables specific to these sorts of units can be conceptualized within the framework of LST. These include the volume or amount of matter-energy or information available to be processed, the turbulence of components or amount of time that they have been together as a system, the degree of training which the components have undergone together, the time since this training took place, the range over which the system can interact with other systems, and the degree of dispersion of processes to other systems. So LST certainly suggests a large number of variables which are worthwhile to study. But, at its present stage of development, LST is a conceptual framework which provides only general guidance as to how to conduct research on these variables. It suggests that one identify the important variables in a system, develop indicators for them, and determine ranges of normality to use in the identification of pathologies. Adjustment processes to maintain behavior within these norms can then be addressed. The accomplishment of these steps is pretty much left up to the experience and common-sense of the applier. For example, LST does not suggest indicators which are different from those suggested by traditional, common-sense approaches.

So what is the utility of LST in this regard? It provides a comprehensive set of variables whose effects and interactions must be analyzed in order to understand a complex system's behavior. It provides a framework for research by providing guidance as to which variables are important in which subsystems. A more detailed living systems analysis than that carried out in this chapter would lead to many more specific research questions relating to specific subsystems and adjustment processes. It also provides a framework for pulling together various avenues of research on a system and developing a wholistic view of it. LST is thus best thought of as a conceptual binder rather than a specific research tool. It also provides a set of hypotheses which have potential application across various levels of living systems. Selected ones of these are discussed in the next chapter before further evaluation of LST is conducted.

CHAPTER 5 - RELEVANT LIVING SYSTEMS HYPOTHESES

A general systems approach is basically a search for patterns of relationships in systems, regardless of their level or the environment in which they exist (Ericson, 1979). It is a search for formal identities or isomorphisms which have generality across systems' levels or contexts. LST is a general systems theory by virtue of the 173 cross-level hypotheses (propositions which can be empirically demonstrated) proposed by Miller (1978). These hypotheses are proposed as being true at two or more levels of living systems, based upon an extensive literature review and experimental work conducted by Miller and others. Such propositions provide a means for coalescing knowledge gained in various levels and types of systems and for seeing patterns of relationships among them. They give predictive and prescriptive power to LST by addressing issues of systems' design and the resolution of systems' pathologies.

The set of cross-level hypotheses proposed by Miller (1978) is not exhaustive; many more could be developed. It is intended as an initial set, many of which are stated rather simplistically and many of which are supported to only a low degree by the research literature, since little cross-level research has been conducted. The hypotheses are not developed as detailed designs for research, although general designs are proposed for study of selected ones of them. Miller (1978) admits that much work is involved in operationalizing these propositions and empirically testing them at two or more levels of living systems. The initial stages of this process are discussed below in the context of tank crews and platoons.

Space does not allow discussion here of all 173 cross-level hypotheses within their original organization by subsystem and system processes, so only selected ones are addressed. The criteria for selection were that the hypotheses can be stated simply and seem to have direct application at the levels of tank crews and platoons. The hypotheses listed are paraphrased from Miller (1978), and are intended as examples of the sorts of research-guiding propositions presented by LST, as well as candidates for initial LST research within the Army. Each hypothesis is followed by its number within the original text and a brief discussion.

1. Components which are incapable of or lack experience in associating must function according to highly standardized rules. As the turnover rate of components rises above the rate at which they can develop associations, rigidity of programming or standardization of rules increases (2-1). This proposition certainly seems to be true in military units, where extremely high turnover rates and standardization are evident. A question which frequently arises in military circles relates to the degree of autonomy which should be given to individual units in training and other activities. This hypothesis implies that little autonomy should be given in the present environment of high turnover of personnel generally having below average intellectual abilities and limited learning experiences (many have not graduated from high school). In recent years the Army seems to have moved toward decreased standardization and increased leniency. Perhaps this trend should be reversed in light of the present quality of personnel accessions. Research is needed to precisely determine the relationship

between associative ability and degree of standardization necessary. Style of leadership could then be knowledgeably tailored to demonstrated capabilities of subordinates. Stabilization of personnel in units may be necessary before they can learn to perform their duties in other than rigid, standardized ways.

2. As the reassignment of functions among components in a long-surviving system is increased, the more likely are components able to perform all critical subsystem processes (2-2). This hypothesis points out that cross-training leads to increased general skill capabilities. While the previous hypothesis can be construed to imply a need for increased stabilization of personnel in units, this one can be used to argue for an increased variety in personnel assignments. The assignment policy of the Army is based upon a perceived need for generalists who can take over for personnel lost in war. These two hypotheses are not really in conflict; the approach they seem to imply is to increase stabilization of personnel in units while cross-training them to perform all the processes therein. Personnel components in tank crews and platoons should certainly be cross-trained to fill in for personnel injured or killed; the optimal degree of such training remains to be determined.

3. Significantly more information is transmitted within a system than across its boundaries (3.1.2.2-3). This hypothesis generally seems to be true for tank crews and platoons, and it could easily be verified by measuring information flows in a variety of situations. What are its implications? Perhaps communications within a unit should be given

priority over external communications. Units which spend more time transducing information externally than communicating internally may be in a pathological state.

4. The larger the percentage of matter-energy input used in information processing rather than matter-energy processing, the more likely the system is to survive (3.3.1). This proposition could be tested by having crews and platoons perform varying degrees of their matter-energy processing and measuring their performance on Tables VIII and IX. It implies that matter-energy processing should be dispersed outwardly from crews and platoons to a large extent, and this was found to be the case in the subsystems' descriptions in Chapter 3. It may also imply that matter-energy processing should be further automated; e.g., automatic loaders would be expected to increase crew survivability. Crews and platoons should be allowed to process the information necessary for target engagement and be left free of support duties to the extent possible.

5. Errors and distortions increase in a system as the number of blocked information channels increases (3.3.3.2-5). This hypothesis is relevant to the operations of tank crews and platoons, particularly since it is expected that communications channels will be extensively blocked in future wars. The hypothesis could be tested by blocking communications (radio) channels to various degrees in exercises such as Table IX. Such an approach might also better prepare platoons for wartime operations. Platoons are expected to be able to successfully engage targets with

communications blocked, but in reality they probably do not receive enough training as a unit to be able to do this. One could also examine other sorts of information blockages under the rubric of this hypothesis; e.g., the effects of obscuration of visual information by smoke or terrain features. It is important to identify what sorts of errors and distortions occur as a function of various types of blockages.

6. Two-way channels which permit feedback improve performance by facilitating processes which reduce error (3.3.3.2-12). Feedback is a process which has received increasing attention in the Army in recent years; many individuals have recognized that it has been too long ignored. It is a very important process, as implied by this hypothesis, and its effects need to be further examined. Such examination could be initiated in tank crews and platoons by studying performance as a function of use of one- and two-way communications channels. The optimal distribution and amount of feedback needs to be determined; there must be a limit at which it becomes too time-consuming to be further beneficial. The general facilitating effect of feedback is currently recognized; the exact parameters of its error-reduction process are potential subjects for future study.

7. Channels which require less encoding and decoding are used more (3.3.3.2-16). A corollary of this hypothesis would seem to be that communications are facilitated by the use of a common, efficient language. This supports the use of fire commands and other standardized forms of communication in order to minimize fire distribution problems. The optimal degree of standardization for various types of units and situations remains to be

determined; some flexibility must be maintained, and any living system will develop its own language to some extent. However, the present hypothesis in conjunction with the first one discussed in this chapter suggest that standardization of communications should be rigidly enforced.

8. Association is slower the higher the level of the system (3.3.5.2-6). This hypothesis is related to another (5.1-28), which states that higher level systems have larger average processing times. With respect to associating, the hypothesis implies that platoons take longer to form relationships among items of information (initiate the learning process) than crews do. Since association is dispersed to the individual level, this proposition may simply be due to the fact that there are more individuals in a platoon than in a crew, thus increasing the numbers of feedback channels and communications nodes. The hypothesis may thus be almost trivial in the case of association, but more important implications may exist for other processes, such as decision making. Knowledge of average times for various processes at crew and platoon levels is necessary for optimizing their operations. For example, one could determine the sorts of decisions most efficiently made at crew and platoon levels.

9. The longer a system has made decisions of a specific sort, the less time each decision takes, up to a limit (3.3.7.2-5). This hypothesis implies that training and experience decrease decision-making time. It is thus important that deciders in crews and platoons (TC's and platoon leaders) have the necessary experience to allow them to react to rapidly changing future battlefields. It is doubtful that they (particularly platoon leaders)

have adequate experience in the present training environment. Examination of the relationship between training, experience, and speed of decision making might reveal a need for changes in training or increased stabilization of deciders in crews and platoons. This hypothesis certainly implies a need for increased realistic training for deciders; this could perhaps be accomplished using simulations with appropriate information loads and time stresses represented.

10. The longer a decider exists, the more likely it is to resist change (3.3.7.2-11). This hypothesis seems intuitively true in the Army and other large organizations, but it is difficult to test since resistance to change is difficult to measure. Perhaps the degree of incorporation of new techniques or tactics in crews and platoons could be measured as a function of the length of assignment of the TC or platoon leader. Stabilization of personnel in decider positions in Army units would not be without problems; resistance to change and overly rigid approaches to decision-making would be among them.

11. As two or more subsystems or components become more interdependent in timing of processes, conflict among them becomes more probable (5.2-18). This hypothesis suggests the most likely places for conflict to occur within crews and platoons. For example, in a crew conflict would be most likely to occur between the TC and gunner, since they are interdependent in target engagement. In a platoon, conflict might be predicted to be most likely between the platoon leader and the platoon sergeant or other TC's. Possible conflicts among members

of crews and platoons have important implications and should be further examined. Conflicts about which targets to engage or which ammunition to use could be disastrous. Conflicts among subsystems or components will occur under stress; ways must be found to minimize them and control their effects. This hypothesis suggests the places to initially address this problem.

12. Lack of clarity of purposes or goals in a system's decisions will produce conflict between it and other components of the suprasystem (5.2-25). This hypothesis implies that lack of clarity or consistency in a crew's decisions will produce conflict between it and other crews in the platoon. Similarly, such lacks in a platoon's decisions will produce conflict between it and other platoons in the company. Such hypotheses seem likely to be true, and they could be tested by varying the clarity of purposes or goals (missions) given to components on Table IX. Such research might demonstrate the importance of clarity of purposes or goals, and might suggest the best formats for their presentation.

The dozen hypotheses listed above present the flavor of cross-level theorizing in LST, and the discussions show that all of them have at least general application to military units. Many other LST hypotheses which also have such application could be discussed. So LST presents a comprehensive set of research hypotheses relevant to the military environment. But, as discussed earlier, many of these hypotheses are only general speculations and much work is needed to operationalize them into specific research designs. The research ideas discussed in this chapter are as yet a sundry list which needs further development within an organized research program.

What has LST provided us here? Whether the hypotheses and research ideas discussed in this chapter could only have been formulated within the framework of LST is a subject for debate. What LST definitely does provide is a comprehensive framework for organizing research and a cross-level approach for general theory development. The utility of LST in this regard can probably only be evaluated by conduct of a comprehensive cross-level research effort following its guidelines. Discussions in this and previous chapters indicate that it is theoretically feasible to conduct such an effort within the context of tank crews and platoons.

CHAPTER 6 - UTILITY OF LIVING SYSTEMS THEORY

A general, initial description of a way in which LST might be applied in a military setting has been presented in the preceding five chapters. The task remaining before us is to determine the utility or pay-off of applying such an approach. Evaluation of LST has been briefly touched upon in previous chapters, but it has not been discussed in depth since the stage of development and degree of application of the theory do not yet support detailed evaluation. However, some general preliminary conclusions can be drawn. First, it is necessary to briefly review applications of LST which have been accomplished.

Applications of LST. Miller (1978), Miller and Miller (1979), and others have referenced and briefly described numerous applications of LST in various fields. One would expect that initial applications of a new general theory would be tentative and general in nature, and that appears to be the case here. The basic principles of LST or most other general systems theories are attractive and easy to grasp and espouse, but the development of specific, detailed, in-depth applications is another matter indeed. Selected published uses of LST are summarized below.

Many authors have suggested that LST has utility within the field of health delivery systems. Baker and O'Brien (1971) used general systems concepts and cross-level generalization for developing guidelines for research on coordinated comprehensive community health service delivery systems. They developed a set of nine general hypotheses about inter-system relations, with potential application primarily at the level of organizations. Bolman (1967) suggested the use of general systems theory as a model for community mental health theory, and he described LST as the most thorough and sophisticated application in this area. He viewed LST as a heuristic theory in need of further development, and proposed additional levels of living systems. Burgess, Nelson, and Wallhaus (1974), Lichtman and Hunt (1971), and Pierce (1972) all refer to systems theory as a useful integrating approach to health delivery systems. However, none of these authors have taken more than preliminary steps in the development of such applications.

Applications of LST have been suggested in other fields. Weiss and Rein (1970) discussed the application of systems theory to evaluation research. They described LST as a process-oriented qualitative (with the potential of being quantitative) approach with great potential for evaluating broad-aim programs. Vandevelde and Miller (1975) used the LST approach to analyze an urban community's problems and its relationship to an urban academic institution. The city's pathologies were described in terms of its 19 critical subsystems, and extensive suggestions were offered for addressing these problems through an urban grant institution. Miller and Miller (1979) addressed the family as a living system and described the structure, process, and pathologies of its 19 subsystems. Suggestions were made for using cross-level systems research to provide an integrated foundation for our knowledge of the behavior of families. While all the above references have made extensive recommendations for the use of LST, none have moved beyond general descriptions of how this might be done. Cross-level systems research is lacking in all these areas.

One of the most extensive uses of LST thus far has been accomplished in an industrial setting (Duncan; 1971, 1972, 1975). While with General Motors Institute, Duncan (1971) initiated a management development program based upon LST concepts, and a training cadre used this approach in seminars taught in several divisions of General Motors. It was found that the living systems framework led to the development of fresh problem-solving approaches and to the solution of several nagging real-world problems. Since this initial application, management seminars based upon living systems concepts have been run in Exxon Corporation, in small businesses, with general management populations in University seminars, and with state public school administrators. The living systems approach has also been used to help plan management curricula and to serve as a guide for the design of organizational structures. So the utility of LST has been demonstrated to some extent in industrial settings and in the public sector. People can understand the basic concepts and use them in real-world problem-solving. However, these applications do not firmly establish the relative worth of LST; nor do they use its full potential power. The seminars conducted demonstrate that a systems approach can have utility for problem-solving by management, but research has not been conducted to establish that LST has more value in this regard than other general systems approaches. Also, work in these applied settings has not led to any cross-level systems research.

Does the paucity of applications of LST indicate that it has few or no real-world uses? The applications summarized in the last paragraph and ongoing research applying LST to analyzing training management in an armor battalion indicate that this is not the case. What is indicated is that LST is still largely in a conceptual stage of development and a good deal of work is required in developing specific applications within complex systems. The University of Louisville Systems Science Institute's battalion research project is not complete and no firm conclusions can be drawn yet, but results are somewhat promising. The project has demonstrated that research instruments can be developed based upon the LST framework, and that operational personnel in the system being studied can understand these instruments sufficiently to provide reliable data. It has also shown that the LST approach provides insights into information processing in a complex organization. The comprehensiveness of analysis provided by the theory is also impressive. But much developmental effort was devoted to this exploratory project, and more is needed to refine the approach. For example, the data collected were subjective survey responses and traditional military indicators; development of objective systems indicators in a complex organization is needed. Also, this project was directed at one level of systems, the organization. Further work is needed to allow realization of the full power of LST in cross-level research. The suggestions outlined in this paper are only a start in that direction.

Miller (1978) noted that few of the possible applications of LST have been realized. The above brief review supports this conclusion and points out that the reason for it may be the large amount of developmental work necessary in applying a comprehensive theory. LST provides a heuristic for analyzing the behavior of various levels of living systems; the derivative algorithms remain to be developed. Whether or not such development is worth the effort cannot be determined until it is tried.

Evaluation of LST. As discussed previously, a complete evaluation of the utility of LST cannot be accomplished at this time, since applications have not been fully developed and tested. However, some general considerations can be discussed and some specific suggestions can be offered.

Why should LST be of interest to the Army in general? As discussed in Chapter 1, the Army is a complex organization which is influenced by a multitude of variables. An integrated approach is needed for assessing the impact of a host of social, political, environmental, and other factors. The complexity of the modern Army is increasing by leaps and bounds. A number of highly complex new weapons systems are scheduled for delivery in the 1980's; for example, the XM1 tank, the HELLFIRE weapons system, and the TACFIRE system. A number of complex new management requirements have been introduced into the Army; for example, Standard Installation Division Personnel System (SIDPERS), Joint Uniform Military Pay System (JUMPS), integration of female soldiers, race relations and equal opportunity programs, drug and alcohol abuse programs, and the Freedom of Information Act. Many of these complexities have been intensified by the reduced quantity and quality of personnel ingested into the Army in recent years. As is frequently the case in any large organization, the Army has tended to deal with complexities such as these in a rather piecemeal fashion. Many systems have been put into operation without complete consideration of their effects on manpower, training time, and combat effectiveness. This is evidenced by the development and fielding of entire new weapons systems without adequate consideration of training or maintenance problems (e.g., the M60A2 tank system). A corporate, reductionistic approach to management of complexity seems to have held sway in the Army in recent years (Gabriel and Savage, 1978). Senior managers of the Army have perceived this problem and have noted that LST may be the sort of integrated approach that is needed. But before an overall integrated picture can be developed, integration must be achieved at lower, more manageable levels.

Take, for example, the case of battalion training management. In recent years numerous requirements have been imposed upon the battalion commander which detract from his primary mission of maintaining optimal combat readiness; e.g., he has been saddled with complete responsibility for battalion-wide personnel and administrative requirements. Numerous requirements not directly related to combat readiness have also been imposed upon the first-line training supervisors, the noncommissioned officer corps; e.g., racial awareness seminars, courtesy patrol, service as survey personnel, and sundry details. Competition for training space and resources is sometimes fierce, and training priorities may change on a daily basis. The result of these and other factors is that battalion training personnel often spend more time requesting, allocating, and scheduling resources and fighting administrative battles than they do conducting and monitoring training. The big picture of "what needs to be trained when" may be lost in the shuffle. Approaches such as the Battalion Training Management System have been recently developed to address this problem, but an integrated approach which can be translated down to specific guidance for individual trainers is lacking. Ongoing battalion-level research using LST at the University of Louisville may provide a small start in this direction.

Before considering more specific suggestions for the application of LST, it is appropriate to briefly discuss the role of LST in science, in general. How does such a general, heuristic theory fit in the pursuit of scientific knowledge? It appears that a general consensus exists among workers in the field that development of a useful, general theory of group and organization effectiveness is years away. Petrinovich (1979) has argued that development of such a theory has been hindered by attempts to apply methods which are appropriate for use in the physical sciences. He goes on to suggest that the reductionistic study of isolated variables can never lead to an understanding of the processes ongoing within an organism, group, or organization. The general approach recommended is a biologically-oriented one, in which evolutionary and environmental factors are functionally considered. Many other theoreticians have also suggested a biological approach to the study of human behavior in complex systems (e.g., Beer, 1972; von Foerster, 1977). LST may provide a general scheme for accomplishment of this objective. It is a biologically-based heuristic which addresses the integrated effects of interacting variables upon all levels of living systems. LST thus has potential impact upon the study of group and organizational behavior.

General considerations aside, what is the utility of LST for the study of tank crews and platoons? In its present stage of development, LST is not a panacea for solving all problems in these systems, but it is rather a general conceptual framework for guiding research. It provides a comprehensive framework for describing the processes of these units, suggests some variables of concern for which indicators need to be developed, and proposes some general hypotheses which may hold true across these levels. Further development of LST applications could lead to establishment of norms for tank crew and platoon behavior, as well as to understanding of the adjustment processes necessary to maintain them. Whether LST provides anything more than any other general, comprehensive theory here is a matter for debate. However, given the lack of such general theories (see last paragraph above) and the fact that LST is basically a common-sense approach, its use appears to be worthwhile. LST costs only some conceptualization time for application, and it guides one to the sorts of objective research which any common-sense approach should lead to. Thus, it certainly doesn't hurt to use LST as a research-guiding framework, and it may help with regard to providing a comprehensive view of the system(s) under study and formulating cross-level generalizations.

For tank crews and platoons, LST points out the need for objective indicators of their process performance (see Wheaton, Allen, Drucker, and Boycan, 1979, for recent developments in this area), highlights the importance of command, control, and communications, shows the need for research simulators, and provides many hypotheses for research. The initial application of LST to these systems certainly hasn't been a hindrance; the degree to which it is a help awaits determination by cross-level research.

What specific suggestions and recommendations has this exercise provided us on the application of LST? A general piece of advice would be to avoid getting mired down by semantics or definitions. Great concern with distinguishing between levels and echelons, subsystems and components, etc., could be detrimental to cross-level research, since more time could be spent conceptualizing than conducting it. It is necessary to develop a general description of the system under study within the LST framework, but if one attends to great detail in this stage he/she may never move beyond it. One should describe the system to the point of determining the prime variables and subsystems of concern and then move out on research on these. Also, the framework of 19 critical subsystems should not be used too rigidly. These subsystems are based upon a biological analogy, and they are easy to identify at the organism level. However, at the group and organization levels many of the subsystems are outwardly dispersed or have relatively low importance. Therefore, one should perhaps not spend a great deal of time identifying and distinguishing between all subsystems at these levels, but should rather concentrate upon the most important subsystems in the system and situation under study. The 19 subsystems proposed by LST are an initial minimum set; research may indicate a need for conceptualizing other subsystems in particular levels or types of systems. For example, it is unclear where motivation, missions, and goals fit in the present framework; an information processing subsystem corresponding to the supporter might be appropriate. LST is still in a conceptual stage of development; initial applications should be developed at specific rather than global levels.

Conclusions/recommendations. Is LST a general descriptive exercise in semantics or a comprehensive theory which can guide meaningful research in important areas for years to come? This question unfortunately cannot yet be answered, due to the as yet general conceptual stage of the theory's development and the scarcity of developed applications. Such applications require a good deal of effort to develop, but there are some indications that such effort will be worthwhile. A general theory of systems' behavior is needed, and many authors see great potential in biologically-oriented approaches such as LST. To test the utility of LST, it should be applied not as a panacea but as a guide for research in specific well-defined situations, such as the operations of tank crews and platoons. LST is a common-sense approach which will not hinder research, as long as one does not become bogged down in its semantics. It has potential for organizing and coordinating research, and it should be carefully applied, refined, and compared to other systems approaches. In this way, a refined theory of living systems' behavior may someday be obtained.

REFERENCES

Baker, F. & O'Brien, G. Intersystems relations and coordination of human service organizations. American Journal of Public Health, 1971, 61, 130-137.

Beer, S. Brain of the Firm. New York: Herder and Herder, 1972.

Bertalanffy, L. V. General System Theory. New York: George Braziller, Inc. 1968.

Bolman, W. M. Theoretical and community bases of community mental health, American Journal of Psychiatry, 1967, 124, 7-21.

Burgess, J., Nelson, R. H., & Wallhaus, R. Network analysis as a method for the evaluation of service delivery systems. Community Mental Health Journal, 1974, 10, 337-345.

Duncan, D. M. Training business managers in general systems concepts. In M. D. Rubin (Ed.), Man in Systems. New York: Gordon and Breach, 1971.

Duncan, D. M. James G. Miller's living systems theory: Issues for management thought and practice. Academy of Management Journal, 1972, 15, 513-523.

Duncan, D. M. Systems perspectives for practicing managers. In A. J. Melcher (Ed.), General Systems and Organization Theory: Methodological Aspects. Kent, Ohio: Kent State University, 1975.

Ericson, R. F. Society for General Systems Research at twenty-five: What agenda for our second quarter-century? Behavioral Science, 1979, 24, 225-237.

Gabriel, R. A. & Savage, P. L. Crisis in Command: Mismanagement in the Army. New York: Hill & Wang, 1978.

Gall, J. Systemantics. New York: Pocket Books, 1975.

Laszlo, E. Introduction to Systems Philosophy: Toward a New Paradigm of Contemporary Thought. New York: Gordon and Breach, 1972.

Litchman, C. M. & Hunt, R. G. Personality and organization theory: A review of some conceptual literature. Psychological Bulletin, 1971, 76, 285-287.

Miller, J. G. Living Systems. New York: McGraw-Hill, 1978.

Miller, J. G. & Miller, J. L. The family as a system. Paper presented at the meeting of the American College of Psychiatrists, Costa Mesa, California, February 1979.

Petrinovich, L. Probabilistic functionalism: A conception of research method. American Psychologist, 1979, 34, 373-390.

Pierce, L. M. Usefulness of a systems approach for problem conceptualization and investigation. Nursing Research, 1972, 21, 509-517.

Shannon, C. E. A mathematical theory of communication. Bell Systems Technical Journal, 1948, 27, 379-423 and 623-656.

U.S. Army, Field Manual 17-12, Tank Gunnery. 21 March 1977.

Vandevelde, K. J. & Miller, J. L. The urban grant university concept: A systems analysis. Behavioral Science, 1975, 20, 273-295.

Von Foerster, H. The curious behavior of complex systems: Lessons from biology. In H. A. Linstone & W. H. C. Simmonds (Eds.), Futures Research: New Directions. Reading, Massachusetts: Addison-Wesley, 1977.

Weiss, R. S. & Rein, M. The evaluation of broad-aim programs: Experimental design, its difficulties, and an alternative. Administrative Science Quarterly, 1970, 15, 97-109.

Wheaton, G. R., Allen, T. W., Drucker, E. H., & Boycan, G. G. Evaluation of tank platoon battlerun performance (Draft Technical Report). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences, September 1979.