Scout Mission Planning Tool (SMPT) Applique'
Design Analysis

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ABSTRACT

U.S. ground forces have an essential requirement to gain and maintain contact with the enemy and provide security for the main body. This will be accomplished through a variety of Reconnaissance, Surveillance, and Target Acquisition (RSTA) means. However, the only system that can complete all required missions, in all weather and terrain conditions, is the ground scout. The ground scout is the "eyes and ears" of the maneuver commander. Cavalry and Scout units must have the capability to reduce their signatures, be mobile, acquire threat information, communicate, navigate, synchronize fires, and collect real-time information for battle decision making without delay. We must give the scouts of the future the very best system possible from which to operate to fulfill the Army's essential requirement.

This design analysis includes an analysis of design requirements, human factors affecting the design requirements, reliability affecting design requirements, and approaches for development, integration, testing, and fielding of a Scout Mission Planning Tool (SMPT) for ground scouts.

This report provides design requirements as they relate to the scout mission, training, eight MANPRINT Domains, reliability, and approaches to executing requirement development of an SMPT system. A secondary goal for this report is to provide background, analyses, methodologies, techniques, and a sound foundation for the possible development of a family of military planning tools for mounted and dismounted warriors. Additionally, crew station ergonomics, technological impact, and human factors in relation to workload, operability, reliability, and maintainability are discussed.

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DISCLAIMER

The opinions expressed in this report are strictly those of the author and are not necessarily those of Raytheon, Texas Tech University, nor any U.S. Government agency. This report is unclassified and considered unrestricted public information in its entirety.

CHAPTER I
FUTURE VEHICULAR-BASED RECONNAISSANCE PLANNING TOOL

1.1 INTRODUCTORY REMARKS

The role of the cavalry scout in Army operations remains relatively unchanged from the traditional role of cavalry and scouts throughout history. The primary missions of ground reconnaissance soldiers are reconnaissance and security. “Bottom-line”, find the enemy before he finds you.

This study will concentrate on factors affecting Vehicle-based Reconnaissance Planning Tool (VRPT) design requirements and strives to provide usable insights for the combat development and materiel development communities. No such VRPT is currently in development to the best of my knowledge. This study is not intended to be an all-encompassing study of the millions of factors affecting system design requirements.

1.2 PROBLEM STATEMENT

Effective reconnaissance and security operations are particularly important on the non-linear battlefields of today and the future. Characteristics of current and future battlefields place an absolute requirement for real-time intelligence from ground-based reconnaissance assets to the maneuver commander. Timely reconnaissance demands real-time, accurate collection, processing, and Command and Control (C^2). Reconnaissance platforms must have the planning and integration tools necessary for information dominance to succeed. Development of a VRPT is absolutely necessary for future reconnaissance platforms to maximize their potential and stay inside the enemy commander’s decision cycle. There has never been a U.S. reconnaissance vehicle developed specifically for the ground-scout and consequently a VRPT has never been developed for the ground-scout. Analyses of how factors affect design requirements for a VRPT must be conducted.

1.3 SCOPE OF ANALYSIS

The scope of the analysis is limited to 8 major activities: review of literature, design process description, concept of design requirement development, brief tactical employment concept, preliminary design concerns, design trade analyses generation concept, formulation of key de sign requirements for further study, and conclusions. The design will not be implemented as part of this analysis.

1.4 BACKGROUND

1.4.1 EVOLUTION OF US SCOUT PLATFORMS

Prior to World War II, the primary modes of transportation for scouts were "Leather Personnel Carriers" (boots) and the horse. In World War II, the US Army began experimenting by giving mounted scouts the "General Purpose Vehicle", more commonly known as the "JEEP", from which to conduct reconnaissance. From World War II and through to the Persian Gulf War, the US Army continued to use this policy of giving mounted scouts platforms that were designed for other missions other than the business of reconnaissance.

The two primary ground reconnaissance platforms used by US Army scouts during Operation Desert Storm were the High Mobility Multi-purpose Wheeled Vehicle (HMMWV) (another "general purpose" vehicle) and the M3 Cavalry Fighting Vehicle (CFV) (a modified personnel carrier). Neither of these vehicles was designed for reconnaissance. The HMMWV is a "thinned skinned" vehicle with no ballistic protection, very poor signature management, poor optics, lightly armed, and not well suited for reconnaissance operations. The CFV is a cavalry vehicle in name only. It was not designed for cavalry operations nor scouting operations of any kind. It was originally designed as a personal carrier to replace the aging M113 Armored Personnel Carrier (APC) fleet (primarily an infantry transport and the Army's tracked "general purpose vehicle"). The M113 itself had been used in a scout role in Vietnam along with the M551 Sheridan (a light tank). Neither of these weapons platforms were suited nor designed for the reconnaissance mission.

After several national level review boards failed to convince the decision makers to produce any of several variants of small light reconnaissance vehicles, the Pentagon and Congress decided instead to force scouts and cavalry to utilize the in development M2 Bradley (an infantry transport vehicle). By the time the Bradley was produced, it was as large as a main battle tank. Not only is the Bradley as large as a tank; but, its signature management is out right terrible. The drive train could not keep up with tanks, let alone stay out front. The M3's lethality was marginal at best and its armor protection was minimal. To complicate matters further in the "New World Order" and "Cold War Peace Dividend", the US and the Russians (former Soviet Union) no longer stare one another down across the "Fulda Gap". The modern political and battlefield situations require rapid deployment capability. The M3 is not very deployable at 27-tons, over 30-ton combat loaded.

The Army senior leadership and the Armor Center Directorate of Force Development (formerly the Armor Engineer Board) were well aware of this grave need for a platform to fulfill the ground reconnaissance and cavalry missions. In 1996, a Joint Review Oversight Council (JROC) approved the Mission Needs Statement (MNS) for the Future Scout Vehicle (FSV). A development process that had started years ago would finally officially get under way. In 1997, the name was changed to Future Scout and Cavalry System (FSCS) and talks of a possible international program began. Throughout 1997 and 1998, coordination began in earnest, a joint US/UK program was developed, the Operational Requirements Document (ORD) was coordinated between the two countries and became a Coordinated Operational Requirements Document (CORD), and the CORD was approved in both countries. In the future, our scouts may finally have the reconnaissance platform they deserved years ago.

It is the opinion of this author that a VRPT system is required to make any future scout platform work. A variation of VRPT or something similar will be required to make all future combat systems optimize the potential of technologies. Ideas about possible planning tools, semi-automated systems, automated systems, robotic systems, and un-manned systems have been tossed around in the minds of cavalry troops for years. However, the VRPT is not an official system, nor has an RFP (Request For Proposal), or any official document decreed it as such. The ideas expressed in this document are to be seen as those of the author and not as an official position of the US Government, nor the Armor Center and Fort Knox. It is strictly the opinion of the author that VRPT be included in FSCS at time of fielding, recently announced by the Commanding General of Fort Knox to be year 2007. A key component to this VRPT will be the SMPT (Scout Mission Planning Tool) Applique'.

1.4.2 OVERVIEW OF MISSION PLANNING TROOP LEADING PROCEDURES AND TIMELINE

Every reconnaissance troop's time is critical. Reconnaissance platform commander's time becomes more and more critical as technologies proliferate, threats advance becoming more powerful, and missions become more numerous and diverse.

Timelines have traditionally been one-third for planning and two-thirds for subordinates/subordinate unit preparation before action. This of course being the ideal situation where the enemy cooperates and gives you all the time you need to prepare. Some commanders have tightened the timelines on their staffs to a “1/5th 4/5ths rule”. However, these timelines, more often than not, do not apply to the subordinate unit responsible for reconnaissance. As rule of thumb, most Commanders send out reconnaissance far enough in front of the main body to give early warning and help the commander refine his plan before the main body moves, at a minimum before his main body crosses the Line of Departure (LD). In the defense, Commander’s prefer to get their scouts out immediately to provide early warning, notification of friendly unit movement, conduct flank coordination, etc. while the Commander and his subordinate commanders continue to work out their plans, positions, obstacles, engagement areas, etc.

“Troop Leading Procedures” for US reconnaissance units are not much different from other successful militaries around the world and similar to the mid-management leadership principles of successful businesses.

- Receive and analyze a plan.
- Issue a warning order to troops (employees).
- Form a tentative plan.
- Begin movement (preparatory actions).
- Conduct a reconnaissance within possible limitations (preliminary investigations, studies, etc.).
- Make decisions and complete the plan.
- Issue operations order, preferably from a vantage point overlooking area of operation (explain your plan to the employees from a vantage point where the “get the most out of it”).
- Supervise the operation refining your plan where necessary.

The lower one is, on the "reconnaissance leadership chain of command", the more vital time becomes before, during and after execution of a plan. There is usually no time to go back and fix something left out during a pre-combat inspection, or fix a component, or train a new troop once the LD is crossed. This is not a business where only money and egos are at stake. This is the lives of the main body, lives of fellow comrades in arms, vehicles, and the pride and freedoms of our nation a stake. The stakes are very high; thus, placing a premium on time. As time and resources are better optimized, the probability of success is drastically increased. Side benefits of optimizing time and easing the workload through SMPT Applique' automated or semi-automated systems include, but are not limited to:

- Reducing fatigue.
- Reducing delays.
- Reducing human error.
- Allows more time for maintenance, subordinate development, rehearsals, etc.
- Increases the area one platform can cover with the same number of eyes.

1.5 LITERATURE REVIEW

Warfare and reconnaissance have been studied to great ends over time. As previously stated, the basic concepts of reconnaissance have not changed drastically over time, even though the battlefield and technologies have. An extensive literature search for documentation of VRPT design requirements analyses has been completed. The results are surprisingly few.

In 1992, W. Weigeshoff, a Naval Post Graduate student, published a monogram titled "An Automated Reconnaissance and Surveillance Planning Tool" [Weigeshoff,W. (1992)]. His document analyzes the plethora of scout missions and their variations from echelons above Corps down through platoon level. His work concentrates on tactics, leadership, the Intelligence Preparation of the Battlefield (IPB) process and workload. The specific target audience was directed toward Battalion Task Force Level Planning. Since the time of his work, there has been some small progress in software developments of individuals that have created power point templates and spreadsheets to assist Battalion Intelligence officers plan and execute the IPB process more efficiently.

In 1993, MAJ Brick T. Miller, a US Army Command and General Staff College student, published an analysis titled "19D Cavalry Scout: Is There Room For Reconnaissance". MAJ Miller's analysis concentrated on the workload of the individual scout (19D). MAJ Miller points out the extraordinary number of individual and crew collective task required of the scout. His analysis includes the amount of task taught in introductory training and "home station" training. Comparisons are made between training levels and task performance observed at the National Training Center (NTC) during simulated warfare.

In 1998, I published my thesis FUTURE SCOUT AND CAVALRY SYSTEM (FSCS) DESIGN ANALYSIS. My analyses concentrated on the need for a scout platform specifically designed for the scout mission. My analyses included:

- Development of an automated tool for Non-Developmental Item (NDI) analyses,
- An analysis of how human factors affect scout platform design requirements,
- And, an analysis of how reliability affects scout platform design utilizing BCIS (a friend or foe identification system) as an example.

A patent and concept search was also conducted of all patents and concepts issued a patent number by the US Patent & Trademark Office. No matches for a Scout Mission Planning Tool were found. However, a list was compiled of potential patents or concepts that might be applicable for use as a component or sub-component of such an applique'. Related technologies for recommended reading were also included in this list. (See **Appendix E Patents and Concepts**)

1.6 SYSTEM DESIGN PROCESS

The design requirement(s) synthesis process used in this analysis is tailored from the Raytheon Integrated Product Development Process (IPDS). Normally, gate reviews are included as a part of the process. Since this analysis will not be assigned a gatekeeper, these reviews were tailored out of the process. Similarly, the normal Integrated Product Development (IPD) deployment, development of an Integrated Master Plan and Integrated Master Schedule (IMP/IMS), and tailoring of task descriptors to a WBS (Work Breakdown Structure) were deleted.

I recommend an Integrated Concept Team (ICT) be formed to further study the operational and technical feasibility of developing a VRPT. The ICT would be comprised of representatives from various industries, material developers and Subject Matter Expert (SME) end users. Concurrently, I recommend Raytheon begin forming a study team to develop technical answers and analyze proposal feasibility.

1.6.1 VRPT SYSTEM REQUIREMENTS

This VRPT system design requirements are driven by the need for an on-board integration system to perform real time integration of sub-system outputs and in some cases inputs. Future vehicular-based reconnaissance platforms will require a variety of sensors, target acquisition devices, communication devices, and weapons. Future weapons systems may or may not have built in fire control. They may rely on other Line Replaceable Units (LRU) to do functions or sub-functions of sub-control for them. This analysis will touch on these issues and recommend areas where further technical investigation is required. Another major driver of the design requirements for a VRPT are the types of missions themselves. Other design drivers discussed later are Standard Operating Procedures (SOP), human interface, operability, reliability, and maintainability.

1.6.2 RECONNAISSANCE (RECON) MISSIONS

There are many types and variations of reconnaissance. For this preliminary analysis, the three basic types of reconnaissance as defined by FM 17-98 are: Area Recon, Route Recon and Zone Recon.

Typically, area reconnaissance is included as a sub-mission within a larger more complex mission. Area reconnaissance is defined as follows: *Scouts conduct an area reconnaissance to gain detailed information about the terrain or enemy activity within a certain area. The could be a town, ridgeline, woods, or other features that other forces intend to occupy, pass through, or avoid…This type of reconnaissance can be a "stand alone" mission, an intermediate mission, or a portion of the overall reconnaissance mission.* [FM 17-98]

Route reconnaissance missions can have a life of their own or be part of a larger mission. Route recons are often only completed in a cursory fashion. The capabilities brought to bare with a VRPT would greatly enhance the thoroughness and accuracy of a route reconnaissance. Time would be saved in planning, reporting or communicating, and in the analysis process to turn collected battlefield information into intelligence information used to support the maneuver commander's decision cycle. The same could be said for the impacts a VRPT would have on area and zone reconnaissance. Route recons are defined in FM 17-98 as: *Scouts conduct a route reconnaissance to gain detailed information about a specific route and the terrain on either side of the route that the enemy could use to dominate movement on the route.* [FM 17-98]

Zone reconnaissance is the most complex, requires the most resources, and can include both area and route reconnaissance. Given a zone reconnaissance requires more planning and preparation time, it makes sense that a VRPT would pay big dividends in a zone reconnaissance. Just as in the proverb in business arenas that “Time is money”, in the case of vehicular-based reconnaissance “Time is lives and money”.

Zone reconnaissance is defined by FM 17-98 as: *Scouts conduct zone reconnaissance missions to gain detailed information about routes, terrain, resources, and enemy forces within a zone defined by lateral boundaries…*[FM 17-98]

Some units include these missions into their Tactical Standard Operating Procedures (TACSOP). TACSOP’s are occasionally referred to as the tactical commander’s “playbook”. (The term “playbook” generally refers to the book of plays a coach might carry with him on the sidelines or in his head.) A TACSOP may include: administrative instructions, check sheets (or reminder list), safety instructions, operational and logistical report formats, and any other information the maneuver commander deems appropriate. The VRPT should have the capability to program in this information and receive updates through some form of secure communications. The following are examples of missions, or “plays”, that might be encoded into the VRPT:

- Screen
- Area Reconnaissance
- Route Reconnaissance
- Zone Reconnaissance
- Guard Mission
- Counter-fire Security
- Building the Defense
- Special Directed Reconnaissance Mission
- Air Assault or other Landing Zone (LZ) Security Mission
- Hasty Attack
- In-Stride Breach

The previous plays might be encoded with a sequence of events to occur on one side and a graphical example on the other. The SMPT Applique’ should allow the graphics to be modified on different pieces of terrain and provide recommended graphics, routes, checkpoints, etc., based on internal databases and algorithms. Human interface aspects are discussed in the next section.

1.6.3 HUMAN FACTORS VS. WORKLOAD DESIGN REQUIREMENTS

Some sub-systems may be designed with total automation in mind to reduce the scout's workload. However, some sub-systems will still require a man-in-the-loop. Some particular individual and crew level task require competent, human, intervention to make a sound decision and/or reaction.

Examples of total automation that may be used follow: embedded diagnostics of a Line Replaceable Unit (LRU) failure; automated tracking of fuel status, ammunition status (if the vehicle requires a weapon system that requires ammunition), battery power, vehicle location; and standoff chemical detection, etc. By automating these types of items the crew workload is reduced, however, we must be careful not to increase the mental capacity required of the crew and mechanics. We must be careful not to drastically increase the skill level required to operate and repair the equipment. Additionally, the scout will still be required to monitor, start, stop, and in some cases react to the fully automated systems. In some cases, the visual monitoring requirement may be supplemented by an aural alarm to reduce eyestrain and reaction times, and maximize performance.

Examples of man-in-the-loop VPRT tasks may include, but are not limited to: transmission of spot reports, calls for artillery fire, laser designation (if laser or far target location equipment included in vehicle design), driving, final target identification, bridge classification, soil composition testing, chemical and biological testing, radiation sampling, reporting, etc. As technology advances, whether or not these types of systems will rely heavily on the man-in-the-loop or on total automation is still debatable at this point. It is recommended this issue be researched further and tested concurrently as technologies are developed.

Currently we are requiring our scouts to master a heavy load of common skills and MOS (Military Occupational Specialty) specific tasks. In order to accomplish each required collective task at least once: *"87 common 10/20 level tasks and 28 MOS 10/20 level tasks must be executed at least once in order to accomplish these collective tasks."* [Miller, 1993] Since 1993, reconnaissance platforms and crews have been fielded with new equipment that has driven the task level count even higher. This, in turn, has reduced each troop's time trained on each task before arrival to a unit and in fact leaves some task untrained. We should not increase the overall number of task required. In fact, we should eliminate multiple older tasks with automated or semi-automated tasks where possible, thereby decreasing the total number of individual and crew task required to be performed. The higher the number of individual tasks required to accomplish a collective tasks, the higher the burden we are giving to the scout with respect to training and workload.

Crew compartment layout may also affect the man machine interface. The crew compartment layout of the host reconnaissance platform may not have the crew in a nice straight line as depicted in Figure 1 (Human Machine Interface)**.**

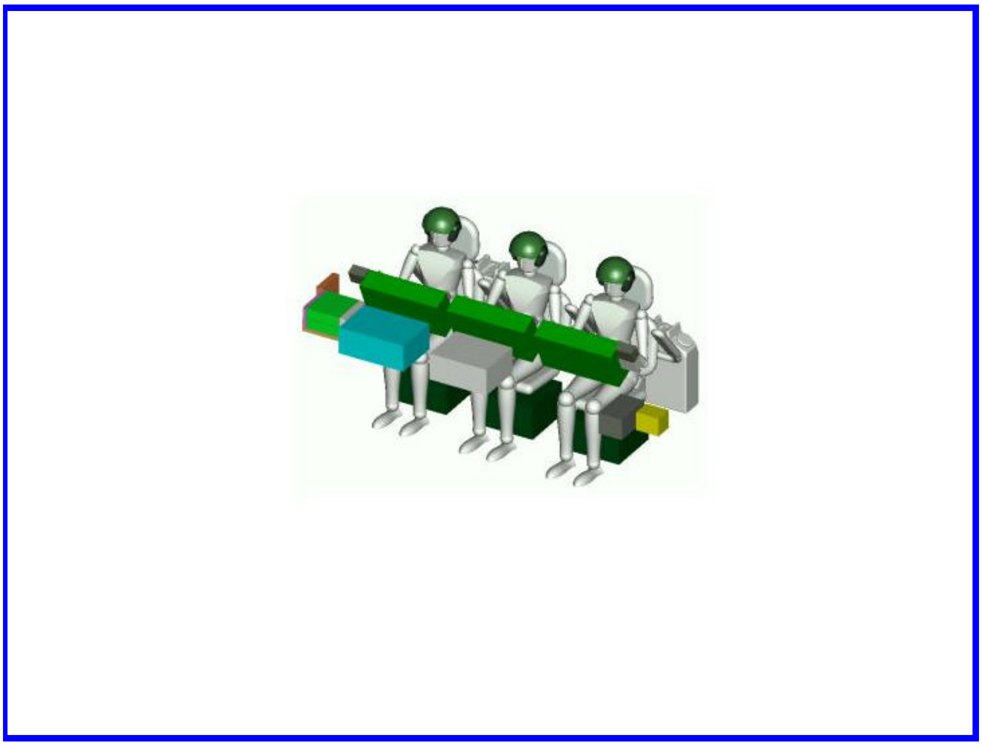

Figure 1 - Human Machine Interface

Computer-aided ergonomic design (CAD) tools and Computer-aided Engineering (CAE) tools should be used to design the most ergonomically feasible and efficient VRPT possible. Crew station ergonomics plays a crucial role in maintaining a competitive edge on the battlefield. When used together, CAD and CAE tools allow for conceptual designs to be used as mock-ups for simulation and testing. Additionally, CAD models are the only practical way to represent the dimensions needed for multivariate analysis of the 5th through 95th percentile person from the target audience without building numerous and expensive prototypes. **Figure 1 (Human Machine Interface)** above was generated with a CAD tool.

1.6.4 OPERABILITY DESIGN REQUIREMENTS

"Reducing uncertainty allows commander's to make more informed decisions." [Fix, 1992] The VRPT must be designed to minimize the loss of life of the crew and follow-on forces, while maximizing the scout crew productivity. In my opinion, and that of many other officers and enlisted personnel from throughout the cavalry and scout community, and during two recent surveys, is signature management. (III CORPS Headquarters conducted Survey #1 during their annual Scout Cup. The Scout Integrated Concept Team conducted survey #2. Both of these surveys were statistically significant. There was no evidence of a statistical difference in responses to the surveys based on neither rank nor platform(s) on which the individual was experienced.)

VRPT should be designed with signature management in mind. The VRPT should be capable of doing an effective terrain, vegetation, route, and Line-of-Sight (LOS) analysis and providing the vehicle commander with recommended routes. The VRPT should also be capable of displaying arcs of effective ranges of suspected enemy positions. Additionally, as the reconnaissance vehicle moves through its Area of Operations (AO), the VRPT should be capable of consolidating input from sensors and modifying recommended routes if necessary.

On command from the vehicle commander, the VRPT should be capable of transmitting data through primary and alternate means to higher headquarters, satellite, or a wireless internet type collection point for further analyses and dissemination. This would be ideal data for various mapping agencies. Some sub-components of the VRPT may even have potential civilian or industrial application.

The VRPT should have the capability to receive and translate various communication media into a common architecture. At a minimum, the VRPT must be compatible to interpret all voice, fax, and digital transmissions in use by the supported force at the time of fielding. The system should also be able to download digital maps of interest from CD-ROM, or media in use for such task at the time of fielding. This in turn leads to the implied requirements that VRPT be able to retrieve, process, transmit, and store large volumes of data.

Improvements over the current systems are required in the capability to safely and rapidly decontaminate vehicles and equipment in order to meet current and future threats. VRPT should be an appreciable asset in planning and execution of decontamination task. The VRPT should track which decontamination points are active and have the capability to plan and recommend “clean” or “dirty” routes to the vehicle commander. In turn, this should save lives, equipment, and time.

Early warning is key to avoiding NBC (Nuclear, Biological, and Chemical) contamination. Sensors for the individual scout and scout platforms must be capable of detecting multiple agents and characterizing new agents are required. A platform mounted standoff chemical and biological detection capability is desired. VRPT must include planning, synchronization of sensors, embedded NBC reports, a down wind analysis capability, and communications support for NBC operations. Improvements are needed over the current systems in miniaturization, lower detection limits, biological detection, radiological monitoring, and logistical supportability. As improvements in NBC detection sensors improve, VRPT will need to upgrade as well. The role of VRPT may increase in the NBC arena as NBC weapons continue to proliferate over time.

VRPT should be able to analyze and display outputs from Line Replaceable Units (LRU) such as the far target display shown here. Figure 2 **(Thermal Display)** depicts a friendly vehicle. This photograph is a digitized thermal view of a CFV (Cavalry Fighting Vehicle) taken at night at a range of 1.7 kilometers. The VRPT should prepare appropriate reports, alert platform commander, update situational awareness data map or screen with appropriate icon, and prepare appropriate communications gear for transmission upon command from human input.

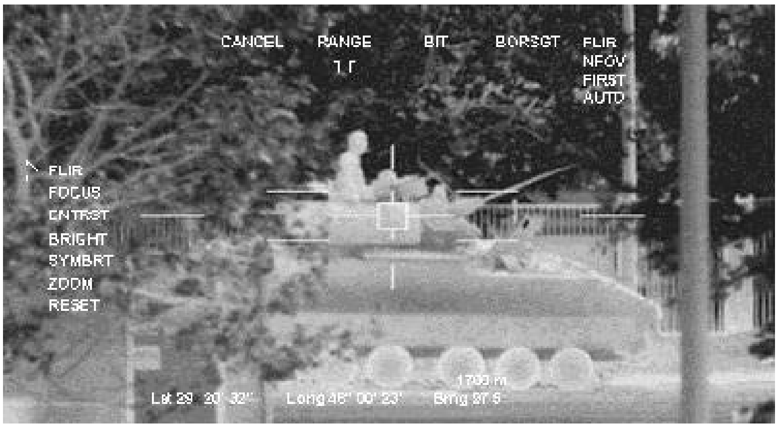

Figure 2 - Thermal Display

(Note: Photo courtesy of the author and Texas Instruments Defense, 1997.

Graphic modified by William W. Kaake.)

SMPT Applique' should have the capability to grow with the future host platforms. Survivability improvements in future host platforms over the current systems must be made in the following areas as outlined in TRADOC PAMPHLET 525-66: prevention of fratricide, fratricide avoidance, collective NBC crew protection, mounted forces mobility, and the implementation of low observable technologies. Material development, vehicle shaping and treatment of visual, acoustic, infrared and radar signatures must be developed to reduce the probability of the reconnaissance platform being acquired and engaged by threat reconnaissance systems and main battle tanks. The vehicular mounted reconnaissance, like the mounted forces it supports, requires improved active and passive security measures. Measures are required to enhance Operational Security (OPSEC), Signal Security (SIGSEC), and surveillance and target acquisition systems. Improvements over the current combat platform collective NBC equipment is required to reduce manpower requirements for employment of systems, improve operational effectiveness, and to reduce logistical support requirements.

1.6.5 RELIABILITY DESIGN REQUIREMENTS

Reliability of the VRPT system would have to be very high. Military standard for reliability vehicular-based systems is defined as having a 90% Operational Readiness (OR) rate. A critical failure is defined as a failure of any part, assembly, or system which:

- Prevents the operator from completing the mission.
- Presents a safety hazard(s).
- Violates federal, state, local, or host nation traffic law.

OR rate is expressed as a percentage and calculated by:

Equation 1

$$OR\_rate = \left(1 - \frac{down\_days}{possible\_days}\right) * 100 = x\%$$

Where,

Equation 2

$$down\_days = \sum \left(veh\_down * num\_days\_down\right)$$

And,

Equation 3

$$possible\_days = num\_veh\_in\_unit * num\_days\_in\_reporting\_period$$

Units with low population of reportable systems can quickly fall below the 90% with as little as one down system. More importantly, if a low reportable system density unit, such as a scout platoon of six platforms, loses one system to failure. Its combat power drops from a maximum of 100% to a maximum of 83.3%. This figure does not include other contributing factors such as increased workload for remaining systems, fatigue, moral, etc.

1.6.6 MAINTAINABILITY REQUIREMENTS

VRPT should be designed so that operator and preventative maintenance of the system is minimized. Built In Test and diagnostics (BIT) should be designed into the system where possible. Further analyses would be needed during prototyping to determine how much to add and determine effectiveness of BIT. Furthermore, the design should not create new occupational nor specialty skill identifiers in order to maintain the equipment.

Designing adequate accessibility for maintenance personnel into the system design can reduce excessive repair time. Military personnel, 5th through 95th percentile male and female, must be able to maintain/repair the VRPT. Embedded diagnostics must be included where possible to reduce: repair time; test, measurement, and diagnostic equipment requirements; and number of tools and manuals required for the repair. If New Equipment Training (NET) is required for the scout, then maintenance NET should also be conducted to the same level of scope and intensity.

1.6.7 COST IMPACTS OF DESIGN REQUIREMENTS

Philosophies of cost and benefits of military hardware are as similar and diverse as the population they support. Cost in current and future dollars can be calculated in a fairly simplistic manner by multiplying development, production, operations and maintenance costs by a constant. This constant represents inflationary and other factors affecting the value of money. Furthermore, Office of Management and Budget (OMB) and the Department of Defense (DoD) publish tables of these constants annually. Development and production costs can generally be expressed as an increasing function of parameter ***(y)***, where ***(y)*** is a measurable maximum performance characteristic (i.e. the more critical points observed on the positive ***x***-axis the better). See Figure 3 **(Cost vs. Performance)**. It should be noted that the relationship between cost ($) and performance characteristic ***(y)*** is not necessarily a linear function and more than likely will have an increasing concave **(y_1)** or convex shape **(y_2)**. See Figure 4 **(Linear vs. Non-linear)**.

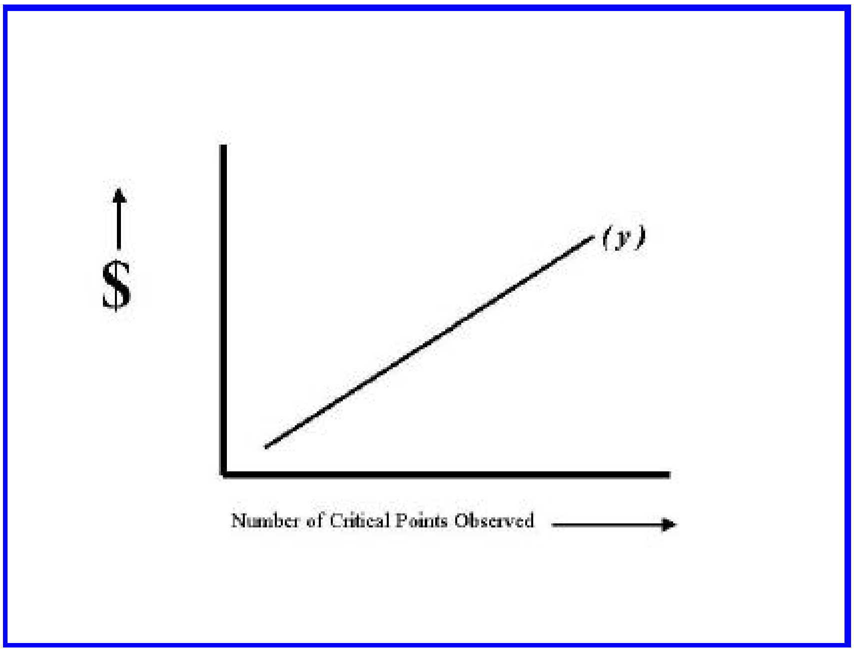

Figure 3 - Cost vs. Performance

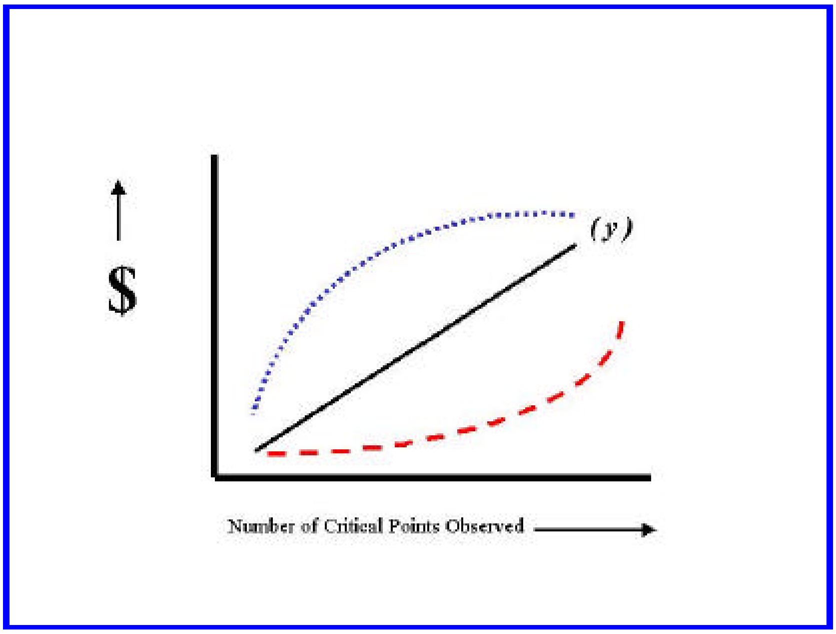

Figure 4 - Linear vs. Non-linear

Some personnel in the “Defense Industry”, and in government, see “Cost” as “By far the single, most important acquisition issue today is cost.” [Pfeffer, R. (2001)] Reduced budgets, shortened timelines, and “criticality” have driven program managers to conduct “trade-offs”. In these “trade-offs”, managers may ignore survivability or lethality requirements in the name of “saving money” or staying “On-Time-On-Schedule”.

Philosophies really start to differ when it comes to costs and benefits that are not easily measured. This is certainly the case with VRPT where an obvious benefit is an undetermined number of lives saved. Interesting debates have occurred over the years trying to establish a price tag on human life. Recent acquisition reform has called for costs to be treated as: Cost as an Independent Variable (CAIV). However, its title is misleading. The acquisition policies define of CAIV as tracking cost separately and leaving cost out of the trade-off analyses, or Analysis of Alternatives AOA (formerly called COEA (Cost and Operational Effectiveness Analysis), and the decision making process. In reality, costs and budgets are always considered in trade-off studies and in the final decisions as to what and how much to buy. The thought process behind leaving costs out of the equation is two fold. First, in theory it should result in the best product being selected and not necessarily the cheapest. Second, it cancels out the problem of having to put price tags and probabilities on human lives.

Metrics should be carefully chosen early on in the development process to ensure measurability and repeatability of simulation and experimentation. This should begin early in the research or Integrated Concept Team (ICT) Process. Each metric chosen will have various associated types and amounts of costs.

Further analyses should be completed to determine the following:

- How much technology from a VRPT type system can be horizontally integrated through a Horizontal Technology Integration (HTI) system? (HTI is meant to transfer technology from one family of platforms to upgrade functionality in another.)
- What are the cost savings in per unit price if some or all of the developed technology goes through HTI?
- Is the system designed with P3I (Product Improvement up-grades) in mind? Which leads to more questions like how expandable, adaptable, complex is the system?
- What would the cost be to integrate new sub-systems, sensors, missions, etc.?

1.6.8 TECHNOLOGICAL IMPACTS ON DESIGN REQUIREMENTS

The only way to design the VRPT to meet the essential requirement for the current and future battlefield is to incorporate/integrate the technological improvements available. For each technological improvement developed in the world today, countermeasures are quickly developed to degrade and/or defeat the new technology. The proliferation of technology throughout the world's defense industries demands we develop the VRPT. The impact of new technologies is so great that we must integrate them immediately into the VRPT design.

Even though great strides have been made in the UAV (Unmanned Aerial Vehicle) and UGV (Unmanned Ground Vehicle) programs, they have not eliminated the need for ground-mounted reconnaissance. UAV's cannot fly in all weather conditions, has limited loiter time, and has not yet proven it can provide real time video imagery to the maneuver commander on the ground [Witte & Kelly, 1994].

> *"Among the most significant lessons of Operation Desert Storm was recognition of the need for real-time battlefield intelligence. UAVs are emerging as cost effective systems for providing vital intelligence in real-time at no risk to soldiers and equipment. In Operation Desert Storm, UAVs were especially effective in gathering information and in searching for mobile, semi-permanent assets. These systems provided reconnaissance, surveillance, target acquisition and battle damage assessment (Defense, 1993)."*
>
> [Witte & Kelly, 1994]

The UGV, in its current configuration, may provide some support to the dismounted infantry, assuming a wheeled vehicle is available to transport it to the "battlespace" required. If made extremely smaller (small enough to be transported by the VRPT without limiting other required cargo, crew space, protection requirements, etc.) and a real time video transmission capability is added, could be used to supplement the VRPT surveillance capability. Given the satellite and aviation reconnaissance capabilities of the US and its allies, there is still a requirement for a rapidly deployable ground mounted reconnaissance capability [Aspen, 1993].

"In counterinsurgency warfare, HUMINT, especially tactical reconnaissance, becomes the major source of intelligence necessary to support tactical operations." Additionally, tactical intelligence is vital for the success in the counterinsurgency environment. This is summarized in FM

90-8, as *"Tactical intelligence is the key to defeating any guerrilla."* [Bryant, 1987] Bryant goes on to say, *"… real-time, tactical intelligence is critical to conducting counterinsurgency warfare successfully."*

Reconnaissance in force is used to create and maintain tempo in offensive operations. Reconnaissance in force can be supplemented by satellite imagery during the planning process and aerial reconnaissance, weather permitting, can be conducted concurrently with a reconnaissance in force. However, neither satellites nor the Air Force can conduct a reconnaissance in force on their own. It must be completed on the ground. *"The Soviets recognized that a high tempo in the attack is impossible without well organized reconnaissance and that reconnaissance must be active and continuous under all conditions to ensure commanders do not make unsubstantiated decisions. It is precisely reconnaissance that will help the commander to make the correct selection, and provide him with the information necessary to maintain a high tempo."* (Fix, 1992) In his thesis Fix goes on to state, *"In short, 'reconnaissance permits commanders to take the initiative and impose their will on the enemy'."*

1.7 CONCLUSIONS AND RECOMMENDATIONS

Human factors and their relationships with the design requirements play a very large role in the design outcome of the SMPT Applique' system. I have briefly discussed some of the impacts and have offered up food for thought that may generate further discussion, research, testing, and analysis. Each of the MANPRINT Domains should be kept in mind throughout the design development and the procurement process. We must give the scouts of the future the very best system possible from which to operate to fulfill the Army's essential requirement.

The proposed system in this report has potential to become a baseline system for a family of systems for US platforms and Allied platforms alike.

It is recommended Raytheon form a "Tiger Team" to study the issues described and potential technologies to meet these issues immediately. Given current and future missions and threats, it is further recommended requirements determination, testing, and analyses must be conducted with emphasis on Joint and Combined environments. Actions today may save lives in the future.

CHAPTER II
GENERIC ENGINEERING DESIGN SCIENCE & METHODOLOGY

2.1 INTRODUCTION

The increased reliance on technology and post "cold-war" reduction in forces drive the need for a Scout Mission Planning Tool (SMPT) Applique' or Vehicular-based Reconnaissance Planning Tool (VRPT). This SMPT Applique' or VRPT may be required for systems such as the Future Scout and Cavalry System (FSCS) and/or the Future Combat System (FSC). From this point forward, this proposed system would be referred to as simply Scout Mission Planning Tool (SMPT). Timelines for these and other systems may in fact be pushed forward as the shape, content, and purposes of future land warfare evolve. [Economist, (2000)] Scout leaders of today and the future must be able to optimize technology to win the information dominance campaign for intelligence at the tactical level.

"Generic Design Science" can be a useful tool in determining design requirements for use in creating a Scout Mission Planning Tool (SMPT).

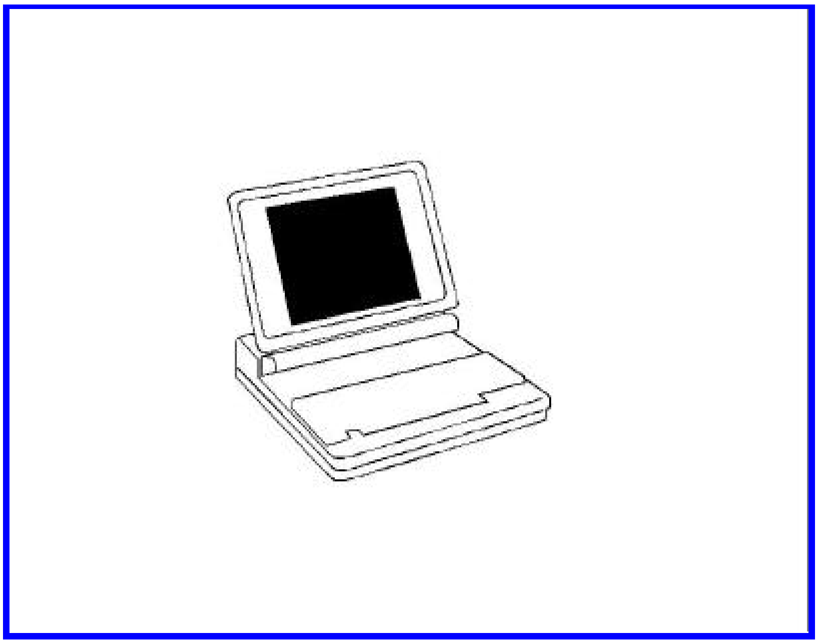

Figure 5 - Artist Concept
(Clipart courtesy Microsoft)

2.2 SCOPE

The scope of this report is to develop an "Option Field" of design requirements through the use of "Category, Dimension, Cluster" generic methodology and facilitate matching the dimensionality of "Target" with dimensionality of design situation.

2.3 TASKS

- Specific tasks include:
  - Identify "significant options" (defined as variables, items, components, etc.)
  - Identify structure of "significant options" (defined as categories)
  - Name each category
- Identify design dimensions (utilize Interpretive Structural Modeling (ISM) to carry out structuring)
  - Discover "clusters"
  - Structure dimensions
- Identify and list interactions and inter-relations
  - Choose sequence or priorities for clusters, or dimensions within clusters as appropriate.
  - Display results in "Option Field" format, "weeping wall", or "solution lists" (See **Figure 6 "Two-quad Tapestry"**)

2.4 GENERIC DESIGN MODEL

2.4.1 APPLICATION OF GENERIC RECONNAISSANCE PLANNING & EXECUTION TOOL GENERIC DESIGN

The following figure depicts the "Two-quad Tapestry" concept applied to Reconnaissance Planning and Execution Tools.

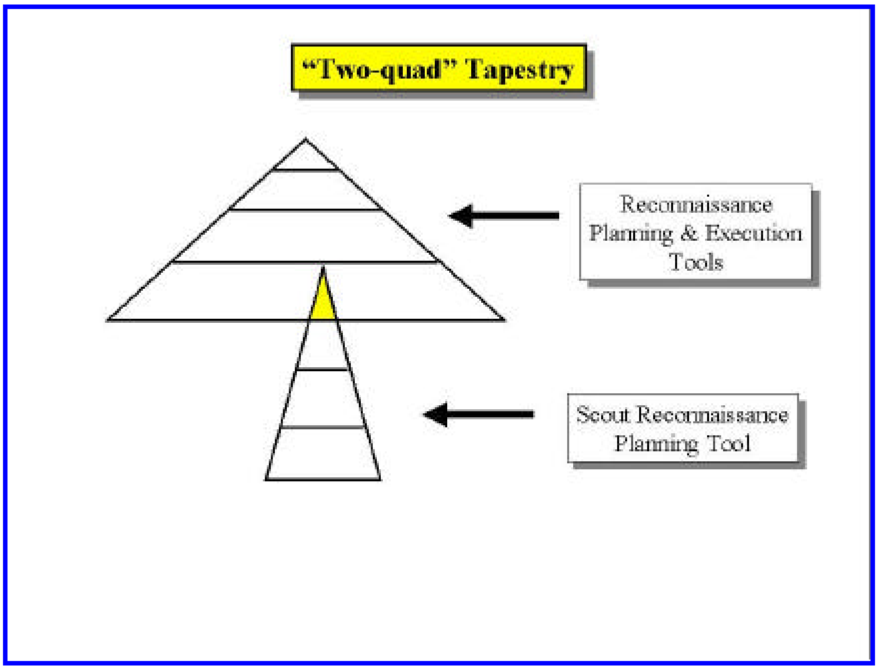

Figure 6 - "Two-quad Tapestry"

Figure 6 **("Two-quad Tapestry")** demonstrates how the "target" of the lower level is itself a "dimension" or "option" of the next higher level. Between "dimension level" and "target", there may be one or more "cluster" or "intermediate" levels. This is further demonstrated in Figure 7 **(Target Dimension Relationship)**, Figure 8 **(Generic "Option Field" Layout)** and Figure 9 **(Partial "Physical System" Design "Two-quad Tapestry")**.

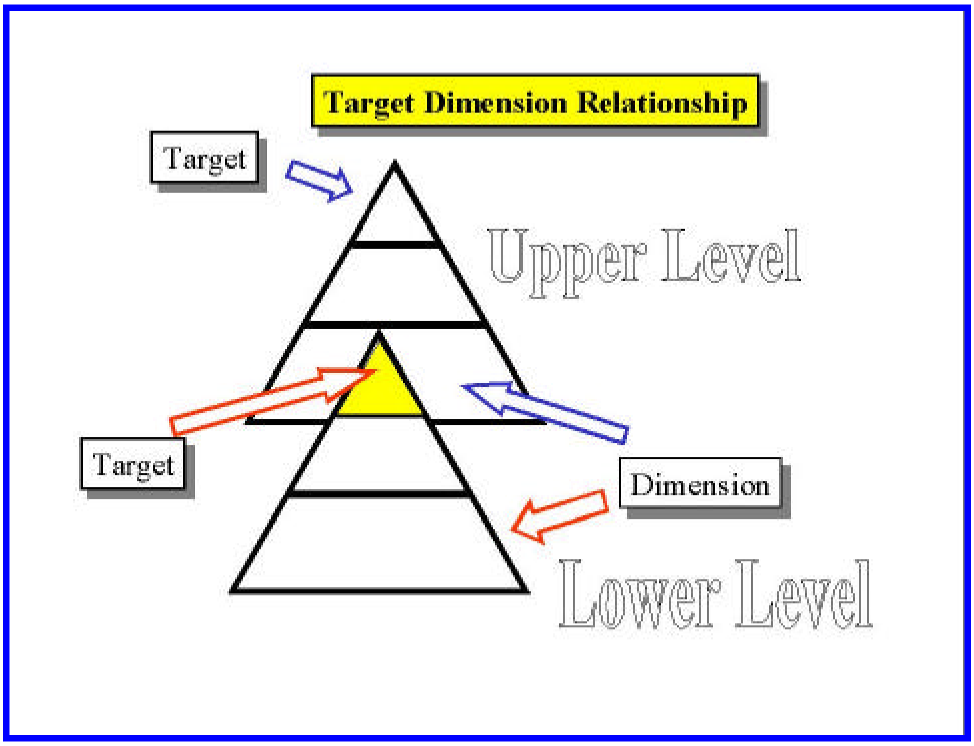

Figure 7 - Target Dimension Relationship

2.4.2 APPLICATION OF GENERIC OPTION FIELD TECHNIQUE

The general format for an "Option Field" Design Layout is depicted in the following figure. [Warfield, J. 1994]

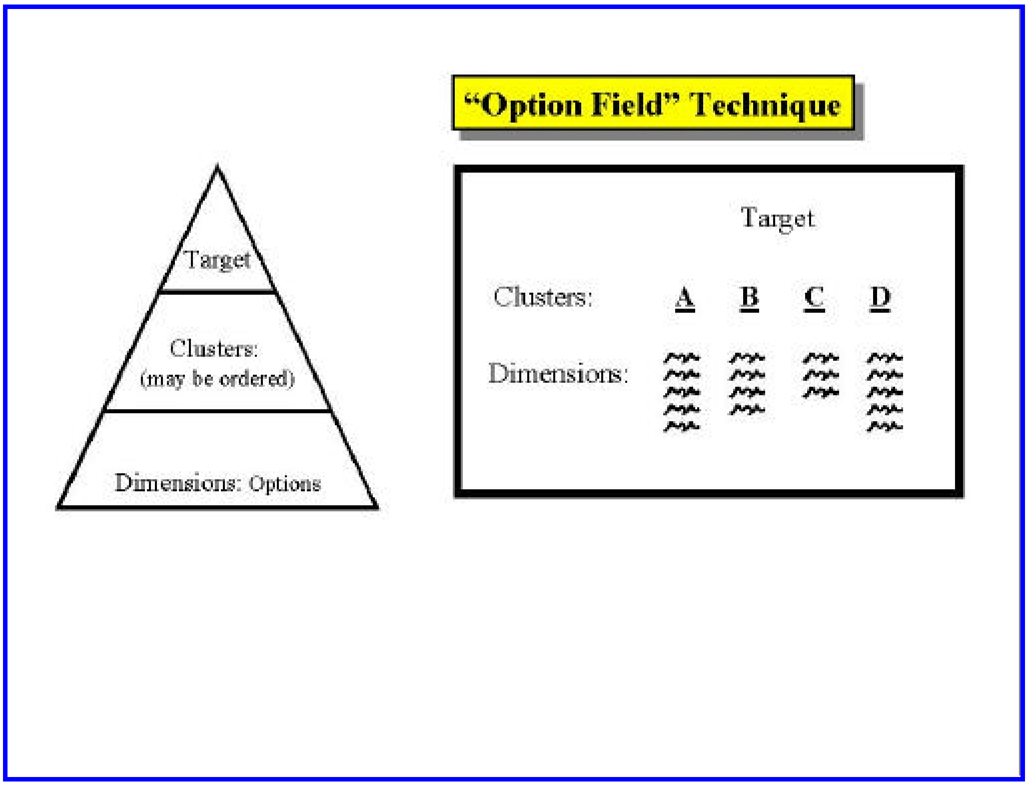

Figure 8 - Generic "Option Field" Layout

The table below is an "Option Field Representation" of the target "Generic Scout Reconnaissance and Surveillance Planning Tool Design Process".

Table 1 Target: Generic Scout Reconnaissance & Surveillance Planning Tool Design Process

Clusters	Generic Engineering Design Processes	Physical System Design	Vision	Reconnaissance and Surveillance Tools
Dimensions	Generic Design Tools	Hardware	Concept of Operations (CONOPS)	Planning
	ICT	Software	Mission Profile (MP)	Training
	TWIG (TWG)	Firmware	White Papers	Logistics
	AOA	Architecture	Doctrine	Administrative
	CAD/CAM	Interfaces	ICT	Security
	Simulation	Protocols		
	White Papers			
	IPDS			
	ISM			
	JTAG			
	FIG			
	NGT			
	ATD			
	Rapid Prototyping			
	JAD			
	RAD			
	JWIG (JWIG)			

From the Target, Cluster, Dimension Process in the above table, the following figure is derived. This figure depicts a portion of the "Physical Design" component using the "Two-quad Tapestry" technique. This cyclic process could be continued until the objective level of design detail is reached for the appropriate level of engineering development. For example, under hardware design, the process could be taken all the way down to the engineering data sheet level for each assembly, sub-assembly, or individual part. Boundaries, constraints, and guidelines should be provided by the Decision-Maker ($DM_{(1)}$) prior to beginning such an exercise. The Integrated Concept Team (ICT), Technical Working Group (TWIG), Joint Working Group (JWIG), etc. should know the objective stopping point level of detail required before "kick off" to successfully execute closure.

Documenting the process followed, derived requirements, and implicit requirements can become key assets in requirement determination. Furthermore, from this database, relationships, groupings or clusters, precedents, and dependencies amongst requirements may become apparent.

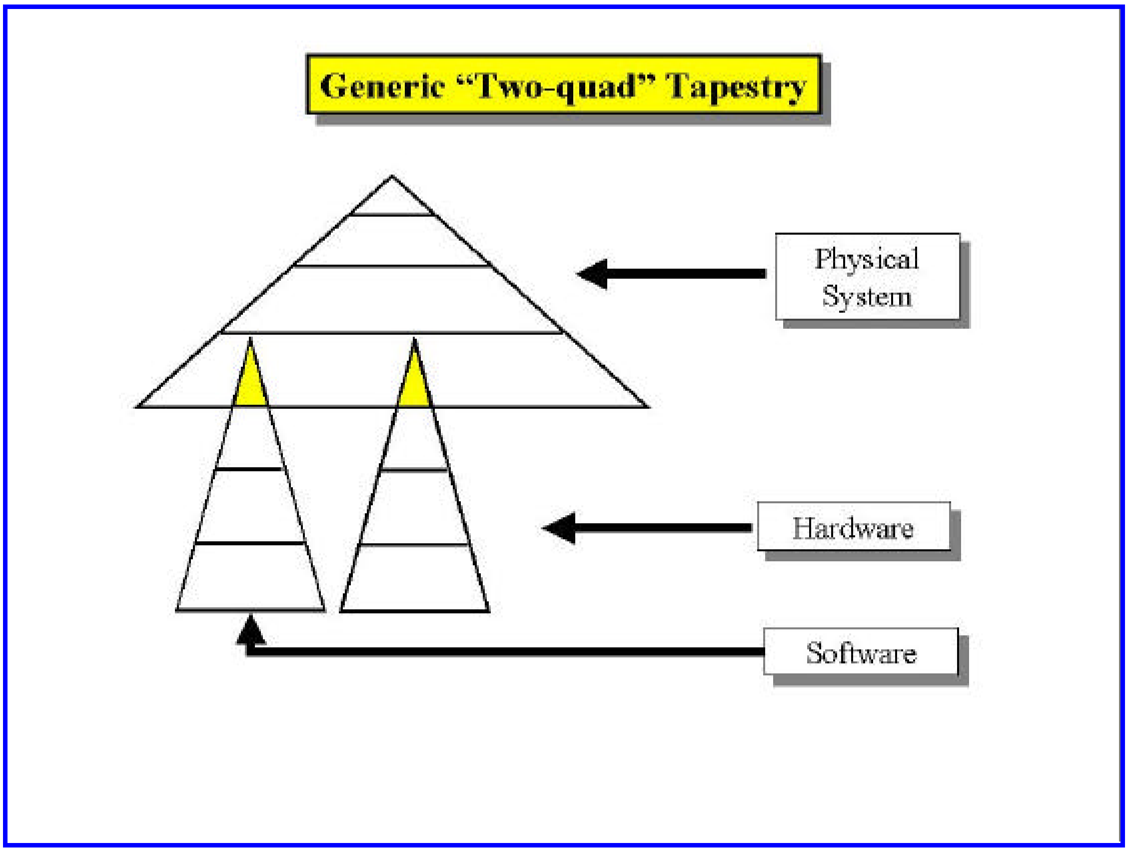

Figure 9 - Partial "Physical System" Design "Two-quad Tapestry"

2.5 RELATIONSHIP ANALYSIS

Pictorial representations can be developed to further organize the brainstorming or "brain-writing" process. The following figure shows the clusters within the Physical Design dimension. Organizing using the "Option Field Method" can lead to interactions the group may or may not have thought of without the graphical representation.

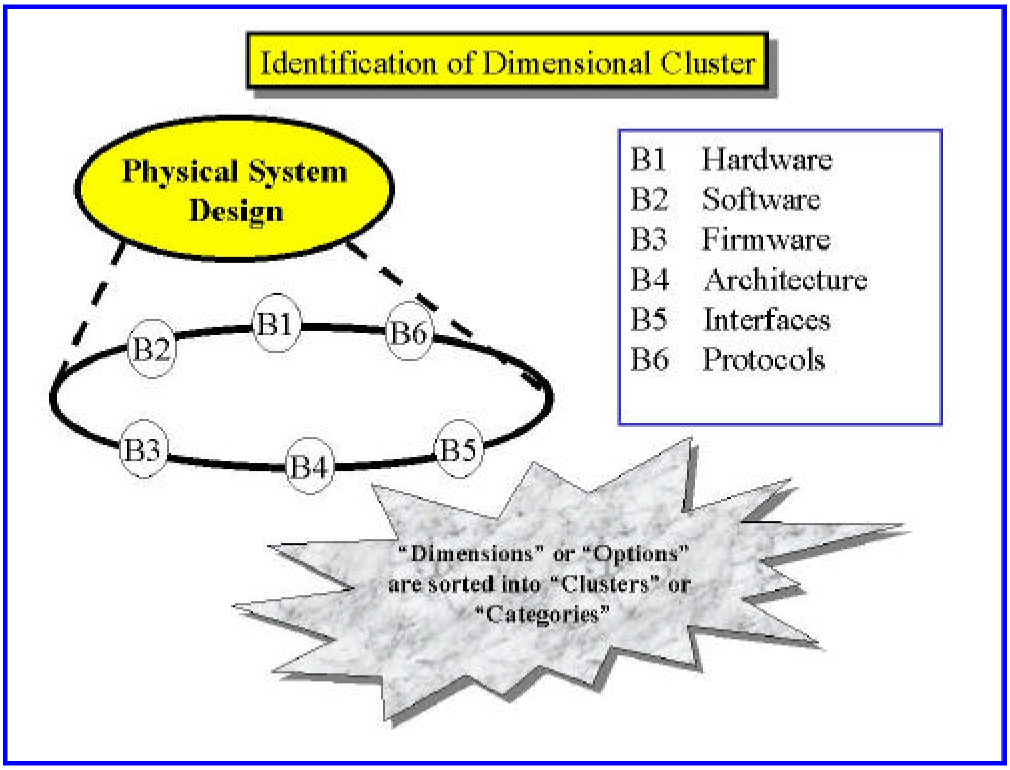

Figure 10 - Identification of Dimensional Cluster

Interactions within "Reconnaissance and Surveillance Tools Cluster", as previously defined, was developed using the ISM (Interpretive Structural Modeling) process. Results are depicted in the following figure. Each dimension within the cluster interacts or interfaces with every other dimension or component within the cluster. Flexibility within this design allows for all components to interact simultaneously or with selected components or a single component running independently. Figure 11 **(Cluster Internal Interactions)** additionally depicts the overarching weight, importance, or priority of the administrative and security functions. These two functions may be run independently, whereas, the other three should be run concurrently with security.

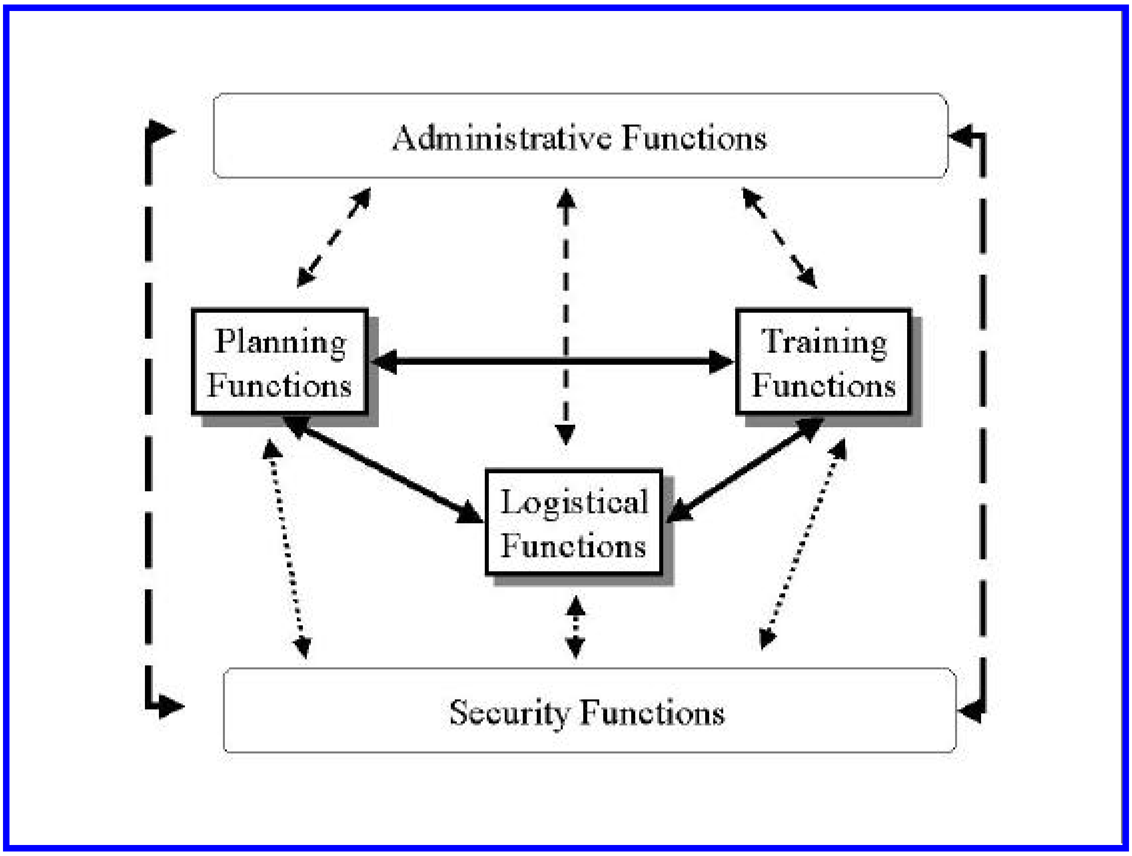

Figure 11 - Cluster Internal Interactions

Effective and efficient design processes will improve situational awareness, Intelligence Preparation of the Battlefield (IPB) process, and R&S (Reconnaissance and Surveillance) planning. The definition of success will further be defined through CONOPS (Concept of Operations) and system Mission Profile (MP) development. The ISM (Interpretive Structural Modeling) process for the "Vision" cluster is depicted in **Figure 12 (Vision ISM)**. This process may be reiterated to further define requirements and manufacturing requirements as the concept transitions to an IPT (Integrated Product Team). Technical Working Groups (TWIGS) could also use this process to assist in identifying technical solution requirements and applications. Furthermore, ISM process could be added as a "tool" to the IPDS (Integrated Product Development System) "tool box".

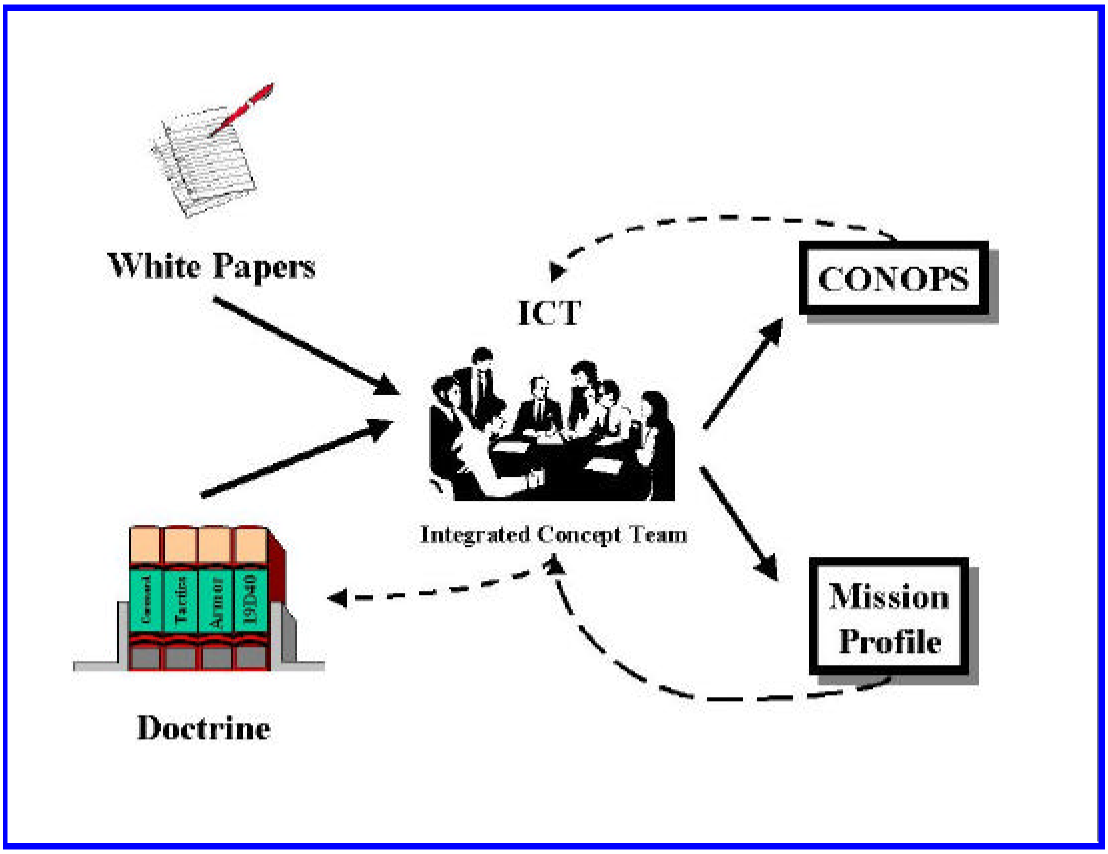

Figure 12 - Vision ISM

Initial priorities of effort, or emphasis, can be defined and applied through the "Dimensional Sequencing" technique. The "Dimensional Sequencing" technique is very similar to the ISM process. The "Option Field" clusters are sequenced in the following figure.

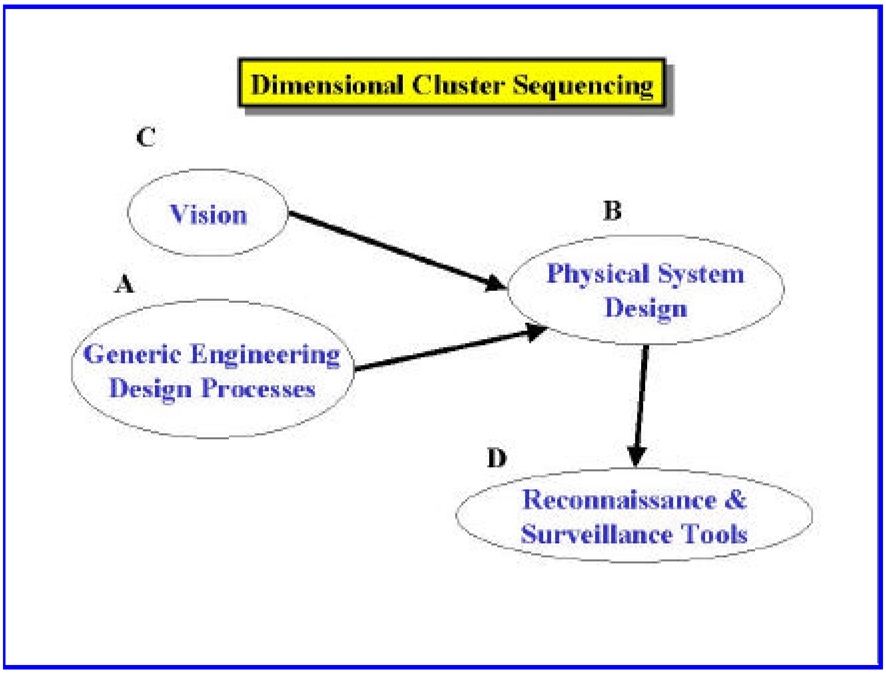

Figure 13 - Dimensional Cluster Sequencing

2.6 CONCLUSION AND RECOMMENDATION

Effective requirement determination will lead to successful integration of available collection assets into successful planning focused on the commander's intent and PIR (Priority Information Requirements). The "Two-quad Tapestry", "Option Field" and ISM processes can be utilized in an efficient manner to identify design requirements. Prioritization of effort or emphasis can effectively be initiated through the "Option Field Method". It is recommended these processes be considered in designing a Scout Mission Planning Tool Applique'.

CHAPTER III
COMPONENT ENGINEERING & DOMAIN ANALYSIS

3.1 INTRODUCTION

This study and analysis has investigates and outlines valid possibilities for consideration of incorporation into an SMPT. A component library approach and methodologies of domain analysis and modeling are applied in analyzing ground-mounted scout planning. The ideas and processes presented culminate in proposals to industry and the user community for adoption into current requirements and specifications to meet the user's capability needs. In the process, a great service will have been done for the country. A key tool will have been placed in the hands of our scout leaders enabling commanders to win the fight for intelligence and information dominance on the battlefields of tomorrow.

3.2 SCOPE

The scope of this chapter is to:

- Define the domain of "Scout Platform Reconnaissance Planning Tool",
- Define a set of components that would comprise a portion of the domain model,
- Describe the components,
- Develop a protocol for components to obey with emphasis on development related rules to assist in development, integration, testing, and fielding of components,
- Develop a methodology for locating, adapting, and integrating new components to build applications or add functionality and capabilities to the domain.

3.3 COMPONENT IDENTIFICATION AND ANALYSES

Potential components and sub-components are listed in Section 3.3.1 and 3.3.2. These items will be further defined in later sections. These initial lists are not intended to be a complete and final listing. In fact, later sections will suggest "rules" for adding additional components and sub-components.

3.3.1 LEVEL 1 COMPONENTS:

- *Operational Planning*
- *Training Tool*
- *Logistical Tool*
- *Maintenance Tool*

3.3.2 LEVEL 2 SUB-COMPONENTS:

- *Zone Reconnaissance Planning*
- *Area Reconnaissance Planning*
- *Route Reconnaissance Planning*
- *Crew Level Training Tool(s)*
- *Individual Level Training Tool(s)*
- *Evacuation / Medical Planning &/or Execution Tool*
- *Fuel (Class III & V) Tool*
- *Food (Class I) & Water Planning / Tracking Tool*
- *PMCS (Preventive Maintenance Checks and Services) Scheduler*
- *PMCS Manuals*
- *Equipment and Maintenance Status Tool*
- *Tool (BII – Basic Issue Items and crew issued items) Inventory System or Tool*
- *Parts (Class IX repair parts) / Requisitions (all classes of supply) Tracking Tool*

3.3.3 "CLASS" DISCUSSION

This domain "Scout Platform Reconnaissance and Surveillance Planning Tool", or "Scout Mission Planning Tool Domain", would be a "Sub-class" or a "Sub-sub-class" to the "Super Class" "Intelligence" discussed in the group domain analysis and modeling project performed by William W. Kaake Jr. and Bradley A. Whittington. Relevant briefing slides from the higher-level domain project are included in **Appendix C (Intelligence Domain Model)**. Slides in **Appendix C** were created from instructor notes, in-class discussions and "off-the-cuff" briefings.

A preliminary crosswalk of potential Level 1 components and Level 2 sub-components in the "Scout Platform Reconnaissance and Surveillance Planning Tool" domain can be found in the following table. This crosswalk is not meant to be all encompassing, but rather a starting point.

Table 2 - "Component Level Crosswalk"

Level 1 Possible Components	Level 2 Possible Sub-components
Operational Planning	➢ Zone Reconnaissance Planning ➢ Area Reconnaissance Planning ➢ Route Reconnaissance Planning
Training Tool	➢ Crew Level Training Tool(s) ➢ Individual Level Training Tool(s)
Logistical Planning Tool	➢ Evacuation / Medical Planning &/or Execution Tool ➢ Fuel (Class III & V) Tool ➢ Food (Class I) & Water Planning / Tracking Tool
Maintenance Tool	➢ PMCS (Preventive Maintenance Checks and Services) Scheduler ➢ PMCS Manuals ➢ Equipment and Maintenance Status Tool(s) ➢ Tool (BII – Basic Issue Items and crew issued items) Inventory System or Tool ➢ Parts (Class IX repair parts) / Requisitions (all classes of supply) Tracking Tool

3.3.4 FURTHER DEFINITION: HIERARCHY APPROACH

The following two diagrams depict the concept through a hierarchy approach in a graphical representation. The first of the two figures depicts the domain and Level 1 components. In the second of the two figures, Levels 1 and 2 are depicted. This approach could be furthered to prioritize within component levels. Components in the Figure 14 **(Level 1 Components: Hierarchy Approach)** and Figure 15 **(Level 2 Components: Hierarchy Approach)** below are not prioritized nor weighted. Managers and "Decision Makers" could choose to transpose this figure into a decision matrix and apply weighting and prioritization based on "user" or customer needs. These two figures provide the framework from which "trade-off" discussions could begin.

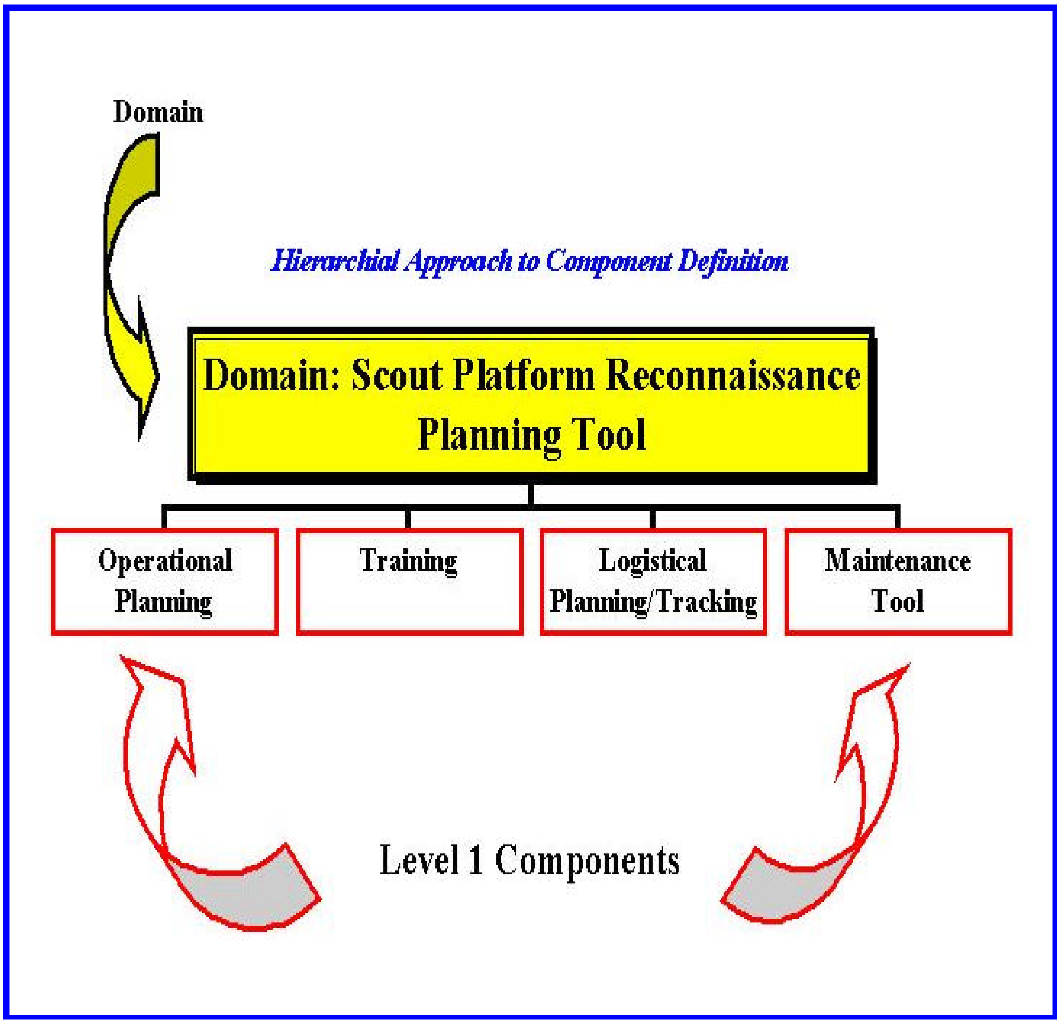

Figure 14 - "Level 1 Components: Hierarchy Approach"

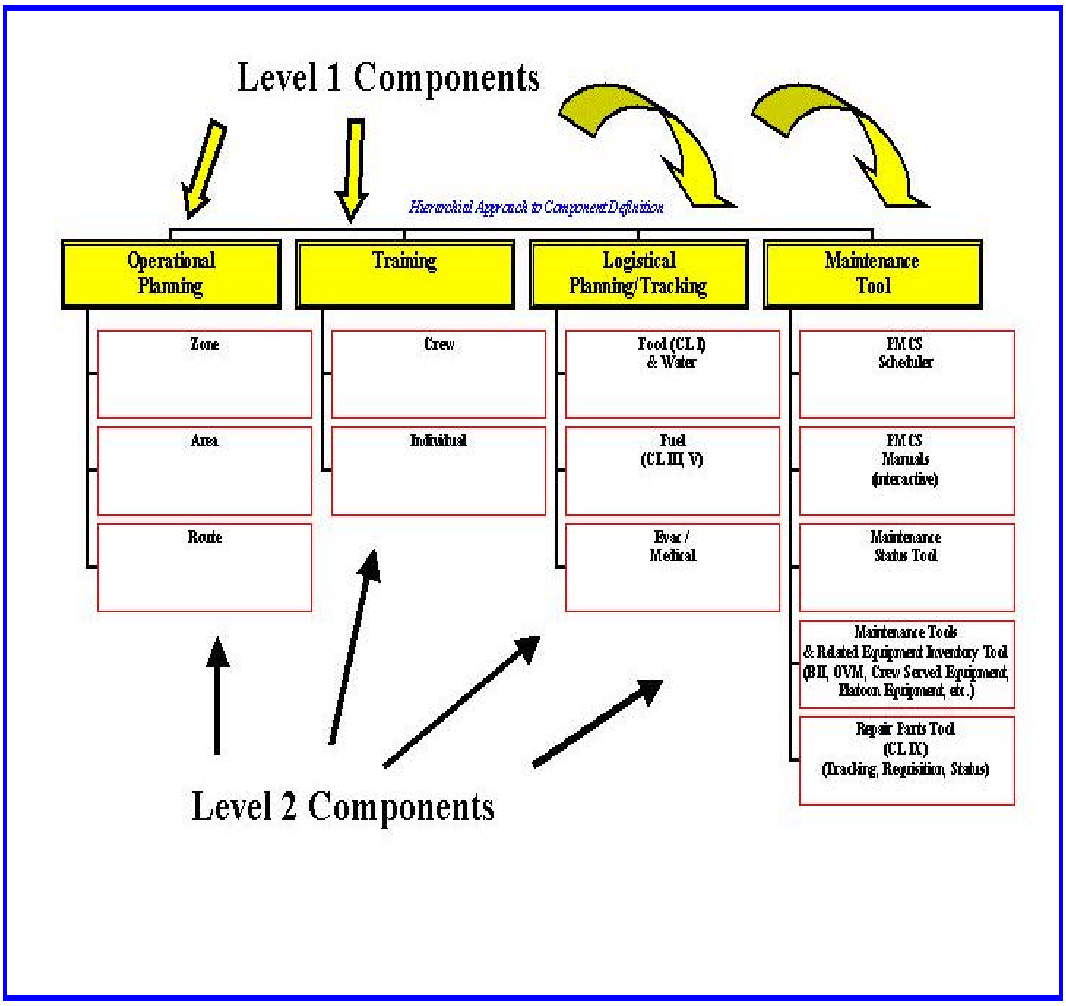

Figure 15 - "Level 2 Components: Hierarchy Approach"

3.4 COMPONENT RULES

3.4.1 GENERAL PROTOCOLS AND COMPONENT RULES

Every component should have at least one interface, which is the default interface. This default interface calls at least one method. The first method called should be a default method consisting of a string or list of available strings or list. String(s) or list(s) may be in "tree" or GUI (Graphical User Interface) format.

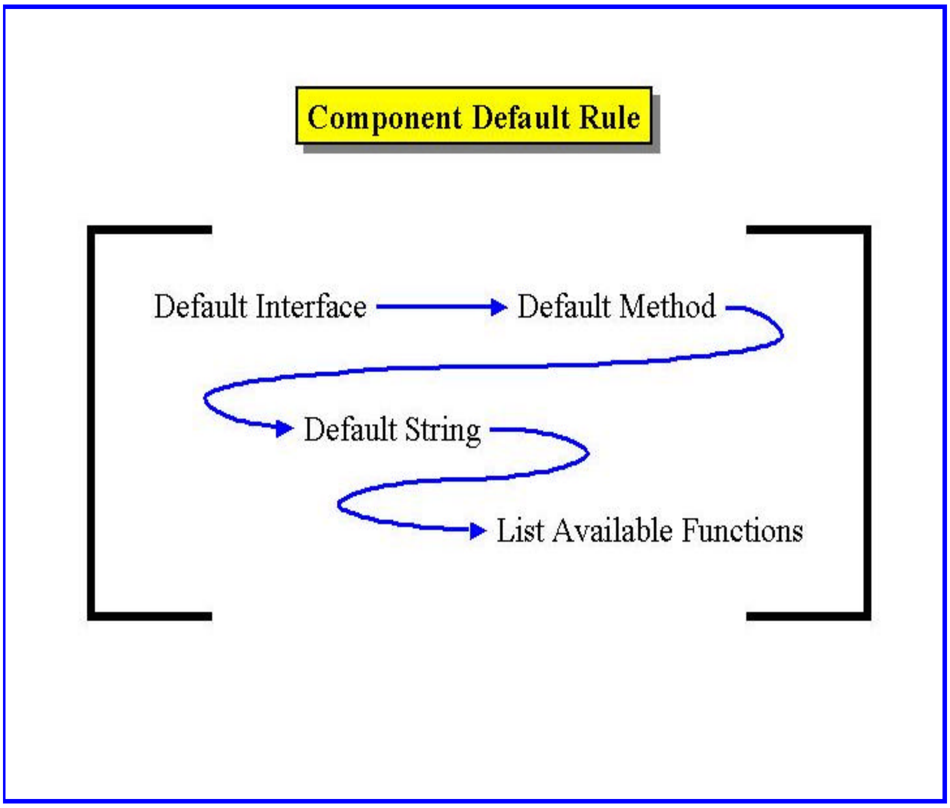

Figure 16 - "Component Default Rule"

Adaptations to change structure should not be allowed unless under contract by vendor for "world-wide", or "country-wide" as the case may be, system product improvement. Structural changes should be minimized in P3I's (Pre-Planned Product Improvements).

New or additional components must benefit the "user" or the customer. As new components are added, they should not detract from the mission of the "user" or customer. In simpler terms, the old adage "benefits must out weigh the cost" applies.

MIL-STD (Military Standard) protocols should be implemented where feasible.

Software licensing procedures and agreements should be followed for all components.

3.4.2 LEVEL 1 COMPONENT RULES

Only vendor should be allowed to modify, add, or delete Level 1 components and/or functionality. An obvious exception to this rule would be the "System Administrator" should be authorized to:

- Add or load new security components via vendor provided load script.
- Add or update virus protection software via vendor provided load script.
- Update "user names" and "passwords" per vendor provided procedures.

3.4.3 LEVEL 2 COMPONENT RULES

- Only vendor developed components may be added.
- Level 2 components may be added or installed by vendor or System Administrator, per contractual Pre-Planned Product Improvement (P3I) agreements.
- All Level 2 components must have they capability of being loaded or reloaded via Configuration Management (CM) load script.
- Only vendor under contract can modify structure of Level 2 components.
- Level 2 components may be adapted before compile, at load, or remotely during run-time.

3.4.4 LEVEL 1 ADD COMPONENT EXAMPLE

A Level 1 component to be added might be a "System Administrator" component. This type of component to be added would have to be decided in a formal means of a "Statement of Work" or other contractual agreement. In addition to new business and contracts personnel, hardware engineers, software engineers, physical security and IT security personnel should be involved as well. The methodology in these areas should be flexible or "tailorable" in nature to the size and scope of system administration functions or component(s) to be added.

The implementation of such a component should have minimal impact on the user. It could be accomplished through a simple "auto-run" script, prepared by the contractor, and executed off a

CD-ROM or other media by a security person, system administrator, or contractor personnel on site. Depending upon the size and complexity of the system administrator component(s) to be added, the scenario may require a thorough integration and test phase complete with hardware and software CM (Configuration Management) and Total Quality Management (TQM).

A Level 2 component, or sub-component of Level 1 "System Administration" would be adding a component to allow the system administrator to change a password, or install a new virus protection device or virus definitions update. Level 2 component examples and methodology are further discussed in the next section.

3.4.5 LEVEL 2 ADD COMPONENT EXAMPLES

An example component that could be added to Level 2 would be "point recon". If "point reconnaissance" was determined to be an application required by user and/or user community. Doctrine writer(s), combat developer, nor a contractor should make this determination "ad hoc". This determination should be made through the establishment of an ICT (Integrated Concept Team). Once the requirements, concept of operation, mission profile, and draft fielding plan are in place, then IPT(s) (Integrated Product Team or Integrated Production Team) should be formed. This team should consist of scouts, combat development representatives, doctrine writers, scenario writers, contractors (contract folks, new development personnel, design engineers, safety engineers, training personnel, etc) and their respective customer counterparts. This methodology is not exactly new in theory, however, is still fairly new to many industries in application and entirely new to others. Bringing the customer and the user into the planning and execution loop early on in the development process is equally important to bringing the contractor in early on in the concept development process. In the future, this sort of methodology may lead to truly functional "interdisciplinary design and integration" [Tanik, M. & Ertas, A. (1997)] for component design in the defense industry and the civilian sector as well.

There are limitations, constraints, and scalability issues that may arise from this approach. However, the earlier these limitations, constraints, etc. are defined in the process the better. Some limitations may be blatantly obvious while others may be implied or required by law or directive. Regardless of methodology or approach chosen to apply a new component to the system, be it hardware, software, or firmware, laws must be followed. "Soldier safety", or "worker safety", standards must be adhered to. Mission of the supported platform should take precedence over cost(s).

Another Level 2 component addition example could be adding a “Platoon Maintenance Status” component. This component might be set-up to access other platform’s maintenance status and provide the leader’s platform with a consolidated view, database, report, or graphic. This concept could also be applied to the troop level. Any such component designed must be compatible with automated systems at the next higher echelon at the time of fielding. A component of this nature may require minimal manual interfaces for some maintenance faults that require a “man-in-the-loop” decision or judgment call. As with any component requiring a human interface, human factors engineering, ergonomics, and Integrated Logistics Support personnel should be involved in the design, product development, integration and testing. Reliability and maintainability must be tracked throughout the development and life cycle of all components and applications. The methodology for designing such a new component must include not only “Subject Matter Experts” (SME), technicians, and Engineers, but, must also include some form of historical database. This database must be tracked and updated throughout the design, production, fielding, and employment process. Another key database to be maintained is the “definitions database”. The methodology of a "definitions database" or "data dictionary" is becoming evermore a necessity as companies and countries begin to move into the “world economy”. Not only do the definitions database have to be compatible to producers, customers, and users, it may be required to be interpreted into multiple languages. See **Appendix D (Data Dictionary)**.

Additional potential components are discussed in **Appendix B (Potential Components).**

3.5 CONCLUSIONS AND RECOMMENDATIONS

Given the device and components described throughout this document are truly theoretical brainstorms of the author in nature, the principles, approaches, and methodologies could be easily applied to develop, integrate, test, and field such a system. Domains and sub-domains must be defined, common definitions established and maintained, concept teams formed, components identified, protocols established, product and/or program team(s) established, contracts let, thorough design integration and test accomplished, system field tested, and then the system fielded fully functional. Implementation of the methodologies described will lead to a successful product in the hands of a satisfied and grateful user.

CHAPTER IV

COMPONENT SOFTWARE ENGINEERING: OBJECT ORIENTED JAVA PROGRAMMING APPROACH

4.1 INTRODUCTION

This study and analysis has investigates and outlines valid possibilities for consideration of incorporation into a SMPT Applique' or VRPT. A Java approach is studied in attacking issue. The ideas and processes presented culminate in proposals to industry and the user community for adoption into current requirements and specifications to meet the user's capability needs. In the process, a great service will have been done for the country. A key tool will have been placed in the hands of our scout leaders enabling commanders to win the fight for information dominance on the battlefields of tomorrow.

The following is a quote from Daniel Verton published in the June 29, 1998 issue of Federal Computer Week. [Verton, D. (1998)]

> ***"After years of developing advanced information technology for the battlefield, the military services are poised to reduce the number of people sent to battle, largely by using IT (Information Technology) to improve the way forces are supplied."***
>
> *Daniel Verton*

4.1.1 SCOPE AND METHODOLOGY

Scope of this study will be limited to Object Oriented (OO) programming methods. Emphasis in potential SMPT Applique' or VRPT uses for Java programming and Java approaches will be discussed with examples of code, buttons, applets, GUIs (Graphical User Interfaces) and concepts. This is not intended to be an all-encompassing analysis nor final coding for an actual device. Rather it is intended for requirements determination and specification idea generation.

4.2 JAVA, GUI'S, APPLETS, AND APPLICATIONS

4.2.1 DOCUMENT MANAGEMENT

SMPT Applique' or VRPT must be compatible with on board "document management tool(s)" and on board "database management system(s)" at the time of fielding. The scout leader will have many of the same issues as current program managers, systems engineers, software engineers, and large corporations face today. [Dart, S. (1997)] The scout leader, however, will at a minimum be the IT manager at the immediate level for document and database management. Higher unit level IT managers will be assigned to staffs of organizations, but the day-to-day operations will be maintained and operated by the individual vehicle commander. These facts must be considered while evaluating requirements and possible solutions in creating an SMPT Applique' or VRPT.

4.2.2 DEVELOPMENT TECHNIQUES

The following list is intended for idea generation. Developers and integrators may choose a single technique, any combination from the list, or choose another method altogether.

- Object-Oriented (OO) methodology.
- Coding in multiple languages.
- Coding in a single language such as Java or C++.
- Visual development tools to create applets and applications using a single technology such as Java. An example of such would be "Parts for Java" created by ParcPlace-Digitalk Inc. or similar package. "Parts for Java" was designed for execution on any Java-enabled browser. In October 1996, this platform sold for approximately $99. [Desmond, J (1996)]
- Development tools to create code, GUIs, applets, subroutines, or applications for multiple technologies simultaneously.

Another decision to be made early on in the development process will be to choose whether the system is to use Sun's Java Bean system for environment development, or a UNIX based system, or Microsoft's ActiveX system. [O'Brien, T. & Heise, D. (1997)] Final fielded system may be required to have the ability to interface with either system or both. Given the current pace of technology advancement, SMPT Applique' or VRPT may be required to interface with systems and or languages not yet developed.

Any system developed must be designed to incorporate Pre-Planned Product Improvements (P3I) and un-planned product upgrades due to technology advances. System must be designed with flexibility for improvements as advances are made in software, firmware, hardware, and any "new-wares" that may be developed.

4.2.3 FUNCTIONS AND POSSIBILITIES

The following figure depicts a possible screen or applet. The buttons depicted in the figure are "Info", "Grid", "Range From My Location", and "Movement Calculator". The "Movement Calculator" button would be linked to an applet or screen of its own. The remaining three buttons could be coded to display information, in "Info Display Window", of location selected on map with mouse or "roller-ball" controlled pointer. Map input could be part of internal design or more likely come from another on board system or storage media such as CD. These buttons were picked for demonstration purposes only and not necessarily operational relationships. Backgrounds, colors, layouts, etc. throughout the system could be coded through the use of Java, HTML, or other XML markup language.

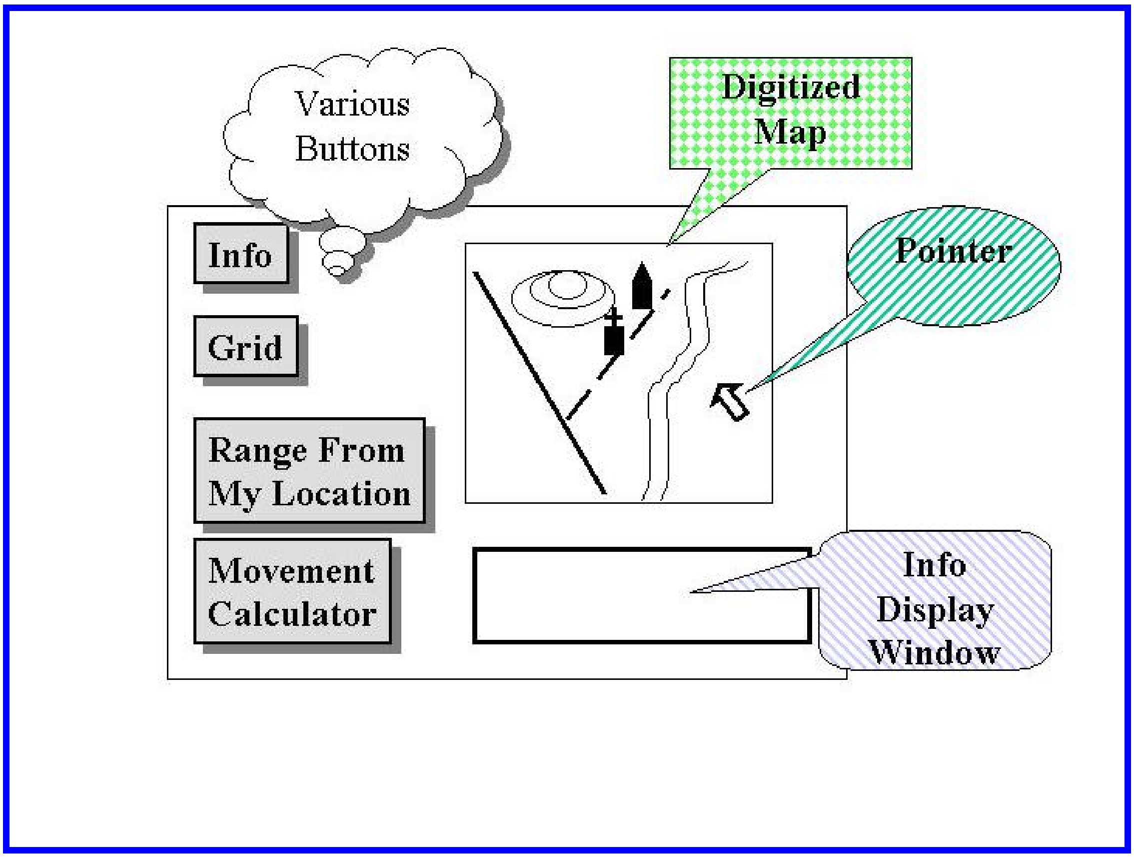

Figure 17 - Possible Display

When operator selects “Movement Calculator” button, complete screen would change to a movement calculator html page or a movement calculator applet could “pop-up” in the display. In addition to fields for data input and its movement rate related functions, the page or applet could have links or buttons to a re-supply screen and/or re-fuel calculator.

Buttons, GUIs, “drop-down” menu’s, html links, “checkbox” applets, etc. could have links to embedded training system, host platform embedded training system, training records, recommended collective and individual training tasks, “hip-pocket” training tools, training manuals, FMs (Field Manuals), TMs (Technical Manuals), maintenance manuals, etc.

System embedded training could include pre-programmed or previously recorded vignettes. These scenarios could be varied in length, detail, and complexity for the scout leader to train/practice specific tasks to hone required skills for success in combat.

Various interfaces could be developed to accommodate common hardware available at the time of fielding. Goals in this area should include making hardware/software interfaces, programming, etc. transparent to the “user”. System must remain flexible enough to accept interface improvements, as advancements in technologies become available. System should also contain a built in system to track software build labels, interface version nomenclature, license serial and version numbers, hardware model, etc. This system should operate transparent to the “user” but its output must be accessible to the “user”.

Figure 17 **(Possible Display)** depicts a GUI with selectable buttons. As each button is selected, the appropriate mission planning application, mission execution information, or TACSOP checklist would appear. An excerpt of Java code for display and execution for such buttons is shown in Figure 18 **(Four Buttons)**.

```
import java.awt.*;
import javax.swing.*;

//This excerpt of code reflects the four buttons described above.
public class JAppletExample extends JApplet {
  public void init() {
    WindowUtilities.setNativeLookAndFeel();
    Container content = getContentPane();
    content.setBackground(Color.white);
    content.setLayout(new FlowLayout());
    content.add(new JButton("Info"));
    content.add(new JButton("Grid"));
    content.add(new JButton("Range From My Location"));
    content.add(new JButton("Movement Calculator"));
  }
}
//Note: “exit listener” is required to allow frame to exit application. It is depicted in the following //figure.
//Note: the setNativeLookAndFeel code is presented in “WindowsUtilities.java” in the following //figures.
```

Figure 18 - Four Buttons

```
import java.awt.*;
import java.awt.event.*;

// A listener that you attach to the top-level Frame or
//JFrame of your application, so
//quitting the frame exits
//the application.

public class ExitListener extends WindowAdapter {
  public void windowClosing(WindowEvent event) {
    System.exit(0);
  }
}
```

Figure 19 - "Exit Listener"

To execute this Java button code excerpt using "swing" technology, one must also include an excerpt of "WindowsUtilities.java" code. This excerpt is depicted in **Figure 20 ("WindowsUtilities.java")**.

```java
import javax.swing.*;
import java.awt.*;
// A few utilities that simplify using windows in Swing.
public class WindowUtilities {
// Tell system to use native look and feel, as in previous releases. Metal (Java) LAF is the default otherwise.
 public static void setNativeLookAndFeel() {
  try{
   UIManager.setLookAndFeel(UIManager.getSystemLookAndFeelClassName());
  } catch(Exception e) {
   System.out.println("Error setting native LAF: " + e);
  }
 }
 public static void setJavaLookAndFeel() {
  try{
   UIManager.setLookAndFeel(UIManager.getCrossPlatformLookAndFeelClassName());
  } catch(Exception e) {
   System.out.println("Error setting Java LAF: " + e);
  }
 }
 public static void setMotifLookAndFeel() {
  try{
   UIManager.setLookAndFeel("com.sun.java.swing.plaf.motif.MotifLookAndFeel");
  } catch(Exception e) {
   System.out.println("Error setting Motif LAF: " + e);
  }
 }
// A simplified way to see a JPanel or other Container. Pops up a JFrame with specified Container as the content pane.
 public static JFrame openInJFrame(Container content,
                        int width,
                        int height,
                        String title,
                        Color bgColor) {
  JFrame frame = new JFrame(title);
  frame.setBackground(bgColor);
  content.setBackground(bgColor);
  frame.setSize(width, height);
  frame.setContentPane(content);
  frame.addWindowListener(new ExitListener());
  frame.setVisible(true);
  return(frame);
 }
// Uses Color.white as the background color.
 public static JFrame openInJFrame(Container content,
                        int width,
                        int height,
                        String title) {
return(openInJFrame(content, width, height, title, Color.white));
}
// Uses Color.white as the background color, and the name of the Container's class as the JFrame title.
 public static JFrame openInJFrame(Container content,
                        int width,
                        int height) {
  return(openInJFrame(content, width, height,
               content.getClass().getName(),
               Color.white));
 }
}
```

Figure 20 - "WindowsUtilities.java"

Another example of button use would be in choosing reconnaissance type for planning. These buttons would link to checklist for planning specific task in each mission. An excerpt of code for the buttons “Route Recon”, “Area Recon”, “Point Recon”, and “Zone Recon” might look like the code in Figure 21 **(Mission Buttons).**

```
import java.awt.*;
import javax.swing.*;

//This excerpt of code reflects the four buttons described above.
public class JAppletExample extends JApplet {
  public void init() {
    WindowUtilities.setNativeLookAndFeel();
    Container content = getContentPane();
    content.setBackground(Color.white);
    content.setLayout(new FlowLayout());
    content.add(new JButton("Route Reconnaissance"));
    content.add(new JButton("Area Reconnaissance"));
    content.add(new JButton("Point Reconnaissance"));
    content.add(new JButton("Zone Reconnaissance"));
  }
}
```

Figure 21 - Mission Buttons

A friend or foe embedded training capability might include the following or similar code. The code below includes “commented out” comments on how this code would be executed. Figure 22 **(Friendly Vehicle ID Code)** is continued on the next page.

```
Import java.awt.*;
import java.applet.*;
//The ImageWithSound class reads in a "gif" image and a "au" audio file. It displays the image and plays the sound. The MediaTracker class is used to wait
//for an image to be completely loaded before displaying it or playing the sound.
Public class ImageWithSound extends Applet {
   public void init() {
//Read in an Image and an AudioClip.
            String imageName = IMAGE;
            String audioName = AUDIO;
            String param = getParameter("image");
            if (param != null) {
               imageName = param;
            }
            param = getParameter("audio");
            if (param != null) {
               audioName = param;
            }
//Create a MediaTracker to inform us when the image has been completely loaded.
            Tracker = new MediaTracker(this);
//getCodeBase() returns the URL of the applet's directory. These calls will read in image and sound files relative to applet's directory.
            Sound = getAudioClip(getCodeBase(), audioName);
//getImage() returns immediately. The image is not actually loaded until it is first used. MediaTracker //ensures the image is loaded before it is displayed.
            Image = getImage(getCodeBase(), imageName);
//Add the image to the MediaTracker.
            Tracker.addImage(image, 0);
   }
//Display the image. The "this" argument to drawImage() is there/because drawImage() expects an "ImageObserver". An image may not be complete when drawImage() returns.
//If so, the ImageObserver argument is notified later.
//The ImageObserver is notified via its "imageUpdate" method. Applets that do elaborate image processing can override imageUpdate() to get information about the state of images.
   Public void paint(Graphics g) {
            g.drawImage(image, 0, 0, this);
   }
//Play the audio clip.
   Public void start() {
//Load the image and wait until it's done.
            Try {
               tracker.waitForID(0);
            } catch (InterruptedException e) {
            }
            repaint();
            sound.play();
   }
//Default values for the image and sound filenames.
   Private static final String IMAGE= "Images/M3.gif";
   private static final String AUDIO = "Audio/friendly.au";
// Private state variables.
   Private Image       image;
   private AudioClip    sound;
   private MediaTracker tracker;
}
```

Figure 22 - Friendly Vehicle ID Code

For example, the "gif" (Graphical Interface Format) file of the "friendly" Cavalry Fighting Vehicle (CFV) "M3.gif" would appear on the screen. Simultaneously, the scout leader would hear and audio warning "friendly M3". To accomplish this the code would execute the audio file "friendly.au". A sample of the type of graphic displayed is depicted in **Figure 23 (Friendly "M3.gif")** on the following page.

Figure 23 - Friendly "M3.gif"

(Note: Photo courtesy of the author and Texas Instruments Defense, 1997.
Graphic modified by William W. Kaake.)

4.3 CONCLUSIONS AND RECOMMENDATIONS

This study and analysis has produced valid possibilities for consideration of incorporation into a SMPT Applique' or VRPT. Programmers, software engineers, systems engineers, and subject matter experts should study the issue further culminating in proposals to the user community for adoption into current requirements and specifications to meet the user's capability needs. In the process, a great service will have been done for the country. A key tool will have been placed in the hands of our scout leaders enabling commanders to win the fight for information dominance on the battlefields of tomorrow.

CHAPTER V
CREATIVE THINKING APPROACH

5.1 INTRODUCTION

This chapter presents several techniques for formulation of design requirements for further study and analyses. Techniques include “My Fuzzy Brainstorming Process,” “Mind-Map” technique, “5-W” technique, “Po” (Provocation) technique, “APC” technique (Alternatives, Possibilities & Choices), and a review of modeling and simulation techniques.

5.2 METHODOLOGY

Present several “Creative Thinking” and/or “Brainstorming” processes useful in requirements determination. Each concept is presented with an implementation as it applies to SMPT requirement determination.

5.3 MY “FUZZY BRAINSTORMING” PROCESS

Several of the processes the author uses to brainstorm ideas are depicted in Figure 24 **(“My Fuzzy Brainstorming Process”)**. Another technique I use is called METT-T. Derived from the military acronym METT-T (Mission, Enemy, Terrain, Troops (and equipment available), and Time). This technique is easily adaptable to developing possible courses of action to many types of scenarios, situations, and problems. With practice and self-training, managers and engineers alike can become adept at using this technique. A short, systems engineering example of METT-T thinking follows.

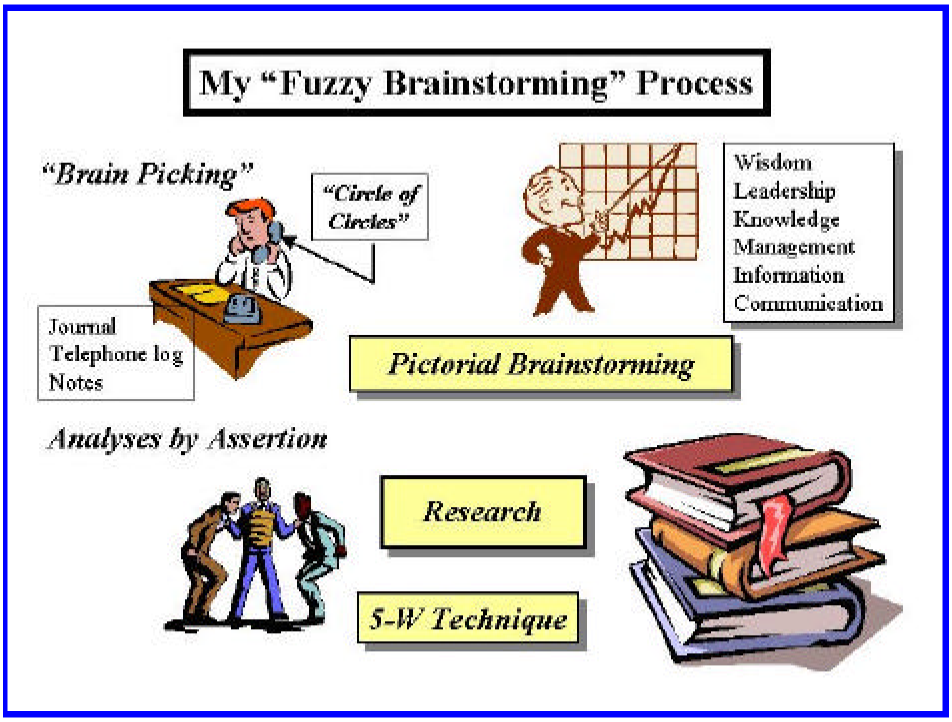

Figure 24 - "My Fuzzy Brainstorming Process"

(Figure designed by author [Kaake, W. (2000)] Clipart courtesy Microsoft and 1000 Clipart Images Inc.)

A systems engineering group is given the task of testing component "A". The group decides to use the METT-T brainstorming method. First, the team decides on the specific mission statement. It decides to choose: "Test component 'A' for functionality, reliability and maintainability." Secondly, the group lists ideas relating to how the customer will inspect, test, or receive a demonstration of the component. It may, additionally, list how competitors would test the component. Thirdly, the group would name all appropriate industry standards, laws, regulations, and statistical guidelines that apply to testing the component. The group would also invoke environmental issues related to the testing. Examples of these may be atmospheric conditions, temperature, or related components affected by the testing. Fourthly, the group list items and ideas affecting quantity and skill sets required of testers, evaluators, and analysts. The group would also list specific test equipment required and availability. The group would then finalize time available and ideas in which to optimize time available to complete testing.

This technique in brainstorming courses of action, lends itself very well to the use of backward planning and various other scheduling techniques. It also provides a basis for evaluating sample size, security planning, and logistical planning. This technique can also be "tailored," as it is in the military, to a lower level as "analysis by assertion" or "gut feel." Through "tailoring" the group or Decision-Maker may set limits on number of items listed, total discussion time, or eliminate one of the areas altogether in the essence of speed. With "tailoring" comes an associated risk level to be considered. When used in its entirety, the METT-T technique can be very effective. This technique is not a "silver bullet" to "solve the world's problems;" but it has worked very effectively for the author in and out of the military.

Networking is an effective means of brainstorming. General John B. Abrams once coined the phrase "Circle of Circles" in personal network development. Everyone has a "circle of circles" whether you use it or not, or even if you are aware of it. In our daily lives, at work, home, or play, we all have a small circle of individuals we deal with on a daily basis. In a networking or brainstorming sense, this is our inner most circle. As the circles go out, the frequency of acquaintance or communication and level of personal trust also diminishes; therefore, it is called "circle of circles." Since this concept inception, it has been found you may have many "circles of circles" on going at the same time. When multiple circles exist, I have found it is effective to keep separate address books, logs, and directories for each "circle of circles." This process is nearly a must when assigned as an engineer and/or manager to multiple projects simultaneously.

Occasionally, brainstorming and analysis by assertion merge and become one. This is a very common trap Decision-Makers fall into and can trap their engineers into. Analysis by assertion in this context is analyses by "gut feel," "gut reaction," or instinct based on personal experience rather than analysis by scientific method or that of statistical significance. It is recommended this technique is for use only when:

- In a small group, and time is of the essence (i.e. time for even minimal analysis does not exist and the answer was needed yesterday).
- The group has technical and operational background in the area and related areas of concern.
- The Decision-Maker has experience in quick risk mitigation.
- The Decision-Maker is experienced in decision making.

5.4 “MIND-MAP” AND “5-W” TECHNIQUES

5.4.1 FISHING “MIND-MAP”

The author and his eleven-year old son developed the fishing mind-map depicted in the following figure. Clouds were used for the first level thinking and boxes for more detailed or lower level thinking. It was found the exercise entertaining and a useful tool from which to develop a checklist for the next fishing trip.

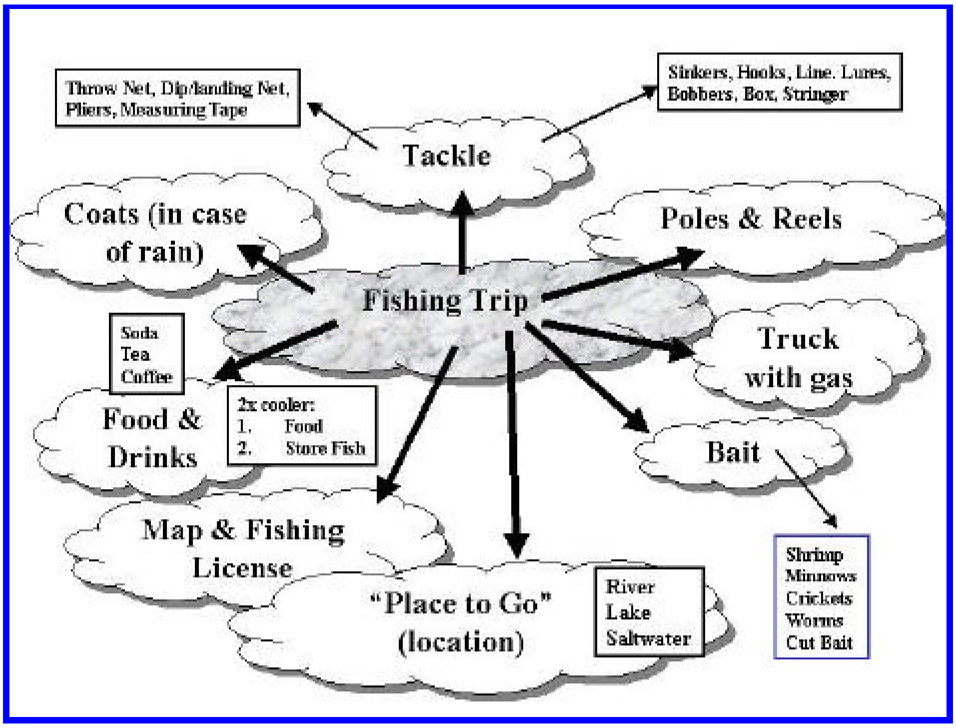

Figure 25 - Fishing “Mind-Map”

(Note: Graphic designed by author using Microsoft Power Point)

This approach could be implemented effectively in solving particular design issues as depicted in Figure 26 **(Graphical Symbols “Mind-Map”)** depicts a solution generation “Mind-Map” to solve the question “What graphical symbols must an SMPT Applique’ display?” The intent of this figure is to provide general requirements and is not intended to be all encompassing.

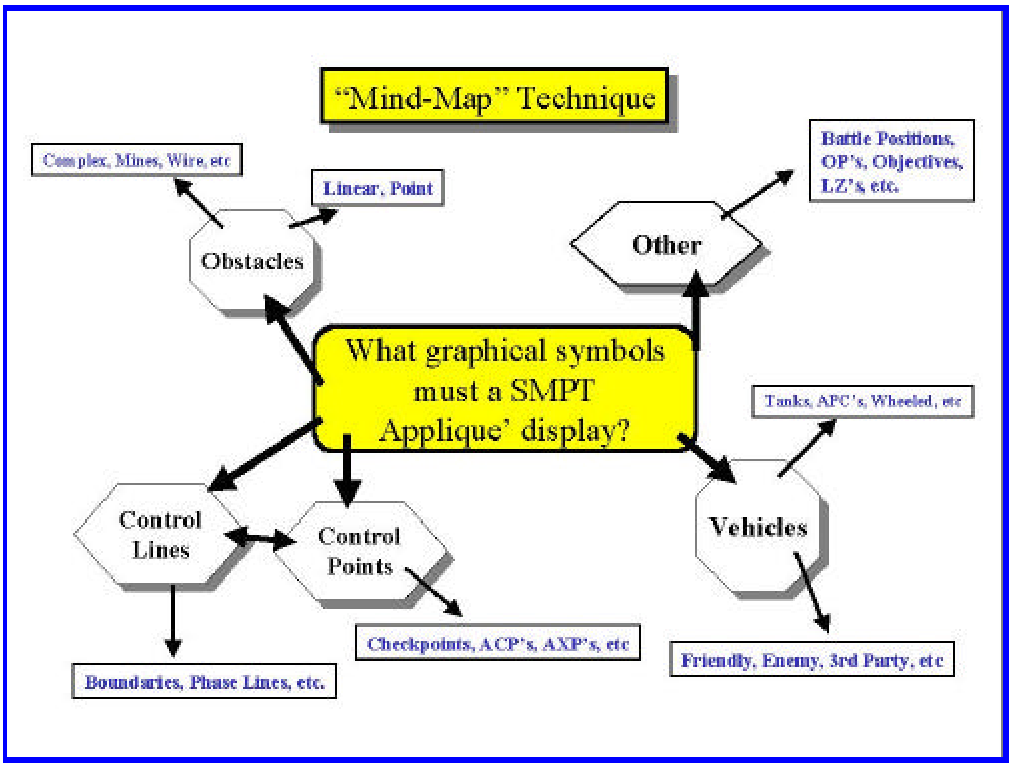

Figure 26 - Graphical Symbols "Mind-Map"

(Note: Graphic designed by author using Microsoft Power Point)

5.4.2 "5-W" TECHNIQUE

After completing the "mind-map," the author then continued the small group brainstorming session using the "5-W" technique. The results are listed below.

- **Who:** Author and sons Willie and William (All interested parties).
- **When:** Sometime soon (Suggested date and time).
- **Where:** Possible locations picked were Lake of the Pines, Port Aransas Pier, Aransas Wildlife Refuge, Baker Ranch Lake, Lake Texoma, Lake Pittman Dam, Lake Lavon, Lake Corpus Christi, Mission River, or the Red River.
- **What:** Fresh or salt water fishing trip.
- **Why:** First, for fun and sport; secondly, to catch good fish to eat.

Several authors, over the years, have credited various individuals for the true origin of the "5-W" technique. [Maxwell, T. (2000)] This technique can be used quickly to identify details and generate ideas or potential solutions. A variation of this technique as presented by Dr. G. W. Evans, Industrial Engineering Professor, University of Louisville, adds "**How?**" [Evans, G. (1997)] The "H" or "**How?**" question; however, is more useful in determining process to reach the desired end-state than in determining initial requirements. One must be careful not to restrict oneself to the "box" of current "know-how" in determining initial requirements. One must always "think-outside-the-box" to reach new innovative solutions.

5.4.3 TEST PREPARATION "MIND-MAP"

The following "Test Preparation Mind-Map," depicted in Figure 27 **("Test Preparation 'Mind-Map'")**, was developed as a visual aid in test preparation. Key items were included as memory joggers. This "mind-map" is not intended to be "all inclusive;" but, it is designed to be generic, yet, "tailorable" in nature. Each sub-level element(s) may in fact fall under multiple, higher level, categories. In some special cases, or for specific test types, particular area(s) may in fact become a higher level of concern. Therefore, gaining its' own "circle" in the "mind-map" and it may have its' own sub-elements.

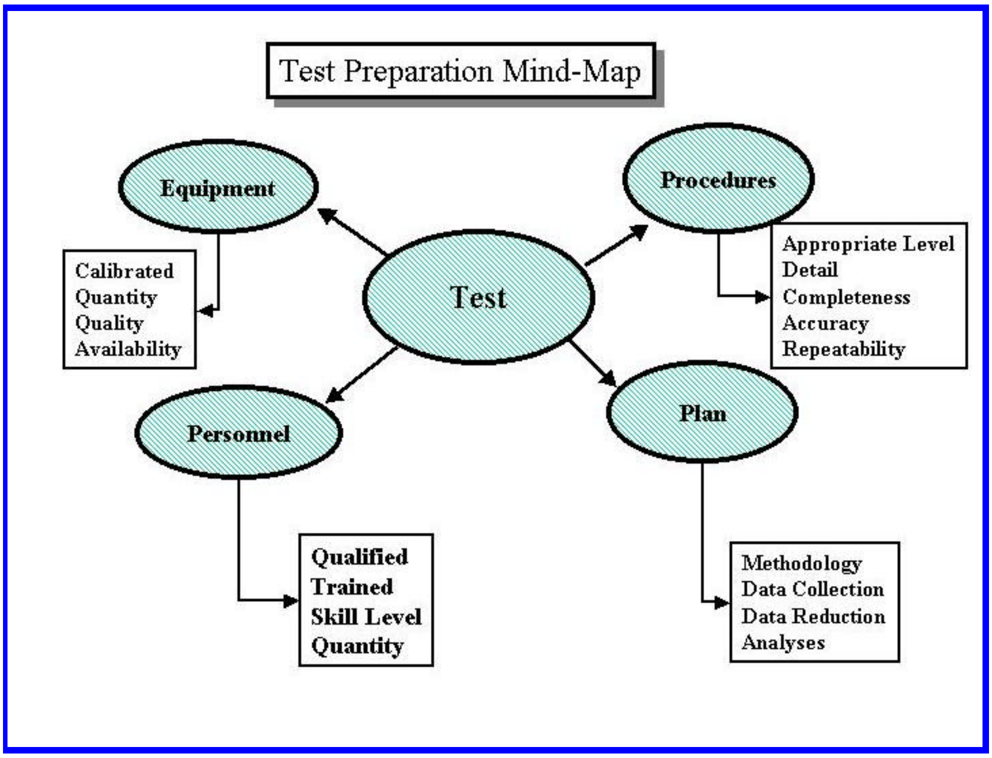

Figure 27 - "Test Preparation Mind-Map"

(Note: Graphic designed by author using Microsoft Power Point)

5.5 "PO" AND "APC" TECHNIQUES

The "Po" (Provocation) technique for idea generation starts with a simple statement. One or more participants list ideas as they occur. Each idea is listed and linked to the idea or question from which it is generated. [Maxwell, T. 2000] The original hypothesis should be somewhat reasonable; however, it can be consciously unreasonable. In general, a "Po" can take on a pattern or "stepping stone" approach to idea generation. This technique provides a basis for other techniques**.** Figure 28 **("Po" Example)** was generated by the author and Bradley Whittington. [Kaake, W. (2000)]

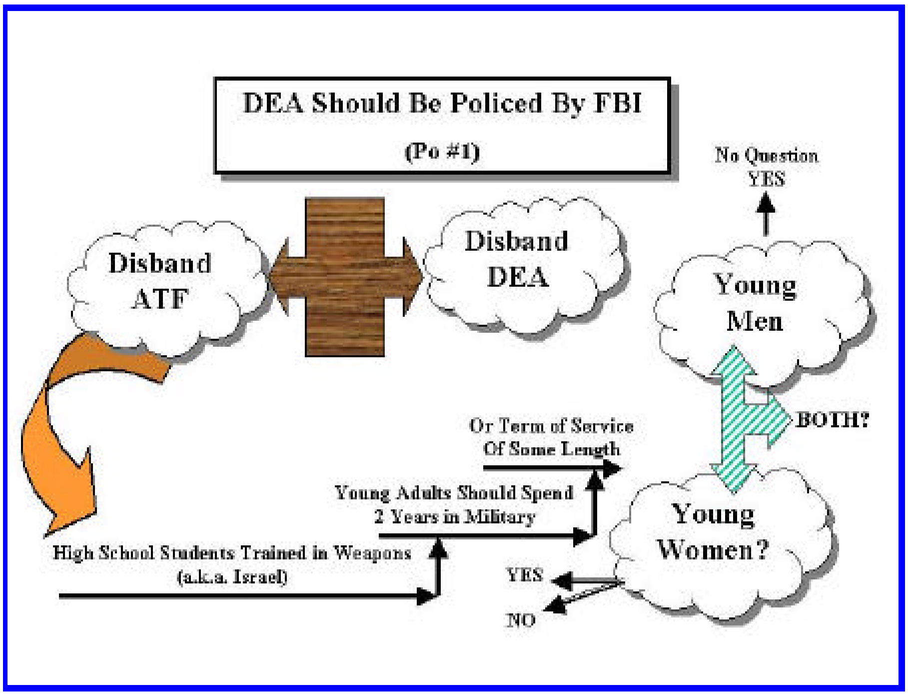

Figure 28 - "Po" Example

(Note: "Po" conducted by William Kaake & Bradley Whittington [Kaake, W. (2000)]. Graphic designed by author using Microsoft Power Point.)

Figure 29 **(SMPT "Po" Example Implementation)** depicts the results of the author conducting a limited "Po." The statement chosen to begin the "Po" was an "SMPT Applique' expanded to include an ELT (Electronic Light Table)". A spin-off of this "Po" process is then demonstrated using the APC (Alternatives, Possibilities, and Choices) technique. First, the APC is demonstrated for SGS (Squadron Ground Station) RAID (Redundant Array of Inexpensive Disc) in Figure 30 **(APC Technique on SGS RAID)**. Second, an implementation of APC is applied to the SMPT Applique'. See Figure 31 **(APC Technique on SMPT Applique' Memory).**

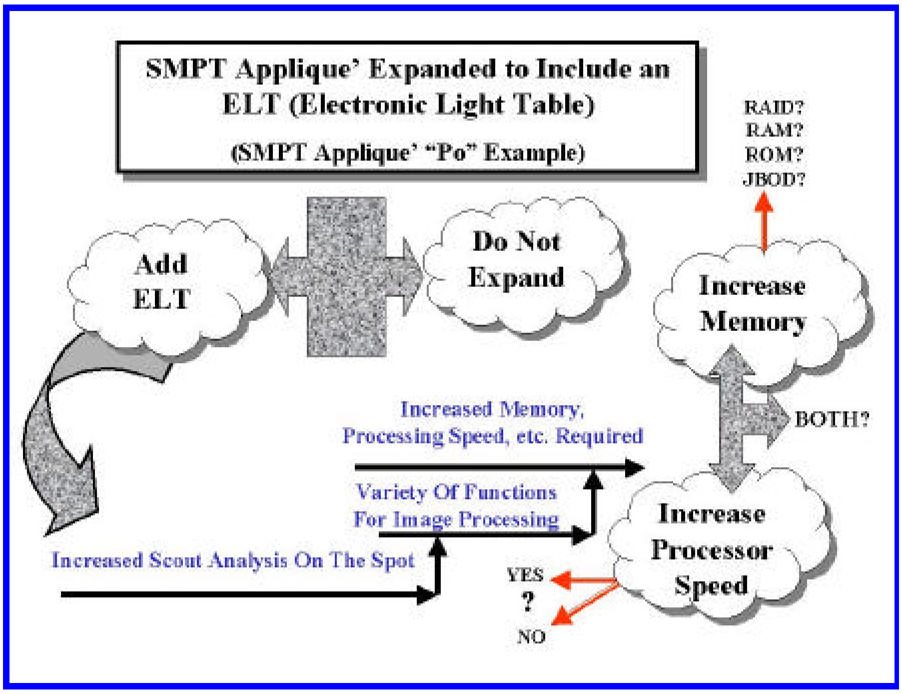

Figure 29 - SMPT "Po" Example Implementation

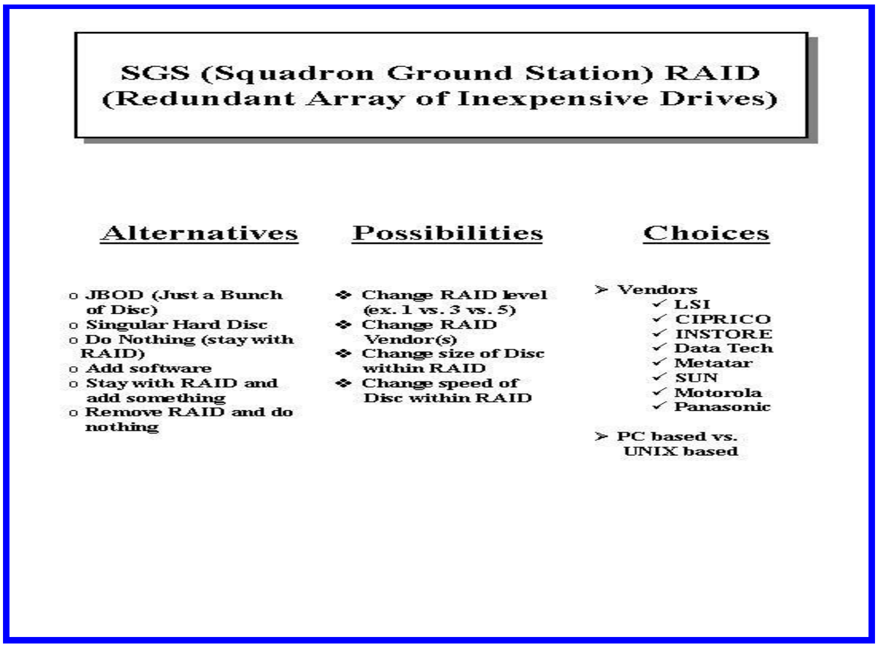

Figure 30 - APC Technique on SGS RAID

(Note: APC conducted by William Kaake & Bradley Whittington (2000). Graphic designed by author using Microsoft Power Point.)

The same APC technique applied to the SGS question, is implemented in Figure 31 **(APC Technique on SMPT Applique' Memory)** to the SMPT Applique' system.

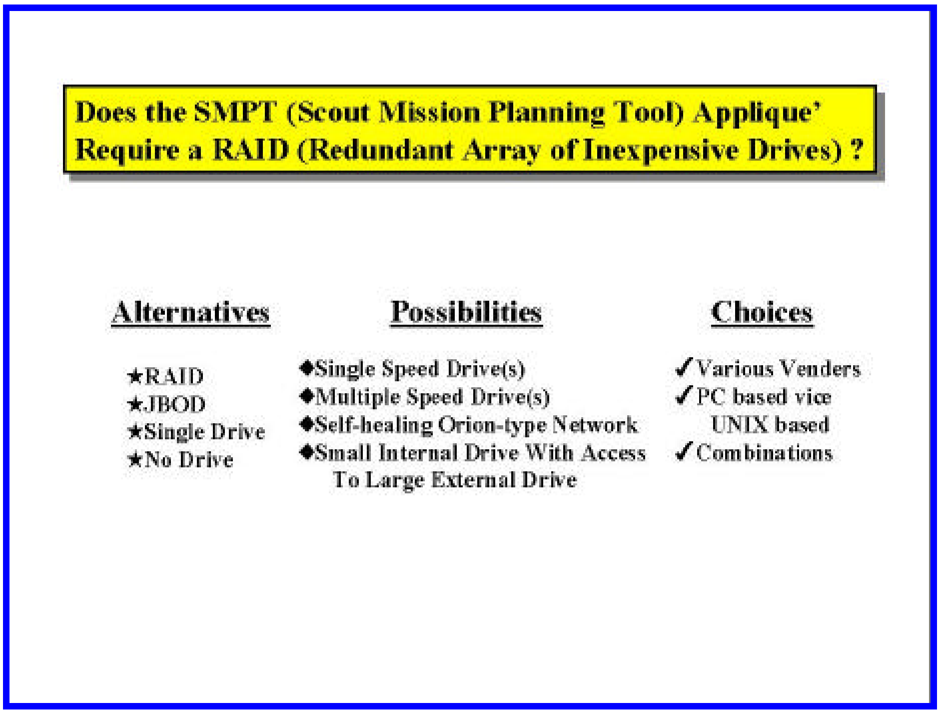

Figure 31 - APC Technique on SMPT Applique Memory

5.6 REVIEW OF CONCURRENT ENGINEERING MODELING AND SIMULATION TECHNIQUES

5.6.1 REVIEW OF CONCURRENT ENGINEERING MODELING TECHNIQUES

Concurrent engineering, "cross talk," and information sharing across multiple engineering disciplines can be an effective source of idea and solution generation. Reviewing of various parameters of recently or simultaneously created models is an effective technique for requirements determination. For example, using the Landis' Model, the following hardware requirements were determined by extracting parameters from a simultaneously created model. Values assigned to each requirement are for demonstration purposes and are not intended as hard and fast values. These values should be discussed in an Integrated Concept Team (ICT) or Integrated Product Team (IPT).

"Objective" and "Threshold" values should be determined, weighted, and "trade-off" analyses conducted accordingly.

Table 3 - Landis' Model: Basic Parameters

(Note: Model parameters developed by Richard Landis [Landis, R. (2001)]. Table modified by author.)

Hardware/Software Assumptions			
	Hardware Purchase Year	**2003**	
	Processor Improvements Per Year	**1.5**	
	Processor Efficiency	**0.25**	
	Disk Capacity Improvements Per Year	**1.6**	
	Active Disks Per Stripe	**8**	
	Max CPU Per System	**64**	
	Intrinsic System Scalability	**0.9**	
	Network Peak Channel Bandwidth	**10**	Gb/s
	Network Channel Efficiency	**0.6**	
Image Data Assumptions			
	Downlink Rate	**1**	Gb/s
	Downlink Rate Efficiency	**0.8**	
	Downlink Bits/pixel	**0**	
	Input:Output Pixel Ratio	**1**	
	Peak Output Images Per Second	**1**	
	Average Output Images Per Hour	**1**	
	Average Output Image Height	**1100**	
	Average Output Image Width	**1100**	
	Sustained Operations/Pixel	**3000**	
	Sustained Gflops for Product Processing	**250**	Gflops
Duty Information			
	Duty Cycle	**0.5**	
Non-SpinAp Single Image Product Timeline			
	Initial Processing		
	Collection - to - Capture on Disk	**0 sec**	
	Capture - to - Processing	**1 sec**	
	Image Processing	**2.0021 sec**	
	Processing - to - Disk	**1 sec**	
	Total Time Available to Product Processing	**4.0021 sec**	
	Product Processing		
	Archive - to - Product Processing	**1 sec**	
	Product Processing	**1 sec**	
	Product - to Archive	**1 sec**	
	Total Time In Product Processing	**3 sec**	
	Total Time To Exploitation	**7.0021 sec**	

The previous table shows nineteen assumptions applicable to SMPT Applique' requirement development and eleven potential requirements. (Note: Values and units in **Table 3** are for demonstration purposes only. These values are not intended to represent hard and fast requirements.) A review of other models under development can be a useful source of requirement idea generation. In today's concurrent engineering environment, keeping in tune with other disciplines, thinking "out-of-the-box," and sharing of ideas and techniques will lead to greater breakthroughs in process and technological advances.

The following table itemizes parameters, or "characteristics," extracted from the Landis' model with direct applicability to SMPT Applique' design requirements and constraints. Each of these items should be considered by a SMPT Applique' Development Team.

Table 4 - Landis' Model: Archive, Network, & Processing Characteristics Extract

(Note: Model parameters developed by Richard Landis [Landis, R. (2001)]. Table modified by author.)

Archive Characteristics	Network Characteristics	Processing Characteristics
Active Disks In Stripe	Peak Network Bandwidth	Purchase Year
ECC Disks	Network Efficiency	Processor Peak
Purchase Year	Effective Throughput	100% Efficiency Number of Processors
Disk Capacity	Disk to Processing Image Transfer Time	Number Per System
Total Number Of Disks		System Efficiency
Total Number of Stripes		System Effective Number
Stripe Width For Capture		Number of Systems
Min. File Systems Per System		Additional For Failure
Max. File Systems Per System		Total Number of Systems
Minimum Number Systems		Image Size
Number Input Channels		Flops Per Pixel
Max Input Bandwidth		Peak Flops Required
Output Rate To Compute		Effective System Peak Flops
Concurrent Outputs		Processing Time
Number of File Transfers		Start-up Time
Number of File Systems So Low Probability of Conflict		Clean-up Time
Total Number of Stripes		Total Processing Time
Total Disk Space		

5.6.2 REVIEW OF CONCURRENT ENGINEERING AND SIMULATION TECHNIQUES

Review of past simulations and conduct of new simulations in environments such as JANUS, CASTFOREM, ARTBASS, MODSAF, and SIMNET can refine requirements, generate new requirements, or alleviate unnecessary requirements. Simulations are especially helpful during the integration and test phases of prototype development. Simulations should be maximized throughout development of a SMPT Applique'.

5.7 CONCLUSIONS

Several techniques for formulation of design requirements for further study and analyses have been presented in this Chapter. "Creative Thinking" and/or "Brainstorming" processes are useful in requirement determination. Each concept was presented with an implementation as it applies to SMPT Applique' requirement determination.

By some estimates, in 2007, "…commanders and their staffs will require maneuver support with enhanced automated decision aid tools to achieve dynamic integrated development and resolution of operational COA's" (Courses of Action). [Bodt, B. (2001)] This directly applies to the scout's portion of C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance). A well designed SMPT Applique' would be a terrific step in the right direction toward providing a key decision aid tool into the hands of the first line scout supervisor.

CHAPTER VI
CONCLUSIONS

"Finding the enemy before he finds you" is a primary role of the ground reconnaissance soldier. Over the years, the techniques that were used effectively will not meet the needs of the future cavalry scout in Army operations. This study encompasses the eight major activities: review of literature, design process description, concept of design requirement development, brief tactical employment concept, preliminary design requirement concerns, design trade analyses generation concept, formulation of key design requirements for further study, and conclusions.

Human factors and their relationships with the design requirements play a very large role in the design outcome of the SMPT Applique' system. The author briefly discussed some of the impacts and has offered up food for thought that may generate further discussion, research, testing, and analysis. Each of the MANPRINT Domains should be kept in mind throughout the design development and the procurement process. We must give the scouts of the future the very best system possible from which to operate to fulfill the US Army's essential requirement. The proposed system in this report has potential to become a baseline system for a family of systems for the United States and potentially Combined Forces platforms.

It is recommended Raytheon form a "Tiger Team" to study the issues described and potential technologies to meet these issues immediately. Given current and future missions and threats, it is further recommended requirements determination, testing, and analyses must be conducted with emphasis on Joint and Combined environments. Actions today, may save lives in the future.

Effective requirement determination will lead to successful integration of available collection assets into successful planning focused on the commander's intent and PIR (Priority Information Requirements). The "Two-quad Tapestry," "Option Field," and ISM processes can be utilized in an efficient manner to identify design requirements. Prioritization of effort or emphasis can effectively be initiated through the "Option Field Method." It is recommended these processes be considered in designing a Scout Mission Planning Tool Applique'.

Given the device and components described throughout this document are truly theoretical brainstorms of the author in nature, the principles, approaches, and methodologies could be easily applied to develop, integrate, test, and field such a system. Domains and sub-domains must be defined, common definitions established and maintained, concept teams formed, components identified, protocols established, product and/or program team(s) established, contracts let, thorough design integration and test accomplished, system field tested, and then the system fielded fully functional.

This study and analysis has produced valid possibilities for consideration of incorporation into an SMPT Applique'. Programmers, software engineers, systems engineers, and subject matter experts should study the issue further culminating in proposals to the user community for adoption into current requirements and specifications to meet the user's "capability needs." In the process, a great service will have been done for the country. A key tool will have been placed in the hands of our scout leaders enabling commanders to win the fight for information dominance on the battlefields of tomorrow.

"Creative Thinking" and/or "Brainstorming" processes are useful in requirement determination. Each technique and concept presented applies to SMPT Applique' requirement determination. A design is only as good as its requirements. A well designed SMPT Applique' would be a terrific step in the right direction toward providing a key decision aid tool into the hands of the first line supervisor. Implementation of the concepts, techniques, and methodologies described throughout this document will lead to successful products in the hands of a satisfied and grateful user.

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Table 5 - Doctrinal Manuals

FM	Title	Dated
17-57-10-MTP	Mission Training Plan For The Scout Platoon	FEB 1996
17-95-10	The Armored Cavalry Regiment and Squadron	SEP 1993
17-97	Cavalry Troop	OCT 1995
17-98	Scout Platoon	SEP 1994
17-98-1	Scout Leader's Handbook	SEP 1990
71-100	Division Operations	1990
71-123	Tactics, Techniques For Combined Arms Heavy Forces: Armored Brigade, Battalion/Task Force, and Company/Team	SEP 1992
90-8	Light Intensity Conflict	

APPENDIX A

ACRONYMS & ABBREVIATIONS

AAR	After Action Review
AO	Area of Operation(s)
AOA	Analysis of Alternatives
AOAC	Armor Officer Advanced Course
An/Trs-2	Platoon Early Warning System (model number)
APC	Armored Personnel Carrier
ATD	Advanced Technology Demonstrator / Advanced Technology Demonstration
AWACS	Airborne Warning And Control System
BII	Basic Issue Items
BIT	Built In Test and diagnostic equipment
BOM	Bill Of Materials
Bn	Battalion
BUA	Built Up Area
C^2	Command and Control (may also be seen as C2)
C4I	Command, Control, Communications, Computer and Intelligence
C4ISR	Command, Control, Communications and Computer Intelligence, Surveillance and Reconnaissance
CAD/CAM	Computer Aided Design/Computer Aided Manufacturing
CAIV	Cost As an Independent Variable
CAS3	Combined Arms Staff and Services School
CD	Compact Disc
CEO	Chief Executive Officer
CFV	Cavalry Fighting Vehicle
CIM	Computer Integrated Manufacturing
CL I	Rations
CL III, V	Petroleum Products
CL IX	Repair Parts
CM	Configuration Management
CM/DM	Configuration Management /Data Management

COEA	Cost and Operational Effectiveness Analysis (replaced by AOA)
COFT	Conduct Of Fire Trainer
CONOPS	Concept of Operations
CORD	Coordinated Operational Requirements Document
CUT	Component Under Test
$DFD_{(1)}$	Directorate of Force Development
$DFD_{(2)}$	Data Flow Diagram
DFT	Design-Fix-Test
DoD	Department of Defense
DOE	Design Of Experiment(s)
$DM_{(1)}$	Decision Maker
$DM_{(2)}$	Data Management
DRP	Design Review Packet
ELT	Electronic Light Table
EM	Electro-Magnetic
EMP	Electro-Magnetic Pulse
ENB	Engineering Notebook
EOAC	Engineer Officer Advanced Course
ESD	Electrostatic Discharge
F/A	Failure Analysis
FA	False Alarm
FCS	Future Combat System
FCW	Federal Computer Week
FD	Fault Detection
FDC	False Detection Circuit
FI	Fault Isolation
FIG	Fault Isolation Group
FLIR	Forward Looking Inferred
FM	Field Manual
FMEA	Failure Mode Effects Analysis
FMECA	Failure Mode Effects Criticality Analysis
FR	Failure Rate
FRU	Field Replaceable Unit
FSCS	Future Scout and Cavalry System

FSV	Future Scout Vehicle (currently FSCS)
GFE	Government Furnished Equipment
Gflops	Giga-flops
gif	Graphical Interface Format
GOTS	Government-Off-The-Shelf
GUI	Graphical User Interface
HMMWV	High Mobility Multi-purpose Wheeled Vehicle
HPT	High Pay-off Target
html	Hypertext Mark-up Language
HTTP	Hypertext Transfer Protocol [Downing, D. et al (1996)]
HUMINT	Human Intelligence
HVT	High Value Target
I/O	Instructor/Operator
ICT	Integrated Concept Team
ILS	Integrated Logistics Support
IMP/IMS	Integrated Master Plan / Integrated Master Schedule
IPB	Intelligence Preparation of the Battlefield
IPD	Integrated Product Development
IPDS	Integrated Product Development Process (Raytheon standard design process)
IPT	Integrated Product Team (Integrated Production Team)
ISM	Interpretive Structural Modeling
ISO 9001	International Standards Organization standard 9001
IT	Information Technology
JAD	Joint Acquisition and Development
JBOD	“Just a Bunch Of Disc”
JROC	Joint Review Oversight Counsel
JTAG	Joint Test Action Group
JWIG	Joint Working Group
JWG	Joint Working Group
KPP	Key Performance Parameter(s)
LC	Line of Contact
LCC	Life Cycle Cost(s)
LD	Line of Departure
LNO	Liaison Officer

LOS	Line Of Sight
LRM	Line Replaceable Module
LRU	Line Replaceable Unit
METU	Middle East Technology University, Turkey
MI	Maintenance Interface
Mil	Military
MNS	Mission Needs Statement
MOS	Military Occupational Specialty
MP	Mission Profile
MTBF	Mean Time Between Failure
MTTD	Mean Time To Detect
MTTR	Mean Time To Repair
NBC	Nuclear, Biological, and Chemical
NCO	Non-commissioned Officer
NDF	No Defect Found
NDI	Non-Developmental Item
NET	New Equipment Training
NGT	Nominal Group Theory
NJIT	New Jersey Institute of Technology
non-RAM	Non-Random Access Memory (hard drive)
NTC	National Training Center
OMB	Office of Management and Budget
OO	Object Oriented
OPSEC	Operational Security / Operations Security
OR	Operational Readiness
ORD	Operational Requirements Document
ORSA-MAC	Operations Research Systems Analysis Military Applications Course
OT & E	Operational Test and Evaluation
OVM	On Vehicle Material
P3I	Pre-Planned Product Improvement
PEWS	Platoon Early Warning System
PIR	Priority Intelligence Requirement
PLT	Platoon
PMCS	Preventive Maintenance Checks and Services

"Po"	Provocation Technique
PSR	Pre-Ship Review
QA	Quality Assurance
QC	Quality Control
R & S	Reconnaissance and Surveillance
RAD	Rapid Acquisition and Development
RAID	Redundant Array of Inexpensive Drives
RAM	Random Access Memory
Recon	Reconnaissance
RFP	Request For Proposal
ROM	Read Only Memory
RSTA	Reconnaissance, Surveillance, and Target Acquisition
SBIT	Start-up Built-In-Test
SCL	Software Configuration List
SCM	Software Configuration Manager
SDF	Software Development File
SDL	Software Development Library
SEC	Standard Evaluation Circuit
sec.	Second(s)
SEM	System Engineering Management
SIGSEC	Signal Security
SIT	System(s) Integration and Test
SLMP	Scout Leader's Mission Planner
SME	Subject Matter Expert
SMPT	Scout Mission Planning Tool
SOI	Software Operating Instructions
SOW	Statement Of Work
SPC	Statistical Process Control
SPM	Software Project Manager
Sqdn	Squadron
SQE	Software Quality Engineer
$SRA_{(1)}$	System Replaceable Assembly
$SRA_{(2)}$	Subsystem Replaceable Assembly
SRD	Software Requirements Document

$SRR_{(1)}$	Shipping Readiness Review
$SRR_{(2)}$	Software Requirements Review
$SRU_{(1)}$	Shop Replaceable Unit
$SRU_{(2)}$	Subsystem Replaceable Unit
STD	Standard
Std.	Standard
SWDP	Software Design Package
T & E	Test and Evaluation
T & M	Time and Materials
TACSOP	Tactical Standard Operating Procedures
TBD	To Be Determined
TBP	To Be Published
TCP/IP	Transmission Control Protocol/Internet Protocol [Downing, D. et al (1996)]
TEDP	Test Engineering Development Plan
TEPI	Test Engineer Process Instructions
TM	Technical Manual
TPED	Tasking, Processing, Exploitation & Dissemination
TPM	Technical Performance Measures
TQD	Total Quality Design
TQM	Total Quality Management
TRADOC	US Army Training and Doctrine Command
TRD	Test Requirements Document
TRR	Test Readiness Review
TS	Test System
TSDO	Test System Development Organization
TTU	Texas Tech University, Lubbock, Texas
TWIG	Technical Working Group
TWG	Technical Working Group
U	Unclassified
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UK	United Kingdom
US	United States of America
USAARMC	United States Army Armor Center

UUT	Unit Under Test
VRPT	Vehicular-based Reconnaissance Planning Tool
WBS	Work Breakdown Structure
WIP	Work In Process (Progress)
www	World Wide Web
XML	Extended Mark-up Language
XMTR	Transmitter
ZVSO	Zero-Value Sales Order

APPENDIX B
POTENTIAL COMPONENTS

The following table of 19D, Skill Level 40, tasks are not an "all encompassing" list the scout leader must accomplish. Each scout leader may be required to accomplish any task in the table or multiple tasks simultaneously. Each task listed has one or more training components associated with it. Most have operational components. These operational components are sub-components to task at the crew, platoon, or higher echelon level. Each task listed is a candidate to become a component of the Scout Platform Reconnaissance and Surveillance Planning Tool. The table below is unclassified and was adapted from the Fort Knox Doctrine web site.

Table 6 - "19D40 Task List"

TASK NO.	Task Name
01-1930.41-1001	Create Obstacles Using Explosives
01-1940.20-1001	Develop An Obstacle Plan
01-1960.21-1002	Evaluate Limiting Factors Of Obstructions To Movement
01-5700.03-0900	Perform Function Of A Radio Net Control Station Using Secure And Non-Secure Equipment
031-507-3003	Supervise Operational Decontamination Operations
031-510-4000	Plan Operations For An NBC Environment
031-510-4001	Conduct Operations In An NBC Environment
03-4000.00-0003	Inspect Ammunition For Compliance With Storage, Safety And Security Regulations
04-3315.02-0002	Conduct Helicopter Movement Of A Platoon
071-730-0004	Plan Installation Of A Platoon Early Warning System An/Trs-2
121-030-3501	Prepare The Rater's/Senior Rater's/Reviewer's Sections Of An NCO Evaluation Report
171-091-1019	Build A Quick Smoke Screen
171-091-1020	Direct Emplacement Of An Obstacle By An Armor/Scout Platoon
171-091-1021	Plan Re-supply Operations At Platoon/Team Level
171-091-1022	Conduct Re-supply Operations At Platoon/Team Level
171-121-3036	Plan Reconnaissance Of A Built Up Area (BUA) At Platoon Level
171-121-3038	Conduct A Relief In Place At Platoon Level

TASK NO.	Task Name
171-121-4001	Control Scout Platoon Fires
171-121-4004 171-121-4005	Conduct A Screening Mission Plan A Screening Mission
171-121-4009	Conduct Scout Platoon Actions On Contact
171-121-4015	Conduct A River Crossing
171-121-4016	Conduct A Displacement At Platoon Level
171-121-4020	Direct Operation Of Live-Fire Ranges
171-121-4021	Plan Range Operations
171-121-4037	Plan A River Crossing
171-121-4038	Supervise Local Security
171-121-4039	Conduct A Platoon Level After-Action Review (AAR)
171-121-4042	Supervise Quartering Party Activities
171-121-4045	Conduct Troop Leading Procedures At Platoon Level
171-121-4046	Direct Emplacement And Activation Of Platoon Early Warning System (PEWS)
171-121-4053	Plan An Armor/Scout Platoon Tactical Road March
171-121-4061	Conduct Armor Tactical Navigation At Platoon Level
171-121-4067	Execute Scout Platoon Pre-combat Operations
171-121-4068	Perform A Reconnaissance By Fire
171-122-1061	Maintain Property Accountability
171-123-1018	Supervise Platoon Maintenance
171-123-1095	Prepare An Operation Order At Platoon Level
171-123-1300	Conduct A Route Reconnaissance At Platoon Level
171-123-1301	Conduct An Area/Zone Reconnaissance At Platoon Level
171-123-1304	Conduct Reconnaissance Of A Built Up Area (BUA) At Platoon Level
171-123-1305	Conduct The Reconnaissance Of An Obstacle At Platoon Level
171-123-1306	Supervise Scout Platoon Tactical Formations
171-123-1313	Plan A Reconnaissance Mission
171-123-4000	Plan The Occupation Of An Assembly Area
171-123-4001	Prepare A Platoon Fire Plan
171-123-4005	Conduct The Occupation Of An Assembly Area
171-123-4007	Coordinate An Armor/Scout Platoon Passage Of Lines
171-123-4008	Direct A Consolidation And Reorganization At Platoon Level
171-123-4009	Conduct An Armor/Scout Platoon Passage Of Lines
171-131-1040	Conduct A Conduct Of Fire Trainer (COFT) Training Session
171-131-1042	Conduct A Preparation For Operation Exercise On The Conduct Of Fire Trainer

TASK NO.	Task Name
	(COFT)
171-131-1061 171-131-1062	Place The Conduct Of Fire Trainer (COFT) Into Operation Operate Equipment During A Training Session On The Conduct Of Fire Trainer (COFT)
171-131-1063	Prepare For A Conduct Of Fire Trainer (COFT) Training Session
171-131-1064	Conduct A Debrief For A Conduct Of Fire Trainer (COFT) Training Session
171-131-1065	Perform Power-Down Procedures On The Conduct Of Fire Trainer (COFT)
171-131-1066	Perform Preventive Maintenance Checks And Services (PMCS) On Conduct Of Fire Trainer (COFT)
171-131-2045	Track Crew Progression On The Conduct Of Fire Trainer (COFT)
171-131-2046	Manage Conduct Of Fire Trainer (COFT) Training Records
171-131-2047	Identify The Senior Instructor/Operator (I/O) Duties And Responsibilities On The Conduct Of Fire Trainer (COFT)
171-131-3000	Supervise A Conduct Of Fire Trainer (COFT) Program
171-131-3003	Plan Range And Tactical Scout Training Exercises
171-131-3004	Conduct Range And Tactical Scout Training Exercises
171-530-3011	Supervise Liaison Officer (LNO) Duties
171-610-0001	Perform A Map Reconnaissance
171-610-0002	Recognize Threat Tactics And Battlefield Organization

APPENDIX C
INTELLIGENCE DOMAIN MODEL

Initial elements, or metrics, of domain defined in figure below. A stair-step approach was taken and percentages applied to goodness of each metric. [Kaake, W. & Whittington, B. (2001)]

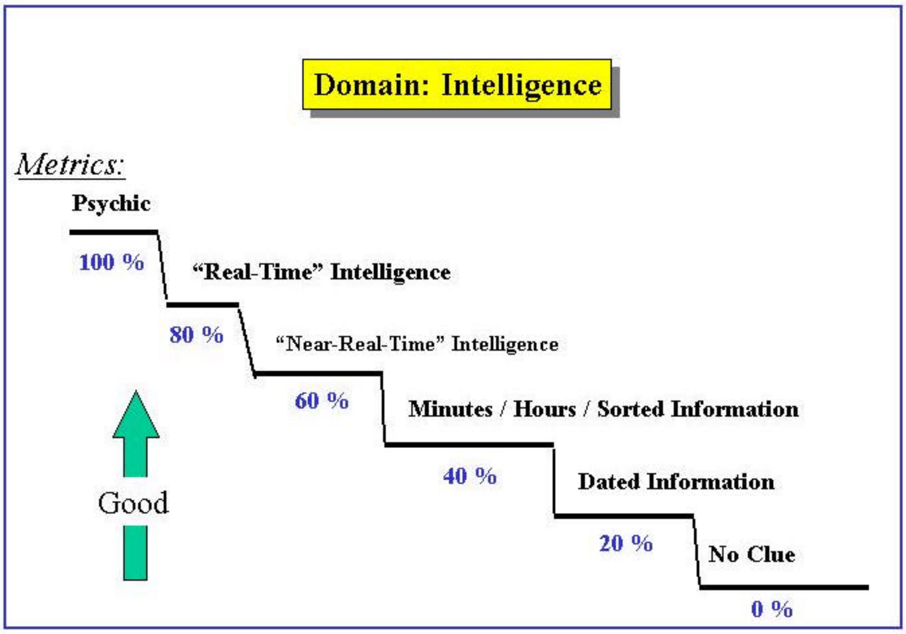

Figure 32 - Domain: Intelligence

Maturity model criteria were defined as "When?" in relation to reaction time required and "How?" defined as data type.

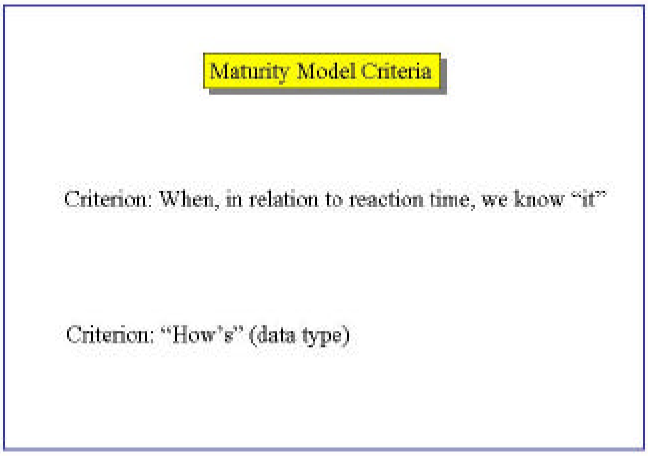

Figure 33 - Maturity Model

Each criterion was then applied to the previously described metrics. Results are depicted in the following two figures.

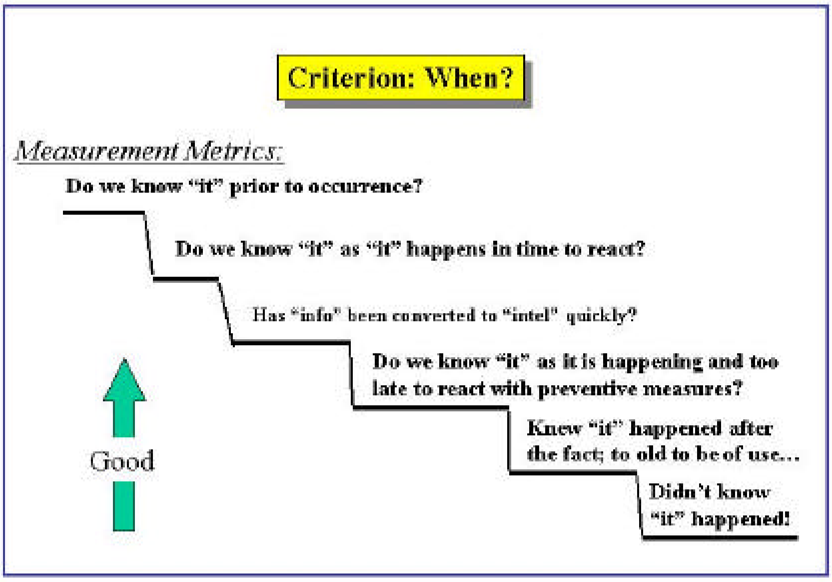

Figure 34 - Criterion: When?

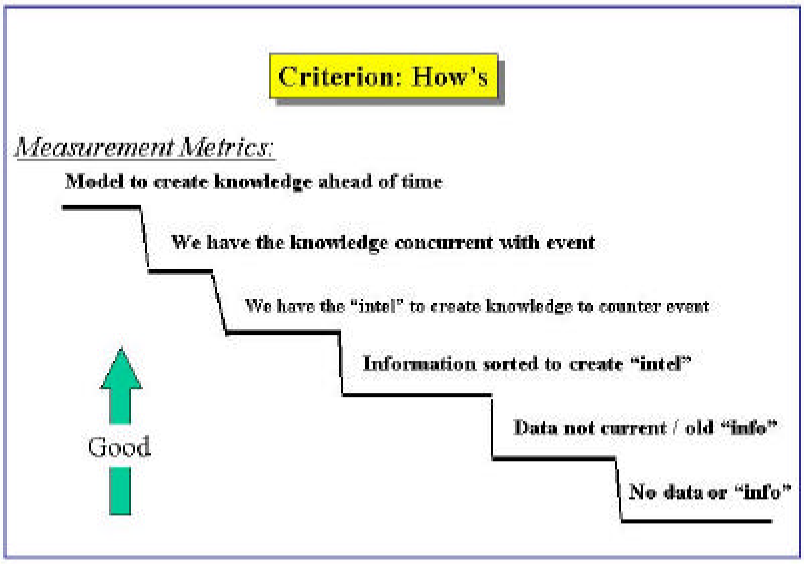

Figure 35 - Criterion: How?

The following figure describes the initial task and boundaries agreed upon to determine structure of generic domain model resulting from the intelligence domain.

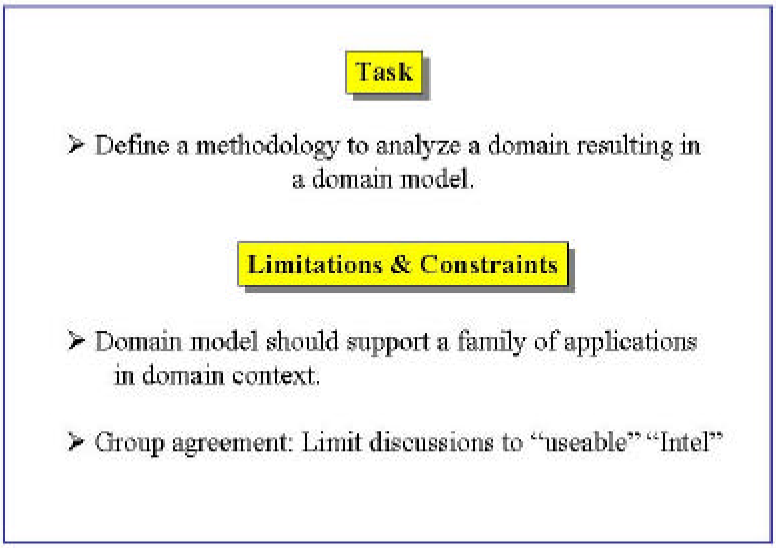

Figure 36 - Task & Boundaries

Group discussions led to task refinement to develop a methodology to analyze, model, and suggest applications for the generic intelligence domain.

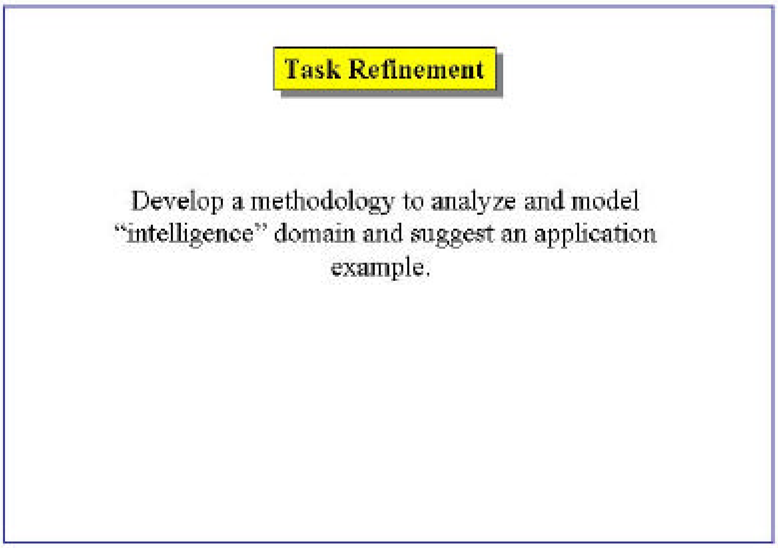

Figure 37 - Task Refinement

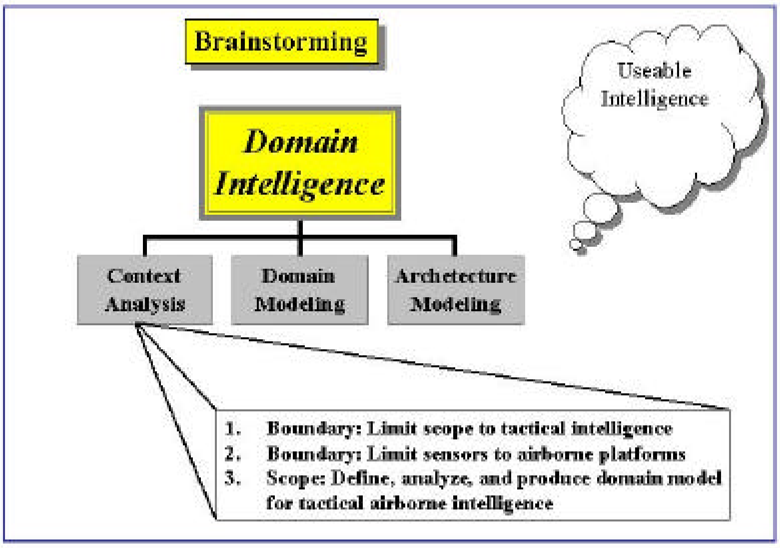

Figure 38 - Brainstorming

The previous figure depicts the results of the team brainstorming of the intelligence domain. To define the domain more clearly, the domain was broken down in a hierarchical technique of context analysis, domain modeling, and architecture modeling. Context analyses resulted in two boundaries and a redefined scope. Boundaries agreed upon included limiting the scope to tactical intelligence with a focus of airborne platforms while generating a generic model for the entire intelligence domain. This in turn led to a redefined scope for the group project. The techniques and philosophies applied here could be used to further define the Scout Mission Planning Tool Domain and the ELT (Electronic Light Table) Domain, as well as any other intelligence sub-domain.

This domain model was designed to be applicable to all levels of the intelligence domain, as well as, describe the interactions within levels. Pieces of the intelligence puzzle compliment each other to provide a clear picture for the commander at each level. The figure below pictorially depicts the intelligence domain puzzle.

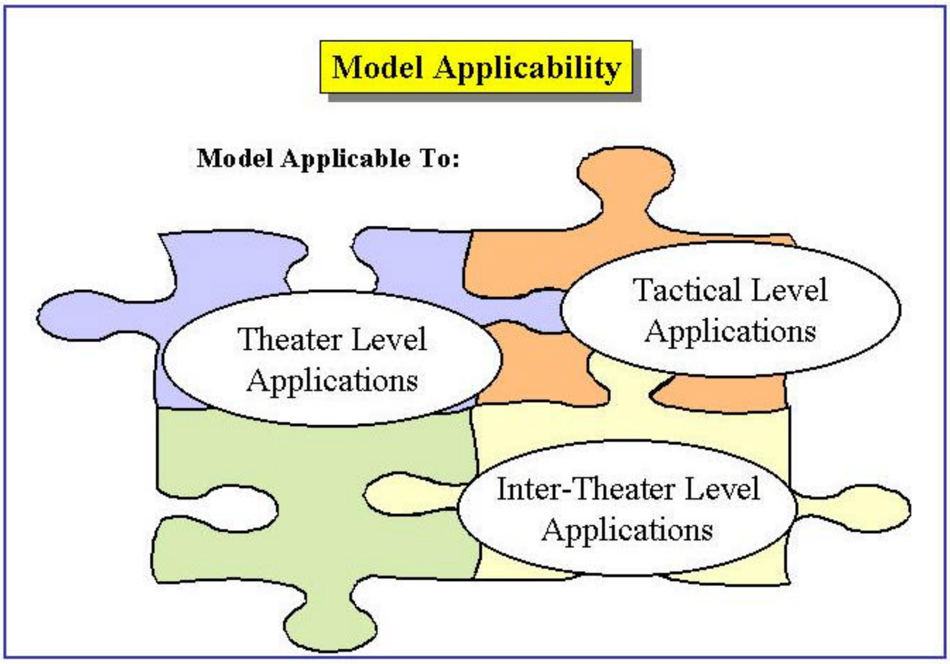

Figure 39 - Model Applicability

Within the scope and applicability previously described, a hierarchical approach was taken to further define the domain.

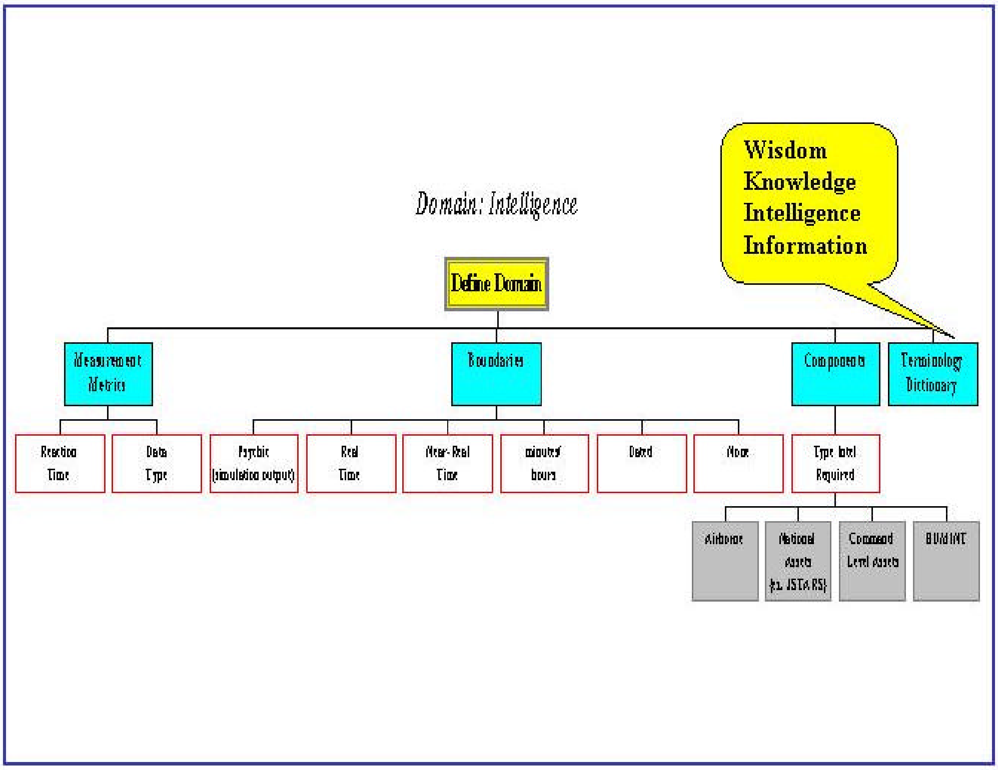

Figure 40 - Hierarchical Domain Definition

Per the “Super-Class”, “Class”, and “Sub-Class” technique presented by Dr. Ali Dogru, the intelligence domain was defined in the following structure. [Dogru, A. (2001)]

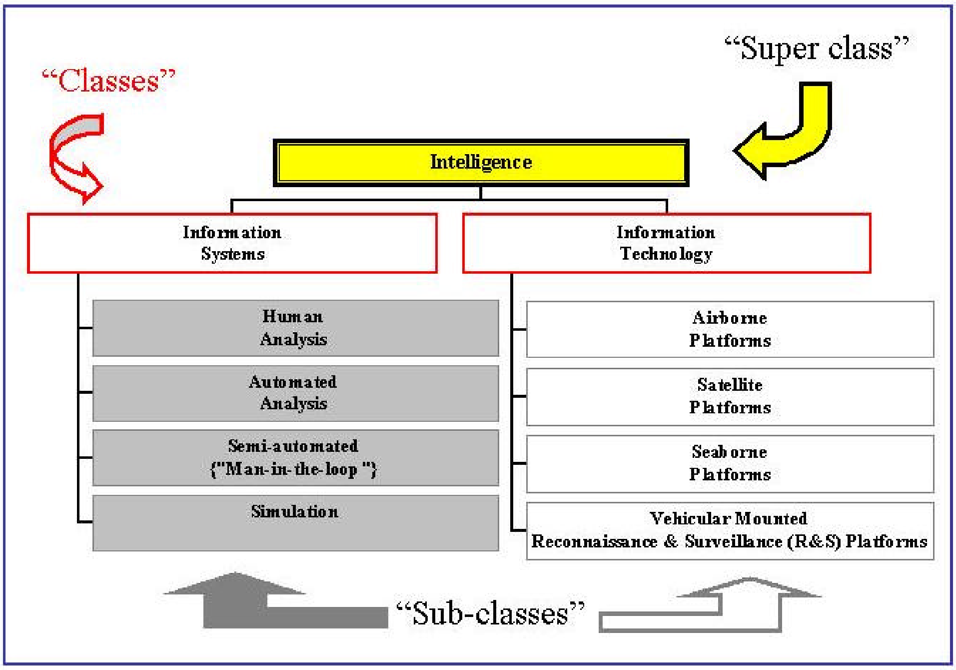

Figure 41 - "Class Structure"

The following generic model and application examples were developed using a "needs based methodology". The generic model is depicted in Figure 42 **(Generic Model of Intelligence Domain)**. Applications of the model are demonstrated in Figure 43 **(Example Application of Generic Model: Theatre Level)** and Figure 44 **(Example Application of Generic Model: Tactical Level)**.

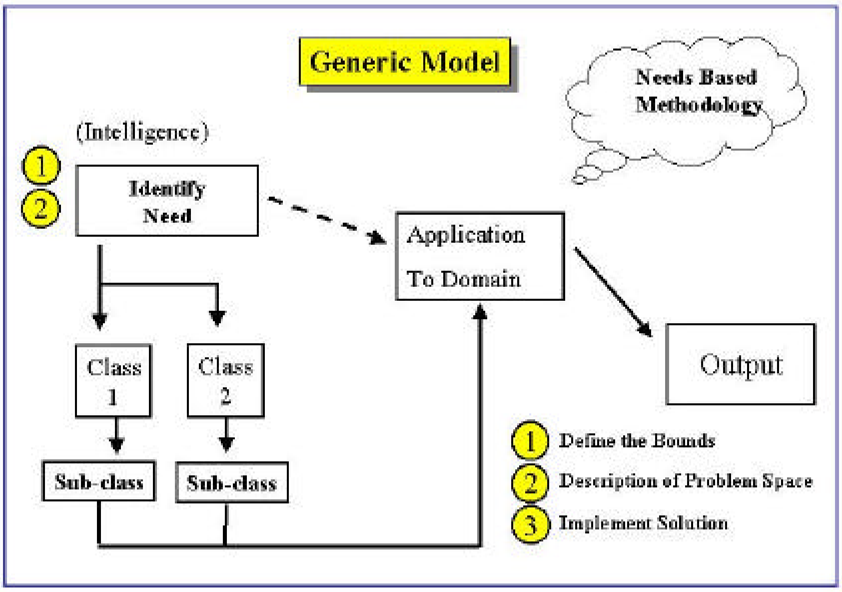

Figure 42 - Generic Model of Intelligence Domain

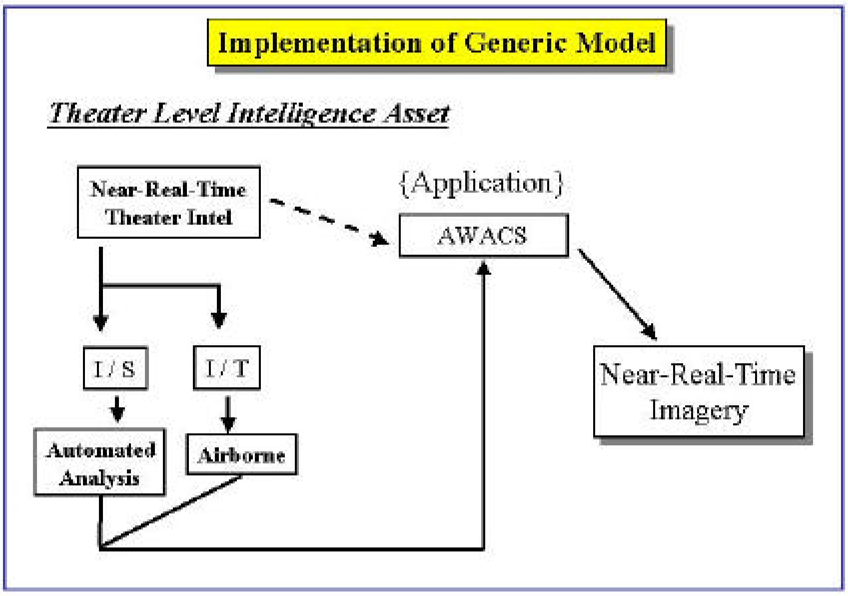

Figure 43 - Example Application of Generic Model: Theater Level

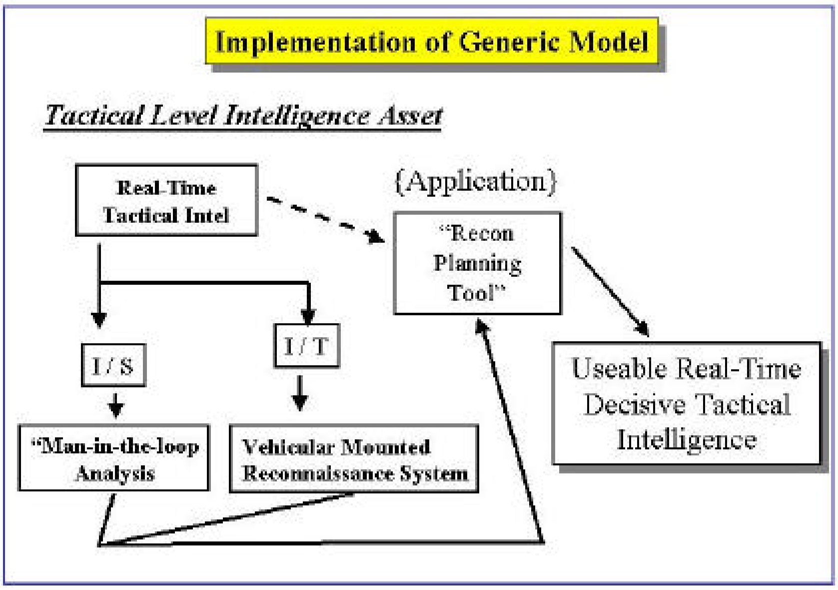

Figure 44 - Example Application of Generic Model: Tactical Level

The generic model is portrayed in "Class Diagram" format in the figure below.

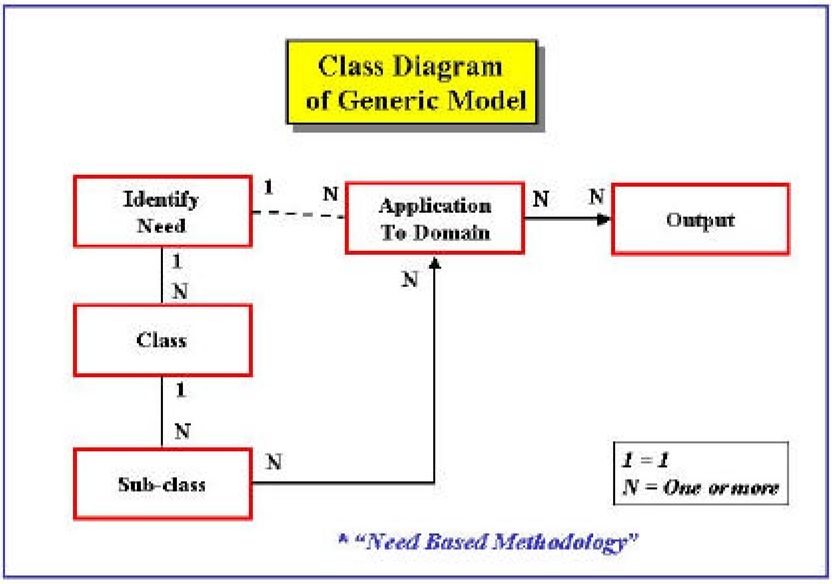

Figure 45 - Class Diagram of Generic Model

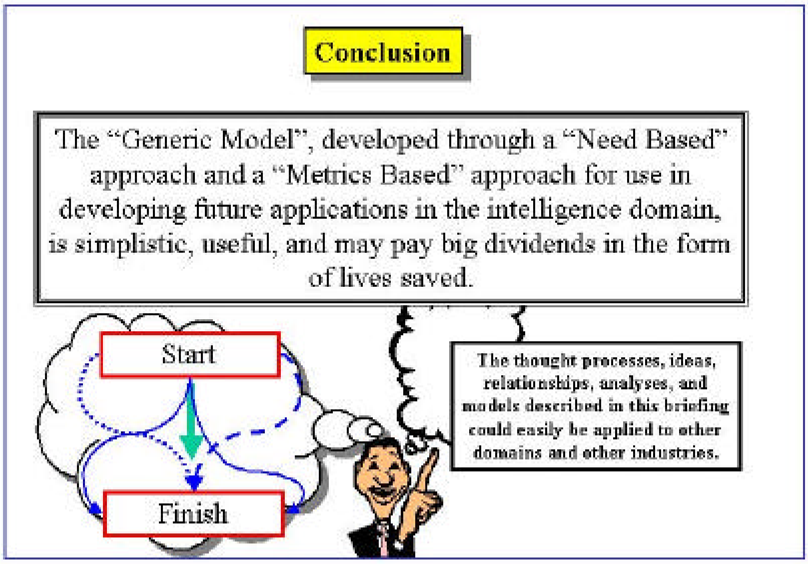

Figure 46 - Generic Domain Model Conclusion

(Clipart courtesy Microsoft "*Office 2000*")

APPENDIX D
DATA DICTIONARY

The following “Data Dictionary” was designed as a starting point for SMPT Applique’ development and discussion. It is not intended to be all encompassing. Rather it is designed as a basis for SMPT Applique’ requirements determination. An Integrated Concept Team (ICT) should further the development of this “Data Dictionary” for use throughout SMPT Applique’ development and implementation.

A

Acceptable – Item being evaluated meets all applicable criteria.

Acceptance Criteria – Criterion a system or component must satisfy in order to be accepted by a user, customer, or other authorized entity. [IEEE-STD-610]

Acceptance Testing – Formal system or sub-system testing conducted to determine satisfaction of acceptance criteria. This testing enables customers to determine whether or not to accept the system. [IEEE-STD-610] Likewise, acceptance testing can be used to determine acceptability from sub-contractor or supplier.

Action Item – An issue, challenge, problem or question assigned to an individual or group for disposition.

Activities – Activities are those actions that must be taken in some order to enable the process step is completed. Activities are single actions or procedures that can sometimes be very simple or complex.

Activity –

1.) Any step or function performed, both mental and physical, toward achieving some objective. Activities include all work the managers and technical-staff undertake to perform tasks of the project and organization.

2.) A group of associated tasks. The results of an activity can produce certain deliverables and can be accomplished by one or more project team members. Several activities comprise a work package.

Ambiguity group - The smallest group of replaceable units into which a fault can be isolated.

B

Benchmark – A standard against which measurements or comparisons can be made. [IEEE-STD-610]

Best Value – A standard evaluation of a product, system, or service based on all reasonable factors including, but not limited to: initial price, life cycle costs, available extended warranties, prior product experience, availability of distribution and service channels, past producer performance, and past vendor performance. Used for the purpose of procuring a product, system, or service that provides optimum satisfaction of the mission need.

Bill of Materials (BOM) – A list of all items, pieces, tools, jigs, fixtures, and information required for production.

Built In Test (BIT) – Software inside the UUT (Unit-Under Test) which conducts an internal review of components and/or sub-components for operational capability.

C

Component-Under Test (CUT) - A generic term used to refer to the hardware, software, and/or firmware being tested on a test system or sub-system. A chip, board, module, thread, or a sub-assembly is an example of CUT.

Computer Integrated Manufacturing (CIM) – "Art and science" of totally integrating manufacturing processes to streamline and reduce waste. [Ranky, P. (1994)]

Conduct Of Fire Trainer (COFT) – A simulator for crew training in the art and sciences of target acquisition, fire control, and engagement.

D

Data Flow Diagram (DFD) Model – Traditional data flow diagram depicting inputs and outputs to a process or system as shown **Figure 47 (Data Flow Diagram)**.

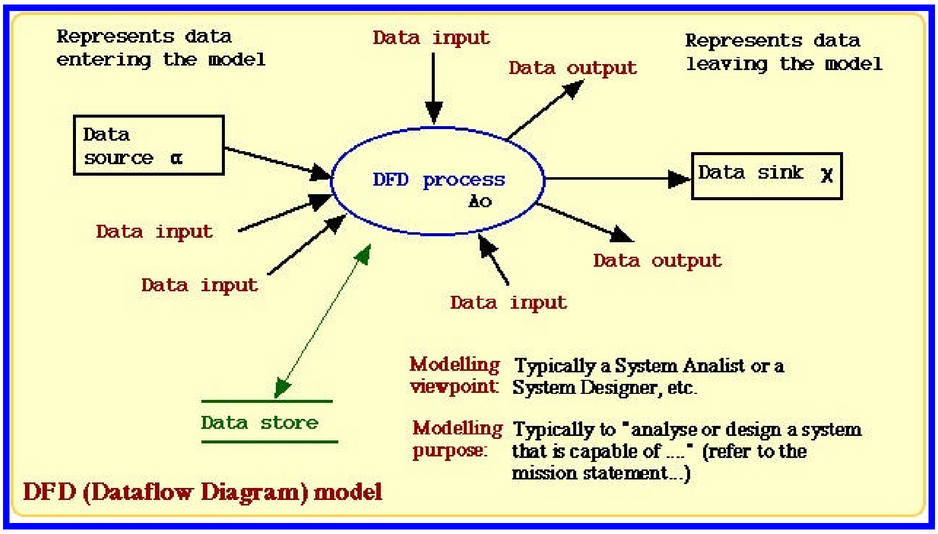

Figure 47 - Data Flow Diagram

(Drawing courtesy CIMware UK&USA, multimedia design by Paul G. Ranky) [Ranky, P. (1997)]

Design Review Packet (DRP) – A set of documentation and/or viewable graphs presented during a system's design review.

Design verification – The process of verifying the correctness of a design relative to its requirement specification.

Destructive testing –

1.) Destructive testing is defined as prolonged endurance testing of equipment or specimen until failure for determination of service life or design weakness.

2.) Testing in which the preparation of the test specimen or the test itself may adversely affect the life expectancy of the UUT (Unit-Under Test) or render the sample unfit for its intended use. [Mil-Std-1309C]

<u>E</u>

Electrostatic Discharge (ESD) – Release of an electric charge, due to potential difference between transmitting and receiving points.

Electrostatic discharge sensitivity – Level of susceptibility a device has to damage by static electricity. ESDS classification testing finds the susceptibility levels and provides the basis for assigning ESDS class. [NASA ASIC Guide]

Engineering Notebook (ENB) – An electronic or hardcopy repository of project notes and working data

F

Failure – The inability state of an item to perform its required function. Failure is the functional manifestation of a fault.

Failure analysis (F/A) –

1.) A formalized approach to determine the cause and nature of part failures and to recommend corrective actions.

2.) Organization(s) that perform work as described in definition 1. (Derived from [NASA ASIC Guide])

Failure mechanism – Failure mechanism is defined as an underlying cause of a defect. For example, a detected circuit open (a "fault") may be caused by a break in an aluminum interconnect (a "defect"), which in turn was produced by electro-migration activity (the "failure mechanism"). (Derived from [NASA ASIC Guide])

Failure mode – Functional, or logical, representation of a physical failure mechanism(s).

Failure Modes and Effects Analysis (FMEA) – Process for analyzing and documenting the set of failure mode effects, which will occur at the interface of an object given a failure mode (fault) in the object as well as the severity of the effects and techniques for mitigating the effects when necessary.

Failure Modes and Effects Criticality Analysis (FMECA) – A Failure Modes and Effects Analysis designed to discover key deficiencies and outcomes.

Failure population – Failures used as a basis for the design and evaluation of tests. [Mil-Std-1309C]

Failure Rate (FR) – The incremental change in the number of failures per associated incremental changes in time.

False Alarm (FA) – A fault indicated by BIT (Built In Test) or other monitoring circuitry where no fault exists. [MIL-STD-2165]

False alarm rate - Number of false alarms per unit of time; or number of false alarms per BIT alarms, expressed as a percentage. [MIL-STD-2165]

Fault - A physical condition which causes a device, component, or element to fail to perform in a required manner, for example, short-circuit or a broken wire. [Mil-Std-1309C]

Fault class – The grouping of equivalent faults. [MIL-STD-2165]

Fault coverage – Ratio of all detectable faults in a circuit to the count of those faults detected by a particular test set (set of test vectors). The ratio is usually expressed as a percentage and is most often associated with stuck-at fault modeling and testing. (Derived from [NASA ASIC Guide])

Fault Detection (FD) – A process that discovers or is designed to discover the existence of faults; the act of discovering the existence of a fault. Fault detection capability is measured as a percentage of faults detected by a process with respect to the total specified fault population.

Fault dictionary – A list containing each fault signature, and its associated failed item (or one of a group of items), causing the fault signature to be generated and displayed by the background BIT.

Fault grade – A measurement of how efficiently test vectors detect manufactured defects in a device or circuit.

Fault indicator – Device which presents a visual display, audible alarm, or other indication, when a failure or marginal indication exists. [MIL-STD-2165]

Fault insertion – The process of inserting actual or simulated faults into a hardware or software representation of the system to validate BIT or test program set performance. [MIL-STD-2165]

Fault Isolation (FI) – A process that identifies or attempts to identify the location of a fault to a specified unit or units. A fault is isolated if and only if it is contained in an isolation unit identified in the specified fault group.

Fault Isolation Group (FIG) – A set of all specified isolation units, which could contain a fault, which causes an error symptom identifying that FIG to occur. (Note: The FIG will typically list replaceable items such as LRU's (Line Replaceable Unit(s)), LRM's (Line Replaceable Module(s)), $SRA_{(2)}$'s (Subsystem Replaceable Assembly) (also known as $SRU_{(2)}$'s (Subsystem Replaceable Unit) and which often consist of electronic assemblies (cards, modules, boards, etc.), inter-back panel and inter-unit cables, back panels or card rack assemblies) and discrete replaceable components.)

Fault isolation resolution – A measure of the degree of ambiguity that exists in the ability of a test system to isolate to a failed replacement unit.

Fault latency – The elapsed time between failure occurrence and fault indication.

Fault list – A list of faults, within those specified by the assumed fault model, which are the target faults for the test pattern set.

Fault model – A means for representing the effects of a failure on circuit signals at the transistor, logical (gate), or functional (register transfer) levels.

Fault population – Faults used as a target basis for the design and evaluation of tests.

Fault signature – The set of all data used to uniquely define an error symptom or syndrome.

Fault simulation – The process of simulating the test process using the actual test patterns applied to a model or models of the UUT. The objective is to determine fault coverage, establish a list of undetected faults, and develop a set of faulty CUT (Component-Under Test) responses for diagnostic applications.

Fault symptom – Measurable, or visible abnormality in an equipment parameter.

Fault tolerance – The capacity of a system, or program to continue operations in the presence of specified faults. [Mil-Std-1309C]

Fault universe – The totality of faults being considered. If all of these faults are detected, then 100% fault coverage has been achieved. [MIL-STD-2165]

Field Replaceable Unit (FRU) – The smallest packaging unit designated as removable and replaceable in a field maintenance environment.

Filtering – A method of selecting and/or removing certain data points (e.g. removing "outliers" of parametric data points by applying a 4 standard deviation filter prior to performing a yield/sigma calculation).

First pass silicon – A device that works, according to its specification, the first time it is manufactured. [NASA ASIC Guide]

Functional Built-In Self-Test – A BIST capability that attempts to exercise the UUT (Unit-Under-Test) as it would work in normal operation. Functions are exercised in an attempt to expose and isolate the symptoms of a fault or faults that are present.

Functional fault – A fault, which can be described by a change in the operational description of some portion of a system. [Derived from Mil-Std-1309C

G

Guidline – Defined as a document providing advice, guidance, or supporting information for the execution of a process. It does not prescribe obligatory conduct.

H

Hypertext Mark-up Language (HTML) – A universal coding language for creating web pages, buttons, algorithms, etc.

Hypertext Transfer Protocol (http) – a standard method of publishing information as hypertext in HTML format on the Internet. Web site addresses normally start with lower case "http…" [Downing, D. et al (1996)]

I

International Standards Organization (ISO) – International organization of industry subject matter experts responsible for defining "ISO-9000" quality standards.

Irredundant fault – A fault that does not exist at a redundant node.

ISO 9001 – Quality System model, with major management responsibilities, for quality assurance in design and development, manufacturing, installation and servicing. [Ranky, P. (1997)**]**

ISO Standard – Standard published by the International Organization for Standardization. The ISO is an organization that develops international standards to support commerce, science and technology.

Item – General term for an entity that is stocked, manufactured, and/or tested that is uniquely identified.

J

Joint Test Action Group (JTAG) – An international organization of electronic industry representatives, whose goal is to standardize boundary scan as a testability feature for chips. JTAG is a common name for IEEE 1149.1, which defines a standard "test access port" and boundary scan architecture.

K

Key Performance Parameter(s) (KPP) – Most critical performance parameters extracted from customer Operational Requirements Document (ORD) or O&O (Operational and Organizational) Concept document.

L

Latent defect – A microcircuit defect that is not likely to inhibit performance until well into the microcircuit's lifetime. [NASA ASIC Guide]

Library – A collection of information about cells, usually created, tested, and verified by the cell manufacturer for a specific fabrication process. Cell libraries given to system designers include function and performance information required for circuit design of a CAD (Computer Aided Design) system. [NASA ASIC Guide]

Life-Cycle-Cost – Total cost of a system over its life cycle from development through disposal.

Limit – A boundary of the designated range through which the measured value of characteristics may vary and still be considered acceptable.

Line Replaceable Unit (LRU) – An item that is replaced at the organizational maintenance level.

M

Maintainability – A characteristic of design and installation expressed as the probability that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

Maintenance Interface (MI) – Interface from a UUT or system to an external tester, to a maintenance processor, or to any other equipment assisting in the maintenance process.

Mean-Time-Between-Failures (MTBF) – A measure of reliability giving the average time between failures.

Mean Time To Detect (MTTD) – The mean elapsed time from one or more of the following defined reference points until the detection of a fault by a specified set of detection mechanisms:

1.) Time of fault occurrence,

2.) Time of initiation of the test mode containing the specified set of detection mechanisms,

3.) Alternatively, time at which the circuitry containing the fault in the equipment is used in its specified environment.

Mean-Time-To-Repair (MTTR) – The arithmetic average of time required completing a repair activity. [MIL-STD-1309C]

Measurement standard – A measuring instrument or artifact used as a reference to establish and maintain the accuracy of other measuring instruments or artifacts. Measurement standards may be used to calibrate other standards of lesser accuracy or to calibrate test and measuring equipment directly. [Mil-Std-1309C]

Measurement uncertainty – Range that a measured value is expected to lie within a given probability. [Mil-Std-1309C]

Mission critical fault – A fault, which causes the system, in which the fault occurs, to be unable to perform or continue to perform its intended mission.

N

No Defect Found (NDF) – Item removed from a higher-level item believed to be defective or a cause of failure, but which passes test when returned and re-tested at original item level. An NDF may be due to intermittent or marginal faults, environmental, application, or usage situation that stresses the item; thus, causing temporary failure, inadequate testing, inadequate specifications, improper usage, inadequate diagnostics, or maintenance procedures.

Non-detectable fault – Fault(s) that no test can be constructed to detect.

O

Object number – A unique identifier for each object in order to identify which object is reporting data for logging.

Object-Oriented Methods – Computer programming methods based on the use of items called objects, which are capable of communicating with each other in the form of global broadcasts. [Ranky, P. (1994)]

Observability – The ability to determine the signal value at any node in a circuit by controlling the circuit's inputs and/or observing its outputs.

Operational Readiness Test (ORT) – Test specifically designed to determine whether an equipment or system is operationally suitable for a mission.

Operational Test and Evaluation (OT&E) – Tests of the operational capability of an item, conducted in as realistic an operational environment as possible, and then, an evaluation of the test results including an estimate of the item's military utility, operational effectiveness and operational suitability. The evaluation is used in deciding whether or not to go into full production of the item. [Mil-Std-1309C]

P

Pre-planned Product Improvement (P3I) – Additions, changes, or upgrades planned or prepared to be executed in the future.

Preventive Maintenance Checks and Services (PMCS) – A list or series of lists of operator tasks to be performed "Before, During, and After" operations of the subject equipment or system. List(s) should contain precise criteria for system success, deficiency, and failure.

Product –

1.) Normally defined as a system, assembly, or component to be delivered or sold to a customer.

2.) An assembly, sub-assembly, or item, created using documented processes.

3.) An aggregation of system elements providing homogeneous set(s) of end use functionality and has, or is intended to have, application to multiple systems. A product may contain multiple configuration items or be contained within a configuration item.

4.) A service provided to a customer, end user, or group of customers.

Program – An undertaking requiring concerted effort, which is focused on developing and/or maintaining a specific product or service. The product may include hardware, software, and other components. Typically a program has its own funding, cost accounting, and delivery schedule. Small programs are sometimes referred to as projects. This analysis uses the term program regardless of size.

Preliminary Design Review (PDR) – A meeting or process during which a test system hardware and/or software preliminary design is presented to project personnel, managers, users, customers, or other interested parties for approval.

Preventive maintenance – Tests, measurements, replacements, adjustments, repairs and similar activities carried out with the intention of preventing faults or malfunctions from occurring during subsequent operation. Preventive maintenance is designed to keep hardware and software in proper operating condition and may be performed on a scheduled basis. [Mil-Std-1309C]

Process monitor – A structure built into a chip or wafer used for regularly scheduled, periodic sample measuring of a parameter during normal performance of production operations in accordance with the manufacturer's approved program plan. The parameter to be measured, the frequency of measurement, the number of sample measurements, the conditions of measurement, and the analysis of measurement data will vary as a function of the requirements, capability, and criticality of the operation being measured. (Derived from [NASA ASIC Guide])

Prototype – A fabricated or assembled item used to verify any or all of the following for the item and/or its system: function, performance, operating limits, and reliability. Proof-of-design parts and engineering parts are prototypes.

Q

Quality – The ability of a device to meet or exceed the expectations of its specification beyond some minimum period time. [NASA ASIC Guide]

Quality Assurance (QA) – The group responsible for verifying that a microelectronics vendor delivers as promised. They are involved in approving a vendor's facilities early in a procurement cycle and then comparing the actual delivered devices with the device contract. [NASA ASIC Guide]

Quality assurance test – Final test of a product, based on sampled inspection, that ensures that the quality control and prior test processes are being performed adequately.

R

Readiness – Degree a system is operationally suitable for a mission.

Released – The point at which a document is approved and the master is under Configuration/Data Management control.

Reliability, Maintainability, and Availability (RMA) – A term applied to analysis of reliability, maintainability, and availability. A series of testing and analyses to determine ability of the system and its components to remain operational over a stated amount of time, determine difficulty of repair, and repetitiveness of deficiencies.

Repeatability – The closeness of agreement among repeated measurements of the same variable under the same conditions. [MIL-STD-1309C]

Replaceable unit – The lowest assembly or individual part that can be fault detected, isolated, removed, replaced, and verified functional at organization level without disassembly of the equipment to which it is attached in consonance with the maintenance concept. [MIL-STD-2165]

Request For Proposal (RFP) – A customer's detailed specification of a desired product and an invitation to submit a cost estimate and proposal for development.

Requirement –

1.) A requirement is something wanted or needed. A requirement is considered to be something essential to the existence or occurrence of something else. From a "Systems Engineering" perspective, a requirement mandates that something must be accomplished, transformed, produced, or provided. The objective of requirements is to define "WHAT" the system must do in order to meet mission needs or program objectives. A requirement describes a characteristic action to be accomplished by one of the system elements of equipment (hardware), software, facilities, personnel, procedural data, or any combination thereof.

2.) Statement expressing an observable, measurable, and/or testable attribute.

S

Software Configuration List (SCL) – Specification type listing(s) of artifacts and versions in a software release.

Software Configuration Manager (SCM) – Person performing activities to identify and manage software configuration.

Software Design Package (SWDP) – Includes items such as: specification of the architecture, components, interfaces, and other characteristics of a software system or component.

Software Development File (SDF) – An electronic or hardcopy repository of project notes, unit testing results and other working data related to a software unit and/or component.

Software Development Library (SDL) – Consists of hardcopy and/or electronic repository of software work artifacts, code, and test code.

Software Operating Instruction (SOI) – Agreed upon software development process procedures.

Software Project Manager (SPM) – Member of the IPT (Integrated Product Team) who is responsible for administering and managing the software aspects of the project.

Software Quality Engineer (SQE) – Person(s) are those that perform specific "quality assurance" activities for software.

Software Requirements Document (SRD) – Specification document of essential system needs to have value and utility. Software requirements may be derived or based upon interpretation of stated requirements to assist in providing a common understanding of the desired operational characteristics of a software product. [Based on IEEE 93]

Software Requirements Review (SRR) – A meeting or process during which a test system hardware and/or software requirements are presented to project personnel, managers, users, customers, or other interested parties for approval.

Standard – A measurement instrument or artifact used as a reference to establish and maintain the accuracy of other measuring instruments or artifacts. Measurement standards may be used to calibrate other standards of lesser accuracy or to calibrate test and measuring equipment directly. [Mil-Std-1309C]

Standard Evaluation Circuit (SEC) – A device used for maintaining qualification of a QML fabrication line, it is typically a memory device. [NASA ASIC Guide]

Standby current – The current drawn by an idle device while in normal operating mode. [NASA ASIC Guide]

Start-Up Built-In-Test (SBIT) – Start-Up BIT is defined as the initial set of built-in-tests performed on equipment. (Usually conducted after the application of equipment power, or of an external reset.) After detection of an error or fault, identification of specific, individual test error decision or cause of the error may not be possible via the equipment's primary error reporting mechanisms (i.e. interface(s)). The function of the Start-Up BIT is to test the circuitry needed to support test execution and error reporting for the other "Off-Line BIT" sub-modes and the "On-Line" and "PORT" test modes. Also called "Power-Up BIT".

Statement of Work (SOW) – Specification by the customer of work to be performed

Statistical Process Control (SPC) – A technique for keeping a process within specified performance limits by measurement, statistical analysis, and feedback. SPC is often used along with "Design Of Experiments" (DOE) to improve yield and provide other enhancements to a microelectronics fabrication line. [NASA ASIC Guide]

Storage element – Any non-RAM (Non-Random Access Memory) or ROM (Read Only Memory) element that retains its' state, such as a flip-flop, latch, register, or counter.

Structural fault model – A fault model based on deficiencies or discrepancies present at nodes in the circuit under test.

Structural test – A test to determine if the structure of a device is correct as specified. Structural tests may be done on many different levels of a circuit.

Structured design for testability – A DFT (Design-Fix-Test) approach that is systematic and structured, such as the scan path techniques, rather than being ad hoc or heuristic based.

Stuck-at fault – A deduction about a circuit problem based on a comparison of expected logical outputs to actual outputs. The underlying assumption is that a gate input or output is inhibited by a defect from switching states and is "stuck at" a particular value. [NASA ASIC Guide]

Support equipment – Equipment required supporting the operation and maintenance of equipment. [Mil-Std-1309C]

System – A collection of components organized to accomplish a specific function or set of functions. [IEEE-STD-610]

System Integration Test (SIT) – Integration Test, which is performed on a system during and after its assembly and prior to executing Acceptance Test. See “Integration and Test.”

System logic – Any item of logic that is dedicated to realizing the non-test function of the component or is, at the time of interest, configured to achieve some aspect of the non-test function. [IEEE 1149.1a-1993]

<u>T</u>

TBD – To Be Determined

Tailor – Modify elements of a process.

Tailoring – The selection and modification of elements of a process to meet a program's requirements. Tailoring results in program plans that satisfy the needs of both the organization and the program and commitments to perform to those plans.

Task descriptor – A textual description of process steps including input, output, and other pertinent information.

Template – Prescribed electronic or paper form that provides a guide or pattern used to gather or convey information.

Test – A process which applies a stimulus to and monitors and evaluates the output or response from an entity (system, device, etc.) to either determine its (performance) characteristics or to determine if its (performance) characteristics are in conformance with previously defined standards.

Test Engineering Development Plan (TEDP) – Description of a particular project’s schedule, resources and approach for developing a test system

Test Engineering Process Instruction (TEPI) – A secondary level of test engineering process documentation that explains the details for executing the test development process.

Test evaluation – The process of assessing the effectiveness of a test.

Test event – A test event is the process of initialization, stimulus, and measurement of the test item, and the evaluation of the results. A test event occurs during a continuous period of time and the start and end times are part of the test event data.

Test event data – Data relating to the context of the test event, for example test item identification, test configuration, environmental conditions, etc.

Test Procedure – Procedures & specifications for connecting test items, setting test conditions, running tests, interpreting results, and troubleshooting failures. Test procedures are required for consistent testing and/or fault isolation in a test item. A test procedure document should contain systematic "traceability" to the test requirement document.

Test Readiness Review (TRR) – A review to determine if the test system is ready to be presented to the customer for acceptance test.

Test Requirements Document (TRD) – A specification that contains the required performance characteristics of a UUT and specifies the conditions, values (and allowable tolerances) of the stimuli, and associated responses needed to indicate a properly operating UUT. A specification of the testing operations that a given test system must perform when testing hardware.

Test System Development Organization (TSDO) – Organization, formal or informal, responsible for developing one or more test systems.

Testability – A design characteristic, which reflects the degree of test performance achieved on a system or which reflects the ability of a system to be tested.

Testing –

1.) The process of determining the absence or presence, and in some cases the location, of one or more design flaws, manufacturing defects, or field failures in a chip, board, or system.

2.) Act of performing a test or tests.

Tolerance – Defined as total permissible measurement deviation from a designated value. [Mil-Std-1309C]

Total Quality Management (TQM) – Organizational approach noted for making all individuals responsible for improving the quality of good and services supplied. Activities in TQM include a rigorous program of on-going internal organizational analysis, benchmarking against competitors, explicit change control and meaningful progress measurement in all areas. [NASA ASIC Guide]

Tool – Hardware or software that automates some portion of product or process implementation.

Total Quality Control (TQC) – Management process designed to minimize product defects while maximizing profits.

Transient failure – A temporary failure induced by a momentary or temporary external factor, such as a power fluctuation, excessive ambient temperature excursion, electromagnetic interference, or by factors internal to a system. [MIL-STD-2165]

Transition fault – A type of memory fault in which a cell fails to transition from a one to a zero (or vice versa).

U

Unit – The smallest logical entity in the detailed design that completely describes a single function in sufficient detail to allow implementation of independent testing of other units. This definition applies to code as well as hardware, firmware, etc.

Unit-Under Test (UUT) – A generic term used to refer to the hardware being tested on a test system. A chip, board, module, or larger systems are examples of UUT.

V

Validation – The process for establishing whether an item will fulfill the purpose for which it has been selected or designed. [Adapted from ISO]

Value Added – Labor or material added to a product, essential to its construction, for which the customer is willing to pay.

Verification – The act of establishing the truth or correctness of a fact, theory, statement, or condition.

Vertical testability – The concept of achieving testability at all assembly or packaging levels.

W, X, Y, Z

Work Breakdown Structure (WBS) – A delineation of work activities whose progress is to be tracked.

World Wide Web (www) – An acronym for consortium of Internet protocols allowing user to user communications.

APPENDIX E

PATENTS AND CONCEPTS

Patents and concepts listed in the table below provide recommended reading material for idea generation of requirement determination and/or implementation. Some may have potential for inclusion in a SMPT in whole or in part as a component, sub-component, or partial implementation process. The following table lists potential related inventions and concepts. Abstracts, findings, text, and images can be found on the US Patent & Trademark Office web site. http://164.195.100.11/netahtml/search-adv.htm

Table 7 - Patents & Concepts

US Patent Number	Date	Title	Inventor
6,199,015	3/6/01	Map-based navigation system with overlays	Curtwright, et al
6,175,343	1/16/01	Method and apparatus for operating the overlay of computer-generated effects onto a live image	Mitchell, et al
6,151,598	11/21/00	Digital dictionary with a communication system for the creating, updating, editing, storing, maintaining, referencing, and managing the digital dictionary	Shaw, et al
6,121,960	9/19/00	Touch screen systems and methods	Carroll, et al
6,100,806	8/8/00	Apparatus and method for continuous electronic monitoring and tracking of individuals	Gaukel, John J.
5,995,651	11/30/99	Image content classification methods, systems and computer programs using texture patterns	Gelenbe, et al
5,987,459	11/16/99	Image and document management system for content-based retrieval	Swanson, et al.
5,948,042	9/7/99	Method and system for digital road maps	Heimann, et al.
5,933,818	8/3/99	Autonomous knowledge discovery system and method	Kasravi, et al
5,848,373	12/8/98	Computer aided map location system	DeLorme, et al

VITA

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The author received a BS in Chemistry from Texas A&M University Kingsville, a MS in Industrial Engineering from the University of Louisville, Louisville, KY, and is currently pursuing a Master of Engineering from Texas Tech University. His military education includes completion of the Armor Officer Advanced Course (AOAC), Engineer Officer Advanced Course (EOAC), Combined Arms Staff and Services School (CAS3), and Operations Research Systems Analysis Military Application Course (ORSA MAC).