Systems Architecture Analysis Report
1st Brigade
82nd Airborne Division Architecture

VERSION - Final

Architecture Integration and Management Directorate (AIMD)
Analysis Division, M&S Branch

5 August 02

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Executive Summary

The objective of the 82d Airborne Division Systems Architecture-Conceptual (SA-C) Performance Analysis was to support the TRADOC Architecture Management Directorate (AMD) and the Architecture Integration and Processing Center (AIPC) in validation of the proposed systems architecture.

The scenario used for network performance analysis was a Panama deployment of the Division Ready Brigade (DRB) and associated Division slice elements. The Brigade was arrayed using force deployment notes from Operation Just Cause. Terrain was factored into the model against a static force, with minimal effects in this area of operation. Actual unit movement across varying terrain was not performed in the simulation.

Analysis was focused on the EPLRS network Situational Awareness (SA) messaging performance at echelons Brigade and below with the exception of EPLRS platforms within the Division Assault Command Post and Land Warrior-Soldier Systems at battalion and below.

The following study questions were the focus of this architecture analysis.

a. Does the EPLRS network distribution plan and doctrinal deployment concept provide for a viable, robust data network supporting the Airborne Infantry Battalions?

b. Do Land Warrior-Soldier System (LW) Block II radios at company and below level have sufficient bandwidth to allow connectivity into the Tactical Internet at echelons above company, specifically predicting bandwidth requirements to support company and below operations?

EPLRSv11 Mode 4 (159.4kps) does not provide viable support to the Airborne Infantry Battalions when LW SU interval is set to every 30-seconds. The FBCB2 ORD Block II performance parameters require a message completion rate (MCR) of 90% and speed of service (SOS) of 15-seconds. MCR was 81.5% and SOS was 1.5-seconds at the “every 30-second” interval. The LW Operational Requirements Document (ORD) does not specify a default SA interval however; TSM-Soldier indicates it will most likely be 30-sec./50-meters. Acceptable network performance at the FBCB2 standard was achieved at 60 and 90-second intervals.

Land Warrior-Soldier System analysis, using two different Infantry Company netting approaches, indicates that sufficient bandwidth is available for Land Warrior Soldier-System connectivity between echelons company and below to the company Tactical Internet (TI) gateway. Finally, the end-state material solution for the company LW-TI gateway needs further refinement by appropriate TSMs. SINCGARS is depicted in the SA-C but isn’t a technically supportable solution.

1. Introduction

1.1. Primary Objective

The primary objective of the 82nd Airborne Division Modeling, Simulation and Analysis study was to support the Architecture Management Directorate (AMD) and the Architecture Integration Processing Center (AIPC) in the validation of the proposed systems architecture (SA) for the 82d Airborne Division, dated 20 May 2002. The focal point of the study deployed the 1st Brigade, 82d Airborne Division, an Airborne Infantry Brigade, and the Division Ready Brigade (DRB) on terrain in Panama, and used the Next Generation Performance Model (NGPM) to derive performance data on the DRBs Enhanced Position Location Reporting System (EPLRS) data networks. Analysis of the simulation output focused on the performance of the EPLRS data network of the Airborne Infantry Battalions with Land Warrior data input. In other words, did the architecture provide a viable, robust data network in the Airborne Infantry Battalions? The premise of the analysis was that if the architecture supports a representative, and admittedly difficult, subset of the division (airborne brigade) in natural terrain, then the conclusion is that the architecture will support the entire division in a similar environment.

1.2. Secondary Objective

Analysis was also performed to predict Land Warrior Soldier-System bandwidth requirements and whether sufficient bandwidth existed at echelons, company and below for connectivity to the Tactical Internet. An Access database was created to determine the bandwidth requirements for this study.

1.3. Scope

1.3.1. This study modeled the entire DRB, specifically focusing on the performance of the EPLRS data nets in the Airborne Infantry Battalions and Brigade. Analysis results were defined by the Speed of Service (SOS) in situational awareness (SA) messaging, Message Completion Rates (MCR), and factors that contributed to saturating the network and the impact on messaging between critical command and maneuver elements.

1.3.2. Study questions and associated essential elements of analysis used to analyze the model were:

1.3.2.1. Does the EPLRS distribution plan and doctrinal deployment concept provide for the development of a viable, robust data network supporting the Airborne Infantry Battalions of the Brigade equipped with Land Warrior?

1.3.2.1.1. EEA1 – What SA update interval provides an adequate Speed of Service for Situational messages?

1.3.2.1.2. EEA2 – What SA update interval provides the adequate message completion rates of SA messages?

1.3.2.1.3. EEA3 – At which load does the SA net become unable to satisfy the demands placed it?

1.3.2.2. Do Land Warrior-Soldier Systems within the Airborne Infantry Battalions have sufficient bandwidth available to support communications within the Tactical Internet?

1.3.2.2.1. EEA4 – What is the bandwidth requirement of Land Warrior traffic internal to an airborne infantry company? Data was derived from existing Information Exchange Requirements (IERs) within the Army Architecture Repository Management System (AARMS) augmented with modeling IERs.

1.3.2.2.2. EEA5 - Is there sufficient bandwidth available to support internal communications requirements for two-thirds of a company force in contact with the enemy for 20-minutes?

1.3.3. References

1.3.3.1. 82d Airborne Division System Architecture-Conceptual, dated 20 May 02.

1.3.3.2. Land Warrior Operational Requirements Document (ORD), 19 April 02.

1.3.3.3. FBCB2 ORD, change 2, Oct 1999.

1.3.3.4. LW Wireless Wide Area Network Communications, PEMSTAR Pacific Consultants, Inc., 6 Jan 02.

1.3.3.5. FBCB2 Tactical Internet Systems Design Document (v)3.4 FINAL , 21 Dec 01.

1.3.3.6. Email between Mr. Larry Hunter, AIPC Analysis Branch, TSM-Soldier and CECOM RDEC-C2D.

1.3.3.7. Initial Working DRAFT, Systems Interface Control Document for Land Warrior System Planned Capability Improvement, dated 22 July 02.

1.3.4. Facts

1.3.4.1. EPLRS / Tactical Internet

1.3.4.1.1. System Architecture used was 82d Airborne Divisions Systems Architecture – Conceptual, dated 20 May 02.

1.3.4.1.2. EPLRSv11 (159.4kps), Mode 4, Short access network was used in this study.

1.3.4.1.3. 350 EPLRS platforms were organic to the architecture studied.

1.3.4.1.4. TI/FBCB2 protocols require each SA generating platform to update the SA network on a repeated basis. Vehicular platforms update every 5-minutes or 100-meters when moving. All SA data from all platforms gets transmitted to the Brigade wide SA position server for dissemination across the Brigade-Wide SA net (FBCB2 TISDD).

1.3.4.2. Land Warrior

1.3.4.2.1. Land Warrior Block II radio is specified for 82d Airborne Division.

1.3.4.2.2. 1381 Land Warrior radios were organic to this architecture.

1.3.4.2.3. LW Block III is to be fully ABCS/FBCB2 interoperable.

1.3.4.2.4. LW bandwidth capacity is 1Mbps.

1.3.4.2.5. LW net structure is not clearly defined and several options are available. One option allocates 3-1Mpbs channels to a Battalion, with each company using a channel on a company wide network. The second option is a battalion being allotted 1-1Mbps channels, with each company using 330Kbps bandwidth.

1.3.4.2.6. Voice over Internet Protocol (VoIP) traffic is priority 1traffic and will be routed prior to data traffic when there is contention on the Land Warrior network.

1.3.4.2.7. Land Warrior ORD states that “interface / interoperability between LW and ABCS is a Block II requirement….”. Phase II (Block II), full integration, implements data exchange (capability) between soldiers using the LW Weapons system and ABCS devices, thru a combination of material and policy changes. It also has a KPP requirement to “provide data exchange from the interim force vehicle to the LW System.”

1.3.4.2.8. LW will have an automatic SA data transmission function. However, the Land Warrior ORD does not specify an interval for Land Warrior Soldier platforms to report SA update data. TSM-Soldier and CECOM RDEC C2D guidance was sought in order to perform this model and simulation. They stated that the range of LW position update intervals were between 15-seconds and 4-hours or at various movement intervals, with 30-seconds or 50-meters being the most likely default intervals.

1.3.4.2.9. LW ORD specifies that LW Block II system Company Commander will transmit SA data to the Battalion Tactical Operations Center (TOC) and the TOC must receive the data within 30-seconds.

1.3.4.2.10. FBCB2 ORD requires FBCB2 to display SA data accurate to 100 meters platform / 10 meters dismounted soldier. Land Warrior ORD is not specific it how it will satisfy the data feed (update interval or reporting echelon) to enable FBCB2 SA display to depict LW system equipped soldiers. It does states that SA functionality is an important feature of the LW system relevant to the specific fielded Block capability.

1.3.5. Assumptions

1.3.5.1. General

1.3.5.1.1. Information provided by subject matter experts was acceptable and usable in absence of clearly defined doctrine.

1.3.5.1.2. The equipment modeled performs in accordance with operational performance specifications.

1.3.5.1.3. Architecture data from sources external to the AIPC, Analysis Branch is usable and valid.

1.3.5.1.4. All equipment deployed was operational.

1.3.5.1.5. Frequency approval for both Land Warrior and EPLRS in Area of Operations was approved.

1.3.5.1.6. Effects of Tactical Unmanned Aerial Vehicles supporting dismounted company or platoons while in contact, in close terrain, and the effects of Land Warrior biomedical data modules were not factored into this study.

1.3.5.2. EPLRS / Tactical Internet. EPLRSv11 Mode 4 (159.4kps user data capable) will be available when 82d Airborne fields Land Warrior, providing greater data throughput on the TI.

1.3.5.3. Land Warrior:

1.3.5.3.1. Land Warrior equipped soldiers “own position” will be transmitted to the lower TI through the company and battalion gateways and posted on Army Battle Command System (ABCS) devices as appropriate. This ensures ABCS interoperability and the “ability to provide data exchanges, situational awareness, orders, etc., with the interim force vehicle to the Land Warrior System,” described in the FBCB2 ORD.

1.3.5.3.2. LW SA data from every LW soldier platform will be transmitted to the Brigade-Wide Position server from the Battalion for dissemination across the Brigade SA Network, providing the capability for FBCB2 operators to filter their view for echelons down to platform or individual system level as specified in the FBCB2 ORD. The end-state SA update from LW has not yet been clearly defined, but there is agreement in the Program Managers office that the frequency and echelon of updates needs to be defined and that data should be aggregated somehow to reduce bandwidth demand.

1.3.5.3.3. Land Warrior SA traffic is assumed to enter the EPLRS network through the Company Commanders support vehicle based on the SA-Cv2.0 and the Land Warrior ORD. The LW ORD and this study assume that an interim / final material solution to the EPLRS – Land Warrior gateway other than SINCGARS will exist at end-state as SINCGARS cannot viably support the gateway protocols required for voice and data transmission.

1.3.5.3.4. Land Warrior SA messages are sent every 30 seconds (likely default provided by TSM-Soldier) and are 216 bits in size for force not in contact. SA messages sent every 15 seconds (suggested by Mr. Kutter, AIPC, SA) from 2/3 of the force.

1.3.5.3.5. Technology will improve between FY02 and FY05 providing between 1-11Mpbs data rate on Land Warrior versus currently rated 1Mbps.

1.3.5.3.6. Land Warrior Message Completion Rate (MCR) was not specified in the ORD but was assumed to be the same as the FBCB2, Block II (Threshold), Category 3 messaging standard of 90% message delivery in no more than 15 seconds.

1.3.5.3.7. VoIP will be the primary mode of transmission when in contact.

1.3.5.3.8. That this study should assess both potential net structure options and predict bandwidth requirements for each since LW ORD is not specific as to how nets will be configured.

1.3.6. Limitations

1.3.6.1. This study only evaluated the EPLRS data nets with associated connectivity (routers, switches, Internet Network Controller (INC), FBCB2 hosts) necessary for SA messaging and the Land Warrior-Soldier System within the DRB. All other C4I equipment was outside the scope of this study.

1.3.6.2. Only EPLRS SA messaging was modeled due to time and resource constraints within the Analysis Branch. EPLRS C2 messaging was not analyzed in the scope of this study.

1.3.6.3. Land Warrior analysis was conducted using intra-company traffic and the projected load of SA data from Land Warrior to the Tactical Internet.

1.3.6.4. The effect of the VOIP capability of Land Warrior is unknown (LW Wireless LAN (WLAN) Communications Briefing, PEMSTAR Pacific Consultants, Inc., Jan 02) and cannot yet be modeled within the AIPC.

2. Methodology

2.1. OPNET model

2.1.1. The study used NGPM, a high-resolution model of the Tactical Internet, well suited to model systems at echelon brigade and below.

2.1.2. Four separate modeling simulations were performed on the EPLRS network at company through Brigade level representing unit movement updates (SA messages) at 30 second (expected Land Warrior default interval), 60-second and 90-second SA update intervals. The 60-second simulations were run 5 times with varying seed iterations.

2.1.3. An additional modeling run was conducted using a 15-second Land Warrior SA interval default, transmitting only Center of Mass (COM) positions for platoon and company through the LW-TI gateway. It should be noted that sending COM only, may be technically impossible and is presently contrary to the FBCB2 ORD and TISDD.

2.1.4. IERs for both the EPLRS and Land Warrior portions of the study were drawn from the AARMS database for the 82d Airborne DRB, with augmentation from additional modeling IERs.

2.1.5. The EPLRS network was established using 20W power out as the standard for EPLRS radios with the baseline message transmission interval set to the expected Land Warrior network default of 30-seconds. Measures of performance resulting from the study were Message Completion Rates (MCR) and Speed-of-Service (SOS).

2.1.6. NGPM cannot specifically simulate the effects of every Land Warrior equipped soldier transmitting a SA message at a specified interval. A mathematical equivalent was calculated and applied to simulate the traffic density and frequency that this capability would impose. This work around caused an increase in the number of collisions experienced as users attempted to access the SA net, reducing the Battalion and Brigade message completion rates.

2.1.7. Entity reports were not specifically generated due to model constraints. The number of “Own Position” reports was appropriately increased to replicate the effects of Entity Reports.

2.1.8. Land Warrior study methodology. Doctrinal net structure of Land Warrior systems within a company is presently immature. Two different study approaches to Land Warrior netting were used to best predict bandwidth requirements in the company as a work around due to the lack of a decisive net structure. Analysis Branch understands that this varies from the currently defined architecture in the Operational Requirements Document (ORD). This study factors in current operational approaches employed by units currently testing Land Warrior. The actual bandwidth requirements will likely fall within the upper and lower requirements predicted in this study through these two approaches. Approach 1 assumed that nets within the company were hierarchical, i.e., soldiers on squad nets, Squad Leaders on Squad and Platoon nets, Platoon Leaders on Platoon and Company nets. Approach 2 assumed that the entire company was on a single Land Warrior net. Figure 2.1-1 and 2 .1-2 graphically depict assumed net structures for each approach. Two operational “branch” analysis’ were performed assuming using the same net structures as Approach 1 and 2 above, with 2 platoons in contact with an enemy, for 20-minutes. Intent was to determine if sufficient bandwidth was still available at the most intense operationally intense point in the analysis period.

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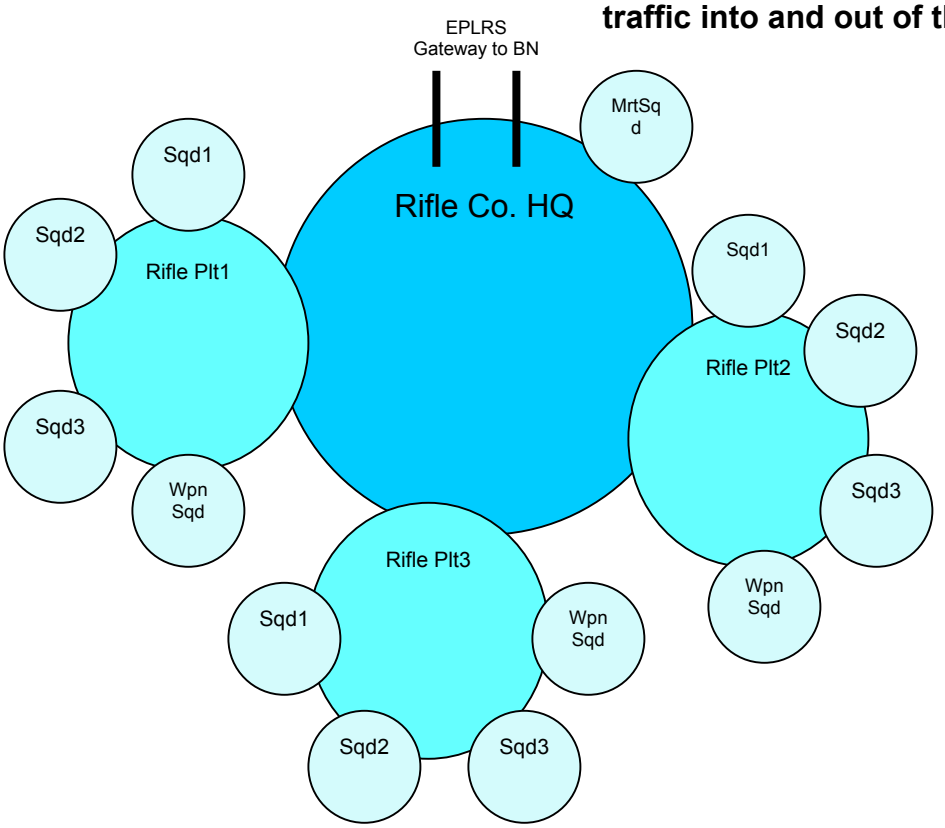
Rifle Company Land Warrior Bandwidth Approach I

EPLRS gateway supports SU and C2 data traffic into and out of the Company



Overlap represents leaders on two nets

Figure 2.1-1 - Rifle Company Land Warrior Bandwidth Approach I

Rifle Company Land Warrior Bandwidth Approach II

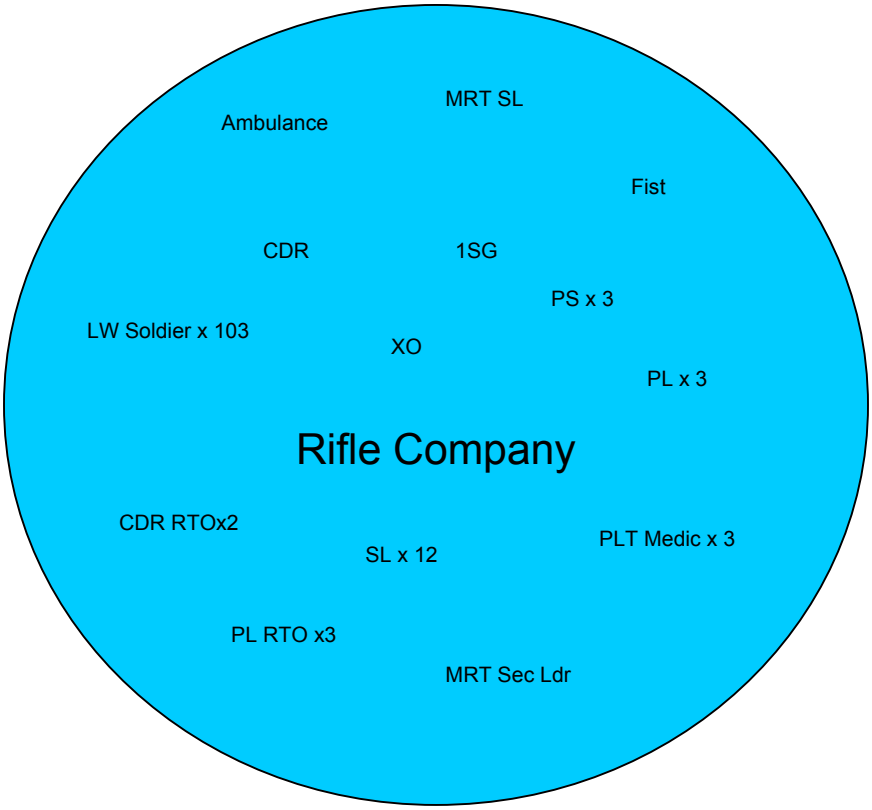


Figure 2.1-2 - Rifle Company Land Warrior Bandwidth Approach II

2.1.9. Approach 1 methodology.

2.1.9.1. Platforms (Operational Network Nodes (ONN)/rules) were assigned to deploy sheets. The deploy sheet is nothing more than a method used to record and organize the analysis. Each sheet represented a net for the purposes of this study, with all platforms on that sheet communicating within the net. Leader platforms were placed on two sheets representing that they communicated on their net and their next higher echelons net. An example is a squad leader communicating on his squad net and the platoon net. A company set of rules was created that contained each iteration of rule assigned on the appropriate deploy sheet.

2.1.9.2. The IER table created for the study was put through a series of three queries to create a table containing each specific information exchange. The queries established unit relationships that ensured each rule sent appropriate traffic to the appropriate recipient rule. An example is that a Platoon Leader only sends traffic to his four squad leaders and not all 12 squad leaders in the company.

2.1.9.3. An Access database report based on the created IER tables determined the bandwidth generated by each rule, on each deploy sheet in the company. Bandwidth for each IER was determined by multiplying the frequency of transmission (times sent in a 24 hour period) multiplied by the message size (in bits), to give total bits for each IER. These totals were added to one another giving a total for each deploy sheet (net). The sum of the deploy sheet totals provided the company total in bits. The busy hour bits were dependant on the intensity code of the IER. 10% of the increasing intensity IER total bits were assumed transmitted during the busy hour. 1/24 or .042 of the bits were assumed for the busy hour for static intensity IERs.

2.1.10. Approach 2 - methodology.

2.1.10.1. A table of 14 unique rules in the company with their appropriate multiplier was created.

2.1.10.2. The AARMS IER table was run through these rules to create a set of IERs with generic producer and consumer rules from the company set of rules. This differs from approach 1. Second squad leader, 1st Platoon sent traffic to 1st Platoon Sergeant in approach 1. In approach 2 a generic Squad Leader sent traffic to a generic Platoon Sergeant. Fields for the numbers of producers and consumers as well as a field to show whether traffic was multi or uni-cast were put into this IER table.

2.1.10.3. Each IER in the table was reviewed to determine if it would multi or uni-cast and was marked appropriately. The number of consumers was set to 1 for all muti-cast traffic and set appropriately for uni-cast traffic. An example is that a Platoon Sergeant would only send to one Platoon Leader, not three.

2.1.10.4. The IER table was used as a basis for creation of an Access report. The report determined bandwidth generated by each IER as numbers of producers multiplied by number of receivers, multiplied by frequency, multiplied by message length. This was done for every rule in the company and then totaled for the company. Busy hour bits were determined in the same way for both approaches.

2.1.11. “Time in contact” period bits for the two Branch analyses were dependant on the intensity code of the IER. If the IER was of increasing intensity, 10% of those IERs total bits were assumed to be transmitted during the twenty minutes of contact. If the intensity was static 1/72 or .014 of the bits were assumed for the busy hour.

2.2. Scenario

The scenario and operational situation used locations and geography based upon Operation Just Cause. The area of operations was roughly 10km x 20 km. The Division Ready Brigade (DRB) consisting of the 1st Brigade, 82d Airborne Division was deployed to conduct a parachute assault on Torrijos airport, isolate and neutralize Panama Defense Force (PDF) forces in Panama Viejo, Tinajitas and Fort Cimmarron and deny PDF reinforcement of Panama City from within the operational area. The scenario addressed intra-net mutual interference minimally but did not include effects of electronic warfare (EW). Unit movements were not specifically conducted.

Figure 2.2-1 (operational force lay down) depicts an array of forces in the area of operations for echelons Battalion thru Brigade, with a Division slice. The full Troop List modeled is at Annex A.

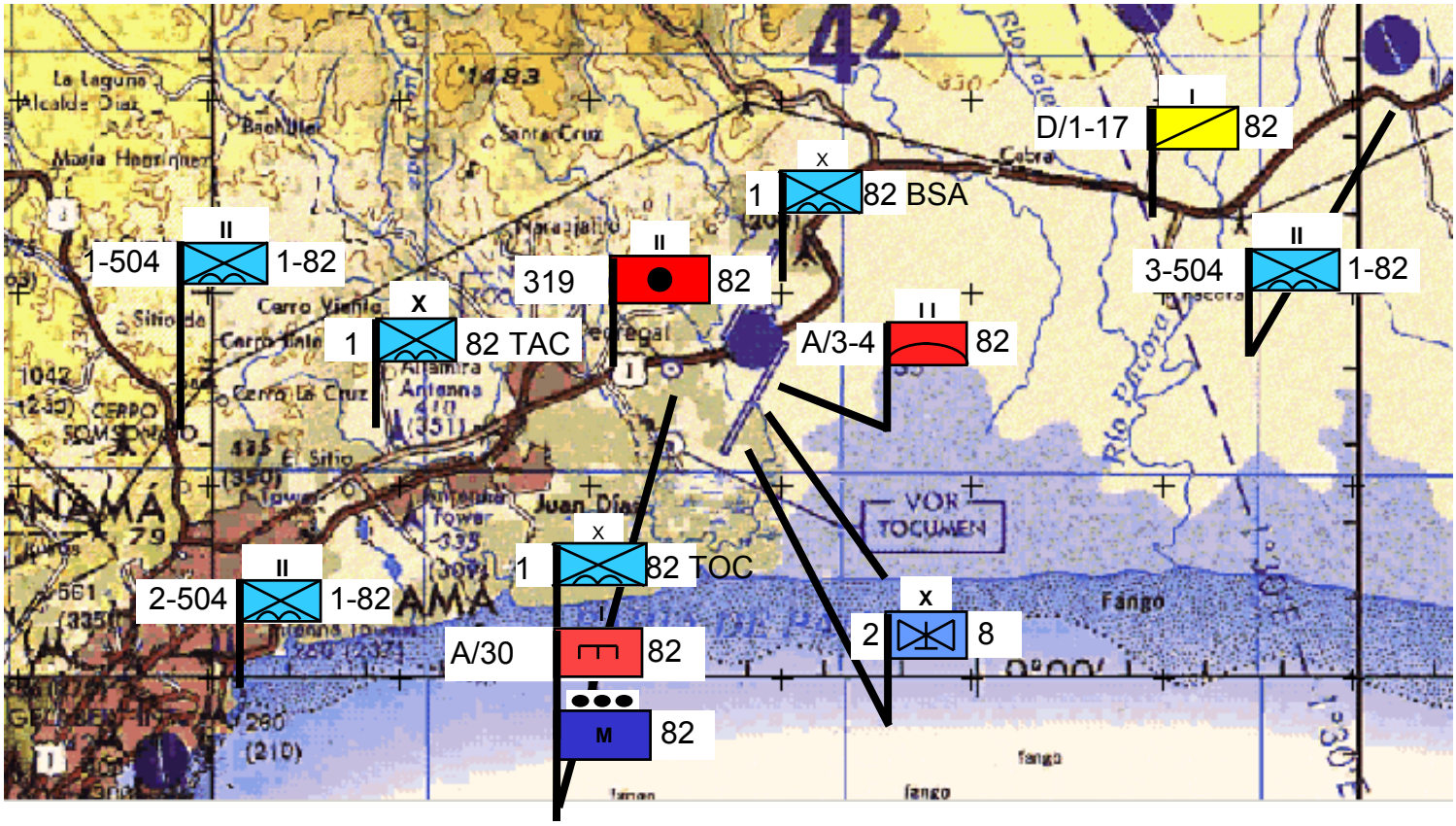


Figure 2.2-1 - 1st Brigade, 82d Airborne deployed vicinity Panama City and associated airfields

2.3. Spectrum Issues

2.3.1. The analysis performed on the 82d Airborne DRB specifically assessed the technical capabilities inherent in EPLRS and Land Warrior and is independent of political approval for frequency use in the 420-450 Mhz frequency range required by EPLRS and Land Warrior as it interfaces with EPLRS to share SA information. However there is presently no host nation request for EPLRS frequency approval and assignments in Panama. No assessment can be offered regarding the potential impact of host nation emitters on the EPLRS and Land Warrior or vice-versa at this time given the current state of frequency authorizations in Panama. Putting this in perspective, there are approvals or precedence for use of other receiver – transmitters or emitters in Panama such as HF, VHF, UHF and SHF. Land Warrior could potentially be used based on precedent approval of systems in the VHF and UHF bands in Panama without impact for other than SA traffic as the architecture is currently designed.

2.3.2. Spectrum approval data was obtained from the Host Nation Spectrum Worldwide Database produced by the Joint Staff as of the 18 June 2002 posting.

2.4. Traffic.

2.4.1. The traffic data used to measure delays in SA end-to-end messaging, message completion rates and network saturation was derived from existing IERs in the AARMS database as well as IERs produced by the Future Traffic Cell (FTC). Traffic effects on the network were modeled using the 30-second expected default update interval as the baseline and varying the SA message transmission interval at 60 and 90-seconds for the subsequent two simulations. Traffic load intervals are depicted in Table 2-4.1.

2.4.2. NGPM generators were used to simulate own position reports generated by each platform. Own Position report generation remained static at every 5 minutes for vehicle platforms (FBCB2 standard) and at the intervals depicted in Table 2-4.1 for the Land Warrior force.

Network	Traffic Load / SA Message Interval	Radios Power	Number of Runs
SA	Every 30 seconds	20 watts	1
SA	Every 60 seconds	20 watts	1
SA	Every 90 Seconds	20 watts	1
SA	Platoon / Company COM – Every 15-seconds	20 watts	1

Table 2.4-1 – Land Warrior Traffic Load Intervals

2.5. Thresholds – Acceptable network performance was based on parameters specified in the FBCB2 ORD for Block II (Threshold) equipment, sending Category 3 messages. Speed of Service (SOS) required by the ORD is 15-seonds or less. The Message Completion Rate (MCR) specification is 90%.

3. Results

3.1. Study question 1 – Does EPLRS distribution plan and doctrinal deployment concept provide for the development of a viable, robust network supporting Airborne Infantry Battalions?

3.1.1. Message completion rates

3.1.2. All messaging was done at the 20-Watt power level. SA messaging interval was varied in each study using intervals of every 30, 60 and 90 seconds respectively. FBCB2 Block II ORD Speed of Service was achieved at each of the three-update intervals tested. MCR was achieved at the 60 and 90-second update intervals. SA updating at the 30-second interval put a strain on the network above the company level as each soldier and above platform transmitted SA data through the company gateway to the Tactical Internet. The 30-second interval baseline was used in order to best replicate the effects of routinely transmitted “Own-position” and randomly

generated and transmitted "Entity Reports." As the transmission interval times increased with each modeling run, message completion rates improved and impact on the network was reduced. A fourth modeling run was conducted with LW SA interval set to every 15-seconds, but only transmitting COM data for platoon and company level through the LW-TI gateway. Sending COM only may be technically impossible and is presently contrary to the TI/FBCB2 ORD and TISDD. Completion rates for the respective modeling runs are depicted in Figure 3.1-1 below.

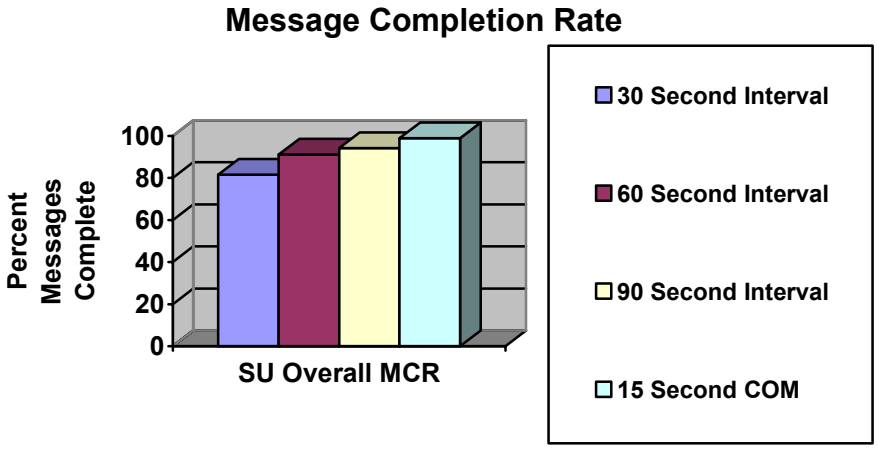


Figure 3.1-1 – Message Completion Rates

3.1.3. Speed of Service / Message Completion Rates are reflected in Table 3.1-1 below.

Simulation	Overall Average Speed of Service (Seconds)	Overall Message Completion Rates (Percentages)
20 watts/30 second message interval	1.5	81.5
20 watts/60 second message interval	1.0	91.1
20 watts/90 second message interval	1.0	94.2
20 watts/15-second COM interval	1.0	98.6

Table 3.1-1 – Traffic Analysis Results

3.1.3. Network saturation results. The network did not perform within FBCB2 Block II parameters when SA transmission interval was set to the 30-second interval. It did perform at the Block I level for each of that time interval. The network performed within defined FBCB2 Block II at the 60 and 90-second interval and when transmitting only platoon and company COM data every 15-seconds.

3.2. Study question 2 – What is the bandwidth requirement for Land Warrior-Soldier system in an Airborne Infantry Company and is sufficient bandwidth available to link the Land Warrior-System soldier to the Tactical Internet?

3.2.1. A comparison of bandwidth requirements for an Airborne Infantry Company determined using study approach 1, 2 and Branch approaches 1 and 2 are depicted in Table 3.1.2 below.

Approach Method Used	Messages Passed	Total bits	Busy Period bits	bps During Busy Period
Approach 1 – Hierarchical	9,245,803 – 24-hours	2,920,440,409	134,357,772 – Busy Hour	37,322 – Busy Hour
Approach 2 – Same Net	41203 – 24-hours	207,698,135	11,464,199 – Busy Hour	3,184 – Busy Hour
In-contact Branch Approach 1	15,215,746 20-minutes	4,401,148,524	93,310,481 "In-contact" period	80,259 "In-contact" period
In-contact Branch Approach 2	79,468 20-minutes	289,263,264	10,794,937 "In-contact" period	8,996 "In-contact" period

Table 3.1-2 – Bandwidth Predictions for Land Warrior Net

4. Analysis

4.1. Analysis of results will be addressed specific to each of the study questions examined.

4.2. Study question 1 – Does the EPLRS distribution plan and doctrinal deployment concept provide for the development of a viable, robust network supporting Airborne Infantry Battalions?

4.2.1. The EPLRS network, company level and above did not support timely (Block II FBCB2 standard) processing of SA messaging when set at the 30-second interval. This interval put a heavy load on the network and made SA timeliness and completion rates drop significantly. When messaging interval was increased to 60 and 90-seconds, leaving numbers and types of platforms unchanged, the network performance (Message Completion and Speed-of-Service) was acceptable. Platoon and company COM SA data sent every 15-seconds was transmitted within acceptable parameters.

4.3. Study question 2 – What is the bandwidth requirement for Land Warrior-Soldier system in an Airborne Infantry Company and is sufficient bandwidth available to link the Land Warrior-System soldier to the Tactical Internet?

4.3.1. The upper level bandwidth requirement as determined by study approach 1 was 38,000 bps. The lower level bandwidth requirement as determined by study approach 2 was 3,200 bps. Results of Branch Analysis 1 and 2 indicated that 80,259 bps and 8,996 bps respectively, were required on the net with two-thirds of the company force in contact with the enemy. The actual bandwidth requirement of the Land Warrior-Soldier System will likely be between the high and low bandwidth determined in this study. Voice Over IP (VoIP) will likely place a heavy demand on the WLAN during operationally intense periods. The effects of this are not fully measurable at this point due to lack of traffic densities and a tool to model the effects. Land Warrior-Soldier System could conceivably be capable of providing between 1 and 11Mbps bandwidth (based on 802.11 wireless LAN technological advances). If that becomes the case, then LW is predicted to easily support the projected bandwidth loads at the lower and upper usage levels in the busy hour and while in contact.

5. Conclusions

5.1. The EPLRS network within an Airborne Brigade equipped with Land Warrior does not provide a viable, robust SA network at Airborne Infantry Battalion and above, given the numbers of platforms and frequency of SA data updates across the net, when the transmission interval was set to the 30-second default interval. It does provide a viable network with an SA update interval of 60 and 90-seconds. The network provided acceptable network performance at that rate with the Message Completion Rate being 91.1% and 1.0 second Speed-of-Service at the 60-second interval. The network also performed to acceptable parameters when SA interval was set at 15-seconds, only transmitting COM data for the platoons and company. It should be noted that the EPLRS network does provide acceptable Message Completion Rates at the 30-second interval when compared with Block I FBCB2 MCR parameter of 80% MCR.

5.2. Using SINCGARS as the Land Warrior-Tactical Internet gateway at the Airborne Infantry Company is not technically feasible. SINCGARS does not have the capacity to handle the volume of data and voice traffic that will be generated and transmitted by each Land Warrior system equipped soldier. This is primarily due to the numbers of radios trying to access the net simultaneously and the limitations of 188.220B messaging protocol.

5.3. Recommendations

5.3.1. That efforts continue to clearly define what the SA data exchange expectations are between the Land Warrior nets and the Lower Tactical Internet in terms of echelons to be reported / displayed, reporting interval for LW system soldiers, method of transmitting SA data from LW net to the Battalion SA net in the most bandwidth efficient manner, and FBCB2 data display requirements. The LW ORD does not provide sufficient detail on netting or specific SA expectations for Block II and III systems, although it does state that specific Block III requirements and capabilities will be published (at some point). PM Soldier Systems has begun to further refine LW net and SA structure in the 22 July 02 DRAFT System Interface Control Document for the Land Warrior Planned Capability Improvement. PM representatives indicated in late July that they will

meet with PM FBCB2 and others to discuss findings in this study and other issues, and address the SA expectations, FBCB2 interoperability functionality and net structure issues.

5.3.2. That the operationally acceptable SA interval, Message Completion Rate and Speed of Service be clearly defined for each echelon and platform type, soldier level and above and that the battalion, company and platoon LW net structure is further defined. Once these are better defined the nets should be re-modeled providing a higher-resolution study.

5.3.3. The amount of Voice over IP traffic could have an adverse affect on the data/SA traffic. While in contact, there is an assumption that leaders at squad and platoon level will send some if not most C2 traffic using voice and that there will be a continued requirement to transmit SA data while in contact to prevent fratricide, coordinate fires, MEDEVC, engineer support, etc. LW ORD does not adequately describe the traffic prioritization protocols that will be established on LW nets. Briefing on LW WLAN communications from PEMSTAR indicates that voice traffic will have priority. That could contend with critical SA data, fires data, etc, while the small force in contact tries to coordinate multiple actions using voice and data on the same bandwidth allocation. To better understand the effects of this, the methods and protocols for sending voice and non-voice data over Land Warrior soldier and leader systems, traffic density and LW net structure, soldier through Battalion, needs to be further defined and evaluated.

5.3.4. That the material solution for the Land Warrior C2 and SA data gateways from the company into the Tactical Internet be determined and messaging protocols (reporting intervals) be clearly defined to reduce any bottleneck at those gateways. The present ORD depicts the gateways as a SINCGARS link. The ability for SA traffic to traverse from Land Warrior to EPLRS and the Tactical Internet is critical. SINCGARS, with Military Standard 188-220B will not support this data movement due to net access restrictions for data transmissions in shared voice / data nets.

5.3.5. That consideration is given to the type of SA device given to Land Warrior units operating at extended ranges from their higher headquarters. Land Warrior platforms such as the Recon Platoon members will likely be separated from their higher headquarters Land Warrior net and have no organic capability for continued SA data updates at ranges beyond the Land Warrior footprint. The Reconnaissance Platoon, for example, has no EPLRS and must resort to SINCGARS voice capability once they exceed the Land Warrior capability, potentially disrupting operations and SA for this key platoon.

5.3.6. While frequency approval was assumed to be deconflicted and approved for the purpose of this analysis, consideration should given to the operational impacts of using these systems in peace or times of hostility and the potentially detrimental impact of host nation emitters on U.S. C4I systems or vice versa.

5.3.7. That effects of bio-medical and similar Land Warrior components be defined and evaluated for effects on Objective Force networks and that protocol is written so that bio-medical data is only transmitted on a need-to–know rather than a set interval basis, to avoid network congestion. For instance if vital signs or other indicators change beyond a prescribed threshold, then a message indicating such is sent, otherwise, no data is transmitted.