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Award Number DAMD17-98-2-8002

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Digital EMS Project

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 Technical Status Report



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## INTRODUCTION

Any condition that interferes with adequate blood flow will cause an impairment of tissue oxygenation, the results of which are cell injury and, if sufficiently prolonged, cell death. The interval of time between the acute catastrophic events that initiate the decrease in blood flow and the establishment of therapies to reverse this cascade of cell injury is critical. Two major interventional avenues are available for altering these processes. Any measure that shortens the interval between the injury and the institution of appropriate therapy will afford the greatest potential for minimizing cell injury and preventing cell death. Physician's virtual presence through telecommunications technologies to support the first responding care-givers at the scene of the incident will create the opportunity for achieving an accurate initial evaluation of the victim's clinical condition and a timely initiation of appropriate interventions.

### Virtual Physician Presence Through Telecommunication Technologies:

The development of a civilian corps of first responding emergency medical technicians (EMT) and paramedics during the past several decades, which was in many ways an extension of that which has long existed among military corpsmen, has had a very positive impact on the survival of all types of injuries and acute illnesses. The reality is, however, that the interpretation of a victim's clinical problems and therapies instituted are at this time dependent upon the individual care-giver's training, judgment and experience. It is hypothesized that having a virtual physician present at the scene through the technology of modern telecommunications will have a favorable impact on patient outcome in many instances. The studies comparing helicopter crews consisting of EMS personnel and on-board physicians to that of ground paramedics alone have shown that "mortality of the patients treated by flight nurse/flight physician team was 35% lower than that predicted, and significantly lower than the flight paramedic team." [3]• Through the application of telecommunications technologies, UTHSCH proposes to virtually bring the physician to the scene of the incident, thereby allowing on-line physician evaluation and intervention with a focus towards interrupting the cell death cycle. Additionally, in hazardous biological or chemical emergencies, the physician's experience and mentoring to the medics in the field could mean a quicker identification of the victims' possible exposure.

### Logistical Issues in the Timely Arrival of First Responding Care-Givers:

Emergency medical service communication problems were highlighted in the recent events of the Oklahoma City bombing. "Phone lines were compromised or overloaded and cellular telephone frequencies were jammed." [1] Without a reliable means of coordinating the rescue effort during the first minutes after the explosion, valuable time was lost in caring for the surviving injured. Although many individuals were killed instantly by the initial blast of the explosion, the survival of many of those that were injured was dependent upon how promptly they were identified and when appropriate therapies were instituted. Medical emergencies involving multiple victims occur regularly and preparations for these occurrences center around effective communication.

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• Bracketed numbers refer to items in the Reference Section.



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In a similar situation encountered on a battle field, logistical problems that impair access to victims, which delays timely therapeutic intervention, recently plagued the Sunset Limited Train wreck near Mobile, Alabama. "As the first calls went out for help, it quickly became evident that the Saraland Bridge wasn't easily accessible by road; there were none nearby. ...it may have been as much as 45-50 minutes before anyone arrived at the scene to begin rescue efforts." [2] Although the obstacles facing the first responders in Alabama differs somewhat from the perils of the battlefield, effective coordination and control of personnel through reliable communication systems remains a vital component of any rescue operation.

## PROGRESS REPORT

### Fourth Quarter Progress

#### Congressional Briefings:

The DREAMS program and the Digital EMS project briefed Mr. Dave Davis (key staff person for Senator Kay Bailey Hutchison) on 19 November. Mr. Davis toured UTHHSC, Texas Heart Institute, and the Institute of Biosciences and Technology Texas A&M University facilities. A visit by key U.S. Representatives from Texas (Delay, Bensen, and Brady) and members of their staff occurred on 30 November. Briefing materials were virtually the same as those for MG Parker's visit of Feb 99. They can be made available upon request.

#### In Process Review:

Dr. Duke (the principal investigator for Digital EMS) attended an In-Process Review at Texas A&M University in College Station on 30 October. Most of the principals and key researchers involved in the program attended. Much of the materials prepared for the IPR are included in this and previous TSRs. As stated in the previous TSR, the objectives of the IPR were as follows:

- To demonstrate an understanding of the technical requirements for the program.
- To present a present a high-level architecture for Digital EMS.
- To ensure that the ongoing development activities for Digital EMS are consistent with original vision of the program.

#### Rural Connectivity:

ResNet, a consortium in East Texas consisting of Livingston ISD, Woodville ISD, Big Sandy ISD, and the Alabama-coushatta Reservation, have constructed a fiber backbone crossing three Texas Counties. On this backbone, the rural county hospital has been equipped with limited telemedicine capabilities. ResNet will be connecting in early 1999 to the Texas Gigapop with a DS3 ATM link. We will meet with ResNet and discuss the potential of utilizing their connectivity to this rural hospital in the second phase of the DREAMS™: Digital EMS Project. We intend to model remote, non-mobile battlefield medical facility requirements by utilizing these traditionally understaffed under-equipped rural hospitals.

Telecommunications Infrastructure Fund (TIF) board is the primary funding agency for the State of Texas rural K-12, telemedicine and library connectivity. We have attended board



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meetings in the past. In the Fourth Quarter, we intend to propose the possibility of connecting at TIF funded rural sites where a Digital EMS ambulance could transfer patient vitals, protocols, and even conduct a video conference to the supervising physician.

Houston Fire Department (H.F.D.) Collaboration:

The Digital EMS project team met with David E. Persse, M.D., Medical Director of H.F.D., to formalize our collaboration relationship for Digital EMS vehicle testing. Dr. Persse supports the program and directed H.F.D. personnel to aid in the development of the Digital EMS Interact vehicle for test runs with H.F.D. later this year. Radio and other equipment specifications have been shared with the Digital EMS team for integration for inclusion in the Interact prototype.

Onboard Systems:

The overall software architecture design will continue stressing robustness, modularity, and scalability. Development of key software components will begin this quarter and interfaces to procured hardware components will be developed. The development team will continue with the prototyping of user interfaces and will begin software development of the interface components as the user community agrees them upon.

The major thrust this quarter will be focused on establishing a "bench" prototype; however, considerable engineering activities will be put forth to address the integration of the system into the ambulance.

Extensive modifications to the prototype ambulance included rework of the air conditioning, isolation of possible noise from conventional onboard systems, and fit and function testing of the major hardware to be added for the April demonstration deadline. The ambulance as delivered included a 4.5 kVa generator in the patient compartment. This generator supplies power to the patient compartment separate to the truck engine or alternator. The rear air conditioner (A/C) is self contained and isolated from the truck's OEM A/C systems as well. In addition to the rear patient compartment cooling this air conditioner was modified and plumbed to the outside radio compartment. This compartment of roughly 18 cubic feet will house the computer systems and communications equipment for the Digital EMS prototype. Fans were installed to aid the movement of air from the A/C through the radio compartment to the interior of the patient compartment. The fans are reversible for winter or cooler climates to keep the computer systems warm.

Nineteen inch standard computer racks were fitted in the radio compartment and in the interior of the patient compartment. The radio compartment rack was fitted with prototype rack slides and isolation mounts to prevent undo vibration and impulse forces on the rack components. The rack fitted inside the patient compartment was placed in front of the head seat away from the paramedic working space. Mounting locations for the Propaq patient monitor, the touch screen flat panel display, disk module for internal components, magnetic strip card reader, personal information card PCMCIA reader, and rack mounted keyboard have been established. Locations for onboard cameras and speakers have also been finalized.

Physician's Workstation



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The physician's workstation is actually comprised of two displays. One display will show the onboard patient's physiological data and can be toggled to show the location and status of multiple Digital EMS vehicle locations (this feature can be used for resource management at a future date). The other display will show the active camera view of the patient on the Digital EMS vehicle. The physician will be able to select from multiple cameras for different views of the patient and can pan, tilt, and zoom each camera.

The physician's display for selecting and controlling the cameras and viewing the patient is very near completion. A screen dump of this display is shown in Figure 1. In addition, to the video portion, a capability for conducting a two-way conversation (sending voice as data packets) over the network has been created. In essence, the system is a non-proprietary video teleconferencing system developed in Java. This system is compliant with the overall architectural design (client-server based) of the Digital EMS and lays the foundation for the seamless integration of other onboard components.

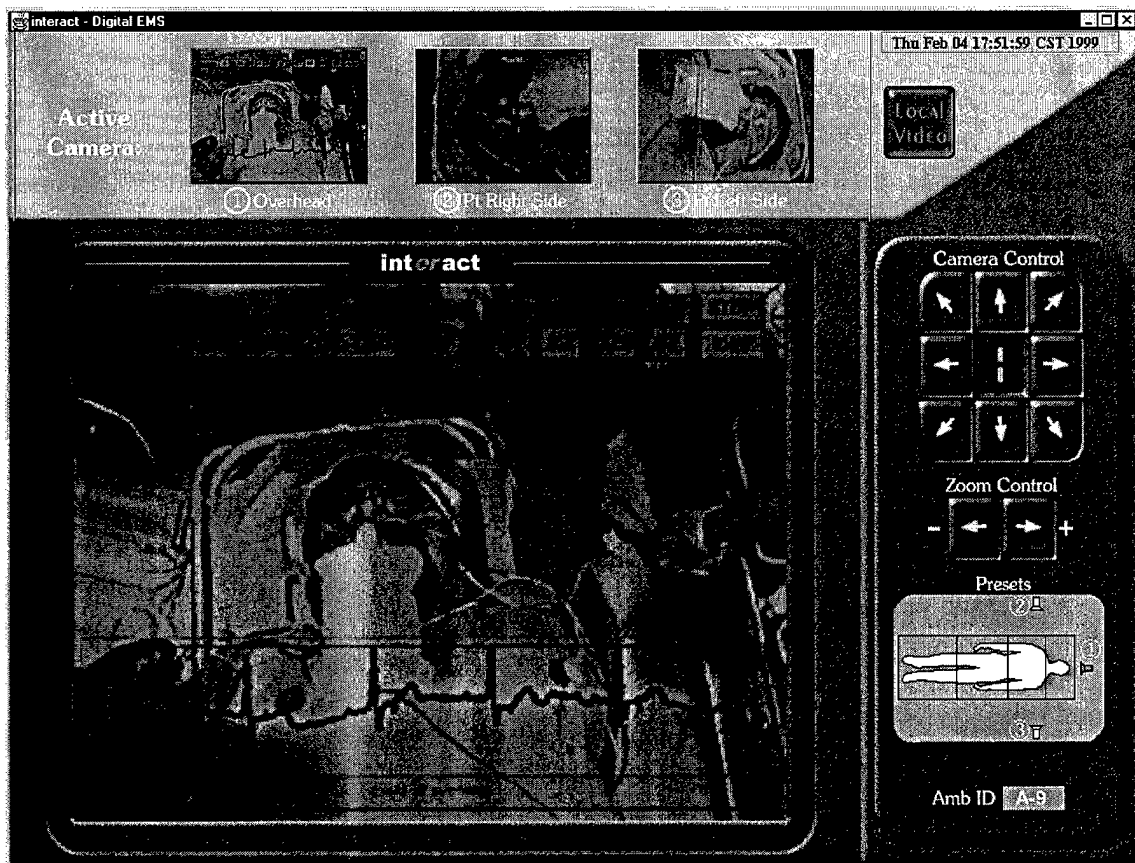


Figure 1. Physician's Workstation

Navigation System





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Efforts during the past quarter have been focused on the integration of Streets 32, a mapping software program from Klynas Engineering in Santa Maria, California, in the Digital EMS Vehicle. This software is low-cost and is being integrated in the Java-based architecture of the Digital EMS. Streets 32 is a stand-alone program; however, Digital EMS personnel will access the program's functionality through a user interface that is consistent with other user interfaces/displays found onboard the Digital EMS.

Streets 32 is GPS compatible and will keep the Digital EMS location centered on the map display. For development purposes, an inexpensive GPS receiver will be used to provide inputs to the system. A higher end GPS system (most likely, Trimble) will be procured for the actual Digital EMS vehicle.

Aggregate command sets for addressing the desired functions in Streets 32 are being built and the Java-based interface is being designed and implemented. This command set will be extended to the physician's display that will show the location and status of multiple Digital EMS vehicles.

### Automated Run Records

The design of the automated run record is nearing completion and the storyboards (shown below) are ready for conversion into Java and subsequent integration into the overall Digital EMS system. The screens have been reworked since the last report based upon inputs from a consulting paramedic.

**interact ON-LINE FORM**

On-Scene	Exam/Observation	Patient Hx	Patient Tx	Narrative
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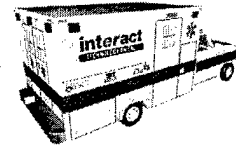
  

<b>Patient Info</b>					
Patient Name: (First)	(MI)	Last	Age (Est)	Wt (Est)	D.O.B.
Timothy	J	Heinselman	41	41	02 / 10 / 54
Street Address		City	State	Zip	S.S.N.
823 Fairmont Court #523		Houston	TX	78241	483-82-5113

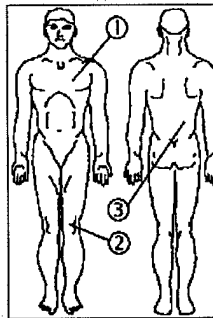
  

<b>Critical Problems</b> Type of Call (add text if desired) Medical - Respiratory Chief Complaint Chest Pain Critical System Problems Circulatory Stability (C/SPS) Potentially Unstable	<b>Mechanism of Incident</b> Mechanism Type MVC Auto Preventive Aid Air Bag Length of Entrapment 75 min. Type of MVA Frontal Impact  Select Position of Patient and Draw line to indicate Direction of Impact
--	---

Video	Run Record	Protocols	Map Display	Comms	Training
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### interact ON-LINE FORM

On-Scene	Exam/Observation	Patient Hx	Patient Tx	Narrative
<p><b>Airway</b></p> <p>Partial Obstruction</p>		<p><b>Skin</b></p> <p>Warm    Diaphoretic    Pale</p>		
<p><b>Breathing</b></p> <p>Inadequate Respirations</p> <p>Breath Sounds <span style="float: right;">R</span></p> <p>Diminished    Wheezing</p>		<p><b>Responsiveness</b></p> <p>Conscious    Responsive to:    Motor/Sensory</p> <p>Alert    Pain    Decreased</p>		
<p><b>Circulation</b></p> <p>Carotid Pulse</p>		<p><b>Type and Location</b></p>  <p>1. Pain</p> <p>2. Broken Bone</p> <p>3. Protrusion</p> <p>4.</p> <p>5.</p> <p>6.</p> <p>7.</p> <p>8.</p> <p>9.</p>		
<p><b>Pupils</b></p> <p>L    R</p> <p>Reactive    Nonreactive</p> <p>Mid-Range    Dilated</p>				
<p><b>Glasgow</b></p> <p>14</p>				
<p>VIDEO    RUN RECORD    PROTOCOLS    MAP DISPLAY    COMMS    TRAINING</p>				

### interact ON-LINE FORM

On-Scene	Exam/Observation	Patient Hx	Patient Tx	Narrative
<p><b>S</b></p> <p>Chief Complaint</p> <p>Chest Pain</p> <p>Symptoms</p> <p>Loss of consciousness, disoriented</p>		<p><b>L</b></p> <p>Last Food    When?</p> <p>Pizza and salad    2 hrs ago</p> <p>Last Fluid    When?</p> <p>Soft Drink    2 hrs ago</p>		
<p><b>A</b></p> <p>Drug Allergies</p> <p>Sulphur, Codine</p> <p>Food Allergies</p> <p>Soy</p> <p>Environmental Allergies</p> <p>Pollen</p>		<p><b>E</b></p> <p>Events that led to the incident</p> <p>Pt was sitting in the restaurant, finished lunch, was struck from behind, gasped for air, then fell unconscious to the floor.</p>		
<p><b>M</b></p> <p>Medications</p> <p>Advil, Morphine</p>		<p><b>P</b></p> <p>Past Surgical Hx</p> <p>Appendectomy about 2 yrs ago</p> <p>Broken leg about 5 yrs ago</p> <p>Past Disease Hx</p> <p>Chicken Pox about 5 yrs ago</p> <p>Other Hx</p> <p>Migrane about 2 yrs ago</p>		
		<p><b>Problem List</b></p> <p>Irregular ECG</p> <p>Loss of consciousness</p> <p>Uncontrolled Bleeding</p>		
<p>VIDEO    RUN RECORD    PROTOCOLS    MAP DISPLAY    COMMS    TRAINING</p>				



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**interact ON-LINE FORM**

On-Scene	Exam/Observation	Patient Hx	Patient Tx	Narrative
<b>Medicines Administered</b> Migrane about 2 yrs ago High cholesterol Colon surgery about 2 yrs ago for polyps		<b>Splints Administered</b> NKA Possible side effects from sulphur		
		<b>Other</b> Vaseretic Lopid Domebors Pauel Tylenol		

VIDEO RUN RECORD PROTOCOLS MAP DISPLAY COMMS TRAINING

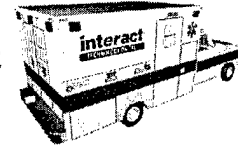
**interact ON-LINE FORM**

On-Scene	Exam/Observation	Patient Hx	Patient Tx	Narrative
<ul style="list-style-type: none"><li>• On 10-97 found 41 yo H/male lying supine in bed CA+OX3, c/o chest pain radiating down L arm c weakness and slight dif breathing.</li><li>• Hx of MI 2 yrs ago, high cholesterol and colon surgery for polyps that was causing bleeding P.E.</li><li>• Skin color good, warm &amp; dry, PERRC, no JVO, no TD.</li><li>• Chest stable c CBBS, abd soft, non tender slt obese.</li><li>• Extremities unremarkable, + distal pulses, no edema, noted, + capillary refill weak grips noted in upper extremities.</li><li>• Obtained vitals, placed on O2 URB @ 12 LPH, cardiac monitor showing SR c depressed ST @ 80.</li><li>• Transferred to amb. Placed on 12 lead - showing SR, Nonspecific ST and 1 wave abnormality.</li><li>• Abnormal ECG, Established N NOCI 0.9% L ante 18ga 1 1/4 x 1 attempt D. Grayson.</li><li>• Tindall sent info to MEDCON. Contacted by phone, spoke c Dr. Galloway.</li><li>• Pt info given to MEDCON c B/P, SPO2, EKG and video being transmitted.</li><li>• Rec'd orders for Nitro SL 0.4mg, and to Life Flight Pt to Hermann.</li><li>• Administered Nitro 0.4mg SL s relief. Orders for Procardia 10mg rec'd from Galloway, given c orders to Bite and swallow.</li><li>• Pt still denied CP continued to rate @ 8 on 1-10 scale.</li><li>• Pt continued to deny relief of CP, also denied dizziness, or lightheadedness.</li><li>• Pt continued to be hypertensive.</li><li>• Dr. Galloway ordered MS 4mg IVP, given L ante after rechecking allergies for drugs.</li><li>• Second 12 lead ran and had no noted change from 1st 12 lead.</li><li>• Dr. Galloway had also ordered 1/2 adult ASA (325mg) p.o.</li><li>• Administered 1/2 ASA, 162.5mg p.o. Pt refused H2O, stated could swallow s it.</li><li>• Continued to monitor pt, after MS &amp; ASA, pt began gasping, stated "Air, Air", elevated head slightly higher &amp; pt relaxed.</li><li>• He still denied any relief from the meds.</li></ul>				

VIDEO RUN RECORD PROTOCOLS MAP DISPLAY COMMS TRAINING



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### interact ON-LINE FORM

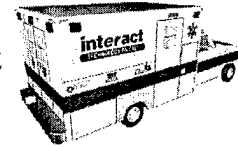
<b>Vitals Report</b>	<b>Billing</b>	<b>Release</b>	<b>Transport/Crew</b>	<b>Report</b>
Incident 0605	Date 10 / 30 / 98	Unit # A-9	Patient 1 of 1	<input checked="" type="checkbox"/> NT <input type="checkbox"/> BLS <input type="checkbox"/> ALS <input checked="" type="checkbox"/> CPR
Dispatch 21: 53	On Scene 21: 59	Departure 22: 20 Set	Arrival 22: 29 Set	In-Service 0 : 36
Type of Call (add text if desired) Chest Pain		Incident Location 2108 Franklin Avenue	Key Map 518 - D	Mileage 52
(Propaq Vitals History)				
Video	RUN RECORD	PROTOCOLS	MAP Display	COMMS
<b>TRAINING</b>				

### interact ON-LINE FORM

<b>Vitals Report</b>	<b>Billing</b>	<b>Release</b>	<b>Transport/Crew</b>	<b>Report</b>
Patient Name (First) (M.I.) (Last) Timothy J Heinselman		Address (Street) 823 Fairmont Court #523		
Responsible Party (First) (M.I.) (Last) Margaret H Heinselman		Relationship Father		
Address (Street) 823 Fairmont Court #523		City Houston	State TX	Zip 78241
Phone # 518 - 582 - 8237				
Insured's Name (First) (M.I.) (Last) Margaret H Heinselman		Bill To: Patient <input type="checkbox"/> Employer <input type="checkbox"/> Resp. Party <input type="checkbox"/> No Bill <input type="checkbox"/> Other <input type="checkbox"/>		
Insured's Address (Street) 823 Fairmont Court #523		City Houston	State TX	Zip 78241
Phone # 518 - 582 - 8237				
Employer's Name and Address Rock & Assoc., 482 Franklin Ave.		City Houston	State TX	Zip 78244
Name of Insurance Company Trustworthy Insurance Co.		CSN 483-82-5113	ID # / PCA 92345	
Medicare Number		Medicaid Number 483-82-5113		
Video	RUN RECORD	PROTOCOLS	MAP Display	COMMS
<b>TRAINING</b>				



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### interact ON-LINE FORM

<a href="#">Vitals Report</a>	<a href="#">Billing</a>	<a href="#">Release</a>	<a href="#">Transport/Crew</a>	<a href="#">Report</a>
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**RELEASE OF RESPONSIBILITY FORM**

I have been informed of the reason I should go to a hospital for further care.

I have been informed of the evaluation and/or treatment that will/may occur when I get to the hospital.

I have been informed of the potential consequences and/or complications that may result by my refusal to go to the hospital for further care.

I, the undersigned, have been advised that emergency medical care on my/the patient's behalf is necessary, and that refusal of recommended care and transport to a hospital facility may result in death, or imperil my/the patient's health by increasing the opportunity for morbidity. Nevertheless, and understanding all of the above, I refuse to accept emergency medical care or transport to a hospital facility, assume all risks and consequences resulting from my decision and release the DREAMS Project and its member(s) from any and all liability resulting from my refusal.

As a competent adult, I fully understand all of the above, and am/is capable of determining a rational decision on my behalf.

**ACKNOWLEDGEMENT**

I hereby acknowledge that I have been informed that I do not require transportation by ambulance to a medical facility. I have been examined by the emergency medical services personnel of the Digital EMS Project named below and they have determined that I am not in need of emergency medical care or because I am neither sufficiently ill nor injured to require transportation by emergency ambulance. I also acknowledge that I have been informed of the need to seek medical care on my own for this problem. I understand that if my condition worsens or changes I can call the ambulance for further assistance or evaluation.

Patient Signature:  Date:  /  /   
 E.M.S. Crew Signature:  E.M.S. Rank:   
 Witnessed By:

<a href="#">Video</a>	<a href="#">RUN RECORD</a>	<a href="#">PROTOCOLS</a>	<a href="#">Map Display</a>	<a href="#">COMMS</a>	<a href="#">TRAINING</a>
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### interact ON-LINE FORM

<a href="#">Vitals Report</a>	<a href="#">Billing</a>	<a href="#">Release</a>	<a href="#">Transport/Crew</a>	<a href="#">Report</a>
-------------------------------	-------------------------	-------------------------	--------------------------------	------------------------

<b>Patient Transported To:</b> <input type="text" value="Hermann Hosp - Life Flight"/>		<b>Physician</b> <input type="text" value="Dr. Galloway"/>	
<b>Method of Transport</b> <input type="text" value="- No Transport -"/>			

<b>Chauffeur</b> (First) <input type="text" value="Ward"/>	(M.I.) <input type="text" value="O"/>	(Last) <input type="text" value="Gatton"/>	<b>E.M.S. Rank</b> <input type="text" value="EMTB"/>
<b>In-Charge</b> (First) <input type="text" value="Denise"/>	(M.I.) <input type="text" value="I"/>	(Last) <input type="text" value="Grayson"/>	<b>E.M.S. Rank</b> <input type="text" value="EMTP"/>
<b>Attendant</b> (First) <input type="text" value="Tony"/>	(M.I.) <input type="text" value="R"/>	(Last) <input type="text" value="Johnson"/>	<b>E.M.S. Rank</b> <input type="text" value="EMT Stud."/>
<b>Additional Personnel</b> (First) <input type="text" value="Doug"/>	(M.I.) <input type="text" value="R"/>	(Last) <input type="text" value="Tindall"/>	<b>Rank</b> <input type="text" value="UTHMS"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<b>Rank</b> <input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<b>Rank</b> <input type="text"/>

<a href="#">Video</a>	<a href="#">RUN RECORD</a>	<a href="#">PROTOCOLS</a>	<a href="#">Map Display</a>	<a href="#">COMMS</a>	<a href="#">TRAINING</a>
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**interact ON-LINE FORM**

Vitals Report	Billing	Release	Transport/Crew	Report
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Select Desired Sections

<input checked="" type="checkbox"/> On-Scene	
<input checked="" type="checkbox"/> Exam / Observation	
<input checked="" type="checkbox"/> Patient History	
<input checked="" type="checkbox"/> Patient Treatment	
<input checked="" type="checkbox"/> Narrative	
<input checked="" type="checkbox"/> Vitals Report	
<input checked="" type="checkbox"/> Billing	
<input checked="" type="checkbox"/> Release	
<input checked="" type="checkbox"/> Transport / Crew	

Video	RUN RECORD	PROTOCOLS	MAP DISPLAY	COMMS	TRAINING
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### Communications Suite

Two wireless communications engineers joined the Digital EMS team since the last report and have begun working on the design and integration plans for multiple communications means (e.g., cellular phone, UHF radios, two-way pager, and satellite communications). Commercial-off-the-shelf (COTS) radio equipment consistent with the radios used by the Houston Fire Department will serve as the initial base case.

### Digital EMS Vehicle

The activity related to the Digital EMS vehicle itself is divided into two parts: the computing/network facilities to be integrated onboard the vehicle to support the migration of software from the "bench" to the prototype and the modifications to the vehicle to provide an acceptable environment for the computing/network facilities (e.g., air conditioning and power distribution).

Equipment lists have been produced and procurement action has been started for the necessary components to build the prototype that will be demonstrated in April 1999. Computer racks are being fabricated and installed. Air conditioning ducts have been reworked to cool compartments that will contain computers.



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### Significant Events During the Quarter

- 19 November 99 - Briefing to Dave Davis
- 30 November 99 - Briefing to U.S. Representatives Tom Delay, Kevin Brady, Ken Bensen
- 8 February 99 - Briefing to MG Parker, U.S. Army Medical Research and Materiel Command

### Upcoming Events

- 19-21 April 99
  - American Telemedicine Association Conference in Salt Lake City, UT
- 28-29 April 99
  - Internet 2 Conference in Washington, D.C.
- 29-30 April 99
  - American Trauma Society in Washington, D.C.
- Summer 99
  - Integrate satellite antenna, NOTE: pending further Digital EMS funding
- Summer 99
  - Satellite antenna testing begins, NOTE: pending further Digital EMS funding
- November 99
  - Texas EMS Conference in Austin, TX

## Fifth Quarter Plans

### Conference Attendance

The Digital EMS Interact vehicle has been invited to attend the American Telemedicine Association annual conference in April. In addition, the Digital EMS Interact vehicle has been invited to attend and demonstrate as a part of the Internet 2, Highway 1 show during the fourth week in April. Attendees at Highway 1 include prominent congressman and senators, and members of the administration interested in high technology and internet gigabit transmission, also call the Next Generation Internet. Vice President Al Gore is expected to attend as well. Following the Internet2 show, members of the American Trauma Society whose conference is in Washington DC coincidentally during the fourth week in April have been invited to Internet2 for a demonstration as well.



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Houston Fire Department (H.F.D.) Collaboration:

The Digital EMS project team has a meeting scheduled with David E. Persse, M.D., Medical Director of H.F.D., to formalize our collaboration relationship for Digital EMS vehicle testing. Work to integrate our medical protocols and data collection not only into H.F.D.'s operating procedures and the emergency patient record will also be addressed. This is a follow up to Dr. Alan Tonnesen's protocol work discussed in previous TSRs.

Onboard Systems:

The overall software architecture design will continue stressing robustness, modularity, and scalability. Development of key software components will begin this quarter and interfaces to procured hardware components will be developed. The development team will continue with the prototyping of user interfaces and will begin software development of the interface components as the user community agrees them upon.

The major thrust this quarter will be focused on establishing a "bench" prototype; however, considerable engineering activities will be put forth to address the integration of the system into the ambulance. The ambulance will be modified to hold additional deep cycle batteries, modifications will be planned for the integration of a prototype satellite antenna, and the installation of the onboard video, vitals, and voice systems.

The Digital EMS team will continue work with the MRMC technical staff to integrate a MRMC recommended instrumented litter (i.e. MiRF) and the Medicam unit into the onboard systems. Completion is not expected by the end of the fifth quarter, but the Digital EMS team is hopeful of having a working model of the Medicam for our integration work sometime during this quarter. Also, work will progress on the presentations and floor demonstration of the Digital EMS Interact unit with MRMC at the American Telemedicine Association annual conference in Salt Lake City, UT during the third week of April.





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## REFERENCES

1. Oldberg C. Oklahoma City - Two-Way radio: The Champion. APCO Bulletin, 1995 Aug.
2. EmergencyNet News. Deadliest train crash in AMTRAK history kills 44. 1992 Sep 23, 0800CDT.
3. Baxt WG, Moody P. The impact of a physician as a part of the aeromedical prehospital team in patients with blunt trauma. JAMA, 1987 Jun 19, 257(23): 3246-50.



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## APPENDICES:

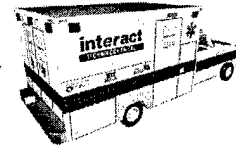
### Statement of Work

#### Digital Emergency Medical Services:

- Design, develop, integrate, and operate a system which allows telecommunication (video, voice, and data) between far forward ambulances and the University of Texas Health Science Center at Houston.
- Test new military technologies like MEDITAG and LSTAT in Houston's diverse environment of, industrial, and medical emergencies.
- Perform expeditious patient evaluations and guide appropriate interventions.
- Collect and analyze outcome data.
- Prepare and submit:
  - Quarterly "Program Status Report"
  - Midterm "Technical Status Report"
  - Final "Technical Program Report"
- Publish findings in appropriate medical journals.



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## First Quarter Progress Report

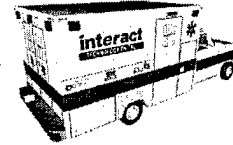
During the first quarter, Digital EMS project concentrated on the selection of collaborative partners. In order to advance the selection process, we formed a Digital EMS working group consisting of leaders in the areas of medical information systems, medical direction, and technology integration within the Medical Center. This working group was tasked to divide the project into sub-projects focusing on medical protocol development, needs assessment, requirements definition, and operational goals.

In a parallel track to the Digital EMS working group, we have been assessing varied medical programs and technology. We attended the ATA Annual meeting in Orlando, Florida learning more about current military medical programs. In addition, we traveled to Texas A&M University at College Station, Texas (TAMU) and to the Texas Department of Transportation Transguide facility in San Antonio, Texas (Southwest Research Institute – SwRI). The purpose of these meetings was to form alliances with institutions within Texas that are working in areas closely related to the Digital EMS project. TAMU has offered technical leadership in the areas of wireless communications, systems development, the human interface, and biological warfare defense. SwRI has offered engineering and technical leadership and their experience with the San Antonio Transguide Urban LifeLink EMS program.

In a partnership with TAMU, we submitted a joint proposal for the use of the Advanced Communications Technology Satellite (ACTS). In a battlefield or rural environment, we feel that mobile high bandwidth communication is central for the success of the Digital EMS project. The first indications from NASA for our use of the ACTS terminal (two of which are located in the TAMU-Medical Center campus) were positive. We are finalizing the formal proposal for ACTS satellite use at this time.

Under guidance from members of the Telemedicine and Advanced Technology Research Center (TATRC), we feel a collaborative partnership between UTHSCH and other centers of excellence in Texas will advance the project while maximizing the opportunity for success. We hope to match Digital EMS collaborators to the sub-projects and goals from the Digital EMS working group.

Once the individual strengths and areas of interest for TAMU and SwRI are identified, we will work together to modify the statement of work (SOW) to show the responsibilities and contributions of each collaborating institution.



## Second Quarter Progress Report

### Online Protocol discussions:

Several meetings between Dr. Tonnesen and Dr. Galloway (Medical Director for MEDCON at Hermann Hospital) have resulted in the selection of two medical and two administrative protocols for implementation. They were selected because they were common enough to expect that they will occur several times each month, but either the protocols are too complex or uncommon enough to cause problems in the clinical setting. These include:

- Management of tachyarrhythmias
- Management of acute pulmonary edema, hypotension and shock
- Facility diversion guidelines
- Prehospital patient triage and facility bypass algorithm

### Functional Analysis:

A functional analysis is currently underway to address the roles and activities of medical specialists and EMT personnel throughout the full cycle of the deployment of an EMS ambulance – pre-notification to recovery. This approach is based on decomposing the complete cycle into a series of state changes and transitions and exploring the roles of all personnel (medical specialists, EMT personnel, dispatchers, etc.) and the ongoing activities at their respective locations. This analysis will include direct observation by Digital EMS researchers participating in real ambulance deployments with the Houston Fire Department. Once this analysis (and further interviews with medical experts) is completed, opportunities for improving this cycle by the introduction of those technologies included in the Digital EMS program will be explored.

### Requirements Definition:

While the Digital EMS concept has been well-defined, the requirements definition continues and is a necessary precursor for development of the technical specification. The level of activity has been and continues to be high in this area given its importance in the early part of the development cycle.

### 3D Modeling of the Ambulance:

A 3-D model of the Digital EMS ambulance has been constructed in 3-D Studio Max for the purpose of addressing space management issues related to add-on components (See Appendix). Also, this model is being used to aid in the location of digital cameras within the ambulance to ensure that the appropriate coverage of an onboard patient can be achieved. While the required area of coverage includes the entire body, the emphasis extends from the groin area to the top of the head.

### Patient Monitors Evaluation:

Three portable patient physiologic monitors are commercially available for consideration by the Digital EMS team. For the purposes of this project, we have specified that the following parameters are the minimum set to be included in the monitor chosen:



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- Electrocardiogram
- Noninvasive blood pressure
- Heart rate
- SpO2
- ETCO2

The three monitors under evaluation include the Physio-Control Lifepak12, the Zoll Medical's M Series Pacemaker-Defibrillator, and the Protocol Systems' Propaq Encore. The first two monitors are still in prototype form awaiting FDA 510K approval and do not include all the vitals monitoring needed. The third has been in the market for a number of years and already carries both flight and military certifications (See Appendix).

The ideal patient monitoring solution would include the multi-parameter monitoring of the Propaq unit with the defibrillator and pacing of either the Lifepak or the M Series. This would allow the paramedics to carry one unit into the field that could meet their needs of pacing, defibrillating, and full patient monitoring. While Protocol's competitors are developing their monitors to do just that, neither the Lifepak nor the M Series monitors currently have the ability to stream data out of the unit to an onboard computer. Both Physio-Control and Zoll Medical have expressed much interest in investigating this capability in future models. The Propaq does support this type of communication through its data port. We foresee continuing relationships with all three manufacturers and the development of a communications standard interface for these and other monitors so that we do not get tied to any one manufacturer.

#### Voice Controlled Equipment:

An important consideration in the project is the ergonomics of the EMT staff. Where possible, voice control of non-critical equipment is desired. The ambulance environment is noisy and non-deterministic. We are evaluating software from several vendors. Several products have been eliminated as too complex or not robust enough for the project. Additional products are being solicited from existing and previous military projects. These will be evaluated as available.

#### Video Transmission Simulation:

A key question that must be answered within the scope of this research effort relates to video quality. What resolution and frame rate must be sustained for the video images to permit medical specialists to evaluate the patient and mentor EMT personnel with regards to medical treatment or procedures. A video simulation has been constructed that varies resolution and frame rate to permit medical personnel to determine what are the minimum acceptable levels of video quality given the technical constraints in this area (See Appendix for example screens from this simulation). This simulation will be refined and used to produce video inputs for interface development in the early prototype development as the project moves forward.

#### Display Monitor Prototype:

Screen prototypes for remote and base station monitoring are in development. These are based on standard monitor layouts already in use in emergency rooms and intensive care



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facilities. Additional screens and functionality are being determined and specified to be added at a later date. Prototyping is being done in Visual Basic.

External Connectivity:

The long term Digital EMS base station will be located in the Herman Trauma Suite. This facility is being built and will be on line in January. It will be connected by fiber backbone to the Texas Medical Center backbone and then on to the Internet. Until the Trauma Suite is completed, the Texas A&M Institute for Biosciences and Technology (IBT) research facility provides all the connectivity to the project. The IBT is the home of the Texas Gigapop project. A private fiber connection from the Trauma Suite to IBT allows access to the Texas Gigapop project, providing connections to the NSF vBNS network project, the Internet2 backbone project, NGI, and the State of Texas Tex-an 2000 state backbone.

Ambulance Acquisitions:

As noted in our joint proposal to subcontract with TEES (Texas Engineering Experiment Station, TAMUS, College Station), we investigated the building of a mockup ambulance patient compartment for the engineering design team to use for fit form and function studies. Since the quotations for materials and labor to build this mockup exceeded the cost to purchase a complete used ambulance from Nacagdoches County Hospital District, we decided to purchase this vehicle. The vehicle, a 1988 Ford F350 diesel ambulance, now resides in the Digital EMS bay at the TEES facility. It will be used for both initial and continuing prototyping of the onboard systems, antenna testing, and for accelerometer force testing.

In addition to the prototype vehicle, we placed the order for a new Frazer, Inc. ambulance with a refurbished 1993 patient compartment. This vehicle will be used for field testing of the prototyped TEES system and patient runs later in the project. We expect delivery of the Frazer unit within the next few weeks. The TEES graphics department has designed the layout for logos and the name for the Digital EMS ambulance for the Frazer unit, provided in the appendix.

TEES Digital EMS Subcontract:

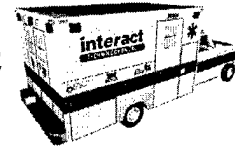
After the acceptance of the UTHHSC-TEES joint proposal for collaboration and subcontract on the DREAMS: Digital EMS project (USAMRMC Cooperative Agreement revision dated July 29, 1998), the contracts and grants offices at both UTHHSC and TEES began final negotiation of the subcontract for integration and design work. This process is proceeding rapidly and the subcontract will be in place in the very near term.. Once the final document is complete, the UTHHSC Office of Sponsored Projects will provide copies to USAMRMC. Interviewing and preliminary staffing is underway at TEES in anticipation of the subcontract. Texas A&M University System provided an office at IBT for the DREAMS project allowing close collaboration and communication with both TEES and the telecommunications team at IBT.

Preliminary ACTS pre-proposal accepted:

Final submission of proposal scheduled for week of August 24th.



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## Third Quarter Progress

### Congressional Briefings:

The DREAMS program and the Digital EMS project is planning a briefing to Mr. Dave Davis (key staff person for Senator Kay Bailey Hutchison) on 19 November. Mr. Davis will tour UTHHSC, Texas Heart Institute, and the Institute of Biosciences and Technology Texas A&M University facilities. A visit by key U.S. Representatives from Texas (Delay, Bensen, and Brady) and members of their staff is scheduled for 30 November.

Our participation in the Texas EMS conference, originally scheduled for November 25<sup>th</sup>, will not occur due to personnel and time constraints associated with the congressional briefings.

### Digital EMS High Level Systems Design:

Digital EMS represents the integration of multiple leading edge technologies, especially in the areas of video processing and wireless communications. The objective is to improve the quality of emergency medical services by allowing highly trained trauma specialists to gain better situational awareness and to direct lifesaving measures sooner, thus increasing the survivability of critical patients. This is accomplished by linking the Digital EMS vehicles with the trauma suite using multiple communications means in order to provide high quality data and video to the trauma specialist. A brief discussion of the high level design follows.

### *Digital EMS Onboard Subsystems (Figure 1)*

The Digital EMS Vehicle onboard subsystems are shown in Figure 1: the EMT Interaction & Communication Subsystem; the Video/Audio Processing Subsystem; and the GPS Positioning & Navigation Subsystem. Onboard components will be linked using a 100 Base-T network hub. The Digital EMS vehicle will have the capability for both wireless and wired connectivity with the main hospital system.



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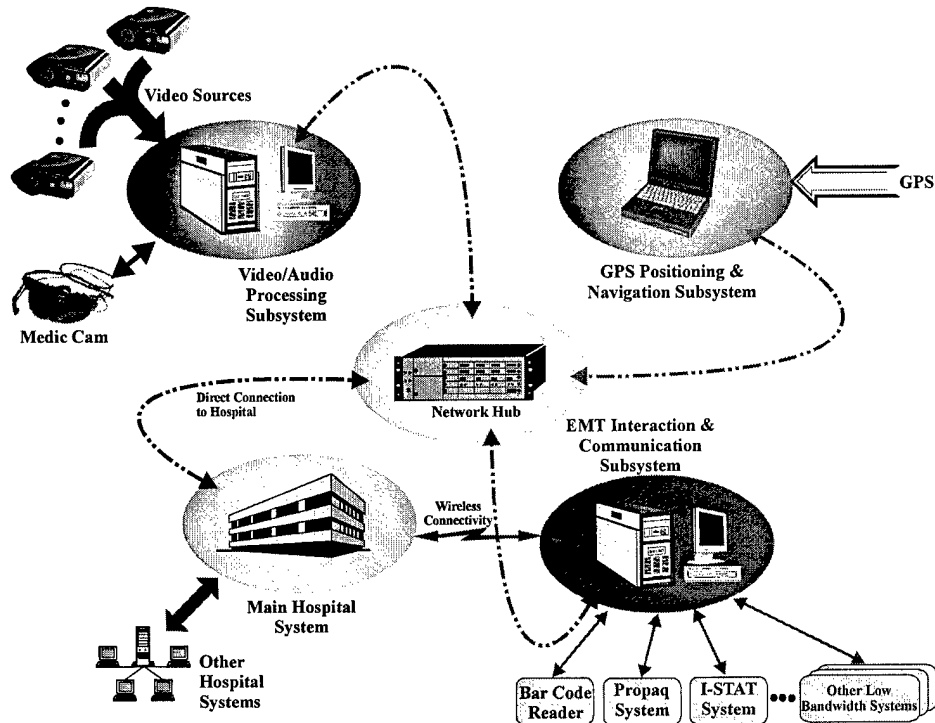
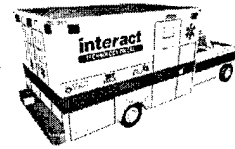


Figure 1. Digital EMS Onboard Subsystems

*EMS Interaction & Communication Subsystem (Figure 2)*

This subsystem will include a multi-functional flat panel display with a touch screen and stylus interface. EMS personnel will use this display primarily for maintaining an awareness of the camera view being used by the trauma specialist at the hospital and to display outputs from the vital signs monitor. This subsystem will host an intelligent communications manager that will match data requirements with available bandwidth. Also, low bandwidth medical support systems (e.g., Propaq, I-Stat, barcode reader, etc.) will be interfaced and managed by this subsystem.





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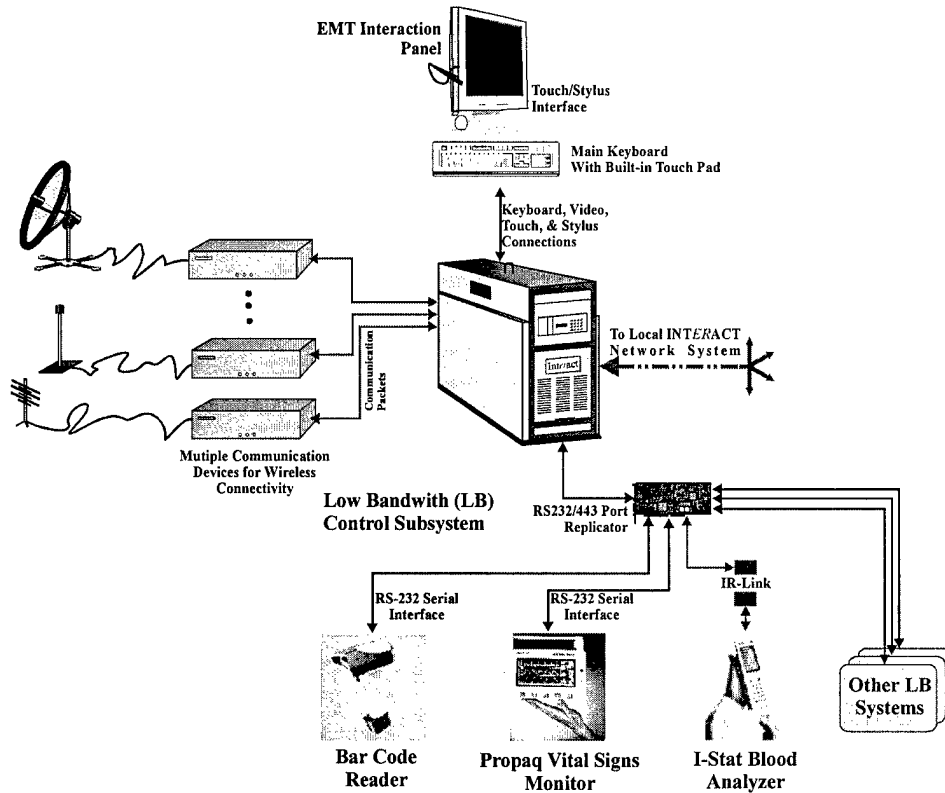


Figure 2. EMS Interaction & Communication Subsystem

*Video/Audio Processing Subsystem (Figure 3)*

The Video/Audio Processing Subsystem will capture video from onboard video sources and the Medic-Cam System when available. Pan, tilt, and zoom control of onboard video sources will be accomplished from the trauma suite. Real-time video CODEC processing, “thumbnail” generation for each camera view, and audio integration will occur within this subsystem. A flat panel display will be used for patient-doctor video interaction.



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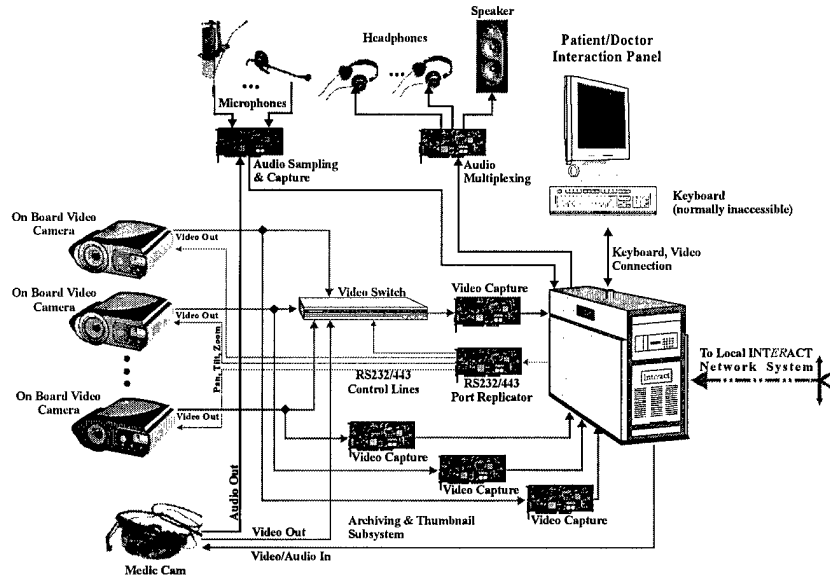


Figure 3. Video/Audio Processing Subsystem

*GPS Positioning & Navigation Subsystem (Figure 4)*

This subsystem will provide real time positioning and navigation based on GPS and local map information. An interface into standard mapping products for route planning, ETA, and navigation will be included. Location inputs (destinations) from multiple sources will be accommodated. A magnetic card reader will be included to extract patient information from driver's licenses, credit cards, etc.

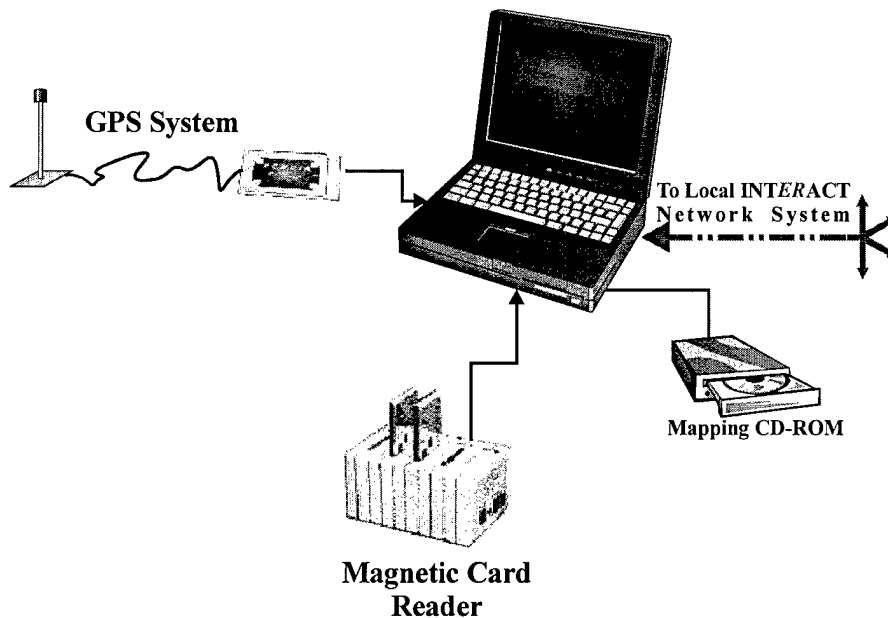


Figure 4. GPS Positioning & Navigation Subsystem



*Hospital Based Subsystems (Figure 5)*

The hospital-based system shown in Figure 5 includes the following subsystems: Doctor Audio/Video Processing Subsystems; Vital Signs, Positioning, & Status Subsystem; and Web Server Situation Monitor and Control Subsystem. The main hospital-based system can interact with the Digital EMS (wireless and wired connectivity), hospitals with comparable systems (wireless and wired connectivity with the same capabilities), and hospitals without a comparable system (Web-based connectivity with degraded capabilities).

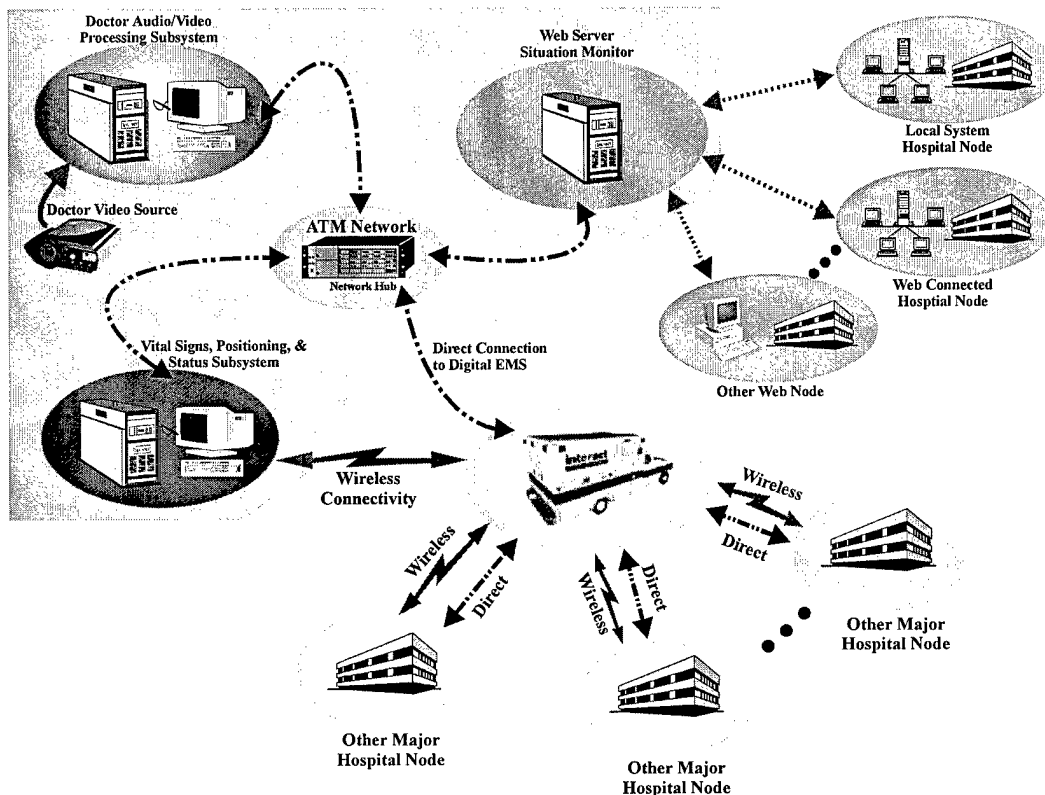


Figure 5. Hospital Based Subsystems

*Doctor Audio/Video Processing Subsystem (Figure 6)*

The Doctor Audio/Video Processing Subsystem will capture video of the doctor, facilitate transmission to the Digital EMS for doctor-patient interaction, decode and display incoming video from the Digital EMS. The incoming video and the vital signs information are essential for increasing the situational awareness of the trauma specialist. Pan, tilt, and zoom for local and remote video sources will be accomplished using joystick/software control. This subsystem will process audio for the patient, EMS personnel, and doctor interaction.

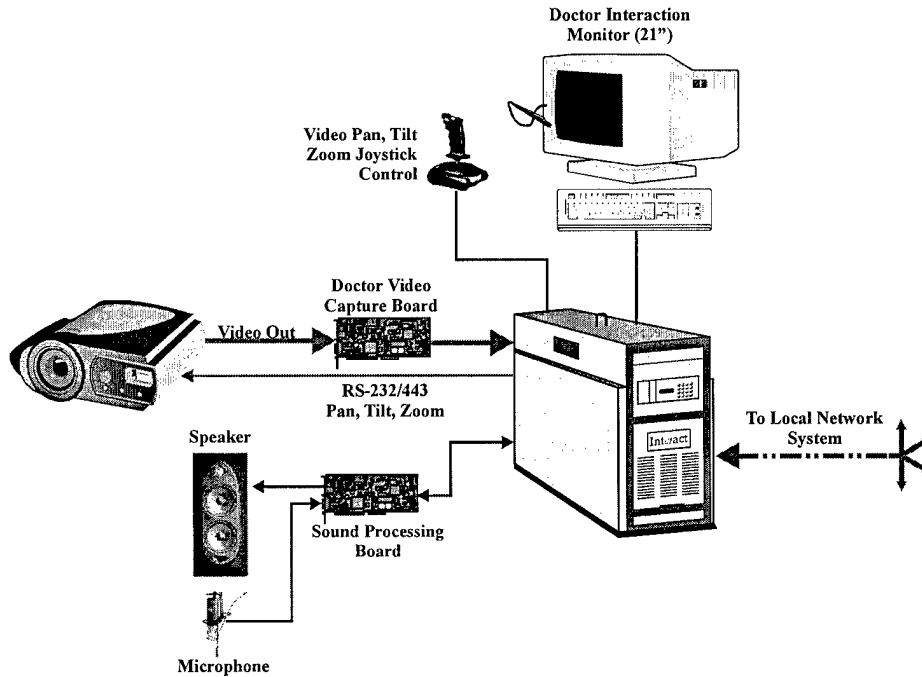


Figure 6. Doctor Audio/Video Processing Subsystem

*Vital Signs, Positioning, & Status Subsystem (Figure 7)*

This subsystem will feature a vital signs monitor for incoming patient data. Control for local and remote resource management will be enhanced by a map display showing all emergency vehicle locations and hand-off control protocol management for virtual collaboration. This subsystem initially will also serve as the intelligent communications manager for local/remote interaction.

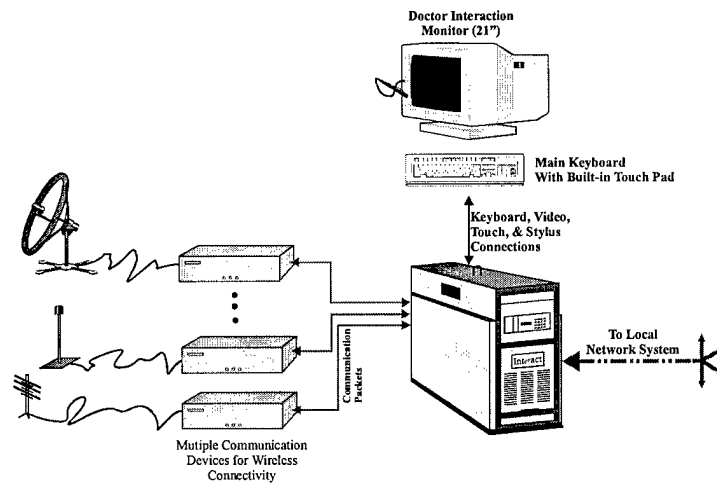
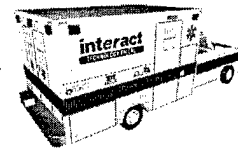


Figure 7. Vital Signs, Positioning, & Status Subsystem



*Web Server Situation Monitor and Control Subsystem (Figure 8)*

The Web Server Monitor and Control Subsystem will be Java-based and can be accessed using a single desktop system to view a facsimile of the dual displays and control systems used in the main hospital system. This subsystem can be a single unit or replicated and mirrored across multiple network nodes.

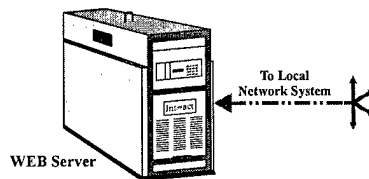


Figure 8. Web Server Situation Monitor and Control Subsystem

*User Interface Prototyping (Figure 9 and 10)*

Another key activity occurring during this reporting period has been the prototyping of user interfaces (Figures 9 and 10). The prototype displays are being developed to gain user feedback.

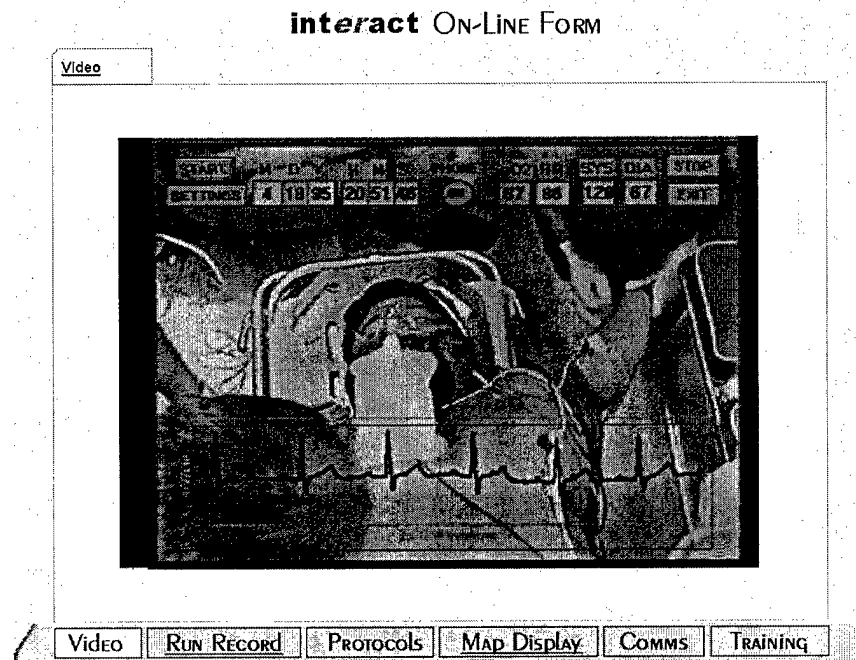


Figure 9. Onboard Video Display with Compositd Vital Signs



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**interact ON-LINE FORM**

<b>Incident</b>	<b>Billing</b>	<b>Primary Survey</b>	<b>Patient HX</b>	<b>Narrative</b>	<b>Release</b>	<b>Transport / Crew</b>
Airway Clear	Breath Sounds L: Clear R: Clear	Pupils L: Reactive R: Reactive	Glasgow 15			
Breathing Adequate Respirations	Warm	Skin Dry	Normal			
Circulation Radial Pulse	RESPONSIVENESS Conscious: Alert		Responsive to: Verbal	Motor/Sensory: Decreased		
M.V.A. SURVEY Preventive Aid: Seatbelt Length of Entrapment: 27 min.		Type of MVA: Frontal Impact	Type and Location 1. Pain 2. Broken Bone 3. 4. Pain 5. <b>Protrusion</b> 6. Broken Bone 7. Amputation 8. 9.			
Select Position of Patient and Draw line to Indicate Direction of Impact						
<b>VIDEO</b>	<b>RUN RECORD</b>	<b>PROTOCOLS</b>	<b>MAP DISPLAY</b>	<b>COMMS</b>	<b>TRAINING</b>	

Figure 10. Sample Screen from Automated Run Record

Digital EMS Breakthrough Technology:

Key areas of breakthrough technology for the Digital EMS includes:

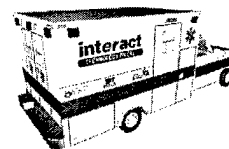
- System Level Impact of Digital EMS
  - A unique collection of digital technologies will create a virtual presence by the physician and permit a remote mentoring environment.
  - This virtual presence will enhance current life-saving protocols by involving the physician sooner and in greater detail.
- Intelligent Communications Processing and Management
  - A “smart” communications manager using software agent technology that can balance bandwidth requirements versus bandwidth availability will be developed.
  - Multi-modal communications will be treated as a single channel with dynamically varying capacity.
- Multi-Channel Real-Time Video/Audio Processing
  - Dynamic management of multiple video/audio streams will permit a high level of on-board situational awareness by physicians at remote locations.

Mobile Satellite Antenna Design Groups:

We are meeting with several groups to discuss tracking, mobile antennas. It is our intent to establish one or more development consortia during the 4<sup>th</sup> quarter. The groups under consideration for development projects include NASA-Lewis, Naval Research Labs, Lockheed Martin, Southwest Research Institute (SwRI), and others.



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Medical Protocols:

Dr. Tonnesen has finalized four online algorithms discussed in the previous status report:

- Management of tachyarrhythmias
- Management of acute pulmonary edema, hypotension and shock
- Facility diversion guidelines
- Prehospital patient triage and facility bypass algorithm