EvacSys – "Evacuation Support System"

Whitepaper

1 Executive summary
In June 2002 USA (DOD) and Norway (MoD) signed a Memorandum of Understanding (MOU) agreement in the area of telemedicine. The objectives were to share experience/lessons learned and together do some research in new concepts/architectures that involves the use of the US PIC (Personal Information Carrier: http://www.tatrc.org).

Since June 2002 the MOU project has developed and tested/evaluated a prototype system called Evacuation Support System. This system uses the PIC as an "electronic field medical card" and addresses the problems of capturing, storing and distributing medical treatment and patient tracking information during the evacuation of a wounded soldier from field. Information is captured through an easy to use graphical user interface on a PDA and stored on the PIC. At Level 1 the medics use tablet PCs to access and update this information. Wireless physiological sensors (Pulse-ox) can be attached to the PDA/Tablet PC. Information can be sent (using military digital radio) from all treatment levels to the subsequent levels, e.g., from Level 1 to Level 2, thus providing "early warning" functionality. When the patient has received treatment at Level 2 and discharged/transferred out, all information from the evacuation is automatically imported into the Military Electronic Health Record.

The primary benefits of EvacSys are:

- Improved patient documentation and patient tracking through structuring and standardization of information elements
- Improved information flow and early warning
- Improved usability in patient documentation process
- Automated data capture and documentation through the use of biosensors
2 Operational Challenges

2.1 The scenario

The traditional way of documenting medical treatment and observation during medical evacuation is using a paper form (field medical card) that has columns and rows that the medic should fill in. In a military medical evacuation, it is not always easy to make sure that medical documentation is done properly. Focus is on patient treatment and on how to deal with the stressful situation in which treatment and evacuation is carried out. Nevertheless, medical documentation is important both from a medical and a command-control perspective; information should be captured, stored and distributed to all actors involved.

When a soldier is injured in an operation (combat or accident) a medical rescue team will start off to evacuate him back to a safe treatment facility. A normal evacuation axis includes several treatment levels starting with (battle) field, transport vehicle, the Level 1 (Mobile Aid Post), another transport vehicle and then to the Level 2 (Light Field Hospital). From Level 2 the patients will either be discharged or sent to a larger full-scale military or civilian hospital (Level 3, 4 or 5).

Table 1 shows these typical treatment facilities (places) along with information about capacity and relative location.

<table>
<thead>
<tr>
<th>FACILITIES/Characteristic</th>
<th>Field</th>
<th>Transport from Field</th>
<th>Level 1/ Mobile Aid Post</th>
<th>Transport to Level 2</th>
<th>Level 2 Light Field Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>002 unit title</td>
<td>Mechanized infantry squad</td>
<td>Tracked vehicle helicopter</td>
<td>Mobile aid post (12-H)</td>
<td>Soft skin ambulance (15-E1)</td>
<td>LFH1 (35A)</td>
</tr>
<tr>
<td>002 geographical location</td>
<td>Front line</td>
<td>1-4 km² behind front line</td>
<td>2-4 km behind front line</td>
<td>Based 4-6 km behind level 1 medical units</td>
<td>15-40km behind front line</td>
</tr>
<tr>
<td>002 communications facilities</td>
<td>Tactical VHF radio (MRR)</td>
<td>Tactical VHF radio (2)</td>
<td>Tactical VHF radio (1)</td>
<td>None</td>
<td>Tactical VHF radio, telephone,</td>
</tr>
<tr>
<td>008 stretcher/seating capacity</td>
<td>None</td>
<td>2 stretcher+3 seated or 3 stretcher³</td>
<td>2 stretcher</td>
<td>2 stretcher+2 seated or 4 stretchers</td>
<td>3 operating tables</td>
</tr>
<tr>
<td>008 no of vehicles available</td>
<td>Snowmobiles and BV</td>
<td>Max 4 in a mechanized battalion</td>
<td>Max 3 in a mechanized battalion</td>
<td>Approx 5 on each evacuation route</td>
<td>None for evacuation purposes.</td>
</tr>
<tr>
<td>Personnel available</td>
<td>1-2 medics</td>
<td>2 medics</td>
<td>1 MD, 1 nurse, 3 medics</td>
<td>2 medics</td>
<td>1-3 MD 2-6 nurses 5-30 medics</td>
</tr>
</tbody>
</table>

Table 1: The table shows important attributes pertaining to each place identified in the scenario. Numbered attribute-captions (e.g., 002 UNIT TITLE) denote data fields from NATO STUDY 2231.

1 Specific call sign used in the Norwegian Brigade Medical Company
2 These are generic distances and time estimates
3 Depending on the patients’ casualty priority
During the evacuation of a soldier, much information should be captured, stored and distributed. Many actors (both people and systems) are involved, each having a special need for information. In addition, medical personnel are required by law to document everything pertinent to the treatment of a patient.

The table below provides an overview of the main actors and their most important information needs during the evacuation of a patient from field.

<table>
<thead>
<tr>
<th>Actor name</th>
<th>Most important information elements</th>
<th>Rationale</th>
</tr>
</thead>
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<tr>
<td>Medic (attending)</td>
<td>• Name, rank, service number</td>
<td>Information should be accurate and updated. When working on a battlefield, information should be available within 1 minute.</td>
</tr>
<tr>
<td></td>
<td>• Patient's blood type, allergies, diseases</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Treatment done /medication given at previous levels</td>
<td></td>
</tr>
<tr>
<td>Medic (next treatment facility)</td>
<td>• Priority</td>
<td>Information should be available before the patient arrives (“early warning”) at the facility so that they can allocate resources and plan for immediate treatment.</td>
</tr>
<tr>
<td></td>
<td>• Type / cause of injury</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Patient tracking (from where to where and when)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Injury category and diagnosis (preliminary)</td>
<td></td>
</tr>
<tr>
<td>Local Commander</td>
<td>• Patient (soldier) id/name</td>
<td>Must know the status of all his soldiers. Priority and patient tracking is important information.</td>
</tr>
<tr>
<td></td>
<td>• Priority</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Patient tracking (from where to where and when)</td>
<td></td>
</tr>
<tr>
<td>Joint Operation Center (HQ)</td>
<td>Number of soldiers/patients with:</td>
<td>Will coordinate overall evacuation if the patient will be evacuated back to Level 3/4. Need to know patient's name/id and diagnosis to inform the patient's family and to decide which hospital is best suited for advanced treatment</td>
</tr>
<tr>
<td></td>
<td>• Soldier ID/name</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• next of kin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Priority</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Diagnoses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Patient Tracking</td>
<td></td>
</tr>
<tr>
<td>Electronic Health Record</td>
<td>• Patient ID</td>
<td>All information pertinent to the treatment of a patient must be stored in the patient's medical file.</td>
</tr>
<tr>
<td></td>
<td>• Full medical documentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• All patient regulating</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• All patient tracking</td>
<td></td>
</tr>
</tbody>
</table>

2.2 Challenges
The main challenges during a military medical evacuation can be summarized in four areas:

1. Information capture: All information pertinent to the medical evacuation should be captured for later medical analysis and storage. The process of capturing the information should not be of hindrance for the attending medic, but support him in carrying out the right procedures in a stressful situation.

2. Information distribution / standardization: The information captured should not only be stored locally, but also distributed to other medical personnel, command-control (C2) units and also to other information systems such as electronic health records, logistics systems and medical surveillance (tactical epidemiology) systems. Systems may also be
cross-national, i.e., a German field information system should be able to provide information to a Norwegian electronic health record, thus introducing a need for information interoperability. There may be some technical data transmission challenges as well, but this is outside the scope for this whitepaper.

3. Information presentation: Along the evacuation axis, a lot of information should be captured and stored. This may also bring about a new problem: how to present the information to the user in a way that makes it easy to get an overview and be able to take (the correct) action based on this information. Aggregation and filtering of information will be a major challenge. E.g., a commander at the Joint Operation Center is not interested in how much fluid has been given to a specific patient, rather the total number of patients and their priorities.

4. Information security: along with the information presentation challenge is the information security challenge. Person identifiable medical documentation is subject to many laws and regulations (personal act and so on). Detailed information about a patient's diagnoses and is considered personal information and must not be given to other people that the attending medic without the patient's (informed or written) consent. Information security is also tightly related to information distribution as detailed information about a nation's patients may not be possible to share with another nation.

3 The Evacuation Support System

EvacSys is essentially a system designed to capture patient information (input), store, and distribute it (output). It replaces the old paper-based field medical cards and much of the verbal communication between treatment levels and C2 units.

The high level goals of EvacSys are to:

- Store information in order to improve medical documentation and patient tracking
- Automatically distribute information in order to improve information flow and early warning
- Improve usability in patient documentation process
- Automate data capture and documentation through the use of biosensors
- Improve information quality through the use of a standardized vocabulary and digitalization of information input and storage.

In order to achieve these goals, the following hardware components play key roles:

- Personal Information Carrier (PIC). This is an electronic “dog tag”, a rugged memory chip capable of holding 16 Megabytes of information\(^4\), developed by the US Army.
- Medical Digital Assistants (MDA). This can be PDAs and Tablet PCs (civilian and military).
- Information Transmitters, such as Multi Level Radio (MRR, a military digital radio), WLAN or Ethernet.
- External sensors such as Pulse-oxymetri sensors and Global Positioning System (GPS) devices

An outline of EvacSys is depicted in the figure below:

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\(^4\) The latest versions of the PIC may store up to 6 GB of information and can be accessed through a wireless link. More information at the TATRC website: http://www.tatrc.org
**Battlefield**

Soldiers are wearing the PIC as an electronic “dog tag”. If a soldier is wounded, a medic arrives with a MDA (PDA in the field). The PIC is attached to the MDA, and relevant information about the patient (name, rank, blood type, allergies etc. is available from the PIC). All information concerning the patient is written to the PIC, including data from biosensor monitoring. Information is entered via touch screen using a GUI that is designed to be operated with fingers only (no stylus needed). The information will follow the patient through all levels of the evacuation chain. The most recent information is always on the PIC. If information is sent from the battlefield to subsequent levels (Level 1, Level 2 etc.) in order to enable personnel to start preparing for arriving patients (early warning), they would always update the information with the more recent information on the PIC upon patient arrival.

**Transport Battlefield-Level 1**

As seen in the previous section, patients are typically transported away from the battlefield to a Level 1 facility. In the transport, medics will access the patient data stored on the PIC to see the patient history, and what treatment he/she has been given. They will also continue the treatment and update...
information on the PIC accordingly. Data can also be sent to later levels.

**Level 1**

At Level 1, patient data has been received from battlefield and transport. Data is received on one computer at Level 1, and can later be distributed via WLAN to other computers at the facility, e.g. at one particular bed. The computers receiving patient data at Level 1 and Level 2 are capable of receiving data from several incoming patients. The patients can be sorted by name, injury and where the patients are coming from. These helps the medics plan and prioritize treatment. As the patient arrives, the PIC is read to receive the most current patient info. As on earlier levels, documentation is written to the PIC to follow the patient, and information is sent to later levels.

**Transport Level 1-Level 2**

Equal to earlier transport description.

**Level 2**

EvacSys works the same way at Level 2 as in Level 1. The difference at Level 2 is that information at this level is prepared to enter into Electronic Health Record (EHR) systems, typically used both by army and civilian hospitals. This is easily accomplished as all the information that flows through EvacSys is XML messages, and has XML-Schemas publicly available to ease integration with 3rd party systems.

**4 Solution Benefits**

The EvacSys system addresses many of the challenges described in section 2.2. In addition, many other possibilities open up with the concept of capturing information digitally from the point of injury and all the way through the evacuation chain. This section provides a brief overview of direct and indirect benefits that a system and concept like EvacSys provides.

**4.1 EvacSys system benefits**

1. Information capture: EvacSys provides an easy-to-use graphical user interface (GUI) for the medic. The GUI is specially designed to reflect the medics' working procedures, thus providing workflow support. The MDAs (PDA or Tablet PC) have a touch-screen interface and 98% of the information can be entered by selecting information elements from a predefined list. This implies that a keyboard is not necessary most of the time, and that 98% of the information is structured (both semantically and syntactically) according to a standard. The fact that the information capture is done digitally opens for both input verification and confirmation. This will again improve information quality as much of the input errors will be detected.

2. Information distribution: Since information is made digital from the point of capture, distribution is just a matter of connectivity. EvacSys can use both IP-based communication and other protocols that provide a serial interface such as RS-232. Information can be sent directly to one receiver or broadcasted to all nodes on a specific
frequency or sub-network. Since all information elements are stored in xml-files separated from the EvacSys application, there are no system constraints for where this information can be distributed. The current version of EvacSys uses a combination of WLAN (IEEE 802.11b/g), Ethernet and digital military radio, but testing with satellite communication is also being conducted.

3. Information presentation: The information captured in EvacSys is structured in four xml-files: 1) Person, 2) Medical Documentation, 3) Patient Tracking, and 4) Sensor measurements. For each xml-file there is an associated data type definition file (DTD) that describes which information elements that can be captured, what data type they have and where they will be stored in the xml-structure. The information presentation screens in the systems uses xml transformation (XSLT) to select and lay out information in a well arranged manner. Having stored all information according to a defined structure enables automated filtering and aggregation of information. All person-sensitive information can easily be removed before distributing information to non-medical personnel, such as logistics command-control units.

Information security: Access to personal medical information should be restricted to authorized personnel only. Using electronic computing devices for input and review, EvacSys opens for the use of standard Role Based access control (RBAC) mechanisms. The current version of EvacSys does however not implement such mechanisms. In addition, other security features such as encryption, digital signatures and integrity checking can easily be implemented on the EvacSys platform. Information availability is also a security issue. EvacSys utilizes the PIC as the main information storage unit. The PIC replaces the paper based field medical card and is not sensitive to rain, being torn apart, text being illegible etc. One will however need a MDA such as a PDA or PC to be able to read information stored on it.

4.2 EvacSys concept benefits
In addition to the abovementioned benefits, the EvacSys concept provides some general improvements as well.

4. Network centric treatment: Each medical team along the evacuation axis will act as a medical information node in a large network providing vital information for other medical and non-medical nodes.

5. Early warning: as information can be sent digitally from all treatment facilities – including site of injury – the concept of "early warning" can be realized. Medical personnel at a higher treatment level (e.g. Level 2 is higher than Level 1 and so on) can received timely and accurate information from a lower treatment level before the patient arrives. This allows the medical team at the receiving facility to allocate necessary resources and prepare relevant medical procedures such as surgery or maybe teleconsultations.

6. Situational awareness – medical surveillance: a major prerequisite for providing medical situational awareness and medical surveillance is access to timely, accurate and reliable information. One way to achieve this is digitizing information at a very early stage in the information chain. In addition, information should conform to an agreed standard and the information capture process should include a quality assurance mechanism. The EvacSys

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5 Since information is stored in XML files, it is not necessary to have EvacSys software to read information on the PIC. A standard web (http) browser such as Internet Explorer can read and present XML-structured information.
concept is founded on these ideas, thus being an important information source both medical situational awareness and medical surveillance.

5 Technical Specification

5.1 System Interaction

EvacSys blends into the well-established evacuation drill in a natural way. The swim lanes in Figure 2 show the typical evacuation process at the various physical locations.

Figure 2: System collaboration model

The TreatObserve activity is decomposed in Figure 3
5.2 Hardware and Software

EvacSys runs smoothly on several configurations of hardware terminal types, referred to as MDAs. Such terminals include PDAs, TabletPCs and Laptops. The default setup is ruggedized PDA’s for battlefield and transport, and military specification Tablet PC’s at the treatment facilities, but there are no restrictions to which configurations that can be used. Even though these terminals run on various software platforms, the EvacSys interface is common. At the same time, it is optimized for the terminal’s screen and input methods. The pictures to the right show screenshots from the EvacSys application on both PDA and Tablet PC. On the PDA you can see the start-up screen where the site of injury is indicated using a red layer along with the most vital information. The PDA and Tablet PC screenshots show how the medic will document blood pressure using slide bars. Almost all information input can be done without typing on a keyboard.

The PIC itself is a compact and ruggedized memory unit is provided by TATRC⁶ and has a capacity between 16 MB to 6 GB. The picture of the PDA shows the PIC being attached to the

⁶http://www.tatrc.org
PDA (on the top). It is accessed with a PC-card/PCMCIA interface. Wireless access from PC to PIC is under development.

5.3 Integration with sensors
EvacSys provides open interfaces for integration with external sensors such as physiological sensors and positioning sensors. The current version of EvacSys has integrated a Pulse-SPO2 sensor from Nonin\(^7\) and a GPS from Holux\(^8\). Both can communicate through a wireless interface (Bluetooth) or a serial cable (RS232).

The images to the right show the wireless Nonin sensor, the wireless GPS receiver and a monitoring screenshot from the EvacSys PDA application.

5.4 Data Communications
Medical and tracking information is always recorded and stored on the soldier's PIC. In addition it is stored as historical data on the MDAs, transmitted locally on the treatment facility, and to the next evacuation level as an “early warning” using long range communication. A central MDA on the treatment facilities acts as a gateway between the local and long range network. The information is finally submitted to the centralized military electronic health record system at the end of the evacuation chain. The information itself is stored as XML data, which ensures interoperability and compatibility with other systems and platforms.

5.4.1 Local communications
On a treatment facility, there is either a wired or wireless network that distributes the incoming, current and historical patient information to stationary bed-post and mobile MDAs. This is realized with regular Ethernet or for instance IEEE 802.11b (WLAN) and a flexible distribution protocol.

5.4.2 Long range communications
For long range communications several options are available. The Norwegian military’s primary choice is the Multi-Role Radio (MRR), which is currently being deployed. This radio has a RS232-interface and a defined instruction set for sending digital data. It is an all-purpose mobile communication radio made for exigent terrains. The picture to the right shows the vehicle based version of the MRR. A light-weight version also exists for higher mobile requirements.

\(^7\) http://www.nonin.com/products/4000.asp
\(^8\) http://www.holux.com.tw/Temp%20web/GR-236.htm
Instead or in addition the MRR, various commercial products can be used, such as satellite phones, cell-phones (GSM, GPRS, and UMTS), PSTN or other networks with TCP/IP support.

6 Target Market

6.1 Military applications
The EvacSys system has been developed, tested and evaluated in close collaboration with the medical battalion in the 6th division in the Norwegian Army. Evaluation has shown that it is possible to replace the paper based field medical card being used today. To fully utilize the potential introduced with the EvacSys system, it should be integrated with and provide information to C2 units along and above the evacuation axis and not limit the distribution to medical levels.

The functionality provided by EvacSys is equally useful for the Navy and the Airforce, as for the Army. During 2005, EvacSys will be introduced for the Norwegian Navy and Airforce as a part of a Telemedicine Concept Development and Experimentation (CD&E) project. Focus will be on information flow between medical levels and information sharing with C2 units that are coordinating transport and other resources.

6.2 Civilian applications
As for the military, civilian prehospital resources such as emergency teams and ambulance services will have to document and share information from field with other personnel involved in the medical treatment process. In a mass casualty situation, information related to priority, diagnosis and patient tracking is of highest importance for the Acute Medical Coordination Centre (dispatch center) responsible for coordination and communication between field units (ambulances) and the hospital emergency room (E.R.) services. A system like EvacSys can capture and provide this information in an accurate and timely manner by integrating with the civilian emergency communication network.

6.3 CIMIC
In crisis situations such as terrorist attacks, Civilian-Military Collaboration (CIMIC) is often necessary. Effective CIMIC requires that all involved parties are using a standardized set of information elements so that information can be exchanged. Civilian prehospital units must use diagnoses, priorities and other vital information elements that are directly or indirectly in accordance with the military once and visa versa. EvacSys is based on open and non-proprietary information standards that are in accordance with NATO. The information interface is XML and information exchange with other systems capable of exporting and importing XML information.

The EvacSys project group is currently working with the Norwegian Coast Guard in order to establish a test for the EvacSys system. This exercise will include CIMIC.

6.4 Case studies
The first version of EvacSys was evaluated during exercise "Interaction" in northern Norway in December 2003. During a 5-day exercise the system was evaluated by the medical battalion in the 6th division in the Norwegian Army. Several complete evacuation run-throughs were conducted and each step was evaluated using observation logs, questionnaires, structured interviews and video recording. The overall result was very positive. Version 2.0 of EvacSys is ready for evaluation in June 2005.
# Contact us

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<thead>
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