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Tempus Pro Patient Monitoring System



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3 April 2015



**Final Report
for July 2013 to March 2015**

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1.0 EXECUTIVE SUMMARY

The study relates to AFMSA Modernization Thrust Area Enroute Care and involved the modification and subsequent demonstration of the Tempus Pro patient monitoring system to include the AF3899L critical care patient movement record.

Tempus Pro is a multi-parameter vital signs monitor designed for use in pre-hospital and remote locations. AF3899L, Patient Movement Record Enroute Critical Care, is an in-depth form which provides the Critical Care Air Transport Team (CCATT) with the capability to document patient care during patient transfer.

The study goal was definition, design and implementation of the AF3899L form on Tempus Pro and was comprised of following key activities:

- Support of a kick-off meeting during which the user requirements were identified.
- Periodic telecoms utilizing use cases to gather feedback from the user on the desired presentation format.
- Support of the First and Final Design Reviews at which the prototype and final developed designs were reviewed by a representative group of CCATT users.
- Delivery of 3 Tempus Pro Units and a Final Report.

The main features added as part of this study were:

- The capability for Air Force (AF) users to electronically record an AF3899L form whilst monitoring a patient. This was provided by the modification of the Tempus Pro's existing patient record engine known as the Summary Record of Care (SRoC), which allows Tempus Pro users to record interventions, patient status observations together with administered medications whilst monitoring in a quick and easy way.
- The ability to review AF3899L patient data points in context, as recorded on the Tempus Pro. This includes the capability to display vital signs trend data annotated with clinically significant AF3899L events and the summary listing of all the AF3899L events combined with all the SRoC events.
- The capability to create a patient report in PDF format containing the AF3899L data augmented with monitored vital signs in addition to photographs, vital signs trend data, 12 Lead ECG recordings, video laryngoscopy images together with ultrasound images. The patient report can be shared using a USB stick or emailed over communications links supported by the Tempus Pro such as Inmarsat or Iridium radios. The patient report containing the AF3899L data can then be stored in an appropriate patient record system.
- Support for patient handover between Tempus Pro devices during the patient movement.

To aid requirement capture a kick-off meeting, lasting two days, was held at Wilford Hall Ambulatory Surgical Center in San Antonio to capture the requirements for an electronic 3899L critical care patient movement record. During the Kick-off Meeting:

- RDT provided an overview of the project tasks, deliverables and schedule.
- To facilitate understanding, CCATT representatives described the use of current AF3889L form during typical patient transports.
- The CCATT representatives collectively reviewed the AF3899L form to identify the initial requirements.

Following on from the Kick-off Meeting and after analysis of the initial requirements:

- To better facilitate effective requirement capture RDT created a number of use cases illustrations for common AF3899L data entry scenarios.
- After further teleconference reviews the Requirement Definition Specification was agreed.

To review the first development prototype the Initial Design Review, which lasted two days, was held at Centre for Sustainment of Trauma and Readiness Skills in Cincinnati. The review took the form of an Operational Assessment (OA) conducted by the Air Force Medical Evaluation Support Activity (AFMESA). After receiving training, a representative group of CCATT users which included physicians, nurses and respiratory technicians performed a number of assessed patient movement scenarios. Observation data was collected during 'hot wash' sessions, via user questionnaires and after analysis of the video footage recorded during the assessed scenarios.

Based on analysis of the OA performed in the First Design review it was evident that the scope of the AF3899L data capture and associated automated features agreed initially made it challenging for CCATT clinicians to use Tempus Pro to record AF3899L data whilst monitoring the patient on the same device. As a consequence it was agreed that the requirements initially agreed should be updated to improve the usability; the key changes are detailed below:

- The automatic calculation of intakes was removed; to allow more flexibility for data entry of intake related parameters
- The requirement to record detailed drug administration details was removed. Instead it was decided that the basic drug administration details should be recorded using the existing SRoC functionality. This decision was based on the observation that detailed drug information is recorded on another record used by CCATT. The requirement to record the medications received, wasted, and turned-over was also removed.
- The ability to enter assessment data for specific flight phases was added.
- The capability to document that an assessment was the same as the last assessment without having to enter the assessment data in full was added.
- The Summary screens were reworked to improve the logical grouping rather than been directly driven from the AF3899L form.

After the development of the final prototype developed in accordance with the updated requirements a Final Design Review, lasting three days, was held at Wilford Hall Ambulatory Surgical Center in San Antonio. The Final design Review, which was performed in a similar way to the First Design Review, took the form of an Operational Assessment (OA) conducted by the Air Force Medical Evaluation Support Activity (AFMESA). After receiving training, a representative group of CCATT users which included physicians, nurses and respiratory technicians performed a number of assessed patient movement scenarios. OA analysis data was collected during 'hot wash' sessions, via user questionnaires and after the analysis of video footage recorded during the assessed scenarios.

Based on analysis of the OA performed in the Final Design Review it was evident that the changes made to the requirements post the First Design Review had significantly improved usability of the Tempus Pro to record, review and modify AF3899L data.

The assessment of the final design at the Final Design review revealed a general satisfaction with the incorporation of the Form 3899L onto the Tempus Pro. Most CCATT users agreed that recording the certain parts of the AF3899L form electronically using Tempus Pro whilst monitoring could well enhance patient care. The consensus view of CCATT users was that the following features developed during the study were beneficial to enroute patient care:

- Ability to record intake and output for the entire patient encounter; consequently Tempus Pro provides a flow chart that can be used by CCATT users to review intakes and outputs at the point of care.
- Support for Pre-flight / Post flight / In Flight assessments; Tempus Pro provides a quick and easy way to document the assessment status being same as last.
- Ability to record patient status observations, interventions and medication administration using the SRoC quickly with minimal key presses.
- Support for patient handover between Tempus Pro devices during the patient movement was also seen a significant benefit since it allowed the new clinical team to have quick and easy visibility of trend vital signs, patient status and the clinical care already administered
- The capability to email the patient report to allow storage in an appropriate patient record system such as AHLTA-T thereby facilitating research to improve patient outcomes.

An EHR system suitable for CCATT use during patient transfer is currently being developed but at the time of writing this system has not been deployed. It was agreed that when the EHR system is ready to be deployed then it may well be appropriate to update the capability of the Tempus Pro to achieve effective integration with the EHR system.

The technology developed in this study can enhance patient care by reducing CCATT workload, improve patient safety by automating tasks allowing the CCATT to devote more time to direct patient care and improve patient health care records during aeromedical evacuation.

2.0 INTRODUCTION

The purpose of this study was to enable AFMSA to further demonstrate, test and develop their concepts for the use of advanced patient monitoring by adding the capability to electronically record AF3899L data in an attempt to enhance AF enroute trauma and resuscitative care and enroute patient safety.

The study involved the modification and subsequent demonstration of the Tempus Pro patient monitoring system to include AF3899L on the Tempus Pro patient monitoring system. The Tempus Pro has the capability for medical caregivers to electronically document the patient information contained on the AF3899L form, while, simultaneously, automatically capturing critical physiologic monitoring data.

The Tempus Pro is a multi-parameter vital signs monitor designed for use in pre-hospital and remote locations. The Tempus Pro offers five capability sets: monitoring, patient record data collection and sharing, real-time telemedicine (branded **Reachbak™**), modular feature selection and scalability.

It provides the user with conventional patient monitoring parameters for use in measuring and monitoring patient’s vital signs. In addition to providing the user with conventional vital signs monitoring and alarming features, the device also gives the user the ability to:

- Collect data in the form of vital signs trends, still photos, 12 Lead ECG recordings, video laryngoscopy and patient data captured using either a Tactical Combat Casualty Care (TCCC) Card form or SRoC.
- Transmit all data in real-time using a variety of integrated communications interfaces

AF3899L is an in-depth form which provides the CCATT with the capability to document patient care during patient transfer, see Appendix A for more details. CCATT teams are providing complex treatments to maintain the stability of a casualty during patient movements. Based on operational constraints pre-flight information is completed at the sending MTF when the CCATT takes responsibility for the patient, enroute to the aircraft, during the flight, enroute to final destination, and at mission completion. It should be noted that AF3899L is not a standalone form; rather it is to be used as a supplement to the current 3899 package. The AF3899L paper completed by the CCATT team during the patient transfer is intended to be scanned and entered as a permanent part of the electronic medical record upon the patient’s arrival at their destination medical facility.

The study goal was definition, design and implementation of the AF3899L form on Tempus Pro and was comprised of following key activities:

- Support of a kick-off meeting during which the user requirements were identified
- Periodic telecons utilizing use cases to gather feedback from the user on desired presentation format
- Support of the Initial and Final Design Reviews at which the prototype and final developed designs were reviewed by a representative group of CCATT users.
- Delivery of 3 Tempus Pro Units and a Final Report.

3.0 METHODS, ASSUMPTIONS, AND PROCEDURES

A phased approach was taken to the development of the AF3899L form. The associated phases of the study which are shown in the diagram below are described in detail in later sections.

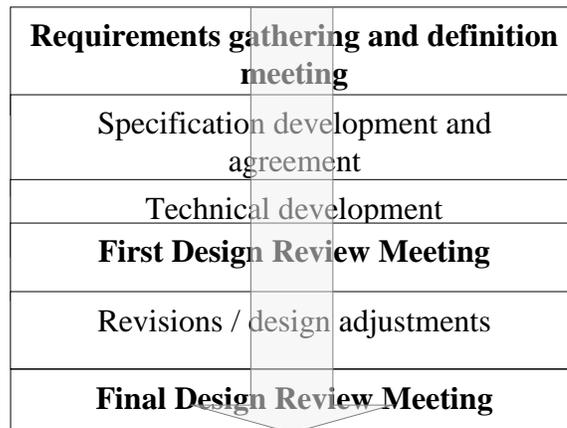


Figure 1 – Study Activity Summary

During the study RDT provided monthly Status Reports together with four Data Accession Reports.

3.1 Technical and User Requirements Definition

Starting on the 10th July 2013 a two day meeting was held at Wilford Hall Ambulatory Surgical Center, Joint Base Lackland, San Antonio to kick-off the project and capture the user requirements for an electronic 3899L critical care patient movement record.

The following attendees were present at the Kick-off Meeting

Mr. Charlie Dean, 711th HPW/FHS
Mr. Calvin Griner, AFMSA/SG51
Ms. Pam Logan, AFMSA/SG51
Maj Charles Morris, AFMSA SG5T, (AFMESA)
Mr. Paul Bailey, AMC SG/SGR
Maj Justice M. Sakyi, AMC SG/SGR
Lt Col Cheryl Hale, AMC SG/SGK
Ms. Debra Schnelle, contract support representing MRMC TATRC, Dr. Gary Gilbert
Mr. Graham Murphy, RDT
Mr. Nigel Pritchard, RDT
Ms. Barney Howell, RDT

Four CCATT representatives

During the Kick-off Meeting the following key activities took place:

- RDT provided an overview of the project tasks, deliverables and schedule.
- To facilitate understanding CCATT representatives described the use of current AF3889L form during typical patient transports.
- The CCATT representatives present at the kick-off meeting collectively reviewed the AF3899L to identify the initial requirements.

Following on from the Kick-off Meeting RDT recorded the requirements identified in a draft version of the Requirement Definition Specification which was then reviewed with the relevant AF stakeholders.

After further consideration of the requirements and with the objective to facilitate effective requirement capture RDT created a number of use cases illustrations. The use cases acted to show the CCATT representatives how the AF3899L form would appear on Tempus Pro. This was done by the use of example Tempus Pro screens arranged in sequence to illustrate specific types of AF3899L data being recorded and subsequently reviewed.

There were a number of joint teleconferences where the following items were discussed:

- The design objectives presented by RDT
- Use cases illustrations presented by RDT
- The Requirement Definition Specification

Based on feedback from the CCATT representatives and AF stakeholders RDT updated both the Requirement Definition Specification and the use case illustrations.

In addition to the AF3899L data centric requirements the following design objectives were agreed:

- The AF3899L development should be based on the Tempus Pro's existing SRoC feature.
- The electronic AF3899L data captured should be augmented with monitored vitals in addition to photographs, vital signs trend data, 12 Lead ECG Recordings, video laryngoscopy together with ultrasound images and a Focused Assessment with Sonography in Trauma (FAST) exam.
- All elements of the 3899L will be provided by the Tempus in a format where the user will be able to complete the record easily with a gloved hand and without the need for a stylus.
- The 3899L will be segmented so the required fields are presented logically for the different phases of the transport.

In an attempt to ensure that the requirements were genuinely representative and not biased toward the group of clinicians who were active in the Kick-off Meeting then an additional teleconference was arranged with a second group of CCATT representatives. During this teleconference RDT presented the use case illustrations previously reviewed with the first group of CCATT clinicians. There were no significant comments received as a result of this additional review with the second group of clinicians.

3.2 AF3899L Technical Development

Based on the agreed Requirement Specification after taking into account the feedback received during the review of the use cases RDT created detailed Software Requirement and Design Specifications.

Initially the software activity was focussed on the development of a prototype in order to facilitate an effective Initial Design Review with CCATT representatives at which the users would be entering all the required AF3899L data points onto Tempus Pro devices.

Based on analysis of the Operational Assessment (OA) performed as part of the Initial Design Review, which is detailed in the Initial Design Review section below, and after a number of joint teleconferences the Requirement Definition Specification was updated. RDT then updated the detailed Software Requirement and Design Specifications accordingly.

Then next phase of software activity was then focussed on the development of a final prototype according to the updated design in order facilitate an effective final design review with CCATT representatives. This prototype supported the following functionality

- The ability to capture and review in context all the agreed AF3899L data points.
- The ability to transfer patient data from one Tempus Pro device to another Tempus Pro device using the export/import patient data capability.
- The ability to create patient reports containing all the captured 3899L data augmented with monitored vitals in addition to photographs, vital signs trend data, 12 Lead ECG

recordings, video laryngoscopy images together with ultrasound images and a FAST exam.

Based on analysis of the OA performed as part of the Final Design Review the Requirement Definition Specification and associated design documents were updated by RDT.

3.3 Initial Design Review

Starting on the 10th April 2014 a two day meeting was held at Centre for Sustainment of Trauma and Readiness Skills, Cincinnati University Hospital Trauma Center, Cincinnati, Ohio to review the initial Tempus Pro prototype that included the AF3899L capability.

The following attendees were present at the First Design Review Meeting

Mr. Charlie Dean, 711th HPW/FHS
Ms. Bobbie Hicks, AFMSA/SG5I
Maj Charles Morris, AFMSA SG5T, (AFMESA)
Mr. John Ingram, AFMSA SG5T, AFMESA
Mr. John Plaga, 711 HPW/HP Human Factors Engineering
Mr. Paul Bailey, AMC SG/SGR
Ms. Lynn DiFato, contract support representing MRMC TATRC, Dr. Gary Gilbert
Lt Col Cheryl Hale, AMC SG/SGK, CCATT Nurse
Mr. Graham Murphy, RDT
Mr. Nigel Pritchard, RDT
Ms. Barney Howell, RDT
Ms. Susie Streefkerk, RDT
Seven CCATT representatives

The design review took the form of an Operational Assessment (OA) conducted by the Air Force Medical Evaluation Support Activity (AFMESA). The OA was based on a representative group of CCATT users performing a number of pre-defined patient movement scenarios defined by AFMESA. The patient encounters were described using Patient Movement Request documents (PMR) and scenario definition documents.

In order to ensure effective use of the Tempus Pro devices, the following training was provided by RDT in advance of the OA.

- RDT's Training Manager provided a general overview of Tempus Pro capabilities.
- RDT summarized the key design objectives taken into account when adding the AF3899L capability to the Tempus Pro
- RDT provided Tempus AF3899L data entry training during which the Tempus Pro screen was displayed to the clinicians while an AF3899L record was completed by the RDT trainer.

There were a total of seven CCATT users which included physicians, nurses and respiratory technicians. After receiving training, users were divided into two groups to allow each CCATT user to have the dedicated use of one of the four Tempus devices provided by RDT. The first patient transfer scenario was performed as a training exercise and assistance was provided by

AFMESA and RDT representatives. Following on from the training scenario, the users performed two further assessed patient scenarios which were evaluated. Cameras were strategically placed to allow filming of CCATT users as they worked through the scenarios. The patient transfer scenarios were designed such that the test user would exercise as much of the software as possible while following a typical workflow. Following on from the assessed scenarios, 'hot wash' sessions were held for each group and user questionnaires were administered by AFMESA.

A number of important issues were identified as a result of the analysis of the OA performed during the Initial Design Review:

- Some users commented that the arrangement of data elements in the summary screens did not reflect a typical workflow sequence and consequently they found it difficult to locate certain types of data.
- The automatic calculation of intake values has the consequence that the user is forced to enter all the associated intravenous fluids (IVFs) and medications to allow the correct intake value to be automatically created.
- The users requested a quicker way to review/correct data that was previously entered.
- The detailed documentation of medications provided was observed to be time consuming and complicated.
- The users needed an easier way to enter assessment data for a specific flight phases retrospectively and also to quickly indicate that the assessment status was unchanged.
- Users made the observation that additional notes were needed to document the following details:
 - defibrillation power used together with the number of defibrillations
 - a patient's location and orientation in the aircraft
- Users commented that a new data entry section to record equipment details that is distinct from the recording of equipment issues should be supported

The evaluators found the Tempus Pro intuitive and easy to use for general monitoring functionality, however there were some observations related to the AF3899L training provided. It was recommended that in future design reviews that there should be more time spent on AF3899L training and additionally the training should be more focused on hands-on usage of Tempus Pro.

Full details of the findings of the OA conducted AFMSA by are provided in Reference 1.

3.4 Final Design Review

Starting on the 2nd February 2015 a three day review meeting was held at Wilford Hall Ambulatory Surgical Center, Joint Base Lackland, San Antonio. The prototype presented for review was updated to reflect the changes agreed by AF and RDT following on from the First Design Review.

The following attendees were present at the Final Design Review Meeting

Mr. Charlie Dean, 711th HPW/FHS
Mr. Calvin Griner, AFMSA/SG51

Maj Charles Morris, AFMSA SG5T
Mr. John Ingram, AFMSA SG5T
Mr. John Plaga, 711 HPW/HP Human Factors Engineering
Mr. Paul Bailey, AMC SG/SGR
Lt Col Cheryl Hale, AMC SG/SGK
Mr. Graham Murphy, RDT
Mr. Nigel Pritchard, RDT
Ms. Barney Howell, RDT
Ms. Susie Streefkerk , RDT
Eight CCATT representatives

As was the case with the Initial Design Review, the Final Design review took the form of an Operational Assessment (OA) conducted by the Air Force Medical Evaluation Support Activity (AFMESA). The OA was based on a representative group of CCATT users performing a number of pre-defined patient movement scenarios defined by AFMESA. The scenarios were essentially the same ones that were used in the Initial Design Review with minor updates to the sequence of data entry and also the documentation of historic medications was removed.

In order to ensure effective use of the Tempus Pro devices, the following training was provided by RDT in advance of the OA.

- RDT's Training Manager provided a general overview of Tempus Pro capabilities.
- AMC provided a briefing describing the scope of the study and the activities of significance that had already been performed. In addition, clarification was provided on the significant requirement changes that occurred as a result of the Initial Design Review.
- RDT provided Tempus AF3899L data entry training. Initially RDT presented the general design concepts involved in the inclusion of the AF3899L form in the Tempus Pro. This was followed by an interactive session where RDT first briefed the data entry for particular sections of the form, then CCATT users made the associated data entry. During this training session the eight CCATT users worked in pairs on four Tempus devices supplied by RDT. At the end of the training session after entering a full set of sample data points, patient handovers were performed between CCATT pairs using the export/import capability offered by Tempus Pro. Each CCATT pair also created a patient report during the patient handover.

There were a total of eight CCATT users which included physicians, nurses and respiratory technicians. After receiving the training, users were divided into two equal groups to allow each clinician to have the dedicated use of one of the four Tempus devices. The first patient transfer scenario was performed as a training exercise and annotated versions of the PMR and scenario description were provided as training aids. During this first scenario, guidance was provided by RDT and AMESA representatives. Following this, two further assessed patient scenarios were performed and evaluated. Cameras were strategically placed to allow the filming of the CCATT users as they worked through the scenarios. Afterwards, 'hot wash' sessions were held for each group and user questionnaires were administered by AFMESA.

The Final Design review revealed a general satisfaction with the incorporation of the Form 3899L onto the Tempus Pro. Most CCATT users agreed that recording the certain parts of the

AF3899L form electronically using Tempus Pro whilst monitoring could well enhance patient care. Full details of the findings of the OA conducted by AFMSA are provided in Reference 2.

The observations made during the Final Design Review that are related to adding AF3899L capability to Tempus Pro were reviewed by AMC/SGR and AMC/SGK. The observations were classified by AMC/SGR and AMC/SGK as follows:

- Priority 1: software change is required within this study
- Priority 2: software change is recommended in the future but not mandated within the current study
- Priority 3: software change is not required

See Appendix B for full details of the Final Design Review observations and associated classifications.

4.0 RESULTS AND DISCUSSION

4.1 Requirements Capture

Although RDT has broad experience converting paper patient care records into software based records, the AF3899L is a significantly more complex and in-depth form compared with the TCCC Card and SROc. Essentially the AF3899L is aimed at advanced users who are providing complex treatments to maintain the stability of a casualty during long transfers rather than recording observations and interventions near to the point of injury as is typically the case with the TCCC Card and SROc.

In an attempt to improve the usability and effectiveness of the overall functionality, the requirements defined during requirements definition stage acted to increase the required capability beyond data defined by the paper AF3899L form by including the following features:

- Automatic calculation of intake fluid volumes based on the IVF and continuous infusion medications.
- Automatic calculation of intake and output total volumes.
- The capability to document multiple flights
- The provision of a flow chart with screens showing the intake volumes, output volumes, tabulated vital signs, graphed vital signs together with O2 delivery readings and settings for each set of intakes and outputs recorded.
- Automatic calculation of medication concentration values based the medication dosage and fluid volumes.
- The ability to record multiple CCATT team members being on/off duty.

As part of the requirements capture, a set of use case illustrations were created in which reference Tempus Pro screens were shown in sequence to depict the user entering data for common AF3899L data entry scenarios. It was agreed by RDT and AF stakeholders that these use cases worked well to clarify understanding during the requirements capture phase.

During the analysis of the agreed requirements then it became clear that the study involved a significant design and development activity that was more complex than had been anticipated

prior to the study and as a consequence the overall duration of the study was extended by 6 months.

4.2 AF3899L Development

Conceptually the design agreed during the study was based on adding the AF3899L capability to SROc. As a consequence, an AF3899L tab was added to the existing SROc top level navigation tabs. This AF3899L tab allows users to access all the required elements of the AF3899L. All the newly developed AF3899L related screens are designed to enable entry using a gloved hand and without the need for a stylus.

The Tempus Pro functionality implemented during this study has the capability to record, review and modify all agreed data points. The AF3899L data points to be collected are significant. In order to allow the user to effectively enter the data without detracting from patient monitoring, the following design concepts were agreed to and implemented in the study:

- Allow users the flexibility to enter the AF3899L data at a convenient time after the occurrence of the event. Thereby, the user would not need to be distracted during periods of critical patient monitoring.
- Summary screens with feedback to show the progress are provided to allow the user to quickly determine which AF3899L data has already been entered
- The number of key presses required to record the AF3899L data points has been minimized. This includes the ability to move directly between associated data entry screens, thus avoiding the need to return to the summary screen, using special navigation buttons known as 'Flow buttons'.
- To provide quick access to the AF3899L screens, the Event and Patient Button present on the Tempus Pro are used to provide quick access to the AF3899L, see figure 2 below.
- The ability to review in context and respectively modify data previously entered has been provided.
- The filtering of the options presented in some data capture screens based on the associated data entered by the user is provided.



Figure 2 – Tempus Pro with AF3899L quick access keys highlighted

Based on analysis of the OA performed in the Initial Design review it was evident that the scope of the AF3899L data capture and associated automated features agreed initially made it challenging for CCATT clinicians to use Tempus Pro to record AF3899L data whilst monitoring the patient on the same device. As a consequence it was agreed that updating the requirements to remove some of the AF3899L data recorded and also to remove the automatic calculation of intake would improve usability. Details of the significant changes made to the study post the Initial Design Review are detailed below:

- The automatic calculation of intakes was removed; to allow more flexibility for data entry of intake related parameters.
- The requirement to record detailed drug administration details was removed. Instead it was decided that the basic drug administration details should be recorded using the existing SRoC functionality. This decision was based on the observation that detailed drug information is recorded on another record used by CCATT. The requirement to record the medications received, wasted, and turned-over was also removed.
- The ability to enter assessment data for a specific flight phase was provided.
- The capability to document that an assessment was the same as the last assessment without having to enter the applicable assessments was added.
- The ability to record a patient's location and orientation in the aircraft was added.
- Support for a new data entry section to record equipment details that is distinct from the recording of equipment issues was added.
- It was agreed that summary screens should be reworked to improve the logical grouping instead of being driven directly from the AF3899L form, see Appendix A for details for details of the updated summary screens.

Based on analysis of the OA performed in the Final Design Review it was demonstrated that the changes made to the requirements after the Initial Design Review had significantly improved usability of the device to record, review and modify AF3899L data.

4.3 Data Sharing

The ability to create a graphically rich patient encounter report in the form of a PDF document has been accomplished in this study. The AF3899L data is augmented with monitored vitals in addition to photographs, vital signs trend data, 12 Lead ECG recordings, video laryngoscopy images together with ultrasound images. The AF3899L data is printed in a format consistent with the current SROc patient encounter PDF report, while the AF3899L data is partitioned according to flight number and flight phase.

Patient handover between Tempus Pro devices during the patient movement is currently supported using USB sticks. The user is able to perform an export from the Tempus Pro that was previously used to monitor the patient to a USB stick and then to perform an import from the USB stick to the new Tempus Pro. All patient data including the entered AF3899L data is transferred during patient handover.

During discussions with AMC representatives it was clarified that the ALTHA-T patient record system does not support the recording of AF3899L data. It was also communicated by AMC that there is not currently an activity in progress to add support for specific AF3899L data points into the ALTHA-T system. Instead it was confirmed that the patient encounter PDF report which includes the AF3899L data can be stored as data in ALTHA-T. The implementation provided by this study has the capability to send the patient report PDF file via email over communications links supported by the Tempus Pro such as Inmarsat or Iridium radios. This emailed patient encounter report can then be added to the ALTHA-T system.

5.0 CONCLUSIONS

The research effort demonstrates to AMC/SGR that it is feasible to perform patient monitoring functions in enroute care scenarios while also recording patient care data using an electronic AF3899L form. This technology can enhance patient care by reducing CCATT workload, improve patient safety by automating tasks allowing the CCATT to devote more time to direct patient care and improve patient health care records during aeromedical evacuation.

During the study the following capabilities were successfully added to Tempus Pro for the purposes of demonstration:

- The capability for Air Force users to electronically record an AF3899L form whilst monitoring a patient. This was provided by the modification of the Tempus Pro's existing SROc feature. The electronic AF3899L data captured was augmented with monitored vital signs.
- The ability to review all the agreed AF3899L data points. This includes the capability to display vital signs trend data annotated with clinically significant AF3899L events and the summary listing of all the AF3899L events combined with all the SROc events.

- The capability to create a patient report in PDF format containing the AF3899L data augmented with monitored vitals in addition to photographs, vital signs trend data, 12 Lead ECG recordings, video laryngoscopy images together with ultrasound images and a FAST exam. The PDF report can be shared via USB or emailed over communications links supported by the Tempus Pro such as Inmarsat or Iridium radios. The PDF report containing the 3899L data can then be stored in an appropriate patient record system.
- Support for patient handover between Tempus Pro devices during the patient movement.

The number of data points to be collected to form the required electronic AF3899L meant that the software developed during the study some required careful design to ensure that the recording of AF3899L data does not detract from patient monitoring.

The Final Design review revealed a general satisfaction with the incorporation of the Form 3899L onto the Tempus Pro. Most CCATT users agreed that recording the certain parts of the AF3899L form electronically using Tempus Pro whilst monitoring could well enhance patient care. The consensus view of CCATT users was that the following features developed during the study were beneficial to enroute patient care:

- Ability to record intake and output for the entire patient encounter; consequently Tempus Pro provides a flow chart that can be used by CCATT users to review intakes and outputs at the point of care.
- Support for Pre-flight / Post flight / In Flight assessments; Tempus Pro provides a quick and easy way to document the assessment status being same as last.
- Ability to record patient status observations, interventions and medication administration using the SRoC quickly with minimal key presses.
- Support for patient handover between Tempus Pro devices during the patient movement was also seen a significant benefit since it allowed the new clinical team to have quick and easy visibility of trend vital signs, patient status and the clinical care already administered
- The capability to email the patient report to allow storage in an appropriate patient record system such as AHLTA-T thereby facilitating research to improve patient outcomes.

During the study there were a number of discussions related to whether the patient care documentation on the Tempus Pro should be complimentary to or act to replace the EHR documentation requirements. An EHR system suitable for CCATT use during patient transfer is being developed but at the time of writing this report the EHR system has not been deployed. It was agreed that the when the EHR system is ready to be deployed then it may well be appropriate to update the capability of the Tempus Pro to achieve effective integration with the EHR system.

6.0 REFERENCES

1. Air Force Medical Evaluation Support Activity, "Remote Patient Monitoring System Operational Assessment Final Report," March –June 2014
2. Air Force Medical Evaluation Support Activity, "Remote Patient Monitoring System Operational Assessment After Action Report," March 2015

Appendix B: Final Design Review Observations

This appendix contains a summary of the observations made during the Final Design Review that are related to adding AF3899L capability to Tempus Pro. Additional observations were made during a demonstration activity at Wright-Patterson Air Force Base (WPAFB) where one of the Tempus Pro devices used during Final design review was shown to a group of clinicians.

The observations were reviewed and classified by AMC/SGR as follows:

- Priority 1: software change is required within this study
- Priority 2: software change is recommended in the future but not mandated within the current study
- Priority 3: software change is not required

Observations noted during the Final Design Review

Item#	Item	USAF Review Classification
FD#1	O2 Delivery Tube: Entering Tube details in advance of entering the O2 delivery type should be supported.	Priority: 2
FD#2	O2 Delivery Settings/Readings: The order of the ventilator settings/readings should be changed in order to better reflect commonly used ventilator settings/readings.	Priority: 2
FD#3	O2 Delivery Tube Size Screen: The Back button should return directly to the Treatment Screen.	Priority: 2
FD#4	Allergies: NKDA should be the first option provided.	Priority: 1
FD#5	Intake and Output: In addition to screens recording Intake and Output then the following screens should be added to the Intake/Output recording sequence: <ul style="list-style-type: none"> • O2 Settings • O2 Readings 	Priority: 2
FD#6	Intake and Output: Flow buttons should be provided within individual output device screens to flow to the next output device.	Priority: 2
FD#7	ABG: ABG limits need to be updated	Priority: 1
FD#8	ABG:	Priority: 2

	The order of the ABG values should be changed to better reflect commonly used ABG readings.	
FD#9	ABG: Allow the entry of multiple ABG values in the Post-flight Screen.	Priority: 2
FD#10	Glucose: The Glucose units should be changed to be mg/dl instead of mmol/l.	Priority: 1
FD#11	General Notes: The size of the general note entry field should be increased to 500 characters from the current 250 character limit	Priority: 2
FD#12	Equipment: Adding equipment events should be modified as follows: <ul style="list-style-type: none"> • Press adds an Equipment Event • Press & hold opens the Equipment Event Editor (Currently pressing the equipment option opens the Equipment Event Editor)	Priority: 2
FD#13	Injury Map: It was noted that having only one Other Injury Option is too restrictive.	Priority: 2
FD#14	Access to Notes on Maps: It was recommended that all body maps should have a Notes button on the body map screen.	Priority: 2
FD#15	Dressing Map: It was noted that having only one Other Dressing Option is too restrictive	Priority: 2
FD#16	Chest Tube Other Size: The default values should be updated to provide the following options: 16, 18, 22, 24, 32, and 36	Priority: 2
FD#17	Pain Level Assessment: Pain level scores between 0 and 10 should be supported	Priority: 2
FD#18	Pupil Size Assessment: The pupil size recorded should be a single value rather than a	Priority: 2

	range	
FD#19	Pulses Assessment: A button should be added that sets all the pulses to Normal	Priority: 2
FD#20	Rhythm Assessment: NSR should be the first option provided.	Priority: 2
FD#21	AE & CCAT Screens: The editor should default to the symbol editor.	Priority: 2
FD#22	Tubes/Lines: Tubes/Lines management should indicate that Tubes/Lines are 'Removed' rather than 'disconnected'.	Priority: 1
FD#23	Documentation of Drainage: It was noted that there was not a clear way to record the drainage details associated with dressings.	Priority: 3
FD#24	Drain Character/Colour: It was mentioned that the character/colour options provided should be different for the different drains.	Priority: 2
FD#25	Intake Category Options: It was suggested that the intake category options should be modified. Comment from AFMESA Operational Assessment: "Ensure vernacular discrepancies are corrected (i.e., fresh frozen plasma, FFP, instead of serum; md/dcl, red blood cells, RBCs, instead of blood products, etc.)"	Priority: 2
FD#26	Pain Assessment: It was noted that two separate Pain Assessment Screens are currently used to record Pain Character and Pain Level separately however character and level values are directly associated.	Priority: 3
FD#27	Pain Assessment: Move the Pain Assessment to allow pain to be more easily recorded during Intake & Output.	Priority: 2
FD#28	Chest Tube: Add "IS" to document inside tube.	Priority: 3

Observations noted during the demonstration activity at WPAFB

Item#	Item	USAF Review Classification
WPAFB#1	<p>Chest Tube: Regarding Chest Tube placement on the body map, there should be both anterior and axillary views with options for upper, middle, and lower locations</p>	Priority: 3
WPAFB#2	<p>Chest Tube: Suction should list options for 20cm, 30cm and Other</p>	Priority: 2
WPAFB#3	<p>Chest Tube: Remove Chest Tube drainage character option</p>	
WPAFB#4	<p>Intake and Output: Can I&Os be recorded automatically after the first setting unless the rate is changed?</p> <p>Comment: Pumps are set up differently and the Maximum Setting typically shows the amount of fluid in the bag, not the amount that was given.</p>	Priority: 3
WPAFB#5	<p>Jackson Pratt Tube: Suction Gravity should be removed and replaced with Bulb Suction</p>	Priority: 1
WPAFB#6	<p>General: Alternatives to touching the BACK key should be explored to go from one screen to another, such as NEXT on Navigation Screen or change BACK to BACK/SEND</p>	Priority: 3
WPAFB#7	<p>Intake and Output: Regarding I&Os, when entering mls per hour, the form should auto populate with mls per hour and then a total shown.</p>	Priority: 3

LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

AF	United States Air Force
AF Form 3899L	Patient Movement Record Enroute Critical Care Form
AFMESA	Air Force Medical Evaluation Support Activity
AHLTA-T	Armed Forces Health Longitudinal Technology Application - Theater
AMC	Air Mobility Command
AMC/SGR	Air Mobility Command Surgeon's Medical Modernization Division
CCATT	Critical Care Air Transport Team
COTS	Commercial off the shelf product
ECG	Electrocardiogram
EMR	Electronic Medical Record
FAST	Focused Assessment with Sonography in Trauma
IVF	Intravenous Fluids
OA	Operational Assessment
MTF	Military Treatment Facility
RDT	Remote Diagnostics Technologies, Limited
SROc	RDT's Summary Record of Care feature that allows users to record interventions, patient status observations together administered medications.
TCCC Card	Tactical Combat Casualty Care Card
WPAFB	Wright-Patterson Air Force Base