Supporting Observers in the Field to Perform Model Based Data Collection

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ABSTRACT

Computerized support systems enhancing taskforce performance are being increasingly used in different organizations in the emergency response, crisis management and military fields. Organizational demands for improved mission capabilities and reduced budgets impose new requirements on data content and system performance. More information needs to be provided by humans in the field, reporting observations from the evolving course of events in order to enhance possibilities for operational analyses and continuous development of organizational abilities. In this paper, we describe a method that can improve human data-collection abilities and data quality when using human observers as data collecting sensors in distributed tactical operations by applying model-based data collection. We introduce a tool that can support observers in the field, the network-based observer tool that can support human observers in determining what to report and how to report observations. We present results and findings from three different use cases.

Keywords

Model based data collection, MBDC, observers, observer tool, NBOT.

INTRODUCTION

Progress in information technology has increased the use of computer systems to support taskforce operations in the field. Depending on the purpose of a specific system the appearance and performance can vary extensively. For example systems can support command and control (C2) in ongoing operations or the purpose can be to support training (Seidenman, 1998; Williams, 2008) or other types of capability improving features like experimentation and field trials (Jenvald & Morin, 1997; Morin, Jenvald & Thorstensson, 2003; Thorstensson, Albinsson, Johansson & Andersson, 2006). Regardless of purpose, all systems handle data from the field to a certain extent and diverse data collection devices (sensors) are used to acquire information on objects, processes and courses of events. Certain information is preferably collected by automated tools, for example units' positions over time using receivers for a global positioning system (GPS), and automatic recording of communications on a radio network (Axelsson, 1997). Some information can be provided by humans observing the operation (Thorstensson, 1997; van Berlo, Hiemstra, & Hoekstra 2003). In some systems, humans collect data to support experimentation or training (van Berlo & Schraagen, 2000; Jenvald & Morin, 1997; Andersson, Pilemalm & Hallberg, 2008), however, we believe human data collection can be improved to provide a much more substantial and usable data set if observers are supported adequately.

Humans in the field, regardless if they are specifically dedicated observers of an exercise or if they are operators in a live operation, have qualities that make them useful to collect specific data where human judgment or the capability to handle flexible situations make them unique as high capability data sensors. Using humans as sensors is not a new phenomenon. In all times commanders have received reports from subordinated units and analysts to build situational awareness in operations; reporters have informed the public on what is happening (Atkinson, 2004; Wright, 2005), and trainers and instructors have observed training sessions and provided feed back and critique to trainees in after-action reviews (AAR) (Rankin, et. al 1995; Morrison & Meliza, 1999). However, these reports from the field have comprised communications between humans. When we now take advantage of improved information technology using computerized systems to support handling the increasing amount of information from operations, we have the problem of having humans communicating with computers. Human language is not always well understood by computers and therefore improved methods and tools are needed to bridge the gap between human and machine to ensure information quality in computerized support systems. There has been a boost of possibilities for observer tools when the market of smartphones exploded in the past few years, which point out the need for a thorough literature review to support developing a new generation of methods and tools.

In this paper, we apply the method of model-based data collection (MBDC) (Thorstensson, 2008) and introduce a computer tool, the network-based observer tool (NBOT), designed to support human registration of observations from the field and supports observers to perform MBDC. The method is a derivative of our work on reconstruction and exploration (R&E) (Morin, 2002) for computer-supported taskforce training (Jenvald, 1999), but with the adaptation to also work as a standalone method when using observers for data collection. We also describe our findings from initial testing in three different use cases.

METHODS TO SUPPORT MBDC

Having observers to collect data from distributed work sessions, for example from distributed tactical operations (DTO) (Morin, 2002), implies certain complications. The two key problems are to support the observers in (1) what to observe and (2) how to report observations. Another factor to be considered is where the observations will be made: some environments require certain equipment, training or skills, which is an issue that will not be addressed in this paper. The relations between identified problems and recommended solutions using observers as sensors are depicted in Figure 1.

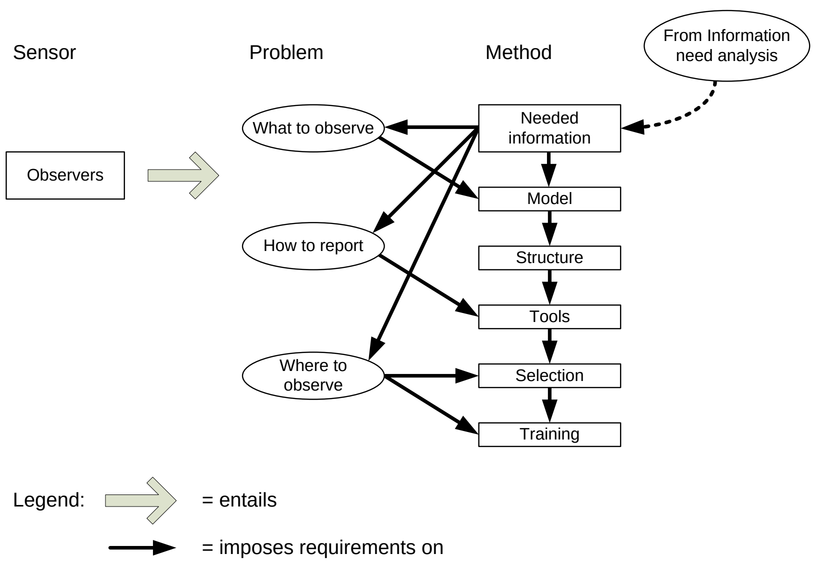

Figure 1: The problem of using observers for data collection (as sensors) relates primarily to the issues of what to observe and how to report, and also secondarily to the issue of where to observe.

Applying MBDC as a means for implementing adequate observation protocols and observer tools can enhance observer performance and data quality considerably. Here we briefly describe the steps in the MBDC method.

- Definition of goals for observer data collection. The overall purpose of the exercise (or operation) forms the basis for designing the data collection process. Preliminary decisions are made on what data to collect with automated tools, and what data to collect using observers. From these decisions, a goal for the observer data collection is formulated.
- Modeling the phenomena of interest. The real life subjects or processes, which the observers are collecting data from, are abstracted to models with desired granularity and all parameters of interest are identified and described. These models will guide the observer in what to observe.
- Model implementation. In this step a data collection plan for the overall information gathering is constructed (Morin, 2002). Preparing for the use of observers necessitates converting the models to observer protocols in the form of structured reports (Thorstensson, 1997). The structure of the corresponding observer protocols will guide and support the observer collecting the data for the parameters

to be measured. An explicit model with a corresponding structured observation protocol will guide the observer in how to report and also provide a structure for the resulting data and limit the amount of free text in the data collected.

- System definition of observer tools. Several factors must be considered when deciding on what tools to provide to the observer. The method of model based data collection is general and we have tested different tool sets ranging from paper, pencil, and clock, to handheld computers with automatic time stamping and positioning, with the ability to attach digital photographs and voice comments and communicate reports to a database in real time. Observer workspace and environmental aspects, as well as time requirements and budget aspects, must be addressed.
- Definition of post mission data compilation. Depending on the choices in the system definition of observer tools, there can be a need for data post-processing tools. If for example, the observers have paper protocols and a standalone digital camera there will be a need for transferring data to a computer and connecting the photographs to corresponding report items.
- Observer training. Communication of purpose, goals, models and tools is fundamental for observer interpretation of the overall task and may significantly affect the outcome of the data collection (Jenvald, Crissey, Morin, & Thorstensson, 2002). Training is an issue that can hardly be overemphasized when using observers for data collection and is a definite key to success.

Following these process steps when using observers to collect data will enhance gathering quality data.

NETWORK-BASED OBSERVER TOOL - NBOT

We have developed a prototype tool for supporting observers in collecting data from training session field trials and other settings where observers work with registering data from the field. The tool developed is named Network-based Observer Tool (NBOT) and it has been tested in different settings: from indoor concept development and experimentation (CD&E) exercises on future Swedish Armed Forces (SwAF) C2 systems (Thorstensson et. al, 2006); by collecting data from outdoor training exercises for military units; to supporting environmental and health inspectors in collecting data from hazardous risk installations in international missions in Kosovo and Sudan. The tool is a research prototype not yet intended as an open source program or a commercial product. Our ambition is to make later improved versions available as open source shareware.

NBOT implements a general tool that supports observers in understanding *what* to observe; *how* to document observations in a structured and uniform way; how to handle complex observation protocols with multiple parameters; and also in communicating observations to specific receivers if desired. NBOT incorporates observation models and structured reports in a computer tool that provides the opportunity to add functionality for automated time stamping and positioning of observations; and inclusion of voice annotations, digital pictures and other files. NBOT can be used as a standalone tool logging all data in the local devise for later handling, but the design is intended to be used in a communication network using available options for transferring data, for example local area networks (LAN), wireless LAN (WLAN), mobile telephone networks (GSM or 3G). Data from multiple observers can be transferred to a common database to which multiple analysis tools also can be connected.

Originally, the NBOT design was intended for supporting multiple observers with different tasks within the same scenario, for example collecting data from different command posts or different sites in a staff exercise environment. Positioning was connected to organizational or logical functions in the chain of command and not to geographical positions. All observation events were sent to an analysis centre in real time using the WLAN in the CD&E environment. In the analysis centre, there was a need to be able to filter reports depending on the current focus of attention, to enable a certain amount of exercise control. This NBOT system setup was tested in a series of exercises in the SwAF Joint Concept Development and Experimentation Center (JCDEC) with satisfying results using a variety of desktop, tablet, laptop, and handheld computers. The functionality of MBDC of events, implementing structured reports with the possibility to attach files, voice comments, and photographs proved powerful in the command-post exercise setting. Generalizing the tool enabling observation support in field exercises comprised the addition of GPS-positioning functionality and adaptation to handheld computers (PDA) with integrated communication capabilities using WLAN, GSM and 3G. This version of NBOT was tested in military field exercises together with the SwAF National CBRN Defence Centre (SkyddC) using PDA with integrated digital cameras, voice recording, and communication capabilities. This system design proved useful and was further tested by another team from SkyddC on a Kosovo Force (KFOR) mission in Kosovo in spring 2007, and for one month in 2007 by environmental and health personnel from the Swedish Defence Research Agency's (FOI) Division of CBRN Defence and Security on a United Nations (UN) mission in southern Sudan.

NBOT System overview

NBOT consists of three parts: an observer tool, an analysis toolset, and a web server for data storage (Figure 2). The observer tool implements observation protocols, which are based on observation models of structured reports. An XML-file stored in the device defines these models. Each report entry generates a separate XML-file to which different attachments can be made. The attachment possibilities depend on the platform used. Recorded sounds, digital photographs and files are standard formats supported by most platforms, but if a tablet PC with sketch functionality is used, a sketch can also be attached.

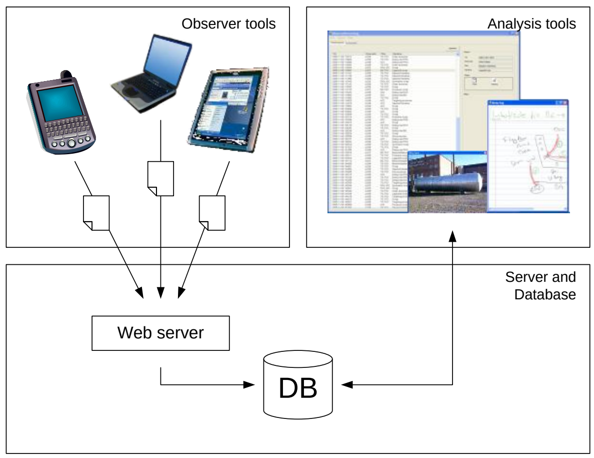

Figure 2: The three parts in the NBOT system: the observer tools, the analysis tools and the NBOT server for data storage

The analysis tools in the NBOT system have been kept fairly simple up to this stage, since the overall purpose is not for NBOT to be a standalone system, but be integrated as one means of data collection in other systems. For example, reports can be imported into R&E systems MIND (Jenvald et. al, 1996; Morin, Jenvald & Thorstensson, 2000; Morin, 2002) or F-REX (Andersson, Pilemalm & Hallberg, 2008) to serve as data in the R&E process. MIND and F-REX comprise integrated tools for time synchronized replay of text reports, map objects, sounds and pictures as well as timeline tools for navigation and analysis support (Albinsson & Morin, 2002; Albinsson, Morin & Thorstensson, 2004; Morin & Albinsson, 2005).

NBOT observer tool

The NBOT observer tool runs under the MS Windows operating systems 2000, XP or Windows Mobile. Depending on what task the observer will perform the tool can be installed on different types of computers. For example on a desktop computer or tablet PC for use in a command post to collect data on C2 processes, or on a handheld device to collect data from the air defense process in a command and control central on a naval ship. It is the available workspace for the observer, dynamism of observer work and the need for different attachments and communication possibilities that sets requirements on type of platform.

The NBOT observer tool implements the idea of MBDC with origin in structured reporting. The observer is guided through each observation, choosing observation objects in a hierarchical tree structure to avoid free text writing. Choices are made by clicking a report item on the screen and then getting to a new level of alternatives, and in that way getting deeper down in the report structure. When coming to a leaf in the tree, it is possible for the observer to attach files, digital photographs or sketches and to record voice comments as sound files. The attachment features are dependent on the platform performance in each specific aspect. In the report leaf there is also a possibility for the report designer to include forms for extra data collection opportunities, and to support the observer to add extra data from checkboxes, forms and lists.

Using the device's internal clock makes it possible to automatically add a timestamp to each report, which relieves the pressure on the observer in making exact time annotations on each report item. In the same way, it is possible to connect a positioning device, like a GPS receiver, to the observer tool, enabling automatic positioning on all report items should that be desired.

All reports registered are transferred to the NBOT database. Depending on the requirements on the data collection this transfer can be done in real time using the network communication capability, or it can be scheduled to certain time frames during a mission. Data can also be transferred after observation is completed after the exercise, mission or operation. To enable access of reports by the analysis tools, reports must be stored in the database.

NBOT analysis tools

Included in the NBOT system are two different prototype tools: one list tool and one map tool. Multiple instances of analysis tools can be connected to the same database.

In the list tool (Figure 3), all reports are listed in temporal order, but can be filtered and sorted on any of the present attributes, for example Observer ID; object for observation; or classification of reports. Using multiple list tools simultaneously with different active filters, makes it possible to create an overview of observation results from a number of locations. In the list tool, all attributes in the reports are stated and attachments can be inspected.

The map tool (Figure 3) is used to visualize the geographical locations of documented reports. The map tool uses the report time stamp to visualize information on when the specific report item was collected. Report details are displayed for the user when activating a specific report with the mouse pointer, which also enables inspection of report attachments. Hence, the map tool enables a spatial and temporal overview of collected reports.

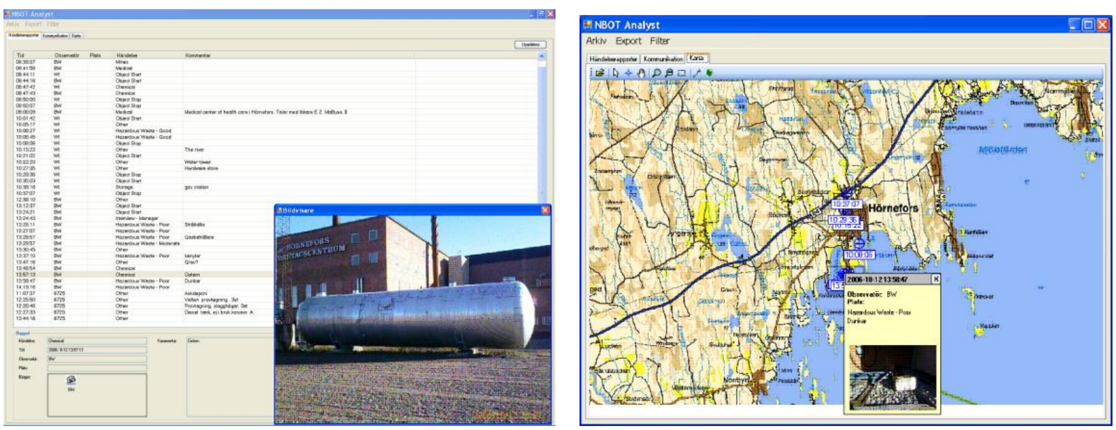

Figure 3: The NBOT list tool (left) displaying observer reports in a list structure, with possibility to inspect attachments. The NBOT map tool (right) displaying observer reports in a map.

Setting up the NBOT system

Setting up the NBOT system starts from the decision of what data to collect with observers, in relation to the overall questions for the exercise or mission, and how this data will be used. When defining the data collection plan, specific data are connected to specific data sources where observers are one source with their specific capabilities. When the purpose of using observers has been defined, the design of the NBOT system and the modeling of the observation objects can be done. The models defined are then implemented into structured report formats that can be imported by an appropriate device to support the observer's tasks. The structured report formats are built up from XML-files that are designed using a report editor tool. In the report editor tool, a hierarchical tree structure of linked lists, with the possibility to add leaf specific report attributes, is constructed. The resulting XML-file defining the report structure of the observation model is then exported to the devices that the observers will use. Choice of computer platform for the observer and configuration of tools are performed according to the operational requirements of the observer performance.

In addition to defining the reporting tools, the overall structure of how to communicate data must also be established. Requirements on data transmission will depend on the intended use of data from the observers:

- *Exercise control*. If data from the observers is needed to execute control of the exercise, real-time data transmission is necessary.
- *After-action review*. If data from the observers is to be used for supporting replay of a mission history at a subsequent AAR the timeframe available between exercise completion and the AAR will affect the decision of data transmission. If only a short timeframe is available and data must be treated before the exercise is ended, a near real-time solution might be necessary. If there is more time available to prepare for the AAR an off-line solution with physical transfer of data might be another alternative.
- *Post-mission analyses (PMA)*. If data from the observers is to be used for post-mission analyses without limiting time constraints, then other factors in data transmission might be of consideration.

Data security is of main concern in certain settings, for example in experimentation with new methods and tools for C2 at the SwAF JCDEC. In other settings, security is of less importance. However, the aspect of security must be addressed in the data collection design process:

- *High security requirements*. If data must be well protected and time is a critical issue, there are different solutions. Data can be handled in a separate secure LAN, as is the case in many exercise or experimental facilities. Encryption might be one possibility to meet requirements on short time when open networks must be used. If there is no requirement on time, an off-line solution using couriers to transport data can be used, but encryption and off-line data communication might be an alternative solution as well.
- *Low security requirements*. If there is no need to protect data, any open network can be used to communicate data, on-line or off-line depending on time constraints. Data can also be transferred using ordinary mail or delivery services.

NBOT use cases

To this end, we have tested NBOT in three different settings: CD&E exercises on future SwAF C2 systems; field exercises on reporting CBRN hazards; and in an international mission supporting environmental and health inspectors collecting data on hazardous installations and waste dumps.

C2 experimental exercises

In the CD&E exercises in the SwAF JCDEC, NBOT was used in a network setting with multiple observers following different command posts, and one central analysis centre (AC). Observers in the exercise were 7 officers from SwAF. They participated in the experimental exercise as domain experts and were required to use NBOT in 3 hour sections of the exercise at 4 different occasions with the purpose of testing the tool (Figure 4). The only equipment available for use was field rugged tablet PCs connected to the network server using standardized cable LAN. No cameras were available and there was a need to not disturb the command posts under observation by for example recording voice comments. Several observers were very keen on adding much additional information as comments in text writing included in several reports for motivating their different choices, which we had not anticipated, which led to adding of an external keyboard. After a brief training session, the observers were sent to work in their respective command post. All reports were sent to the database in real time as soon as they were completed. In the AC, a set of list tools were used to create an overview of the processes in all command posts. After each exercise, all NBOT observer collected data was imported to the MIND system mission history and used to support AAR and PMA.

Post-exercise evaluation of NBOT was performed as group discussions with all participants and individual interviews with 4 of the officers, and revealed that the observers were very content with having a computer tool guiding them in what to observe. The support for time stamping was appreciated and the ability to attach files was considered very good since this made it possible to include plans or screen dumps which was extensively used, and most observers used the attach file function to include plans generated by the staff. The choice of platform using field rugged tablet PCs was less satisfactory because of the observers' choice to include certain amounts of textual comment to a large number of reports. An ordinary laptop had been a better alternative but we did not have access to that type of computer in this setting, and a laptop with a touch screen would have been the platform of choice. From an analytical standpoint the use of free text makes data compilation and analyses more difficult and should be kept to a minimum. However, several observers felt a need to explain and motivate their choices of classification in most reports. This is not the intention in MBDC and more research is needed to address this problem. However, analysts working with the collected data appreciated the initial classifications made by the observers, and also having the narrative motivations for deeper understanding. The initial observer classification is a good step in reducing time in the PMA processes, as well as in the exercise control execution.

Figure 4: Observers using NBOT during a command post staffs exercise in the SwAF JCDEC.

CBRN hazards field exercises

NBOT was adapted to support data collection on CBRN hazards in the field together with the SwAF SkyddC. Modifications were made to run NBOT in a handheld device with integrated GPS receiver, digital camera, sound recording facilities, and communication capabilities using GSM and WLAN. The NBOT system setup process, with definition of data collection goal, modeling of data collection objects, and requirements for data usage, was done in collaboration with domain experts from SkyddC and the FOI Division of CBRN Defence and Security. A version of NBOT was then implemented to a small PDA device for use in the field. In this case we used a Qtek S200. In this case the communication capability of NBOT was omitted and the tool was used as a stand alone data collection device, where data compilation to a database was performed after the exercise. A short introduction to the overall goal of the data collection and the data collection models implemented was given to the 4 different patrols with 4 conscript soldiers in each who would use the device in the full day exercise. The time given for NBOT training before this exercise was not within our control and was limited to 15 minutes.

A post-exercise review of NBOT, performed as a group discussion with all 16 soldiers, revealed that voice recording was a much appreciated feature in the scope of the international scenario, where interviews with local actors were a major source of information (Figure 5). These interviews were recorded in the device as attachments to the corresponding observation reports. Making reports of hazards in the field, with data from a classification scheme and automatic integration of a time stamp and a geographic position, was straightforward. The option of attaching a photograph and a short voice comment was also found very useful. The problems reported concerned two major issues: making correct choices in the classification scheme, and the handling features of the PDA device. Definition of appropriate classification schemes is a general problem and this must be thoroughly emphasized in the modeling process. Training of the observers is also important to overcome this insecurity when applying MBDC. The handling features of the PDA which was used are not optimized for outdoor military use, but for initial field trials this was chosen as a cost effective commercial-of-the-shelf product. However, much of the handling problems could have been addressed with more training.

The NBOT version tested in this exercise was later used by SkyddC personnel on an international mission in Kosovo, for collecting data on health and environmental risks on real objects in the mission area. Having access, post- mission, to positioned and time stamped data on each recorded object was found very useful. This is strived for in all activities, but support from automatic, accurate positioning and time stamping was appreciated. Data from this mission is owned by KFOR and can therefore not be published here.

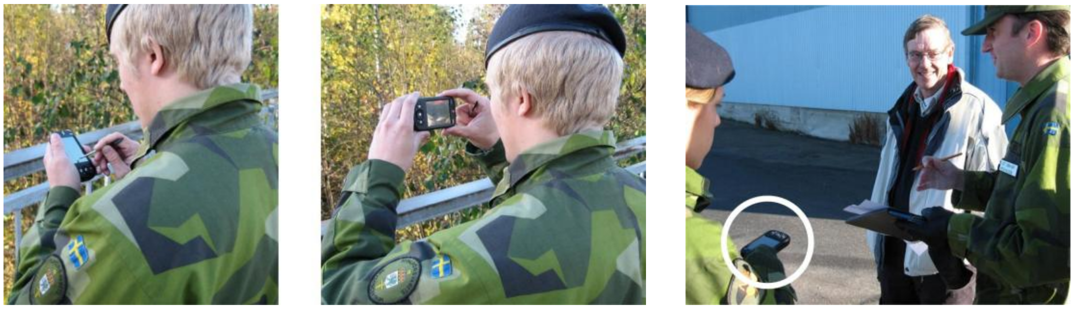

Figure 5: A soldier from SkyddC using NBOT to make observations (left) and adding a photograph as attachment (middle), and records the commander's interview with a chemical factory manager in a CBRN exercise (right).

Environmental and health inspectors in Sudan

The NBOT system version developed for SwAF SkyddC was also used by a team of environmental and health inspectors from the FOI Division of CBRN Defence and Security on a month long United Nations (UN) mission to the southern parts of Sudan. The system setup was identical to the SkyddC setup described above and the tool was used as a standalone tool supporting each observer in collecting data from objects in the field. Post mission review of the NBOT use was performed as a group discussion with the 4 team members and reveled that the possibility to quickly generate reports on hazards identified, with integrated geographical position, time stamp, digital photographs, and voice comment was considered of substantial value. However, the small format of the PDA induced problems to follow the observation protocols. Data from the observer tool was transferred to a database after returning home from the mission and was then transferred to be used in a UN geographical information system. Some problems occurred when data was documented in different formats and conversion became necessary. Implementation of a transformation tool solved the problem in this specific situation, but the necessity to always be aware of data formats was stressed.

DISCUSSION

The presented implementation of MBDC and NBOT to support using human observers for collecting data from DTO is derived from our general method for R&E which has been tested and improved through a number of field trials and indicate great possibilities to improve data collection results from using observers. Combining the method with adequate tools gives a strong support for achieving good results from observer data collection. Initial tests and field use of NBOT indicates a great potential for applying MBDC in computer tools to support observers documenting events and phenomena in DTO, both in taskforce training scenarios as well as in live operations. From the observers' data-collection stand point, support from time stamping and geographical positioning of reports, as well as being able to add voice comments and digital photographs directly to a report item, is valuable. However, choosing adequate platforms for each specific observer should be more carefully emphasized in the system setup process. Definition of models for the data collection subjects must be addressed early in the process, and needs to be refined to take into account initial observer experiences. Using multiple NBOT equipped observers in a distributed command-post experiment exercise setting improved the quantity as well as the quality of data collected. Exercise control can also be enhanced by using a set of NBOT list tools to increase the AC's situational awareness of the course of events in the exercise as they evolve.

NBOT serves well as a standalone tool supporting observers in data collection in live operations. There is a need for more research and development in how to handle data through the process of definition of observation items all the way to organizational distribution and use of data. Documenting observations is rarely done solely for individual purposes, even if that can be the case in specific scenarios, but is more likely part of a systems approach to collect data with multiple sources, where observers are one specific data source with specific capabilities. Our preliminary testing of NBOT helps us define requirements for the next generation of observer tools. We argue that the MBDC and NBOT approach has a great potential, but there are specific requirements that must be fulfilled to support observers in collecting data meeting the overarching purpose of the exercise or mission:

- The modeling phase needs to be addressed thoroughly. Correlation between models defined, the data collection plan and the exercise goal must be made explicit.
- The system setup must meet the needs of communication and security issues in data transfers.
- Choosing the observer information handling tool (i.e. computer platform) must take into account the operational environment of the observer: work space; climate; endurance; and human-machine interaction.
- Observer training must be emphasized and needs to be twofold:
  - Mission purpose and data-collection goals must be made clear and understood.
  - Handling of the different tools and devices that make up the NBOT tool must also be learned.
- Post-processing tools may be required. If so, they must be specified and developed.

These are some loosely formulated requirements that must be addressed in a research and development (R&D) process for the next generation of observer tools. The NBOT system was originally designed as a prototype for addressing the problem of having multiple observers providing data in DTO in the scenario of CD&E exercises for future C2 systems. Our intention is to use NBOT in the coming R&D process on observer's MBDC from exercises or live operations and to keep developing NBOT through applied field tests with subsequent analysis and evaluations.

From a research perspective there are still interesting issues to address in using observers for MBDC. Modeling phenomena in reality to serve as a basis for implementing structured reports in an observer tool is still difficult, and this process may be improved by having an interdisciplinary team of researchers from computer engineering and algorithms as well as from human factors and human-machine interface areas. Communicating the models defined and corresponding observation protocols in relation to the overarching goals of data collection in the exercise or mission to the people acting as observers is one more important question to address. Making observers skilled and qualified is not achieved simply by giving them an advanced computer tool. Our findings indicate that training of observers is a critical parameter for success in collecting sufficient and high quality data. We believe that specific quantitative studies would be of much interest in further investigation of MBDC approach and observer training parameters.

CONCLUSIONS

Supporting the use of observers in DTO with adequate methods and tools can enhance quality and amount of collected data to support CD&E or training exercises as well as live operations. The presented methodology together with adapted observer tools can improve outcome of human data collection in different settings. Implementing MBDC in an appropriate computer device can be a powerful support in the field helping observers to identify what to observe and how to report it. We have implemented NBOT and tested it in three use cases with initial results indicating that the main benefits of the tool, compared to traditional observer reports, are: getting support with time stamping of observations; positioning of reports; and the possibility to structure observations to get support in *what* to observe and *how* to document it. The functionality to include photographs, voice recordings and sketches were of great value for certain types of reports. Our initial findings are not sufficient to validate the tool but serve as indicators of valuable follow-up studies, both qualitative and quantitative, to analyze if number of reports and report quality is really is enhanced. We have had great value of NBOT as a research platform and plan to proceed with field trials in different settings.

REFERENCES

1. Albinsson, P.-A. & Morin, M. (2002). Visual exploration of communication in command and control. In *Proceedings of the 6th International Conference on Information Visualization* (IV 02), July 10–12, London, UK.
2. Albinsson, P.-A., Morin, M. & Thorstensson, M. (2004). Managing metadata in collaborative command and control analysis. In *Proceedings of The 48th Annual Meeting of the Human Factors and Ergonomics Society*, September 20–24, New Orleans, Louisiana, USA.

3. Andersson, D., Pilemalm, S. & Hallberg, N. (2008). Evaluation of crisis management operations using Reconstruction and Exploration. In *Proceedings of the 5th International ISCRAM Conference*, May 4–7, Washington, DC, USA.
4. Atkinson, R. (2004). *In the Company of Soldiers: A Chronicle of Combat in Iraq*. Washington, DC: Henry Holt and Company.
5. Axelsson, M. (1997). *Computer-aided Time-stamped Sound Recoding* (in Swedish). M. Sc. Thesis LiTH-IDA-Ex-97/72, Linköping, Sweden: Linköpings universitet.
6. Jenvald, J. (1999). *Methods and Tools in Computer-Supported Taskforce Training*. Linköping Studies in Science and Technology, Dissertation No. 598, Linköping, Sweden: Linköpings universitet.
7. Jenvald, J., Crissey, M. J., Morin, M. & Thorstensson, M. (2002). Training Novice Observers to Monitor Simulation Exercises. In *Proceedings of the 13th International Training and Education Conference*, ITEC 2002, pp. 68–78, April 9–11, Lille, France.
8. Jenvald, J. & Morin, M. (1997). Multiple Use of Information from Force-on-Force Battle Training. In *Proceedings of The 8th International Training and Education Conference*, ITEC'97, pp. 637–647, April 22–27, Lausanne, Switzerland.
9. Morin, M. (2002). *Multimedia Representation of Distributed Tactical Operations*. Linköping Studies in Science and Technology, Dissertation No. 771, Linköping, Sweden: Linköpings universitet.
10. Morin, M. & Albinsson, P.-A. (2005). Exploration and context in communication analysis. In C. Bowers, E. Salas & F. Jentsch (eds.), *Creating High-Tech Teams: Practical Guidance on Work Performance and Technology*, pp. 89–112, Washington DC: APA Press.
11. Morin, M., Jenvald, J. & Thorstensson, M. (2003). *Methods for developing future defence forces*. User report FOI-R--1064--SE. Swedish Defence Research Agency, Linköping, Sweden.
12. Morrison, J. E. & Meliza, L. L. (1999). *Foundation of the after action review process*. Special report 42, Alexandria: United States Army Research Institute for the Behavioral and Social Sciences.
13. Rankin, W. J., Gentner, F. C. & Crissey, M. J. (1995). After action review and debriefing methods: Technique and technology. In *Proceedings of the 17th Interservice / Industry Training Systems and Education Conference*, pp. 252–261, Albuquerque, New Mexico, USA.
14. Seidenman, P. (1998). New realism for brigade-level training. *Jane's International Defense Review*, 31(10), 34–35.
15. Thorstensson, M. (1997). *Structured reports for manual observations in team training*. M. Sc. Thesis LiTH-IDA-Ex-97/64, Linköping, Sweden: Linköpings universitet.
16. Thorstensson, M. (2008) *Using Observers for Model Based Data Collection in Distributed Tactical Operations*, Linköping Studies in Science and Technology, Thesis No. 1386, Linköping, Sweden: Linköpings universitet.
17. Thorstensson, M., Albinsson, P.-A., Johansson, M. & Andersson, D. (2006). *MARULK 2006—Methods for developing functions, units and systems* (in Swedish). User Report FOI-R--2188--SE. Swedish Defence Research Agency, Linköping, Sweden.
18. van Berlo, M. P. W., Hiemstra, A. M. F. & Hoekstra, W. (2003). Supporting Observers During Distributed Team Training—The Development of a Mobile Evaluation System. In *Proceedings of the NATO Symposium on Advanced Technologies for Military Training*. October 13–15, Genoa, Italy.
19. Van Berlo, M. P. W. & Schraagen, J. M. C. (2000). A generic assessment tool for evaluating C2 exercises. In *Proceedings of the 22th Interservice/Industry Training Systems and Education Conference* (I/ITSEC), pp. 652–660, November 28–30, Orlando, Florida, USA.
20. Williams, H. (2008). A tale of many cities: demands of urban warfare fuel CQB skills. *Jane's International Defence Review*, 41(10), 51–53.
21. Wright, E. (2005). *Generation Kill*. New York: Berkley Publishing Group.