A Joint Organizational and Technical Development of a Telematic Rescue Assistance System for German Emergency Medical Services

Marie-Thérèse Schneiders, Daniel Schilberg, Sabina Jeschke
Institute of Information Management in Mechanical Engineering (IMA)
RWTH Aachen University
Aachen, Germany

Email: {schneiders, schilberg, jeschke.office}@zlw-ima.rwth-aachen.de

Abstract— **The German research project Med-on-@ix aims at optimizing the efficiency and quality of preclinical emergency health care by introducing a Telematic Rescue Assistance Systems into the Emergency Medical Services. Paramedics and emergency physicians will be supported on site by a specialized physician in a remote Competence Centre. During the last three years, an interdisciplinary project team of emergency physicians, university scientists and developers supported by industrial enterprises developed a telematic system supporting the emergency care. The Telematic Rescue Assistance Systems provides the real time transmission of voice communication, vital parameters, pictures and videos from any emergency site using mobile radio networks. Both the technical development of the Telematic Rescue Assistance System and the organizational implementation into the regular operations of the Emergency Medical Services constitute the central pillars of the research project. Beside the technical requirements, the user centered requirement management applied within Med-on-@ix identified the necessary organizational changes to realize the introduction of the telematic system into Emergency Medical Services. This paper traces the joint organizational and technical development of the Telematic Rescue Assistance Systems based on a consistent user involvement into the development process. Simulation studies have been used to identify the main challenges regarding the implementation process. Exploring the impact of the system on the working process, organizational changes have been worked out, aiming at the design of a successful implementation process.**

Keywords - Telematic Rescue Assistance System; German Emergency Medical Services; telemedicine; joint organizational and technical approach; implementation process.

I. INTRODUCTION

German Emergency Medical Services (EMS) professionals are supported in 50% of all missions by a qualified emergency physician to guarantee the highest quality of care on emergency sites. These days, demographic development contributes amongst others to a considerable rise of missions involving EMS physicians [1]. Whereas the demand of EMS has doubled since 1990, a serious lack of physicians particularly in rural areas can be considered. The closing of various EMS physician stations lead to a delayed arrival of the physicians on scene and thereby to an augmented interval without sufficient therapy. As paramedics and EMS physicians are organized in a so-called "rendez-vous system" [2], physicians and paramedics arrive at the accident scene in different vehicles. The ambulance, staffed with paramedical professionals, reaches the patient in general within the statutory period of 12 minutes after the emergency call. Whereas mainly in rural areas the physicians gets delayed to the emergency patient, making it decisive to bridge the time period before the arrival of the emergency doctor [3].

To secure a high quality of treatment in the chain of survival [4], innovative strategies to assure an early professional aide on scene are needed. As the German EMS is one of the highest qualified in the world, efforts are made to stick to the physician-led EMS in Germany by structural measures and hereby to provide the highest medical qualification to the patient. The expensive German emergency care gets a lot of stick these days, innovative solutions are needed to preserve the fundamental philosophy of bringing physician-centered definitive care to the patient, rather than bringing the patient to the care, as paramedic based EMS systems do.

The legislators have paved the way by assimilating rescue service acts, restructuring the rescue service catchment areas and the introduction of integrated demand-oriented control stations with a consequent quality management system as well as the implementation of a medical leader for each rescue department. Besides these improvements, the technological support of EMS offers a wide scope of possibilities to reduce the "no-therapy-time" by referring to communication technology that is used as self-evident in non-professional context.

The quality of EMS work is directly related to an efficient information management. As everyday experiences of EMS personnel are characterized by adverse surrounding conditions of work, it is furthermore affected by a constant lack of information regarding the specific emergency situation, the patient's history or his

 ISBN: 978-1-61208-119-9

actual medication. The use of modern information technologies has the potential to intensify and to accelerate the information flow related to the actual mission.

So far research and development activities focus in particular the transmission of vital data from an ambulance to a hospital. The German project "Stroke Angel" [5] transmits audio and video data from the ambulance in order to diagnose and pass on stroke patients directly to the nearest stroke unit. Using telemedicine the contact-to-balloon time decreased on average from 32 min to 16 min. Various similar publications testify that teleconsultation systems are considered potentially lifesaving [6]. The necessity to increase the mobility of telemedical support systems for EMS operations is evident. Furthermore to avoid the development of isolated telemedical solutions and to foster the adoption into regular practice of EMS, integrated development and implementation approaches are needed.

Within the research project Med-on-@ix, the Telematic Rescue Assistance Systems (TRAS) offers the possibility to make medical know-how available at any time for professional helpers on scene. Medical and mission tactical data is transmitted via 3G mobile radio networks from the place of emergency or the ambulance vehicle to the remote emergency physician in the Competence Center (CompC), communicating with the staff at the place of emergency via audio connection. The CompC also helps to optimize workflows by arranging communication with the health care facilities to which patients subsequently will be sent [7]. The technical components on site are connected to a communication which connects to the ambulance vehicle via an 802.11 network or directly to Public Switched Telephone Network (PSTN) and the Internet through GSM/TETRA and GPRS/UMTS. On the CompC's side the servers are connected to the PSTN via ISDN and to the Internet. The Clients in the CompC connect to the Servers through a reliable local network or VPN [7].

The application scenario shown in Figure 1 illustrates the central position took up by the remote EMS physician in the CompC.

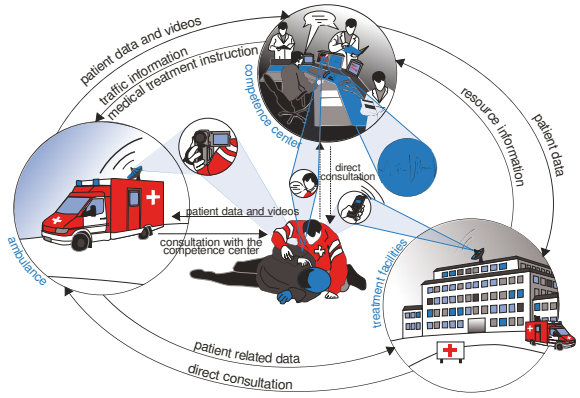

Figure 1. The Telematic Rescue Assistance System

The CompC serves as an information hub between the involved clinical and preclinical facilities. The use of the TRAS in the work of EMS is related to decisive changes in working processes. The remote emergency physician is confronted with an unknown job specification and a new working environment. The EMS team on site has to handle new medical equipment and modified team and communication processes.

By a constant participation of the University Hospital Aachen (UKA) in the requirement management process as well as the technical development and the implementation process, a one-year trial run could be realized (2009-2010). The trial run – as well as the preceding simulation studies - focused two possible scenarios involving on first level physicians and on second level paramedics on site being supported by the CompC. The elaboration of the organizational concept enabling the EMS to implement the system was designed in line with the requirement management used for the technical development.

This paper outlines the approach for a joint organizational and technical development of a TRAS referring to two simulation studies carried out within the last two years. Based on the example of the identified impact of the TRAS on communication processes on the emergency site, the change management approach is described. By the use of user group surveys, necessary changes and measures for a successful implementation into daily work of EMS were identified. Finally the described example will show the possibilities to face organizational and technical requirements regarding the operation of a TRAS.

II. JOINT ORGANIZATIONAL AND TECHNICAL DEVELOPMENT

The TRAS can be described as a sociotechnical system [7] considering the relevant interactions between social, technical and organizational aspects in line with the development and the implementation of the system.

An iterative and incremental requirement management constitutes the core of the development process within Med-on-@ix. The agile development of the TRAS [9] foresees the consequent involvement of the users at different stages of development. The applied research methods within Med-on-@ix meet this approach by considering aspects of human, organization and technology in every research question. The progressive specification of the TRAS is realized by the identification of the relevant functional and non-functional requirements within the scope of two experts workshop [7] and two simulation studies.

The development process regarding both organizational and technical requirements is consequently attuned on the involvement of the different user groups (emergency physicians, paramedics), to increase system quality, user satisfaction and at least the usage of the TRAS. Both product requirements and functional specification have been elaborated in cooperation with the medical partners from UKA.

 ISBN: 978-1-61208-119-9

User involvement is referring to the participation of a representative group of potential users especially in two relevant areas: participative decision making and planned organizational change. The involvement of the target group contributes in both areas to higher motivation of users and the success of change processes **Fehler! Verweisquelle konnte nicht gefunden werden.**.

In the Med-on-@ix project opinion surveys and interviews involving EMS professional have been used for example in line with the studies focused in this paper.

EMS teams and emergency physicians tested within different simulated rescue scenarios the telematic support system at different stages of development. Different social research methods were applied to survey 135 test persons (87 in the first study in 2008, 48 in the second study in 2009) in terms of acceptance and utilization issues [10]. The studies targeted on technical, as well as organizational and human research aspects. The test persons were trying out the main functions of the TRAS in simulated rescue scenarios, to test the handling of the technical system and to evaluate the impact on the working process. The developers gained awareness of usability aspects and susceptibilities of the system, whether the social scientists acquired knowledge about the impact of the TRAS on teamwork and communication processes.

Using replicated emergency situations as a testing environment the studies have specified and validated the implemented exigencies. The simulated test setting aimed at encouraging new behaviors dealing with the TRAS and at least to promote shared meanings about the system. Fostering the dialogue between developers and users especially in line with the requirement management has been contributing to a positive trend in terms of user acceptance of the TRAS [10]. The latter important results, described in related publications, reinforced the chosen research strategy of joint organizational and technical development combining user involvement and a holistic requirement management.

In addition, the present paper focuses the possibility using the described research approach to design a user oriented technology implementation process. The pursued change management approach based on transferring research results into change tasks will be described in the following by reference to the simulation studies.

III. EXEMPLIFIED CHANGE MANAGEMENT APPROACH IN MED-ON-@IX

The implementation of the TRAS into German EMS goes in line with the several changes regarding the working process in EMS Teams. To meet those challenges, the changing aspects have been identified at early stage in the development process in line with the incremental requirement management. The change tasks regarding in particular the organizational development of EMS have been detected for example in line with the conducted simulation studies. To illustrated the change management used in the Med-on-@ix project the concept and gained results of the simulation studies are exemplarily presented here.

Meeting the user centered research approach the studies encouraged paramedics and physicians to enter a dialog with developers and by there aimed at a system improvement through reflective practices using different methods of social sciences. Based on the results of those surveys the necessary changes were detected and transferred into change measures.

A. *Simulation studies*

Within the scope of the simulation studies carried out at the Interdisciplinary Medical Simulation Center (AIXSIM) of the UKA, one main research question referred to the impact of the TRAS on the teamwork on site. The first survey in 2008 addressed the support of an emergency physician by another highly involved physician in two standardized simulated missions (ST-elevation myocardial infarction; severe traumatic brain injury). The second simulation study tackled the support of an EMS Team (two paramedics) by the remote emergency physician in the CompC. Five different scenarios (a diving accident, a renal colic, a second-degree burn, an intoxication and a hypoglycaemia) partly performed by patient-actors playing patients partly by involving a patient simulator offered the possibility to analyze the handling with and the potential of assistance of the TRAS.

To allow a comparison of the quality of treatment with and without the application of the TRAS, control groups acting without the telematic support were drafted in. Questionnaires and group interviews were used to survey the EMS Teams after the simulated operations. The issue-focused interview guide, applied within the semi-structured interviews, enabled the scientists to focus on behavior patterns observed before. The video-documented interviews were transcribed and put to a qualitatively oriented content analysis.

B. *Results*

Taking into account the results from both simulation studies, the impact of the TRAS on team internal processes turned out to be one of the main challenges within the organizational development of the system. The involvement of the remote physician created an unusual working environment, adding to the demanding emergency situation a new communicative arrangement and the use of supplementary equipment.

The communication structure during the operation is illustrated in the following Figure 2: the standardized scenario foresees an EMS Team consisting of a physician and two paramedics respectively only two paramedics in the second study. As a new participant the remote emergency physician in the CompC is connected via mobil radio to all members of the team.

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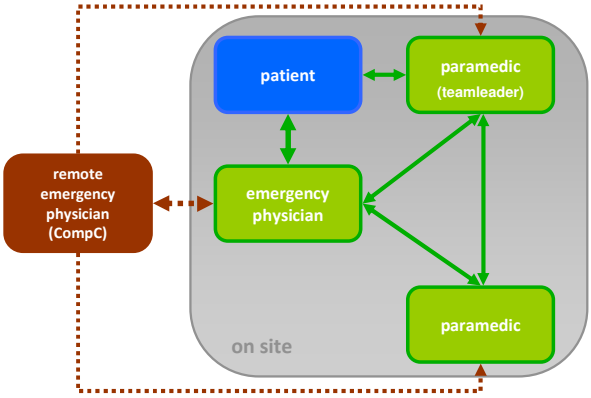

Figure 2. Mission-related Communication structure

The first simulation study immediately revealed the main changes in the working situation. The test persons experienced an altered situation having a remote team member being involved into the scene. The interviews revealed a negative impact of the TRAS on the communication with the patient. The emergency physician was struggling to concentrate on both the communication with the remote colleague and with the aggrieved patient on site. The interviewed paramedics underlined furthermore the necessity to be connected to the CompC, to be able to follow the diagnoses and treatment discussion between the physicians. 83% of the interviewees stated in 2008 a negative impact of the TRAS on the communication situation during the operation.

Based on these results communication rules were elaborated and evaluated in the 2nd simulation study (2009) to prevent miscommunication, as the loss of information can be related to a safety hazard for the treatment of the patient. These rules compromise a clear role allocation between the team members assigning a standardized information committal between the physician (alternatively the team-leading paramedic) on site and the CompC after a first anamnesis. Furthermore the test persons in the second study were instructed in thinking loud, to reduce the necessity for the remote physician to ask question. The standardization of the working process on site using the ABCDE (Airway Breathing Circulation Disability Exposure) mnemonic, usually used for the prioritization in the management of trauma patients, also follows the aim of reducing the quantity of possible follow-up inquiries by the CompC.

The application of the elaborated communication rules clearly had a positive effect on the team communication in the 2nd study. Figure 3 indicates that over 50% of the questioned test persons stated a positive or no impact of the TRAS on team communication, compared to 83% complaining about negative impact in the first study.

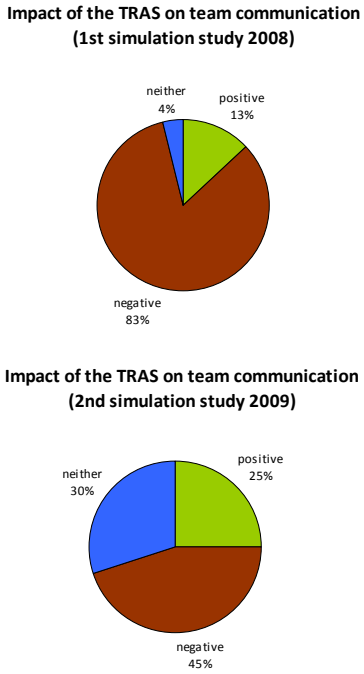

Figure 3. Comparing results from simulation studies

Besides the importance of communication rules, the simulation studies uncovered the importance of mutual confidence between all members of the EMS team, including the remote EMS physician. The interviewees pointed out the importance of working on both sides, the CompC and on site, to acquire a team spirit that fosters the efficiency of teamwork, being exposed to stressful working conditions as in EMS missions.

Regarding the results of the studies three main challenges have been identified:

- The alternate communication structure needs to be supported by the use of communication rules.
- Both sides the CompC and the team on the emergences site have to follow standardized procedures to avoid miscommunication.
- The success of the teamwork is mainly related to a sense of belonging between all involved team members.

To meet these requirements organizational changes have been designed and implemented to support a successful trail run.

C. *Identification of change management tasks*

The selected results from the simulation studies were transferred into the change management concept, coming along with the implementation of the trial run in Aachen.

The standardized management of operations in the emergency department improves significantly the outcome of prehospital care [12]. The upcoming training concept of Prehospital Trauma Life Support® (PHTLS) teaches a standardized and established approach to the trauma patient in EMS operations [12]. This concept for

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prehospital management includes the ABCDE approach instructing EMS personnel to act according to the principle „treat first what kills first“:

- Airway management, cervical spine stabilization
- Breathing (ventilation)
- Circulation (hemorrhage and perfusion)
- Disability
- Exposure/Environment

By using these steps, the EMS personnel on site follow the standardized process, consisting in a primary survey focusing the vital functions of the patient, followed by a secondary survey to identify the relevant injuries. The application of this concept helps the remote physician to follow and to document the ongoing operation easily.
The achievement of a standardized working process using the ABCDE concept was supported by the implementation of a digital checklist (Figure 4) in the CompC, supporting the physician in following step by step the work of his team on site.

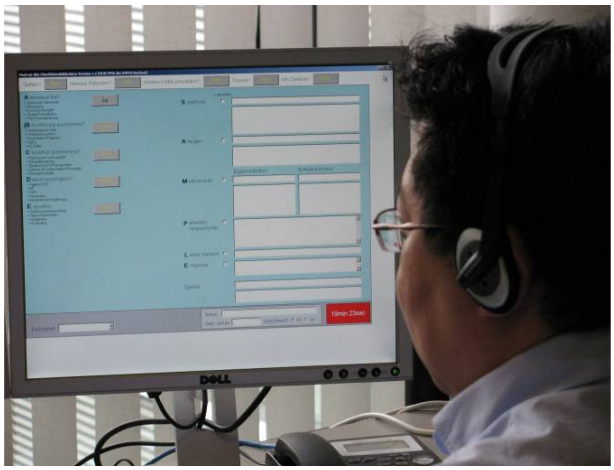

Figure 4. ABCDE Checklist in the CompC

The EMS personnel were trained on the use of the concept mainly on the job, supported by debriefings of the missions. Within the first phase of the trial run, the EMS teams got used to the standardized procedures.

The compliance of the defined working process was additionally fostered by the implementation of job rotation for the involved physicians between the CompC and the mission site. Furthermore the rotational assignment between the two positions counteracted the lack of mutual confidence required by the users. The experience of working together on site and knowing the working processes in the CompC encouraged the manageability of the TRAS.

To prepare the EMS personnel for the trial run of the TRAS, a specific training was inserted into the regular weekly classes at the fire department. Besides lessons on the content of the project, the regulatory framework of the trial run and the intensification of pharmaceutical knowhow, the formation comprised trainings on operational techniques like the initialization of intravenous accesses. In line with these courses the communication rules were integrated into a specialized lesson on communication in critical situations. The participants were put into the complex communication situation by different exercises, to be able to reflect the situation on site as well as the challenges, the remote physician is facing at. The lessons were used to discuss and first of all to further develop the rules of handling the TRAS. The training was consequently used to enhance the involvement of the user groups into the research project and hence to affect the user acceptance of the TRAS.

IV. CONCLUSION AND OUTLOOK

The TRAS as a sociotechnical system compromises beside technological challenges particularly many organizational challenges, critical in view of a successful implementation of the TRAS into daily work of EMS. The development of such assistance systems therefor requires the involvement of all relevant stakeholders. The approach by a joint technical and organizational development has enabled the scientists to identify the necessary change management tasks. The latter were developed in cooperation with the user groups. The described results demonstrated the importance of user involvement right from the beginning of a development project. Various research results have shown so far “that user engagement during the installation phase is strongly associated with user satisfaction” [13]. The described research results underline the necessity of a development approach regarding both technical and organizational challenges enabling thereby an accepted implementation into the target organization.

The aim of Med-on-@ix is to support EMS in their daily work by using today’s technological innovations. To achieve an optimized work in emergency missions the user has to identify the requirements in terms of both types of requirements technical and organizational. Neglecting the latter is oftentimes the reason why innovative technological assistance is not turned into daily operation.

The final evaluation of the Med-on-@ix trial run by the end of 2010 will identify further change management tasks, which will support the implementation of the TRAS. To be able to run in a future scenario the telematic support of EMS paramedics throughout the “no-therapy-time”, the system will be further developed in a follow-up project already started in August 2010. The challenge of the latter will be the parallel implementation in five other regions around Aachen. The one-time approved change management approach developed within the Med-on-@ix project will be further developed in view of the design of an incremental implementation concept deserving at a time five emergency departments.

Due to the federal topology of the German EMS the user groups from different emergency department will differ particularly in qualification, but moreover in the handling of medical instruments or supporting systems. Therefore the organizational and technical requirements

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from the user groups have to be consistently refreshed and adopted to the specificities of the involved emergency department. This matter of fact reveals a further research subject: Besides the realization of a multi-case implementation the change tasks have to meet the individual requirements of the target departments.

The methodology of transferring the identified technical and organizational requirements into implementation measures of different types will be carried on in the coming month, on the one hand to develop an optimized change process but also to gain the necessary user acceptance by consequently involving the target user groups.

V. ACKNOWLEDGMENT

This work was supported in part by the German Federal Ministry of Economics and Technology, the University Hospital Aachen, Philips HealthCare, P3 communications GmbH and the Fire Department of the City of Aachen.

All authors are members of the Institute of Information Management in Mechanical Engineering of RWTH Aachen University, Germany.

REFERENCES

[1] A. Gries, M. Helm, and E. Martin, “Die Zukunft der präklinischen Notfallmedizin in Deutschland.“ Der Anaesthesist, vol. 52, 2003.

[2] T.A. Bey, S.A. Hahn, and H. Moecke, “The current state of hospital-based emergency medicine in Germany”. Int J Emerg Med 2008, pp.273-277

[3] B. Reimann, B. C. Maier, R. Lott, and F. Konrad “Gefährdung der Notarztversorgung im ländlichen Gebiet.“ Notfall Rettungsmed 7, pp. 200–204

[4] Cummins, R. 0., Ornato, J. P., Thies, W., Pepe, P., et al.. Improving survival from cardiac arrest: the chain of survival concept. Circulation 83, 1991, pp. 1832-47

[5] Ziegler V. et al., “Einsatz mobiler Computing-Systeme in der präklinischen Schlaganfallversorgung“ Anaesthesist 57, 2008, pp. 677–685

[6] Latifi R, Hadeed GJ, Rhee P, O'Keeffe T, Friese RS, Wynne JL, Ziemba ML and Judkins D. “Initial experiences and outcomes of telepresence in the management of trauma and emergency surgical patients”. Am J Surg. 2009 Dec;198(6), pp.905-10

[7] M. Protogerakis, A. Gramatke, and K. Henning, “A System Architecture for a Telematic Support System in Emergency Medical Services.”, Proceedings of The 3rd International Conference on Bioinformatics and Biomedical Engineering, 2009, 1–4. IEEE.

[8] S. Marks, “Gemeinsame Gestaltung von Technik und Organisation in soziotechnischen kybernetischen Systemen,“ VDI Reihe 16: Technik und Wirtschaft, Nr. 60. Düsseldorf, 1991.

[9] M. Protogerakis, “Systemarchitektur eines telematischen Assistenzsystems in der präklinischen Notfallversorgung”, RWTH Aachen University, Books on Demand 2010

[10] I. Blakes and M.H. Olson, “User involvement and MIS success: a review of research” Management Science. 1984; 30, pp. 586-603

[11] M. Schneiders, M. Protogerakis, and I. Isenhardt „User acceptance as a key to success for the implementation of a Telematic Support System in German Emergency Medical Services”. Proc. of International Conference on Successes & Failures in Telehealth 2009: SFT-09 Australia. 2009, pp.170-174

[12] C.G. Wölfl, B. Bouillon, C.K. Lackner, A. Wentzensen, B. Gliwitzky, B. Groß, J. Brokmann, and T. Hauer, “Prehospital Trauma Life Support® (PHTLS®). Ein interdisziplinäres Ausbildungskonzept für die präklinische Traumaversorgung.“ Unfallchirurg 2008, Springer Medizin Verlag

[13] L. A. Kappelman and E. R. McLean, “The respective roles of user participation and user involvement in information system implementation success.” Proceedings of the twelfth international conference on Informationsystems, New York, New York, United States, University of Minnesota, 1991, pp. 339-34

 ISBN: 978-1-61208-119-9