Rapport: KMC-FO-*2020-01*

KMC simulation capabilities

Peter Berggren, Carl-Oscar Jonson, Erik Prytz

Centre for Disaster Medicine and Traumatology (KMC)

www.regionostergotland.se

Region Östergötland

Contents

1 Introduction

The purpose of this report is to describe the simulation capabilities and possibilities available at Centre for Disaster Medicine and Traumatology (KMC) in Linköping and partner organizations in the region.

KMC is a center under Region Östergötland tasked to train and educate personnel in disaster medicine, command and control, psychosocial crisis response, and incident scene response. The center also maintains the preparedness organisation for the regional health care system. This includes the designated duty officers and command and control facilities for major incidents. Most recent example is the incident management and coordination for the Covid19-response in the region.

Another responsibility for KMC is the interdisciplinary research environment (https://www.katastrofmedicin.se/) that spans over two organizations, Linköping University and Region Östergötland. The academic side of the center is set at the Division of Surgery, Orthopedics and Oncology (KOO) at the Department of Biomedical and Clinical Sciences at Linköping University. KMC is in parallel an independent center in Region Östergötland. Both entities of KMC are co-located and well-integrated to enable synergies between education, science, and medical emergency incident management. Research in the Focus Area "Modelling and Simulation" aims to develop and evaluate the use of simulation for training of medical practitioners, preparedness assessment of organizations and modelling of proposed interventions. Projects within the Focus Area include the development of a digital disaster management training system, DigEmergo®, and a method for modelling a health care region's disaster management capacity to respond to a major incident with many critical patients. A computer software system has been developed to simulate emergency resources, staff, competences, patients, and managers involved in such scenarios. The system uses a dynamic patient model to track each simulated patient and calculate preventable deaths depending on the health care organization's capacity. Another project aims to model the Swedish Military medical organization and assess the capability to treat and manage wounded soldiers and get them to definitive care hospitals. Projects are typically organized in teams of researchers and practitioners to guarantee operative relevance and sound implementation plans.

2 Theoretical foundation

The word simulation comes from the Latin verb *simulare*, meaning *to imitate* or *behave as if*. Simulation is an activity that imitates an activity or phenomenon. Simulation is "[…] any system that is believed, or hoped, to have dynamical behaviour that is similar enough to some other system such that the former can be studied to learn about the latter" (Winsberg, 2019).

Rybing (2018) has proposed a model with four central theoretical concepts: *simulands*, *referents*, *models*, and *simulators*. The *simuland* is the real-world phenomena that we wish to simulate. The *referent* is the knowledge about the simuland that is available to describe the simulation. A *model* is a simplified, selective, and abstracted physical, mathematical, or logical (conceptual) representation of the simuland. A *simulator* is the device that somehow executes the model to produce the simulation process.

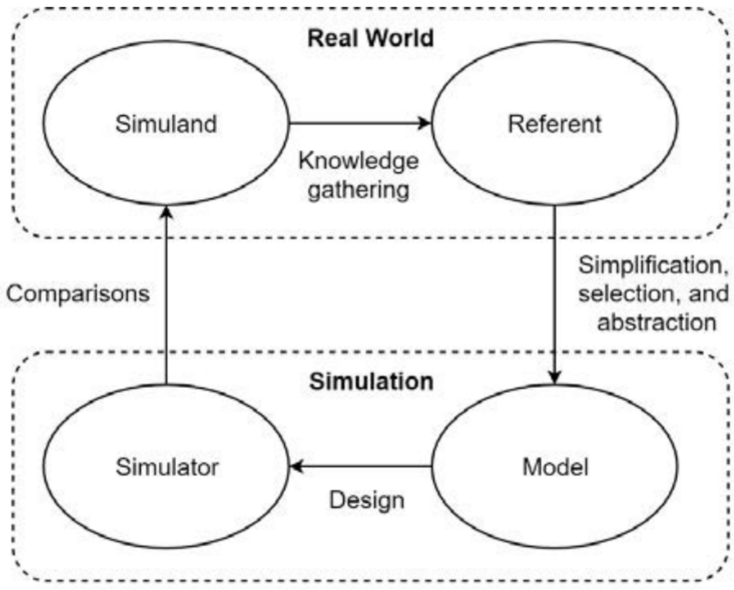

Figure 1. Simulation concepts and their relation (from Rybing, 2018).

Simulation do not require technical expression; it can be role-playing or a board game.

Simulation can be used for training, experimentation, analysis, engineering, and acquisition. Simulations can be categorized into live, virtual, or constructive (Sokolowski & Banks, 2010). Live simulation involves people operating real systems and attempts to be as similar as possible to the real thing. Virtual simulation involves people operating simulated systems, whereas constructive simulation use real people making inputs into a simulation executing these inputs as simulated people operating in a simulated system.

Another way of categorizing simulation is the amount of randomness. It can be deterministic or stochastic. Stochastic simulation admits random variables as inputs, which lead to random results that can be used for sensitivity analysis. Deterministic simulation includes no uncertainty and no variability.

3 Facilities

The KMC environment includes several simulation systems. These are described below.

3.1 Emergo Train System® (ETS)

Emergo Train System® (ETS) is a simulation system for exercises to test and train personnel involved in crisis response and disaster management. It was developed in the mid-1980s to be a simulation tool for training disaster medicine. Emergo Train System® is owned by Region Östergötland, Sweden, administered by KMC - Centre for Teaching & Research in Disaster Medicine and Traumatology, and developed in collaboration with Linköping University, Sweden.

In 2005 new material, version 2, was introduced which had a stronger emphasis on evaluation. Performance indicators were introduced in the ETS material as well as a standardised three day long Senior Instructor course. Since then, ETS has evolved from an academic/educational tool for simulation exercises to become a complete training concept with an association of ETS Educator faculties who run Senior Instructor courses around the world. Today more than 2300 Senior instructors from 42 nationalities have been certified. This network of ETS Educator faculties and Senior Instructors is also important for the development of ETS. In recent years there has been an ongoing development of the ETS. For example, in-hospital patients (patients already in hospital when the exercise starts) who are possible to evaluate during a surge capacity exercise in hospital. New victim banks with injuries that did not exist before in the ETS but have been requested from instructors have been developed, for example patients with burn injuries and patients with war/shootings-injuries. ETS figurant cards have also been developed to be used for exercises using patient actors and a set of patients for training decontamination at hospital. In 2018 version 4 of ETS was released (Hornwall, Berggren, Kristedal, Pettersson, & Prytz, 2018). In version 4, all victim and patient banks have undergone a complete medical review and update. The training material has a new design and the training sets are available in different sizes.

ETS is developed in collaboration between the KMC and Linköping University. The ETS developments are also made in collaboration with universities and subject matter experts from different specialities around the world. All new ETS material is tested and validated before being distributed to instructors for use in exercises. This link to research and subject matter experts along with the organisation of Educator faculties and Senior Instructors is essential to maintain the high quality of the ETS, and to provide high quality simulation training globally.

The ETS patient outcome performance measure allows for structured and detailed evaluations of crisis response on multiple levels in a response system. All patients in the victim banks are associated with a certain patient outcome category. These categories can be evaluated against *risk of preventable deaths* and *risk of preventable complications*. These two outcome measures can provide a result of management effectiveness and can be related to decisions made. In addition there are quality indicators for assessing prehospital command and control and in-hospital management. Several publications are available exploring performance measures in medical command and control related to ETS (for example, Rüter, Nilsson, & Vikström, 2006; Nilsson, & Rüter, 2008; Wakasugi, Nilsson, Hornwall, Vikström, & Rüter, 2009; Gryth, Rådestad, Nilsson, Nerf, Svensson, Castrén, & Rüter, 2010; Nilsson, Vikström, & Rüter, 2010; Nilsson, Vikström, & Jonson, 2012).

ETS has been translated into several languages: Swedish, English, Dutch, Finnish, Greek, Japanese, Korean, and Italian. The system consists of magnetic symbols that are placed on whiteboards to illustrate, for example, a disaster scene or the assembly point at a hospital. The core of ETS is the victim banks with injured patients divided into categories depending on the type of the injuries. The ETS Instructor in an exercise can choose suitable patients for a particular scenario. Maps, frames, models, and pictures are also included in the material to help construct and visualize the scenario. The ETS training material version 4 is available with the pre-hospital set and hospital set in sizes large, medium and small. In addition there are complementary victim banks: a trauma victim bank, in-hospital patient bank for emergency department, in-hospital patient bank for surgery department, in-hospital patient bank for ICU department, a trigger victim bank, a burn victim bank, a military victim bank (consisting of patients with 'war-injuries'), and decontamination at hospital set (including patients who have been are exposed to ammonia or cyanide). For hybrid simulation there are figurant cards available. ETS includes other areas for simulation related to disasters and first responders. There is a victim bank for uninjured/psychological shock and there is a set for training psychosocial support. There is also a first responder set for use with rescue services.

The entire emergency medical services chain – from the incident scene (including collaboration and coordination among first responder organisations) to the emergency department, OR and ICU in the hospital – can be involved in an ETS exercise. Alternatively, focus can be on parts of the service chain, for example coordination at the incident scene or surge capacity at the intensive care unit.

ETS exercises can be viewed as serious gaming (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Crookall, 2010) or role-playing simulation (Trnka, 2009; Laere, de Vreede, & Sol, 2006). The exercises concerns experiential learning (Kolb & Kolb, 2017; Kayes, Kayes, & Kolb, 2005), team training (Salas, 2015; Salas & Cannon-Bowers, 1997), and organisational learning (Crossan, Lane, & White, 1999; Senge, 2006).

3.2 DigEmergo

As part of a project funded by the Swedish Civil Contingencies Agency, a PhD project has focused on translating the core functions of the ETS system into a digital training environment. A prototype has been developed and studied (Jonson et al., 2017; Rybing, 2018; Rybing et al., 2015; 2016a; 2016b). DigEmergo is intended to train command and control functions both at the scene of an accident and at the hospitals for surge capacity management. The key tasks for the trainees are to manage and allocate resources, such as ambulances or hospital staff, to perform triage, treatments, and transportation of patients both from the accident site and the normal, everyday flow at the hospital. The prototype currently supports individual training of emergency coordinator nurses and prehospital command staff and a first responder joint command training module has been designed. DigEmergo uses a client/server solution that enables geographically distributed training.

Figure 2. The DigEmergo system used in an exercise.

3.3 Stochastic simulator with a Dynamic Patient Model

Stochastic simulation methods can be a powerful complement to traditional capability assessments methods. The developed simulation software can be used for both assessing emergency preparedness with some validity and as a complement to analogue capability assessment exercises, both as input and to validate results. Combined with a patient model that has dynamic health states based on predefined injure trajectories this would have a greater temporal resolution and therefore increase overall simulation validity, compared to ETS which has static states.

In the project "Stochastic simulation and medical capacity assessment" KMC is studying and developing a planning and decision support tool for emergency preparedness coordinators. The goal is to provide a dynamic model so that emergency preparedness coordinators can specific their healthcare region's prehospital and hospital resources and test different scenarios. With further development, it should also provide guidance for planning, education and reinforcement interventions, and show which interventions would have the greatest impact on patient outcome.

3.4 Advanced Medical Training Center

KMC has access to a facility for Advanced Medical Training that train civilian and military medics in care under threat and complex scenarios. More information can be given upon request.

3.5 KMC Facility

KMC has staff, equipment, and "props" to work with high fidelity simulations. Within the center there are dressing rooms and equipment for advanced moulage make up for live actors in full scale live exercises. The center also has an equipped ambulance and crashed vehicles for training prehospital car crash scenarios.

Mannequins and part-task trainers for airway and bleeding control management are used in different training scenarios. Laerdahl SimMan and trained instructs is available in collaboration with the hospital clinical training center.

The center facility is designed for operative incident management and control, and is used to train healthcare and multi-agency coordination between command staffs. The facility's IT infrastructure allows both broadcast and recording between rooms that can simulate as command staff operations centers.

4 Networks

4.1 PS

PS (Swedish abbreviation for Prehospital Sjukvårdsledning[1]) is the Swedish national concept for medical incident scene management (Rüter, Nilsson, & Vikström, 2006) directed towards medical first responders. KMC is the national administrator of the concept and is the coordinator for the 22 regional PS-faculties. The concept is used in all Swedish regions. There are 250 trained PS instructors in Sweden using ETS training material for pre-hospital command and control exercises.

4.2 ETS

Emergo Train System[2] is the hub of a network currently consisting of more than 2300 Senior instructors from 42 countries and 14 faculties worldwide. These are: ETS Australia – New South Wales, ETS Australia – Queensland, ETS Australia – Western Australia, ETS Finland, ETS Greece, ETS Japan, ETS Korea, ETS Italy, ETS Netherlands – Trauma region in the North of The Netherlands, ETS Netherlands – Zwolle, ETS New Zealand, ETS Sweden, ETS United Arab Emirates, and ETS United Kingdom.

4.3 Clinicum Östergötland

Clinicum Östergötland[3] is a simulation facility for clinical skills training located at Linköping University hospital. Clinicum Östergötland are concerned with several focus areas: clinical skills, procedural skills, professional and inter-professional teamwork (IPL), scenario-training, simulation with mannequins, simulated patients for skills training, virtual laboratories, virtual patients and other web-based applications, and visualization of anatomy and physiology. Clinicum Östergötland is used by both Region Östergötland and Linköping University.

4.4 Linköping University (LiU)

LiU[4] is closely connected with KMC. Several KMC employees have dual employment or are adjunct lecturers. This allows for knowledge exchange and joint grant applications. KMC is collaborating with all three faculties (Philosophical, Technical, and Medical) at LiU to support and develop simulation capabilities. KMC is located next to LiU:s main campus.

4.4.1 Center for Advanced Research in Emergency Response (CARER)

One area of collaboration with LiU is the research center CARER[5] where KMC is a stakeholder. CARER is a broad, interdisciplinary research environment spanning over three faculties and with

---

[1] https://www.psconcept.se/

[2] https://www.emergotrain.com/

[3] https://vardgivarwebb.regionostergotland.se/Startsida/Verksamheter/Halso--och-vardutvecklingscentrum/Clinicum/

[4] https://liu.se/

[5] https://liu.se/en/research/center-for-advanced-research-in-emergency-response

research and knowledge development on various aspects of first response and the incident site. CARER has been involved in several of the work described in this report (e.g. through PhD work and co-funding by the research programme Effective Response at the Incident Site of Tomorrow) and provides an additional platform for distribution of collaboration results.

4.4.2 Division of Communication and Transport Systems (CTS)

The CTS division at LiU[6] has a long tradition of applying quantitative methods, in particular discrete event simulation and optimization modeling, to planning problem broadly within the area of transportation and communications. In collaboration with KMC and CARER, they have developed models and decision support tools for e.g. emergency medical services, fire services, hospital operating rooms, emergency volunteer management. Concrete examples include emergency vehicle travel time modelling, emergency call forecasting, dispatch support for professional and volunteer emergency resources (SMS-lifesaver), and simulation models for tourniquet location strategies (Prytz et al., 2020).

4.4.3 Linköping University Department of Physics

The Department of Physics at Linköping University hosts the research center Security Link, which both KMC and CARER are part of. Security Link has a long research tradition in radio-based localization. To test the radio-based localization concept in the air, researchers have equipped commercial drones with radio detection and localization capabilities for different applications: (i) Missing people scenarios where the person is assumed to have any kind of radio transmitter (phone or BLE gadget). The radio receiver will make a coarse localization, and video and thermal images can assist the search and rescue team to find the victim.

4.5 Swedish National Road and Transport Research Institute (VTI)

KMC and VTI[7] have collaborated on projects concerned with traffic behaviour and driving for ambulance personnel (Prytz, et al., 2019). VTI and KMC are located in the same geographical area in Linköping.

4.5.1 Emergency-driving simulator (EDS)

Emergency driving entails risks since the emergency vehicle often drives significantly faster than the other vehicles. Speed in itself, and speed differences between road users, are hazardous. Emergency vehicles on call, using sirens and warning lights, therefore have substantially higher accident rates than when not being on call. Further, the emergency driver often has a complex task to perform during driving. Traffic accidents involving an emergency vehicle on call and another vehicle can obviously to varying degree depend on the driver of the emergency vehicle and the driver of the other vehicle, respectively. To this end, an emergency-driving simulator has been developed. The EDS is designed for highly specialized education and training of emergency driving, in a physically safe, environmentally friendly, and economically sound package. All the above-mentioned aspects of risks with regard to emergency driving may be targeted in the EDS training.

The simulator rig is transportable (mounted on wheels, 270 kg; 190 x 123 x 159 cm collapsed) and consists of seat, steering wheel, instrument cluster, and pedals from a Volvo car, a sound system, sirens

---

[6] https://liu.se/en/research/communications-and-transport-systems

[7] https://www.vti.se/

and blue emergency lights with an authentic control panel, and a >180° horizontal view of the surroundings on three flat screen monitors that can be adjusted to the driver's seating position. The software enables emergency driving with any vehicle dynamics of choice.

Figure 3. Portable Emergency-driving simulator (EDS)

4.5.2 Simulator for emergency care during transport (SECT)

Emergency care requires extensive education and training and can generally be quite difficult and stressful. This applies even if it is performed in a hospital, and on firm ground. In an ambulance, during an urgent transport, and perhaps on a bumpy and winding road, there are several further difficulties to handle when giving emergency care. There are road-safety issues that must be adhered to, communication with colleagues may be difficult because of noise, performing medical examinations and administrating drugs may be difficult or dangerous because of vibrations and g-forces. It is essential that ambulance personnel can train emergency care during transport, and this is not viable in real traffic. Even on a closed track, there would be considerable physical risks (Åkerstedt, Lidestam, & Prytz, 2018). It would also be time-consuming, be energy-inefficient and increase CO2 emissions, and expensive.

VTIs and KMC proposed solution is an ambulance care-space mounted on a moving platform of a sort that has been extensively used for simulated driving. This will allow for realistic vibrations and g-forces during patient transport scenarios. The primary aim is to train ambulance personnel in efficient emergency care, under very realistic conditions (but that can be made even more difficult than real-life transports). Both quality and amount of training may thereby be substantially increased – and it would allow for controlled studies.[8, 9]

4.6 Swedish Defence Research Agency (FOI)

FOI[10] and KMC have collaborated on research regarding regional medical command and control and disturbances in society (Hermelin et al., 2019; Herrera et al., 2019; Save et al., 2018; Cedrini et al., 2017;

[8] https://liu.se/en/news-item/sa-blir-ambulanstransporter-sakrare

[9] https://vti.diva-portal.org/smash/get/diva2:1251952/FULLTEXT02.pdf

[10] https://www.foi.se/

Rosi et al., 2017; Branlat et al, 2017; Schachtebeck et al., 2016). FOI and KMC are located in the same geographical area in Linköping.

4.7 Off-campus training sites

KMC has established contacts with WARA – PS UAV[11], the WASP research arena for public safety.

Östergötland Rescue Services regularly set up full scale live exercises together with KMC at their fire fighter training sites or in actual scene environment.

Roxtuna prison is an abandoned prison that is used by KMC and local police to train antagonistic attacks in school environments.

[11] https://wasp-sweden.org/research/research-arenas/wara-ps-public-safety/

5 References

Branlat, M., Herrera, I., Grøtan, T.-O., Woltjer, R., Trnka, J., Hermelin, J., Oskarsson, P.-A., Nilsson, S., Svenmarck, P., Nevhage, B., Darin Mattsson, K., Save, L., De Piano, R., Rozzi, S., Cohen, O., Aharonson-Daniel, L., & Goldberg, A. (2017). *Generic Resilience Management Guidelines* (D2.1). DARWIN.

Cedrini, V., Mancini, M., Giorgi, S., Mandarino, G., Save, L., Ruscio, D., Woltjer, R., Trnka, J., Hermelin, J., Nevhage, B., Oskarsson, P.-A., Branlat, M., & Herrera, I. (2017). *Generic Resilience Management Guidelines Adapted to Air Traffic Management Domain* (D2.3). DARWIN.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers and Education*, *59*(2), 661–686. https://doi.org/10.1016/j.compedu.2012.03.004

Crookall, D. (2010). Serious games, debriefing, and simulation/gaming as a discipline. *Simulation and Gaming*, *41*(6), 898–920. https://doi.org/10.1177/1046878110390784

Crossan, M. M., Lane, H. W., & White, R. E. (1999). An Organizational Learning Framework: From Intuition to Institution. *The Academy of Management Review*, *24*(3), 522–537. https://doi.org/10.2307/259140

Gryth, D., Rådestad, M., Nilsson, H., Nerf, O., Svensson, L., Castrén, M., & Rüter, A. (2010). Evaluation of Medical Command and Control Using Performance Indicators in a Full-Scale, Major Aircraft Accident Exercise. *Prehospital and Disaster Medicine*, *25*(02), 118–123. https://doi.org/10.1017/S1049023X00007834

Hermelin, J., Bengtsson, K., Woltjer, R., Trnka, J., Thorstensson, M., Pettersson, J., Prytz, E., & Jonson, C.-O. (2019). Operationalising resilience for disaster medicine practitioners: capability development through training, simulation and reflection. *Cognition, Technology & Work*, *0123456789*. https://doi.org/10.1007/s10111-019-00587-y

Herrera, I., Branlat, M., Grøtan, T. O., Save, L., Ruscio, D., Woltjer, R., Hermelin, J., Trnka, J., Feuerle, T., Förster, P., Cohen, O., Cafiero, L., Cedrini, V., Mancini, M., Ferrara, G., Mandarino, G., Rosi, L., Jonson, C.-O., Morin, E., … Costello, M. (2019). *Resilience Management Guidelines for Critical Infrastructures, Practical Solutions Addressing Expected and Unexpected Events*. Zendo. https://doi.org/http://doi.org/10.5281/zenodo.3368185

Hornwall, J., Berggren, P., Kristedal, E., Pettersson, J., & Prytz, E. G. (2018). *Manual version 4 Emergo Train System*. Region Östergötland.

Jonson, C.-O., Pettersson, J., Rybing, J., Nilsson, H., & Prytz, E. G. (2017). Short simulation exercises to improve emergency department nurses' self-efficacy for initial disaster management: Controlled before and after study. *Nurse Education Today*, *55*, 20–25. https://doi.org/10.1016/j.nedt.2017.04.020

Kayes, A. B., Kayes, D. C., & Kolb, D. A. (2005). Experiential learning in teams. *Simulation and Gaming*, *36*(3), 330–354. https://doi.org/10.1177/1046878105279012

Kolb, D. A., & Kolb, A. Y. (2017). *The Experiential Educator: Principles and Practices of Experiential Learning*. Experience Based Learning Systems.

Laere, J. Van, Vreede, G. J. de, & Sol, H. G. (2006). A social simulation game to explore future coordination in knowledge networks at the Amsterdam Police Force. *Production Planning and Control*, *17*(6), 558–568.

Nilsson, H., & Rüter, A. (2008). Management of resources at major incidents and disasters in relation to patient outcome: a pilot study of an educational model. *European Journal of Emergency Medicine*, *15*, 162–165.

Nilsson, H., Vikström, T., & Jonson, C.-O. (2012). Performance indicators for initial regional medical response to major incidents: a possible quality control tool. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *20*(81), 1–8. https://doi.org/10.1186/1757-7241-20-81

Nilsson, H., Vikström, T., & Rüter, A. (2010). Quality Control in Disaster Medicine Training - Initial Regional Medical Command and Control as an Example. *American Journal of Disaster Medicine*, *5*(1), 35–40.

Prytz, E., Grönbäck, A.-M., Steins, K., Goolsby, C., Andersson Granberg, T., & Jonson, C.-O. (2020). Evaluating the Effect of Bleeding Control Kit Locations for a Mass Casualty Incident Using Discrete Event Simulation. *The 17th International Conference on Information Systems for Crisis Response and Management (ISCRAM)*, Blacksburg, VA, USA, May 2020.

Prytz, E. G., Åkerstedt, Z., Lidestam, B., Lampi, M., & Jonson, C.-O. (2019). A Pilot Investigation of the Effect of Transport-Related Factors on Care Quality in a Moving Ambulance. *Prehospital and Disaster Medicine*, *34*(S1), 158. https://doi.org/doi:10.1017/S1049023X19003571

Rosi, L., Giorgi, S., Mandarino, G., Boccanera, M., Save, L., Ruscio, D., Cedrini, V., Woltjer, R., Trnka, J., Hermelin, J., Oskarsson, P.-A., Nilsson, S., Forsberg, R., Berggren, P., Jonson, C.-O., Pettersson, J., & Branlat, M. (2017). *Generic Resilience Management Guidelines Adapted to Healthcare* (D2.2). DARWIN.

Rüter, A., Nilsson, H., & Vikström, T. (2006). *Medical command and control at incidents and disasters: From the scene of the incident to the hospital ward*. Studentlitteratur.

Rüter, A., Nilsson, H., & Vikström, T. (2006). Performance indicators as quality control for testing and evaluating hospital management groups: A pilot study. *Prehospital Disaster Medicine*, *21*(6), 423–426. https://doi.org/10.1017/S1049023X00004131

Rybing, J. (2018) Studying Simulations with Distributed Cognition. (Linköping University No. 1913). Linköping: Linköping University.doi:10.3384/diss.diva-145307

Rybing, J., Larsson, J., Jonson, C.-O., & Prytz, E. G. (2016a). Preliminary Validation Results of DigEmergo for Surge Capacity Management. *Proceedings of the International ISCRAM Conference 2016*, *May*.

Rybing, J., Prytz, E. G., Hornwall, J., Nilsson, H., Jonson, C.-O., & Bång, M. (2016b). Designing a Digital Medical Management Training Simulator Using Distributed Cognition Theory. *Simulation & Gaming*, *48*(1), 131–152. https://doi.org/10.1177/1046878116676511

Rybing, J., Prytz, E., Hornwall, J., Jonson, C.-O., Nilsson, H., & Bång, M. (2015). Preliminary evaluation results of DigEmergo: A digital simulator prototype for disaster and emergency management training. *Prehospital and Disaster Medicine*, *30*(Sup 1), s92. https://doi.org/10.1017/S1049023X15002691

Salas, E. (2015). *Team Training Essentials: A Research-Based Guide*. Routledge.

Salas, E., & Cannon-Bowers, J. A. (1997). Methods, tools, and strategies for team training. In M. Quinones A. & A. Ehrenstein (Eds.), *Training for rapidly chaning workplace: Applications of psychological research* (pp. 249–279). American Psychological Association.

Save, L., Ruscio, D., Lanzi, P., Woltjer, R., Trnka, J., Hermelin, J., Thorstensson, M., Bengtsson, K., Oskarsson, P.-A., Nordström, J., Nevhage, B., Jonson, C.-O., Forsberg, R., Pettersson, J., Hornwall, J., Morin, E., Cedrini, V., Mancini, M., Rosi, L., … Feuerle, T. (2018). *Pilots' implementation and evaluation* (D4.3). DARWIN.

Schachtebeck, P. M., Rozzi, S., Save, L., Sujan, M.-A., Woltjer, R., Trnka, J., Jonson, C.-O., Forsberg, R., Cedrini, V., Ferrara, G., Giorgi, S., & Mandarino, G. (2016). *Initial Evaluation of the Guidelines* (D4.2). DARWIN.

Senge, P. M. (2006). The Fifth Discipline: The Art and Practice of the Learning Organization. In *Performance Instruction* (2Rev e.). Random House Books. https://doi.org/10.1002/pfi.4170300510

Sokolowski, J. A., & Banks, C. M. (2010). *Modeling and Simulation Fundamentals Theoretical Underpinnings and Practical Domains*. John Wiley & Sons, Inc.

Trnka, J. (2009). *Exploring Tactical Command and Control: A Role-Playing Simulation Approach* [Linköping University]. https://doi.org/oai:DiVA.org:liu-20641

Wakasugi, M., Nilsson, H., Hornwall, J., Vikström, T., & Rüter, A. (2009). Can performance indicators be used for pedagogic purposes in disaster medicine training? *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *17*(15), 1–5. https://doi.org/10.1186/1757-7241-Received

Winsberg, E. (2019). Computer Simulations in Science. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy*. https://plato.stanford.edu/archives/win2019/entries/simulations-science/

Åkerstedt, Z., Lidestam, B., & Prytz, E. G. (2018). Akutvård under ambulansfärd: Naturalistiska data från simulerade typsituationer vid körning på testbana. In *VTI Rapport* (VTI rapport 984). VTI. http://vti.diva-portal.org/smash/get/diva2:1251952/FULLTEXT02.pdf