Scaling And Varying A Service Engineering Blueprint Through a DSM

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Abstract: During a rising disaster or catastrophe, such as in the Iranian Conflict 2026, critical infrastructure around the Gulf region is hit in multiple neighbouring states (Reuters, 2026). For instance, this led to a full air traffic stop in the sky and on the ground in the Emirates and many other bordering states (The Independent, 2026). Civil and military emergency services are struggling with the ever-worsening crisis and the increasingly complex cooperation between the various emergency service organisations. In addition, each rescue organisation is structured differently. This complexity increases further when two countries cooperate in search, rescue and evacuation (Cyprus Mail, 2026). This paper implements the service engineering thought into disaster management and displays it on a matrix-related metalevel for scaling and varying multiple organisations by using service engineering blueprints and design structure matrices. This is intended to accelerate search and rescue procedures and make them as error-free as possible.

Keywords: service engineering blueprint, design structure matrix, disaster scaling, emergency organisation variant

1 Introduction

Sudden disasters require the mobilisation, organisation and coordination of emergency services. It is not uncommon for more than one rescue organisation to be involved in larger incidents. Therefore, the research question at this point is how to make this organisational complexity manageable for multiple emergency services in dynamic disasters?

As civil and military emergency services adhere to strict up to rigid internal organisational hierarchies, or to put it another way, intra-hierarchy domains, there are no actively cross-linked relations between those domains until a disaster occurs (Holmes et. al., 2008). Thus, spontaneously cross-linked interactions between emergency service organisations are always based on the current disaster and derived tasks, which are never identical. So how can we represent these inter-domain-cross links for collaboration?

If the word "service" in "emergency services" is explicitly addressed, one can scientifically assign the field of disaster management to the discipline of service engineering, which is normally used by companies in non-disaster fields such as information technology (IT), events and concerts, hotels and restaurants and so on (Khusid and Shardin, 2011; Meiren and Schiller, 2020a). With this scientific paper, a "Design Structure Matrix (DSM)" in combination with a so-called "Service Blueprint (SBP)" is used (Maurer et al., 2008a; Meiren and Schiller, 2020b). This is done not only to handle one emergency service organisation, but multiple of them in a real-world disaster scenario. Resulting research goals are, on the one hand, the comparison of the pace of emergency organisation development in the beginning and ending of disaster handling and, on the other hand, the quality of oversight as organisational complexity increases across multiple domains.

2 The Service Blueprint (SBP)

SBP-introduction

Before outlining the state of the art, it is necessary to explain what is required in terms of the system model, subject matter, and application. The service blueprint is a unidirectional, process-oriented method for executing a service system across domains such as user/customer, personnel, resources, logistics, information and communication (ICT)-technologies, and others. The central characteristic of an SBP is the customer´s or user´s view, not to be mistaken for the user who is deploying the SBP themselves. The service process is designed to ensure that a service is delivered to the required quality. It displays two things at the same time: How a service is evolving and how it is deployed in front of at least one user or customer. The SBP distinguishes between different levels of visibility for the final user: Firstly, the external line of interaction, where one or more process elements interact directly with a user or customer. Secondly, the line of visibility is what a user or customer notices as part of the service but only perceives indirectly. Thirdly, the internal line of interaction, which offers background resources, logistics, information technology (IT) and ICT for the mentioned service lines above (Meiren and Schiller, 2020c). A fully executed service can only be seen as positive or neutral from the customer's perspective, but never in a negative way. If something is missing, takes too much time, does not work or is even harmful, the service system has caused an error, which can be seen and identified in at least one process element in the SBP. Therefore, an SBP is a practical tool for time-based and error-propagation analysis. If the SBP-architecture itself is part of the error, the SBP can be varied. Another important conceivable application of an SBP is the transfer into software diagrams, which enables a first draft of a software architecture plan based on an SBP with its process models on a meta-level in the backend to develop a (partially) digital service solution.

For example, an emergency call as a service is shown with a legend as follows:

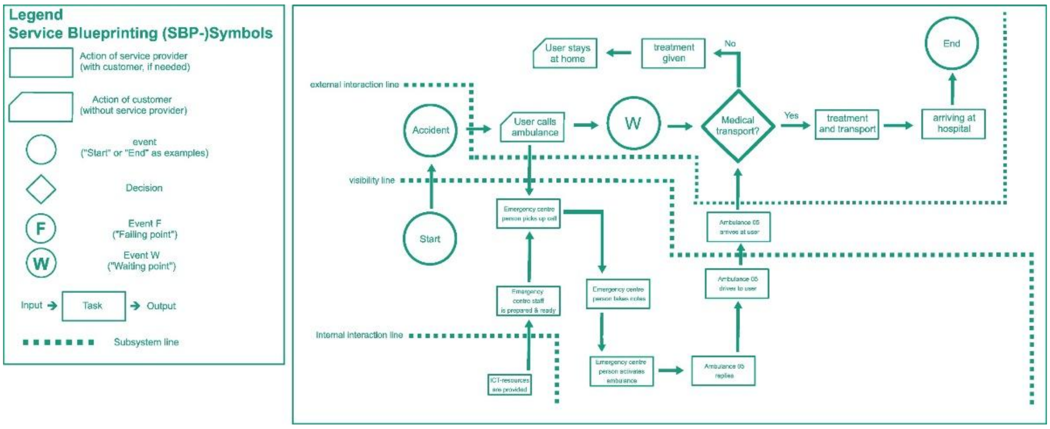


Figure 1. Service blueprint (SBP) with legend and example of an ambulance call with deployment.

SBP-development and design thread

Behind every SBP, there is an extensive development and design thread to map it. For this research, the SBP-referenced process model of the Fraunhofer Institute for Industrial Engineering (Fraunhofer IAO) has been chosen:

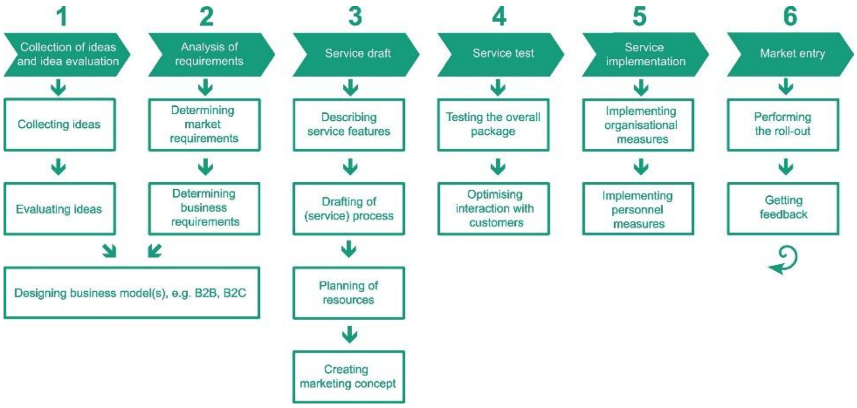


Figure 2. Reference process model for the development and design of an SBP (Meiren and Barth, 2002).

The first step is the collection of ideas and the evaluation of related ideas. This is implemented via the prior art research and the initial draft of a multiple domain-matrix (MDM) to estimate core and additional requirements, which are translated into service process elements and their interdependencies until step four of the reference process model above (Kreimeyer, 2010; Maurer et al., 2008b). The resulting MDM is shown and explained in successive (sub-)sections below. There are other existing methods, including "Conjoint Analysis" for pricing modelling or "Quality Function Deployment (QFD)" for a customer service order, but these do not fit with our development and design approach in disaster management solutions (Meiren and Schiller, 2020d). In parallel, step 2 involves determining market and business requirements. In short, the addressed markets are command-and-control (C2)-centres and mobile command posts in disaster management to handle both civil and military emergency services simultaneously. Business requirements can be listed as elements of a design structure matrix as follows, which is part of the overall MDM (Azzouni, 2023):

DSM-Subdomain "Core business requirements (CBRq)" (Meiren and Schiller, 2020e):

- Spatial handling of at least two different independent emergency services on the spot during a disaster,
- Moderating between the leading command posts of each emergency service,
- Managing civil-military cooperation about emergency service operations,
- Not interfering with the intra-communication hierarchy of each emergency service,
- Picturing non-violent disasters (natural disasters, human failure, technical error).

DSM-Subdomain "Additional business requirements (ABRq)" (Meiren and Schiller, 2020e):

- Enabling ICT between stationary and mobile command posts of each emergency service,
- Picturing violent disasters (war zone, robbery, kidnapping).
- Indirect consulting on the spatial restructuring of emergency service organisations on the spot during a disaster.

Both the first step and second step of the reference process model for SBP result in a so-called "business canvas" on business-to-business (B2B)-level, which can be shown as a domain (Osterwalder, 2004):

DSM-Domain "B2B-SBP-Canvas" with a double slash between each sub-domain:

- protocol head // Key partners // Key activities // Key resources // Value propositions // Customer or User relationships // Channels (for marketing) // Customer or User segments

To maintain a clear overview and reduce complexity, the requirements and the "B2B-SBP-Canvas" are not explicitly shown in the resulting MDMs, but serve as explicit knowledge for mapping the SBP lines.

Step 3 contains the "Service draft" category and begins by describing service features based on the requirements. As core and additional requirements are already defined, core and additional service features can now be specified in detail for customer benefits, service performance and logical interdependencies (Meiren and Schiller, 2020f). In science and research, there are many ways to implement this, such as product models, process models or service description language (Meiren and Schiller, 2020g). For this scientific paper, process modelling is chosen as it displays appropriately structure elements and their domain affiliations with the possibility to simulate them in a unidirectional, process-oriented way (Meiren and Schiller, 2020h). It is important to adhere to the process model rules, which say that a process model must be correct, relevant, economical, reasonable, clear to understand, comparable, have a systematic process structure, have unambiguous pathways (except for communication hubs) and symbols (Meiren and Schiller, 2020i). At this point, SBP drafting involves quasi-iterative steps, where resources and roles are modelled in the process model, which will later be used to plan real resources and roles within the real service environment. For this sub-step, the resource planning is done on the process model level (Meiren and Schiller, 2020j). For emergency services in a larger disaster, this mainly includes the domains of deployed transport systems and subdomains such as consumables, ICT, and additional equipment. After resource planning for modelling comes the further sub-step for role concepts, which is a wide discipline. Role concepts can contain interaction design of user and/or provider, customer segmentation, customer journey-method with role play in a scenario with or without service theatre, drama of interaction, design aesthetics and design of the service environment (Meiren and Schiller, 2020k). What is new with this scientific paper is the fact that the process modelling is done via MDM and its internal DSMs for keeping the overview and staying flexible to add to emergency service domains with respective units as elements. As the next sub-step, the SBP is modelled based on the process model on a beta-ready level. This SBP can provide feedback on timespan, failures, service profitability, or movement analysis in space. In this scenario case on a map layer of a geoinformation system (GIS), time, space and potential failure are crucial to understand for fast and effective deployment in a disaster zone (Meiren and Schiller, 2020l). Based on the given requirements from the SBP-section above, different emergency service domains operate together in a disaster scenario, which is presented in the subsequent main sections "The DSM method as SBP-metalevel" and "Emergency service scenario of Paderborn" in Sitaware (Staff members of Systematic, 2024). In 2022, for this real executed scenario with SBP-data, which is exclusively published in this paper, real and virtual resources, as well as real and virtual emergency service personnel were used in cooperation with the real "Fire Service Control Centre" of the Airport Paderborn-Lippstadt, which is also in charge of the whole rural district of Paderborn. Usually, a marketing concept follows at the end of step 3, which can be neglected for this research (Meiren and Schiller, 2020m).

In step 4, the whole SBP on the beta level with its process model and MDM in the background is tested and optimised with regard to possible failures and unnecessary delays. This improvement was done via the deployed scenario at Airport Paderborn-Lippstadt and failure mode and effect analysis (FMEA), which led to an improved SBP in the section "The DSM method as SBP metalevel" (Meiren and Schiller, 2020n). In this context, the emergency personnel deployed in C2-posts and incident command vehicles should be regarded as end-users or customers for this SBP, not to be mistaken with casualties, as addressed third-party users over the line external interaction in an SBP model (Staff members of Feuerwehr Flughafen Paderborn-Lippstadt, 2000). After the completion and final analysis of this scenario, practised in real life at the Airport of Paderborn-Lippstadt, a full-established SBP based on an optimised MDM and process model could be deduced.

What has not been necessary for this scientific research were development steps 5 and 6, which comprise service implementation and market entry. These represent stages of economic exploitation that did not apply to this research project (Meiren and Schiller, 2020o).

3 State of the art / Prior art

Prior art research for this research question is divided into method research, topic research, existing scientific or commercial solutions and related combinations of those. First, general research on service engineering at a systems- or matrix-related level is investigated.

For the usage in a full digital surrounding and software applications, Trappey et. al. developed an SBP for the patent analysis of bike-sharing services in 2024. This research integrates knowledge ontologies of existing patents, keyword extraction, k-means clustering, and a technology-function matrix (TFM) to analyse the wide range of intellectual property combinations in bike-sharing systems. The first half of the research provides a macro overview of the prior art in bike-sharing technologies. The second stage uses SBP to identify practical usages of technology patterns with a focus on the bike sharing market in Taiwan, with examples of bicycle locks and bike parking stations. The SBP with its four stacked subsystems contains a customer journey (SBP-subsystem 1), as frontstage a customer can uses either digital (app, website) or manual (kiosk) means to rent a bike (SBP-subsystem 2), as backstage a fully digital ecosystem with membership check-in, customer feedback, charging and recording of a bike (SBP-subsystem 3) and finally, as SBP-system 4, a fully digital support process behind the line of interaction with database, logistics engineering and e-business. The applied TFM-analysis identifies and maps published patents worldwide via k-means clustering based on the sub-technologies of the respective SBP. Furthermore, the TFM provides potential innovation related to the bike-sharing system patents. A total analysis of 1460 patents has identified innovation in bicycle lock technologies, application interfaces, station locks, docks, and station design that improve security and customer satisfaction. The remarkable feature of this SBP is the application of a process-oriented customer journey method as SBP-subsystem 1, which operates at the same level of direct user interaction as SBP-subsystem 2 (Trappey et al., 2024).

In 2025, Shie, Xu, Wang, Yang and Wu developed an optimised service process to address the emotional needs of elderly people in medical care. The four main methodological approaches being used are TRIZ, a Russian acronym for "Teoriya Resheniya Izobretatelskikh Zadatch," which translates to the "Theory of Inventive Problem Solving", Kansei Engineering, a Japanese user-centred development methodology that translates users' subjective emotions, feelings and sensory impressions (Kansei) into concrete design parameters (shape, colour, material), the Service Engineering Blueprint and Failure Mode and Effect Analysis (FMEA) for service failure diagnostics. Regarding the research framework, a digital model with data mining is used, which contains three phases as process model blocks. Phase 1is Kensei Engineering with the data mining of recorded emotional vocabulary, which operates at the subsystem level through mapping and extracting of elderly customers' feedback via a stepwise satisfaction model and a "k-means++" algorithm for cluster analysis. Phase 2 determines service failure locations via a novel SBP, followed by a fuzzy FMEA, which uses questionnaire data to generate a ranked output indicating which service process steps went wrong. Subsequently, the customer feedback extracting of phase 1 and the FMEA-ranked service failures of phase 2 feed phase 3, which should eliminate the customers' dissatisfaction and corresponding service process step failures via TRIZ with the TRIZ contradiction matrix and TRIZ innovation principles. With this multiple methods approach, an optimised and reactive service process thread with three stacked subsystems of combined medical and elderly care (CMEC) could be achieved by identifying and assigning elderly people's actions and feelings (SBP-subsystem 1), onstage interactions of medical staff (SBP-subsystem 2) and backstage interactions of the physical and digital healthcare system in the SBP (SBP-subsystem 3). Moreover, a digital solution could be derived from this, which measures the satisfaction of service steps for elderly customers (Shie et al., 2025). Secondly, for the topic-related research that focuses on (digital) services in crisis response and disaster management, the following publications are found:

In Sendai, Japan, the United Nations was holding its 2015 conference on indicators in risk management, with the main question: "Are they a user-friendly interface between natural hazards and societal responses?" Four years later, in 2019, Ivčević, Mazurek, Siame, et al. analysed the results of the UN conference on a series of indicators to better cope with human losses and economic disasters, and whether those indicators could serve as effective input parameters for decision-making tools. Moreover, a deeper literature review was conducted between 2013 and 2017 to evaluate how indicators are constructed in risk management, focusing on flooding, coastal, and seismic risks at spatial and temporal scales, and how they could fit within the needs of the governmental framework. Based on a global map, it could be seen that the United States of America (USA), China, and Southern Europe, with Italy in particular, had published the most. The authors point out that there should be a balance between social (vulnerability) indicators and natural (hazard) parameters. A successful mechanism shall display an ensemble between those indicators and parameters, (alternative) decision-making with political involvement and local participation at the operational disaster zone level for real risk perception. In conclusion, an iterative process model is presented with the process blocks "Vulnerability Pre (Phase)", Potential Hazard", "(Disaster) Event", "Vulnerability Post (Phase)" and "Memory resilience" which connects risk analysis, emergency engineering, information and education as well as the emergency organisations and first responders, post actions on the respective disaster territory with governmental action based on existing capacity. Finally, the authors recommend closing the communication gap between the scientific community, decision-makers, managers, and the population, as there is a lot of research but not the same level of improvement in disaster management. Although an SBP is not shown, this circular, iterative process for disaster event handling could have been transformed into an SBP for better understanding (Ivčević et al., 2019).

In 2020, Baughman, Hirschberg, Lucas et al. developed an "Incident Command System (ICS)" in the early days of the "coronavirus disease 2019 (COVID-19)"-pandemic in Boston, USA. In the state of Massachusetts, 64% of COVID-19 deaths were cases in long-term care facilities. Moreover, academic medical centres (AMCs) and safety-net hospitals were affected and were all designated as disaster zones. Therefore, the disaster response focus was on post-acute care (PAC) patients in a new 1000-bed field hospital, which interacts with those areas and their respective patients. Four independent emergency response teams were deployed: "Military Task Force" for fast procurement and transportation skills as the

United States Armed Forces (USAF) holds overarching procurement and transport licences in the USA, "Medical Team" for acute medical procedures, which is directly interconnected to the "Military Task Force", "Nursing Team" and a "Clinical Team", who both work internally independent in the field hospital. All four emergency response teams were guided by a colonel or chief officer in medical, nursing or clinical matters. The highest command-and-control (C2)-hierarchy was formed by the mentioned colonel plus a civil co-director for the three civil chief officers above to interconnect external with internal field hospital processes. For each subtask in the ICS, staff members had been assigned. Therefore, service blocks were mirrored in the organisational structure. From the highest staff command over to direct patient care to indirect medical assistance and to backstage processes such as logistics and data analytics, four service lines could be identified, although an SBP was not explicitly used (Baughman et al., 2020).

Also, based on the COVID-19 pandemic, Gupta, Siddiqui, Phillips, et al. published "Recruitment, Readiness, and Retention of Providers at a Field Hospital During the Pandemic" in 2022. The state of Maryland, USA, set up a 250-bed emergency response field hospital at the Baltimore Convention Centre. 65 full-time clinicians had to be hired within 4 weeks. 300 applications were proofread, 186 candidates had been interviewed, and 159 of them were credentialed. Afterwards, the chosen clinicians were trained in COVID-19- and field-hospital-related procedures. Multidisciplinary teams comprising experienced medical and laboratory personnel were required for this mass-casting and training program. For achieving this, a special organisation had been set up, an 8-step recruitment process established, 5 principles for field hospital preparedness defined and 4 strategies derived to keep up the field hospital operation in any case. Although the 8-step recruitment process and interconnected organisational building are key tasks for an SBP, this method was not considered. An SBP could have been a conceivable improvement to connect recruitment organisation forming with the recruitment procedure itself (Gupta et al., 2022).

Other noteworthy papers that exceed the page limit of this paper are referenced in this phrase (Scholz et al., 2012; Wei & Fei, 2018; Navya et al., 2024; Ongesa et al., 2025). There is already software in industrial use in the field of organisational management regarding disasters and SBP-modelling, where only a small part can be highlighted and cited via the next phrase. But those tools lack the ability to reorganise themselves dynamically when multiple teams are involved (Khusid, A., and Shardin, O., 2011; Meiren and Schiller, 2020p; Staff members of d4h, 2026; Staff members of noggin 2026).

4 Emergency service scenario of Paderborn with Incident Command Vehicle (ICV)

On the 2nd of December 2022, a flooding disaster was simulated at Airport Paderborn/Lippstadt in Germany. The scenario involved two historical disasters, which were simulated in succession. Between the 17th and 19th of June 2019, the region and city of Paderborn were hit by a severe storm with heavy rainfall, hail and strong winds of 100 km per hour. 100,000 hectares of land were damaged by flooding and hail and a total of 1000 persons had to be evacuated (Rittershaus and Staff members of Hallo24, 2019). On the 20th of May 2022, a rare tornado hit the region and city of Paderborn, injuring 40 people (Staff members of Stuttgarter Zeitung, 2022). The respective "scenario 1" was carried out at Paderborn Airport, involving mainly real emergency services personnel and simulated units. Subsequently, resulting simulation corrections and improvements were done until 21.03.2023 in the software Sitaware Headquarters (SW HQ) (Staff members of Systematic, 2024). The C2 posts consisted of three higher-level units: An ICV, a pioneer bridge battalion (PzPiBtl-130) and a fire service control centre at the airport (KFTZ-LP), although the engineer battalion was only represented virtually (Azzouni, 2023; Staff members of Bundeswehr, 2010; Staff members of Feuerwehr Flughafen Paderborn-Lippstadt, 2000). The ICV, in turn, was supported by a police support command vehicle (PSV), a fire service command vehicle (FSV) and the ICV-command post itself, which had six seats (fire service, German Armed Forces (Bundeswehr), police, the District Administrator of Paderborn, a drone pilot flying systems and a drone pilot for autonomous ground units). In total, 4 flying drones (smaller monitoring quadrocopter [4-copter or quattrocopter] tethered, communication quadrocopter, fixed wing drone for wider area search and autonomous ambulatory aerial drone Grille), four ground-based drones (Excavator Alice, Tractor Arion I, Tractor Arion II, Forklift MATS), one PSV, one police vehicle "PoliceV 01-01", one FSV, one fire truck "FireTr 01-01", one ambulance "AmblceV-02-01" and one bridge tank "Biber 01" were deployed in reality or simulated for this scenario. Also, an ambulance exchange point "Amblce-ExchP-Airp" was set up next to the runway for medical evacuation (MedEvac). The emergency units and other product service systems are listed as follows:

Figure 3 (Left). ICV with its drones 1. Figure 4 (right). Police and firefighter vehicles of Airport Paderborn-Lippstadt and bridge tank (Firefighters of Airport Paderborn-Lippstadt, 2022; Police Paderborn District, 2023; Staff members of Bundeswehr, 2010).

With the shown emergency service units above, "Scenario 1" at Airport Paderborn-Lippstadt was carried out with an organisational chart on the left of the map for a combined flooding and fire disaster, whereas blue units are civil emergency service units, the green bridge symbol representing a military bridge tank beneath the yellow single casualty-symbol with car accident on top right, the yellow group-symbol a larger flooding incident on bottom left and a fire-symbol in red for a castle fire on top right. Moreover, ground-based drones were virtually digging a flooding break on the top left. During this disaster protection exercise, some real-life photographs were also taken, which are summarised below:

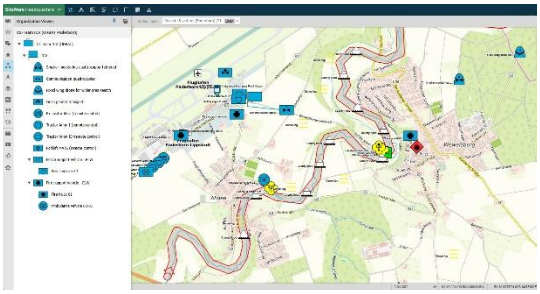


Figure 5 (left). Scenario 1 on a SW HQ-map (Staff members of Systematic, 2024). Figure 6 (right). Real deployment of scenario 1.

Following the implementation and completion of the scenario at the airport, this second scenario was extended within three months to include the town of Paderborn, which had also been affected by flooding from the River Alme in 2019. This was combined with the tornado that struck the town in May 2022. The actual units from the city of Paderborn shown here have been added to the scenario virtually, based on operational data from 2019 and 2022, which was provided exclusively for research purposes. In total, the combined figures from the two operational years showed an increase of 12 ambulances, 8 fire engines and 7 police vehicles, which were coordinated by the fire service control centre and the traffic police department of the City of Paderborn. The combined data from the two incidents in 2019 and 2022 can be summarised on a map as "Scenario 2" as follows:

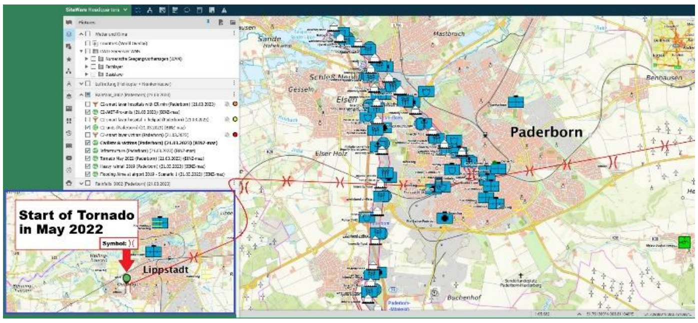


Figure 7. Scenario 2 on a SW HQ-map (Staff members of Systematic, 2024). Figure 8. Police and firefighter vehicles of Paderborn (Firefighters of Paderborn City and Feuerwehrmagazin, 2022; Police Paderborn City and Taxi heute, 2020).

5 The DSM method as SBP metalevel

Presenting the dynamic situation in a disaster and making it tangible. This will always be the primary focus as the search and rescue (SAR) for life and additionally livestock counts first.

Although emergency services have improved handling inter-organisational complexity via the nearly seamless exchange of information through digital, geographical, phone and radio communication solutions, the lack of handling inter-organisational building dynamics for emergency services costs time the larger the disaster becomes and the more complex the disaster subtopics become. From the point at which a disaster becomes unimaginably huge, such as a volcanic eruption, a tsunami, a hurricane or a war, dynamic inter-organisational cooperation is just as crucial as the assessment of the situational picture. With the increased complexity of an SBP, it is becoming more and more difficult to keep an overview of a service system. No solutions were found based on the literature review in the previous section, "State of the art / Prior art". This is precisely where the Design Structure Matrix is intended to help at a higher level as an organisational architecture (Eppinger and Browning, 2012). In the subsequent section about a deployed scenario at Airport Paderborn-Lippstadt, an MDM filled with emergency service units is used, which is shown in the figure below. The matrix analysis was carried out with the software LOOMEO (Maurer and Braun, 2015):

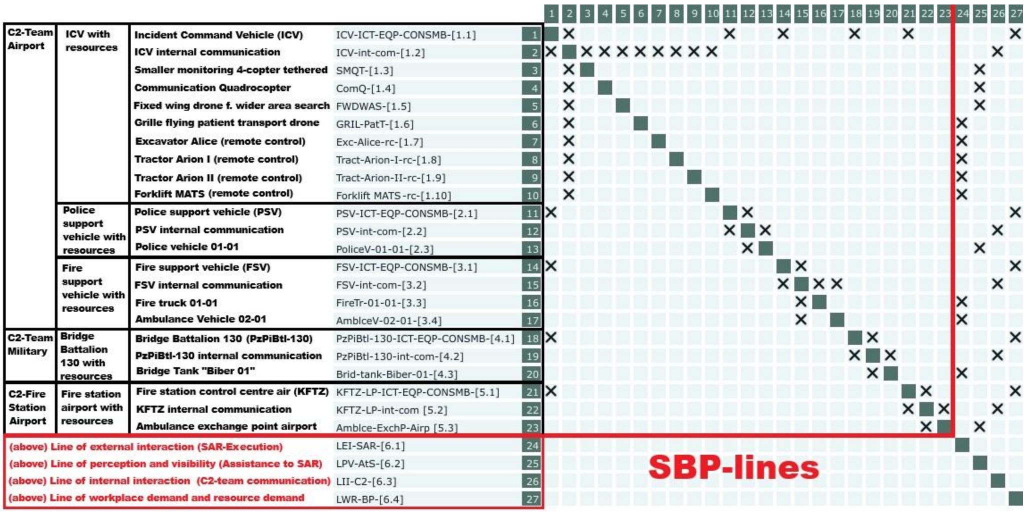


Figure 9 (left). MDM of scenario 1 with a non-optimised matrix sorted by element numbers.

The MDM-figure above is cross-linked unidirectionally with a "1" in an MDM, otherwise "0" for a successive process model, displayed as an "X" for a "1" (Yassine, 2004). No larger differences were detected between the linearly optimised and unoptimised matrix as the SBP lines, whose domain was already in last place before optimisation, remain in last place even when the MDM is optimised linearly. This is due to the mathematical fact that SBP lines do not link directly, but are only linked passively and in reverse, all other elements must be linked actively to exactly one SBP-line element. What gives more information is the clustering graph, where the SBP-lines can be drawn in addition to a pre-model of an SBP (Maurer and Braun, 2015):

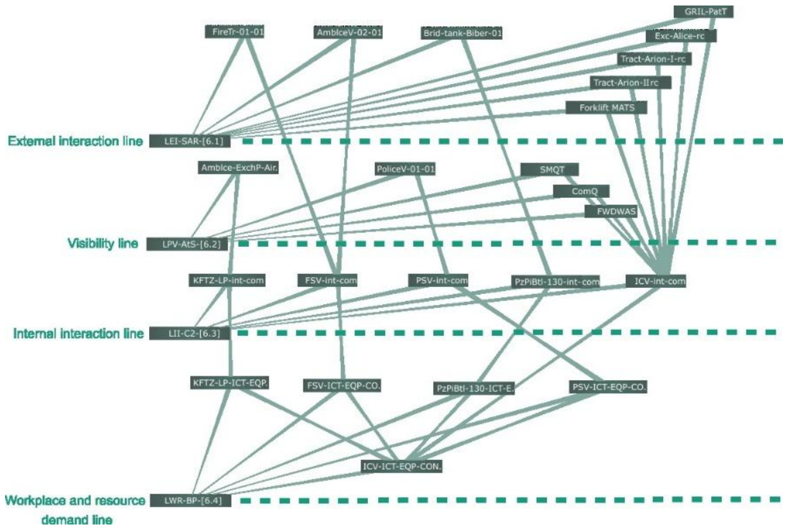


Figure 10 (right). Process model from MDM of scenario 1.

Core and additional requirements and respective services from the SBP-introduction section define the assignment to SBP-lines: Ambulance, fire truck, bridge tank, ambulance drone Grille, excavator drone Alice, tractor drones Arion I and Arion II work actively over the external interaction line, where search and rescue as well as infrastructure protection is necessary. The police vehicle 01-01 has the passive task of blocking roads and taxiways at the airport near the ambulance exchange point of the airport, while the three drones for surveillance of the ICV are monitoring the situation above the line of visibility. The communication processes are done over the internal line of interaction, while the fire station of the airport, the police command vehicle, the additional fire command vehicle, the military bridge tank command, and the ICV itself are placed over the line of workplace demand and resource demand. Cross-links can either be information, resource, or energy flows, as this matters for service processes, which are later described in detail in an SBP. For a final SBP model, it is necessary to convert elements into tasks, which means that an element is complemented with a "task verb", which represents the trait of an element's output. With this completion, the cross-links get their service-oriented relation flow meanings, which gives an operational understanding for a superior C2-post. For Scenario 1, the following proposed solution from an SBP is presented:

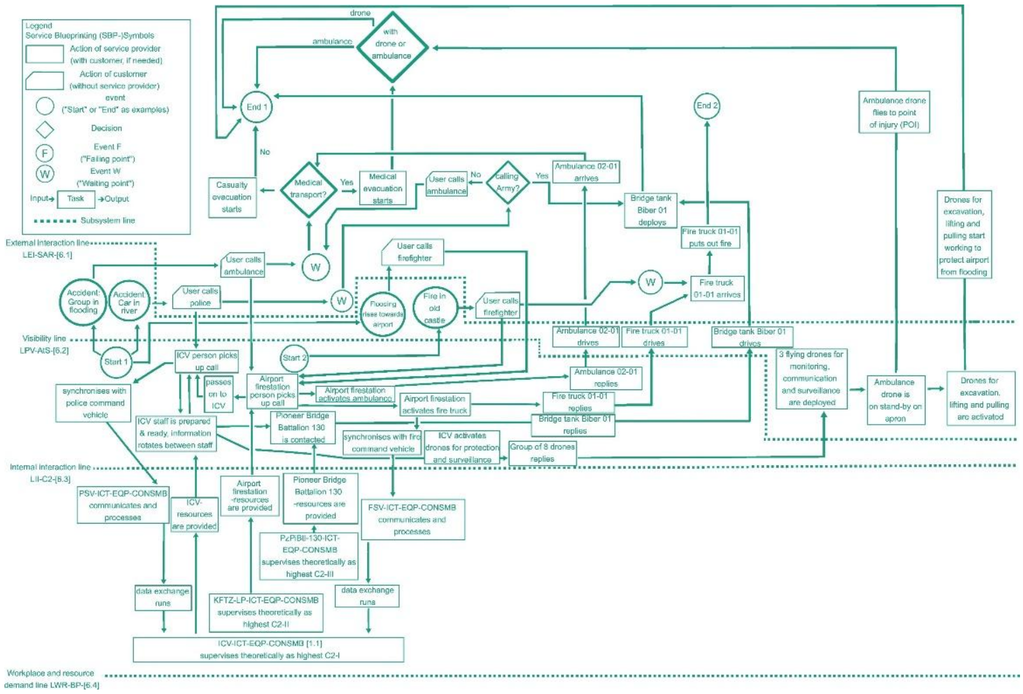
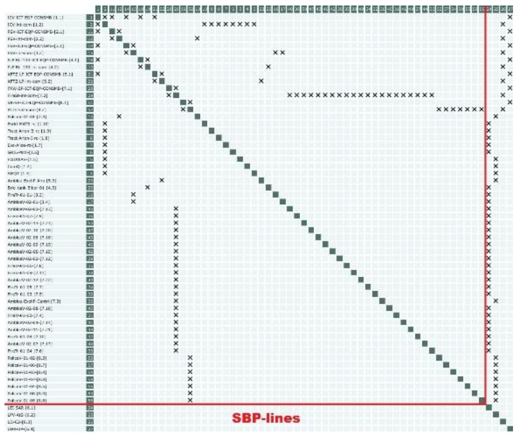


Figure 11. Overview of the service blueprint of scenario 1

The SBP of scenario 1 illustrates how quickly the overview can be lost when switching between a process model with SBP lines and a fully-fledged SBP. Fully-fledged SBPs are suitable for service concepts involving small to medium-sized groups and are also useful for identifying waiting points and failure points, including. However, as soon as a service or customer team grows in size or already exists in a larger form, it becomes a disadvantage to move beyond the simpler process model-style with SBP lines. A fully visualised SBP-model would not be suitable anymore.

With the extension to scenario 2, the flooding of 2019 is displayed for the city of Paderborn itself, which is a true story. To simulate a scenario involving a mass casualty event and infrastructure overload, the 2022 tornado event in Paderborn was incorporated using real weather data, which can be viewed in the scenario section. This incident required additional emergency services to 12 more ambulances, 8 more fire trucks, 7 more police vehicles and 1 ambulance exchange point at the central station controlled by the fire service control centre and the traffic police department of the City of Paderborn (Firefighters of Paderborn City, 2022; Police Paderborn City, 2020). The extended MDM of scenario 2 is crosslinked to scenario 1 and the respective emergency service units are assigned to the same SBP-lines based on the given core and additional services. The extended MDM can be used either unoptimised or optimised with the resulting process model of unidirectional clusters. If a linear optimisation algorithm is applied, such as the Dijkstra algorithm, the SBP-lines on Positions 24, 25, 26 and 27 are automatically shifted to the very last positions of the MDM for a better overview (Maurer and Braun, 2015):



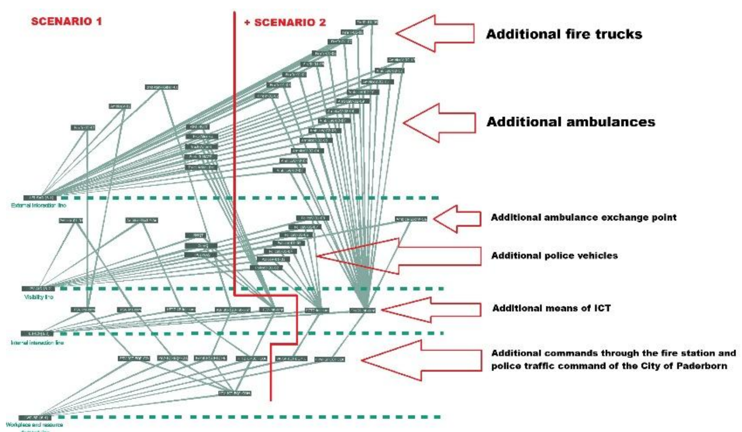


Figure 12 (left). Optimised MDM of scenario 1 plus 2 with an extra 12 ambulances, 8 fire trucks, 7 police vehicles and 1 ambulance exchange point at the central station, controlled by the fire service control centre and the traffic police department of the City of Paderborn. Figure 13 (right). Process model of scenarios 1 and 2 from MDM.

6 Conclusions and outlook

Trials with an SBP based on a process model deduced from an MDM or DSM have shown that dynamic organisation forming at the highest C2-level in disaster handling can be improved. The C2-participants in the ICV of the scenario play were overwhelmingly satisfied for having a better overview and making quicker and better decisions. The process model, acting as an intermediary between the DSM and the SBP, is particularly well-suited to spatial organisation, even across different emergency services organisations. A resulting, final SBP, on the other hand, is suitable for temporal organisation forming as well as for analysing errors and unnecessarily dangerous waiting times in the search and rescue process. Moreover, a process model is useful for huge, dynamic disasters. It must be decided to use this approach at the tipping point where a C2- post cannot handle the situational picture without virtually reorganising. In summary, based on an MDM or DSM, a process model is suitable for spatially organised scaling. In contrast, the SBP is designed for varying by identifying time-based faulty or slow substructures within a process model. Developing and designing an MDM and process model are easy in this field, as those models can be solved linearly with feasible solutions, which is important for quick decision-making in a C2-post for SAR. However, creating an SBP based on a process model or at least a subsystem from it takes time, which needs an additional software solution, which does not exist so far, but could be set as an outlook for this research. The software task would turn MDM elements into task blocks, including their output trait definition, add SBP-rules and -event states such as waiting points, failing points, incident points, and decision rhombuses, set SBP-lines again and finally mark task blocks as provider-blocks or customer-blocks.

In total, research objectives are connecting requirements with organisations, their units, equipment and places, sorting those elements above the dedicated SBP-lines and developing fast and error-free procedures in SAR, firefighting or technical relief. A disadvantage and boundary of this C2-approach is the level restriction. Those models could not be applied directly on-site across the different emergency service units, as this could cause further organisational chaos. It would be a software tool at the highest C2-Level, only for incident command vehicles and control centres, to maintain overview and optimise operations through better spatial grouping or error-propagation analysis.

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