

Uncovering Impact of Innovation: Continuous Stakeholder Engagement through Scenario-based Systems Engineering

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ABSTRACT

The importance of extreme weather situations is increasing due to their number and, above all, their impact on stakeholders in emergency response. They are characterized by cascading effects with global and local interdependencies. Extreme data must be included as a basis for decision-making. The impact in emergency response depends on diverse, multidisciplinary competencies required to interpret information. Scenarios are used in various forms of preparation: in exercises, but also for the design of information systems and validation. Based on literature, this article brings together different types of scenarios and related work in the field of Model-Based Systems Engineering. Using an exemplary case relating to possible pluvial urban floods, the added value resulting from a focus on the impact of innovative solutions is discussed. It is shown that the use of scenarios helps to make the desired impact assessable for decision-makers in all phases of research and development projects.

Keywords

systems, scenarios, engineering, models, innovation

INTRODUCTION

Extreme weather situations are increasing due to climate change (Lee et al., 2023). Weather-induced emergencies are characterized by cascading effects with global and local interdependencies (Schauwecker et al., 2019). In hazard analysis and response, it is therefore necessary to deal with extreme data that is obtained from heterogeneous data sources and evaluated using various methods, including machine learning (cf. (Abily et al., 2020)). Examples include global data such as geodata, traffic information, satellite images and weather forecasts on the one hand, and local data from sensor systems such as weather stations, ground-based or flying robots (UAV/UGV) on the other (Kruijff-Korbayova et al., 2021). Extreme weather therefore places extreme demands on information and communication technologies (ICT) (Terti et al., 2019) and self-protection of the population (Gräßler et al., 2018). Effective support for all stakeholders requires the provision of weather forecasts and, above all, constantly updated impact forecasts as the emergency progresses, in order to prepare for such an emergency and its development over time (e.g., (Sutanto et al., 2019)). This becomes even more important the less specialist expertise is available in a command and control post in areas such as meteorology, geology or sensor technology.

The management of critical situations in real time with extreme and complex data must therefore be based on an assessment of the information quality of extreme data. Different fields of view and sampling frequencies of sensor technology, latencies in communication, gaps in data collection, differences in data formats, etc. characterize "extreme data" - the term "big data" is therefore avoided due to the too narrow reference to volume. In the decision-making process, an awareness must be created that uncertainty is always inherent here. Indicators of data and information quality offer a possible approach (Eppler, 2006). The achievable effect depends on the application context in different command and assistance centers as well as the available infrastructure with devices for visualization, interfaces of weather services, sensor systems and rescue robotics. This article is therefore based on the assumption that the consistent use of scenarios is crucial for the successful impact of innovative solutions in the application. This can be based on the approaches of Model-Based Systems Engineering (MBSE) (Gräßler et al., 2023). While requirements can be represented in previous system models, there is no explication of narrative knowledge. In scenarios, these can be discussed and referenced (cf. (Friberg et al., 2010)).

The article summarizes different types of scenarios based on the literature in the following chapter. Related work in the field of MBSE is adopted for application in emergency management. The concept for the conceptualization and abstraction of different types of scenarios covers the entire chain from domain exploration to the evaluation of the impact of a technology in this domain. Using a case study relating to possible pluvial urban flooding situations, the added value that arises along the chain from actual practice scenarios to target application scenarios and validation scenarios is discussed. In the conclusion, it is shown that the use of scenarios can help to make the desired effect of innovations explicit early on in development and research projects and thus make them assessable for decision-makers.

STATE-OF-THE-ART IN SCENARIO REPRESENTATION

The aim of scenarios is to transform statements into descriptive, intuitively usable auxiliary artifacts. They thus combine the illustrative perspective with a purpose-related, constructive view. The challenge is the qualitative description based on subjective descriptions and perceptions. These can be related to the problem and solution space. With regard to the problem space in particular, it becomes clear that the need for information extends well beyond the domain of product development. Accordingly, information from different domains is integrated here. Distortions as a result of the scenario form must be taken into account (Sabatucci et al., 2015).

Scenarios in Research on ICT in Impact-Oriented Emergency Management

Systematically researching the ISCRAM library following the principles of the PRISMA statement (Page et al., 2021), several notions of "scenarios" become obvious. This is supported by cross-checking with Web of Science and Scopus databases. Amongst others, there is a variety of work that applies scenarios in (virtual) simulations resp. exercises. Further references are available that make use of scenarios to model and understand a certain domain of interest or type of hazard, like people evacuation, food supply or humanitarian assistance. When searching for an exact match of scenarios and systems engineering or related terms, there are not direct matches. Extending the scope, some papers can be identified that support the relevance of scenarios along design and engineering activities for ICT systems in emergency and crisis management. Intending an advanced User Experience, TOULOU M et al. propose to incorporate service touchpoints explicitly in scenarios (Touloum et al., 2013). Based on structured scenarios from overall scenarios to activity diagrams and interaction models (cf. (Friberg et al., 2010)), touchpoints are extracted representing those system elements that require UX design interventions. GARCIA-ARISTIZABAL et al. introduce their work on Cascading Effects Scenarios with several case studies (Garcia-Aristizabal et al., 2015). Their work combines analytical elements when describing past emergencies through scenarios (as-is scenarios) with prescriptive use cases when targeting supportive measures like ICT systems. RAMIREZ et al. focus on risk analysis based on scenarios (Ramirez de la Huerca, Miguel et al., 2015). Even though this is not directly linked to Systems Engineering, the presented approach can help to prioritize scenarios targeting risks of cascading events. This could be coupled with Systems Engineering approaches targeting similar risk-oriented objectives (Gräßler et al., 2022). On a different layer, POLIPARKUS et al. research on collaboration in (virtual) scenario generation (Poliparkus et al., 2018). Understanding Systems Engineering as a set of tasks that needs to be fulfilled in a collaborative manner, especially the findings regarding feedback loops and finetuning of scenarios to ensure realistic settings are considered in the paper at hand.

Criteria to Categorize Scenario Types

Process-related scenarios usually include events and/or activities in narrative form. One example is the description of an actual process within which problems are to be identified. Situation-related scenarios, on the other hand, describe states as intended or anticipated situations. One example is future scenarios that anticipate possible

futures. They can also include a temporal dimension that describes the achievement of this situation or a further development. Selection scenarios are used to support decision-making and therefore have a reference to a decision-making situation. In the application perspective, the use of a product is assumed, which must be available accordingly. ROLLAND et al. recommend a classification of scenarios based on form, content, purpose and life cycle (Rolland et al., 1998, p. 45; Weidenhaupt et al., 1998, p. 35). FILIPPIDOU identifies form- and content-related comparison criteria for the classification of scenarios based on a literature analysis (Filippidou, 1998, p. 5) (extended based on (Jarke et al., 1998; Pohl, 2010, p. 148; Rolland et al., 1998; Weidenhaupt et al., 1998, p. 37)).

Table 1. Criteria to categorize scenario types

Layer 1	Layer 2	Values
form	degree of formalization	informal to formal
	form of presentation	statistical to animation/simulation
	stakeholder input	purely synthetic to intense (workshops etc.)
	abstraction hierarchy	existing (e.g., use case models) to not existing (unstructured, without underlying schema)
	complexity hierarchy	Existing or non-existing classification with regard to a combination of generalization and specialization
	method of generation	automated (e.g., (Bagschik et al., 2018, p. 1816)), reference models, ...
	method of analysis	observatory, argumentative, automated
	intention	descriptive, explorative or explanatory (Pohl, 2010, p. 148)
content	concreteness	„3ague“ (e.g., future scenarios) to detailed (e.g., test scenarios)
	boundedness	specific situation to “big picture” (overarching, generic view), system-related differentiation into system-internal, interaction and environment/context scenarios (Jarke et al., 1998; Pohl, 2010, p. 148)
	plausibility	differentiation between desired/positive scenarios and scenarios to be avoided/negative scenarios or scenarios that contribute to or jeopardize objectives (incl. misuse scenarios) (Pohl, 2010, p. 148)
	visualization	current/actual/indicative vs. planned/optional scenarios (cf. (Jarke et al., 1998, p. 157)), also differentiation between instance and type scenarios (Pohl, 2010, p. 148); supplements are anticipated scenarios
life cycle	criticism	not done – testable/possible – tested/iterated
	evolution	temporary scenarios with dynamics vs. persistent scenarios
	alternatives	alternatives: main, alternative and exceptional scenarios (Pohl, 2010, p. 148)

Requirements Engineering: Practice und Interaction Scenarios

Requirements engineering is a cooperative, iterative and incremental process (Pohl, 2010). It includes eliciting, analyzing and structuring, documenting, negotiating and specifying as well as managing and validating requirements (Pohl, 2010, 41ff; Rupp, 2014). The use of scenarios as auxiliary artifacts is taken up in Scenario-Based Requirements Engineering (A. G. Sutcliffe et al., 1998). Scenario types in the development of e.g. requirements and prototypes require a concrete, possibly simulatable and at least semi-formal form of representation. They are used a) to represent a current state or a current situation or b) to describe a desired state or a desired situation (Pohl, 2010, 149ff). ROSSON and CARROLL emphasize problem scenarios in the first case (Rosson & Carroll, 2008, p. 26). In the future-oriented case, the focus can be on interaction with the technical system to be developed (interaction scenario, e.g. in the form of user stories or use cases). Anticipated errors in product use (misuse scenario), deliberately incorrect use (abuse scenario) and even threat scenarios can be modeled here (see, e.g., (Gräßler et al., 2020; Tuma et al., 2018)).

RELATED WORK IN MODEL-BASED SYSTEMS ENGINEERING

The largest group of related work deals with metadata modeling for scenarios in requirements development. ARRUDA et al. develop the BD-REAM in the form of an entity-relationship model (Arruda, 2020; Arruda & Madhavji, 2017). Big data requirements are placed in the context of software, system and quality requirements, test and business cases. In a software implementation (QualiBD), for instance the completeness of a requirements set is checked (Arruda, 2020, p. 157). BERKOVICH et al. develop a domain mapping matrix (DMM) for mapping relations of different requirement types (Berkovich et al., 2014). Even though “needs” are explicitly addressed, a formal mapping seems to start later at the level of customer requirements. The Scenario-based Requirement Model (SBRM) from Xi et al. models scenarios from the perspective of requirements: A requirement is visualized by scenarios, processes and rules contained therein (Xi et al., 2019). This perspective is deepened by the ontology development in this domain (see, e.g., literature studies (Castañeda et al., 2010; Dermeval et al., 2016)). ReqIF, as mentioned above, contains a data schema for “SpecObjects” (requirements) and “Specification” (requirement set) (Object Management Group [OMG], 2016). There is no abstraction to the semantic level here, only recommendations for the exchange of requirements artifacts. TUDORACHE models dependencies between development artifacts including requirements. It uses the semantic level to check consistency, conformity and compliance with the specification by means of “design models” (Tudorache, 2006). The SoftWiki Ontology for Requirements Engineering (SWORE) is a central work in terms of metadata modeling (Riechert & Berger, 2009; Riechert et al., 2007). SIEGEMUND is more specific in the area of the representation of metrics (also in the form of qualitative SoftMetric), test cases and obstacles (Siegemund, 2014, p. 60). He maps the response to uncertainty with reference to risks, without modeling the uncertainty directly. Individual works focus on requirements change management. ALSANAD et al. present an ontology that declares the requirements, parts of requirements and requirements sets for the Aspect_of_Change as reference objects for changes (Alsanad et al., 2019, p. 49357). Uncertainty is part of the motivation in some works (e.g. (Heling et al., 2018)), but only in a few approaches explicitly part of the solution approach. FEHLMANN et al. do not focus on the representation of uncertainties, but describe the propagation of “customer needs” to use cases or test cases (measurable e.g. via the number of bugs) (Fehlmann & Santillo, 2007, p. 204). The solution approaches mentioned are presented in Figure 1 in a comparative overall context. Work that focuses on the work processes for creating these scenario artifacts without explicit modeling is not considered here (see, e.g., (Georg et al., 2015)).

Criterion	<ul style="list-style-type: none"> ● focus area ◐ partial approach ○ only initial - no contribution 				
	Formalized management of scenario data	Traceable RE metadata model	Traceable interfaces to other development artifacts (internal)	Traceable interfaces to underlying sources (external)	Explicit representation of uncertainty
Arruda et al. (BD-REAM, 2017/2020)	○	●	●	-	-
Berkovich et al. (2014)	-	◐	●	-	-
Xi et al. (SBRM, 2019)	●	○	-	-	-
Kügler et al. (2018)	-	◐	◐	●	-
ReqIF (2016)	-	●	○	-	-
Tudorache (2006)	-	◐	●	-	-
Riechert et al. (SWORE, 2007/2008)	◐	●	○	-	-
Siegemund (2014)	◐	●	-	-	○
Alsanad et al. (2019)	-	○	●	-	-
Fehlmann et al. (2007)	-	○	○	○	●
Binger (2006)	●	-	-	◐	◐

Figure 1. Related work on impact-oriented, scenario-based Systems Engineering

CLASSIFICATION AND ABSTRACTION OF SCENARIOS

Along Systems Engineering phases, different scenario types are relevant (Anggreeni & Voort, 2007), which are incorporated in Figure 2 based on criteria in Table 1: Illustrative scenarios in the form of explorative scenarios (e.g. (potential) stakeholder stories) and actual or intended practical scenarios serve to reduce ignorance in early phases of the V model. Interaction, detailed scenarios and validation/test scenarios are used in later phases, also closing feedback loops across engineering iterations.

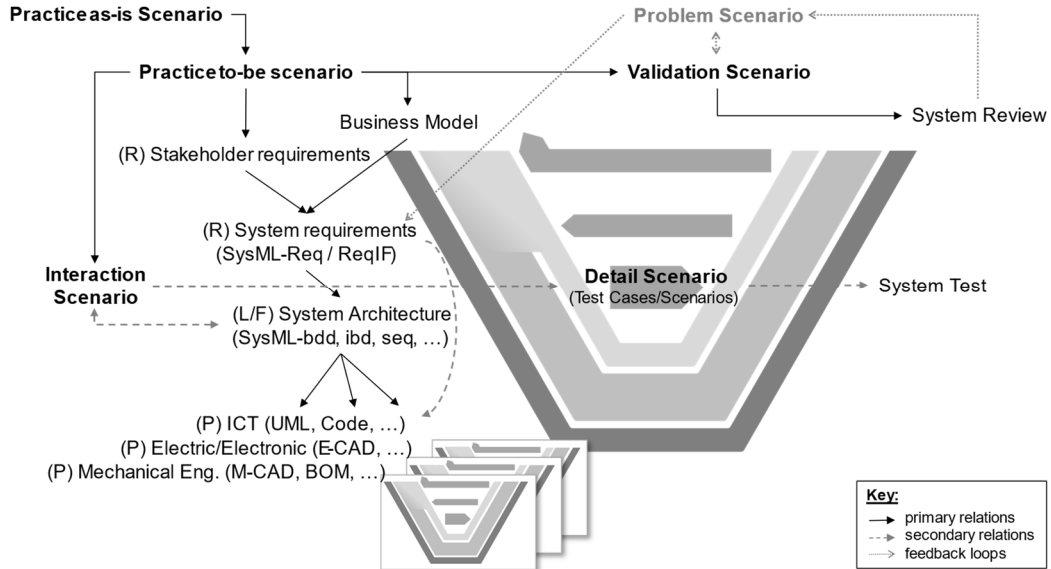


Figure 2. Utilization of scenarios along (Model-Based) Systems Engineering tasks

Classification of Scenarios

Based on the classification scenarios, basic assumptions can be made with regard to the dependence on information quality (Figure 3). Modeling and representation in the form of information resources is usually carried out using standard software as an authoring tool (e.g. Microsoft Office). Special tools can be used in scenario management, but are rarely in productive use (see as an example (Anggreeni & Voort, 2009)).

		<ul style="list-style-type: none"> ● high ◐ dependent on implementation ○ low 														
		Possible degree of formalization	Dynamics in the form of presentation (simulation)	Independence from stakeholder contribution	Existing abstraction hierarchy	Specificity in complexity hierarchy	Automated creation	Automated analysis	Intention (observational to explanatory)	Concreteness	Boundedness	Degree of plausibility assurance	Degree of visualization	Degree of criticism received	Dynamics of a possible evolution	
1	Future Scenario	○	○	○	○	○	○	○	●	○	○	○	○	○	○	
2	Explorative Scenario	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
3	Practice Scenario	as-is	○	○	○	○	○	○	○	○	○	○	○	○	○	
4		to-be	○	○	○	○	○	○	○	○	○	○	○	○	○	
5	Interaction Scenario	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
6	Problem Scenario	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
7	Detail Scenario	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
8	Validation Scenario	○	○	○	○	○	○	○	○	○	○	○	○	○	○	

Figure 3. Classification of scenarios with corresponding interrelations

Abstraction of Scenarios

The definition of scenarios is initially based on the definition of a scenario type and an associated scenario form. Figure 4 shows a corresponding procedure with reference to data sources. These include free text, structured text, images, animations or simulations, state charts, process models, activity and interaction diagrams (Weidenhaupt et al., 1998, p. 37). For these types of scenarios, formalized and standardized forms are defined to varying degrees. Depending on the type of scenario, priorities are set: For example, while state machines (standardized as part of UML and SysML, among others) emphasize the relationship between events and states and activities are secondary, the latter are the focus of process models (e.g. UML/SysML, eEPK and BPMN) with only implicitly recognizable state changes. In line with this focus, data and information are collected and processed in order to design scenarios. These are purpose-related. Validation is recommended as a prerequisite for reuse (A. G. Sutcliffe et al., 1998, p. 1074). One example is the use for requirements elicitation and later for the derivation of test cases.

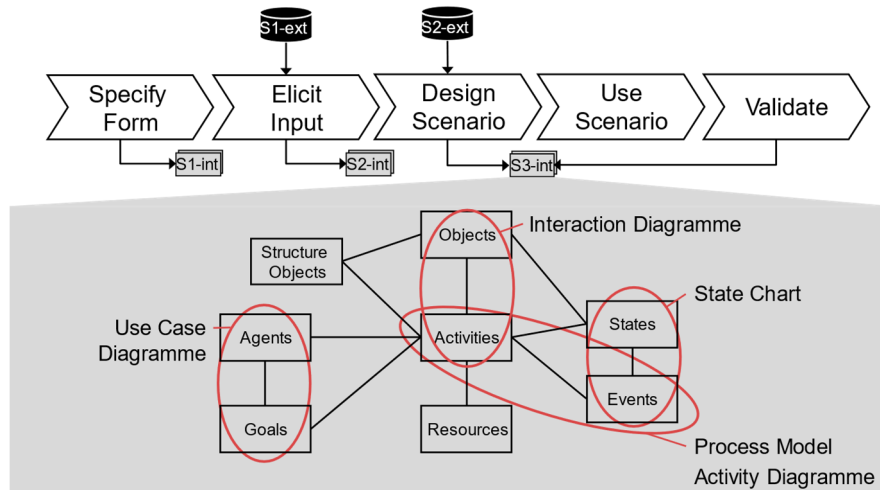


Figure 4. Scenario definition, elements and types (based on (A. Sutcliffe, 1998, p. 51; A. G. Sutcliffe et al., 1998, p. 1074))

The input (S1-ext) is collected, for example, through observation or questioning, content analysis on the basis of specifications including underlying regulations or the interpretation of experiences from previous product generations. As a result of this step (S2-int), ignorance with regard to the initial data must be taken into account as well as ignorance with regard to the relevance for the product to be developed. When designing scenarios, (partial) scenarios that have been defined for comparable products and product types can be reused (S2-ext). The indeterminacy in the design of scenarios as an active, decision-making activity results from the selected form (S1-int) and the content depicted therein (S3-int). Both forms of uncertainty must be examined in the validation.

Conceptualization of Practice and Interaction Scenarios

A metadata model to support scenario-based requirements engineering must support the use of scenarios in the activities from elicitation to analysis and validation of requirements. Accordingly, the differentiated integration of scenarios in requirements engineering must be realized on the one hand, and integration into the higher-level system model on the other. In addition, the projections of future requirements and the risk of change to requirements are challenges in requirements analysis (Graessler et al., 2020).

Requirements should be modeled in a (semi-)structured way. Templates prepare the formalization of metadata and can be used as a basis for conceptualization. Natural language is used for the representation of requirement descriptions. Requirement attributes are defined in the SysML requirement artifact specification, among others. (INCOSE, 2014). Templates are available in the form of the Volere template for requirements (Robertson & Robertson, 2013) and the SOPHIST schemas for requirement descriptions (Rupp, 2014). Its use ensures both a high degree of structuring and flexibility for intuitive descriptions. The semantic model is extended by an ontology for requirements engineering, which is based on the „SWORE – SoftWiki Ontology for Requirements Engineering“ (Dermeval et al., 2016; Riechert & Berger, 2009; Riechert et al., 2007). According to ReqIF (OMG, 2016, p. 12) and the concept introduced by BEVAN et al. (Bevan et al., 2018, p. 8), a distinction between stakeholder requirements and system requirements is recommended. Requirements are logically bundled into sets, which in turn are documented in specifications at defined points in time or events.

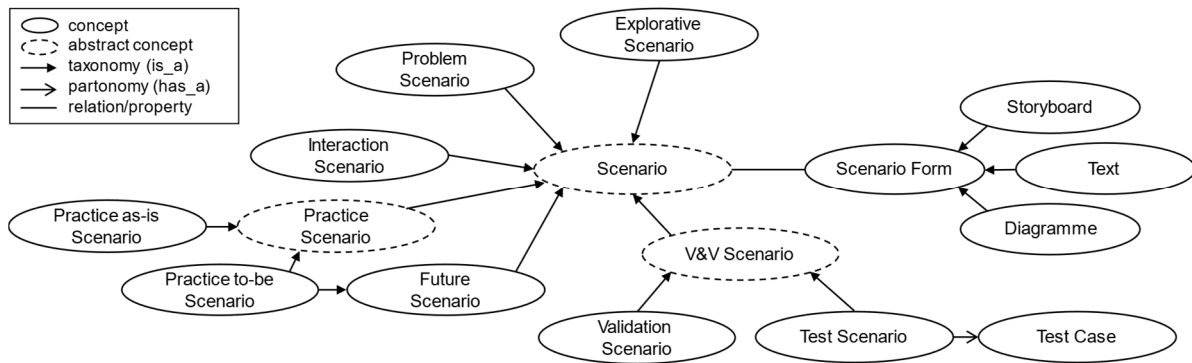


Figure 5. Representation of scenario types and their interrelations

The basis of the conceptual model presented in Figure 5 is attributed by the above-mentioned properties. As special scenario form, practice scenarios are derived as indicative actual or optative target scenarios. Future scenarios depict needs or serve to illustrate business cases. They have an explanatory effect or are used for exploratory analysis (Anggreini & Voort, 2007). This prepares the ground for both market-oriented and order-related use. Interaction scenarios are derived in a solution-oriented manner, which can also be expressed in the negative form of problem or even misuse scenarios (Pohl, 2010, p. 148). Validation scenarios in the broader sense mentioned above are concretized in terms of Verification and Validation (V&V). Such V&V scenarios are understood as an abstract concept which is detailed by validation scenarios (involving end users or representatives) and test scenarios. Test scenarios are either created based on test cases (e.g., when field trials are scheduled from scratch), or test cases are incorporated into existing test scenarios (e.g., when an exercise is already scheduled).

ADOPTION FOR INNOVATION IN WEATHER-INDUCED EMERGENCIES

The value of traceable scenario utilization of discussed based on two successive exemplary projects. They focus on the algorithms and technical capabilities indicated by the layers in Figure 5. In general, data needs to be integrated including both the current situation (data collected until t_0) and a projected situation (anticipating situation at t_{+m}). Challenges subsume spatial and temporal domains. All layers are based on efficient data acquisition. They include the entire chain from processing close to the sensor, extraction of information and its visualization. It is crucial to ensure explainability in the user interface. Instead of technical explainability, which is understood as technical measures to explain the underlying model, solutions are required to provide decision-makers with information that they perceive as “sufficiently explained”. In this case example, rescue robotics (Kruijff-Korbayova et al., 2021) are combined with a Geo Information System (GIS) which was built on the basis of results from the ANYWHERE project (see Figure 6, cf. (Abily et al., 2020; Van Lanen et al., 2019)). Users include civil protection, but also public or private institutions such as water management or the management of flood evacuation plans in campsites. This functional basis is available to implement and discuss the chain of interdependent scenarios. Figure 6 shows the processing levels from data at the bottom to visualized information on top of the stack. The vision of CREXDATA is to develop a generic platform for real-time critical situation management including flexible action planning and agile decision making over data of extreme scale and complexity. Temperatures, videos, forest fire index and wind conditions are indicated as examples of data at the bottom. All of these data types are processed using methods such as trained classifiers or Complex Event Forecasting (cf. (Pottebaum et al., 2012)). An ‘explainability layer’ in the sense of eXplainable AI (XAI) complements content with additional information that is understandable to humans. This creates the basis for applying visualization approaches.

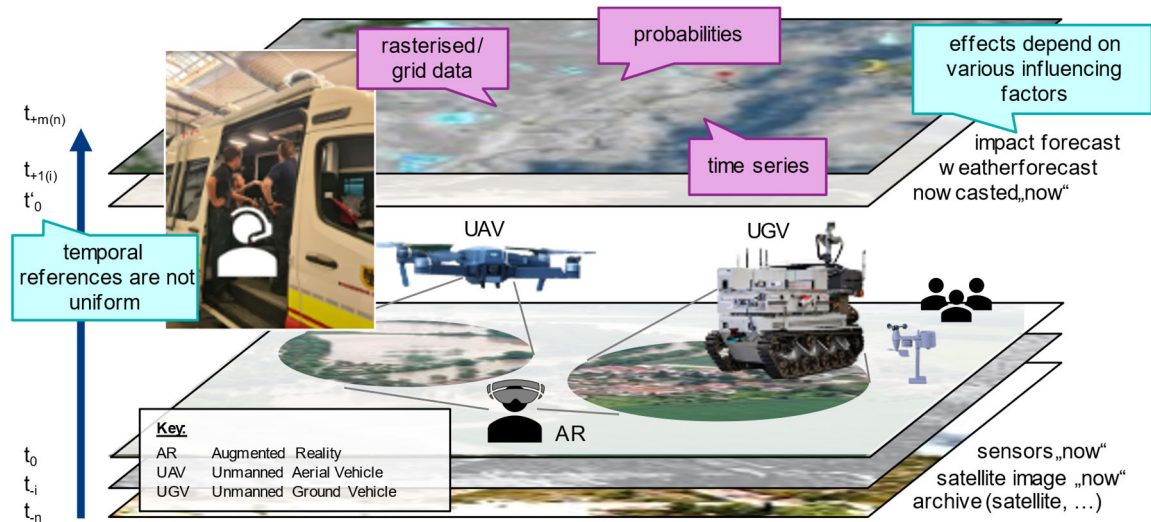


Figure 6. Exemplary case of an ICT solution to support multi-level decision-making in extreme weather scenarios considering global data, for example provided by UAV/UGVs and meteorological services (Pottebaum et al., 2023).

The design of the system is extremely challenging due to several reasons. In addition to the general challenge that there is a large gap between technical opportunities and technologies actually deployed, such reasons include:

- complexity of stakeholder landscape and use cases across functions/institutions (breadth of use cases) and along hierarchy of command (depth of use cases)
- sparsity of extreme weather events, implying that only few experienced stakeholders can be acquired
- variety of domains, often requiring deep knowledge up to scientific competences (like meteorology)
- intellectual Property across data sources, with heterogenous users and their licenses
- variety of technical interfaces
- uncertainty of data along the data processing pipeline

Therefore, the concept of scenarios was applied from early explorative phases through requirements engineering to planning of evaluation with laboratory settings and field trials. Figure 7 presents an overview of the approach incorporating different types and forms of scenarios utilized in impact-oriented research.

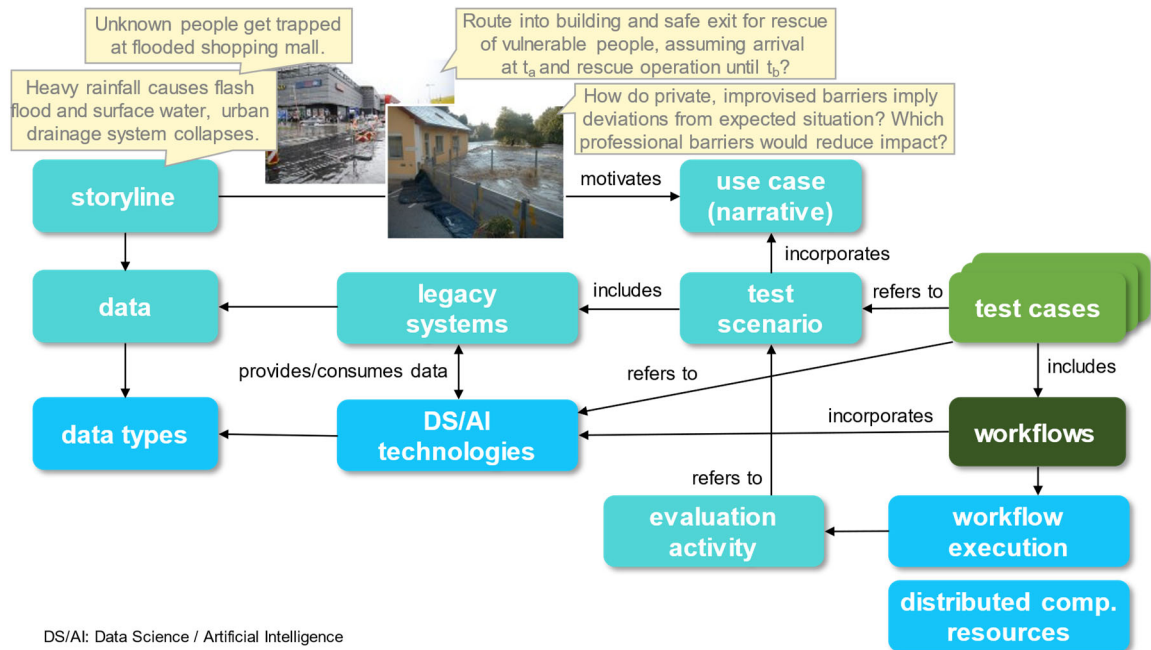


Figure 7. Adoption of various types of scenarios in research on utilizing extreme data with high uncertainties for precise decision support in weather-induced emergencies

The explorative phase of the CREXDATA project was supported by informal “storylines”, established in the form of storyboards. Two storylines are created in intense stakeholder meetings to detail the general “pluvial urban flooding” scenarios. In the first storyline, the evacuation of a shopping mall in Dortmund (Germany) with heterogenous visitors is required. In the second storyline, water management with barriers is needed to assess and to avoid threats to traffic and buildings in Innsbruck (Austria). Individual steps within these storyboards become referable by linking them to simple activity diagrams. Process modelling with Business Process Model and Notation (BPMN) simplifies uptake of existing process models wherever possible. From such storylines, an early exploration is possible regarding relevant data (cf. distinction of global and local data introduced above) and corresponding data types. This is essential in projects that envisage uptake of Data Science (DS) and Artificial Intelligence (AI) technologies. For instance, for technologies like Complex Event Forecasting (CEF), time series data is required in combination with logical modelling of relevant event types to be recognized resp. forecasted. The initial indication on potential data sources enables a two-sided approach: Potential event types can be prescribed by users parsing storylines stepwise, and data sets can be analyzed by CEF partners to identify patterns in data without in-depth domain knowledge. Problem-oriented storylines as explorative scenarios and practice as-is scenarios are transformed into practice to-be scenarios and use case narratives. Such narratives still subsume sketches and natural language bodies but described in a solution-oriented way. These artefacts incorporate knowledge about the technologies to be integrated into the system under development. Bridging system design and system Verification & Validation (V&V), test scenarios are derived. Each test scenario subsumes specific test cases. In research on DS/AI data processing, test cases refer to specific data processing workflows designed using Altair RapidMiner Studio. Test scenarios are utilized with respect to evaluation activities in a two-fold approach: On the one hand, scheduled exercises of stakeholders are identified and checked for applicability in the CREXDATA project. Often, exercises conducted by stakeholders like civil protection authorities, technical relief agencies or fire departments anyhow are most realistic measures for gathering feedback. Researchers need to map exercise objectives and evaluation objectives. On the other hand, field trials are scheduled with the dedicated purpose of evaluation. Practicing procedures is a side-effect for stakeholders then. For the CREXDATA project itself, the mapping of evaluation activities to workflows through test scenarios and test cases ensures traceability of results, enables actual conclusions from application to data processing foundations, and simplifies communication among all partners.

CONCLUSIONS

The article summarizes different types of scenarios based on the literature. A focus is set to scenario types utilized in Requirements Engineering, as there is a variety of background available to gather feedback from stakeholders. Related work in the field of MBSE is adopted for application in emergency management. Scenario types subsume problem-oriented types like exploratory and practice as-is scenarios, as well as solution- and, as such, impact-oriented types like practice to-be and interaction scenarios. The concept for the conceptualization and abstraction of different types of scenarios covers the entire chain from domain exploration to the evaluation of the impact of a technology in this domain. It is based on the V model of Systems Engineering. Using a case study relating to possible pluvial urban flooding situations, the added value that arises along the chain from actual practice scenarios to target application scenarios and validation scenarios is discussed based on two successive exemplary projects. As a conclusion, the mapping along the entire chain from explorative storylines through practice scenarios to evaluation activities ensures traceability of results. The linkage of these scenarios to workflows through test scenarios and test cases enables actual conclusions from application to data processing foundations and simplifies communication among all partners.

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