Continuous systematic situation monitoring: pitfalls and possibilities

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ABSTRACT

Situation pictures are helpful to make sense of what is happening and to prevent further escalation. These situation pictures are typically text- or map-based and focus on the current effects of the crisis. For long-lasting transboundary crises that impact many critical infrastructures and different parts of society directly and indirectly, such situation pictures have limitations. Crisis management teams might benefit from continuous monitoring of societal performance indicators, so the current situation can easily be compared with historical and future data to reveal trends and escalations. This research project explored how a successful approach for systematic monitoring of indicators in crime prevention could be transferred to crisis management. Several pilot studies revealed nine challenging pitfalls and six promising possibilities. The findings of this study can inform future research on how continuous systematic situation monitoring can strengthen societal resilience.

Keywords

Situation awareness, indicators, monitoring, Business Intelligence, Business Continuity Management.

SITUATION MONITORING FOR CRISIS MANAGEMENT FROM A BUSINESS INTELLIGENCE PERSPECTIVE

In the ongoing Covid-19 pandemic, the general public and crisis management teams have got used to seeing data about the number of infected people, hospitalised people or vaccinated people, per area and time period, in diagrams and heatmaps on so called dashboards. Whereas these diagrams most often focused on health related figures, the Covid-19 pandemic has also had an impact on many other parts of society, i.e. the amount of traveling, absence from work, participation in cultural events, shopping behaviour and so on. When second and third order effects of a crisis on all parts of society could be monitored continuously, a richer situation picture of the ongoing crisis would arise. Cross disciplinary crisis management teams, who coordinate the societal crisis response, could benefit from such overviews in different ways. First, the teams could experience how different indicators are increasing or decreasing over time (i.e. whether the impacts of the crisis are escalating or have been mitigated). Secondly, the team could become aware of unexpected second- and third-order effects of the escalation.

Business Intelligence (BI) has been applied by organizations for decades. It is often defined as an umbrella concept that includes a set of technologies and software that enables users to access and analyze data in order to make better decisions (Wixom and Watson, 2010). In a similar way, Foley and Guillemette (2010) define BI as "*a combination or processed, policies, culture, and technologies for gathering, manipulating, storing, and analysing data collected from internal and external sources, in order to communicate information, create knowledge, and inform decision making.*" Typically, BI gathers relevant data from operational systems internally as wel as from external sources, and stores this data in a datawarehouse where it can be accessed by analists or decision makers by means of queries. According to Olszak and Ziemba (2012), realising BI in organisations is challenging from multiple perspectives. Amongst many other issues, it is critical to realise data access and guarantee data quality, it is required that employees get sufficient education so that they use the BI tools in the correct way, and finally much effort should be put in creating awareness for the benefits of BI for the organisation. The latter involves amongst others to select the most relevant indicators, rather than many indicators that are of minor interest (Rockart, 1979). There are not so many studies that have discussed how BI could be applied in a crisis management context, see Panrungsri and Sangiamkul (2017) for an exception.

As BI involves continuous data collection, processing and visualisation of data for decision making over long periods of time, and crises are often rather ad-hoc in nature, it is not self evident to apply BI in this context. It is envisioned that continuous monitoring of the status of for instance critical infrastructures and other important

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societal services, could inform crisis management teams when a crisis is occurring. When the crisis hits, it would instantly become visible what the impact of the crisis is on different critical infrastructures and different parts of society. These indicators are nowadays partly available in many different source systems and web applications, but it requires enormous manual efforts to collect and compile data for the crisis management team. A BI approach would instead result in automated collection of the most relevant data sources and present easy to consult data in a dashboard on a web portal. To apply BI methods in a fruitful way, BI could be integrated with insights from situation awareness theory (Endsley, 1995; Wolbers and Boersma, 2013) and Business Continuity Management (Herbane, 2010; Hassel and Cedergren, 2019), which are research areas that have been applied in a crisis context more frequently.

This study has explored what pitfalls and possibilities could arise in the development of continous systematic situation monitoring for crisis management.

SITUATION AWARENESS AND BUSINESS CONTINUITY MANAGEMENT

Endsley (1995) describes how the creation of situation awareness involves data collection from many sources to create a data driven overview of the current situation (i.e. what is commonly understood as a situation picture or common operational picture in crisis management), and how that next needs to evolve in interpretation of the current situation (what does the observed data mean to us?) as well as prediction of future states (how do we envision that the situation may develop or escalate?). From a socio-technical research perspective, the use of situation pictures involves a lot of acts of interpretation (Wolbers and Boersma, 2013), and the same holds for the data collection phase. Endsley (1995) shows how our values, beliefs and assumptions not only influence interpretation, but also affect what data we collect in the first place. In this way, the situation awareness model does highlight that data collection from a BI perspective should not only be seen as data management and a "*technological tools problem*" (as is acknowledged in many BI methods). At the same time, BI could clarify how the data collection phase of the situation awareness model could be organised more systematically and effectively by guiding what data to collect and automating the collection process.

Whereas BI adresses the continuous gathering and monitoring of key performance indicators from an everyday business perspective, Busines Continuity Management (BCM) has in more detail studied indicators related to risks, threats and minimal service levels for critical systems and infrastructures (Herbane, 2010; Hassel and Cedergren, 2019). Although BCM primarily does these kind of analyses from a prevention perspective (i.e. analysing what the most critical risks are, and identifying actions to prevent escalation before the crisis hits), these indicators, and the challenges involved in representing them in an appropriate way, could be very informative when identifying indicators for a crisis management dashboard from a BI perspective. Whereas a BCM analysis judges the potential impacts of simulated crisis scenarios, BI would monitor the actual state of the same indicators before, during and after a crisis event to visualsise the actual impact. Hassel and Cedergren (2019) discuss multiple challenges in choosing appropriate indicators, as for example the definition of threshold values (what performance is acceptable and not acceptable), the pros and cons of measuring something in absolute numbers, and the influence of the chosen time interval for the shown measurements (i.e. per hour, per day, per week and so on).

SITUATION MONITORING FOR CRIME PREVENTION: A SUCCESSFUL EXAMPLE

In this research project, a case from crime prevention served as a best practice example. The crime prevention process previously had a resembling resource demanding and time consuming manual process of data collection. Researchers and practitioners have succeeded in gradually transforming an ad hoc manual data collection and analysis process into a fully digitalised work process where data vislualisation includes heat maps and graphs showing trends over time. Whereas now, respondents from many different organisations on a weekly basis report incidents via a phone app by clicking their exact location on a city map, and next describe what happened including a time stamp, the same process was earlier done by listing incidents with much more rough indications of time and place in text (most often an e-mail). Consequently, the resulting overviews were previously "*one pdf file for each week and a lot of text that was hard to compare over time*", and is nowadays portrayed in a web portal where reported and collected incident data can be analysed from many perspectives by for example selecting area, period and type of incidents (see images at https://www.embrace-safety.se/ in order to get an impression).

The main success factor of this way of working is not the technological tools or the attractive visualisations. Rather, users of the approach emphasise the cyclical systematic work process as the key cornerstone, i.e. consistently collecting data on what happens in your own city/area so you become more knowledgable. Preventive actions are based on analysis of facts, rather than on opinions and assumptions on what the most exposed areas are. Furthermore, much effort has been put in making data collection "*easy*" (some quick clicks in a phone app). The most important feature is however "*systematic*", i.e. every week reporting incidents in fixed categories (which enable comparision) as well as reporting them in a very detailed way with respect to time stamp and location.

RESEARCH DESIGN

The aim of the research project was to explore how the best practice example of continuous systematic situation monitoring could be transferred from the context of crime prevention to the context of crisis management. The project team consisted of entrepreneurs (two IT companies), end users (municipalities, police, rescue services) and two researchers. One of the researchers has been studying crisis management for over 15 years (first author), the other researcher has a been studying implementation of Business Intelligence for about 6 years (second author).

In Sweden, the municipality has a so-called geographical area responsibility at the local level, which aims at stimulating collaboration between all actors involved in a crisis, while not overruling or taking away the existing sector responsibilities of all involved organizations (Wimelius and Engberg, 2015). A similar integrating role with geographical area responsibility exists at the regional level (the county) and at the national level (the Swedish government). The geographical area responsibility involves coordination before crises (risk analysis, training) and during crises (alarming relevant actors, coordinating their response efforts, communication with the public) while the partners involved may differ from crisis to crisis. Consequently, situation monitoring from an all hazards perspective, and together with other relevant societal actors analysing impacts and their potential escalation, is a vital part of the geographical area responsibility. Respondents in this study are municipality officials and representatives from other government agencies and companies that actively participate in cross sectorial crisis management in Swedish society.

The research approach follows an interpretative philosophy and inductive research strategy as the aim is theory building rather than theory testing (Eisenhardt & Graebner, 2007). An inductive research strategy is appropriate as there are no clear theories on how to establish continuous situation monitoring for crisis management. To develop hypotheses on what such a theory could include and address, a qualitative research method was followed. Qualitative research is particularly suited for how and why questions, in this case: How can continuous situation monitoring be applied in a crisis management context? Why can certain elements of strengths of the crime prevention best practice not easily be transferred to the crisis management context? To obtain the research aim a number of small studies were conducted in order to illuminate different perspectives of the research problem. These small studies were planned in a rather agile way. Each time a currently interesting subquestion was identified, and a small study was designed to collect relevant research data on that matter (see table 1). Research data was continuously analysed for each study individually, and for the overall research project as a whole.

Table 1. Series of substudies in the research project

Research question	Data collection methods
Why is the crime prevention case a successful best practice?	document study, interviews
How are situation pictures nowadays created in ad-hoc crisis management at the local level?	document study, interviews
How are crisis situation pictures created for regular monthly orientation meetings at the regional and national level?	document study, interviews
How can continuous systematic situation monitoring be implemented in a crisis management context?	interviews, project team meetings
How can a prototype for electricity indicators look like?	document study, interviews, project team meetings
How can a prototype for food distribution indicators look like?	document study, interviews, project team meetings
How can a prototype for social health indicators look like?	document study, interviews, project team meetings
How can a prototype for staff absence indicators look like?	document study, interviews, project team meetings
Why is it so challenging to transfer the crime prevention best practice to the context of crisis management?	interviews, project team meetings

The first three studies aimed at understanding the current situation (i.e. the strengths of the crime prevention case, as well as the current way of creating situation pictures for crisis management). From these first three studies, ideas arose how the method could be applied in the crisis management context and these ideas were tested and

discussed both in the project team and in interviews with end users not part of the project team. Next, four small prototype studies were conducted to see what kind of indicators could be identified. The areas of interest for these studies were chosen in consultation with end users. During the four prototype studies it became more and more obvious that transferring the crime prevention best practice to the context of crisis management was far from self-evident. As a result, the final study was initiated. The final study identified typical challenging pitfalls but also promising possibilities which are presented in the results section of this paper. Although this paper primarily focuses on answering the final research question, data collected throughout the previous eight substudies has contributed to the cumulative understanding of the phenomenon of interest. Data analysis involved identification of themes in the document study summaries, the interview transcripts and the project meeting notes. Themes were roughly categorised as hampering (pitfall) or enabling (possibility) which resulted in the list of themes presented in table 2 in the results section.

The studies were performed under 2020 and 2021 in Sweden, i.e. under the same period when many of the respondents and societal collaboration partners have been handling the Covid-19 pandemic. It needs to be emphasised that the research question already had been identified before Covid-19 struck, but that the execution of the project and obtained results clearly have been influenced by how the respondents and collaboration partners were experiencing crisis management of the Covid-19 pandemic.

PITFALS AND POSSIBILITIES OF CONTINUOUS SITUATION MONITORING FOR CRISIS MANAGEMENT

Data analysis revealed nine pitfalls hampering continuous situation monitoring for crisis management and six possibilities that would enable applying the successful best practice of the crime prevention case in the context of crisis management. The pitfalls and possibilities are discussed below.

Table 2. Pitfalls and Possibilities of Continuous Situation Monitoring

Pitfalls
Data Gathering is Time Consuming and Ineffective
A Few Respondents Determine the Situation Picture Content
Situation Pictures show the Current Situation and lack a Historical and Future perspective
Data Formats do not Allow Comparison of Indicators over Time
Decision Makers cannot Easily Identify Performance Indicators
Different Indicators are Key Performance Indicators depending on What is at Stake
Informative Levels of Detail may Threaten Privacy and Integrity
Available Data is not always Actionable Data
Respondents and Decision Makers lack Incentives to Monitor Continuously

Possibilities
Open Data is Available at Many Different Public Agencies
The Covid-19 Pandemic is a Strong Illustrative Case for the Value of Monitoring Indicators
Continuous Monitoring of Indicators can Complement Text Based Situation Pictures
Continuous Monitoring of Indicators can Reveal Neglected Second Order Escalations
A Dashboard with Potential Indicators can be Developed Incrementally
Start with Automating Data Gathering rather than Indicator Interpretation and Interaction

Pitfall: Data Gathering is Time Consuming and Ineffective

Currently, when local municipalities are preparing situation pictures during the Covid-19 pandemic, or when regional and national authorities are preparing situation pictures for regular general (all hazards) collaboration meetings, data collection involves many ad-hoc manual routines and is poorly routinized or automated. Questions are sent out to internal departments or external partners by mail or via dedicated communication systems (i.e. systems only used for crisis management). Independent of what software is used, a recurrent observation is that questions and answers are copy pasted from one system to another several times by different people and that information collected needs to be manually processed or summarised several times before it has been travelled all

the way from information source to the crisis management team that needs the compiled overviews. Also, those people that need to provide the source information, are often the ones that are most pressed by the ongoing crisis. Sometimes, they are not creating "*new*" information, but copying information that is already digitally available in their own internal systems into word processing or spreadsheets that are sent out by crisis management teams at the local, regional or national authorties. Consequently, the crisis management teams get reluctant in requesting more information "*we would like to know more from them, but we do not want to put them under more pressure, so we only send out the questions of the national agencies and refrain from adding our own questions*". At the same time, security officers are heavily occupied themselves with operational information processing duties, leaving less time left for more strategic coaching of their organisations "*it takes me a lot of time twice a week to collect, copy-paste and summarize all responses from the different departments and compiling it into the situation picture for the crisis management team meeting*".

From a situation awareness theory perspective it is desirable to put as less effort as possible into data collection, and to put most energy in the important process of interpreting the information at hand. Business Intelligence methods include clear directions how such processes can be automated to a much larger extent, which would make situation monitoring in crisis management more effective.

Pitfall: A Few Respondents Determine the Situation Picture Content

A respondent argues: "*So, we send out the questionairre to an organisation with over 5000 employees, but we do not really know whether the contact person is answering all the questions, whether the contact person fills in the answer together with their crisis management team or leadership group, or whether the contact person sends out the questions to different experts in each and every department of their large organisation. So we do not know if the opinions returned are the answer of one representative, or from many knowledgeable experts*". The severity of this pitfall is a litte dependent of the type of information that is collected. When the organsiation reports hard facts, it is less important who copies those given facts from the source system into the questionairre. However, when the questions require free text answers, or when the questions involve an evaluation on a 5-point scale (i.e how does the crisis impact schools in your municipality?: "*no impact*", "*moderate impact*", "*significant impact*", "*serious impact*" or "*critical impact*"), it is more important to know whether this is the impression or opinion of the contact person, the top management, or different topical experts spread out in the organization. A benefit with one person/group answering would be that the answers "*critical impact on schools*" and "*moderate impact on culture and leisure*" are weighed against each other by the same evaluator. When different experts from different divisions determine the impact on each of their respective units seperately, this could give a more valid answer for each of them, but at the same time various people might interpret the scale (what is moderate, what is serious) rather differently. In the end, the collected figures showing "*what parts of society are suffering most*" might have rather dramatic consequences for resource allocation or other crisis mitigation matters.

Both situation awareness theory and Business Intelligence methods address data quality, validity and reliability as an important point of attention. In situation awareness, fusion or triangulation of data sources (i.e. combining different information sources about the same phenomenon) is one remedy, and carefullness in interpreting the meaning of data (i.e. in going from situation picture to situation awareness) is another. Business Intelligence suggests clear data definitions (i.e. what is meant with questions, how should the answer options be understood) and highlights routines for data cleaning (i.e. correcting unlogical answers or outliers). As outliers or unexpected values could be correct in extreme crisis episodes, such routines need to be adjusted for the crisis context.

Pitfall: Situation Pictures show the Current Situation and lack a Historical and Future Perspective

In crisis management, situation pictures show the current situation. A crisis is most often an ad-hoc event and the need of the crisis management team is to understand and judge the severity of different consequences just now, rather than following the same figures or phenomena under a very long time period. Crisis managers do absolutely see the need of thinking ahead, the need to foresee undesirable escalations, and are aware that their current decisions may have an impact in a couple of days or weeks, and not immediately. Despite that, their situation pictures address the current state. The so called "*estimations of future states*" are either dealt with in other documents "*we have a scenario group working with different escalation scenarios, so that is addressed in another document, not in the situation picture*"; or in the meetings where the current situation picture is discussed "*from the current situation picture we reason about how we expect things to become worse*". An interesting observed difference between crisis management and crime prevention is that crisis managers look ahead (how can we mitigate unwanted consequences?) and crime prevention officers look back (what caused this increase, what can we do to act upon the cause?). In Business Intelligence, the steering philosophy is by nature continuous and long-term with strong interests in analysing the past and predicting the future. During the Covid-19 crisis, dashboards and graphs have popped up in crisis communication and crisis management incidently (i.e. focusing on number

of infected people, number of hospitalised people and number of deaths per region and period). These graphs, and the data collection to continuously update these graphs, are however not systematically organised for a recurring set of key performance indicators as in the crime prevention case, or as in Business Intelligence in general.

Pitfall: Data Formats do not Allow Comparison of Indicators over Time

Consequently, situation pictures are not designed from the need to compare several of them over time. So, a typical comment was "*our situation pictures are a set of pdf files, one for each week or each meeting, if I would want to see the development over time I need to print out the pdf files and put the paper documents in a row on a table*". So, under the Covid-19 pandemic, a typical figure reported every week was "*staff absence*" for different departments. Although these figures are digitally available over time in the HR system, and could easily be presented in a spreadsheet or graph to allow comparision and trend analysis over time, the figures are reported in tables in a word processing or pdf file. Hence, crisis management teams and decision makers focus on the current value rather than trend analysis. Crisis management teams do not recognise the need and do not ask for a spreadsheet, graph or diagram format. As a consequence, data gathering is demanding in time and resources. As the perception is that information needs are unique from crisis to crisis, data gathering and data presentation has historically evolved as consisting of text descrriptions or events/resources plotted on maps, rather than graphs with indicators per region over time.

Pitfall: Decision Makers cannot Easily Identify Performance Indicators

When discussing the envisioned dashboards with indicators capturing the state of important services (i.e. the state of critical infrastructure per area over time) with end users, i.e. decision makers, crisis managers or security officers, a returning problem was that respondents not easily could list their five main key performance indicators (KPIs), as suggested in Rockart (1979). Initially, this surprised us. One would expect that every decision maker knows the critical KPIs by heart. When returning to these observations again and again, it became clear that the respondents were confused due to the crisis management framing. They tried to imagine the next crisis, or all kinds of crises, and come up with indicators for them. They were not focusing on "*what needs to be protected*", but tried to imagine "*what threats could arise and how they could be detected*". Business Continuity Management and Business Intelligence, with their focus on key performance of the everyday organisation and services that are critical to uphold on a certain minimal level, could be very helpful to instruct respondents to think in the right way. Generating a number of suitable indicators is not self-evident and needs careful instruction and faciliation.

Pitfall: Different Indicators are Key Performance Indicators depending on What is at Stake

Another hinder for identifying a limited set of key performance indicators was that the relevance of indicators differs from crisis to crisis. Many respondents, as well as the project team members, repeatedly returned to the observation that depending on the type of crisis at stake, some indicators would be of main interest, while others would be completely irrelevant. For the next type of crisis other indicators would be interesting, and the earlier important indicators would be of less importance. So for each type of crisis, this would imply completely different lists. That would as a consequence mean that an enormous amount of indicators need to be included, while only a few of them would be relevant from case to case. Partly, this would imply that a lot of data would be collected with minimal or no use. Also, this would require flexibility in which indicators are highlighted from crisis to crisis or period to period to prevent information overload issues. In contrast, the crime prevention best practice case is by definition including a limited set of given (i.e. nationally defined) indicators. As such, the whole idea of defining them, and the issue of switching between highlighting different indicators from time to time is less relevant in crime prevention. Whereas recent developments in Business Intelligence, so called Self Service Business Intelligence, accommodate for users to select personal views of data depending on their interests and needs, implementation of such practices is challenging (Lennerholt et al, 2022).

Pitfall: Informative Levels of Detail may Threaten Privacy and Integrity

After having identified some relevant indicators, a next challenge was to define on which granularity data needs to be collected. In Business Intelligence and Business Continuity Management, the perspective is often a single organisation who owns their data. In the case of continous situation monitoring for crisis management, where the problem is approached from a societal perspective and data needs to be shared between different organisations, all kind of privacy and integrity issues may arise. From a crisis management perspective, more detailed information, espcially att the lower levels, could be informative. But, when arriving at small numbers or small areas, data could reveal confidential information of either private companies or private citizens. Hence, different indicators might require different levels of granularity while at the same time it is for comparison reasons between

areas important that data is structured so it is available on similar levels. Trade-offs are required. These are not only governed by what is juridically allowed. Sometimes, organisations owning potentially sensitive data are reluctant to share it, even when juridical experts have said it would be completely fine to share the data.

Pitfall: Available Data is not always Actionable Data

In contrast to "*having a hard time defining indicators*", respondents could also end up in the opposite trap: listing all kind of indicators that they are aware of, without critically asking the question "*would showing that information to a crisis management team be relevant in any way*". This is a typical trap well-known in Business Intellgence. Organisations compile overviews of information that is ready at hand, rather than asking management what information is crucial: "*Why do I have to have dozens of reports a month and yet very little of the real information I need to manage this company? There must be a way to get the information I need to run this company!*" (Rockart, 1979, page 81). Again, Business Continuity Management and Business Intelligence do provide established methods to address these issues. Nonetheless, in combination with the previous experience that respondents have a hard time to identify relevant indicators, facilitators and designers need to be aware of the tendency to pick ready at hand indicators, rather than the indicators which actually are relevant.

Pitfall: Respondents and Decision Makers lack Incentives to Monitor Continuously

A final issue of concern that arose in the data analysis is the need for a clear incentive. Most clearly expressed by one of the respondents: "*but how would you motivate us to discuss all indicators regularly, like we do in the crime prevention process, when there is no actual ongoing crisis: that would be a waste of our time*". So, respondents do not really see the need of continuous monitoring, as they interpret crisis management as something that only is activated "*after something has happened*". Similarly, a resource and time demanding data collection process is questioned. From the current perspective, where organisations put enormous resources in data collection, data processing and compiling situation pictures, these kind of investments are of course not deemed reasonable when there is no ongoing crisis. As stated by a respondent: "*how are you going to motivate employees to fill in weekly questionnaires, when they week after week fill in "no impact" for each and every question*".

In the crime prevention case, similar challenges appear. Here, the act of filling in "*everything fine, nothing to report*" is highly valued and rewarded. In the whole philosophy that a data driven approach, acting on facts rather than assumptions, is the ultimate aim, it is repeatedly communicated that reporting which areas are "*crime free*" is of utmost importance. Also, from a Business Intelligence perspective, a major purpose is to avoid that people repeatedly should copy digitally available data from one system to the other. Instead, it is desirable to solve this with automated protocols, i.e. that data autmatically is transferred from the source system to the dasboard. As mentioned earlier, this may be challenging when data moves across organisational borders. Hence, it is advisable to start with relevant data sources which are not sensitive and can be shared without being questioned.

Apart from the above pitfalls, a number of promising possibilities have been identified.

Possibility: Open Data is Available at Many Different Public Agencies

The four pilot studies have shown that, in Sweden, a lot of interesing data is openly available at many agencies. The Swedish Civil Contingency Agency has listed what can be considered as critical infrastructures, for instance, electricity, data communication, food supply, water supply, transportation and so on. Currently, to create similar graphs as the Covid-19 diagrams that have been available the past two years, security officers would need to go to the public website of each and every sector agency, download a spreadsheet with values (every time the figures are updated), select the data that is relevant for their area, and create graphs to show them in their own environment (which currently would be a pdf file). Instead of that time consuming process which also results in a hard to handle end product, the data sources that are deemed relevant could be collected automatically and shown in a web portal. In future research (i.e. coming substudies) these kind of contributions to a web portal will be developed.

Possibility: The Covid19 Pandemic is a Strong Illustrative Case for the Value of Monitoring Indicators

As shown in the above discussion, decision makers and crisis managers have had a hard time envisioning what the value and purpose of a dashboard showing the status of all kind of critical infrastructures would be. While testing several approaches to clarify with examples which kind of indicators would be of interest, the Covid-19 crisis has proven to be a strong illustrative case. First, as mentioned before, everybody has gradually become used to see graphs which show how the number of Covid-19 cases over time and per area. So it has been helpful to be able to suggest how similar graphs could be shown for other societal indicators. Next, the Covid-19 pandemic is

also a typical example of a long lasting crisis as well as a crisis which Ansell et al (2010) have defined as a transboundary crisis. Over time, the Covid-19 pandemic has had a major impact on different types of societal sectors. Consequently, it has been easy to draw up examples like "*an indicator showing the number of people traveling by train*" or an indicator showing "*the number of people absent from work*". People can now more easily envision how such an indicator could have been informative throughout the whole Covid-19 crisis, compared to before. Therefore, a lesson learned is to import historical data so the distinction between "*normal periods*" (2018-2019) and "*world wide pandemic ongoing*" (2020-2021) becomes visbile. Currently, a lot of such analysis (how Covid-19 impacted traveling, how Covid19 impacted production of goods) are presented in individual reports, where again, tables, figures and graphs are presented in pdf files. Hence, it is argued that such information would be more valuable when it is available in a dashboard web portal, rather than in a bunch of pdf files.

Possibility: Continuous Monitoring of Indicators can Complement Text Based Situation Pictures

Such reports, analysing the impact of a crisis on other societal sectors, are of course more informative when a table or graph is explained or commented by a text fragment which highlights the most important issues and guides interpretation. As such, the proposed dashboard with indicators should not replace map based and text based situation pictures, but rather complement them. In that way a richer situation picture is created which would help crisis management teams in developing understanding how a an ongoing crisis currently impacts different parts of society (and how initiated trends may escalate further). Also, crisis management teams could easily scroll back to earlier episodes (we had a similar storm two years ago, what happened then, which areas and societal sectors were impacted and how?).

Possibility: Continuous Monitoring of Indicators can Reveal Neglected Second Order Escalations

Also, whereas impacts on other parts of society have been discussed and analysed more roughly the past two years, data analysis of the number of Covid-19 cases and closely related health care figures have been scrutinised in much more detail. When the crisis management teams in society would have had detailed indicators on each and every part of society from the start, which automatically are generated without much manual efforts, crisis management teams would have had more time to analyse which parts of society actually are effected. This would probably earlier in the sequence of events, create understanding for second and third order escalations which are harder to imagine for scenario groups. Again, a richer data driven dashboard could inform the crisis management team and improve their analysis capabilities.

Possibility: A Dashboard with Potential Indicators can be Developed Incrementally

Whereas it may be perceived as an endless task to create 100 to 200 indcators that would cover each and every part of society, a more fruitful approach suggested would be to develop incrementally. When two new indicators are introduced every week in an agile development way, the envisioned dashboard will slowly become more and more complete. Such an approach can also be valuable from the perspective that early mistakes are not replicated for numerous indicators. Instead, the process of identifying and automating the data collection of a new indicator becomes more effective over time.

Possibility: Start with Automating Data Gathering rather than Indicator Interpretation and Interaction

Finally, both project team members and end users have mentioned that Artificiell Intelligence (AI) in the long run could help to analyse interaction between indicators, i.e. how a crisis escalates from one sector to others, and also suggest predictions of how these escalations may occur during an ongoing crisis. Whereas these kind of apllications also are attractive, this research shows that major work still has to be done in the preceding data collection phases, which both would free a lot of resources now occupied with gathering and compiling data manually, and which would create a better datavolume for AI to work with.

CONCLUSION

From the above analysis, it is evident that the challenge of monitoring crisis impact from a Business Intelligence perspective does not lie in technical tools or data availability. Rather, major improvements could be attained by clarifying the steering philosophy (i.e. which indicators matter) and addressing the organizational issues (i.e. determining the work flow from data collection to decision making, as well as automating the workflow as much as possible to avoid resource demanding manual operations).

It can be concluded that combining methods and theories from Business Continuity Management and Business Intelligence could create a new kind of situation pictures that are particularly relevant for long-lasting

transboundary crises as the Covid-19 pandemic. As, according to Ansell et al (2010), such kind of crises are expected to become mainstream rather than the exception, it would be worthwile to explore how such kind of critical infrastructre continuity measures (used for preventive analysis in Business Continuity Management) could be transformed to real time Business Intelligence indicators informing crisis management teams under an ongoing crisis. When developing such applications, designers and faciliators could use the findings of this study to avoid typical pitfalls and to take advantage of identified possibilities.

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