Understanding dependencies: Why safety, security and sustainability are increasingly challenging for cities and regions

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The increasing effectiveness and efficiency of modern society is not only beneficial, but also liable for new or increased vulnerabilities. The seemingly ever-increasing complexity of modern society is in other words bringing new challenges for safety, security and sustainability. At the heart of these challenges lay an incremental increase in dependencies between sectors, infrastructures, stakeholders, etc, making it more and more difficult for stakeholders to grasp and manage risk to critical flows and functions. Without acknowledging this process and its consequences for the resilience of cities and regions, there is a grave risk that we allow society to slowly drift into danger. Creating a resilient society is a collective endeavour, as most stakeholders depend on each other in fulfilling their responsibilities. Stakeholders thus need to come together to map and address various types of critical dependencies. Although the complexity of modern society is likely to continue to increase for the foreseeable future, there are innovative ways forward to promote resilient cities and regions.

1. Introduction

Our world is changing, bringing new challenges for safety, security and sustainability of cities and regions. Most domains of modern society witness technological development at staggering speed, growing scale of industrial installations, increasing degree of integration of various systems, and a progressively more aggressive and competitive environment [1]. It is in this dynamic context that various stakeholders, from state, market and civil society, converge to develop and ensure the functioning of society on a daily basis. This functioning of society depends largely on effective and efficient flows of people, capital, goods and services, both within and between cities and regions.

There are ample examples of recent events, which in various ways have affected different critical flows and thus also the functioning of society, e.g. floods, terrorist threat, volcanic ash cloud and severe winter conditions. In addition to these dramatic events, there are countless examples of more mundane incidents that also impede sustainable development by disturbing and disrupting critical flows and functions everyday, e.g. recurring gridlock traffic and frequent power-cuts. Regardless of type or scale, it seems to be increasingly difficult for stakeholders to overview and manage risk, as well as the consequences of actual events and decisions, since their effects can spread rapidly and widely throughout society [1]. At the heart of this increasing challenge for safety, security and sustainability lay in other words dependencies through which effects cascade [2]. Consequently, making the risk of disturbances or disruptions of one critical flow depend of the risk of disturbances or disruptions in all other flows that it depends upon.

The loss of the Galaxy IV satellite in 1998 disrupted around 90% of all pagers in USA, including communications within healthcare, and affected credit card purchases and ATM transactions all over the country [3].

The purpose of this professional paper is to present ideas concerning dependencies, which can help professionals in maintaining the safety, security and sustainability of their critical flows and functions, by helping them to understand and manage the complexity of society.

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2. A drift into danger

Understanding and managing the complexity of society entails understanding and managing dependencies. A dependency is here a connection between two entities in society (flows, sectors, infrastructures, stakeholders, etc) through which the state of one influences the state of the other. These dependencies do not only allow the effects of an unwanted event to cascade throughout society [2]. They also transmit the effects of human decisions and action [3], for good and for bad, and make it difficult for us to foresee the actual effects of our policies and practice.

It has been suggested that society is getting increasingly complex for decades [4] and more and more stakeholders are buying into that conclusion. This process is neither anything that has happened over night, nor will it be in the future. It is a gradual continuous process increasing both the number and intensity of dependencies in society. Such slowly evolving increase of complexity, called creeping dependencies [5], accumulate and reach eventually a threshold over which we loose overview and much of our ability to maintain our critical flows and functions.

The slow gradual increase of dependencies is generally driven by the processes of:

1. *Optimisation*
2. *Institutional fragmentation*
3. *Increasing aggressive and competitive environment*

One of the changes that drive these creeping dependencies is the process towards increasing effectiveness and efficiency. Such drive for optimisation has been vital for the development of modern society, as its positive effect of increasing cost-effectiveness free up resources to aim even higher or to utilise for other important things. However, optimisation implies exploitation of the advantages of operating at the fringes of conventional practice, approaching the boundaries of safety and sustainability [1]. In addition to the actual risk of venturing too close to, or perhaps even over these boundaries, optimisation has the downside of increasing vulnerability by reducing buffers that could be used to maintain critical flows or functions during disturbances. Hence, optimisation means increased efficiency in everyday circumstances, but also increased vulnerability to disturbances [6], as steadily less buffers make smaller and smaller disturbances to potentially lead to disruptions of entire flows and functions. It is in other words no coincident that the concept of “just-in-time” or “lean production”, applied in almost every segment of modern society, originally was called “fragile production” [7].

At the same time as the ever-increasing push for optimisation, there is also an ongoing process of diversification of stakeholders responsible for maintaining and developing most critical flows and functions in society. These two processes are closely related to each other, since the arguments for allowing more stakeholders to be involved often focus on the expected increase in cost-effectiveness through competition. This process is generally called institutional fragmentation [8, 9] and further increases complexity as it adds dependencies between multiple stakeholders, posing a number of new challenges for safety and sustainability [8].

Another closely related process is the increasingly aggressive and competitive environment that most stakeholders operate in. This environment is a result of the processes of optimisation and institutional fragmentation, and has the effect of focusing the incentives of decision-makers on short-term financial gain rather than on safety and sustainability [1]. It is under these pressures of cost-effectiveness and competition that the defined boundaries of safety and sustainability are increasingly approached, making stakeholders accustomed to a degree of performance of their flows and functions that

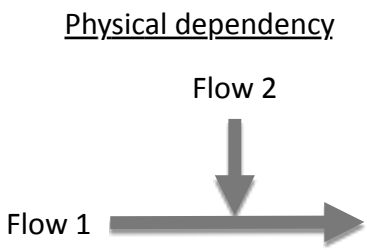
earlier was considered risky, and effectively recalibrating the boundaries of safety and sustainability [10]. This process is not confined to the market environment of the private sector, but is also influencing the public sector as a result of increasing service demands and reduced resource allocations. Although the process of eroding margins is part of a normal process as human beings gain experience, the challenge lies in knowing when we have gone too far [10].

The slow incremental increase of complexity through creeping dependencies, driven by the processes of optimisation, institutional fragmentation and increasing aggressive and competitive environment, make it progressively more difficult for stakeholders to grasp and manage risk to their critical flows and functions. Without acknowledging these processes and their consequences, there is a grave risk that we allow society to slowly drift into danger.

3. A typology of dependencies

Identifying and analysing dependencies for service continuity of flows, which are critical for the functioning of society, requires an as holistic approach to dependencies as possible. In many instances, it is rather straightforward to grasp more tangible dependencies, such as the importance of electric power for modern means of communication, or of clean drinking water for human health. However, other dependencies are no less real if not as visible [2]. In order to facilitate a more comprehensive understanding of dependencies, it helps to divide them into four main categories and make sure that all are remembered when analysing dependencies in practice. These four categories are: (A) physical, (B) information, (C) geographical, and (D) logical dependencies [3].

First of all, two entities in society (flows, sectors, infrastructures, stakeholders, etc) are physically dependent if the condition of one is dependent on the material output of the other [3]. For example, an electrified rail network depends among other things on electric power, and an industrial car manufacturer depends among other things on the supply of parts from specialised companies. Without a steady supply of electricity in the first example and car parts in the second, neither the rail network nor the car manufacturer would function appropriately.



The 2002 Akalla tunnel fire in Stockholm, Sweden, was likely to have started in a faulty cable splice on a high-voltage electric power cable. The fire destroyed a number of high-voltage electric power cables and a number of central telecommunication and IT cables, causing around 50 000 people and companies with a total of 30 000 employees to loose electric power. The fire also caused parts of the roof to collapse, complicating the ensuing response and recovery activities. Most customers had to wait more than two days for the electricity to get back on.

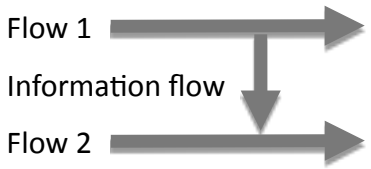
On top of the inconvenience for modern households to get by without electricity for that long, the resulting costs and potential danger of the event was substantial. Parts of the Metro system stopped working, not only demanding complicated evacuation of passengers through tunnels, but also increasing the traffic on the streets above. Traffic lights and streetlights were not functioning, causing traffic flows to slow down considerably. Telephone landlines, mobile phone networks and IT networks stopped working. Elevators had to be manually evacuated and the increasingly common code locks were generally made useless. Water and sewage pumps stopped and failing refrigerators and freezers caused foodstuff to spoil.

Most authorities and companies in and around the affected area had in other words to disband normal activities and several critical functions in society stopped working for a substantial period of time [11].

Although these dependencies are the most straightforward to identify and analyse in themselves, they are often combined in such a way that it is difficult to grasp the full complexity of what influences each critical flow or function in society.

Secondly, one entity in society has an information dependency with another if its state depends on information transmitted between them. For example, an ATM is not only dependent on electricity to function (physical dependency), but also on a steady flow of information concerning bank and account details. This type of dependency is a result of the comparatively recent processes of automation and computerisation [3], making the flow of information central for a large part of modern society.

Information dependency



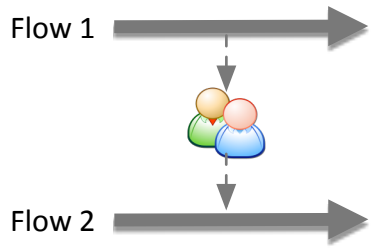
Information dependencies are closely related to physical dependencies, as it is possible to view the information in itself as a commodity in a similar way to electricity. However, it is beneficial to separate information dependencies from physical dependencies, since mixing them may result in the often less tangible information dependencies being seen as less important or even forgotten.

Thirdly, two entities in society are geographically dependent if they are located in such a way that a local event can affect them simultaneously [3]. This type of dependency is not arising from the two entities being dependent on the actual functioning of each other, as in physical or information dependencies, but instead from their spatial proximity. For example, although a high voltage electric cable and a telephone copper cable are not in any way directly connected, when they run in the same duct they may be affected by the same disruptive event. Such event may be independent from the entities themselves, e.g. an explosion of a gas bottle in an adjacent service duct, or originate from one of the two entities, e.g. an electric cable fire. The information flow through the copper cable is in other words not affected by disruptions in the electric current through the high voltage cable itself, but by the explosion or fire that also affect the electric power. In addition, it is important to note that more than two entities can be geographically dependent.

Geographical dependency

Finally, two entities in society are logically dependent if the condition of one depends on the condition of the other through a mechanism that is not physical, informational or geographical [3]. This may seem as a way of covering for everything else, but logical dependencies are often the most difficult to grasp and have vital roles in the overall safety and sustainability of critical flows and functions.

Logical dependency



For example, an increasing proportion of Europeans choose to use IP-telephone over their traditional domestic landlines, knowing that this new technology will not function in a power-cut. The common reasoning behind this decision is that if the phone stops working in an emergency, they will use their mobile phone to communicate. However, if suddenly a substantially greater

part of the population than usual attempts to use their mobile phones, the network will be overloaded and reduce the proportion of successful calls. Logical dependencies are in other words related to human expectations, decisions and behaviour, and not on any material or information input, or spatial location. Other examples of logical dependencies are fluctuations in the stock market due to rumours of the poor health of a CEO, reduced traffic congestion as a result of increased fuel price, the implementation of legislation, etc.

4. A suggestion for a safer and more sustainable future

The processes behind the increasing number and intensity of dependencies in relation to critical flows and functions are likely to continue for the foreseeable future. However, there are suggestions on how to address this challenge for societal safety, security and sustainability.

First of all, we need to address our tendency to attempt to reduce problems into parts that fit functional sectors and organisational mandates. Dividing the problem and addressing each part in isolation may be a fruitful strategy in other areas, but not in this context [12]. What we must do is instead to approach the creation of a resilient society as a collective endeavour, acknowledging how we all depend on each other in performing our responsibilities. In order to map and address all types of critical dependencies, it is thus important to involve stakeholders on multiple administrative levels (vertical integration), as well as from multiple functional sectors and from state, market and civil society (horizontal integration) [13]. In short, we need to start meeting each other and seeing ourselves as parts that have a higher purpose than only fulfilling our individual responsibilities. Together we have the responsibility of developing and maintaining the functioning of society, now and for the future.

Secondly, after having come together and mapped the complexity of critical flows and functions of a city or region, it is time to attempt to manage that complexity. To do so we must identify clusters of flows, functions and stakeholders that are highly dependent on each other, and develop collaborative processes that to the furthest possible extent traverse administrative and organisational boundaries. This is called compartmentalization [14] and is intended to redirect focus from internal organisational interests and agendas to the common interest of maintaining a particular set of critical flows or functions. However, it is important not to forget to also monitor the dependencies between such identified clusters [14], as these also are vital for the overall functioning of society. Monitoring these inter-cluster dependencies is the collective responsibility of all the clusters that share each dependency.

The main message for safety, security and sustainability of cities and regions is in other words increased collaboration. Modern society has simply become so complex and integrated that not many stakeholders can assure a critical flow or function on their own. Each stakeholder still has his or her own goals and agenda, but reaching and fulfilling them is increasingly determined by the ability to function together as a whole.

5. Final remarks

Understanding complexity, how critical flows and functions in society are connected through various types of dependencies, are crucial for safety, security and sustainability. Although it may be difficult to hinder the processes underlying the gradual increase in complexity through creeping dependencies, there are innovative ways forward to promote the resilience of cities and regions.

This professional paper is a first step on a longer journey to assist professionals responsible for maintaining and developing

the functioning of society. By addressing dependencies and explicitly seeing ourselves as vital parts fulfilling a larger common purpose, we will not only promote the overall safety, security and sustainability of cities and regions, but also advance service continuity, and thus also the productivity or profitability, of individual stakeholders.

6. References

1. Rasmussen, J. & Svedung, I. *Proactive risk management in a dynamic society* (SRSA, Karlstad, 2000).

2. Little, R. G. 'Controlling cascading failure: understanding the vulnerabilities of interconnected infrastructures'. *Journal of Urban Technology* **9**(1) 109-123 (2002).

3. Rinaldi, S. M., Peerenboom, J. P. & Kelly, T. K. 'Identifying, understanding, and analyzing critical infrastructure interdependencies'. *IEEE Control Systems Magazine* **21**(6) 11-25 (2001).

4. Perrow, C. 'A society of organizations'. *Theory and Society* **20**725-762 (1991).

5. Hills, A. 'Insidious Environments: Creeping Dependencies and Urban Vulnerabilities'. *Journal of Contingencies and Crisis Management* **13**(1) 12-20 (2005).

6. Carlson, J. M. & Doyle, J. 'Highly optimized tolerance: Robustness and design in complex systems'. *Physical Review Letters* **84**(11) 2529-2532 (2000).

7. Oliver, N. & Hunter, G. 'The financial impact of 'Japanese' manufacturing methods'. in *Manufacturing in transition* (eds Delbridge, R. & Lowe, J.) (Routledge, London and New York, 1998).

8. De Bruijne, M. & Van Eeten, M. 'Systems that should have failed: Critical infrastructure protection in an institutionally fragmented environment'. *Journal of Contingencies and Crisis Management* **15**(1) 18-29 (2007).

9. Pírez, P. 'Buenos Aires: fragmentation and privatization of the metropolitan city'. *Environment and Urbanization* **14**(1) 145 (2002).

10. Kirwan, B. 'Incident reduction and risk migration'. *Safety Science* **49**(1) 11-20 (2011).

11. Deverell, E. *Elavbrottet i Kista den 29–31 maj 2002: Organisatorisk och interorganisatorisk inlärning i kris* (CRISMART, Stockholm, 2004).

12. Hale, A. & Heijer, T. 'Is Resilience Really Necessary? The Case of Railways'. in *Resilience Engineering: Concepts And Precepts* (eds Hollnagel, E., Woods, D. D. & Leveson, N.) (Ashgate, Aldershot and Burlington, 2006).

13. National Research Council *Building Community Disaster Resilience through Private-Public Collaboration* (The National Academies Press, Washington D.C., 2010).

14. Perrow, C. B. 'Organizing to Reduce the Vulnerabilities of Complexity'. *Journal of Contingencies and Crisis Management* **7**(3) 150-155 (1999).

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