

Full length article

From cyber security incident management to cyber security crisis management in the European Union[☆]

Jukka Ruohonen^a, Kalle Rindell^b, Simone Busetti^c

^a University of Southern Denmark, Denmark

^b University of Turku, Finland

^c University of Teramo, Italy

ARTICLE INFO

Keywords:

Risk management
Risk analysis
Incident management
Crisis management
Regulations
Governance
EU

ABSTRACT

Incident management is a classical topic in cyber security. Recently, the European Union (EU) has started to consider also the relation between cyber security incidents and cyber security crises. These considerations and preparations, including those specified in the EU's new cyber security laws, constitute the paper's topic. According to an analysis of the laws and associated policy documents, (i) cyber security crises are equated in the EU to large-scale cyber security incidents that either exceed a handling capacity of a single member state or affect at least two member states. For this and other purposes, (ii) the new laws substantially increase mandatory reporting about cyber security incidents, including but not limited to the large-scale incidents. Despite the laws and new governance bodies established by them, however, (iii) the working of actual cyber security crisis management remains unclear particularly at the EU-level. With these policy research results, the paper advances the domain of cyber security incident management research by elaborating how European law perceives cyber security crises and their relation to cyber security incidents, paving the way for many relevant further research topics with practical relevance, whether theoretical, conceptual, or empirical.

1. Introduction

“Europe has been in crisis management mode for a decade and a half” (Handler, 2024, p. 1). Although the statement quoted is true in many respects, it does not (yet) apply to the cyber security domain. In other words, to the best of the authors' knowledge, there has not been a truly large-scale, pan-European cyber security crisis thus far. This statement does not mean that the EU would not have prepared for such a crisis. These preparations, including those mandated by the EU's new cyber security laws, are what the paper is about. The paper's relevance and contributions can be elaborated with four brief points.

To start from practical relevance, first, the topic is timely. In fact, the European Commission (EC) just recently released a new proposal for handling large-scale, cross-country cyber security crises in Europe (EC, 2025a). The second point follows from this timeliness; again to the best of the authors' knowledge, the paper is the first to elaborate cyber security crisis management in the EU context. While there are some existing works, they have concentrated on national cyber security crisis management (Boeke, 2017; Collier, 2016; Østby and Katt, 2020). That is, the EU context has been missing thus far, including with respect

to the EU's new judicial framework. In addition, governance below national administrations has received limited attention in general (Béland et al., 2024). Subsequently, third, the paper contributes to the recent efforts to digest and analyze the EU's many new cyber security laws and their implications (Alexopoulos et al., 2025; Busetti and Scanni, 2025; Mueck and Gaie, 2025; Rataj, 2025; Ruohonen, 2024b; Ruohonen et al., 2025b, among many others). Regarding existing research and knowledge more generally, fourth and last, the paper contributes to the incident management research domain by elaborating, analyzing, and theorizing on how incidents are related to and may transform into crises. Because crises typically have immense consequences, the paper's overall relevance is well-justified; it is important to understand how the EU's new cyber security legal framework is designed with crisis management in mind.

With respect to the last point, both incident management research and frameworks for it have traditionally operated at the organizational level; incidents are something that organizations may face, and thus they should also prepare for them. For instance, a classical incident management framework from the National Institute of Standards and

[☆] This article is part of a Special issue entitled: ‘Cybersecurity, Privacy, Trust and Regulation’ published in Computers & Security.

* Corresponding author.

E-mail address: juk@mmmi.sdu.dk (J. Ruohonen).

Technology (NIST) defines cyber security incident as “a violation or imminent threat of violation” of any cyber “security policies, acceptable use policies, or standard security practices” established and enforced by organizations (Cichonski et al., 2012, p. 6). The organizational focus is thus clear. According to an early literature review, a similar focus is present in many other well-known frameworks and standards for incident management and closely related topics (Tøndel et al., 2014). From the previous quotation it also follows that an organization should have cyber security policies established and enforced because otherwise an incident remains only implicit and vaguely defined. A similar claim applies to cyber security crisis management; also larger entities, whether industry sectors, geographic regions, or countries and beyond, should have policies in place for handling cyber security crises. As will be seen, in the EU these policies are partially but still explicitly written in recent cyber security laws.

A further point about the organizational focus is that it has typically been present also in different socio-technical frameworks for incident management and cyber security management in general (Al Sabbagh and Kowalski, 2015; Jaatun et al., 2009; van Haastrecht et al., 2021). Motivated by a recent work on layered cyber security frameworks (Panteli et al., 2025), the paper adopts a multi-level perspective sometimes used in the socio-technical frameworks (Malatji et al., 2019), but extends it beyond organizations. Thus, the first part in the socio-technical term refers to an adjective societal and particularly a noun European. Although societal cyber security is not a well-defined concept, it has sometimes been discussed in a context of critical infrastructure protection (Gjesvik, 2019). Such a framing serves also the paper’s purposes well because among the EU laws considered is an important new law for critical infrastructure protection in Europe.

With these motivating remarks in mind, the following three research questions (RQs) are examined:

- RQ.1: What constitutes a cyber security crisis in the European Union?
- RQ.2: What do recent EU laws impose upon cyber security incident and crisis management?
- RQ.3: How cyber security crises are managed, governed, and coordinated in the EU and by whom?

The paper’s remainder is structured into four sections. The opening Section 2 motivates the background further, including with respect to the multi-level approach pursued and the EU laws considered. The methodology for analyzing these is also elaborated, and a few clarifying framings are also done to restrict and limit the paper’s scope. Section 3 continues by elaborating how different law-imposed incident types are related to the multi-level approach. In general, the section answers to RQ.1 and RQ.2. The subsequent Section 4 answers to RQ.3 by elaborating the various institutions, organizations, and networks involved in cyber security crisis management in the EU context. The last three Sections Section 5, 6, and 7 present a conclusion as well as a few points about limitations and associated future research directions.

2. Background

2.1. Framings

Some framings are required for limiting and aligning the paper’s scope to a manageable composition. To begin with, the paper is framed toward cyber security alone. The paper’s opening quotation about Europe having been in a crisis management mode for a long time helps to understand that crises vary a lot; from financial crises all the way to wars and the existential climate change crisis. While notions such as cascading effects and risks (Adkins et al., 2020; Ruohonen, 2024a; Ruohonen et al., 2025b) make it understandable that many crises may be interconnected to each other, no attempts are made to connect cyber security crises to other crises. The same applies

regarding threats. Some cyber security threats, including particularly those related to advanced persistent threat (APT) actors, are today, in Europe, often perceived to be linked with a broader class of so-called hybrid threats (Anagnostakis, 2023; Jungwirth et al., 2023). While acknowledging the linkage’s theoretical and practical validity, no attempts are made to move beyond plain cyber security. By implication, as hybrid threats may involve also a military dimension, also the EU’s other cyber security pillars (Christou, 2016; Ruohonen, 2024b), whether cyber defense or data protection, are excluded from the paper’s scope. Furthermore, theorizing about different types of cyber security crises are further omitted for brevity, clarity, and alignment with the EU’s laws considered.

With respect to large-scale cyber security crises, ENISA (2024b, p. 12) emphasizes a need to distinguish between a creeping crisis, “which simmers under the radar” before “suddenly and unexpectedly erupting”, an acute crisis, “which is sudden, unforeseen and can have a massive impact in a very short amount of time”, and a recurring crisis, which occurs almost continuously. Similar categorizations have been presented in the academic literature (Boin et al., 2018; Head, 2022). Of these three types, denial of service attacks, in particular, could be seen as something recurrent, whereas a severe data breach or a successful ransomware attack might be seen to belong to the category of acute crises. Though, these examples are more about incidents than crises; therefore, also risk analysis is presumably more challenging when trying to assess crises rather than incidents; when operating at a level of societies or beyond rather than at the conventional organizational level. At the societal level, an example of a creeping crisis might involve a discovered large-scale espionage campaign conducted by an APT actor. Beyond these brief remarks, as said, more elaborate theorization is left for further work.

2.2. Methodology

The paper operates in the domain of policy studies. Within this domain, a separation between policy analysis and policy (process) research is sometimes done. Broadly speaking, the former is about prescriptive research seeking to inform policy-making, whether in terms of evaluations, impact assessments, or something else, while the latter is descriptive research focused particularly on theory-building (DeLeon and Weible, 2010; Secchi, 2016). Given this characterization, the paper is about policy research. Regarding descriptive policy research, an *ex post*, a *post hoc*, and generally a retrospective approach is used (cf. Patton et al., 2016). This choice is also unavoidable because the EU laws considered have already been enacted. As soon described in Section 2.4, these laws also provide the primary materials for the study.

Regarding *ex ante* policy analysis, it is worth remarking that the EC did prior impact assessments for most — but not all (EP, 2024) — of the laws considered in the paper. For the paper’s purposes, it is particularly worth remarking that these assessments indicated a lack of joint situational awareness and crisis management between the member states, and between them and the EU-level administration; information sharing was concluded to operate on an *ad hoc* basis and cross-border spillovers were omitted from risk analyses (EC, 2020, pp. 21–22). This point justifies an academic expert evaluation of the three RQs postulated.

Regarding theory-building, the paper analyzes and theorizes how the EU’s new laws align with common analytical frameworks used in incident and crisis management research. On the side of engineering and computer science, within which theory-building often has a different meaning, the paper aligns with requirements engineering research within which legal requirements are a distinct genre (Ruohonen et al., 2025b). This research branch justifies RQ.2. In other words, it is important to know what laws require, whether from organizations, producers, or public administrations. Once an answer is known, it is possible to continue toward empirical policy research; without knowing the legal

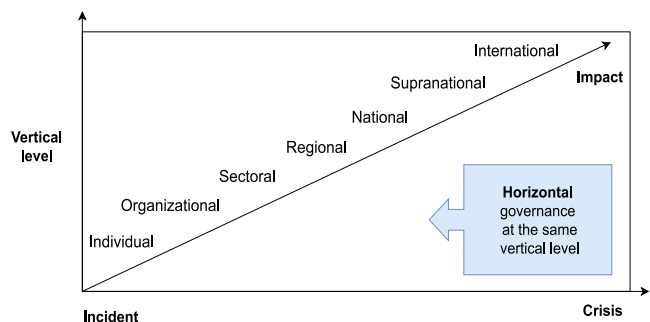


Fig. 1. Analytical levels.
Source: Adopted from ENISA, 2024b, pp. 17–18.

requirements, formulation of relevant research questions is difficult—if not questionable altogether. This point also applies to the framings done; insofar as policy analysis is concerned, it is pointless to evaluate responses to hybrid threats without knowing about the preparations and frameworks for handling them.

In addition, a brief scenario analysis is presented to better elaborate the legal interpretations drawn and their potential practical implications. By following existing research (Ruohonen et al., 2025c), the short scenario analysis presented is purely hypothetical, using an imaginary but still plausible case for the elaborations. Although most scenario analyses are about foresight and the future (Sus and Hadeed, 2020), the analysis pursued aligns with the descriptive tenet in policy studies. Besides elaborating the legal aspects, the scenario analysis also helps at the theory-building tenet, including with respect to the analytical levels subsequently described.

2.3. Analytical levels

The paper’s conceptual and theoretical background can be motivated by considering an analytical relation between incidents and crisis through different vertical levels of analysis often used in social sciences. A term multi-level analysis is sometimes used to refer to approaches that operate at two or more such levels (Béland et al., 2024; Hutzschenreuter et al., 2020). A term multi-level governance is a common alternative (Bartle and Flinders, 2016). The terms should not be equated to multi-level (cyber) security, although there is a rough conceptual similarity because both involve a hierarchy (cf. Anderson, 2020). In any case, an incident that involves multiple analytical levels could be called a multi-level incident—or, depending on which levels an incident has transcended, a cyber security crisis.

2.3.1. The international level

The international level is at the top of the hierarchy. When operating at this level, an analysis typically functions horizontally, focusing on relations between states. In terms of cyber security, good examples about such interstate, transnational relations would cover cyber norms, cyber diplomacy, and even what is known and debated as cyber war. However, as said, such topics are beyond the paper’s scope. Another point is that it is also possible to consider information systems and other technical solutions at this level; such systems and solutions are those that transcend both national and organizational boundaries (Rukanova et al., 2015). Such transcendence can also be seen as something that separates cyber security incidents from cyber security crises.

If a cyber security incident escalates to the international level, it is not really any more a mere incident but rather a crisis. With this point in mind, Fig. 1 displays seven analytical levels through which incidents may become crises. As can be seen, the impact is taken to increase the further a cyber security event is from an incident.

2.3.2. The supranational level

Below the international level is a supranational level. This level is at which the EU operates; the European Union is a supranational union. At the same time, however, it operates in intergovernmental terms; the Council of the European Union would be the prime example in this regard. In contrast, the European Union Agency for Cybersecurity (ENISA) operates at the supranational level, although intergovernmental tenets may still be present in terms of staffing and related aspects. While there is a classical debate regarding the meaning of and interplay between these two theoretical governance terms (Bickerton et al., 2022; Handler, 2024; Tsebelis and Garrett, 2021), without a particular loss of specificity and rigor, the term supranationalism is used in case there is no particular reason to emphasize the intergovernmental dimension.

Note also a difference between the terms transnational and intergovernmental; the latter is about relations between governments, as is the case in the Council in which ministers or other heads of states represent their member states, whereas the former can be seen to cover also supranational governance because the meaning is essentially about relations between nations. These relations may be about states, but they may also include transnational non-governmental organizations, different transnational collaboration and coordination networks, and international organizations (Gänzle et al., 2022). When such transnational relations are accounted for, the term multi-level governance can be seen to cover also a horizontal dimension; a coordination and collaboration between different entities not directly linked to governmental representatives. These terminological clarifications are important because the EU’s overall multi-level crisis management framework covers numerous actors operating at different governance levels and policy areas (Anagnostakis, 2023). The concepts also provide a theoretical foundation for analyzing the EU’s cyber security crisis management framework in terms of governance and coordination.

2.3.3. The national, regional, and sectoral levels

When taking a step downwards from the supranational level, the national level is encountered. Regarding governance, authoritative computer security incident response teams (CSIRTs) are particularly relevant in Europe; according to both old and new EU laws, each member state should have an authoritative CSIRT or a related competent authority for nationwide incident management.¹ However, presently it remains still somewhat unclear how national administrations are, or will be, arranged in each and every member state. By hypothesis, the divergence is, or will be, large across the twenty-seven member states.

Although there are no clear demarcations, operations at the national level are sometimes (but not always) about crisis management rather than incident management. The same could be said even about the regional level, especially when keeping in mind that it includes both smaller geographically bound administrative units as well as larger geographic units, such as is the case in the Germany’s federalist administration. Also crisis management tends to be decentralized to the regional, *Länder*, level in Germany, although strategic management and high-level political coordination occurs at the federal level (Christensen et al., 2016). Without the federalist twist, the setup is rather similar to many other European countries within which strategic and political aspects are oftentimes centralized, while the operational level is often more or less decentralized (Christensen et al., 2016; Gjesvik, 2019; Ramsell and Wahlborg, 2012). Regions also intervene with industry sectors in many member states. Whether an example is about the Ruhr region in Germany or the Emilia-Romagna region in Italy, specialized industry activity has often concentrated to specific regions in Europe and also elsewhere. Authoritative CSIRTs in some European

¹ Here, the adjective authoritative is used for emphasizing a difference to other CSIRTs, including sectoral teams as well as teams within organizations and companies. Note also that in practice the abbreviation CSIRT is equivalent to an abbreviation CERT, denoting a computer emergency response team.

countries have also been decentralized with sectoral specialization in mind (Boin et al., 2018). In terms of incident management, many industries also have different sectoral and regional coordination networks and governance hubs.

2.3.4. The organizational and individual levels

Then, below the sectoral level is the organizational level. As said in the introduction, this level has been the traditional focal point in incident management and its research. Again, coordination may occur horizontally between organizations (inter-organizational coordination) and within organizations (intra-organizational coordination), and vertically between organizations and individuals (Heine, 2019; Panteli et al., 2025). The intra-organizational coordination is relevant also for establishing organizational CSIRTs; typical choices for large organizations include outsourcing, a centralized organization-wide team, or distributed teams across an organization’s departments (Mitropoulos et al., 2006; Cichonski et al., 2012). Organizations may also coordinate vertically with sectoral or regional entities, such as industry associations, as well as entities operating at a national level, including authoritative CSIRTs in particular. Finally, as seen from Fig. 1, it is also possible to consider incidents at a level of individuals, whether employees, citizens, or consumers. Given the extensive research and evidence on the human factors in cyber security, it is also possible that an incident affecting an individual escalates to the organizational level or even beyond that.

2.3.5. An example of a multi-level incident

A good example about a multi-level incident would be the attacks against Danish energy sector companies in 2023. Given that over twenty energy sector companies were compromised, the incident prompted also international media attention (Antoniuk, 2023). Regarding the analytical levels, the example is illuminating because it involved three or four levels in Fig. 1.

To begin with, the incident was not only organizational but also sectoral due to the involvement of multiple companies in the same sector. Given the potential concentration of the energy sector companies to some particular regions in Denmark, the incident could be perhaps interpreted to involve also the regional level. In any case, the sectoral level manifested itself also in the investigation conducted by SektorCERT (2023), a non-profit CSIRT composed by Danish critical infrastructure companies and operators. The investigation revealed that the compromises were conducted by exploiting a vulnerability in a firewall product.² Furthermore, an update had been available but the energy sector companies had not patched their firewalls for a reason or another. During the incident management, the issue escalated further to the national level.

Among other things, CFCS (2023), the authoritative CSIRT in Denmark, raised the threat level against the Danish energy sector to the very high level category. However: while multiple levels were involved, the incident is not yet something that could be interpreted as a cyber security crisis according to the EU’s laws. This point will become clear in Section 3.1 that elaborates different incident types present in the recently enacted EU laws.

2.4. The EU’s strategy

The EU’s new cyber security strategy can be summarized in the form of Fig. 2. Three of the strategy’s pillars—prevention, detection, and response—resemble rather similar phases in incident management frameworks. For instance, the NIST’s noted framework is structured around preparation, detection and analysis, containment, eradication, and recovery, and post-incident phases (Cichonski et al. 2012; cf. also Mitropoulos et al. 2006). Rather analogously, ENISA (2024b) builds

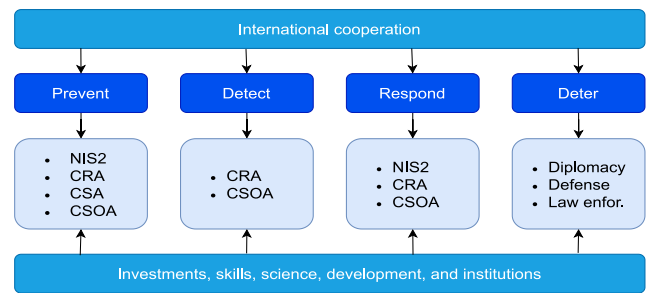


Fig. 2. The EU’s current cyber security strategy in a Nutshell. Source: Adopted from EC, 2025b.

upon prevention, preparedness, and response and recovery phases. Another example would be prepare, detect and recover, and learn (Jaatun et al., 2009). A further point is that the EU’s strategy is structured around specific laws, which are also supported by funding instruments, education, research, development, and innovation projects, and specific governance bodies, some of which are new.

Before continuing to enumerate the laws covered, it should be emphasized that there are many further EU laws explicitly or implicitly related to cyber security, some of which are sector-specific and some others of which overlap with each other (EC, 2025a; Fischer-Hübner et al., 2021; Ruohonen et al., 2025b). Against this backdrop, it is no wonder that regulatory fragmentation and complexity have been a source of commonly expressed criticism (Alexopoulos et al., 2025; Ruohonen, 2024b). In any case, it should be emphasized that the specific laws considered are particularly relevant for the paper’s topic. In other words, as will be elaborated in Section 3, the laws also help to understand how a transgression from an incident to a unionwide crisis is legally perceived and structured.

Of the four laws abbreviated in Fig. 2, particularly important are the second network and information security (NIS2) directive (EU, 2022a) and the Cyber Resilience Act (CRA) regulation (EU, 2024). Although a concept of essential and important entities (EAIes) is used in the NIS2 directive, the directive is essentially about critical infrastructure protection. Overall, the directive builds upon a sectoral approach; numerous sectors are enumerated as carrying “critical societal or economic activities”, to quote from the NIS2’s Article 2(2)(b). This quotation aligns with the notion of societal cyber security noted in the introduction. The actual sectors specified range from traditional critical infrastructure sectors, such as energy and transport, to banking, healthcare, finance, drinking and waste water management, the Internet’s core infrastructure, and space technologies.

In contrast, the CRA regulation is a product-specific law. While in the NIS2 directive criticality as a concept is tied to sectors, as has been typical in the critical infrastructure domain, in the CRA products are categorized according to their real or perceived criticality to cyber security (Ruohonen et al., 2025a). Regardless of these categorizations and with a small number of explicitly excluded products, practically all products must comply with the CRA’s essential cyber security requirements. As these requirements have already been considered in detail (Ruohonen et al., 2025b), including with respect to new obligations regarding vulnerability coordination and disclosure (Ruohonen and Timmers, 2024), in what follows, the CRA is only discussed with respect to its mandates for incident reporting. Having said that, it is worth remarking that the CRA’s essential requirement about preferably automated security updates would have prevented the Danish energy sector case noted earlier in Section 2.3.5, and, furthermore, some of the essential requirements contain also elements aligning with the technical detection and prevention of incidents.

Regarding the CRA more generally, also the older Cybersecurity Act (CSA) can be mentioned (EU, 2019). While it strengthened the role

² CVE-2023-28771.

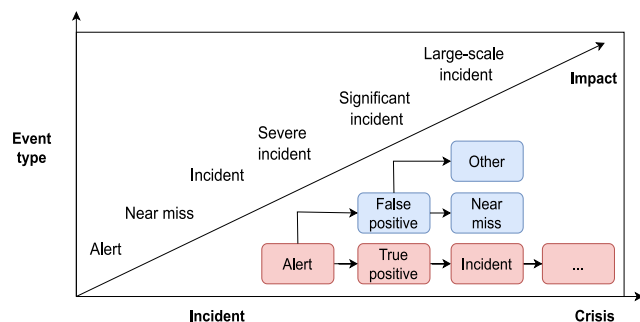


Fig. 3. An event type hierarchy.

and mandates of ENISA, it also introduce a common cyber security certification scheme for information technology products. This certification scheme aligns with the CRA in that conformance can be attained also (but not only) through certification. Given that standards are also an important part of the CRA and compliance with it, the regulation seems to have at least partially answered to criticism from the industry and practitioners (Fischer-Hübner et al., 2021). Finally, recently a new Cyber Solidarity Act (CSOA) regulation was agreed upon (EU, 2025). As can be seen from Fig. 2, it covers aspects from all the three pillars noted earlier.

A couple of additional remarks are in order before continuing to elaborate the laws and their implications in detail. The first remark is that deterring of cyber security threats appears in Fig. 2. While this topic is beyond the paper’s scope, it can be noted that deterrence has long been debated in the literature (Goodman, 2010, among many others), some authors having taken a critical stance about the working of deterrence in the cyber security context (among them Soesanto and Smeets, 2021). The second remark is that all of the laws are more or less risk-based, some explicitly and some only implicitly. In particular, the NIS2 directive’s Article 21 obliges EAIEs to carry out comprehensive risk analyses. These should be done by following a so-called “all-hazards” approach, which is also familiar from the academic literature (Ayyub et al., 2007; Izumi, 2024). According to NIS2, the approach means that anything and everything from incident handling, backups, and supply-chain security to security awareness campaigns and business continuity should be assessed. The CRA too is a risk-based regulation; the essential cyber security requirements should be prioritized, designed, implemented against particular, product-specific risks identified.

3. Incident types

3.1. Events

Events, including alerts, whether from intrusion detection systems, other monitoring systems, or somewhere else, are important building blocks for incident management (Cichonski et al., 2012). These also allow understanding how incidents may transform into crises according to the EU’s jurisprudence. Thus, Fig. 3 displays the core event types in the new EU laws. The figure can be elaborated by moving from the bottom to the top, from alerts to incidents, severe incidents, and beyond. In line with the previous discussion, at least the last incident type shown is analytically already on the side of crises.

As was remarked in Section 2.4, the CRA’s essential cyber security requirements for products contain elements that may (or should) foster the detection cyber security incidents. For instance, the requirements include a monitoring functionality for a product’s internal activity, including with respect to authorizations and integrity guarantees (Ruohonen et al., 2025b). In addition, as seen also from the earlier Fig. 2, the CSOA regulation is relevant too with respect to incident detection.

In particular, the regulation envisions a development of a large-scale, pan-European network of cyber security alert systems for coordinated incident detection and improved situational awareness capabilities. While these systems are labeled as “cyber hubs” in the regulation, they are essentially what security operation centers (SOCs) and threat intelligence systems in general are about. The network is planned upon voluntary pooling of national alert systems into large cross-border systems. The national systems may include not only those maintained by authoritative CSIRTs but also those operated by private sector companies.

3.1.1. Near misses

An alert can be a false positive or a true positive. Although the NIST’s definition noted in the introduction covers both, for the present purposes, it makes sense to frame incidents only toward true positives. Regarding false positives, the EU’s recent laws introduce a concept of near misses. A near miss is defined in the NIS2’s Article 6(5) to mean “an event that could have compromised the availability, authenticity, integrity or confidentiality of stored, transmitted or processed data or of the services offered by, or accessible via, network and information systems, but that was successfully prevented”. Thus, within the context of incident management, the concept can be seen to be about false positives; about alerts that were successfully prevented from becoming actual incidents (true positives). In any case, reporting about near misses is voluntary. According to Article 15(2) in the CRA regulation, manufacturers and other parties, whether natural or legal persons, may voluntarily report near misses either to a national authoritative CSIRT or ENISA. Likewise, according to Article 30 in the NIS2 directive, EAIEs may voluntary report near misses to a authoritative CSIRT or some related public sector authority.

Voluntary reporting seems sensible already due to overhead and related reasons. Because alerts are voluminous due to various monitoring systems deployed by organizations, most of them are false positives, and interoperability is a typical issue with the monitoring systems and their reporting formats (Alahmadi et al., 2022; Zibak et al., 2022). Analogously to abuse reporting in the Internet (Jhaveri et al., 2017), a signal to noise ratio is often low. Against these backdrops, a mandatory reporting of near misses would have presumably required large financial investments and considerable coordination between various stakeholders involved, including the authoritative European CSIRTs and producers of cyber security monitoring solutions. The issues with false positives in the cyber security context are well-recognized in the literature also more generally; not only is a minimization of them generally difficult but also a cost of handling them is often significant (Bhatt et al., 2014). However, the EU laws do not say anything how organizations should actually demarcate between false and true positives, and whether there are any consequences from accidentally reporting a false positive as a true positive or the other way around.

3.1.2. Incidents

Also reporting of most (but not all) true positives—that is, according to the terminology adopted, incidents—is voluntary (see Table 1). According to the NIS2’s Article 6(6), an incident is defined as “an event compromising the availability, authenticity, integrity or confidentiality of stored, transmitted or processed data or of the services offered by, or accessible via, network and information systems”. When compared to the earlier definition for near misses, an incident is thus something that has actually compromised data or services. While the definition aligns with classical framings (Brownlee and Guttman, 1998), there is a difference to the NIST’s definition noted in the introduction. Although availability, authenticity, integrity, and confidentiality may well belong to an organization’s cyber security policy, the NIS2 only notes, in Article 24, cyber security policies with respect to open source software associations. In any case, according to the NIS2’s Article 30, reporting of these “conventional” incidents is voluntary.

Table 1
References for legal definitions and reporting obligations.

Type	Discussion	Definition	Reporting
Near miss ^a	Section 3.1.1	Article 6(5) in the NIS2 directive	Voluntary
Incident ^b	Section 3.1.2	Article 6(6) in the NIS2 directive	Voluntary
Severe incident	Section 3.1.3	Article 14(3) in the CRA	Mandatory
Significant incident	Section 3.1.4	Article 23(3) in the NIS2 directive	Mandatory
Large-scale incident	Section 3.1.5	Article 6(7) in the NIS2 directive	Mandatory
Actively exploited vulnerabilities	Section 3.1.3	Article 3(42) in the CRA	Mandatory ^c

^a The same article in the NIS2 directive is explicitly referenced in the CRA's Article 3(45).

^b The same article in the NIS2 directive is explicitly referenced in the CRA's Article 3(43). Although the so-called critical entities resilience (CER) directive (EU, 2022b) was omitted from the paper's scope (cf. Fig. 2), an incident is defined also in its Article 2(3). For a reason or another, however, the CER's definition is not identical with the NIS2 directive's definition.

^c Though, there is an option to delay reporting (Ruohonen and Timmers, 2024).

3.1.3. Severe incidents

When moving a step upward in the event hierarchy (see Fig. 3), the CRA regulation (but not the NIS2 directive) uses a concept of severe incidents. It is mandatory to report such incidents to both a national authoritative CSIRT and ENISA according to the CRA's Article 14(3). A twofold definition for severe incidents is given in the regulation's Article 14(5). The first part emphasizes negative impacts *and* potential negative impacts upon a product's ability to protect the availability, authenticity, integrity, or confidentiality of data or services, whereas the second part emphasizes an execution *and* a potential execution of malicious code. It remains to be seen how manufacturers will interpret the demarcation between the impacts and executions on one hand and the potential impacts and executions on the other hand.

Another important point is that the CRA is about manufacturers of information technology products, not about operators of such products, including EAIEs covered by the NIS2 directive. With some relaxations, manufacturers are also mandated to report about actively exploited vulnerabilities (Ruohonen and Timmers, 2024). These are archived to a new European vulnerability database maintained by ENISA (2025b). In any case, the divergence between the scopes of the two EU laws reiterates a criticism expressed both in research and industry about a lack of an explicit legal synchronization between different reporting obligations imposed by different laws (BusinessEurope 2025, p. 49; Fischer-Hübner et al. 2021, Ruohonen 2024a). In particular, in case a manufacturer reports to a national authoritative CSIRT and ENISA about a severe incident, either the given CSIRT or ENISA, or both, should presumably consequently report to all EAIEs and others using the manufacturer's given product to which the severe incident applies. Again, it remains to be seen how such consecutive reporting will work in practice.

3.1.4. Significant incidents

The remaining two incident types are specified in the NIS2 directive. According to the directive's Article 23(3), a significant incident either "has caused or is capable of causing severe operational disruption of the services or financial loss for the entity concerned", or it "has affected or is capable of affecting other natural or legal persons by causing considerable material or non-material damage". The again twofold definition warrants three brief remarks.

The first remark is related to the earlier point about potential effects; the wording "capable of" yet again entails a demarcation problem between actual significant incidents and those merely conveying a probability of such incidents. Presently, no guidance is available upon this demarcation (Busetti and Scanni, 2025). The second remark is related to the wording about "severe operational disruption". Here, it would seem that anything from severe denial of service attacks to severe ransomware attacks are in the scope. The definition's emphasis of severe financial losses further underlines ransomware attacks, although also other so-called destructive cyber attacks are likely in the NIS2's scope. The third remark is about the emphasis about "considerable material or non-material damage" to natural persons. Therefore, it

has been suspected that also severe personal data breaches are in the directive's scope (Ruohonen et al., 2025b), but a definite conclusion can likely be given only after guidelines have been released or enforcement has occurred.

While keeping these and other potential interpretation issues in mind, including regarding the rich role of adjectives and other qualifying words in law (Bertoldi et al., 2007), EAIEs must report about significant incidents to a national authoritative CSIRTs or, where applicable, other public authorities, as well as other entities concerned according to the NIS2's Article 23(1).³ Thus, broadly speaking, unlike "conventional" incidents, significant incidents fall into a category of mandatory reporting by EAIEs. According to guidance from ENISA (2025c), EAIEs should also carefully evaluate and document all significant incidents and adjust their risk analysis results accordingly.

3.1.5. Large-scale incidents

Finally, there is the notion about large-scale cyber security incidents. A large-scale incident is defined in the NIS2 directive's Article 6(7) as an incident which either (a) exceeds a handling capacity of a single member state or which (b) has a significant impact on at least two member states. Regarding incident management frameworks, the first part of the definition resembles a concept of escalation at the organizational level; an organizational CSIRT or some related security team cannot get an incident under control on its own (cf. Jaatun et al., 2009). Another point is that the EC's (2025a, p. 12) noted recent proposal clarifies that these large-scale incidents are what is meant by a cyber security crisis in the EU context. While keeping the earlier remarks about terminology in mind, a cyber security crisis is thus something that moves from the national level to the supranational level in Fig. 1. Also the NIS2's recital 69 clarifies this point by noting that large-scale incidents "may escalate and turn into fully-fledged crises". Despite such an escalation potential and interestingly enough, NIS2 does not explicitly say about reporting obligations of large-scale incidents, but because these must be something that also satisfy the definition for significant incidents, reporting can be interpreted as mandatory.

The CSOA's cyber security alert systems noted in Section 3.1 are also related to large-scale cyber security incidents. According to the regulation's Article 7, particularly the envisioned cross-border alert systems are seen as relevant for detecting large-scale incidents and sharing information about them. There are also a couple of other important points to make about the relation between large-scale incidents and the CSOA regulation.

The first point is about the exceeding of a member state's handling capacity used in the definition for a large-scale cyber security incident. Here, the CSOA's Article 14 specifies an establishment of a specific

³ All laws considered contain numerous qualifying words (Ruohonen et al., 2025d). For the present purposes, particularly the many adjectives present in the definitions listed in Table 1, such as severe, significant, and considerable, convey also semantic meanings. However, a contextual interpretation is only possible once guidance is available or enforcement actions have occurred.

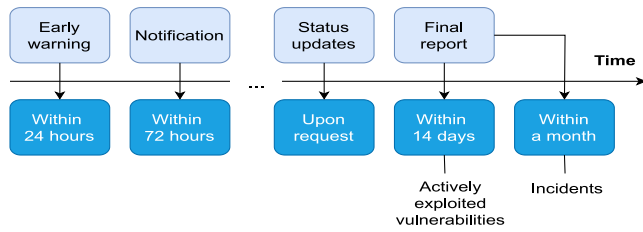


Fig. 4. Reporting deadlines for actively exploited vulnerabilities and severe, significant, and, by implication, large-scale incidents.

cyber security “reserve” for handling large-scale incidents. The reserve is composed by national public sector representatives as well as other trusted parties. According to Article 15, a member state in need may then request help from the reserve to recover from both significant and large-scale cyber security incidents. Furthermore, the CSOA’s Article 19 specifies that help can be requested also by countries outside of the EU, provided that they are taking part in the EU’s Digital Europe Programme (DEP), a funding instrument for digital technologies and digitalization in general.

The second point is that the CSOA specifies a new cyber security incident review mechanism. Its scope is restricted to significant and large-scale incidents. ENISA and a network of authoritative CSIRT are specified as the responsible parties for the actual reviews according to the regulation’s Article 21(1). In line with the post-incident activities in the NIST’s incident management framework (Cichonski et al., 2012), the reviews are used for improving the union’s and the member states’ cyber security practices. Despite an incident’s or a crisis’ negative consequences, there is always also something to learn from them.

3.2. Deadlines

There are strict deadlines for incidents that are mandatory to report. When comparing the CRA’s Article 14 and the NIS2 directive’s Article 23, the wordings about the deadlines are not verbatim similar but their meaning is more or less the same.⁴ For this reason, the deadlines can be summarized in the form of Fig. 4. As was noted in the preceding Section 3.1.5, the deadlines for reporting about large-scale incidents are implicit but follow from their inevitable connection to significant incidents. Another clarifying remark needed is that the CRA’s notion about actively exploited vulnerabilities is not about incidents *per se* but can be discussed alongside them because the reporting deadlines are similar.

Thus, severe, significant, and large-scale incidents should be initially reported to an authoritative CSIRT, or some other competent authority, no later than twenty-four hours after becoming aware of them. Then, a more detailed incident report should be delivered no later than seventy-two hours after becoming aware of a given incident. The report delivered should include an initial assessment about a given incident, including its severity and impact, as well as, where applicable, any indicators of a compromise. After these two reports, an authoritative CSIRT may request status updates at any time. A final report should be delivered within a month. In addition to severity and impact, the final report should contain a root cause analysis, any applied and

⁴ Although data protection was framed out from the paper’s scope (see Section 2.1), it is still worth mentioning that in case personal data is processed, there is an overlap with the General Data Protection Regulation (GDPR) (EU, 2016), as also recognized in existing research (Ruohonen et al., 2025b). That is, according to the GDPR’s Article 33, most personal data breaches must be communicated to data protection authorities within 72 hours. In addition, some sector-specific laws, such as the one for the resilience of financial services (EU, 2022c), impose further incident reporting obligations.

ongoing mitigation measures, and, where applicable, an assessment about any cross-border impacts. The cross-border impact assessment again signifies the relation to large-scale incidents. Regarding actively exploited vulnerabilities, the CRA’s Article 14(2)(c) specifies that a final report should be delivered already no later than fourteen days. It should describe a given vulnerability’s severity and impact, information about potential exploitation, and details about security updates or other corrective measures made available.

Finally, it should be emphasized that while these reporting obligations and their deadlines are only toward public authorities, also other parties typically need to be informed, including further external parties, such as stakeholders and business partners, and internal parties, such as an organization’s management and, where applicable, its employees (Kulikova et al., 2012). Thus, existing incident management plans at the organizational level presumably require or benefit from updating; a synchronization with the law-imposed obligations might be a good idea. Due to the various reporting obligations and strict deadlines, an analogous point applies on the public sector side; so-called incident triaging (ENISA, 2010) likely requires planning.

4. Crisis management

4.1. Governance units

The management of cyber security crises is generally challenging in the EU due to the involvement of at least two member states, given the definition for a large-scale cyber security incident noted in Section 3.1.5. Given the analytical levels discussed in Section 2.3, the management is about the national level and the supranational level. In terms of the former, the term transnational could be used to characterize the horizontal interstate management and coordination between the member states involved. While governments may be involved too in a case of particularly severe crises, the term intergovernmental might be too strong or even misleading because the actual day-to-day crisis management would not likely involve governmental representatives in most cases. The NIS2 directive also established new crisis management bodies that are not explicitly and directly about the member states’ central governments. These also coordinate vertically toward units operating at the supranational level.

In general, the NIS2 directive specifies cyber security crisis management to occur through three governance bodies:

1. The first is the authoritative network of European CSIRTs upon with the EU’s whole cyber security framework was initially built (Ruohonen et al., 2016). As the CSIRT network extends beyond Europe, the international level may be involved too, as also indicated by Fig. 2. In general, NIS2 strengthens the European CSIRT network further, obliging also the authoritative CSIRTs to carry out further tasks.
2. The second is a specific NIS2 cooperation group. However, as specified in the NIS2’s Article 14(4), its tasks are largely on the political side instead of the operational crisis management side. Among other things, the group is specified to help at formulating further policies, exchanging best practices and viewpoints, including regarding sectoral implementations, carrying out risk analyses, providing strategic guidance, and meeting with private sector stakeholders.
3. The third is a new European cyber crisis liaison organization network (EU-CyCLONE). As specified in the NIS2’s Article 16, unlike the cooperation group, EU-CyCLONE is on the operational side; in particular, it is explicitly tasked to manage large-scale cyber security incidents. In general, the management involves similar phases that were noted in Section 2.4, among them preparedness and response. The EU-CyCLONE network is specified to also coordinate with the network of authoritative European CSIRTs.

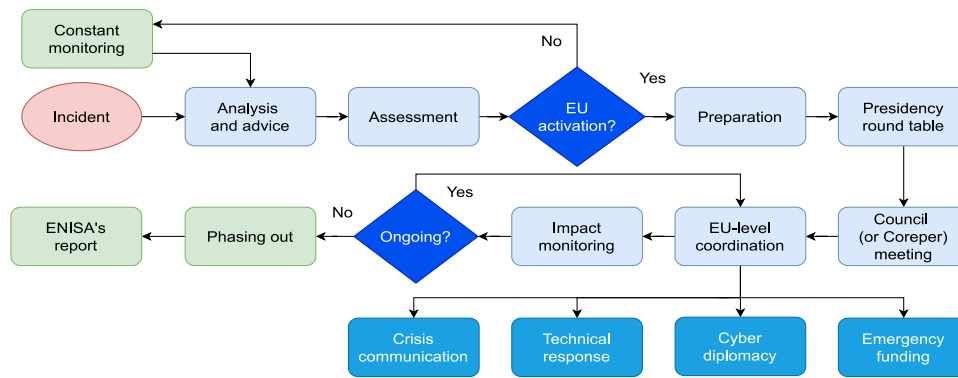


Fig. 5. Cyber security crisis management at the EU-Level. Source: Adopted and modified from EU, 2017, Fig. 2.

The political side of crisis management deserves a further comment. This side is seen in the composition of the NIS2 cooperation group. As specified in the NIS2’s Article 14(3), it is composed of representatives of the member states, the EC, and ENISA, but also other public sector authorities may be present, including the European External Action Service (EEAS) who is responsible for the EU’s foreign policy. While the activities of the EEAS were framed to outside of the paper’s scope via the discussion in Section 2.1, it is still worth emphasizing that cyber security crisis management in the EU may involve also diplomacy and related foreign policy activities, as also indicated by the summary in Fig. 2. Analogously, the NIS2 directive’s Article 16(3)(d) specifies that the EU-CyCLONE network should also “support decision-making at political level”.

Given these elaborations, it is understandable that some criticism has been levied about increased administrative complexity, fragmentation, and bureaucratization of the EU’s cyber security governance model in general (Ruohonen, 2024a,b). Such criticism aligns with a broader branch of research on the “bureau-politics” of crisis management (Rosenthal et al., 1991), including potential “turf wars” between governance bodies (Finke, 2020; Senninger et al., 2021). The COVID-19 pandemic provides an excellent reference point in this regard (cf. Lipsky, 2020; Zahariadis et al., 2023). This research branch is relevant to note because rapid responses and timeliness in general are important particularly in the cyber security context. As already the deadlines in Fig. 4 demonstrate, rapid responses are required from EAIEs and others, but it remains generally unclear how fast and well the responses travel through the bureaucracy and politics at the receiving end.

4.2. Management at the supranational level

The CSIRT and EU-CyCLONE networks as well as the NIS2 cooperation group operate both at the national level and the supranational level. At the former level, these allow horizontal coordination between the member states; at the latter level, these enable the member states to coordinate with EU-level institutions, among them the EC and ENISA. As was noted in Section 2.3.2, the Council is on the side of intergovernmental governance, and within the Council, the member states have permanent representatives through the Committee of the Permanent Representatives of the Governments of the Member States to the European Union—or Coreper in short. With these clarifications, a high-level crisis management framework at the EU-level can be illustrated in the form of Fig. 5.

The process starts when an early warning or a later incident notification is received, possibly from an EAIE or a larger set of EAIEs, through an authoritative CSIRT or multiple authoritative CSIRTs. For the present purposes, the phase after the initial assessment, the EU activation phase, is the crucial one; during this phase, the two part definition for a large-scale cyber security incident should be likely assessed.

Politically, the activation is done by the rotating Presidency of the Council after consulting the EC and the EEAS’ high representative (EU, 2018). As noted in the CSOA’s Article 20, the political activation procedure is similar to requesting help from the new cyber reserve as well as those used for natural and other disasters requiring civil protection. Technically, however, the available documentation is unclear about the actual incident analysis. The EEAS, EC, ENISA, CSIRT and EU-CyCLONE networks are mentioned alongside Europol, the EU’s own CSIRT (known as CERT-EU), and even the EU’s intelligence and satellite institutions (EC, 2025a; EU, 2017). Given that the political activation depends on, or should depend on, the adequacy and correctness of a technical incident analysis, already the amount of potential actors is enough to reiterate the earlier point about administrative complexity and its possible consequences. Nor is it possible to deduce what might be a cost of a false positive.

Assuming that political activation is done, a further bottleneck might be the subsequent phases. As seen from Fig. 5, there are preparations and meetings before the actual EU-level coordination starts looping. If a response time is short, these phases may cause undesirable delays. In addition to a technical response, including the containment, eradication, and recovery tasks in the NIST’s framework (Cichonski et al., 2012), the EU’s crisis management plans include also considerations about funding needs, diplomatic responses, and crisis communication. In addition to academic research (Kulikova et al., 2012), the role and importance of crisis communication have recently been emphasized also by ENISA (2024b) who further stressed a need to develop clear technical indicators and decision mechanisms for activating the EU machinery.

4.3. A hypothetical scenario

4.3.1. Setup

A brief hypothetical scenario can be presented by extending the real-world case briefly described in Section 2.3.5 toward a cyber security crisis. Thus, the context is again the energy sector. Although the European energy sector has not seen frequent incidents (see Fig. 6), supposedly because of the sector’s cyber security maturity (ENISA, 2024a), the energy sector is categorized as critical in the NIS2 directive. The energy sector also continuously ranks high in terms of criticality assessments (ENISA, 2025a). As will be seen, the sector’s criticality partially stems from potential cascading effects. To this end and other ends, the energy sector has also been a topic of exercises conducted by the national and EU-level authorities (ENISA, 2024a). To further frame the hypothetical scenario toward the real-world case, the context can be restricted to the Nordic countries. The electricity grids in these countries are mostly connected and synchronized.⁵ The large

⁵ Though, Iceland and parts of Denmark are disconnected.

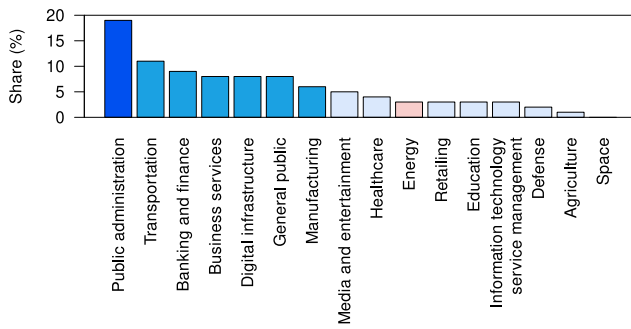


Fig. 6. Shares of reported incidents in selected sectors between July 2023 and June 2024 in the European Union.

Source: Adopted from ENISA, 2024a, Fig. 5 on p. 18.

synchronized Nordic smart grid further has non-synchronized links to Germany, Poland, Lithuania, the Netherlands, the United Kingdom, and Estonia (SK, 2025). When keeping in mind the definition for a large-scale incident or a crisis (see Section 3.1.5), the Nordic smart electricity grid thus provides an excellent case for the hypothetical scenario.

4.3.2. Events

With the previous notes, consider that a large international producer reported both to ENISA and a national authoritative CSIRT in one Nordic country about an actively exploited vulnerability in an industrial control system product. The producer had reliable evidence about active exploitation in Southeast Asia but was not aware about any actual incidents in Europe, including severe incidents that would warrant additional mandatory reporting. The notification about the actively exploited vulnerability was done within the 72 h deadline. The authoritative CSIRT started to investigate the vulnerability notification.

About a week after the initial notification, an authoritative CSIRT in Southern Europe received a few almost identical reports about near misses caught by intrusion detection systems deployed by two companies operating in the water management sector, which too is defined as critical in the NIS2 directive. After consulting the companies, the CSIRT concluded these to be noise that is typical to intrusion detection systems. It did not notify ENISA or other coordination bodies. In the meanwhile, the Nordic CSIRT was still investigating the actively exploited vulnerability in collaboration with the international producer.

About two weeks after the initial notification about active exploitation outside of Europe, another authoritative CSIRT in another Nordic country received an urgent notification about a significant incident in the energy sector; two relatively large regions were out of power due to a suspected cyber attack. Soon after, a similar notification was received by the Lithuanian authoritative CSIRT. The two CSIRTs notified ENISA and started to investigate the incidents through the EU-CyCLONE network. Thanks to redundancy mechanisms, the EAIEs involved managed to solve the power cuts within about eight hours. As the incidents were under control, the EU-CyCLONE network urged the EU-level administration to not activate the EU's cyber security crisis management framework even though already the preliminary investigation revealed that the definition for a large-scale incident was satisfied. Nevertheless, the coordination network decided that a joint internal investigation was needed.

About a month after the initial notification, the internal investigation was ready. It indicated that the power availability issues had resulted from a cyber attack that involved tampering with control messages delivered to industrial control systems used by the EAIEs involved. However, there had been a significant *cyber security incident* only in one Nordic country; the Lithuanian case had occurred merely because of the disruption to the shared grid. Furthermore, it was

concluded that all previous notifications were related. The root cause was the actively exploited vulnerability initially reported to another Nordic authoritative CSIRT. Also the near misses in an unrelated sector had been about the same vulnerability.

4.3.3. The points raised

Although only hypothetically, the scenario illustrates seven points: (1) the potential involvement of entities outside of Europe; (2) the criticality concept's ties not only to sectors but also to products; (3) the potential cascading effects and relationships between confidentiality, integrity, and availability; (4) the potential difficulties to triage, analyze, and correlate different notification types; (5) the potential dangers involved in making decisions about true and false positives; (6) the potential delays and related problems in vulnerability and incident coordination; and (7) the potential political and other uncertainties about the EU-level activation. Regarding further scenarios, whether hypothetical or empirical, particularly the escalation and containment dynamics require better understanding. Despite the seventh point raised, the scenario is also a good way to conclude by answering to RQ.1, RQ.2, and RQ.3.

5. Conclusion

The paper's conclusion can be summarized by answering to the three RQs specified in the introduction. Thus:

1. The EU's new cyber security laws distinguish four incident types: "conventional" incidents, severe incidents, significant incidents, and large-scale incidents. Albeit only implicitly, the last incident type is equated to the concept of a cyber security crisis. The definition for such a crisis is twofold: *a cyber security incident becomes a cyber security crisis either in case it exceeds a handling capacity of a single member state of the EU or in case it significantly affects at least two member states simultaneously.*
2. The EU's new cyber security laws significantly extend reporting obligations toward public sector authorities. Both operators of critical infrastructures and producers of many information technology products are mandated to report incidents; only reporting of the "conventional" incidents is voluntary. The deadlines for reporting are also strict. Furthermore, there are overlaps presents between the reporting obligations.
3. Cyber security crisis management and its governance in the EU are still strongly built upon national authoritative CSIRTs and their EU-level coordination bodies, including ENISA in particular. However, the new laws have also brought additional governance bodies, among them EU-CyCLONE that was specifically established for cyber security crisis management. In addition, a new staff reserve has been established for helping countries facing cyber security crises. Despite—or due to—these new crisis management bodies and recent policy proposals, it remains generally unclear how—and how well—crisis management works at the EU-level administration.

6. Limitations

The most notable limitation is related to interpretation, including a degree of subjectivity that inevitably follows from descriptive policy research dealing with laws and theory-building. Among other things, as was noted in Section 3.1.4, many of the qualifying adjectives, such as significant and severe, are open to further interpretation. However, definite interpretations are likely possible only after guidance from the public authorities involved, including in terms of administrative fines or other enforcement actions. As both the fines and other enforcement actions, such as a potential withdrawal of non-compliant products from the EU's internal market, can be severe, it is likely that some

future cases will end up also to courts whose decisions entail the final interpretations.

Another notable limitation is related to the national adaptations and implementations of the EU laws considered. Existing results indicate a substantial variation already between the national transpositions of some related EU cyber security laws (Becker, 2025). In general—and despite the new EU laws and frameworks for these (ENISA, 2025a), national and other definitions for alert levels and criticality itself remain unclear, non-harmonized, and generally vague (Alexopoulos et al., 2025; Ruohonen, 2024a; Ruohonen et al., 2025a).⁶ Thus, further research is needed to better understand the national level in Fig. 1. As was noted in Section 2.3.3, a divergence between the member states can be expected.

7. Further work

The three concluding answers can be accompanied by four points about further research. To motivate the first point, it can be noted that despite uncertainties about actual crisis management particularly at the EU-level, it seems the NIS2 directive has addressed a commonplace problem among many member states whose national laws and frameworks lacked a definition for a cyber security crisis (Boin et al., 2018). However, the NIS2's definition for a large-scale cyber security incident might also be argued to be about too large crises in a sense that an escalation to a national level might already be perceived as a crisis in some severe cases. This point motivates the first avenue for further research.

Given the overall escalation theme in incident management research (Mitropoulos et al., 2006), as already said, (1) further theoretical and comparative research is needed about the analytical levels in Fig. 1. Regarding comparisons, a good starting point would be a comparative examination of national laws and frameworks for cyber security crisis management in the member states. National adaptations and implementations would also help at addressing the interpretation limitation. Also the paper's framings noted in Section 2.1 would deserve a theoretical visit. Despite the research on hybrid threats, the relation between cyber security incidents and crises, including their potential cascading effects, and other incidents and crises remain arguably poorly understood and theorized. These points justify further theoretical and conceptual research too. Regarding comparative research more generally, (2) further research is also needed to compare the EU's cyber security crisis management framework with other countries. China and the United States would be good candidates for a comparison.

Regarding the EU-level cyber security crisis management, (3) further research is required also on the roles, duties, and other functions of various different administrative units, whether national, supranational, or something in-between. Composites such accountability, collaboration and coordination, transparency, information sharing, decentralization and autonomy, and responsiveness could be used to frame an evaluation (cf. Vu et al., 2025). However: even though it is easy to agree with an argument that more empirical research is needed on incident management in general (Tøndel et al., 2014), a problem with the NIS2's large-scale incidents is that thus far at least publicly disclosed cases are missing. In other words, it is difficult to properly evaluate a management of something that has not supposedly yet happened in Europe.

Therefore, regarding empirical research, it might make sense to start from smaller evaluations. In particular, (4) the increased reporting

⁶ For instance, ENISA (2025a, p. 12) has assessed criticality in terms of socio-economic impacts, spillovers to other sectors and countries, an incident's or a crisis' longitudinal persistence, and reliance on information and communication technologies. Although sensible as such, it remains unclear how objective such broad assessment criteria are. Many aspects of criticality are also missing from sectoral frameworks, including the NIS2 directive (Ruohonen et al., 2025a).

obligations, including the strict deadlines, would offer a good topic for empirical evaluation research. Already the points raised in Section 4.3 would provide a theoretical motivation. A lot of research and other work have also been done to help at evaluating the efficiency, accuracy, and other aspects CSIRTs and their incident management practices (Connell and Waits, 2013; Dorofee et al., 2007, among many others). However, a broader evaluation is required also with respect to EAIEs and others who are obliged to report about incidents or do so voluntarily. Given the CRA's and NIS2's strict deadlines, as well as the penalties from non-compliance, it may be that organizations and others will report eagerly and possibly incautiously. Thus, the quality of early warnings, incidents notifications, and particularly final reports (Busetti and Scanni, 2025), including a rate of false positives, would provide a good research topic with practical relevance. A related topic would involve examining whether reporting guidelines and a systematic reporting format might increase reporting quality and reduce noise. As it stands, neither the NIS2 directive nor the other laws say anything about *what* should be reported.

The reporting topic is generally important because regulatory obligations upon incident management have recently been argued to work poorly in improving organizations' cyber security postures (Patterson et al., 2024). This point serves well to end the paper by reiterating that something should always be learned from cyber security incidents and crises. Because the reports are likely confidential, however, it may well be that the topic could only be studied by indirect means, such as surveys or interviews of public authorities and EAIEs.

CRedit authorship contribution statement

Jukka Ruohonen: Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Kalle Rindell:** Writing – review & editing, Validation, Investigation, Conceptualization. **Simone Busetti:** Writing – review & editing, Methodology, Investigation, Conceptualization.

Declaration of competing interest

There are no conflicts of interest.

Acknowledgments

The authors thank Muhammad Mohsin Hussain for helpful comments.

Data availability

No primary data was used for the research described in the article.

References

- Adkins, H., Beyer, B., Blankinship, P., Oprea, A., Lewandowski, P., Stubblefield, A., 2020. Building Secure and Reliable Systems: Best Practices for Designing, Implementing, and Maintaining Systems. O'Reilly, Sebastopol.
- Al Sabbagh, B., Kowalski, S., 2015. A socio-technical framework for threat modeling a software supply chain. *IEEE Secur. Priv.* 13 (4), 30–39.
- Alahmadi, B.A., Axon, L., Martinovic, I., 2022. 99% false positives: A qualitative study of SOC analysts' perspectives on security alarms. In: Proceedings of the 31st USENIX Security Symposium. USENIX, Boston, pp. 2783–2800.
- Alexopoulos, M.J., Niemi, A., Skobieć, B., Torres, F.S., 2025. Examination of the critical infrastructure resilience directive from the maritime point of view. *J. Common Mark. Stud.* 63 (2), 667–678.
- Anagnostakis, D., 2023. Hybrid threats: A European response. In: Balomenos, K.P., Fytopoulos, A., Pardalos, P.M. (Eds.), *Handbook for Management of Threats: Security and Defense, Resilience and Optimal Strategies*. Springer, Cham, pp. 425–441.
- Anderson, R., 2020. *Security Engineering*, third ed. Wiley, New York.
- Antoniuk, D., 2023. Nearly two dozen danish energy companies hacked through firewall bug in may. *The Record*, available online in March 2025: <https://therecord.media/danish-energy-companies-hacked-firewall-bug>.

- Ayyub, B.M., McGill, W.L., Kaminskiy, M., 2007. Critical asset and portfolio risk analysis: An all-hazards framework. *Risk Anal.* 27 (4), 789–801.
- Bartle, I., Flinders, M., 2016. Multi-level governance. In: Ansell, C., Torfing, J. (Eds.), *Handbook on Theories of Governance*. Edward Elgar, Cheltenham, pp. 486–498.
- Becker, M., 2025. Transposing EU-legislation on critical infrastructure protection legal implementation performance in the Baltic Sea Region. *Int. J. Crit. Infrastruct. Prot.* 50, 100781.
- Béland, D., Marier, P., Paquet, M., 2024. Subnational comparative policy analysis: Institutions, methodology, and research agenda. *J. Comp. Policy Anal.: Res. Pr.* 26 (6), 553–566.
- Bertoldi, A., de Oliveira Chishman, R.L., da Rosa Alves, I.M., 2007. Adjectival semantics and the legal domain: A study for ontology improvement. *Intel. Artif.* 11 (33), 19–26.
- Bhatt, S., Manadhata, P.K., Zomlot, L., 2014. The operational role of security information and event management systems. *IEEE Secur. Priv.* 12 (5), 35–41.
- Bickerton, C., Brack, N., Coman, R., Crespy, A., 2022. Conflicts of sovereignty in contemporary Europe: A framework of analysis. *Comp. Eur. Polit.* 20, 257–274.
- Boeke, S., 2017. National cyber crisis management: Different European approaches. *Governance* 31 (3), 449–464.
- Boin, A., Ekengren, M., Rhinard, M., 2018. Hiding in plain sight: Conceptualizing the creeping crisis. *Risk, Hazards Crisis Public Policy* 9 (2), 116–138.
- Brownlee, N., Guttman, E., 1998. Expectations for computer security incident response. RFC 2350, the internet engineering task force (IETF). available online in March 2025: <https://www.ietf.org/rfc/rfc2350.txt>.
- Busetti, S., Scanni, F.M., 2025. Evaluating incident reporting in cybersecurity. From threat detection to policy learning. *Gov. Inf. Q.* 42 (1), 102000.
- BusinessEurope, 2025. Reducing regulatory burden to restore the EU's competitive edge. Available online in September 2025: https://www.business-europe.eu/wp-content/uploads/2025/02/2025-01-22_business-europe_mapping_of_regulatory_burden-d55-1.pdf.
- CFCS, 2023. The cyber threat against the danish energy sector. Centre for cyber security (CFCS). available online in March 2025: <https://www.cfcs.dk/globalassets/cfcs/dokumenter/trusselsvurderinger/en/-cyber-threat-against-the-danish-energy-sector.pdf>.
- Christensen, T., Danielsen, O.A., Pægreid, Rykkja, L.H., 2016. Comparing coordination structures for crisis management in six countries. *Public Adm.* 94 (2), 316–332.
- Christou, G., 2016. *Cybersecurity in the European Union: Resilience and Adaptability in Governance and Policy*. Palgrave Macmillan, New York.
- Cichonski, P., Millar, T., Grance, T., Scarfone, K., 2012. Computer Security Incident Handling Guide Recommendations of the National Institute of Standards and Technology. National Institute of Standards and Technology (NIST), Special Publication 800-61, available online in January 2025: <https://nvlpubs.nist.gov/nistpubs/specialpublications/nist.sp.800-61r2.pdf>.
- Collier, J., 2016. Strategies of cyber crisis management: Lessons from the approaches of Estonia and the United Kingdom. In: Taddeo, M., Glorioso, L. (Eds.), *Ethics and Policies for Cyber Operations: A NATO Cooperative Cyber Defence Centre of Excellence Initiative*. Springer, Cham, pp. 187–212.
- Connell, A., Waits, T., 2013. The CERT assessment tool: Increasing a security incident responder's ability to assess risk. In: *Proceedings of the IEEE International Conference on Technologies for Homeland Security. HST 2013*, Waltham, pp. 236–240.
- DeLeon, P., Weible, C.M., 2010. Policy process research for democracy: A commentary on Lasswell's vision. *Int. J. Policy Stud.* 1 (2), 23–34.
- Dorofee, A., Killcrece, G., Ruefle, R., Zajicek, M., 2007. Incident Management Capability Metrics Version 0.1. Software Engineering Institute, CERT Program, Carnegie Mellon University, available online in March 2025: <http://pstorage-cmu-348901238291901.s3.amazonaws.com/12060836/file.pdf>.
- EC, 2020. COMMISSION STAFF WORKING DOCUMENT: IMPACT ASSESSMENT REPORT accompanying the document proposal for a directive of the European parliament and of the council on measures for a high common level of cybersecurity across the union, repealing directive (eu) 2016/1148. COM(2020) 823 final – sec(2020) 430 final – swd(2020) 344 final, the European commission (EC). available online in March 2025: <https://ec.europa.eu/newsroom/dae/redirection/document/72176>.
- EC, 2025a. Proposal for a COUNCIL RECOMMENDATION for an EU blueprint on cybersecurity crisis management. COM(2025) 66 final, 2025/0036 (NLE), the European commission (EC). available online in March 2025: <https://ec.europa.eu/newsroom/dae/redirection/document/113086>.
- EC, 2025b. Shaping Europe's Digital Future: Cybersecurity. The European Commission (EC), available online in March 2025: <https://digital-strategy.ec.europa.eu/en/policies/cybersecurity>.
- ENISA, 2010. Good Practice Guide for Incident Management. The European Union Agency for Cybersecurity ENISA, Available online in March 2025: https://enisa.europa.eu/sites/default/files/publications/Incident_Management_guide.pdf.
- ENISA, 2024a. 2024 Report on the State of Cybersecurity in the Union. The European Union Agency for Cybersecurity (ENISA), Available online in August 2025: <https://enisa.europa.eu/sites/default/files/2024-11/2024%20Report%20on%20the%20State%20of%20the%20Cybersecurity%20in%20the%20Union.pdf>.
- ENISA, 2024b. Best Practices for Cyber Crisis Management. The European Union Agency for Cybersecurity (ENISA), Available online in March 2025: <https://enisa.europa.eu/sites/default/files/2024-11/ENISA%20Study%20Best%20Practices%20Cyber%20Crisis%20Management.pdf>.
- ENISA, 2025a. ENISA NIS360 2024: ENISA Cybersecurity Maturity & Criticality Assessment of NIS2 Sectors. The European Union Agency for Cybersecurity (ENISA), Available online in March 2025: https://www.enisa.europa.eu/sites/default/files/2025-03/ENISA%20-%20NIS360%20-%202024_0.pdf.
- ENISA, 2025b. European Union Vulnerability Database. The European Union Agency for Cybersecurity (ENISA), Available online in March 2025: <https://evud.enisa.europa.eu/>.
- ENISA, 2025c. Technical Implementation Guidance: On Commission Implementing Regulation (EU) 2024/2690 of 17 October 2024 Laying Down Rules for the Application of NIS2 Directive As Regards Technical and Methodological Requirements of Cybersecurity Risk-Management Measures. The European Union Agency for Cybersecurity ENISA, Available online in August 2025, https://enisa.europa.eu/sites/default/files/2025-06/ENISA_Technical_implementation_guidance_on_cybersecurity_risk_management_measures_version_1.0.pdf.
- EP, 2024. Cyber solidarity act. Briefings: EU legislation in progress, the European parliament (EP). available online in March 2025: [https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/754614/EPRS_BRI\(2023\)754614_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/754614/EPRS_BRI(2023)754614_EN.pdf).
- EU, 2016. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons With Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC (General Data Protection Regulation) (Text With EEA Relevance). The European Union, (EU), available online in March 2025: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R0679&qid=1750652352977>.
- EU, 2017. Commission Recommendation (EU) 2017/1584 of 13 September 2017 on Coordinated Response To Large-Scale Cybersecurity Incidents and Crises. The European Union (EU), available online in March 2025, <https://eur-lex.europa.eu/eli/reco/2017/1584/oj/eng>.
- EU, 2018. Council Implementing Decision (EU) 2018/1993 of 11 December 2018 on the EU Integrated Political Crisis Response Arrangements. The European Union (EU), available online in March 2025, https://eur-lex.europa.eu/eli/dec_impl/2018/1993/oj/eng.
- EU, 2019. Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the European Union Agency for Cybersecurity) and on Information and Communications Technology Cybersecurity Certification and Repealing Regulation (EU) No 526/2013 (Cybersecurity Act) (Text with EEA Relevance). The European Union (EU), available online in March 2025, <https://eur-lex.europa.eu/eli/reg/2019/881/oj/eng>.
- EU, 2022a. Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on Measures for a High Common Level of Cybersecurity Across the Union, Amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and Repealing Directive (EU) 2016/1148 (NIS 2 Directive) (Text with EEA Relevance). The European Union (EU), available online in March 2025, <https://eur-lex.europa.eu/eli/dir/2022/2555/oj/eng>.
- EU, 2022b. Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the Resilience of Critical Entities and Repealing Council Directive 2008/114/EC (Text with EEA Relevance). The European Union (EU), available online in March 2025: <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32022L2557>.
- EU, 2022c. Regulation (EU) 2022/2554 of the European Parliament and of the Council of 14 December 2022 on Digital Operational Resilience for the Financial Sector and Amending Regulations (EC) no 1060/2009, (EU) No 648/2012, (EU) No 600/2014, (EU) No 909/2014 and (EU) 2016/1011 (Text With EEA Relevance). The European Union (EU), available online in March 2025: <https://eur-lex.europa.eu/eli/reg/2022/2554/oj/eng>.
- EU, 2024. Regulation (EU) 2024/2847 of the European parliament and of the council of 23 october 2024 on horizontal cybersecurity requirements for products with digital elements and amending regulations (EU) no 168/2013 and (EU) 2019/1020 and directive (EU) 2020/1828 (cyber resilience act) (text with EEA relevance). The European Union (EU), available online in March 2025: <https://eur-lex.europa.eu/eli/reg/2024/2847/oj/eng>.
- EU, 2025. Regulation (EU) 2025/38 of the European Parliament and of the Council of 19 December 2024 Laying Down Measures to Strengthen Solidarity and Capacities in the Union to Detect, Prepare for and Respond to Cyber Threats and Incidents and Amending Regulation (EU) 2021/694 (Cyber Solidarity Act). The European Union (EU), available online in March 2025: <https://eur-lex.europa.eu/eli/reg/2025/38/oj/eng>.
- Finke, D., 2020. Turf wars in government administration: Interdepartmental cooperation in the European commission. *Public Adm.* 98 (2), 498–514.
- Fischer-Hübner, S., Alcaraz, C., Ferreira, A., Fernandez-Gago, C., Lopez, J., Markatos, E., Islami, L., Akil, M., 2021. Stakeholder perspectives and requirements on cybersecurity in Europe. *J. Inf. Secur. Appl.* 61, 102916.
- Gänzle, S., Kern, K., Tynkkynen, N., 2022. Governing the Baltic Sea Region at critical junctures (1991–2021): How do transnational and intergovernmental organizations cope With External Regional change? *J. Balt. Stud.* 54 (3), 421–442.

- Gjesvik, L., 2019. Comparing Cyber Security: Critical Infrastructure Protection in Norway, the UK and Finland. Norwegian Institute of International Affairs (NUPI), available online in March 2025, https://nupi.brage.unit.no/nupi-xmlui/bitstream/handle/11250/2598280/NUPI_Report_5_2019_Gjesvik.pdf.
- Goodman, W., 2010. Cyber deterrence: Tougher in theory than in practice? *Strat. Stud. Q.* 4 (3), 102–135.
- Handler, H., 2024. *Europe Tested By Crises: The EU on the Path To a New Identity*. Springer, Wiesbaden.
- Head, B.W., 2022. *Wicked Problems in Public Policy: Understanding and Responding To Complex Challenges*. Palgrave Macmillan, Cham.
- Heine, M., 2019. Managing systemic risks: Opening up public crisis. In: *Proceedings of the First Workshop on Systemic Risks in Global Networks, Co-located with the 14. Internationale Tagung Wirtschaftsinformatik. WI 2019, CEUR-WS, Siegen*.
- Hutzschenreuter, T., Matt, T., Kleindienst, L., 2020. Going subnational: A literature review and research agenda. *J. World Bus.* 55, 101076.
- Izumi, T., 2024. Introduction and overview of the all-hazard approach. In: Izumi, T., Abe, M., Fujita, K., Shaw, R. (Eds.), *All-HAZards Approach: Towards Resilience Building*. Springer, Singapore, pp. 3–15.
- Jaatun, M.G., Albrechtsen, E., Line, M.B., Tøndel, I.A., Longva, O.H., 2009. A framework for incident response management in the petroleum industry. *Int. J. Crit. Infrastruct. Prot.* 2 (1–2), 26–37.
- Jhaveri, M.H., Cetin, O., Gañán, C., Moore, T., van Eeten, M., 2017. Abuse reporting and the fight against cybercrime. *ACM Comput. Surv.* 49 (4), 1–17.
- Jungwirth, R., Smith, H., Willkomm, E., Savolainen, J., Villota, M.A., Lebrun, M., Aho, A., Giannopoulos, G., 2023. *Hybrid Threats: A Comprehensive Resilience Ecosystem*. Publications office of the European union, Luxembourg. a report prepared by the joint research centre (JRC) and the European centre of excellence for countering hybrid threats (hybrid CoE). available online in March 2025: https://www.hybridcoe.fi/wp-content/uploads/2023/04/CORE_comprehensive_resilience_ecosystem.pdf.
- Kulikova, O., Heil, R., van den Berg, J., Pieters, W., 2012. Cyber crisis management: A decision-support framework for disclosing security incident information. In: *Proceedings of the International Conference on Cyber Security. CyberSecurity 2012, Alexandria*, pp. 103–112.
- Lipsy, P.Y., 2020. COVID-19 and the politics of crisis. *Int. Organ.* 74 (51), E98–E127.
- Malatji, M., von Solms, S., Marnewick, A., 2019. Socio-technical systems cybersecurity framework cybersecurity framework. *Inf. Comput. Secur.* 27 (2), 233–272.
- Mitropoulos, S., Patsos, D., Douligeris, C., 2006. On incident handling and response: A state-of-the-art approach. *Comput. Secur.* 25 (5), 351–370.
- Mueck, M., Gaie, C., 2025. Introduction to the European cybersecurity act. In: Mueck, M., Gaie, C. (Eds.), *European Digital Regulations*. Springer, Cham, pp. 229–247.
- Østby, G., Katt, B., 2020. Cyber crisis management roles – a municipality responsibility case study. In: *Proceedings of the 4th IFIP TC 5 DCITDRR International Conference. ITDRR 2019, Springer, Kyiv*, pp. 168–181.
- Panteli, N., Nthubu, B.R., Mersinas, K., 2025. Being responsible in cybersecurity: A multi-layered perspective. *Inf. Syst. Front.* 1–19, (Published online in February).
- Patterson, C.M., Nurse, J.R.C., Franqueira, V.N.L., 2024. I don't think we're there yet: The practices and challenges of organisational learning from cyber security incidents. *Comput. Secur.* 139, 103699.
- Patton, C.V., Sawicki, D.S., Clark, J.J., 2016. *Basic Methods of Policy Analysis and Planning*, third ed. Routledge, London.
- Ramsell, E., Wihlborg, E., 2012. Governing technical information systems in local crisis management. *Public Work. Manag. Policy* 17 (3), 303–318.
- Rataj, P., 2025. Botnet defense under EU data protection law. *Comput. Law Secur. Rev.* 56, 106080.
- Rosenthal, U., 't Hart, P., Kouzmin, A., 1991. The bureau-politics of crisis management. *Public Adm.* 69, 211–233.
- Rukanova, B., Wigand, R.T., van Stijn, E., Tan, Y.-H., 2015. Understanding transnational information systems with supranational governance: A multi-level conflict management perspective. *Gov. Inf. Q.* 32 (2), 182–197.
- Ruohonen, J., 2024a. A systematic literature review on the NIS2 directive. Archived manuscript. available online: <https://arxiv.org/abs/2412.08084>.
- Ruohonen, J., 2024b. The incoherency risk in the EU's new cyber security policies. In: *Proceedings of the 23rd IFIP Conference on E-Business, E-Services, and E-Society. I3E 2024, In: Lecture Notes in Computer Science, vol. 14907, Springer, Heerlen*, pp. 284–295.
- Ruohonen, J., Choudhary, G., Alami, A., 2025a. An overview of cyber security funding for open source software. Archived manuscript. available online: <https://arxiv.org/abs/2412.05887>.
- Ruohonen, J., Hjerpe, K., Kang, E.-Y., 2025b. A mapping analysis of requirements between the CRA and the GDPR. In: *Proceedings of the IEEE 33rd International Requirements Engineering Conference Workshops. REW 2025 Valencia, IEEE, (Forthcoming)* Available online: <https://arxiv.org/abs/2503.01816>.
- Ruohonen, J., Hyrynsalmi, S., Leppänen, V., 2016. An outlook on the institutional evolution of the European union cyber security apparatus. *Gov. Inf. Q.* 33 (4), 746–756.
- Ruohonen, J., Koskinen, J., Klausen, S.H., Gerdes, A., 2025c. A scenario analysis of ethical issues in dark patterns and their research. Archived manuscript. available online: <https://arxiv.org/abs/2503.01828>.
- Ruohonen, J., Nielsen, J.L., Skórczynski, J., 2025d. Risks and compliance with the EU's core cyber security legislation. Archived manuscript. available online: <https://arxiv.org/abs/2508.21386>.
- Ruohonen, J., Timmers, P., 2024. Vulnerability coordination under the cyber resilience act. Archived manuscript. available online: <https://arxiv.org/abs/2412.06261>.
- Secchi, L., 2016. Policy analysis in Brazil: A comparison of rationalist and argumentative approaches. *J. Comp. Policy Anal.: Res. Pr.* 18 (1), 88–101.
- SektorCERT, 2023. The attack against danish, critical infrastructure. Available online in March 2025: <https://sektorcert.dk/wp-content/uploads/2023/11/SektorCERT-The-attack-against-Danish-critical-infrastructure-TLP-CLEAR.pdf>.
- Senninger, R., Finke, D., Blom-Hansen, J., 2021. Coordination inside government administrations: Lessons from the EU commission. *Governance* 34 (3), 707–726.
- SK, 2025. Karta över transmissionsnätet. Svenska kraftnät (SK). available online in 2025: <https://www.svk.se/om-kraftsystemet/om-transmissionsnatet/transmissionsnatskarta/>.
- Soesanto, S., Smeets, M., 2021. Cyber deterrence: The past, present, and future. In: Osinga, F., Sweijs, T. (Eds.), *NL ARMS Netherlands Annual Review of Military Studies 2020: Deterrence in the 21st Century—Insights from Theory and Practice*. Asser Press, The Hague, pp. 385–400.
- Sus, M., Hadeed, M., 2020. Theory-infused and policy-relevant: On the usefulness of scenario analysis for international relations. *Contemp. Secur. Policy* 41 (3), 432–455.
- Tøndel, I.A., Line, M.B., Jaatun, M.G., 2014. Information security incident management: Current practice as reported in the literature. *Comput. Secur.* 45, 42–57.
- Tsebelis, G., Garrett, G., 2021. The institutional foundations of intergovernmentalism and supranationalism in the European union. *Int. Organ.* 55 (2), 357–390.
- van Haastrecht, M., Ozkan, B.Y., Brinkhuis, M., Spruit, M., 2021. Respite for SMEs: A systematic review of socio-technical cybersecurity metrics. *Appl. Sci.* 11 (6909).
- Vu, B.T., Obaitor, O.S., Grobusch, L.C., Sett, D., Hagenlocher, M., Schinkel, U., Nguyen, L.K.H., Bachofer, F., Ngo, S.T., Garschagen, M., 2025. Enablers and barriers to implementing effective disaster risk management according to good governance principles: Lessons from central Vietnam. *Int. J. Disaster Risk Reduct.* 120, 105344.
- Zahariadis, N., Petridou, E., Exadaktylos, T., Sparf, J., 2023. Policy styles and political trust in europe's national responses to the COVID-19 crisis. *Policy Stud.* 44 (1), 46–67.
- Zibak, A., Sauerwein, C., Simpson, A.C., 2022. Threat intelligence quality dimensions for research and practice. *Digit. Threat.: Res. Pr.* 3 (4), 1–22.