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Service Design for Resilience: A Multi-Contextual Modeling Perspective

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ABSTRACT This paper introduces a conceptual framework aiming to broaden the discussion on resilience for the design of public services. From a theoretical point of view, the paper explores service design with a Systems Thinking lens. A multi-contextual perspective aiming to analyze, decompose, and design smart cities services where resilience is an input at the service design level is described and the *four diamonds-of-context model for service design* (4DocMod) is introduced. This service model accommodates various actors' contexts in public service design and consists of four design artefacts, the diamonds (***S***ee, ***R***ecognize, ***O***rganize, ***D***o). From a practical point of view, guidelines for the application of the 4DocMod service model extension for resilience are described along with two case studies addressing the recent COVID-19 pandemic that illustrates a clear situation of resilience with insights in multiple contexts. According to the findings of this paper, it is obvious that resilience is not "just" a request. Instead, it plays a higher role within the service system. It is not "just" another Context, either. Instead, it goes through many contexts with different circumstances. In this manner, it is possible to address the qualities through which actors can become resilient, at the service design stage, to ensure continuity of the public services in times of emergency. As our approach using the 4DocMod is proposing, resilience may be is achieved when specific properties are provisioned at information service design level.

INDEX TERMS Public services, resilience, service design, service model, system thinking.

I. INTRODUCTION

In the new way of cities, the *Smart Cities way*, powered by data and driven by people, smart city services evolve as a public service ecosystem. In this ecosystem, smart city services emerge out of the coordination of Actors as Agents for service design, where interaction is fueled by technology [1] and driven by the underlying information services [2]. With a significant involvement of digitization [3], such as social media and the myriads of connections powered by smart devices, non-traditional knowledge actors may engage innovatively with science and technology. This sort of co-creation practices becomes a driver for service provisioning and delivery via knowledge generation [4]–[6].

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In the actual multi-disciplinary context of society, this new kind of interaction, fundamentally based on the manipulation of information, effectively connecting people to information with technology, expects for the consideration of multiple perspectives, both on theoretical and practical dimensions. The exploration of various contexts that may be developed within various actors' perspectives that brings the possibility if creating new activities, giving the opportunity of understanding, learning, and defining practical implications for service organizations. In a service society, it invites for the development of, not just smarter, but also wiser service systems [7], that are dedicated to human to human interactions, facilitated by various means, including technology, digital, for knowledge exchange.

A common word that has been used extensively in association to the current COVID-19 crisis is *resilience*, a concept

comprehensively understood as a characteristic of ''institutional resistance'' [8] when facing a difficult situation, aiming to assure the continuity of human activities immediately and in short-term after event. Practitioners and decision making actors link resilience of cities to ensuring continuity of critical public services, such as supply chains, healthcare chains, electricity, water, communication, transportation [9], and stress the need to redefine ''the baseline requirements for resilience'' [8].

Resilience, *per se*, has been widely discussed under various aspects and domains. *As a multidisciplinary concept*, resilience has been studied within different fields of knowledge, including psychology [10], supply-chain management [11], corporate strategies [12], organizational models [13], disaster management [14], or human resource management ([15]. In general, resilience is recognized as *the ability to prepare for and adapt to changing conditions to withstand and recover rapidly from disruptions due to deliberate attacks, accidents or naturally threats* [16]. Resilience aspects are also studied together with other practical implications, such as food system resilience [17]–[19], urban design for resilient cities [20] and communities [21], resilience within the environmental education practice [22], resilient libraries as part of larger, complex systems [23], or, more comprehensive, resilience of systems [24]–[26], enterprises [27], and resilience for managerial implications [28].

Both resilience and sustainability have received significant attention among practitioners, policymakers, researchers, and academia, especially within the targets of the United Nations 2030 Agenda for Sustainable Development along with the 17 Sustainable Development Goals (SDGs) defined by the United Nations General Assembly [29]. At a global scale, the SDGs have emerged as a political framework to guide, align, and resolve, though partially, these cities' development issues. Therefore, it is necessary that ''*every global citizen should be able to acquire relevant knowledge, skills, and values to advance humanity's collective progress towards sustainable futures*'' [22].

Facing these current strenuous situations of disruption, such as pollution, natural (e.g. earthquakes) and health hazards, as in the case of the COVID-19 pandemic, the need for new frameworks of *transdisciplinary research* addressing societal challenges [30] is shaping. In this context, to develop a *transdisciplinary perspective on resilience*, including knowledge from different science disciplines and other stakeholders communities, as traditional or non-traditional knowledge actors, there is a need to expand and further develop the adoption of service logic to enable researchers and practitioners in understanding and exploring the potential of contextual value creation with knowledge co-production in local communities [20], [31], [21]. Therefore, amid and beyond the current disruption caused by the COVID-19 pandemic, it becomes commendable to find a new way to explain and instruct how complex, more meaningful, value co-creating interactions can emerge between Actors, as resources integrators in the Society, formalized at service level exchanges and accomplished in service activities.

Recently, scholars have started to raise concerns on public service resilience post COVID-19 [32], to increase the public value response from private and community sectors [33], and to pave the way for the collaborative development of *transdisciplinary information services and service systems* where all relevant actors may contribute to the digital construction for the progression of Society [2], [34], [35]. New institutions and institutional arrangements [36] are needed to drive the new value chains in public services and to guard the new strategic relationships [37] between entities to achieve resilience. As well, a more formalized, conceptual, approach of the actors' interactions in value co-creation networks has started to emerge [38], [39], drawing new perspectives from service dominant logic [40], [41] as a method theory [42].

However, *resilience* has yet to be considered *as a first hand design requirement* in the development of public services, at local and national levels. This is especially important for the enablement of the required activities to support emergency preparedness and bolster response capabilities, including multi-contextual resource integration [8]. Unfortunately, during the last few months it was widely acknowledged that community resilience confronting the COVID-19 pandemic has come short in allocating resources, boosting capacities, and growing capabilities to respond to this emergency [9].

This paper is developed in a System Thinking approach, applying the service ecosystems lens [43] to address resilience in a system perspective. The main contributions of this paper are organized around a major extension of the work presented in [44], that describes how various circumstances of service activities may be accommodated in a complex service design where stakeholders act within different contexts. The same way the complex services cannot exist in isolation from other services in the entire service ecosystem, the role of each agent acting in a service interaction, which can be the provider, collaborator, or receiver of the service, in a specific context, must be connected to the other contexts when the service is designed.

The incipient multi-contextual analysis for complex service design introduced in [44], which is based on the *diamond model*, a specific framework of Service Thinking built by [45], is evolved here as a multi-contextual service model, henceforth named the *four diamonds-of-context model for service design* (4DocMod). Provisioning resilience related capabilities through a good public service design is not an easy endeavour. First, a thoroughly understanding of the various aspects where the concept of resilience is used today is needed (Section II). Second, a thoroughly understanding on building new service models able to assure these capabilities is required, as well (Section III). The 4DocMod is further enriched with conceptual reflections addressing resilience as an input at the service design level (Subsection IV-A), accommodating them within *the service model artefacts*, *the four diamonds* that complete the complex service model (***S***ee, ***R***ecognize, ***O***rganize, and ***D***o).

This is an exploratory paper which is grounded upon a Service Design approach to provide an original conceptual way to establish resilience in the informational infrastructure of Society, further illustrated by the COVID-19 situation. Therefore, we support practical implications of the 4DocMod with two case studies underscoring advantages of a multi-contextual, goal oriented perspective, in the analysis of the public services related to the COVID-19 pandemic (Subsection IV-B). A discussion on the practical implications of the extension for resilience of 4DocMod in continuity planning as an essential base for public services' design and provision is included in Section V. Finally, Section VI concludes the paper stressing the relevance of the contributions in this paper, extracting guidelines for further research.

II. BACKGROUND AND RELATED WORK

Service design is a multidisciplinary domain integrating various contributions from service research and practice. However, to leverage the full potential of innovation in services, it still lacks transdisciplinary models and methods towards a good engineering practice. Various approaches have been explored to develop artefacts with theoretical and practical relevance for developing service design related artefacts, such as Design Science Research [46], information systems research [47], and action research [48].

However, a good engineering practice in creating resilience related artefacts with suitable relevance in service design is still in exploration. Resilience is relevant in various circumstances that may appear in real life. A service that must provide resilience along with its underlying activities can touch more than one context without disturbances when used successfully in more than one circumstance. This kind of situation is illustrated in the *participatory budgeting in Mnichovice* example in Subsection II-B.

Therefore, there is a need to develop universal tools able to be applied for any kind of service where actors are involved in various contexts. In this perspective, the utility of the *diamond model* [45] for the Smart Cities services design and analysis has become significant. It evolved as a reaction to the increasing service complexity and the limitation of similar modeling tools (such as UML, BPMN) to react to real world changes. The ''diamonds'' provide a tool to analyze, decompose, and design services in a multi-contextual environment.

The *diamond model* is a specific framework of Service Thinking, designed to help service analysts to bridge the gap between IT logic and service logic. In this perspective, several diamonds are created to instruct the service designer on how to understand the world around us (the ***S***ee diamond), and how any other stakeholder could understand it (the ***R***ecognize diamond).

A first step in understanding how to address resilience as a requirement at service design level is drawing a broader view on the related research (Subsection II-A), then grounding the perspective of the paper with an illustrative example (Subsection II-B), based on our previous work [44], [49] on using the diamond model to explore complex service design in a multi-contextual perspective.

A. RESILIENCE AS A BROAD AREA OF RESEARCH

As recent literature reveals, the semantic of the concept of resilience has evolved from an engineering perspective to an ecological, holistic one, focusing on the adaptability between the stable states under different structures and configurations where the entity can transition to maintain its core functions [50]. In this respect, both hard resilience sub-concept (i.e. applying specific measures to strengthen structures of institutions when placed under pressure) and soft resilience sub-concept (i.e. emphasizing on elasticity and adaptability of a system as a whole to recover from the impact of disruptive events) appear in the literature [24], [51].

Resilience and sustainability are used as complementary concepts [52]. Sustainability can be considered a measure of system performance, in its capacity to achieve current goals, while maintaining the future capacity to achieve them [52], [53]. Whereas, resilience can be seen as a means to achieve sustainability [52], [54], to assure the dynamic capacity of continuity (to provide a function) in spite of disturbances or shocks [55], [56].

Fig. 1 presents a map of conceptual pieces from existing work on resilience, across disciplines, aiming to provide a multi-level insight and to broaden the vision on the concept with the following discussion. The dictionary of terms created here, followed by the general guidelines for service design for resilience introduced later in the paper, in Section III, and summarized in Fig. 2, introduces an useful terminology in the specific domain of *resilience for cities*. Within the scope of this paper, these are cities able to enable knowledge co-production activities for public services, based on which they will support emergency preparedness with multi-contextual resource integration.

Following our previous work in [28], we introduce five interpretative propositions (***PN.i***) to express various angles of analysis.

The origins of resilience thinking lie in ecology [57]. Concepts of resilience contribute to understanding dynamic Social-Ecological Systems (SES) [25], [50], [58], [59]. Relating to the early 2000s, we can identify two different perspectives for resilience. The first one concerns High Reliability Organizations (HROs) that operate in extreme conditions, as an attempt to reduce errors and inefficiencies [60]. The second taps the notion of reconstitution (restoration) of the abilities and resources of an organization [61].

PN.1 *Resilience is a function of the context in which it operates*. Block and Block (1980) believe that resilience is the organizational dynamic ability to modify its model according to the changing characteristics of the reference context, emphasizing the negative aspect of this variability [62]. Resilience is close to the themes of autopoiesis and self-regulation. Vogus and Sutcliffe (2007) argue that resilience is the capacity of organizations to preserve themselves and always recover despite the adversities [63].

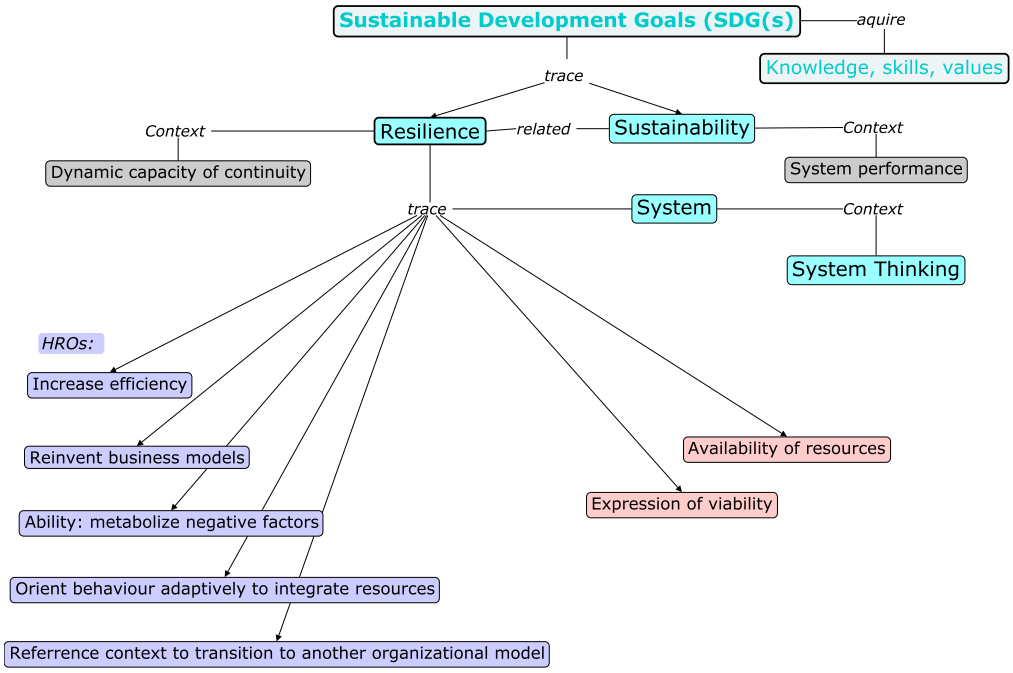

FIGURE 1. Concept map: A broader view of research on resilience.

PN.2 *Resilience is linked to the availability of resources*. Resilience may be associated with the dynamics that create or maintain resources (cognitive, emotional, relational or structural) in a form that is sufficiently flexible, memorable, convertible, and malleable [13]. This allows organizations, their units and individuals to behave sufficiently in an adaptive approach to cope with uncertainty, turbulence and discontinuities. In [64] the 3R elements that influence resilience are summarized: requisite variety, redundancy, resources. These are typical factors of complex environments.

PN.3 *Resilience is about being able to adapt*. Weick and Sutcliffe (2001) speak of resilience as the collective ability to implement adaptive behaviors able to reduce the stress condition deriving from the contingencies that appear, more or less suddenly, on the path of development [60]. Mallak (1998) has considered resilience as the ability to anticipate, respond or adapt quickly in response to catastrophic and destructive events [65]. In [66] resilience is identified as a function of the vulnerability of a system and its effective adaptability. They talk about situational awareness and resilience ethos (referring to an intrinsic instinctive self-preservation approach).

PN.4 *Resilience is also an expression of viability*. Resilience is the ability to overcome potential unexpected harmful situations, as expressed in [67]. Resilience has been evaluated as the ability to absorb, collect and metabolize negative surprises that can affect the survival of organizations by effectively overcoming destructive shocks and debilitating consequences. Some authors believe that resilience can help to reinvent business models and organizational strategies [12]. As presented in [61] and [68], resilience derives from a mix of abilities, routines, practices and processes integrating resources, able to orient behavior in an adaptive way. In this sense, according to [69], it is important to consider a decided orientation to results, to strong values, to a genuine vision, and to a certain property of language (understood as the ability to interface with others).

PN.5 *Resilience can be linked to the concept of system*. The concept of resilience does not concern structural characteristics but rather the system capacity to react to negative situations to find solutions and to convert an apparent risk into an opportunity to co-create value. In Service Science, studies on Smart Service ystems (SSS) and business behavior are very relevant [70], [71]. These studies identify complexity of contexts in the attempt to pursue conditions of viability [72], [73]. We therefore need to understand the most appropriate behaviors in complex contexts, and analyze their resilience [74]. As suggested by the univocal and interpretative Service Science lens, a common language and a multi-disciplinary approach to this topic are necessary [75]. Systems Thinking (ST) and Social Sciences associate resilience with different concepts of system, context, resources, self-regulation, adaptation and viability. In the context of the firm, a decision maker of a viable system must put in place all the necessary actions to be able to survive over time, and not only to demonstrate its resilient abilities. Resilient behavior is therefore an element of support for a viable decision-making process [28]. For [76] resilience is the intrinsic ability of an organization (understood as a system) to dynamically maintain a stable equilibrium and implement growth actions even in the presence of continuous stress.

The arguments that lead to the interpretation of resilience from a system approach, in ST mode, particularly through the Viable Systems Approach (VSA) can be structured from different positions. First, VSA provides a holistic lens, with

the ability to catch signals, dynamics, and on-going little things occurring around us ''as a whole'' [77]–[79]. This may lead observers to ''see'' (***S***ee) or ''reconstruct'' (***R***ecognize & ***O***rganize) a big and complete picture of observed phenomena [80].

Second, using VSA helps in understanding how to survive in due course, by employing adaptive behaviors to external changes [81]. This means that to be reactive and pro-active, in such a way to be able to gain an ability to increase the chances to ''continue'' one's action (***D***o) [28] through the support of one's own experience. Viability, in this sense, is the outcome and a consequence of all of these understandings [82].

In the third position, VSA distinguishes between environment and context [78], [83]:

- *Environment* is objective (i.e. the same for every Actor) and intended as a set of rules, laws, cultures, geographical boundaries, other constraints [82];
- *Context* derives from the personal perceptions of Actors and is defined by the number of interactions prompted in a stated moment [84], [85]. Therefore, context is the set of all direct or non-direct connections and can be modified (narrowed or expanded) by new exchange, new agreements, new partnerships, and so on.

In the fourth position, VSA faces uncertainty of future situations, because, unless we get the right instruments to predict upcoming evolutions, we can only estimate what might be to the next [86]. In this sense, we need to ''train'' our brain to foster personal interpretative schemes, to have new knowledge, to elaborate and use billions of data, in order to be more sensitive and to anticipate future trends.

Following this line of thought, we can acknowledge that many definitions exist today for resilience, according to the usability context across disciplines. The resilience of a system is specifically related to its capacity to withstand, absorb and adapt to disruptive, unpredictable events over time [56], [87], while continuing to provide its services or accomplishing its functions [17], [88]. Therefore, resilience, seen as an entity's attribute, is the capacity to resist stress causing experiences and successfully adapt after shock.

From a system design principle, *resilience is expressed as the ability of a system to maintain certain functions, processes, or populations after ensuing from a disturbance; it is a system attribute (What a system can be)*. Meanwhile, sustainability may manifest itself as the ability of service to be maintained at a certain rate or level; it is a parameter of System Performance (*How the system performs*).

In cities, Primary Mission Essential Functions (PMEFs) are those *functions that need to be continuous or resumed within 12 hours after an event and maintained for up to 30 days or until normal operations can be resumed* [89]. While efforts by public agencies to ensure the continuity of PMEFs during and after disruption, ''continuity of services'' is a characteristic of a system's operation (*What is the expected outcome from one or multiple interconnected systems*).

B. DESCRIBING CONTEXTS FOR RESILIENCE IN PUBLIC SERVICE DESIGN

In this section we present an illustrative example of various context integration in public service provisioning in times of emergency. The example has been elaborated based on a real case, the *participatory budgeting in Mnichovice*, in Czech Republic.

The town of Mnichovice has decided to introduce participatory budgeting, as a way to involve its citizens and create services tailored to their needs. In support of local volunteer firefighters, the citizens of Mnichovice voted for a project that would buy two defibrillators. The representatives, in collaboration with the firefighters themselves, created a first aid workshop. The workshop allowed citizens to see the equipment and to learn something new. As a result, citizens became interested in the participatory budgeting, and since then, every year, they cast a winning vote on a project supporting firefighters.

There are many contexts in this case study showing mutual influence between active actors, the service customers and providers. The first context can be described from the City Hall point of view. The representatives wanted to create suitable services for the citizens and allow them to create their own projects. The citizens took the participatory budgeting as a way to show gratitude to the volunteer firefighters. From the citizens' context, they gave back to those who intervene in serious accidents in the fallout area. From the context of the firefighters' brigade, creating the workshop for the citizens was a way to demonstrate the equipment to those who decided to support their work, the citizens. While this process was able to assure interest in participatory budgeting, it may have, unknowingly led to the continuous support for the firefighters.

However, if we add the effect of an externality or disturbing event (such as COVID-19), we see that both services (participatory budgeting and firefighter workshops) need to be reconfigured to react to the unexpected situation. However, action taken to reconfigure the service without investigating the influence of such a disruptive change on other contexts would be a mistake. Information about the set of related contexts, the effect of real-world change, and externality are critical to the ability of the whole system to be truly resilient in its real-time response. Therefore, the externality that must be considered when reshaping the services in our example, based on the critical situation induced by the pandemic, can be represented as:

- Formulation of the new goal: for example, ''Protect the citizens against the threat of COVID-19'' and splitting to goal breakdown structure in the diamond of context model;
- Identification of a new context: for example ''Quarantine because of COVID-19'' and defining new use-cases and common rules;
- Formulation of new requests, depending on the new goals: for example, ''Mapping the citizens movements to identify possible ways of infection''; those

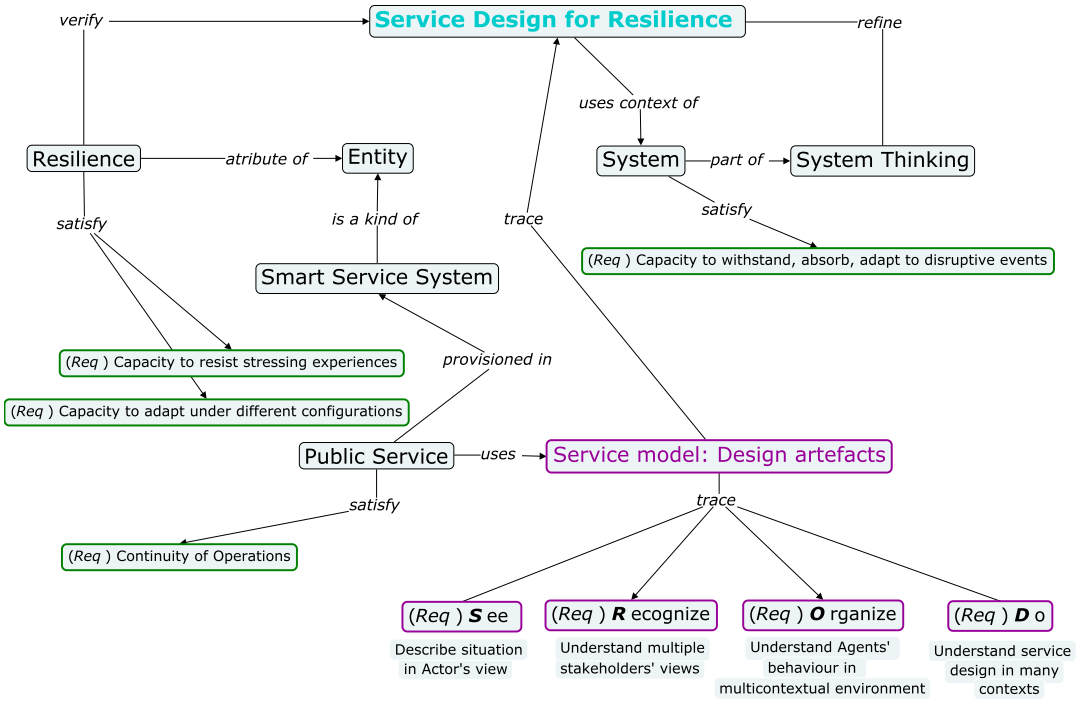

FIGURE 2. Concept map of terms and requirements: guidelines for service design for resilience.

requests can be the impulse for the new services creation;
- Services can be redesigned just because they are affecting new contexts, for example, the addition of the context of banks that need to redefine their payment service to address the new request defined at point 3.

In the multi-contextual design perspective described further in Section III, the service designers do not need to recreate a new model from start to be able adapt to the new situation. Instead, it is necessary to adapt the model while keeping all useful and valuable links. Modifications would be made only to help cope with a new situation, without forgetting the important consequences. Modifying the model to react to externality is just a beginning of the process. Every time a new element is added or changed, it is necessary to decompose the whole situation and recompose the new complete understanding of it.

For example, if the Town of Mnichovice wants to continue to support the cooperation between firefighters and citizens, new ways for citizens' involvement must be explored, when face-to-face workshops are not possible due to COVID-19, potentially relying on video tutorials, Facebook sharing, or similar ways. This capability will possibly widen the portfolio of services provided in the future, after the end of the pandemic. The firefighters of Mnichovice can take action to demonstrate the use and importance of the new equipment to the life of citizens in the current context of COVID-19.

III. MULTI-CONTEXTUAL DESIGN OF SERVICES: WORKING METHODOLOGY

This section introduces a multi-contextual design for resilience approach. Within this working methodology, the a System Thinking lens is applied to explain resilience as requirement at service design level. The role and purpose of each "diamond" in the four diamonds-of-context multi-contextual model for service design (4DoCMod) are explained. The four diamonds represent a service model. A reflection on resilience is presented for each of these diamonds in Subsection IV-A. The development guidelines for service design for resilience are summarized in Fig. 2.

As mentioned before, "*to be resilient, one has to adapt to changes, to react to contingencies, to overcome problems, to face adversities*". Whenever the situation changes and there is a need to react to it, designers tend to build new models to adapt to new situation or circumstance. To build public services resiliently, a resilient design model is needed as well, for each service. In the majority of such cases, a new model must be built for each circumstance, even though we are using a common modeling tool. Each service must be adapted to different circumstances, as well. Therefore, resilience requirements must be an input into the model itself.

The *Four Diamond-of-Context model for service design* (4DoCMod) described in this paper consists of four diamonds:

- ***S***ee diamond. It gives the description of a situation in the Actor's view (Fig. 3 in Subsection III-A);
- ***R***ecognize diamond. It provides the understanding of the situation in a multi-stakeholders' perspective (Fig. 4 in Subsection III-B);
- ***O***rganize diamond. It fosters the analysis of Agents' behavior (Fig. 5 in Subsection III-C);
- ***D***o diamond. It completes the overview of the service design in more contexts (Fig. 6 in Subsection III-D).

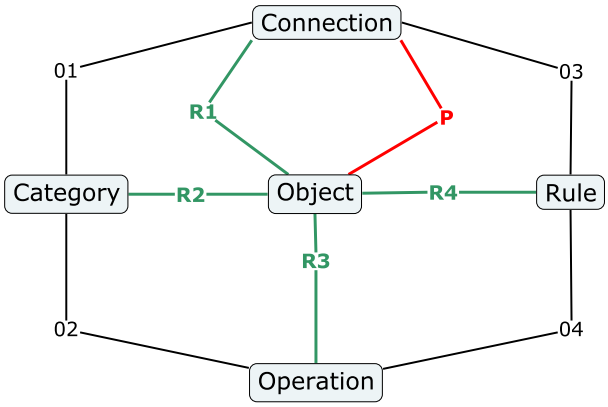

FIGURE 3. *See* diamond (Diamond of Attention Focusing), adapted from [49].

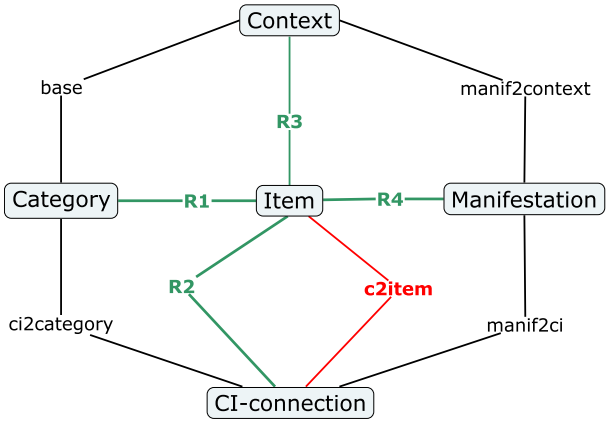

FIGURE 4. *Recognize* diamond (Diamond of Cognitive elements), adapted from [49].

The first two diamonds, ***S***ee and ***R***ecognize, may help us understand the different positions of stakeholders within their contexts. The categorization (and perception) of the item is individual (as ***S***ee diamond describes), but through the ***R***ecognize diamond those different approaches can be merged. To be able to finish the whole model and analysis, the information about all aspects of the past, current and new context must be shared and properly used. Without that, establishing new configuration for the whole system would not be possible.

In modeling, in the ***O***rganize diamond, which defines the organization of Agents involved into the current service within the context, new actions and flows are added. If we follow the case of Mnichovice, we need to add the `Action` "video recording" and the `Flow` "social network administration", and to describe all necessary information about those elements and the involved `Agents`.

The role of the `Agent` in service modeling, as a provider, collaborator, or receiver of the service can be integrated in the ***D***o diamond of Agent and Team organization (a diamond of predictive behavior, by which one can answer how data and information may be used in `Flows` and `Actions` of `Agents`, in given `Contexts`) [44].

Considering the example detailed in Subsection II-B, a new externality (circumstance, situation, context) may be directly added in the elements of the "diamond". Understanding information flows is the main factor for resilience of the whole system.

A. SEE DIAMOND

The ***S***ee diamond (Fig. 3), illustrates how people are modeling the reality in their minds. For any seen object (or sets of objects), each person has a very clear categorization, and a recollection of associated operations (*what* to do), including rules on how these operations can be used.

This is a major reason why stakeholders may have very simplified solutions on how to build resilience - in their mind, everything is clear. Here, we can find many examples of personal interpretation of resilience, which can work only in a social group within the same context and mindset. For example, people with epidemiological education may suggest isolating the population without realizing the economic or social consequences. For them, this approach represents an ideal solution.

The constituent elements of the ***S***ee diamond, a design artefact, are the following:

- `Object`: Projection (constructor) of the object(s) observer's mind;
- `Connection`: Set(s) of relationships among objects - projection (*edge P*);
- `Category`: Categorization of the object(s), related to particular setting (*edge 01*);
- `Operation`: Container of possible operation that can be applied on the object(s) from specific `Category` (*edge 02*);
- `Rule`: Container of the rules, defining how and when the particular operation can be performed (*edge 04*). The specific set of rules is defined by the connection (*edge 03*);
- `R-edges`: Representation of the *Mention-Use principle*[1] [45]. Each element can be used or be moved to the `Object` for recursive construction.

B. RECOGNIZE DIAMOND

The ***R***ecognize diamond (Fig. 4) extends the view on inanimate objects to their relations in the real world. It informs that the situation is much more complicated and that different stakeholders can have different perspectives of the same object, just because they are acting in different contexts. Here we recall that, in service design, challenges arise from different contexts and different views.

The constituent elements of the ***R***ecognize diamond, a design artefact, are the following:

- `Item`: Objects as such, not their constructors;
- `Context`: The context within which the item is identified;

[1] *Mention-Use principle*: *Mention*, such as to plan what/ how/ who/ where/ when/ why to do; *Use*, such as to use our capabilities, tools, or components to act to bring a value.

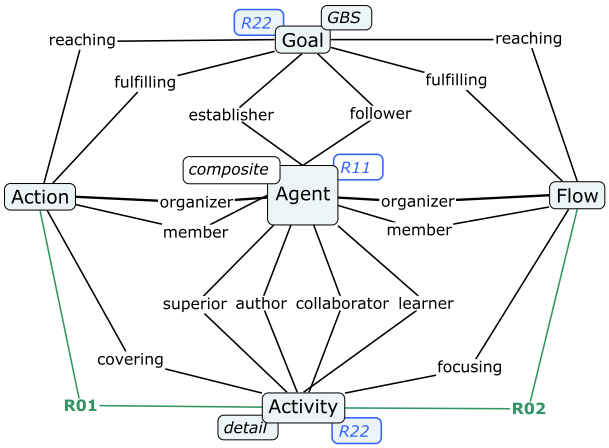

FIGURE 5. ***O*rganize diamond (Diamond of Agent-Team organization), adapted from [49].**

- `Category`: Categorization of the items(s), defined by the Context (*edge Base*);
- `CI-connection`: Connection of an item (*edge c2item*) to the specific category (*edge ci2category*) with given level of certainty;
- `Manifestation`: Specific design of an item in the given context (*edge manif2context*). It supports the level of certainty of the CI-connection (*edge minf2ci*);
- `R-edges`: The same, as for ***S***ee diamond.

Therefore, the ***R***ecognize diamond highlights two main issues in the attempt to connect more contexts:

- When discussing situations with others, nobody can be 100% sure about which context they currently are in. Therefore, the categorization of each real object (item) is never absolute. That brings home the point that the main task for keeping or improving resilience is to reduce uncertainty;
- Understanding of the context depends on knowing how items are connected in it and why, which ties in to the level of certainty that the item belongs into a specific category. In evidence, improvement of resilience is directly linked to multi-disciplinary education of stakeholders.

C. ORGANIZE DIAMOND

By using the ***O***rganize diamond (Fig. 5), we switch the focus to the analysis of Agents (and organizations), to gain a better understanding of how `Agents` are driving their behavior in a multi-contextual environment.

The constituent elements of the ***O***rganize diamond, a design artefact, are the following:

- `Agent`: A living entity (human) or organized set of living entities;
- `Goal`: The final state (aim) that is *Followed* or *Established* by the `Agent`;
- `Activity`: The phenomenon of space-time or cyberspace, where the execution of it cause a change of some structures of this space, originated by the `Agent`; the `Agent` can be:
  1) *Superior* - Agent evaluates the results of an Activity;
  2) *Author* - Agent formulated an idea of the Activity;
  3) *Collaborator* - Agent is participating on the Activity;
  4) *Learner* - Agent is monitoring the Activity to get a knowledge for future actions.
- `Action`: It is a sequence of activities which are: a. unique; b. non repeatable; c. deterministic; d. it heads to one goal or to intersection of some goals. `Agent` can be organizer of `Activity` (can set or modify it) or is a member of it (just participating);
- `Flow`: It is a sequence of activities which are focused to a particular topic in continuous attention that influence the space and/or time complexity of the `Agent`, to achieve specific `Goal`;
- `Composite`, `GBS`, and detail edge: Enables to decompose a specific element into breakdown structure;
- `R0n-edges`: The `Action` can be `Activity`; `Flow` can be `Activity` in a different context;
- `Rnn-edges`: The specific `Object` can appear in different contexts.

The axis `Goal` - `Activity` describes the motivation of the `Agent` (human being, team or organization), who has a `Goal` to reach, in the service context. The `Agent`:

- can *generate* the `Goal` (as *Establisher*) or
- can *follow* a `Goal` (as *Follower*).

The `Agent` can perform `Activity`-ies, such as focused behaviors, to fulfill a `Goal`. From an organizational point of view, the `Agent` can take part in:

- `Actions`, that represent a set of `Activity`-ies executing only once, and in
- `Flows`, that represent a set of `Activity`-ies executing repeatedly.

Therefore, a `Goal` is the generator of the framework in which `Actions` and `Flows` are interconnected with `Activity`-ies [44].

D. DO DIAMOND

The fourth diamond, the ***D***o diamond (Fig. 6), answers the question on how to design and offer the service in a multi-contextual environment.

The constituent elements of the ***D***o diamond, a design artefact, are the following:

- `Requirement`: Requirement as the result of an *addressed* will of an `Agent`;
- `Goal`: The aim that was the source for `Requirement` (it is *fulfilling* the `Goal`);
- `Service`: Container of possible answers that can *solve* the `Requirement`;
- `Context`: The container of situation where the `Requirement` can be *identified*. It also defines if the specific `Goal` can be *achieved* and the `Service` can be *created*;

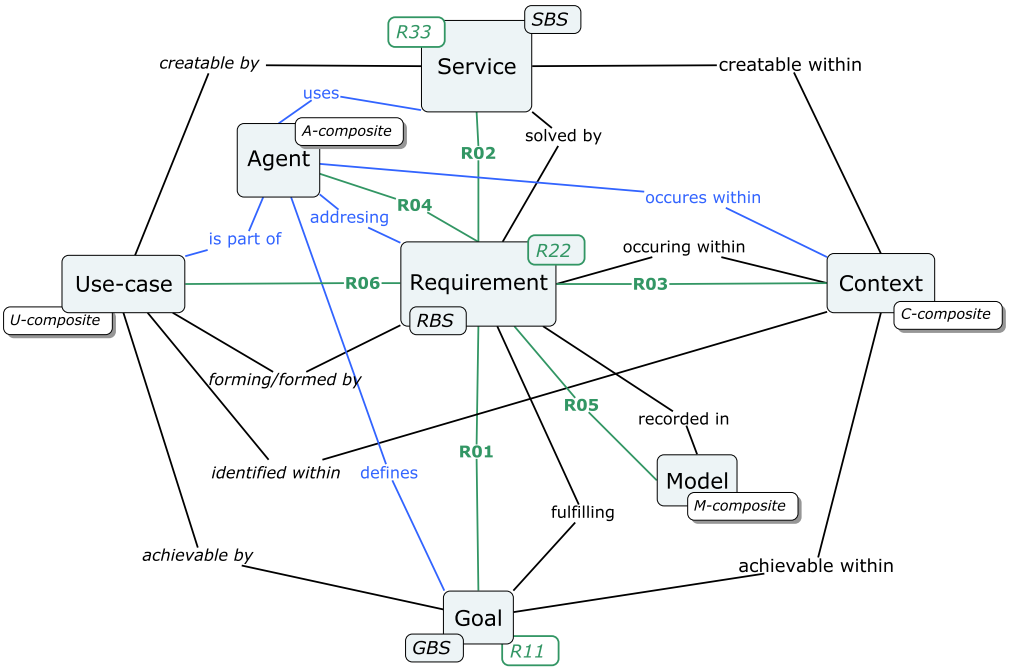

FIGURE 6. ***D*o diamond (Diamond of Predictive Behaviour), adapted from [49].**

- `Use-case`: Container of previously realized solutions that are *forming* or *formed* by `Requirement`. Indeed, the `Service` is also *created by* `Use-Cases` and vice versa. `Use-Cases` are *identified* in the current or other `Context`. They are used to *achieve* specific `Goal`;
- `Agent`: Container of all Agents that are related (in touch with) all other elements of the model (*all blue edges*);
- `Model`: Element to record all actions to serve as a model (*all red edges*);
- `Composite edges`: To be used to decompose specific element;
- `GBS`, `RBS`, and `SBS edges`: To be used to decompose specific element to a breakdown structure;
- `R0n-edges`: The selected elements can play a role of `Requirement` in a different `Context`;
- `Rnn-edges`: The specific object can appear in a different `Context`.

Even if it seems a little bit confusing because of the number of edges, the ***D*o** diamond represents the complete overview of the service design in more contexts.

In the vertical axis, we see the motivation for establishing a `Service`. Service is created because of the existence of `Requirement`, and it is part of fulfilling the `Goal`. Those relations are critical for the resilience of the system. In case of change or disturbance, many stakeholders tend to protect the `Service` instead of the `Goals` and `Requirements`. The utility of the system is based on its ability to react to the `Requirements`, in addition to maintaining the current design of the services. The horizontal axis of the ***D*o** diamond helps to understand the adaptability of the system. It is based on the `Context` where the `Requirement` is defined. All these features must affect the final formulation of the `Requirement` and the design of the `Service`.

IV. THE 4DocMod MODEL: REFLECTIONS ON RESILIENCE

The design artefacts that create the 4DocMod model for service design, the four diamonds, may accommodate various aspects on resilience.

A. THE APPLICATION OF A RESILIENCE LENS TO THE DIAMONDS

PN.6 *The **R**ecognize diamond contains critical information addressing resilience*. If we are speaking about services supporting resilience, a common understanding of the situation, based on free information sharing and exchange of perspectives, is the first step to consider. To build a sustainable solution, it is necessary to investigate the connections between two aspects: *preserving* the same situation and *sharing* all acquired knowledge in a multi-disciplinary way.

The connection between the logic of the first two diamonds, ***S**ee* and ***R**ecognize*, and the common resilience concept is based on the understanding that different contexts coexist and are closely related. The connection is that different items may appear in different contexts and their features (`Operations` and `Rules`) are, or may be, specific in each `Context`, separately. The change in one context, often exhibited by the change of the item's manifestation, may affect the certainty of categorization in other context and via this, the resilience of the whole system. A key factor for common understanding relies in information sharing among stakeholders. Information sharing enables us to recognize the `Manifestation` (a design for instance) of an item within different contexts.

This takes us back to our COVID-19 related discussion. The initial solution (to live the life in isolated communities with strict reduction of contacts), seemed very logical from the epidemiology viewpoint. Economic and sociology experts refuse this solution for its negative impact on the economy, social and psychological level of society. Resilience leads us to investigate more complicated or hidden connections, beyond the visible and direct links. In our case, this extension can be through analysis of psychological, economic or environmental aspects that can affect other contexts, from different perspectives.

PN.7 *The **O**rganize diamond express the resilience of the system on a simple reflection of the re-established relationships through edges' deconstruction*. In the case of the ***O***rganize diamond, the connection with resilience may not be readily apparent. All activities in one context are mostly affected by what is happening in different contexts. Though, sometimes, researchers and analysts forget to reflect on the role and position of the same `Agent` in different contexts. Previously, in the ***S***ee diamond, we have not used the element of `Context`, because it was not necessary. Instead, we have acted in one context, the current position of the observer. That is incomplete as, in service delivery, actors perform in different settings and actors' `Goals` and `Activity`-ies can be parts of more `Contexts`.

In the *O*rganize diamond, the contexts' environment is represented by R-edges. R11, R22 and R33 connect the elements with their presence in another `Context`. R01 and R02 reflect situations where `Action` can be `Activity` in other contexts. The same can apply for the `Flow` and `Activity`, and indeed vice versa.

For the resilience extension, we need to keep in mind the lesson learned from COVID-19, when most of the people and organizations had to adapt to the isolation, remote work, with the obvious implication of a sudden change of their behavioral patterns. It is necessary to investigate how such a big negative externality affected the behavior of whole company, departments and individuals. According to the investigation of Moore Czech Republic [90], comparing to the situation before COVID-19, the work output of employees working in the home office was about 10% less for the first month of quarantine and about 30% less in the next month. Expressing a resilient solution by use of Agent - Team organization requires a deeper analysis of the related contexts of each involved stakeholder. For example, to understand the phenomena of decreasing work output of employees working on the home office, we need to investigate their personal private life, how it was affected by COVID-19, and how has it changed their structure of `Goals`.

PN.8 *With the **D**o diamond, resilience is supported by the reflection of previous solutions and interconnecting them with the current situation and Context*. It is a very efficient way for how to illustrate the dynamics of the whole system. The last perspective (connection among `Agent`, `Requirement`, and `Model`) is about finalizing the service design process. The two last elements are involving the `Agents` into the `Service` design (`Agents` need to be interconnected with every other element) and the `Model`, that is here to represent the memory of the system.

Like the ***O***rganize diamond, the primary importance for the resilience of the system in the ***D***o diamond can be hidden. It is again represented by R-edges that have the two different roles here, too:

- The `Rnn-edges` enable the appearance of `Goal`, `Requirement`, and `Service` in another context that is relevant. It is crucial, for example, to realize that the same `Service` can provide value in two or more `Contexts`. Then, any change in the configuration of the `Service` must be inspected in all related contexts; otherwise, we risk decreasing the total utility of the `Service` in the multi-contextual environment, even if the efficiency in one `Context` can be increased;
- The `R0n-edges` represent the possibility that `Context`, `Goal`, `Use-Case`, and `Service` may become a `Requirement`. This enables us to decompose the whole structure of services and to create a new, potentially more useful/relevant one. The ability to redefine the whole environment, but without losing the connection with previous situations can be a very important feature of the system.

The resilience of the whole system depends on understanding the connection between the elements and contexts. The ability to bring a value can be independent from the level of resiliency of the system. It is related to the potentiality of the system for reconfiguration in reaction to changes, in order to maintain stability.

PN.9 *To analyze the **D**o diamond for resilience, we need to investigate how system resilience affects the provisioning and delivery of the service*. The most suitable position for resilience in the ***D***o diamond is that one of the `Goals`, which is a part of the *Goal Breakdown Structure* (GBS). Resilience, therefore, seems to be an exceptional type of `Goal`, relevant to the one `Context`, using the `GBS` edge. It also connects to other contexts using the R11-edges.

To add clarity to this notion, Subsection IV-B presents insights from two case studies in public safety service design.

B. APPLICABILITY CASE STUDIES

According to a rich literature on urban resilience, city environments typically get affected by physical disaster phenomena; namely floods, earthquakes, tsunamis and tornadoes. Such phenomena usually impact a city's hard infrastructure. The COVID-19 pandemic presents a case of a rare biological occurrence with the potential to deplete national health systems and disrupt the provision of public services. While health systems are part of a country's national infrastructure, early findings suggest that the spread of the virus was very much city dependent, meaning positively or negatively affected by urban variables, such as the density of the city [91].

The COVID-19 pandemic is perhaps the most important new public *health challenge* to Humanity appearing in the

TABLE 1. COVID-related Information Services: Establishing resilience in the informational infrastructure with the Goal Breakdown Structure (GBS).

Information Service	Description	GBS L1	GBS L2
CHCIS	Enable communication between CDHP and citizens	(**CHCIS 1.1**) Serves as an example of planning for data collection for future actions (**CHCIS 1.2**) Demonstrates resource integration between the different stakeholders, part of the diamond (**CHCIS 1.3**) Shows how data act as a future capability (**CHCIS 1.4**) Building resilience within future systems (**CHCIS 1.5**) Service based with voluntary user input	(**CHCIS 1.3.1**) Necessary to understand the value and the meaning of the data among contexts
SKCIS	Containing the virus spread through digital infrastructure	(**SKCIS 1.1**) Multi-contextual actions with prediction mechanism: COVID-19 as an enlargement of an already known context (**SKCIS 1.2**) Reaction to the changing situation (Goal, Context): Changing the current design of the service (**SKCIS 1.3**) Health status service as a precautionary measure: mandatory use (**SKCIS 1.4**) Information Common Goods: Data as a capability to inform decision makers and as feedback mechanism	(**SKCIS 1.1.1**) Shift between contexts: Country's ability to comprehend the importance of different contexts (**SKCIS 1.1.2**) Prediction mechanism: Country's previous experience on pandemics (**SKCIS 1.2.1**) Fast adaptation mechanism (national, urban): Advanced pre-existing digital infrastructure (**SKCIS 1.4.1**) Information Common Goods to influence Agent's decisions on changes to respond to the Goal and can help identify new specific Flows and Actions

last 100 years. The situations due to COVID-19 are not / can not be considered a typical health incident management policy, like in [92]. COVID-19 has been developed across countries to a global issue. It is changing social behaviors, whereas public health security incidents usually do not significantly affect social behaviors. Further, COVID-19 does not evenly affect industries, where resilience is somehow reflected with digitalization, e.g. technical companies are less affected than traditional industries such as manufacturing industries. Also, COVID-19 affects people's cognition to resilient city. People begin to realize the importance to be adaptive and resilient. This can be observed via home office and online teaching. As such, this pandemic has a significant economic influence. It has many facets that develop under various contexts at the Society level.

Therefore, resilience in the context of this pandemic is necessary to be achieved from every person, organization, and process. Critical services, involving people, organizations, and processes, need to be adapted in order to become more resilient to this pandemic, as well as to every other important *challenge* along with the pandemic.

Having these consideration in mind, using new COVID-19 tracking information services as an example seems to be applicable and inspiring in service modeling, so that the results may be then applied to other challenges as well.

Amid this crisis, the significance of the establishment of e-governance related digital services became exponentially evident. We saw the rapid response of certain governments such as South Korea, Greece, Croatia, France, in speeding up the roll-out of public digital platforms with the objective to ensure the minimum disruption of citizens' and businesses' public service provision. In specific cities, data-infused technologies were used in order to track, analyze, and form predictions about the spread of the virus.

The exploration of `Goal` from a multi-contextual perspective in depicted in Table 1 for two representative case studies in information system design: **CHCIS** - the Chi COVID Coach information service and **SKCIS** - South Korea answer to the COVID-19 pandemic. The role of the 4DocMod artefacts to complete a service model for these two information services is described in Table 2. The comparison included in these two tables indicates how they can be described in terms of the main attributes of the diamond model approach. In order to support resilience, the paper suggests that an information service should share purposely similar properties addressed at design level.

1) CHCIS: CHI COVID COACH INFORMATION SERVICE

An example of how resilience can be built within future systems is the Chi COVID Coach information service introduced by the City of Chicago. Its aim is to enable the communication between the Chicago Department of Public Health (CDPH) and Chicago residents during the COVID-19 pandemic, and in the stages following the pandemic. The service interfaces with a mobile app, built in collaboration with Google and MTX on Google Cloud [93]. Additionally, this information service assures a registry-type functionality for future vaccinations against the virus. As well, it allows for pre-registration for vaccine dissemination, once this becomes available [94]. This case study demonstrates how resources may be integrated between the different stakeholders that are involved in the service design, to produce one commonly used service.

TABLE 2. COVID-related Information Services: Depicting connections to the 4DocMod artefacts.

Information Service	Description	GBS L1	GBS L2	Explanation of the 4DocMod artefacts
CHCIS	Enable communication between CDHP and citizens	(**CHCIS 1.1**)		***O***rganize diamond: the same service can provide value in two or more contexts
				Do diamond: add new context to fulfill the new goals added in the GBS
		(**CHCIS 1.2**)		***R***ecognize diamond: to merge the manifestations of the same item among contexts
		(**CHCIS 1.3**)	(**CHCIS 1.3.1**)	
		(**CHCIS 1.4**)		
		(**CHCIS 1.5**)		
SKCIS	Containing the virus spread through digital infrastructure	(**SKCIS 1.1**)	(**SKCIS 1.1.1**)	***R***ecognize diamond: all important and related contexts are identified
			(**SKCIS 1.1.2**)	***O***rganize diamond: capability to analyze Agents' behavior in public health security incidents
		(**SKCIS 1.2**)	(**SKCIS 1.2.1**)	***D***o diamond: rapid intervention, real-time monitoring with digital tools
		(**SKCIS 1.3**)		***R***ecognize diamond: the pre-existing use-cases in combination with cultural elements affect the citizens' willingness to share their personal data
		(**SKCIS 1.4**)	(**SKCIS 1.4.1**)	

The Chi COVID Coach information service case demonstrates two perspectives that are crucial for the design of resilient services according to the 4DocMod service model, namely the importance of context for the multiplicity of stakeholders embedded in the different diamonds, and building resilience within future systems.

This is an example of the usefulness of modeling via the ***R***ecognize diamond where there is a merge between manifestations of the same item among different contexts. Moreover, it can be observed that, in line with the ***O***rganize diamond, the same service provides value in more than one context: at the same time, it provides information for residents, allows them to disclose their status, acts as a communication tool, and helps to accept pre-registration for future vaccines. The connection via the ***D***o diamond, is significant where there are continually new added contexts that fulfill the same goals. Further, related to the latter, as the CHCIS collects data crucial for future actions, it serves as an example of embedding `Actions` for the accomplishment of future `Goals`, a crucial aspect of the ***D***o diamond. These data, collected for future use, act as a future capability with variable value-in-context for the developed service, i.e. variable value according to each context.

2) SKCIS: SOUTH KOREA ANSWER TO THE COVID-19 PANDEMIC

The case study addressing the South Korea's answer to the COVID-19 pandemic describes the most significant factors that largely influenced the speed of response and explains how the resilience built in already existing systems, exploiting lessons from previously enacted responses. The Goal Breakdown Structure (GBS) of the COVID-related services in South Korea is depicted in Table 1.

Throughout the years, South Korea withstood a series of outbreaks, namely, the SARS virus outbreak in 2003 and the MERS virus outbreak in 2015, as well as other disasters such as earthquakes, forest fires and marine accidents that have exposed the limitations in its disaster management systems and have triggered its reform [95].

The government agencies of South Korea have shown arguably one of the fastest and most efficient responses to the COVID-19 pandemic. They have deployed a holistic plan that required rapid interventions, largely based on digital tools [96]. These, among others, include real-time infection rate tracking based on geographical areas, free emergency text alert apps communicating spikes in the infection rate of the residents' locality, self-quarantine and telemedicine apps [97]. Accordingly, the Seoul Metropolitan Government has made digital platforms available to citizens, such as information services and dashboards that offer continually updated precise - yet anonymized - information on the infected citizens. This includes information about which public transport they have used or which restaurant they have attended while infected, in an effort to track potentially infected residents [98]. The main goal is to provide Seoul's residents with adequate tools to take precautions to avoid infection, self-monitor and report early symptoms.

The success of the South Korean approach to COVID-19 is directly linked to the country's ability to comprehend the importance of different contexts and shift between them, as well as their previous experience on pandemics. The ability of South Korea's agents to build resilient systems that switch between national and local contexts demonstrates how resilience is based on understanding that the different contexts are not existing next to each other but related to each other instead. The change of an item's manifestation can influence the certainty of categorization in other contexts and on the whole system consequently, as described in Section III. This is particularly related to the ***R***ecognize diamond, where all the important and related contexts are identified, and

all the manifestations of all objects related to the particular service are recognized.

For South Korean Agents, COVID-19 was not a new Context, but rather the enlargement of an already known context; while such use-cases were mostly absent from the reaction protocols existing in European countries. Thus, in this case, we see an example of the ***O***rganize and ***D***o diamonds with multi-contextual actions and prediction mechanisms, largely based on Use-cases. Furthermore, in this case, continuity of the public service was principally dependent on the advanced pre-existing digital infrastructure, both nationally and on a local level and on the fast response and agility in, not only adapting already existing technologies (as in other cases), but rapidly developing new ones. Despite their fast creation, they address a common Goal and thus, a common Requirement, by providing a set of Services (acting as possible solutions) that are planned based on a Model. It is imperative to note that the Requirement (response to the pandemic) is not changing for the most part. What is changing is the current design of the Service, thus the reaction to the changing situation (Goal, Context).

V. DISCUSSION AND PRACTICAL IMPLICATIONS

Continuity planning is an essential aspect of public services. Vital public services must endure risk and continue to provide the services to the target population. Local authorities, the primary actors in the public service ecosystem, have the obligation to implement adequate contingency plans in order to maintain public safety and guarantee essential services during disruption and abnormal events [99]. This is only possible through the strong concertation and co-design processes with specialists of disasters, public administration, service-related research, and digital systems [100].

Following the above exploration on the nature of the resilience concept, we may say that ensuring continuity of data-triggered processes in data-driven public services is not a trivial task, as a disruption may happen any time. The connection between continuity and resilience with the use of Digital to improve the evolution of the Society-level processes is not a trivial endeavor. Systems that support resilience should build a capability to detect, respond, measure, and provide real-time feedback to assess the effectiveness of the response action, and then to take iterative corrective action, until a desired level of service is realized. The collection and manipulation processes count on reliable, timely, and accurate data and must be strictly followed and monitored for defects. Continuous services require resilient actors, planned sustainable activities, and the essential information common goods [101] to be integrated in a layered approach for providing continuous service value [102]. Consequently, a thorough understanding of the type of knowledge that promotes citizens to become resilient in the *Smart Cities way* of cities context is needed [103].

In the ''new normal'' future [104], for example, after the COVID-19 pandemic, we need to gather, contextualize, and highlight people's experience and tacit knowledge in a systematic and structured way, in order to purposefully address the new context of living requirements. At the same time, the role of the Actors in the society must be reconsidered [105], such as:

- to be able to understand new contexts they are within (be ''cognitive'');
- to comprehend how much they must modify themselves and their behaviors, when and how (be ''adaptive'');
- to ensure and reinforce their own identity (be ''autopoietic'', in order to maintain its own configuration, valorizing expertise, experiences, new instructions);
- to be fit with the context's main aim and expectations (be ''responsive'', in terms of the ability to react, the readiness to act, using reliable data and information.

Our two case studies demonstrate how cities around the world have deployed small and large-scale initiatives to respond to the COVID-19 pandemic. Most of the initiatives are based on pre-existing digital services or data collected from pre-existing sensors. The ability of the actors to use and adapt already developed software and hardware demonstrates the strategic agility of such actors. It is the first step of building resilience within urban systems, allowing involved actors to become resilient along with the service.

Considering the involvement of smart cities' stakeholders, there is a crucial element that differentiates the two case studies previously presented, revealing a critical aspect related to the ***R***ecognize diamond.

The Chi COVID Coach information service is a service based on voluntary user input. Thefore, the co-created value dependents on the direct interaction with the users and their willingness to provide their resources (in this case, data). This is directly related with the institutional arrangements under which the users operate, largely dependent on socio-political factors [39].

In the second case study, due to the institutions bounding the South Korean socio-political situation, citizens were obligated to use these digital services. While many of the apps are voluntary, the app that tracks your health status is obligatory and acts as a precautionary measure for citizens to avoid potentially infected areas.

The pre-existing use-cases, in combination with cultural elements, affect the citizens' willingness to share their personal data, especially where and when personal data privacy has considerable importance, as in the European countries. This point is directly related to the significance of data that may act a capability to be transformed into knowledge influencing decision-making actors in designing services:

- Data in the South Korean case study may act as a direct feedback mechanism that provides insights into the positive or negative effects of the Action on the system. It can provide information as to what changes the Agent needs to perform to respond to the Goal and can help identify new specific Flows (for example, in this case, the need to wear masks, use disinfection measures) and Actions, depending on the existence of the new Context of COVID-19;

- Considering the voluntary input services, such as the Chi COVID Coach, the accuracy, time-correspondence and validity of the data have an impact on their quality. Thus, it makes them less appropriate to inform decision making `Agents`, to create new `Flows`.

In agreement with our paper's central notion, the 4DocMod model for service design, government agencies and smart city actors (`Agents`) must identify relevant and trusted sources for data and define the underlying conditions (`Contexts`) for the mapping of data requirements for the continuity of the service (`Goal`). According to the primary responsibilities that may be defined [106], the need to be able to continue to deliver products and services at an acceptable predefined capacity during a disruption warrants the ability to detect (***S***ee), recognize (***R***ecognize), assess (***O***rganize), and react to the impact of any incident (***D***o). This includes individual activities of data collection from services in use, bringing at confluence the information gained by collecting multidimensional data for assessment activities, mapping of historical events, and implementing technology to capture and correlate data from multiple points in the service system.

VI. CONCLUSION AND OPEN RESEARCH QUESTIONS

This paper addresses an important problem facing our everyday life, public safety, especially in the current pandemic situation. Taking into consideration the complexity of the service ecosystems in public safety, in this paper we argue that a clear design methodology for public services based on various contexts is needed. A word that has been extensively used during the past months is *resilience*. But how can we explain what resilience really is, while so many definitions, implications, and activities aiming to comply to this concept exist today? And how can we crystallize *actionable knowledge* to help integrate this concept *at the service design level*?

A clear vision emerges today to give Actors in society an actively participation to new and resilient knowledge creation and distribution [100]. Thus, in a society whose processes are driven by service beneficiary data, new ways to describe and start this *process of collective knowledge creation at the service design level* are needed [2]: inevitably, through the Actors' creative and motivational application of competences to the contributive development of transdisciplinary services.

What we have learnt from the COVID-19 pandemic by now is that resilience, at the level of cities operations, but also at the level of resilient knowledge exchange between Actors, should be contextualized and addressed thorough the systemic lenses of complexity arising from major global and local societal challenges. COVID-19 pandemic is a clear example of a situation of resilience. It is obviously different from being just an incident as a major disruption that put pressure on the society. Effectively, this situation of resilience is evolving in various contexts.

This *exploratory paper, following conceptual principles to provide consistency of the approach*, presents two cases: the CHCIS (Chicago COVID Information Services), and the SKCIS (South Korea COVID Information Services). As our approach using 4DocMod is proposing, resilience follows from information services with such properties, and we will be working on more concrete examples, and improved modeling approaches that may expose weaknesses is the service systems.

The resilience of any enterprise at society level is based on information and powerful information systems, because behind it stays the collective cognitive resilience. To be resilient, one must adapt to changes, to react to contingencies, to overcome problems, to face adversities. ST and VSA favor a new meaning of resilience, based on the different features and aspects of actors' mode in actions confirming some of other scholars' statements on the topic [63], [65], [107], [108]. It is:

- not just bouncing back, but bouncing forward (not only reaction, but pro-action);
- not just resource recovery but resource renewal (not only to restore previous initial status quo, but to create a new one, with new elements, intending the knowledge as and increasable resource);
- not just comfort-zone but challenge zone (not only to be protected by what we already know, but ready to explore new ways to be viable).

Further research is needed to make citizens resilient in an urban context of the *Smart Cities way*, and to explore how Actors become resilient through service design. We formulate three assumptions to be addressed multi-contextually:

- Phase of engagement, by giving information and motivation, in order to know *why* to contribute effectively to service provision (just for public services to citizens);
- Phase of education, by giving directives, procedures, protocols, communication channels and interfaces, in order to know *how* contribute (just for the use);
- Phase of collaboration, by giving the sense of actively participation in the resource sharing and integration, in order to know *when and how much* to contribute (just for the interactions).

In the same way, further research can explore how to make actors resilient, stressing much more the concepts of *awareness* (to be part of something bigger every Actor is influenced by), *consciousness* and *acquaintance*. This can give Actors an insightful support to proceed further, make more informed decision, and trigger a knowledge-based mode for the way they take actions for their survival. Furthermore, this allows to explore other concepts such as *cognitivism* (to reach signals, classify and qualify information, interpret on-going situations and changing conditions, *consonance* (the alignment with the common aim and vision of context in which Actors are and operate), *adaptation* (by comprehending how much Actors must modify themselves and their behaviors, when and how), and *responsiveness* (in terms of the ability to react, the readiness to act, using reliable data and information, and being fitted with the context's main aim and expectations).

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