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Science Fiction: Past and Future Trends of Crisis Management

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ABSTRACT

This paper is a position paper, presenting an original but very anticipative and mainly imaginative vision of the evolution of the crisis management domain. After analyzing the options to make the past evolutions of that domain somehow explainable (mainly by analyzing the data of all the articles of the last fifteen editions of the ISCRAM conference), the paper aims at providing a framework to assess and evaluate the maturity of the domain of crisis management. Moreover, this framework is also used to tentatively infer some future evolutions and some directions that could be relevant, dangerous, tricky or of great benefit for the crisis management domain.

These future trends are mainly based on the current maturity of crisis management (according to the proposed framework) and current or future influential practices, technologies or threats. It will be necessary to wait for fifteen years to see if these bets should be considered as accurate.

Keywords

Information, Decision, Action, Future, Trends, Anticipation, Framework.

INTRODUCTION

This paper aims at analyzing the way crisis management domain has been evolving during the past twenty years to (i) provide a general framework of this evolution, and (ii) exploit that framework to outline some future trends for the next decades. This is a position paper with no strong scientific ambition: just a simple bet from the authors taken with the ISCRAM community as witness. In that sense, it walks into the footsteps of (Van de Walle and Turrof, 2006) by analyzing the contributions of ISCRAM community.

The initial hypothesis of this paper is to pretend that the domain of crisis management does not progress according to any classical paradigms. This is mainly due to (i) the strong discontinuity of the domain (even if crises are more and more frequent, there is no continuity in the “business”) and (ii) the lack of real “juicy” market that would drive research, innovation and industrialization of solutions. Basically, in most other domains, progress and improvements are “*innovation pushed*” or “*need pulled*” (or both simultaneously). “*Innovation pushed*” means that there is a tangible and potentially useful innovation (wherever it comes from) that can be industrialized, sold and that can find its market even if it was not expected by the society (e.g. Smartphone). “*Need pulled*” means that there is a tangible and intense expectation (from the society or part of it) that requires a response which will automatically fall into this ready market (e.g. electric vehicles). The following pictures illustrate both these paradigms:

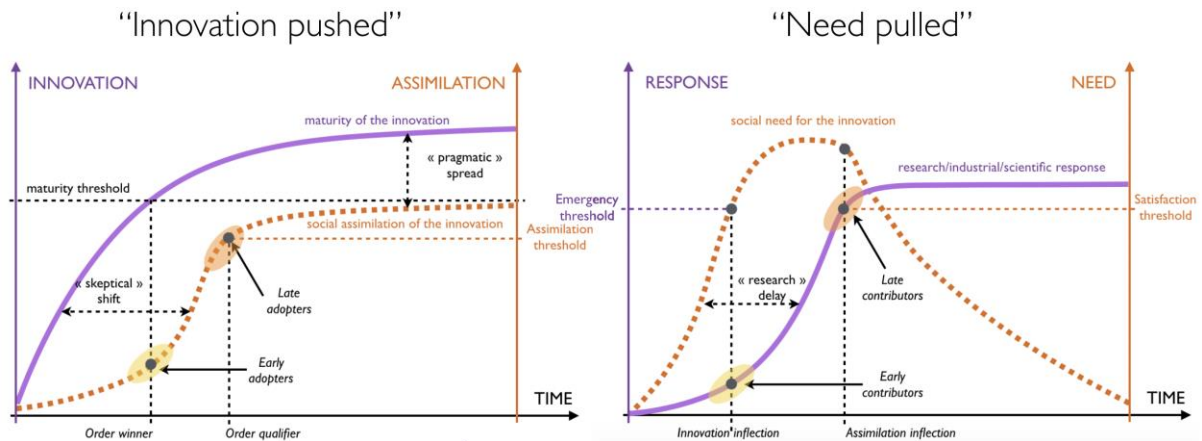


Figure 1. “Innovation pushed” and “Need pulled” paradigms of progress for social domains

On the left part, the “*innovation pushed*” paradigm is illustrated. A subject is studied by the “innovation community” (let’s say scientists, researchers, industry and other stakeholders able to innovate) according to the purple solid line. Depending on the results, the “social community” (let’s say integrators, service providers, sellers, final users and institutions) would assimilate that innovation according to the orange dashed line. There are some particular elements that can be noticed: two inflection points representing the moments when the innovation maturity reaches a significant maturity (first one: maturity threshold) and when the assimilation level reaches the required assimilation level (second one: assimilation threshold). There are also shifting: one in time due to the ignorance or observation phase before the innovation become potentially relevant for the “social community” (first one: skeptical shift), and another in assimilation due to the satisfaction level of the social community which is classically lower than what the “innovation community” can actually offer.

On the right part, the “*need pulled*” paradigm is illustrated. A need is growing in the “social community” according to the orange dashed line. Depending on its ability to respond, the “innovation community” would start working and responding to that need according to the solid purple line. On this figure as well, there are some particular elements that can be noticed: two inflection points representing the moments when the need of the “social community” reaches some emergency threshold that would trigger the commitment of the “innovation community” (first one: innovation inflection). One should notice that this inflection could not only be triggered by the high level of the need but also by the capability of the “innovation community” to respond. The second inflection point represents the moment when the “innovation community” drastically slows down its involvement due to the reaching of a satisfaction level that satisfies the “social community” (providing the expected service).

Based on these initial considerations, this paper discusses in the first section the evolution and improvement paradigm of the domain of crisis management according to ISCRAM publications in the last fifteen years (this is a biased point of view obviously, but this is one relevant point of view). This is close to the study made in (Reuter, et al., 2018), however, that study mainly focuses on social media articles. The second section is dedicated to provide a maturity framework of crisis management according to the results of the previous section and to outline, throughout that framework, some hypothetical trends for the future of crisis management.

EVOLUTION OF THE CRISIS MANAGEMENT DOMAIN IN THE LAST FIFTEEN YEARS

As mentioned earlier, one hypothesis of this paper is that the domain of Crisis Management does not follow one of the two “standardized” maturation paradigms presented in the introduction (“innovation pushed” and “need pulled”). The strict and major hypothesis is thus the following: ***Actually, on the one hand the domain of crisis management does not represent a trustable and juicy market (which does not encourage “innovation pushed” propellant), and on the other hand, due to the discontinuity of disasters and crises events crisis management does not represent a continuous business context (which does not encourage “need pulled” propellant).*** However, the innovation community, and especially the research stakeholders, have been continuously trying to push forward contributions and results (due to their nature of scientists and researchers). But this community and its contributions are quite small with regards to other innovation domains. Similarly, the social community, and especially the practitioners and institutional stakeholders, have been continuously trying to pull progress and advances from the innovation community (due to the facing of more and more cruel disasters). Consequently, the evolution of the crisis management domain is more chaotic and anarchic due to multiple and minority propellants. The next two subsections aim at describing the most significant events in both the “innovation pushed” and “need pulled” perspectives. For the first one, this is mainly about scientific contributions, while for the second one, this

is mainly about major disasters.

“Innovation pushed” perspective

We have studied the most significant innovations (mainly services and technologies) in the last fifteen years and have kept the ones that may have impacted the most the socio-economic world. These innovations have been considered as the basis of innovation pushed in the domain of crisis management. The following figure lists these innovations and their theoretical assimilation by the crisis management domain. This is the “*innovation pushed hypothesis*”.

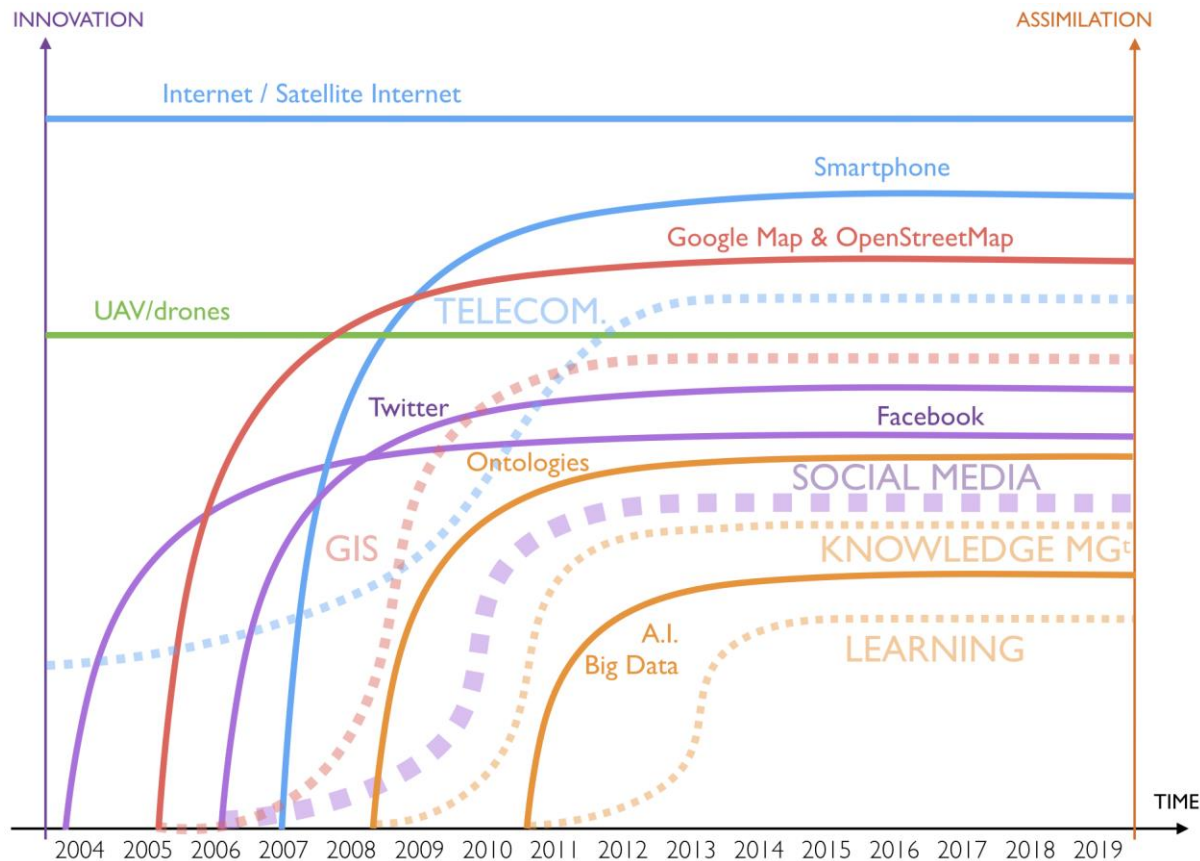


Figure 2. The set of main “Innovations” since 2004 and their theoretical impact on social assimilation

On the previous figure, innovations are presented by type with colored solid lines (drones, internet, A.I., digital maps, ontologies, smartphones, etc.). There are also five dashed lines which are the assimilation curves of these innovation by the crisis management domain: internet and smartphone improve communication, maps improve geographical information systems, Facebook and Twitter bring social media in the game, etc. These theoretical consequences and assimilation curves are representing the “*innovation pushes hypothesis*”.

To evaluate that hypothesis, we have studied and mined the proceedings of all ISCRAM conference since 2004 (using the ISCRAM Digital Library¹) and have analyzed all words in the *titles*, *abstracts* and *keywords* of all articles in the proceedings. The objective is to identify the major trends in the last fifteen years and to analyze which ones can have played a role of propellant with the “*innovation pushed*” paradigm. The following figure 3 illustrates, first the number of occurrences of most mentioned words in ISCRAM papers between 2004 and 2019 (left part of the figure) and the mapping between these principal concepts and the “*innovation pushed hypothesis*” presented on figure 2 (right part of the figure). On that figure, the y-axis presents the absolute number of occurrence of terms (even if it would have been probably more significant to count the number of papers mentioning the term, maybe pondered by the number of occurrences within the article) while the x-axis presents the years of ISCRAM editions.

¹ <http://idl.iscrum.org/> (accessed January 20th 2020)

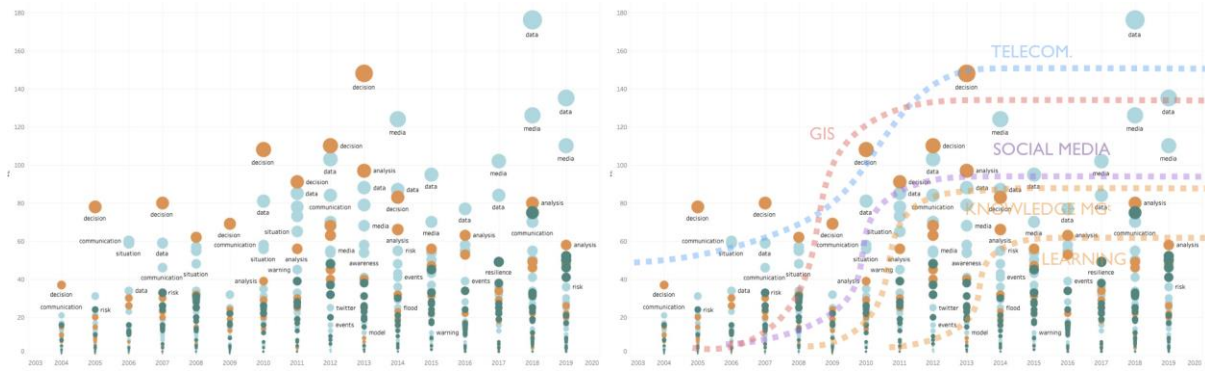


Figure 3. Main subjects addressed in ISCRAM articles (left) and mapping with the hypothesis of figure 2 (right)

From the right part of the figure, it is reasonable to provide the following statements:

- The exploding emergence of “social media” in the domain of crisis management clearly appear on the word analysis (“media” skyrocketing from 2012) and also on the “innovation pushed hypothesis” (cf. the purple dashed line on the right).
- Similarly, the occurrence of the word “communication” is rising from 2004 to 2012, then stagnating. This is consistent with the innovation curve of “Telecom” (cf. the light blue dashed line on the right).
- The rise of the word “data” from 2016 can be considered as consistent with the “learning” innovation curve. However, this is quite questionable (mainly because there is nothing about “machine-learning” or deep learning”, which should be the most significant keyword of that very last years).
- There are several words that are pretty difficult to connect to “innovation pushed” elements. For instance, “warning”, “situation”, or “risk” are very relevant terms from the ISCRAM perspective, but there are not connectable to the considered “innovation pushed” trends.

From this analysis, the main conclusion is that it looks quite relevant to consider the emerging technologies, tools principles and paradigms as factors of innovation in the domain of crisis management. However, it also seems obvious that these social progresses should not be solely considered. For instance, it is probable that other factors such as contemporary disasters events, impacted countries and area of the world, would also impact the orientations of the innovation. But that part is more in line with the “need pulled” paradigm, developed in the following subsection.

There is another aspect that could connect these social innovations to the evolution of the domain of crisis management: the economic and social consequences of these innovation might be the origin of crisis events. For example, the massive exploitation of a mineral resource for batteries could open the door to some next socio-economic crisis. This aspect is not studied in this article.

“Need pulled” perspective

During the same period as the study of the previous subsections, we have identified major and significant disastrous or critical events. Similarly to the previous subsection, the objective is to identify which of these events may have perturbed the socio-economic world enough to generate a significant need with regards to crisis management. The following figure lists these events by year and presents their theoretical impact on “need pulled” paradigm. Figure 2 roughly presents a succession of “need pulled” schemas and the associated theoretical consequences on topic-based innovation. This is the “*need pulled hypothesis*”. The reader should keep in mind that the y-axis on the next figure not only represent the research maturity or amount of scientific contribution (the RESPONSE purple axis) but also the intensity of the social need due to the occurrence and associated societal pressure to deal with that subject (e.g. in the period of the COVID-19, a lot of unexpected calls for project from NSF, European Commission and some National Research Agencies, emerged suddenly to encourage researchers to work on this specific subject)

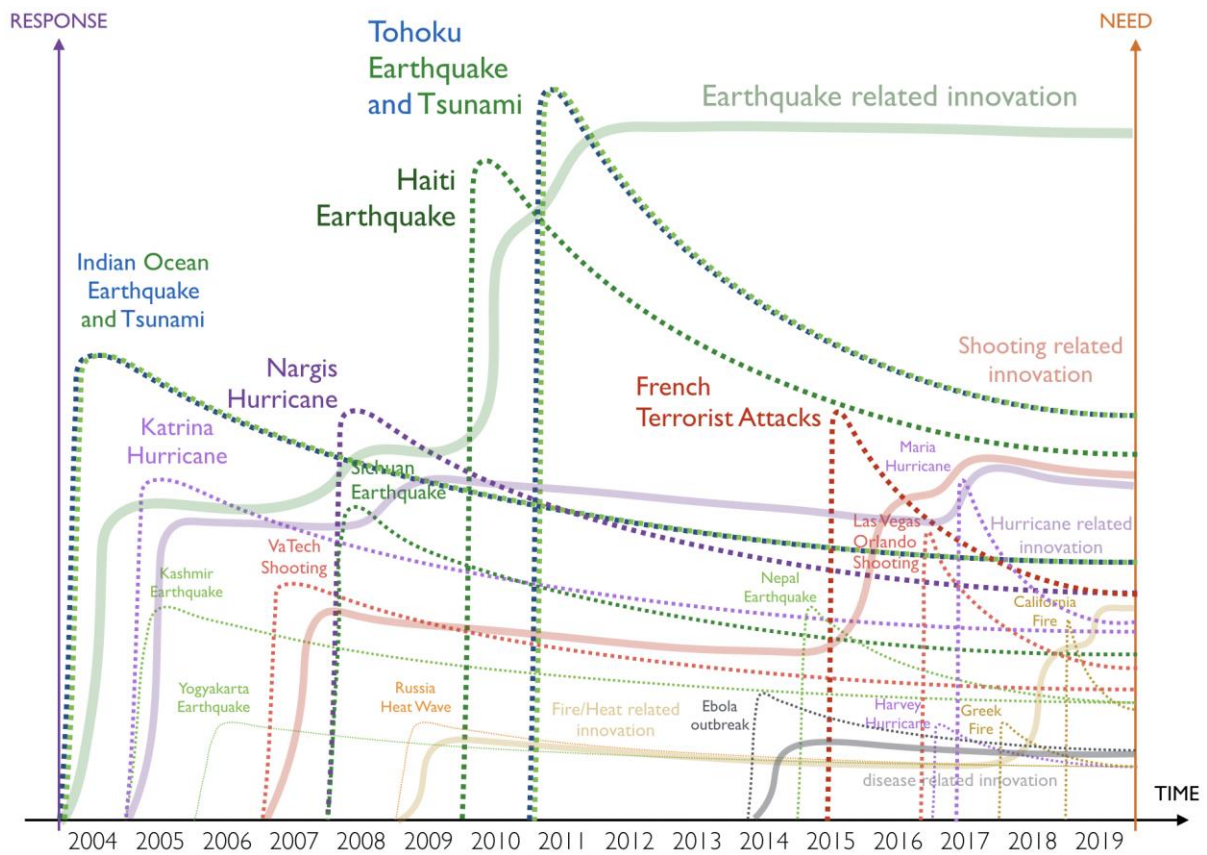


Figure 4. The set of main “Need pulled” paradigm disaster events since 2004 and their impact on innovation need

On the previous figure, events are presented by nature (green for earthquakes, blue for tsunamis, purple for hurricanes, red for shootings, yellow for fires, gray for diseases). There are also five solid lines named “earthquake related innovation”, “shooting related innovation”, “hurricane related innovation”, “fire related innovation” and “disease related innovation” representing the theoretical response (according to the “need pulled” paradigm) of the innovation community to the occurrence of disastrous events.

We have studied and mined the proceedings of all ISCRAM conference since 2004 (from the ISCRAM digital library as well) and have analyzed all words in the titles, abstracts and keywords of all articles in the proceedings. The objective is to identify the major trends in the last fifteen years and to analyze which ones can have played a role of propellant with the “need pulled” paradigm. The following figure 5 illustrates, first the natures of disasters mainly addressed in ISCRAM papers between 2004 and 2019 (left part of the figure) and the mapping between these natures and the “need pulled hypothesis” presented on figure 4 (right part of the figure).

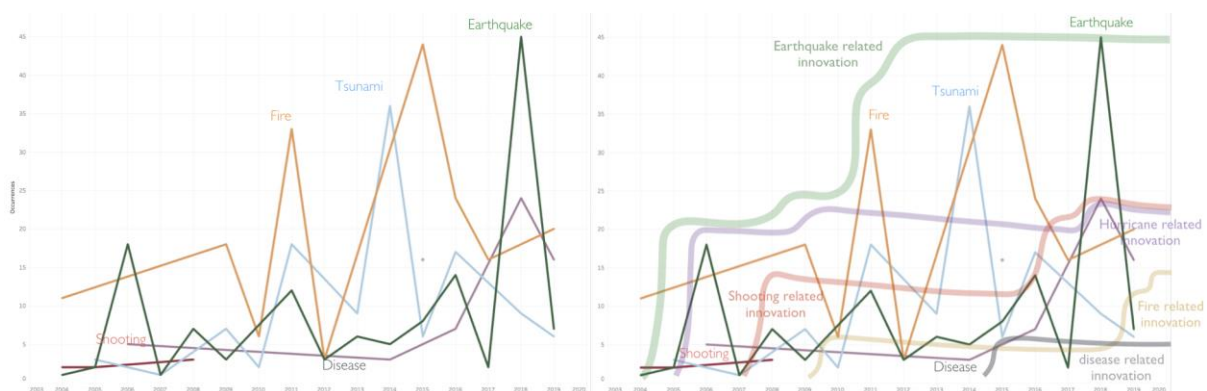


Figure 5. Main topics addressed in ISCRAM articles (left) and mapping with the hypothesis of figure 4 (right)

From the right part of the figure, it is reasonable to provide the following statements:

- Considering that “earthquake related innovation” actually merge “earthquake” and “tsunami” related events, the mapping seems to be very relevant: the wide light green line increases massively after 2011,

just like the combination of Tsunami and Earthquake (light blue and strong green lines).

- The “shooting related innovation” mainly appears in 2007, just like the dark red line from ISCRAM analysis, however, the following of that topic is not present in ISCRAM. Basically, it means that the Virginia Tech shooting had a big impact while the shootings in France, in Las Vegas and Orlando did not really impact ISCRAM research activities.
- The “disease related innovation” follow the same pattern as the dark grey line of ISCRAM analysis. This is mainly due to the “ebola” crisis.
- The “fire related innovation” and the orange line of ISCRAM analysis are very different. This probably means that this topic is a recurring topic in ISCRAM, almost independent from the context.

From this analysis, the main result is the following: considering the closeness of the results to the “need pulled hypothesis”, it is realistic to conclude that the context and the surrounding events significantly influence the research activities. This seems to confirm the general hypothesis that the domain of crisis management is somehow driven by a succession of micro-paradigms of evolution (and not a generic evolution paradigm). This makes the domain of crisis management a very different and original field. Besides, Crisis Management Researchers definitely need data and reliable use-cases to work, test and evaluate their hypothesis. This is another reason why the crisis management research trends stick to the actual crisis events in such a tied way.

However, the trends identified in Figure 4 have only been exploited to map the type of crisis addressed in scientific articles. These trends could also be exploited for the management needs they could infer. For instance, working on earthquake clearly pushes the need for efficient virtual cartography and stresses the question of logistics and supply chain. On a different point of view, working on terrorist attack clearly pushes the need for research on evacuation schemas and behavioral / psychological social studies. These considerations on the exploitation of crisis events for research topic identification, even if clearly identified and of great relevance, is not addressed in this paper. These ideas could be particularly studied from the European Report (Poljansek et al., 2017).

Finally, the question of maturity evaluation of the crisis management domain and the support of its maturation still remains.

EVOLUTION OF THE CRISIS MANAGEMENT DOMAIN IN THE NEXT FIFTEEN YEARS

The main conclusion of the previous section is that, even if some trends can be detected, the domain of crisis management basically evolves in a very anarchic way. Being basically pushed and pulled by (i) crisis events that drive, on the one hand the choice of crisis subjects to be addressed (earthquake, terrorist attack, flooding, etc.) and on the other hand the needs associated to these specific types of crisis (not addressed in this article) and (ii) innovations that are assimilated by the crisis management domain. Based on these elements, the evolution trends are definitely not obvious. The suggested approach is then the following: *on the basis of the last and current innovation tendencies and the main statements about crisis types, some principal trends can be defined and described according to a structuring framework.*

A Maturity Framework for Crisis Management

The central and main principle of that framework is to consider that whatever the phases of Crisis Management (prevention, preparation, response or recovery, as stated in (Atlay and Green, 2005)), the questions and concerns are always about *information, decision, and action*. *Information* in the sense of acquiring, maintaining and improving a common operational picture (in the meaning of the COP described in (Dickinson, 2013)). *Decision* in the sense of exploiting the long-term accumulated experience and knowledge conjunctly with the current information of the situation to infer choices and orientations. *Action* in the sense of performing the required activity, whatever the objective, appropriately and relevantly to the faced situation. From that initial statement, the proposal is to use these three dimensions of *information, decision, and action* to structure the maturity framework and to evaluate the maturity of crisis management according to each of these points of view:

- **Information:** as a first approximation, we suggest three maturity levels for that dimension:
 - **Aware:** there is a communication link from the crisis site to the crisis cell.
 - **Connected:** Sensors, IoT and other type of data sources are used to inform the crisis cell.
 - **Sentient:** the gathered data is interpreted and treated to support the crisis cell.
- **Decision:** We also suggest three maturity levels regarding the decisional dimension:
 - **Reactive:** Decision is made on the flow, according to the collected information about the crisis.

- **Global:** Decision is made according to a COP describing continuously the situation.
- **Anticipative:** Decision is made according to the COP and the way the situation may evolve.
- **Action:** Similarly, three maturity levels are considered for that dimension:
 - **Effective:** Actions performed with regards to objective satisfaction.
 - **Efficient:** Actions performed with regards to objectives satisfaction and resources availability.
 - **Optimized:** Actions performed in the best way with regards to objectives and resources.

The following picture illustrates that framework as a 3D conceptual environment:

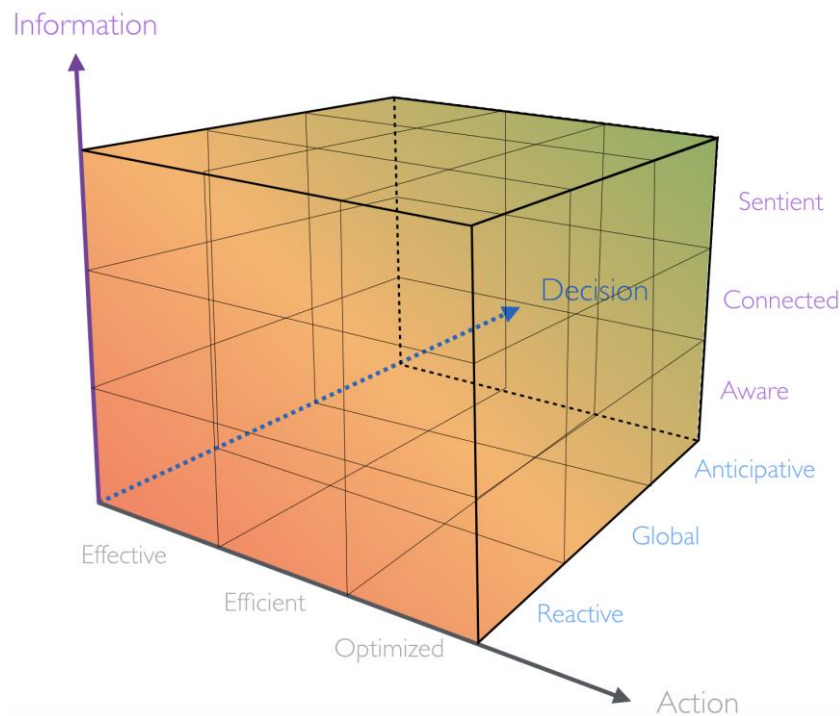


Figure 6. A 3D framework for maturity assessment of the Crisis Management domain.

One interesting aspect is the connections between these three dimensions. Obviously, *information* is required to perform *decision*, and *decision* is the prerequisite to *action*, then *action* supposedly changes the faced situation and consequently the *information* about the crisis, and so on. These relations between dimensions are important because they may design the evolution path within that framework.

FUTURE TRENDS FROM THE SUGGESTED MATURITY FRAMEWORK

The previous considerations regarding the dependencies between *information*, *decision*, and *action* give some theoretical guidelines regarding the way progress in Crisis Management Domain can be envisaged. Basically, and very schematically, the progress can be seen in a “spiral” way, chaining improvements and evolutions from the *information* perspective, to the *decision* perspective, then to the *action* perspective, looping back to the *information* perspective again, and so on. The figure 7 illustrates very schematically this idea:

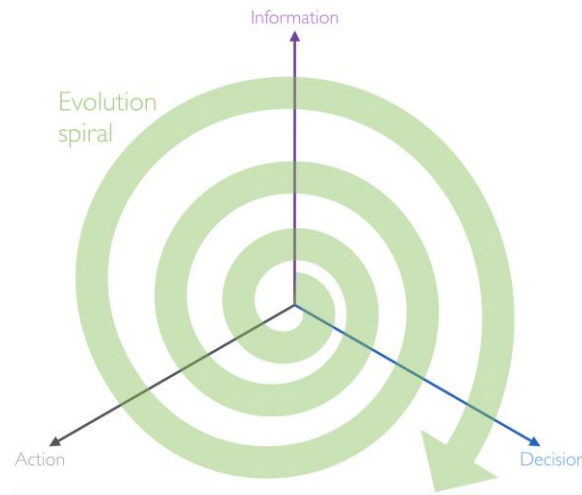


Figure 7. The looping chain of evolution and progress according to the three considered dimensions.

What that figure illustrates basically is that in addition to the trends identified in the first section, mainly based on “innovation pushed” and “need pulled” principles, there is another propeller that should be considered: the looping chain of evolution and progress *information, decision and action*. This means that the evolution of crisis management, from the point of view of this paper, is basically propelled by three sources:

- Technological and services innovation: Contextual “innovation pushed” evolutions.
- Needs coming from the actual crisis events: Domain “Need pulled” evolutions.
- The succession of crisis management topics in progress: Nature “looping chain” evolutions.

Back on the framework of figure 6, and following the spiral principle, the progress path related to that third evolution source can be outlined as represented on figure 8.

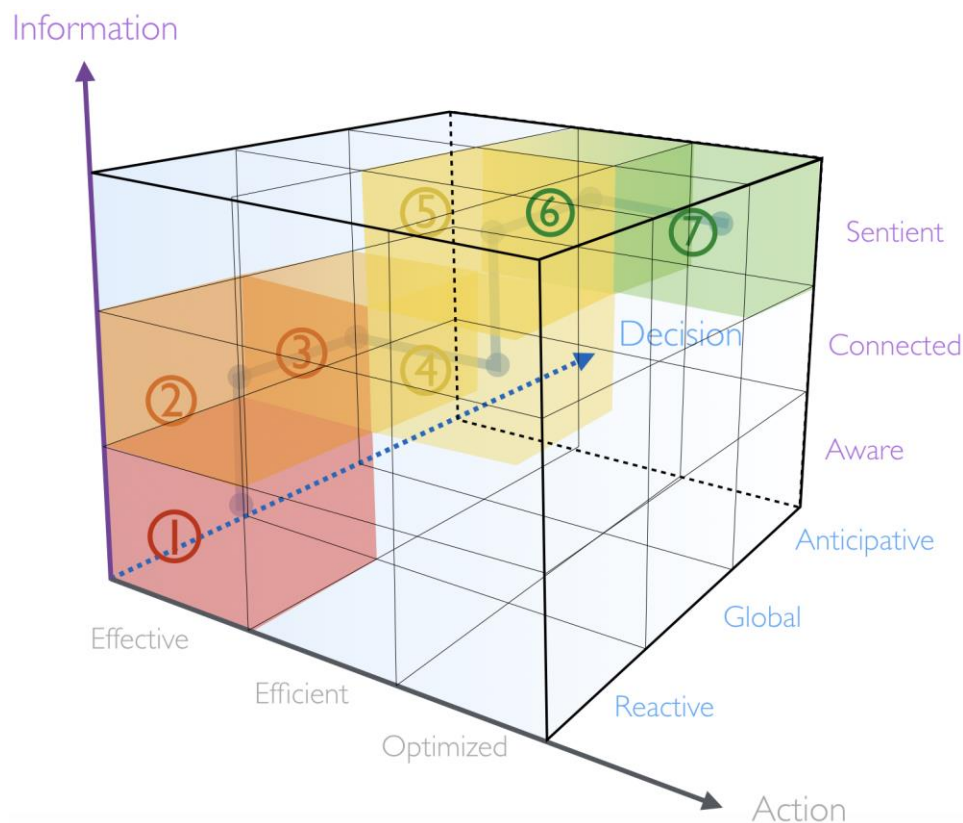


Figure 8. The trajectory of progress of the crisis management domain in the information/decision/action framework.

Starting as 1:(Aware, Reactive, Effective), the progress should then concern *information* and move to 2:(Connected, Reactive, Effective). Then the improvement should concern *decision* and move to 3:(Connected,

Global, Effective). The next move concerns *action* and position 4:(Connected, Global, Efficient), etc. until 7:(Sentient, Anticipative, Optimized). Obviously, there may be some next levels on each dimension, but they are still to be invented and defined.

Based on the previous considerations, the prevision that can be made for the next fifteen years are the followings:

- Technological and services innovation:
 - The first and most significant current innovation that would certainly transform the domain of crisis management is *Artificial Intelligence*. This current topic is still at its early infancy and should revolutionize crisis management by contributing to a far better decision making. It should also make decision makers free from the large majority of their duty, allowing them to actually focus on the task that actually require their humanity. Even if AI could contribute to the *information* stage (by supporting data interpretation, data visualization, etc.), its contribution will massively and eventually concern the *decision* stage (a new track appeared in ISCRAM 2019: AI Systems for Crisis and Risks).
 - The second innovation that should be considered are drones or UAVs. Even if they are currently largely considered (they have been first introduced in 2005 in ISCRAM, see (Claessens, *et al.* 2005)), they have not yet reached the point where they would change the information stage by an order of magnitude. Even if UAVs could also contribute to the *action* stage (for instance by delivering rescue materials in inaccessible areas), their contributions will massively and eventually happen in the *information* stage.
 - The third innovation that would drastically and deeply transform crisis management is virtual / augmented / mixed reality. It has been first mentioned in ISCRAM in 2013 with (Ardila, *et al.*, 2013) and not very often discussed since (three articles in total). VR/AR/MR could obviously be used for its ability to mimic reality: For instance, VR could seriously remove some of the strongest inconveniences of real size exercises, as presented in (Congès, *et al.* 2019). But VR/AR/MR could also be used for its ability to escape reality and provide an environment able to ensure immersive analytics for instance. VR/AR/MR could contribute to the *Action* stage by enriching the context of the responders, but it also could contribute to the *Decision* stage by providing decision makers with a more exploitable COP representation.
- Needs coming from the actual crisis events:
 - The first type of crisis that will impact crisis management research is clearly climate change and global warming. This man-made systemic change will doubly impact the domain of crisis management: first by being an unavoidable domain of study, and second by generating specific needs due to its multi-domain nature.
 - The second type of crisis to be considered is the global overpopulation. That topic would generate so many sub-crisis (disease, famines, conflicts, etc.) that it may become the root of all social crisis.
- Dynamics of the evolution: Basically, considering that the current position of the crisis management domain (with regards to figure 8) is not at the “sentient” level on the *information* axis, not at the “anticipative” level of the *decision* axis, and not at the “optimized” level on the *action* axis, it is reasonable to say that this position is between 2 and 4 (IoT and sensors makes it more mature than 1). The lack of coordination between ministers or between governments and the individualized objectives of stakeholders on crisis management make the *decision* level definitely not “global”. As a consequence, the current position is probably very close to 2. It is so easy to see that the next evolution steps will mainly concern the barriers to 3, 4 and 5. It is funny to see that the innovations mentioned earlier (A.I., UAVs and VR/AR/MR) will clearly contribute to these three leaps.

So, roughly speaking, the future of crisis management will see a fleet of drones taking off at the first ring of the early warning system, flying urgently to a coastal flooding to instantaneously generate a 3D model of the crisis site, enriched by other data (interpreted from satellite, sensors, social media). This 3D model, enriched with knowledge content, will be analyzed by a computer system that will provide the users with a clear and constantly updated COP (including prospective analysis). The COP will be used by decision makers to continuously control the situation through a VR/AR/MR digital twin of the site.

CONCLUSION

This article claims that by mapping social and technological innovations, and crisis events on the crisis

management evolution chain (*information, decision, action*), and by considering the evolution chain of that domain, one can predict some of the main tendencies of the future. It is necessary to mention explicitly that at least two restrictions should be considered on the way the data is considered in this article: First, the ISCRAM article cannot be considered as completely independent from the topic of the conference (each year, a precise topic is supposed to map the time period of the conference but also the expertise of the organizing team. This fact might certainly influence and somehow bias the “colors” of the submitted papers. Second, only considering titles, abstracts and keywords certainly reduce the scope of the considered terms. For instance, regarding the need-pulled aspect, it is possible that a lot of use-cases and scenarios, which explicitly carry the “need-pull” information, might not be mentioned in Title, Abstract and Keywords, somehow distorting the obtained results. These limitations, even if it is difficult to evaluate for now their actual influence should be kept in mind when reading the conclusions and contributions of the paper. Clearly, this is a position paper that would definitely require far more studies and comparison, and some more sources (than only the ISCRAM digital library). Studying funded research program like European, American NSF, Chinese NNSF, etc. would also be a good input. However, this article identifies some trends and their potential occurrence in the future. These are bets on the next fifteen years, based on the analysis of the last fifteen years. It is clearly risky but this is what research is made of.

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