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Post-earthquake damage assessment: feedback from a cross-border crisis exercise

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ABSTRACT

In November 2021, a large-scale crisis exercise was organized in the heart of the Pyrenees. The main objective of this cross-border exercise between France, Spain and Andorra was to allow practitioners to prepare for a large-scale earthquake, by testing the contribution of the tools developed within the framework of the European project POCRISC. Among the different functions activated during the exercise, this article focuses on the particularly critical function of emergency assessment of building damage. It analyses the feedback from the exercise participants asked to evaluate the deployment, coordination and operation of the damage assessment function, including the use of a tool developed specifically for these activities.

Keywords

Crisis exercise, Earthquake, Post-earthquake damage assessment, Cross-border disaster management, Crisis management digital platform

INTRODUCTION

The Pyrenean massif, which is the natural border between France and Spain, and which is also home to the Principality of Andorra, is one of the regions most exposed to earthquakes in mainland France and Spain, with hundreds of earthquakes recorded each year, of which about ten are felt locally. Despite their relatively moderate seismic activity compared to other European countries, the Pyrenees have historically experienced many destructive earthquakes, including the events of 1428, 1660, 1750 and 1967 (SisFrance database, Jomard *et al.*, 2021).

Despite the relative rarity of destructive earthquakes occurring in the Pyrenees, the occurrence of such a disaster cannot be excluded. It is therefore essential to be prepared to face such an event. This preparedness is even more important in contexts of moderate seismicity such as that of the Pyrenees, where the low frequency of destructive earthquakes limit the experience of the services concerned (Borodzicz *et al.*, 2002). Furthermore, an effective decision-making process of crisis management requires that the operator is trained both in the devices, tools and interfaces he will have to implement during the crisis, and in the mobilization of his knowledge and thinking skills (Fredholm, 1999). Thus, crisis management exercises become essential for improving the skills of involved actors, as they ensure an adequate appropriation of practices and technical tools.

In this context, an exercise mobilizing French, Spanish and Andorran stakeholders was held in the French Pyrenees in November 2021, focused on the management of early post-earthquake damage assessment.

PROBLEMATIC

The recent Le Teil earthquake in France on November 11, 2019, and before it the Lorca earthquake in Spain on May 11, 2011, have confronted the French and Spanish civil protection authorities with the issue of conducting mass damage assessments, which triggered the need of improving existing practices, from a methodological, technical and organizational point of view. Feedback from these two earthquakes (Martínez *et al.*, 2014; Taillefer *et al.*, 2020; Peverelli *et al.*, 2021), corroborated by the experience of the 2016 Central Italy seismic crisis (Auclair and Monfort, 2017), highlights two main areas for progress:

1. The coordination of the parties involved in damage assessments tasks, with in particular the need for greater collaboration between the associative experts mandated by the authorities, and the structural specialists among the firefighters of Urban Search and Rescue (USAR) teams.
2. The workflow of the damage assessment, from the request made by the citizens to the Certificate of Occupancy inspection, passing through the field survey, the feedback to the DAC (Damage Assessment Coordination) and the synthesis of the information for the coordination of the crisis management. Experience shows that the timing required by this process needs optimization of supporting digital tools, such as the ERIKUS system, used by the Italian Civil Protection (Mayneri *et al.*, 2017).

PRESENTATION OF THE EXERCISE

Objectives and scenario

Co-organized by the partners of the European POCRISC project (https://pocrisc.eu), the prefecture and the departmental emergency service of the Hautes-Pyrénées (SDIS-65), and the municipality of Séméac, in the practice this exercise aggregated several independent initiatives, to take advantage of the presence of cross-border teams and to test the capacity for cooperation of local and foreign resources.

Following the occurrence of a magnitude 6 earthquake south of the city of Tarbes and the damage to the prefecture, the scenario planned to move the departmental crisis center (COD) to the site of the Tarbes engineering school (ENIT). It is in this degraded environment, with limited equipment and without knowing the workplace, that the prefecture's crisis director had to organize the management of the event. The exercise included both a tabletop part, with a COD coordinated by the prefecture in ENIT, and a field part. The exercise mobilized 75 participants for the part described in this article (Figure 1), and more than 250 (players, observers and facilitators) in total, from France, Spain and Andorra.

Among the issues that the players were confronted with, particular attention was paid to the emergency assessment of building damage. It aimed to provide the crisis manager with tangible elements for the identification of premises useful to the crisis response and recovery (strategic buildings or buildings intended to accommodate populations), and the sheltering needs assessment, based on the damage rate of residential buildings located in the impacted perimeter.

Function	Andorra	France	Spain
Civil protection	1	9	
Exercice control		16	
Firefighters		10	4
Observer	2	9	7
Structural safety experts	3	9	5
Total	**6**	**53**	**16**

Figure 1. Details of the function of the participants in the exercise by country

This main purpose led three specific objectives:

1. To test the digital platform developed by the DeveryWare company within the POCRISC project. It is composed of a mobile application for field inspectors and a web GIS tool for coordinators, and allows planning building assessment tasking, data entry in the field, and results monitoring from the DAC (Martinez and Goula, 2019).
2. To encourage the French local authorities to engage firefighters together with the experts from the French earthquake engineering association (AFPS), mandated by the French civil protection for post-earthquake building damage assessment.
3. To coordinate effectively response and recovery resources available from regional (from neighbor French departments) and cross-border (from Spain and Andorra) entities. Within the scope of the exercise, outside the framework of the European civil protection mechanism (UCPM), this assistance were considered to be mainly operational. In particular, building inspectors from Cataluña integrated SDIS-65 and AFPS (activation of the Catalan earthquake engineering association integrated in the Association of Structural Consultants - ACE) field survey teams.

FEEDBACK ON DAMAGE ASSESSMENT

The purpose of the feedback is to evaluate the decisions and actions taken during the exercise, by comparing the points of view of all the stakeholders, and to start an improvement process that may involve updating plans and procedures. After the organization of a "hot" feedback immediately after the end of the exercise, a "cold" feedback is being carried out. To facilitate the collection of the participants' feedback, an on-line questionnaire was proposed to all the participants. We will present hereafter a first analysis of 41 responses we got, with a specific focus on the coordination and conduct of damage assessment function.

Articulation within COD between the coordination and the DAC

The management of a seismic crisis requires the activation of numerous coordination functions attached to the COD. Among them, a task force dedicated to the damage assessment was created: the DAC, aimed to coordinate the damage assessment, and to report to the chief coordination unit only the information necessary for the overall management of the crisis (Figure 2). The answers to the questionnaire show contrasting opinions upon the interactions between these two units (Figure 3).

The areas for improvement identified relate in particular to the requirement:

- For the authorities, to identify the experts available for intervention (associations, institutions, etc.), to assign them prioritized tasks and to provide them with the means for effective coordination;
- For the experts, to identify the expectations of the authorities and to advise them on the prioritization and results of the expert assessments carried out.

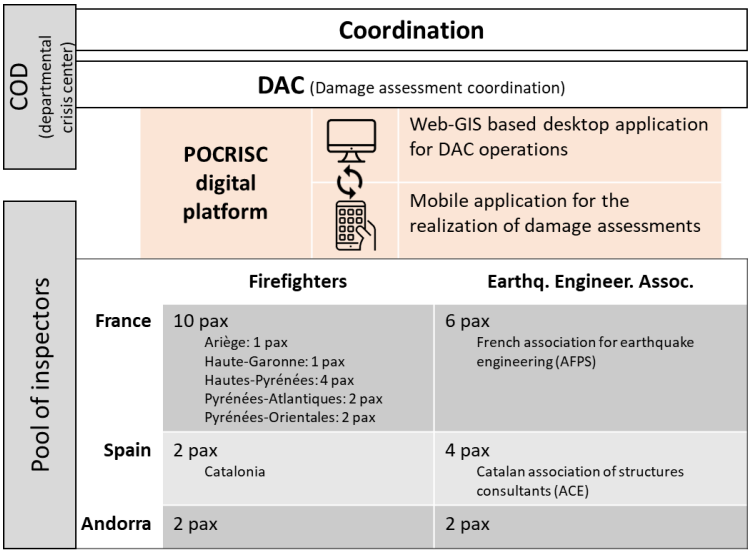

Figure 2. Functional representation of the technical and organizational "damage assessment" system used in the exercise

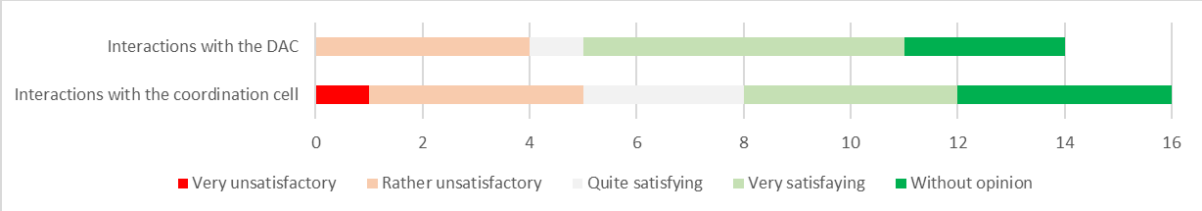

Figure 3. Participant satisfaction with interactions between COD coordination and DAC (number of responses received)

Functioning of the DAC

Exercise participants involved in the DAC were asked about its composition, its working mode, and the strategy adopted by this coordination and relaying task force (Figure 4).

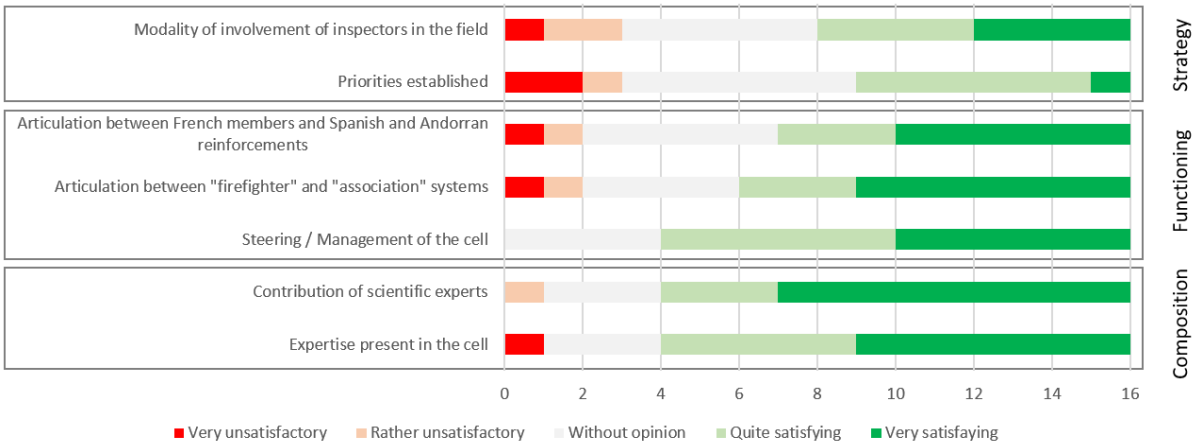

Figure 4. Participant satisfaction with DAC operations (number of responses received)

First, the action of the DAC is generally judged positively. A particular level of satisfaction was expressed concerning the composition of the workgroup and its management. It was appreciated that the coordination of the associative and firefighters' systems was brought together within the same unit. Another positive highlight was about the delegates appointed to represent the various international teams supporting the building damage assessment. Although the official language was French, the experts were able to understand each other. To improve the efficiency of the work of the DAC, and in particular for the right interpretation of the results of the assessments and the rapid exploitation of information got from the hit inhabitants, some participants suggested

the integration of technical officers from the most damaged municipalities.

Concerning the strategy adopted by the DAC, the principle retained for the constitution of the field survey teams was to prioritize mixed pairs, associating an inspector from the voluntary associations with an expert firefighter. This principle, which was suggested following the Le Teil earthquake (Auclair *et al.*, 2020) and successfully tested during the damage assessment mission carried out in the southeast of France in the aftermath of storm Alex in October 2020 (Auclair *et al.*, 2020). It is supposed to allow the enrichment of professional cultures and facilitate the homogeneity of the survey outcome. This configuration was strongly appreciated. The identification of criteria for prioritizing inspections tasks was difficult due to the time actual duration of the exercise.

Contribution of the POCRISC digital platform

The POCRISC digital platform was generally appreciated by the participants, both for the functions provided and its general usability. Nevertheless, the two components of the platform should be considered separately: at the DAC level, the coordination function was used via a web-GIS platform, while the field inspectors used a smartphone mobile application (Figure 2 and Figure 5).

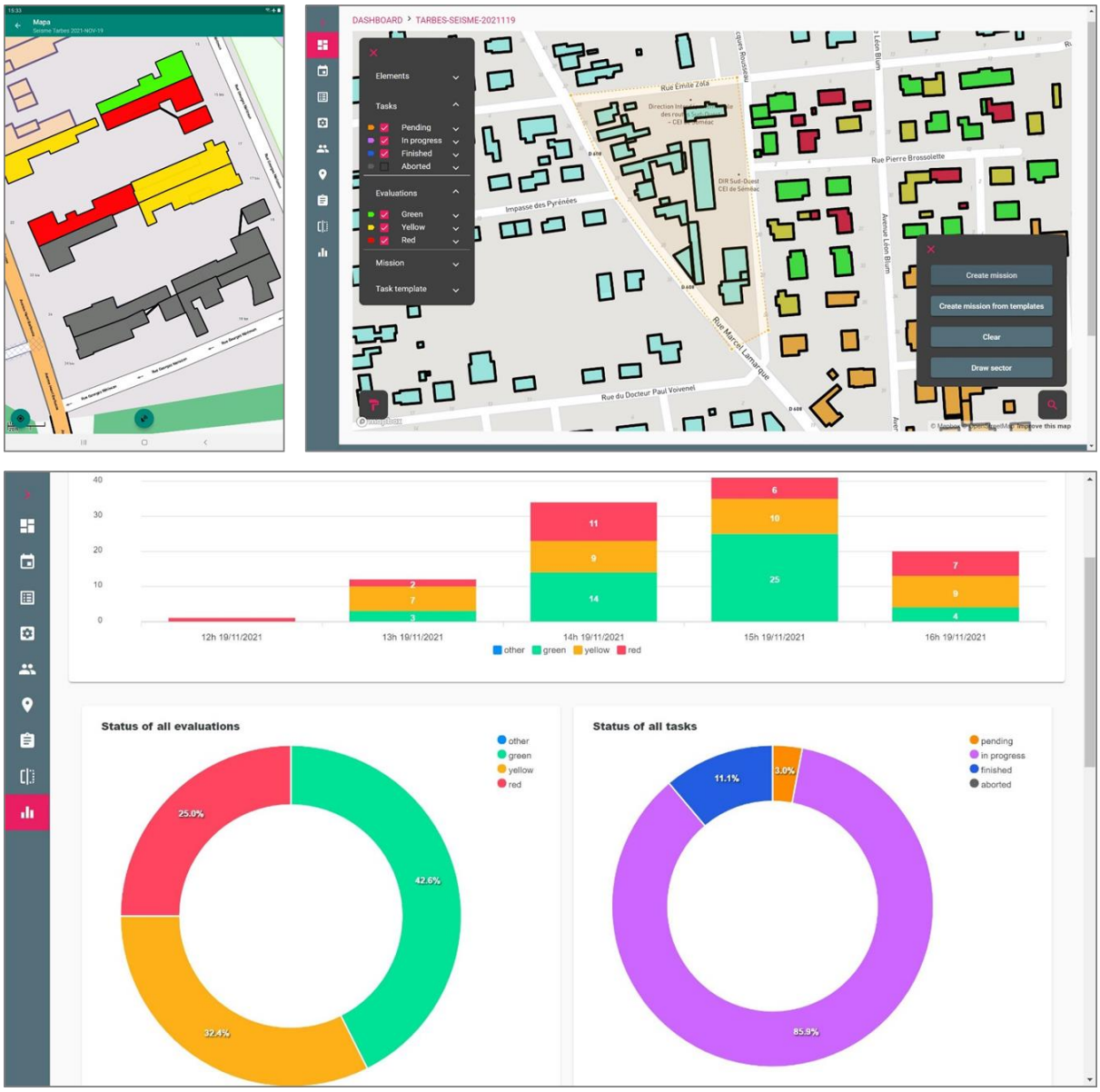

Figure 5. Screenshots of the POCRISC platform: mapping from the mobile application (left) and the coordination tool (center), and coordination dashboard (right)

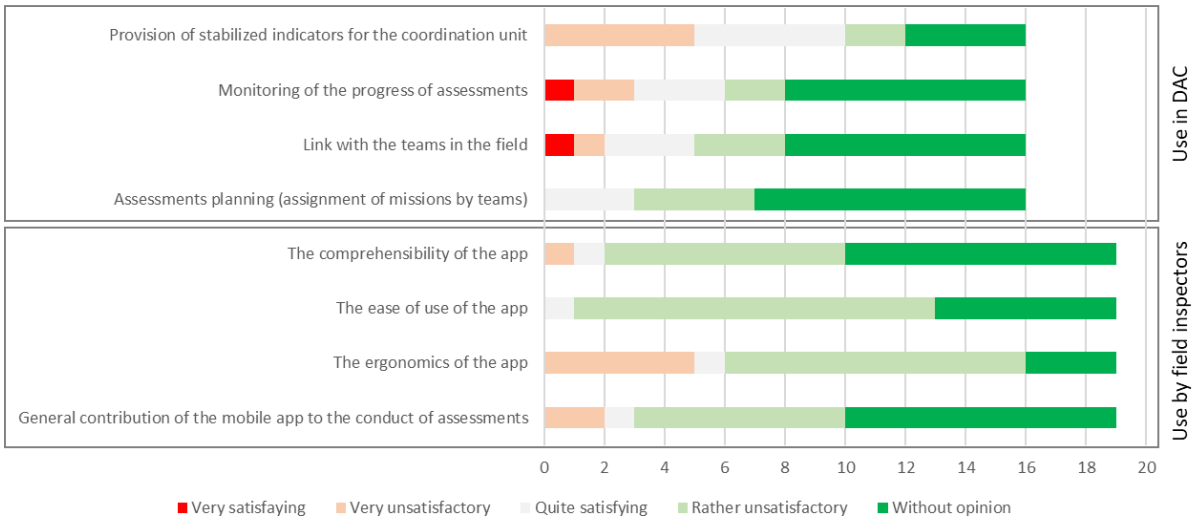

Figure 6. Satisfaction of the participants concerning the contribution of the POCRISC digital platform (number of responses received)

Use of the coordination digital platform by the DAC

Concerning the coordination platform, it first allowed the allocation of building assessment tasks by pairs, either by identifying sectors to be investigated on the map, or by identifying buildings individually. After a training phase, the tool proved to make this activity relatively easy, despite problems related to the tasking of certain target areas very large: the identification of large sectors can indeed correspond to hundreds of buildings, each one representing an assessment task. It is interesting to note here that the DAC had to manage, at the request of the coordination unit, the sectorization of an area not covered by the cadastral data pre-loaded into the tool for the exercise. Nevertheless, the use of the GIS back-end and the technical assistance of DeveryWare made it possible to quickly integrate the missing data and plan the survey. This unforeseen event highlighted the agility of the tool, and its ability to be deployed quickly.

However, the most valuable feature for the DAC remains the ability to receive real-time results from teams deployed in the field. It provides a constantly updated view of the situation and allows to save a considerable amount of time for data consolidation, compared to workflows based on paper forms. This process of dynamic data transfer from the field proved to be very efficient, and the DAC had access to an updated map showing the progress of the building assessment campaign, as well as the individual building findings. Even if a dashboard with summary indicators is also available on the platform, it turned out that these indicators and their restitution modes did not meet the COD's needs. The objective of defining the indicators useful to the decision-makers was partially attained: work should be done to identify them clearly in peacetime, so that they can be automatically produced on the dashboard. In addition, users and observers pointed out the lack of functions to use field data more easily to report effectively damage to municipal authorities, so that they can take decisions and safeguard measures about the occupancy.

Use of the mobile application by field inspectors

Apart from a few difficulties in downloading and configuring it, the mobile application worked correctly on Android devices (application not available for iOS). The assignment of tasks worked without any problems other than the one already reported, when hundreds of tasks were scheduled at a time. This situation caused slowing data transmission. Once the tasks were assigned, the inspectors could go to the field to inspect the assigned buildings one by one. While the mapping provided in the application made it relatively easy for inspectors to find the survey area, the exact positioning of the buildings was more difficult. The users suggest improving the use of the on-board GPS (refresh rate and accuracy of the GPS questioned by the respondents), and adding an aerial view map background, as well as the use of on-board navigation services such as GoogleMap.

This question of localization raises the more fundamental question of the choice of the referential used to identify buildings and postal addresses useful for navigation (cadastral parcels, building footprints, address database, etc.). Although apparently simple, this issue is not trivial as the precise positioning of buildings is essential for building damage assessment in dense urban areas for inspectors not familiar with the survey area. In the case of the exercise, the referential in use did not allow to have a postal address.

Once the building was located, the in-situ entry of the survey form via the application proved to be functional, even if many inspectors pointed out the need to improve the navigation within the form, in particular by reproducing the logical path of its paper version, as well as by offering a synthetic view of the information before validation. A valuable benefit of digital entry via the application was the ability to attach photos taken in the field. Another strong point of the application is the ability to embed different technical reference forms: French inspectors were able to work on the AFPS system, while Spanish and Andorran inspectors used the ACE system. When the reference forms result compatible each other (as in this case), the digital management of the form allows different inspectors to collaborate effectively even if they do not know each other and are used to different assessment plan.

Some inspectors complained that it was difficult to get feedback from the DAC. The application, at its current stage, does not include any protocol for inspectors to communicate with DAC. Furthermore, once an assessment task is validated by an inspector, the result is automatically transmitted to DAC and the task disappears from the app. This is very frustrating for the inspector and possibly harmful when the inspector needs to review tasks, by request of the DAC, which is a fairly common issue at the beginning of early damage assessment investigations. Thus, many inspectors ask for an overview of their work and neighbors', as well as getting possibility to reopen and correcting tasks already completed. Many inspectors also advocate the use of both paper and digital devices, and entering only information on the application that is strictly useful to DAC.

CONCLUSION

Unlike other very seismic European countries, carrying out exercises such as the one described in this article is critical for regions with moderate seismicity such as the Pyrenees. The exercise thus made participants aware of the criticality of the function of damage assessment. Beyond the organizational issues that must be dealt with on a case-by-case basis depending on the civil protection organization specific to each country, we were able to discuss the question of the tools to be deployed to support the coordination and the realization of postseismic damage assessment.

In this regard, the POCRISC digital tool tested as part of the exercise was favorably appreciated. Although improvements needs to make it more effective, the majority of participants to the questionnaire would like to use it in the future (Figure 7). While many tools already exist for digital input of diagnostic results in the field and raising them to a level of coordination, the originality and added value of the POCRISC tool lies in its bidirectional mode, allowing in particular the allocation duties to inspectors. However, the feedback also shows that the use of highly automated tasking systems, such as the Pocrisc platform, should not distract stakeholders from the need for frequent feedback between inspectors in the field and their points of contact in DAC. Furthermore, the conduct of such damage assessments, which can involve many different entities, sometimes from several countries, raises the question of the interoperability of procedures and tools. This question deserves to be addressed at the international level, and with regard to Europe, within the framework of the European Civil Protection Mechanism (UCPM).

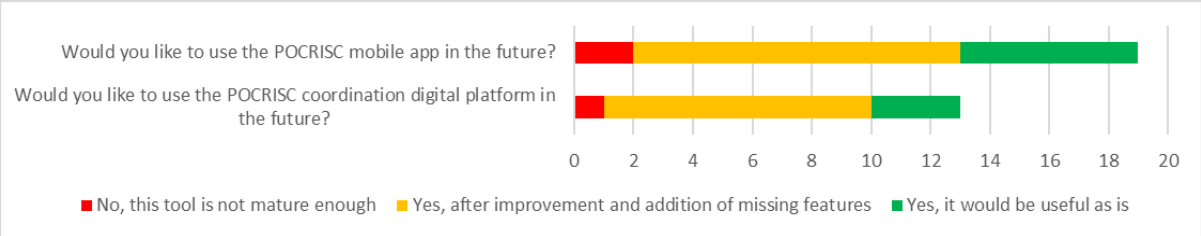

Figure 7. Participants' desire to use the POCRISC application in the future (number of responses received)

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