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SOCIAL DISTANCING IN CONSTRUCTION: INVESTIGATING THE ROLE OF TECHNOLOGIES IN SUPPORTING REMOTE MANAGEMENT

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ABSTRACT

As the current health crisis, "Covid-19" disrupts how work is performed on construction projects and slowing construction and engineering projects down, causing delay and disruption, therefore builders and project owners are seeking new approaches to enable progress while protecting workers. This study investigates the opportunities of applying remote management on the construction projects by depending on a theoretical approach to discuss the impact of the pandemic on construction, illustrate different mitigation plans, and identify how to apply them. Also, one to one interviews with experts in the field were conducted to help in deciding the risks and benefits of different technologies, with the objective of choosing the most proper technology. Through an analytical approach, the paper analyzes the way technology can enable "social distancing" on worksites and evaluates the most appropriate technology to be implemented on the projects to overcome the challenges that might face construction during this crisis. The analysis shows that integrating innovative technologies, to propose a remote management framework could be the best solution to support remote monitoring of worksites, help organizations track progress remotely, enhance social distancing, support the progress on the sites, avoid project delays while maintain worker safety.

KEYWORDS: Remote management, Construction Engineering Projects, Social distancing, Innovative technologies, Augmented reality.

1. INTRODUCTION

Covid-19 is having a massive effect on construction projects, which are being under the challenge of slowing them down, so now various stakeholders are looking towards comprehensive recovery [1]. The objective of this paper is to overcome the challenges through deciding the proper technology that supports remote management and social distancing on worksites, then comparing between different technologies.

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2. IMPACT OF THE CRISIS ON THE CONSTRUCTION INDUSTRY

Covid-19 pandemic and its impact on business sectors and financial action is introducing a scope of challenges to construction projects. Some construction projects have been postponed, and some canceled, because of the effects of Covid-19 on organizations and governments [2]. Price Waterhouse Coopers Company, conducted a statistical survey to quantify the five top risks concerning Covid-19 [3], and the outcomes are shown in Fig. 1.

Fig. 1. Top risks concerning the effect of Covid-19 on the construction industry [4].

Accordingly, different countries tried to deal with the risks of Covid-19 on the construction industry by issuing guidelines such as allowing projects to continue provided workers follow social distancing, and other Covid-19 protocols [5], also more guidelines concerning the United States are identified as illustrated in Fig. 2.

3. COVID-19 MITIGATION PLANS FROM THE PERCEPTION OF STAKEHOLDERS

Although many construction projects are being impacted by the pandemic, whether totally shutdown or disrupted [10], however stakeholders could reduce the previously illustrated impacts through considering mitigation plans for owners, contractors, companies and workers as shown in Fig. 3, then follow the procedure to achieve them, which is illustrated in the following sections.

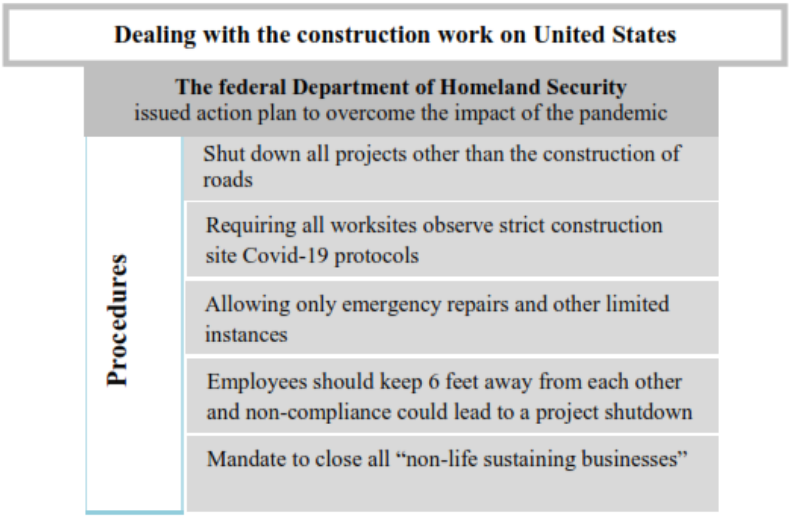

Fig. 2. The procedure of United States to overcome the impact of the Covid-19.

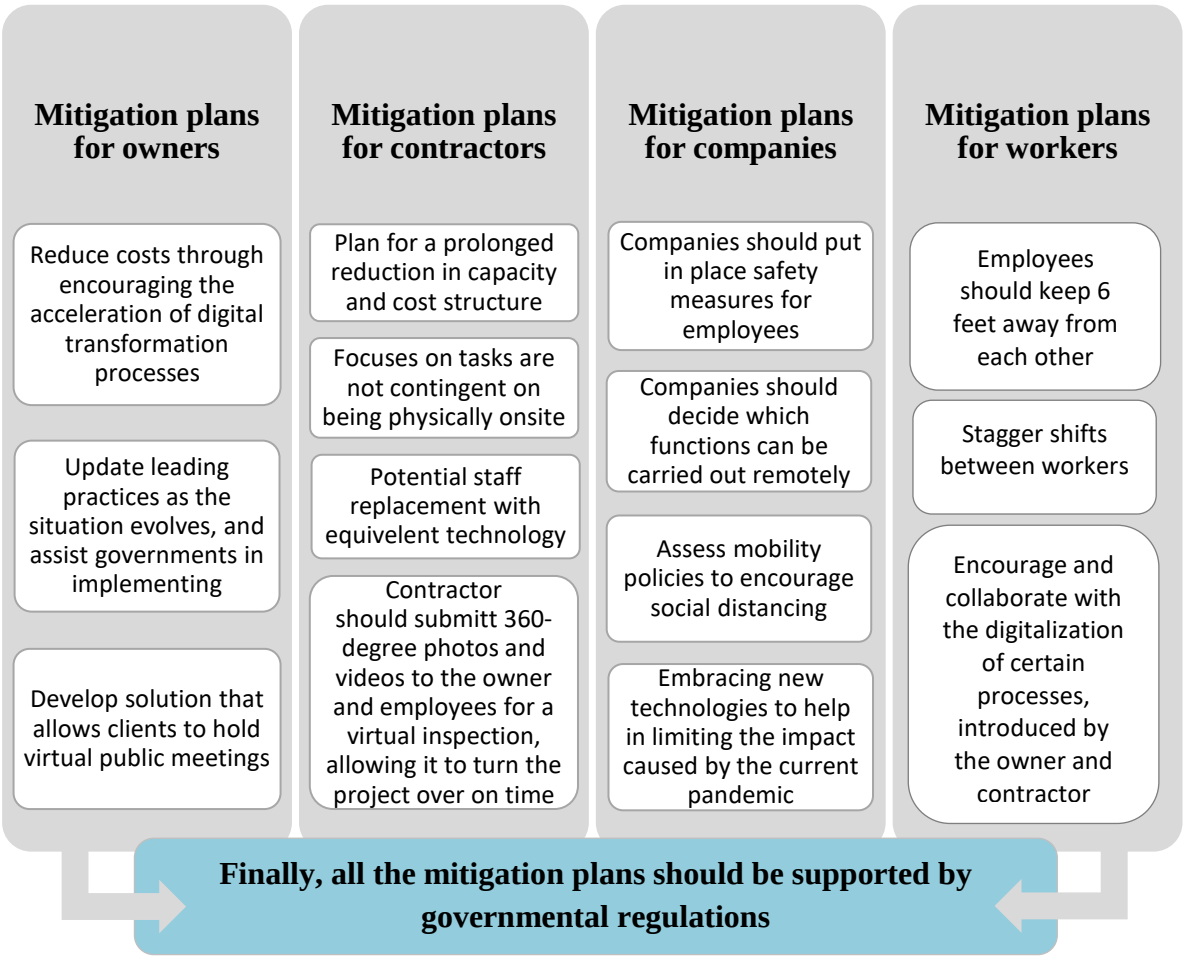

Fig. 3. Mitigation plans for stakeholders to overcome Covid-19 impact [10-12].

As identified from the illustrated mitigation plans, the procedure of overcoming the challenge depends on keeping construction projects running through remote work [13], relying on technology, as shown in Fig. 4. Although there are variety of technologies to choose from such as drone technology, augmented reality, virtual reality and building information modelling [14], however the selection criteria depends on choosing the technology that will achieve the mitigation plans aspects. More characteristics are illustrated in details through the study to explain how social distancing and remote management are achieved, the following technologies are selected based on the characteristics needed to achieve the previously mentioned mitigation plans and other selection criteria related to construction industry.

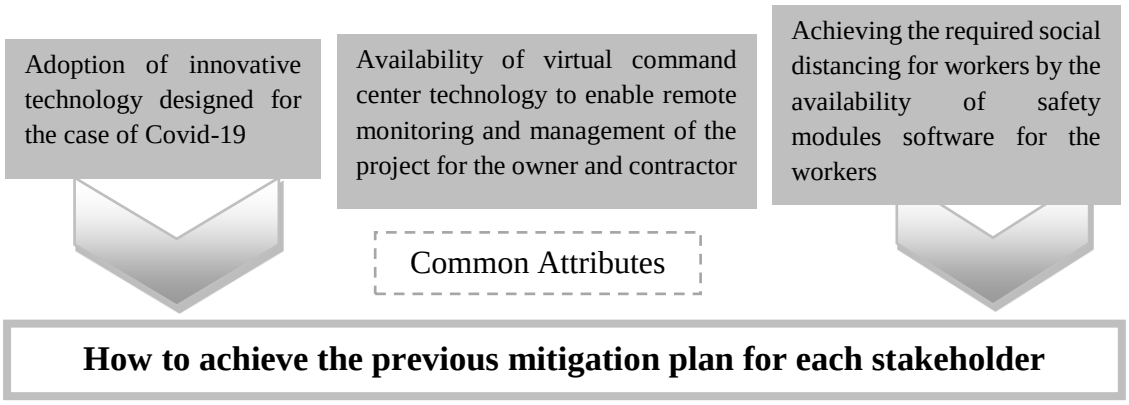

Fig. 4. Identifying the characteristics of solutions needed to overcome the pandemic.

4. TECHNOLOGIES SUPPORTING REMOTE MANAGEMENT

After identifying the role and importance of technology in achieving the proposed mitigation plans and overcoming the challenges of the pandemic, three of the most innovative solutions, which are specifically developed for supporting remote management and social distancing in construction and engineering projects and the selection criteria are illustrated as shown in Fig. 5.

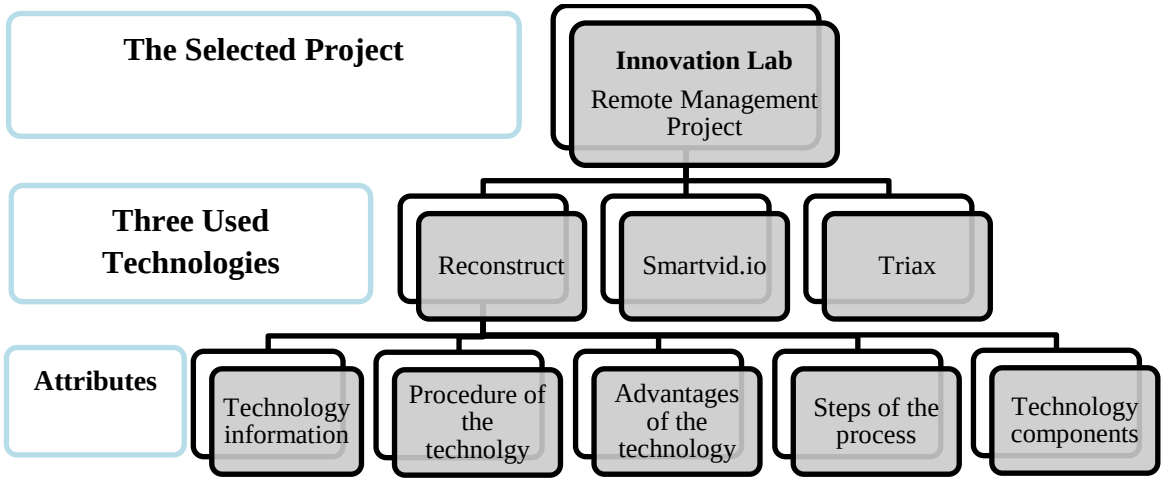

Fig. 5. Evaluation factors for illustrated technologies.

4.1 The Selected Project Information

The Industries Innovation Lab is a simulated worksite demonstrating the transformative power of the internet of things, drones, autonomous equipment, artificial intelligence, and other developing technologies, as shown in Fig. 6 [15]. Technologies such as Reconstruct, Smartvid.io and Triax are driving rapid change across the project and asset lifecycle, therefore innovation lab helps organizations experiment each technology, learn, and stay on the leading edge. The industries innovation lab- key use cases:

- Worker safety/location
- Remote Progress reporting with autonomous devices
- Virtual command center to reduce workers on site and to provide transparent views for remote monitoring to the stakeholders.
- Augmented reality-supported activities to enable different stakeholders to monitor the onsite work remotely

The project has two phases and the first one was successful, but after phase two the project like many other construction projects faced new complexities from Covid-19 pandemic [16], therefore their project team needed to explore new ways to work while keeping job sites safe and maintain the social distancing, so they corporate with other partners to find out how their solutions could work together to help the

construction industry deploy social distance technologies to respond to this new challenges.

Fig. 6. Industries innovation lab –phase two construction after Covid-19 [16].

The project attribute is fixed for the three technologies and the reasons for focusing only on innovation lab project from Oracle Company are:

- Oracle is one of the mega international companies which were chosen to apply on its project a comparative observation, since oracle had passed by all stages of innovative technologies experience [17].
- Oracle applied the same technology in the same project which is the innovation lab before and after the pandemic [17], so it will be the best scenario to compare between the normal and the new normal in the construction industry.
- In order to explore the importance of remote management technologies with different parameters through fixing the company/project parameter and measure the different aspects which vary and could affect the process.

4.2 Criteria of the Technologies Selection Approach

The three used technologies have mitigation plans, remote management procedures for the construction projects after the Covid-19 pandemic and safety modules for the workers, and the selection of each technology is based on:

- It should be innovative technology designed and applied specifically for the case of Covid-19.
- Implemented in a recent project; to explore the latest state of practical technology implementation and the efficiency of the technology.

- Applied through international firm that executes mega projects worldwide to make a successful comparison.
- The software must have a virtual command center.
- The software must navigate these challenges.
- The software must support social distancing and remote management
- Availability of safety modules for the workers.

4.3 Technologies' Attributes

Attributes of the three technologies are fixed in order to facilitate the comparative analysis and to explore the importance of remote management technologies with measuring each technology aspects, and the following are the three technologies that could help to navigate the previously mentioned challenges: Reconstruct, Smartvid, and Triax.

4.4 Reconstruct Technology

The first technology is Reconstruct, which is a software solution supports remote visual monitoring for construction sites by bringing three different types of data (images and videos - drawings and models - the schedule data) that have always been working separately and traditionally to be in one software, as shown in Fig. 7 [18].

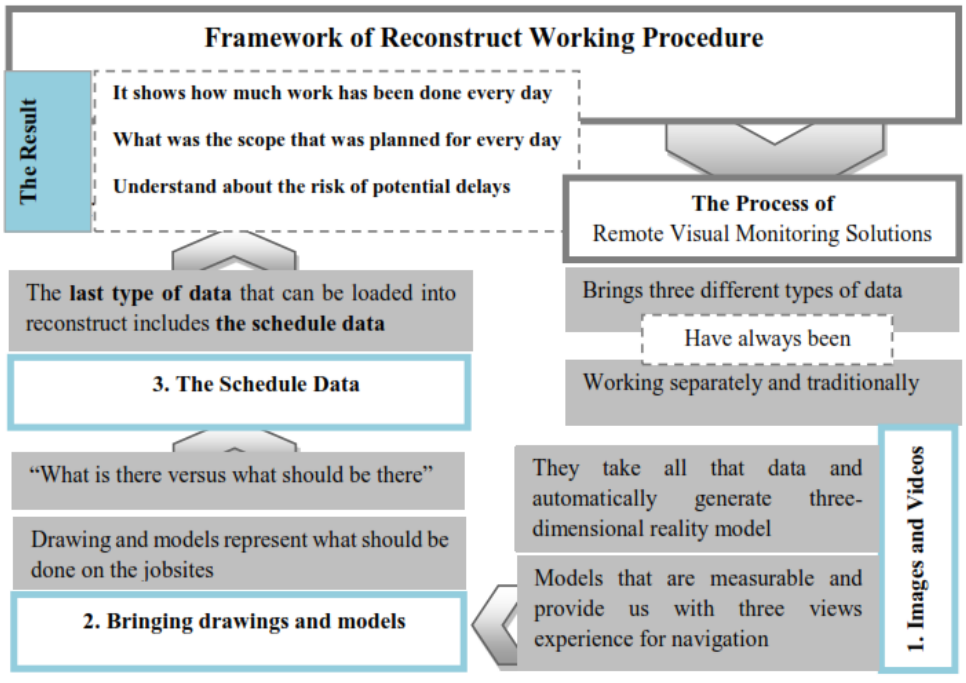

Fig. 7. Framework for Reconstruct working procedure [18].

According to the framework, the uses of Reconstruct can interact with different modality through using the web App to show the data, as shown in Fig. 8.

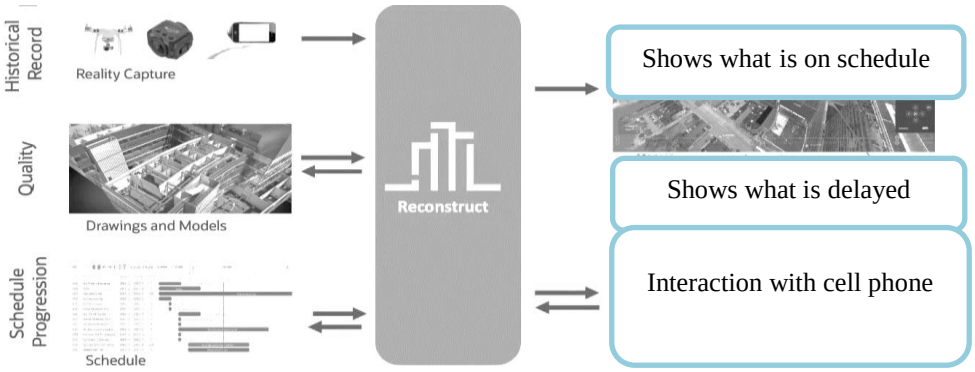

Fig. 8. Reconstruct process, remote monitoring solution [18].

4.4.1 Procedure of Reconstruct

The system works based on the images and videos uploaded into the system, as Reconstruct has an engine that automatically maps what exactly happens on the jobsite into two dimensions and maps the sites into three dimensions , which enables different stakeholders to see the progress of the reality job site and remotely manage the quality, schedule and drawings of any construction project and as a result, it reduces the physical existence of the stakeholders and supports the safety measures for Covid-19 [18]. The program can walk the users through three different workflows that Reconstruct could support, as shown in Fig. 9.

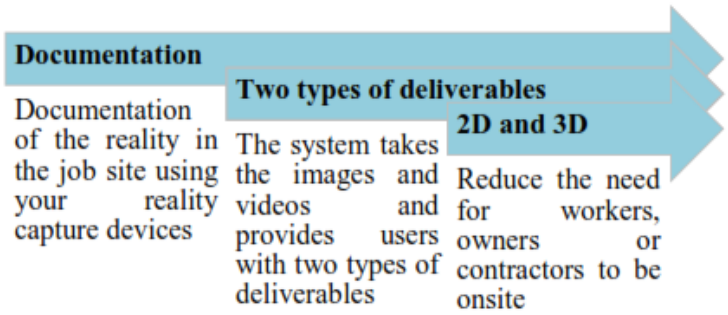

Fig. 9. Procedure of Reconstruct, different workflows.

4.4.2 Advantages of Reconstruct

The system works based on the images and videos uploaded into the system, as Reconstruct has an engine that automatically maps what exactly happens on the jobsite into two dimensions and maps the sites into three dimensions to support remote management aspect. Within two dimensional systems, it will be applicable to contrast reality against the design without being physically on site [19], more advantages will be illustrated in Table 1.

Table 1. Advantages of Reconstruct in supporting remote management [19].

	Advantages of the system	Benefits to the indoor	Benefits to the outdoor
Characteristics	Availability of time travel. Allows the user to measure areas and volumes.	No manual pinning of images. It generates the point cloud.	Automatically get the same 2D, 3D reality model.
	User can go from one room to another remotely to know what is happening on the site.	It offers a street view experience, showing a cross section of the same level.	Drone capture allows the time travel to study progress,saftey, quality without being on jobsite.
	The team control the job site by navigating the site using a web-based system.	The navigation map shows what is exactly happening on the site.	The solution provides historical record of the project.

4.4.3 Steps of the process

There are different modalities of data that could be brought to Reconstruct: The user can use his 360 camera and naturally video tape the site then, then the video is uploaded to the system, to be able to automatically generate a 3d model of the reality of the job site to support remote management [19], then the second thing the system do once the user access to these videos, is to automatically generate the plan, so there is no need to manually locate any thing. Then it transforms into point cloud and in this point cloud there are algorithms that produce indoor orthophotos, to allow the user to upload the 3D drawings and the design information to the system, as shown in Fig. 10.

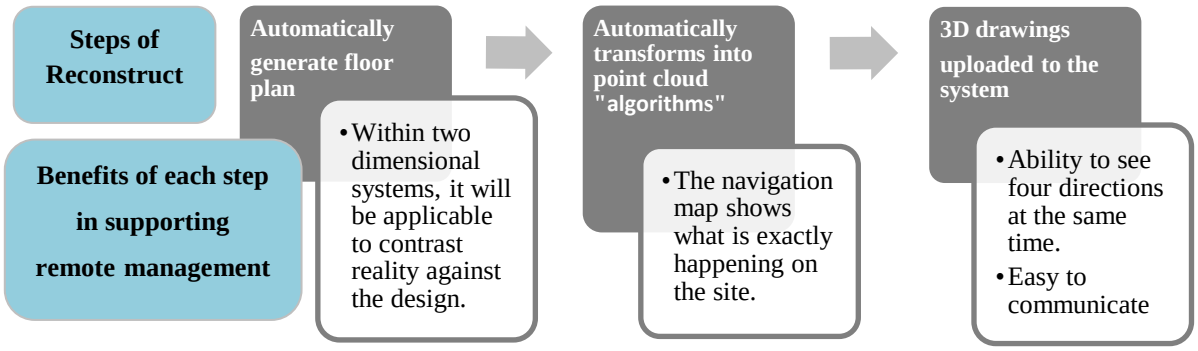

Fig. 10. Analysis and benefits of each step in the construction projects.

4.4.4 Technology components

The first component is Building Information Modeling "BIM" support and Augmented Reality, where most of the work flow supports visual documentation, and it also bring 2D and 3D information so the user can contrast the construction work from the perspective of "what is done versus what should be done". The second component is the Visual Command Center, which illustrate the design versus reality/in the context of primavera schedule and look-ahead plans [19], as illustrated in detail in Fig. 11.

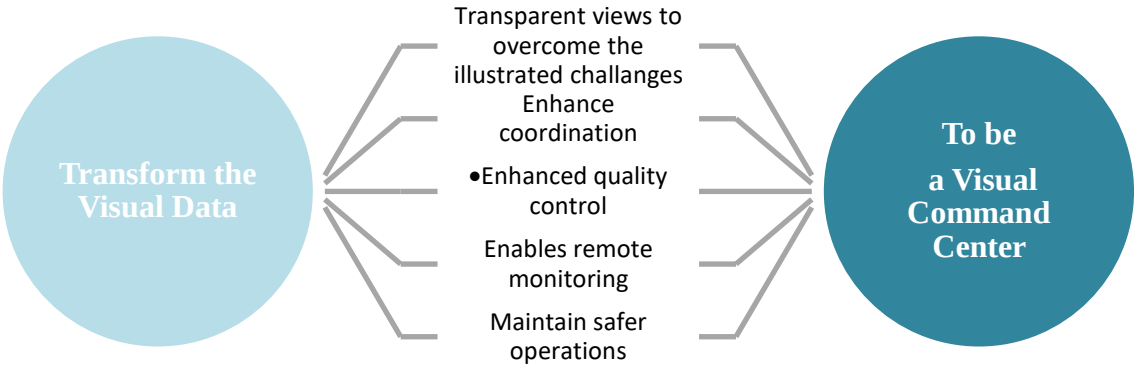

Fig. 11. The role of Reconstruct in providing a visual command center for the user.

So now every day on the calendar the user can actually see what is the work that needs to be done without being on the site to maintain safety aspects and at the same time continue the work on the site without any delays, and overlay it into the reality so Reconstruct enables the user to see what is there based on the reality and what should be there based on the schedule.

To summarize the first technology, the role of Reconstruct in construction is illustrated as follow:

- Enables remote monitoring through using the visual command center
- Enhance the coordination process through the transparent views to contrast the design and progress versus reality
- Integration with Primavera schedule to allow progress tracking
- Higher stability of resource planning and logistics through the outdoor process
- Payment applications to help contractors through Covid-19 pandemic
- Safer operations through reducing the physical existence of workers

4.5 Smartvid.io Technology

The next analyzed technology is involving Smartvid.io with Oracle industry innovation lab project, Smartvid is an innovative software solution to support the construction and reduce the risks facing the industry through the pandemic by offering social distancing matrix, remote documentation as well other safety activities, also for the help of producing automatic Covid-19 mitigation plans and reinforce the right kind of behavior on site by using artificial intelligence [20].

4.5.1 Procedure of Smartvid.io

It provides software pulling data such as photo and video from any sources that would be on the job site [20], with 100% focused on the construction industry, as shown in Fig. 12.

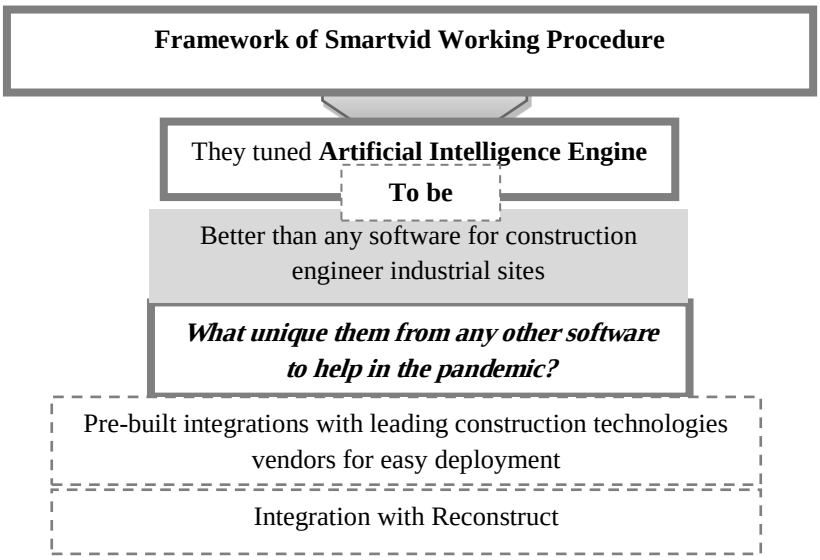

Fig. 12. Working procedure of Smartvid [20].

4.5.2 Advantages of the technology

Smartvid is working like Automated Covid-19 Mitigation Manager, as it identifies positive cases to create an automatic Covid-19 plan, furthermore it is looking at each image and identifies specific indicators of risks; such as detecting and reporting workers within 6 feet of one another to maintain social distancing, as shown in Fig. 13. Smartvid could be integrated with other technologies as it is not only detecting and reporting other software, but also enables them to mitigate each risk in the construction field. It allows safety management and the project team to see how this project is doing remotely [20].

Fig. 13. Smartvid detects workers within 6 feet of one another [20].

4.5.3 Smartvid.io components

The first component is “Safety Monitoring” which is the artificial intelligence analytics including the analytics for social distancing, then the **“**Safety Observation” gathered data from field including Covid-19 inspections to observe the positive and negative cases, and support Covid-19 mitigation program. Finally, the **“**Predictive Analytics” takes the input of safety monitoring and safety observation data and combine it with other project data to create prediction about where the risks will be [20].

4.5.4 Steps of the process

The first step in Smartvid process is the safety detections process through artificial intelligence engine, then it gathers the data and gives analysis reports, which produced through automatic integration with other technologies, as it has a pre-built integration platform, as shown in Fig. 14. Finally, like Reconstruct has done with Oracle

innovation lab the information, the data, and the photos start flowing and refreshed automatically.

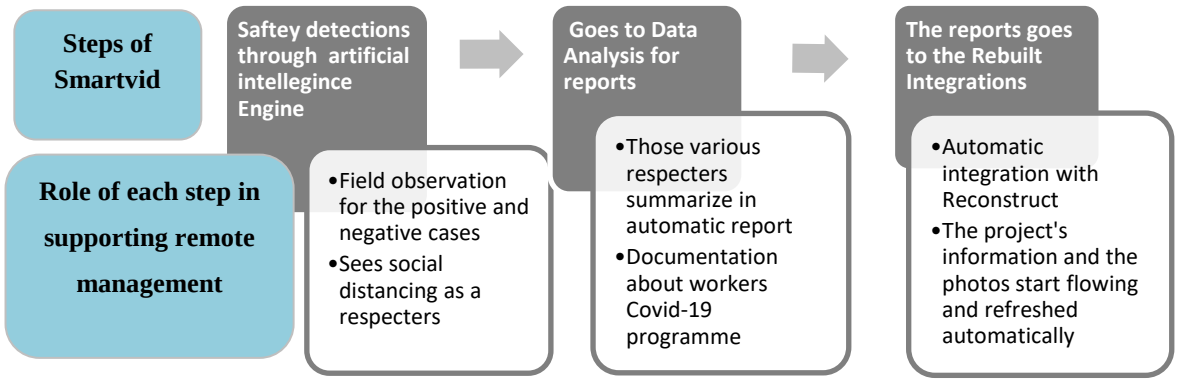

Fig. 14. Analysis of the steps and the role of each step in the construction projects.

So, their mission is to reduce risk in the construction industry by using artificial intelligence to improve safety, quality, productivity and safety, also to detect Covid-19 related safety matrix like social distancing, the use of gloves and even some new capabilities like weather, face covering and masks.

To summarize the second technology, the role of Smartvid in construction is illustrated as follow:

- The use of Smartvid enables remote monitoring, as it supports the automatic set of data that comes from the field without field personal needing to do anything, for example it can be tied to site cameras
- Enhance the coordination process through comparing the imagery and the project data that have been gathered with construction to artificial intelligence
- Integration with each technology field to help identifying and mitigate risks on by sending reports to each stakeholder then take the suitable mitigation action.
- Help contractors through Covid-19 by allowing them to keep an eye on the results in real time
- Supports safety program through observing the positive and negative cases
- Supports social distancing through tagging people within 6 feet of one another, groups of 10 or more workers or who are practicing proper social distancing

4.6 Triax Technology

Triax technology provides the way to maintain safe working distances in the time of Covid-19, social distancing with proximity contact tracing is the process of identifying who an individual, with a confirmed case of Covid-19, came in contact with over a period of time [21].

4.6.1 Procedure of Triax

The way Triax trace work is by giving each worker their own center which they call “a trace tag”, then it gives alerts if two workers work within 6 feet distance to each other, then all of this information of the trace tag is uploaded to the cloud to be available on the contact trace supporting [21]. If someone tested to be positive for Covid-19 or the user wants to have exposure for any of the historical information about any workers, all of this is available in the “Contact Trace Report”.

4.6.2 Advantages of Triax

This system keeps workers and operations to move safely through, providing a proactive system to support and condition workers to comply with social distancing and limiting the number of subject 1st but also be able to identify them automatically when necessary, besides helping businesses get back to normal operations with an easy to implement, user-friendly solution.

4.6.3 Steps of the process

In designing Triax platform they focus on two needs for two separate applications for the clients and the market in construction, as shown in Fig. 15.

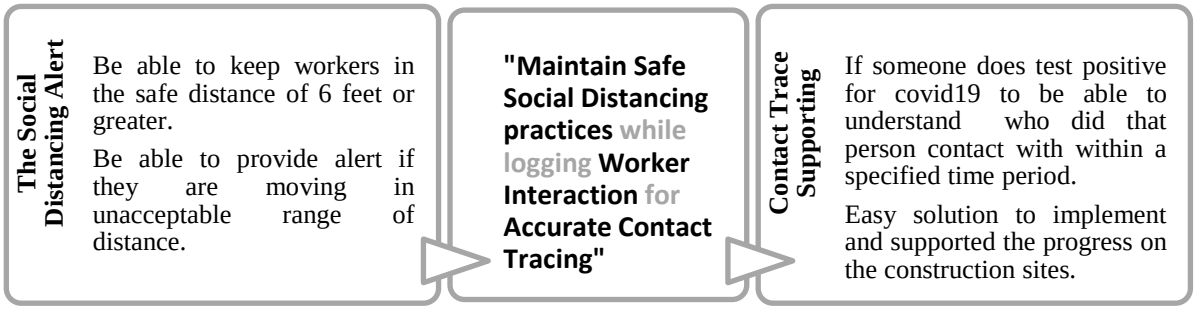

Fig. 15. Two needs for two separate applications of Triax platform.

To summarize the third technology, the role of Triax in construction is illustrated as follow:

- Provide a proactive system to support workers to comply with social distancing
- Limit the number of subject 1st but also be able to identify them automatically
- Passively collect worker interactions and duration to automate and digitize contact tracing efforts
- Provide the information needed to guide Covid-19 protocols at essential facilities
- Help businesses get back to normal operations with an easy-to-implement, user-friendly solution
- A solution that supports measures to limit the spread of infection

After studying the three technologies, a comparative analysis is illustrated in Table 2, in order to identify how to achieve each mitigation plan attributes through the use of the three technologies, then develop a remote management framework from all of the previously analyzed data to enhance the construction process and support social distancing through the pandemic.

Table 2. Comparison between the technologies to identify its importance.

	Reconstruct	Smartvid Technology	TRIAX Technology
Remote monitoring	Enables remote monitoring through using the visual command center	Through the automatic data that comes from the field without field personal needing to do anything	
Coordination	Enhance the coordination process through transparent views to contrast the design versus reality	Through comparing the imagery and the project data to artificial intelligence	Passively collect worker interactions and duration to automate and digitize contact tracing efforts
Resource Planning and Logistics	Higher stability of resource planning and logistics through the outdoor process	Stability of resource planning and logistics through artificial intelligence	
Integration with other technologies	Integration with Primavera schedule to allow progress tracking	Integration with each technology field to mitigate risks by sending reports to each stakeholder to take action	

Table 2. Comparison between the technologies to identify its importance, (Cont.).

Stakeholders	Payment applications to help contractors and owners through the pandemic	Help contractors by allowing them to keep an eye on the results in real time	Provide the data needed to guide Covid-19 protocols for different stakeholder
Operation Safety	Safer operations through reducing the physical existence of workers	Supports safety program through observing the positive and negative cases	Limit the number of subject 1st but also be able to identify them automatically
Social distancing		Tagging groups of 10 or more workers or who are practicing proper social distancing	Provide a system to support and condition workers to comply with social distancing

Based on the previous analysis, the study finds that integrating Reconstruct, Smartvid.io with Triax solution help in supporting remote monitoring of worksites, helping organizations to track progress while limiting onsite activities by workers during the pandemic, this could be achieved through combining them to work as a closed loop, as each technology has a certain complementary role to each other, as shown in Fig. 16.

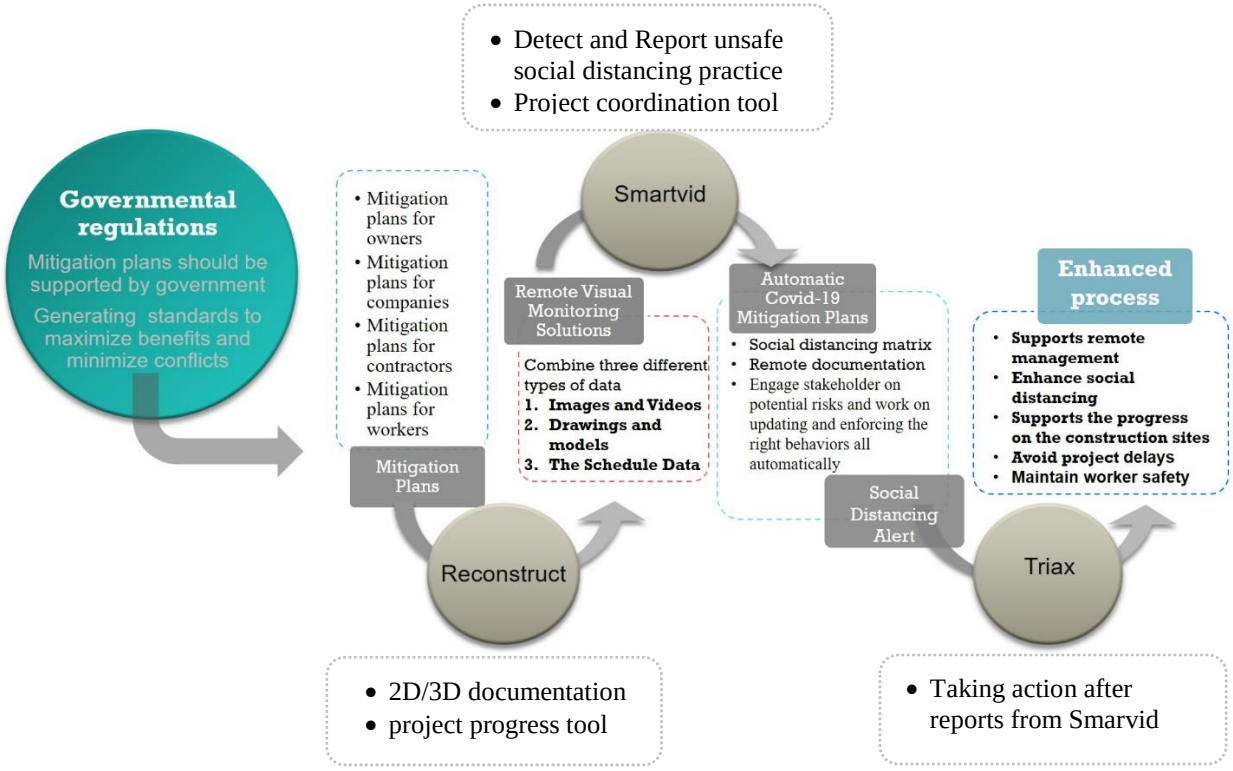

Fig. 16. Remote management framework to enhance the construction during Covid-19.

5. CONCLUSIONS

This paper investigates the role of three technologies, which are Recostruct, Smartvid.io, and Traix in supporting remote management in construction projects to achieve efficient management and overcome the challenges during this crisis. The paper was divided into two sections: The first section is a theoretical approach to study the impact of Covid-19 on the construction and how to mitigate the challenges through different mitigation plans. The second section is an analytical part to study how to achieve the mitigation plans and support remote monitoring through selecting innovative technologies designed specifically for the case of Covid-19. Based on the considerations presented herein, the research paper concludes that:

1- Integration of the three technologies is a solution to enhance the construction process through Covid-19, support remote monitoring, while limiting onsite activities by workers to enable "social distancing" protocols on worksites.

2- The integration process works as inputs and outputs, each technology input is the output for the following technology.

3- Reconstruct works as "Remote Monitoring Solution" having all the images, videos, 2D drawings 3D models and the schedules to contrast design against reality and to update the drawing/models automatically and remotely.

4- Then all the updated data goes to Smartvid, which works as "Automatic Covid-19 Mitigation Plans" to mitigate any risks in the construction site to detect, report unsafe practices, and enhance remote documentation.

5- Then the integrated data goes to Triax, to take actions in each detected practice through a system that support workers to comply with social distancing

6- Achieving the integration between the three technologies could be the best solution to support remote management, enhance social distancing, support the progress on the construction sites, avoid project delays and maintain worker safety.

DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interests.

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التباعد الاجتماعي في مجال البناء: فحص دور التقنيات الجديدة في دعم الإدارة عن بُعد

نظرا للأزمة الصحية العالمية الحالية (أزمة فيروس كورونا) التي أثرت علي أداء العمل في مشاريع البناء، وأحدثت تباطؤاً في المشاريع الإنشائية والمعمارية، فقد توقفت العديد من المشاريع. ومن ثم، يبحث أصحاب المشاريع عن طرق جديدة لتمكين التقدم فى مواصلة المشاريع الهامة مع الحرص على حماية العمال والناس بعامة. وهذه الدراسة تبحث في إمكانيات تطبيق الإدارة عن بُعد فى مجال التشييد والبناء، بالإضافة إلى أنها تحاول تحليل الطريقة التي يمكن أن تساعد بها التكنولوجيا في تمكين بروتوكولات "التباعد الاجتماعي" في مواقع العمل، وذلك بأن تقوم الدراسة بتقييم أنسب التقنيات لتنفيذ المشاريع من أجل تحقيق إدارة فعالة والتغلب على التحديات التي قد تواجه المشاريع الإنشائية والمعمارية خلال هذه الأزمة. اعتمدت الورقة على مراجعة شاملة للأبحاث السابقه التي قامت بدراسة تحديات فيروس كورونا في مجال صناعة البناء وخطط التخفيف للتغلب عليها. ومن ناحية أخرى، فقد تم إجراء مقابلة مطوَّلة مع خبير في هذا المجال لتقديم التقنيات الحديثة، بهدف اختيار أنسب التقنيات للدمج مع حلول إدارة المشروعات ولدعم المراقبة عن بُعد لمواقع العمل، مما يساعد المؤسسات على تتبع التقدم في المشاريع مع الحد من الأنشطة التي يقوم بها العمال في الموقع.