Pre-planning Coordination for Co-located Infrastructure Projects in Saudi Arabia

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Abstract. Infrastructure projects are essential for the prosperity of all societies. In many cases, infrastructure assets of different types, both above ground and underground, share the same corridor such as the right of way for roads. Typically, these infrastructure assets are owned and managed by different public and private entities. Failure, delay, or increase in the cost of these projects is clearly reflected with negative impact on society and the economy. Sources of these project deficiencies include poor planning, poor coordination, and weak communication between the concerned entities regarding their ongoing and future plans for their infrastructure assets in a specific corridor. The problem of poor coordination leads to the stumbling of many projects leading to project suspension, cancellation, restudy, and/or redesign. This paper focuses on the pre-planning coordination among the owners of co-located infrastructure assets in Saudi Arabia. Two aspects of the problem are the lack of coordination regarding future projects between parties that has the same interest in a given location and the lack of coordination between those parties regarding existing assets. The objectives of this paper include assessing the current practice in pre-coordination for co-located infrastructure assets and providing recommendations that contribute to improving the coordination among infrastructure owners in their planning process for their infrastructure assets. These objectives are achieved using surveys of owners and contractors of infrastructure projects to validate the identified effects of the poor communication during pre-planning stages and to identify the factors contributing to this problem. In addition, the study involves reviewing case studies in Saudi Arabia, case studies of global success stories, and interviewing experts to identify which lessons are considered fit to Saudi Arabia. The outcome of this research is to provide recommendations/solutions that may contribute to solving the mentioned problems. The importance and the effectiveness of these solutions are discussed to assist decision makers in selecting the best approach to tackle the current issue and maintain the sustainability in the current practices.

1. Introduction
Saudi Arabia is witnessing a huge growth through implementing many development projects in different uses to support its three pillars of 2030 vision: a vibrant society, a thriving economy and an ambitious nation. One of the major challenges towards this transformation is infrastructure development. Infrastructure utility systems are known to be the backbone of cities as it provides energy, potable water, communication, wastewater and storm water management. Saudi Arabia has acknowledged this challenge in many documents and summits related to its future. For instance, in the quality-of-life program [1] (one of the 12 Vision Realization Programs for Vision 2030) 41 out of the 220 initiative were related to infrastructure and transportation. Moreover, Saudi Arabia is committed to achieve its sustainable development goals on several summits and reports such as “Towards Saudi Arabia’s Sustainable Tomorrow” [2] and “Saudi Cities Report 2019” [3]. It also stated that the demand is expected to rise exponentially, therefore, the planning of the infrastructure systems needs to be more optimized and efficient.
The lack of addressing the problem of poor coordination leads to the stumbling of many projects resulting in project suspension then restudy and redesign. Consequently, this results in waste of recourses, decrease in the level of service of roads, increase in the time of disruptions felt by the residents, decreasing the quality of the infrastructure, and ultimately affecting the sustainability and the city’s quality of life. This paper focuses on the pre-planning coordination among the owners of co-located infrastructure assets in Saudi Arabia. Two aspects of the problem are (i) The lack of coordination regarding future projects between parties that has the same interest in a given location and (ii) the lack of coordination between those parties regarding existing assets.

The lack of coordination regarding future and/or ongoing projects results in more frequent disruptions to the corridor by different utility authorities. In addition, it causes delays and redesign of ongoing projects that share the same location due to the lack of coordination between the projects’ entities during the planning and design stages. In other words, in many cases, this co-location of ongoing projects is not discovered until the construction activities begin. These problems result in cost overruns, waste of resources and decreased quality of life for road users/residents due to noise exposure and decreased mobility and level of service. The lack of coordination between those parties regarding existing assets is a primary problem facing contractors when they are planning the execution of roadworks for maintenance or a new installation is the limited information regarding the existing underground assets which leads to delays and contract total cost overrun, similarly, in many times this problem results in a dispute between the contractor and the owner of that project. In addition, this limited information affects the planning of future projects for any other party. Often, the source of this issue is the lack of as-built drawings from previous works, or the existing as-built drawings are poor and doesn’t illustrate the actual existing underground services and its coordinates.

Usually, the government is the sole owner of public corridors, however, the parties that has an interest in these corridors are far more complex than anticipated. For instance, the parties/agencies that may have the interest of a given corridor in Riyadh city can be as high as 15 agencies (authorities and municipalities, electricity company, water company, telecommunication companies, etc.) Each of these parties/agencies can be described as an owner of one of the underground services, and has its needs and plans regarding installing, maintenance and upgrading those services. Making the situation worse, many of these parties has the mandate to execute their works without referring to the city’s municipality or overstep their mandate and execute without referring to the city’s municipality. Moreover, currently, each one of these parties has its own future plan and knows nothing about the other parties’ plans.

1.1 Local efforts on infrastructure pre-planning coordination.

1.1.1 Royal Commission for Riyadh City. RCRC had some of contributions in facilitating planning-stage communication between different entities in the city for specific sections of main corridors. For example, the RCRC has required all infrastructure authorities to communicate their future plans that lays within the right of way of the Riyadh Metro Project. This information was then considered in planning and designing the components of the metro project to minimize future disruptions the metro corridor. In addition, RCRC issued a masterplan for Riyadh city called “Medstar” which covers many aspects for future development of the city and forecasted the growth of Riyadh. one of the covered aspects was a full report of future plans of the city’s infrastructure. However, this plan is considered outdated since its last update was in 2013, and that update forecasted the population of Riyadh city to be 7 million in 2030. The city reached that number already as it has a population of 7.6 million in 2021. The latest contribution from RCRC was in 2011 when it started the Infrastructure Coordination Plan (ICP) which aims to have a committee from each agency/party responsible for the infrastructure development in the city. However, the ICP has faced some challenges in 2017 due to the limited authority of RCRC to get involved with the other parties’ work and budgets. Nevertheless, a recent high decision was issued that obligates every other agency/party to refer to RCRC for their new projects in the city. The decision also allows RCRC to transfer the authorization from one agency/party to another if it is needed, with the
approval of RCRC board of directors. RCRC has started developing an initial strategy reflecting this decision.

1.1.2 Future Projects Forum (FPF). In 2019, the Saudi Contractors Authority has launched the Future Projects Forum [4] which is a platform held annually for project owners to present their projects and increase the number of contractors applying for their tenders. Also, as more than 37 owners (including governmental and private sectors) were participating in the forum, it was a chance for project owners to review their work and enhance the principle of transparency which supports the high-level coordination between these parties. However, this initiative is directed to only major future projects and does not cover the majority of underground utility projects.

1.2 Summary of obstacles related to infrastructure pre-planning coordination
Throughout the case studies (e.g. Greater London Authority business case [5]) and conducted interviews with local experts, These obstacles can be categorized as: Governance, knowledge accessibility, interest/motives, and competence as shown in Figure 1.

Governance obstacles include problems in the current mandate for some major parties. In many cases, the mandate/authorization of the entity often allow them to plan and execute these infrastructure works without referring to a central agency. In addition, the lack of strict control is also a governance-related issue as some parties doesn’t have the mandate, but they proceed to plan and execute anyway. In regard to knowledge accessibility, each party/agency has their own isolated plans and can’t access the plans of other parties as there is a lack of an active common hub or agency that gathers all the plans and make it possible for these parties to access. Interest or motive is a major obstacle in this subject, each party has their own priorities as well as their timelines, and they have no reason to collaborate with any other party and disturb their own goals, there’s no reward nor penalties for doing so, and that could also be a result of the current governance framework. Other possible source of obstacles is the lack of competence for both the technical and managerial aspects, this result in inaccurate as-built drawings and even the loss of as-built drawings. It also results in ineffective coordination and knowledge exchanging practices.

1.3 Summary of the proposed strategies/solutions
From the reviewed case studies (Mapping the underworld [5], fees implementation [6] and open data hub [7]) in addition to the interviews conducted with local experts, several solutions can be categorized under the same obstacles' categorization (Governance, knowledge accessibility, interest/motives, and competence). Governance related obstacles can be tackled by updating the mandate of major parties to require the approval of municipality or any central agency for their works. Also, an action should be taken for enhancing the control of parties that overstep their mandate and execute without referring to the municipality. On the lack of knowledge accessibility aspect, establishing a digital portal for new infrastructure projects permits can solve this obstacle. In addition, it may be feasible for the long term
to scan and map the existing underground utilities using the suitable technologies. One way to tackle the lack of interest and motive, along with the governance solutions, is implementing fees per square meter for utility projects, these fees will reflect the pavement degradation and surface restoration costs. After that, these parties may have more interest to coordinate with the others to share these fees. Finally, one major obstacle is the lack of competence, and to be precise, it is in handling the as-built drawings, the solution is to provide more monitoring and control over the process of creating, handover and archiving these drawings.

In summary, the proposed strategies/solutions are as following:

S1. Updating the mandate (or authority) of major utility owners to require the approval of municipality for planning and executing their works.
S2. Enhancing the control of parties that overstep their mandate and execute their utility works without referring to the municipality.
S3. Enhancing the monitoring and control of as-built drawings process (preparation, submission and archiving).
S4. Establishing a governmental program for scanning and mapping the existing underground utilities using several technologies.
S5. Establishing a digital portal for sharing proposed infrastructure projects (e.g., in the form of issuing planning permits) that shows any common plans (between different owners) for a given location.
S6. Implementing fees for utility projects to reflect the effect of project on pavement degradation and surface restoration costs.

These strategies are sorted to four groups as shown in Figure 3: Governance, Knowledge Accessibility, Interest/Motives and Competence.

| Governance       | Knowledge Accessibility | Interest/Motives | Competence                  |
|------------------|-------------------------|------------------|-----------------------------|
| • Updating mandate  | • Digital portal         | • Implementing fees | • As-built control enhancement |
| • Control enhancement  | • Underground mapping     |                   |                             |

Figure 2: The proposed strategies sorted in groups

2. Methodology

The main objectives of this study are to prioritize the major obstacles related to the pre-planning coordination among the owners of co-located infrastructure assets in Saudi Arabia and to assess the importance and effectiveness of different potential strategies that might help tackling these issues and enhance pre-planning coordination process.

To achieve the research objectives, a list of potential obstacles of pre-planning coordination are identified based on interviews with experts of infrastructure projects, reviewing the related literature and global best practices. Initial lists of issues in the current practice and potential strategies to address them were prepared by reviewing prior studies and reports related to the issue of project coordination for collocated infrastructure assets (discussed in the previous section). The two lists of issues and potential strategies were further refined and confirmed based on interviews with four subject matter experts, each with a minimum of 10 years of experience in the field. Interview approach was selected to explore the different views of experts working in the field and to have more information to understand the current practice through identifying the obstacles and the proposed strategies. To validate and assess the identified obstacles, and to evaluate the proposed strategies, a survey was designed and deployed among construction practitioners working on the field of infrastructure projects. The survey method was
selected as it can provide more accurate results since it collects the views of many experts related to the subject with different backgrounds and goals. It also allows for more in-depth data interpretation which helps to understand the situation more. The process that explains the research methodology can be summarized in figure 4.

Since the targeted audience come from different backgrounds and occupations, they are expected to have different perception for both the obstacles and strategies. Thus, the questionnaire used a 5-point Likert scale ranging from “strongly agree” to “strongly disagree” to assess the participants’ opinion regarding the presented statements. Likert scale is one of the most used instruments in research where different perspectives are anticipated [9].

In order to classify and label the results, a weight range is calculated as shown in Table 1, each question has its weighted average Likert score (ranging from 1 to 5) and falls in its corresponding classification (e.g. a score of 4.30 is considered as “strongly agree”).

| Classification       | Scale | Weight Range       |
|----------------------|-------|--------------------|
| Strongly disagree    | 1     | 1.00 – 1.80        |
| Disagree             | 2     | 1.81 – 2.61        |
| Neutral              | 3     | 2.62 – 3.42        |
| Agree                | 4     | 3.43 – 4.23        |
| Strongly agree       | 5     | 4.24 – 5.00        |

Weight range interval calculation = (5-1)/5 = 0.8

The size of the targeted population for the survey was unknown. Therefore, in this research, estimating the minimum sample size was done using the formula of Cochran as follows (Cochran, 1963, p.75) [10]. Therefore, with a confidence level of 95% and a ±10% margin of error, a sample size of 96 has been calculated. The Survey distribution was performed through directly messaging the carefully selected audience of infrastructure workers in order to obtain the best possible inputs. The survey’s questionnaire consists of 4 parts. The first part incudes demographic questions which collects the name, job title, work location, years of experience, working field, role in project, and work sector. The second part includes general questions to validate the overall issue of the lack of coordination in pre-planning stage and to get a slight indication about the impact of the issue. The third part assesses the obstacles obtained from interviews and literature review. The fourth part aims to evaluate the proposed strategies that were also obtained from interviews and literature review.
The proposed strategies are sorted using the importance-effectiveness rate model to highlight the high-priority strategies that should be the focus of decision makers. The model was derived from the importance performance analysis (IPA) which was developed by Martilla and James (1977) [11] where they identified which attributes of a product or service an organization should focus on to enhance customer satisfaction. In this study, Importance measures how necessary it is to have the strategy in place, and effectiveness evaluates to what extent the strategy will solve the issue. Using both importance and effectiveness measures provides deeper evaluation of proposed strategies since some strategies may not be highly effective but still important for the success of other strategies (e.g., establishing standards and protocols). The model is divided into four quadrants depending on importance and effectiveness level (Figure 5). The axes that define the borders of quadrants are found through the mean of importance and effectiveness values. These axes divide the graph into the following quadrants: high importance-high effectiveness, low importance-high effectiveness, high importance-low effectiveness and low importance-low effectiveness.

![Importance-Effectiveness model](image)

**Figure 4: Importance-Effectiveness model**

3. Results and Analysis
The overall completion rate for the questionnaire was 82%, and all 97 completed responses were analysed. Survey was distributed between November and December 2021. 48% of respondents are working in Riyadh while the rest are distributed across the Kingdom (e.g., Dammam, Jeddah, and Tabuk). The survey participants had a wider range of experience in their field with more than 30% having an experience of 10 years or more. The participants had worked on different fields of infrastructure works with the majority (42%) have worked or currently working in transportation projects. Also, respondents have worked in infrastructure related works (water pipeline, wastewater, stormwater drainage, electrical and communication, etc.). In terms of the role of the respondents in these projects, the majority are working as representatives of owners in these infrastructure projects (with 46%), 24% are working as contractors, and 19% are consultants while the rest of respondents (11%) have chosen the “other” option. The majority of responses (66%) were obtained from participants working in public/governmental projects while 30% were working on projects in the private sector, and 4% of respondents are working on both public and private projects.

3.1 Overall Problem Assessment
The majority of respondents confirmed that there is a lack of coordination regarding future projects between parties that has the same interest in a given location. In addition, they agreed that there is a lack of coordination between those parties regarding existing assets (as shown in Table 2). This data confirms the main problem addressed in this research which proposes that there is poor performance in pre-planning coordination for co-located infrastructure projects in Saudi Arabia.
Table 2: General Questions related to the obstacles

| Question | Weighted Average score | Classification | Standard Deviation |
|----------|------------------------|----------------|-------------------|
| To what extent do you agree that there is a lack of coordination regarding future projects between parties that has the same interest in a given location. | 4.01 | Agree | 0.95 |
| To what extent do you agree that there is a lack of coordination between those parties regarding existing assets | 4.01 | Agree | 0.88 |

Also, the survey introduced an initial assessment of the impact of these obstacles on the overall project cost. The majority (31.25%) indicated that poor pre-planning and planning coordination results in cost overruns that are equivalent to more than 10% of project total cost while 25% assessed the impact to be around 6-10% of total cost, 11.5% estimated the cost overrun to be between 3% to 5%, and 9.4% of answers stated that its below 2% of project total cost, the rest of respondents (22.9%) had no specific estimation of the impact of this issue on the project cost performance. These results emphasise the importance of coordination during the pre-planning and planning stages of infrastructure projects and its direct impact on projects successful execution.

3.2 Evaluation of Obstacles

The survey proposed five obstacles which were obtained through the interviews with subject matter experts along with reviewing the literature and global practices. By amazing the average scores for obstacle, the respondents agreed with all obstacles except one obstacle that they were neutral on which is where parties are doing work without referring to a central hub. The most agreed-upon obstacle is “The lack of an active central hub or agency that gathers all the plans for future/proposed infrastructure projects and make it possible for other parties/owners to access (plans, timelines, as-built drawings, etc.).” which may indicate that it is the most critical obstacle to infrastructure pre-planning coordination.

Table 3 shows these obstacles ranked from the highest to lowest score with the weighted average and standard deviation.

Table 3: The obstacles ranked from most agreed to lowest agreed based on respondents’ assessment

| Rank | Obstacle | Weighted Average | Classification | Standard Deviation |
|------|----------|------------------|----------------|-------------------|
| 1    | The lack of an active central hub or agency that gathers all the plans for future/proposed infrastructure projects and make it possible for other parties/owners to access (plans, timelines, as-built drawings, etc.). | 4.15 | Agree | 0.95 |
| 2    | The lack of Interest or motive for these parties/owners to coordinate together. | 3.55 | Agree | 0.99 |
| 3    | The lack of strict control over parties that overstep their mandate (or authority) and execute their works without referring to the municipality. | 3.54 | Agree | 1.03 |
| 4    | The lack of competence in both the technical and managerial aspects. | 3.51 | Agree | 0.98 |
| 5    | The mandate (or authority) of some parties/agencies that allow them to plan and execute infrastructure utility works without referring to a central agency. | 3.36 | Neutral | 0.99 |

In general, there was no significant observations of the impact of the participants’ background on their responses. However, contractors and participants who were working in private projects showed less agreement with the obstacle “The mandate (or authority) of some parties/agencies that allow them to plan and execute infrastructure utility works without referring to a central agency”, the reason might
be that there is no active central agency to begin with, this also may reflect why the absence of an active central hub was the highest rated obstacle.

3.3 Evaluation of Proposed Strategies
The survey proposed six strategies/solutions obtained through the interviews with subject matter experts along with reviewing literature and global practices. The participants were asked to rate each strategy based on its importance and effectiveness with a 5-point Likert Scale. To find the best solutions using the IPA-Model, the average value of the weights of strategies for performance and importance are calculated. Then horizontal and vertical axes are drawn according to the average values of weights of performance and importance as shown in figure 6.

The IPA model shows that the high importance-high effectiveness quadrant includes the following strategies: enhancing the monitoring and control of as-built drawings process (S3), establishing a governmental program for scanning and mapping the existing underground utilities using several technologies (S4), establishing a digital portal for sharing proposed infrastructure projects that shows any common plans for a given location (S5), and enhancing the control of parties that overstep their mandate and execute their utility works without referring to the municipality (S2). Those strategies should be implemented and given priority to overcome the preplanning coordination issues. The high-importance-low effectiveness quadrant contains only one strategy which is Updating the mandate of major utility owners to require the approval of municipality for planning and executing their work (S1). This strategy needs to be improved before adoption with top priority. For the strategy of implementing fees for utility projects to reflect the effect of project on pavement degradation and surface restoration costs (S6), the model locates it in the low importance-low effectiveness quadrant indicating the recommendation of not adapting this strategy. After calculating the magnitude of each strategy, these strategies can be ranked from most important and effective to least in Table 4.
Table 4: proposed strategies rated based on magnitude

| Rank | Proposed strategy                                                                 | Importance Weighted Average | Effectiveness Weighted Average | Magnitude* |
|------|-----------------------------------------------------------------------------------|-----------------------------|-------------------------------|------------|
| 1    | Enhancing the monitoring and control of as-built drawings process (preparation, submission and archiving) (S3) | 4.53                        | 4.27                          | 6.22       |
| 2    | Establishing a governmental program for scanning and mapping the existing underground utilities using several technologies (S4) | 4.44                        | 4.25                          | 6.14       |
| 3    | Establishing a digital portal for sharing proposed infrastructure projects (e.g., in the form of issuing planning permits) that shows any common plans (between different owners) for a given location (S5) | 4.259                       | 4.20                          | 5.98       |
| 4    | Enhancing the control of parties that overstep their mandate and execute their utility works without referring to the municipality (S2) | 4.19                        | 4.05                          | 5.83       |
| 5    | Updating the mandate (or authority) of major utility owners to require the approval of municipality for planning and executing their works (S1) | 4.19                        | 3.93                          | 5.74       |
| 6    | Implementing fees for utility projects to reflect the effect of project on pavement degradation and surface restoration costs (S6) | 3.47                        | 3.37                          | 4.84       |

*\text{Magnitude} = \sqrt{\text{Importance}^2 + \text{Effectiveness}^2}*

4. Conclusions

This research focuses on the pre-planning coordination for co-located infrastructure projects in Saudi Arabia, the obstacles and the proposed enhancement strategies related to the pre-planning coordination process were obtained through reviewing global and local case studies, in addition to interviewing the local subject matter experts. The research highlighted the obstacles from most to least critical, and proposed enhancement strategies to solve these obstacles sorted according to its importance-effectiveness rating. This research was performed on a high-level management perspective for the infrastructure utility works, and it has validated the obstacles and assessed the proposed strategies found from local subject matter experts and global experience. However, this study has some limitations such as not evaluating the practicality and costs of the found strategies, which are going to be considered in future work.

Therefore, this research can be considered as a starting point towards enhancing the infrastructure pre-planning coordination in Saudi Arabia, which may lead to a more sustainable practices that preserve the country’s resources. Hence, more in depth analysis for the highest priority strategies is needed in order to build a comprehensive utility project framework that helps the decision makers enhancing the pre-planning coordination for co-located infrastructure projects in Saudi Arabia.
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