Repairs and Refurbishing of The Guajataca Dam following Hurricane Maria: A Case Study

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Abstract*– Hurricane Maria made landfall on September 20, 2017 in Puerto Rico causing severe damage to the island´s infrastructure. As a result of the hurricane, the Guajataca Dam was damaged. This paper presents the results of a Five-Dimensional Project Management for Coastal Communities Workshop. During the workshop, participants learned the fundamentals of a five-dimensional project management model, analyzed the sources of complexity in repairing and refurbishing the Guajataca Dam and developed complexity maps to manage the project. The paper concludes that challenges in communication due to electrical and communication infrastructure failure, the limited amount of time that could be devoted for planning and other external influences increased the project's complexity following the natural disaster. It also concludes that the most complex project management dimension to repair and refurbish the Guajataca Dam is context.

Keywords—five-dimensional project management, infrastructure project, complexity, critical asset

I. INTRODUCTION

Hurricane Maria made landfall on September 20, 2017 in Puerto Rico causing severe damage to the island´s infrastructure due to strong winds, extreme precipitation, floods and landslides. As a result of the hurricane, the Guajataca Dam was damaged. The Guajataca Dam is the most important water storage structure in the northwest of Puerto Rico. As result of the hurricane, the Dam was found to be "in an active state of failure resulting from water overflowing the spillway" [1]. An emergency declaration was issued. The challenges in communication due to electrical and communication infrastructure failure, the limited amount of time that could be devoted for planning and other external influences increased the complexity of reconstruction projects following the natural disaster [2]. This paper presents the results of a Five-Dimensional Project Management for Coastal Communities Workshop that was held at the Federal Emergency Management Agency (FEMA) Aguadilla branch. Workshop participants learned the fundamentals of a five-dimensional project management model, analyzed the sources of complexity in repairing and refurbishing the Guajataca Dam and developed complexity maps to manage the project's complexity.

II. METHODOLOGY

The study replicated the methodology that was developed for the second Strategic Highway Research Program (SHRP 2) research project for collecting data to develop case studies [3]. Case studies can be used as a tool to increase knowledge and understanding about a particular case by obtaining details from a number of relevant or involved sources related to a project [4]. The methodology used in this study includes triangulating multiple sources of information to cross-check that the information collected was accurate.

The workshop was divided into two parts. The first part introduced participants to the five- dimensional project management model (5DPM) to manage complex projects. The second part focused on working in groups to identify critical success factors and develop complexity maps for a project. After the workshop (part 3), the research team documented the results of the workshop and used multiple sources of information including public records, project websites, media coverage and articles to develop the case study. Figure 1 shows the methodology flowchart.

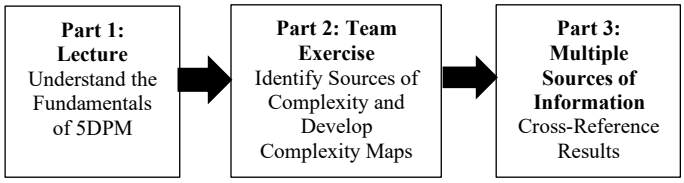


Fig. 1: Case Study Workshop Methodology Flowchart

A. *Part 1: Understanding the Fundamentals of 5DPM*

The first part of the workshop consisted of a presentation that introduced participants to the fundamentals of the complex project management theory. The following five dimensions of project management were introduced: cost, schedule, technical, context and financing. Cost is quantifying the scope of work in monetary terms. Schedule are the calendar-driven aspects of the project. Technical are the typical engineering requirements including scope of design and construction and project quality. Context are the external influences impacting project development and progress, such as political/procurement constraints and environmental issues. Financing are the sources of the project's funding [3]. After participants gained a basic understanding of 5DPM, the team exercise was introduced.

B. *Part 2: Identify Sources of Complexity and Develop Complexity Maps*

The team exercise involved identifying the sources of complexity and developing complexity maps. Complexity maps visual tools that create a project´s footprint to manage complexity. The first step to create a complexity map is to identify the sources of complexity in each of the five dimensions. Participants were provided a list of potential

sources of complexity per dimension and were asked to work individually to select the top three sources of complexity per dimension. In addition to the list of sources of complexity provided, participants were given the opportunity add other sources based on their experience. After the individual selection of sources of complexity was completed, participants were asked to discuss with the group their selections and reach consensus on the top three sources of complexity per dimension. By completing the assignment first as individuals and then as a group, participants were able to have a productive discussion taking into consideration different perspectives and viewpoints.

The second step was to rank the five dimensions in descending order of complexity, where 5 being the most complex dimension and 1 being the least complex dimension. The third step was to assign a value to each dimension. A routine project has a complexity of 50, if participants believed that a dimension was more complex than in a routine project, they were asked to assign a value higher than 50. If they believed that it was less complex than a than a routine project, they would assign a value lower than 50. Since the dimensions were ranked in order of complexity in the first step, no two dimensions could receive the same score. The final step was to plot the data on a radar diagram and calculate the area of the pentagon.

B. *Part 3: Multiple Sources of Information*

After the radar diagram was completed, the research team discussed in-depth the data collected on the project and cross-referenced the findings using public records, project websites, media coverage and articles. The results were shared with workshop participants and were verified for accuracy.

III. Results

The results of the workshop indicate that participants believe that the Guajataca Dam repairing, and refurbishing is more complex than a routine project. When participants were asked to identify the sources of complexity in each of the five dimensions, they identified them and stated the reasons for their selections as shown in table 1.

TABLE I
SOURCES OF COMPLEXITY AND REASONS FOR SELECTION FOR THE GUAJATACA DAM PROJECT

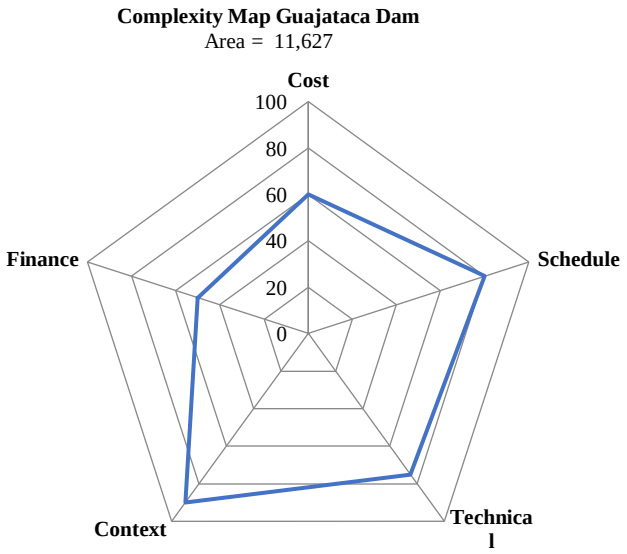
Dimension	Source of Complexity	Reason
Cost	Estimate formation	Critical infrastructure
Cost	Risk analysis	Potential for loss of life, evacuation in case of disaster is complex
Cost	Optimization's impact on project cost	Complex because 200,000+ citizens depend on this infrastructure
Schedule	Milestones	Important deadlines during lifecycle so that project occurs in a timely manner.
Schedule	Risk Analysis	Climate impact (rain, drought)
Schedule	Work Breakdown Structure	Various stakeholders involved
Technical	Prequalification of bidders	Potential corruption issues
Technical	Typical climate	Annual climatic events
Technical	Existing conditions	Danger because the structure is old.
Context	Jurisdictions	Public Private Partnership, seven municipalities as stakeholders, plus state and federal stakeholders.
Context	Public emergency services	Importance of evacuation routes.
Context	Sustainability goals	Includes maintenance, to better design to last longer.
Financing	Transition to alternate financing sources	Long-term sources.
Financing	Project manager financial training	Training is needed due to project size/ complexity.
Financing	Public-Private Partnerships	Investigate if this would be viable.

As shown in table 2, the results of the ranking and rating of the dimensions indicate that participants believe that context is the most complex dimension (rank 5= most complex), followed by schedule and technical. Participants indicated the cost was slightly more complex than a routine project and financing was as complex as in a routine project. Their reasoning behind assigning financing a 50 was that they believe that they will either get the funds to design and build the project or they will not receive the funds and there will be no project.

TABLE 2
RANKING AND RATING PER DIMENSION FOR THE GUAJATACA DAM PROJECT

Dimension	Rank	Rating
Cost	2	60
Schedule	4	80
Technical	3	75
Context	5	90
Financing	1	50

Figure 2 shows the complexity map for the Guajataca Dam. As it can be seen, the Guajataca Dam has a footprint area of 11,627 out of a possible 23,776. An area of 23,776 would indicate that all dimensions were rated 100.



Ave Area = 5,944; Max Area = 23,776

Fig. 2: Guajataca Dam Complexity Map

IV. CONCLUSION

The Guajataca Dam is a critical infrastructure asset that needs to be repaired and refurbished to ensure safety of the public. The damaged caused by hurricane Maria increased awareness of the need to maintain critical infrastructure assets. As stated in the results, the most complex dimension to repair and refurbish the Guajataca Dam is context. Due to the project´s visibility and need of maintaining the safety of residents in the northwest of Puerto Rico, it is essential to manage the context dimension adequately to ensure project success.

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