PALAU VM STUDY PAVES ROAD TO SUCCESS

By

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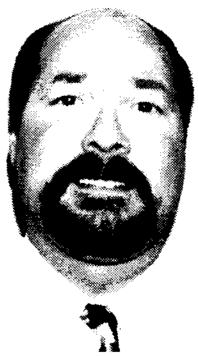

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ABSTRACT

This study offered value enhancements for a safe, high quality, all weather vehicular roadway on the Pacific Island of Babeldaob, Republic of Palau. A very diversified study team, including participation by a construction firm in the South Pacific, permitted a realistic assessment of cost and schedule issues. This paper highlights the VE techniques of Pareto cost analysis, probabilistic cost modeling, time modeling, risk modeling and function analysis logic diagramming which resulted in a wide range of technical recommendations. Key proposals regarding civil/site, structural/geotechnical, design criteria & standards, and project management are presented. Tropical South Pacific Island construction created a number of unexpected and complicated challenges for the VE study team.

I. STUDY BACKGROUND

Project Description

The purpose of the proposed project is to provide a safe, high quality, all weather vehicular roadway on the Pacific Island of Babeldaob, Republic of Palau. According to the provision of the Compact, the U.S. Government has an obligation to assist the Republic of Palau, "in its effort to advance the economic development and self-sufficiency of the people of Palau." This roadway represents a major infrastructure investment that is expected to serve as a precursor to economic growth on Babeldaob and ultimately, the nation of Palau. Consequently, the national highway project is one of the most important infrastructure projects in the Republic of Palau.

Completion of this major component of the Palau vehicular transportation system with its links to potential development areas for tourist facilities is expected to contribute to the sustained growth of the national economy. In addition, the compact road is expected to facilitate local travel due to the relocation of the national capitol to Melekeok; the expansion of fisheries and agricultural centers; and the return of many Palauans to their ancestral villages.

According to the Republic of Palau Economic Development Plan for 1995-96, "the Compact mandated that the 53 mile road must be aligned to link all communities on Babeldaob with Koror. The road should also provide access through or near to known areas having potential agriculture, forestry, mining, industry, tourism, near watersheds for future water resource development, rock resources for quarries, potential port development sites on the west coast of Babeldaob, and the proposed site for the new capital of the Republic of Palau in Melekeok State."

The vehicular transportation system on the island of Babeldaob consists of an existing network of roads with dirt, gravel or crushed coral surfaces that need four-wheel drive vehicles. Sections of the roadway have become impassable as a result of heavy rains and overuse. Steep grades and uneven road surfaces in some areas have resulted in potentially hazardous driving conditions. Erosive forces potentially carry away fertile top soil and cuts made to earth may not revegitate leaving permanent scars on the landscape of the island. Consequently, Babeldaob currently lacks a safe, reliable vehicular transportation system. In addition, the visual character, natural beauty and pristine marine environment throughout Palau continues to be jeopardized while existing roadway conditions and practices persist.

The current, estimated total construction cost is over 160 million U.S. dollars. The project budget is $124 million. The construction design consists of packages A, B, C, and D which connect all ten states on Babeldaob. Refer to Figure 1 which shows the general road alignment on the island.

Study Objectives

The following VE study objectives were identified by representatives from the Republic of Palau; the U.S. Department of Interior; the U.S. Corps of Engineers; and the four consulting engineering firms on the first day of the workshop. They are:

- Identify elements of the design which have significant potential to reduce costs to the budget of $124 million
- Identify critical project risk areas and strategies for mitigation
- Minimize environmental impact of the project
- Seek completion of construction by October, 2000
- Strive to maximize local Palau business involvement
- Utilize local labor and construction materials where possible
- Minimize road maintenance costs

II. METHODOLOGY

Value Study Team

The VE manager of the U.S. Department of Interior requested a value engineering study to address the above project issues and concerns and to minimize the gap between the estimated construction cost and the actual project budget. In response, a team was assembled which consisted of geotechnical, structural and civil engineers, along with a construction contractor who was very familiar with road construction in the Polynesian Islands. The team was led by a Certified Value Specialist.

Site Visit

The VE team visited the site and existing roads on the Island of Babeldaob over the period of May 24 thru 28, 1997. The purpose of the site visit was to familiarize the VE team members with the proposed project in preparation for the workshop. The resident engineer from the Corps of Engineers made arrangements in Palau and provided valuable information and technical support for the team members during this site visit. The aim of the visit was to:

- Meet with the Palau Minister of Public Works and other officials to discuss their objectives, expectations, availability of local labor and material (including quarries), cost escalation, logistics and other project related issues that could impact the completion of this project.
- Collect all available information that could assist the VE team during the upcoming workshop.
- Fully understand unique project issues that would impact design elements, such as mitigation of soil erasion to protect pristine coastal, marine and estuarine resources; archaeological sites; and removal / disposal of World War II ordinance.

Workshop Approach

The six-day VE workshop followed the SAVE Value Methodology Standard which included information gathering, function analysis, creativity, evaluation, proposal development and recommendations for potential value improvements. The VE presentation occurred on the last day of the workshop which was held at the Corps of Engineers office in Honolulu.

Throughout the VE workshop all participants, including representatives from the design firms demonstrated a high degree of team cooperation. This cooperation, along with the multi-disciplined VE team expertise, was key to the success of this study.

Benefits/Savings

During the workshop, over 150 ideas were generated, in the categories of civil / site; structural / geotechnical; design criteria; and project management. From these ideas, some 40 recommendations were developed by the VE team for consideration by the Palau government and the U.S. Corps of Engineers.

These proposals offered a savings potential in the range of $50 to $95 million dollars. These VE recommendations also offered benefits such as improvements to the schedule; increasing local Palauan businesses involvement; reduced project risk; environmental impact and maintenance costs.

III. VALUE TECHNIQUES

Several techniques such as Pareto cost analysis, probabilistic cost modeling, risk modeling and time modeling were used to help the VE team isolate areas of poor value. In addition, a function analysis diagram was prepared to clarify critical project functions.

Pareto Cost Analysis

Cost information for this study was provided by the design team under the direction of the Corps of Engineers. This information was organized by project function so that a "Pareto cost analysis" could be prepared. This distribution of costs is shown as Figure 2. This diagram highlights "earthwork" as the largest single component of cost. The "worth" of each item was established based upon the budgeted cost allocation per element. This analysis helped the VE team identify high cost areas.

Probabilistic Cost Model

The VE team observed a number of areas in the estimate which were significantly lower than their work experience in the South Pacific. Because of these variations, a "probabilistic cost model" was prepared to determine a more realistic cost estimate range. Individual line items of cost, such as escalation, were input into an Excel spreadsheet with the add-on probabilistic software called @RISK. A range was specified for each item (low, most likely, high). The model was then run for 200 iterations to generate the probabilistic distribution curve of project cost. It ranged from a low of $176 million to a high of $221 million, depending on the probability shown on the "Y" axis of Figure 3. For example, if the owner wanted an 85 percent chance of having enough money to build the road, then the owner should budget $206 million. This model indicated a significantly higher project cost than the design team's estimate of $160 million.

Risk Model

The VE team identified a number of potential risks associated with the project. The elements of risk examined included:

- Management, financial and administration
- Environmental and geotechnical
- Technical
- Social / Cultural
- Implementation

Areas of highest risk concern included land acquisition; permitting delays; schedule delays; inflation; environmental restrictions such as the mangrove trees and coral reef; and lack of labor and material availability.

Time Model

To better understand the complete design and construction schedule, a time model was prepared from the information provided by the Corps of Engineers. The list of activities, in sequence, along with associated duration, helped the VE team identify missing activities as well as ways to decrease overall project duration. The original and VE proposed schedules are illustrated as Figure 4.

Function Analysis Logic Diagram

In order that the team might better understand the overall functions of the project, a "Function Analysis Logic Diagram" was prepared. Reading from left to right, it was used to help explain how the designer chose to solve the functions. The function logic diagram, when read from right to left, also helped answer why these functions were important to the owner.

This diagram helped translate government goals, objectives and tasks into a hierarchial logic diagram of functions for a better in-depth understanding of owner needs. This diagram is illustrated as Figure 5.

IV. TECHNICAL RECOMMENDATIONS

The recommendations with the greatest impact on cost savings and project quality improvement are categorized as follows:

Civil / Site:

- Use laterite island material for road base and sub-base construction
- Use chip seal coating on top of laterite base in lieu of conventual road construction material
- Minimize paved shoulder width
- Use 20' road width in lieu of 24' width for packages C&D (low use roads)
- Eliminate shoulder seal coat and base
- Use riprap in lieu of concrete lined drainage ditches
- Replace asphalt concrete pavement with two coats of chip seal for all pavement
- Reduce cut, to balance fill, which may require change of road slope criteria
- Improve existing road whenever possible in lieu of creating a new alignment
- Use modified causeway design to reduce materials and simplify design
- Use general select fill in lieu of granual fill or surge rock at causeway for packages B and D
- Eliminate guard rails at East route, near the Mangroves and low fill areas of package B
- Use existing electric poles for highway lighting

Structural / Geotechnical:

- Use culverts in lieu of bridges where possible
- Use hollow core prestressed concrete planks for bridges
- Use high strength steel girders for bridges
- Establish uniform design standards for bridges and other structures
- Use precast concrete piles in lieu of cast in-situ piles
- Use corrugated aluminum pipe versus reinforced concrete pipe
- Utilize dredged coral and local aggregate in lieu of crushed stone
- Use geomatrix or shotcrete in lieu of reinforced concrete or riprap for swales and gutters

- Use geotextile erosion mat for ditches

Design Criteria:

- Identify priority of road sections. Reduce standards for lower priority sections including road width and shoulder width
- Design should be based on local / regional practices
- Deviate from ASHTO project standards as follows:
    - Adjust shoulder width from 1.8m to 1.2m
    - Modify road width in villages to 18' in lieu of 24'
    - Revise pavement thickness based on 25 years road life
    - Minimize guard rails and swales along the road
    - Adjust design live load criteria from HS-20 to HS-15 or HS-10
- Consider joint AE design firm subteams to design standards for culverts, structures and piling.

Project Management:

- Develop and give presentation to Palau community regarding road project and initiate land acquisition process
- Identify public versus private land ownership along road alignment and resolve land acquisition issues as soon as possible
- Resolve land acquisition, road survey and geotechnical issues
- Build a permanent landing site if required for construction located in a future area of development
- Use local food catering for contractor's staff and crews
- Give option for Palau public works department to retain some of contractor's construction equipment for road maintenance
- Seek additional funding through other governments, agencies, private industries / developers, bridge tolls, road and gas taxes and Palau government.
- Seek Palau state government support to provide land, rock, coral, water and other raw materials
- Allow contractors to offer ideas for reducing project cost at time of bidding through a prebid conference then hold prebid meeting with potential contractors
- Research competitive pricing in the local region for earthwork, cement, rock, asphalt, crushed rock, stockpiled coral and offshore fabrication
- Defer certain elements of the project including guard rails; shoulder drainage protection; signage and striping; cutoff ditches and the causeway for future completion by local contractors
- Conduct a VE study at 60 percent design stage in early 1998
- Use one structural consultant in lieu of three
- Use only one electrical power pole consultant in lieu of three.

The VE effort generated a wide range of ideas and proposals, when implemented, will result in achieving required project functions while improving project quality and reducing cost to meet the current budget.

V. ESTIMATE & SCHEDULE EVALUATION

The VE team was also requested by DOI to comment on the estimate and schedule prepared by the design team.

Estimate Review

The VE team reviewed the estimate prepared by the design team. Generally, the estimate appears low in a variety of areas including:

- Unit rates of construction items
- Cost escalation
- Mobilization / demobilization
- Idle time / resource balance / support functions
- Design and construction contingencies

The VE team performed a probabilistic cost analysis as discussed earlier in order to identify a more likely range of project cost. A range of estimates was made based on the current estimate and the VE team's experience. This analysis indicated a mean value for the total construction cost of $195,000,000 in lieu of the design estimate of $160,000,000.

Schedule Review

The VE team also reviewed the project schedule prepared by the design team. This schedule does not reflect acquisition of land, a responsibility of the Palau government. The schedule indicates a three year construction period. The time allocated to make the contract award is very short and there is a concern that this action may take significantly more time.

The VE team developed a schedule which includes a large number of project tasks that must be carefully coordinated, to achieve the overall project completion date. One key task, land acquisition, has been organized into a series of sub-tasks to help the Palauan government in completing the effort. The VE team believes the construction of the road could occur in as little as 18 months if the "right" contractor is selected. Contract award actions are anticipated to take longer than the current schedule illustrates. Both the original and the VE schedules indicate a project completion in 2001. This is one year later than the original compact agreement of October 2000. The actual road completion date will depend significantly on how quickly the Palau government can procure land for the project.

VI. NEXT STEPS

A second VE workshop is planned for early 1998 in Hawaii. A number of objectives have been identified for this workshop. This follow-up will assist DOI and the Palau government in determining the status and progress of the project at the 60 percent design stage. It will also help to identify management actions that should be taken prior to bidding for the project construction. Specific VE objectives include:

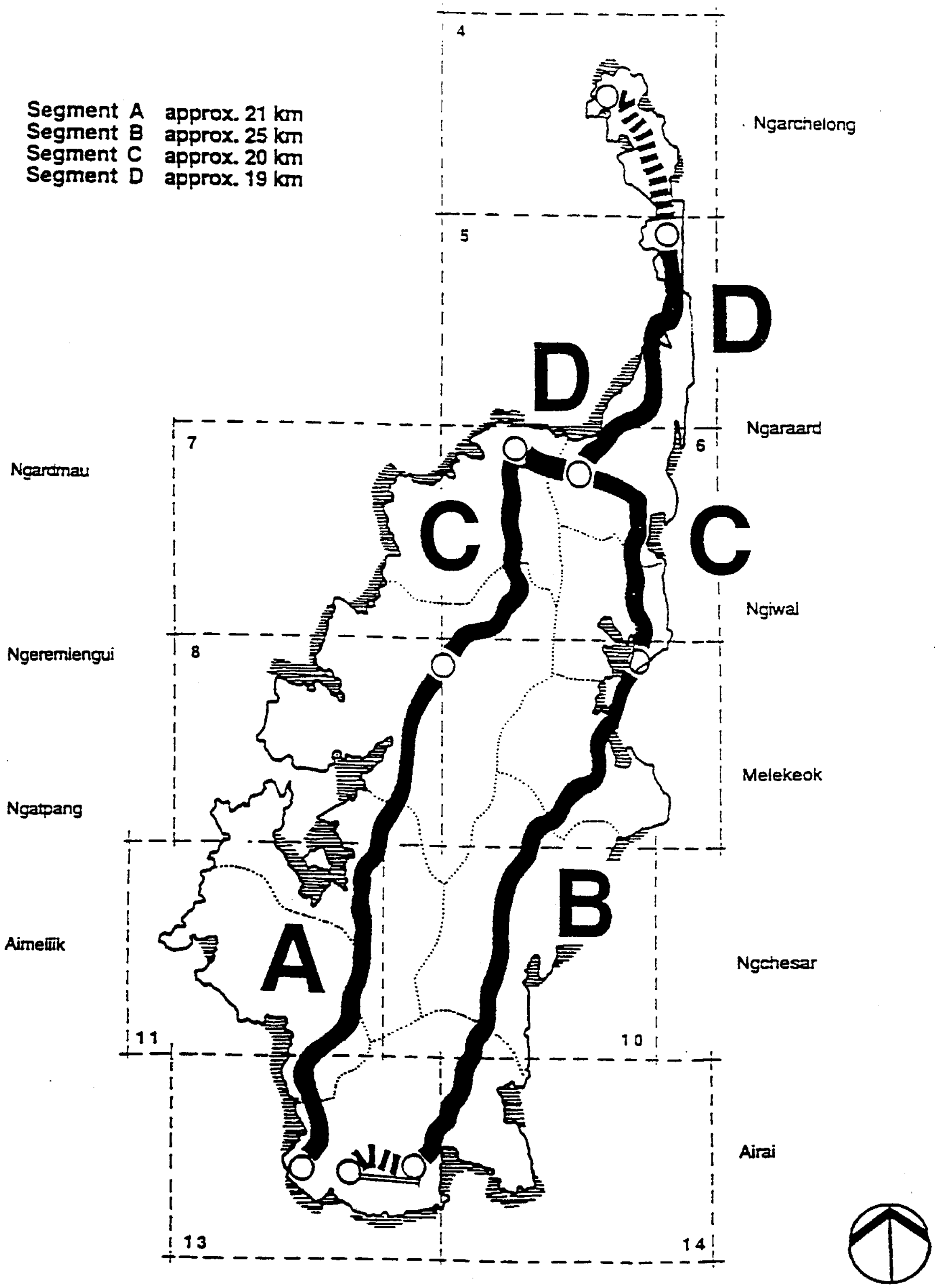
- Assess land acquisition status and progress
- Review the approach to be taken at the pre-construction bidder conference
- Review and evaluate the 60 percent stage cost estimate
- Establish bid evaluation criteria and procedures
- Prepare an independent 60 percent stage cost estimate
- Assess the progress and the status of the 60 percent design
- Identify bid deduct alternatives
- Review and comment on bid documents (including Palau government business rules)
- Seek best value, life cycle options (including ideas for long term low maintenance)

VII. CONCLUSION

This VE study provided a forum which included representatives of all relevant decision-making entities to integrate broad Palau government mission goals with the specific needs of an all-weather access road. It was successful in addressing a broad range of topics and in raising issues of concern such as, lack of progress in land acquisition and significant cost overages, both of which require resolution before the project can proceed smoothly.

The VE study was successful in identifying and evaluating the significant risks and uncertainties associated with this project. A wide range of VE proposals where developed to reduce project risks and result in the realization of project objectives, as well as improved project quality and reduced total project cost.

Figure 1


Segment A approx. 21 km
Segment B approx. 25 km
Segment C approx. 20 km
Segment D approx. 19 km
Ngarchelong
Ngaraard
Ngardmau
Ngiwal
Ngeremlengui
Melekeok
Ngatpang
Aimeliik
Ngchesar
Airai
A
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4
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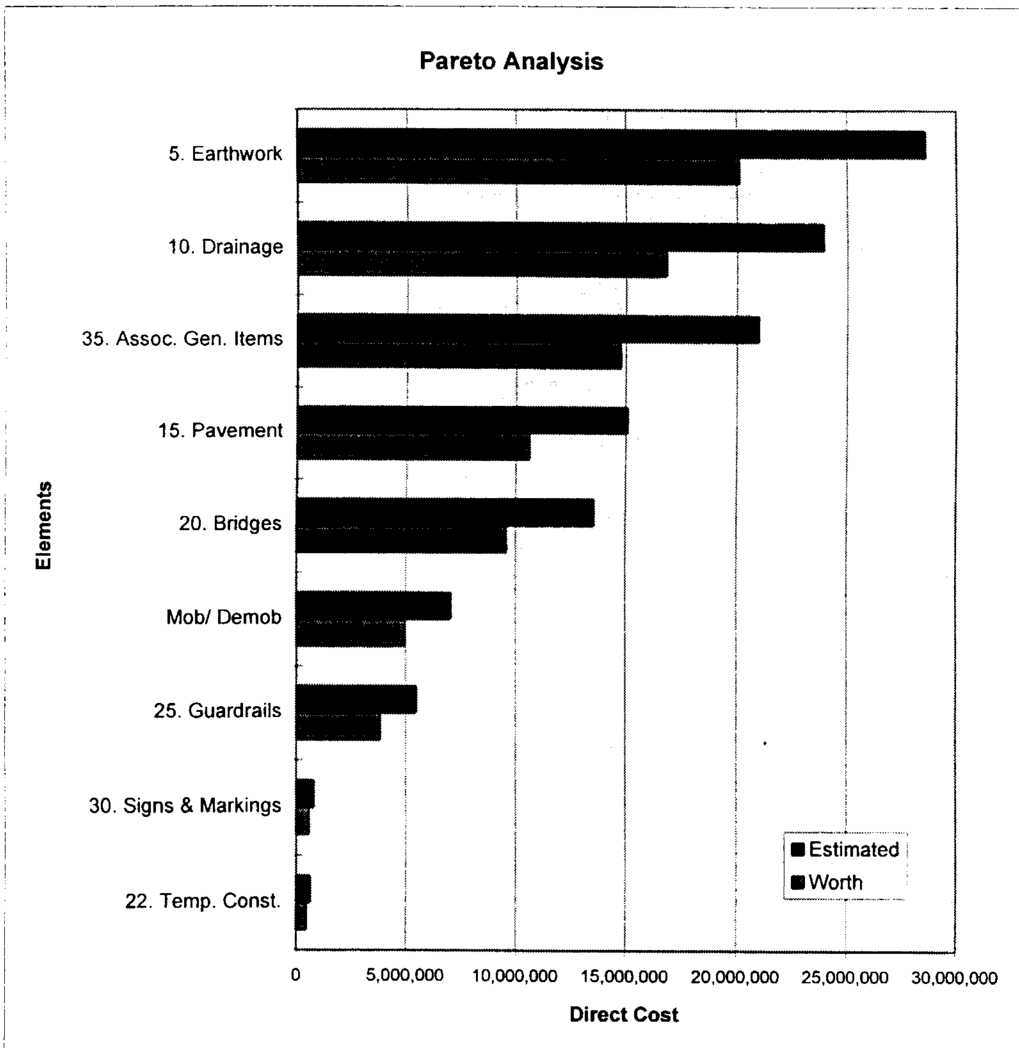
14

Pareto Analysis

Figure 2

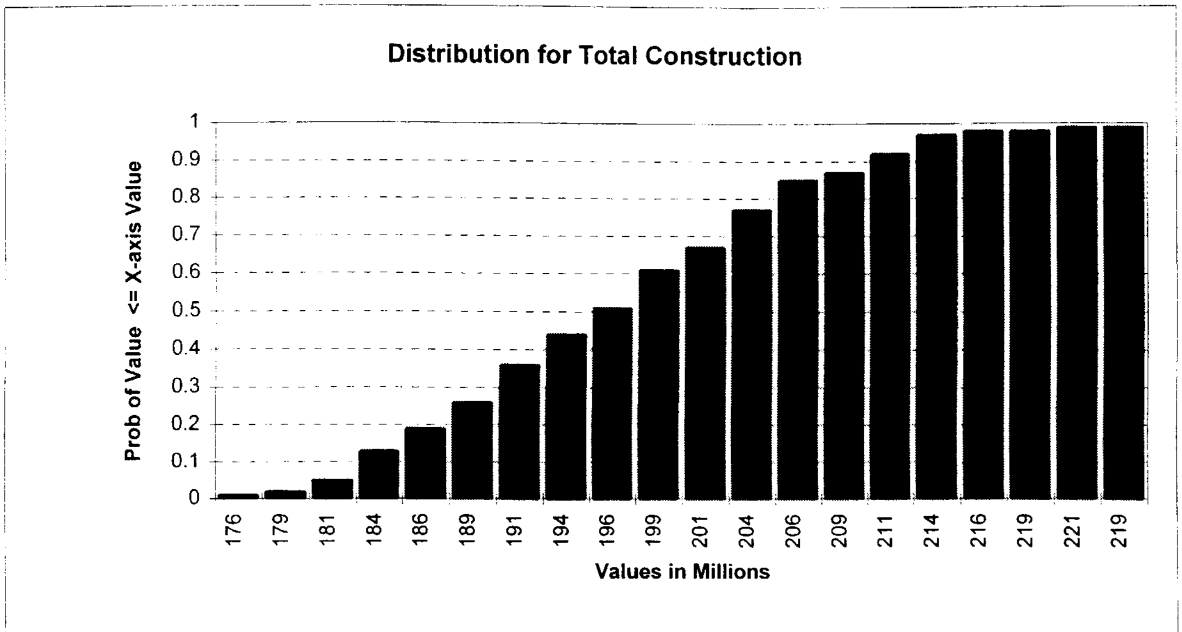
Palau Compact Road Project
Babeldoap Island, Palau

Element	Worth	Direct Costs Estimated	Worth %
22. Temp. Const.	468,554	665,315	70.43%
30. Signs & Markings	583,199	828,104	70.43%
25. Guardrails	3,866,551	5,490,242	70.43%
Mob/ Demob	4,978,944	7,069,766	70.43%
20. Bridges	9,592,070	13,620,094	70.43%
15. Pavement	10,643,888	15,113,605	70.43%
35. Assoc. Gen. Items	14,805,595	21,022,950	70.43%
10. Drainage	16,884,325	23,974,606	70.43%
5. Earthwork	20,149,471	28,610,894	70.43%



PROBABILISTIC COST MODEL **Figure 3**

Compact Road, Babeldaob Island, Republic of Palau



TIME MODEL

Figure 4