FEASIBILITY OF CABLE REMANUFACTURING

Industrial and Systems Engineering | IE3100R Systems Design Project

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1. Company Overview

- World's largest oil field services company with more than 120,000 employees in over 85 countries
- Products range from oil exploration, drilling, extraction and providing information solutions to customers
- Singapore Artificial Lift Centre opened in 2006 to manufacture Electric Submersible Pumps used worldwide.

2. Problem Description

Problem Statement

Falling oil prices has led to loss in revenue with many oil wells operating at reduced capacity affecting company's stock price and profit margins. There is urgent need to cut costs and an oil services company wants to evaluate the cost reductions from remanufacturing electric cables.

Problem Objective

The project aims to determine the economic feasibility and the optimality of investing in cable remanufacturing process in a new manufacturing centre in Latin America. By exploring the various alternatives to utilize their used cables; analysis results and recommendations should be proposed to assist an oilfield services company in maximizing return of the investment.

3. Methodology

1. System Analysis
- Understand company operating procedures & functions
- Understand requirements, define problems & objectives

2. Potential Factors
- Identify influencing factors (e.g. transportation cost, capital investment & cost of remanufacturing)
- Explore alternative locations that may vary the arrangements

3. Modeling Cash Flows for Various Choice of Locations
- Obtain transportation cost from SIMTech simulation model (including validation & verification of model)
- Formulate & estimate the cost of each respective factors at each location using past records & expert feedback

4. Identify Best Case Alternative
- Compare cash flows for all options and choose the one with the highest profit

5. Output Analysis
- Identify sensitive factors using Tornado diagram & Spider diagrams
- Conduct risk analysis using Monte Carlo Simulation

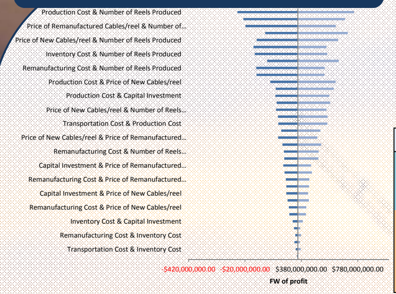
6. Scenario-Based Analysis
- Test possible what-if scenarios (surge in transportation cost, oil shock, extensive capital investment) for any possible implications & decision reversal

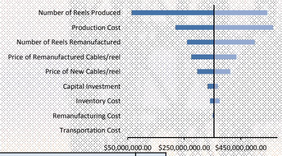
7. Recommendations
- Discuss the strengths and weaknesses of various options by doing cost-benefit analysis
- Feasibility of cable remanufacturing

8. Future Directions
- Select optimal location and capacity allocation for the production of new cables in an attempt to further minimize cost in addition to cable remanufacturing

4. Problem Analysis

Tornado Diagrams

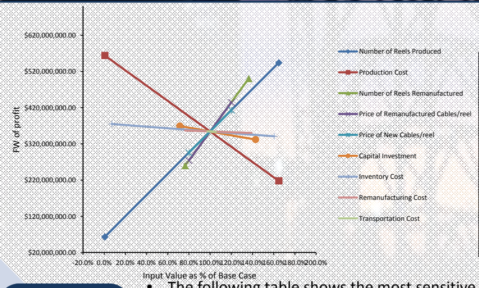




Input Variables	Swing
Production Cost & Number of Reels Produced	233%
Number of Reels Produced & Number of Reels Remanufactured	203%
Price of Remanufactured Cables/reel & Number of Reels Produced	181%
Production Cost & Number of Reels Remanufactured	165%
Price of New Cables/reel & Number of Reels Produced	163%
Capital Investment & Number of Reels Produced	146%
Inventory Cost & Number of Reels Produced	145%

- FW of profit is more sensitive under the change of two input variables because of a larger percentage of swing.
- The top three combinations of variables (highlighted in blue) are combinations that could lead to a decision reversal, that is, FW can become negative at low values of these combinations.

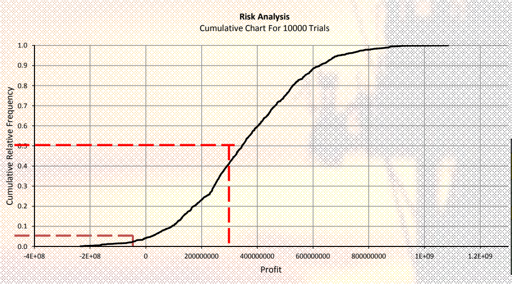
Spider Diagrams



Input Variables	Swing
Number of Reels Produced	51.25%
Production Cost	26.57%
Number of Reels Remanufactured	12.84%
Price of Remanufactured Cables/Reel	5.71%
Price of New Cables/Reel	3.05%
Capital Investment	0.31%
Inventory Cost	0.26%
Remanufacturing Cost	0.01%
Transportation Cost	0.00%

- The following table shows the most sensitive variables, highlighted in blue. These were selected based on the magnitude of the swing in FW of profit, the larger the swing in FW, the greater the sensitivity. The variables are listed in decreasing order of sensitivity.
- All swings are within the range of positive FW of profit. This implies that even if a single variable is at its low value, it is unable to cause a change in the economic feasibility of the remanufacturing project.

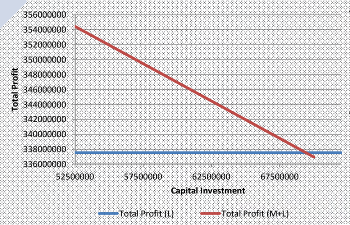
Monte Carlo Simulation



Input Variables	Distribution
Inventory Cost	Triangular
Transportation Cost	Triangular
Production Cost	Normal
Remanufacturing Cost	Normal
Capital Investment	Triangular
Price of Reman. Cables	Normal
Price of New Cables	Normal
Numbers of Reels Reman.	Normal
Number of Reels Produced	Normal

- The Cumulative Distribution Function graph of Monte Carlo Simulation shows the probability distribution of profit. There is an approximate of 0.04 probability that the remanufacturing operation in Latin America may book a loss
- Probability of this operation books profit that exceeds the estimated future value of profit is roughly 0.5

What-If Analysis



- We have considered extreme cases of which 2 out of 3 cases have indicated that the option proves to be viable.
- The breakeven graph shows that if capital investment involves a substantial amount, it may not be a wise option to pursue for Latin America.

Oil Crisis – Simultaneous fall in demand, supply of cables (fall by 30%). Price of new cables & price of remanufactured cables (fall by 20%).

Surge in Transportation Cost – Spike in Third Party Logistics transportation cost by 70%

Higher Capital Investment – Capital Investment for Latin America is 200% higher compared to US.

5. Recommendations

According to the tornado and spider diagram in the Analysis section, transportation cost has less impact to the profit than production cost, capital Investment and remanufacturing cost. This implies that changes in transportation cost are less likely to affect profit tremendously.

In the case of oil crisis where there is reduced supply and demand for the cables and a slump in cable price as well as a surge of transportation costs, we might expect the overall profit to go down. However, based on our cash flow analysis, remanufacturing in Latin America during crisis times is still the best solution.

Hence, we recommend the oilfield services company to locate remanufacturing in Latin America to reap the economies of scale of centralizing remanufacturing works and utilize the lower operational cost in Latin America.

6. Future Directions

Optimize network that maximizes long-term profitability in addition to cable remanufacturing

Objective Function:

$$Minimise\ cost \sum_{i=1}^{n} f_i y_i + \sum_{i=1}^{n}\sum_{j=1}^{m} c_{ij} x_{ij}$$

Subject to the following constraints:

$$Demand\ constaint: \sum_{i=1}^{n} x_{ij} = D_j$$

$$Supply\ constaint: \sum_{j=1}^{m} x_{ij} \leq K_i y_i \qquad y_i \in \{0,1\}$$

Decision Variables:

$y_i = 1\ if\ MARTC\ i\ is\ open, 0\ otherwise.$

$x_{ij} = Quantity\ Shipped\ from\ MARTC\ i\ to\ ARTC\ j$

Model Inputs:

$n = Number\ of\ MARTC\ (Supply, Production) Locations$

$m = Number\ of\ ARTC\ (Demand, Distribution) Locations$

$D_j = Monthly\ Demand\ from\ ARTC\ j$

$K_i = Potential\ Capacity\ from\ MARTC\ i$

$f_i = Fixed\ Cost\ of\ Keeping\ MARTC\ i\ Open$

$c_{ij} =$ $Cost\ of\ Producing\ \&\ Shipping\ One\ Reel\ of\ Cable\ from\ MARTC\ i\ to\ ARTC\ j$ $where\ cost\ includes\ production\ (energy, material\ \&\ labor)\ and\ transportation$

If the production is gradually shifted to Latin America MARTC, savings of about $1.7 Million per month will be gained.

Results show that it is optimal for MARTC in the USA to reduce production and shutdown eventually.