Constructive Healthcare Technology Effectiveness and Assessment Model (COHTEAMO)

Health care technology adoption requires assessment of the benefit of the system, by measuring the cost and cost-effectiveness of the system. This paper outlines a parametric model based novel approach to measure CBA of health care technology adoption.

11/25/2007
Cost Estimation and Measurement Systems
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Acknowledgement

I would like to thank my peers of ESD.936 Cost Measurement and Estimation Techniques, Prof. Ricardo Valerdi, and David Opolon, PhD candidate in Engineering Systems Division. Ricardo's lecture was helpful in sowing the seed and the laying out the inspiration to write this paper. Also, David and I had brief discussions about something of this nature even before the class. The paper has been however, an independent contribution from the author's side.

I would also like to thank Pat Hale for providing overall inspiration and support.

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Executive Summary

Background

Healthcare industry is undergoing transformation in various developed and developing countries. There have been various measures taken by communities, Governments, and global public/private organizations to improve the global urban and rural health, quality and efficiency. This includes health intervention programs, community programs, technology adoption programs, and health infrastructural development programs.

Developed nations are implementing tools, techniques and frameworks, to reduce muda (Womack, 2003) and increase healthcare quality, thereby implementing a lean enterprise. The goal of these programs is to provide efficient use of resources and processes for the benefit of the stakeholders. Developing nations, on the other hand, are working on leveraging technology as a means to increase the outreach of doctors and providers, and bridge the gap of inequality caused by distance and inequity of economics and poverty. All the above programs require a significant cost-benefit analysis for either launching programs, or improving the efficiency of the existing programs. Cost benefit analysis (CBA) and cost-effectiveness analysis (CEA) are widely used by various Government, private and business stakeholders, however there is no standardized approach to measure costs.

Concept

Universal/Urban Rural Health (URHealth™), is an effort to provide integrated solutions, involving technology advancements, to provide quality care for the betterment of healthcare in developing countries. Design of a cost model, not only fits the needs of the URHealth project team, but also aids in policy making and decision analysis for Government agencies across developing and developing nations. India's National Rural Health Mission (NRHM) - a mission launched by Government of India to improve rural healthcare, is an example of a program that could directly benefit from this study. The goal of this paper is to suggest models which will aid in cost-estimation and cost-effectiveness analysis of the URHealthPoint™ [1] project.

Project Details

Problem Statement

Governments of developing countries have created policies for increased spending in technology adoption, infrastructural development, community programs and clinical enhancements to increase the healthcare delivery and quality. For the all round development of health, World Health Organization (WHO) prescribes increased spending in rural healthcare. Considering this, it becomes important for any technology adoption program, to consider the cost estimation and cost-effectiveness models. **Error! Reference source not found.**, explains the dynamic relationships of healthcare spending and qualitative and quantitative benefits of technology intervention programs. Arrows in black denote a positive co-relation, whereas blue arrow indicates the co-relation could be positive or negative. Variables like reliability, timeliness of care, cycle time, accessibility and effectiveness of care given, affect quality of care. Quality or

[1] URHealthPoint™ is one of the project/venture being undertaken by the URHealth™ team.

effectiveness of care is measured quantitatively using Quality Adjusted Life Years (QALY) (Quality of life measures in health care. III: Resource allocation.), or Disability Adjusted Life Years (DALY). These parameters are measured and are used for decision and policy analysis. It must also be pointed out that there is no standardized model to perform a Cost Effectiveness Analysis (CEA) for healthcare technology intervention programs.

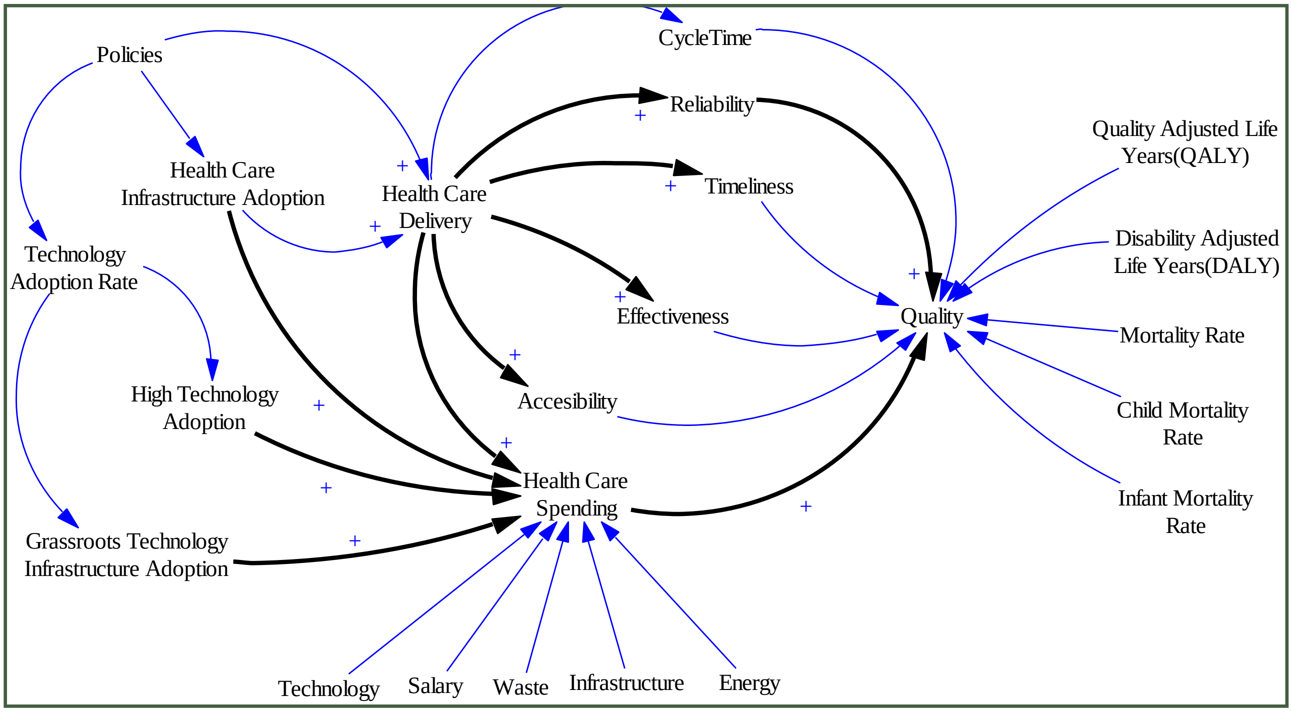

Figure 1 - Mental model of health policies

General Framing and Design of the Analysis

As part of the inception and elaboration phase[1] of the URHealthPoint™ - an Electronic Health Record (EHR) project, our team evaluated various technological hardware and software options. Since there has not been widespread implementation of EHR systems in rural settings, a comprehensive cost-benefit analysis[2] is being performed. Our goal is to create a cost-benefit model, the foundation of which lies on initial research and theoretical/empirical data. Our model will then be calibrated against the primary and secondary data collected after a successful implementation of the URHealthPoint™ system.

Boundaries of the Analysis

This paper describes the model and aids in identification of factors responsible for technology assessment in healthcare industry. The data will be collected from the community and village clinics in Dokur and Kodakadra, in Andhra Pradesh, India. Even though the model is being created for a limited set of community, it will give us enough insight to extend the model in

[1] Inception and Elaboration phases are Rational Unified Process (RUP) phases for a software engineering project. An analogy could be formed for System Engineering projects as well.
[2] Cost-benefit analysis of the technological system includes cost-estimation, cost-effectiveness and cost-utility analysis.

other frontiers, and adopt a Systems of Systems (SoS) approach to extend it to the entire URHealth™ project, the mission of which is to take a systems approach and implement a conglomerate of healthcare systems.

Target Population

The target population of this study is 5000 villagers who visit the clinic from various parts of the district.

Cost Benefit Model

The cost-benefit model takes a health-center centric approach to measure the benefits of any technology intervention program. Cost-benefit analysis involves measurement of benefits of a system or intervention program, and reducing the program cost from the benefit. **Error! Reference source not found.** shows the program cost flow for a healthcare technology project.

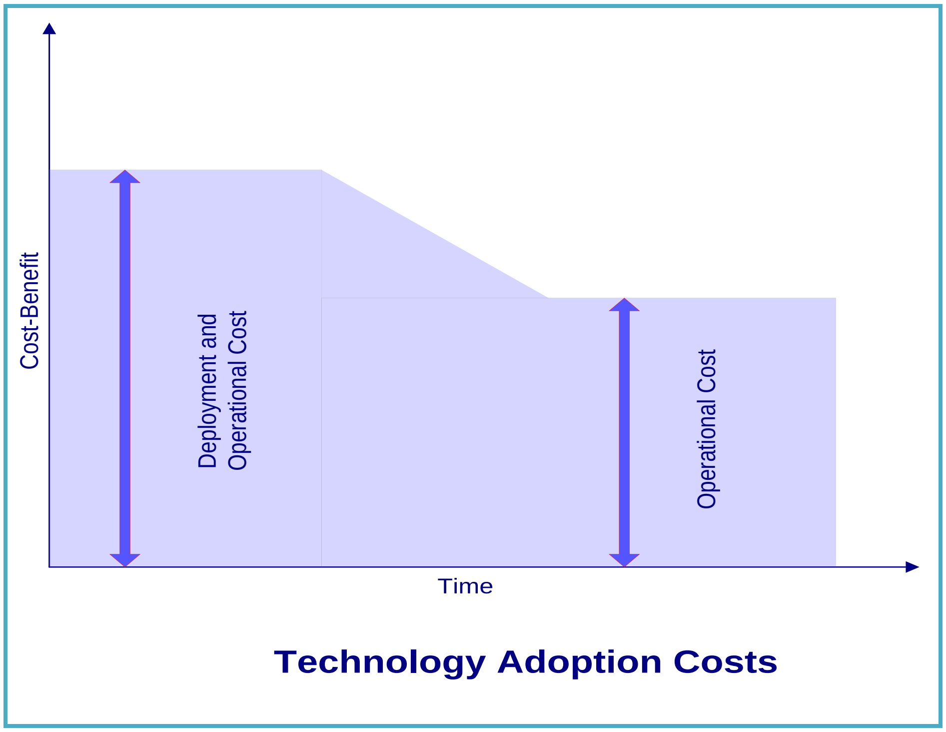

Figure 2 Technology Costs

For the system under consideration, program costs for the system can be broken down into the following cost buckets.

1) Operational Costs
    a. Technology Licensing Costs
    b. Transaction Costs
    c. Energy costs (if any)
2) Installation/Deployment Costs

Equation 1 - Technology Costs

Technology Cost/yr = Annual Operational Costs + Deployment Costs (distributed over the life of the technology).

It may be noted that a separate cost model can be created for calculating the Technology Operational and Deployment Costs, and a comprehensive model can be created for the HealthCare Technology costs and benefits. This however, is outside the scope of this paper.

As outlined in the background section of this document, there are no quick ways to measure the benefit of the system. There is a need to accurately model the effectiveness and benefit of the system. The benefit should be measured in terms of money, to aid in calculation of the overall cost-benefit. Considering this, a Constructive Technology Adoption Model (COHTAMO) has been devised, which will only aid in the Systems Engineering Pugh analysis, design considerations, but also help in upstream and downstream policy making and decision analysis.

Constructive HealthCare Technology Effectiveness and Assessment Model (COHTEAMO)

Constructive HealthCare Technology Effectiveness and Assessment Model (COHTEAMO), is based on sub-models for measuring cost-effectiveness. The sub-models are COHTEAMO Health Detection sub-model (HDES), COHTEAMO Health Accessibility sub-model (HACS). COHTEAMO Health Diagnosis sub-model (HDIS), COHTEAMO Health Utility sub-model (HUS) and COHTEAMO Health Diagnosis Error sub-model (HDIERS).

COHTEAMO Health Detection Sub-model (HDES)

COHTEAMO-HDES is designed to capture the health detection effectiveness of any technology intervention. The following factors are related to any equipment, process or personnel tied to the detection sub-system of the technology being adopted. [See **Error! Reference source not found.**]

No	Category	Drivers	Description	Driver Code	A/M/E
1	Personnel (PE)	Personnel Capability	Training of personnel to use the system	HDES-PECA	M
2		Personnel Education	Education background of the personnel	HDES -PEED	M
3		Personnel Cost	Cost to employ the person	HDES -PECO	M
4	Product (PD)	Product Operational Reliability	Product Operational Reliability measures the reliability of the system while it is performing.	HDES -PDOR	M
5		Product Execution Time	Execution time of the product	HDES -PDET	M
6		Product Volatility	Volatility of the product	HDES -PDVO	M

7	Process (PR)	Detection Rate	Detection rate of the disease using the product and personnel	HDES -PRDR	M
8	Disease (DI)	Disease Prevalence Rate	Prevalence rate of a disease	HDES-DPRE	M

Equation 2

Health Detection Sub-model (HDES) Effectiveness (HDESE) $= \prod_{driver=1}^{8} (HDS)_{driver}$

where:

i, identifies the multiplicative factors for HDES.

COHTEAMO Health Accessibility Sub-model (HACS)

COHTEAMO-HACS has been designed to capture the accessibility benefits of any technology adoption. There are many factors related to the ease with which healthcare can be accessed. It may be noted that increase in accessibility to healthcare delivery can significantly increase the cost effectiveness of technology.

No	Category	Drivers	Description	Driver Code	A/M/E
1	Distance (DI)	Distance	Distance of the health center from the home/working location of patient	HACS-DIS	M
2	Weather (WE)	Weather Condition	Weather condition affects the accessibility of healthcare.	HACS-WE	M
3	Transportation (TR)	Cost of transportation	Cost of transportation measures the total to-fro cost for the patient.	HACS-TRCO	M
4		Reliability of transportation	Reliability of transportation measures the operational reliability of the transportation means. e.g. Once the patient is using the transportation, what is the likelihood s/he will reach the health center	HACS-TRRE	M
5		Availability of transportation	Availability of transportation reflects the ease with which the transportation can be accessed	HACS-TRAV	M

Equation 3

Health Accessibility Sub-model (HACS) Effectiveness (HACSE) $= \prod_{driver=1}^{tot} (HACS)_{driver}$

where:

i, identifies the multiplicative drivers for HACS.

tot, identifies the total number of drivers for HACS , and tot = 5

COHTEAMO Health Diagnosis Sub-model (HDIS)

COHTEAMO-HDIS is designed to capture the health diagnosis effectiveness of any technology intervention. The following factors are related to any equipment, process or personnel tied to the detection sub-system of the technology being adopted. [see **Error! Reference source not found.**]

No	Category	Drivers	Description	Driver Code	A/M/E
1	Personnel (PE)	Personnel Capability	Training of personnel to use the system	HDIS-PECA	M
2		Personnel Education	Education background of the personnel	HDIS-PEED	M
3		Personnel Cost	Cost to employ the person	HDIS-PECO	M
4	Product (PD)	Product Operational Reliability	Product Operational Reliability measures the reliability of the system while it is performing.	HDIS-PDOR	M
5		Product Execution Time	Execution time of the product	HDIS-PDET	M
6		Product Volatility	Volatility of the product	HDIS-PDVO	M
7	Process (PR)	Diagnosis Rate	Diagnosis rate of the disease/health-condition using the product and personnel and the process.	HDIS-PRDR	M

Equation 4

Health Diagnosis Sub-model (HDIS) Effectiveness (HDISE) $= \prod_{driver=1}^{tot} (HDISE)_{driver}$

where:

i, identifies the multiplicative drivers for HDIS.

tot, identifies the total number of drivers for HDIS , and tot = 7

COHTEAMO Health Diagnosis Error Sub-model (HDIERS)

COHTEAMO-HDIERS is designed to capture the cost of health diagnosis errors due to incorrect diagnosis caused by technology adoption.

No	Category	Drivers	Description	Driver Code	A/M/E
1	Personnel (PE)	Personnel Cost	Cost to employ the person	HDIERS – PECO	M
2	Product	Product	Execution time of the	HDIERS -	M

	(PD)	Execution Time	product	PDET	
5	Process (PR)	Diagnosis Rate	Diagnosis rate of the disease/health-condition using the product and personnel and the process.	HDIERS – PRDR	M
	Patient (PI)	Patient Wages	Patient wages earned	HDIERS-PI	A

Equation 5 - Cost of Erroneous Diagnosis

Health Diagnosis Error Sub-model (HDIERS) Effectiveness (HDIERSE) = (PECO + PI) * PDET * (1-PRDR) + Operational Cost of equipment [note: operational cost of the equipment is derived from initial annual operational cost of an equipment + discounted set-up cost.]

COHTEAMO Health Utility Sub-model (HUS)

COHTEAMO-HUS is designed to capture the utility function for measuring healthcare benefits. HUS can use QALY, DALY or any empirical function to calculate health quality. This sub-model is an area of further calibration and study.

COHTEAMO Benefit of Technology

Based on the equations identified for measuring effectiveness of various sub-models, a quantifiable benefit, can be calculated by using the following equation.

Equation 6 - COHTEAMO Benefit

COHTEAMO Benefit = (HDESE * HACSE * HDISE * HUS) – (HDIERSE)

Equation 7 - Technology Cost-benefit

Therefore, Technology Cost-benefit =

COHTEAMO Benefit - Technology Cost (*from* ***Error! Reference source not found.***)

COHTEAMO Benefit can be used to perform Pareto-chart analysis and aid in architects, entrepreneurs, health care directors to decide on adoption of a technological system or even a component of the system. **Error! Reference source not found.**. **Error! Reference source not found.**), shows Pareto analysis of sample Technological systems. It can therefore be inferred that COHTEAMO, can provide a quick measure for calculation of CBA.

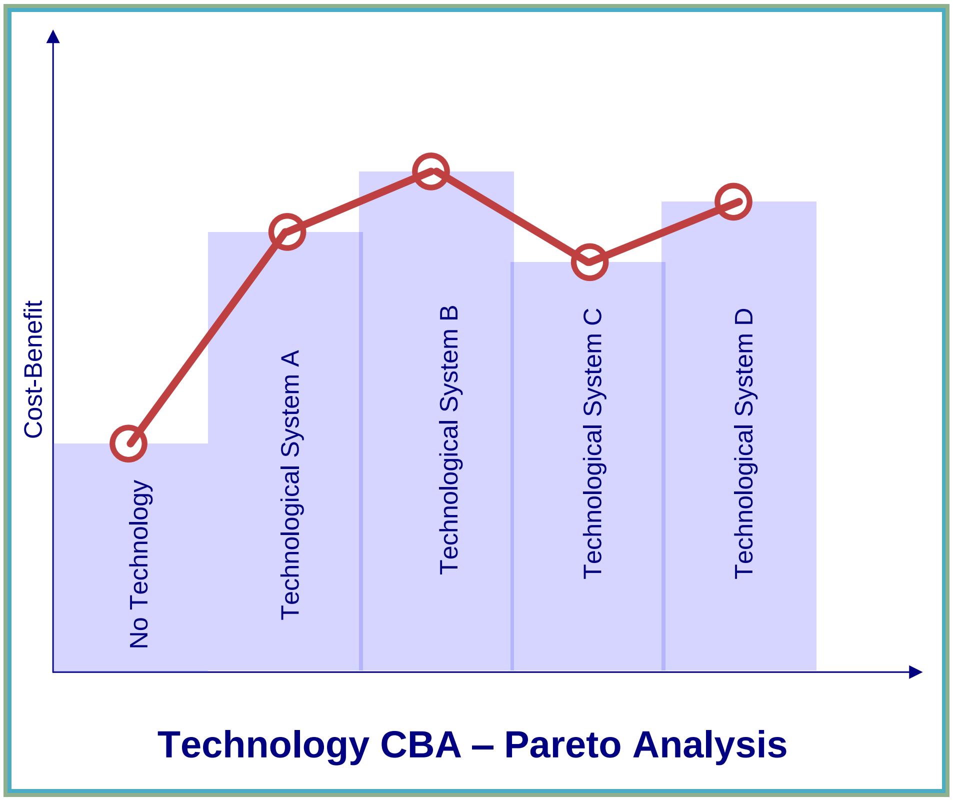

Figure 3 Pareto Analysis of Technology adoption and its Cost Benefit Analysis

Conclusion

Based on your theoretical research and analysis, COHTEAMO will be very instrumental for our project and research needs. However, the system and the technologies under consideration have the scope of transforming itself from a community project to a network of community projects. Further extensions of COHTEAMO can be designed to apply the Systems of Systems (SoS) approach of cost-estimation, and provide a comprehensive and holistic view of cost-estimation, and benefit analysis.

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Appendix

HDES Rating Scales

HDES Rating scales are used to estimate the detection effectiveness of a particular technology.

Personnel Rating Scale

	Very Low	Low	Nominal	High	Very High
PECA Rating Scale	Poor	Low	Fair	Good	Excellent
	0.1	0.8	1.0	1.2	1.5
PEED Rating Scale	Uneducated	8th grade	12th grade	Bachelor	Masters
	0.1	0.8	1.0	1.2	1.5

Product Rating Scale

	Very Low	Low	Nominal	High	Very High
PDOR	<0.6	[0.6, 0.75)	[0.75, 0.8)	[0.8, 0.95)	[0.95, 1.00]
PDET					
PDVO	<0.8	[0.8, 0.9)	[0.9, 0.95)	[0.95, 0.98)	[0.98, 1.00]

Process Rating Scale

	Very Low	Low	Nominal	High	Very High
PRDR Rating Scale	<90%	90%	100%	100%	100%
	0.5	0.8	1.0	1.0	1.0

Disease Prevalence Rating Scale

Disease	Prevalence Rate
x	0.80
y	0.20
z	0.35

HACS Rating Scales

HACS Rating scales are used to estimate the accessibility effectiveness of a technology adoption.

Distance Rating Scales

	Very Low	Low	Nominal	High	Very High
DIST	0	[0.5, 1]	[1,5]	[5, 10] km	>10km
Rating Scale	1.0	1.0	1.0	0.8	0.6
WECO	Excellent	Very Good	Good	Harsh	Extreme
Rating Scale	1.0	1.0	1.0	0.5	0.2
TRCO	0	0	[0, 5)	[20,50]	[50,2000]
Rating Scale	1.0	1.0	1.0	0.8	0.5
TRRE	<50%	<70%	<85%	<90%	<=100%
Rating Scale	0.2	0.5	1.0	1.0	1.0
TRAV	<50%	<70%	<85%	<90%	<=100%
Rating Scale	0.2	0.5	1.0	1.0	1.0

HDIS Rating Scales

HDIS Rating scales are used to estimate the diagnosis effectiveness of a particular technology.

Personnel Rating Scale

	Very Low	Low	Nominal	High	Very High
PECA	Poor	Low	Fair	Good	Excellent
Rating Scale	0.1	0.8	1.0	1.2	1.5
PEED	Uneducated	8th grade	12th grade	Bachelor	Masters
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PDET					
PDVO	<0.8	[0.8, 0.9)	[0.9, 0.95)	[0.95, 0.98)	[0.98, 1.00]

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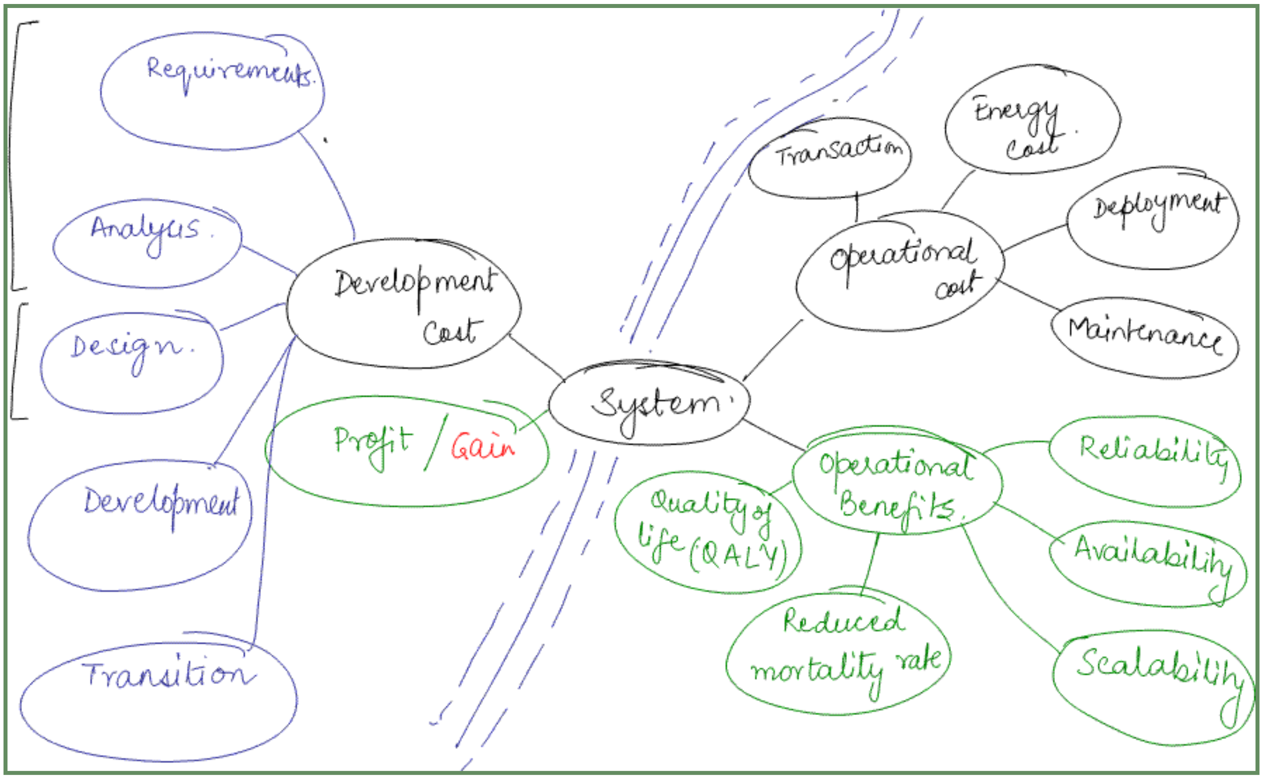

Figure 4 - Map of project cost breakdown