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Budget Estimate and Network Analysis of an Improved Smart Waste Bin: Microsoft Project Approach.

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ABSTRACT

The study, budget estimate and network analysis of an improved smart waste bin using Microsoft project approach was successfully carried out. The large scale budget estimate was achieved using small scale improved waste bin resources. Results revealed that the actual budget estimate was found to be # 2,005,000.00 with project duration of 159days and actual work of 784 hours. In addition, the % complete line was above the cumulative cost line and that indicated that the project was not over budgeted. Work/task started on Sat 9/24/22 and finished on Mon 1/30/23 with % completion of 99% as study indicated. Also, the work burn down, which shows 99% of completed work and 1% of remaining work existing among the supervisor and stakeholder, was discovered to be a work of 4 hours respectively. The study also showed that the welding Engineer and the supervisor Engineer have the largest work availability among other work resources. It was further discovered that the critical tasks were welding work and supervisory work with the critical path being found to be 7, 8,9,10. The researchers made the following recommendations: Project crashing could be adopted to reduce project duration when cost is not a constraint, Two supervisory Engineers and two welding Engineers could be employed to reduce workload and tasks duration, Contingency cash reserve should be made available to accommodate market fluctuation, etc.

Keywords ---- budget estimate, Microsoft project, actual work, resources, critical tasks, cumulative cost line.

I. INTRODUCTION

Background of the Study

Effective and efficient waste management is a critical component of a smart city. Generally, waste management has proved to be a tedious task for bodies assigned with the task. Waste overflow and the menace of degradable wastes as they affect communal health and environmental aesthetics are key challenges faced by waste managers (Ogunwolu, Mbom, Raji and Omiyale, 2020).

Karadimas, Papalambrou, Gialelis, and Koubias (2016) defined a smart city as urban area that integrates different types of internet of things (IOT) sensors to collect data and use the data to manage assets and resources such as schools, libraries, transportation system, hospital, power plants, traffic system and waste management efficiently. This concept is associated with real time systems and array of sensors by gathering data from human, objects and processing the data for decision making in real time situation.

An improved Smart Waste Bin here refers to an intelligent waste management system that tracks in real time the fill-level and smell (biodegradability) of the waste in it and alerts the waste managers once the set threshold for level or smell is reached.

Microsoft project in this article is project management software designed to assist a project manager in developing a schedule, assigning resources to tasks, tracking progress, evaluating critical tasks, managing budget and analyzing workloads.

Network analysis is a system of planning project outline by evaluating different activities associated with it. A project is broken down into smaller activities or tasks, which are then organized according to a logical sequence.

UNEP (2005) stated that the management of waste has been considered to be the responsibility of government, financed by general revenues. Currently, moderations policies and pressures from multilateral financial institutions, and partly as a result of pressures to limit taxes, governments have increasingly focused on identifying specific revenue sources for waste management. This necessitated need to control the production cost of waste management systems. Hence, the paper aimed at studying budget estimate and network analysis of an improved smart waste bin through Microsoft approach.

Statement of Problem

The minimization of the production cost of a smart waste bin begins with effective and efficient development of a schedule, proper assignment of resources to tasks, tracking progress, evaluating critical tasks, managing and meeting budget timeline and analyzing workloads for simplifications.

According to UNEP (2005) the management of waste has been considered to be the responsibility of government, financed through general revenues. Currently, moderations policies and pressures from multilateral financial institutions, and partly as a result of pressures to limit taxes, governments have increasingly focused on identifying specific revenue sources for waste management. This necessitated need to control the production cost of waste management systems. It is on this note that the researchers aimed at determining the budget estimate and network analysis of an improved smart waste bin through Microsoft project approach.

Purpose of the Study

The general purpose f the study is to determine the budget estimate and network analysis of an improved smart waste bin through Microsoft project approach. Specifically, the study would evaluate the:

1) Critical activities
2) Critical path
3) Actual cost and actual work required.

Significance of the Study

The result of this study will be beneficial to environmental /production engineers and project managers in the following ways:

1) Production/ environmental Engineers can use the study to avoid cost override during production/fabrication of smart waste bins to achieve a reliable and affordable product.
2) The knowledge of network analysis can be used by project managers to improve quality and supervision of project deliverables.

Scope of the Study

This research focused on establishing the budget estimate and network analysis of an improved smart waste bin through Microsoft project approach. So, all efforts were directed towards the general objectives. It must be noted that the design and fabrication of the adopted smart waste bin are beyond the scope of this paper. The budget estimate for large scale smart waste bin was done using a small scale smart waste bin resources. Researchers are members of Federal Polytechnic Nekede, within South East of Nigeria. Results may be subject to variations within other parts of the World or in using other project management software.

Review of Related Literature

Navghane et al., (2016) studied a microcontroller-based dust bins using the Infrared Wireless Systems and central device that displays up-to-date garbage status on the Wi-Fi mobile web client with HTML page the workings of the Wi-Fi module, necessary for its implementation, are a major component of the prototype. Folianto et al., (2015) evaluated a smart bin system for data collection and data supply by a network of wireless mesh. In order to reduce power consumption and optimize operating time, they suggested duty cycle approach. Glouche and Couderc (2013) studied an insightful waste management of self-describing objects. Each waste object was connected with a smart bin application based on information found in their tags. The waste is monitored with intelligent bins utilizing an RFID-based program without external support. Yusof et al., (2017) studied the implementation of an intelligent waste monitoring system in real-time, and in particular to notify municipalities through SMS. The sensing elements were waste level ultrasound sensor, a GSM module to deliver the SMS, and an Arduino UNO to monitor the operation. Karadimas et al., (2016) defined a smart city as urban area that integrates different types of internet of things (IOT) sensors to collect data and use the data to manage assets and resources such as schools, libraries, transportation system, hospital, power plants, traffic system and waste management efficiently. Ogunwolu et al., (2020) stated that the effective and efficient waste management is a critical component of a smart city. Generally, waste management has proved to be a tedious task for bodies assigned with the task. Waste overflow and the menace of degradable wastes as they affect communal health and environmental aesthetics are key challenges faced by waste managers. UNEP (2005) stated that the management of waste has been considered to be the responsibility of government, financed by general revenues. Currently, moderations policies and pressures from multilateral financial institutions, and partly as a result of pressures to limit taxes, governments have increasingly focused on identifying specific revenue sources for waste management.

Principle of operation of the implemented system

The first ultrasonic sensor senses a user close to the bin and directs the servo motor through the Arduino MCU to open the lid for some predetermined time, after which it closes the lid. The MQ series sensors sense the presence of methane, ammonia and Sulphide gases (which are functions of level of biodegradability of waste in the bin) emerging from the bin. These data are read by the microcontroller in real time and displayed on the serial monitor. The second ultrasonic sensor also measure the fill levels of the waste in real time and sends the result to the microcontroller unit, which is also displayed on the serial monitor. The data from the sensors are sent to a Thing Speak web server in real time by the microcontroller unit via wireless technology using ESP8266 Wi-Fi module. The concerned authorities manage the web server with login access to the webpage (Ogunwolu, Mbom, Raji and Omiyale, 2020).

Fig 1.0: a typical smart waste bin.

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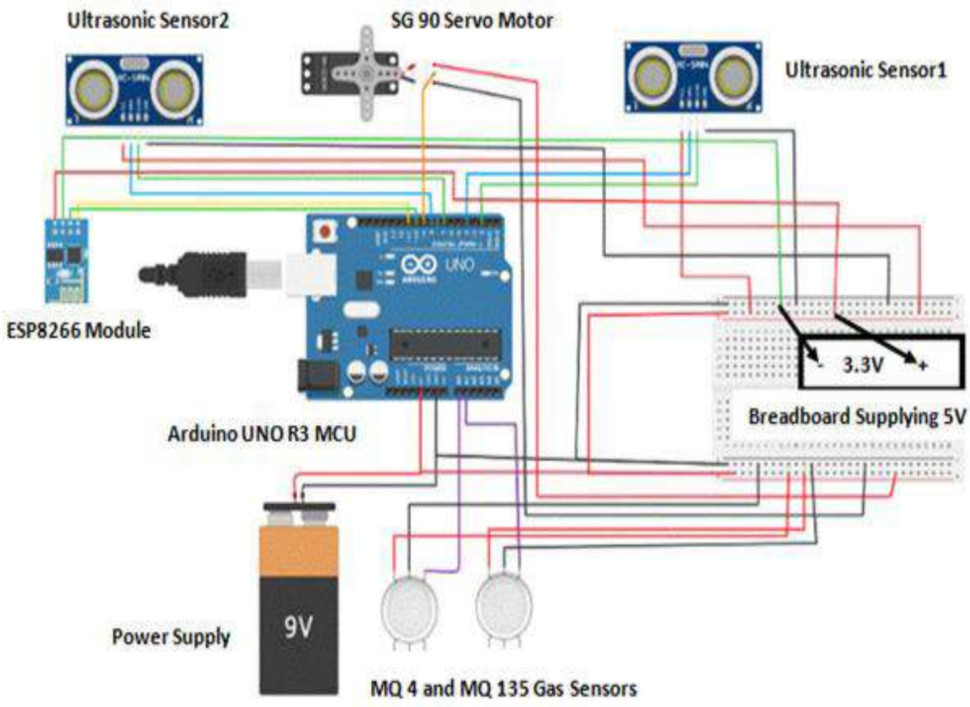

Source: (Ogunwolu et al., 2020)
Implemented circuit of an improved smart waste bin

Methodology

The table 1.0 below gives the various resources used for the implementation of an improved smart waste bin. The resources would further be analyzed using Microsoft project. The budget estimate for large scale smart waste bin was done using a small scale smart waste bin resources as shown in the table1.0 below. The Work Break Down/ activities required for the building of the small scale project were entered at the task column with their respective predecessors.

Design Analysis

Size of Storage Container $= \frac{N \times G \times F}{D + \text{Capacity margin}}$ m^3 …(as cited in Ogani et al., 2018)

Where N = number of population served;
G = generation rate in kg/day;
F= frequency of collection, can be broken down to be either 7 days or 6 days;
For 7 days, capacity margin of 33 is chosen whereas for 6 days, capacity margin of 66 is chosen.
D = number of individual containers required.

Volume of vehicle required in the collection is as below:

$V_v = \frac{V_w}{R}$ ….. (2)

Where V_v = volume of vehicle required; V_w = volume of solid waste generated; and R = compaction ratio.

Number of trips required is given below

$N_{tr} = \frac{\text{total volume of solid waste to be discarded}}{V_v R}$ … (3)

The Ultrasonic Sensor distance is given below;

Distance $= \frac{\text{speed} \times \text{time}}{2}$ … (4)

The operation of the MQ gas sensor is as per the function below;

R = f(N) … (5) (Abdelhalim, 2020)

Where R = resistance of the sensor; and N = gas concentration.

The relative sensor response is shown below;

Relative Sensor Response $= \frac{(X-Y)}{Y}$ … (6)

Where X = maximum value of sensor measured parameter; and Y = initial value of sensor measured parameter.

The formulas for determing the cost of metal welding operation are shown below:

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$$\text{Labor \& overhead} = \frac{\text{Labor \& Overhead cost}/hr}{\text{Deposition rate},\frac{kg}{h}\times \text{operatingfactor}} \quad \text{.... (7) (Raj, 2006)}$$

$$\text{Electrode} = \frac{\text{Electrode cost}/kg}{\text{Deposition efficiency}} \quad \text{...(8)}$$

$$\text{Gas} = \frac{\text{Gas flow rate},\frac{l}{min}\times \text{gascost}/l}{\text{Deposition rate},kg/hr} \quad \text{...(9)}$$

$$\text{Power} = \frac{\text{Cost per kWh}\times \text{volts}\times \text{amps}}{1000\times \text{deposition rate}} \quad \text{...(10)}$$

$$\text{Flux} = \frac{\text{flux cost}/kg\times 1.4}{\text{Deposition efficiency}} \quad \text{.... (11)}$$

II. RESULTS AND PRESENTATIONS

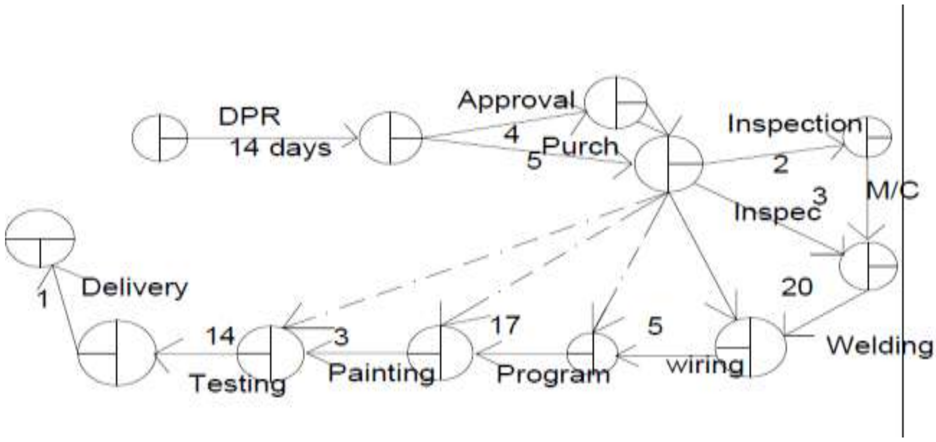

Fig. 0.0: Network Diagram of the Project.

Table 1.0: Resources used for Improved Smart Waste Bin.

S/N	MATERIALS	FUNCTION	COST #	DURATION
1	(5) mild steel sheet, 1.5mm thickness	Forming the body	30,000	
2	Mild steel sheet thicker	Waste bin cover	6000	
3	Angle iron	Handle	1000	
4	4 caster wheel	Movement	4000	
5	Cover shaft support	Reinforcement	3000	
6	Arduino UNO	Microcontroller	8000	
7	Servo motor	Opening of cover	3000	
8	LCD 16*4	Display	3000	
9	Lead acid battery 12v	Power source	7000	
10	SIM900AV4.0	GSM module	12000	
11	DC wire 3 yards	Connection	450	
12	1 SPDT	Switch	2000	
13	3 terminal block	Connectors	9000	
14	2 HC-SR04	Ultrasonic sensor	6000	
15	2 MQ135/4	Gas sensors	5000	
16	Bolts and nuts	Mounting of motor	300	
17	Sim card	MTN 4G	500	
18	2 packs of electrodes	Welding	20000	
19	Cutting stones	Cutting	6000	
20	Welding Engineer	Welding	20000	7 days
21	Filler and sand paper	Finishing	7000	

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22	Electrician	Wiring	10000	9 days
23	Programmer	Programming	15000	7 days
24	Painter	Painting	10000	3 days
25	Engineer supervisor	Testing	25000	14 days
26	Stakeholder	Delivery		1 day

Table 1.1: Shows Task, Duration, Start, Finish, Predecessors, Resource Name and Cost from Microsoft Project.

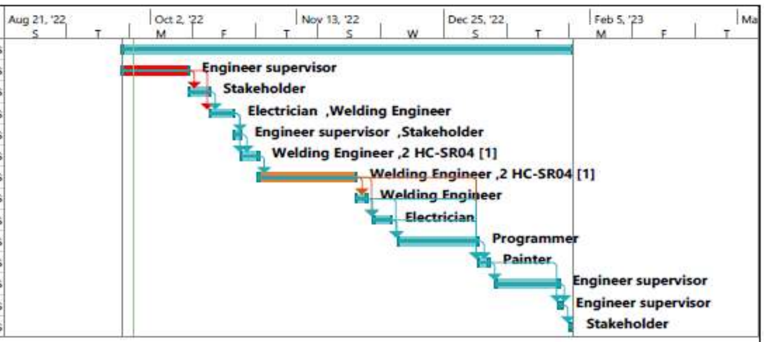
ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Cost
1	✓		SMART WASTE BIN	92 days	Sat 9/24/22	Mon 1/30/23			₦ 2,005,000.00
2	✓		Detailed project report	14 days	Sat 9/24/22	Wed		Engineer	₦ 375,000.00
3	✓		Approval	4 days	Thu 10/13/22	Tue 10/18/22	2	Stakeholder	₦ 0.00
4	✓		Purchasing of materials	5 days	Wed	Tue 10/25/22	2,3	Electrician	₦ 180,000.00
5			Inspection	2 days	Wed 10/26/22	Thu 10/27/22	4	Engineer superviso	₦ 75,000.00
6	✓		Measurement and cutting	3 days	Fri 10/28/22	Tue 11/1/22	4,5	Welding Engineer	₦ 89,000.00
7	✓		Welding	20 days	Wed 11/2/22	Tue 11/29/22	6	Welding Engineer ,	₦ 429,000.00
8	✓		Finishing Operation	3 days	Wed 11/30/22	Fri 12/2/22	7	Welding Engineer	₦ 80,000.00
9	✓		Wiring	5 days	Mon 12/5/22	Fri 12/9/22	7,8	Electrician	₦ 60,000.00
10	✓		Programming	17 days	Mon 12/12/22	Tue 1/3/23	8,9	Programmer	₦ 270,000.00
11	✓		Painting	3 days	Wed 1/4/23	Fri 1/6/23	10,7,8,9	Painter	₦ 40,000.00
12	✓		Testing	14 days	Mon 1/9/23	Thu 1/26/23	11	Engineer superviso	₦ 375,000.00
13	✓		Delivery	1 day	Fri 1/27/23	Fri 1/27/23	11,12	Engineer superviso	₦ 50,000.00
14	✓		Closing	1 day	Mon 1/30/23	Mon 1/30/23	13	Stakeholder	₦ 0.00

Project: Project1 SMART WAST
Date: Tue 9/27/22

Page 1

Table 1.2: Shows Gantt chart of tasks, Actual cost and Actual work hours from Microsoft Project.

Actual Cost	Actual Work
₦ 2,005,000.00	248 hrs
₦ 375,000.00	112 hrs
₦ 0.00	32 hrs
₦ 180,000.00	80 hrs
₦ 62,500.00	24 hrs
₦ 89,000.00	24 hrs
₦ 429,000.00	160 hrs
₦ 80,000.00	24 hrs
₦ 60,000.00	40 hrs
₦ 270,000.00	136 hrs
₦ 40,000.00	24 hrs
₦ 375,000.00	112 hrs
₦ 50,000.00	8 hrs
₦ 0.00	8 hrs



Project: Project1 SMART WAST
Date: Tue 9/27/22

Page 2

Table 1.3: Shows Resource Sheet from Microsoft Project.

Resource Name	Type	Material Label	Initials	Group	Max. Units	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar	Code
packs of electrodes	Material		P			₦ 10,000.00		₦ 20,000.00	Prorated		E7018
<New Resource>	Material		<			₦ 0.00		₦ 0.00	Prorated		
1 SPDT	Material		1			₦ 0.00		₦ 2,000.00	Prorated		
2 HC-SR04	Material		2			₦ 3,000.00		₦ 6,000.00	Prorated		
2 MQ135/4	Material		2			₦ 2,500.00		₦ 5,000.00	Prorated		
3 terminal block	Material		3			₦ 3,000.00		₦ 9,000.00	Prorated		
Angle iron	Material	1 by 1 inch	A			₦ 1,000.00		₦ 1,000.00	Prorated		HS 72169
Arduino UNO	Material		A			₦ 0.00		₦ 8,000.00	Prorated		
Bolts and nuts	Material		B			₦ 150.00		₦ 300.00	Prorated		
caster wheel	Material		c			₦ 1,000.00		₦ 4,000.00	Prorated		
Cover shaft support	Material		C			₦ 1,000.00		₦ 3,000.00	Prorated		
Cutting stones	Material		C			₦ 0.00		₦ 6,000.00	Prorated		NIC 2396
DC wire 3 yards	Material		D			₦ 0.00		₦ 450.00	Prorated		
Electrician	**Work**		**E**		**0%**	**₦ 1,250.00/hr**	**₦ 0.00/hr**	**₦ 10,000.00**	**Prorated**	**Standard**	
Engineer supervisor	**Work**		**E**		**100%**	**₦ 3,125.00/hr**	**₦ 0.00/hr**	**₦ 25,000.00**	**Prorated**	**Standard**	
Filler and sand paper	Material		F			₦ 0.00		₦ 7,000.00	Prorated		
LCD 16*4	Material		L			₦ 0.00		₦ 3,000.00	Prorated		
Lead acid battery 12v	Material		L			₦ 0.00		₦ 7,000.00	Prorated		
mild steel sheet thicker	Material	8mm	m			₦ 6,000.00		₦ 6,000.00	Prorated		HSN7207
mild steel sheet	Material	1.5mm	m			₦ 6,000.00		₦ 30,000.00	Prorated		HSN7207
Painter	Work		P		0%	₦ 1,250.00/hr	₦ 0.00/	₦ 10,000.0	Prorated	Standard	

							hr	0			
Programmer	Work		P		0%	₦ 1,875.00/hr	₦ 0.00/hr	₦ 15,000.00	Prorated	Standard	
Servo motor	Material		S			₦ 0.00		₦ 3,000.00	Prorated		
Sim card	Material		S			₦ 0.00		₦ 500.00	Prorated		
SIM900A V4.0	Material		S			₦ 0.00		₦ 12,000.00	Prorated		
Stakeholder	Work		S		100%	₦ 0.00/hr	₦ 0.00/hr	₦ 0.00	Prorated	Standard	
Welding Engineer	**Work**		**W**		**0%**	**₦ 2,500.00/hr**	**₦ 0.00/hr**	**₦ 20,000.00**	**Prorated**	**Standard**	

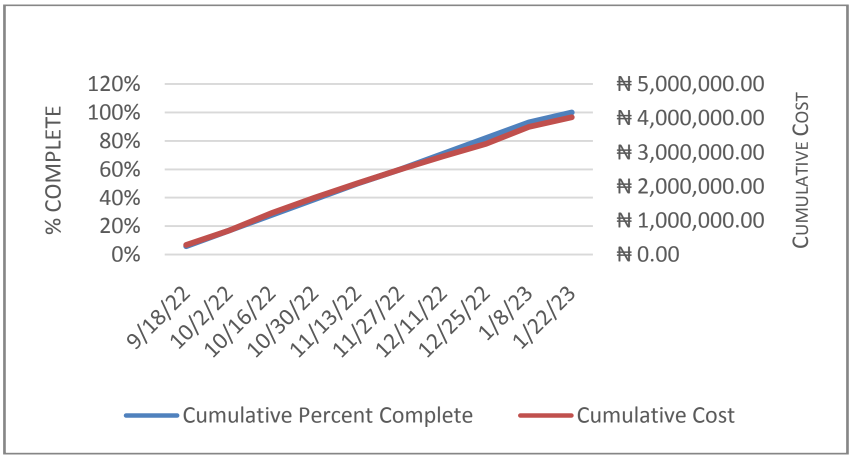


Fig 1.0: Progress versus Cost

Progress made versus the cost spent over time. If % complete line below the cumulative cost line, your project may be over budget.

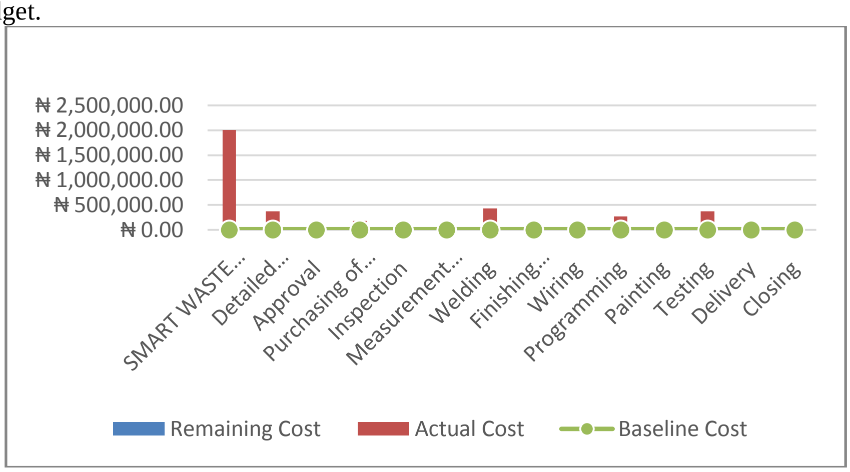


Fig 1.1: Progress versus Project Budget

Table 1.4: Shows Project cost Summary.

Name	Actual Cost	Remaining Cost	Baseline Cost	Cost	Cost Variance
SMART WASTE BIN	₦ 2,005,000.00	₦ 0.00	₦ 0.00	₦ 2,005,000.00	₦ 2,005,000.00
Detailed project report	₦ 375,000.00	₦ 0.00	₦ 0.00	₦ 375,000.00	₦ 375,000.00
Approval	₦ 0.00	₦ 0.00	₦ 0.00	₦ 0.00	₦ 0.00
Purchasing of materials	₦ 180,000.00	₦ 0.00	₦ 0.00	₦ 180,000.00	₦ 180,000.00
Inspection	₦ 62,500.00	₦ 12,500.00	₦ 0.00	₦ 75,000.00	₦ 75,000.00
Measurement and cutting	₦ 89,000.00	₦ 0.00	₦ 0.00	₦ 89,000.00	₦ 89,000.00
Welding	₦ 429,000.00	₦ 0.00	₦ 0.00	₦ 429,000.00	₦ 429,000.00
Finishing Operation	₦ 80,000.00	₦ 0.00	₦ 0.00	₦ 80,000.00	₦ 80,000.00
Wiring	₦ 60,000.00	₦ 0.00	₦ 0.00	₦ 60,000.00	₦ 60,000.00
Programming	₦ 270,000.00	₦ 0.00	₦ 0.00	₦ 270,000.00	₦ 270,000.00
Painting	₦ 40,000.00	₦ 0.00	₦ 0.00	₦ 40,000.00	₦ 40,000.00
Testing	₦ 375,000.00	₦ 0.00	₦ 0.00	₦ 375,000.00	₦ 375,000.00
Delivery	₦ 50,000.00	₦ 0.00	₦ 0.00	₦ 50,000.00	₦ 50,000.00
Closing	₦ 0.00	₦ 0.00	₦ 0.00	₦ 0.00	₦ 0.00

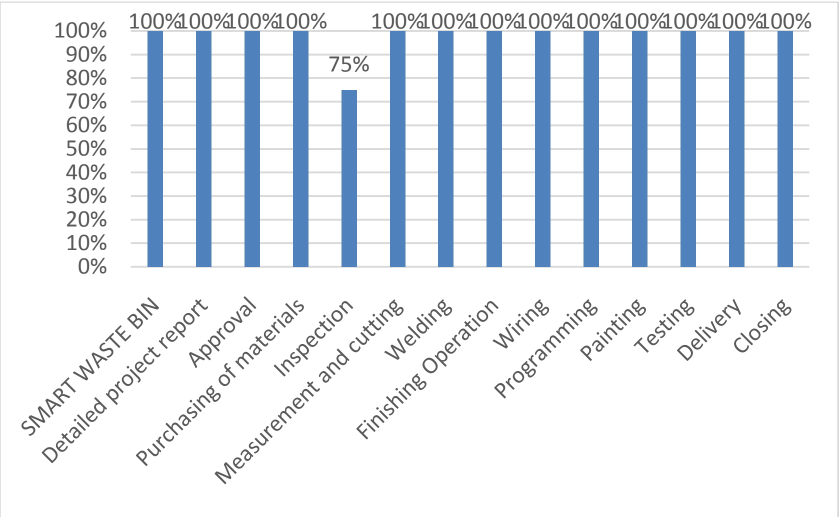


Fig 1.2: % Complete (99%)

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Status for all top-level tasks.

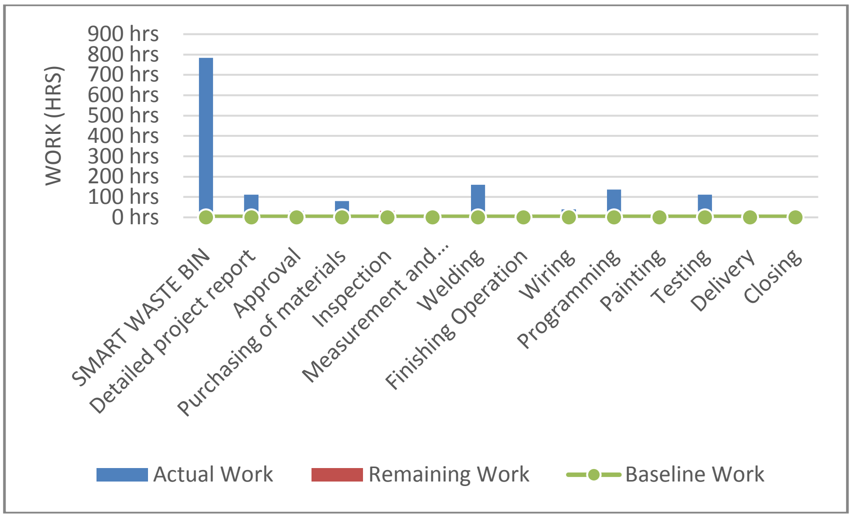

Fig 1.3: Actual work hour is 784hrs.

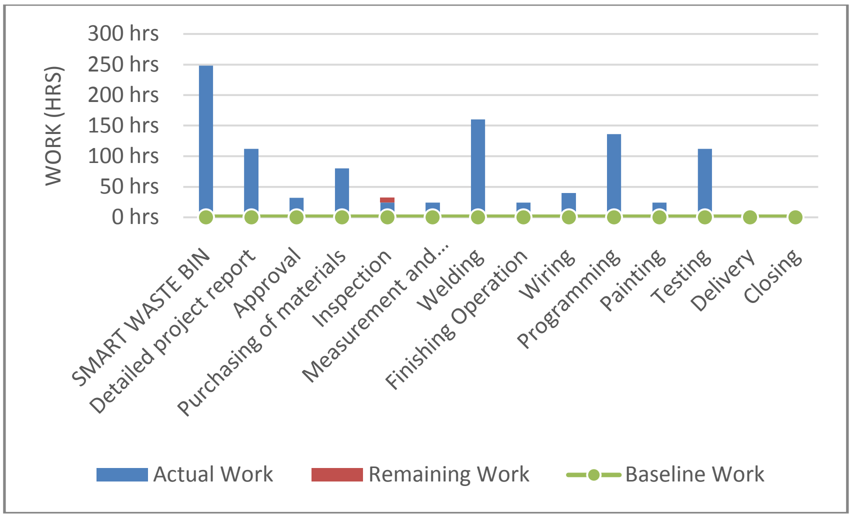

Fig 1.4: Work Overview

Work started on Sat 9/24/22 and finished on Mon 1/30/23.

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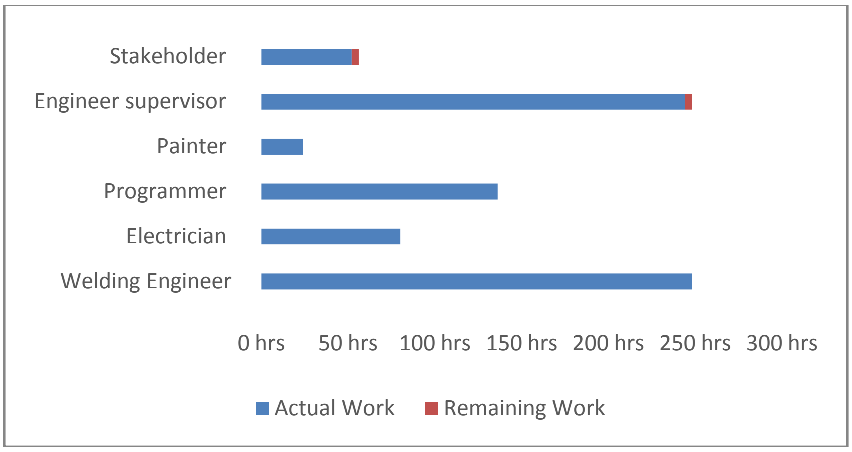

Fig 1.5: Work Burn downs

Work burn down shows how much work you have completed and how much you have left. If the remaining cumulative work line is steeper, then the project may be late.

Table 1.4: Shows Project remaining work was found to be 8 hrs

Name	Start	Finish	Remaining Work
Welding Engineer	Wed 10/19/22	Fri 12/2/22	0 hrs
Electrician	Wed 10/19/22	Fri 12/9/22	0 hrs
Programmer	Mon 12/12/22	Tue 1/3/23	0 hrs
Painter	Wed 1/4/23	Fri 1/6/23	0 hrs
Engineer supervisor	Sat 9/24/22	Fri 1/27/23	4 hrs
Stakeholder	Thu 10/13/22	Mon 1/30/23	4 hrs

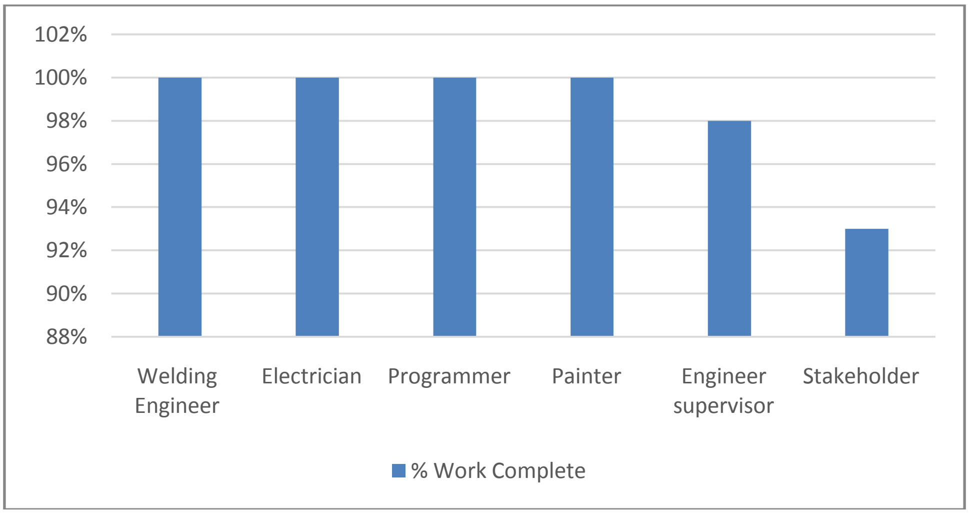

Fig 1.6: %work complete

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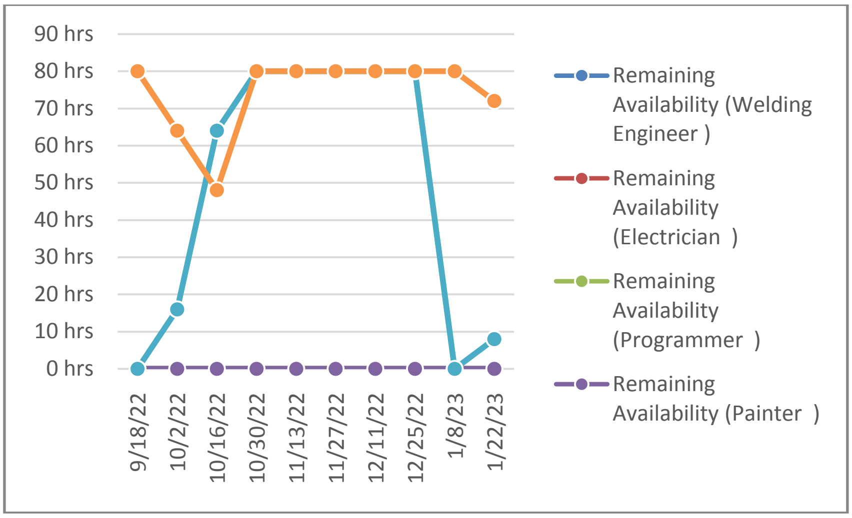

fig 1.7: Remaining Availability

The figure above shows remaining availability for all work resources.

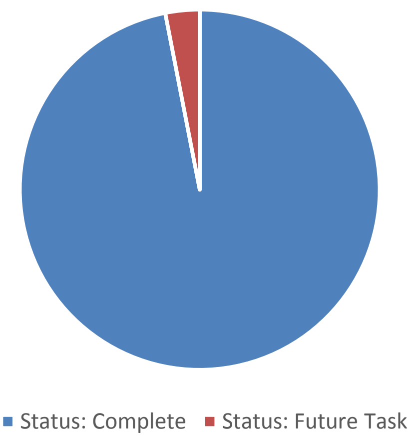

Fig 1.8: Critical Tasks

III. DISCUSSION

The results of the study, budget estimate and network analysis of an improved smart waste bin were discussed here. The large scale budget estimate was achieved using small scale improved waste bin resources. According to **table 1.1 and table 1.2,** the actual budget estimate was found to be **# 2,005,000.00** with project duration of 159days and actual work of 784 hours. Furthermore, **Fig 1.0** shows that the % complete line was above the cumulative cost line and that indicated that the project was not over budgeted. Work/task started on Sat 9/24/22 and finished on Mon 1/30/23 with % completion of 99% as shown in **fig. 1.2. Fig. 1.5** indicated the work burn down, which shows 99% of completed work and 1% of remaining work among the Engineer supervisor and stakeholder with the remaining work of 4 hours each according to **table 1.4.** The study also showed that the welding Engineer and the supervisor Engineer have the largest work availability among other work resources, as shown in **fig. 1.7.**

Table 1.2 and fig. 1.8 indicated that the critical tasks were welding work and supervisory work with the critical path being found to be 7, 8,9,10.

IV. CONCLUSION

The budget estimate and network analysis of an improved smart waste bin through Microsoft project was correctly achieved. Obviously, the budget estimate and network analysis for large scale improved smart waste bin was done using resources of a small scale smart waste bin. However, reduction in project cost and project duration could be achieved through effective project cost control measures and project crashing respectively. The results of the study was in line with Samann (2017) who estimated the budget of a small scale improved smart waste bin to be # 127,680.00 or 168$.

V. RECOMMENDATIONS

The following recommendations are suggested based on the study:

1) Project crashing can be adopted to reduce project duration when cost is not constraint.
2) We recommended that two supervisory Engineers and two welding Engineers can be employed to reduce workload and tasks duration.
3) Contingency cash reserve should be made available to accommodate market fluctuation.
4) This research can also be done using other advanced software for generalization.

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