# Design of Software used in Oxbow Concept & Resources Limited Project Planning

[1]OJONG, O.E., [2]OKWU, N.O
[1]*Lecturer Department of Chemical Engineering, Faculty of Engineering and Technology, University of Calabar, P.M.B 1115, Calabar, Cross River State, Nigeria*
[2]*Research Student of Department of Chemical/Petrochemical Engineering, Rivers State University, P.M.B 1050, Nkpolu Oroworukwo Port Harcourt, Rivers State, Nigeria.*

***ABSTRACT***
*The sequence of activities from the beginning of a project to its completion is essentially the same, whether it's a small two or three-day project or a large project that spans for several months. These activities are grouped into four different phase which are the initiation phase, planning phase, execution phase, and the close out or termination phase. This research work focused on both the planning and execution phases. The research was aimed at providing a suitable project planning and scheduling advisory system. The critical path method (CPM) was employed in achieving it. A computer program (software) in project scheduling used for determining critical paths, shortest project duration, and project completion date was developed. The developed software was compared with existing planning software (primavera). The result on the critical paths were the same but the newly developed software was more user friendly (much easier to use) as it does not require high level of expertise to use. The result of this comparison suggest that the developed planning software is a better planning model for oxbow concept & resources Limited in particular, and the construction industry in general, because of its ability to save the cost of training personnel to use primavera planning software (which cost N200,000 per personnel). This will thereby enhance grassroots reduction of scarce resources and increase productivity in the industry.*

***Keywords****: Design, Software, Project, Planning, Oxbow Concept & Resources LTD, and Critical path.*

## I. Introduction

The innovative project planning software available to construction firms is the Microsoft project (MPS) and it make use of the Gantt chart (a horizontal bar chart developed as a construction control tool in 1917 by Henry L. Grantt, an American engineer and social scientist) *[1]*. The other one is the PERT chart (a project evaluation and review technique otherwise known as the program evaluation and review technique developed in 1958 by Booz Allen Hamilton) *[2]*. Both the Gantt charts and PERT chart have the simple versions created on graph paper and the more complex automated version created using project management applications such as Microsoft project or excel *[3]*.

The most common mathematical programming approaches are linear programming (LP) models, of which a wide variety exists *[4]*. In most of these models capacity is modeled as a fixed upper bound on the total amount of a resource that can be consumed in a time period *[5]*.

The classic algorithms also called exact algorithms are group of algorithms that separates the environment into different sections. These are enhanced version of the preliminary motion planning algorithms bug, potential field *[6]*. Mathematical programming and the geometry-based algorithm are widely used for this research work *([7], [5])*.

A vast amount of literature has been dedicated to project scheduling and includes: *Demeulemeester and Herroelen, (1992) [8]; Ozdamar and Ulusoy, (1995) [9]; Kolisch and Drexel, (1996) [4];* to develop a Linear Programming model with both work in progress (WIP) and finished goods inventories that were modeled distinctly, under most reasonable assumptions on inventory holding costs (specifically, that inventory holding costs are non-decreasing in the amount of processing that has be completed on the project) *[10];* De Boer and *Schutten (1999) [11]* propose several heuristic algorithms for RCCP problem in which they try to minimize the total number of hours of non-regular capacity that is used, that is $C_{kt} = 1$ ($\forall$ K, t); Linear programming models, as pointed out by Hackman and Leachman (1999) implicitly assume that a project is uniformly distributed tenuously.

*Mohring, (1984) [12]* utilized linear programming in his model formulation. He commented that while there is no difficulty in problem formulation, there are a large number of variables and constrains even for small-sized problems and as such, the model has very little practical application. He concluded that in order to be certain of achieving the 'best' solution, it might be necessary to try different heuristics and to select the best, which may give the optimal or near-optimal result, *Akpan and Chinzea, (2000) [13]; De Boer and Schutten (1999) [11]* proposed on problem (P) that one or more precedence relations are violated in intervals $(r_i, d_i)$ and $(r_j, d_j)$ overlap and the precedence relation between job $J_i$ and job $J_j$ is "repaired" by specifying a week $T_{ij}$ $(r_i + p_i \leq T_{ij} \leq d_i - p_j + 1)$ before which job $J_i$ must be finished and before which job $J_j$ cannot start; *De Boer and Schutten (1999) [11]* suggest a number of heuristics based on problem (P), that is, based on problem (Ps) with set S such that $S_j = r_j$ and $C_j = d_j$ ; *Hans and Froyld, (2002) [5]*, and also consider the so-called resource loading problem. The resource loading problem can be seen as an RCCP problem with simple precedence constraints, where the project network is a chain. They present a hybrid model of the resource-driven and the capacity-driven variants; they extended the precedence relations as in our RCCP problem description *[5]; Kolisch and Kelly (1995) [14]* was more interested in those heuristics that give the shortest project duration; *De Boer and Schutten, (1999) ([11], [15])* conducted similar studies for the multi-project-scheduling situation, and their conclusion was that the shortest activity for shortest project (SASP) and maximum total work contents (MAXTWK) were found to be superior to the other scheduling rules; Some early pioneers include Sir James Watt, who built the first stem engine and Charles Babbage (from the United states of America) one of those who developed the modern day computers.

However, the above planning software requires a high level of training, and cannot be used by everyone. It is for this problem that the research will focus to develop a computer program (a user interface) in project scheduling used for determining critical paths, shortest project duration, and project completion date, in construction industries (Oxbow Concept and resources limited as a case study) and to achieve this a simplified project capacity planning process that encourages the entrepreneur in the use of computational approach to project plan *([16], [17], [18])*.

## II. Material and Methods

### *A. Materials*

***Study Location***

Oxbow Concept and resources limited was hired by Exxon mobile limited at Onne terminal has fire protection system installed along side with the piping facilities that carry its petroleum products which was studied in this research work conducted at Onne terminal, Rivers State which was specifically based on reconstruction of the terminal's fire protection system, changing the pipe from epoxy coated carbon steel to heavy wall carbon steel.

***Data Collection***

Project planning in the construction industry has been investigated through the civil engineering. Project executed are broken down into activities prior to execution. Data for the project of reconstructing the terminal's fire protection system was collected from the department of civil engineering and project planning unit of Oxbow Concept & Resources limited and tabulated as shown in Table 1

**Table 1: Showing activities and resource data for the case study**

| Activities | Nodes | | Duration (weeks) | No. of shifts |
|---|---|---|---|---|
| | Starting | Ending | | |
| Mobilization | 1 | 2 | 1 | 1 |
| Engineering Design | 1 | 3 | 2 | 1 |
| Scarification & draining pipelines | 1 | 4 | 4 | 1 |
| Setting out | 2 | 5 | 8 | 1 |
| Cracking of road surface & concrete walls | 3 | 5 | 9 | 1 |
| Laying of pipeline | 5 | 7 | 7 | 1 |
| Casting and laying of Kreb & slabs | 3 | 6 | 3 | 1 |
| Installation and coating of pipelines | 4 | 6 | 6 | 1 |
| Charging line with foam seal chemical & Testing | 5 | 7 | 5 | 1 |
| Clean up and Demobilization | 7 | 8 | 10 | 1 |

***B. Methods***

***Data Analysis***

The project is broken into a number of rather large work packages, called job. The network diagram analysis is used to establish the critical path, which is the optimum solution. The models for the earliest finish time, latest finish time, total float time and others are developed as shown below.

$C_j$ = min ($d_j$, min $k_{1J}$; - $J_k$ $r_k$ – 1) (1)

**To determine earliest finish time:**

EFT=EST + Duration (2)

To determine late start time:

LST = LFT – Duration (3)

**To determine total float time**:

TF = LET – EST- Duration (4)

**Determination of the critical path or activities**

TF= LFT – EST – Duration = 0 (5)

**Determination of the critical cost**: sum up the duration of the activities on the critical path. Time is money (resource) as such referred to as cost.

Other important formulae or Equations are follows:

$$\text{(P): min} \sum_{t=1}^{T}\sum_{k=1}^{K} C_{kt}\ U_{kt}, \quad (6)$$

Subject to

$$\sum_{t=r_j}^{d_j} x_{jt} = 1 \qquad \forall j, \quad (7)$$

$$x_{jt} \le \frac{1}{p_j} \qquad \forall j,\ t, \quad (8)$$

$$U_{kt} \ge \sum_{j=1}^{n} q_{kj}\ x_{jt} - Q_{kt} \quad \forall k,\ t, \quad (9)$$

$$x_{jt}, U_{kt} \ge 0 \qquad \forall j,\ k,\ t, \quad (10)$$

$$x_{jt} \le \frac{s_{jt}}{p_j} \qquad \forall j,\ t, \quad (11)$$

Where parameter $S_{jt}$ indicates whether processing of job $J_j$ is allowed in week t:

$$s_{jt} = \begin{cases} 1 & \text{if } S_j \le t \le C_{j,} \\ 0 & \text{otherwise} \end{cases} \quad (12)$$

$$\sum_{\tau=r_j}^{t-1} \chi_{i\tau} \ge y_{jt} \quad \forall (i,j) \in \rho, \quad r_j \le t \le d_{i,} \quad (13)$$

$$\sum_{\tau=r_j}^{t} \chi_{jt} \le y_{jt} \qquad \forall j, t, \quad (14)$$

$$y_{jt} \in \{0,\ 1\}. \quad (15)$$

**Design the Software ([3], [19]}**

For the purpose of clarity, some of the codes used in designing the software are shown in the figure below:

```
Public Class Form3
    Dim act, desc As String
    Dim dur, start, en As Integer
    Dim ES, LS, EF, LF, TTF As Integer
    Private Sub btnLoadInput_Click(ByVal
sender As System.Object, ByVal e As
System.EventArgs) Handles btnLoadInput.Click
        act = Me.txtActivities.Text.ToString()
        desc =
Me.txtDescription.Text.ToString.ToString()
        start =
Val(Me.txtStartingPoint.Text.ToString())
        en = Val(Me.txtEndpoint.Text.ToString())
        dur = Val(Me.txtDuration.Text.ToString())
        Me.DataGridView1.Rows.Add(act, desc,
dur, start, en)
        Me.txtActivities.Text = ""
        Me.txtDescription.Text = ""
        Me.txtDuration.Text = ""
        Me.txtEndpoint.Text = ""
        Me.txtStartingPoint.Text = ""
        Me.txtActivities.Focus()
    End Sub
    Private Sub btnCompute_Click(ByVal sender
As System.Object, ByVal e As
System.EventArgs) Handles btnCompute.Click
        Dim I, J, K, N, MIX As Integer
        N = Me.DataGridView1.Rows.Count - 1
        K = 0
        Do
            For I = 0 To N
                J =
Me.DataGridView1.Rows(K).Cells(4).Value
                If
Me.DataGridView1.Rows(I).Cells(3).Value = 1
Then

Me.DataGridView1.Rows(I).Cells(5).Value = 0

Me.DataGridView1.Rows(K).Cells(6).Value =
```

```
Me.DataGridView1.Rows(K).Cells(5).Value +
Me.DataGridView1.Rows(K).Cells(2).Value

            ElseIf
Me.DataGridView1.Rows(K).Cells(4).Value =
Me.DataGridView1.Rows(I).Cells(3).Value
Then


Me.DataGridView1.Rows(I).Cells(5).Value =
Me.DataGridView1.Rows(K).Cells(6).Value

Me.DataGridView1.Rows(I).Cells(6).Value =
Me.DataGridView1.Rows(I).Cells(5).Value +
Me.DataGridView1.Rows(I).Cells(2).Value


              ElseIf I <> J And J = Me
DataGridView1.Rows(I).Cells(4).Value Then
                 MIX =
Math.Max(Me.DataGridView1.Rows(K).Cells(6
).Value,
Me.DataGridView1.Rows(I).Cells(6).Value)

Me.DataGridView1.Rows(I).Cells(5).Value =
MIX -
Me.DataGridView1.Rows(I).Cells(2).Value

Me.DataGridView1.Rows(I).Cells(5).Value =
Me.DataGridView1.Rows(I).Cells(6).Value -
Me.DataGridView1.Rows(I).Cells(2).Value

'Me.DataGridView1.Rows(I).Cells(6).Value =
Me.DataGridView1.Rows(I).Cells(5).Value -
Me.DataGridView1.Rows(I).Cells(2).Value
                 'Return

              End If

           Next

           K = K + 1

       Loop Until K = N

   End Sub

End Class
```

### *C. Flow Chart*

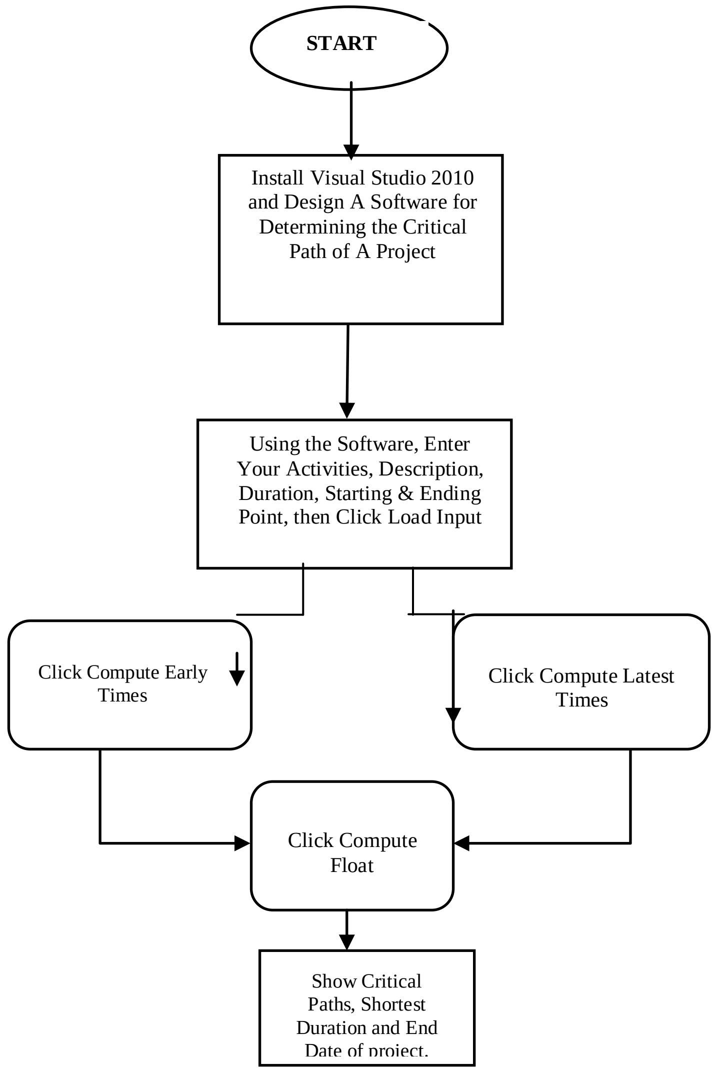


**Figure 1: Flow chart used in designing the software.**

### ***D. ALGORITHM*** *[5]*

An algorithm is a special case of an iterative method, which generally need not converge in a finite number of steps. Instead, an iterative method produces a sequence of iterates from which some subsequence converges to a solution. An algorithm terminates in a finite number of steps with a solution. In using algorithm to solve planning problems, three (3) basic ingredients are considered: objective function which is required to be either minimized or maximized**;** set of factors of variables which affects the valve of the objective function**;** and set of constraints that allow the variables to take on certain values but exclude others.

## III. Results and Discussion

### *A. Results*

The network diagram for the case study is shown below.

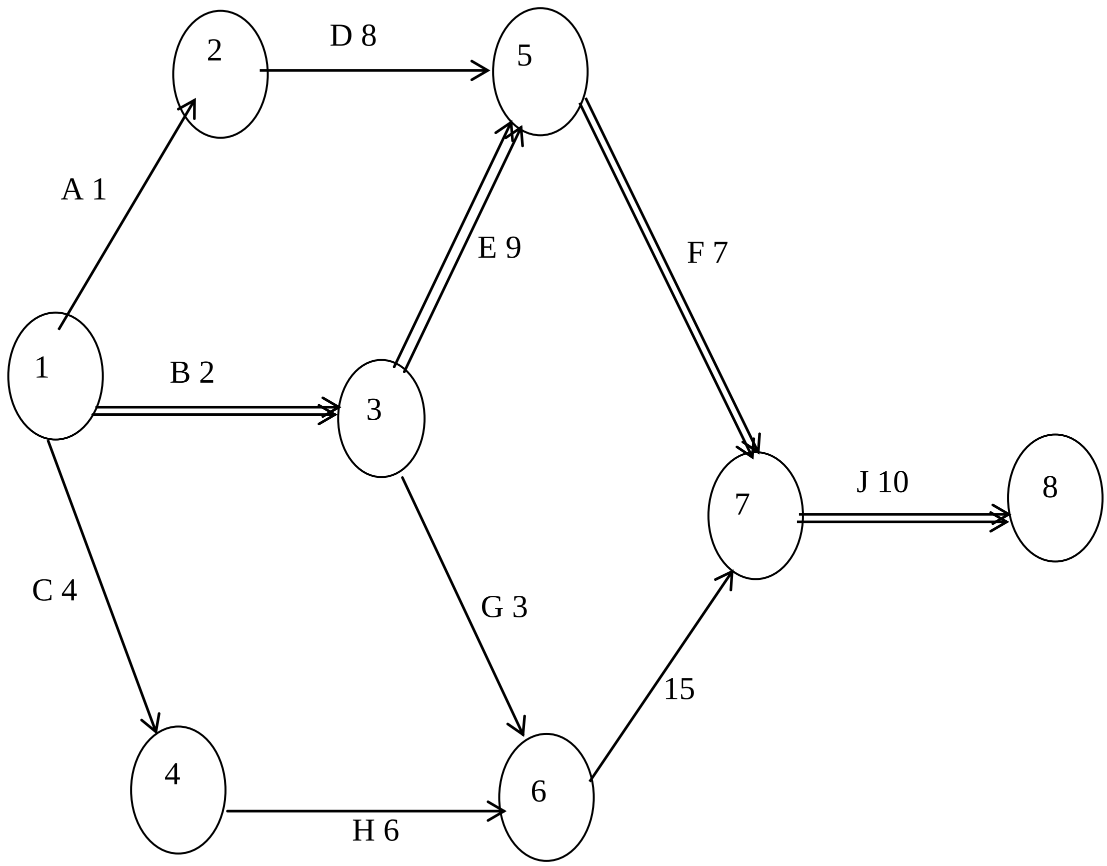


**Figure 2: Network diagram for the case study project.**

At the bottom right hand corner is located the start button, when clicked, you are taken to a windows views as shown in the figure (a,b, & c) below. The bottom left hand corner of the welcome page has the exit button, and when clicked, it exits the program.

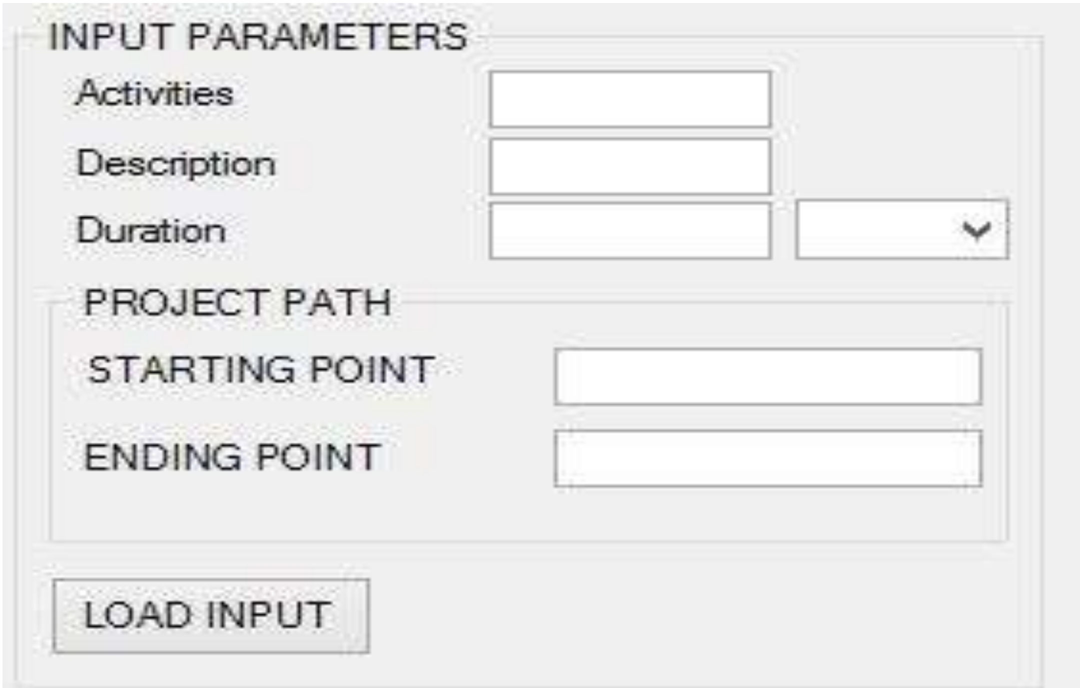


**Figure 3: A display of the analysis window for input parameter**

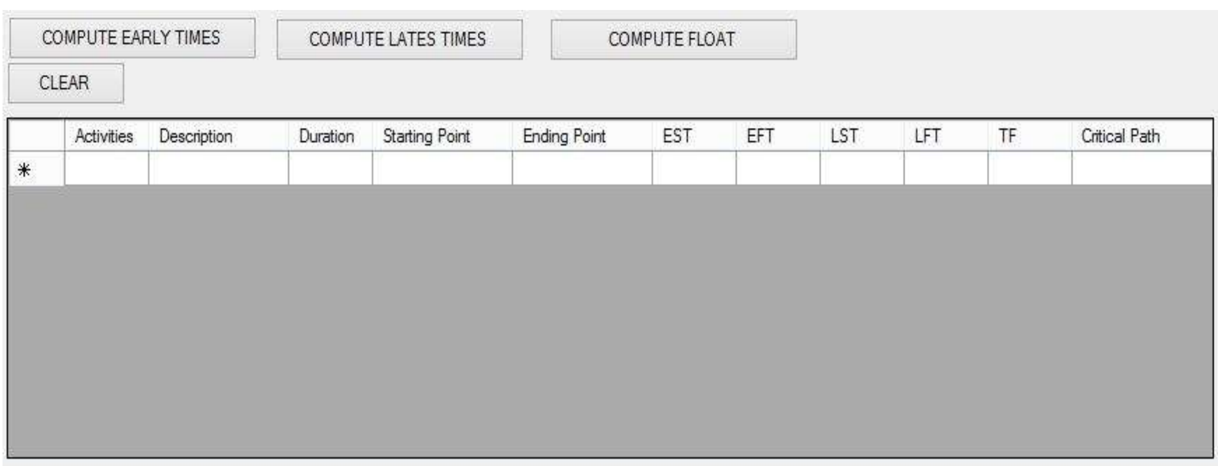


**Figure 4: A display of the analysis window for the critical path design software**

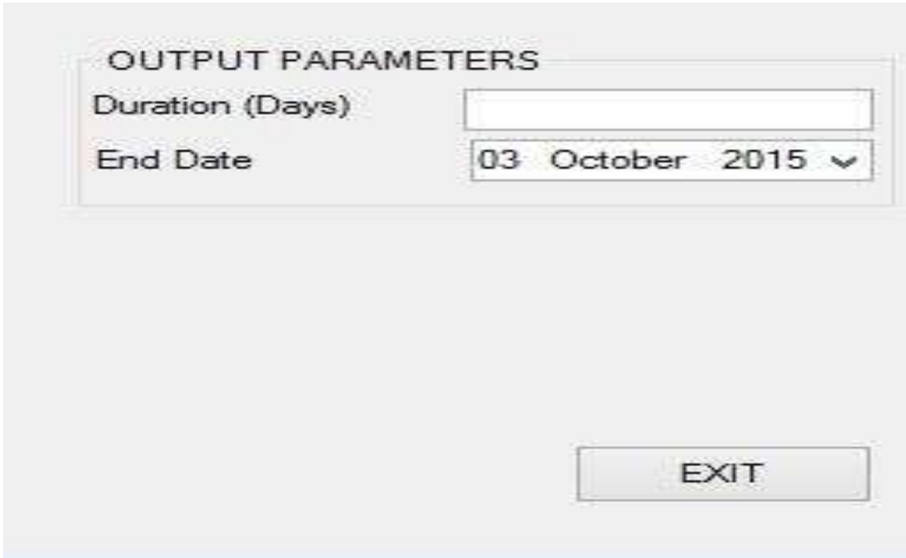


**Figure 5: A display of the analysis window for output parameters.**

Once the load input button is clicked, it transfers the input parameters to the designed table waiting for computation of the early times, latest times, and float (which determine critical activities and hence critical path). Once the table of data from the information (input parameters) has been entered and computed in Figure 5.

**Table 2: The display computed values of total float and critical path for different activities.**

COMPUTE EARLY TIMES | COMPUTE LATES TIMES | COMPUTE FLOAT | CLEAR

| Activities | Description | Duration | Starting Point | Ending Point | EST | EFT | LST | LFT | TF | Critical Path |
|---|---|---|---|---|---|---|---|---|---|---|
| A | | 1 | 1 | 2 | 0 | 1 | 2 | 3 | 2 | |
| B | | 2 | 1 | 3 | 0 | 2 | 0 | 2 | 0 | 1-3 |
| C | | 4 | 1 | 4 | 0 | 4 | 3 | 7 | 3 | |
| D | | 8 | 2 | 5 | 1 | 9 | 3 | 11 | 2 | |
| E | | 9 | 3 | 5 | 2 | 11 | 2 | 11 | 0 | 3-5 |
| F | | 7 | 5 | 7 | 11 | 18 | 11 | 18 | 0 | 5-7 |
| G | | 3 | 3 | 6 | 2 | 5 | 10 | 13 | 8 | |
| H | | 6 | 4 | 6 | 4 | 10 | 7 | 13 | 3 | |
| I | | 5 | 6 | 7 | 10 | 15 | 13 | 18 | 3 | |
| J | | 10 | 7 | 8 | 18 | 28 | 18 | 28 | 0 | 7-8 |

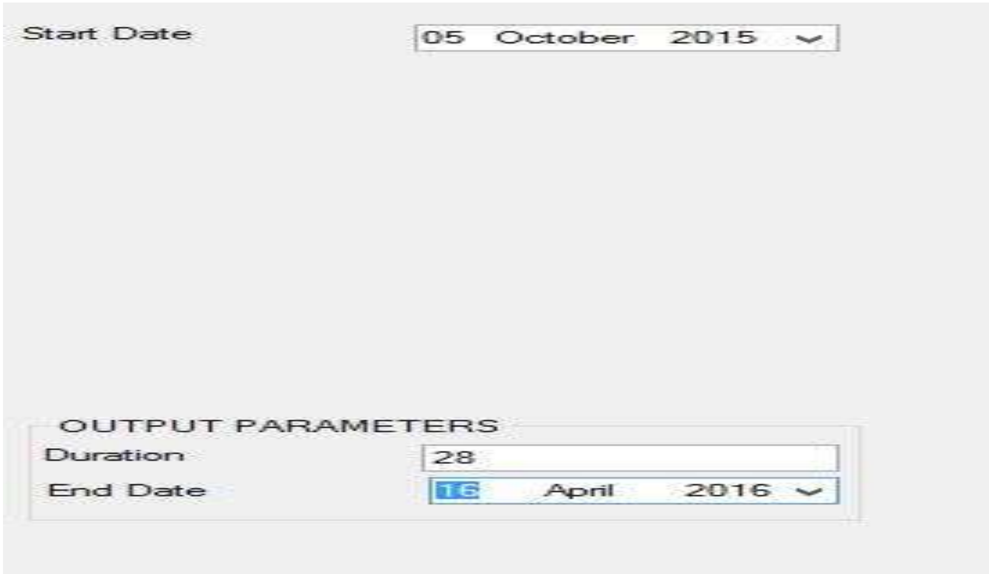


**Figure 6: The display computed values of Project Duration and End Date**

**Table 3: Computer output of Schedule data and the critical path for the fire protection system renewal project.**

| Activities | Duration (Weeks) | Starting point | Ending point | Earliest start time | Earliest finish time | Latest start time | Latest finish time | Total float | Critical path |
|---|---|---|---|---|---|---|---|---|---|
| A | 1 | 1 | 2 | 0 | 1 | 2 | 3 | 2 | |
| B | 2 | 1 | 3 | 0 | 2 | 0 | 2 | 0 | (1-3) |
| C | 4 | 1 | 4 | 0 | 4 | 3 | 7 | 3 | |
| D | 8 | 2 | 5 | 1 | 9 | 3 | 11 | 2 | |
| E | 9 | 3 | 5 | 2 | 11 | 2 | 11 | 0 | (3-5) |
| F | 7 | 5 | 7 | 11 | 18 | 11 | 18 | 0 | (5-7) |
| G | 3 | 3 | 6 | 2 | 5 | 10 | 13 | 8 | |
| H | 6 | 4 | 6 | 4 | 10 | 7 | 13 | 3 | |
| I | 5 | 6 | 7 | 10 | 15 | 13 | 18 | 3 | |
| J | 10 | 7 | 8 | 18 | 28 | 18 | 28 | 0 | (7-8) |

### *B. Discussion*

In the fire protection system renewal project, the first activity is the mobilization of all the necessary resource needed for the project. The resources include materials (such as pipes, new flanges, values, red oxide coating, and so on), machinery (such as trolleys, pumps, vice, and so on), and man (expatriate, quantity survey, fitters, and so on).

Based on Table 3, the Critical Path for the case study used in this research work is (1-3), (3-5), (5-7), (7-8), or (B-E), (E-F), (F-3).

The existing computer programme (developed software) is used to automatically computer early times, latest times, total float, and critical activities, requiring as input the activities, duration (their performance time requirement), and the precedence relationships established (i.e starting and ending nodes). The computer output are the duration for the whole project (shortest completion time), and the end date of the project.

### *a) Study of Sensitivity Analysis*

The project duration is 28 weeks using the developed software be confirmed by solving manually. The calculation of total float which determine the critical paths, are based on the two extremes of the earliest and latest starting times. Actually, there are over five (5) different paths from start to finish through the network, but the shortest path is that of 1 – 3 – 5 – 7 –8. This route gives the best option to the completion of the fire protection system renewal project. The total cost of this path is 28weeks. For projects networks with multiple paths (such as this case study), one could enumerate all the alternative paths/routes to find the longest path, but it has no relevance and there is no advantage in doing so. This is because clients normally subscribe to the shortest delivery date as long as the quality of the completed project is not compromised.

***b) Advantage of the Newly Developed Software over Existing one (Primavera) used by Oxbow Concept & Resources Limited***

The project planning unit of Oxbow Concept & Resources limited uses primavera software as a tool in managing their project. This software determines the critical path/activities of any project when the activities start nodes, end nodes, and duration arc inputted. Figure 5 shows a display of the computed values the critical path for the project activities using Primavera. The result as seen in Figure 5 is the same arrived at using the newly developed software. The use of primavera planning software requires a high level of' expertise hence it requires training of personnel's that needs be in the planning control/monitoring to learn. Training before now, requires sending personnel abroad (United States of America) and it involves a lot of money (transportation, lodging, feeding, and cost of training). However, training is relatively cheaper now (at a cost of N200.000 per personnel) as it is now done in Nigeria.

This cost of training personnel can be saved by employing the software developed in this research work. Apart from other stall' in the planning unit, the case study has five (5) personnel's working directly with the primavera planning software. So if the existing planning software is replaced with the newly developed one, it will help Oxbow Concept & Resources limited to save (5 x 200,000) used for training alone. Also the cost of' purchasing the existing Engineering construction software (Primavera) is very high. A licensed one cost N800.000.

## IV. Conclusion

Project capacity planning has over the years received more attention in the production and/or manufacturing industry than in the construction industry. This created some vacuum in the management of resources in the construction industry. Development of software that is very suitable for the construction industry in project planning was done and tested with Oxbow Concept & Resources limited. Successfully developed project planning and scheduling advisory system such as critical paths, total duration and date of project completion for non-expert without any problem was achieved. The project completion data was determined from the designed software. The successful completion of any project is a function of appropriate firms (contractor) to perform key project activities (critical activities), clarity of project assignment. Secondly, making provision for networks communication system within the project than, making use of performance milestone and giving adequate financial incentives for all groups involved leads to a successful completion of projects on time. If time is spent up front planning the project (in all ramifications) and subsequently working the plan through proper execution and control as can be achieved based on the performance of this software (developed computer program) is it obvious that project are likely to be completed within budget, and specification and on schedule. A project would therefore run accordingly if and only if these principles and techniques are applied as and at when due by the project manager through a team while making sure that the owners specification are always met.

**Nomenclature**

| **Symbol** | **Meaning** | **Units** |
|---|---|---|
| EST | Earliest Start time | s |
| EFT | Earliest Finish time | s |
| LST | Earliest Start time | s |
| LFT | Latest Finish time | s |
| TF | Total Float | s |
| FF | Free Flout | s |
| Jn | Set of n-Jobs | - |
| Rk | Plans on k-resources | - |
| T | Time Horizon | s |
| Qkt | Capacity of Resources in week, t | tons |
| Xjkt | Fraction of job Jj performed on Resource Rk in week,t | % |

| | | |
|---|---|---|
| $I/_{Pj}$ | Maximum fraction done per week | % |
| $C_{kt}\ U_{kt}$ | Cost of $U_{kt}$ hours of non-regular capacity of resources, $R_k$ in week, t | $ |
| S | Set allow to work (ATW) window | - |
| A | Activities | - |

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