

Labor Productivity improvement in Construction projects using WBS & OBS Integration

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1. ABSTRACT

Abu Dhabi is one of the cities in GCC where Construction field is booming very fast, this technical paper is intended to show the effects of labor productivity on construction projects profits, The factors which result in productivity loss and how to improve the productivity using WBS & OBS framework. The author seeks to illustrate how loss productivity will affect *direct labor cost* which may results in reducing project profits by using Earned Value management (*Accomplished man-hours*). Upon applying earned value calculations the negative deviation from planned man-hours will be analyzed and root cause of productivity loss and how it may affect the direct labor cost. Hence establish WBS & OBS integration matrix to recover this losses. Examples and figures used in this report are adopted from On-going construction project within Abu Dhabi city and estimated productivity rates are limited to this project only. The results of this study will show the effect of establish WBS & OBS integration matrix to monitor the project performance and improve the labor productivity by assigning works to appropriate organizational units using right combination between Responsibility assignments' matrix and organizational breakdown structure by identifying the individual responsibility for performing the work.

2. INTRODUCTION

Labor productivity is one of the most vital challenge during construction projects life cycle that concerns project managers, it was noticed that most of project managers can't achieve *neither* planned labor productivity *nor* their organization strategic plans in this regard. Failure in achieving required or planned labor productivity may affect the direct labor cost and incurred huge losses to the project. In most of construction projects if the standard and or planned productivity rates are compared to actual accumulative accomplished productivity it may shows that the actual productivity is less than planned due to many circumstances' illustrated later in this technical paper, which means that the actual manpower used to accomplished specific task is greater than the planned that should be used for the same task and this may escalate the labor direct cost and may affect the planned budget of the project, this can be cleared if simple Earned Value management is applied which will show that the project till specific period of its life cycle is over budget.

This difference of labor productivity may be because of lack of duly supervision and or non availability of foundation to assign work to appropriate organizational units to ensure right combination between project works and responsibility assignment matrix and organizational breakdown structure, Hereinafter this technical paper goal is to show how to achieve the labor productivity improvement using proper methodology to analyze the weakness of labor productivity and how to improve it as well. In this technical paper the actual accomplished labor productivity will be compared to standard and or planned productivity rates to analyze the deviation and its reasons then study the effect of using WBS & OBS integration matrix to

ensure that each work package will have a single point of responsibility which will be used as main objective of controlling direct labor cost and to identify the individual responsibilities for performing the work to monitor the project performance.

3. DEFINITIONS

Obviously the term productivity bring to mind a lot of definitions that used in construction filed, hereinafter we will illustrate the terms related to the objectives of this technical paper as follow:

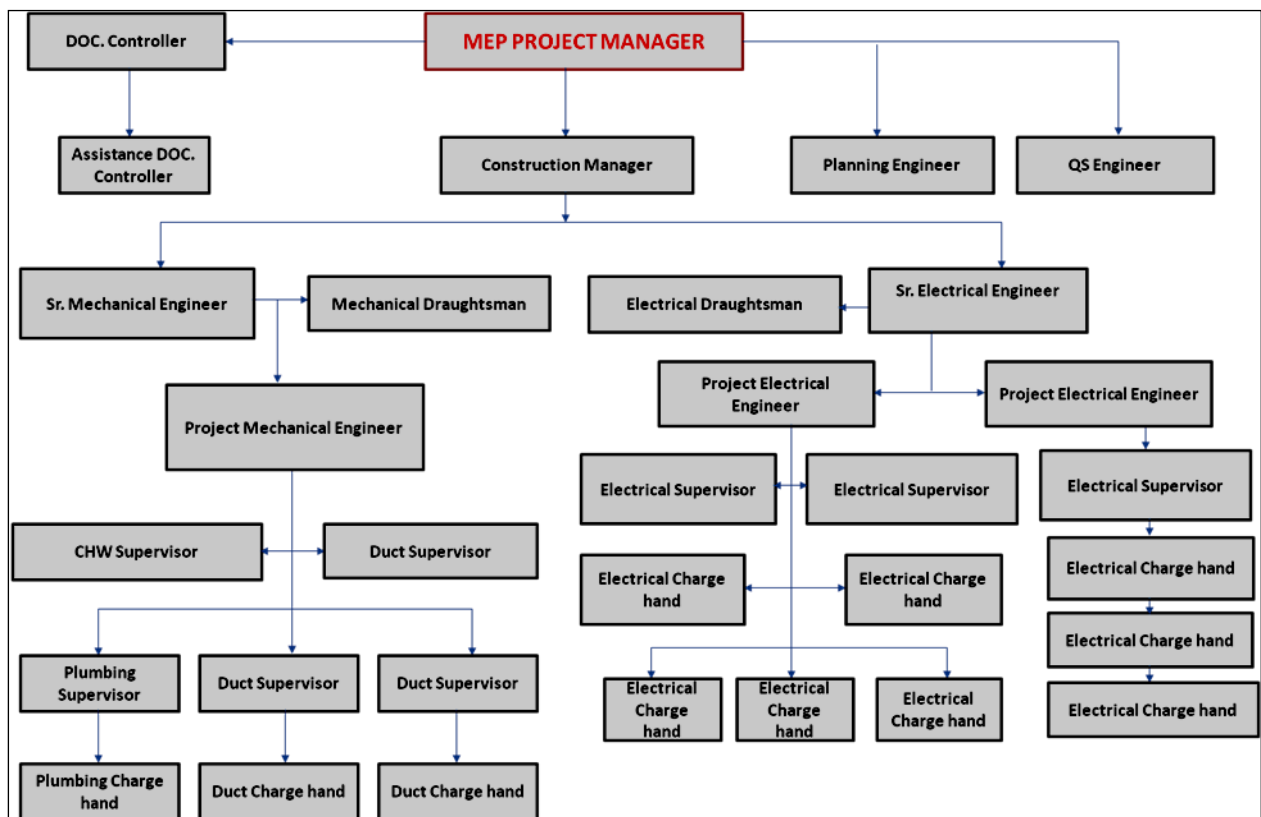
- a. Performing organization** ⁽¹⁾. An enterprise whose personnel are most directly involved in doing the work of the project or program.

Table: 1. Performing organization Decomposition

Team Member	Role	Reporting To	Responsibilities
Project Manager (PM)	1- Lead project Team	Organization Management	1- Monitor Cost 2- Monitor Time 3- Achieve Planned cost 4- Achieve Planned Time
Construction Manager (CM)	1-Lead Activities Execution 2- Monitor Progress	Project Manager (PM)	1-Monitor progress 2-Momitor Subcontractors Performance 3-prepare payments 4-Follow issues with consultant
Project Engineer (PE)	1- Lead Drawing approvals 2- Lead material approvals 3- Follow material delivery 4- Distribute activities	Construction Manager (CM)	1- Deliver Drawings & materials As per project requirements 2-Issue Materials orders. 3- Follow materials delivery 4- Distribute activities with related Materials & Drawings 5- Conform Quality.
Site Engineer (SE)	1-Leads Supervisors 2- Lead Technicians 3- Lead Store	Project Engineer (PE)	1- Distribute supervisors & Technicians 2- Follow planned Activities. 3- Issue materials from stores 4- Achieve progress 5- Perform Quality
Supervisors	1- Lead Technicians 2- Supervise installation	Site Engineer (SE)	1- Perform Drawings 2- Control Technicians productivity 3- Control Materials installation 4- Achieve Quality

- b. **Work Breakdown Structure (WBS)** ⁽²⁾. A hierarchical decomposition of total scope of work to be carried out by the project team to accomplish the project objectives and create the required deliverable.
- c. **Organizational Breakdown Structure (OBS)** ⁽³⁾. A Hierarchical representation of project organization that illustrate the relationship between project activities and the organizational units to perform those activities.

Figure: 1. Organizational Breakdown Structure



- d. **Earned Value (EV)** ⁽⁴⁾. The measurement of work performed expressed in terms of the budget authorized for the works.
- e. **Productivity** ^{(5), (6)}. A relative measure of labor efficiency either good or bad when compared to an established base or norm as determined from an earlier great experience.

4. WHY WBS

The term WBS and its definition in the previous section bring to mind project cost estimate, cost control, schedule development, schedule control, performance monitoring and many other processes as project management point of view, but we will focus here how to use WBS and integrate the organizational breakdown structure with it to control the labor direct cost by monitoring and controlling their productivity by understanding the common causes of loss productivity and how to improve it, hence the WBS model should be understood.

5. RODUCTIVITY vs. PRODUCTION

Here we should discriminate between productivity and production. Production in construction projects has many definitions, as full product is “*Completed Project*”, while the project has many parts such as *Activities* it means “*Each Activity Completed is a Product*”. While Productivity in construction refers to relation among activities completion against time spent to complete those activities and as defined earlier (Refer to section 3 part e) it’s a measure of labor efficiency. Our goal is to analyze productivity against time planned for each activity. On a simple words Production is a measure of output although Productivity is a measure of production performance.

To achieve our goal we should realize the common causes, circumstances and events that may affect the productivity.

6. COMMON CAUSES OF LOSS IN PRODUCTIVITY

In construction projects there are numerous causes, circumstances and events that may affect the labor productivity which results in productivity loss and impacts direct labor cost which increases proportionally and results in decreasing project profitability, those common cause are all driven from lack of WBS, the following are common causes of productivity loss:

- a. **Technical Issues.** Incomplete drawings or specified material for each activity may create ambiguity to project team and this may creates uncertainties due to lack of information’s.
- b. **Missed Supervision.** This generally falls into two major categories, Changes in instructions without respecting planned activity duration in short terms “*Relocation of work force before task is completed*”. The second major category over loading supervisors with multitasks in different areas. This two major categories resulting missed supervision and low performance as well.
- c. **Wrong Distribution of resources.** Each activity has its own location, hence the right materials, tools, equipment and any other resources must be provided to that location in order to have the desired productivity. An unplanned distribution result in delays due to shifting wrong materials and any other resources to the area of subject matter work is required.
- d. **Over allocation of resources.** Each zone and/or activity has limited capacity of labors, hence assigning extra people to perform same activity results into *idle* people. Example “*you cannot put 10 persons to work in one square meter in the same time*”.
- e. **Overtime.** It’s a technique but has limited usage privileges, it can be used for a certain activities but cannot be general practice as it exhaust labors and this will results in less productivity.
- f. **Sequence of Activities.** Planning is arranging logical sequence of activities so we cannot disturb it, otherwise project will go Out of Control and results in Re-work and remedy actions which results in extra cost and time as well.

Let us see the following example:

Example f.1. Installation of Air Duct for Exhaust system at parking area *Figure .2*. Normally follow the following criteria,

- 1- Fixing supports.
- 2- Lifting fabricated Duct and Erecting at supports.
- 3- Make holes at side of Air Duct to fix Air Registers.
- 4- Fix air registers by using shoe collar fitting.

Figure.2. Air Duct for Exhaust system



Actually there are two criteria that can be followed:

- (A) Follow the normal method of work sequence described above.
- (B) Modified criteria by shifting points 3 & 4 before point 2, in other words “We make holes and fixing shoe collar at duct before lifting it to its final position”.
- (C) Results from criteria (A) & (B).

Table: 2. Compare Criteria (A) & (B).

	Manpower used (Nrs.)	Duration (Hrs.)	Production (Nrs.)	Incurred Cost (Hrs/Pc)	Cost Hrs/Psc
Criteria (A)	3	10	3	(10 Hrs*3 Labors)/3 Pcs	10 Hrs / Pcs
Criteria (B)	2	10	8	(10 Hrs*2 Labors)/8 Pcs	2.5 Hrs /Pcs

Conclusion: Criteria (B) proved to be higher productivity rates per hour which means less cost & better timing to complete the same task.

- g. **Cost of Quality.** One of the most important concerns in construction projects is Quality, referring to (*PMPBOK Guide fifth edition Page 235 clause 8.12.2 Cost Of Quality*) it’s clear that Cost of conformance is less than cost of non-conformance which may negatively influence the productivity rates as Non-conformance with quality requirements will incurred error need to be rectified with incurred additional manpower cost.

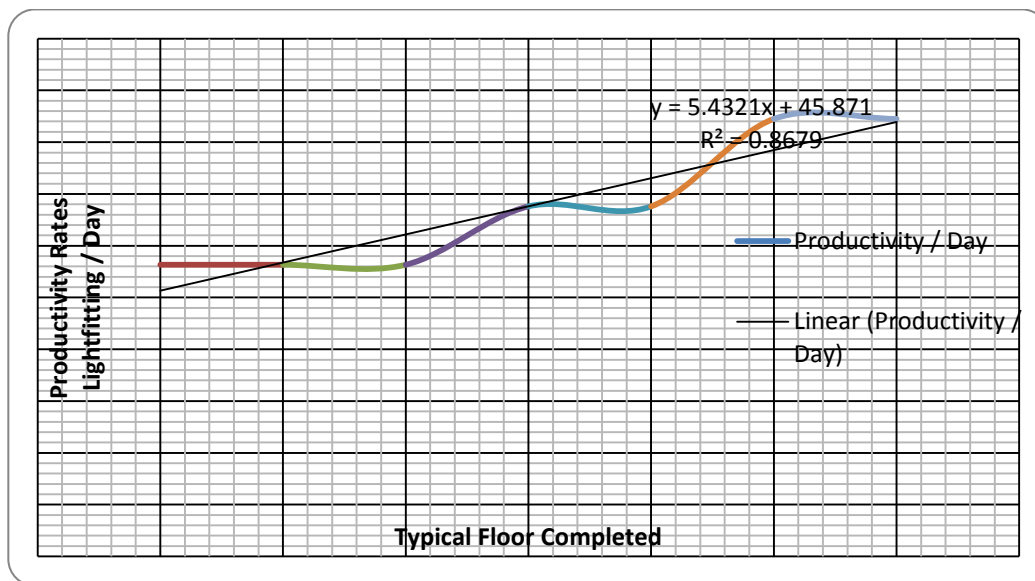
h. Learning Curve. It's a technique achieved by repeating same activity in different zones by a fixed group of technicians, in case those groups got interrupted before completing same activity in all zones the productivity of those groups will be lower when we assign them again to the previous activity zone, Look at the following example to find the implications of interrupting learning curve.

Example h.1. In residential tower has typical floors, we assigned a group of technicians to fix light fitting under supervision of one supervisor, we noticed the following,

Table: 3. Technicians productivity increments

Floor	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th
Light fitting Fixed	169	169	169	169	169	169	169
Durataion (Days)	3	3	3	2.5	2.5	2	2
Productivity / Day	56.3	56.3	56.3	67.6	67.6	84.5	84.5

Figure.3. Learning Curve Improvement

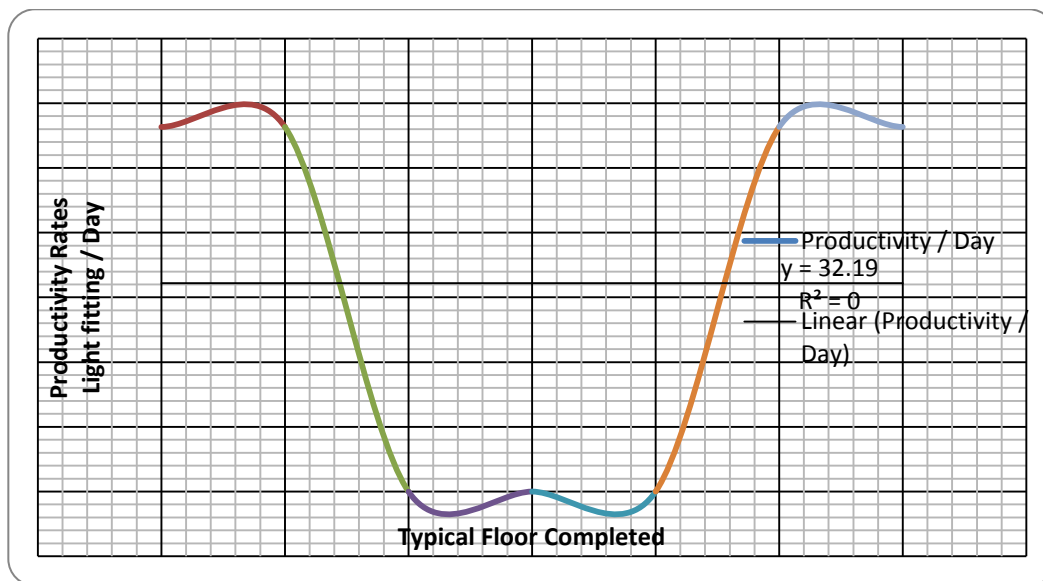


Looking to Table: 3. Indicates that fixing group of 3 technicians to perform the same activity repeatedly will increase their productivity day to day as the same group will be more familiar with the type of the light fitting and site conditions hence give more productivity (See Figure.3. showing learning curve improvement), while interrupting those groups will disrupt the learning curve of the technicians as in second building with same specifications we have the same arrangements, but the activity were interrupted by reassigning the technicians to other activities then returning back to the light fitting installation activity

Table: 4. Technicians productivity interruption

Floor	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th
Light fitting Fixed	169	169	169	169	169	169	169
Duratation (Days)	3	3	0	0	0	3	3
Productivity / Day	56.3	56.3	0.0	0.0	0.0	56.3	56.3

Figure.4. Learning Curve Interruption



Comparing the results between **Figure.3** and **Figure.4**. Will show that productivity rate changed drastically due to interrupting learning curve.

7. EARNED VALUE IMPLEMENTATION

As common causes of productivity loss is shown it brings to mind how to improve the labor productivity which results in controlling the direct labor cost, but this require to implement Earned Value management to monitor the performance, hence we have to compare the actual work accomplished against planed work to get a proper performance analysis of productivity rates, the following example (**Table.5.activity progress chart**) showing an activity of light fitting installation and how the performance is tracked and how to implement Earned value management, this implementation requires the following formulas to be applied as follows:

$$7.1 \text{ Productivity} = \frac{\text{Output}}{\text{Input}}$$

$$7.2 \text{ Productivity Rate} = \frac{\text{Actual productivity}}{\text{InputBaseline or planned productivity}}$$

$$7.3 \text{ Earned Value} = \frac{(\text{Acutual work} - \text{Planned workd}) \times \text{planned manpower} \times 10 \text{ hours}}{(\text{productivity Rate of the Total Manpower} \div \text{Day})}$$

Table.5. Activity progress chart

Light fixtures Typical Floor	Activity Name														Manpower Cumulative	Completed floors	planned target	Target floors	Balance Work	Earned Value Of Manpower Hours				
	Planned Manpower	Total Group	Productivity Rate/Group/Day	Unit	Target Duration/Days	Actual ay 1	Actual ay 2	Actual ay 3	Actual ay 4	Actual ay 5	Actual ay 6	Actual ay 7	Actual ay 8	Actual ay 9							Actual ay 10	Actual ay 11	Actual ay 12	Actual ay 13
24	3G	1	Floor	11	13	13	13	13	13	13	13	13	14	15	15	14	5	2	169	8	6.5	11	3	360.0

The figure shows the following:

- 1- Work required to be completed “Light Fixture Installation in Typical Floors”.
- 2- Planned manpower required to complete 1 Floor is 1 Group of 8 labors.
- 3- Planned Duration for 1 Group to complete 1 Floor is 1 day (10 Working hours) and Total Duration for this activity is 11 Days and Total planned manpower is 24 labors per day.
- 4- Actual work done in the period (from 1st Day to 14th Day) is 63%.
- 5- Actual consumed manpower in the period (from 1st Day to 14th Day) is 169 labors.
- 6- Planned work to be completed is 33 floors in 11 days using 3 groups (24 labors) per day or total 264 labors.
- 7- Apply earned value calculations using *Equation.7.3*. the actual spent manpower 169 should give 8 floor where the planned should be 6.3 floors using the same number of manpower, which means although we are behind schedule the productivity achieved by the available manpower achieved 136 hours under budget.

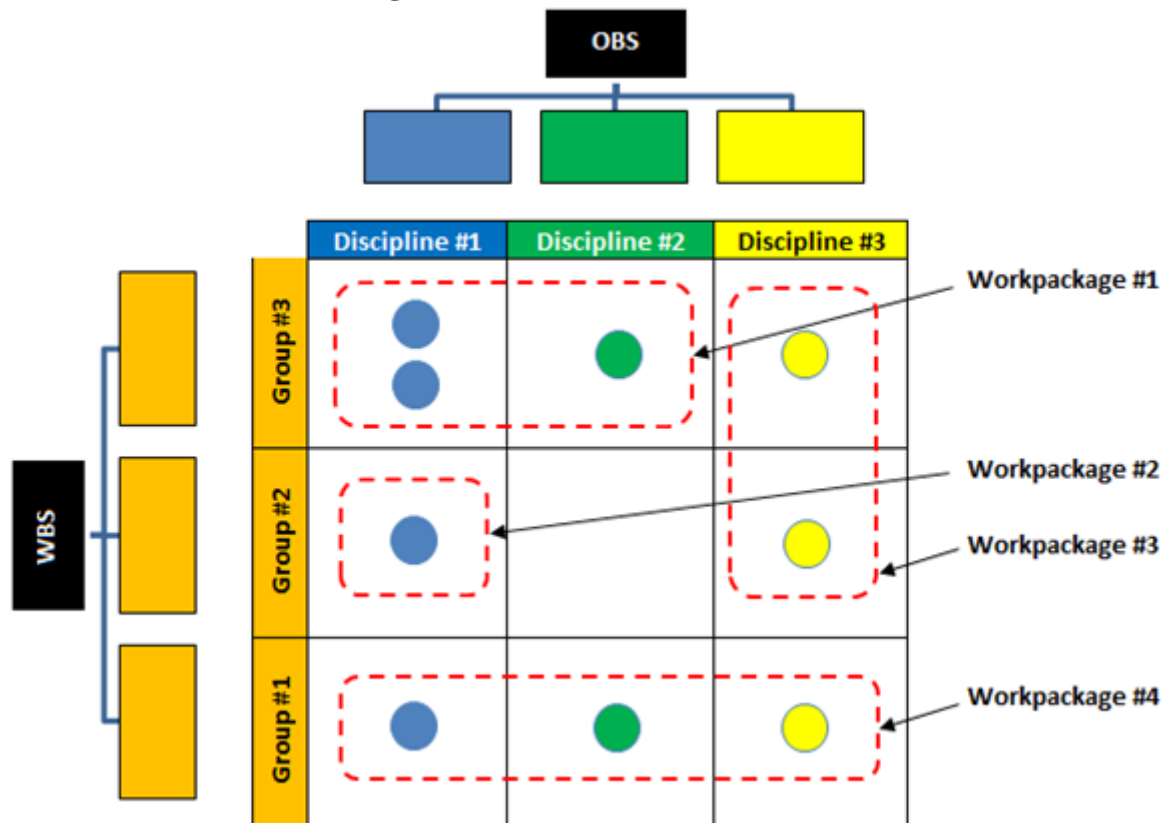
As we can see from the example a clear scope with specific single organizational component in the organizational break down structure will give the right framework of monitoring the project performance and labor productivity as well, further to this it’s apparent that this model reflects avoidance of many causes of productivity loss mentioned in Section.5. Such as miss of supervision, learning curve improvement and resource wrong of distribution. This will bring to mind where the necessity of WBS & OBS integration matrix is and what the real effect of direct labor cost control is?, here we come to the objective of this technical paper which is how to improve labor direct cost using WBS & OBS integration and how it can be implemented.

8. PRODUCTIVITY IMPROVEMENT

To monitor manpower performance during construction project life cycle we have to use clear framework that control the process of monitor and this requires all project team members to know their roles and responsibilities here the necessity of Responsibility Assignment matrix arises where you can assign specific resources to specific task using WBS & OBS integration hence you can control either productivity and cost as well, the following **Figure.5.** Showing the WBS & OBS integration matrix which represents the idea of this

technical paper as a proper technique to monitor the work progress and improve the labor productivity rates.

Figure.5. OBS & WBS Model



The figure shows that each and every work package is assigned to specific group to facilitate resource control including manpower and performance monitoring and this scheme should be incorporated with the roles and responsibility matrix defined earlier in *section.3.a. Table.1*. Hence the OBS & WBS integration technique will results in:

- All team members will understand the required activities and tasks to be performed.
- All team members will be aware of their responsibilities.
- Well define scope, WBS decomposition and activities duration will avoid over manning and excessive overtime as well.
- Well defined scope and WBS will avoid wrong sequence of activity and give high rate of manpower productivity.
- Fixing specific groups will avoid learning curve disturbance and strengthen it and results in high productivity rate due to awareness of the activities.

9. CONCLUSION

From all illustrated examples we may conclude that manpower cost is one of the most important aspects that should be properly monitored and controlled by project managers during the construction project life cycle as this will consequently affects the manpower direct cost, and as a normal practice project managers they always used to state that “*The success of a project manager is to apply a high level of manpower cost control to keep the*

project under budget as the Budget and cost of materials are almost known during project planning phase and it's being monitored and or tracked during the project life cycle”.

Here the necessity of using OBS & WBS integration technique is arises as useful methodology to achieve the required goal.

Finally we should know that productivity improvement is not limited to be the project manager challenge to perform more profit to the assigned project, it's one of the most important target of any organization as this will results in:

- 1 . Invest the manpower by continues appraisals’.
- 2 . Give the organization a clear idea about recourse pool availability for other projects within the organization.
- 3 . Manpower productivity rates improvement will give the organization to bid competitive prices for new projects acquisition.
- 4 . A high productivity rates prevent outsourcing.
- 5 . A high productivity rate gives the organization standard index of activities duration which will results in right cost and time estimation.
- 6 . High productivity rates and targets completion on time will give the organization chance to award the team members which will motivate team members.

10.References:

- 1) *A Guide to the Project Management Body of Knowledge (PMBOK- Fifth Edition) – page 549.*
- 2) *A Guide to the Project Management Body of Knowledge (PMBOK- Fifth Edition) – page 567.*
- 3) *A Guide to the Project Management Body of Knowledge (PMBOK- Fifth Edition) – page 548.*
- 4) *A Guide to the Project Management Body of Knowledge (PMBOK- Fifth Edition) – page 538.*
- 5) *A Guide to the Project Management Body of Knowledge (PMBOK- Fifth Edition) – page 558.*
- 6) *AACE International Recommended Practice No. 25R-03 **ESTIMATING LOST LABOR PRODUCTIVITY INCONSTRUCTION CLAIMS TCM Framework: 6.4** – Forensic Performance Assessment, Copyright 2004 AACE, Inc.*

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During his employment tenure with his past employers Suez Canal Electrical Distribution Company, United Engineering & Trading Company – ENTRACO, and TROJAN General Contracting, he has successfully managed various projects, in addition enhancing the process capabilities and organization performance as well. Essam Lotffy is actively pursuing potential opportunities in the project management field, where a room of growth and opportunities for advancement exists. He can be contacted at esam_mese@hotmail.com.