
POLITECNICO DI TORINO

Department of Management and Production Engineering

Master's Degree Course in Engineering and Management

Master's Degree Thesis

# *"Exploring Industry 4.0 paradigm as applied to project management towards proof of concept"*

Supervisors:
Prof. De Marco Alberto (DIGEP)
Demagistris Paolo Eugenio (External Teacher)

Candidate:
Waseem Khan
Student# S252664

## Acknowledgment:

First of all, I would like to praise ALLAH, for bestowing upon me this opportunity to work on this important topic, granting me the capability to progress positively and providing me such friendly supervisor and co supervisor. This thesis is a result of guidance and support many people and I would like to offer my sincere thanks to all of them.

I would like to thank **Prof. Alberto De Marco**, my honored supervisor from **DIGEP - Department of Management and Production Engineering, College of Management Engineering, at Politecnico di Torino**, for accepting me as a research student and his support.

I want to deeply thank **Prof. Paolo Eugenio Demagistris,** my valued co-supervisor from **DIGEP - Department of Management and Production Engineering, College of Management Engineering, at Politecnico di Torino,** for trust in me, the insightful discussions, unconditional support, and friendly coordination throughout the duration of the research study by introducing me to new ideas, to the experts and professionals of the work scope, specially your patience, guidance, critical comments and corrections in the thesis work.

I would also like to thank my friends who supported me in this work and gave me courage in the weak time when I was working on this thesis.

I cannot finish without thanking my family, my dear friends who supported me in every phase of my life. I must express my deepest gratitude to my father, mother and siblings for their endless patience and providing me with their uncondiltional love, support, and never ending encouragement throughout my years of study and uptill the completion of this thesis work. This accomplishment would never have been possible without them.

At the end I would like to thank to HEC, Pakistan and Government of Pakistan for selecting me for the scholarship, due to which I am able to work with the esteemed professor of this prestigious university.

Thank you all.

# 1 Summary:

Employee and project performance management is very crucial for project managers, because it makes them enable ensuring that employee is giving their best for the achievement of project goals and objectives. Performance management regulates expectations for employee performance and keeps them motivated to work in such a way that is demanded by the project nature.

For managers the method to increase the work performance effectiveness, time monitoring, and control is a very powerful tool for the overall project performance. But time monitoring and control is not as easy as the way it is considered and imagined. This term of time management and control is the allocation of different task to different work force, which can perform the tasks with high performance under constrained time.

This research work is focused on constructive research approach in which concepts of Industry 4.0 will be elaborated in order to discuss the feasibility of these concepts in the field of project management and development of the ICT infrastructure for the implementation of I4.0 in project monitoring and control, this thesis will also help in other researches in the context of quantitative approach focused on Industry 4.0 implementation in project management domain for other potential problems.

In this thesis famous 5-layer architecture of industry 4.0 will be adopted, which comprises of data acquisition layer in which data will be collected on human device interaction, data to information conversion layer on device and digital system interface, cyber physical system layer comprises of digital formulation of project management concepts and tools like EVM and other useful calculation to calculate useful information in order to be compared for the performance analysis, cognition layer includes comparison performances of employee and other useful Performance indicators, this layer is driven by decision makers, it makes decision makers able to make correct decision for the better performance of projects, and configuration layer which may either be driven by some automated mechanism which may implement decisions taken by decision makers, from digital to physical world or it may be driven by project managers to implement decision in project and assign or reassign different tasks to different work force.

For the experimentation purpose, and exploration of concepts the data used in the research has been considered based on the most likely scenarios in the project management, the employee selected for the evaluation was supposed a typical fixed unit income allocation, more likely on monthly basis. The data is then analyzed with the Earned Value Analysis formulas and mathematical algorithms in order to receive meaningful information.

Research has been conducted in several steps, starting from the information collection about I4.0, followed by literature reviews on the I4.0 and Project management domains, and extraction of the literature gap, after that deep research in the 5 layer architecture of I4.0 for project management. And at the end concentration of the CPS layer of 5 layer architecture for the generation of management tool based on EVM mathematical algorithms.

As the objective of the thesis is to explore I4.0 concepts applied to project management, in this context upon exploration of I4.0 concepts, the research study comes to the fact, Study of the research on the topic and proves the feasibility of Implementation of Industry 4.0 concepts for project management, especially for project monitoring and control.
According to the literature review these concepts were never discussed in these details despite of some research papers explaining only common definitions and importance.
This research study elaborated every step in detail for the implementation of automation trend in project management for the advancement of this field.
There are some limitations as well to the research study, which is the concept has not been tested in real life, no physical sensors of devices able to track and monitor time been utilized, and the data used is a supposed data on real life scenarios.
As per implication, in this research work an ICT infrastructure is developed for the implementation of the concept to project monitoring and control. If physical sensors and time tracking devices are obtained and connection between devices and CPS system is established then this concepts can be successfully tested and implemented. The white box or digital twin of the problem is ready and in line the matter to cover is the input or real data allocation. Input and data will be evaluated by CPS system with the help of EVM mathematical algorithms.
Work presented in this thesis will help managers to overcome above problems by identifying productive resources for specific tasks, calculate resource performance index and identify project performance index based on resources productivity.

### 1.1 Keywords:

Industry 4.0, Project Monitoring and Control, Earned Value Analysis, I4.0 feasibility Project Management, Employee Performance

## 2 Introduction:

This thesis is focused on qualitative research in which concepts of Industry 4.0 will be elaborated in order to discuss the feasibility of these concepts in the field of project management, this thesis will also help in other researches in the context of quantitative approach focused on Industry 4.0 implementation in project management domain for other potential problems.

In this thesis the work is solely based on the problem of employee productivity monitoring or work force performance index according to time spent on assigned task. Time expenditure on task is the basis concern of employee and managers which is a very valuable resource for employee, it is equally important for every employee either personal or professional and effective time management is the key of success for projects, that is the reason it is the problem for every project manager to effectively manage utilization of time allocated for tasks to employee working on the projects, it's an irreversible resource and consumes constantly, which can never be stored for future use, so it's efficient allocation and utilization is very essential for projects success. The skills devoted to analyze, allocate,

and organize available time to specific tasks and projects are termed as time management. The better the time management the better will be quality of work.

Theories claim that for managers the method to increase the work performance effectiveness, time monitoring, and control is a very powerful tool for the overall project performance. But time monitoring and control is not as easy as the way it is considered and imagined. This term of time management and control is the allocation of different task to different work force, who can perform the tasks with high performance under constrained time.

Work presented in this thesis will help managers to overcome above problems by identifying productive resources for specific tasks, calculate resource performance index and identify project performance index based on resources productivity.

In this thesis famous 5-layer architecture of industry 4.0 will be adopted, which comprises of data acquisition layer in which data will be collected on human device interaction, data to information conversion layer on device and digital system interface, cyber physical system layer comprises of digital formulation of project management concepts and tools like EVM and other useful calculation to calculate useful information in order to be compared for the performance analysis, cognition layer includes comparison performances of employee and other useful Performance indicators, this layer is driven by decision makers, it makes decision makers able to make correct decision for the better performance of projects, and configuration layer which may either be driven by some automated mechanism which may implement decisions taken by decision makers, from digital to physical world or it may be driven by project managers to implement decision in project and assign or reassign different tasks to different work force.

For the experimentation purpose, and exploration of concepts the data used in the research has been considered based on the most likely scenarios in the project management, the employee selected for the evaluation was supposed a typical fixed unit income allocation, more likely on monthly basis. The data is then analyzed with the Earned Value Analysis formulas and mathematical algorithms in order to receive meaningful information.

Beside the core discussion point of this thesis which is to discuss the compatibility of I4.0 concepts to monitor and control the performance of an employee/workforce, the concepts of this thesis may be used to direct project monitoring and control with the help of IoT, IoP and CPS system interconnected with each other on the basis of cloud computing and programming inn such a way that it can monitor availability of resources on each task on daily basis and report this status to CPS system regularly which can calculate task status, CPI, SPI, expected completion and excepted delivery based on calculations of project management formulas and methodologies.

Research has been conducted in several steps, starting from the information collection about I4.0, followed by literature reviews on the I4.0 and Project management domains, and extraction of the literature gap, after that deep research in the 5 layer architecture of I4.0 for project management. And at the end concentration of the CPS layer of 5 layer

architecture for the generation of management tool based on EVM mathematical algorithms.

This research study claims the feasibility of I4.0 in project management especially in project monitoring and control.

## 2.1 Problem Statement:

Employee and project performance management is very crucial for project managers, because it makes them enable ensuring that employee is giving their best for the achievement of project goals and objectives. Performance management regulates expectations for employee performance and keeps them motivated to work in such a way that is demanded by the project nature.

It is a much known reality that employee performance management and monitoring is a very difficult task for managers, it almost impossible for them accesses the efficiency of their employee. That is the reason project management is a very hard nut to crack. Project managers have this responsibility to deliver project in time and manage all the tasks in the project in line for project success, which depends on the performance of employee allocated to tasks, in this type of scenario if manager can not access the performance of their employee then for him to manage a project will be very difficult.

As a quick example if a project is supposed to be completed in 2 months, and there are 3 activities in this project 1,2, and 3 respectively each of them can be done 1 month, activity 1 and 2 started simultaneously, while activity 3 can only be started if activity 1 and 2 are completed, activity 1 has completed in 1 month while activity 2 is not completed in 1 month and as a result activity 3 started late and the whole project got delayed.

In the context of above example if the manager of the project could have been access to the employee performance, he could realize this delay in the mid-way and could have allocated more resources to this task or maybe he could allocate some other more efficient resource to this task.

## 2.2 Research Question:

This work aims to address following questions:

- Is it possible to implement concepts of Industry 4.0 in project management?
- What is the relation between employee performance and project performance?
- Can a project manager access employee performance index in the midway of task progress?
- Can previous data of employee be used for future task allocation to them?

## 2.3 Importance of Study:

On one hand this study is very useful in the solution of the problem as described “application of industry 4.0 concepts to access the employee data and calculation of

performance indexes and analyze productivity and its further work in future tasks allocation".

While on the other hand, this research work is the gateway of the research era to implement Industry 4.0 for project management problems, it opens the doors of project management to Industry 4.0, this work can used as a reference to further research works in this field of study.

Furthermore, it is also a reference for the researchers who wish to work on the same problem in order to further improve it and to the one who aim to make it completely autonomous without any physical interpretation, because here is a big potential to do it so.

## 2.4 Objectives:

Objective of the work is to discuss the feasibility and reality of implementation of industry 4.0 in project management, and to know if it is possible for project management to align with the pace of technology.

Furthermore, this work has the aim to address the problem of manager's accessibility to employee performance which leads to project performance and the help in planning and decision making for the task allocation and project monitoring and control.

After all these objectives this work will make some suggestion and recommendation of the project control and employee appraisal and enhancement in the organizational capability.

The work will also present the dependent and independent variables for the project success, and the relationship between employee performance and project performance.

## 2.5 Variables:

### 2.5.1 Dependent Variable:

Project Performance is the dependent variable, which means it is dependent on other variables, and the performance will be achieved if the performance of other independent variables are satisfactory.

### 2.5.2 Independent Variables:

- Employee performance

Project performance is directly proportional to the employee performance, the higher the employee performance the higher will be project performance.

- Self-management

Self-management of employee is also a key to success to a task which ultimately result in higher project performance.

- Technological Development

Technological development also results in higher project performance, it gets tasks done easily due to higher development in underlying technology, such as Industry 4.0 in automotive industry

- Training of Time Management

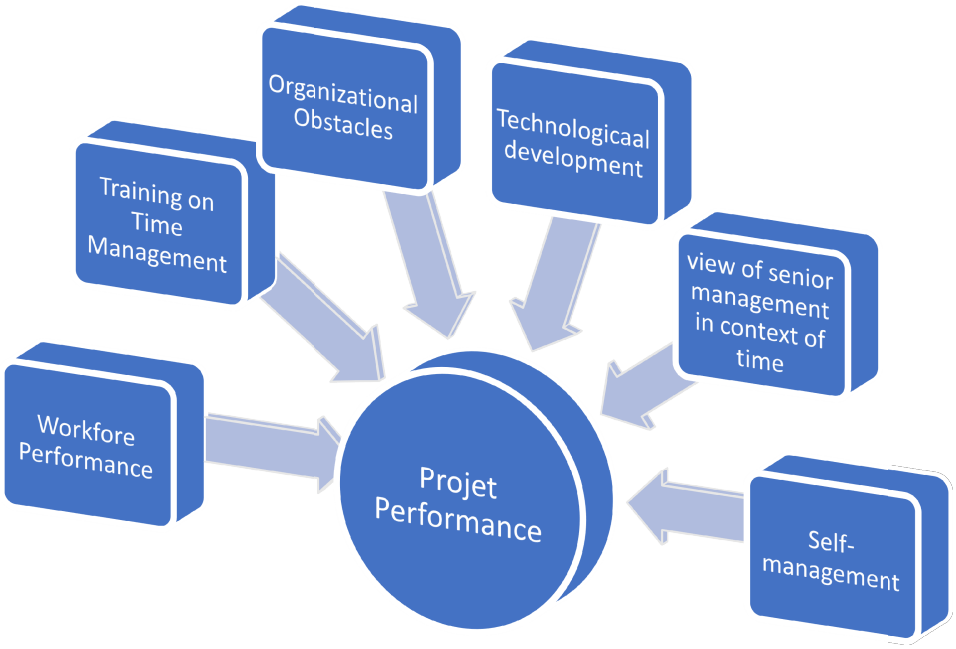
Employee training in time management also helps in higher project performance because employee efficiency is increased in time management.

- View of Senior Management in context of time

Senior managers view towards the project time allocation and monitoring is also a very important factor for project success

- Organizational Obstacles

Organizational obstacles also effect project performance, it can make employees confused about the task they are working and even obstacles can make them confident on time wasting.



## 2.6 Terms of the Study:

This study will use several terms, which needs proper definition to understand them clearly, the definition are elaborated below as:

### 2.6.1 Time:

Time in this work indicates the duration of time for official business day globally recognized as period between 9 am and 5 pm, which is standard all over the world and counts for 8 hours totally.

The proper definition of time the study is based upon is “keeping aligned with characteristic speed, efforts utilized, perfection and cost, for an official task to perform in an official business, the total duration required to accomplish this task is time”

### 2.6.2 Time Management:

Time management is a skill, which makes you capable to complete the tasks and achieve goal in the business work, making you efficient in your line of actions and career path. The process of time management comprises of various layers designed and calculated for the need of your actions and performance accordingly, and to align them with reosurces and time available for tasks. (Al-Sharary, 2004)

### 2.6.3 Time Monitoring:

Time monitoring is a process to keep record of the task getting done, through out time the time consumption in the progress, it help in analysis of performance.

### 2.6.4 Employee:

An individual who provides labor force to a company or another person, employee is a part of project team, who acts individually for the assignment, employee can be anyone, from organization or outside organization.

### 2.6.5 Planning:

Robbin and coulter, 2019, defined planning as identification of goals set by organization, and with the help of developing comprehensive plans and integration in different activities the accomplishment of goals is called planning.

Its is the process of exploring past experience, understanding present problems and forecasting future in order to achieve goal with the result having best quality and lower cost.

### 2.6.6 Earned Value Analysis:

Earned Value Analysis is said to be a standard method for measuring the progress of a project, at any instant in the project proceedings, which is used to evaluate project completion date, completion cost, and identify variances for schedules and budgets on the way of project progress.

### 2.6.7 Planned Value:

Planned Value is a part of total cost of the project, that should have been spent on the task up to the evaluation time. It is also called Budget Cost of Work Scheduled (BCWS) and denoted as cost units.

### 2.6.8 Actual Value:

Actual Value of Actual cost is the total cost incurred either direct or indirect in the accomplishment of the task, during the evaluation period. It is also called as Actual Cost of work Performed and expressed in cost unit.

### 2.6.9 Earned Value:

Earned Value is also termed as Budget Cost of Work Performed (BCWP), is the approximation of the value of physical work actually performed. It is the relationship between the scheduled cost of the project and the rate with which the resources of the project performs their task, it is mentioned as cost units. In order to calculate earned value the total budget is multiplied with the percentage of work performed.

$$EV = Percent\ work\ Performed\ \times\ Total\ Budget\ Allocated$$

### 2.6.10 Budget at Completion:

Budget at completion (BAC) is the total budget which is expected to be utilized for project completion, in other words the expectation of PV to reach its maximum according to project plan, and expressed in cost units.

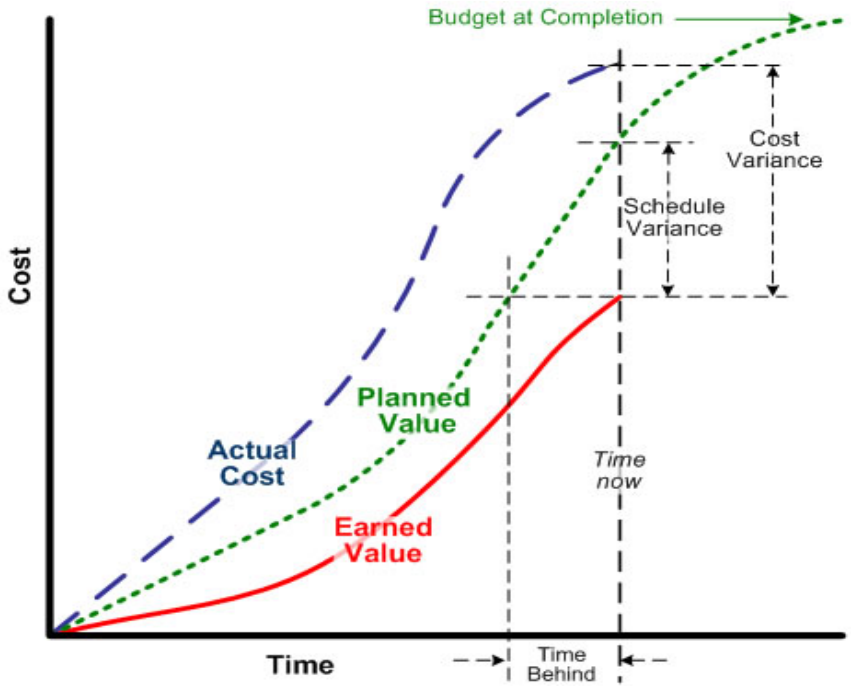
### 2.6.11 Cost Variance:

Cost variance (CV) is the term used for the difference between value of the work actually performed for the task or project and actual cost incurred, it the cost performance measurement. Expressed in cost units and can be determined as:

$$CV = EV - AC$$

### 2.6.12 Schedule Variance:

Schedule Variance (SV), the term is used for the difference between value of the work actually performed and the value of the work which should have been done on evaluation



instance according to the plan. It is the measure of schedule performance and expressed in cost units. It can be determined as below:

$$SV = EV - PV$$

### 2.6.13 Cost Estimate to Complete:

Cost Estimate to Completion also known as Estimate to Complete is the analysis of the in-progress activity status, according to its cost expenditure, It is the forecast of the remaining expenses of the task or project to complete, ETC indicates further cost expenses on the activity according to its current cost performance. It is denoted as currency units.

### 2.6.14 Cost Estimate at Completion:

CEAC also known as Estimate at completion is the expected value of the task or project on its completion. It is the forecast of activity completion value according to the current performance of the activity.

### 2.6.15 Cost Variance at Completion:

Cost Variance at Completion evaluates the estimation of the cost at the completion of activity or project, either its under-run or over-run, based on its performance.

### 2.6.16 Schedule at Completion:

It is also called budgeted work (BW) is the actual planned duration at completion for activity or project, and mentioned in time units.

### 2.6.17 Planned Accomplishment Rate:

Planned Accomplishment Rate is also called Planned Value rate (PV Rate), is the average of planned value per specified time period, (usually days, or hours). Denotes planned expenses per time period, and expressed in cost units.

### 2.6.18 Actual Time:

Actual Time (AT) is the actual time duration from project initiation to reporting date.

### 2.6.19 Time Variance:

Time variance is the upgraded version of Schedule variance, TV is the measure of the schedule performance evaluation of activity or project in time units. As SV is in cost units so TV has been evolved to overcome the issue and introduce time units for schedule performance. TV may be negative, Positive and Zero indicating project behind schedule, ahead of schedule and on schedule respectively.

### 2.6.20 Earned Schedule:

Earned Schedule (ES) is the time instant on which current earned value was supposed to complete. In time units it is the point on which PV should have been equal to current Earned Value.

### 2.6.21 Time Variance Percent:

Time Variance Percent is the upgraded version of Schedule variance percent, indicating the percentage of time variance performance, these results will be consistent with the SV%, this the more realistic verison of SV% to measure the performance of schedule.

#### 2.6.22 Time Performance Index:

Time performance index (TPI), shows time consumption efficiency of the project or task, it can be less than 1, greater than and equal to 1, for behind time schedule, ahead of time schedule and on time schedule respectively.

#### 2.6.23 Expected Accomplishment Rate:

Expected Accomplishment Rate Indicates the rate at which a project or task is expected to be accomplished based on its current performance, it is expressed in cost units.

#### 2.6.24 Time Estimate at completion:

Keeping in mind the enefficiency of SPI after the scheduled actual Completion (SAC) date, which is actually after the instant when SAC is reached SV tends to zero and SPI tends towards 1. So time estimate at completion can be concluded to take care of this issue, time estimate at completion calculates the total time spent on the task or project to be complete, expressed in time units.

#### 2.6.25 Time Variance at Completion:

Time variance at completion calculates to time difference between planned time for the task or project and actual time for completion. Expressed in time units.

### 2.7 Background:

#### 2.7.1 Industry 4.0:

As the core of this thesis is the implementation of concepts of industry 4.0 in projects monitoring and control, so before going to the point let's get to know industry 4.0 and its background and evolution over time.

Starting the beginning of "background" leading to industry 4.0 "the fourth industrial revolution", let's have a look at its evolution, the first industrial revolution was basically the introduction of mechanical production facilities in the industries, its evolution period was starting in the middle of eighteen century and span over the entire nineteenth century, while the second industrial revolution started evolving from the 1870s and onward with electrification and the division of labor (i.e. Taylorism), while the third industrial revolution started emerging from around 1970s which is also called digital revolution, in which production processes were further automated by advanced electronics and information technology. Now the age of fourth industrial revolution has been emerged which is revolutionizing the production and management with the idea of digitalization together with some autonomy and self-behavior of the machines.

If we consider, generally fourth industrial revolution "industry 4.0" is a broader domain that takes production processes, efficiency, data management, relationship with customers, competitiveness, and much more with in its boundary. Specifically, Industry 4.0 has become the new theme for management.

This advanced innovation is rising achievements in various fields, for example, mechanical autonomy, AI, Nano-innovation, quantum computing, biotechnology, the Internet of Things (IoT), 3D printing, Augmented Reality and self-governing vehicles, frameworks, fabricating. Numerous modern chiefs anticipate that the Industry 4.0 will convey uncommon dimensions of development and profitability over the coming decades.

At its hearth industry 4.0 is about deploying a stack of technology which enables cyber-physical systems deployment. This means that as industry 4.0 allows the creation of new business models, the same PP&PM may develop different methodological frameworks. The paradigm of cyber-physical systems is the orchestration of processes by integrating data repositories with IoT and IoP, the internet of people - through hand held, wearable or recognition devices by which people can interact through apps with nodes of IoP itself or the IoT - to achieve a data driven execution system. Data collection and analysis, also trough machine learning, allows to track transformations, be them material, as in manufacturing and construction, or immaterial, as information or knowledge creation. Eventually this will lead to a full set of analytical capabilities: descriptive, diagnostic, predictive, prescriptive.

Industry 4.0 is generally the interest of research these days in educational institutions, they are making future generation able to adopt the trending technology, as well as industries are also focusing on the trend evolving rapidly, industries want to increase productivity and ease in operations.

### 2.7.2 Earned Value Analysis and Management:

Earned Value Analysis aids project managers in measuring the performance of the projects, a management tools helps in finding differences in the baseline and actual work performed, mean variances are evaluated in the project progress.

Earned Value Analysis and Management concept was first developed by the US Department of Defense, in order to assess the programs during the early sixties, from 2005; this concept of project evaluation took place in the general federal project risk management. These days EVA and EVM has become a mandatory need of thee US government. OMB (Office of Management and Budget) promotes the utility of EVM to be preferred mode of management of software projects which are performance based. It is now a day’s used in variety of industries, consulting and educational establishments including public and private sectors, Including NASA, PMI, Society of Cost Estimating and Analysis (SCEA) and others.

# 3 Research gap/Literature Review:

Research gap and literature review is considered one of the most important part of a research project, it is the initial point where research should be started. It helps us to assess and analyze most relevant literature on the specific study and lead us to the possible research gap and leads to strengthen the field of study.

This section of thesis represents current work of industry 4.0 and its contribution to project management, here we will also highlight research gap in the work done so far. Which will guide us to the way to further work in the direction of project management completely done through I4.0concept.

This literature review is based on articles assessed from various databases devoted for knowledge sharing and knowledge transfers.

For the selection and review of articles, we had considered 5 step methodology approach


## 3.1 Selection of Database:

To find our research gap started literature review. As our search strategy, first of all we have gone through the relevant data sources known as Database. For this purpose, we had access to online databanks such as GoogleScholar, ScienceDirect, ResearchGate, Emerald Insight, theWebofScience, Polito online library PICO and some other databases.

## 3.2 Selection of Keywords:

Specific keywords selection for a literature review is a very essential task, its help in prioritizing most related citations. Keywords selected for our review is Industry 4.0, Internet of things (IoT), Cyber-physical systems, Cloud computing, Modern Project Management, Employee time monitoring, effective time utilization, I4.0 and employee performance, Earned Value Analysis, EVM, Project Performance Analysis

## 3.3 Articles Collection:

Articles were carefully collected from the stated sources with the help of keywords. No of collected articles were total 30.

## 3.4 Filtration (Inclusion/Exclusion)

Out of 30 articles collected, we selected only 15 articles for complete review based on their coherence to our specific title and inclusion of all the information present in remaining 15 articles.

For review of industry 4.0 and its application in project management, 8 articles were selected, while for Earned Value analysis no of articles selected were 5, on the other hand 2 articles were reviewed for employee performance, time evaluation and its impact on project performance

## 3.5 Review of Articles:

According to the researchers work in the area of I4.0, the integration of CPS is increasing very rapidly in the production and manufacturing sectors. They have identified the goal of I4.0 as optimization of the value chains by adopting and implementing such phenomenal procedures and technology which can help us in autonomously controlling and dynamic production.

Based on its specialized nature of work for different sectors it is very difficult to establish a comparison of the work which has presented in the domain. There are several architectures for the integration of CPS in I4.0 present on literature that has already been presented previously.

There are several research domains in which researches are available on described online databases including Industry 4.0 concepts and theories, Human and machines collaboration, equipment integration, technologies for I4.0 (IoT, Bigdata, cloud computing, simulations and prototypes, AR, Robotics and Cyber security) but for our review we will collectively review all these works and discuss the most relevant irrespective of the specific domain.

On the other hand Earned value analysis has been worked by a lot of researchers including protagonists who support and advocate EVA, objectionists who challenges EVA on the basis of utility, practicality and reliability, Extensionists who extends their work to overcome objections.

### 3.5.1 Reviews for Industry 4.0 and Project Management:

**Thee Zin Win et al (2018):** they drew basic concept of I4.0 and its implementation in project management, they also highlighted challenges for project management in I4.0, project managers roles, role of cloud computing, IoT and other basic aspects, however their research could not explain architecture for implementation and were not able to define the working procedure of I4.0 for project management monitoring and control.

**Kolberget al (2015):** Presented basic architecture for lean manufacturing in I4.0 concept, they established a concept how I4.0 should be integrated into already available lean systems. They also claimed the fact that lean system is natural precursor for I4.0. however, their work is blank for the implementation of CPS based manufacturing system.

**Lee et al (2015)**: Proposed a CPS architecture for I4.0 in the area of manufacturing systems, they modeled a 5C architecture which is also known as 5-layer pyramidal architecture, with layers for smart connections, data to information conversions, cyber integration, cognition and configuration. Their research also provides the implementation of their work. However, the theme of this research 5 layer is still in study.

**Strange and Zucchela (2017):** they discuss the global value chain and implications of I4.0 for global value chain in their research. They rise the point that development of I4.0 will affect the activities and strategic decisions of MNEs. the MNEs should control the structure and

distribution phases of the global value chains. They further report that 3-D printing innovation and virtual building will conceivably enable clients to give contribution on product plan and impact choices on where and when the product to be manufactured. The improvement of BDA and IoT are distinguished as the capabilities that will control authoritative execution later on. Their work has particular conceptual guidelines for implementation of I4.0 in project management.

**Oesterreich and Teuteberg (2016):** they identified the components of I4.0 whose markets are matured and whose market are still under study. They claimed that cloud computing, mobile computing, and modularization is matured in terms of market while additive manufacturing, robotics and AR/VR are still in development.

**Kong et al (2018):** in their work they highlight the critical issues of integration between human and machine/robots, they established a HCPS (human cyber physical symbiosis) for supporting trust, real time and dynamic interactions among production equipment, operators, and system. However, it is only a concept.

**Theorin et al (2017):** In this conceptual paper, considering current factory infrastructure they studied the rapid integration of smart services. And presented LISA (line information system architecture). Which very innovative and simple. By the way this research is dedicated to production factories but its concepts are of great worth for project monitoring.

**Muller et al (2018):** they investigated the relations between I4.0 opportunities and challenges in context of sustainability. They claimed in their work that strategic, operational, environmental and social opportunities are favorable for sustainable implementation of I4.0.

### 3.5.2 Review on Earned Value Analysis and Project Performance:

Derivations and Descriptions of Earned Value Analysis and Management is although completely entertained in a lot of sources in different perspectives, including Project Management Institute PMI, around a decade ago, if we take PMI as our base reference, the Standard Practice of PMI published in 2005, differentiate EVM in two classes, first the Key Parameters (Planned Value, Earned Value and Actual Cost), and EVM measures including Variances, indices, and forecasts.

Now focus on the literature about Earned Value analysis:

**Howard Hunter (2014):** In his work, this researcher claimed EVA to be the value provider to the project management team, in the manner that it enhance the capability to monitor costs and schedules, and helps in foresee expected problems, corrective plans and implementation of corrective strategies. In his work it was also claimed that key factor for EVMS success is the capability of working team in planning, monitoring, and controlling the project in correct balance between process and outcomes. EVA environment is effective for cost and schedule problem.

**Sunil Ganpat Mahadik (2013):** EVA is improvement against traditional accounting system, it helps the management to see potential risks in time. It is considered as the early alarming tool for project managers, enabling them to recognize and control issues before they become a liability. It is a tool to manage better, on time and on allocated budget.

Now discussion on some criticism on traditional EVA procedures:

**Narbaev and De Marco (2013):** These researchers in their work, analyzed the traditional earned value procedures to determine the Estimated Actual cost at completion (EAC), and based on outcomes it was claimed that these outcomes were unreliable in the initial stages of the project, in their work they also proposed a mathematical model to overcome the situation.

**Vandevoorde and Vanhoucke (2006):** They also notified errors in EVA process on different stages, while forecasting performance of the project, and claimed inadequacy of the EVA.

**Anabri (2003):** he focused on earned value analysis and described earned value analysis by using various parameters,

### 3.5.3 Review for effective employee time allocation and their impacts on project performance:

Above literature articles review focused on Industry 4.0 concepts for the implementation in project management, and on the Earned value Analysis, now as the concepts of industry 4.0 and Earned Value Analysis is covered, the literature review can be diverted to the concepts of effective employee time allocation and their impacts on project performance and success

**Adeojo (2012):** In the title of "Effective time management for high performance in an organization" he focused to explain the improvement of efficiency and productivity of employee if their time is effectively managed he used a quantitative approach for this research, as a case study he used the questionnaire which was sent to management and staff of the Lasco assurance plc, Nigeria. And colleted their responses data, based on its analysis the conclusion was made that effective time management can accelerate the organizational performance.

**Okolo (2012):** "effective time management: A panacea for higher productivity in organizations" as it is evident from the title of research that it highlights the solution for higher productivity as effective time management, in this thesis the examination is between the time management and managerial performance, that it needs some time management skills, and is one the critical aspect of managerial process, and it highlights that for organizational performance effective time management is a very powerful tool.

## 3.6 Conclusion of research review:

A lot of work has been done so far in the field of I4.0 which is evident from bulk number of researches available but specifically for project management in the context of project monitoring and control there are just a few conceptual papers available, and specially for employee performance evaluation and earned value analysis for project performance in the context for I4.0 no work has be found on the research databases, Nothing has done to identify how I4.0 could be implemented for employee time monitoring and project monitoring and control.

Also there is a big gap available in the project community to utilize the concepts of industry 4.0 for the EVA and EVM, no work can be found on the sources claiming the utilization of renowned technology for the evaluation of earned value analysis.

In spite of the gave advantages, associations from the PP&PM have not figured out how to incorporate these innovations to stay aware of their counterparts. Notwithstanding, there exist numerous challenges explicit to the project management industry that must be

considered. For instance, the whole PM esteem chain is very influenced by tight joint efforts with clients, subcontractors and stakeholders. Henceforth, the PP&PM require a more elevated amount of expert information. Moreover, the PP&PM business area comprises of a high number of little and medium-sized ventures with constrained capacities for investments in new innovations.

This thesis will focus on the concept of Industry 4.0 utilization for the project earned value analysis and employee performance analysis based on the mathematical algorithms, application in cyber physical system.

# 4 Purpose:

According to Walliman (2001), the starter step in the progress of research is the research problem, if it is known then this suit will be followed by goals and questions. How objective and goals are regulated is the priority of work.
Purpose of this thesis is based on the fact that project management in this age of revolution is not observing any innovation in its processes and methodologies, as well it is not claiming its ability to adopt recent trends in technology, these days project monitoring and control is a lengthy and time consuming task, it takes time to identify delays and their mitigation and involves calculations and reporting by conventional methodologies are used, and above all these problems, project managers are unable to access the efficiency of its employee and time consumed by them during a task workout. where all the other business sectors are adopting technological trends in their processes using IoT for all the similar purposes, hence reducing efforts and increasing efficiency and profitability.
Project Management these days is effective but not efficient; it is now time to introduce project management with latest technological innovation, so that this sector also gets benefitted from new trends.
This thesis targets to reduce this gap between project management and new technological trends, in this thesis I4.0 concept will be discussed in the scope of project management and its application in this sector will be evaluated. This thesis will address various aspects of I4.0 for implementation in project management and will briefly explain the process of employee time monitoring and its earned value analysis with the help of I4.0 concepts, and will elaborate how managers can get access the productivity and efficiency of their employee in projects, the objective of the thesis is to increase efficiency of project monitoring and control and enhance profitability, improve internal processes, and organization capability by using concepts I4.0.

# 5 Diagnostic

Industry 4.0 is the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems (CPS), the Internet of Things and cloud computing.

projects monitoring and control is a lengthy and time-consuming task, it takes time to identify delays and their mitigation because of calculations involved and conventional

reporting methodologies, and there is almost no procedure to access employee performance and time to time project earned value analysis based on employee performance that can be done automatically with IoT, IoP devices, which is very important in project monitoring and control.

Purpose of this work is implementation I4.0 concepts in project management to help project managers in accessing employee efficiency and productivity and making them enable in decision making of tasks allocation and time constraints in projects planning, now a days, it is very difficult to access employee time utilization patterns and almost impossible to find their productivity and efficiency, effective time utilization is the basis of product success, because in project management time is a very basic factor, if a tasks gets delayed it can cause more project costs and penalties, as well as it effects quality of project and indirectly it can effect the reputation of management firm.

On the other hand employee time utilization data can also help in their counselling and upgradation of firm capability and identification of firms core competence in project management, some firms may be very efficient in project planning, some in project execution and some in operations. These competencies depend on the efficient resources available for projects which makes firms enable to get the positioning in their competence. So, employee performance indexes can help organization identify their weak points and their strong points on which they can work upon and try to minimize or eliminate weak points by conducting some training sessions and counseling.

The overall conclusion of diagnostics of employee management and control area of project management suggests that employee time consumption data and patters are very important to determine so that project manager can utilize them to access employee performance indexes, their productivity, task performance and expected time of completion. On other hand these type of data collected for different tasks and response of employee to these tasks can help in getting some highly beneficial knowledge on project type and its required efforts, this information can be used in future prediction of employee allocation according to project types, such as if a project is highly potential for daily follow-up meeting and constant communication to customers or planning division is required for a project then it is understood that this project will need more time, so for this type of project more employee will be needed to complete it earlier, as compared to other projects which does not need any of above constraint.

According to the diagnostics this work will be focused on time consumption data collection and their analysis for managers for decision making and other useful actions in favor of project success. Thesis will elaborate which methodology can be utilized to access employee time data and how this data should be interpreted and calculated to performance indexes and other information.

# 6 Industry 4.0 5-Layer architecture:

Introduction to 5-Layer architecture and exploration of its compatibility with employee performance index analysis.

Here for addressing research problem, work will be based on industry 4.0 concepts for generation and collection of time data from employee daily activities on tasks and other doable activities, mathematical algorithms will be used to find further performance parameters and indexes for the decision-making use.

For this purpose, we will need to get help of IoT, smart gadgets, and a software application to interpret and record data.

## 6.1 5-Layers:

The 5-Layer architecture of CPS system, Industry 4.0 which should be applied to the monitoring and control in project management are elaborated below:

### 6.1.1 Smart Connections: (to acquire accurate and reliable data.)

Acquisition of accurate and reliable data from devices is the first step in deploying CPS system application for implementation of industry 4.0 and for the problems illustrated in diagnostics of this thesis data acquisition of time utilized by employee in project and tasks is a starting factor or base of success, because without a reliable data no outcomes are possible, time spending of different activities should be recorded in the databank which will be further utilized, these data may be directly measured by sensor or from ERP, SCM or coordinates measuring machines.

For this thesis selection of proper device is very important and very critical, such kind of device which can record time of different activities inn accordance is very important, there are many such devices available in market which can connect to mobile apps via Bluetooth and record time according user instructions, as well as there are several time tracking apps available in mobile app stores which can track time for user. But here we need such type of a device which can be controlled mechanically such as “Timeular (a time tracking device and application available online)” if a user starts some sort of task he can just check-in the interpreter for that task on and other task which were previously in progress can be checkout automatically, there can be one device like dice having same 6 faces, each face for a different task, the user when working on a task can change the position of dice to be that particular face up, which can check out previous activity and record time and duration for that activity.

Two important factors should be considered, first considering various types of data, a seamless and tether free method to manage data acquisition procedures and transferring data to the central server is required, where specific protocol such as “MTConnect (which is protocol to connect SW application to computer, exchange data, open standard, common language, better communication, and uses HTTP and XML codes)

Second consideration is proper device selection for the activity to monitor and control.

### 6.1.2 Data to information conversion:

Meaningful information must be inferred from the data. Currently, there are several tools and methodologies available for the data to information conversion level. In recent years, extensive focus has been applied to develop these algorithms specifically for prognostics

and health management applications. By calculating health value, estimated remaining useful life etc., the second level of CPS architecture brings self-awareness.

This work needs system which extracts information collected from data on time utilization of employee which can be stored in the databank, if we consider the same "dice" as data collection device, 6 faces for different tasks be the device for data acquisition, then data to information conversion system will be the system which can convert the useful data to such an array which may be storable to databank, with task name, its check-in and checkout time, in the predefined manner such as "{Dice Face(task), Check-in-Time, Checkout-Time}.

This information collected from data can be stored in database.

### 6.1.3 Cyber Layer:

The cyber layer acts as central information and calculations hub in this architecture. Information is being called from the database. Having information received, specific algorithms and analytics have to be used to extract additional information that provide better insight over the status of every individual employee in the project. These algorithms and analytics provide performance indexes of employee, time utilization graphs, and task performance patterns for predictions and decision-making processes.

This layer will use project management concepts for determination of RPI, which is the ratio of BCWS (Budgeted cost of work scheduled) and ACWP (Actual cost of work performed).

#### *6.1.3.1 CPS for Employee Performance:*

Let's assume we have an employee who is allocated to a task which needs to be done solely on MS project, and the task was supposed to be done in 5 days, and needs total effort of 30 hours, which means it needs to do 6 hours/day.

Now while checking his activities data collected from the device for 3 days (supposed same dice as device) cyber physical system collected from database have the data for time spent on MS project as:

| Day 1 | Day 2 | Day 3 |
|---|---|---|
| 4 | 5 | 6 |

Now if as we know our total effort was 30 hours/5 days

And there will be 6 hours/day and for 3 days total effort should have been 18 hours (BCWS) but according to data actual effort (BCWP) is 4+5+6 = 15, so:

The algorithms set in the CPS system will calculate all these based on the data stored in database

The final Resource performance index will be calculated as

$$Performance\ Index = \frac{BCWP}{BCWS}$$

So, data assumed will result in 0.8333 (83.3%) of work done which was scheduled for 3 days so the employee is 0.1667 (16.67%) behind schedule.

If this result were greater than 1, the task would have been ahead of schedule while below 1 indicates behind schedule and 0 mean on schedule.

And according to this result it is very easy to predict that this task will be delayed by the factor 16.67% which will result in completion of the task in 35 hours of total,

$$Expected\ Time\ of\ Completion = BCWS \times (1 + (1 - Performance\ Index))$$

Which means this activity is already delayed by 1 day.

While schedule variance can be calculated by:

$$SV = BCWP - BCWS$$

So, the data will result as SV = 15-18 = -3 hours, negative sign indicated that this task is behind time allocated so ill performance. If it would have been positive it shows task is ahead of time and 0 shows the task on time.

#### *6.1.3.2 CPS for the Earned Value Analysis:*

Suppose a task of Process Design, which needs to be performed by process design software.

To the CPS system the data about the task is already sent for the records and baseline, sent data from the project planning tool to CPS is Date of allocation of the task, max days to complete the task, total hours of work for task required, and cost per day of the designated employee, other useful information will be extracted automatically by CPS system from the received data, like cost per hour of employee, total BAC planned, hour per day required for task completion.

Based on received information from the tracking or monitoring device about the time spend each day on the task, CPS system will calculate other parameter of Earned Value Analysis for task tracking and monitoring, such as Schedule Performance Index and Variance, Cost Performance Index and Variance, CV and SV percentage, Resource Variance Index, Cost Estimate to completion, Estimate at completion, CV at completion, Planned Accomplishment Rate, Time Variance, TV %, Earned Schedule, Time Performance Index, Expected Accomplishment Rate, Time Estimate at completion, Time Variance at completion.

Like below formulations:

Note: all the calculations are based on accumulated schedules and cost.

- **Planned Work% (Accumulated):**

$$Planned\ \%\ work = previous\ planned\ \%\ work + \left(\frac{scheduled\ activity\ for\ day}{total\ scheduled\ Task}\right)$$

In this research total scheduled activity is 64 hours total:

So,

Table 1 Planned Work %

| Days | scheduled activity/day | Planned % work |
|---|---|---|
| **1** | 8 | 12.50% |
| **2** | 8 | 25% |
| **3** | 8 | 38% |
| **4** | 8 | 50% |
| **5** | 8 | 63% |
| **6** | 8 | 75% |
| **7** | 8 | 88% |
| **8** | 8 | 100% |
| | **64** | |

- **Budgeted Work, SAC (Accumulated on days basis):**

Budgeted work which is also known as Schedule at completion is determined by multiplying planned % Work by total schedule work:

So for 64 hours of total schedule when multiply accumulated planned value of each day with total schedule, BW can be obtained for each day.

$$BW = Planned\ \%\ work * total\ scheduled\ activity\ (hrs)$$

Table 2 BW

| Days | scheduled activity/day | Planned % work | BW (SAC) (Hrs) |
|---|---|---|---|
| **1** | 8 | 12.50% | 8 |
| **2** | 8 | 25% | 16 |
| **3** | 8 | 38% | 24 |
| **4** | 8 | 50% | 32 |
| **5** | 8 | 63% | 40 |
| **6** | 8 | 75% | 48 |
| **7** | 8 | 88% | 56 |
| **8** | 8 | 100% | 64 |
| | **64** | | |

- **Actual % Work (Accumulated formulation):**

Actual work percent is the work actually performed in hours, despite schedule hours work which were supposed to be performed, for this calculation actual hours of work done is supposed to be received from time tracking devices, with the help of industry 4.0 data

acquisition layer, and transmitted to CPS system with the help of data to information conversion and transmission layer. So,

$$Actual\ \%\ work = previous\ actual\ \%\ work + (\frac{actual\ activity\ per\ day}{total\ scheduled\ Task})$$

Table 3 Actual Work %

| Days | scheduled activity/day | actual Activity/day | Actual % work |
|---|---|---|---|
| **1** | 8 | 4 | 6% |
| **2** | 8 | 5 | 14.1% |
| **3** | 8 | 3 | 18.8% |
| **4** | 8 | 4 | 25.0% |
| **5** | 8 | 5 | 32.8% |
| **6** | 8 | 7 | 43.8% |
| **7** | 8 | 6 | 53.1% |
| **8** | 8 | 3 | 57.8% |
| | **64** | **37** | |

- **BC, Budgeted Cost or BCWS (accumulated for consecutive days):**

As this thesis considers to evaluate the performance of a project based on fixed pay employee's actual hours spent on activity per day, so budgeted cost of activity is the employee cost for the whole scheduled activity of the day, so BC will be total schedules work hours of day multiplied by employee cost per hour, so:

$$Budgeted\ Cost(Acc.) = prev.\ BC + (Sched.activity/day * Employee\ Cost/\ hour)$$

Can also be determined by following formula of BCWS

$$Budgeted\ Cost(Acc.) = prev.\ BCWS + (Planned\ \%\ Work * Total\ Task\ Budget)$$

In supposed data for this research employee is considered to be paid 800 euro/day, so based on 8 hours work per day will cost, 100 euro/hour, and for 8 days of activity total budget of the task will be 6400 euros so based on this supposition.

Table 4 BCWS

| Days | scheduled activity/day | unit | Planned % work | BC | BCWS |
|---|---|---|---|---|---|
| **1** | 8 | hrs | 12.50% | € 800.00 | € 800.00 |
| **2** | 8 | hrs | 25% | € 1,600.00 | € 1,600.00 |
| **3** | 8 | hrs | 38% | € 2,400.00 | € 2,400.00 |
| **4** | 8 | hrs | 50% | € 3,200.00 | € 3,200.00 |

| | | | | | |
|---|---|---|---|---|---|
| **5** | 8 | hrs | 63% | € 4,000.00 | € 4,000.00 |
| **6** | 8 | hrs | 75% | € 4,800.00 | € 4,800.00 |
| **7** | 8 | hrs | 88% | € 5,600.00 | € 5,600.00 |
| **8** | 8 | hrs | 100% | € 6,400.00 | € 6,400.00 |
| | **64** | | | | |

- **Actual Cost of Work Performed, ACWP (Accumulated):**

As research is based on the project with fixed pay employees, so the actual cost of work performed will be same as Budgeted cost of work performed on entire duration of work scheduled, irrespective of the variance in work actually performed, the main measure of performance will be schedule variance, means get paid for full work but actually performed less than expected.

ACWP can be calculated by multiplying scheduled work (hours) to cost per hour of employee.

$$ACWP(Acc.) = prev.\ ACWP + (Schd.Activity/day * Employee\ cost/hour)$$

Table 5 ACWP

| Days | scheduled activity/day | ACWP |
|---|---|---|
| **1** | 8 | € 800.00 |
| **2** | 8 | € 1,600.00 |
| **3** | 8 | € 2,400.00 |
| **4** | 8 | € 3,200.00 |
| **5** | 8 | € 4,000.00 |
| **6** | 8 | € 4,800.00 |
| **7** | 8 | € 5,600.00 |
| **8** | 8 | € 6,400.00 |
| | **64** | |

As accumulated ACWP calculated for proceeding days shows same results as BCWS, this is the fixed payment effect, when employee get paid full pay but accomplished less work, the actual difference will be evidenced on the last day of project plan, when the task will still be remaining while cost of task will be on its planned accumulation. On this instant further proceeding in task will result in cost overrun of task.

- **Earned Value, or BCWP (Accumulated):**

Earned Value or Budget Cost of Work Performed is the actual value of the work performed so far, in this context if the employee cost is fixed and productivity is not satisfactory, the EV or BCWP will always be less then BCWS, and ACWP, so according to the project management practices the task or project will be in the cost and schedule overrun.

$$EV\ or\ BCWP(Acc.) = pre\ .\ BCWP + (Total\ Budget\ Cost * Actual\ \%\ Work)$$

Table 6 EV

| Days | scheduled activity/day | actual Activity/day | unit | Planned % work | BW (SAC) (Hrs) | Actual % work | ACWP | BCWS | EV |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 8 | 4 | hrs | 12.50% | 8 | 6.3% | € 800.00 | € 800.00 | € 400.00 |
| **2** | 8 | 5 | hrs | 25% | 16 | 14.1% | € 1,600.00 | € 1,600.00 | € 900.00 |
| **3** | 8 | 3 | hrs | 38% | 24 | 18.8% | € 2,400.00 | € 2,400.00 | € 1,200.00 |
| **4** | 8 | 4 | hrs | 50% | 32 | 25.0% | € 3,200.00 | € 3,200.00 | € 1,600.00 |
| **5** | 8 | 5 | hrs | 63% | 40 | 32.8% | € 4,000.00 | € 4,000.00 | € 2,100.00 |
| **6** | 8 | 7 | hrs | 75% | 48 | 43.8% | € 4,800.00 | € 4,800.00 | € 2,800.00 |
| **7** | 8 | 6 | hrs | 88% | 56 | 53.1% | € 5,600.00 | € 5,600.00 | € 3,400.00 |
| **8** | 8 | 3 | hrs | 100% | 64 | 57.8% | € 6,400.00 | € 6,400.00 | € 3,700.00 |
| | **64** | **37** | | | | | | | |

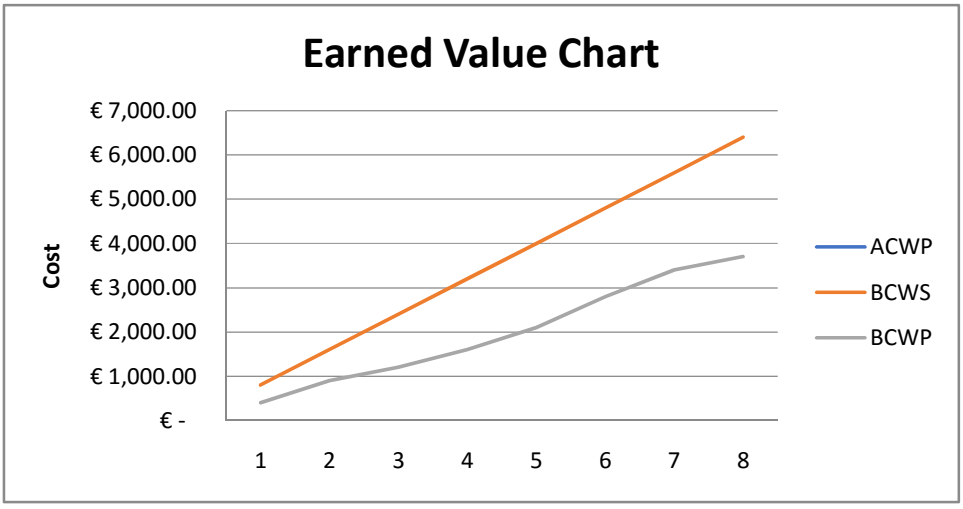



Figure 1 Earned Value Chart

Table and earned value chart above shows same values of ACWP and BCWP, because employee is fixed pay, so upto the duration of task deadline it will show same results but after the deadline, ACWP will increase above BCWS because BCWS will get zero at the end of planning period. This is called fixed units pay effect. However CEAC of the project or task if calculated at this event can evidence task overrun even in this situation despite of the fact if task deadline is not reached at the event.

- **Schedule Performance Index, SPI:**

Schedule Performance Index determines the schedule performance of a project or task, means fraction of scheduled task which is actually performed despite of its scheduled full task. So,

$$SPI = BCWP/BCWS$$

Table 7 SPI

| Days | scheduled activity/day | actual Activity/day | unit | BCWS | BCWP | SPI |
|---|---|---|---|---|---|---|
| **1** | 8 | 4 | hrs | € 800.00 | € 400.00 | 0.5 |
| **2** | 8 | 5 | hrs | € 1,600.00 | € 900.00 | 0.5625 |
| **3** | 8 | 3 | hrs | € 2,400.00 | € 1,200.00 | 0.5 |
| **4** | 8 | 4 | hrs | € 3,200.00 | € 1,600.00 | 0.5 |
| **5** | 8 | 5 | hrs | € 4,000.00 | € 2,100.00 | 0.525 |
| **6** | 8 | 7 | hrs | € 4,800.00 | € 2,800.00 | 0.583333333 |
| **7** | 8 | 6 | hrs | € 5,600.00 | € 3,400.00 | 0.607142857 |
| **8** | 8 | 3 | hrs | € 6,400.00 | € 3,700.00 | 0.578125 |
| | **64** | **37** | | | | |

All value of SPI less than 1 means the project is behind schedule, if these values were above 1, it means project is ahead of its schedule, while 1 means project is on schedule.

- **Schedule Variance, SV:**

SV corresponds to the delays in schedule due to poor performance of employee, it is mentioned in cost units, and is the difference of BCWP and BCWS.

$$SV = BCWP - BCWS$$

- **Cost Performance Index, CPI:**

CPI is a measure of cost performance of task or project; it indicates either task is on budget, overrun or under run. Measured in cost units and can be determined dividing ACWP by BCWS.

$$CPI = BCW / ACWP$$

- **Cost Variance, CV:**

CV indicated the difference in the value of work performed and actual expenses incurred in the work so far.

$$CV = BCWP - ACWP$$

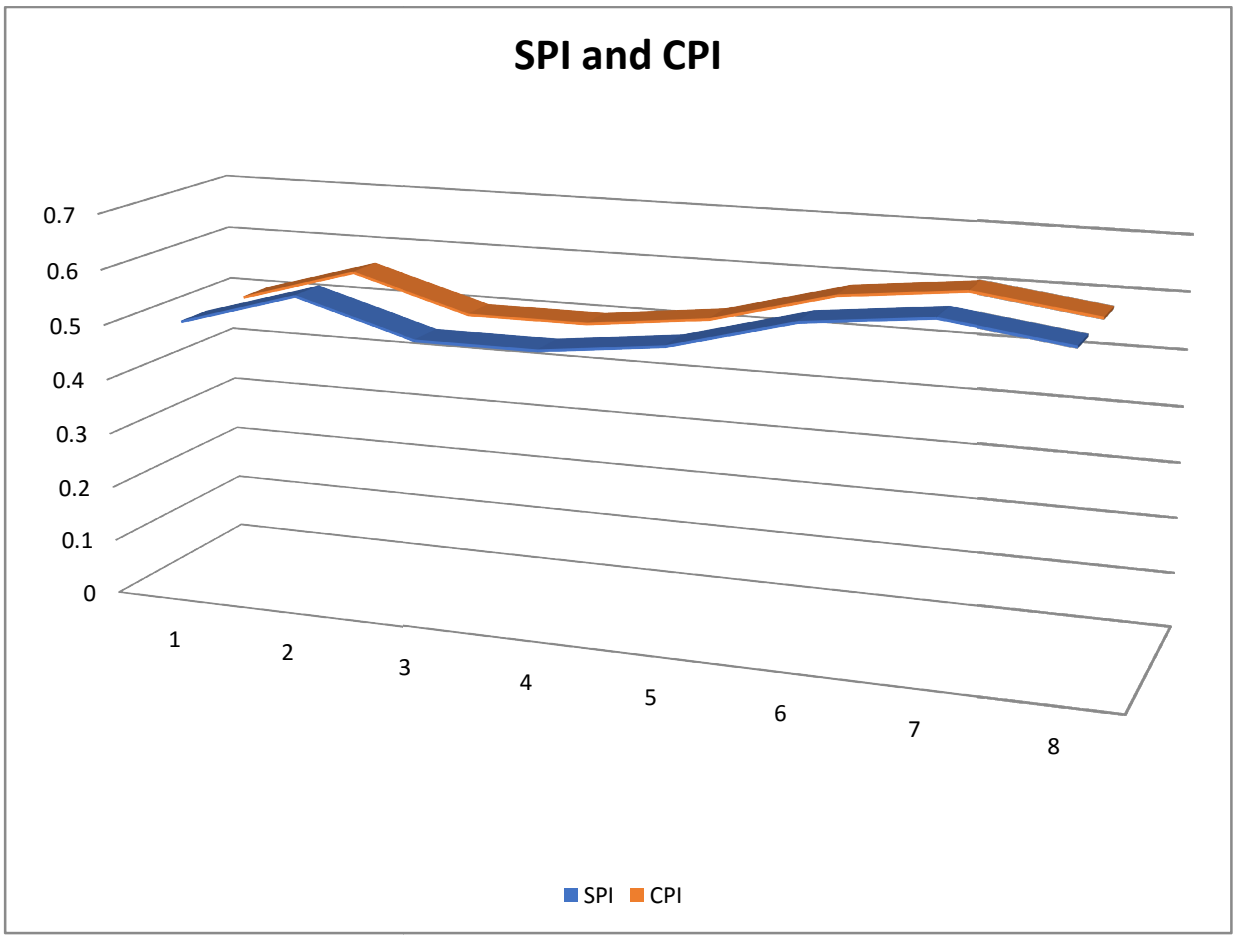



Figure 2 SPI and CPI Graph

Table 8 Cost PErformance and Variance

| Days | scheduled activity/day | actual Activity/day | unit | ACWP | BCWP | CPI | CV |
|---|---|---|---|---|---|---|---|
| **1** | 8 | 4 | hrs | € 800.00 | € 400.00 | 0.5 | € (400.00) |
| **2** | 8 | 5 | hrs | € 1,600.00 | € 900.00 | 0.5625 | € (700.00) |
| **3** | 8 | 3 | hrs | € 2,400.00 | € 1,200.00 | 0.5 | € (1,200.00) |
| **4** | 8 | 4 | hrs | € 3,200.00 | € 1,600.00 | 0.5 | € (1,600.00) |
| **5** | 8 | 5 | hrs | € 4,000.00 | € 2,100.00 | 0.525 | € (1,900.00) |
| **6** | 8 | 7 | hrs | € 4,800.00 | € 2,800.00 | 0.583333333 | € (2,000.00) |
| **7** | 8 | 6 | hrs | € 5,600.00 | € 3,400.00 | 0.607142857 | € (2,200.00) |
| **8** | 8 | 3 | hrs | € 6,400.00 | € 3,700.00 | 0.578125 | € (2,700.00) |
| | **64** | **37** | | | | **0.544512649** | |

All value of CPI less than 1 means the project is in cost overrun, if these values were above 1, it means project is in cost under run, while 1 means project is on budget.

CV negative value means this much extra cost will be needed to get the job done.

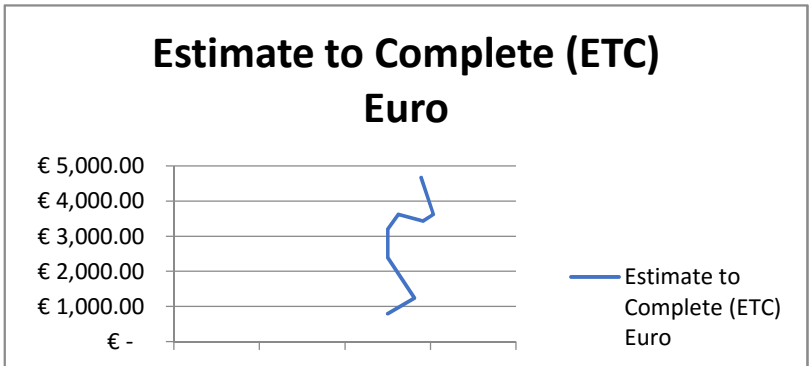
Point to notice is that in this case SPI and CPI both are same, this effect is because of fixed paid employee on daily or monthly basis, so the expenditure of daily activities are same with less work than expected, that's why CPI and SPI are same

- **Estimate to Complete, ETC (accumulated):**

Estimate to complete is another measure to calculate the remaining expenses for the task be accomplished, which were supposed to be complete on the evaluation instant. It is mentioned in cost units.

ETC can be calculated as follows:

$$ETC = (BAC - EV)/CPI$$



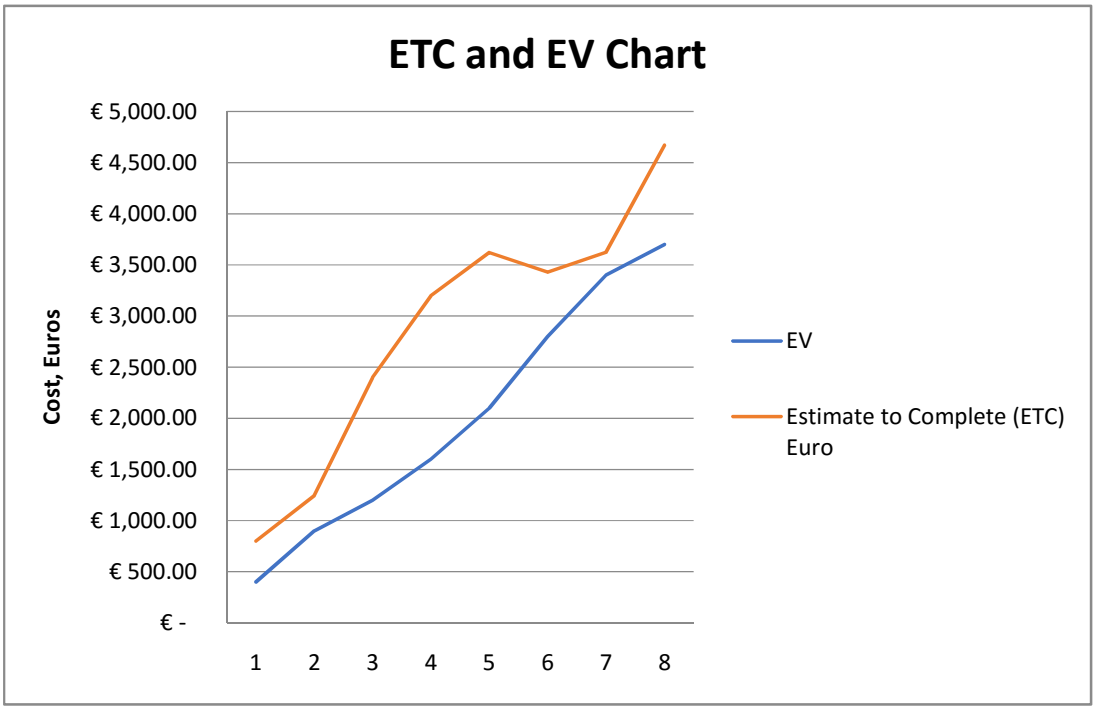



Figure 4 ETC and EV

- **Estimate at Completion, EAC (Accumulated):**

Estimate at completion is the cost forecast, shows the total expense of the task when it will be completed, despite of the actual planned expense. It is different from the planned expenses because it considers the task delays and extra expenses incurred during the accomplishment of the task. It is denoted as cost units.

$$EAC = BAC/CPI$$

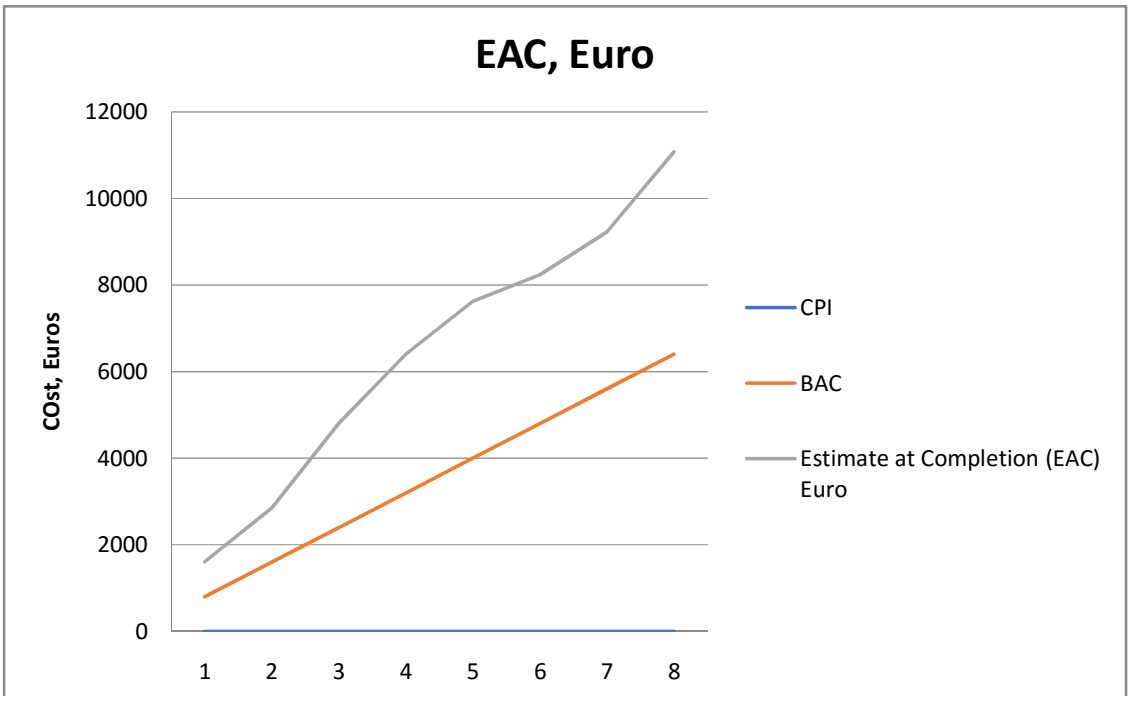


Table 9 ETC and EAC

| Days | scheduled activity/day | actual Activity/day | BCWP | EV | CPI | BAC | Estimate to Complete (ETC) Euro | Estimate at Completion (EAC) Euro |
|---|---|---|---|---|---|---|---|---|
| **1** | 8 | 4 | € 400.00 | € 400.00 | 0.5 | € 800.00 | € 800.00 | € 1,600.00 |
| **2** | 8 | 5 | € 900.00 | € 900.00 | 0.56 | € 1,600.00 | € 1,244.44 | € 2,844.44 |
| **3** | 8 | 3 | € 1,200.00 | € 1,200.00 | 0.5 | € 2,400.00 | € 2,400.00 | € 4,800.00 |
| **4** | 8 | 4 | € 1,600.00 | € 1,600.00 | 0.5 | € 3,200.00 | € 3,200.00 | € 6,400.00 |
| **5** | 8 | 5 | € 2,100.00 | € 2,100.00 | 0.5 | € 4,000.00 | € 3,619.05 | € 7,619.05 |
| **6** | 8 | 7 | € 2,800.00 | € 2,800.00 | 0.59 | € 4,800.00 | € 3,428.57 | € 8,228.57 |
| **7** | 8 | 6 | € 3,400.00 | € 3,400.00 | 0.61 | € 5,600.00 | € 3,623.53 | € 9,223.53 |
| **8** | 8 | 3 | € 3,700.00 | € 3,700.00 | 0.58 | € 6,400.00 | € 4,670.27 | € 11,070.27 |
| | **64** | **37** | | | **0.54** | | | |

- **CV at Completion:**

It is the measure of cost over spending for the task completion as compared to planned cost for the task. It is the difference between Estimate to compete and budget actual cost for the task planned. It is montioned is cost units and negative means task is in cost overrun while positive value indicates cost under run and 0 indicates on budget.

$$CV\ at\ Completion\ = Estimate\ at\ completion - BAC$$

Table 10 CV at Completion

| Days | BAC | Estimate to Complete (ETC) Euro | Estimate at Completion (EAC) Euro | CV at Completion Euro |
|---|---|---|---|---|
| 1 | € 800.00 | € 800.00 | € 1,600.00 | € (800.00) |
| 2 | € 1,600.00 | € 1,244.44 | € 2,844.44 | € (1,244.44) |
| 3 | € 2,400.00 | € 2,400.00 | € 4,800.00 | € (2,400.00) |
| 4 | € 3,200.00 | € 3,200.00 | € 6,400.00 | € (3,200.00) |
| 5 | € 4,000.00 | € 3,619.05 | € 7,619.05 | € (3,619.05) |
| 6 | € 4,800.00 | € 3,428.57 | € 8,228.57 | € (3,428.57) |
| 7 | € 5,600.00 | € 3,623.53 | € 9,223.53 | € (3,623.53) |
| 8 | € 6,400.00 | € 4,670.27 | € 11,070.27 | € (4,670.27) |

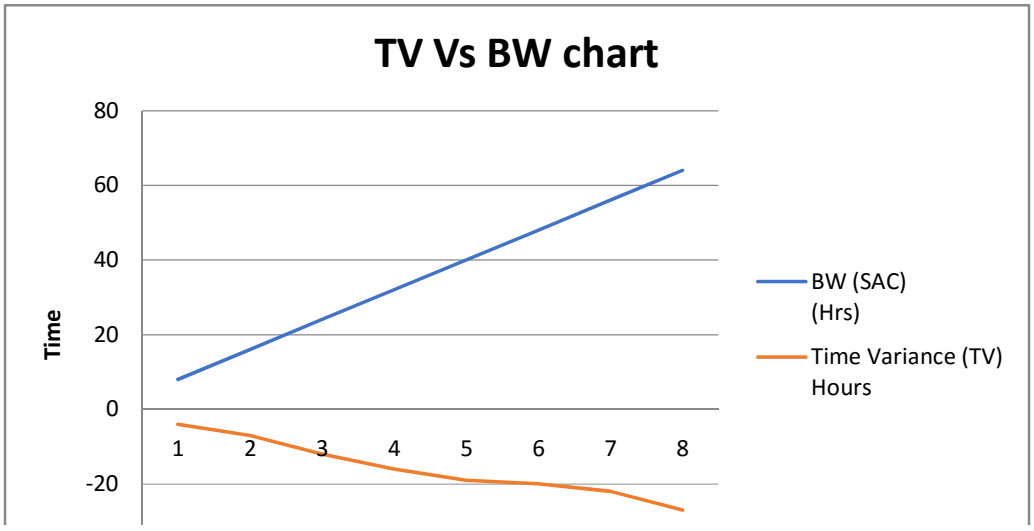
- **Time Variance, TV:**

Time variance is the measure of time difference between the planned schedule and estimated schedule based on performance of tasks, it is latest version of SPI, because schedule variance is in cost units, so Time variance is in hour's unit.

It can be obtained by dividing Schedule variance for the reporting time by Planned Accomplishment rate.

$$TV = SV/PAR$$

PAR, Planned Accomplishment Rate is per unit time cost of task accomplishment, which needs to be spend for the task completion.



- TV%:

Time Variance percent is the percentage of time variance as compared to the actual budgeted works in hour. It has the same meaning as SV%. It can be calculated by dividing TV with Budgeted Work Planned for the completion. Mentioned in percentage.

$$TV\% = TV/BW$$

Table 11 TV, TV%

| Days | scheduled activity/day | unit | BW (SAC) (Hrs) | SV | Planned Accomplishment Rate (PAR) Per hour | Time Variance (TV) Hours | TV% |
|---|---|---|---|---|---|---|---|
| 1 | 8 | hrs | 8 | € (400.00) | € 100.00 | -4 | -50% |
| 2 | 8 | hrs | 16 | € (700.00) | € 100.00 | -7 | -44% |
| 3 | 8 | hrs | 24 | € (1,200.00) | € 100.00 | -12 | -50% |
| 4 | 8 | hrs | 32 | € (1,600.00) | € 100.00 | -16 | -50% |
| 5 | 8 | hrs | 40 | € (1,900.00) | € 100.00 | -19 | -48% |
| 6 | 8 | hrs | 48 | € (2,000.00) | € 100.00 | -20 | -42% |
| 7 | 8 | hrs | 56 | € (2,200.00) | € 100.00 | -22 | -39% |
| 8 | 8 | hrs | 64 | € (2,700.00) | € 100.00 | -27 | -42% |

- **Earned Schedule:**

Earned Schedule as elaborated in the terms of the study, is the duration from the beginning of the project to the point on which it should have been completed with PV equal to current actual value.

It can be calculated as:

$$ES = EV/PAR$$

- **Time Performance Index:**

Time performance index, as compared to the schedule performance index is the more practical measure of performance of the task or project for the productivity, it is also confused with SPI.

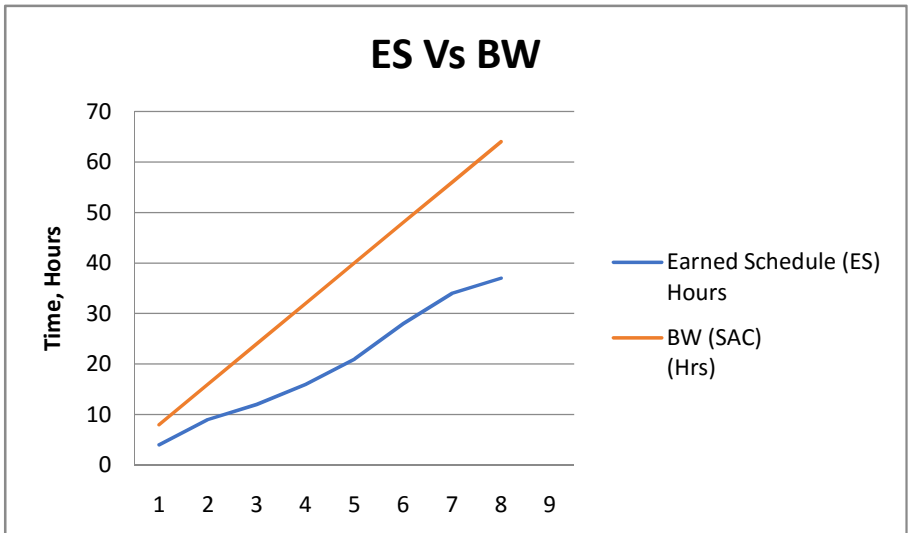
TPI is the ratio of Earned Schedule to Budget Work

$$TPI = E / BW$$

As given in below table:

Table 12 TPI

| Days | scheduled activity/day | unit | BW (SAC) (Hrs) | Earned Schedule (ES) Hours | Time Performance Index TPI |
|---|---|---|---|---|---|
| **1** | 8 | hrs | 8 | 4 | 0.5 |
| **2** | 8 | hrs | 16 | 9 | 0.5625 |
| **3** | 8 | hrs | 24 | 12 | 0.5 |
| **4** | 8 | hrs | 32 | 16 | 0.5 |
| **5** | 8 | hrs | 40 | 21 | 0.525 |
| **6** | 8 | hrs | 48 | 28 | 0.583333333 |
| **7** | 8 | hrs | 56 | 34 | 0.607142857 |
| **8** | 8 | hrs | 64 | 37 | 0.578125 |
| | **64** | | | | |



- **Expected Accomplishment Rate:**

As compared to Planned Accomplishment rate, which is the planned per unit cost of project or task completion, expected accomplishment rate is the forecast of the per unit time cost of project completion, it is the ration of Earned Value and Budgeted work.

$$EAR = EV/BW$$

The difference between TPI and EAR is that, TPI is in fraction, while EAR is in cost units, this is because ES is expressed in Hours units while EV is expressed in Cost units.

If the performance actually scheduled was according to plan, then this EAR would have been equal to PAR, but because performance is not as expected, EAR predicts that work is performing as half of its expectation, so if they are paid according to their performance their rate would have been EAR values per hour as compared to PAR which is 100 Euros per hour.

Table 13 EAR

| Days | scheduled activity/day | actual Activity/day | unit | BW (SAC) (Hrs) | EV | Expected Accomplishment Rate EAR |
|---|---|---|---|---|---|---|
| **1** | 8 | 4 | hrs | 8 | € 400.00 | € 50.00 |
| **2** | 8 | 5 | hrs | 16 | € 900.00 | € 56.25 |
| **3** | 8 | 3 | hrs | 24 | € 1,200.00 | € 50.00 |
| **4** | 8 | 4 | hrs | 32 | € 1,600.00 | € 50.00 |
| **5** | 8 | 5 | hrs | 40 | € 2,100.00 | € 52.50 |
| **6** | 8 | 7 | hrs | 48 | € 2,800.00 | € 58.33 |
| **7** | 8 | 6 | hrs | 56 | € 3,400.00 | € 60.71 |
| **8** | 8 | 3 | hrs | 64 | € 3,700.00 | € 57.81 |
| | **64** | **37** | | | | |

- **Time Estimate at Completion, TEAC:**

This is the most important measure in project forecast, TEAC predicts according to current performance the actual time to complete a task or project. If performance of a project is not as planned, then TEAC will be changed compared to the planned date or time of completion of the task or project.

It is denoted in time units, and can be calculated as:

$$TEAC = BW + (BAC - EV)/EAR$$

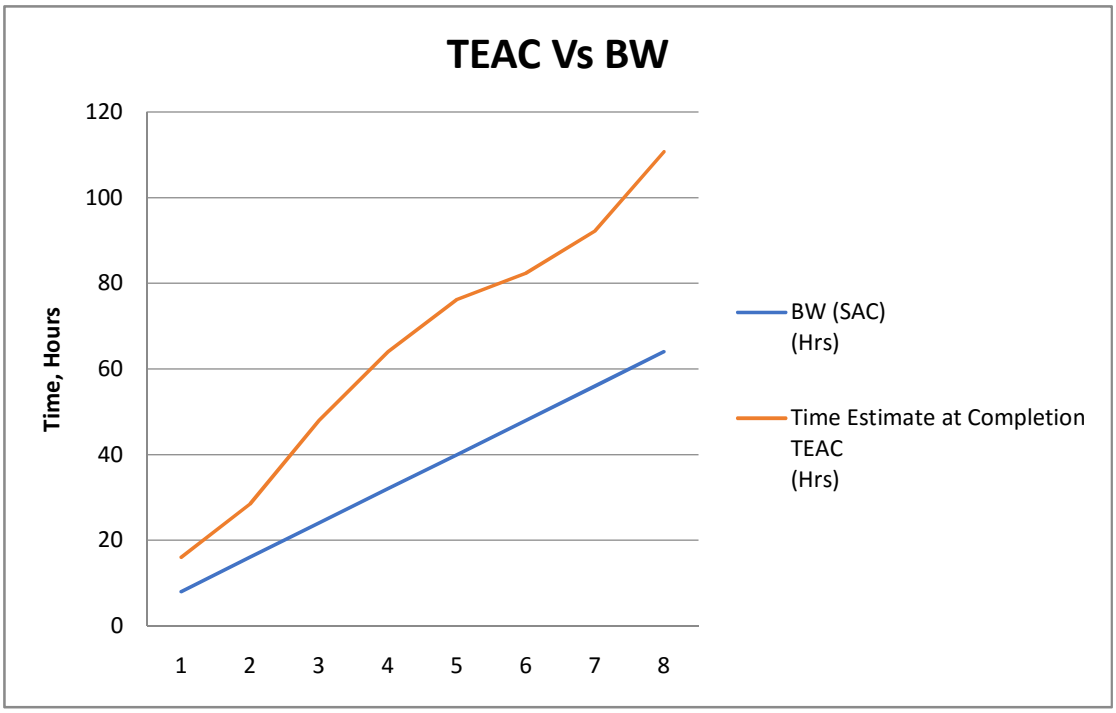



Figure 8 TEAC

- **Time Variance at Completion, TVAC:**

Time variance at completion is the measure of time difference between planned and actual progress of the work, at its completion. It forecasts at completion our work status at completion, either behind, ahead or on schedule.

It can be calculated as:

$$TVAC = BW - TEAC$$

It is expressed in time units, negative value of TVAC indicated behind schedule and positive value shows ahead of schedule while, 0 indicates on schedule status.

Table 14 TEAC, TVAC

| Days | scheduled activity/day | actual Activity/day | BW (SAC) (Hrs) | EV | BAC | Expected Accomplishment Rate EAR | Time Estimate at Completion TEAC (Hrs) | Time Variance at Completion TVAC (Hrs) |
|---|---|---|---|---|---|---|---|---|
| **1** | 8 | 4 | 8 | € 400.00 | € 800.00 | € 50.00 | 16.00 | -8.0 |
| **2** | 8 | 5 | 16 | € 900.00 | € 1,600.00 | € 56.25 | 28.44 | -12.4 |
| **3** | 8 | 3 | 24 | € 1,200.00 | € 2,400.00 | € 50.00 | 48.00 | -24.0 |
| **4** | 8 | 4 | 32 | € 1,600.00 | € 3,200.00 | € 50.00 | 64.00 | -32.0 |
| **5** | 8 | 5 | 40 | € 2,100.00 | € 4,000.00 | € 52.50 | 76.19 | -36.2 |
| **6** | 8 | 7 | 48 | € 2,800.00 | € 4,800.00 | € 58.33 | 82.29 | -34.3 |
| **7** | 8 | 6 | 56 | € 3,400.00 | € 5,600.00 | € 60.71 | 92.24 | -36.2 |
| **8** | 8 | 3 | 64 | € 3,700.00 | € 6,400.00 | € 57.81 | 110.70 | -46.7 |
| | **64** | **37** | | | | | | |

These analysis and results will be presented in graphs and performance reports for quick overview and further interpretation by managers, the analysis, reports and graphs are stored in database for further utilization.

When implemented these algorithms in CPS system, system when received information about inputs will calculate all other parameters and measures by itself and present its reports and interpretation. In this way project control will become as simple as possible.

The coding to be implemented in CPS based on above discussed algorithms is as follows:

#### 6.1.3.2.1 Python Coding for Mathematical Algorithms, CPS system.

```
from datetime import date
import matplotlib.pyplot as plt

#------------------------------------------------------------
def divide(x, y):
    li = []
    init = 0
    for i in y:
        init += i/x
        li.append(init)
    return li

def multiply(x, y):
    li = []
    init = 0
    for i in y:
        init += i*x
        li.append(init)
    return li

def li_mul(i, j):
    return list(map(lambda x: x*i, j))

def li_div(i, j):
    return list(map(lambda x, y: x/y, i, j))

def li_sub(i, j):
    return list(map(lambda x, y: x-y, i, j))
```

```
def li_add(i, j):
    return list(map(lambda x, y: x+y, i, j))

#-------------------------------------------------------------

taskDuration = 8
# Duration of Task to be completed in days
dateOfAllocation = date(2019, 9, 24)
totalScheduleTask = 64
#in hours
effortPerDay = int(totalScheduleTask/taskDuration)
employeeCostDay = 800
#rough estimate
employeeCostHour = employeeCostDay/effortPerDay
#based on 8 hours normal office working hour
bac = employeeCostHour*effortPerDay*taskDuration
#per task

days = list(range(1, taskDuration+1))
scheduledActivity = [effortPerDay for i in range(taskDuration)]
#schedule time array for task completion
actualActivity = [4, 5, 3, 4, 5, 7, 6, 3]
#in hours, actual workout on task by employee, time tracking devices can be used to monitor for activity of task, aas well as some autonomous devices can also be used which tracks activity and record it in the system automatically with the help of coding and synchronization

plannedWorkPercentage = divide(totalScheduleTask, scheduledActivity)
```

```
#calculates the percentage of task scheduled accumulated to date.

BW = list(range(effortPerDay, totalScheduleTask+effortPerDay, effortPerDay))

actualWorkPercentage = divide(totalScheduleTask, actualActivity)

actualWork = li_mul(totalScheduleTask, actualWorkPercentage)

#Calculates in every element of an array

BC = multiply(employeeCostHour, scheduledActivity)

ACWP = BC

BCWS = li_mul(bac, plannedWorkPercentage)

BCWP = li_mul(bac, actualWorkPercentage)

EV = BCWP

SPI = li_div(BCWP, BCWS)

CPI = li_div(BCWP, ACWP)

CV = li_sub(BCWP, ACWP)

CVPercentage = li_div(CV, BCWP)

SV = li_sub(BCWP, BCWS)

SVPercentage = li_div(SV, BCWS)

RV = li_sub(BCWS, ACWP)

RI = li_div(BCWS, ACWP)

BAC = li_mul(bac, plannedWorkPercentage)

ETC = li_div(li_sub(BAC, BCWP), CPI)

#Estimated Time to Complication

EAC = li_div(BAC, CPI)

CVatCompletion = li_sub(BAC, EAC)

PAR = li_div(BAC, BW)

TV = li_div(SV, PAR)

TVPercentage = li_div(TV, BW)

ES = li_div(EV, PAR)

TPI = li_div(ES, BW)

EAR = li_div(BCWP, BW)
```

```
TEAC = li_add(BW, li_div(li_sub(BAC, BCWP), EAR))

TVAC = li_sub(TEAC, BW)



#Employee performance andividually based on accumulated and
each day activity, irrespectivve of the project performance

# Overall Evaluation

evaluation = 6

employeePerformance                                          =
sum(actualActivity[0:evaluation])/sum(scheduledActivity[0:eval
uation])

statusOfTask    =    ('Task    is    Behind    Schedule'    if
(employeePerformance   <   1)   else   'Task   is   On   Time'   if
(employeePerformance == 1) else 'Task is Ahead of Schedule')

delta = abs(employeePerformance-1)

estimatedTimeOfCompletion = taskDuration*(1+delta)

statusAccordingToDeadline            =            taskDuration-
estimatedTimeOfCompletion


#Performance Evaluation of Single Day

daysOfEvaluation = 5

effortOnTheDay = actualActivity[daysOfEvaluation-1]

effortPerDayRequired = effortPerDay

performanceEvaluation = effortOnTheDay/effortPerDayRequired

statusOfCurrentDay  =  statusOfTask  =  ('Behind  Schedule'  if
(performanceEvaluation   <   1)   else   'On   Schedule'   if
(employeePerformance == 1) else 'Ahead of Schedule')


# Plots

plt.figure()


plt.subplot(211)

plt.plot(days, ACWP, days, BCWP, days, BCWS)

plt.title('Earned Value Graph')
```

```
plt.xlabel('Duration')
plt.ylabel('Cost')

plt.subplot(212)
plt.plot(days, SPI)
plt.axis([0, taskDuration+1, 0, 0.7])
plt.title('Performance Chart')
plt.xlabel('Duration')
plt.ylabel('Schedule Performance')
plt.show()

print('Planned work percentage is ', plannedWorkPercentage)
print('BW is ', BW)
print('Actual % Work is ', actualWorkPercentage)
print('Budgeted Cost of Work Scheduled is ', BCWS)
print('Actual Cost of Work Performed is ', ACWP)
print('Budgeted Cost of Work Performed is ', BCWP)
print('Earned value is ', EV)
print('Scheduled Performance Index is ', SPI)
print("{:.1%}".format(performanceEvaluation))
print('Schedule Variance is ', SV)
print('Schedule Variance % is ', SVPercentage)
print('Cost Variance is ', CV)
print('Cost Performance Index is ', CPI)
print('Cost Variance % is ', CVPercentage)
print('Estimate to Complete is ', ETC)
print('Estimate at Complete is ', EAC)
print('CV at Completion is ', CVatCompletion)
print('Time Variance is ', TV)
print('Time Variance % is ', TVPercentage)
print('Earned Schedule is ', ES)
```

```
print('Time Performance Index is ', TPI)

print('Expeccted Accomplishment Rate is ', EAR)

print('Time Estimate at Completion is ', TEAC)

print('Time Variance at Completion is ', TVAC)


print('for task duration', taskDuration, 'allocated on', dateOfAllocation, 'total schedule of activity (hours)', totalScheduleTask, 'and effort per day as respected to total schedule is', effortPerDay, 'per day cost of nominated employee is', employeeCostDay, 'so per hour cost of working on this task is', employeeCostHour, 'in this response total schduled budget of task is', bac)

print('for schedules per day as', scheduledActivity, 'employee workout on activity as', atualActivity, 'so according to analysis, Eatimate to complete of the project will be', ETC, 'while estimate at complete will be', EAC, 'while time estimate at compeion will be', TEAC)
```

### 6.1.4 Cognition Layer:

Implementing CPS upon this level generates a thorough knowledge of the monitored tasks. Proper presentation of the acquired knowledge to expert users supports the correct decision to be taken. Since comparative information as well as individual tasks status are available, decision on priority of tasks to optimize the controlling activities can be made. For this level, proper info-graphics are necessary to completely transfer acquired knowledge to the users.

In this level, performance of a single task can be compared with the planned schedules of that task. On the other hand, these analytics may be used to measure and predict the future performance of the employee.

Here project manager or decision maker can access the performance indexes, reports and graphical representation of productivity of employee generated by cyber layer to understand the patterns and effectiveness of employee, in this way managers are able to make correct decisions.

This data can also help managers in selection of different caliber of employee for different specific task requirement, based on their past data and performance in different types of tasks. Because there may be some employees who are good at planning and while there may be some employees who are good at MS project and so on. So by assessing their history in performance a manager can easily access which employee should be allocated to which kind of tasks.

### 6.1.5 Configuration Layer:

The configuration level is the feedback from cyber space to physical space and acts as supervisory control to make tasks satisfactory. This stage acts as supervisory control to apply the corrective and preventive decisions, which has been made in cognition level, to the monitored tasks.

The decisions made in the cognition layer by managers on the basis of reports and graphs available from the database, is controlled in this layer.

Based on performance analyzed by system, manager can act accordingly to control the employee, which is if the performance of employee is satisfactory, he must be appreciated for the performance, while if the performance is not satisfactory, he can be managed with some consultancy and trainings.

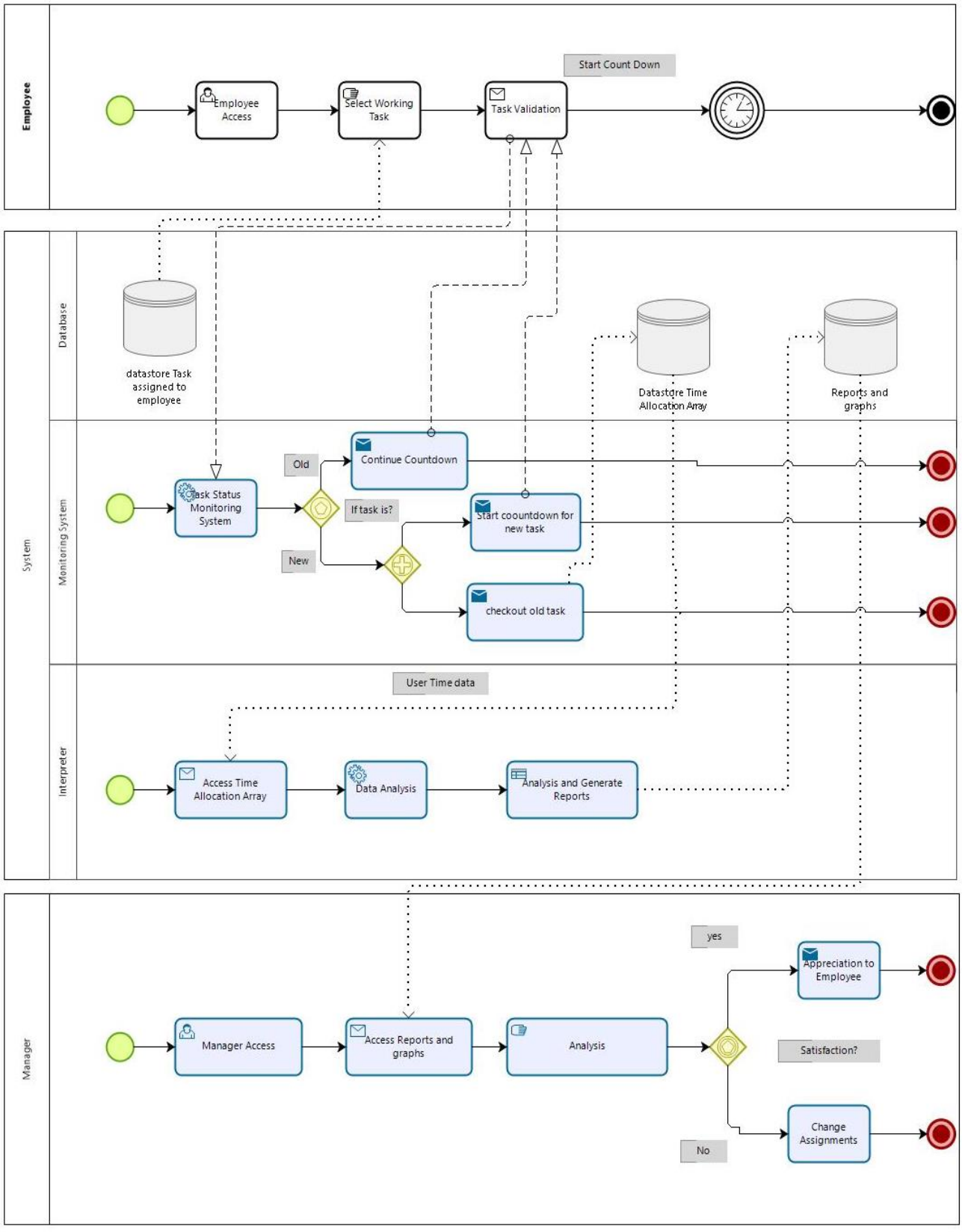
## 6.2 Process Model (BPMN):

The model of the whole is generated using Business Process Modelling and Notations known as BPMN, BPMN is graphical representation for the purpose to summarize business processes in the form of model and notations, so that process can be understood easily.

BPMN is widely used for modeling and representations of simple and complex both kinds of processes worldwide. Its version 2.0 was released in the year 2011, while the latest version 2.0.2 was released in 2014.

BPMN is standard for process models in business modeling dedicated for graphical notations to elaborate business process diagrams (BPD) to support business process management for the business and technical users.

For the process elaborated for employee management and to analyze their performance, BPMN standards are used to specify the model of process with essential notations:



### 6.2.1 Process of Working Model:

When I4.0 based CPS system is implemented to project monitoring and control upon employee time monitoring, the system model as elaborated above with the help of Business Process Modeling and Notations techniques and rules, the process is elaborated below:

When in an employee loop, an employee starts to work on an assigned task, he can access his time monitoring device, where he can select a working task which is assigned to him, as soon as task is selected the process proceeds towards the validation of that specific task, for this validation an information request is sent to the System monitoring loop in syetem group, where Task status monitoring system generates an activity of task validation and confirm the status of task, if task selected was an old task, means employee was already working on that task before logging off, task status will generate task of continue countdown, which means Task validation in employee loop will generate check-in and start countdown. On the other hand if the task is new means employee logoff was another task, then a parallel fork will be generated, it will send information to task validation for starting new task countdown and check in and employee time tracking loop is terminated on end task. On the other hand Task monitoring system will logout old task and save Time information to Time Allocation Array Database.

Now Interpreter loop, which consists of CPS system, receive Time Allocation Array information from the database and starts data analysis based on pre designed mathematical algorithms for analysis, when analysis is done, reports and graphs are generated, which are sent to Database for further analysis by manager.

Manager loop starts when manager access generated reports and graphs for review and decide if employee performance is satisfactory, an appreciation is snet to employee or is performance is not satisfactory then employee is subject to relocation to another task.

There are several tasks and their specific notations which are used in this model, according to BPMN standards. Given below are details of tasks.

### 6.2.2 Service Task:


Service task is defined as the task which uses other services for the completion of task, such as some web services, an automated application, or some other types of services. In our PBMN model there are two tasks which can be called the service tasks Task Status Monitoring System in the monitoring system loop, and Data Analysis Task in the Interpreter Loop.

### 6.2.3 Send Task:


In BPMN standards a send is elaborated as a task which for completion send a message to acquire necessary information to a different lane or pool, and when information is received task is performed. In presented BPMN model there are five send tasks including tasks Continue Countdown, Start Countdown for new Task, Checkout Old Task in Monitoring System Loop, while Tasks as Appreciation to Employee, Reallocation of Employee in the Manager Loop.

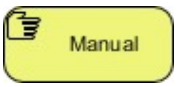
### 6.2.4 Receive Task:


A receive task is called such kind of task, which has to be started when a certain kind of a message is arrived to it. Task is completed when the message is received. Presented BPMN model have three Tasks of this type, including Task Validity in Employee Loop and Access TimeAllocationArray, and Access Reports and Graphs in Interpreter and Manager Loops respectively.

### 6.2.5 User Task:


User task as evident from its name is such kind of task that has to be performed by human, by means of software application of other tools. BPMN model shown above includes two user tasks from Loop Employee its Employee Access and From Loop Manager its Manager Access.

### 6.2.6 Manual Task:




Manual tasks are that tasks which are performed without the help of business process execution engines or other types of application. Manual Tasks includes “Select Working Task” in Employee Loop while “Analysis” in Manager Loop.

### 6.2.7 Business Rule Task:


It a new addition to BPMN 2.0 standard, which elaborates the procedure for the business process to give input to a business rule engine and in response the output is given by BRE. In presented BPMN model there is one BRT which is Analysis and generation of Reports and Graphs from the Interpreter Loop.

### 6.2.8 Script Task:


This kind of task is performed by business process engine, task defines a script as evidence from task name that the engine can read. When task initializes, the engine performs as scripted, and task completion depends on script completion.

### 6.2.9 Process Flow:

The Process flow in BPMN models is indicated as dimensional complete arrow in the direction of flow of process.

### 6.2.10 Information Flow:

In BPMN models information flow is mentioned as dotted arrow in the direction of information flow.

# 7 Methodology:

## 7.1 Title of the Research:

As stated in the previous section according to title of the research which is “Exploring Industry 4.0 paradigm as applied to project management and Analytical study of relationship between employee performance and project success in response of Time monitoring by Industry 4.0 concepts, by using Full Earned Value Analysis methodology”, this research is basically a constructive approach research, which means in this work focus is kept on the application of Industry 4.0 concepts in possible areas of Project Management so that projects can be managed and monitored in a more advanced and efficient way to ensure the performance and productivity of project in the near future, this work also consists explanation of employee time monitoring techniques with Industry 4.0 procedure and an explanatory analysis of time expenditure for allocated task to employee, with the help of famous project management procedure for evaluation of projects performance, which is Earned Value Analysis.

Algorithms formulated to access project performance in relation to the employee time allocation array, Earned Value Analysis is the core of Industry 4.0 which is Cyber Physical System, these algorithms can be used to design a CPS system for the I4.0 based monitoring and control system for project management.

## 7.2 Rationale of the research study:

Whenever project performance is concerned of the study or analysis, employee performance is one of the very important factors to discuss, and it is the main factor of project performance and success. In this context organization needs to consider very solid

actions to improve employee performance and make strategies to optimal consumption of employee skills and capability. This research study apart from analysis of expected outcomes of the Industry 4.0 concepts adopted for performance analysis of employee, will also target the basic calculation which needs to be implemented for the CPS system.

This research also aims to figure out the relationship between the proposed ideas on the project success.

## 7.3 Scope and coverage of research study:

The scope of this research study lies in the core of project management, especially for performance evaluation of project and project team. This thesis will cover performance analysis of the project with fixed pay based project team, which means such kinds of project team who are regular employed by organization and paid on monthly basis a fixed amount.

Performance of project on the ground of fixed pay team, working on the project, Earned value analysis and its result on the assumed data for employee time spent on a task in accordance with the and relation with the project overall performance.

This thesis work will also cover the employee individual work duration performance with respect to actual baseline plan.

In parallel this research work will open door for project management to the Industry 4.0 technology.

## 7.4 Objective of Research study:

The overall objective of study is as elaborated in the introduction part, but for convenience can be summarized here,

- To study the feasibility of method and efficiency of industry 4.0 if adopted for project management.
- Procedure for I4.0 application for the earned value analysis.
- Effects of employee performance on project performance, evaluated with the help of EVA.

## 7.5 Research Design:

This research is based on quasi experimental research methodology, which means this research looks like experimental research but is not actually experimental research based on real data. Although data used in this research is supposed data according to the real life scenarios and conditions, which regards the constructive approach of research. The independent variable which is employee time allocation for allocated task is manipulated, keeping other variables baseline constant.

Keeping in view worst employee performance, the data supposed is based on the actual daily time allocation to an assigned task by employee, if employee has no other task in under study duration of the task, means employee is supposed to work only on assigned task.

Following data will be used for the evaluation:

- Employee Time Expenditure on allocated task, on daily basis
- Baseline of project task allocated
- Employee fixed payment, either daily or monthly basis
- Deadlines
- Tools to be used for task accomplishment
- Project or Task Planned budget

## 7.6 Sources of Information:

### 7.6.1 Primary Data:

Primary data refers as the data which is gathered or supposed by the researcher by himself for the purpose of experimentation and exploration.

For this thesis primary data on time expenditure of employee on the task allocated has been supposed for the purpose of evaluation and exploration of the concept, time supposition is based on the real life scenarios, and common time utilization patterns followed by average employee on projects.

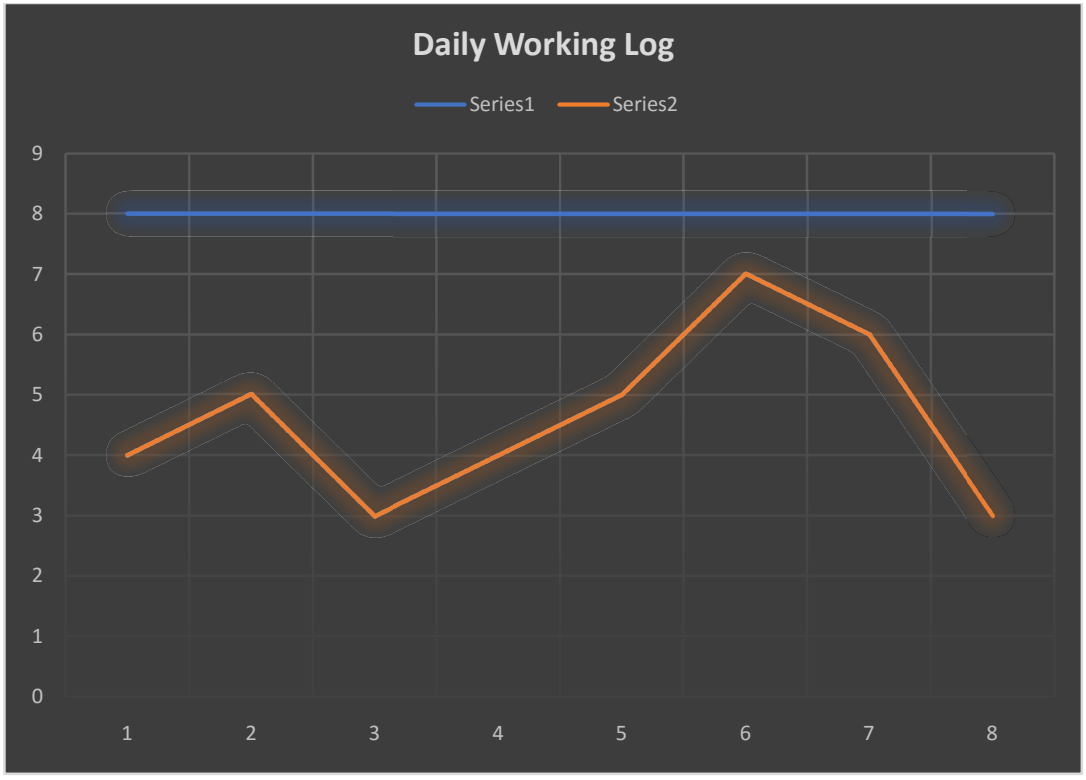
Apart from that Task Planned Value (BCWS), Task Duration had also been supposed for exploration and lies in the borders of primary data.

For research purpose our supposed data is as follows:

| Task Allocated to Employee | Process Design |
|---|---|
| Tools | Design Software |
| Deadline | 8 Days Max. |
| Total Required Effort | 64 hours |
| Employee Cost | 800/Day |

| Days | scheduled activity/day | Supposed actual Activity/day | Unit |
|---|---|---|---|
| **1** | 8 | 4 | Hrs |
| **2** | 8 | 5 | Hrs |
| **3** | 8 | 3 | Hrs |
| **4** | 8 | 4 | Hrs |
| **5** | 8 | 5 | Hrs |
| **6** | 8 | 7 | Hrs |
| **7** | 8 | 6 | Hrs |
| **8** | 8 | 3 | hrs |
| | **64** | **37** | |

According to supposed data on random basis overall efficiency is less than 60%, which means more than 40% of working time has been theft and utilized out of project. The earned value analysis will evaluate effect of this time theft on overall project performance.




In the graph above blue plot is for scheduled time, while orange is for time actually spent.

However this supposed time allocation array is considered to be obtained autonomously with the help of Time Tracking Devices, connected to the I4.0 based project monitoring

systems. Here, for the exploration of idea this data is been supposed bypassing the need of time tracking devices.

### 7.6.2 Secondary Data:

Secondary data about average employee time utilization on allocated task is obtained from the online researches, according to research on daily employee time expenditure, around 40% of time is being theft everyday on average.

According to US Pay Roll Association, Time theft affects about 75% of business, and creating a loss of around 400 Billion $ per year. It is supposed to be a silent killer of efficiency.

Data collected from time tracking device or any other mean can be utilized for earned value analysis of project.

### 7.6.3 Significance of the Research Study:

The research work of this thesis has considered the objective of implementation of industry 4.0 concepts to be explored in project monitoring and focused on the earned value analysis and employee performance evaluation and monitoring, and analysis of employee performance for the project performance. This thesis also links the concepts of industry 4.0 to other cores of project management by theoretically explaining the process of implementation.

The concepts explained in this thesis can be utilized for project tracking, project budget revisions, contract renegotiations for possible delays and budget overruns, to conclude employee productivity, helpful in employee rotations, task reallocations.

# 8 Approach:

## 8.1 Research Approach: Quantitative or Qualitative?

Patel &Tebelious (1987) claimed that research can be based on time factor and can be mainly classified into two types, one is qualitative and other is quantitative. These two approached can have some pros and cons, in each case neither one nor the other can be considered superior to the other because the good research method which should be used for a study depend on the purpose of the research and the question structured to be asked.

Quantitative research is a considered to be the best research approach, the appropriate methodology in data acquisition lead to a suitable calculated information. The processes which can be used to collect data can be questionnaires, surveys, and coded synthetic monitoring (Lowe 2007)

While on the other hand qualitative research can be interpreted as the acquisition of knowledge that should be examined, analyzed and completely understood the processes through the medium of a concise point of view. Researchers claimed that qualitative research is mostly based on the interviews and interactions which are open-end and on the data of other field, sometimes can also consist of quantitative data or disruptive statistics.

In the light of explanations for quantitative and qualitative approach, this work is based on qualitative as well as quantitative research approach because this work is aimed at the acquisition of knowledge, examination of the concepts and analysis of the theories in order to understand feasibility of Industry 4.0 in project management and interpretations of data to prove the feasibility of concept.

The broad quantitative approach could also be adopted for the research, but due unavailability of capable resources for the acquisition of real data in order to access real information, qualitative approach is widely adopted, on the other hand quantitative approach is being utilized in a narrow scope.

For further research in this area quantitative approach will be very beneficial.

### 8.2 Research Method: Constructive or Empirical?

Research method is a scientific term used for the nature of research conduction, to evaluate how the facts has been derived in the research work, it is a label to research based on the procedure of work done in research.

According to definition constructive research is based on the theories and its evaluation and feasibility or possibility to apply in some technology, it does not need that research must be as per solidity, these type of research may be some case studies, may be based on hypothesis and supposition, while on the other hand Empirical research should be based on reality, must be solid observations, and proofs of theories, in which real data should be utilized to obtain the results.

According to the definitions elaborated above this research is based on the Constructive research, because this work is based on supposed data and utilization of I4.0 theories to finding out the feasibility of I4.0 in project monitoring and control.

Furthermore, this research can also be carried out in the empirical research domains, by using real data and proving the hypothesis true.

## 9 Findings:

As the objective of the thesis is to explore I4.0 concepts applied to project management, in this context upon exploration of I4.o concepts, the research study comes to some conclusions,

### 9.1 Feasibility of Industry 4.0 in project management:

Study of the research on the topic and proves the feasibility of Implementation of Industry 4.0 concepts for project management, especially for project monitoring and control.
According to the literature review these concepts were never discussed in these details despite of some research papers explaining only common definitions and importance.
This research study elaborated every step in detail for the implementation of automation trend in project management for the advancement of this field.
With this research the project management will be able to manage project without troubles, employee performance will be able to evaluate in the midway to project, project performance measures will be evaluated autonomously, project managers can manage project autonomously, this research will equip project management with new technology, competences of project management will be efficiently improved, and all the emerging problem related to project performance and employee productivity will be addressed successfully.

Further research in this domain can also be conducted for the optimization of the solution and implementation to the other areas of project management such as contract design, financial management, resources management, and others

# 10 Research limitations/Implications:

## 10.1 Research Limitations:

There are some limitations as well to this research,

1. Worked elaborated in this research work has not been tested, in order to get real results.
2. For the acquisition of data no physical sensors or devices been used in order to get real data, instead considered data values has been utilized to check the feasibility and meaningfulness of the concepts for the field.
3. Data has been considered randomly keeping in mind the actual average behavior of employee working in enterprises on fixed unit income allocation basis.

## 10.2 Implications:

Implications concluded from the research work are:

1. The ICT infrastructure for the implementation of Industry 4.0 to project management for monitoring and control has been prepared.
2. Due to the fact that no physical sensor or device been utilized in the research work, if physical sensors or devices with the ability to track and monitor time consumption of employee on specific task and the connection between the device and CPS are established, this concept can be tested.
3. The white box digital twin is ready to be implemented; the matter to resolve is input to the CPS system by devices, if input is established output can be delivered by CPS system.
4. For the CPS system mathematical algorithms, EVM has been adopted in order to evaluate the performance of project and generate results.

**References:**


1. Thee Zin Win, Nang Saing, & Moon Kham. (2018). Transformation of Project Management in Industry 4.0.
2. Dennis Kolberg and Detlef Z¨uhlke. Lean automation enabled by industry 4.0 technologies.IFAC-PapersOnLine, 48(3):1870–1875, 2015
3. Edward A Lee. Cyber physical systems: Design challenges. In 2008 11th IEEE International Symposium on Object and Component-Oriented Real-Time Distributed Computing (ISORC), pages 363–369. IEEE, 2008.
4. Roger Strange, Antonella Zucchella, (2017) "Industry 4.0, global value chains and international business", Multinational Business Review, Vol. 25 Issue: 3, pp.174-184, https://doi.org/10.1108/MBR-05-2017-0028
5. Oesterreich, T.D., Teuteberg, F., 2016. Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the con-struction industry. Comput. Ind. 83, 121–139. https://doi.org/10.1016/j.compind.2016.09.006
6. Kong, X. T. R., Luo, H., Huang, G. Q., & Yang, X. (2018). Industrial wearable system: the human-centric empowering technology in Industry 4.0. *Journal of Intelligent Manufacturing*, *29*(3), 1–17.
7. Gonzalez, A. G. C., Alves, M. V. S., Viana, G. S., Carvalho, L. K., & Basilio, J. C. (2018). Supervisory Control-Based Navigation Architecture: A New Framework for Autonomous Robots in Industry 4.0 Environments. *IEEE Transactions on Industrial Informatics*, *14*(4), 1732–1743.
8. Theorin, A., Bengtsson, K., Provost, J., Lieder, M., Johnsson, C., Lundholm, T., &Lennartson, B. (2017). An event-driven manufacturing information system architecture for Industry 4.0. *International Journal of Production Research*, *55*(5), 1297–1311.
9. Müller, J. M., Kiel, D., & Voigt, K. I. (2018). What drives the implementation of Industry 4.0? The role of opportunities and challenges in the context of sustainability. *Sustainability (Switzerland)*, *10*(1), 247.
10. Li, Z., Wang, Y., & Wang, K. S. (2017). Intelligent predictive maintenance for fault diagnosis and prognosis in machine centers: Industry 4.0 scenario. *Advances in* Manufacturing, 5(4), 377–387
11. Hunter, H., Fitzgerald, R., & Barlow, D. (2014). Improved cost monitoring and control through the Earned Value Management System. Acta Astronautica, 93, 497-500.
12. Sunil Ganpat Mahadik, Pankaj P. Bhangale, “Study & Analysis of Construction Project Management with Earn Value Management System”, International Journal of Innovative Technology and Exploring Engineering ( 2013 ) Vol 3
13. Narbaev and De Marco (2013). Combination of Growth Model and Earned Schedule to Forecast Project Cost at Completion
14. Vandevoorde, S. and Vanhoucke, M. (2006). A comparison of different project duration forecasting methods using earned value metrics. International Journal of Project Management, 24:289–302.

15. Anbari, F. (2003). Earned value project management method and extensions. Project Management Journal, 34:12–23
16. Adeojo, A. (2012) Effective Time Management for High Performance in an Organization, Thesis presented at Seinajoki University of Applied Science.
17. Okolo (2012), Effective time management: A panacea for higher productivity in organizations”