

Project and Construction Management of Large Warehouses Logistics

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Abstract

The objective of the subject thesis is the application of construction management principles for large logistic warehouses including a case study for the construction management of new facilities for the company “General Commercial” located in the industrial area of Sindos, Thessaloniki in Northern Greece. In modern global markets, the intense competition, forces companies to seek new and improved methods to achieve effective customer service. In recent years companies have become increasingly aware that the effectiveness of their activities depends largely on the cooperation and coordination with their suppliers as well as with their customers. This coordination role is implemented by the logistics. Therefore, attempts are made to present the concept of logistics, of supply chain and the current trend regarding management. Based on the above, it is evident the importance and the incentives which lead in the construction of large warehouse logistics complex. The construction of a storage center must be an integral part of a comprehensive business plan with clear goals and objectives for the entire supply chain. Therefore, the engineer is called to manage properly the construction of such a project. Following are different steps that the engineer must follow in order to construct large warehouse complexes. Finally, the present thesis discusses some methodologies for monitoring and assessing the progress of works by applying as an example a case study of new facilities constructed in the Industrial Area of Sindos. It is evident that a certain methodology should be applied in order to monitor the progress of a project taking into consideration the initial cost and time estimations. The two methods applied to monitor and estimate the progress of the project which are applied here is the method Earned Value Analysis (EVA) and the method of Earned Schedule (ES).

Keywords

Logistic, supply chain, construction management, project progress, Earned Value Analysis (EVA), Earned Schedule (ES).

1. Introduction

The historical development of civilization and of the human society are intertwined with the implementation of projects. Regardless of the project type, the organized approach of its accomplishment namely the project management is a prerequisite for the success.

The intense domestic and international markets competition require scientific project management. The scientific project management of the projects draws knowledge and technology from many disciplines. It requires time scheduling, appropriate organization, cost - benefit analysis, selection of alternative

methods, financial planning, control techniques, risk analysis, quality assurance and quality control. Therefore, the project manager must be qualified not only with technical knowledge but also with experience to express different point of views, proceed to corrective actions having always the necessary authorizations. From the above, it is evident why in recent years is observed internationally intense interest mainly in developed economically and technologically countries in construction management.

Project management tries to provide concrete answers and solutions to all issues related to a project from the beginning as an idea or necessity until its replacement or abandonment. It includes preparation of datasheets, financial support, formulation and evaluation of implementation methods, estimation of cost and time, quality program, health and safety issues, risk management and project design and construction teams management. The management of a project after its completion and up to its estimated life time it is also an issue where an enginner is involved and participate. (Papadimitriou S. & Sxoinas O. 2002)

2. Contemporary trend in Logistics Management

The fast growth rates, the continuous competition and the rapid developments in industry and commerce was the incentive for the transition of traditional techniques and attitudes to modern ideas solely to customer satisfaction. This theory is fully implemented by logistics operating activities which together with the other departments of the company e.g. marketing, warehouse, accounting etc. cooperate in order to achieve a high level of customer service.

2.1 Concept and Supply Chain Management

The term supply chain means the flow of materials, information and services from raw material suppliers through factories and warehouses to the customers as shown in figure 1.

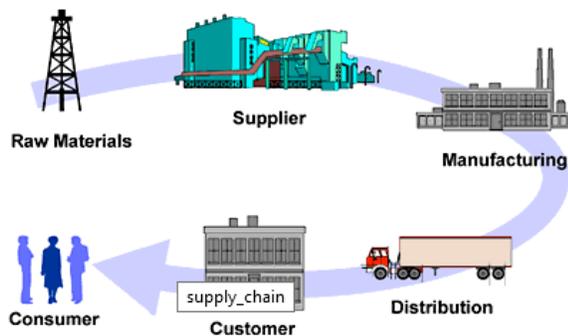


Figure 1: Supply Chain

As supply chain management is defined the planning, the organization and the coordination of all supply chain activities. Supply chain management is a relatively new and promising field of science, with great impact on the effectiveness of the companies and on the security of quality assurance procedures within the highly competitive environment of modern enterprise. Its spread is attributed mainly to the significant results that brings about changes in the cost reduction of the companies as well as towards the optimal coordination of the company procedures associated with suppliers and distributors.

2.2 Definition and activities of logistics

Logistics is the department of the supply chain management which plans, implements and controls the efficient and effective flow and storage of goods, services and information from the point of origin to the point of consumption. Following is an analysis of the three issues related to the products management:

Planning: Planning covers the entire spectrum of the operational activity of logistics starting from the selection of the warehouse and of the product packaging up to the efficient use of by-products produced during the production process and the handling of returns. Specifically it includes the procurement of materials, the manufacturing of products, the distribution and marketing of products as well as the materials recycling and the use of the by-products and residues.

Control: The control system includes an assessment of the results and of the correct implementation of the procedures. Refers mainly to the accuracy of the actions in order quality products to be available from the supplier to the final consumer.

Implementation: The implementation includes all the procedures involved up to the products delivery to customers. It is a reliable way to find out if the company achieves the goal, if the goal was feasible to be achieved, if there are deviations in the actual cost compared to the estimated one as well as if problems that had not been arranged in advance by the staff can be rectified. (Kiriazopoulos P. 1996)

3. Construction of large warehouse complexes

3.1 Construction stages

The construction of a storage facility is a very critical decision and requires compliance with specific and accurate steps for its implementation in order to ensure maximum efficiency of the investment.

The basic steps that should be followed to complete the project are:

- Selection and systematic approach for the purchase of land.
- Studies assignment. Selection of a suitable manufacturing process with basic criteria of quality, speed and cost.
- Selection of funding - Application to join an investment law.
- Preparation of final design.
- Approval for suitability. Environmental issues compliance.
- Obtain a license installation.
- Issuance of building permit as well as of other permits required (e.g. firefighting safety).
- Connection to utilities networks, roads etc.
- Commencement of building erection works.
- Purchase and installation of machinery as well as of other equipments.
- Works for the facilities surrounding area.
- Issuance of operation permit.

3.2 Industrial ground floors

The correct choice of a suitable industrial ground floor is proved indeed imperative and simultaneously an important design parameter in order to ensure the proper functioning of modern distribution centers so that quality logistics services are provided for the benefit of the clients. The success of the industrial ground floor application is fully connected to the warehouse productivity degree since the forklifts speed when moving within the storage area is maximized when the construction quality of the floor is high.

3.2.1 Proper design and construction of industrial ground floors – Specifications

Despite the possibility of restoring the industrial ground floors it is obvious that the construction of a suitable floor is a necessity. The specifications which should be considered are the following:

Operating Specifications - Industrial ground floor loadings: we must set out with accuracy the worst loading requirements of the floors, which are derived from the geometry and the goods weight, the piling levels on the floor or the shelves, the technical characteristics of the forklifts and other transportation means, the floor flatness for smooth vehicles operation, the necessary mechanical properties such as wear, abrasion, corrosion/erosion, health etc.

Industrial ground floor construction specifications: the construction specifications of the floor must include at least information related to the soils and sub-base, the vapor barrier and the concrete slab. The floor sub-base should be filled with excavated materials, quarries gravel and 3A well compacted in successive layers. Of great importance is the flatness and levelness of the sub-base. The floor elevational differences must be limited maximum 10% along the length and width otherwise this would have significant effects on the industrial ground floor thickness. After compaction and flatness/levelness confirmation a vapor barrier is placed in order the surface to receive the ground supported slab. The slab technical characteristics along with the necessary loads derived from the output of the study are: the floor thickness (15, 18, 20, 25 cm) depending on the concrete quality (C20/25 or C25/30 or C30/35) and the gravel grade, the type and the quantity of steel fibres, the environmental condition during concreting (temperature, relative humidity) as well as concrete admixtures. The concreting of large surfaces it is necessary for optimum results to be carried out with mechanical means (Laser Screed) in order to gain the advantages of smooth application flatness and levelness control, speed and uniformity. Extremely important issue related to the strength of the floor is the additional reinforcing in the areas of ramps and columns. Depending on the characteristics of the slab and the design of the concreting areas, suitable techniques are selected.

3.2.2 The significance of the industrial ground floors flatness (levelness)

Ensuring high accuracy in floor flatness both facilitate the smooth movement of the forklifts (wear protection) and offers high safety in products piling. Consequently the incorrect flatness compliance of the floor specifications leads to a significant reduction in speed and productivity of forklifts that can be less than half of their capacity.

The existence of bumps on the floor along the corridor (first parameter) as well as its incorrect levelness between left and right forklift wheel (second parameter), are responsible for the problems. In each case the measurements must be taken at any point on the floor corridors of the warehouse and in practice this can be achieved only by a special robotic mechanism which moves along the corridor just at the point where the forklift wheels are travelling and records the above two parameters. The diagram records indicate the floor points and the values of non conformity of the specifications.

In case of a flatness problem the floor is polished. The polishing method must be such that when we repair one of the two parameters as described above, not to destroy the other one. For this reason, the polishing is carried out by a Laser special machine which polishes using a very small "entry angle" on the floor with a specific preset cutting depth at the repair points and finally comes out of the floor also with very small "exit angle".

At the end the corridor is rechecked with the special robotic mechanism. If there are no deviations from the specifications, the appropriate certificate is issued. If not, the polishing repair procedure is repeated as many times needed so that the flatness specifications are fulfilled. (George Sigalas, 2011)

4. Erection of new facilities (Geniki Emporiou of Northern Greece) in the Industrial area of Sindos

The project for the erection of new facilities in the Industrial Area of Sindos is covered by subsidy through participation in a program of Development Law 3299/04 offered by the company INVESTO BC -

Business Consultants. The study and issuance of building permit, the erection of the new facilities and the arrangement of the facilities surrounding area are offered by EKME S.A., an Engineering industrial and commercial company.

4.1 Preparation of feasibility study and application file

Before the project construction, a feasibility study was performed along with the preparation of an application file for the participation in the Development Law 3299/2004. The provided subsidies from the feasibility study are shown in the following table:

Table 1: Percentage of total subsidy

A/A	Provided Subsidy	Subsidy Percentage %
1.	General provided subsidy (% percentage in investment cost)	30%
2.	Additional percentage due to the installation of the company in the Industrial area of Sindos	5%
3.	Additional percentage due to company size (medium sized company according to European Community legislation)	5%
	TOTAL SUBSIDY	40%

4.2 Study – Issuance of building permit

The duration of the necessary studies / drawings for submission to the city planning authorities lasted 1 ½ months after the project award. Together with the Environmental Impact Study (EIS) and the approval of the necessary permits by the appropriate department of the Ministry of Industry, the issuance time of the building permit was three months.

4.3 Construction – Erection of new facilities

The industrial complex of GEVE S.A. in the Industrial area of Sindos consists of the following sub-facilities:

- A. Large warehouse, a steel structure building of total surface area 4.000 m² having dimensions 160x25 m and net height 11 m.
- B. Small warehouse, a steel structure building of total surface area 2.000 m² having dimensions 125x16 m and net height 11 m.
- C. Office building having four floors constructed from reinforced concrete with external dimensions 28x28 m, which is equipped with a 15x15 m atrium and a peristyle at the entrance.
- D. Atrium constructed of a truss – shape structure.

4.4 Methodologies for monitoring and assessment of the projects progress

A large number of projects go over budget with significant delay in the anticipated time of completion. It is immediately apparent that a certain methodology should be applied to monitor the progress of a project in relation to the initial cost and time estimation. Two well known monitoring methods for assessing the projects progress are the Earned Value Analysis (EVA) and the Earned Schedule (ES). The two methodologies will be summarized below and will be applied to monitor the construction progress of the new facilities of GEVE S.A. in the Industrial area of Sindos. (Handshuh R. 2006)

4.4.1 Earned Value Analysis (EVA)

This method first appeared as a project management tool by the United States Ministry of Defense in the decade of 1960. The "Earned Value Method" is based on the comparison of the project actual cost with its budgeted cost and with the project performed works cost, which has been completed and credited. For the implementation of the method it is required the acceptance for the performed works, the development of a

time schedule for the completion of the works to be performed and the correspondence of a cost for each performed part of the work. In other words, the project, the project time schedule and its cost should be determined from the beginning.

The method is based on the Budgeted Cost of the Work Scheduled or Planned Value (BCWS), the Budgeted Cost of Work Performed or Earned Value (BCWP) and the Actual Cost of Works Performed or Actual Cost (ACWP). Figure 2 illustrates the fundamentals of the method and shows the curve of certified cost.

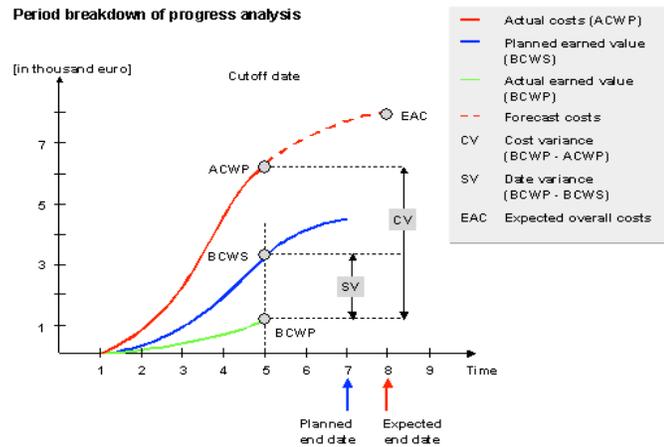


Figure 2: Certified cost curve

4.4.2 Earned Schedule Method (ES)

The Earned Schedule method shown in figure 3, which was proposed in 2003 by Walter Lipke, is a technique which is originated from Earned Value Analysis (EVA), is an extension of it and significantly improves it. Contrary to the EVA method parameters which are based on the cost, the ES method uses parameters based on time and provides reports and the possibility of project time schedule assessments similar to those given for the cost of EVA method.

The method works as follows: draw the curves BCWP (EV) and BCWS (PV) and find out the actual deviation of the program based on time $SV(t)$, which results from the projection of EV curve on curve PV, the time that both curves have equal value. The moment that BCWS (PV) and BCWP (EV) curves are equivalent is for the earned value (BCWP or EV) the moment which is called Actual Time (AT) and for the scheduled cost (BCWS or PV) the moment which is called Earned Schedule (ES).

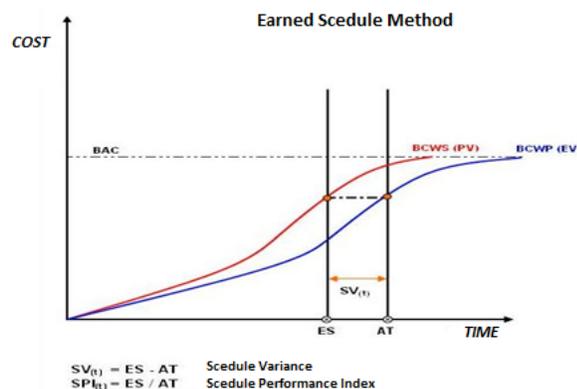


Figure 3: Schematic illustration of the method Earned Schedule method

4.5 Construction time schedule

The project construction works were carried out between June 2006 and May 2007. According to the original time schedule the project had to be completed within 43 weeks, but eventually it was finished in 49 weeks. The project time schedule was controlled through a project management software, Microsoft Office Project 2007 as shown in figure 4.

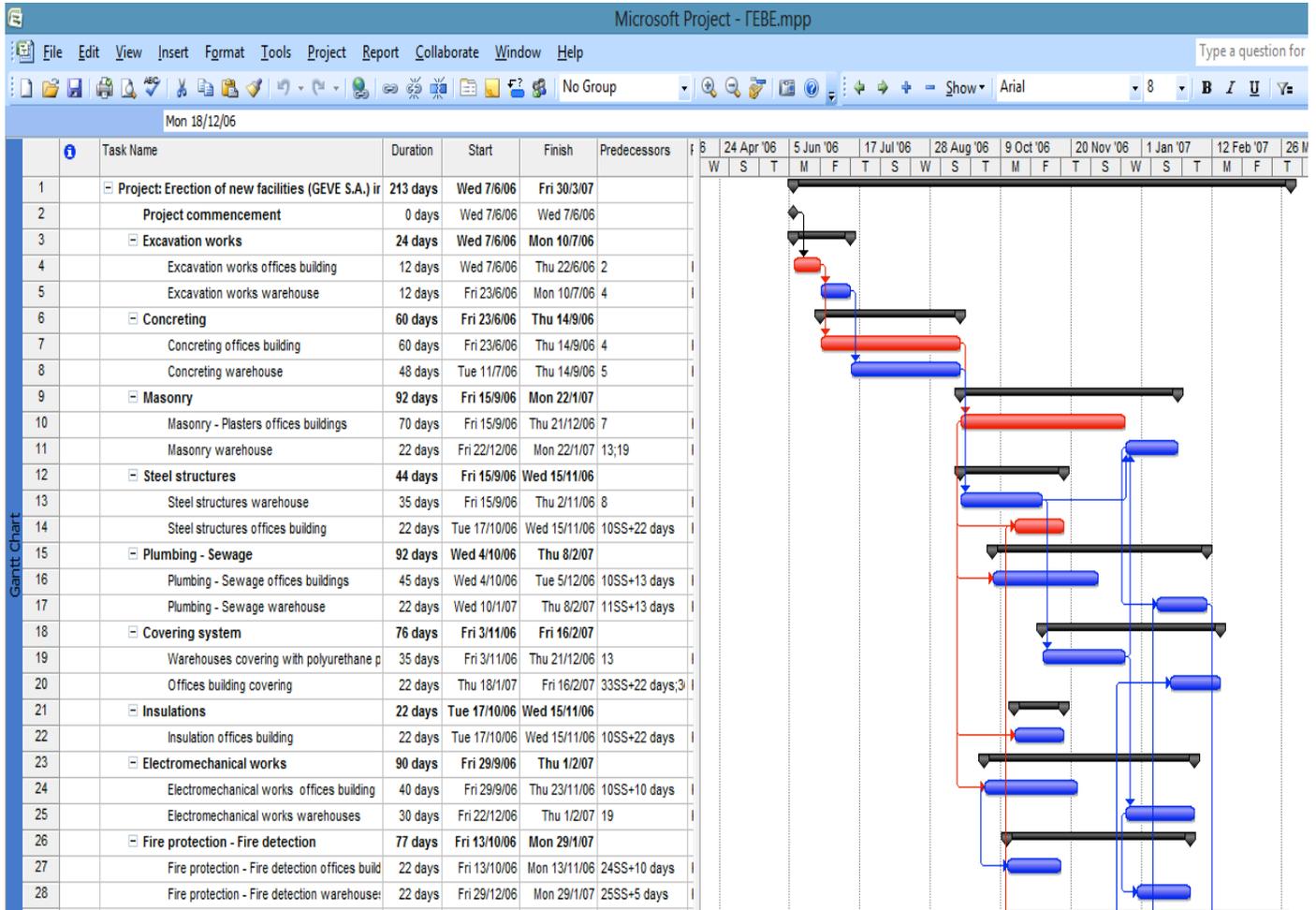


Figure 4: Project construction time schedule

4.6 Checking the project construction progress

The project progress is shown at various dates that coincide with the dates of the project progress payments certificate. We select five dates of the project inspection. The checking dates along with the related percentage of works completion are shown in Table 2.

4.7 Results of the Earned Value (EV) and Earned Schedule (ES) methods – Comparison of the results

The results of Earned Value method are given in figure 5 where ACWP, BCWS, BCWP diagrams are shown. The project experiences zero deviation in cost and negative time schedule deviation during the entire construction period. The cost performance index (CPI) is equal to one and the schedule

performance index (SPI) is less than one during the entire construction period. In general the project is progressed according to the budget but shows a time lag.

Table 2: Project progress check dates

a/a	Date	Week after the project commencement	Remarks	Project works completion percentage
1	21/08/2006	11	1 st payment certificate	11%
2	23/10/2006	20	2 nd payment certificate	24%
3	18/12/2006	28	3 rd payment certificate	48%
4	19/02/2007	37	4 th payment certificate	74%
5	30/04/2007	47	5 th payment certificate	95%

In the 47th week and while the project completion has been delayed by four weeks, the schedule variance which is given by the method is $SV=0$, while the schedule performance index is $SPI=1$. This leads to the paradox of the Earned Value method, to know that the project will be delayed but the reports indicate that the project will be completed on time.

Figure 6 shows the diagram BCWS, BCWP, from which the cost of the Earned Schedule method (ES) is presented graphically.

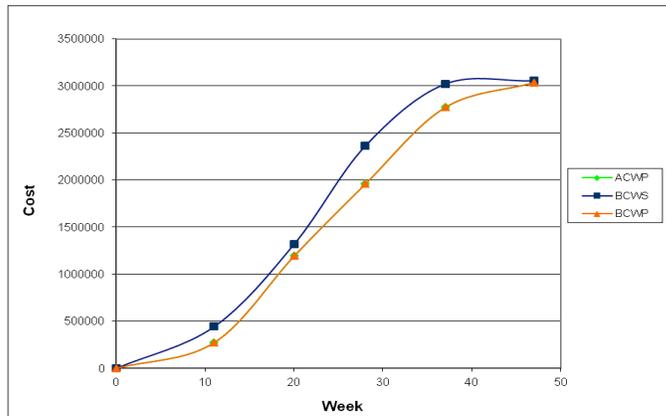


Figure 5: ACWP, BCWS, BCWP diagrams

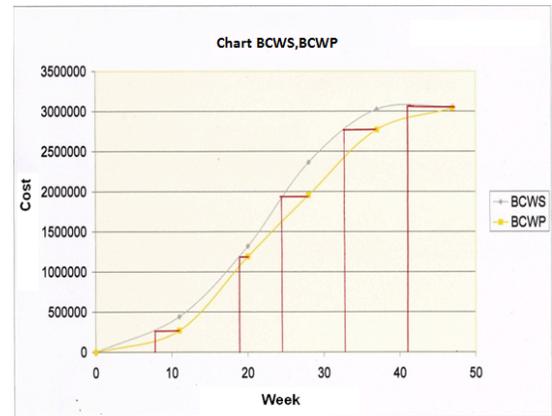


Figure 6: BCWS, BCWP diagrams

In figure 7 (left chart) is shown the diagram of the schedule performance index and in figure 7 (right chart) the diagram of time estimate at completion for the two methods. The schedule performance index remains less than one for the Earned Schedule method until the end of the project contrary to the Earned Value method where the index value at the end of the project is equal to one and therefore the Earned Schedule method shows a time lag during the entire construction period. The Earned Schedule method gives a reliable appraisal of the project duration, especially in the last project stages contrary to the Earned Value method. This can be proved from the fact that the Earned Schedule method gives the 47th week estimated duration of 49 weeks which was the actual project duration, while the Earned Value method gives the 47th week estimated duration of 43 weeks, which was the original appraisal of the project duration.

The results comparison of the two methods confirms that the Earned Schedule method gives more reliable estimation for the project duration, particularly in the late stages and proves that both methods must be used for monitoring and assessing the progress of a project construction.

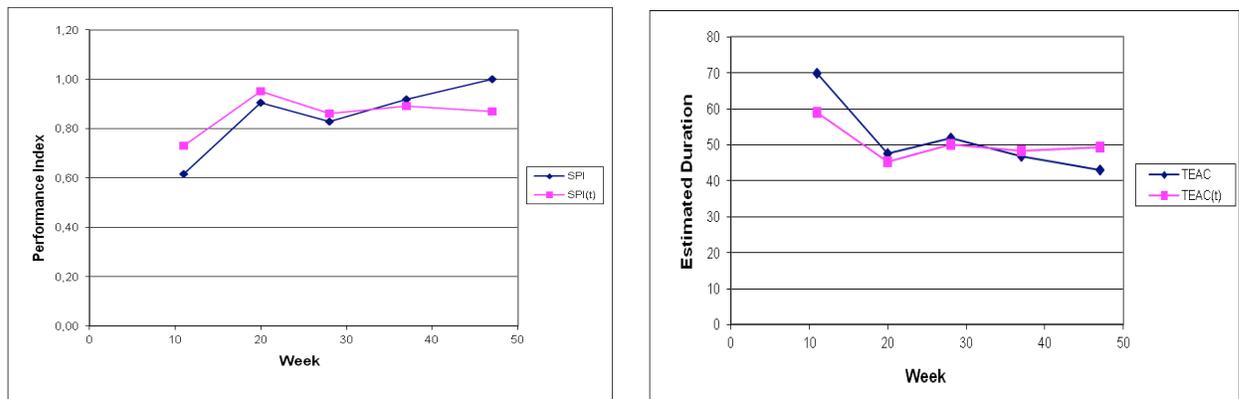


Figure 7: Schedule performance index chart (left) and Time estimate at completion (right) for both methods

5. Conclusions

In today's global market, the growing need of the companies to compete against the cost, quality, innovation, flexibility and services has led to a tendency to develop modern logistics systems. Based on the above, it is evident the importance and the incentives which lead to the construction of a large storage logistics complex. The construction of a storage center must be an integral part of a comprehensive business plan with clear goals and objectives for the entire supply chain. Therefore, the engineer is called to manage properly the construction of such a project. The construction management is the "key" to successful projects, that is, projects are finished on time, transparently, without exceeding their budget and with acceptable quality. This fact has been universally accepted and thus management standards are produced. It is promptly evident that a certain methodology should be applied to monitor the progress of a project in relation to the initial cost – time considerations.

6. Acknowledgements

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7. References

- Kiriazopoulos P. (1996), Logistics Management, Edition Sixroni Ekdotiki
- Papadimitriou S. & Sxoinas O. (2002), Introduction to Logistics, Edition Stamouli, Athens
- Procedures Manual for the establishment, installation, operation of industrial sites and warehouses
- Handshuh R. (2006), "Earned Schedule – New analysis of schedule in Earned Value Management", Air Force Aeronautical Systems Center Cost and Schedule Workshop, September 2006
- Article, George Sigalas, Industrial floors in modern warehouses: <http://www.supply-chain.gr/articles.php?artic=2392#.VNTnCy5yHIU>
- Concrete industrial ground floors, a guide to design and construction, Concrete Society Report TR34 – Third Edition 2003
- Website: Geniki Emporiou of Northern Greece: <http://www.gcb.gr/>