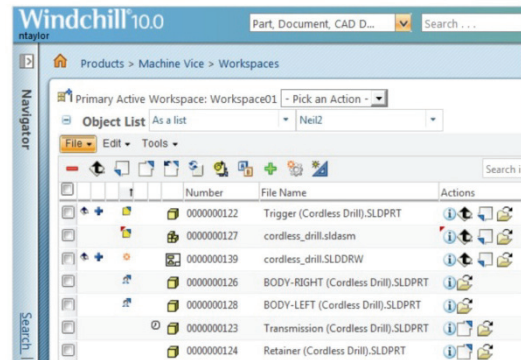
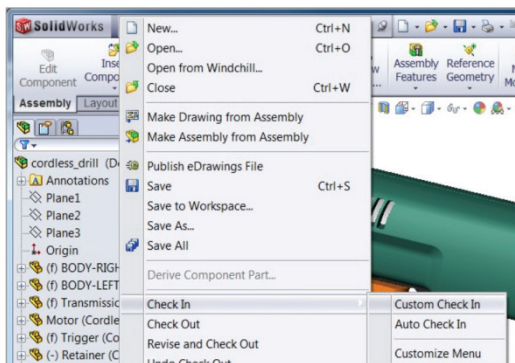


Discovering Windchill® Investigation of the Windchill® PLM System

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Faculty of Engineering LTH • Lund University • 2014



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Preface

This Master thesis is the end of my Master's degree of Mechanical Engineering in product development at Lund University Sweden. This thesis has been performed with the collaboration of PTC and a company from Stockholm called PDSVision which among others provides the university with PTC's software of Creo.

Firstly, I would like to thank whole IT support that working at Lund University both at the M-huset and at IKDC for supporting me during my study and my master thesis as well. It has been the best experience of my life to finish my degree considering I came from another country from different culture despite of I have already finished my bachelor's degree in my country. So I am very lucky to do my Master thesis in the Division of Machine Design, Department of Design Sciences at the Faculty of Engineering LTH.

Furthermore, I would like to thank Damien Motte for his attention and assistance in my thesis, and always be available to attend to me. I would also like to thank Giorgos Nikoleris of being my examiner. I am thankful for two more persons were working behind the scene Rudolf Abelin and Robert Olsson.

On the other hand, I would like to thank all my friends in school, my colleagues at work and family who have always support me to reach this moment.

Lund, November 2013

Yazin Al-Khayyat

Abstract

This Master Thesis contains the whole development process of a basic-intermediate and advanced product lifecycle management (PLM) course for university students. The basic course has been written by Pol Rebenague we worked together and after he has done the basic part about PLM and integrated between PLM and Creo 2(one of CAD module). I continue working on this course in advance level by investigating about other modules integrating CAD software and Microsoft Office in Windchill as well as the links with enterprise resource planning (ERP).

First, theory about PLM is introduced to the readers. Afterwards, the necessary material to teach the course, including the planning of each lecture, the theory, the exercises or even the slides is presented. In this course students learn what PLM is and they work with a specific PLM software called Windchill, with which students learn how to manage a project, all kind of documents and especially to work with CAD data.

Keywords:

PLM, Windchill, ERP, course, SolidWorks

Sammanfattning

I dagens tillverkande företag är kraven stora på tidigt integrerad produktutveckling. Ett sätt att underlätta kommunikation mellan avdelningar samt samverka mellan människor och möjliggöra tidigt delad produktinformation inom företaget, är att använda product lifecycle management. Mitt huvudarbete är att försätta skriva om en kurs som ska användas för LTH Lund Teknik Högskola och handlar om mjukvaran Windchill och CAD-programmet SolidWorks. Tidigare har en student börjat med PLM och Creo 2 i en grundkurs. Jobbet detta examensarbete går ut på är att fortsätta där han har slutat och skriva fortsättningen till en avancerad kurs. En föreläsningssession har lånats från Giorgos Nikoleris (kursföreläsare i Creo 2) för att skapa en uppfattning för eleverna hur integration mellan PLM och CAD kan skapas. Syftet med detta examensarbete är att ta fram en kurs för utbildningsprogrammet maskinteknik på LTH.

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Acronyms and abbreviations

API	Applications Programming Interfaces
AEC	Architectural, Engineering, and Construction
BOM	Bill of material
BOP	Bill of process
CAD	Computer Aided Design
Catia	Computer Aided three dimensional interactive App.
CAx	Product Design (CAD/CAM/CAE)
CASE	Computer Aided Software Engineering
CBO	Common Business Object
CFA	Cross Functional Agreement-Concept
cPDm	Collaborative Product Definition Management
CIM CAD	CAD system for 2D drawings
CM	Control Manufacturing – MRP-system
CRM	Customer Relationship Management
DA	Drawing Archive – lagrar 2D-ritningar
DBOM	Design Bill Of Materials
EBoM	Engineering Bill of Materials
ECO	Engineering Change Order – basis for design changes
EDA	Electronic Design Automation
EOM	Original Equipment Manufacturer
ESI	Enterprise system Integration
ERP	Enterprise Resource Planning
FMEA	Failure Mode and Effects Analysis
IP	Intellectual property
LCA	Lifecycle assessment

MBOM	Manufacturing Bill of Materials
MCAD	Mechanical computer-aided design
MES	Manufacturing Execution Systems
MRO	Maintenance Repair & Overhaul
MRP	Material Requirement Planning
MPM	Manufacturing Process Management
MOSS	Microsoft Office SharePoint Server
NPI	New product introduction
NPDI	New product development and introduction
NC	Non-Bundled Numerical Control
PDM	Product Data Management
PLM	Product Lifecycle Management
PPM	Product and Portfolio Management
ROI	Return on investment
SCM	Supply Chain Management
SCCM	Software Configuration, Change Management
SE	Systems Engineering
SFC	Chief Financial Officer
SIS	System Integration
S&A	Simulation and Analysis
STEP	Standard for the Exchange of Product Model Data
UML	Unified Modeling Language
VAR	Value Added Resellers
WWS	Windows Share Point Service
XML	Extensible Markup Language

1 Introduction

In today's manufacturing and development companies there is greater early integrated product development. The reason for this is the desire to detect any errors and problem areas and to build knowledge as early as possible in the product development process. If the errors can be corrected before the secondary faults have time to occur, so does the quality of the product increase, lead times are shortened and operation cost effective. One way to communication between departments and the interaction between people and thereby enable early split product of the company is to use product lifecycle management (PLM). A PLM system improves communication and collaboration between internal departments, as well as external suppliers and partners. As the technology is advancing forward new opportunities for companies to improve and refine their techniques and technical systems. New powerful computer aided design (CAD) systems are available today on the market, but in order to exploit this software effectively that requires even PLM environment developed to support the new opportunities which CAD systems generate. On the PLM side development has not progressed as far and therefore it is difficult to buy a ready PLM system that fits a specific business needs. The term CAD / PLM is relatively young but there is much literature written in the field.

The project presented in this thesis concerns the further development for a basic course on product lifecycle management (PLM). The software used for the course is PTC's Windchill PLM, including its interfacing with enterprise resource planning (ERP), Microsoft Office and SolidWorks.

PTC Windchill is the chosen application because it enables the users to exchange PTC Creo Elements/Pro files and associated metadata across PTC, the CAD software used at the Faculty of Engineering (LTH).

1.1 Background

1.1.1 Background about PLM and Windchill

In today's producing companies, there is a high demand on early integrated product development. For manufacturers, there is constant pressure today to compete in rapidly changing markets. Companies must be innovative in keeping costs low while maintaining high-quality results. The stakeholders involved in the product development process have also changed. Teams today extend far beyond the central engineering department to include globally dispersed cross-functional groups working on hundreds of products with thousands of parts the result is an enormous amount. To stay

ahead of the global competition, companies find that they must create a collaborative environment that brings together engineering, manufacturing, marketing, and sales teams.

As the readers can understand in the text above, the importance of the PLM system is increasing every year for the companies which want to increase and improve their product development. Windchill is one of the most used PLMs in the world, so it is good for the new design engineers to know something about it. This thesis aims therefore at developing a whole course of PLM using Windchill as an application, which in the future could be used by LTH to bring the students closer to a real company and to show them which role they can play inside it and how it works. The basic course has already been created by Pol Rebenaque (student who did his Master thesis about management part of PLM and in help with he created the basic and intermediate course by integrated Creo2 in Windchill) [44]. I will work for further development of the basic course.

1.1.2 The Division of Machine Design, Department of Design Science at LTH.

The Division of Machine Design at LTH will start teaching a new course on PLM and Windchill. According to the plan this course will be held in the academic year 2014 in co-operation between LTH (The Division of Machine Design) and PTC. My assignment in this project to carry on the basic course who was written by Pol by develop it by edit new material to be eligible for the student who studying product development.

1.2 Purpose

The purpose of the thesis is to complete a new course about PLM with Windchill application that in the future could be used by LTH. It has to be an advanced PLM and Windchill course. The students will learn how to manage all types of files e.g. Microsoft Office, Microsoft Project and how to integrate modules e.g. CAD/SolidWorks and share them through Windchill. The basic course has already been created by Pol Rebenaque (student who did his Master thesis about management part of PLM and in help with he created the basic and intermediate course by integrating Creo2 in Windchill). I will work for further development of the course.

1.3 Aims

As I explained above I will do further development to the basic course as shown below:

Further development of this course includes:

- A. SolidWorks: how to integrate SolidWorks in Windchill.
- B. Microsoft Office: this part includes how to use Microsoft Office in Windchill and how to open it, save, save it, edit and remove from Windchill server.
- C. ERP (Enterprise resource planning) and relation with PLM and Windchill.
- D. Project management by using Microsoft Project.
- E. Investigations about the other modules of Windchill.

1.4 Method and Process

This project can be divided in 4 different parts.

First part was in the basic course that done by Pol Rebenaque and includes basic theory about PLM and integrate Creo 2 with Windchill.

The second part is the development of a testing course done in the IKDC on the first month of the thesis. In this chapter, the readers can know how this test realized and its results and conclusions.

The third part includes the further development of this course regarding the integration of other CAD Software e.g. SolidWorks in Windchill and by integrating Microsoft Office in Windchill.

The final part concerns the investigation of other modules of Windchill such as Integrity (requirements management), as well as the coupling with ERP.

1.5 Assumptions and limitations

We assume that the students who will study this course have background about the programs below:

- CAD
- SolidWorks
- Microsoft Project

The basic course involved software readily available on the campus. But when I started doing my Master thesis in the same course but on advanced level many modules and software needed licensing and installation and unfortunately many problems started to show up and all of these problems were out of control. I will briefly explain the problems we were faced below:

- First and foremost we contacted the wrong persons. PTC tried to help us but unfortunately it took time to get information and details. They were eager to help us by for example setting up a meeting with Damien Motte and Giorgos Nikoleris and PDS Vision sale agency but as I mentioned above take a long time to get whole information and details (basically couple of weeks or so between each meeting).
- LTH has not sufficient IT-administration resources. The problem is that LTH only has one person who has control and is authorized to install Windchill server and related modules. Windchill is a complex software that requires experience and LTH has not this competency. So it was unfortunately this person couldn't install further Windchill modules. (that took roughly 1 month to figure it out).

- I would prefer to recommend LTH to fix a backup and employ a new staff some can help Rudolf Abelin and other departments to make it more easy for students like me in case the same problem would show up.
- Moreover we tried to contact a university in Sweden that had the same server to see if there is any possibility to try the practical part with them but unfortunately they didn't get back to us.

1.6 Outline

This report consists of 4 parts.

The first part is about how I build up this report from the theoretical basis for the analysis and conclusions. Especially, chapters 3 and 4 consist of the essential part and the part to this report concept about product lifecycle management, enterprise resource planning and Windchill. What is PLM? The benefit of using PLM? What is ERP? The benefit of using ERP? What is PTC? What is Windchill software?

The third part, chapter 5, further explains how to integrate between Microsoft office, Microsoft Project and SolidWorks in Windchill.

Finally, chapter 6 consists in the investigation of other Windchill modules and which of them suitable for the course and in chapters 7 and 8, I collect whole the course material like plan of the course, intermediate test and schedule of the course has been written by Pol Rebenaque and me.

2 Concurrent engineering

In order to assimilate the information in this report it is important to understand some basic concepts. This chapter presents the underlying facts that form the theoretical basis for the analysis and conclusions of this work about product lifecycle management and Windchill.

2.1 Concurrent engineering

The competition between the manufacturing companies in recent years has greatly increased which has led to greater demand for their products. To meet the requirements, companies have had to revise their organization and implement the changes needed to keep up with developments. An increasing trend is that companies are market leaders are the most innovative, not only regarding their products, but also regarding their processes. [11]

Three challenges facing companies is: to improve customer relationships and customer knowledge, to achieve optimum operation and to provide the market with leading products. It is therefore important to understand and quickly respond to customer requests. In practice this means that the company must get the right product in the right market at the right time and at the right price. [12]

One way to steer the company towards these goals is to design the organization after concurrent engineering thinking. Concurrent engineering, which is often called integrated product development, is a concept that highlights the importance of cross-functional work throughout the product development process. The purpose of concurrent engineering is to minimize the time for each iteration in the development process and to parallelize functional development. All functions of the company affect necessary areas in product development process, they influence it early and have opinions about product design [13-15]. Early changes help:

- Lower development costs since early design changes are less costly because considerable resources have not yet invested in the product. Late design changes often cause compromises which may cause an inefficient and costly manufacturing process.
- Shorter lead times, which is a result of the early iterative process that occurs when all departments jointly developed product.
- Improved product quality, as late changes to the product is often not optimal from a quality point.

In traditional product development usually a small part of the development time is dedicated to define the product. The engineering design phase starts early and much time is needed to design and redesign the product. The key to reducing lead times is to clearly define the product before engineering design begins, which requires many departments involved in the work before the engineering design phase begins. A simplified picture of the different phases of the traditional product development is to plan, design, monitor, and redesigns the product. Concurrent engineering means rather that many departments together generate a concept, approve, develop and ultimately implement a product that meets the goals. This approach usually involves fewer design changes and that the product has fewer errors at the start of production, factors resulting in lower product development costs, see Figure 1. The main idea is that the development should not only be carried out by technical departments, but also for example, production, purchasing and after-sales departments will be participating in defining the product to best produce a product that is tailored to customer requirements [16, 17].

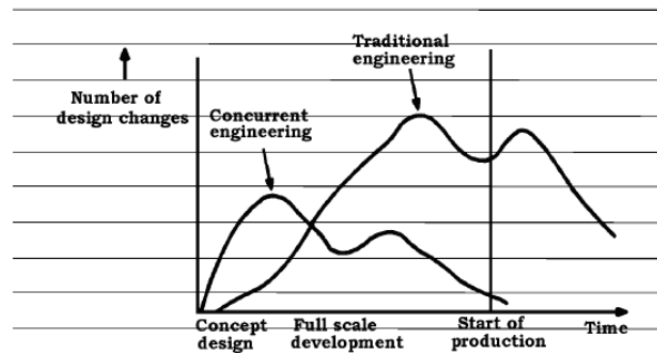


Figure 1 An example of design changes as a function of time for an American car, produced using traditional product, and a Japanese car, developed with the help of concurrent engineering.

Then concurrent engineering involves great interaction between departments, this means that large amounts of information exchanged within the company. To make it possible to work with the concept concurrent engineering, and thus cost efficiency of operations, have created product handled in an efficient manner. One way to manage information relating to products and processes and facilitate communication among departments, to support concurrent engineering as working, is the use of PLM,. PLM can help the company to cost-efficiency of their operations by [12]:

- Deliver more innovative products and services.
- Reduce costs.
- Improve the quality of products and services.
- Shorten lead times.
- Establish close and deep customer relationships.

Figure 2 shows some of the effects that the use of PLM can have on a business, such as reduced costs, shorter lead times and increased profits.

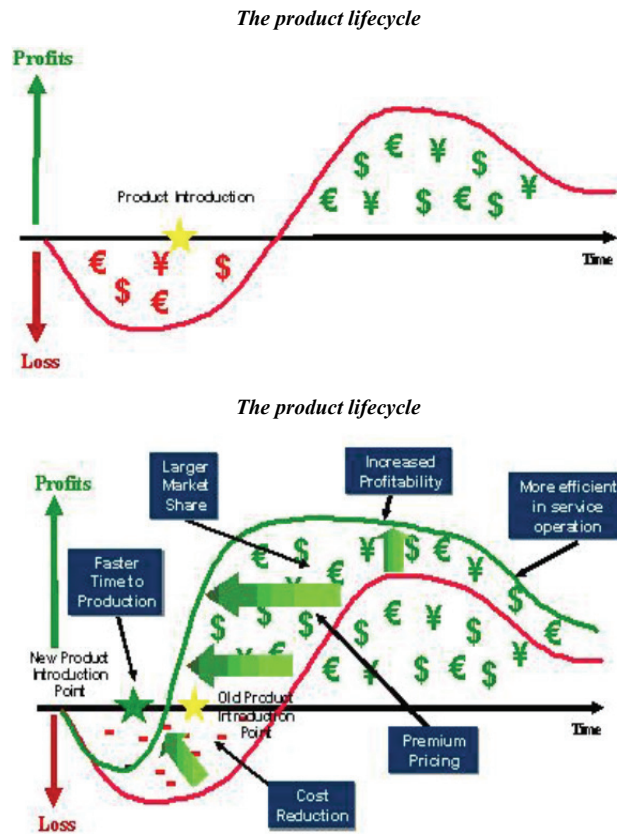


Figure 2 The top picture shows a typical curve of the profitability of a product's lifecycle. The bottom image shows a shift of the curve to the left, which is the goal of PLM and product focused investments. [11]

3 PLM and ERP

In this chapter I will explain the PLM concept and the functions of PLM and how it is working in integration with other software or modules. I will then discuss PLM with ERP.

3.1 PLM – Product Lifecycle Management

PLM or product lifecycle management is the integral, corporate-wide management and control of all data and process related to the entire lifecycle of a product from its conception and envisioning through its manufacture, deployment and maintenance and culminating in its removal from service and final disposal. It is important to note that PLM is not a definition of a piece or pieces of technology, but it is a definition of a business approach to solve the problem of managing the complete set of a product. PLM systems are enabling technologies for integrating people, data, business processes, manufacturing processes and anything else pertaining to a product, and they also provide a product information backbone for companies and their extended enterprise. PLM arose in response to the growing needs of product design organizations, as they struggled to manage, synchronize and share increasingly complex, interdependent CAD files among global teams involving both internal and external members. PLM enabled product engineers to work and rework products to optimize designs, and with the rise of Internet, to collaborate on the goal globally, in real time. The other important benefit was the ability to make changes early, while the products are in a digital state in the PLM system, results in tremendous savings, when compared to the cost of making changes once the product is released to manufacturing and in production. [7]

PLM has emerged from the concept of Product Data Management (PDM), which emerged in the mid-1980s. There was then a lot of confusion around what management of product-related information would be called, but since this type of information is increasingly becoming known as product data became PDM, with associated PDM system, a suitable concept [12].

Over time some companies introduced more concepts which manage information available on the company and the overall concept of PLM grew as presented. PDM is now only a fundamental part of the broader concept of PLM, which is more seen as a business strategy, and together with enterprise resource planning (ERP), supply chain management (SCM), customer relation management (CRM) and provides a basis for the company. CIMdata defines PLM as [12]:

- A business strategy that applies a number of business solutions that support the creation management, dissemination and use of product information.
- Support for the entire company and its customers and suppliers.
- Apply from concept to end-of-product or -plant life.
- Integrate people, processes, business systems and information.

The PDM system in the 1980s was only designed to handle management of CAD files between different applications [18], PDM was before PLM and concept of PLM includes PLM so now there is talk most about PLM systems. A PLM system is a major part of PLM and it will, unlike a PDM system, also support the concept, design, planning, production, and maintenance stages of the product until its decommissioning.

PLM system collects product information and makes it accessible to everyone in the organization through various tools, from CAD systems to web-based tools [19]. The key features in a PLM system can be summarized as follows:

- Handling of articles, article data and documents and product structures and spare parts management.
- Functions for review, approval and release of documents.
- Management of requirements and requirements documents, and version control.
- Electronic case management (supports a variety of functions to make documents in electronic formats available in cases).
- Opportunities for integration with CAD systems and business systems.

PLM cannot be achieved through technology only; it is equally important changes in processes and procedures in all areas of the company [21]. It is important to understand the broad meaning of the PLM and what the consequences are for the business. The main difficulty for many companies is the actual implementation of the PLM system without communicating the need and benefits of PLM to everyone in the organization. Successful implementation of PLM assumes that management is familiar with its importance and supports the decision [11].

PLM enables efficient product and process changes, and facilitate cross-functional work by sought after information more easily found, see Figure 3. Is difficult to document and distribute only using a computer system. It is therefore important to emphasize that although a PLM system facilitates the dissemination of information that verbal communication is still important [20].

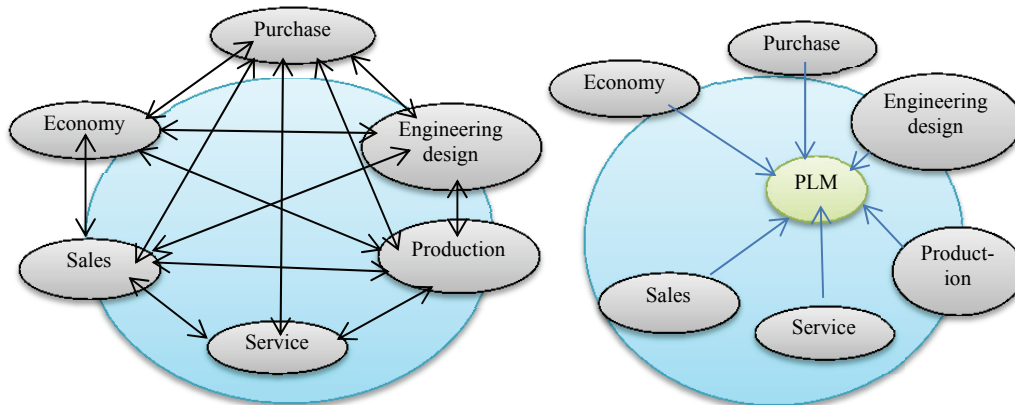


Figure 3 The picture on the left shows a computer system environment without a PLM system. The arrows illustrate a user's path when they want information available on other departments. The right picture visualizes how a common PLM system collects information on the company and makes it easily accessible to all departments.

Today, PLM encompasses significant areas of process. It is not just program and project management processes. It is also the processes required to manufacture the product or plant, operate it in the field, and dispose or decommission it at the end of its useful life. PLM solutions help define, execute, measure, and manage key product-related business processes. Manufacturing and operational process plans are also now viewed as an inherent part of PLM. Processes, and the workflow engines that control them, ensure complete digital feedback to both users and other business systems throughout each lifecycle stage.

Areas of PLM

1. Systems Engineering (SE).
2. Product and portfolio (PPM).
3. Product design (CAx).
4. Manufacturing process management (MPM).
5. Product data management (PDM).

Finally, as it is showed in figure 6, PLM gathers the four cornerstones of a corporation's information technology structure. All companies need to manage communications and information with:

1. Their customers through customer relationship management (CRM)
2. Their suppliers through Supply Chain Management (SCM)
3. Their resources within the Enterprise Resource Planning (ERP)
4. Their Product Data Management (PDM) including all these activities related to the manufacturing and develop of the product.

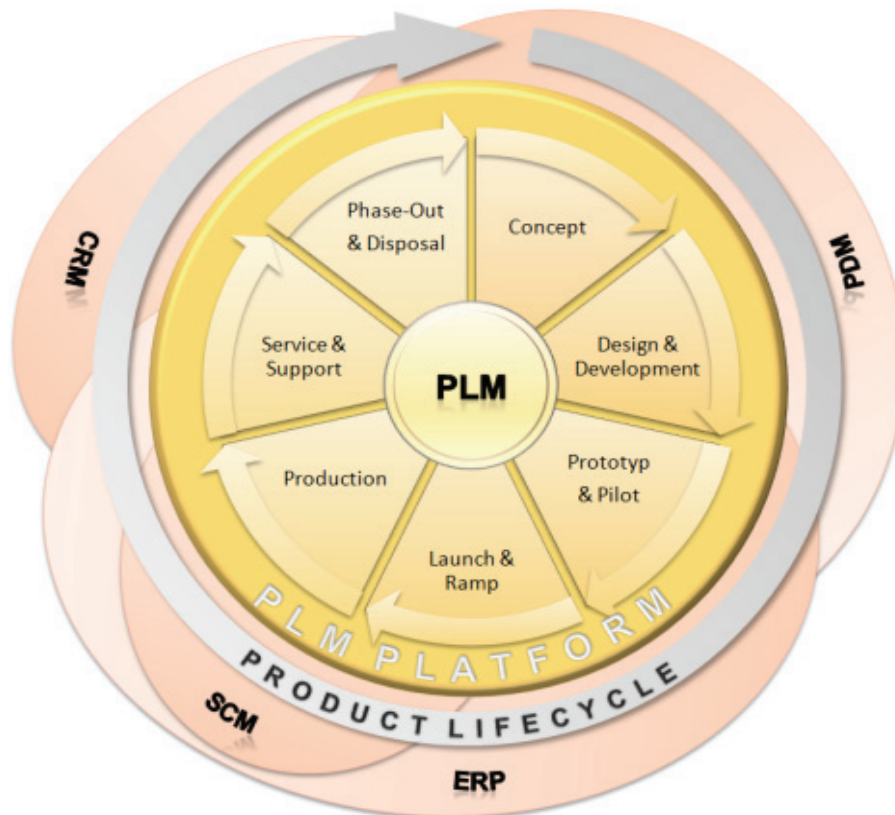


Figure 4 Representation of PLM [26]

3.2 The Functions of PLM

PLM Software can do a lot. It can streamline product development processes, enhance productivity and create a more effective environment for deploying, implementing and achieving strategic business initiatives. Following are some key aspects of PLM [4]:

- Manage design and process documents
- Construct and control bill of material (product structure) records
- Provide an electronic file repository
- Include built-in and custom part and document metadata ("attributes")
- Identify materials content for environmental compliance
- Permit item-focused task assignments
- Enable workflow and process management for approving changes
- Control multi-user secured access, including "electronic signature".
- Export data for downstream ERP system [4]

3.3 Benefits of PLM

PLM Software supports the product development process, integrating people, data, processes and business systems and providing a product information backbone for companies and their extended enterprise. The benefits of PLM software focus around time, cost and quality. These benefits include

- Faster time-to-market
- Improved cycle times
- Fewer errors
- Less scrap & rework
- Greater productivity
- Greater design efficiency
- Better product quality
- Decreased cost of new product introduction
- Insight into critical processes
- Better reporting and analytics
- Standards and regulatory compliance
- Improved design review and approval processes
- Improved communication
- Reduced product cost and greater profitability
- Better resource utilization
- Improved integration and communication with extended supply chain.

3.4 Return on investment (ROI)

Any organization can benefit from PLM in many ways. Among these are improved quality, streamlined operations, greater efficiency, and financial return on investment (ROI). According to AMR/Gartner [4], ROI can be broken down into three categories, each occurring at different time intervals — immediately, within the first year, and well into the future.

- Now: Infrastructure savings — Accrue immediately after go-live. Often the result of improved collaboration and better IT efficiency.
- Next year: Improvement in established operating metrics — Accrue 6-12 months after go-live. Based on widely used and generally well-benchmarked operating metrics.
- +5 years: Strategic competitiveness impacts — Accrue 3-5 years after go-live. Includes savings on internal programs and process as well as improved strategic position.

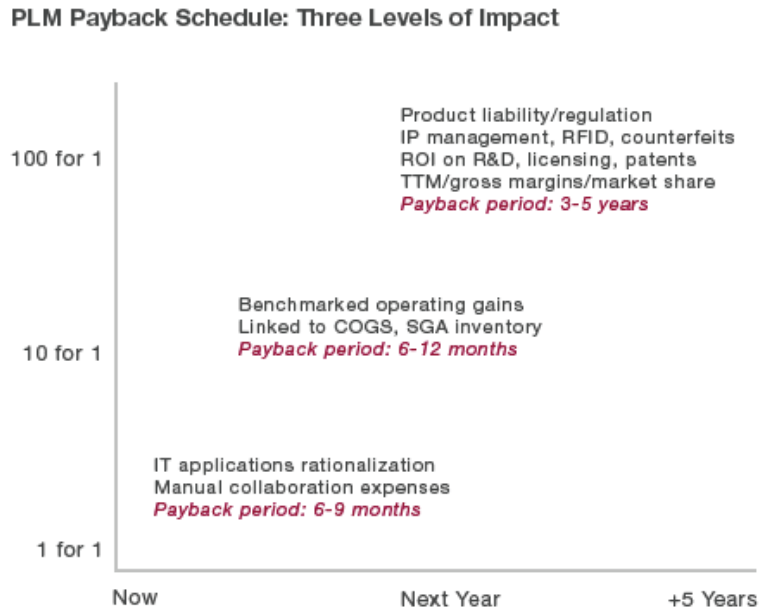


Figure 5 PLM payback schedule: three levels of impact [4]

3.5 Who uses PLM?

Companies achieving great success with PLM software are focused in the following industries:

- Aerospace & defense
- Automotive
- Consumer goods
- Education
- Energy
- Financial
- Food & beverage
- Government
- Healthcare
- High tech electronics
- Industrial
- Medical devices
- Pharmaceutical

Demand for PLM Software is usually a result of a desire for greater efficiency in the product development process. The efficiencies, or improvements, sought often relate to cost reduction, quality improvement and time management.

"**The Problem**", as PLM Technology Guide [1] labels it, is that paper-managed systems tend to be serial, fragmented and slow, making innovation and new-product development and introduction (NPDI) challenging. "The result is that many companies suffer from NPDI practices that are slow, resource intensive, costly, inflexible, provide little visibility, and are difficult to manage and control." [1,2] The fragmented nature of paper-managed PLM systems is shown to the right, which each department involved in product management is separated. [2]

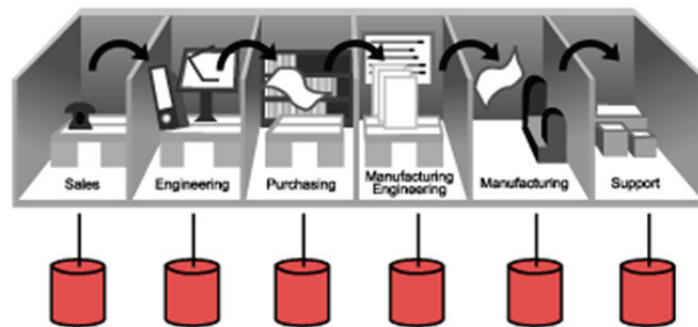


Figure 6 Transformation of the processes in companies which implemented PLM [1]

PLM systems, or "**The Solution**", transform this process by integrating all product information to help define, execute, measure and manage key product-related business processes. With a PLM system, product information from marketing and design comes together, and leaves in a form suitable for production and support. [2]

3.6 PLM costs

The overall cost of a PLM solution varies depending on the provider and several factors, such as the number of users and your individual business goals. In a comprehensive chart provided by PLM Technology Guide [34], the elements of PLM are shown with their percentage of the total initial cost of implementing a PLM solution. [34]

One-time capital investment

Software - 30% of initial cost¹

Cost dependent on:

- Number & type of users
- Required functionality or functional modules
- Deployment option: On-premise or on-demand
- Floating licenses or named user licenses
- List price and discount

¹ Approximate share of total initial cost (one-time capital investments, first-year software maintenance, one-time expenses and initial post-go-live support).

Hardware 8% of initial cost¹

Cost dependent on:

- Number of users & sites
- Configuration & performance requirements
- Quantity of data and required disk space
- Required system availability and uptime
- Deployment option: On-premise, hosted or on-demand
- List price and discount

One-time general expenses

Education and Software Selection - 8% of initial cost¹

Cost dependent on:

- Understanding of PLM & PLM Market
- Duration & thoroughness of evaluation
- Involvement of an external PLM consultant

Process optimization – 8% of initial cost¹

Cost dependent on:

- Number of processes & methodology
- Size of organization & understanding of PLM
- Documentation of existing practices and processes
- Involvement of an external PLM consultant

Implementation Services – 25% of initial cost¹

Cost dependent on:

- Required configuration and/or customization
- Contract terms: Fixed price or time & material
- Hourly rate and discount

Training – 5% of initial cost¹

Cost dependent on:

- Training delivery: Vendor or Train-the-Trainer
- Training material: Standard or custom
- Training location: Vendor, on-site, and/or web-based

Data Migration -5% of initial cost¹

Cost dependent on:

Approach: Manual or automated

- Number of source systems
- Type of data: Metadata, structured data and files
- Quality & quantity of data

Annual Recurring Expenses

Software Maintenance -5% of initial cost¹

Cost dependent on:

- Number & type of users

- Required functionality or functional modules
- Deployment option: On-premise or on-demand
- Floating licenses or named user licenses
- List price and discount

Post-Go-Live Support -5% of initial cost¹

Cost dependent on:

- Duration
- Type and level of support
- Response time and system availability requirements
- Hourly rate and discount. [34, 36-38]

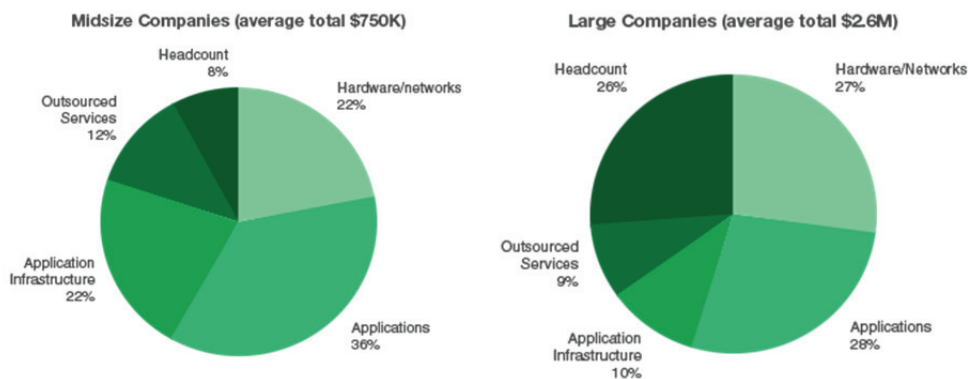


Figure 7 In a separate research study by AMR/Gartner of PLM projects, the results showed the typical fully budgeted PLM project costing \$750K for midsize companies and \$2.6M for large companies. [34, 36-38]

3.7 Marketing segment

The PLM market can be divided into three primary segments:

- Tools—those applications used to create, analyze, and simulate products and plants and associated intellectual property (IP). Sub-segments include: mechanical computer-aided design (MCAD), simulation and analysis (S&A), non-bundled numerical control (NC), electronic design automation (EDA), architectural, engineering, and construction (AEC), and other tools such as computer aided software engineering (CASE).
- collaborative Product Definition management (cPDm)—cPDm addresses managing the complete product or plant definition lifecycle, including all of the mechanical, electronic, software, and documentation IP components and the processes that are used during the product lifecycle including in-service operation and maintenance. Subsegments include: Comprehensive Technology Providers, Focused Application Providers (including visualization and collaboration, content, and document management, etc.), and System Integration (SIS), Value added resellers (VAR) [25].

- Digital Manufacturing—systems that support definition of the processes used to produce a product, including supporting simulation and analysis of those processes, and the manufacturing environments used to produce the product including production equipment, resources, work cells and lines. Digital Manufacturing is focused on transitioning product designs into production. PLM solutions and methods are being applied to an increasingly wide range of industries, including many industries within which PLM has not previously been established (e.g., financial services, insurance, health care, etc.). [25]

3.8 ERP system

Enterprise resource planning (ERP) system or enterprise system is software system for business management, encompassing modules supporting functional areas such as planning, manufacturing, sales, marketing, distribution, accounting, financial, human resource management, project management, inventory management, service and maintenance, transportation and business. The architecture of the software facilitates transparent integration of modules, providing flow of information between all functions within the enterprise in a consistently visible manner. Corporate computing with ERPs allows companies to implement a single integrated system by replacing or re-engineering their mostly incompatible legacy information systems. American Production and Inventory Control Society [43] has defined ERP systems as “a method for the effective planning and controlling of all the resources needed to take, make, ship and account for customer orders in a manufacturing, distribution or service company.” [44]

We quote several definitions from the published literature to further explain the concept: “ERP (enterprise resource planning systems) comprises of a commercial software package that promises the seamless integration of all the information flowing through the company—financial, accounting, human resources, supply chain and customer information” [45]. “ERP systems are configurable information systems packages that integrate information and information-based processes within and across functional areas in an organization” [48]. “One database, one application and a unified interface across the entire enterprise” [47]. “ERP systems are computer-based systems designed to process an organization’s transactions and facilitate integrated and real-time planning, production, and customer response” [49]. The concept of the ERP system can be illustrated, following [45], with the diagram in the figure below. [43]

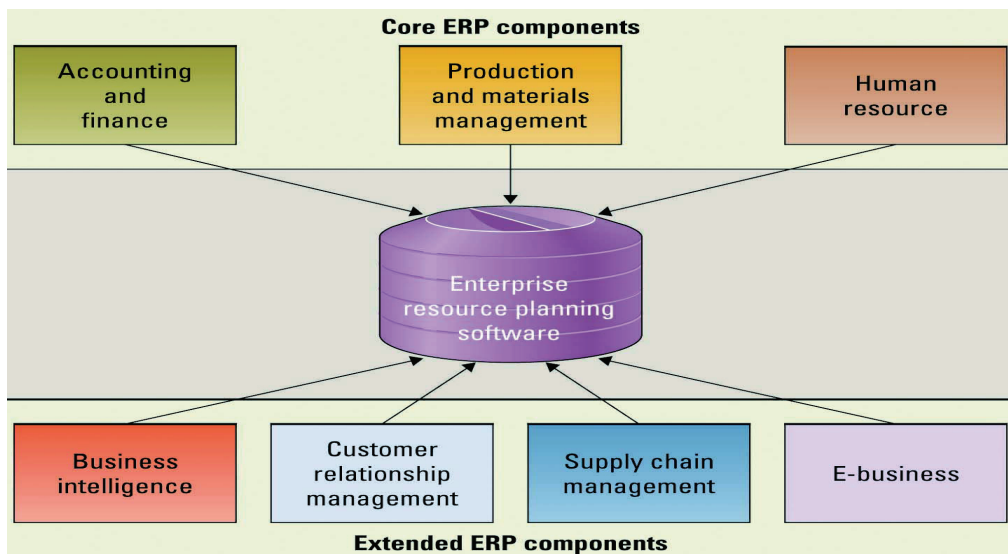


Figure 8 ERP system

3.8.1 The benefits of using ERP software

The following are the 7 benefits of using ERP software [39]:

1. ERP helps in reducing operational costs by coordinating various departments of the organization and increasing their efficiencies. Its centralized working system assimilates the business processes and controls inventory, lower production and marketing costs. It also lowers help desk support.
2. This software boosts day-to-day management activities of a business. Since it has better accessibility to data, business heads can make immediate references to it for decision making and managerial control. It also performs activity based costing by keeping track of actual costs.
3. ERP software backs strategic planning that defines a set of goals and objectives for the business. Reports and functions of resource planning assist employees to develop an all-inclusive strategic plan.
4. Many programs offer mobile facilities so that you can always remain aware of the working of your business. You can choose from the various packages for the most appropriate one for your business needs.
5. ERP software comes handy while dealing with high volumes because of its real time capability and future-based orientation. Your company will no longer be plagued by inventory shortage or wastage of time while transferring files.
6. Another advantage of ERP is in accounting application. It can integrate costs, profits and revenue information of sales. A company can know when to update its products through a dating structure. Quality can also be enhanced. Thefts and industry spying can also be prevented.
7. ERP offers the best business and monetary solutions for a small company and a company facing financial crisis. By allowing flow of money into diverse and im-

portant business endeavors it results in increased efficiency and smooth running of the business.

3.8.2 Benefits of integrating PLM/Windchill and ERP

- Improved decision making
- Reduction in BOM Errors
- Lower cost of quality
- Reduction manually synchronizing systems.

3.8.3 The integrated ERP-PLM strategy

ERP and PLM offer distinct, unique value. Together, ERP and PLM offer even greater business value. Manufacturers today need to innovate rapidly, and execute confidently on innovations big and small. Closing the loop between innovation and execution helps drive more rapid time to market, reduce cost, and improve quality. Having the right PLM and ERP solutions to enable strong innovation and execution is crucial to product profitability. Integrating the solutions extends the value of each, giving manufacturers the ability to rapidly innovate and the confidence to speed that innovation to market where it can provide new business value.

As clear as the lines between ERP and PLM have become, innovation is not limited to engineering. While major new product developments typically come from engineering, manufacturing and service organizations frequently identify smaller innovations that can improve quality or reduce total lifecycle costs. These day-to-day innovations, such as minor part revisions to improve manufacturing efficiency or make products more robust, are frequently implemented in a disjointed way. [30]

An integrated ERP-PLM strategy, on the other hand, provides the opportunity for a rapid, confident flow of innovation to and from manufacturing. In today's lean and competitive business environment, companies can't afford disconnect. Manufacturing must develop a strategy to close the loop between engineering and manufacturing to get the most business value from innovation in all its forms.

Most manufacturers have learned what to expect from ERP. The integrated nature of ERP provides a single view into manufacturing, sales, sourcing, and financial activity. This centralized data helps companies plan effectively and make better business decisions. In particular, ERP has proven very valuable in helping manufacturers manage and control the complexities of business in today's global, fast-paced markets. ERP helps companies control cost, manage operations, and balance supply with demand to ensure they deliver on customer expectations, and do so in a profitable way. Most manufacturers today are using some form of ERP system to manage their business. In essence, ERP's role is executing the business of manufacturing (see Figure 9).

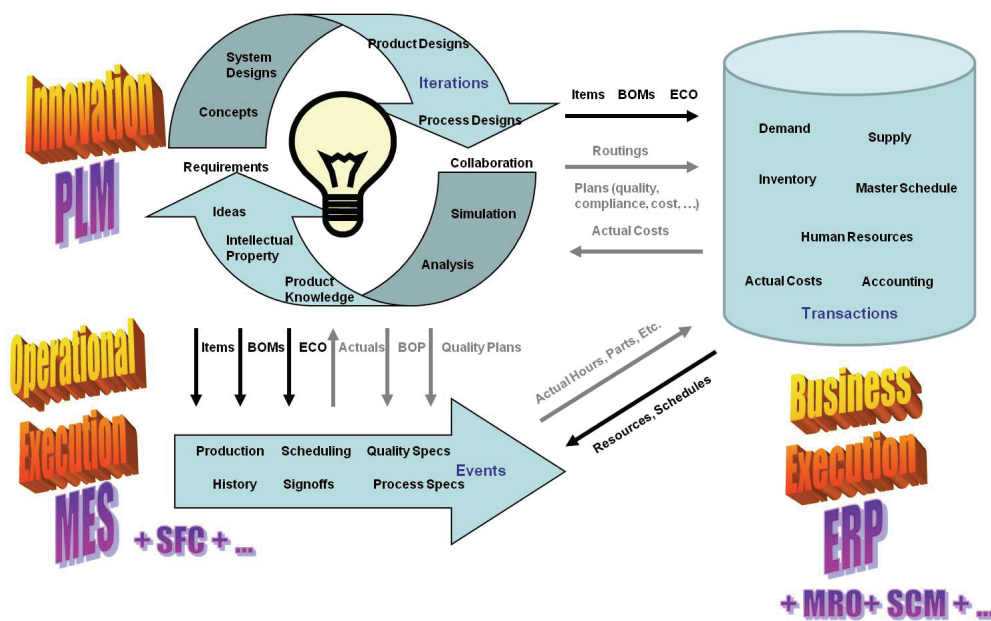


Figure 9 The integration between PLM and ERP [30]. Abbreviations: SCM: Supply chain management, MES: Manufacturing Execution Systems, MRO: Maintenance Repair & Overhaul, BOM: Bill of material, BOP: Bill of process, SFC: Chief Financial Officer, MPM: Manufacturing Process Management., ECO: Engineering Change Order, SFC: Shop Floor Control

3.8.4 Integration PLM/Windchill with ERP

ERP connector interfaces with the ESI services to produce output from Windchill in a format that can be easily accepted by any of the available types of distribution targets. This output can be processed and mapped to a distribution target such as a file system. The output from Windchill is in XML format. ERP Connector does not contain the middleware business logic that would allow for two-way communication. Instead, ERP Connector communicates in one direction only (from Windchill PDMLink to the distribution target). ERP Connector allows for the manual customization of all Windchill components in order to create business objects in a format that is acceptable for each individual distribution target.

3.8.5 Conclusion

ERP and PLM offer distinct, unique value. Together, ERP and PLM offer even greater business value. Manufacturers today need to innovate rapidly, and execute confidently on innovations big and small. Closing the loop between innovation and execution helps drive more rapid time to market, reduce cost, and improve quality. Having the right PLM and ERP solutions to enable strong innovation and execution is crucial to product profitability. Integrating the solutions extends the value of each, giving manufacturers the ability to rapidly innovate and the confidence to speed that innovation to market where it can provide new business value.

4 Windchill

This chapter is an overview of Windchill where readers can enlarge their knowledge of PTC product lifecycle software.

4.1 Background and definition

Windchill is an integrated global product development platform providing companies with a module solution. This provides growing companies with the ability to scale functionality to the base Windchill system as required for customer-specific needs.

The Windchill system is 100% web-based and stores, shares, and maintains information on the products being controlled and managed across the intranet or extranet. Windchill is written in Java and integrates with existing IT, the internet, and security infrastructure. In addition, the system is CAD heterogeneous and is interoperable with multiple CAD system. [6]

Common Windchill Functionality includes:

- **Vaulting**, this provides the ability to store content in a central data repository.
- **Product Data Management (PDM)**, which provides the ability to control user's access to content through defined lifecycle states and a version scheme.
- **Change Management**, which provides the ability to define a process for problem reports, change requests, and change notices to document information related to the modification of production content.
- **Configuration Management**, which provides the ability to create multiple products structures for different end-users, such as a design bill of materials (DBOM), manufacturing BOM (MBOM), or a maintain-in-filed BOM.
- **Collaboration Management**, which provides the ability to share data between internal departments, suppliers, and customers.
- **Project Management**, which provides the ability to develop a central project plan visible to all users. Common examples include new product introduction (NPI) and bid management.

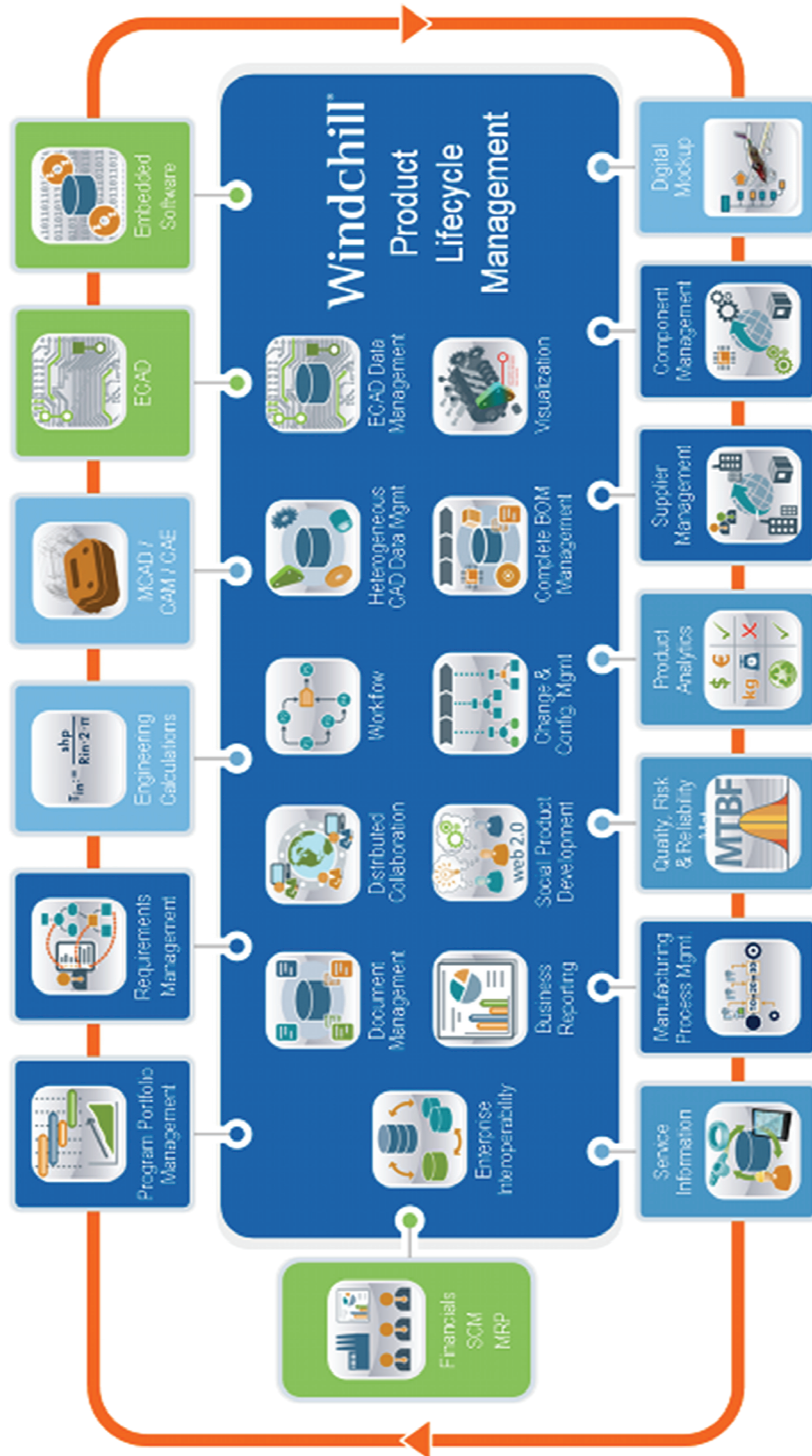


Figure 10 Product Development Systems in PTC [27]

4.2 Introduction to PTC Windchill: A complete solution for PLM

Windchill technology forms a solid foundation for a variety of packages that PTC offers to address data, change, configuration, and process management; product development collaboration; project management and execution; and the release of product information to manufacturing management systems. One of them for example, product data management (PDM) link to use for managing Creo parametric design information in Windchill.

Windchill PDMLink consolidates scattered islands of product content into a single information source, which can help bring order to chaotic product development processes such as change management and speed the development of new product configurations. Windchill ProjectLink creates a virtual workspace that becomes the central access point for a project, enabling team members to collaborate with access to the same information. By automating project management activities, Windchill ProjectLink helps customers better manage all of their programs, project schedules, information, and processes. As an integral component of PTC's Product Development System (PDS), see Figure 10, Windchill manages all product content and business processes throughout a product's lifecycle. Windchill connects seamlessly to Pro/ENGINEER for three-dimensional (3D) computer-aided design (CAD) models, ProductView® for advanced mock-up and interactive visualization, Mathcad® for engineering calculations, and Arbortext® for dynamic publishing.

5 Integration of Windchill with SolidWorks and Microsoft Office

Windchill is PTC's PLM software. Fast, secure, and requiring only a Web browser to access, this business collaboration software enables companies to streamline product development processes and deliver superior physical goods and information products. Windchill is a single source of product information/content enables development efficiencies, reduces errors and rework.

5.1 Integration Windchill with SolidWorks by Workgroup manager

In the basic course we have done integrated Creo 2 with Windchill direct from server manager by create a new part and server on Creo 2 and save it after that we opened it through Windchill, while using Windchill to manage SolidWorks data it is quite more advance and complicated. Basically we need to install a special program called Workgroup management, the only program that can manage SolidWorks data within Windchill.

The Windchill Workgroup Manager common framework supports the following CAD and CAD-related applications.

- AutoCAD
- Autodesk Inventor
- CATIA V5
- SolidWorks
- NX
- Mathcad
- Arbortext IsoDraw
- Creo Elements/Direct Drafting
- Creo Elements/Direct Modeling
- ECAD
- Creo Illustrate

With Windchill Workgroup Manager, one can work with any of the company's supported CAD applications and Windchill. For example, if the companies use SolidWorks for one project and NX for another, once they open Windchill Workgroup Manager, they can easily switch between the two CAD applications. Accessing data through Windchill Workgroup Manager provides the same, consistent set of core features that are available when accessing Windchill through a standard internet browser. Examples of this are opening files from a CAD application supported by

Windchill Workgroup Manager, saving a CAD structure, and renaming a CAD object.

Windchill Workgroup Manager supports two modes, standalone and connected:

- Standalone (not connected to a CAD application)—Windchill Workgroup Manager can be launched on its own, so that you can access your CAD data stored in the Windchill database or in your private working area (workspace) without having to start the CAD application. This also allows you access to Windchill through the Windchill Workgroup Manager HTML browser.
- Connected to a CAD application—Windchill Workgroup Manager can be launched with your CAD application so the two are connected. [28]

5.2 Benefits of integrating SolidWorks in Windchill

Improve collaboration

- Fully incorporate the use of SolidWorks data in product development processes that span multiple organizations
- Extend the sharing of design data beyond engineering, departmental and corporate boundaries using standard Internet technology

Improve data quality

- Eliminate mistakes associated with duplicate or incomplete data by managing data from multiple CAD systems in a single, controlled location under the umbrella of a single product structure
- Centralize the management of business processes such as change control
- Provide all relevant groups with accurate, up-to-date product content information that's held in a single location

Improve engineer productivity

- Improve efficiency through design data reuse and a reduction in the number of design steps
- Embed Windchill actions within the SolidWorks application, enabling the designer to focus on design activities rather than data management
- Minimize engineer interruptions by utilizing background processes to upload files to Windchill, thus allowing the designer to continue using SolidWorks without having to wait for database actions to complete.

Increase enterprise efficiency

- Reduce the number of product development systems by providing one system that can manage multiple sources of data (e.g., different CAD and documentation formats)
- Enforce standard design processes across multiple design projects and organization

5.3 Windchill in Microsoft Office

People at various responsibilities in an organization are highly comfortable with Microsoft Office products to capture relevant information / data. Microsoft Office e.g. Word or Excel document stands very popular as tool to capture all business / general data. Following are the risks foreseen

- Loss of data
- Machine and people dependency
- Delay on data availability for other groups
- As no control on data, possibility of losing uniqueness in market

To avoid all risks related to uncontrolled data, every organization are using enterprise systems for their data management. These enterprise systems capable of accommodating all data collated from various groups of the organization on a neutral format. Windchill is one of such enterprise system capable of managing both complete engineering data of products from an organization and their related business information. Windchill provides very rigid access control, well-defined workflows and efficient reporting mechanism for effective handling of enterprise data. [29]

5.3.1 Business challenge example (Excel)

A global networking solution major faced a challenge with data at their business:

- All of their ROI reports existed in Excel document right from their inception. This posted huge overhead on handling these documents as they are huge in number.
- Quicker report is essential as cross functional agreement-concept commit gate (CFA) report is very essential to take business decision (in the past when the companies worked decentralized they took individual decision without regarding to other department so they have problems with agreement. But now the decision is centralize through cross functions so they communicate to each other and they take a decision does not affect any department).
- For better control, they loaded the entire ROI report documents as content into Windchill system. This resolved safe storage of data and ease of control, but was not able to generate read only reports from the existing data. [35]

Due to the scalability of this solution and common use of Excel document for data gathering in various industries, this solution could be applied for lot of Windchill customers. Following is the sample list of potential beneficiaries of this solution:

- Project team in any industry that uses Excel to calculate ROI of project/ program

- Engineering industry people who manages their engineering data calculations in Excel document
- Quality control organization holding their tracking summary in Excel document

The solution described in this document would add following benefits.

- Central repository and better control to the business data
- Data validation and correctness
- Ease of data access and quicker business decision
- More flexible
- Best scalability

5.4 Microsoft Project in Windchill

Two modules of Windchill ProjectLink and PPMLink are very important and rather the keys for integrating Windchill and Microsoft Project. In the previous chapter I explained and defined each module and now I will write directly how it works and each module functions in Microsoft Project.

Windchill ProjectLink supports an optional Microsoft Project plug-in component to support exchange of plan information, such as tasks and resources with Microsoft Project 2003, 2007 and 2010. Project or program members with permissions to create and edit plan objects can import and export plans between Microsoft Project and Windchill. They can also edit plan information within Microsoft Project and then save it to Windchill. With the plug-in installed you can choose Save to PTC from the File menu in Microsoft Project. The plug-in also facilitates exporting and editing Windchill plan information by opening the plan directly in Microsoft Project.

Windchill PPMLink extends the tools Microsoft Project Server provides with a set of program and portfolio management features designed specifically as a solution for product development organizations within the manufacturing industry. Windchill PPMLink relies on Microsoft Project Server's best-in-class traditional PPM capabilities for the basics of project management and portfolio organization, and extends them with product development program portfolio management capabilities.

Windchill PPMLink gives Program Managers an integrated view of product deliverable status and schedules to enable better governance of the organization's stage gate processes while helping Product executives make better informed investment decisions by improving visibility to resource allocations and product family performance.

With Windchill PPMLink, program team can concentrate on the processes, milestones and deliverables that matter most, while aggregating detailed data—gathered from popular project management tools and your product data management system—into actionable metrics. The results are powerful: more effective and better-informed decisions, smarter allocation of resources, and more predictable program execution.

Benefits of the PPMLink and Projectlink in Windchill

- Maximize the performance of new Product development initiatives
- Align programs across divisions, product families, and product lines to current business, product and technical strategies.
- Measure key development objectives to balance resources across different risk, market, strategy and cost factors. Automate critical product development processes
- Efficiently and consistently execute processes across programs and product families to deliver more products to market faster.
- Mitigate both quality and market risk by establishing well defined program and portfolio decision points. Develop unique insight into program health
- Aggregate information from different project management tools into metrics that provide a consolidated view of program and portfolio health.
- Complement traditional project metrics with product development metrics derived directly from your product data management (PDM) or PLM system. [32]

5.5 Conclusion and reflection

As you see in the explanation above there are two methods to integrate Microsoft Project in Windchill the first one by Project Link and the other methods the classic methods. In general the integration between Microsoft Project and Windchill is important and vital for the strategy of any project and planning as well. Moreover I can epitomize in the points below:

- Plan program resources with Microsoft Project Server
- Create master schedules using Microsoft Project Server
- Manage new project requests with Microsoft Project Server demand management
- Perform Portfolio Scenario Analysis with Microsoft Project Server

6 Modules of Windchill

Windchill is the general software, but there are different modules of it depending on what the customer needs to do. In this part I will present each module with a brief definition. I would add that because of the limitation I mentioned in 1.6 I couldn't test the modules.

6.1 Modules of Windchill [31]

- **Windchill product data management (PDMLink):** is the suitable solution. Web-based for easy enterprise-wide access, this industry-proven product data management (PDM) system supports geographically dispersed teams while managing critical processes such as change/configuration management, and detailed design. PTC Windchill PDMLink also serves as the foundation for many optional modules such as Pro/INTRALINK, PTC Windchill MPMLink, PTC Windchill Parts Link and PTC Windchill Supplier Management.
- **Windchill ProjectLink:** is web based software that supports online project collaboration. ProjectLink can also be integrated with other PTC solution. ProjectLink Provides instant access to the right product development and project management information at the right time, keeping the team aligned, on track, and moving forward.
- **Windchill MPMLink:** An ideal solution for the manufacturing engineers because it gives mechanical engineers the tools they need to digitally design and manage all of their process plan deliverables concurrently with design.
- **Windchill FlexPLM:** It provides line planning, specification management, and other essential PLM capabilities for managing any company's complete assortment of products.
- **Windchill PPMLink:** It is uniquely designed to meet the Program Portfolio Management (PPM) needs of discrete manufacturers. Program teams get transparent access to accurate product data, without compromising the 'single source of engineering truth' provided by PDM.
- **Windchill Compliance:** It tracks and manages the compliance of the products, beginning early in the innovation process and continuing throughout the product lifecycle.
- **Windchill Cost:** This module helps making decisions related to cost targets. By providing real-time product cost estimates and analysis it makes product cost analyt-

ics an integral part of the standard product development process and allows cost analysis to be performed on every product design change.

- **Windchill Materials & Substances:** It is a module which integrates with the existing enterprise systems to provide visibility into the materials and substances in your products and supply chain, based on real-time bill-of-material (BOM) and product data.

- **Windchill LCA:** Empowers manufacturers to scale the production and usage of life cycle assessment (LCA) data and reports across the entire enterprise. You can assess the environmental impact of any product or product component throughout the development process and compare it to design alternatives to optimize environmental performance.

- **Windchill Prediction:** Provides the basis for reliability evaluation and analysis of system by allowing assessing reliability metrics early in the process.

- **Windchill FRACAS:** Allows you to establish a clear, systematic way to address errors or incidents that occur within a product or system, develop and manage a plan of action to correct them, and ensure that these processes have a positive effect on future performance.

- **Windchill FMEA:** Failure Mode and Effects Analysis is a failure mode and effects analysis tool that gives you the power to systematically identify the potential failure modes of a system, and control or prevent their occurrence or effects.

- **Windchill FTA:** The powerful analytical capabilities of Fault Tree Analysis quantify system risk and reliability, helping you makes targeted decisions about design, maintenance, and controls to reduce the probability of failures.

- **Windchill Customer Experience Management:** Supplies the highly structured, automated, and repeatable processes necessary to meet regulatory requirements for addressing external quality issues reported through customer complaints.

6.2 The most potentially modules interesting for the course

As the goal of this project is to create an introductory course about PLMs for engineering students who has never worked with these programs, in the basic course Pol has focused on the two important modules as proper for his work in basic course and for the developed course as well, so I got through them on my report as well.

They are **Windchill PDMLink** and **Windchill ProjectLink** for the following five reasons:

1) Windchill PDMLink is the foundation for many other optional modules that are mentioned above. So, everybody has to learn how it works if they want to be available to use another one, later.

2) Windchill PDMLink helps students to get an overview of the data management in an enterprise, while Windchill ProjectLink enables users to manage as many projects as they want, in an easy and organized way.

3) Windchill ProjectLink is a practical way to improve all the knowledge because it fosters innovation through real-time group collaboration.

4) Windchill ProjectLink can be integrated with Microsoft Office. There is a related course on product development at LTH where students learn about Microsoft Project, so Windchill's course can be related to this one.

5) Both modules operate seamlessly together and with PTC Creo, which is very interesting for design engineers.

6.2.1 Selection of suitable modules for the course

For the advanced course I propose the other interesting modules from Section 6.1. Afterward I will choose two modules only, based on several factors that affect the method of choice like times of thesis, license from PTC and contact with the persons who take responsibility from LTH and PTC and the co-operations between them. For example, if we need to install a server from PTC related to our work we have to go through many process like contact PTC and investigate about the license and contact the administration in LTH etc.

Among the different Windchill modules I have chosen the most interesting modules for the course.

As you can reads from the definition in 6.1 each module is interesting and has properties and special specifications difference from other module but that is not enough to be a subject in the course. Therefore I have selected only three modules as they were suitable to the course.

I have chosen the modules based on the specifications below:

- Related to mechanical engineering and product development
- Related to requirements management
- Cost
- Fulfill with customer needs
- Administration problem related to install and run on the server
- Relations between the module and my thesis (related to the course)
- Relations with design, manufacturing, innovation, requirement management

The three selected modules are:

1. Windchill PPMLink
2. PTC Integrity
3. FMEA (Failure Mode and Effects Analysis)

6.3 Explain the selected modules

In this part I will explain the selected modules functional and properties and why they were been selected among other modules.

6.3.1 Windchill PPMLink

Windchill PPMLink is PTC's solution for program and portfolio management (PPM) for product development organizations. It extends the capabilities of Microsoft's project server 2012 solution with configurable stage and gate process, scorecard tools that combine traditional project management metrics with product-oriented design metrics. Additionally, it provides unique visibility into the social nature of how your products are developed, thereby improving product development process in manufacturing organizations.

The technology prerequisites for Windchill PPMLink are Microsoft Project server 2012, which requires share point server 2010 Enterprise Edition.

Windchill PPMLink extends the tools Microsoft Project Server provides with a set of PPM features designed specifically as a solution for product development organizations within the manufacturing industry. Windchill PPMLink relies on Microsoft Project Server's PPM capabilities for the basics of project management and portfolio organization, and extends them with product development program portfolio management capabilities.

In the description below Windchill PPMLink is compared to other modules like ProjectLink

Windchill ProjectLink preserves its role as a solution that provides virtual collaborative workspaces with embedded visualization and rich data sharing for product development teams, and as a project management solution for managing individual projects. Windchill PPMLink complements Windchill ProjectLink as a PPM solution designed to reach across engineering teams and product development functions to facilitate cross-program portfolio decisions and manage the overall cross-project delivery of products and components.

Windchill PPMLink has been designed to be loosely-connected to the project management tools that individual teams or programs may use to manage their day-to-day activities. Windchill ProjectLink is one such project management environment that will be able to feed specific project metrics to Windchill PPMLink for aggregation into broader program and portfolio views.

Differences between Windchill ProjectLink and Microsoft Project Server for project management

Windchill ProjectLink is a solution that provides high-value, easily-administered collaborative project workspaces for teams that need to coordinate their own activities and collaborate on engineering and other product data that are specific to the product development process. With its embedded visualization, rich data sharing, and project management capabilities, it provides an excellent solution product teams to manage individual projects while integrating directly with product data from Windchill PDMLink.

Many companies use Microsoft Project Server as their tool for project management within and across departments. Microsoft Project Server 2010 provides the broad functionality for a multi-department organization that needs to schedule, manage, and report on projects within and beyond engineering departments who focus on product development.

PTC has developed the necessary integrations to import Microsoft Project-based project plans into Windchill ProjectLink, or to export them from Windchill ProjectLink into Microsoft Project.

PTC has integrated Windchill PPMLink with Windchill ProjectLink

With the initial release of Windchill PPMLink, business objects defined in Windchill PPMLink can be associated with content objects (i.e., deliverables) managed in Windchill ProjectLink or Windchill PDMLink. Over time, the level of integration will improve to allow Windchill PPMLink business objects to be associated to Windchill ProjectLink project plan objects so that there is a rich bi-directional exchange of data, thus eliminating redundant project metadata and the need for any user to access two systems.

Windchill PPMLink is not designed or positioned as a content management system. Windchill PDMLink (or a combined installation of Windchill PDMLink and Windchill ProjectLink) is the appropriate system of record for product information. The initial release of Windchill PPMLink provides transparent access to content managed in Windchill. Thus, while Windchill PPMLink will manage “program” information related to program or process deliverables, the actual content will remain in Windchill PDMLink or Windchill ProjectLink.

6.3.2 - PTC Integrity and requirement management

As shown in the figure below PLM users can interactively and graphically explore object relationships and traverse up, down, and across information structures. Objects supported in the initial release: Parts, Documents, CAD Documents, Requirements, and Change Objects. [40]

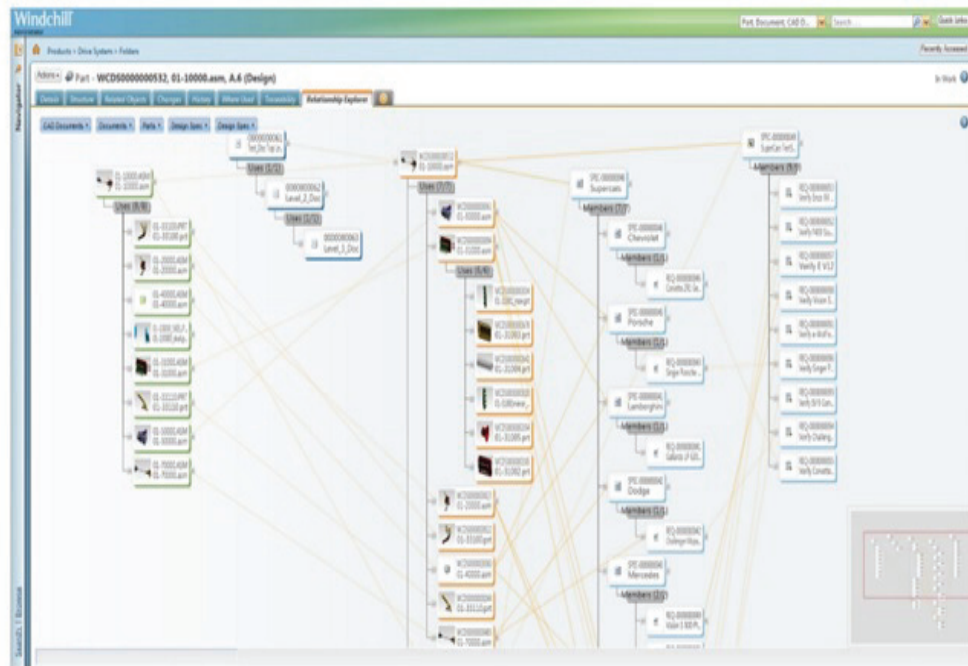


Figure 11 shows the PTC integrity module[40]

PTC Integrity provides requirements management capabilities that go beyond the mere capture of product information, though — the traditional view of the tool that mainly focuses on the acquisition of raw materials and manufacturing processes, but aims to instill the discipline as an interactive part of the product development lifecycle. PTC Integrity's core functions, however, are its software configuration, change management (SCCM), and software re-uses capabilities. This provides complete source code management, unifying software configuration management and software change management, facilitating enhanced team collaboration and communication - that mouthful means that teams work better if they are running similar levels of software.

PTC Integrity enables all software all software engineering artifacts, including requirements, models, code, and test, ensuring comprehensive lifecycle traceability to be configured and managed throughout an entire organization, including the situation regarding software re-use - a more prudent way of managing complex software development issues, although one which raises significant questions.

Finally, PTC Integrity provides native support for modeling and simulation tools, such as Simulink and MATLAB, ensuring complete traceability between all functions, data and processes - an integrated solution that addresses the specific needs of a model-based development process providing complete traceability among requirements, test cases, models, and other assets to ensure the accuracy of designs, address design changes in the models (and test cases) and ultimately reduce development cycle times. A complete software lifecycle management solution is now wrapped up in a complete product lifecycle management solution. [33]

6.3.3 Windchill Failure Mode and Effects Analysis (FMEA)

Windchill FMEA provides a structured methodology to identify all potential failure modes of a system and evaluate their effects, enabling design engineering to introduce risk controls that prevent or mitigate their impact. Supporting a variety of industry standard formats, such as AIAG and MIL-STD-1629 [41], Relx FMEA is equally adept at performing process, design, functional, and piece-part level FMEAs. The module supplies templates and allow the customized ones.

6.3.3.1 FMEA Overview

A FMEA consists of breaking a system down into what can fail, how it can fail, and why it fails, and then determining the effects of those failures on your system. FMEAs can also include the analysis of criticality, and in this case is referred to as FMECAs (failure mode, effects, and criticality analysis). FMEAs are typically performed based on published standards or guidelines; however, some organizations develop their own guidelines for FMEA. The most common FMEA standards include MIL-STD-1629, various automotive FMEA standards, and SAE ARP5580. [41]. The FMEA process is a bottom-up approach to system analysis. The analyst begins at the lowest level desired for analysis, such as a part or a step in a process, and ascertains the possible failure modes associated with that item. The next step is to establish, based on system knowledge, what the resulting effect of the failure modes are. Along with each end effect, the analyst might also determine the Severity of that effect, the probability of occurrence of that effect, and how the effect could be detected. This process continues up the system tree until overall system end effects are evaluated. Once this detailed analysis is complete, some type of ranking criteria is employed. The ranking is then used to determine how critical failures can be eliminated or the risks mitigated. [41]

The main objective of a FMEA is to evaluate all parts of your system or process to ensure that system reliability and safety objectives are met.

7 Plan of the course

In this section, it is defined which topics fit in each lesson according to their estimated duration. The outline of the course will be run as showed in the tables below:

7.1 Plan of the course

In the basic course we put the outline plan for this course. Pol Rebenaque presented in his work except some lessons that should I write after I finish my work and I do modified on some lessons, according to the course needs as shown below:

Lesson 1 → Pol Rebenaque and Yazin Al-Khayyat

LESSON 1 - Introduction to PLM and Windchill Environment	90
Introduction and previous knowledge of the students	20
What is a PLM	3
History of PLM	2
Business drivers	2
Functions, benefits and costs	3
ERP vs. PLM	2
PLM Market	1
PLM Models	2
Models	3
Overview of Home Page	5
Data Management Objects: Documents, CAD Documents, Parts & End Items	25
Storage Locations: Projects, Libraries and Products	3
Iteration and Revision Controls: Version, Check In and Check Out	4
Questionnaire 1	15

7 Plan of the course

Lesson 2 → Pol Rebenaque

LESSON 2 - Preparation and Customization of Windchill & PTC Guest	90
Introduction and review of the previous lesson	10
Logging On to Windchill	2
Help menu (Help Center, Quick Guide)	5
Setting preferences(Profile and Calendar)	2
Event Management	1
My Notebook	1
Software Downloads	2
Customization of Home Page	10
Locating information: Search and Browse	1
Use the Browser: Navigating Products, Libraries and Projects	1
Exercise Navigate	10
A professional from PTC comes to the university to talk about Windchill	45

Lesson 3 → Pol Rebenaque

LESSON 3 - Management of CAD data	90
Introduction and review of the previous lesson	10
Installation and use Creo View	3
Integrate Windchill with Creo	5
What is a workspace	2
Manage workspaces	15
Share CAD models	5
Understanding Save, Upload and Check In	10
CAD Modification Process	5
Exercise Modifying CAD models	20
Questionnaire 2	15

Lesson 4 → Pol Rebenaque

LESSON 4 - Management of Product Structures	90
Introduction and review of the previous lesson	10
Use parameters	25
Definition Product Objects: End items and Parts, CAD Documents and Documents	5
Create Windchill Parts	10
Create CAD documents from Product Structures	5
Create Product Structures from CAD documents	5
View and Explore Product Structures	15
Questionnaire 3	15

Lesson 5→ Pol Rebenaque

LESSON 5 - Management of Product Structures II	90
Introduction and review of the previous lesson	10
Modify a part in a Product Structure	10
Add replacement parts in a Product Structure	10
Compare Product Structures	10
Navigate Product Explorer	25
Practical Exercise: Create a new Product Structure	25

Lesson 6→ Yazin Al-khayyat

lesson 6 Management of Solidworks	90
introduction and review of the previous lesson	10
installation WGM	15
Integrate Windchill with Solidworks	10
Manage workspace	10
Open solidworks from Windchill	10
save, Upload and Check in	10
Modifications and actions	10
Exercise Modifying Solidworks	15

Lesson 7→ Yazin Al-Khayyat

Lesson 7- Management of Documents	90
Introduction and review of the previous lesson	10
Installation and configure MS Office Integration	10
Integrate Windchill with MS Office	5
Create Document	5
Modify Document: Check out,Edit,Save and Check in	5
Associating Documents with Windchill Parts	5
Create Folders	1
Manage your Work	4
Manage subscriptions	5
Learn some of the options in the Folder Content Actions	25
Questionnaire 4	15

7 Plan of the course

Lesson 8→ Pol Rebenaque and Yazin Al-Khayyat

Lesson 8- Management of a Project	90
Introduction and review of the previous lesson	10
Create and configure a project	5
invite your team to the project and define roles	15
Manage resources	3
Create activities, milestones and deliverables	15
create project from Windchill	25
Collaboration tools: Meetings and discussions	10
Create links and notes	7

Lesson 9→ Yazin Al-Khayyat

Lesson 9- Management of a Project	90
Introduction and review of the previous lesson	10
Route documents	25
install and configure MS Project	10
Integrate Windchill with MS Project	10
Create Project from MS Project and export it to Windchill	35

Lesson 10→ Pol Rebenaque and Yazin Al-Khayyat

Lesson 10- Guest Lecture	90
Introduction and presentation of the conferencer	10
A professional from PTC or a company which use Windchill come to the school to talk about Windchill from his point of view	80

Lesson 11 & 12→ Pol Rebenaque and Yazin Al-Khayyat

Lesson 11 & 12- Final Exercise : Project of Fake Company	180
Introduction and Presentation of the Final Exercise	10
Final Questionnaire	15
Final Exercise: Project Fake Company	155

7.2 Intermediate test of PLM/Windchill

In order to get an idea about how Windchill PLM Software would be interesting for students, and in co-operation with Giorgos Nikoleris (who is the teacher of an advanced Creo 2 course) we used a whole lesson of his Creo 2 lessons to give his students idea about PLM and particularly Windchill. In the information below the readers can see how this test was?

7.2.1 Objective with test

Objective with the test is divided into two parts. First we wanted to get student feedback and reaction about this lecture of integrated Windchill PLM Software with Creo2 and second we wanted to use this feedback together with the future teachers of the course in order to improve the course.

7.2.2 Test of the system (CAD and Windchill) by lecture held in IKDC

The lecture's title was "Discovering Windchill PLM Software." We introduced his students to PLM and Windchill. The lecture took place at IKDC room 148 on 28th February 2013 from 17:30 pm to 21:00 pm.

The lesson was divided into three parts of one hour. I started the first part and it was about introduction of PLM. I went through all this points below:

- What is PLM?
- What are the functions of PLM?
- What is the benefit of PLM?
- Is it important nowadays or not?
- Pros and Cons of PLM?
- How much is cost? What is the market area of PLM?
- Which companies deal with PLM today and why?
- Conclusion about PLM and why it is important today

After I got through all of the points over I asked the student if they were wondering about something or if they have questions. Pol has started the second part of the lecture and the goal of this part to teach the student how to use Windchill as a designer. He has to go through these points below:

- What is Windchill? (Windchill concept)
- What is the benefit of using Windchill?
- How many companies using Windchill today?
- Modules of Windchill
- How to use Creo View?
- Use of Windchill in Creo 2
- Workspace in Creo 2 and Windchill?
- How to share CAD models in Windchill?
- Understanding Save, Upload, and Check In in Windchill?
- CAD Modification Process?

The goal of all the points above is to give the student overview about the next step. The next step is the practical part and this part includes some basic principle like how to log on in Windchill, how to navigate in Windchill, how to makes server in Creo and use it in Windchill, Check in, Check out and save in Windchill, etc.

When Pol Rebenaque started log in Windchill I supports the student in case they faced a problems with Creo or Windchill. So I helped the student with integrated Creo in Windchill and especially in the final exercise as some student get stuck in some process or so.

In the table below an overview of the lecture:

Table 1 Plan of the intermediate test

Introduction
PLM information
Windchill modules
Storage Locations: Projects, Libraries & Products
Data management Objects
Overview of Revision Controls: Check In, Check Out
BREAK
Logging On to Windchill
Customize Home Page and Navigating Windchill
Workspaces
Understanding Save, Upload, Check In
CAD Modification Process
Exercise: Workspace, Understanding & CAD Modification
BREAK
Use Parameters
Exercise: Using Parameters
Exercise: Working as a real company “Modification of Spindle Column”

7.2.3 Result of the lecture

The lecture was very interesting for both teachers and students as well. We had talked about it with Damien and he was quite satisfied but he mentioned some important points to be considered for the course. Giorgos was satisfied as well and he has talked to Pol as Pol told on the other day.

The students were quite few, 8 persons from different backgrounds and they were in different ages older between 19-46 years old and that was very positive and effective as well because we could get so many different ideas from different experience in various ways.

After the lesson was finished one of the students told me that the practical part was very interesting, and they like the way we managed the lectures as well as Pol has got the same comment about the second part was very interesting opposite the first part (theoretical part) was very boring for students. I recommend that someone stand by in the lecture to help and support students as I did.

7.2.4 Way to further developing

Suggestions for the development course:

- 1- Focus on the other modules of Windchill and which of them are the most interesting for engineering design.
- 2- Integrates with numerous mechanical and electrical CAD solutions,
- 3- investigate about how we can integrate with other applications supports like Arbortext, CADD5, AutoCAD, CATIA, Inventor, or Mathcad.
- 4- Add to the course new modules for example PTC Integrity.

7.3 Schedule of the course

These lectures have been written by Yazin Thamir Al-Khayyat and Pol Rebenaque in the basic course and after discussion about how to put the outline for these lectures. The outcome was of cooperation between the two above-mentioned persons. The PowerPoint describes separately the lectures handled by each one.

7.3.1 Lecture 1

Time: 90 minutes (60' theory + 30' exercises)

Title: Introduction to PLM and Windchill Environment

Material of the lesson: PowerPoint slides written by Pol Rebenaque and Yazin Al-Khayyat in the basic course

Description:

The initial lesson is the introductory one, where the teacher and all students introduce themselves. These last ones are supposed to know nothing about PLMs, so before they will learn how Windchill works, is very important to teach them what are PLMs, all their functions, the most important brands existing in the world and a little bit of history about this topic.

A brief description of a company, its structure and the role of PLM into it, take the following minutes of the class.

The second half of the lesson, is an overview of PTC, the company of Windchill, and it is described some important aspects such as its modules to know which one has to be used each time, interface of Windchill 10 or an introduction of one of the main reason of using Windchill, the iterations and revision controls.

At the end of the class, students must realize a questionnaire to check their knowledge.

The purpose of the 1st lecture is to provide students an introductory level of PLMs and an overview of Windchill environment.

Objectives:

- 1) Introduction and previous knowledge of the students
- 2) PLM
 - i. What is it, history, business drivers, functions and benefits
 - ii. What is ERP
 - iii. ERP vs. PLM
 - iv. Integration ERP and PLM
 - v. PLM market and models
- 3) Windchill Environment
 - i. Modules
 - ii. Overview of Home Page
 - iii. Data Management Objects: Documents, CAD Documents, Parts & End Items
 - iv. Storage Locations: Projects, Libraries and Products
- 4) Iteration and Revision Controls: Version, Check In, Check Out

7.3.2 Lecture 2

Time: 90 minutes (35' theory + 55' exercises)

Title: Preparation and Customization of Windchill & PTC Guest

Material of the lesson: PowerPoint slides in the basic course written by Pol Rebenaque

Description:

In this lesson, students prepare and customize the PLM system to work more effectively and comfortable in the future. They learn how to log in Windchill, so from this moment they can follow the course exploring PLM and putting on practice the theory by themselves, so maybe the classes will proceed slower.

At the second half of class, a worker from PTC comes to university to talk about Windchill and his experience as a professional in PLM.

The purpose of the 2nd lecture, besides listening to the PTC worker, is to show students that it is very important to spend some time customizing the software and learning the basic functions, because afterwards, it will help you to work faster, easier and more effectively.

Objectives:

- 1) Introduction and review of the previous lesson
- 2) Log On to Windchill
- 3) Use Quick Links Menu
 - i. Help menu
 - ii. Setting preferences
 - iii. Event Management
 - iv. My Notebook
 - v. Software Downloads
- 4) Customize Home Page
- 5) Search and Browse
- 6) Use navigator

7.3.3 Lecture 3

Time: 90 minutes (35' theory + 55' exercises)

Title: Management of CAD data I

Material of the lesson: PowerPoint slides Written by Pol Rebenaque and Yazin Al-Khayyat in the basic course

Description:

This lesson is one of the most interesting for design engineers because they learn how to use CAD data, which is the type of objects they use to work with. So, they will learn to use workspace; create, modify, share and save CAD data, etc., in a nutshell, manage CAD data. As it is taught in Lund University, the CAD software used in this course is Creo 2.0, so students will not have any problem or extra difficulties to build and an assembly with it. As it is described before, it is very important, so to get the learning to students easier and funnier, most of the lesson is practical.

At the end of the class students must realize a questionnaire to check their knowledge.

The purpose of the 3rd lecture is to show students how to manage CAD data, and how to integrate it with Windchill.

Objectives:

- 1) Introduction and review of the previous lesson
- 2) Use Creo View
- 3) Integrate Windchill with Creo
- 4) What is a workspace
- 5) Manage a workspace
- 6) Manage CAD models
 - a. Create, Modify, Upload, Save and Retrieve
 - b. Share
 - c. Revise: Check in, Check Out

7.3.4 Lecture 4

Time: 90 minutes (45' theory + 45' exercises)

Title: Management of CAD Data II & Product Structures I

Material of the lesson: PowerPoint slides written by Pol in the basic course

Description:

The fourth lesson starts with using parameters in Creo, a continuation of the previous lecture (there was not time enough). In the real life almost all the designers use to work with parameters, so in this class students learn to work with them, and to integrate them in Windchill. After, students learn everything about another big field of Windchill called Product Structures, which enables users to work with BOM (Bill of Materials) and building their own assemblies without design anything, just taking pieces already built from old assemblies. Due to its extensive syllabus, it takes too much time, so they will continue it.

Past the end of the class students must realize a questionnaire to check their knowledge.

The purpose of the 4th lecture is to see how designers can create their own product structure from Windchill. Moreover, students improve his Creo knowledge learning how to work using parameters.

Objectives:

- 1) Introduction and review of the previous lesson
- 2) Use parameters
- 3) Definition of Primary Product Objects (End items and Parts, CAD Documents and Documents)
- 4) Create Windchill Parts
- 5) Create CAD documents from Product Structures
- 6) Create Product Structures from CAD documents

7.3.5 Lecture 5

Time: 90 minutes (25' theory + 65' exercises)

Title: Management of Product Structures II

Material of the lesson: PowerPoint slides Written by Pol Rebenaque in the basic course

Description:

As it is mentioned before, this lesson is the continuation of the previous one. Students know to create a Product Structure, so at this time, they learn how to modify it. Using Product Explorer and comparing both assemblies, it is not necessary to rebuild a CAD file again, just to change some pieces; you can do it just selecting the pieces you want to add.

As difference with the other lessons, it has no questionnaire at the end of class, but there is a practical exercise in appendix B where students must use all their knowledge acquired during the last two classes to create a new product structure.

The purpose of the 5th lecture is to show students that there are a lot of tools which enables you to rebuild an assembly without using CAD program.

Objectives:

- 1) Introduction and review of the previous lesson
- 2) View and Explore Product Structures
- 3) Modify a Part in a Product Structure
- 4) Add replacement parts in a Product Structure
- 5) Compare Product Structure
- 6) Navigate Product Explorer

7.3.6 Lecture 6

Time: 90 minutes (40' theory + 50' exercises)

Title: Management of CAD Data II & Windchill Workgroup Manager for SolidWorks

Material of the lesson: PowerPoint slides written by Yazin Al-Khayyat

Description:

This lesson is quite interesting and important for the student especially design engineering because it is more advanced and more expanded than the lesson before. Basically the student will stay in touch with CAD Data as they have learned before how to integrate with Creo2 in the previous lesson but now in more or advanced way system. They will learn what Windchill Workgroup Manager is. What is Windchill Workgroup Manager common framework supports for CAD applications? As well as understanding the client and server system architecture and Windchill Workgroup Manager Capabilities. It is very important, so to get the learning to students easier and funnier most of the lesson is practical. At the end of the class students must realize a questionnaire to check their knowledge.

Objectives:

- 1) Introduction and review of the previous lesson
- 2) Definition of Workgroup Manager
- 3) Integration Windchill with SolidWorks.
- 4) Explain and manage Workspace in SolidWorks.
- 5) Define PDM action and know the commands below:
 - i. Save to workspace
 - ii. Check in, check out.
 - iii. Undo check out and update.

7.3.7 Lecture 7

Time: 90 minutes (40' theory + 50' exercises)

Title: Management of Documents

Material of the lesson: PowerPoint slides Written by Yazin Al-Khayyat and Pol Rebenaque in the basic course and advanced course

Description:

Windchill provides you with tools that help you manage your work. In this class, students explore how tables on Windchill's home page help you managing the objects that you are working on. Students also learn how they can use the notebook and subscription features to help them keep track of objects that they are interested in monitoring.

Students also learn how they can configure and integrate Windchill with Microsoft Office, so they can work from their computer to server and vice versa. Lastly, students learn all sort of options which enable users to manage all existing documents, such as move, new, add, check, compare, etc.

At the end of the class students must realize a questionnaire to check their knowledge.

The purpose of the 6th lecture is to help students in managing of documentation work.

Objectives:

- 1) Introduction and review of the previous lesson
- 2) Integrate Windchill with MS Office
- 3) Manage objects
 - i. Create, Modify and Save
 - ii. Revise: Check In and Check Out
- 4) Manage folders and options of its drop-down
- 5) Manage subscriptions

7.3.8 Lecture 8

Time: 90 minutes (55' theory + 35' exercises)

Title: Management of a Project I

Material of the lesson: PowerPoint slides Written by Pol Rebenaque in the basic course

Description:

In this lecture, students learn how to function as a project manager within Windchill. They learn about the key concepts of project management such as define project's team members or how to create activities and milestones that define the project timeline. They must assign ownership responsibility of the activities and milestones to the project's team members. Lastly, they learn some knowledge about communication and collaboration tools enable in Windchill.

The purpose of the 7th lecture is to provide students enough knowledge to be able to create a new project and manage it correctly.

Objectives:

- 1) Introduction and review of the previous lesson
- 2) Management of a project
 - a. Project Manager's Responsibilities
 - b. Planning Projects
 - c. Create a project
 - d. Invite team members and define their roles
 - e. Manage resources
 - f. Manage activities, milestones and deliverables
 - g. Plan a project from Windchill
- 3) Collaboration and communication tools (meetings and discussions)
- 4) Create links and notes

7.3.9 Lecture 9

Time: 90 minutes (45' theory + 45' exercises)

Title: Management of a Project II

Material of the lesson: PowerPoint slides Written by Pol Rebenaque and Yazin Al-Khayyat in the basic and advanced course

Description:

This lecture helps students to get the rest of knowledge needed to know everything about management of a project, at least from this intermediate level point of view. Students learn how to route documents and how to create new projects from Microsoft Project and export them to Windchill.

The purpose of the 8th lecture is to provide students with the rest of knowledge about management of a project and to show them that Windchill can be easily integrated with several programs.

Objectives:

- 1) Introduction and review of the previous lesson
- 2) Route documents
- 3) Microsoft Project
 - i. Integrate Windchill with Microsoft Project
 - ii. Plan a project with Microsoft Project

7.3.10 Lecture 10

Time: 90 minutes (30' theory + 60' exercises)

Title: Management of a Project

Material of the lesson: PowerPoint slides written by Yazin Al-Khayyat in the advanced course

Description:

In this lecture student will learn how to create and manage any project plan by Microsoft Project. As well as learn how to co-operate between project management and Windchill working by integrated Microsoft Project in Windchill and how to use other options e.g. (upload plan, import and export plan) as they learn in the previous lesson (management of documents). The student will learn to methods to integrate Microsoft Project in Windchill the 1st by Installation PTC- Plug in for Microsoft Project exchange plan information between Windchill Project link and Microsoft Project how to use it and get access from Microsoft Project even how they will save it and open it in Windchill. The 2nd methods it is the classical method by create a normal document (Microsoft Office Document) and upload it as any types of documents.

The goal of this lecture to provide the student knowledge about manages a project by using Microsoft Project and how it is important for a project plan.

Objectives:

- 1) Introduction and review of the lesson of (Management of a document).
- 2) Fast idea about Microsoft Project.
- 3) How to integrate between Windchill and Microsoft Project.
- 4) Plan a project in Microsoft Project in Windchill.

7.3.11 Lecture 11

Time: 90 minutes

Title: Guest Lecture

Material of the lesson: PowerPoint slides written by Pol Rebenaque in basic course

Description:

In this lecture a PTC worker comes to university to take a conference about his job. Obviously, he will talk about his company and his products focusing on Windchill, but it could be very interesting if he explain how is general situation of companies either in Sweden or rest of the world.

At the end of the conference, there is questions period where students can ask all curiosities and doubts they have.

Alternatively, a representing from a company using Windchill cab be also invited.

The purpose of the 9th lesson is to get more information about PLM, but from a professional point of view, which, of course, is interesting for students.

Objectives:

- 1) Get more information about PTC
- 2) Know what the real situation in companies, currently is.
- 3) Learn some skills about PLM from a professional point of view
- 4) Know the main functions of Windchill from a PTC worker point of view
- 5) Description of the roles in a company focused on designers

7.3.12 Lecture 12

Time: 180 minutes

Title: Final Exercise: Project of a Fake Company

Material of the lesson: PowerPoint slides written by Pol Rebenaque and Yazin Al-Khayyat in the basic course

Description:

Last lesson of the course is the evaluation one, where students have to show everything they know.

Firstly, there is a theoretical exam where students answer a questionnaire which comprises a summary of all questions of the questionnaires done previously.

After that there is a practical exercise, which comprises the most time of the class. Students gather in groups of 4 and they have to use their Windchill's skills to solve a design project. It is a simulation of a project in a real company, so each member has a different role in a group: Project Manager and three Designers; teacher is supposed to be the headmaster of the company. Although in the real life they may work in different places, in this case they can help each other easily, so it is very important the relationship between members of a group and their teamwork.

The purpose of the 11th and 12th lectures is to evaluate all students' skills and see if they are able to realize and complete correctly a real design project.

It is important to know that the drawings of the milling machine come from another Master Thesis done by Enrico Frittelli [46].

Objectives:

- Evaluate theoretical skills of students acquired during the whole course
- Evaluate student skills acquired during the whole course
- Teamwork
- Know how is the real job in a huge international company
- Know the different roles in a company
- Know how is a real project

8 Conclusion and recommendations

I have written a short conclusion after each chapter but in this chapter I will try to summarize my conclusion about the project as a whole and describe the circumstances affecting this project.

Windchill course is a very interesting subject for the university and the students as well because the result combines between Management and Engineering.

In the basic course Pol had contact with responsible people in the PDSVision and PTC so we were very pleased at that time and we came a long way in this course. Unfortunately after that the responsible person quit his job in PTC the project became harder for further development despite the fact that they tried to help us as much as they can.

I focused on the integration between SolidWorks and Windchill by installation Workgroup Management Program by integrated them in the server but I couldn't do real experiment because of license issue, time limitation and installation so the course will suffer of lack of real experience. I would add that Workgroup Management is very important to the students and to the course because it gives a multiple choice to integrate with other CAD modules not only SolidWorks.

In the second part I focused on how to integrate Windchill with Microsoft Office and Microsoft Project and I could prove that in the real experiment by integration both of them in Windchill.

I would like to recommend the university to get a license and carry on with this interesting project and to find a solution for LTH's administration to install this server. The university should contact Linköping University again about this project because they have Windchill server.

Finally I would like to add that I am available in anytime for this project in case they get a license so that it would be a chance for me to test the system and see how it would work with Workgroup Management. I would like to attend the first week's lecture to see the students' reaction about this course.

Note: in the basic course I did the integration between Microsoft Office and Windchill and design a new part and assembly in Creo 2 to use it in the basic course, I have made the last part for the final assignment in the course (Spindle) and I worked with Pol by investigation about PLM, design a new part of Creo 2 and participate in the lesson that we were gave it on IKDC as a lecture.

In the advanced course I continue for further development for the course and my major duties were Windchill in SolidWorks, ERP and PLM and Integration Microsoft Office in Windchill.

Further reflection of the course:

Despite all the problems I would love to recommend this course and subject. It is very interesting subject to teach the student especially with nowadays technology so PLM will be available in all of the industries and huge factory in a few years I guess. Concept and approach is very intellectual, easy, save a time and give better result than classic method. LTH most consider the points I wrote above to carry on this interesting project and they should solve all above e.g. (with PTC and PDSVision, fix stuff for Administrations beside to Rudolf Abelin and put a little more money for this course.

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Appendix A: PowerPoint of Windchill course

In the PowerPoint presentation in this appendix are presented the plan of the lectures written by Pol's in his Master Thesis [42, Appendix A] and the complementary slides for the lectures concerned by my work.

PTC's Product Development

LUND UNIVERSITY

Discovering Windchill® PLM software

• By Yazin Al-Khayyat

Windchill Product Lifecycle Management

Plan of the Course

- Lecture 1- Introduction to PLM and Windchill Environment. *Pol Rebenaque and Yazin Al-Khayyat.*
- Lecture 2 - Preparation and Customization of Windchill and PTC *Guest. Pol Rebenaque.*
- Lecture 3 - Management of CAD Data I. *Pol Rebenaque.*
- Lecture 4 - Management of CAD Data II & Product Structures I. *Pol Rebenaque*
- Lecture 5 - Management of Product Structures II. *Pol Rebenaque*
- Lecture 6 - Management of SolidWorks. *Yazin Al-Khayyat*
- Lecture 7 - Management of Documents. *Yazin Al-Khayyat*
- Lecture 8 - Management of a Project I. *Pol Rebenaque and Yazin Al-Khayyat*
- Lecture 9 -Management of a Project II. *Yazin Al-Khayyat*
- Lecture 10 - Guest Lecture. *Pol Rebenaque and Yazin Al-Khayyat*
- Lecture 11-12 - Project of a Fake Company. *Rebenaque and Yazin Al-Khayyat.*



Agenda

- The following complementary course elements are to be included in Pol Rebenaque's basic course.
 1. Lecture 6 - Introduction to Windchill Workgroup Manager (WGM)
 2. Lecture 6 - Registering a CAD Application and Server
 3. Lecture 6 - Integrated SolidWorks with Windchill
 4. Lecture 7 - Microsoft Office in Windchill
 5. Lecture 9 - Microsoft Project in Windchill





Discovering Windchill® PLM software

LECTURE 6 – MANAGEMENT OF WORK GROUP MANAGEMENT



Introduction WGM I

- What is Windchill Workgroup Manager?
- The Windchill Workgroup Manager common framework supports the following CAD applications.
 - Auto CAD
 - Autodesk Inventor
 - CATIAV5
 - SolidWorks
 - NX
 - Mathcad
 - Arbortext IsoDraw
 - Creo Elements/Direct Drafting
 - Creo Elements/Direct Modeling
 - ECAD
 - Creo Illustrate



Note

A common practice when using Windchill Workgroup Manager, while connected to your CAD application, is to minimize the Windchill Workgroup Manager client and work predominantly in the CAD application.

The Windchill Workgroup Manager full interface is presented only when an action is invoked in the CAD application (such as Save, Custom Check In, Update), or when you are notified of the status of an action. It is a temporary environment you enter to connect actions in the CAD application to actions on the Windchill server.

With Windchill Workgroup Manager, you only need to launch one CAD application in order to work with any of your company's supported CAD applications and Windchill. For example, if you use SolidWorks for one project and NX for another, once you open Windchill Workgroup Manager, you can easily switch between the two CAD applications. Accessing data through Windchill Workgroup Manager provides the same, consistent set of core features that are available when accessing Windchill through a standard internet browser. Examples of this are opening files from a CAD application supported by Windchill Workgroup Manager, saving a CAD structure, and renaming a CAD object.

Introduction WGM II

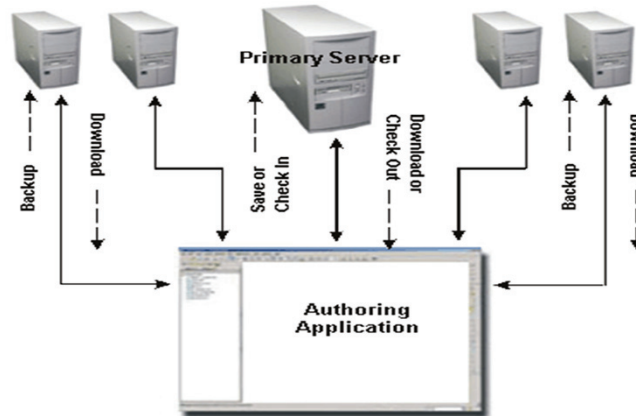
Windchill Workgroup Manager supports two modes, standalone and connected:

- Standalone (not connected to a CAD application)—Windchill Workgroup Manager can be launched on its own, so that you can access your CAD data stored in the Windchill database or in your private working area (workspace) without having to start the CAD application. This also allows you access to Windchill through the Windchill Workgroup Manager HTML browser.
- Connected (connected to a CAD application)—Windchill Workgroup Manager can be launched with your CAD application so the two are connected.



Using Windchill Workgroup Manager

- Windchill® Workgroup Manager for SolidWorks®



The Windchill Workgroup Manager HTML user interface supports connectivity between SolidWorks and Windchill. You register Windchill servers that are designated to contain your CAD data. Windchill Workgroup Manager allows connections to multiple Windchill servers. One server is always set as primary, and any additional servers that you register are considered secondary servers. The next graphic illustrates how a primary server and secondary servers connect with Windchill Workgroup Manager.



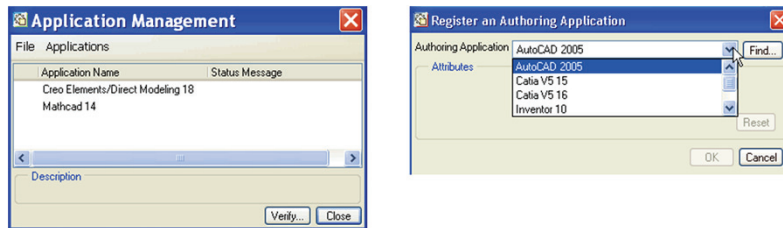
Discovering Windchill® PLM software

LECTURE 6 – REGISTERING A CAD APPLICATION AND SERVER



Registering a CAD Application and Server

- Access the Application Management utility from the Windchill Workgroup Manager Tools menu.

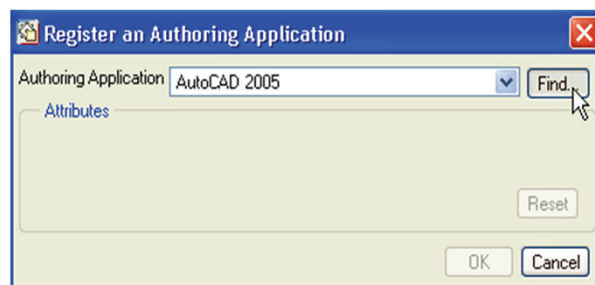


- Select Applications ► Register New Application... The Register an Authoring Application window opens and displays the CAD applications your administrator has made available. The next graphic illustrates the Register an Authoring Application window.



Register CAD Application

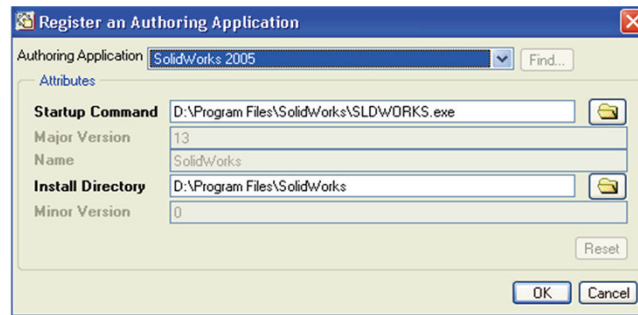
- Select the CAD application that want to register.
- Click Find to locate this application. The next graphic illustrates the Find button on the Register an Authoring Application window. Once the CAD application has been located, the Register an Authoring Application window displays the appropriate directory paths.



This is old version of Windchill. In the new version (Windchill 10) you do not go through all this process. You can select which module you need direct instead of go to FIND or so.

Register CAD Application

- Browse to change the directory. The next graphic illustrates the Attributes panel that appears when Find has been activated. In the following example, SolidWorks 2005 was found on the D: drive, and its installation directory is also on the D: drive in Program Files.



I just upload this tow slides because I couldn't test integrate SolidWorks in real.

Registering a Server

- Connecting to the Server.
- In an active Windchill Workgroup Manager session, select Tools ► Server Management. The Server Management utility opens.
- Select Server ► Register New Server..... The Register New Server window opens.
- Specify the server name to appear in the Folder Navigator.
- Enter the URL to the Windchill server codebase location (you can get this information from your Windchill administrator).
- Select Check to validate the server location.
- Enter the user name and password in the Authentication window.



In order to work in Windchill from SolidWorks, you must first establish a connection by registering a Windchill server. This is done through the Tools menu in Windchill Workgroup Manager. Once this is done, you can select a workspace and start working with your CAD data.

Note

-As a working practice, it is recommended that all users in a company register the server using the same name.

-A default workspace already exists for each Windchill Product that you have access to. If you want to create new, additional workspaces, click Workspace ► New to create a new one. This option is only available when the server is registered and has been given primary importance.

Registering a Server

- Select the workspace name from the list of workspaces wanted to be Active workspace.
- Select Close.
- Select Server ► Set as Primary Server. This enables the server and workspace to be main working server.



In order to work in Windchill from SolidWorks, you must first establish a connection by registering a Windchill server. This is done through the Tools menu in Windchill Workgroup Manager. Once this is done, you can select a workspace and start working with your CAD data.

Note

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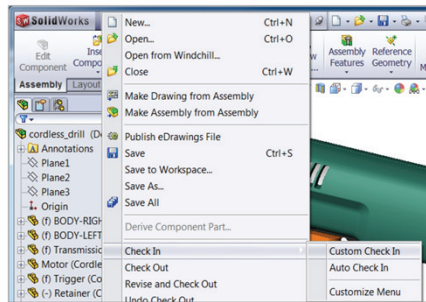
Discovering Windchill® PLM software

LECTURE 6 – INTEGRATION WINDCHILL IN SOLIDWORKS



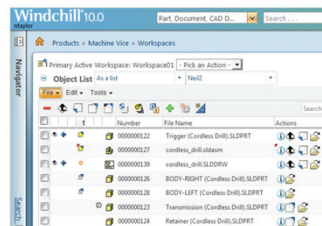
Integration Windchill and SolidWorks

-Embedded PTC Windchill menu option within the SolidWorks environment.



- I have written about how to create and save a part in SolidWorks in my main Report.

Integration Windchill in SolidWorks

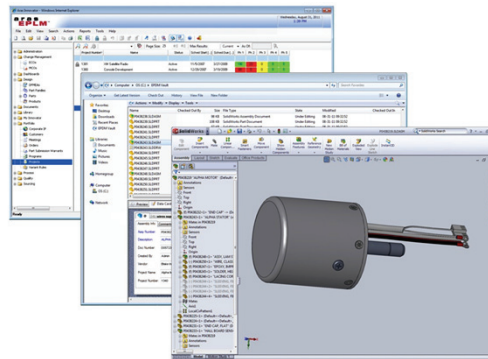


Display SolidWorks file types, as well as different status icons, within PTC Windchill.



- And here you can upload any types of CAD includes SolidWorks in Windchill.

SolidWorks in Windchill



-An example show the process of integrate Windchill and SolidWorks.



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LECTURE 7 – MANAGEMENT OF DOCUMENTS
(MICROSOFT OFFICE AND MICROSOFT PROJECT)



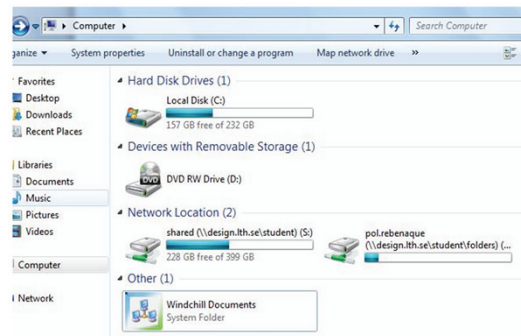
Agenda

- In this Lecture i will explain how to integrate between Microsoft Office in Windchill.
- Microsoft Office in Windchill
- Integrate Windchill with MS Project
- Plan a project with MS Project



Integrate Windchill with Microsoft Office

- When installation is completed a new icon appears in My Computer



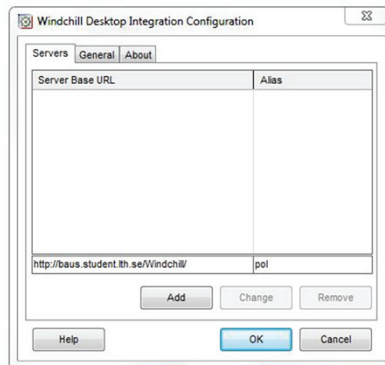
Integrate Windchill with MS Office

On the Quick Links tab, click Software Downloads and then click Windchill Desktop Integration 64 bit. Then the installation starts and you just have to follow the instructions.

After the installation has completed, go to My Computer and look for the Windchill Documents System Folder icon, and then start to configure the access to the FIRST Windchill Server.

Integrate Windchill with Microsoft Office

- Double click on the icon, right click and Select Windchill/Configuration
- Complet blank fields, click Add and OK.



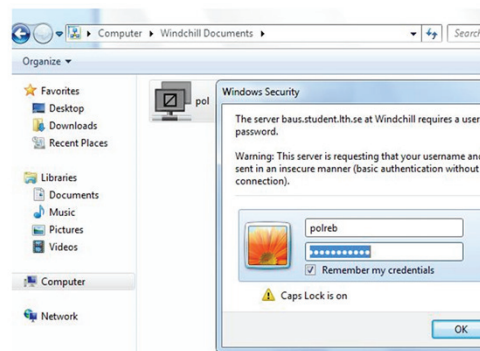
Integrate Windchill with MS Office II

Double click on the Windchill Documents icon and then perform Right click action with your mouse button and select Windchill->Configuration. A new window appears where you have to complete the Server Base URL : <http://baus.student.lth.se/Windchill/> and the Alias with the name you want i.e. POL. Then click Add button.

After those areas have been completed click on the OK button.

Integrate Windchill with Microsoft Office

- Right click on this new icon and Select Connect option. Enter Windchill username and password.



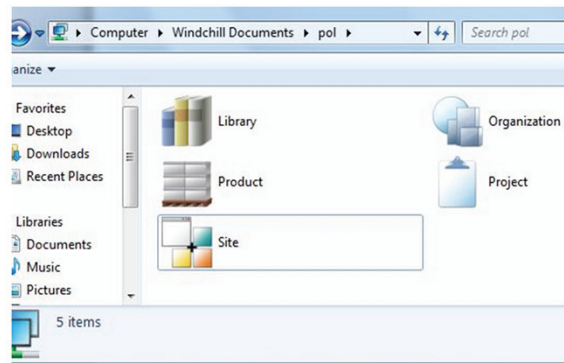
Integrate Windchill with MS Office III

Then you will notice that a new icon has appeared with the name as the Alias defined in the step before.

Right click on this icon (pol icon) and select the Connect option. A window will pop-up asking you for your Windchill user credentials. Enter your Windchill username and password and you will be able to access your Windchill projects from Windows Explorer.

Integrate Windchill with Microsoft Office

- If the connection is successful the icon will change its color. Double click on the icon and you will access Windchill through Windows Explorer.

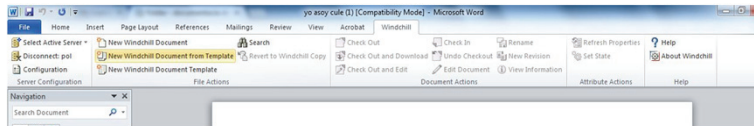


Integrate Windchill with MS Office IV

If the connection is successful the icon will change her color. Then double click on the FIRST Windchill icon and you will access Windchill directly from your desktop.

Integrate Windchill with Microsoft Office

- When you open Microsoft Word, Excel or PowerPoint, you will see a tool bar.



Integrate Windchill with MS Office V

Thanks to this integration, you can work, upload and share documents directly from the Office application's Open and Save As menu.



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LECTURE 9 – MANAGEMENT OF A PROJECT
(MICROSOFT OFFICE AND MICROSOFT PROJECT)



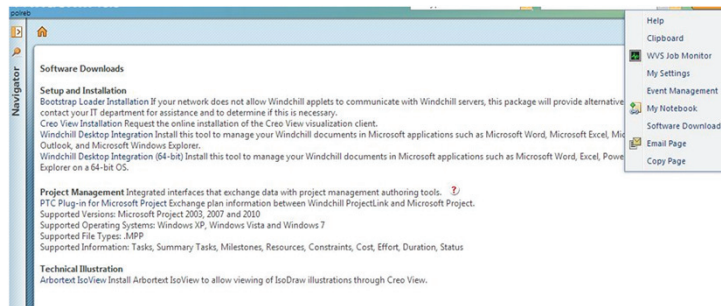
Agenda

- In this Lecture I will explain how to integrate Microsoft Project in Windchill to help us by set a plan for any project. And then as a result I will explain the other way to integrate Microsoft Office and Microsoft Project in Windchill.
- Microsoft Project in Windchill
- Integrate Windchill with MS Project
- Plan a project with MS Project
- The other way to integrate Microsoft Project and Microsoft Office



Integrate Windchill with MS Project

- Download the Microsoft Project Plug-In from the Windchill Software Utilities page.



Microsoft Project Plug-In

The PTC Plug-in for Microsoft Project is an optional download that, when installed, enables Microsoft Project to communicate directly with Windchill. This greatly simplifies Microsoft Project and Windchill integration.

You use the following procedure to download the Microsoft Project Plug-In:

On the Windchill header, select Quick Links > Software Downloads.

Click Accept on the License Agreement page.

Click PTC Plug-in for Microsoft Project. The File Download window appears.

Click Run.

Complete the installation by following the instructions on the Wizard.

As of the time of this writing, the Plug-In is supported for use with Microsoft Project 2003, 2007 and 2010.

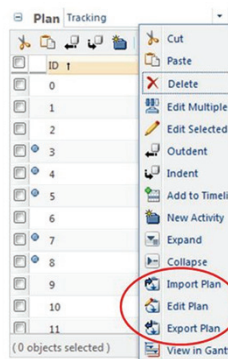
Text source: "Introduction to Windchill ProjectLink 10.1", Section "Managing Projects/Microsoft Project Plug-in"

Integrate Windchill with Microsoft Project

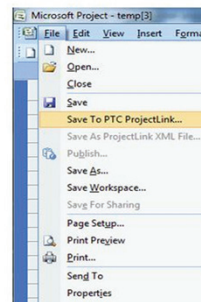
- There are multiple methods for using import existing MS Project plans into a Windchill project:
- Execute the MS project plan in Windchill.
- Use Windchill to provide access to the project plan.
- Export snapshots of plan in execution.
- Use Windchill as a repository.
- Use Windchill as a read-only Web accessible plan.
- You can also export Windchill projects to Microsoft Project for offline editing.



Plan a project with Microsoft Project



Import and Export Microsoft Projects in Windchill



Save to ProjectLink from Microsoft Project



Importing, Exporting, and Syncing Plans with Microsoft Project

Import Plan imports a Microsoft Project plan. The plan may be in .mpp or .xml format. When you import a plan, a dialog box appears asking if you want to replace or sync the plan.

Replace ensures that the Microsoft Project plan replaces the entire Windchill project plan whether the plan elements are new, edited, or the same.

Sync causes only the added or modified plan elements to be changed in the Windchill project plan.

Edit Plan and Export Plan do the same thing – export the entire project plan in Microsoft Project format. Windchill sends temp.ppp, which is your file in Microsoft Project XML format.

If you have the Microsoft Project Plug-In installed, you can open the .ppp file and Microsoft Project launches automatically, the same as if you opened a .mpp file.

If you do not have the Microsoft Project Plug-In installed, save the file with a .xml extension. You can open the .xml file in Microsoft Project.

If you have the Microsoft Project Plug-In installed, you can click Save > Save to PTC ProjectLink from the Microsoft Project 2003/2007 menu bar, or click Save to PTC ProjectLink from the Add-Ins tab on the Microsoft Project 2010 ribbon bar.

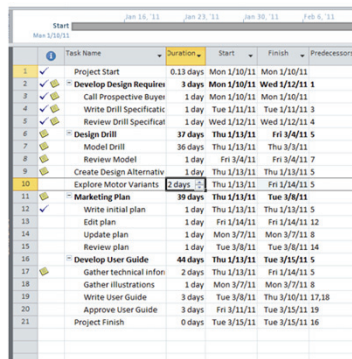
This accomplishes the same task as importing the plan. A dialog box appears asking if you want to replace or sync the project, just like importing a plan.

Exporting or editing a plan to Microsoft Project does not lock the plan in Windchill. Other users can edit the plan, and those changes can easily be overwritten when you import the plan back into Windchill.

Text source: "Introduction to Windchill ProjectLink 10.1", Section "Managing Projects/Importing, Exporting, and Syncing Plans with Microsoft Project"

*Exercise source: "Introduction to Windchill ProjectLink 10.1",
Section "Managing Projects/Exercise: Importing a Microsoft Project Plan"*

Microsoft Project in Windchill



The screenshot displays a Microsoft Project interface with a Gantt chart at the top and a task list below. The task list includes:

Task Name	Duration	Start	Finish	Predecessors
Project Start	0.13 days	Mon 1/10/11	Mon 1/10/11	
Develop Design Requires	3 days	Mon 1/10/11	Wed 1/12/11	1
Call Prospective Buyer	1 day	Mon 1/10/11	Mon 1/10/11	
Write Drill Specifics	1 day	Tue 1/11/11	Tue 1/12/11	3
Review Drill Specifics	1 day	Wed 1/12/11	Wed 1/12/11	4
Design Drill	37 days	Thu 1/13/11	Fri 3/4/11	5
Model Drill	36 days	Thu 1/13/11	Thu 3/3/11	
Review Model	1 day	Fri 3/4/11	Fri 3/4/11	7
Create Design Alternatives	1 day	Thu 1/13/11	Thu 1/13/11	5
Explore Motor Variants	2 days	Thu 1/13/11	Fri 1/14/11	5
Marketing Plan	39 days	Thu 1/13/11	Tue 3/8/11	
Write initial plan	1 day	Thu 1/13/11	Thu 1/13/11	5
Edit plan	1 day	Fri 1/14/11	Fri 1/14/11	12
Update plan	1 day	Mon 3/7/11	Mon 3/7/11	8
Review plan	1 day	Tue 3/8/11	Tue 3/8/11	14
Develop User Guide	44 days	Thu 1/13/11	Tue 3/15/11	5
Gather technical info	2 days	Thu 1/13/11	Fri 1/14/11	5
Gather illustrations	1 day	Mon 3/7/11	Mon 3/7/11	8
Write User Guide	3 days	Tue 3/8/11	Thu 3/10/11	17,18
Approve User Guide	3 days	Fri 3/11/11	Tue 3/15/11	19
Project Finish	0 days	Tue 3/15/11	Tue 3/15/11	16

Editing Windchill Projects in MS Project and then upload it again to PLM



First way of integration Microsoft Project in Windchill by download the PTC plug-in for Microsoft Project from Windchill homepage and follow the procedure below:

On the Windchill header, select Quick Links > Software Downloads.

Clicks accept on the license agreement page.

Click PTC Plug-in for Microsoft Project. The file download window appears.

Click run.

After finished installed PTC Plug-in click on click Save > Save to PTC Project Link from the Microsoft Project 2003/2007 menu bar, or click Save to PTC ProjectLink from the Add-Ins tab on the Microsoft Project 2010 ribbon bar.

This accomplishes the same task as importing the plan. A dialog box appears asking if you want to replace or sync the project, just like importing a plan

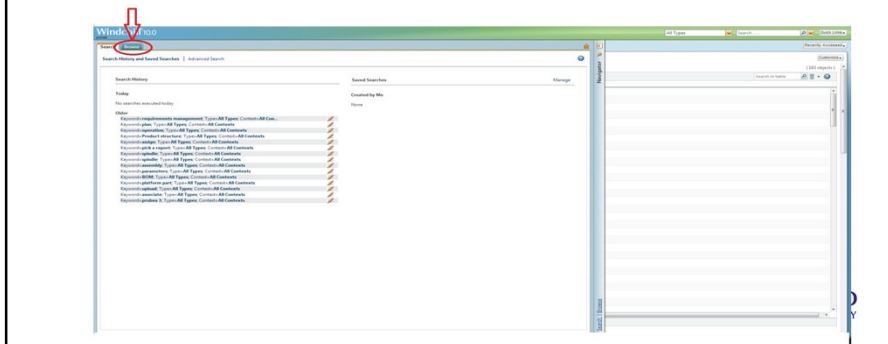
Click on action then a window appears with multi choice

Click on Import Plan

Then automatically Microsoft Project file will upload and ready to use from Windchill.

The other Method of integrate Microsoft Project and Microsoft Office

- The other way of integrate Microsoft Project in Windchill I can say it is the classic way. I will explain by points and picture as well. Before you started you have to log on in Windchill.
- Log on to Windchill then click Browse



The other way of integrate Microsoft Project in Windchill I can say it is the classic way. I will explain by points and (picture in the PowerPoint). Before started.

Log on to Windchill

Click to navigate then Browse

Click on Project

Click on View all project

Then click on create a new project.

Next step you will have a new window as shown below just fill this window and upload your file and this classical methods works with Microsoft Office beside to Microsoft Project and Pdf file.

Fill the normal window display then click ok.

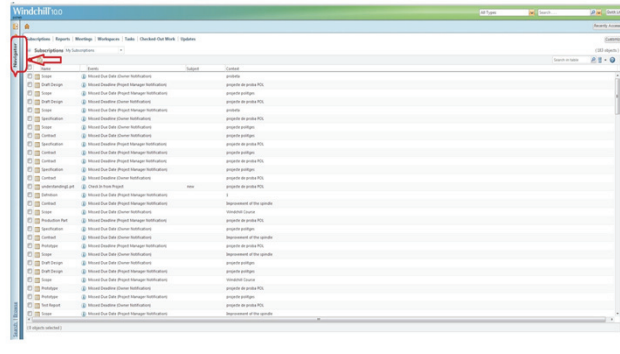
You will get a project and the next step click on project action then view information.

Click on New document in the new window.

As a previous a new window will show up and you will selected which type of part you want upload.

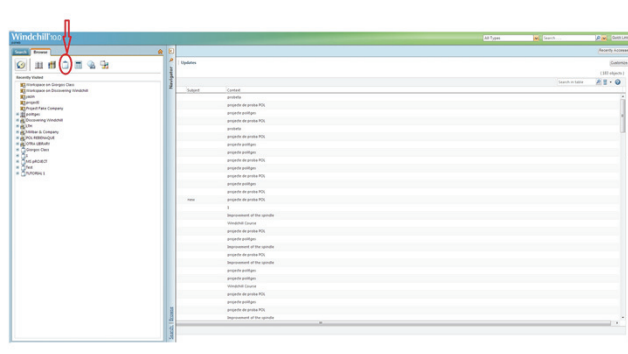
The other method of integrating Microsoft Project and Microsoft Office

- Click Navigate



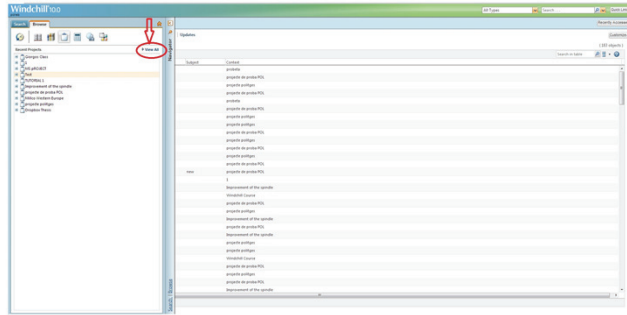
The other method of integrating Microsoft Project and Microsoft Office

- Click on Project



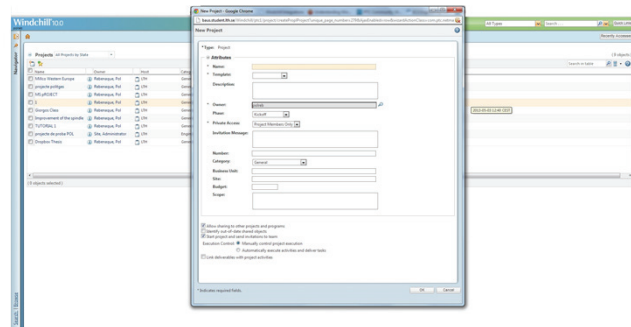
The other method of integrating Microsoft Project and Microsoft Office

- Click on View all



The other method of integrating Microsoft Project and Microsoft Office

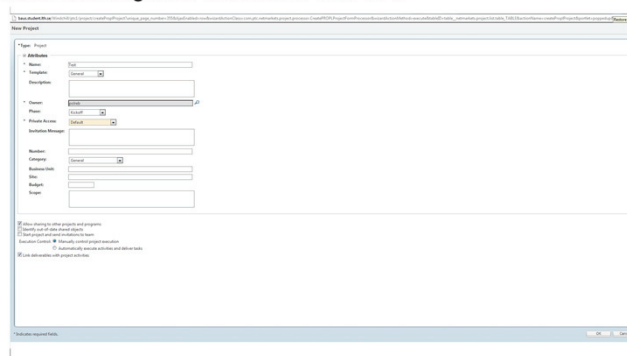
- Then you have to fill the window below with document details e.g. Name, Template, Description, etc.



Next step you will have a new window just fill this window and upload your file.

The other method of integrating Microsoft Project and Microsoft Office

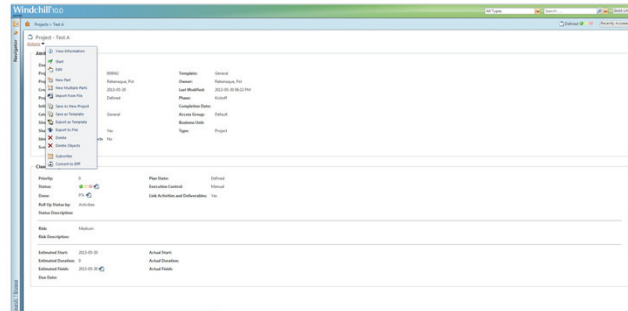
- After finishing filled the details click OK.



The screenshot shows the 'New Project' dialog box in Microsoft Project. The 'Project' section is expanded, showing fields for Name, Description, Start, End, and Resource Name. The 'Resource Name' field is highlighted in yellow. Below these fields are sections for Number, Category, Resource Code, Title, Subject, and Topic. At the bottom, there are several checkboxes for project settings, including 'Show summary tasks', 'Show tasks with no subtasks', 'Show tasks with no subtasks and subtasks', 'Show tasks with no subtasks and subtasks', and 'Show tasks with no subtasks and subtasks'.

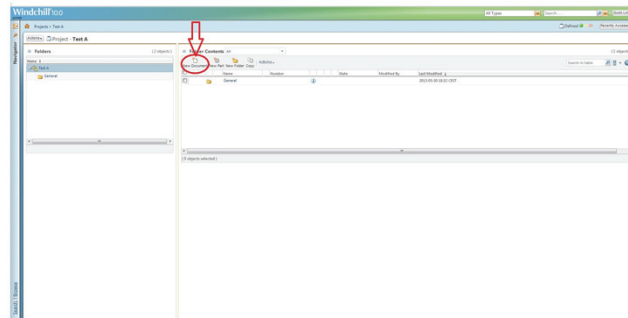
The other method of integrating Microsoft Project and Microsoft Office

- You will get a project as shown below then click on project action view information.



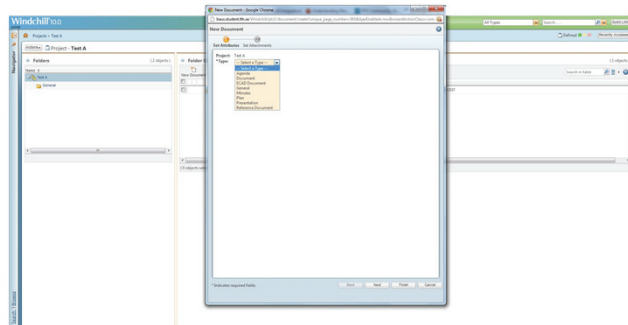
The other method of integrating Microsoft Project and Microsoft Office

- Click on New Document as shown in the picture.



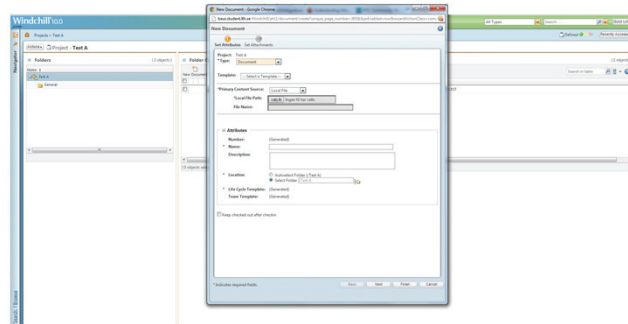
The other method of integrating Microsoft Project and Microsoft Office

- As a previous a new window will show up and you will selected which type of part you want to upload. In this case you should select a document.



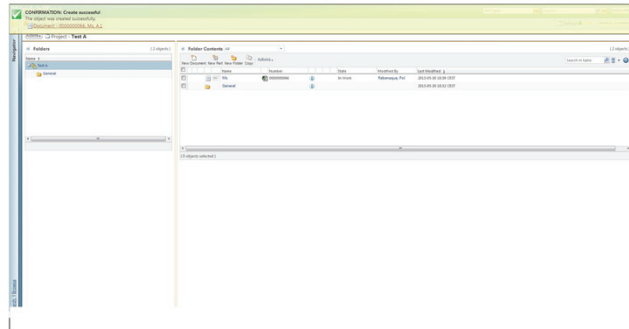
The other method of integrating Microsoft Project and Microsoft Office

- When you fill the first two fields. A new window will appear and you have to choose to upload the file you want from e.g. local file, desktop or somewhere else.

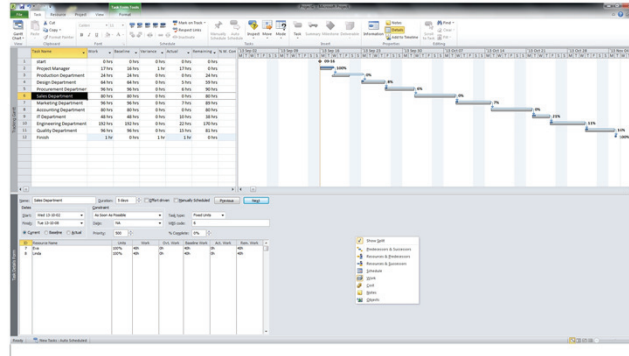


The other method of integrating Microsoft Project and Microsoft Office

- Then the Document upload and ready for use in Windchill.



The other method of integrating Microsoft Project and Microsoft Office





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Appendix B: Exercises in the Windchill course

B.1 Lesson 4. Exercise: Understanding workspace, saves, upload and check in written by Pol Rebenaque

In this exercise, students will practice one of the most important issues of the integration between Windchill and Creo. They will understand how to save and where are to save documents at every moment.

1) Integrate Creo in Windchill

i. File/Manage Session/ Server management

ii. Server/Register New Server

- Name: Pol

- Location: <http://baus.student.lth.se/Windchill>

- Click Check, and a drop-window appears where everyone has to write his username and password.

iii. Select workspace and click OK, then Click Server/Set as Primary Server/Close

2) Click in Common Folders· Workspace and we can see that the workspace local is empty

3) Create a part with Creo

i. New

ii. Write a name

4) Save the part and enter to the workspace. Now we can see that the part has been saved in the local workspace. If we go to the server workspace there would not be anything

5) Return to Creo and from the window of the local workspace click the icon, in the part, Upload.

6) Now, if we go by internet to Windchill, we see that the part or CAD document has been uploaded or saved. Nevertheless, there is still nothing in the context or folder.(Windchill Cabinets)

- 7) Return to Creo and from the window of the local workspace click the icon, in the parts, Check In
- 8) A pop-window appears, but just click next. Do not forget to select location folder where we want to Check In the CAD document. Check it In the corresponding folder of the library Discovering Windchill.
- 9) In the next window, select Auto Associate Parts to CAD Documents and click Finish.
- 10) Go to the folder and we will see the part.
- 11) Maybe you are not able to see the representation in the folder. In this case, click icon Creo to open the part again.
 - i. When the part is opened click File/Check In/ Custom Check In/ OK/ Models and Viewables.

B.2 Lesson 5. Exercise: Using Parameters written by Pol Rebenaque

We can use Windchill when modifying some parameterized CAD document. Let's try to upload a part in Windchill and then, Check it Out, Modify a parameter of a relation and Check it In. With this exercise, we will practice everything taught in the previous lecture (Share, Upload, modify, Check Out and Check in CAD Data).

Exercise:

- 1) Creation of the basement with a hole in the center. Save it, Upload it and Check it In
- 2) Creation of the column. Save it, Upload it and Check it in
- 3) Assemble both of them and write the following relation: diameter of the basement = diameter of the column
- 4) Try to modify the measure of the basement diameter. It is impossible because it is blocked, it will be always the same as the column.
- 5) Let's go to the column diameter. Then, regenerate assembly and you will see that, automatically, basement's diameter changes.
- 6) File- Check In- Custom Check In- OK- Models and Viewables
- 7) Ok to the conflicts window, because you have to check out if you have not do it before.
- 8) Save it, Upload it and Check it In. Remember that you have to check it in the corresponding folder of the library Discovering Windchill.

B.3 Lesson 6. Exercise: Understanding workspace, saves, upload and check in written by Yazin Al-Khayyat

In this exercise, students will practice one of the most important issues of the integration between Windchill and SolidWorks. They will understand at all how to save and where are you saving documents in every moment.

- Integrate SolidWorks in Windchill

I will starting explain briefly how to create a simple part in SolidWorks then how to integrate it in Windchill.

To create a new part or assembly in SolidWorks you have to follow the instructions below:

- Open SolidWorks program then **New**
- A new window will appear on your display with three options so you are free to select which one do you want to do for example part so you have to press the first choice

A 3D representation of a single design component.

- Choose which Plane you want to create a part on it e.g. **Front Plane**, **Right Plane** or **Top Plane** and then click on **Sketch**. After that design what part you want with the help of material menu and dimension.
- Save the part you have already created.

To integrate SolidWorks in Windchill you have to install the **Workgroup Management** first then Workgroup Management give you access on multi modules **SolidWorks** one of them. So you can upload SolidWorks part to Windchill through workgroup management.

You work in a private area in Windchill called a workspace. To interact with your authoring application, a workspace must be set as active on the primary Windchill Server. This can be done from the **Server Management** utility, which is accessed from the **Windchill Workgroup Manager Tools menu**. The primary active workspace icon indicates that the server and workspace is active and connected to the primary Windchill server. When you want to switch and work in another workspace, you activate that workspace and set it as primary. If you need to **create a new workspace**, access the Workspaces menu from the **Server Management window in Windchill Workgroup Manager**. This menu allows you to create a new workspace, edit its name, or delete it.

To populate your workspace, you use the Save to Workspace command from your CAD applications after you have created CAD models, drawings, or assemblies. This puts the CAD document into the primary active workspace, and saves it to the workspace local directory. You can also remove a file from a workspace through the File ► Remove action

The following **SolidWorks** file extensions are supported by the Windchill Workgroup Manager.

- .slddrw
- .sldprt

- .sldasm
- .sldlfp
- .prtdot
- .asmdot
- .drwdot
- .edrw
- .eprt

Windchill Workgroup Manager changes the behavior of some of the native commands in your CAD application, such as *Save* or *Open*. For example, when the CAD application is connected to Windchill Workgroup Manager, Open and Save operations default to the workspace local directory.

B.4 Lesson 7. Exercise: managing folders, Documents, etc. written by Pol Rebenaque

This exercise helps students to reinforce their skills of managing work.

- 1) From Windchill, click the library called Discovering Windchill and then enter to the folder corresponding to this exercise.
- 2) Create New Folder and write your name as a title.
- 3) Open Word, which has to be properly integrated with Windchill. If it is not integrated, do it according to the knowledge acquired during the lesson.
- 4) Open a New Word File and write something. It has to be short, just to identify your document.
- 5) From the flange in Word called Windchill create a New Windchill Document.
- 6) Select the context Discovering Windchill and click Next.
- 7) Select the type called General, write the name of the document and select to store it in the folder which you have already created. Now you have created and check in a document to Windchill, let's go to modify it.
- 8) Go to your web browser, log in Windchill and go to your document which has just created.
- 9) Click Word icon to open it in Word again. If a pop-window appears asking you for checking the document out, click Yes.
- 10) Modify the document, i.e. write something else.
- 11) In the upper tool bar click Check In and do not select any option, just click OK.
- 12) If you go to the folder treated you will see that the version of the document has already changed. Now let's open again the same document to modify it but at the last moment we decide not to modify it.

- 13) Open the document from Windchill as we did before. Agree the checking out process which Word asks you.
- 14) Write something to modify the document again.
- 15) But now, instead of checking the document in, we decide that we do not want to save what we have done, so we close the whole program, Word.
- 16) Apparently nothing happens, but if we go to the folder through our Web browser we will see that our document is still checked out, so nobody can to edit it. and we do not want it. So let's undo the check-out to allow everyone to edit it.
- 17) Click the Word's icon and open the document.
- 18) From the Windchill's flange click Undo Checkout and click OK. Now, let's go to Windchill and let's see that the document is already checked out, so everyone can access it. Now, students know how the modification process of a document looks like, let's see how you can move a document through Windchill.
- 19) From Windchill, click the document which is in your folder. Click Actions button and it will display a dropdown with a lot of options.
- 20) Click Move and select a folder belonging to one of your classmates. Your document will be moved.

NOTE: If you want to move a document to the same context, i.e. from library to library, you can use the options Move, but if you want to transfer a document from a project to a library you must use an option called Send to PDM.

B.5 Lesson 8. Exercise: Routing Tasks written by Pol Rebenaque

In this exercise students learn how to route tasks.

- 1) Students must do groups of three people (student1, student 2 and student 3)
- 2) Each member of the group has to create a new part in Creo
- 3) Remember to Save, Upload and Check In. Each group has to Check In their work in the corresponding folder considering that Group A is composed by student 1, 2 and 3, then Group B is composed by student4,5 and 6 and so on.
- 4) Route CAD document using the way called "Review Routing" and with the following structure:
 - Student1 select student2 as Observer and student3 as Reviewer
 - Student2 select student3 as Observer and student1 as Reviewer
 - Student3 select student1 as Observer and student2 as Reviewer

With this closed circle structure we achieve that everyone plays all roles

- 5) Accept and Complete Tasks. It does not care the observer's opinion to complete the task, but even that, builder of the parts wants to show him his work. What it really

cares is the reviewer opinion. Whit out his agreement the task or routing is not completed, unless the author of the part wants to force the ending of the task and Cancel it.

B.6 Lesson 11&12. Final Exercise: Project of a Fake Company Written by Pol Rebenaque and Yazin Al-Khayyat

“Millbar&company” or “Millco” as usual is called, is a big company who manufactures a lot of milling machines per year. It was founded in 1956 by an important Spanish engineer called Pol Rebenaque. At the beginning, Millco only sold its products to Spain and Portugal, but it was gaining market slowly around Europe. During 1980s it tried to expand to America, and it was such a successful that in early 1990s it became the most important milling machine company around this continent. As a result of the success its founder starts enlarging his company and built a lot of factories and offices around the world. In 2000 the number of factories and offices widespread around the world were so many that the group of managers decided to split the company in 5 different divisions: Western Europe, Asia & Eastern Europe, North America, South America and Africa. Nevertheless, the headquarter of the corporation always remained in Barcelona. During this big expansion, it was very difficult to get a good communication, so Millco installed everywhere PLM software called Windchill from PTC which improved the interaction between divisions. Furthermore, this new network system enabled suppliers, customers and everyone involved in Millco’s projects, to be in permanent and easy communication. Since then, Millco has become the worldwide leader manufacturer of milling machine, but the best product ever built was in 2003 when this Spanish company launched a machine called MM10 which revolutionized the market. There were sold more than 2 million MM10 around the world and they are still working in most of the workshops. Nowadays, Pol Rebenaque who is 72 years old wants to realize his last huge project before retiring and let his company to his son. During the last year, a group of engineers have been designing a new spindle that works twice as fast as the others, so Pol wants to adapt it to his best-seller machine that it is mentioned previously. To do it, he has ordered each division to start a project to be able to adapt this spindle column to MM10 and later, he will choose between the five options the best one and he will implement it. Each division will be able to see only its project but Pol, as a company boss, has the rights to access to any project at any time.

Each division is composed of the Project Manager (PM) and three Designers (D). Obviously, there are more departments in each division such as Procurement, Sales, Production, Marketing, Accounting, IT, Engineering or Quality control but we will only play the first 4 roles. The teacher will be Pol Rebenaque, so he could access to any division project.

In the next pages, there is a weekly schedule explaining what happen in this project, So the four members of each division must cooperate and work in team to solve this Project and to try that Pol Rebenaque implement their idea.

WEEK 1:

Pol Rebenaque

The Project Manager has received a notification from Pol Rebenaque, the founder of Millco ordering him to start a new project about the adaptation of a spindle column to the MM10. So, the Project Manager has to invite all his staff to that project and define their roles (the three ones will get the role as members). At the same time, he must create a meeting where has to be every team member. The topic will be “*WELCOME TO THE PROJECT*”, and this has to comprise the following message:

<< Hello everyone. We are going to work in this new project for the next 20 weeks. Please, introduce yourself telling your name and department. In the folder “PRESENTATION” you can see the other people who are going to help us to finalize correctly this project. I hope it is a pleasure to work together. >>

Obviously, the rest of the staff must answer him. At the end of the week, there are two computer operators who help everybody to install and configure the software needed for the project.

WEEK 2:

Pol Rebenaque

After a meeting with Sr. Rebenaque, the Project Manager knows a lot of information about this project. It is very important that only the members of the project would be available to access to any information of the project. The goal is to adapt a spindle to a specific milling machine. This kind of project would take around 120 days of work, but for some reasons that only the bosses know, it has to be completed in 100 days, so as everyone can see we are in front a high risk project. Each division has a budget around 385 000€ for this project and even they have more on working which cannot stop, the priority during the next 20 weeks will be this one. This budget was agreed upon the meeting between the Project Manager and Pol, where they considered all kinds of costs (raw materials, labor costs, energy costs, etc.) and they distributed them according to their departments. As a Project Manager he is the responsible of planning the project, so he needs the budget which is shown underneath to create all resources involved in the project. (He can also find it in the folder of Windchill called Accounting Department as well.)

Week 3:

Pol Rebenaque, Yazin Al-Khayyat with the help of Enrico Frittelli

In week three you have to start with a project in real after the experience you have got from the first couple of weeks. First step in any project to have a plan and in Windchill the plan create by Microsoft Project then you have to upload it to Windchill server you First thing you have to do a plan and integrate this in Windchill. I suppose we have already installed PTC Plug-in for Microsoft Project Exchange plan information between Windchill ProjectLink and Microsoft Project. Then the student should create a PLAN via Microsoft Project then upload in the Windchill Plan.

Appendix B: Exercise of Windchill course

The information for the project is:

Resource	Cost (Kr/hr)	Work (hour)	Cost/Labour
Project Manager	120	800	96000
Production Department	80	720	57600
Design Department	65	620	40800
Procurement Department	45	420	18900
Sales Department	45	380	17100
Marketing Department	40	190	7600
Accounting Department	50	580	29000
IT Department	60	470	28200
Engineering Department	85	620	52700
Quality Department	70	540	37800

I have done this exercise for the teacher with other numbers and value and I put a very interesting link for the teacher and student for this exercise below:

http://www.youtube.com/watch?v=sPwURRG9_Gs

WEEK 4-12:

Pol Rebenaque and Yazin Al-Khayyat

One month later, the designers come into action. Paperwork period has finished and it is time to start adapting the spindle column to the milling machine MM10. Before starting, Sales Department has upload in their folder a document with some images of the MM10 so that designers can get an idea of the situation (view “MM10” document in Sales Department’s folder). It is very important the communication between the three designers, so it should be a good idea to create a meeting at the beginning of this period to talk and plan what they have to do. So, Designer 1 must create a standard meeting called “Designers Meeting”, which takes 90minutes and the participants have to be the three of them.

After the meeting, designers ask the Engineering Department to review what they want to modify, and in four days engineers upload a document on Windchill explaining all changes that will allow the spindle column to have a good adaptation. So, designers have to open this document in the folder of Engineering Department, and they can start rebuilding the spindle according to engineers’ instructions. After these 6 weeks, the modification of the spindle parts have to be completed, so it is time to do rebuild the assembly, which is work of the Designer 1. If all parts are modified

properly, the assembly should be an easy work, because it is modified almost automatically.

Once the assembly is done, the Project Manager has to review the assembly, so Designer 1 must route the whole work to him. To route the assembly it is used the routing process called Review Routing where the Project Manager is the Reviewer, and the rest of designers are observers. If everything is correct, Project Manager approves the assembly and it is ready to be manufactured in the factory.

WEEK 13:

Pol Rebenaque

The thirteenth week is the most relaxed one. Nothing important happens in the project. Everybody leverages this week to go on with other projects and works. Nevertheless, Designer 2 and Designer 3 look for some other milling machines enterprises to get more ideas to continue improving the spindle column. Designer 2 finds an interesting website (<http://www.bpt.com/>) and Designer 3 finds another one (<http://www.makino.co.jp/>), so they decide to share this information creating links in the Design Department's and Project Management's folders to do it viewable for the Designer 1 and Project Manager

WEEK 16-17:

Yazin Al-Khayyat

As expected, the Procurement Department needed 2 weeks to find another supplier. They have found a supplier cheaper than the other and more or less with the same conditions. The only difference is that the new one uses a software called SolidWorks and in our company everything is designed by Creo, but apparently nothing will happen. So, designers have to add the new screws in the assembly and check if they fit correctly.

Assumption: LTH will get the license for Workgroup Management and in cooperation with PTC and PDS vision.

Here the student will learn how to integrate between Windchill and other modules. In the same sequence for how to learn integrated CAD with Windchill but in advance level and they will learn how to create SolidWorks, save, Check in and Check out and then upload it in Windchill.

According to the assignment in the previous lectures so the student should create a new SolidWorks Part and assembly and use it instead of CAD (Creo 2) and analysis the results they come up with.

WEEK 18:

Pol Rebenaque and Yazin Al-Khayyat

Time is running out, and now it is impossible to do big changes, so Sr. Rebenaque sends an email to the five Project Managers ordering them to share their assemblies in the library to allow other divisions to compare and view their work. So, the Project Manager of each division must share his final product to the library. (Remember that you are moving a CAD file from a project to a library)

Once all divisions have shared their assemblies of the spindle column, Project Managers must compare his assembly with another one. The order is the following one:

- Western Europe compares with Asia & Eastern Europe
- Asia & Eastern Europe compares with North America
- North America compares with South America
- South America compares with Africa
- Africa compares with Western Europe

WEEK 19-20:

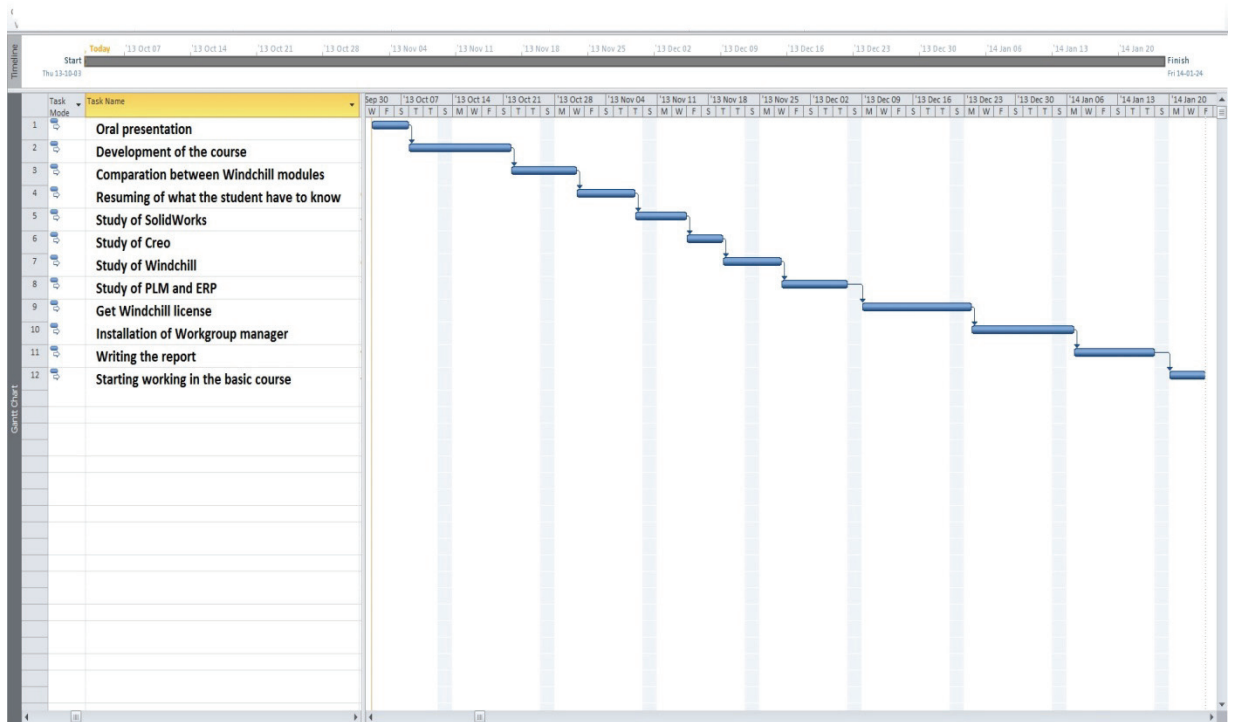
Pol Rebenaque and Yazin Al-Khayyat

Now, the measurements are correctly and will be the final ones, so the factory receives the order to start manufacturing the assembly. It will take these last two weeks, so luckily, the project will be completed on time. Project Manager can complete this project.

Appendix C: Thesis time schedule

The following 2 diagrams show readers the initial plan of this thesis and the final plan. There is a big difference between the basic course and advanced course the problem was to get Windchill License and installation of Workgroup manager. We got a short term license that valid for 2 months and another problem was about installation of Workgroup manager as is mentioned in 1.6 Assumptions and limitation. Below is in the final diagram.of time schedule.

Initial Gantt Diagram of Investigation of the Windchill PLM System



Appendix C: Thesis time schedule

Final Gantt Diagram of investigation of the Windchill PLM system

