Spring 2014

A Sandbox Development For Demonstrating Bom Transmission In A Plm And Erp Integrated System

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Graduate School ETD Form 9
(Revised 01/14)

PURDUE UNIVERSITY
GRADUATE SCHOOL
Thesis/Dissertation Acceptance

This is to certify that the thesis/dissertation prepared

By Zhen Zeng

Entitled
A SANDBOX DEVELOPMENT FOR DEMONSTRATING BOM TRANSMISSION IN A PLM AND ERP INTEGRATED SYSTEM

For the degree of Master of Science

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Head of the Department Graduate Program Date

A SANDBOX DEVELOPMENT FOR DEMONSTRATING BOM TRANSMISSION IN A PLM AND ERP INTEGRATED SYSTEM

A Thesis

Submitted to the Faculty

of

Purdue University

by

Zhen Zeng

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

May 2014

Purdue University

West Lafayette, Indiana

To my beloved family

ACKNOWLEDGEMENTS

I would like to thank my graduate committee chair, Dr. Edie K. Schmidt for her support and guidance during my time at Purdue University. I would also like to thank my other committee members, Dr. Henry W. Kraebber and Dr. Nathan W. Hartman for their direction and assistance in the completion of this thesis.

Most importantly, I would like to thank my husband, my son and my parents for their endless loves and supports.

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ABSTRACT

Zeng, Zhen M.S., Purdue University, May 2014. A Sandbox Development for demonstrating BOM transmission in PLM and ERP Integrated system. Major Professor: Edie K. Schmidt.

Integrating Product Lifecycle Management (PLM) and Enterprise Resource Planning (ERP) in a company is important. Currently, many companies have difficulties on integrating PLM and ERP systems. This study developed a prototype (sandbox) of PLM and ERP integrated system for demonstrating BOM transmission in a PLM and ERP integrated system, describing key aspects of system integration and BOM transmission. This sandbox will facilitate users' knowledge on how to process transactions in a PLM and ERP integrated system. The BOM accuracy was examined by comparing BOM data in PLM system to BOM data in ERP system after implementing engineering changes. This study was limited to Teamcenter PLM, SAP ERP and Tesis Gateway for SAP.

CHAPTER 1. INTRODUCTION

1.1 Background

Companies are learning the value of implementing concurrent engineering (CE) techniques in reducing time-to-market and cost while increasing quality. These changes result from the improvement of coordination within an organization (Abdalla, 1999). One vital part for concurrent engineering practices is having tools for managing information within departments. The tools enable sharing information between various participants in the product lifecycle and ensure this information is consistent and synchronized (Huet, 2009). Two systems that are widely used in manufacturing industries as management systems for concurrent engineering practices are enterprise resource planning (ERP) system and product lifecycle management (PLM) system.

ERP systems are used to illustrate an extended system for material requirements planning, manufacturing resource planning, and computer-integrated manufacturing. Some well-known ERP software producers include SAP, Oracle, and PeopleSoft. It is internal organizational applications, while PLM system is product-oriented applications (Hvolby, 2010). The PLM system, which evolved from product data management (PDM), typically includes the processes of computer-aided design, computer-aided manufacturing, computer-aided engineering, and product data management (Sirnivasan, 2011).

The benefits of integrating PLM and ERP system include reducing the time-to-market and cost, ensuring BOM consistency, and standardizing product-related terminology and processes within an organization (CIMdata, 2005). In some cases, manufacturing and production data are stored in a PLM system, while the costing and sourcing data are stored in an ERP system. ERP has not been the primary location to store design and engineering data, which is usually stored in PLM system. To fill the gap in most ERP systems, integrating PLM and ERP becomes the most common choice (AberdeenGroup, 2008). However, in most cases, companies encompass the loss of efficiency during the initial implementation processes of these software systems, as they implement the software and learn the new routines in the software at the same time (Davis, 2004). To implement PLM and ERP integrated system is complicated, as several factors should be considered during integration, such as corporate cultures and organizational structures, business practices and technology (CIMdata, 2005). In addition, when using PLM system and ERP system, the transactions in software represent reals business processes and transactions. The users need to develop comprehension on making symbol or transaction in the software associated to real parts or real business processes in a company. In this situation, users who are lack of experience in the functional area of a company can have difficulty on understanding the business processes embedded in the software. When fail to relate the operational task in software systems to a business process in a company, users have difficulty to correct errors and understand impacts of their works on others (Davis, 2004). An industry-based business process model and the implemented working information system can provide a platform for users to develop problem based learning experience on software systems, as it facilitates users' comprehension of relations between organizational business process and information systems, and leads users to think about how to solve business problems by using technical solutions of software systems (Stewart, 2008).

1.2 Statement of the problem

Many companies have difficulties implementing a PLM and ERP integrated system, especially for transferring BOM data consistently. This study documented the sandbox development for demonstrating BOM transmission in PLM and ERP integrated system. The results of this study can help to enhance user's comprehension of relations between business processes and transactions in PLM and ERP integrated system.

1.3 Significance

Integrating PLM and ERP in a company is important to reduce the time-to-market and costs of new products, as it ensures consistency and use of product related information throughout the company. However, it is difficult to integrate PLM and ERP in a company, especially for BOM data. Generally, the difficulties of implementing PLM and ERP integrated system are attributed to these two aspects. On one hand, several factors should be considered during integration, such as corporate cultures and organizational structures, business practices and technology (CIMdata, 2005); on the other hand, users who are lack of experience on software systems can have difficulty on understanding the business processes embedded in the software(Davis, 2004). In this situation, a report that address key steps of integration for specific work scenarios could help them to better understand transactions embedded in the PLM and ERP integrated system.

However, most existing reports on integrating PLM and ERP are developed to emphasize the benefits and strategies; very few reports address key processes of integration for specific work scenarios. Few researchers in academia generate papers about implementing PLM and ERP integration system, as it is expensive to purchase either PLM or ERP software and then develop integrated system in lab environment. While in industry, companies who implemented PLM and ERP integrated system are hesitated to share their experiences on system integration publically by using their data, as in most cases, the data used in PLM and ERP integrated system are sensitive. Some consulting companies, such as CIMdata, Aberdeen Group, generate reports about issues on PLM and ERP integrated system, but these reports focus on benefits and strategies of PLM and ERP integrated system. Therefore, it is meaningful to generate a report that emphasizes on key steps of transactions in PLM and ERP system for specific work scenarios, as it can enhance user's comprehension of relations between business processes and transactions in PLM and ERP integrated system.

1.4 Purpose of the study

The purpose of this project was to provide information related to a sandbox development for demonstrating BOM transmission in PLM and ERP integrated system by documenting key considerations of integration and key steps of BOM transmission. The questions central to this research are:

1. What are key considerations of integrating PLM and ERP to transfer BOMs?
2. What are key steps of transferring BOM in a PLM and ERP integrated system?

1.5 Assumptions

The assumptions of this research included:

- a successful integration of PLM and ERP depended on factors from corporate cultures and organizational structures, business practices, and technology (CIMdata, 2005);
- the barriers of integrating PLM and ERP were intentionally ignored in order to focus on basic steps of integration; and
- the BOM structure in this study represents a general BOM structure.

1.6 Limitations

1. The framework of integration in this study would be more complicated when discussing integration besides the technical perspective (Kahkonen, 2013).
2. The key considerations of PLM and ERP integrated system and the key steps of BOM transmission that listed in this study may change depending on requirements of integration objectives and workflow designs.

1.7 Delimitations

1. The software used in this research was limited to Teamcenter PLM, SAP ERP and Tesis Gateway for SAP, which are donated software at Purdue University.
2. The BOM information transferred in this study was limited to BOM structure and material information.

1.8 Summary

This chapter provided an overview of PLM and ERP transmission needs. The statement and significance of the problem were reviewed, and assumptions, limitations and delimitations in this study also were discussed. Many companies have difficulties to make consistent data transmissions between PLM and ERP, especially for BOM data. This study provided detailed information related to a sandbox development for demonstrating BOM transmission in PLM and ERP integrated system. This study can enhance user's comprehension of relations between business processes and transactions in PLM and ERP integrated system.

CHAPTER 2. LITERATURE REVIEW

In this chapter, literature related to the methodology of PLM and ERP integration including the benefits, considerations and methods of integrating PLM and ERP system are reviewed from the research reports, which are generated by top consulting companies- Aberdeen Group and CIMdata, Inc.. In the section of software information, the information of software used in this research is listed. In order to understand work scenarios of BOM transmissions, concurrent engineering scenarios and types of BOMs are also reviewed from journals and conference papers by searching with the key words of concurrent engineering, engineering change management, and bill of material.

2.1 Integrate PLM and ERP

ERP system is used to illustrate an extended system for material requirements planning, manufacturing resource planning, and computer-integrated manufacturing. It is internal organizational applications, while PLM system is product-oriented applications (Hvolby, 2010). A PLM system typically includes the processes of computer-aided design, computer-aided manufacturing, computer-aided engineering, and product data management (Sirnivasan, 2011).

ERP has not been the primary location to store design and engineering data, which is usually stored in PLM. To fill the gap in most ERP systems, integrating PLM and ERP becomes the most common choice, as shown in Figure 2.1 (AberdeenGroup, 2008). Companies are classified into three categories: the top

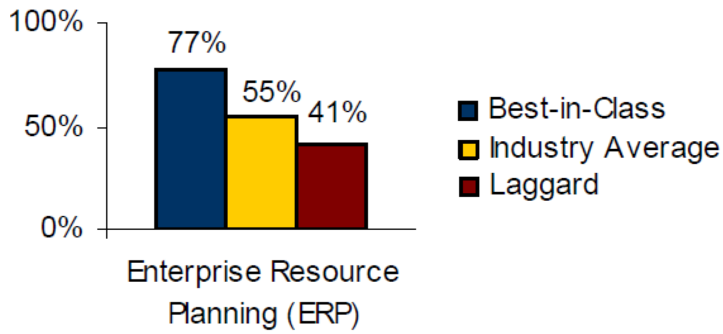


Figure 2.1 The integration of PLM across the enterprise ecosystem (AberdeenGroup, 2008)

20% (Bestin-class), the middle 50% (Industry Average) and the bottom 30% (Laggard) of performers. In Table 2.1, 90% of information flows are sending BOMs from PLM to ERP, and 60% of them are sending change orders. It is because companies store data of item parts, EBOM, configurations, product graphics and item specifications in PLM systems, while storing data of item costs, and MBOM in ERP system.

Table 2.1

Data integration from PLM to ERP (AberdeenGroup, 2008)

	Best-in-Class	Industry Average	Laggard
Bills of Materials(BOMs)	90%	93%	86%
Change orders	60%	60%	71%

2.1.1 Implementation consideration of integration

Integration is defined from a technical perspective as data exchanging happen between at least two interconnected systems (Kahkonen, 2013). Business systems integration can be discussed from the dimension of information integration, where information is sharing directly, and the dimension of synchronized planning, where engineering changes are synchronized in the integrated business systems (Hvolby, 2010). When implementing PLM and ERP integrated system, several factors should be considered. These factors include organizational and cultural factors, business practice factors and technology factors (CIMdata, 2005). For organizational and cultural factors, it is important to determine which system is the master and which system owns and controls information and processes. Integrating PLM and ERP is a process of eliminating overlaps of functionality and processes in a company (CIMdata, 2005). For business practice factors, a key step is to understand how a specific business operates. An effective integration should address the direction of data flow and add process automation whenever possible, as it reduces non-value added work significantly (CIMdata, 2005). For technology factors, some factors should be considered, including:

- The type of information to be integrated: generally, starts from the information of product structure and BOM exchange, and then covers change information (CIMdata, 2005).
- The processes to be supported: to determine what information should be exchanged and what information should be accessible, and what

process steps should be managed in which systems (CIMdata, 2005).

- The type and complexity of integration required: to determine the level and direction of data flow. Is it one-way transfers or bi-directional exchange? What information should be exchanged between PLM and ERP? (CIMdata, 2005).
- The tools and methods to be used to create and maintain the integration (CIMdata, 2005).

2.1.2 Approaches of integration

Three primary methods for PLM and ERP integration are generally used as shown in Fig2.2. The Encapsulation is a relatively simple solution, which is easier

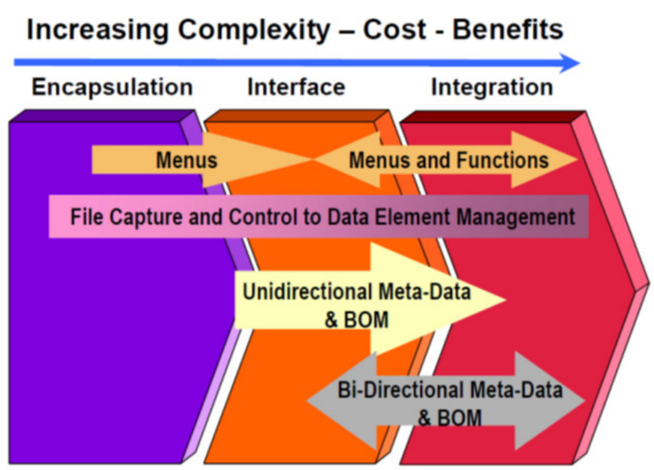


Figure 2.2 The methods for integration (CIMdata, Inc., 2005)

to implement than other two, as it usually takes only person days to complete. The Interface is more difficult to implement than Encapsulation, and usually takes person weeks to complete. The Integration is the most difficult to implement of these three solutions, and usually takes person months to person years to complete (CIMdata, 2005).

Multiple approaches can be chosen for integration, no matter which method and starting point are chosen, and one approach is an Enterprise Application Integration (EAI) tool. Compared to other approaches, the cost and required resource can be reduced due to the decreased number and complexity of integrations (CIMdata, 2005). In addition, EAI is usually for integrating information systems within a single company (Kahkonen, 2013).

2.1.3 Training on software systems

Companies encompass the loss of efficiency during the initial implementation processes of software systems, as they implement software and learn new routines in the software at the same time (Davis, 2004). When using PLM and ERP software systems transactions represent real business processes and transactions, the users need to develop knowledge to make symbols or transactions in the software associated with productions parts or real business processes in a company. In this situation, a user without experience in the functional area of a company can have difficulty understanding the business processes embedded in the software. Failure to relate the operational task in software systems to a business process in a company result in users having difficulty correcting errors and recognizing the impacts of their works on others (Davis, 2004). An industry-based business process model and the implemented working information system can provide a platform for users to develop problem based learning experience on software systems, as it facilitates users' comprehension of relations between organizational business process and information systems, and leads users to think about how to solve business problems by using technical solutions of software systems (Stewart, 2008).

2.2 Software information

In this section, the information regarding software that was used in this research is reviewed. All software was donated by Purdue industry partners.

2.2.1 PLM system

The Siemens Teamcenter PLM (TC PLM) system is one of the most widely-used PLM solution suites in the market and is used by more than 6,400 customers across about 9,900 operations with 5 million licensed seats. The first version of Teamcenter was released as computer-aided design (CAD) data management software in the mid 1980's. In 2007, Siemens released Teamcenter 2007, which has a four-tier unified architecture incorporating the latest technology and business functionality. In 2009, Teamcenter 8 was released, which is designed to make customer configuration and expedition of functionality easier than before (Siemens, n.d.).

The Teamcenter PLM system covers three foundational areas, which are enterprise knowledge foundation, platform extensibility services and lifecycle visualization. These foundational areas contain 14 functional areas, such as

BOM management, engineering process management, maintenance, repair, and overhaul (MRO), and manufacturing process management (Siemens, n.d.).

2.2.2 ERP system

The SAP ERP software is one of market-leading enterprise resource planning software used by nearly 50,000 customers over the past 40 years. This ERP software covers key areas within organization, such as manufacturing, sales, and finance, and is designed to satisfy information needs for small to large businesses including multi-lingual and multi-currency functionalities (SAP, n.d.).The latest version of SAP ERP is released as SAP ERP 6.0. Compared to previous versions of SAP ERP, SAP ERP 6.0 enhances capabilities for finance, procurement, and human capital management by providing automated financial and management accounting and financial supply chain management to users; managing end-to-end procurement and logistics business processes for whole business cycles; and supporting the innovation, core human resource processes and workforce deployment (SAP, n.d.).

However, the SAP ERP system is strong in functionality but complicated to use. In order to inspire users to master SAP software, ERPsim Lab designed SAP ERP simulation games as a learning-by-doing approach for educational purposes. These ERP simulation games include the distribution game, the logistics game, and the manufacturing game (ERPsimLab, 2012). In the ERP simulation game participant’s guide, key concepts and processes for setting up a simulation client are listed. As one of the cornerstones of a client in SAP ERP system, master data are stored in ERP system's central database, and are used in many business processes within organizations. Figure 2.3 shows the main

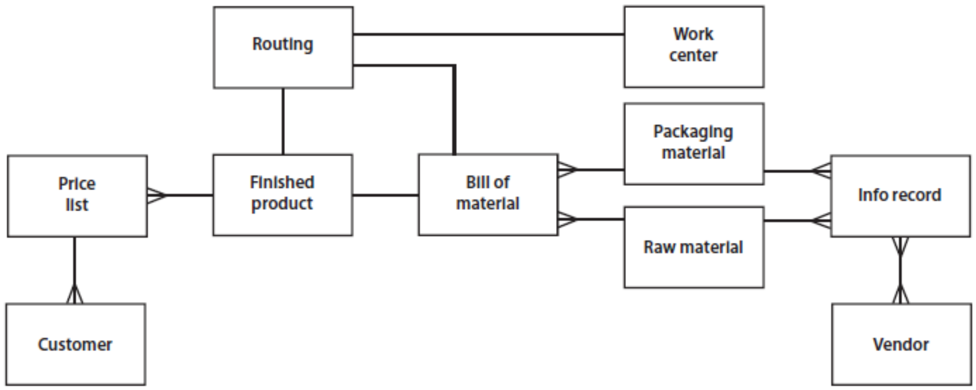


Figure 2.3 Conceptual model of the main master data of SAP ERP client in the simulation game (ERPsimLab, 2012)

master data of SAP ERP client in the conceptual model including BOM, raw material, information record, vendor, finished product, work center, and routing. In addition, the relationship of master data with organizational elements and other master data are shown in Table 2.2. The main master data can be grouped as material master, production master data, purchasing master data, financial master data, and cost controlling master data (ERPsimLab, 2012).

Table 2.2

The relationship of master data (ERPsimLab, 2012)

Master Data	Relationship with organizational elements	Relationship with other master data
Material master		
Finished products	Link to a plant, a storage location, a sales organization and one or more distribution channels	The composition of a finished product is shown in the BOM
Raw materials	Link to a plant and a storage location	The raw materials are included in the BOM
Production master		
BOM (Bill of material)	Link to a specific plant defined for a specific product	Link the finished products with the raw material
Work centers	The work centers are located in a specific plant	A work center must be specified for each operation defined by the routing
Routings	Routings are specific to a plant	The finished products and work centers are related to routings.
Purchasing master		
Vendors	Vendors are defined for a company code and a purchasing organization.	Vendors are linked to raw materials they sell through the info-records.
Info-records	The logical tie between a vendor and a raw material.	Info records link the vendors with the raw materials they provide.
Source list	Specific to a plant and a purchasing organization.	Tie together an approved/blocked vendor to a material. Info-records need to be created before a material can be put on a source list.

2.2.3 EAI system

EAI system is enterprise application integration system. Tesis Teamcenter Gateway for SAP (T4S) is the SAP certified EAI system for integrating Siemens Teamcenter PLM system with SAP applications. This software ensures consistent data transmissions across functional divisions by controlling data sharing and providing intelligent data mapping (Tesis, n.d.-a). In the integrated system shown in Figure 2.4, various information types in the TC PLM system

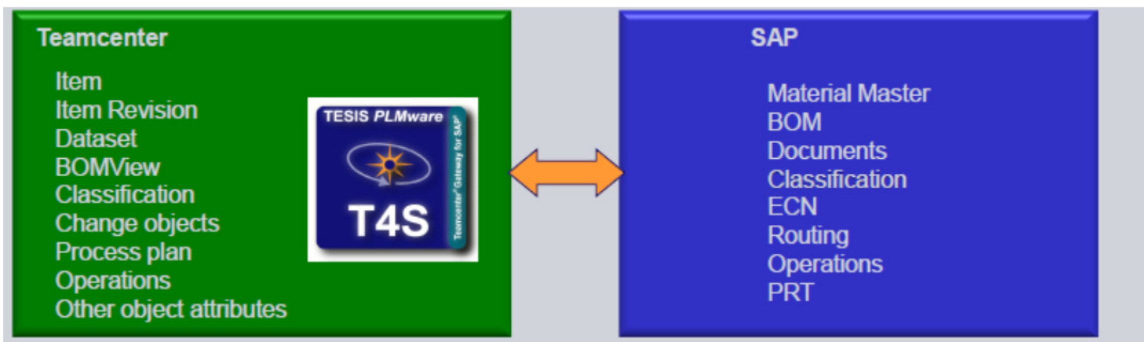


Figure 2.4 The sample of data map in TC PLM and SAP ERP integrated system with T4S (Tesis, n.d.-a)

including Item, Item Revision, BOMView and Operations are connected with the related information types in the SAP ERP system, such as Material Master, BOM, and Operations (Tesis, n.d.-a). For these information types in the TC PLM system, T4S defines seven object types including Material Master, Bill of Material, Document Info Record, Engineering Change Master, Equipment Master, Functional Location and Vendor, while adopting nine transaction types, such as, create, change, display, and reserve (Tesis, n.d.-a).

One of the popular transfer directions in TC PLM and SAP ERP integrated system by using T4S is to transfer data from TC PLM to SAP ERP. The T4S can build a bidirectional communication from TC PLM to SAP ERP. The T4S process

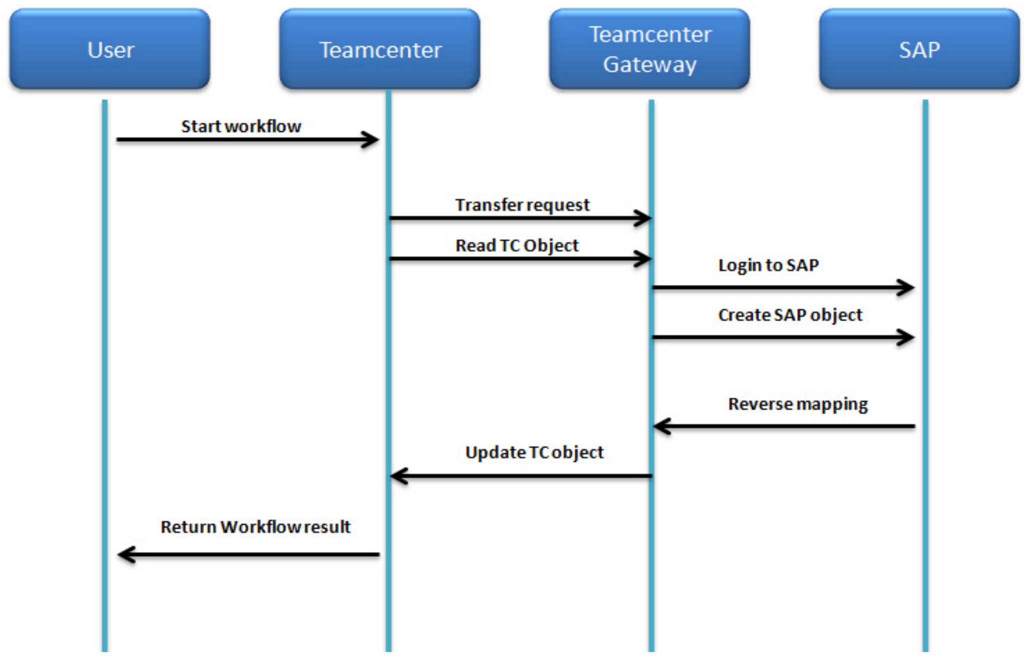


Figure 2.5 The data transmission processes in TC PLM and SAP ERP integrated system through T4S (Dirk, 2012)

flow for transferring data from TC PLM to SAP ERP has two steps. As shown in Fig 2.5, the first step is forward mapping, which includes reading item information from TC PLM, creating the material master object in SAP ERP; and the second step is reverse mapping, which reads SAP material master object and sends to TC PLM (Dirk, 2012).

2.3 Concurrent engineering scenarios

In concurrent engineering (CE) system, the product design and related manufacturing processes are developed simultaneously. Typically, an integration is accomplished by cross-functional groups (Smith, 1997). Compared to traditional sequential business processes, concurrent engineering systems have a simultaneous design and manufacture process, which aims to reduce total time and costs for a product from concept to delivery, while satisfying both consumers and industrial customers (Prasad, 1998).

Benefits of implementing CE techniques in global manufacturing include reducing time-to-market and cost and increasing product quality. These benefits come from the improvement of coordination within the whole organization (Abdalla, 1999). The best practices of CE show that information system software for managing information within departments is vital. The information system software provide platforms for sharing information between various participators in product lifecycles and ensuring that information is consistent and synchronized (Huet, 2009).

2.3.1 Engineering change management

Engineering change (EC) is used to describe change of products or constituent components. Three typical types of EC include engineering change involving drawing changes only, engineering change involving drawing and BOM changes and engineering change involving BOM changes only (Balcerak, 1992). In most cases, a poor engineering change control might cause a low BOM accuracy, as these changes bring a series of downstream changes (Huang, 2001). Typical working scenarios of concurrent engineering in industry are presented in Table 2.3 (Sobek, 1999). In example 1, design engineers make an agreement with manufacturing engineers on product design, while in example 2, 3, and 4, design engineers discuss manufacturing design limits with manufacturing engineers, and works on modifying initial product design for better functional performance as well as meeting manufacturing design requirements.

Table 2.3

Examples of concurrent engineering (Sobek, 1999)

	Example 1	Example 2	Example 3	Example 4
Design Engineering	"We've come up with several designs that would meet our functional requirements. They look roughly like this"	"Great. We will work within these limits and keep you posted on developments "	"We've narrowed the possibilities to this set and also fleshed out some more of the detail"	"This is very close to you final design. Please do your final manufacture ability review."
Manufacturing Engineering	"Our manufacturing capabilities are best suited for designs with these characteristics"	"OK. We can handle any solution in that set. This is enough information to order tool steel and start process planning"	"Looks good. Your set is still within our capabilities. We have some minor design changes to request, then we'll order castings"	"This design looks good. Thanks for including us early on. We'll start fading the tools and get into pilot as soon as possible!"

2.3.2 Bill of material

A class and relationship hierarchy model for bill-of-materials is listed as Fig 2.6. A BOM generally contains three major subclasses, which are end-product, subassembly, and component, which is also called as part. The end-product is

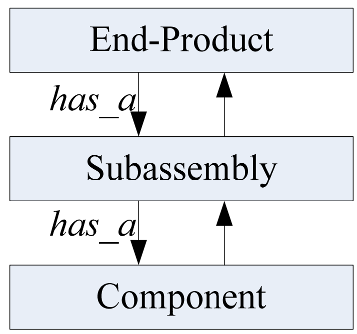


Figure 2.6 The class and relationship hierarchies for BOM and operation (Jiao, 2000)

composed by subassemblies or components, and a subassembly is composed by components (Jiao, 2000). The accuracy of BOM is measured from four perspectives: the part numbers, the quantity per unit, the unit of measure, and the structure (Garwood, 1997). In an accurate BOM, the right part numbers are listed, and each part is with right quantity per unit. Meanwhile, the unit of measure in quantity per unit and the structure are correct.

CHAPTER 3. METHODOLOGY

The purpose of this project was to provide documentation of the processes for developing a sandbox for a PLM and ERP integrated system, which will transfer BOM data. This chapter illustrates the methods used in this study, including the PLM and ERP integrated platform building and configuration, and BOM transmission processes in concurrent engineering scenarios.

3.1 Framework of integrating PLM and ERP

Integration is defined from a technical perspective as data exchange between at least two interconnected systems (Kahkonen, 2013). Business systems integration can be discussed in the dimension of information integration, where information is sharing directly, and the dimension of synchronized planning, where engineering changes are synchronized in the integrated business systems (Hvolby, 2010). This study discussed the framework of integrating PLM and ERP from a technical perspective, especially on the dimension of information integration and synchronized planning. Several considerations and factors were addressed for integration. For organizational and cultural factors, it is important to determine which system is the master, and which system owns and controls information and processes. Integrating PLM and ERP eliminates the overlap of functionality and processes in a company. For business practice factors, it is key to understand how a specific business operates, to address the direction of data flow and to add process automation whenever possible, and reduce non-value added work significantly. Further, for technology factors, it is crucial to consider the type of information to be integrated, the processes to be supported and the type and complexity of integration required (CIMdata, 2005). The framework of integrating PLM and ERP was set by answering these questions listed as following:

1) Which system is the master? Which system owns and controls information and processes?

2) What type of information should be integrated?

3) What is the direction of data flow? What process automation can be added?

4) What information should be accessible?

5) Which process steps should be managed in which systems?

6) What information should be exchanged between PLM and ERP?

7) Which tool and method could be used to create and maintain integration?

3.2 Systems configuration

The ERP system was SAP ERP 6.0, EHP 6 with SP 4, the PLM system was Siemens TC PLM 9.1 and the EAI software was T4S V9.1. T4S is SAP certified software for integrating TC PLM with SAP applications. T4S ensures consistent data transmissions across functional divisions by controlling data sharing and providing intelligent data mappings. Fig 3.1 illustrates the PLM and ERP integrated platform design for this study.

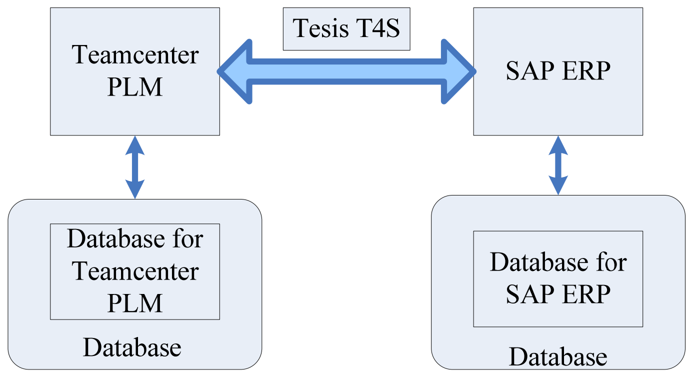


Figure 3.1 TC PLM and SAP ERP integrated system design

3.2.1 Software platform development

Technical support for the selected software was provided by Purdue technical support groups from Information Technology at Purdue (ITaP) and Purdue Engineering Computer Network (ECN). Support groups for this study helped install and build the PLM and ERP integrated system platform. In order to build the TC PLM and SAP ERP integrated system platform, TC PLM, SAP ERP and T4S system were installed by IT support from ITaP and ECN in this study. The SAP ERP system was installed and key installation activities are listed below.

1) Obtain the SAP Master Guide, Installation Guide and the Central Installation notes for SAP ERP 6.0
2) Determine the Operating System requirements by reviewing the SAP Master Guide and Installation Guide

3) Plan the SAP ERP system layout based on the customer requirements
4) Obtain the necessary installation media from SAP and stage it on the servers
5) Install the SAP ERP 6.0 system
6) Create user accounts
7) Test and confirmed network connectivity

The TC PLM and T4S system were installed by IT support from ECN, and were maintained in the College of Technology Product Lifecycle Management Center. The key processes for installing TC PLM included the following steps.

1) Obtain the TC PLM 9.1 Installation Guide
2) Develop a server for TC PLM 9.1
3) Obtain the installation media for TC PLM 9.1
4) Install TC PLM client based on customer requirements
5) Test the network connectivity

For installing the T4S system, the key processes included:

1) Obtain the T4S installation Guide
2) Install T4S BGS on TC PLM server
3) Install T4S client code
4) Install T4S data model templates
5) Test the network connectivity

The validation of installation method was implemented by the TC PLM and SAP ERP system experts at Purdue. When the TC PLM and SAP ERP systems were installed, the TC PLM expert from ECN and the SAP ERP experts from ITaP evaluated the initial configuration of the TC PLM and SAP ERP system.

3.2.2 The TC PLM configuration design

The product data selected for this study was a 3-D product created by undergraduate students in CGT 423. The END-PRODUCT was 5-3-18. The BOM structure was generated based on three major subclasses of BOM (Jiao, 2000). Figure 3.2 shows the product overview. There are three subassemblies: 5-2-2, 5-2-12 and 5-2-11 included in BOM 5-3-18. Each subassembly contains several components. The quantity of component 5-1-7, 5-1-8 and 5-1-9 is two, and the quantity of other components is one. Appendix A shows the detailed steps of product configuration in TC PLM system in this study.

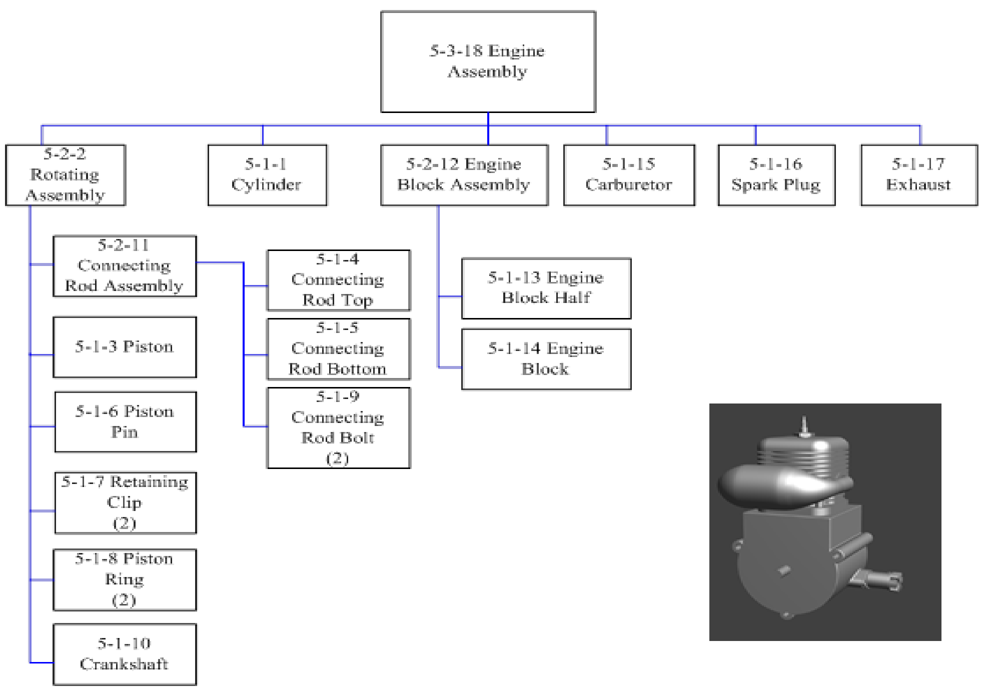


Figure 3.2 5-3-18 overview and BOM structure

3.2.3 The SAP ERP configuration design

For an SAP ERP client, the organizational elements and main master data are configured. Fig 3.3 shows the data model of organizational elements in SAP ERP client in this study, which contains company code, plant, controlling area, purchasing organization, storage location, plant, distribution channel, sales organization, and division (ERPsimLab, 2012).

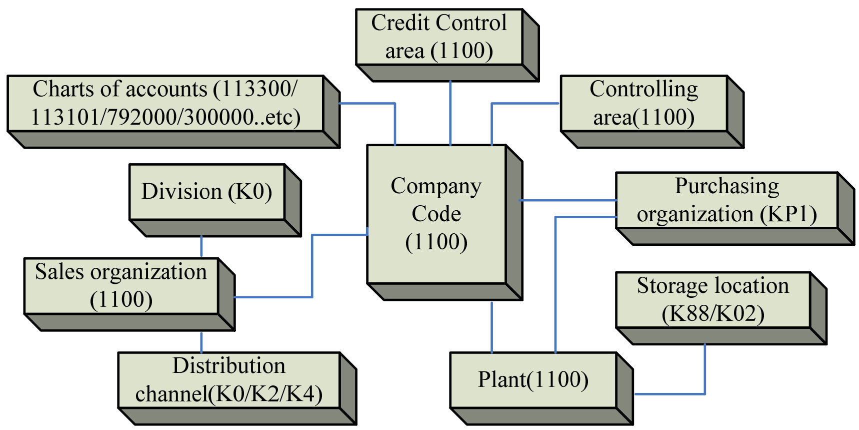


Figure 3.3 Data model of organizational elements in SAP ERP company client in this study

3.2.4 The T4S configuration design

The author performed the T4S preference configuration, identifying the object and transaction type sharing between PLM and ERP system. Configuration design generally contains two key steps. The first step is to define the object to be supported in T4S GUI, and the second step is to choose the transaction type to be transferred between TC PLM and SAP ERP. In the first step, there are seven object types included in T4S configuration, such as Material Master, Bill of

Material, Document Info Record, Engineering Change Master, Equipment Master and Vendor, which are shown in Fig. 3.4. The configuration of T4S covered four

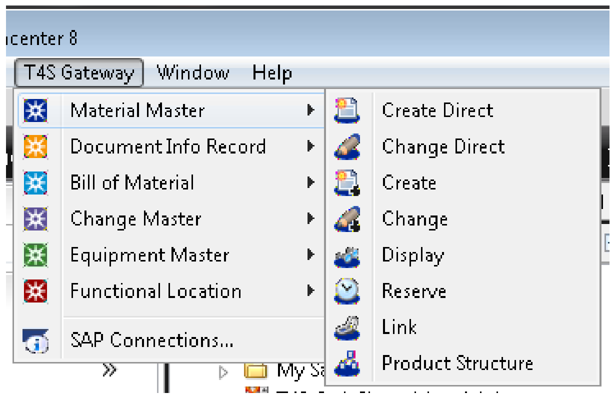


Figure 3.4 The screen print of T4S configuration object and transaction types

object types: Material Master, Document Info Record, Bill of Material, and Change Master. In the second step, there were nine transaction types included in T4S configuration including create, change, display, reserve and link. The configuration of T4S covered two transaction types: create and display (Tesis, n.d.-b). The T4S Configuration Guide and Installation Guide were used as references during configuration. Appendix B lists out the details of configuring T4S in this study.

3.3 BOM transmission process

This research developed a sandbox for the TC PLM and SAP ERP integrated systems to transfer BOM information in concurrent engineering in a laboratory environment. The BOM transmission processes were designed under three scenarios:

- Scenario 1: Transmit BOMs from the TC PLM system to the SAP ERP system;
- Scenario 2: Synchronize a related BOM in the SAP ERP system after revising a BOM in the TC PLM system;
- Scenario 3: Import a new part from the SAP ERP system to the TC PLM system, and synchronize a related BOM in the SAP ERP system after adding this new part to a BOM in the TC PLM system.

Table 3.1

Examples of concurrent engineering (Sobek, 1999)

	Example 1	Example 2	Example 3	Example 4
Design Engineering	"We've come up with several designs that would meet our functional requirements. They look roughly like this"	"Great. We will work within these limits and keep you posted on developments"	"We've narrowed the possibilities to this set and also fleshed out some more of the detail"	"This is very close to you final design. Please do your final manufacture ability review."
Manufacturing Engineering	"Our manufacturing capabilities are best suited for designs with these characteristics "	"OK. We can handle any solution in that set. This is enough information to order tool steel and start process planning"	"Looks good. Your set is still within our capabilities. We have some minor design changes to request, then we'll order castings"	"This design looks good. Thanks for including us early on. We'll start fading the tools and get into pilot as soon as possible!"

These three scenarios were generated from the typical concurrent engineering working scenarios in industry as shown in Table 3.1(Sobek, 1999). In Table 3.1 example 1, a design engineer made an agreement with a manufacturing engineer on product design. Scenario 1 illustrated a BOM transmission process under this situation, where BOM data was transmitted directly from TC PLM to SAP ERP, which generated the related BOM in SAP ERP system for manufacturing purposes. In Table 3.1 example 2, 3, and 4, a design engineer discussed manufacturing design limits with a manufacturing engineer, and worked on modifying initial product design for better functional performance, as well as meeting manufacturing design requirements. In scenario 2, a new product part was added on a BOM in TC PLM system, and a related BOM in SAP ERP was updated through engineering change management workflow, while in scenario 3, a new product part was imported from the SAP ERP system into TC PLM system. After adding this new part on BOM in TC PLM system, the related BOM in SAP ERP was synchronized. The screen prints show key steps for transferring BOM between the TC PLM and SAP ERP integrated system were documented in Chapter 4. In Chapter 5 the research results observed in this study were analyzed.

3.3.1 Scenario 1

In this scenario, a related BOM in SAP ERP was created from a BOM in TC PLM by using the T4S model -- Material Master and Bill of Material. In this study, the product parts of 5-3-18 are defined as end-products in the TC PLM system.

The BOM data in SAP ERP were compared to the BOM data in TC PLM in part number, quantity, unit and structure, as these four indexes are key measurements of BOM accuracy in Garwood (Garwood)'s research.

Step 1: Opened BOM 5-3-18 in TC PLM structure manager screen by searching 5-3-18 in search bar.

Step 2: Moved all product parts from TC PLM to SAP ERP through T4S model by clicking T4S Gateway-> Material Master-> Create Direct

Step 3: Checked the moved materials in SAP ERP system by using transaction code MM03.

Step 4: In "My Teamcenter" screen, moved BOM Structure from TC PLM to SAP ERP by clicking T4S Gateway-> Bill of Material -> Create Direct.

Step 5: Checked the material BOM of finished product in SAP by using transaction code CS03.

3.3.2 Scenario 2

In this scenario, a new part was added on a BOM in TC PLM system, and then the related BOM in SAP ERP system was synchronized by using T4S model "Change Master". The product parts of 5-3-18 are defined as end-product in TC PLM system. The BOM data in SAP ERP were compared to the BOM data in TC PLM in part number, quantity, unit and structure.

The key steps of transactions in scenario 2 included:

Step 1: In "Structure Manager" screen, clicked 5-3-18, and then created a new part 5-1-99 under BOM 5-3-18 in TC PLM.

Step 2: Moved 5-1-99 from TC PLM to SAP ERP.

Step 3: Updated the related BOM in SAP ERP through TC PLM workflow process of T4S_BOM.

Step 4: Checked the related BOM in SAP ERP system by using transaction code CS03.

Step 5: In “My Teamcenter” screen, created change request S2 and attached 5-3-18 to it by copying and pasting 5-3-18 in the folder of affected items.

Step 6: Created a change master for the related BOM in SAP ERP by using T4S model change master-create direct.

Step 7: Checked the change master created in SAP ERP system by using transaction code CC03.

Step 8: In “My Teamcenter” screen, released the change request S2 through workflow process of T4S_ECM.

3.3.3 Scenario 3

In this scenario, a new part was imported from SAP ERP to TC PLM. After adding this new part to a BOM in TC PLM, the related BOM in SAP ERP was synchronized through T4S model. The BOM data in SAP ERP were compared to BOM data in TC PLM in part number, quantity, unit and structure. The key steps of transactions in scenario 3 included:

Step 1: Created a new product part by using transaction code MM01 in SAP ERP.

Step 2: Searched new product part TE00R stored in SAP ERP by opening search view, and choosing T4S_DEMO_QUERY in TC PLM. Imported this new product part from SAP ERP into TC PLM by importing T4S Query row.

Step 3: Searched TE00* in search bar and added TE00R to 5-3-18 by copying and pasting TE00R to 5-3-18 BOM structure in TC PLM-Structure Manager screen.

Step 4: Updated the related BOM in SAP ERP through T4S_BOM workflow.

Step 5: Checked the related BOM in SAP ERP system by using transaction code CS03.

Step 6: Created change request S3 in TC PLM system, and attached 5-3-18 to this Change Revision in TC PLM-My Teamcenter screen.

Step 7: Created a change master for the related BOM in SAP ERP system.

Step 8: Checked the SAP change master in SAP ERP system by using transaction code CC03.

Step 9: Released the change revision through workflow process of T4S_ECM.

3.4 Summary

A framework of integrating PLM and ERP was developed by considering organizational and cultural factors, business practice factors and technology factors. Three BOM transmission scenarios were designed based on concurrent engineering work scenarios. The BOM transmission processes were validated by visually comparing BOM data from part number, quantity, unit and structure. The BOM transmission scenarios were performed on two computers. The TC PLM system was operated on computer in PLM laboratory, while the SAP ERP system was operated from the Supply Chain Management Technology (SCMT) laboratory. When preceding the BOM transmission scenario, both the TC PLM and SAP ERP were opened in the SCMT lab by remotely controlling the computer for TC PLM. The BOM data in TC PLM and SAP ERP was shown on two parallel screens. By visually comparing BOM data in two screens after each transaction, the BOM transmission scenarios were validated.

CHAPTER 4. RESEARCH RESULTS

In this chapter, research results in this study are described. The key considerations of PLM and ERP integrated system are analyzed and the screen prints of key steps of transferring BOM in TC PLM and SAP ERP integrated system are documented.

4.1 Key considerations of integrating PLM and ERP

This study adopted the framework of integrating PLM and ERP by summarizing key considerations and factors of integration in CIMdata report (CIMdata). The key considerations of PLM, ERP and EAI system in this research were determined by answering questions in the framework of integration. These key considerations include data and process ownership, master source of information, and the level of integration. The answers of questions in the framework of integrating PLM and ERP are listed as following:

1) Which system is the master? Which system owns and controls information and processes?

The PLM and ERP system have similar functionalities in data and process management. From the technique's perspective, either PLM or ERP can be defined as the master, which system owns and controls information and processes. Typically, the processes of engineering reside in the PLM system, while the processes of manufacturing reside in the ERP system. BOM and change requests were shared between the PLM and ERP integrated system. In order to ensure the data consistency, the PLM system was assigned as “owner” and “controller”, as the BOM and change request data was initially generated from engineering processes. The PLM system was the only source of BOM and change request data.

2) What type of information should be integrated?

The processes of engineering design and change management was included. As BOM and change request information is associated with the processes of engineering design and change management, the information from the BOM and change request data should be integrated between PLM and ERP.

3) What is the direction of data flow? What process automation can be added?

PLM was the “master, so to ensure that PLM is the only source of BOM and change request, BOM and change request transmission was defined as one-way directional from PLM to ERP. While the product part information is bi-directional between PLM and ERP, as in concurrent engineering scenarios where the design engineer who manages the PLM system data or the sourcing engineer who manages the ERP system data, and may create new product part data. The process of synchronizing the BOM and creating the related change request in ERP can run automatically by using EAI, as the EAI tool has pre-configured packages for this functionality.

4) What information should be accessible?

In concurrent engineering scenarios adopted in this study, the manufacturing engineer in the ERP system can check BOM and change request data created by design engineer in PLM system, so the BOM and change request data should be accessible in both systems.

5) Which process steps should be managed in which systems?

As PLM is the only source of BOM and change request data in this study, and the EAI tool has the functionality to automatically create BOM and change request in the ERP system, so the process of creating and editing BOM and change request data should be managed in the PLM system. The process of creating new product parts was managed in both PLM and ERP systems in this study, because in concurrent engineering scenarios adopted in this study, the design engineer (PLM) needed to use new parts created by sourcing engineer (ERP). The EAI tool has the functionality to import data from SAP ERP to TC PLM.

6) What information should be exchanged between PLM and ERP?

The BOM and the data which is associated with BOM synchronization processes should be exchanged between PLM and ERP.

7) Which tool and method could be used to create and maintain integration?

The EAI tool T4S was used to create and maintain integration in this study, as it is the SAP certified EAI system for integrating Siemens TC PLM system with SAP applications, and was provided by our vendor partner in this study.

4.2 BOM transmission transactions

In this section, the BOM transmission transactions under three concurrent engineering scenarios were documented. The results were analyzed in chapter 5.

4.2.1 Scenario 1

In this scenario, a related BOM in SAP ERP was created from BOM 5-3-18 in TC PLM. All product parts and BOM structure was created in SAP ERP through T4S model-- Material Master and Bill of Materials. The BOM data transferred in PLM and ERP integrated system were recorded in Table 4.1.

Table 4.1

The records of BOM 5-3-18 in scenario 1

BOM in TC PLM				BOM in SAP ERP			
Part No.	**Quantity**	**Unit**	**Structure**	**Part No.**	**Quantity**	**Unit**	**Structure**
5-3-18	1	Each	End-Product	5-3-18	1	Each	End-Product
5-1-1	1	Each	Component	5-1-1	1	Each	Component
5-2-2	1	Each	Subassembly	5-2-2	1	Each	Subassembly
5-1-3	1	Each	Component	5-1-3	1	Each	Component
5-1-6	1	Each	Component	5-1-6	1	Each	Component
5-1-7	2	Each	Component	5-1-7	2	Each	Component
5-1-8	2	Each	Component	5-1-8	2	Each	Component
5-1-10	1	Each	Component	5-1-10	1	Each	Component
5-2-11	1	Each	Subassembly	5-2-11	1	Each	Subassembly
5-1-4	1	Each	Component	5-1-4	1	Each	Component
5-1-5	1	Each	Component	5-1-5	1	Each	Component
5-1-9	2	Each	Component	5-1-9	2	Each	Component
5-2-12	1	Each	Subassembly	5-2-12	1	Each	Subassembly
5-1-13	1	Each	Component	5-1-13	1	Each	Component
5-1-14	1	Each	Component	5-1-14	1	Each	Component
5-1-15	1	Each	Component	5-1-15	1	Each	Component
5-1-16	1	Each	Component	5-1-16	1	Each	Component
5-1-17	1	Each	Component	5-1-17	1	Each	Component

Step 1: Opened BOM 5-3-18 in TC PLM structure manager screen as shown in Fig 4.1 by searching 5-3-18 in search bar.

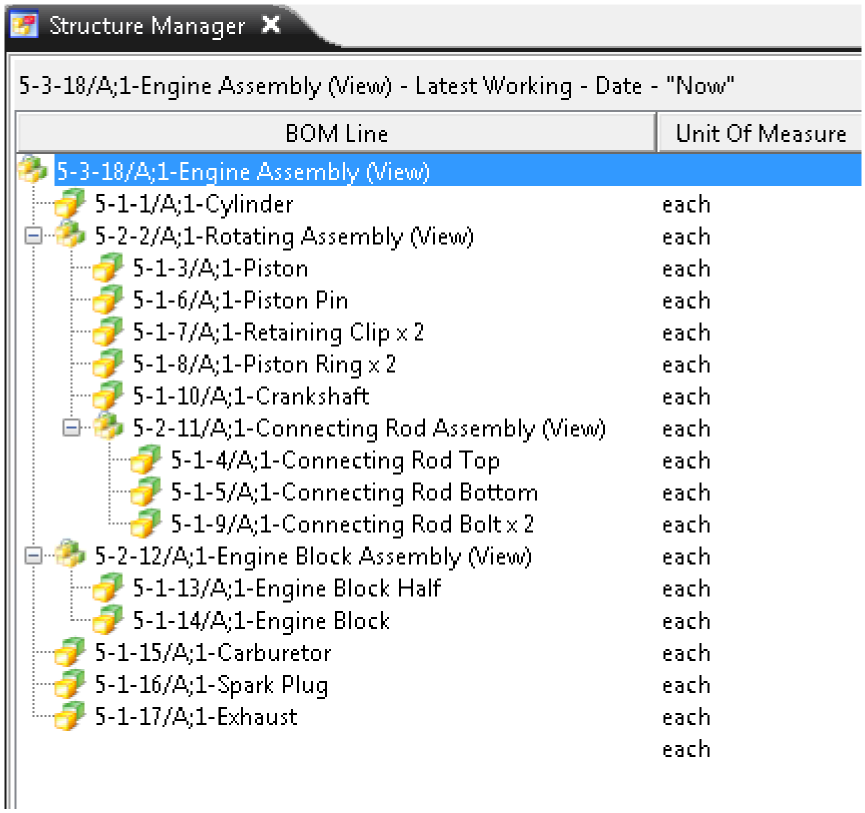


Figure 4.1 Screen print of BOM 5-3-18 in TC PLM

Step 2: Moved all product parts from TC PLM to SAP ERP through T4S model as shown in Fig 4.2 by clicking T4S Gateway-> Material Master-> Create Direct. The T4S transfer window of Material Master-Create Direct is shown as Fig 4.3

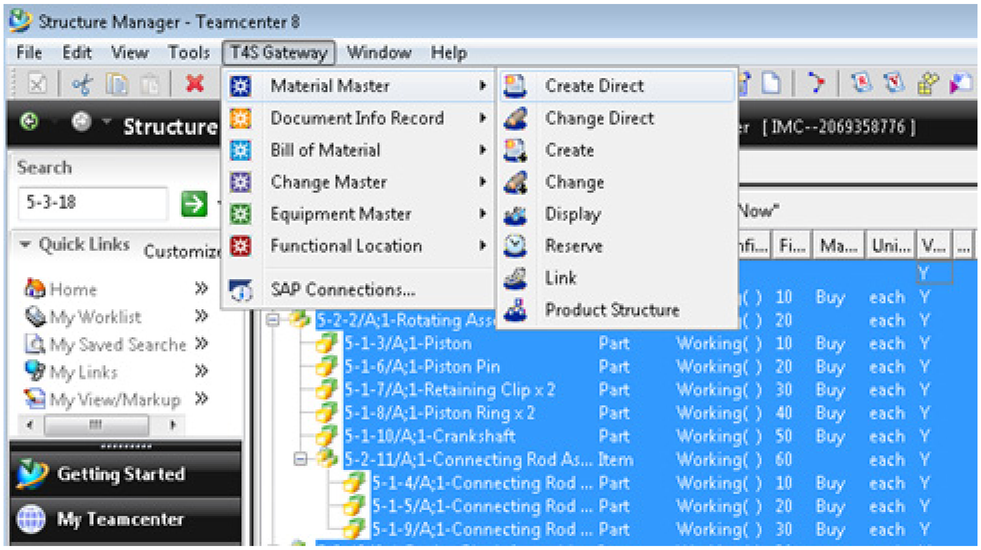


Figure 4.2 Screen print of creating material master through T4S in TC PLM

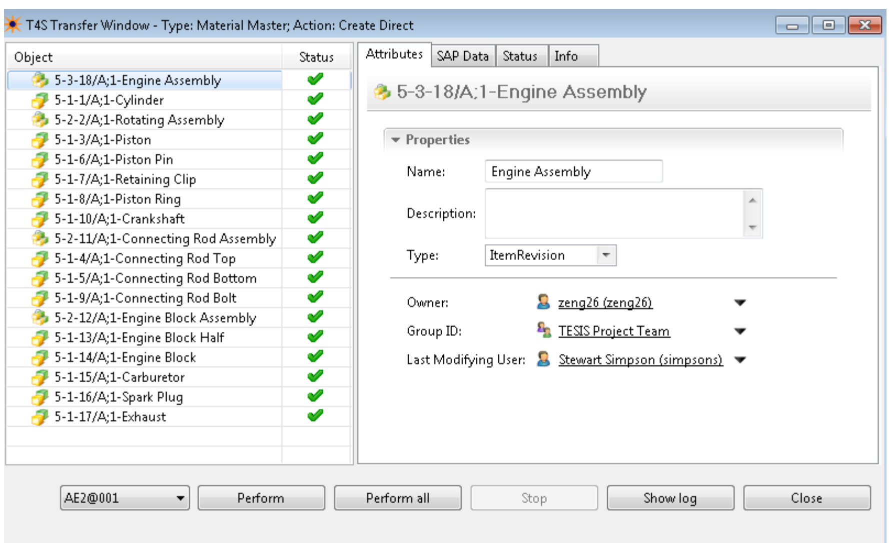


Figure 4.3 Screen print of T4S transfer window of Material Master-Create Direct

Step 3: Checked the moved materials in SAP ERP system by using transaction code MM03 as shown in Fig 4.4. The search results of checking material master in SAP ERP are shown as Fig 4.5

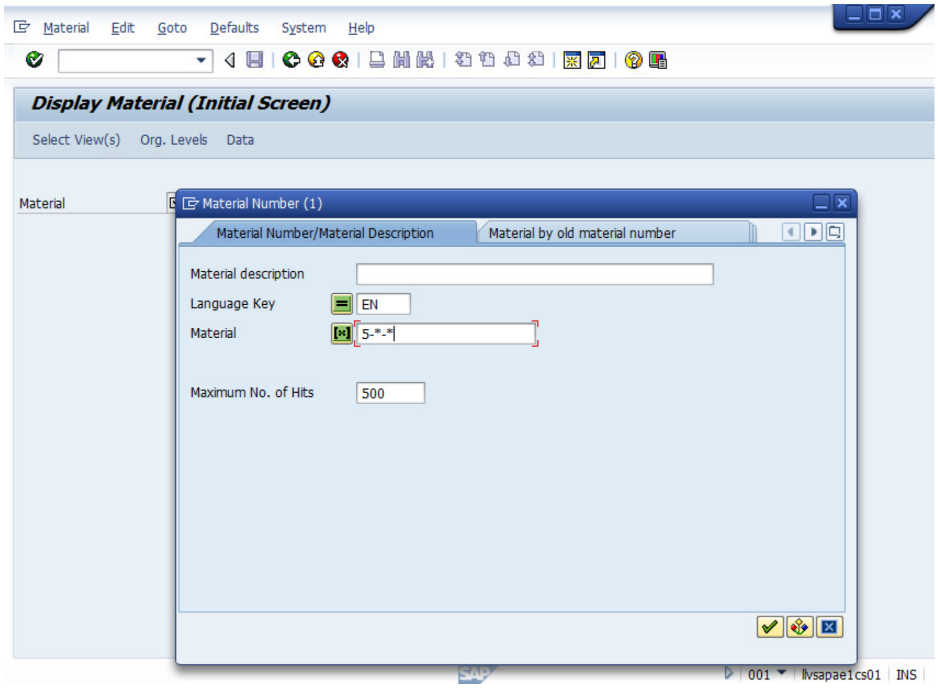


Figure 4.4 Screen print of SAP ERP transaction MM03

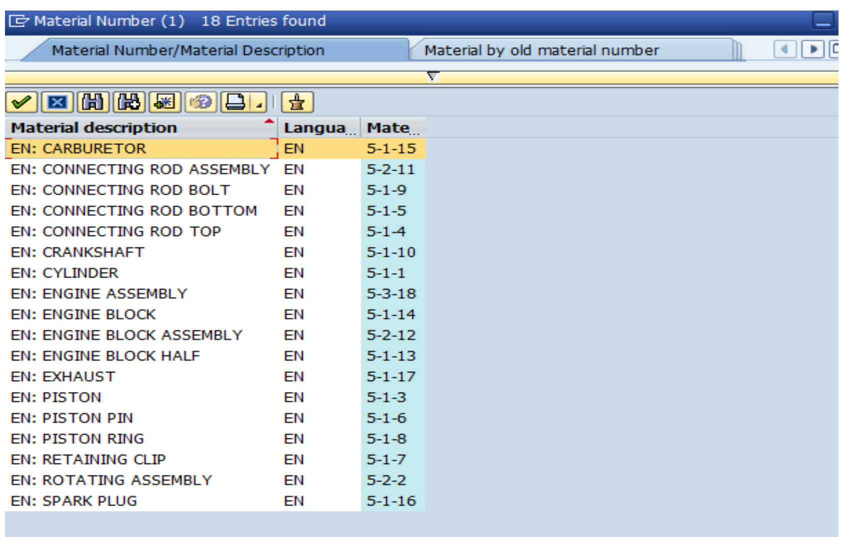


Figure 4.5 Screen print of material master created in SAP ERP through T4S

Step 4: In “My Teamcenter” screen, moved BOM Structure from TC PLM to SAP ERP through T4S transaction window as shown in Fig 4.6 and Fig 4.7 by clicking T4S Gateway-> Bill of Material -> Create Direct. All BOM structure in assembly and subassembly need to move through T4S model “Bill of Material-Create Direct”. In this scenario, the BOM structure 5-2-11/A-View, 5-2-12/A-View, 5-2-2/A-View, and 5-3-18/A-View as shown in Fig 4.8 were transferred from TC PLM to SAP ERP.

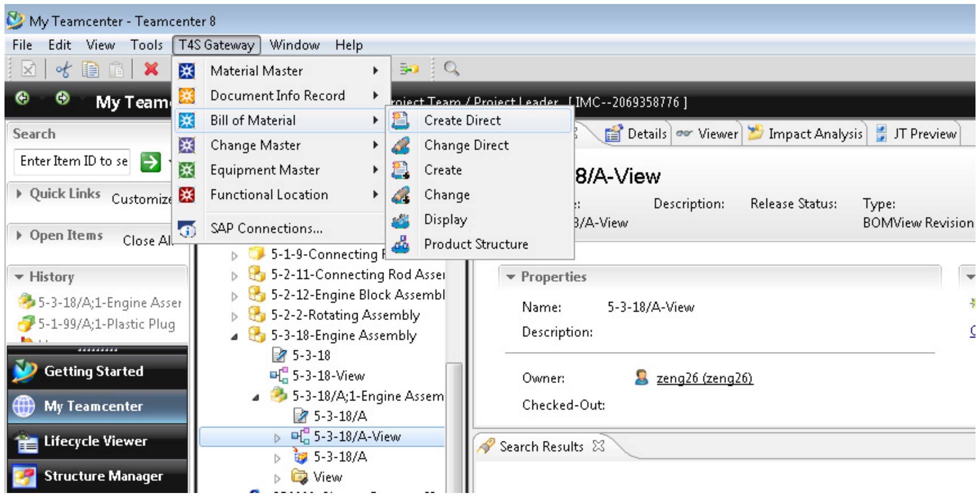


Figure 4.6 Screen print of T4S model Bill of Material- Create Direct

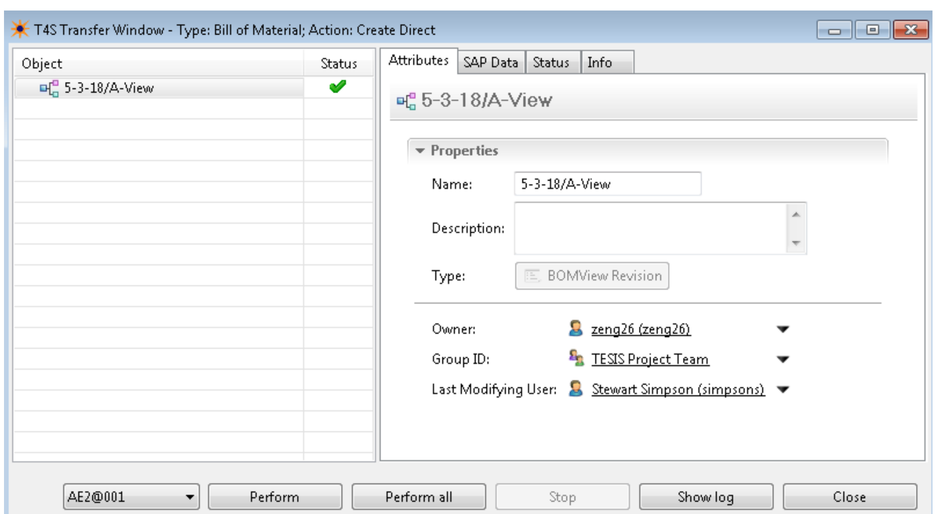


Figure 4.7 T4S transfer window of Bill of Material-Create Direct

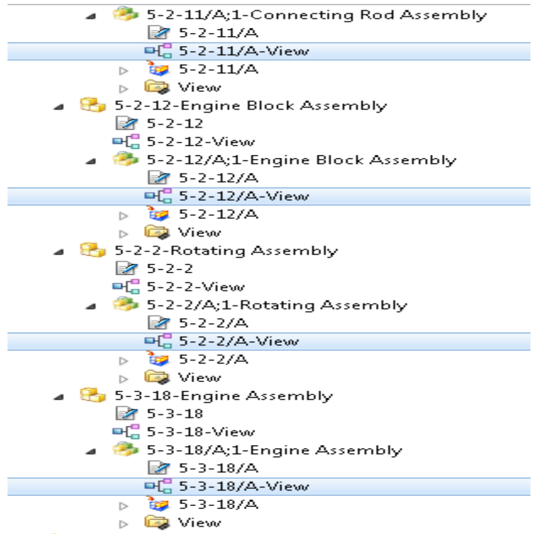


Figure 4.8 Screen print of all BOM structures of 5-3-18 in TC PLM

Step 5: Checked the material BOM of finished product in SAP by using transaction code CS03 as shown in Fig 4.9. The BOM structures of 5-3-18 and its subassemblies 5-2-2, 5-2-11, and 5-2-12 are shown as Fig 4.10 to Fig 4.13.

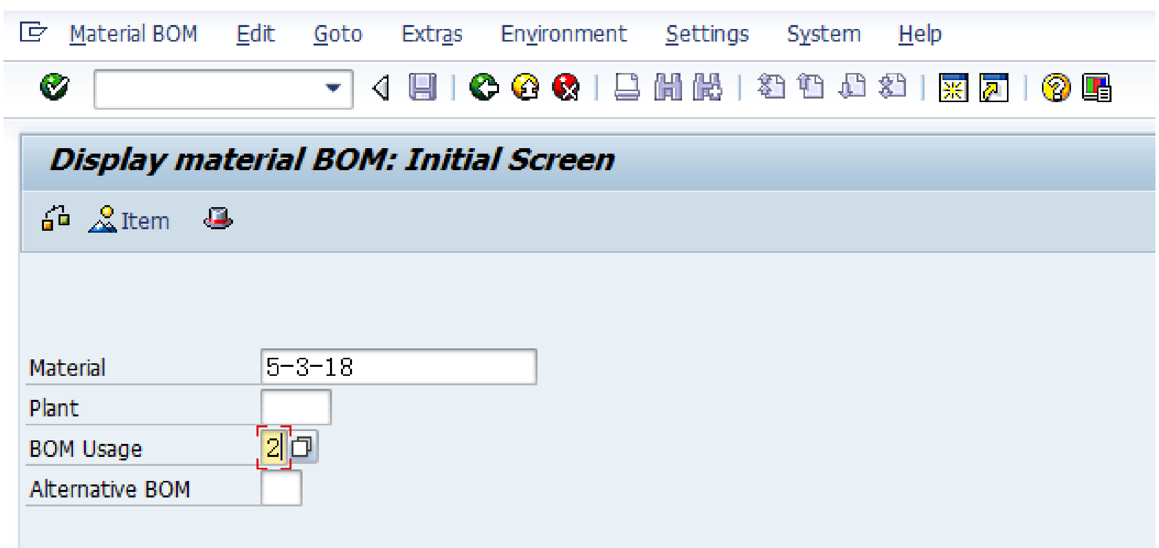
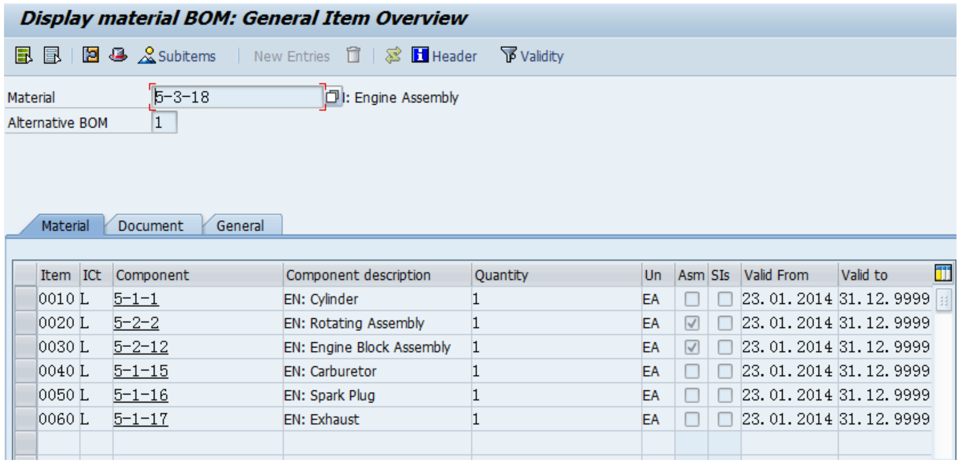


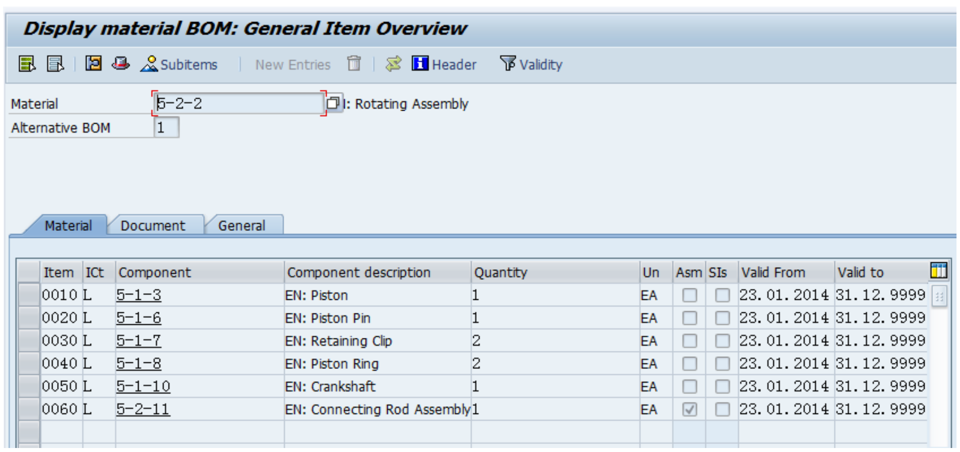
Figure 4.9 Screen print of SAP ERP transaction CS03


Display material BOM: General Item Overview

Material: 5-3-18 : Engine Assembly
Alternative BOM: 1

Item	ICt	Component	Component description	Quantity	Un	Asm	SIs	Valid From	Valid to
0010	L	5-1-1	EN: Cylinder	1	EA	☐	☐	23.01.2014	31.12.9999
0020	L	5-2-2	EN: Rotating Assembly	1	EA	☑	☐	23.01.2014	31.12.9999
0030	L	5-2-12	EN: Engine Block Assembly	1	EA	☑	☐	23.01.2014	31.12.9999
0040	L	5-1-15	EN: Carburetor	1	EA	☐	☐	23.01.2014	31.12.9999
0050	L	5-1-16	EN: Spark Plug	1	EA	☐	☐	23.01.2014	31.12.9999
0060	L	5-1-17	EN: Exhaust	1	EA	☐	☐	23.01.2014	31.12.9999

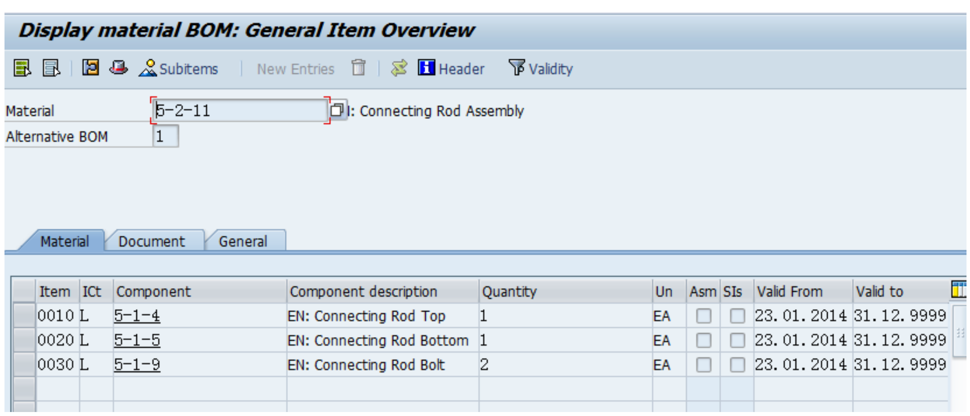
Figure 4.10 Screen print of displaying BOM 5-3-18 in SAP ERP


Display material BOM: General Item Overview

Material: 5-2-2 : Rotating Assembly
Alternative BOM: 1

Item	ICt	Component	Component description	Quantity	Un	Asm	SIs	Valid From	Valid to
0010	L	5-1-3	EN: Piston	1	EA	☐	☐	23.01.2014	31.12.9999
0020	L	5-1-6	EN: Piston Pin	1	EA	☐	☐	23.01.2014	31.12.9999
0030	L	5-1-7	EN: Retaining Clip	2	EA	☐	☐	23.01.2014	31.12.9999
0040	L	5-1-8	EN: Piston Ring	2	EA	☐	☐	23.01.2014	31.12.9999
0050	L	5-1-10	EN: Crankshaft	1	EA	☐	☐	23.01.2014	31.12.9999
0060	L	5-2-11	EN: Connecting Rod Assembly	1	EA	☑	☐	23.01.2014	31.12.9999

Figure 4.11 Screen print of displaying subassembly 5-2-2 in SAP ERP


Display material BOM: General Item Overview

Material: 5-2-11 : Connecting Rod Assembly
Alternative BOM: 1

Item	ICt	Component	Component description	Quantity	Un	Asm	SIs	Valid From	Valid to
0010	L	5-1-4	EN: Connecting Rod Top	1	EA	☐	☐	23.01.2014	31.12.9999
0020	L	5-1-5	EN: Connecting Rod Bottom	1	EA	☐	☐	23.01.2014	31.12.9999
0030	L	5-1-9	EN: Connecting Rod Bolt	2	EA	☐	☐	23.01.2014	31.12.9999

Figure 4.12 Screen print of displaying subassembly 5-2-11 in SAP ERP

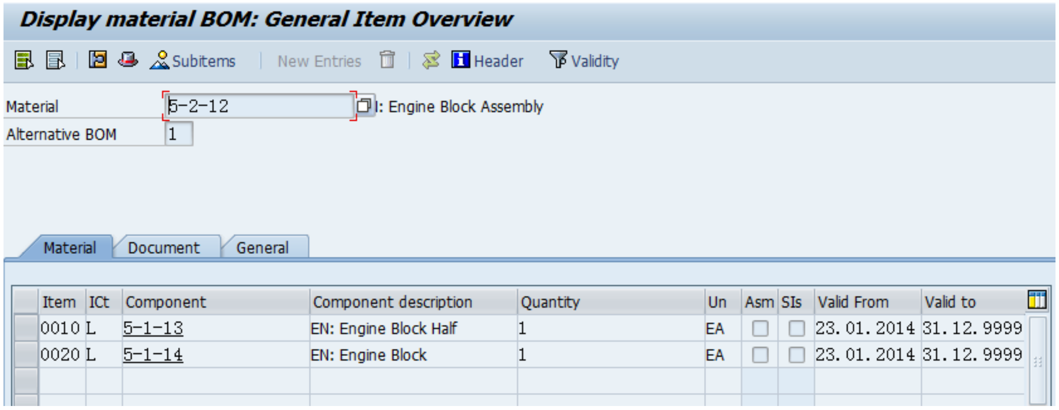


Figure 4.13 Screen print of displaying subassembly 5-2-12 in SAP ERP

4.2.2 Scenario 2

In this scenario, a new product on the BOM in TC PLM was added, and then the related BOM in SAP ERP was synchronized. The T4S model-Change Master was used for synchronizing the related BOM in SAP ERP with the BOM in TC PLM system. The BOM data transferred in scenario 2 were recorded in Table 4.2.

Table 4.2

The records of BOM 5-3-18 under engineering change in scenario 2

BOM in TC PLM				**BOM in SAP ERP**			
Part No.	**Quantity**	**Unit**	**Structure**	**Part No.**	**Quantity**	**Unit**	**Structure**
5-3-18	1	Each	End-Product	5-3-18	1	Each	End-Product
5-1-1	1	Each	Component	5-1-1	1	Each	Component
5-2-2	1	Each	Subassembly	5-2-2	1	Each	Subassembly
5-1-3	1	Each	Component	5-1-3	1	Each	Component
5-1-6	1	Each	Component	5-1-6	1	Each	Component
5-1-7	2	Each	Component	5-1-7	2	Each	Component
5-1-8	2	Each	Component	5-1-8	2	Each	Component
5-1-10	1	Each	Component	5-1-10	1	Each	Component
5-2-11	1	Each	Subassembly	5-2-11	1	Each	Subassembly
5-1-4	1	Each	Component	5-1-4	1	Each	Component
5-1-5	1	Each	Component	5-1-5	1	Each	Component

Table 4.2 (continued)

The records of BOM 5-3-18 under engineering change in scenario 2

5-1-9	2	Each	Component	5-1-9	2	Each	Component
5-2-12	1	Each	Subassembly	5-2-12	1	Each	Subassembly
5-1-13	1	Each	Component	5-1-13	1	Each	Component
5-1-14	1	Each	Component	5-1-14	1	Each	Component
5-1-15	1	Each	Component	5-1-15	1	Each	Component
5-1-16	1	Each	Component	5-1-16	1	Each	Component
5-1-17	1	Each	Component	5-1-17	1	Each	Component
5-1-99	1	Each	Component	5-1-99	1	Each	Component

Step 1: In "Structure Manager" screen, clicked 5-3-18, and then created a new part 5-1-99 to BOM 5-3-18 in TC PLM system as shown in Fig 4.14 by clicking File-> New-> Part. The new BOM 5-3-18 after this change is shown as Fig 4.15, where the new part 5-1-99 is added on BOM 5-3-18.

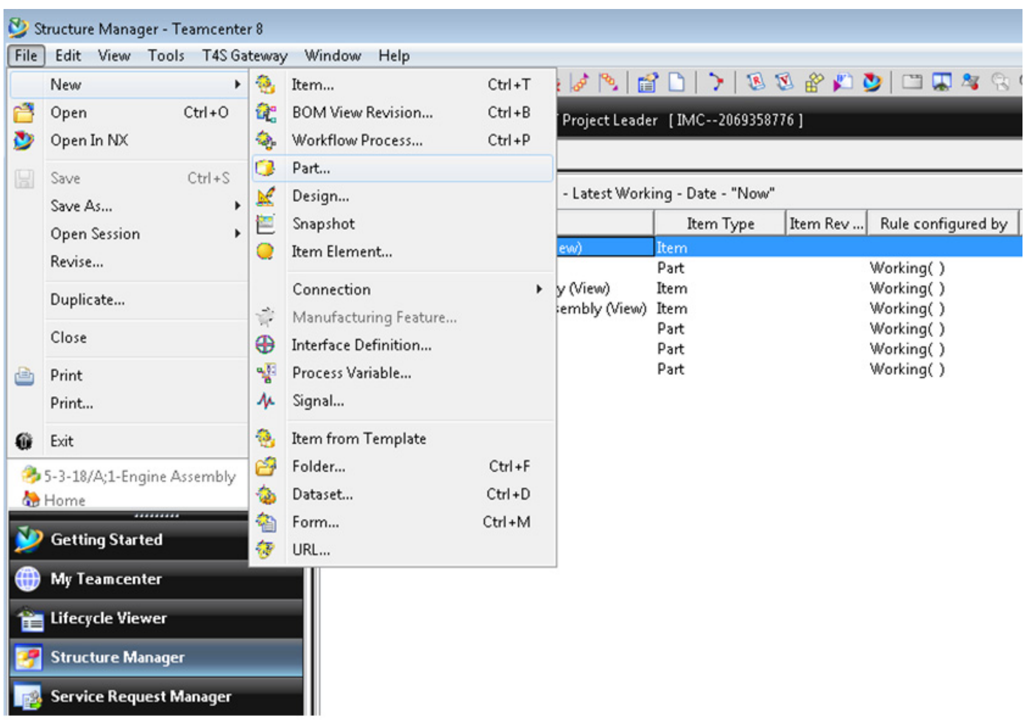


Figure 4.14 Screen print of opening transaction to create new part in TC PLM

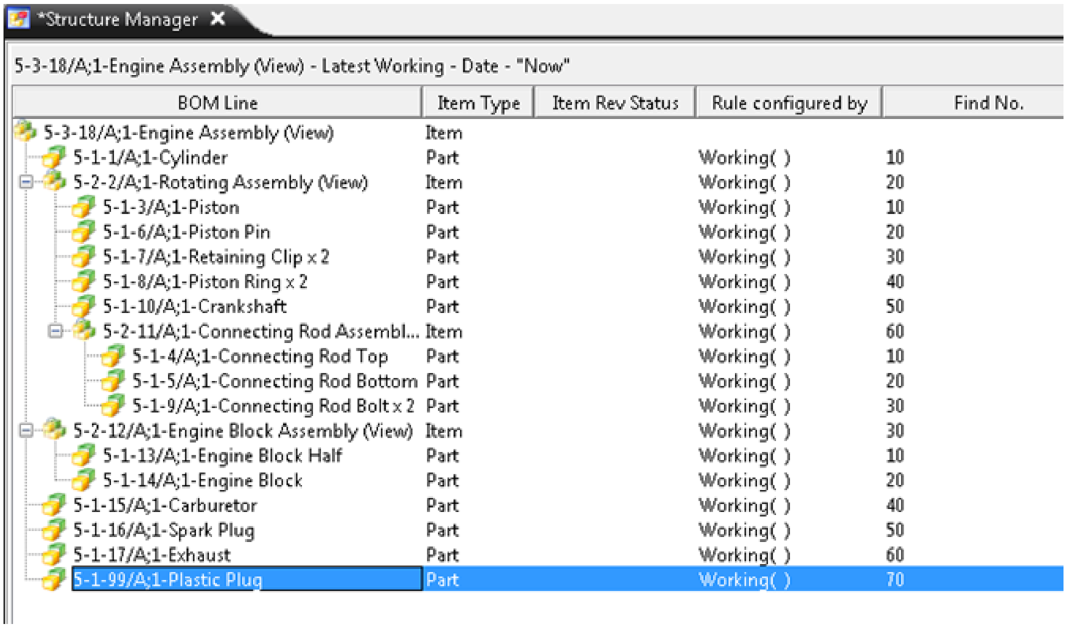


Figure 4.15 Screen print of BOM 5-3-18 after adding new product part 5-1-99

Step 2: Moved 5-1-99 from TC PLM to SAP ERP through T4S model as shown in Fig 4.16 and Fig 4.17 by clicking T4S Gateway-> Material Master -> Create Direct.

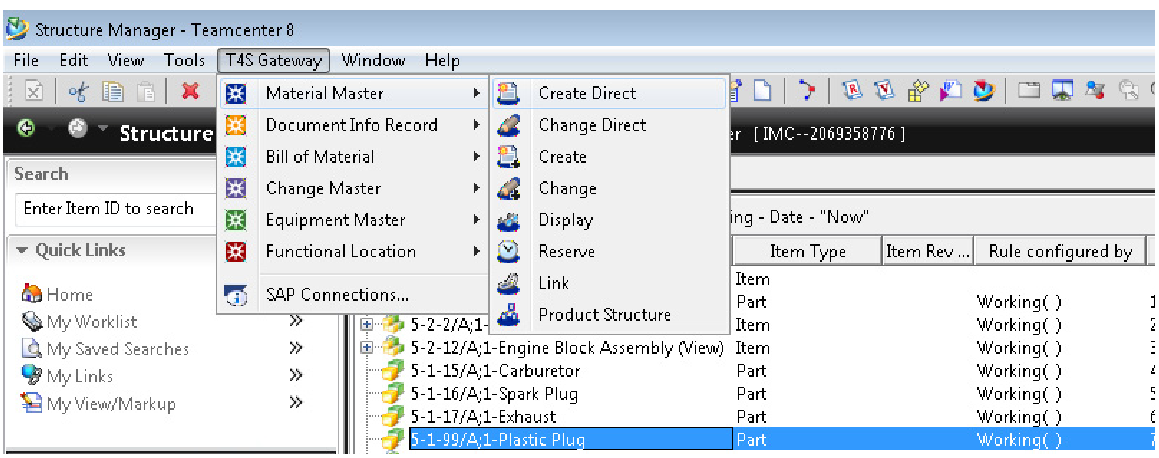


Figure 4.16 Screen print of opening T4S model Material Master-Create Direct

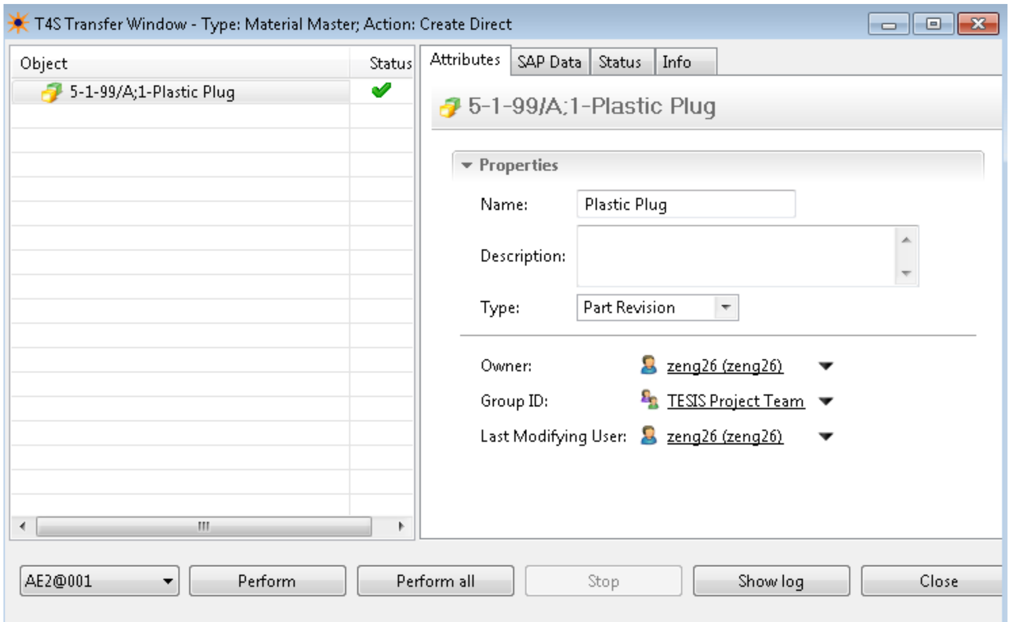


Figure 4.17 T4S transfer window of Material Master-Create Direct

Step 3: Updated the related BOM in SAP ERP through TC PLM workflow process of T4S_BOM as shown in Fig 4.18 and Fig 4.19.

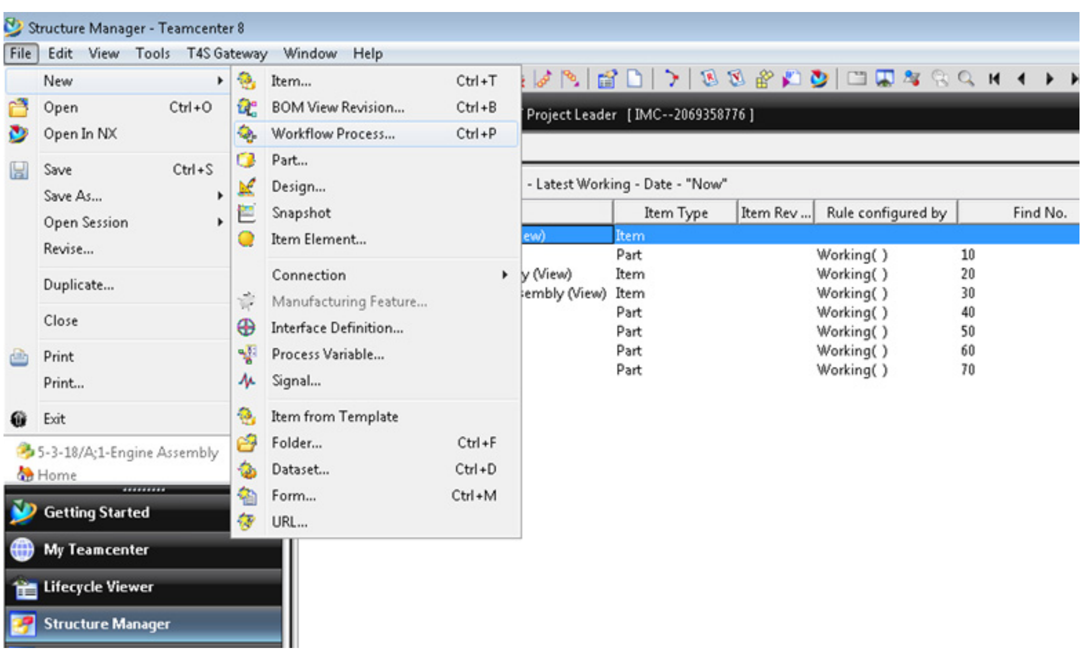


Figure 4.18 Screen print of opening workflow process in TC PLM

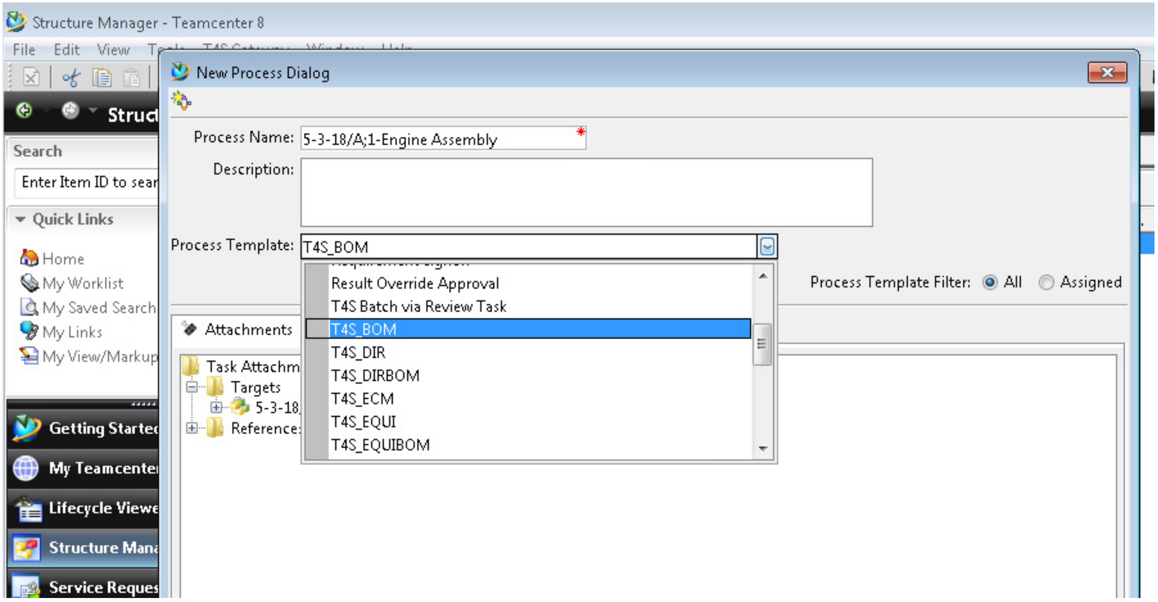


Figure 4.19 Screen print of T4S_BOM workflow in TC PLM system

Step 4: Checked the related BOM in SAP ERP system by using transaction code CS03 as shown in Fig 4.20.

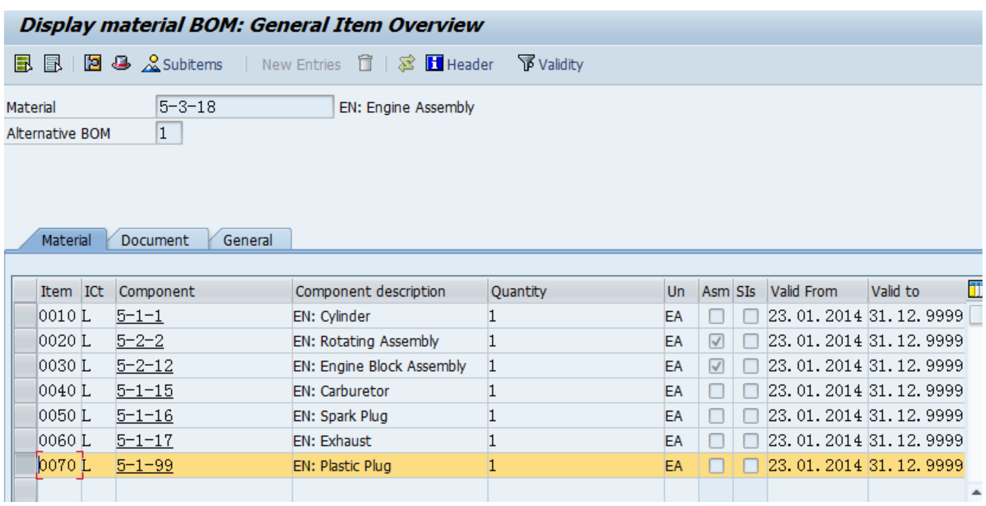


Figure 4.20 Screen print of BOM 5-3-18 in SAP ERP

Step 5: In “My Teamcenter” screen, created change request S2 as shown in Fig 4.21 by clicking File-> New-> Classic Change, and attached 5-3-

18 to this change request by pasting 5-3-18 in the folder of affected items as shown in Fig 4.22.

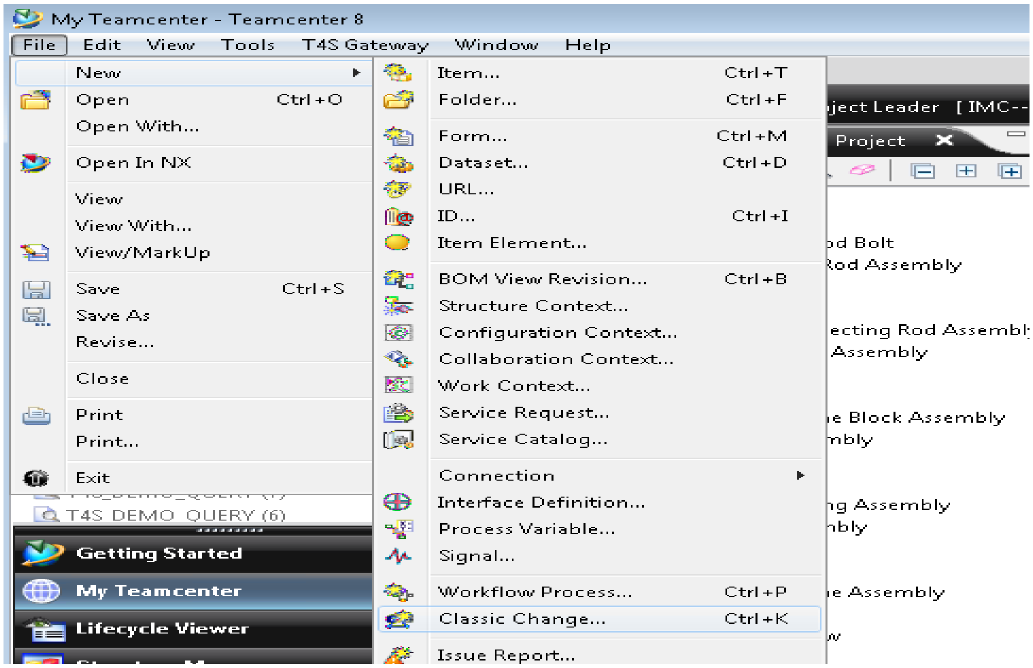


Figure 4.21 Screen print of opening classic change in TC PLM

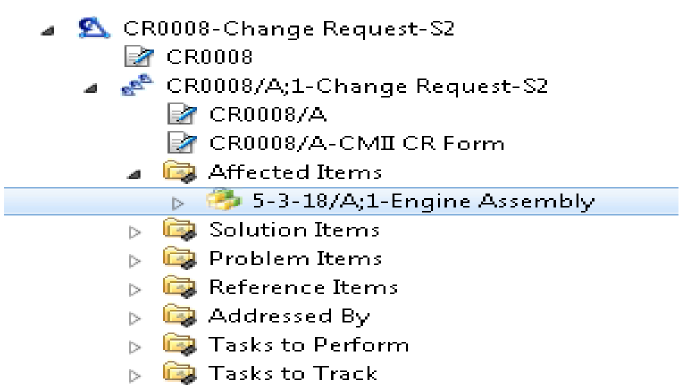


Figure 4.22 Screen print of adding BOM 5-3-18 to change request S2

Step 6: Created a change master for the related BOM in SAP ERP system through T4S transfer window as shown in Fig 4.23 and Fig 4.24 by clicking T4S Gateway-> Change Master -> Create Direct.

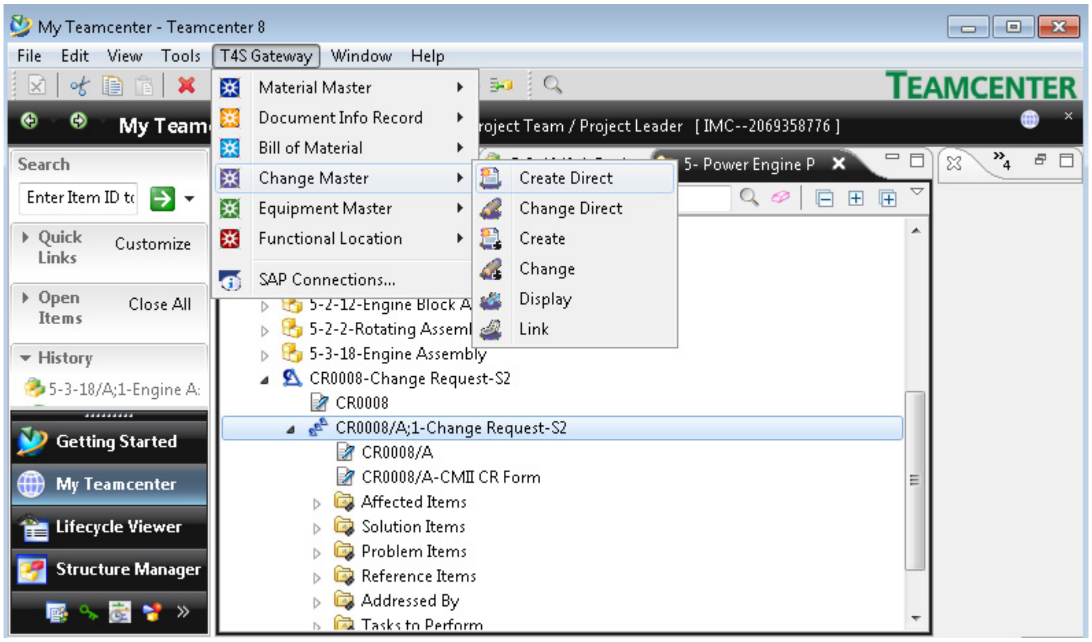


Figure 4.23 Screen print of opening T4S model Change Master-Create Direct

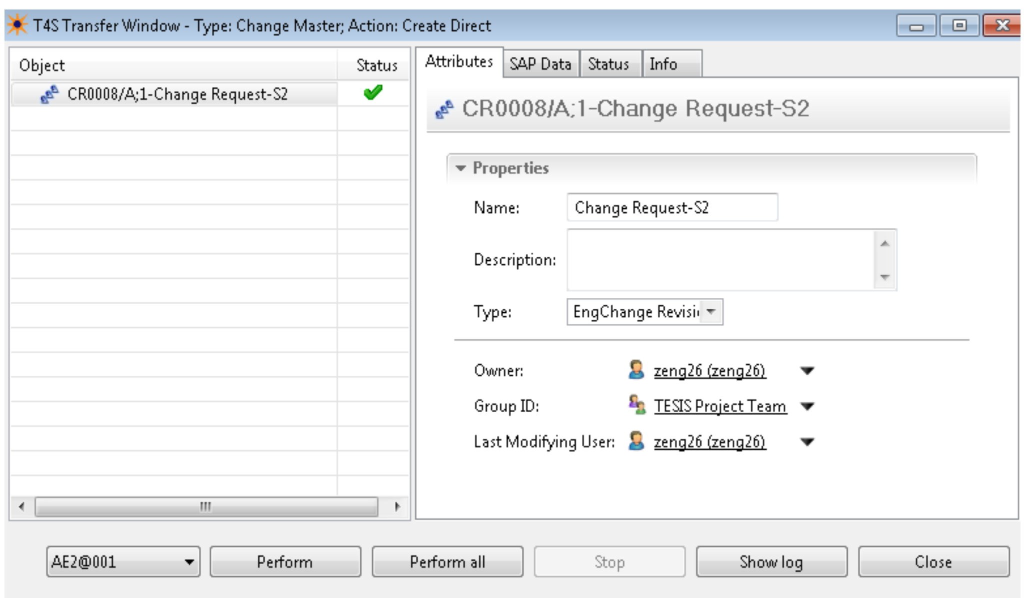


Figure 4.24 Screen print of T4S transfer window of Change Master-Create Direct

Step 7: Checked the change master created in SAP ERP system as shown in Fig 4.25 and Fig 4.26 by using transaction code CC03.

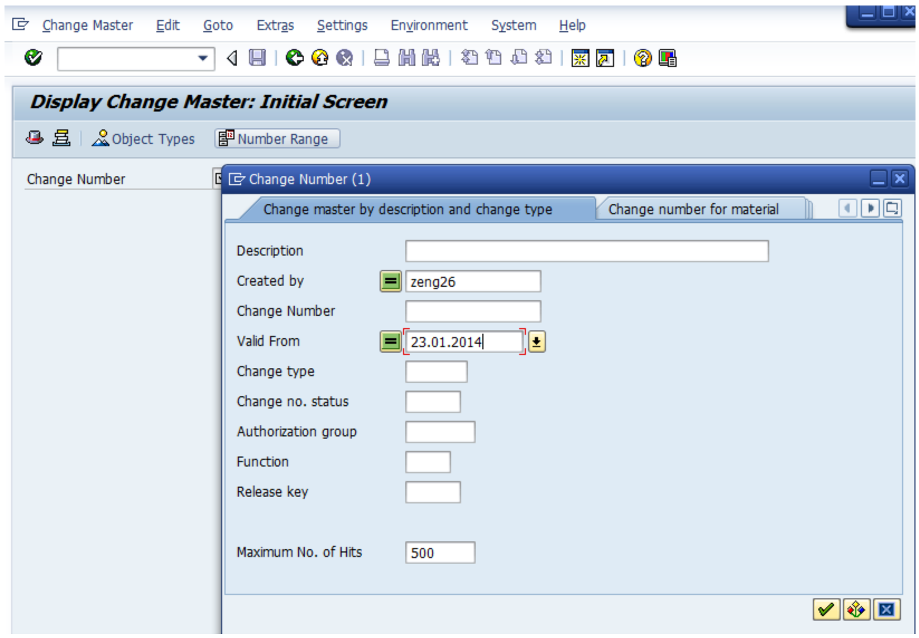


Figure 4.25 Screen print of searching change master in SAP ERP

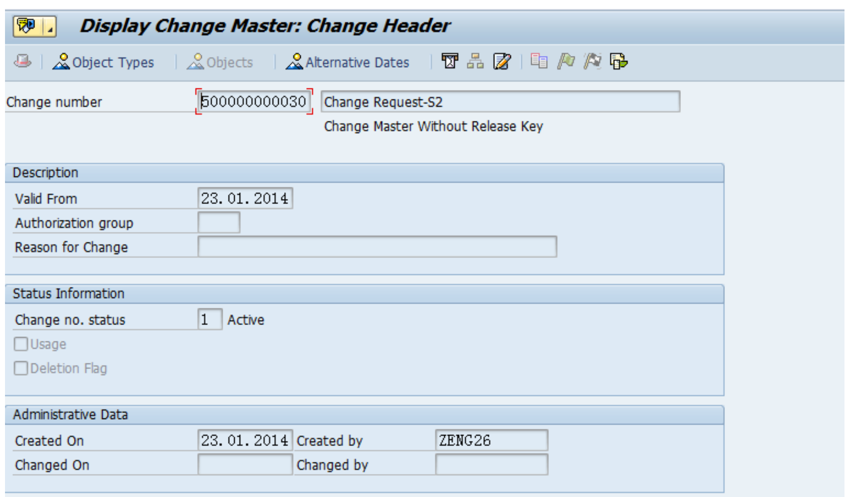


Figure 4.26 Screen print of displaying change master created in SAP ERP

Step 8: In "My Teamcenter" screen, released the change request S2 through workflow process of T4S_ECM as shown in Fig 4.27 and 4.28 by clicking File-> New-> Workflow Process.

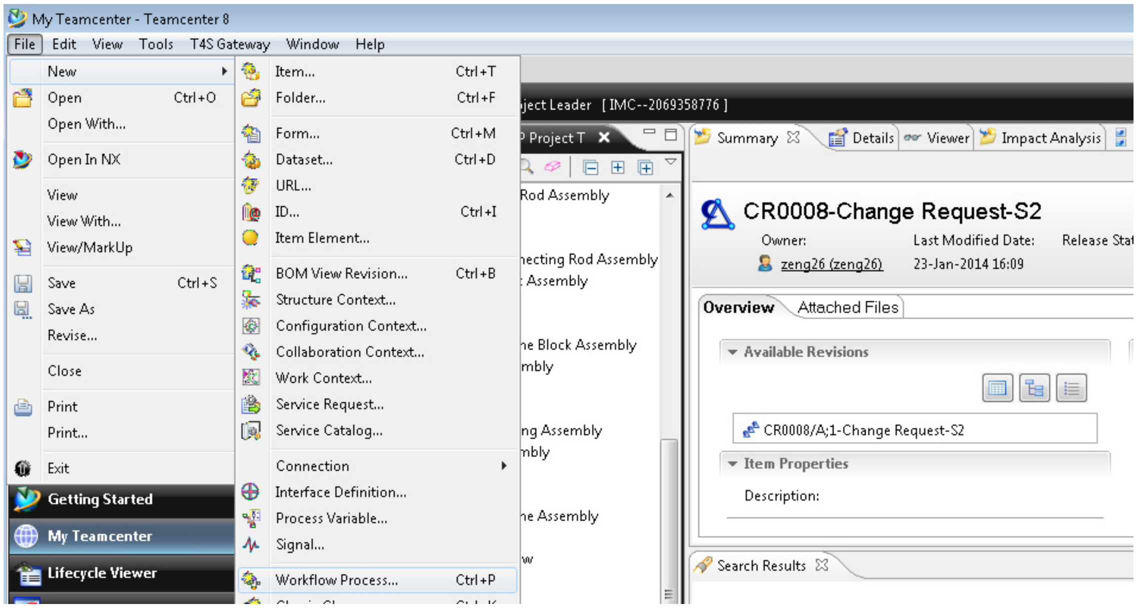


Figure 4.27 Screen print of opening workflow processes in TC PLM

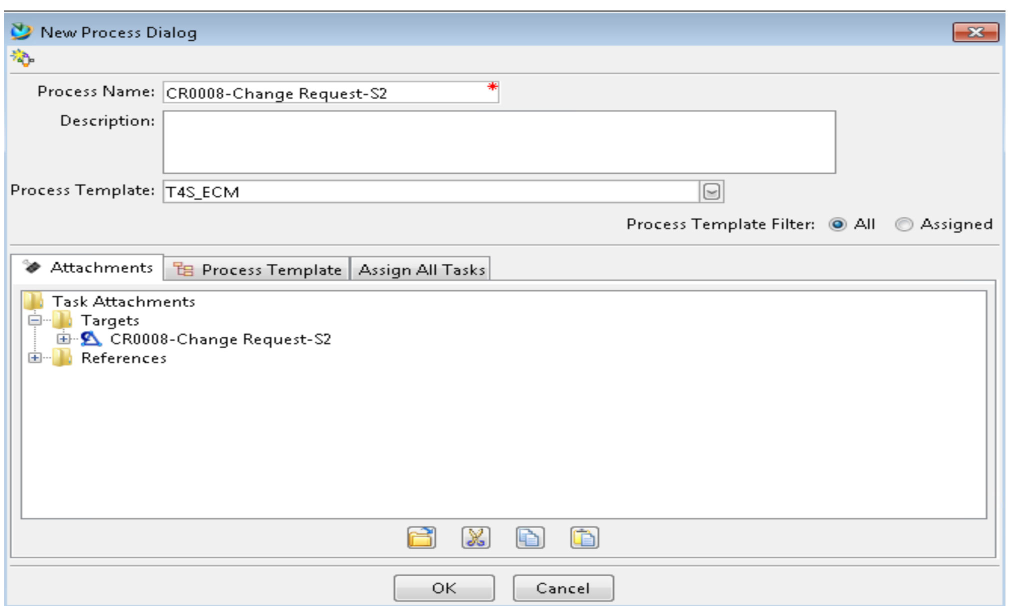


Figure 4.28 Screen print of releasing change request S2 through T4S_ECM workflow

4.2.3 Scenario 3

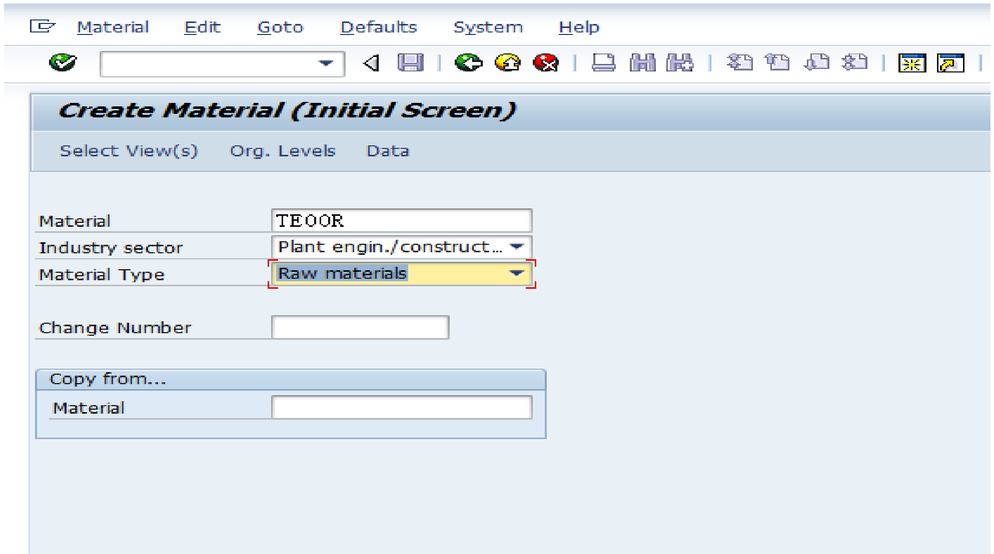
In this scenario, a new part from SAP ERP was imported to TC PLM. A BOM in TC PLM was modified by adding this new part, and then the related BOM in SAP ERP was synchronized. The BOM data transferred in scenario 3 were recorded as Table 4.3.

Table 4.3

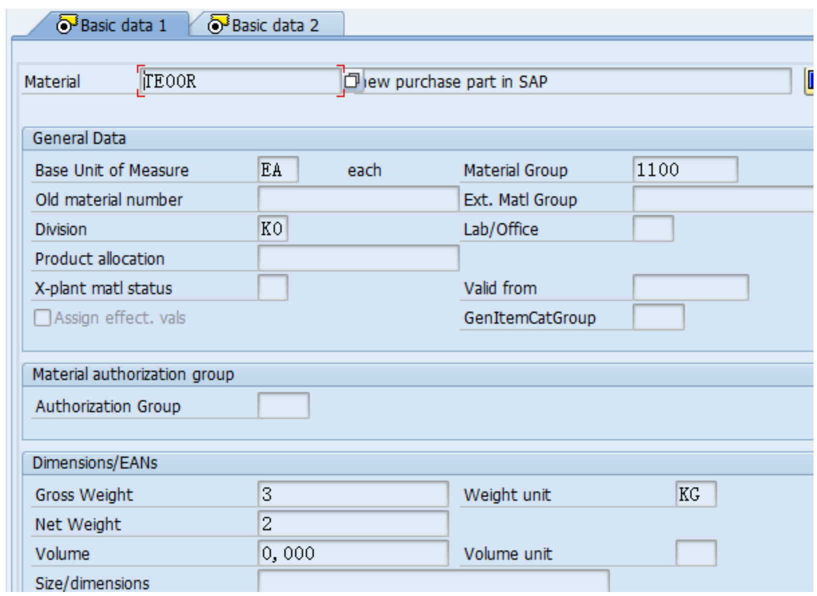
The records of BOM 5-3-18 under engineering change in scenario 3

BOM in TC PLM				BOM in SAP ERP			
Part No.	**Quantity**	**Unit**	**Structure**	**Part No.**	**Quantity**	**Unit**	**Structure**
5-3-18	1	Each	End-Product	5-3-18	1	Each	End-Product
5-1-1	1	Each	Component	5-1-1	1	Each	Component
5-2-2	1	Each	Subassembly	5-2-2	1	Each	Subassembly
5-1-3	1	Each	Component	5-1-3	1	Each	Component
5-1-6	1	Each	Component	5-1-6	1	Each	Component
5-1-7	2	Each	Component	5-1-7	2	Each	Component
5-1-8	2	Each	Component	5-1-8	2	Each	Component
5-1-10	1	Each	Component	5-1-10	1	Each	Component
5-2-11	1	Each	Subassembly	5-2-11	1	Each	Subassembly
5-1-4	1	Each	Component	5-1-4	1	Each	Component
5-1-5	1	Each	Component	5-1-5	1	Each	Component
5-1-9	2	Each	Component	5-1-9	2	Each	Component
5-2-12	1	Each	Subassembly	5-2-12	1	Each	Subassembly
5-1-13	1	Each	Component	5-1-13	1	Each	Component
5-1-14	1	Each	Component	5-1-14	1	Each	Component
5-1-15	1	Each	Component	5-1-15	1	Each	Component
5-1-16	1	Each	Component	5-1-16	1	Each	Component
5-1-17	1	Each	Component	5-1-17	1	Each	Component
5-1-99	1	Each	Component	5-1-99	1	Each	Component
TE00R	1	Each	Component	TE00R	1	Each	Component

Step 1: Created a new product part by using transaction code MM01 in SAP ERP as shown in Fig 4.29.



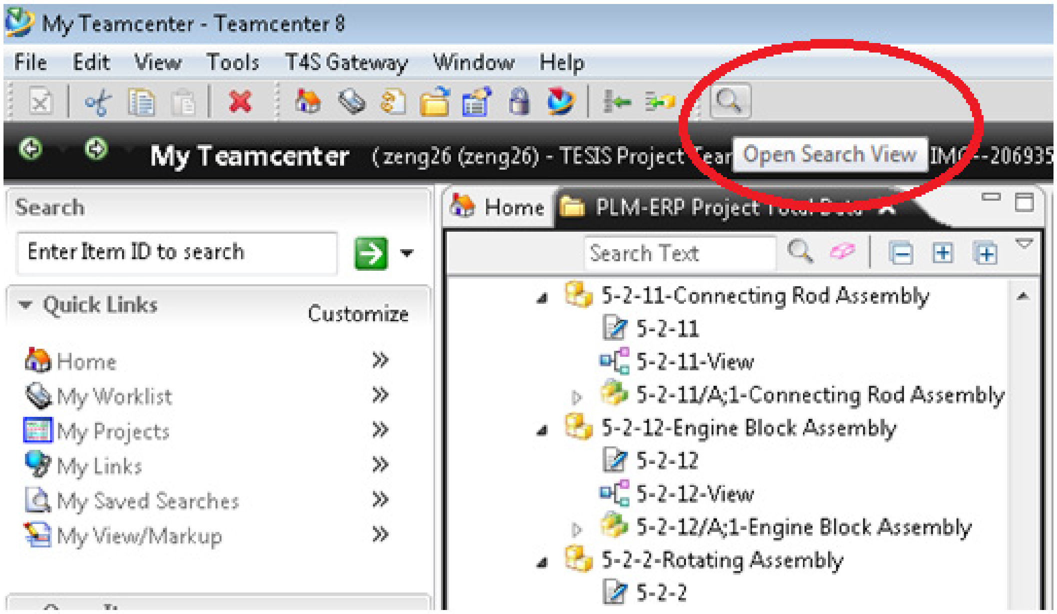
(1)



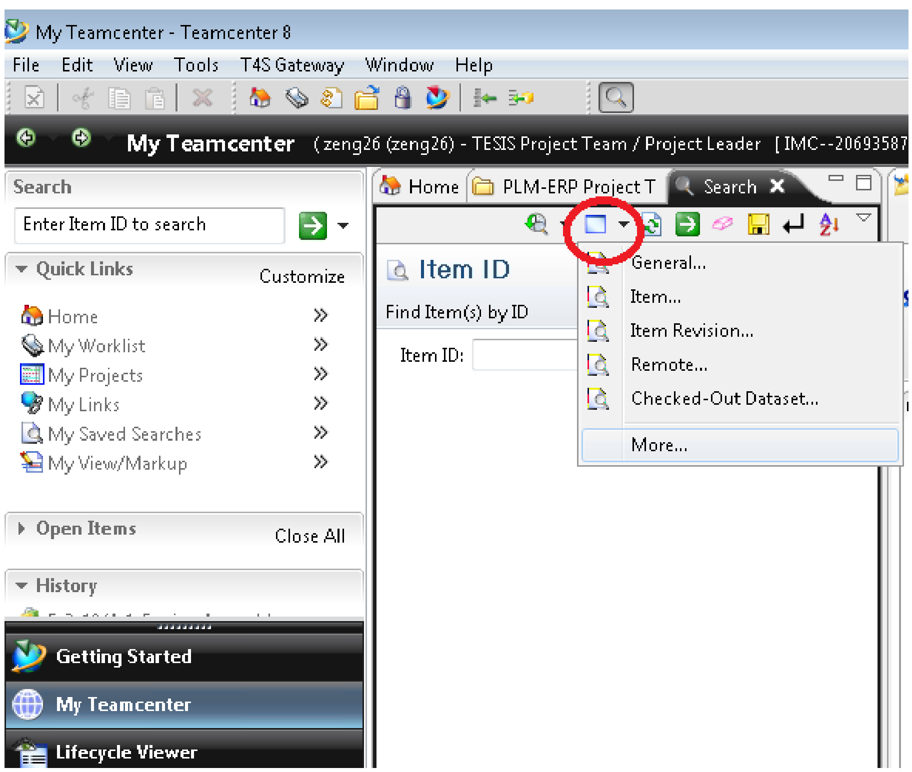
(2)

Figure 4.29 (1)-(2) Screen print of creating TE00R in SAP ERP

Step 2: Searched new product part TE00R stored in SAP ERP by openning search view, and choosing T4S_DEMO_QUERY in TC PLM as shown in Fig 4.30 and Fig 4.31. Imported TE00R from SAP ERP into TC PLM by importing T4S Query row as shown in Fig 4.32.


My Teamcenter - Teamcenter 8
File Edit View Tools T4S Gateway Window Help
My Teamcenter
Open Search View
Search
Enter Item ID to search
Quick Links
Customize
Home
My Worklist
My Projects
My Links
My Saved Searches
My View/Markup
Search Text
5-2-11-Connecting Rod Assembly
5-2-11
5-2-11-View
5-2-11/A;1-Connecting Rod Assembly
5-2-12-Engine Block Assembly
5-2-12
5-2-12-View
5-2-12/A;1-Engine Block Assembly
5-2-2-Rotating Assembly
5-2-2

(1)


My Teamcenter - Teamcenter 8
File Edit View Tools T4S Gateway Window Help
My Teamcenter (zeng26 (zeng26) - TESIS Project Team / Project Leader [IMC--20693587
Search
Enter Item ID to search
Quick Links
Customize
Home
My Worklist
My Projects
My Links
My Saved Searches
My View/Markup
Open Items
Close All
History
Getting Started
My Teamcenter
Lifecycle Viewer
Home
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Remote...
Checked-Out Dataset...
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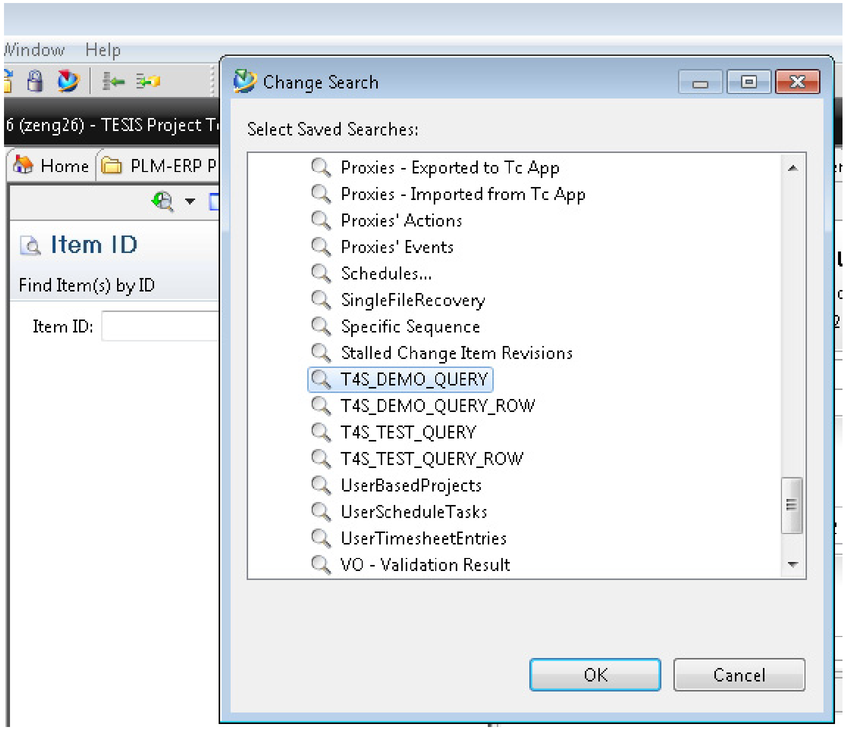
(2)



(3)

Figure 4.30 (1)-(3) Screen print of opening T4S_Demo_Query in TC PLM

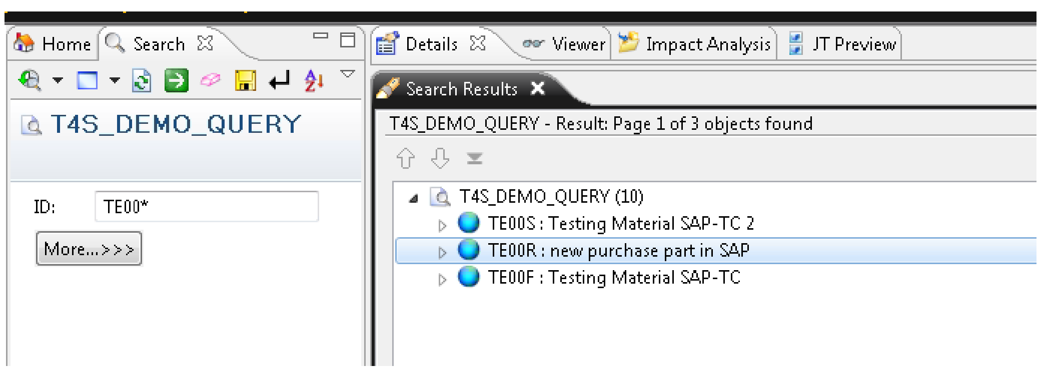


Figure 4.31 Screen print of search results in TC PLM

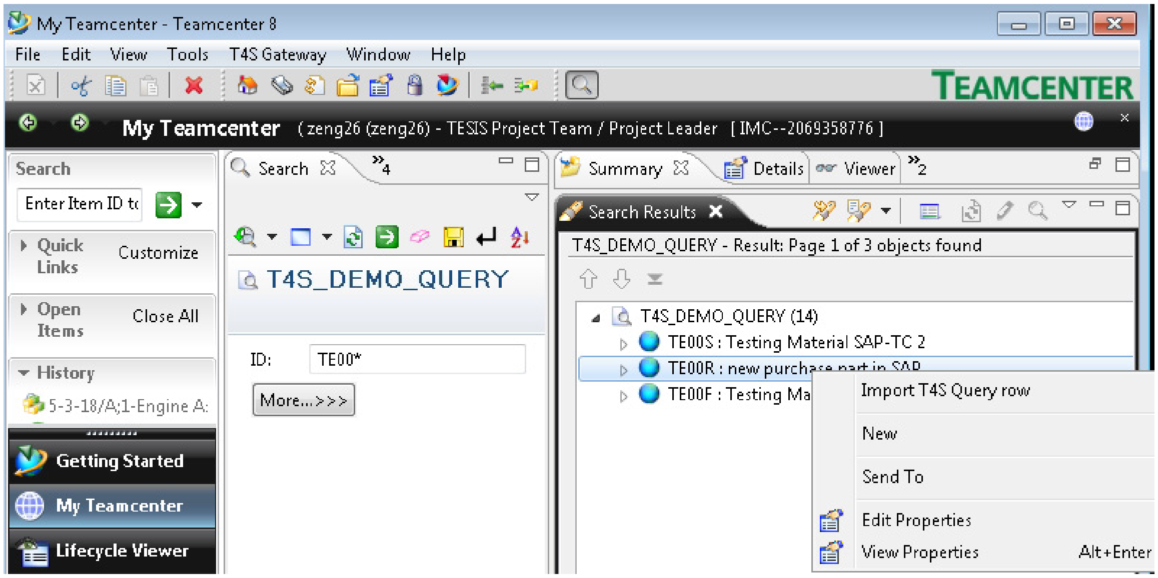


Figure 4.32 Screen print of importing TE00R through T4S query row

Step 3: In "structure manager " screen, searched TE00* in search bar and added TE00R to 5-3-18 as shown in Fig 4.33-Fig 4.35 by copying and pasting TE00R to 5-3-18 BOM structure. Fig 4.36 shows the BOM strucure of 5-3-18 in scenario 3.

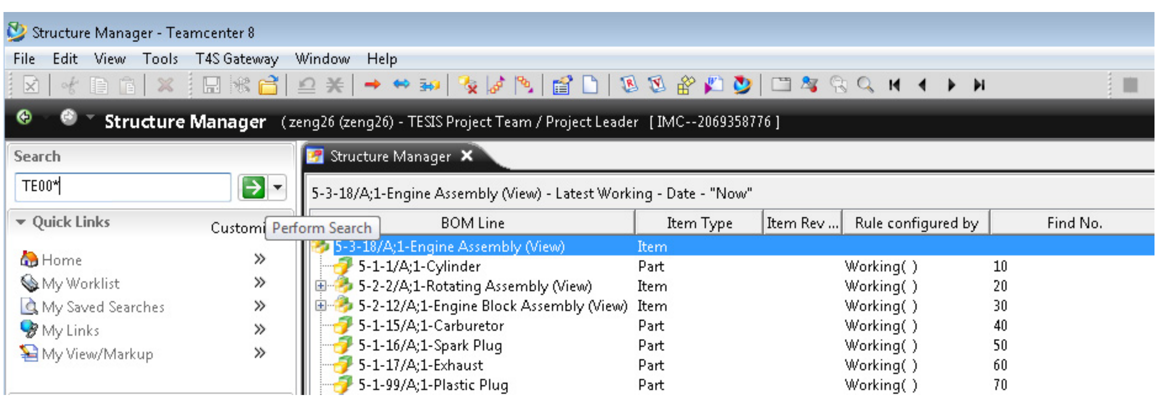


Figure 4.33 Screen print of searching TE00R in TC PLM

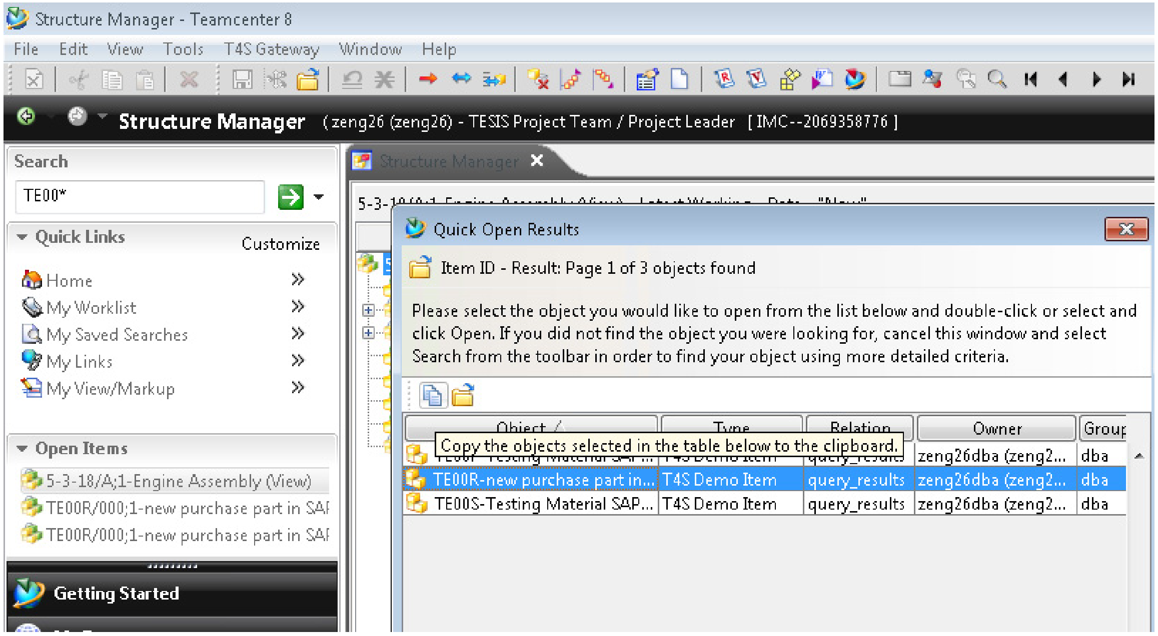


Figure 4.34 Screen print of copying TE00R

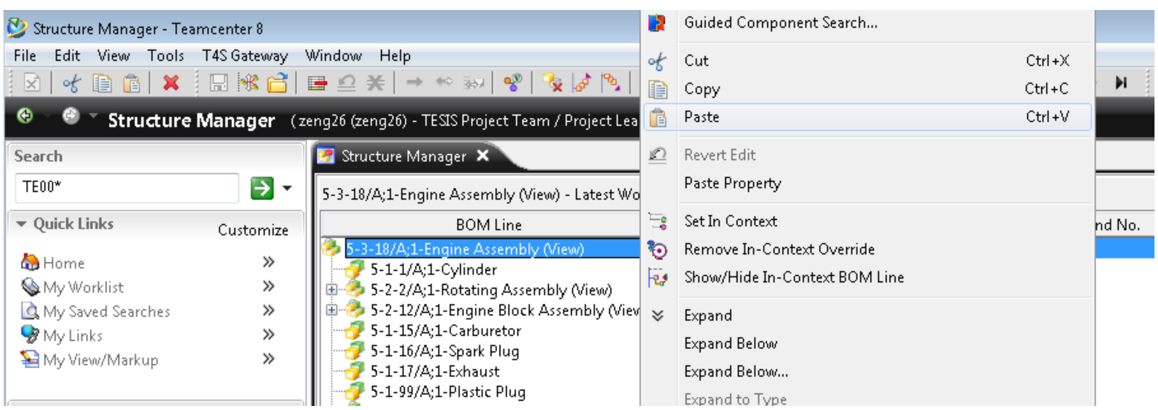


Figure 4.35 Screen print of pasting TE00R to BOM 5-3-18

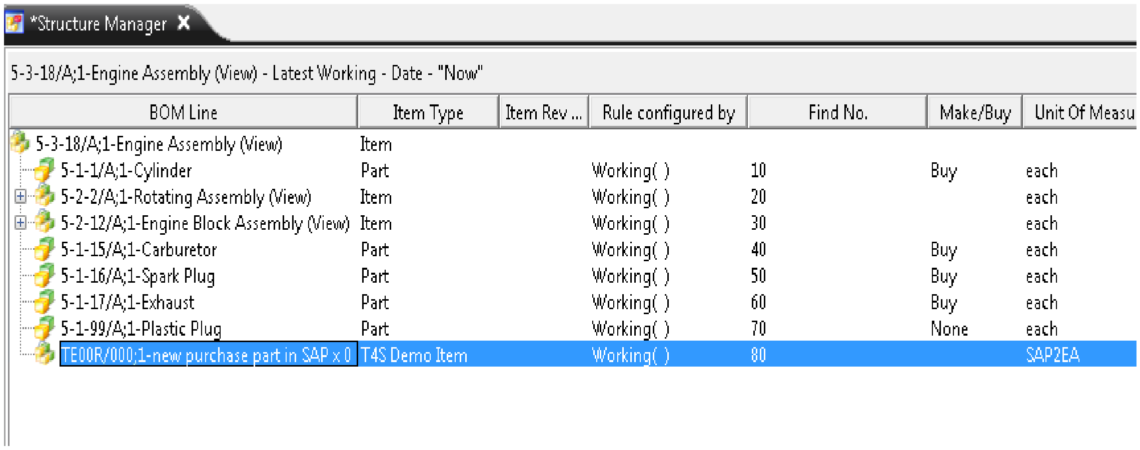


Figure 4.36 Screen print of BOM 5-3-18 in scenario 3

Step 4: Updated the related BOM in SAP ERP through T4S_BOM workflow. Open a new workflow process as shown in Fig 4.37- Fig 4.38 by clicking File-> New-> Workflow Processes.

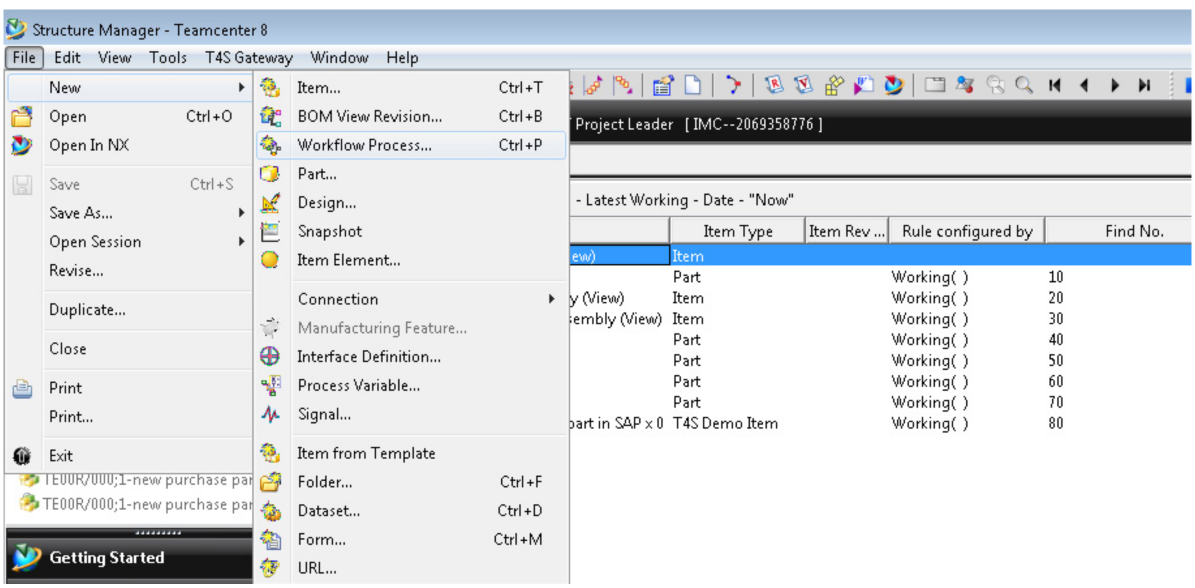


Figure 4.37 Screen print of opening workflow process in TC PLM

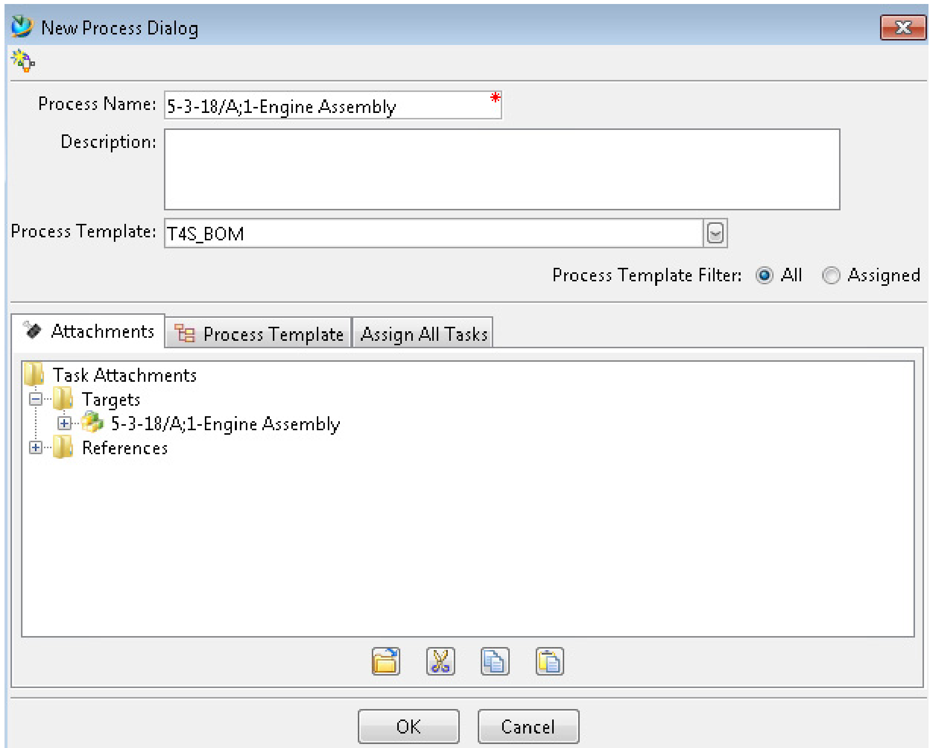


Figure 4.38 Screen print of workflow process of T4S_BOM in TC PLM

Step 5: Checked the related BOM in SAP ERP system as shown in Fig 4.39 by using transaction code CS03.

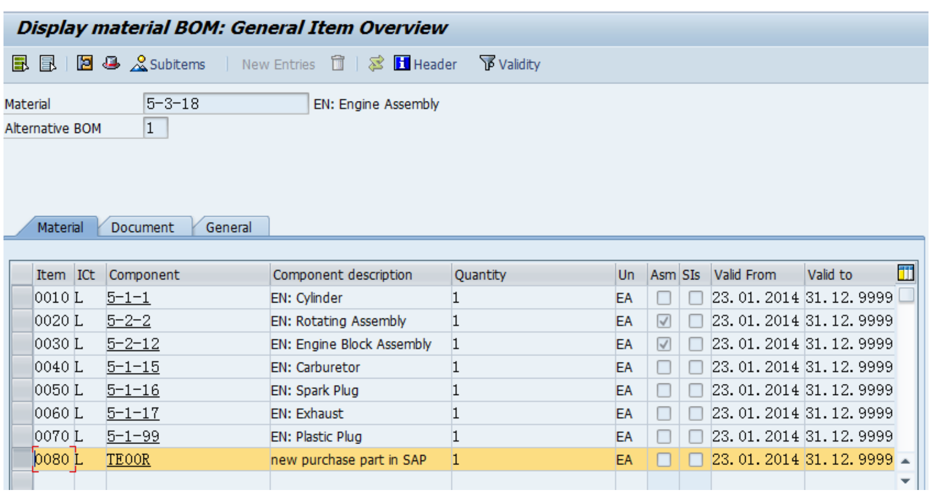


Figure 4.39 Screen print of BOM 5-3-18 in SAP ERP in scenario 3

Step 6: In "My Teamcenter" screen, created Change Request S3 in TC PLM system as shown in Fig 4.40 by opening classic change, and attached 5-3-18 to this Change Revision as shown in Fig 4.41.

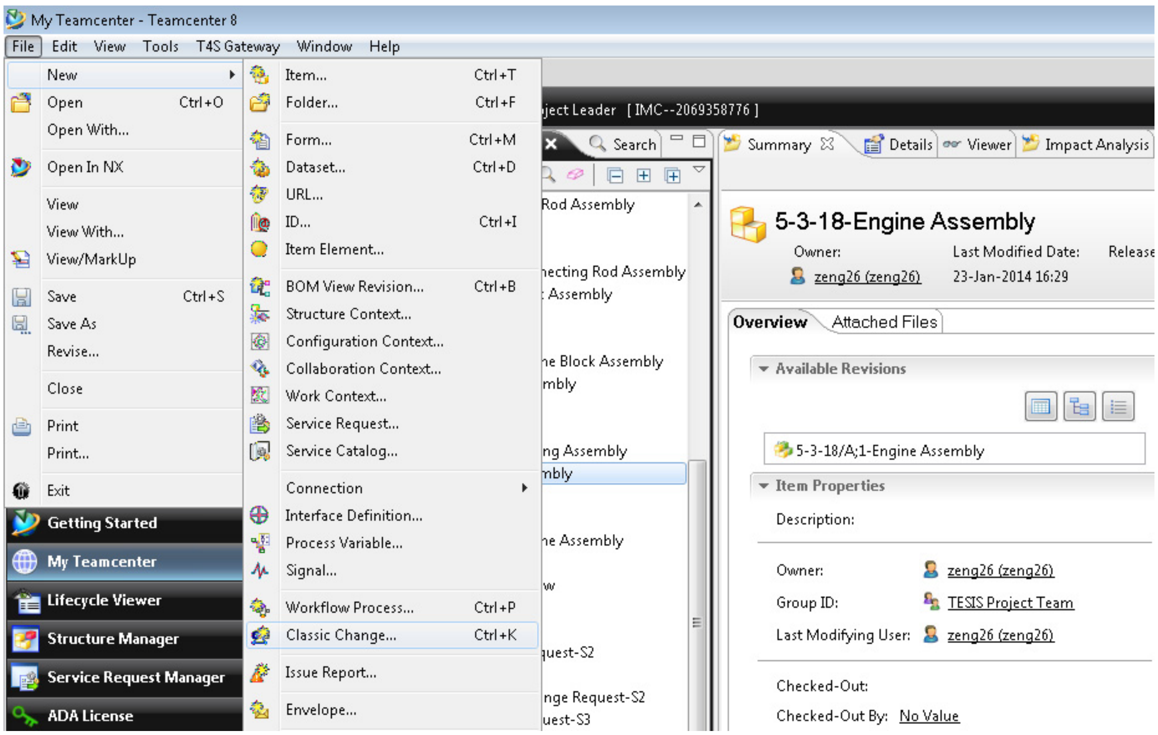


Figure 4.40 Screen print of opening classic change in TC

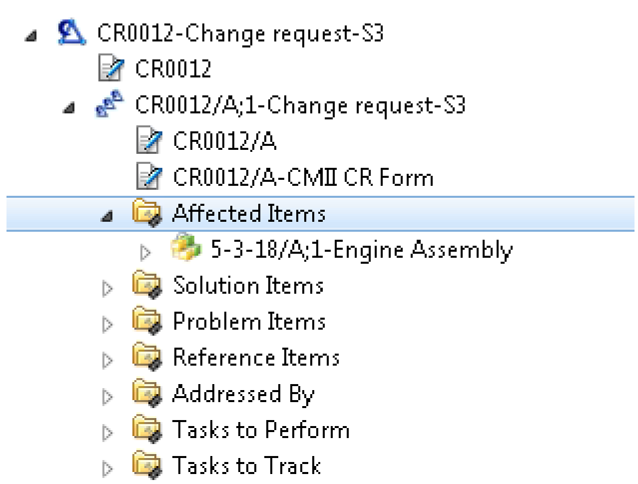


Figure 4.41 Screen print of attaching 5-3-18 as affected item of change request S3

Step 7: Created a Change Master for the related BOM in SAP ERP system as shown in Fig 4.42 by clicking T4S Gateway-> Change master-> Create Direct, and transferred change request S3 from TC PLM to SAP ERP through T4S transfer window of Change Master-Create Direct as shown in Fig 4.43.

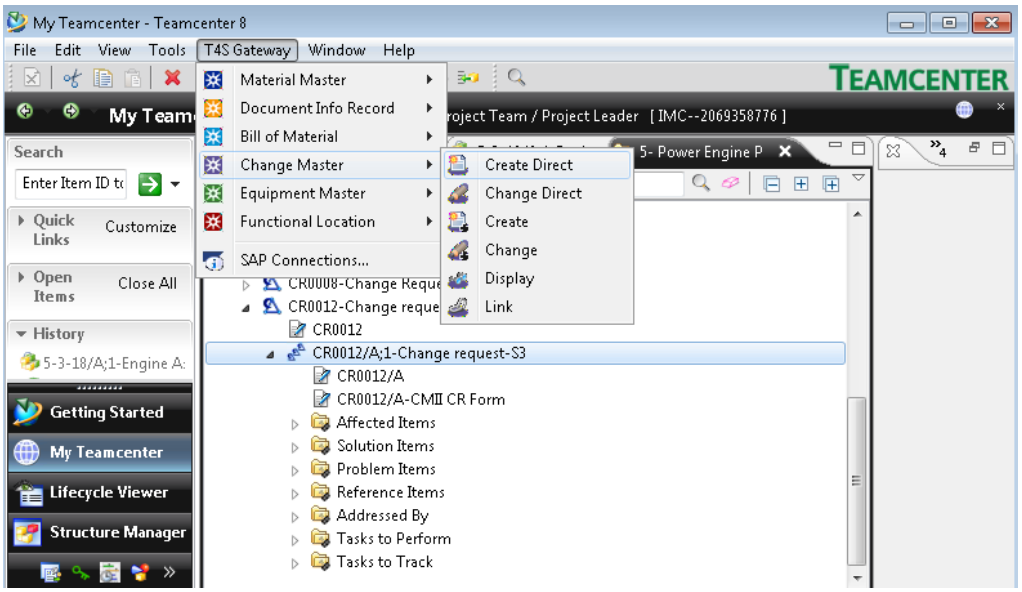


Figure 4.42 Screen print of opening T4S model Change Master-Create Direct

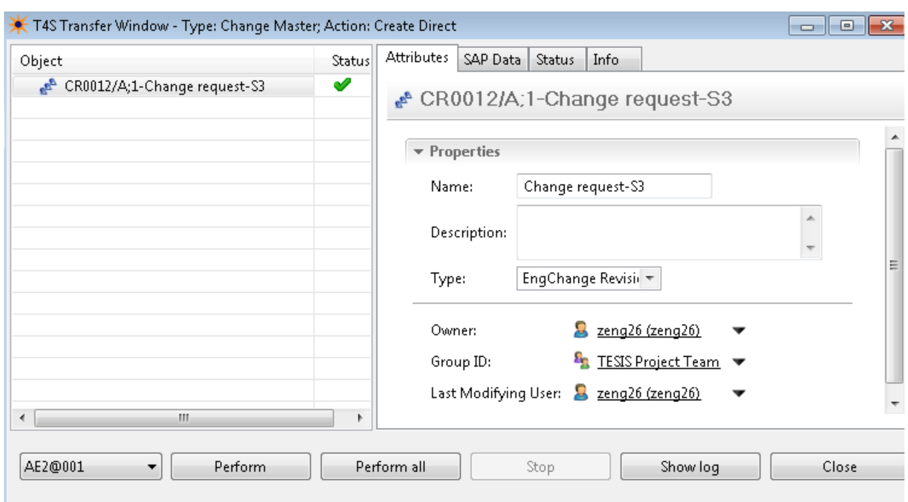


Figure 4.43 Screen print of T4S transfer window of Change Master –Create Direct

Step 8: Checked the SAP Change Master in SAP ERP system by using transaction code CC03 as shown in Fig 4.44 and Fig 4.45.

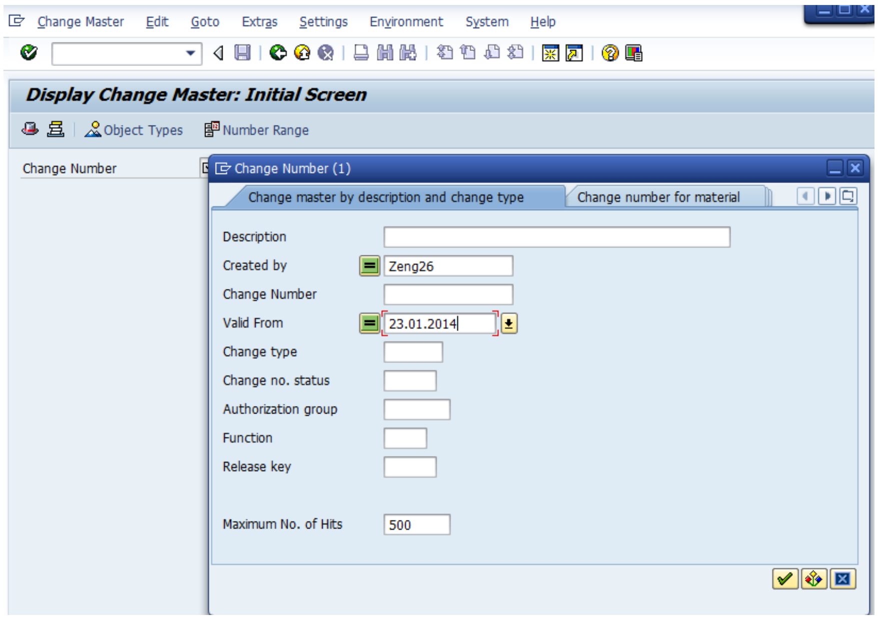


Figure 4.44 Screen print of SAP transaction CC03

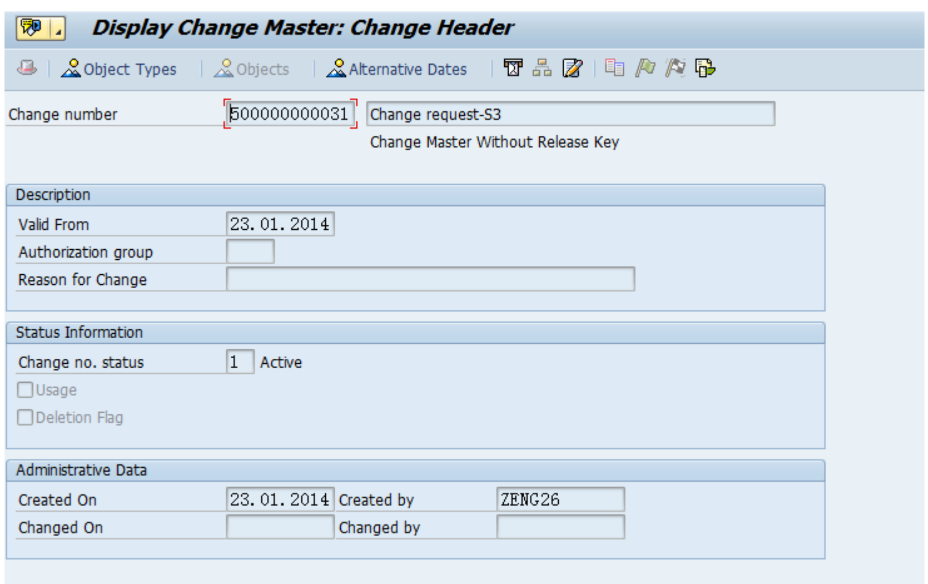


Figure 4.45 Screen print of displaying change request S3 in SAP ERP

Step 9: Released the Change Revision through workflow process of T4S_ECM as shown in Fig 4.46-Fig 4.47.

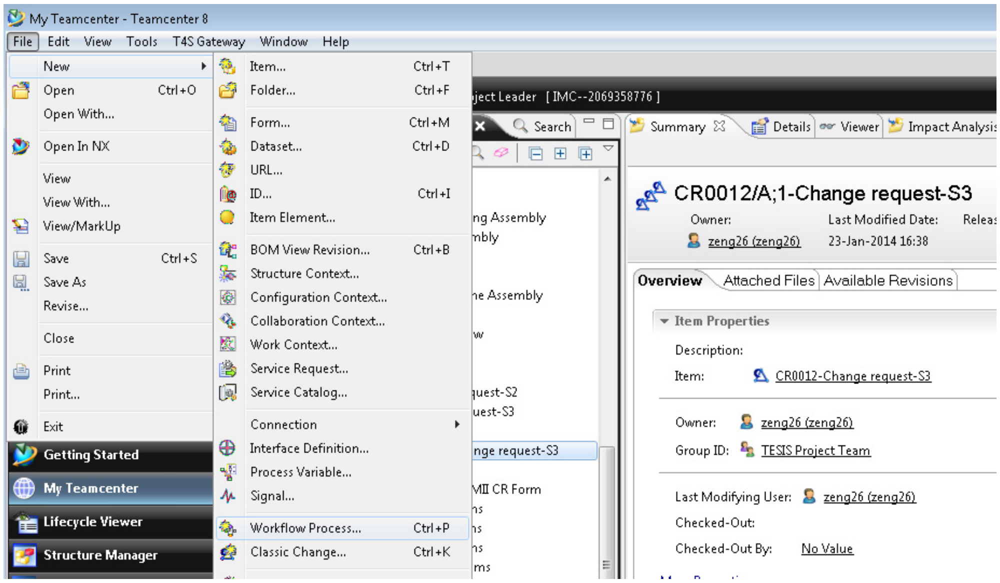


Figure 4.46 Screen print of opening workflow processes in TC PLM

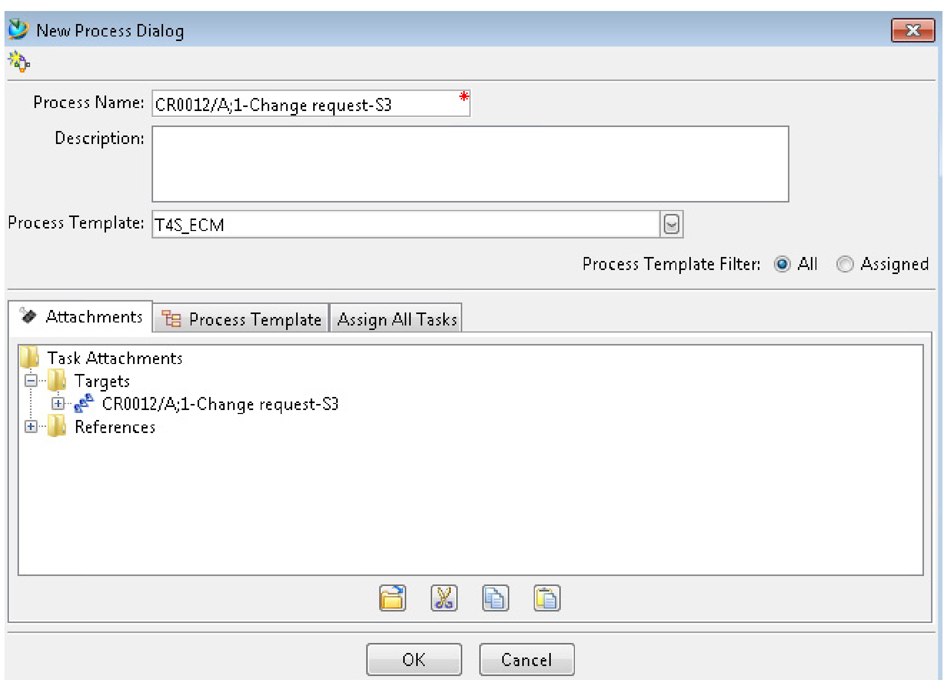


Figure 4.47 Screen print of releasing change request S3 through T4S_ECM workflow

CHAPTER 5. SUMMARY, DISCUSSION AND FUTURE RESEARCH

This study developed a sandbox for demonstrating BOM transmission in a PLM and ERP integrated system. The study helps to enhance user's comprehension of how to relate business processes to transactions in a PLM and ERP integrated system. In chapter 4, key considerations of integration and the key steps of BOM transmission scenarios and findings were presented. The BOM accuracy was also examined by comparing BOM data in the PLM system to BOM data in the ERP system after implementing engineering changes.

5.1 Research results summary

Key considerations of integrating PLM and ERP systems, including data and process ownership, master source of information, and the level of integration, were discussed. BOM and change request data was shared between the PLM and ERP integrated systems. In order to ensure the data consistency, the PLM system was assigned as "owner" and "controller", as BOM data and change request data was generated from the processes of engineering design. The PLM system was the only source of BOM and change request data, which was integrated between PLM and ERP. The direction of data flow was decided based on work scenario requirements. For example, the product part information was bi-directional between PLM and ERP, as in concurrent engineering scenarios, where the design engineer who stores data in the PLM system or the sourcing engineer who stores data in the ERP system may create new product part data. Meanwhile, the accessibility of information and the system assignment of business processes were determined to meet specific needs for the work scenarios. The manufacturing engineer (in ERP) needed to check the BOM and BOM change request data that was created by the design engineer in the PLM system, so the BOM and change request data was accessible in both systems. The process of creating and editing BOM and change request was managed in PLM, as PLM was the only source of BOM and change request data in this study. The Enterprise Application Integration (EAI) tool can automatically create the BOM and change request data in the ERP system.

Key steps for transferring BOM data in the TC PLM and SAP ERP integrated system was documented through screen prints of the transferring processes. By summarizing the data collected in these three scenarios, the BOM transmission processes in this study included both forward mapping and reverse mapping. The forward mapping shows the direction of data flow from TC PLM to SAP ERP, while the reverse mapping shows the direction of data flow from SAP ERP to TC PLM. Fig 5.1 shows the data transferred path. The data elements from the BOM View, Item Revision and EngChange Revision were moved from TC PLM to SAP ERP as BOM, Material Master and EngChange, while the Material Master data field was successfully moved from SAP ERP to TC PLM as Item Revision in this study.

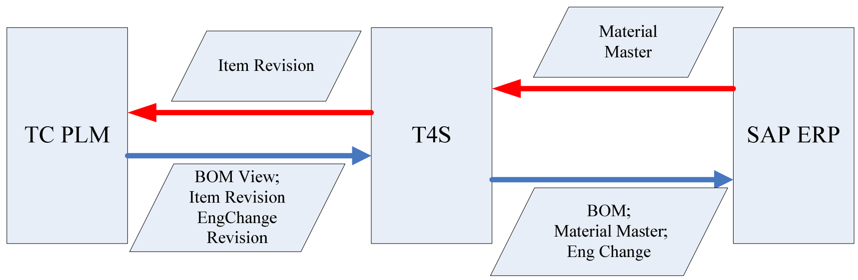


Figure 5.1 The data transferred path in this study

In Fig 5.2, forward mapping was performed between the PLM and ERP integrated systems, and the data types of BOM View, Item Revision in TC PLM were successfully transferred to SAP ERP as BOM and Material Master. The

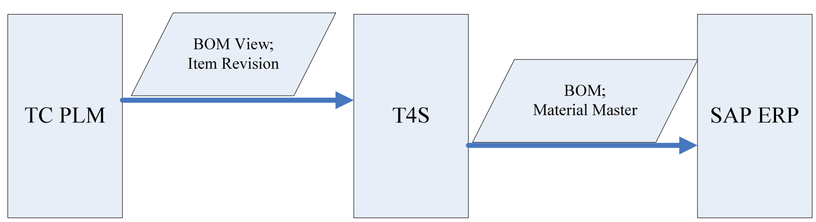


Figure 5.2 The data transferred plan for scenario 1

BOM transmission process in scenario 1 represents the following work scenario in a company: after design engineers creating BOM for a product in TC PLM system, the BOM was sent to SAP ERP system through T4S to support manufacturing operations. Before implementing T4S transactions, the SAP ERP system did not have any material master and BOM data. BOM data can be created in the ERP system through the transactions listed in scenario 1.

As shown in Fig 5.3, forward mapping was performed. The BOM View, Item Revision, and EngChange Revision data fields in TC PLM were successfully transferred to SAP ERP as BOM, Material Master and Eng Change. In the work

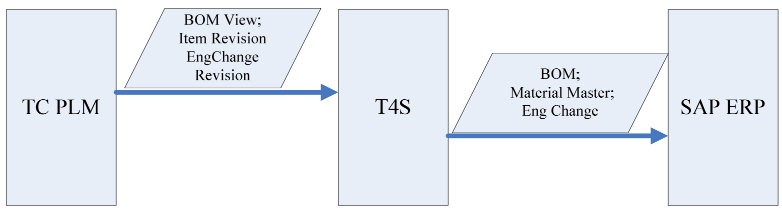


Figure 5.3 The data transferred plan for scenario 2

scenario represented by BOM transmission scenario 2, design engineers changed BOM data in the TC PLM system, and then synchronized the related BOM in SAP ERP through T4S transactions. A request for this engineering change was created in TC PLM, and was sent to SAP ERP through T4S transactions. All changes on the BOM in SAP ERP were implemented using T4S transactions. The design engineer can easily synchronize the BOM change on TC PLM to SAP ERP without extra transactions in SAP ERP.

In Fig 5.4, forward mapping and reverse mapping were successfully performed. The data types of BOM View, EngChange Revision in TC PLM were transferred to SAP ERP as BOM and EngChange, while the data types of Material Master in SAP ERP were successfully transferred to TC PLM as Item Revision in scenario 3. In this work scenario, sourcing engineers, who typically work in SAP ERP system, introduced a new part from a supplier company by creating this new part data in SAP ERP system. Design engineers searched this new part number in TC PLM system through T4S transaction, and imported this new part to TC PLM system from SAP ERP. After using this new part to modify the product BOM in the TC PLM system, the related BOM was synchronized in SAP ERP through workflow processes. An engineering change request was created in TC PLM to reflect this change, and was sent to SAP ERP through T4S transactions. The engineers who work separately on either a PLM or ERP system can share information in this manner in PLM and ERP integrated systems.

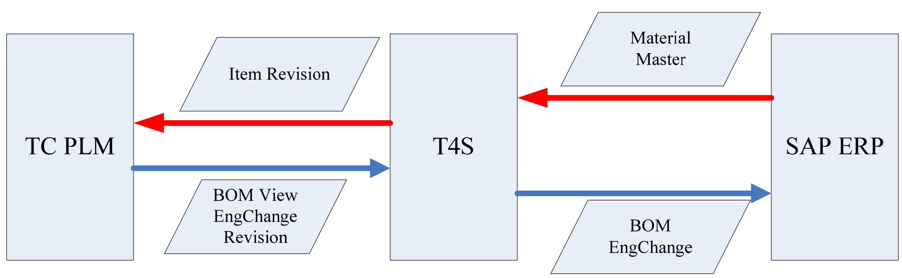


Figure 5.4 The data transferred in scenario 3

The BOM transmission of three work scenarios was validated by visually comparing BOM data in TC PLM to the related BOM data in SAP ERP. The product parts and BOM structures observed in SAP ERP matched the data in TC PLM in scenario 1. In scenario 2, a change of BOM observed in SAP ERP was the same as change of BOM in TC PLM. A new product part 5-1-99 was added on BOM 5-3-18 in TC PLM system, and a related BOM in SAP ERP system was updated through engineering change management workflow successfully. In scenario 3, a product part in SAP ERP was searched and imported to TC PLM. The design engineer can synchronize BOM in TC PLM to SAP ERP without extra transactions in SAP ERP and use information stored in SAP ERP in the PLM and ERP integrated system. Additional validation for the SAP ERP system configuration and expected material master data was performed through comparing the material master data from a separate SAP client dataset. This allowed the researcher to validate the typical data that would be present in the material master file. The TC PLM validation was conducted through discussions with the TC PLM experts in the PLM Center. The data was verified for consistency with the typical TC PLM data files.

5.2 Discussion

A sandbox was developed for demonstrating BOM transmission in a PLM and ERP integrated system. Key considerations of integration and key steps of BOM transmission scenarios were documented. This research can help to enhance users' understanding on a PLM and ERP integrated system by demonstrating the linkage of business processes and transactions in a PLM and ERP integrated system, and providing an overview of BOM transmission processes in this integrated system. This knowledge may help companies make decisions when choosing software systems for their business or to improve business process by introducing integrated system. The biggest challenges were to identify key considerations for the integration objective, as it requires knowledge of the systems—the PLM system, the ERP system and the EAI system. Either TC PLM or SAP ERP system can work as the master to own and control information and processes in a PLM and ERP integrated system. The PLM system is generally chosen to be the master in a company where BOM and change request data is generated from the processes of engineering design. However, in a company who assembles purchased and semi-finished products, it may be better to choose the ERP system as the master. For these companies, the majority of necessary data for the processes of procurement and fulfillment, so generally the ERP system should control the data transmissions.

The BOM transmission processes were identified by reviewing documents about engineering change and concurrent engineering. The knowledge of the PLM and EAI systems was gained by studying user manuals. Knowledge of the ERP system was gained by studying the SAP ERPSim game. When launching a project of integrating PLM and ERP in a company, besides having experts of Information Technology, it is better to involve experts from different departments in this company to generate a detailed list of integration objectives. These experts need to have enough knowledge of work scenarios and business processes, such as designing, manufacturing, accounting and other key processes can be developed from these objectives to ensure the PLM and ERP integrated system meets users' needs. Integration objectives include, but are not limited to, the product properties, the processes related to the product, and workflow of processes.

This study enhanced the collaboration between unique functional areas at Purdue University including the Supply Chain Management Technology

Laboratory, College of Technology PLM Center, Information Technology at Purdue and Purdue Engineering Computer Network. Several months were required to install and configure software, and several technical problems occurred during this process, such as the disconnection between TC PLM servers and SAP ERP, and transaction failures of T4S. These experiences provided learning opportunities for all participants, and enhanced the programing and system configuration and integration skills, which are required to build the PLM and ERP integrated system in a laboratory environment. This sandbox was developed in a lab environment, which has the risk of oversimplification.

5.3 Future research

To validate the sandbox developed for this research, future cooperation with industry to develop research scenarios might be needed. A future study may also improve this sandbox by evaluating users' learning performance on using transactions in the PLM and ERP integrated. Future research topics could be created to demonstrate BOM transmission processes under different workflow designs. The complexity of engineering change management increases as the user roles in workflow increase. The processes of BOM transmission might vary under different workflow designs. Another future expansion could incorporate TC MRO (Maintenance, repair, and overhaul) software functionality in the TC PLM and SAP ERP integrated system. By sharing and updating complete and accurate maintenance information in the PLM and ERP integrated system, maintenance data visibility might be enhanced. A sandbox could be developed to demonstrate BOM transmission processes in an aftermarket supply. The results of this research can help users understand how the PLM and ERP integrated system involves with aftermarket supply chain and then help to facilitate the process of supply chain integration. Additional research addressing unique industry needs would enhance the existing sandbox, and better replicate complicated product designs within companies.

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APPENDICES

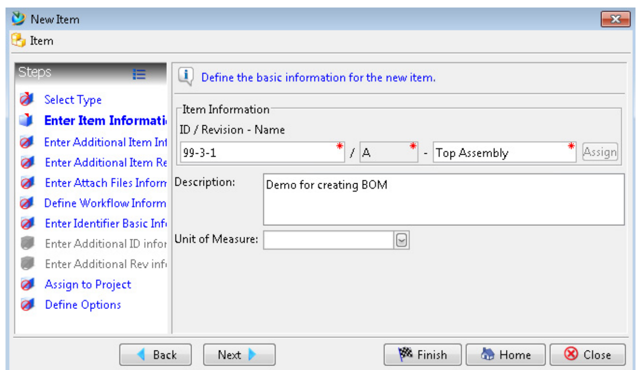
Appendix A Configuration of products in TC PLM system

In this study, the configuration of products in the TC PLM system included four steps shown as follows:

1) Created Top Assembly.

a. Opened Structure Manager in TC PLM system

b. Created new Items by following path: File-> New-> Item, and name the part and click Assign, then click next.



A 4 Screen print of creating new Items in TC PLM system

2) Created subassembly under the top assembly

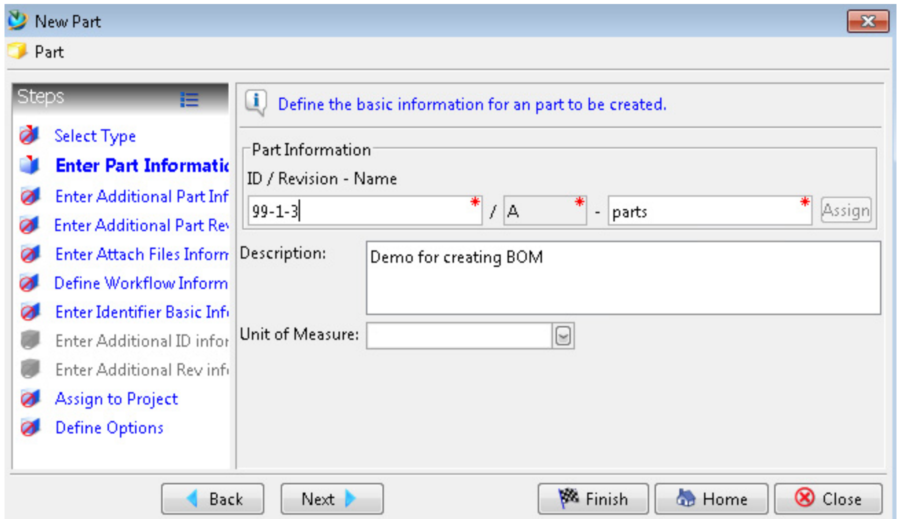
   a. Chose the Top Assembly item in Structure Manager

   b. Created new Items by following path: File-> New-> Item.

3) Created new parts in the right assembly level

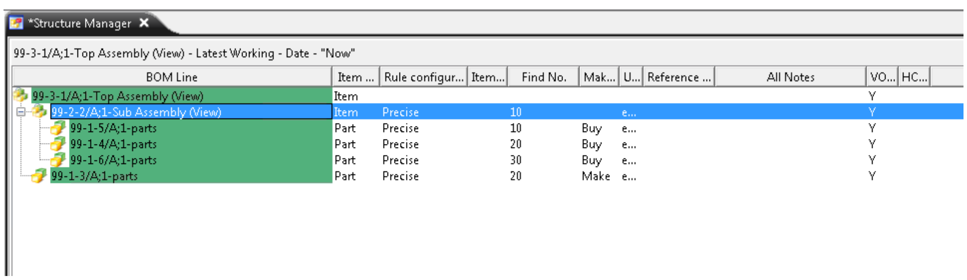
   a. Chose the assembly level that you want to add new parts in.

   b. Created new parts by following path: File-> New-> Parts, and name the part and click Assign.



A 5 Screen print of creating new part in TC PLM

4) Checked the BOM structure for Top Assembly 99-3-1.

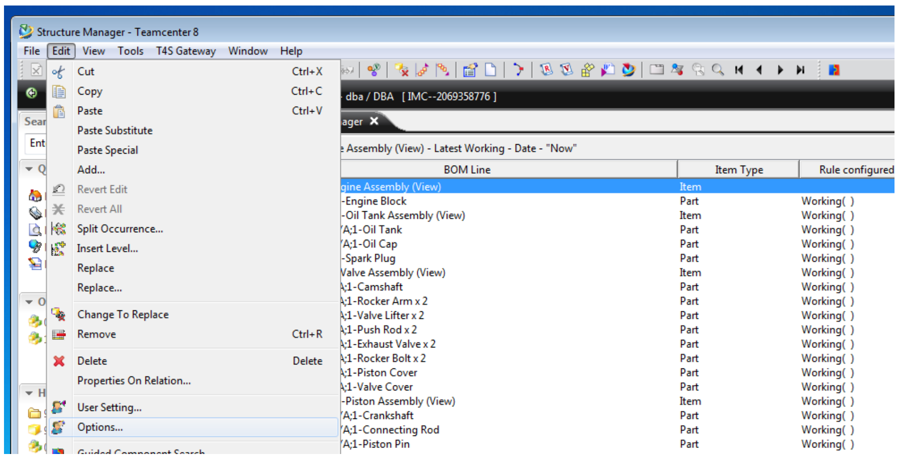


A 6 Screen print of sample BOM structure

Appendix B Configuration of T4S

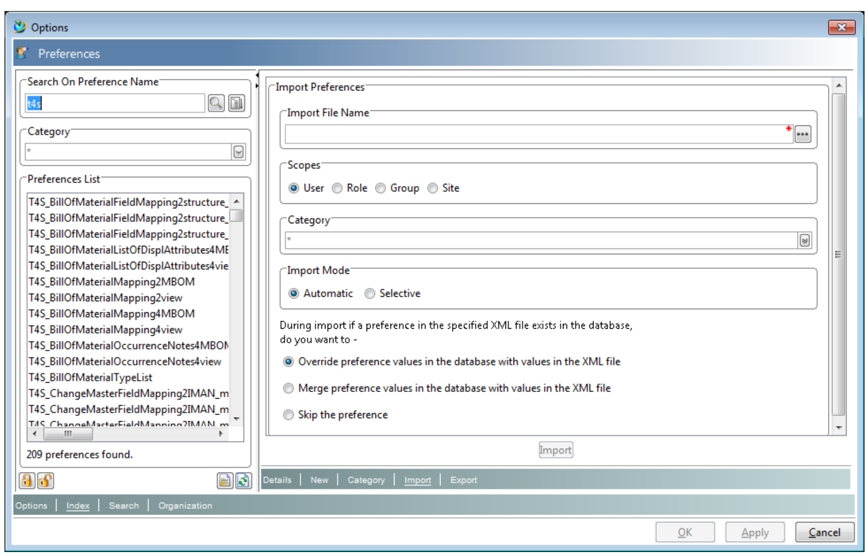
The detail steps of configuring T4S are shown in the Teamcenter gateway for SAP configuration Guide Version 9.1. The key steps of T4S configuration include:

1) Configure the data in the Teamcenter Preference by this path: Edit-> Option-> Index



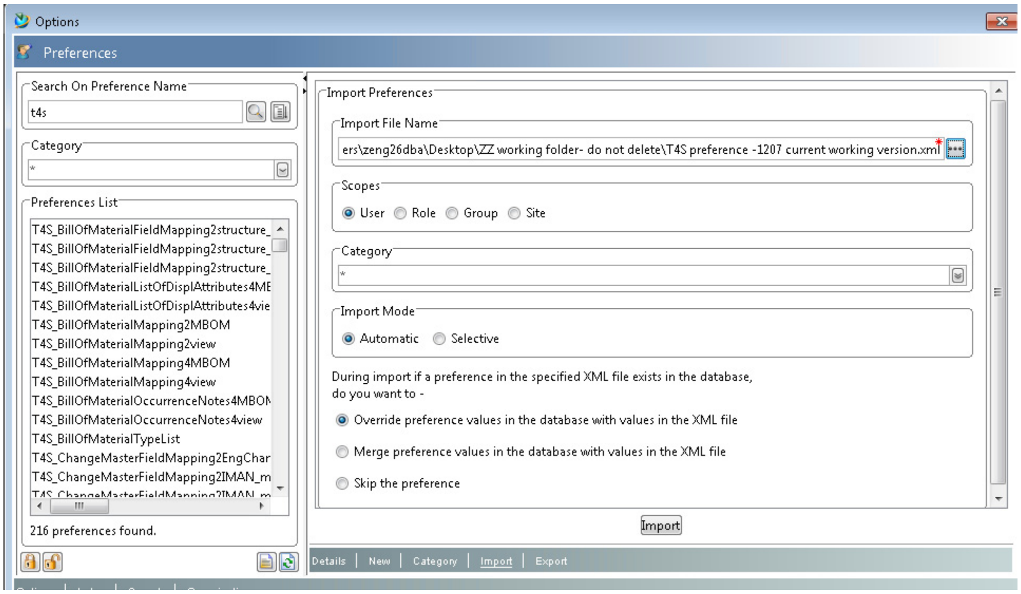
B 9 Screen print of T4S configuration path

2) Search “t4s” for all T4S related preferences.



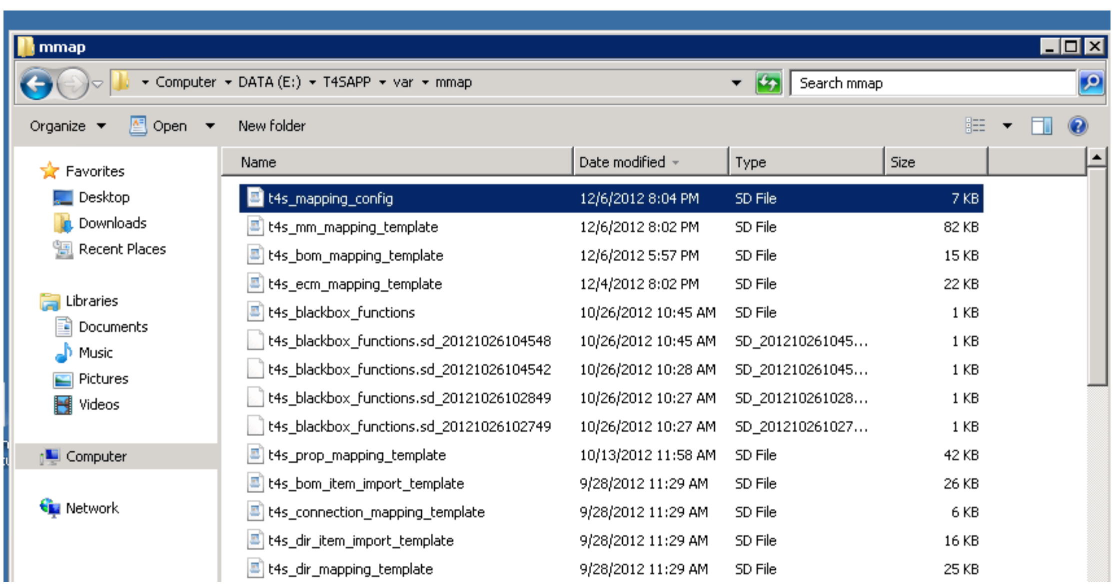
B 10 Screen print of T4S preference

3) Export the T4S preferences as xml file, and modify the configuration based on this xml.file. When finish modification, import the updated xml.file into system.



B 11 Screen print of uploading T4S preference

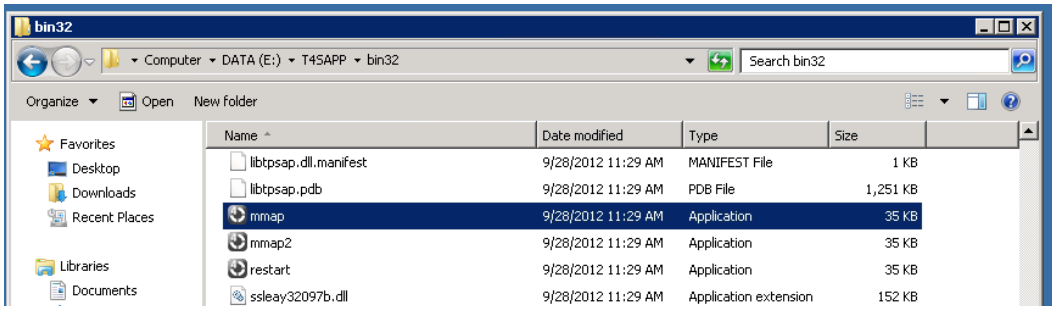
4) Specify the mapping in the mapping files



B 12 Screen print of T4S mapping file path in this study

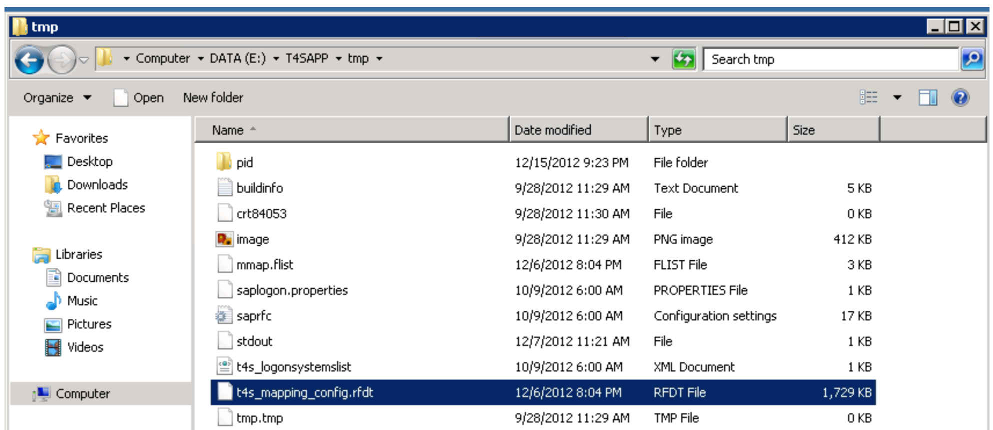
5) Create the compilation of all mapping source files: t4s_mapping_config.rfdt .

a. Run mmap.exe



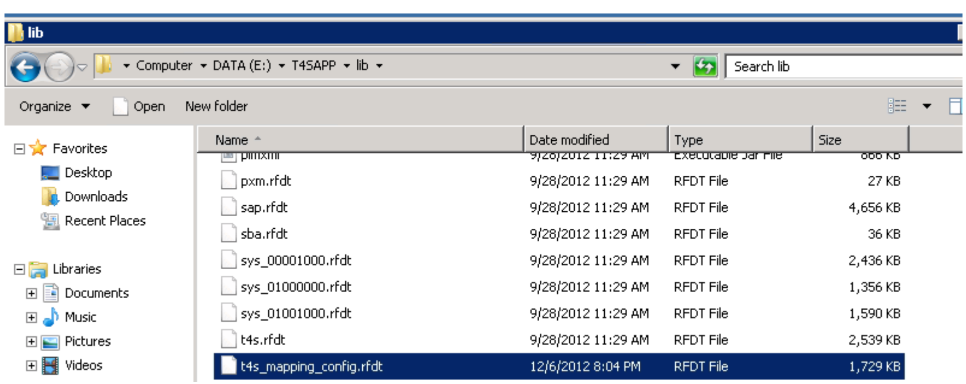
B 13 Screen print of T4S application files path in this study

b. Find t4s_mapping_config.rfdt in the folder of T4SAPP\tmp



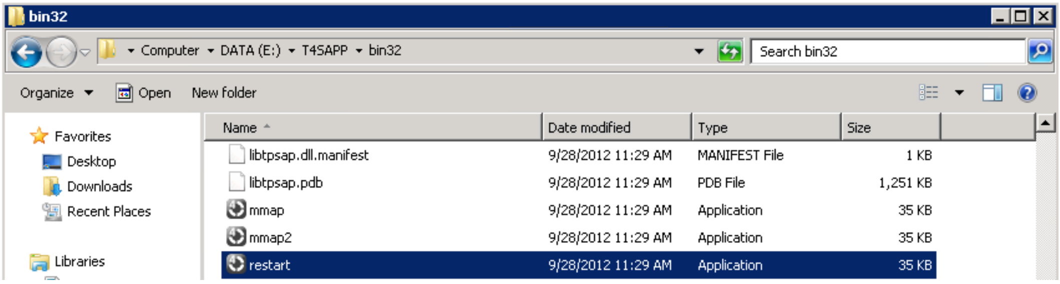
B 14 Screen print of T4S configuration file in this study

c. Move this file to <T4S_ROOT>\lib



B 15 Screen print of T4S RFDT file path in this study

d. Restart T4S by running restart.exe



B 16 Screen print of T4S application of restart in this study