ESTABLISHING INVENTORY TRANSPARENCY TO TEMPORARY STORAGE LOCATIONS

- A case from the mobile telecommunications industry

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Abstract: Efficient logistics control demands for transparency to inventory in the whole distribution network. However, current information technology (IT) solutions do not support creating inventory transparency to temporary storage locations, which poses severe problems for supply chain management in project-oriented industries. This paper presents how inventory transparency can be built with quick-to-install shipment tracking systems. The results are based on a case study of a pilot implementation in a supply chain of mobile telecommunications networks. The results of the case study indicate that shipment tracking systems can be used to provide inventory transparency to any supply chain location, including temporary storages currently lacking inventory management applications. Furthermore, the case company was also able to generate logistics control information from the shipment tracking information that was considered valuable for both project and logistics management.

Key words: Supply chain management, tracking, inventory transparency, project industry

1. INTRODUCTION

Several authors have proposed that supply chains or supply networks should be integrally controlled to obtain optimal results (see e.g. Christopher, 1992; Cooper et al., 1997; Burgess, 1998; Magretta, 1998; de Leeuw et al., 1999; Mason-Jones and Towill, 1999; Norek and Pohlen, 2001). Successful centralised control of a logistics system requires transparency for all the materials in the whole distribution network

(Gunasekaran and Ngai, 2004; Lee and Billington, 1992; White and Pearson, 2001). This means that inventory should be monitored in all locations of the supply chain (Ballard, 1996).

The need for total visibility to the supply chain is natural, as it is widely acknowledged that for maximum benefits supply chains should be managed as single entities (Cooper et al., 1997; Burgess, 1998; Magretta, 1998; de Leeuw et al., 1999; Mason-Jones and Towill, 1999; Norek and Pohlen, 2001). Effective management of the supply chain is just not possible without knowledge of the status of the chain. Furthermore, increased material flow transparency opens up several new possibilities of organising logistics and distribution, such as virtual stockholding, virtual trading, virtual production, and virtual logistics services (Clarke, 1998).

However, information technology (IT) solutions enabling inventory transparency are expensive and heavy to install and, thus, not applicable for short-term distribution networks. This is a major shortcoming in project-oriented industries where temporary storage locations that do not even have their own inventory control systems are often utilised (Ala-Risku and Kärkkäinen, 2004).

The aim of this paper is to bring forth the difficulties of building inventory transparency to temporary storage locations with the currently prevalent solutions. Furthermore, the paper presents how inventory transparency can be built in short-term distribution networks with quick-to-install shipment tracking systems.

The paper is organised as follows: In the first section, we will review literature on the needs for temporary storage locations, current inventory transparency solutions, and shipment tracking systems. Research design and methods are presented in the second section of the paper. The third section describes the results obtained in a case study and concluding remarks and future research directions are discussed in the final sections.

2. LITERATURE REVIEW

2.1 Temporary storages

Temporary storage locations are most frequent in the supply chains of project industry, typical examples being supply chains delivering equipment for construction projects (Agapiou et al., 1998). Storage locations near the construction site are used as a buffer to guard for disturbances in material deliveries or installation schedule that could result in non-productive time for the labour force (Thomas and Napolitan, 1995; Li et al., 2001). Buffer storages are used only for the duration of the installation project, and even the supply chains are typically established only for a single project delivery (Vrijhoef and Koskela, 2000; Dainty et al., 2001).

Since buffer storages need to be located near the installation site for logistical efficiency, warehouses are not always conveniently available. Instead, a temporary storage has to be set up, often with no sophisticated inventory management systems (Ala-Risku and Kärkkäinen, 2004). Even in situations where the storage location is equipped with inventory control systems, the short-term nature of the projects inhibits costly systems integration efforts to provide transparency to the storage (Dainty et al., 2001).

The temporally limited use of the storage location and the often inadequate infrastructure at the location make specific demands for the use of inventory transparency systems in temporary inventory locations.

2.2 Inventory transparency solutions

There are two fundamental architectures to create supply chain inventory transparency: 1) centralised inventory systems that are used to control the whole supply chain, and 2) inventory data transfers from different supply chain entities to a dedicated database. The former are usually used only within a single company or corporation, while the latter are used when building transparency between separate organisations (Kärkkäinen and Ala-Risku, 2003).

Both of these approaches demand continuous relationships between the supply chain entities. If a centralised system is used, the supply chain entities end up to be extremely tightly connected, as their operative processes are run on the same system. Therefore, integral systems encompassing several companies in the supply chain ("Mega ERP" or "Virtual Enterprise Resource Planning (VERP)" – systems) have not been implemented in practice (Kärkkäinen and Ala-Risku, 2003).

In multi-company supply chains, the systems in practical use have been implemented according to the second design alternative (Kauremaa et al., 2004). In practice, companies gather the relevant information on their own information systems and share this information with specific information technology tools, as illustrated in Figure 1.

This means that in order for the transparency system to function, the following prerequisites need to be met:

- Each supply chain entity has an inventory management system
- The systems of each supply chain entity have to be integrated with the transparency system

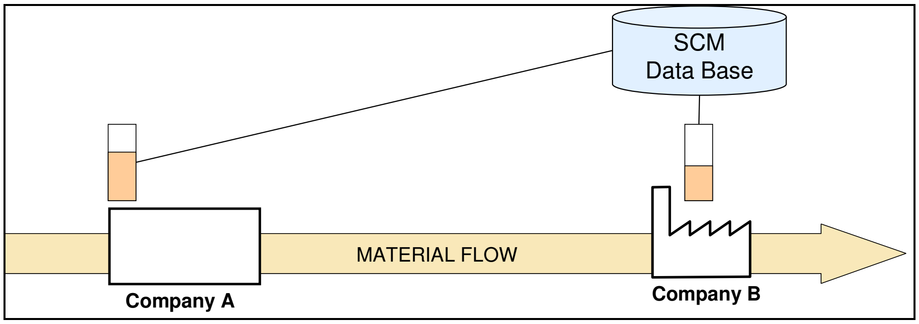

Figure 1. The functionality of traditional inventory transparency solutions

However, these characteristics make the traditional transparency systems problematic for temporary storage locations that:

- are only temporarily included in the supply chain
- do not often encompass information systems
- lack personnel with good IT skills
- are possibly operated by third parties

This signifies that it is often difficult to implement common inventory management system to the temporary locations, both due to the financial resources needed for their implementation and the expertise needed for operating them. Also, due to the short-time inclusion of the storage location in the supply network, it is often not worthwhile to assign resources to systems integration for establishing transparency to the temporary storages operated by third parties.

2.3 Generating transparency with shipment tracking systems

Kärkkäinen and Ala-Risku (2003) have presented how shipment tracking information can be used in building inventory transparency. The approach is based on collecting tracking information with a Forwarder Independent Tracking (FIT) system that can be installed quickly and cost-efficiently even in locations currently without any information systems (for a description of FIT see (Kärkkäinen et al., 2004)).

When building inventory transparency with tracking systems, checkpoints that track all in- and out-going material of a warehouse or a specific inventory area need to be established. By interrogating the tracking database it is then possible to find out what shipments are currently in the inventory location (Ala-Risku and Kärkkäinen, 2004).

For establishing stock keeping unit (SKU) -level inventory transparency, information of the content of the shipments is also needed (Ala-Risku and Kärkkäinen, 2004). The inventory levels for each SKU can be calculated by counting the number of the SKUs in each shipment in any given storage location. Correspondingly, the inventory value for any location can be calculated by summing up the values of shipments residing in that location.

3. RESEARCH PROBLEM AND DESIGN

3.1 Research problem

While reviewing the difficulties of integrating temporary storage locations with current supply chain transparency solutions, the authors identified a previously developed tracking-based transparency approach as a potential solution for overcoming the challenges. Therefore the following research problem for the study was set: "Can the tracking based transparency approach be applied to logistics control in supply networks with temporary storage locations?"

The research problem was addressed by initiating a case study that consisted of a pilot implementation of the tracking approach in a supply chain with temporary storages and an analysis of the pilot experiences.

3.2 Research approach and design

The methodology used in the research is based on the "Innovation Action Research (IAR)" approach (Kaplan, 1998). The aim in IAR is to initially document major limitations in contemporary practice, identify a new concept to overcome the limitations, and to continually develop the concept through publication, teaching and active intervention in companies.

The research process started during 2001, as the authors became familiar with the difficulties of managing and tracking project deliveries in short-term multi-company networks after discussions with a group of project-oriented companies operating in the mechanical engineering industry. These findings were reported in (Kärkkäinen et al., 2003). The poor suitability of existing tracking systems for the multi-company environment was determined in an extensive literature review, and a technical solution proposal for tracking in multi-company networks was developed later during the same year in co-operation with the companies. The first specification of the system was published in (Främling, 2002).

Early in the following year the operability of the solution was validated in a pilot installation carried out with a manufacturing company and its subcontractor delivering equipment to heavy industry investment projects. Based on the experiences of the pilot and discussions with the representatives of different organisations in heavy industry supply networks, a conceptual model for a new tracking approach for short-term multi-company networks was developed. The approach was named the Forwarder Independent Tracking (FIT).

During 2003 the research team was involved with the case company Nokia Networks that aimed to establish transparency for the temporary storage locations in its distribution network. The FIT approach was deemed a potential solution for creating transparency, and a piloting project was initiated to evaluate the applicability of the approach.

Two analysis dimensions were used for the pilot experiences: the operational feasibility of the approach and its suitability for logistics control. The first one encompasses issues related to the required short-time usability: technical expertise required for installation, costs of installation, and effort needed for use in operations. The second one includes the breakdown of different pieces of information that can be generated for logistics control.

The findings of the pilot analysis are reported in this paper. The following sections describe the pilot implementation and present the data collection methods used in the case study.

3.2.1 Case setting

The setting studied consisted of the case company and four installation companies that were employed to perform the equipment installations in the target country. The four installation companies operated a total of 16 temporary storages that were used to receive equipment deliveries from the case company. These temporary storages, often called drop-off-points (DOPs), were necessary in synchronising the arrival of equipment and workforce at the installation site. The materials could not be delivered directly to the sites due to access restrictions and a risk of pilferage. The case company had a local project manager who was responsible for issuing the equipment orders to the distribution centre for the entire installation project. As a rule, the materials for one installed site were ordered with a single site-specific order. Thus, the shipments in the supply chain are pre-assembled installation packages for single project tasks.

The installation companies transported the equipment to the sites and confirmed successful installation operations to the local project manager of the case company. The installation companies were required to report the equipment in stock in their temporary storages to the local project manager via e-mail on a weekly basis. The reporting was performed with a PC spreadsheet application. This reporting was however considered suitable mainly for generating after-the-fact statistics on inventory values, as it was too infrequent and unreliable to be used for efficient delivery monitoring and logistics control by the case company. The unreliability of the stock reports resulted in unsolvable accusations for the case company in cases where problems in material deliveries were suspected to have caused delays for the installation companies. A transparency tool with a better real-time response was needed for the temporary storages.

With experts from the case company, a system for creating transparency to the temporary storages based on the FIT approach was designed. The previously developed tracking software was configured to generate the elementary timestamp data on shipments entering and leaving the temporary storage locations of the installation companies. The software consists of two module types: client components that are used on the storage locations to send tracking messages, and a server component that receives and stores the messages in a database at the case company. The use of the FIT approach was facilitated by the fact that the case company already used unique shipment identifiers that could be registered with the tracking software. A method for creating unambiguous location identifiers for each of the temporary storages was developed for the use of the tracking system.

The case company stored details of all shipments dispatched from its distribution centre in its ERP system. This enabled the conversion of the shipment-level input of the tracking software to information on the actual SKUs and their values in the storages where they were registered. The ERP system also included dispatch dates for the shipments to be compared with the timestamps of the tracking software for analysis of distribution lead times.

The local project manager of the case company monitored the progress of the installation project with specialised project management software. In the management system, the installation confirmations for each individual installation site were registered. The site materials were managed based on issued sales orders that were also available in the company's ERP system and could thus be linked to the tracking system to generate transparency to the storages of the installation companies.

The supply chain phases along with the respective management systems for the case setting are illustrated in Figure 2. For the purposes of the pilot project, a reporting database was set up separate from the operative systems to avoid all potential interference with the daily processes of the company.

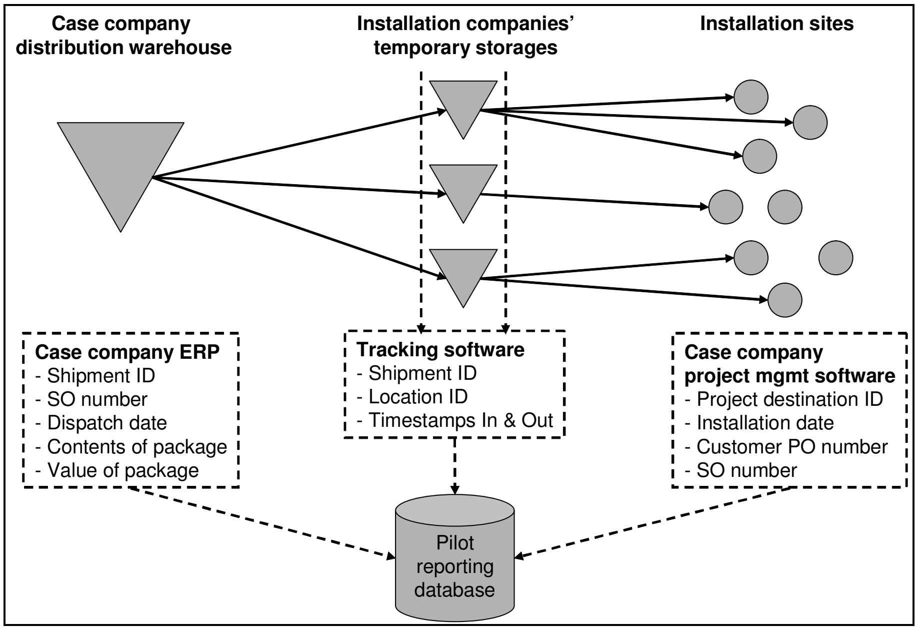

Figure 2. The construction of the piloted transparency system

The designed system required the use of the tracking software in the temporary storages of the installation companies. To support the take up by these companies, the research team developed training material on the setting up and use of the tracking software. The software and educational material was distributed to the installation companies in a training session. The training session was arranged by the research team in co-operation with the appointed pilot manager and local logistics coordinator of the case company. The representatives of the installation companies were assigned to hand out the training materials and instruct the personnel in each of their temporary storages.

3.2.2 Data collection

The main data collection method in this case was active participation in the planning of the pilot, in the development of a business case for the pilot and in actual piloting. The researchers were responsible for the development of the piloted transparency approach, participated actively in the planning of the implementation, prepared all education and instruction material related to the pilot and were responsible for holding the educating session for the personnel implementing and using the software at the pilot locations. Furthermore, once the pilot was in progress, the researchers acted as a helpdesk for the companies installing and using the systems. After the initial implementation, the researchers remained in close contact with the company representatives responsible for the pilot and received first hand knowledge on the progress and impacts of the pilot.

In addition to active participation, semi-structured interviews were conducted with key personnel of the case company. In total, eight different respondents from four different organisational areas of the case company were interviewed. The respondents are described in Appendix A. The interviews were performed in order to assess the utility of the generated information from the viewpoints of different organisational units.

To ensure the reliability of the collected information the following generic practices were taken up:

- Special care was taken when making interpretations from the answers of the interviewees, and interpretations made from the interviewees' responses were cross-checked between the interviewers to guard from subjective bias. Cross-checking has been possible, as there usually were two interviewers present in the interviews.
- Several informants were used whenever possible in order to minimise the subjective bias from the side of the informants. Also the information acquired with the other data collection methods was compared with interview findings when possible.
- To ensure the transparency of the research and enable re-analysing the findings, discussion memorandums based on the interviews were written. The memos have been stored in a case study database along with the used interview questions for easy future access.
- The completeness of the information was endeavoured by re-contacting the interviewees in the case of missing information or additional information requirements. In instances where the original informant was not able to fill our information needs, the researchers were directed to additional respondents.

4. RESULTS

The results of the pilot are presented in two parts. First, the experiences of the implementation phase are given. Second, the information variety generated with the pilot system is reviewed.

4.1 Implementation experiences

The pilot implementation was formally initiated in the tracking software training session arranged for the installation companies. The companies were asked to implement the tracking system in four weeks to all the 16 temporary storages. The first storage started to use the software within a week, and within the given time three more followed.

The local logistics coordinator of the case company was in regular contact with the operators of the storage locations to sort out potential difficulties experienced by the operators during the pilot. The research team was also available for consultation, and was contacted several times. The low adoption rate during the first month was due to both technical and organisational issues.

The technical challenges encountered were related to different operational environments between the case company and installation companies. The main difficulty inhibiting installation was created by company firewalls that did not allow the tracking software clients to communicate with the server at the case company. The research team addressed this problem by developing an alternative version of the software, which the storage operators could run remotely on the web pages of the case company. Other, less obstructive technical challenges included for example that the shipment identities that were input to the tracking system did not conform to the expected format due to different keyboard locales, but this was solved within the case company database by conversion runs.

Organisational issues were a much greater challenge for the pilot implementation. Some of the storage operators were very aware of the contractual relationship between their organisation and the case company. They referred to the agreed workload, and demanded additional compensation for the additional work of registering each incoming and outgoing shipment with the software. However, the pilot project did not have resources for such compensations. Also, the increase in workload could not be compensated by terminating the existing inventory reporting practices to the local project coordinator of the case company, as the pilot reporting database was not connected to operational systems. Furthermore, as the case company could not be assured on the continuity of the pilot, it refused to offer the generated inventory transparency information to the installation partners that asked for it in order to help their own reporting tasks. The installation partners later complained that the inability to access the inventory information they gathered themselves was a significant de-motivating factor.

After three months, the initially planned time span of the pilot, a total of seven storage locations had used the software in their operations, four of which used it on a regular basis. Despite the encountered organisational resistance to take up the tracking software in the temporary storages, those storage operators that agreed to use the software had little trouble in setting up and using the software.

4.2 Logistical utility of tracking based transparency

Although the pilot implementation did not reach the intended scope of all 16 temporary storages of the case supply chain, the four storages using the software intensively provided the necessary tracking data to generate transparency to their inventories. Integrating the tracking data with other data available from management systems enabled constructing several pieces of information on the performance of the supply chain: logistics information such as lead-time and inventory measures, financial statistics, and project control information. The reports the company implemented based on the collected data are illustrated in Figure 3. In practice, the information was disseminated as Extranet reports and could be viewed through password protected www-pages.

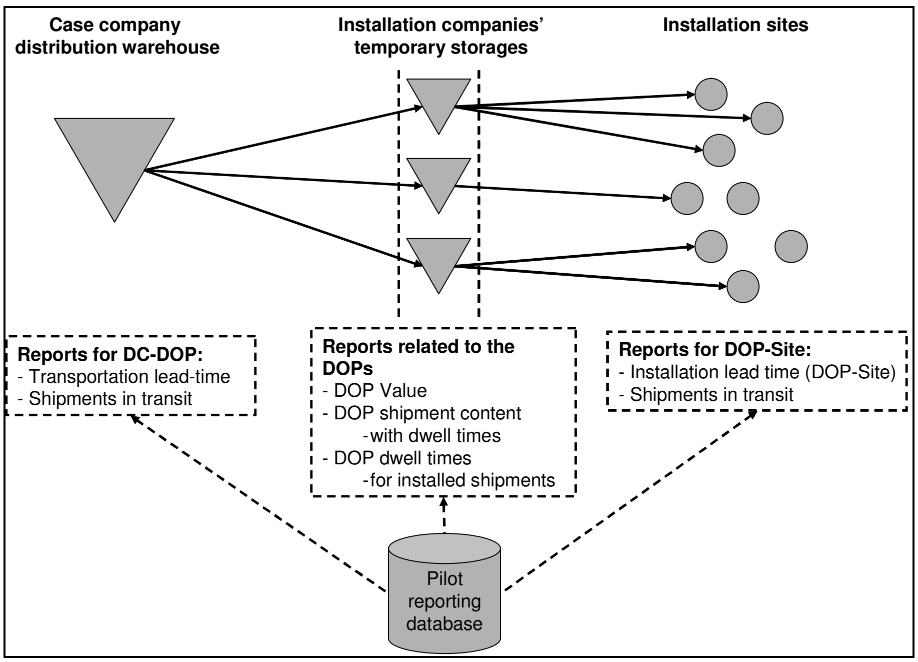

Figure 3. The construction of the piloted transparency system

Further, the company planned to implement a total progress report following the progress of the material packages from the distribution centre to the incoming and outgoing checkpoints at the DOP to the installation site. This total progress report was, however, not implemented during the pilot.

To find out the practical relevance of the generated information, key stakeholders of different organisational units were interviewed. In general, the interviewees considered the generated information extremely relevant, and only a few interviewees presented requirements for further information related to the material flow of the project equipment.

– **Project management:** The project management regarded the generated information very useful. One of the interviewees in the project management side however underlined that the dwell times of individual delivery items are a far more important metrics for controlling and developing the material delivery operations than inventory value or turn over. He argued that as the project operations are carried out with installation packages, not SKUs, the distribution process should also be controlled and measured on the delivery item level to ensure effective support to the installation project. The project management interviewees also stated that knowledge on the whereabouts of the goods to a certain site would ease their minds and objective information could reduce unnecessary communication/debate with the logistics organization.
– **Project logistics control:** The project logistics control regarded the DOP-site lead time as an important metrics, as it could be used for controlling that no informal warehousing points were included between the DOP and the sites. The project logistics also considered inventory value and especially inventory turn-over (that is also possible to calculate based on the gathered data) to be important metrics because they could help in spotting out and reacting to slow moving inventory. They also regarded the dwell times of single packages as a relevant metrics as they could be used for identifying problem orders and from that get to the root causes of long dwell times.
– **Central logistics control:** From the viewpoint of central logistics control the dwell times of individual shipments are an important metrics because they enable recalling shipments that are not installed. The central logistics control also pressed the importance of the lead time measures, as they are key inputs in the assessment and development of the efficiency of the processes. Furthermore, they emphasised that the lead-times should be de-constructed so that the performance of all pieces of the process could be estimated. Also, shipment level visibility to the contents of DOPs was regarded as essential.

5. CONCLUSIONS

The case study had two main goals in its attempt to evaluate the applicability of tracking based inventory transparency: 1) Is it feasible to implement a system based on tracking for temporary storages with no inventory control systems? and 2) Can the data provided by such a system be used to generate information for logistics control?

The information that could be generated by combining the tracking data with data in the management systems of the case company was more extensive than the research team had expected. The pilot was initiated to provide real-time inventory transparency to improve the prior practice of receiving weekly material listings from the temporary storages. This target was readily achieved by combining data from the tracking system with shipment details from the case company ERP system. However, since the tracking system's data was based on registering the movements of shipments, the data could also be used for temporal measures (lead-times) on a logistically relevant level of individual shipments.

This possibility for temporal inventory measures on a single shipment-level was welcomed by all case company interviewees. Project management personnel considered the available information on single shipments much more useful than inventory values or turnovers that have no use in controlling the project. Both project logistics and central logistics control saw that the level of detail available with FIT-based inventory measures enables identifying and reacting to slow-moving goods and isolating problematic deliveries for tracking down problem causes and thus developing the delivery process.

The wealth of valuable information that could be based on the tracking data emphasises two issues: the importance of transparency to temporary storage locations in project supply chains as they are the decoupling point between suppliers and project execution, and the greater usefulness of tracking information compared to mere stock counts at predetermined intervals. Therefore, it is safe to state that the tracking approach received a strong proof-of-concept in the pilot implementation. Thus, the paper extends the previous body of knowledge by presenting an alternative solution for building inventory transparency that can also be used in temporary storage locations.

The feasibility of the implementation of the tracking system however received mixed support. The technical expertise required for the installation was very low: the operators of the storage locations that had no firewall-related obstacles with the initial version of the software were reported to have spent approximately ten minutes installing the software from the installation CD. The training session given by the research team lasted only two hours, and even storage operators who were not present in the session were able to take the software in use by consulting the training material. The latter version of the software was even easier to adopt, as it was operated on a web browser. Technical expertise requirements or costs of installation were thus not an inhibiting issue for using the system.

The most essential challenge for the feasibility of the system was related to the effort needed in operating the system. Some operators refused to implement the system, as this additional inventory reporting workload was not compensated financially or by terminating the current reporting practices with the case company. While this can be considered a feature of the pilot implementation set-up and not a feature of the tracking approach as such, the motivation for data sharing between distinct organizations remains an important issue to be accounted for when designing inter-organisational information systems.

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APPENDIX A: INTERVIEWED PERSONNEL

Organisational unit of interviewee	Title of interviewee
Project management	Director of global project management practices development program
Project management	Head of operations development, delivery services
Project management	Project manager
Project logistics control	Senior manager, demand supply chain management
Project logistics control	Product owner, customer logistics
Central logistics control	Delivery process owner
Central logistics control	Delivery model development, manager
Information technology support	Head of Project Management Solutions