A SIMULATION ANALYSIS OF PALLET MANAGEMENT SCENARIO BASED ON EPAL-SYSTEM

Maria Grazia Gnoni[(a)], Gianni Lettera[(b)], Alessandra Rollo[(c)]

[(a), (b), (c)]Department of Engineering for Innovation, University of Salento, Lecce, Italy

[(a)]mariagrazia.gnoni@unisalento.it, [(b)]gianni.lettera@cerpi.it, [(c)]alessandrarollo@unisalento.it

ABSTRACT

Pallet management usually involves direct and reverse logistic models as it represents a critical activity in supply chain management. Pallets are needed in order to ship products from the producers/distributors to the retailers. The ”EPAL-System“ is a cross-sector open pallet exchange pool based on standardized quality-assured EURO pallets. The whole performance of a pallet management system could be improved by an appropriate strategy which aims both to increase pallet availability in the direct logistics and to reduce total cost of the reverse logistics. A simulation model has been applied to compare alternative pallet management scenarios based on EPAL-System aiming to assess more effective policies.

Keywords: pallet management, simulation model , scenario analysis

1. INTRODUCTION

In logistics activities, producers, distributors and retailers share a common objective, such as optimizing logistic costs and performances. Logistic activities are mainly based on a standardized equipment: the pallet. Several researches are focalized on pallet loading problem; few attention has been assigned to the overall pallet management process. The reverse logistic of empty pallet represents usually a valuable activity; a recent survey (Dallari and Marchet 2008) has evaluated the annual volume of palletized load units in Italian logistic market about 600.000 units. These issues contribute to confirm that pallets represents an important company asset; therefore, enterprises have to face with new organizational, economic and managerial issue regarding pallet management.

The most widespread pallet type is the wooden pallet which are characterized by unified features; this is the so called *EURO pallet* which specific features have been defined by the European Pallet Association (EPAL) aiming to asses a shared level for quality assurance and inspection standards. Others pallet types are mainly made by plastic and aluminum. In the last years, pallets with a RFID tag are spreading throughout the market, but they currently represent a low quantity in the whole market.

The purpose of the paper is to propose a simulation model of a pallet management scenario in which direct and postponed interchange are implemented simultaneously to analyze the flows of incoming and outgoing pallets. The simulation analysis can provide an effective tool to manage both direct and reverse flow involved in pallet management. The software AnyLogic ®6.0 has been applied to develop a discrete event simulation model for evaluating most effective pallet management system. The virtual prototype of the pallet management scenario is made up by system state variables, entities and attributes, lists processing, activities and delays. Moreover AnyLogic has animation functions allow the development of visually rich, interactive simulation environments (Borshchev 2010). The pallet flows can be analyzed under certain conditions like pallet storage capacity, the frequency of incoming shipment or orders processing, the quantity of new pallet annually purchased, the percentage of pallet repaired or disposed, etc.. Through a dynamical setting of operative conditions in the simulation model, the quantity of pallets exchanged in direct or postponed way can be evaluated.

At first, an analysis on main issues concerning organizational procedures and factors which affect pallet reverse logistic has been carried out. Next, a brief description on discrete event simulation model and related tool are reported. Finally, the simulation model of pallet management based on the well know “EPAL-System” is described. The developed scenario could represent a baseline in order to compare economical and technical performances of different organizational alternatives in pallet management such as pallet pooling or outsourcing.

2. THE PALLET MANAGEMENT: MAIN ISSUES AND ORGANIZATIONAL SCENARIOS

2.1. Organizational scenarios

Traditionally, one of the main cost added activity in pallet management is the reverse logistic: pallets have to be collected downstream in the supply chain where products are delivered to final customer. Pallet management activities are analyzed considering a supply chain configuration where a producer or a distributor ships products to a wholesaler or a retailer. Two organizational procedures are mainly applied for reverse logistics of pallets: the direct and the postponed interchange. In the *direct interchange*, all pallets have been collected by the final logistic provider at the final customer (such as the wholesaler or the retailer) during delivery activities; therefore, the total delivery time increases due to required pallet interchange activities, such as quality and integrity check. The logistics provider picks up the same pallet number delivered; usually, this activity usually does not require additional waiting time until pallets have to be unloaded because they could be collected in following deliveries. By an organizational point of view, an identification pallet activity will be carried out by logistic provider.

In the *postponed interchange*, the final customer supplies during delivery activities a pallet voucher to the logistics provider according to pallet number delivered in each trip. This order allows to collect – usually within three months in EPAL interchange system – such a pallet (ECR 2006). Therefore, tracking and tracing pallets may be represent a complex activity in this procedure. Moreover, quality check carried out on delivered pallets and the administration of pallet voucher may require time and effort were not acceptable. These activities affects the overall logistic cost.

Different organizational options could be implemented to manage pallets aiming to reduce its costs. The main organizational scenarios identified are direct management, outsourcing management and pallet pooling which are analyzed following.

- <u>Direct Management scenario</u>: all activities regarding pallet management - such as purchase, tracking and shipping, collection, maintenance, washing and sanitizing disposal, and, finally, recovery activities - has been carried out internally by the firm. The firm has to evaluate investment costs both in pallet park purchase and in management activities. Pallet interchange could be immediate or postponed.
- <u>Outsourcing Management scenario</u>: the firm has to carry on investment in pallet park purchase; pallet management activities are carried out by an external logistic company(e.g. a third-party provider). The logistics provider retrieves the pallets downstream in the supply chain and it tracks them via customer dispatch data. Pallet interchange requires only postponed type. Services supplied by external logistic company usually are pallet maintenance, disposal, monitoring, handling, and final collection. The global leader firm in pallet management is *CHEP- Commonwealth Handling Equipment Pool*, which manages the so called "blue pallet" in several sizes all over the world. Other European companies are *PGS Groupe* (France), *iPallet* (Italy), *Palletpol Ltd* (United Kingdom).
- <u>Pallet Pooling scenario</u>: a third-party logistics provider rents its own pallets to customers (i.e. producers and/or distributors) according to a service contract. The company ships pallets to his customers and usually supplies tracking service about time and location of customer shipments. One of the most important pallet pooling operators is *CHEP*.

2.2 Critical activities

Each process consists of one or more activities defined by their outputs. Then, main activities involved in pallet management are detailed following in order to highlight critical areas of interventions.

Pallet Replenishment: this activity refers to the annual cost supported for annual pallet park renewal due to breakage or loss. The unitary cost varies according to pallet type; the total purchase cost incurred has been evaluated based on a specific renewal level defined by the firm management.

Pallet Disposal: wooden and plastic pallets represent a source for recycling; otherwise, if recycling option is not suitable, pallets have to be disposed as a waste. Wooden pallets have a shorter life cycle than plastic pallets; they are easily disassembled due to their simple designs and standardized part sizes (Bejune et al. 2002).

Maintenance: the activity involves all repairing actions – e.g. adding new nails, metal brackets or replacing a broken board - carried out periodically on pallets aiming to maintain their full functionality as defined by the European Pallet Association (2009). Maintenance activity affects mainly wooden pallets; usually, plastic pallets could not be repaired, because they are a one-piece design.

Cleaning: the specific activity depends on pallet type. It mainly consists of the sterilization activity carried out by a specific heat treatment for wooden pallets; Cleaning activities are required by an international Standard for Phytosanitary Measure – the standard ISPM-15 (FAO 2002) – aiming to disinfect wooden pallets. The ISPM-15 is being progressively implemented throughout the world; this treatment is obligatory when exporting to several industrial countries. Similarly, a cleaning activity has to be carried out periodically for plastic pallet.

Storage: a percentage of empty pallets needs continuously a dedicated storage areas inside and/or outside the plant. The percentage level depends on organizational procedures for pallet management (i.e. the direct and the postponed interchange).

Reverse logistics: a closed loop system affects pallet management at the wholesaler/retailer level. The time spent for reverse logistic activities mainly depends on organizational scenarios applied by the firm for managing the reverse flow of pallets from retailer: if direct interchange is working, pallet quality has to be verified among retailer and pallet carriers. Otherwise, in postponed interchange, usually pallets are stored by the retailer in a dedicated area; thus quality control is reduced because carrier retires its own pallets.

Pallet tracking and tracing: pallets, like other industrial assets, require an effective control during all their lifecycles; thus, tracking and tracing refer mainly to monitor load and empty pallet trips along the distribution chain. In traditional pallet management systems, the main cost is due to accounting activities required for evaluating the actual number of pallets available in the systems; usually it represents a high operational cost.

Pallet information management: data about pallet availability (both in terms of quantity in the storage areas and at each destination) have to be placed in the Warehouse Management System (WMS); in traditional systems, this represents a high time-requiring activity. This activity supplies an information reporting system about pallet utilization.

Inspection activities: it regards control carried out by the carrier during both pallet loading and empty pallets returned from end users. These activities are carried out manually by an operator or semi-automatically by optical barcode readers.

Accounting. This activity is closely linked to tracking and tracing systems and specific organizational procedures for pallet management applied in the firm. It also includes administrative activities involved in pallet vouchers management if postponed interchange is applied. In the proposed model, the management of legal disputes between actors involved has been neglected.

3. THE SIMULATION MODEL

A simulation model has been developed aiming to compare performance of two different management scenarios for pallet reverse logistics: **direct interchange scenario** where the logistics provider returns an equivalent number of pallets delivered, and **postponed interchange scenario** where vouchers can be returned for pallets. The model simulates major processes (previously described) which characterize traditional pallet management system; a brief description is proposed as follows:

- *Warehouse of empty pallets*: empty pallets are stored in a dedicated warehouse. Here, quality control activities are performed to select pallets compatible to EPAL requirements; a selection activity highlights pallets requiring maintenance or disposal as they cannot be reconditioned. In direct interchange scenario, a stock level below the safety stock results in a purchase order for new pallets.
- *Entry Pallets:* two main inputs for the pallet warehouse have been evaluated in the simulation model. The first type refers to by purchased orders: the company has decided to define an average level of its pallet park, thus, order have been carried out periodically to maintain this level. The second input derives from empty pallets from received goods: the goods are delivered as palletized loads; therefore, a pallets entry in warehouse with goods. The activity of separation of pallet from its contained goods has not been evaluated in the simulation model.
- *Returning empty pallets or voucher*: when entry goods are handled in the warehouse, the logistics provider has to supply to the carrier an equivalent pallet number. In the postponed interchange scenario, if the company has a stock of empty pallets which are under the minimum stock level, vouchers are issued.
- *Internal Operations*: received goods could be quickly delivered or stocked by the logistics provider; a certain number of empty pallet are needed for the picking activity.
- *Empty pallet reverse logistics*: empty pallets that are shipped with the goods, have to came back to the warehouse. The return may occur under immediate or postponed interchange. Some pallets pull off the whole system as they were lost or broken.
- *Repair and disposal*: pallets that are failed the quality control are sent to maintenance center; if they could not be repaired according to EPAL standards, they are disposed or recycled as secondary materials.

3.1. The model hypothesis

The simulation model is based on a set of parameters which characterize quantitatively the dynamic of the problem. A brief description is proposed as follows.

Pallet input by purchased order: the P_1 represents the maximum number of pallets purchased in a year by the firm and P_2 represents number of pallet units for each purchase order. The order lead time is defined by parameter P_3.

Pallet input by receiving goods: I_1 represents is incoming pallets per delivery; I_2 is the interarrival time of deliveries (expressed in minutes) and I_3 the required time for unloading of goods delivered in entrance.

The Returning activity of empty pallets or voucher is defined by F_1, i.e. the percentage of pallets or vouchers that are not returned to the carrier because it arrived broken or heavily being damaged and therefore not interchangeable according to the standards EPAL.

Empty pallets warehouse is characterized firstly by W_1 which represents the Safety stock level of empty pallets. The W_2 is the required time for pallets quality control: this parameter defines the effort applied for pallet sorting pallets. Activity results determine number of “good” pallets and those not usable or interchangeable according to the EPAL standards; thus, a parameter (W_6) defines the average rate of pallets which fail the quality control. Required manpower is defined by W_3 and W_4 is the average lead time for pallet handling. Finally, W_5 defines the Number of empty pallets simultaneously drop off from the warehouse;

Internal Operations. Picking activity is characterized by several parameters: O_1 is the Picking rate, that is percentage of palletized loads affected by picking activities; the lead time required for delivering palletized load without picking is defined by O_2. *Lead time* before picking is defined by O_3; O_4 is utilization rate of empty pallets in picking activities defined as the ratio between empty pallets and palletized load processed. The time required for picking activities *is* O_5; O_6 is the picking capacity. O_7 represents the percentage of pallet not shipped after picking activities and O_8 pallets per shipment, i.e. the number of palletized loads for each shipment.

Reverse Logistics of empty pallets. R_1 represents the failure rate, that is the percentage of pallets lost or not interchangeable due to a poor quality over the palletized loads delivered. In this rate, passive franchise is included. R_2 is the estimated time for quality control of pallets, and R_3 the manpower required by this activity. Three scenario parameters are R_4 which represents the Postponed interchange rate, R_5 is the Direct interchange time, which is the time needed for returning of shipped pallets when direct interchange is implemented and R_6 the Postponed interchange time, that is the time required for returning shipped pallets when postponed interchange is implemented.

Repair and disposal of pallet. This activity is characterized by D_1 the pallet disposal rate and D_2 – which represents the average time required to repair pallets.

4. THE MODEL APPLICATION

The case study analyzed regards a small distribution center: its pallet park is about 11.500 units; the simulation period is one years, i.e. 300 work-days. Two different management scenarios were simulated as defined previously:

- **Scenario 1 – Direct interchange**: to the carrier making the delivery of palletized loads is returned immediately an equivalent number of empty pallets. The number of pallets to be returned is agreed with the carrier following the quality control of pallets delivered. Incoming deliveries are processed individually, and the single process ends with the return of empty pallets to the carrier. Therefore the following carrier waits that the previous carrier releases the unloading platform.
- **Scenario 2 – Postponed interchange**: to the carrier has made delivery of the goods can be returned an equivalent number of empty pallets or vouchers. In particular, if the company has a stock of empty pallets which are under the minimum stock level, vouchers are issued.

Each year an average value of 5.000 pallets were purchased due to replenishment policies in both scenarios. Moreover, in the direct interchange scenario, up to 7.000 units of new pallets can be purchased during the year to overcome the temporary unavailability of pallets to be returned to transporters. In the postponed interchange scenario, in the absence of pallets to be returned, vouchers are issued and they are accounted at year end. The parameters used in the case study are presented in table 1.

Table 1: Estimated values in the case study

Model Flows	Parameter	Value
Pallet input by purchase order	P_1	7.000 pallets
	P_2	100 pallets
	P_3	1 day
Pallet input by receiving goods	I_1	30 pallets
	I_2	60 minutes
	I_3	60 minutes
Returning empty pallets or voucher	F_1	5% of pallets received
Warehouse of empty pallets	W_1	300 pallets
	$W_2 – R_2$	20 seconds
	$W_3 – R_3$	1 person
	W_4	4 minutes
	W_5	10 pallets
	W_6	1 over 300 pallets controlled
Internal Operations	O_1	20% of pallets received
	O_2	2 days
	O_3	20 days
	O_4	2/3
	O_5	20 minutes
	O_6	1.500 pallets
	O_7	20% of pallets picked
	O_8	25 pallets
Reverse Logistics of empty pallets	R_1	1 over 200 of shipped pallets
	R_4	20% of shipped pallets
	R_5	1 day
	R_6	30 days
Repair and disposal of pallets at the repairer	D_1	10% of pallets sent at the repairer
	D_2	3 days

4.1. Results analysis

First results obtained by the simulation outline that palettized loads received and shipped are 215.970 and 249.332 in scenario 1 and 2 respectively, with a ratio between the flow of incoming and outgoing pallets equal to 1,15. Moreover, the average value of empty pallets in stock is equal to 413 pallets in the scenario 1, and 394 empty pallets in the scenario 2. Therefore, scenario 2 is characterized by a slight increase in the average level of empty pallet warehouse; the comparison in the two scenarios of the level of stock is shown in Figure 1.

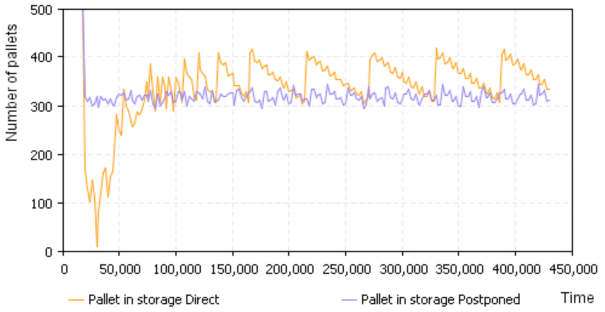

Figure 1: Comparison between warehouse level of empty pallets in the two scenarios.

As reported in Figure 1, safety stock level of empty pallets is guaranteed by issuing vouchers in the postponed interchange scenario; otherwise, stock levels below the safety threshold will generate a purchase order of new empty pallets in the direct interchange scenario. This scenario is the critical one as the lack of empty pallets determines a slowdown in deliveries to final customers. Therefore, Out of stocks occurs in scenario 1, determining a delay in unloading of goods. This determines a domino effect by inducing a delay in the empty pallet return, in internal material handling and picking activities (see Figure 2).

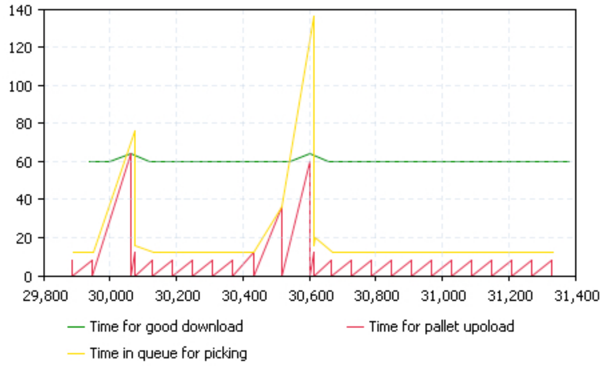

Figure 2: Estimated firm service level in scenario 1

The time trend of purchase orders of new pallet for the restoration of the level of stock in direct interchange scenario is reported in figure 3, compared with total pallet voucher in the postponed interchange scenario.

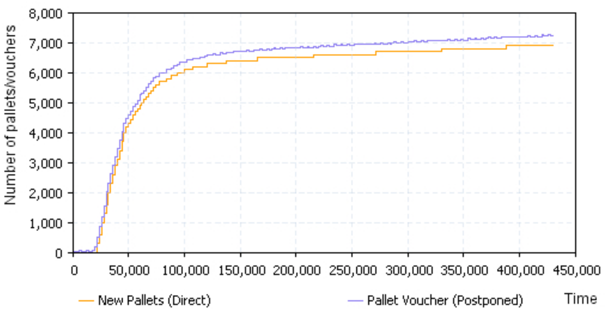

Figure 3: New pallets purchased in scenario 1 and pallet vouchers emitted in the scenario 2.

Overall in a year of activity (i.e. in the simulion period) 7.230 vouchers are issued in the postponed interchange scenario, while the new pallets purchased in scenario 1 are 6.900. This means that the direct interchange scenario in which new pallets are purchased according to fixed order quantity method is characterized by lower cost of assets purchase.

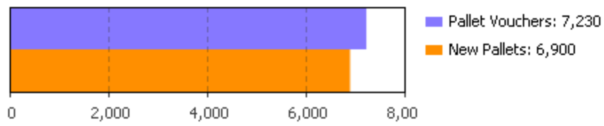

Figure 4: New pallets purchased level (scenario 1) versus pallet vouchers emitted (scenario 2).

Other types of delay occur in the picking activities in both scenarios. These delays of less importance, are related to normal operation and occur in association with certain goods deliveries: if the pallets are picked from the warehouse for returning the carrier, they could not be taken for picking activities. Thus, delays are generated for picking activities.

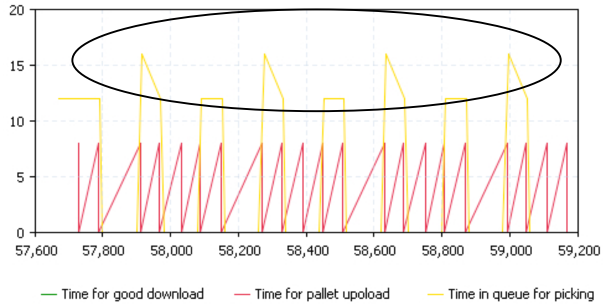

Figure 5: Estimated delays in picking activities

On the contrary, if empty pallets are loaded from the warehouse for picking activities, an incoming delivery is processed, the activity of the return of empty pallets suffers minor delays as outlined by the Figure 6.

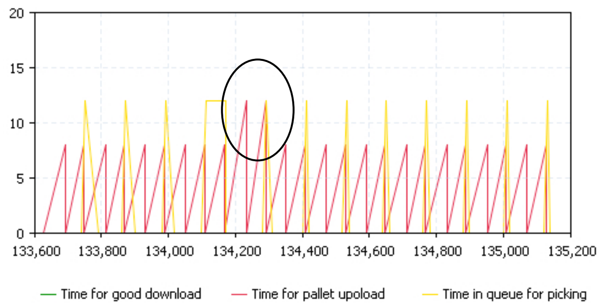

Figure 6: Example of delay in empty pallet restitution to carrier when empty pallets are needed both for picking activity and interchange.

Finally, Table 2 shows the minimum, maximum, average, the confidence interval for the mean and standard deviation of service level characterizing the logistics provider.

Table 2: Statistics for analyzed scenarios.

	Scenario	min	max	mean	mean confidence	deviation
Good unload Time	1	60	64	60,001	$2{,}812 \cdot 10^{-4}$	0,067
	2	60	60	60	0	0
Empty pallet upload Time	1	0	64	4,07	0,014	3,418
	2	0	12	4,046	0,014	3,294
Picking Queue Time	1	0	136	3,301	0,078	5,535
	2	0	16	2,888	0,072	5,132

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AUTHORS BIOGRAPHY

Maria Grazia Gnoni is Assistant Professor at the Engineering Faculty of the University of Salento. Her research interests are focused on the design and the management of sustainable supply chains and logistics.

Gianni Lettera is a contractor researcher at the Department for Innovation of the University of Salento. His research activities are focused on environmental and safety management.

Alessandra Rollo, Phd student, master degree cum lodem in Management Engineering at the University of Salento (Italy) in 2007. Her research interests are in the fields of operations management with the attention on IT utilization (in particular RFID technology).