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Simulation of Air Cargo Operations in West PACTL

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Abstract: This study illustrates a simulation model for air cargo operations in west cargo terminal of Shanghai Pudong International Airport, People's Republic of China. The simulation model is developed by software Flexsim 5.0. We first discussed the complex and stochastic natured air cargo terminal operations in West PACTL, which makes formulation of analytical model difficult. The model verification and validate is carried out through various objective and subjective methods and it is found that the simulation model and its behaviors are reasonable by the proving of managers from PVG. The simulation model is used to analyze the bottleneck resources of the West PACTL. The results show that the inefficient manpower supply plan is the most important bottleneck of the whole process. Improvement suggestions for the whole process have been proposed within the example of manpower supply plan.

Key words: West PACTL, air cargo operation, simulation, flexsim

INTRODUCTION

According to 2012 World Airport Traffic Report (ACI, 2013), Shanghai Pudong International Airport (PVG), with 2.94 million tons throughput, is the third busiest cargo airport in the world. PVG has kept its top first cargo volume in mainland China since 2002. In order to meet the needs of a rapidly growing market, Shanghai Pudong Int'l Airport Cargo Terminal Co., Ltd. (PACTL) designed and began to construct the West cargo terminal at PVG. The West PACTL put into operation in 2009. In 2010, the cargo handled in West PACTL was 1.34 million tons, while the designed capacity is 1.20 million tons per year (Liu and Chen, 2013). Now the air cargo industry is still growing rapidly in China, so does the handling demands in PVG. But there is no new expansion plans on cargo facilities in PVG. The airport terminals' utilization/occupancy rates is a key factor for airlines' ground operation cost reducing, for attracting more customs (Suryani *et al*., 2012). In order to improve the cargo handling capacity of PVG with the existing resources, we take the West PACTL as the object.

Simulation modeling has been wildly used by the scholars, the consulters and the airport engineers to analyze the operation of an air cargo terminal in the circumstances of uneven distribution of resources and less efficiency result in less advanced operating technology (Bai, 2010).The use of simulation for evaluation and analysis of air cargo operations by describing the development of a simulation model for the Dallas/Fort Worth Airport cargo hub of AA Cargo was first discussed in 1992 (DeLorme *et al*., 1992). The use of simulation for evaluating and analyzing air cargo operations at Toronto Pearson Airport was carried in 2004 (Nsakanda *et al*., 2004). These researches provided a possible way to study the operation in air cargo terminal, but there are little simulation studies on PACTL, while many related studies are essentially descriptive.

This study contains 5 parts. We discuss operations in West PACTL in section 2, then the modeling simulation and the output, finally, our conclusions and plans for future work in section 5.

OPERATIONS IN WEST PACTL

The planning and the construction of PACTL can be divided into 2 stages. The first cargo terminal was ready for operation in 1999, while the second stages terminal is the West PACTL, which is four times as big as the former one and is specialized in international cargo services, as shown in Table 1.

Table 1: Size of the West PACTL

Item	West PACTL
Total area	365,100 m^2
Warehouse area	121,809 m^2
Office area	12,110 m^2
Designed capacity	1.20 million tons $year^{-1}$
Peak handling capacity	4,799 tons day^{-1}
Parking	
Truck	245
Car	216
Forklift	100
Cargo constitute	
International	100
Inbound	42
Outbound	58

Source: Liu and Chen (2013)

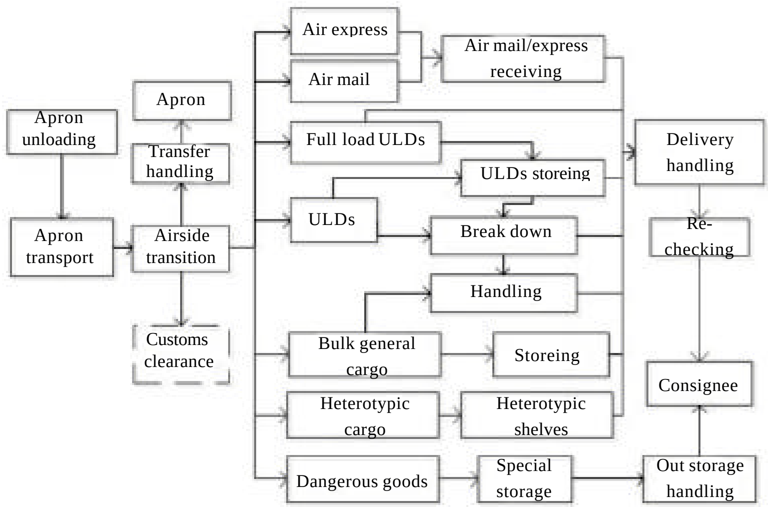

Fig. 1: Inbound cargo Handling process in West PACTL source: (Liu and Chen, 2013)

Besides the general inbound and outbound operation areas, the West PACTL also specially designed the pallet building area and transit cargo area for forwarders, so the operation process is distinctly different from many other airports.

Inbound operation process of West PACTL: Figure 1 presents an overview of the inbound movement of goods.

Step 1: After the unloading of cargos from the aircrafts on the apron, the trailers will transport the cargos to the airside cargo terminal for handling. Transshipments will be directly transferred to specify apron and just waiting for uploading and outbound, while non-transshipments will be turn to Step 2 after declaration to the customs. Step 2: Cargos will be sent to different area according to the type. Airmails will be sent to the specified area and keeping on time delivery, directly turn to Step 7 after sorting, while the general cargo ULDs (Unite Load Device) to Step 3, the bulk general cargos to Step 4, the heterotypic cargos to Step 5 and the danger goods to Step 6. Step 3: For the general cargo ULDs, without breaking down, some will be delivered directly and turn to Step 7, while some will be stored within the ULDs. Some of the stored ULDs will be break-down, handled or restored and then waiting for the delivery, then to Step 7. And some of stored ULDs will directly turn to Step 7 without break-down. Step 4: Some of the bulk general cargos will be directly delivery, while others will be stored and finally all turn to Step 7. Step 5: The heterotypic cargos will be stored in the heterotypic shelves before sending to delivery area, then to Step 7. Step 6: The danger goods will be stored in the danger cargo warehouse before sending to the terminal outbound handling area for the consignees, who will deliver these cargos by themselves. Step 7: All the cargos will be re-checked and proofed before signed by the consignees and will on load to the trucks on the cargo terminal's landside platform and finally will be delivered after custom clearing.

Outbound operation process of West PACTL: Figure 2 presents an overview of the outbound movement of goods. Step 1: The consignors need to clear the customs and conduct the documents for cargos, while the cargos are unloading from the trucks on the cargo terminal's landside platform, then go through security check and weight measurement and then will turn to Step 2. Step 2: Cargos will be sent to different area according to the type. Airmails will be sent to the specified sorting area and will be stored before turn to Step 7, while the bulk general cargos shipments to Step 3, the batch general cargos to Step 4, the heterotypic cargos to Step 5 and the danger goods will to Step 6. Step 3: Some of the bulk general cargos shipments will be send directly to airside transitional area, while some will be assembled before sending to the airside and all will be turn to Step 7. Step 4: Some of the ULDs will be directly send to the airside, while some will be stored firstly and then all will turn to Step 7. Step 5: The heterotypic cargos will be stored in the heterotypic shelves before sending to airside for uploading the aircrafts, i.e. Step 7. Step 6: The danger goods will be directly send to the airside for outbound, i.e.

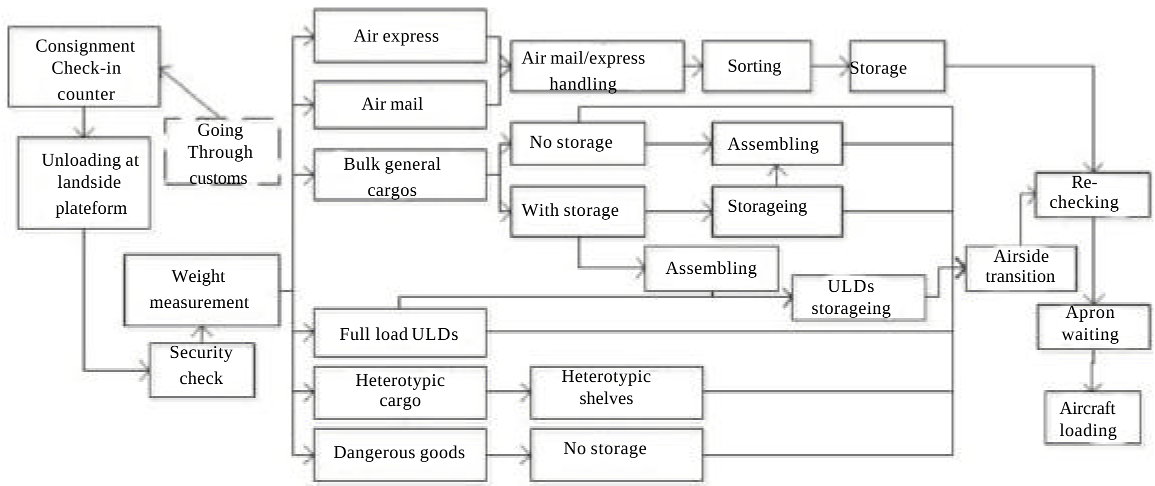

Fig. 2: Outbound cargo handling process in West PACTL Source: (Liu and Chen, 2013)

Step 7. Step 7: The cargos will be re-checked and proofed and then waiting on the apron for uploading on to the aircrafts.

MODELING AND SIMULATION

In this study, we focus on the source allocation of the West PACTL operation process. According to the operation process illustrated in section 2, the composition and the interrelationship of each module in the simulation system can be determined through a reasonable simplification. We simplified the model by only simulating the general cargo process, for over 90% of the volume in an international cargo terminal are usually general cargos (Ou *et al*., 2007).The structure of the West PACTL operation system is shown in Fig. 3.

There is a lot of simulation software on hand, such as eM-Plant, Servicemodel, which are more focused on statistical analysis of data, but ignoring the model visibility. Flexsim is the latest 3D simulation software based on VR technology, not only powerful in statistical analyzing, but also well at 3D display.

So, combined with the functional layout of West PACTL and the operation system, we create an operation process simulation model by using the Flexsim 5.0, as shown in Fig. 4.

The simulation model must be established based on the practice data in West PACTL. And the data needed for simulation should include the arrival of the outbound shipments, the flight schedule, the manifest data for the flight and the resource and task time for each sector of the process. Most of the data are taken from the database system of PACTL and some of the others are collected through site investigation.

According to the actual situation of West PACTL, we set up the parameters for sources, queues and merge spots, conveyors, racks, ASRSvehides and forklifts, etc. in Flexsim 5.0. And in the process of the simulation, PACTL employees of different levels, such as workers, managers and leaders are involved in our research team for giving advices. And the behavior of the final simulation model is reasonable by the senior management team.

EXPERIMENTAL DESIGN AND OUTPUT ANALYSIS

According to the characteristics of air cargo arrival, we make some further refine on the running of simulation. And the whole running of the model is divided in to two parts. The first running period is between a.m. 7:00 to 10:00 and the other one is from p.m. 16:00 to 22:00. The inbound cargo ratio of the two periods is 8:5, while the outbound one is 6:9. By analysis the output of the simulation model, we found that some of the cargos suffer redundant movement, parts of the cargos' temporarily storage is a little longer, the manpower supply plan is a very important factor and the customs clearance is also the bottleneck of the whole process.

Take the output of manpower supply in a.m. for example; the Operator 2 in the inbound process during morning hours is too idle, while the Operator 6 and 7 are too busy, as show in Table 2.

According to the output, we suggest increasing or decreasing the number of the operator and experiment the operation process optimization model in two periods for three times.

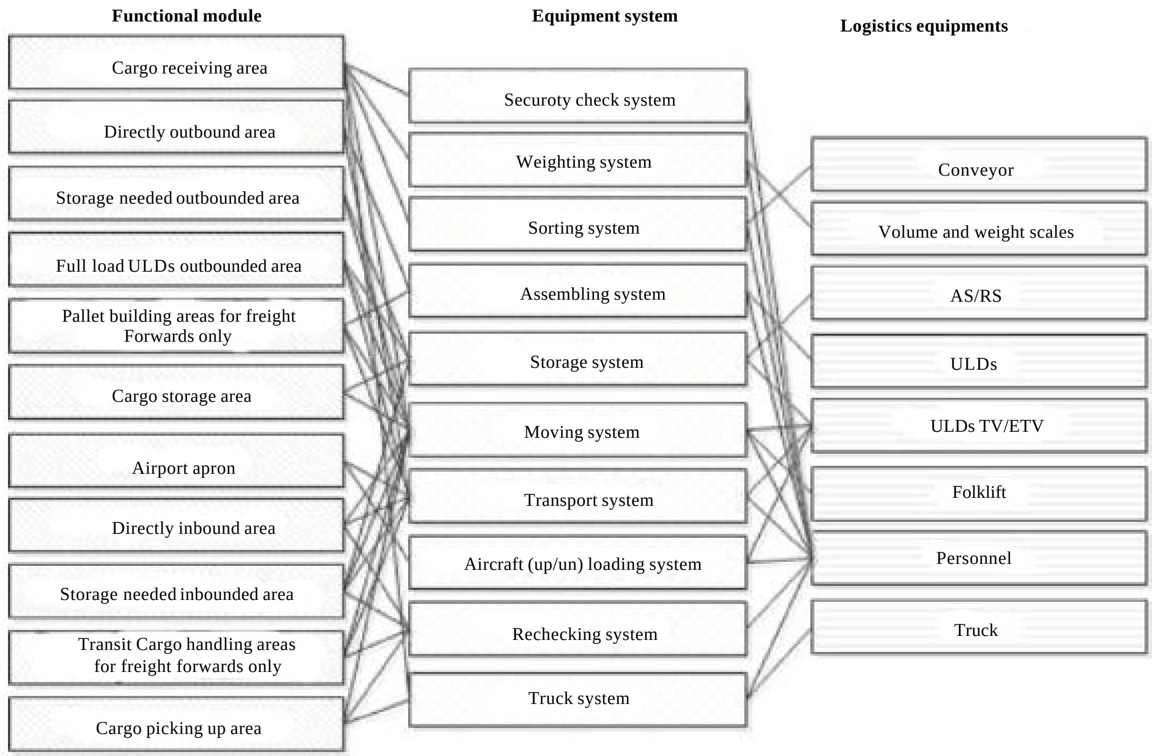

Fig. 3: Structure diagram of West PACTL operation system

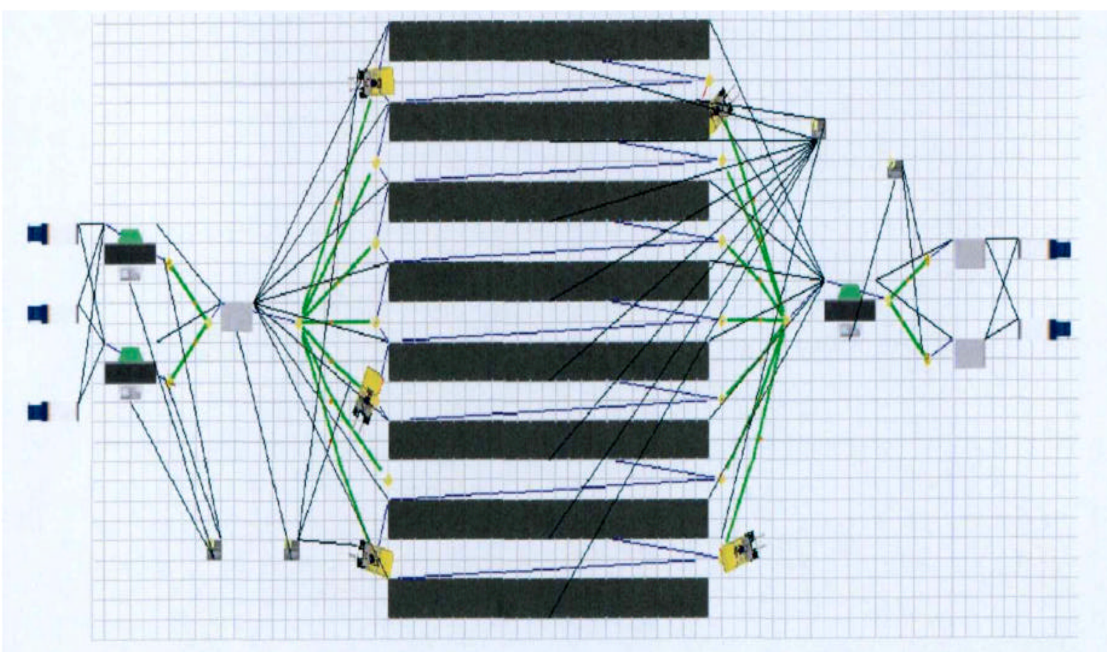

Fig. 4: Simulation model of West PACTL operation process

Table 2: Simulation results of the morning hours in the inbound process

Object	Idle (%)
Operator 1	58.12
Operator 2	72.18
Operator 3	62.34
Operator 4	24.36
Operator 5	28.55
Operator 6	17.52
Operator 7	14.92

After optimization, the idle ratios of the operators meet a significant improvement. The idle ratio of Operator 2 is reduced to 63.27%, while Operator 6 and 7 is not too much busy. The idle ratios of them reach 21.02 and 24.37%. And after the optimization, efficiency of the whole system increase 1.4%.

CONCLUSION

We illustrate the use of *Flexsim* to simulate the air cargo operations at West PACTL in PVG. A brief description of the air cargo operations in West PACTL has been described as well as the simulation modeling approach and the experimental designing.

The preliminary results obtained show that the proposed simulation model can be used to find the bottleneck, to analyze the resource allocation strategy. And we found that the bottlenecks of the whole process are the redundant movement, long temporarily storage and inefficient manpower supply plan and long customs clearance time.

We only simulated the operation process of general cargo, without any considering on the air express, the dangerous goods and the heterotypic cargos. So we will integrate the simulation model on other types of cargos processing with *Flexsim*, in the future and estimating the expansion requirement of West PACTL based on the model.

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