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AIR CARGO OPERATIONS EVALUATION AND ANALYSIS THROUGH SIMULATION

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ABSTRACT

This paper illustrates the use of simulation for evaluating and analyzing air cargo operations at one of the new state-of-the art cargo facilities at Toronto Pearson Airport. The establishment of a facility equipped with some of the latest in modern material handling systems available today and a computerized-based inventory control system that interfaces with all aspects of its cargo operations, has driven the airline company involved in this study to developing new processes to ensure that products and services are aligned with customers' needs. One of the challenges faced is a lack of an evaluation tool that can be used to quantitatively evaluate and compare different policies, business practices and processes within a given set of operational and business constraints. This work aims in developing such an evaluation tool. We describe the modeling approach, the challenges involved and the potential use of the simulation tool. Preliminary results are also reported.

1 INTRODUCTION

Toronto Pearson Airport is Canada's busiest airport. In order to meet the needs of a rapidly growing market, the Greater Toronto Airport Authority (GTAA 2002) has developed a strategic plan for redesigning and modernizing the airport's infrastructure. Some of the initiatives undertaken previously required the displacement of cargo facilities occupied by airlines and other users and their relocation to new cargo buildings.

Thus, witnessing an impressive market growth, the airline company involved in this study set up a project to build a state-of-the art cargo facility in order to expand its capacity. The new facility emphasizes the airline's market domination in the region and was projected to be equipped with some of the latest in modern material handling systems available today, such as a small package handling system, flexible build-up and break-down workstations, unmanned operated elevating transfer vehicles, manned and unmanned operated transfer vehicles, scissor lifts, turntables and right angle decks, powered conveyors, vertical conveyors, an automated storage and retrieval system (AS/RS), and an inventory control system that tracks movement of units throughout the terminal.

Parallel to building the new facility, a business process reengineering team (BPR) has been created with the mandate of redesigning the cargo handling processes to ensure that products and services are aligned with customers' needs in terms of speed, quality, service, and cost. One of the challenges faced is the lack of an evaluation tool that can be used to quantitatively evaluate and compare different policies, business practices and procedures within a given set of operational and business constraints. This work aims at developing such an evaluation tool. It is in line with related previous studies on air cargo operations evaluation and analysis (e.g., Delorme et al. 1992, Khan 2000). DeLorme et al. (1992) illustrated the use of simulation for evaluating the impact of various operating procedures on the effectiveness of some cargo functional areas. The proposed model has been applied to an existing facility equipped with a manned cargo handling system. Khan (2000) illustrated, through a case study of an airline's cargo handling facility, the application of the business process reengineering technique to achieve improvements in critical measures of performance such as speed, quality, service, and cost. The study is essentially descriptive and does not enable the study of dynamic behavior of the system nor the study of the impact of various redesign strategies on the system performance. Our work attempts to address both the issues of dealing with modern cargo handling facilities and evaluating BPR efforts. We describe the modeling approach, the challenges involved and the potential use of the simulation tool. Preliminary results are also reported. For other challenging issues to air cargo, we refer the readers to related studies, such as revenue management (Kasilingam 1996), fleet planning (Marsten and Muller 1980), and personnel scheduling (Norbert and Roy 1998).

This paper contains five sections. A brief description of the airline's cargo operations are described in section 2. We discuss our modeling and simulation model in section 3. Some preliminary results are reported in section 4. Finally, in section 5 we present our conclusions and plans for future work.

2 OVERVIEW OF THE AIRLINE'S CARGO TERMINAL OPERATIONS

Figure 1 presents the layout of the airline's new cargo facility. The terminal is divided into an import area and an export area. The import area is dedicated to receiving, processing and releasing inbound freights. The export area is dedicated to receiving, processing and preparing outbound freights. The flow of goods through the terminal is either from the airside to the landside (terminating freights or connecting freights requiring the road feed service), from the landside to the airside (originating freights or connecting freights arriving from a road feeder service), or from the airside to the airside via the terminal (connecting freights).

At the import level, freights on dollies or carts are transferred with a tractor–trailer from the aircraft to the airside level of the cargo terminal. Shipments on carts are transferred to the import bulk cart break-down station where they are sorted, scanned, placed into a roll box, conveyed and stored either in an AS/RS or in other dedicated storage areas upon their retrieval (terminating goods) or their preparation for transfer to build-up areas (connecting goods). Shipments on containers or pallets (referred to as ULDs) are introduced into the terminal throughout a manned operated and computer-assisted airside transfer vehicle (ATV). From this point, the ULDs may be transferred either to the road feeder service (RFS) dock area, to the import ULDs storage area, to the import ULDs break-down area or to the export ULDs storage. A fully automated ULD handling system is used for this purpose. It is equipped with such components as powered ULD conveyors for moving ULDs to different transfer points, turntables for ensuring that ULDs can be rotated or reoriented when changes in direction are required, unmanned operated elevating transfer vehicles (ETV) for ensuring ULDs storage, retrieval or transfer on multiple levels, lowerable workstations for enabling safe build-up and break-down processing, scissor lifts for ensuring transfer interface between conveyors and road trucks with various heights at the RFS area, fork lifts for transporting goods between various transfer points, transfer vehicles (TV) for enabling the interface in both ways between either non-rollarized vehicles and the first conveyor system set at the RFS area, between this last and the second conveyor system set at the RFS area, or between the import area and the export area. After being stored in the import ULDs storage area, an ULD is retrieved and transferred without breakdown processing either to a customer, if terminating shipments (via the RFS dock or truck dock pick area), or to the airside if connecting (via an ETV and an ATV). A ULD may also be transferred to the ULD break-down area where its contents are sorted by airway bill, scanned, placed into a roll box, conveyed and stored into the AS/RS or other storage areas upon their retrieval for releasing to a customer (terminating goods), or transfer for preparation to the carts or ULDs build-up areas (connecting goods). Figure 2 presents an overview of the movement of goods at the import level.

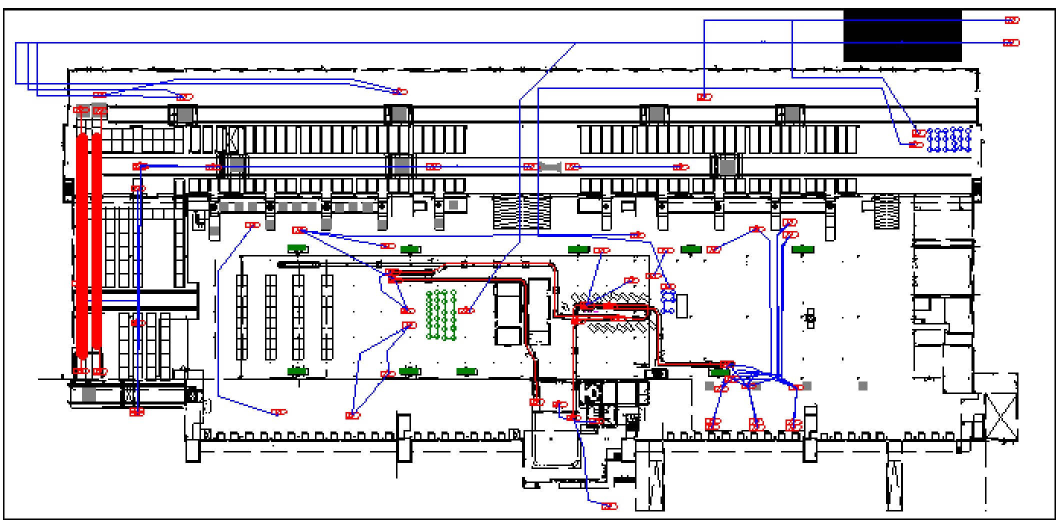

Figure 1: Cargo Facility Layout

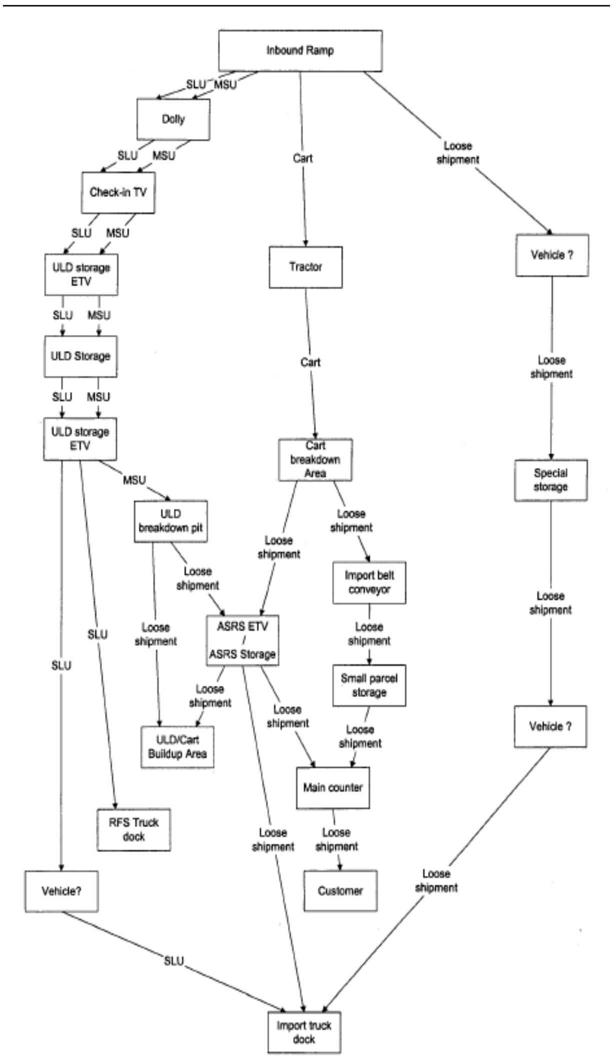

Figure 2: Overview of the Flow of Inbound Goods (Source: Airline's Company)

At the export level, shipments are received either loose or in ULD's. Shipments in ULD's may then be transferred from the RFS area or the export truck acceptance area to the airside area either directly or through the export storage area. An ULD handling system is used for this purpose and is equipped with the same components as described previously. Shipments tendered loose are sent to the cart or to the ULD build-up area either directly or after being stored and retrieved from the AS/RS or from any other storage areas. In the first case, a small package conveyor system is used and in the second case the same system previously described is used. After completing the ULDs or the cart break-down processing the shipments on ULDs are sent to the airside area, either directly or after being stored and retrieved from the export ULD storage. The ETVs are generally used for this purpose. At the airside level, ULDs are placed on dollies throughout an ATV and delivered to the aircraft staging area with a tractor-trailer. Similarly, shipments on carts are transferred, according to a pre-established schedule, to the aircraft cargo loading area. Figure 3 presents an overview of the movement of goods at the export level.

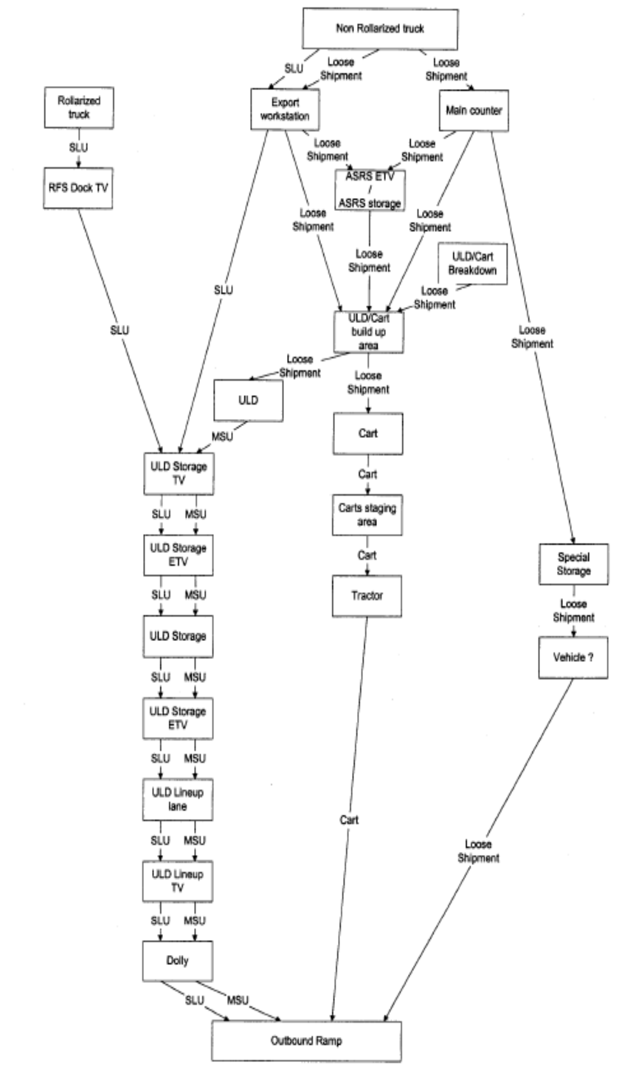

Figure 3: Overview of the Flow of the Outbound Goods (Source: Airline's Company)

Finally, we should point out that a computerized inventory control system (ICS) is used to track the movement of units in the terminal. This means various information must be captured at different processing steps using various means such as scanners (wire or wireless), wired scanners, touch screens, card readers, printers, PC computers, etc.

3 MODELING AND SIMULATION

Modeling the cargo operations described above is very complex due to the nature of the processing activities involved. The elements of complexity include the shipment status (originating, termination, connecting), the shipment service type (express, regular freights), the type of commodity involved per shipment (e.g., general goods, perishable goods, live animals, high value items, dangerous goods, mail, etc.), the shipment arrival mode (bulk, ULDs, pallet), shipment market destination (e.g. domestic, transborder, international, south), the types of aircraft involved (DH, CRJ, 319, 320, 330, 340, etc.), the shipment carriage mode available per aircraft type (bulk only, bulk-ULDs only, bulk-ULD-Pallets), the types of ULDs of Pallets (LD9, LD6, LD8, PMC, PKC, etc.), the types of compatible ULDs per aircraft type (unique, multiple), and the cargo capacity available per aircraft type (limited, unlimited).

One possible modeling alternative is the "push" approach. It consists of generating incoming (or outgoing) shipments, assigning shipments to flights based on business rules, processing and delivering shipments to assigned flights (or customers). While this approach seems promising, its implementation is more challenging since it has to cope explicitly with all the elements of complexity discussed above. In this study we adopted a "pull" approach where an existing flight schedule is used to generate the total inbound and outbound cargo volume for each aircraft type coming from (or going to) a given airport in terms of number of carts, number of goods per cart, number of ULDs, and number of goods in a ULD. Despite its lack of generalization, we adopted this approach because it helps in achieving the main objective of this study. The objective consists of developing a simulation-based tool that can be used by the BPR to quantitatively evaluate and compare different policies, business practices and procedures within a given set of operational and business constraints.

3.1 Overview of the Stages Involved in the Pull Simulation Model

Figure 4 presents an overview of the different modules involved within the pull simulation model in processing goods at the export or import cargo level.

At the export level, the modules consist of the generation of originating shipments (OSG), the shipments handling and processing (SHP), and the outbound shipments preparation for delivery to the aircraft cargo loading area (SDP). The OSG module takes its input from the cargo volume module to generate, for each outbound single flight and according to a pre-specified arrival pattern, the shipments that will be received, processed in the terminal facility, and then delivered to the corresponding flight number on cart or ULDs. At this stage, the shipment attributes such as the service type (express versus regular), the arrival or delivery mode (bulk versus ULD) are known. The SHP module consists of checking-in any shipment generated and processing it according to its attributes. Depending on the outbound flight departure time and the shipment check-in time, the shipment may or may not be first stored and

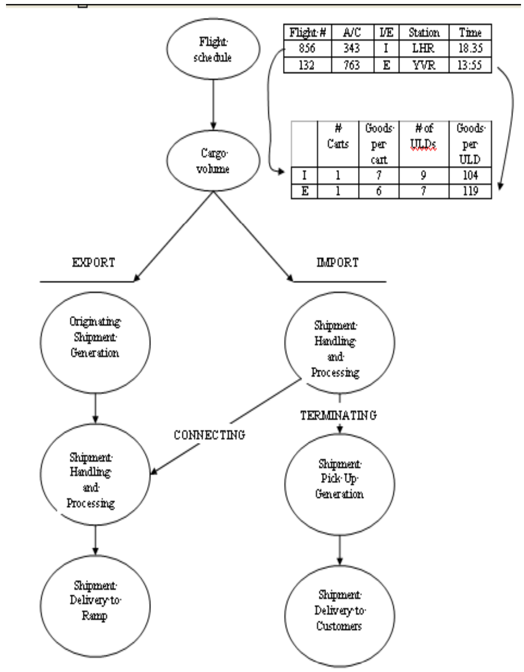

Figure 4: Overview of the Simulation Model

then sent to the cart or ULD build-up area for pre-flight final assembly and staging. In addition to the originating shipments, the other inputs to this module are connecting shipments. The outputs of this module are the shipments on carts or on ULDs pre-defined in the cargo volume module with a known completion time at different processing steps. The SDP module consists of lining up the shipments in order to transfer them to the aircraft loading area. The ULDs lineup consists of retrieving ULDs at the ULDs build-up area, at the RFS dock area, or at the import ULDs area, as well as moving the ULDs to the line-up area and loading them on dollies for delivery with a tractor to a pre-specified aircraft on the ramp. In case of the shipments on cart, the process consists of hooking up carts to a tractor for delivery to a pre-specified aircraft.

At the import level, the modules are the handling and processing of the inbound shipments (ISHP), the generation of the pick up time for terminating shipments (SPG), and the delivery of shipments to customers (SDC). The ISHP module receives shipments on carts or on ULDs from the cart staging area, from the airside area, or from the import ULDs storage area. These shipments are then split into small pieces, sorted, checked-in, and stored until their retrieval for delivery to a customer (terminating cargo) or transferring to the build-up or RFS area (connecting cargo). At this stage, various attributes of a shipment are know (e.g., express VS regular goods, terminating VS connecting, weight, etc.). The SPG module is used to generate, according to a pre-defined pattern (or schedule in case of connecting shipments throughout the RFS area), the pick-up time of inbound terminating (or connecting) goods. At this point of the simulation model, the completion time of any scheduled inbound shipments that need to be processed in the system is known. The SDC module uses the output of the SPG module in order to release goods from the cargo terminal. When a request is received, shipments in bulk or on ULDs are retrieved from one of the storage areas and delivered to customers either at the main counters, at the import truck dock area, or at the RFS area.

3.2 Input Modeling and Data Analysis

The data inputs were determined through data collection and interviews with cargo managers, cargo facility designers, and the manufacturer agents of cargo handling equipments. The data requirements fell into five categories (a) shipment attributes, (b) shipment arrival or pick-up pattern distribution, (c) shipment processing time, (d) shipment routing data, and (e) other.

For the first two categories, a sample of historical data representing about one month of cargo activities was collected from various real time corporate databases. This data was merged according to the airway bill number into another database that gives a representation of the movement of cargo within the terminal. This merged file provides details such as shipment types (originating, termination, connecting), shipment service types (express, regular freights), shipment arrival or departure modes (bulk, ULDs, pallet), number of pieces and weight per shipment, shipment arrival or departure stations, types of aircraft involved, etc. The data analysis allows us to determine the following inputs required in the simulation model, (a) the distribution of cargo volume as shown in Fig. 2 per station and per aircraft type; (b) the distribution of shipment between express and general freight, and (c) miscellaneous probabilities such as:

- probabilities of inbound connecting shipments that will be transferred in an outbound flight on cart or on ULDs
- probabilities of a terminating good arriving on cart to be retrieved by the customer at the main counter or at a good acceptance area
- probabilities of a terminating good arriving on a ULD to be retrieved by a customer at the main counter or at a good acceptance area
- probabilities of an originating good leaving the terminal on cart to be checked in at the main counter area or at a good acceptance area
- probabilities of an originating good leaving the terminal on a ULD to be checked in at the main counter area or at a good acceptance area
- probabilities of an originating shipment preloaded on a ULD to be checked in at the RFS dock area
- probabilities of a connecting shipment preloaded on a ULD to be checked out at the RFS dock area
- probabilities of an originating shipment preloaded on a ULD to be checked in at the RFS dock area
- probabilities that an originating ULD contains only one single shipment (SLU) or multiple shipments (MSU)
- probabilities that a terminating ULD contains only one single shipment (SLU) or multiple shipments (MSU).

The shipment arrival patterns were obtained after collecting and matching a sample of a new set of data representing two weeks of stamped airway bills (date and time) with the merged database discussed above. A total of 16 arrival patterns were generated depending on the shipment service type (express VS regular freights), shipment market destination (domestic, transborder, international, and south), shipment arrival mode (bulk, ULD). We also considered 8 arrival interval times. The length of each interval was assumed different per arrival pattern. Figure 5 presents an example of arrival patterns where the X-axis defines the number of minutes before the flight cut-off departure time (the latest time the cargo must leave the terminal without delaying the flight departure). The plot shows that:

- 1% of express shipments arriving on bulk for a domestic market can still be received between 60 minutes and 30 minutes before the flight cut-off departure (EXPRESS-DOM-BULK)
- 10% of express shipments arriving on SSSLU for a domestic market can still be checked in 120 minutes before the flight cut-off departure (EXPRESS-DOM-ULD)
- 100% of regular shipments arriving in SSLUD for a domestic market must be checked in 300 minutes to 360 minutes before the flight cut-off departure time
- 100% of regular shipments arriving in bulk for a domestic market must be checked in 240 minutes to 120 minutes before the flight cut-off departure time.

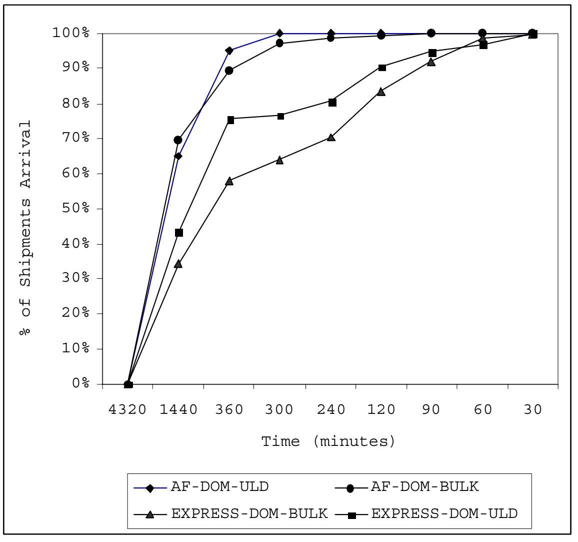

Figure 5: Arrival Pattern Illustration

For the arrival at the RFS area, the truck schedule was used and processed as an inbound flight.

The pick pattern was determined following the same methodology of the arrival pattern. Two pick-up patterns were considered depending on the shipment service types (express versus regular freights).

The determination of a third category of data related to the shipments processing time was primarily based on the experts evaluation because the new facility was not yet operating at the time of this study. A 3-step methodology was followed. Firstly, all the single activities involved in cargo operations were described and their times were estimated. For those activities not affected by the move to the new cargo facility, a time study was conducted to get the estimates of the processing time. For the remaining new activities, three estimates of the activity processing time were asked to experts (pessimistic, most probable, the optimistic). A total number of 92 activities were considered. Secondly, the cargo terminal was subdivided into 33 stations or departments (e.g., Import RFS airside dock, Import ULD airside dock , import RFS truck dock, import ULD storage, export ULD storage, AS/RS, cart break-down, ULD break-down, etc.). The assignment of tasks to different stations allows for the determination of the shipment processing time at each station. We assumed a step-wise linear function in determining the cart or ULD break-down processing time. Lastly, an estimate of the movement time between stations is determined. This time represents the transfer of a shipment using one of a combination of the handling equipments described in section 2.

The fourth category of data describes the different steps or stations a shipment needs to go through in order to complete its operation. These define a shipment route within the terminal. There are many attributes associated with a shipment and miscellaneous probabilities are possible for different attributes. The flow of goods shown in Figures 2 and 3 indicate that many processing routes of shipments within the terminal are possible and the selection of each is driven in this study by a random process taking into account the business rules.

The other category contains additional data that are mostly required to select a processing route for a shipment and include the time fence to avoid the storage at the main counter, the time fence to avoid the storage at the AS/RS, and the AS/RS storage delay for connecting goods.

3.3 Model Building and Translation

The model has been developed using Arena software. The key entities are bulk shipments or shipments on ULDs to be processed at different stations within the cargo terminal according to a random processing route determined according to the shipment attributes. The following assumptions were adopted:

- The cargo volume per destination and per aircraft type is known and remains unchanged during the simulation
- All shipments arrive and check-in within 4320 minutes (3 days) before the flight cut-off departure times
- All shipments are checked-out within 3420 minutes (2.375 days) after flight arrival times
- Processing requests are on a first come, and first serve basis
- A flight schedule is given
- No flights are cancelled or delayed on the day of simulation
- The processing time of various activities follow a triangular distribution
- Only one type of commodity is involved (general goods)
- The maximum number of carts per tractor is known and remains constant during the simulation
- The maximum number of ULS per tractor is known and remains constant during the simulation
- The runners are available on an unlimited number (this involves that the transfer time of cargo to/from terminal is not considered)
- The cart or ULD break-down processing time is a step-wise linear function depending on the number of pieces.

3.4 Model Verification and Validation

The statistical validation of the model was not performed because the new facility cargo was not yet operating at the time of this study. However a structured walk-through approach, the face validity, and the Turing tests were used to proceed to the model verification and validation (Kelton, Sadowski, and Sturrock 2004; Sargent 2000). Therefore, the logic of the model and its representation using the animation capability of Arena were presented to various knowledgeable individuals (cargo managers, cargo facility designers, and to the manufacturer agents of cargo handling equipments selected for this new cargo facility) to ensure that the model is a good representation of the system. In addition, some aggregate measures of processing times (minimum, average, maximum) at different key stations were collected and presented to the same knowledgeable individuals in order to determine that the model and/or its behaviour is reasonable.

4 PRELIMINARY USE OF THE SIMULATION MODEL AND FINDINGS

The simulation model has been applied using a cargo volume that represents one peak day of cargo operations at the airline's existing cargo facility. Table 1 presents a summary statistic regarding the cargo volume.

Table 1: Summary Statistic of Cargo Volume (Do Not Include Truck Arrivals)

	IMPORT	EXPORT
# of flights	370	368
# of aircraft types	15	15
# of stations	83	81
# of carts	342	332
Total goods on carts	3248	2444
# of ULDs	348	327
Total goods on ULDs	5123	888

The simulation model was used to evaluate the following preliminary scenarios:

- EXPORT – What is the effect of storing shipments in the ASRS and then moving them to build-up area when required (base scenario)– versus moving the shipments directly to the build-up area (scenario 1)
- What is the effect if all the interface points between man and machine were to take longer than expected (50% more, 100% more). This scenario might be a start-up scenario as people are confused or struggling with the new systems (scenario 2 and 3)
- What is the effect of certain equipment components (RFS lane, vertical conveyors, ETV, ATV, etc.) being out of action (scenario 4, 5, and 6).

4.1 Output Modeling

The output measures considered are respectively the service level standard and the maximum queue size (MQS). The labor and equipment resources were constrained at their current settings. The MQS measure was required to ensure that the queue space projected in the current design is sufficient. The service level was measured by the lateness or the readiness of the shipments. The lateness of a shipment is measured as the proportion (LR) of outbound shipments that have been processed after the latest time a shipment must be transferred to the aircraft loading area, without delaying a flight. Since they have different arrival modes (bulk versus ULDs) and different service levels (express versus regular), a distinction has been made for each combination (SLU-SCT, MSU-SCT, SLU-AFT, MSU-AFT). The readiness of a shipment is measured throughout the proportion (RR) of express inbound goods that have been processed within the terminal, after the time defined in the corporate standard for an express inbound shipment to be available for pick-up by a customer.

4.2 Base Scenario Description

The base scenario represents the new cargo facility according to its projected settings in terms of resource availability, processing times, cargo volumes, and business rules. We assume the following:

- a time fence of 120 minutes for an ULD and 180 minutes for loose goods. This states that an ULD completed 120 prior to the flight departure time is automatically transferred first to the ULD storage area and then to the ULD line-up. Otherwise, the ULD is transferred directly to the ULD line-up. A loose shipment moves directly to the cart or ULD build-up area if it arrives within 180 minutes before the flight departure time. Otherwise, it moves first to the AS/RS or other dedicated storage areas
- A terminal cut-off time of 45 minutes has been considered. This states the latest time to send an ULD or a cart to the aircraft loading area
- A break-down or build-up team size of 4 people each in the labor capacitated-finite case
- No breakdown of an equipment
- Cargo volumes, processing time, availability of material handling system and storage, allocation policy of equipment to tasks according to the current settings (e.g., 2 import ATV, 1 import ETV, 4 break-down workstations, 2 exports ATV, 2 export ETV, etc.).

4.3 Effect of Changing the Shipment Storage Policy at the Export Level

The effect of storing shipments in the ASRS and then moving them to the build-up area when required (base scenario)–versus moving the shipments directly to the build-up area (scenario 1), has been represented within the model by changing the time fence for an outbound loose shipment from 180 minutes to 360 minutes. According to the business rules described, goods need to move directly to the build-up area. Table 2 presents a summary of our findings. In both scenarios, the lateness ratio is positive. This means that the processing of all shipments was not completed on time considering the projected settings. The greatest impact of changing the shipment storage policy is on the maximum queue size at the build-up area. This may create a space storage issue at the cart or ULD build-up area.

Table 2: Time Fence Changing Impact on Outbound Shipments

LATENESS RATIO (%)		
	Base scenario (TF=180 min)	Scenario 1 (TF = 360 min)
MSU-SCT	5.63	2.50
MSU-AFT	6.65	3.02
Maximum Queue Size for some key resources (MQS)		
	Base scenario (TF=180 min)	Scenario 1 (TF = 360 min)
ULD build-up	13	72
Cart build-up	22	84

4.4 Effect of Processing Time Changes

The effects of increasing the processing time by 50% (scenario 2) and 100% (scenario 3) respectively at all the interface points between man and machine are summarized in Table 3 for outbound shipments and Table 4 for inbound shipments. These scenarios were required to evaluate the impact as people are confused or struggling with the new system during the transition period. An important increase in both the lateness ratio and the readiness ratio has been observed with the increase of processing times.

Table 3: Processing Time Changes Impact on Outbound Shipments

LATENESS RATIO (%)			
	Base Scenario	Scenario 2	Scenario 3
MSU-SCT	5.63	28.78	59.7
MSU-AFT	6.65	30.31	57.9
SLU-SCT	5.13	28.21	43.6
SLU-AFT	0.00	37.5	63.6

Table 4: Processing Time Changes Impact on Inbound Shipments

READINESS RATIO (%)			
	Base Scenario	Scenario 2	Scenario 3
MSU-SCT	37.3	31.13	33.3
SLU-SCT	14.3	1.61	3.23

4.5 The Effect of Breakdown

The effects of certain equipment components being out of order have been estimated through 3 scenarios involving the breakdown of the ETV import (scenario 4), the breakdown of the ATV import and of the ATV export (scenario 5), or a breakdown of the ETV import, ATV import and of the ATV Export (scenario 6). Table 5 and Table 6 present the results for the outbound and the inbound shipments respectively. Since the entrance or the exit from the cargo terminal is throughout the use of an ATV, the breakdown of one component has a significant impact on the lateness ratio or the readiness ratio.

Table 5: Equipment Breakdown Impact on Outbound Shipments

LATENESS RATIO (%)			
	Scenario 4	Scenario 5	Scenario 6
MSU-SCT	4.07	38.44	24.28
MSU-AFT	6.10	6.28	6.10
SLU-SCT	6.67	10.26	12.56
SLU-AFT	0.00	0.00	0.00

Table 6: Equipment Breakdown Impact on Inbound Shipments

READINESS RATIO (%)			
	Scenario 4	Scenario 5	Scenario 6
MSU-SCT	32.6	38.4	34.0
SLU-SCT	3.23	1.61	3.23

5 CONCLUSION AND FUTURE WORKS

This work illustrates the use of simulation for evaluating and analyzing air cargo operations at one of the new state-of-the-art cargo facilities at Toronto Pearson Airport. A brief description of the airline's cargo operations has been described as well as the simulation modeling approach. The preliminary results obtained show that the proposed simulation-based tool can be effectively used in its current level of development to quantitatively evaluate and compare different policies, business practices and procedures within a given set of operational and business constraints.

In addition to the scenarios described in this study, the proposed model can be used in evaluating scenarios such as the effect of an increase of cargo volume or the effect of changing the product service standard.

Since the cargo facility is currently operating, future work includes updating the model inputs throughout a data collection study to obtain a better understanding of the system. Further scenario analysis at the disaggregated level can then be envisaged.

Finally, since the pull approach has been adopted in this study, the cargo demand is essentially flight driven. It will be interesting to develop a general simulation model that will driven by market demand instead of flight schedules in an effort to tackle the various scenarios of moving from a cost hub cargo facility center to a profit center.

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