

AVOIDING THE BLUES FOR AIRLINE TRAVELERS

Jane L. Snowdon

IBM T.J. Watson Research Center
Route 134, Office 31-219
Yorktown Heights, NY 10598,
U.S.A.

Soad El-Taji

Operations Research and
Business Innovation Solutions
Air Canada Centre 045, PO
9000
Station Airport, Dorval
Quebec H4Y 1C2, CANADA

Mario Montevacchi

Travel & Transportation
Industry
IBM Corporation
150 Kettletown Road
Southbury, CT 06488, U.S.A.

Edward MacNair

IBM T. J. Watson Research
Center
P. O. Box 218, Office 31-255
Yorktown Heights, NY 10598,
U.S.A.

C. Adam Callery

Travel & Transportation
Industry
IBM Corporation
One IBM Plaza, 9th Floor
Chicago, IL 60611, U.S.A.

Scott Miller

Consulting Services Team
Systems Modeling Corporation
The Park Building,
504 Beaver St.
Sewickley, PA 15143, U.S.A.

ABSTRACT

The fast growth in airline passenger traffic combined with the slow growth in airport capacity worldwide is putting a severe strain on the capability of airlines to adapt their processes to maintain satisfactory levels of customer service. The urgent need to better utilize assets, handle more flights in shorter periods of time, increase the number of waves at hubs, coordinate schedules with alliance partners, and quickly respond to irregularities, such as weather and malfunctioning equipment delays, is confronting airlines worldwide. IBM Research and IBM's Travel and Transportation Industry Solution Unit are helping airlines and airports to use advanced information technology to get passengers through check-in, security, and boarding faster, and to improve baggage handling systems, thus improving the passenger experience. Simulation models, built using IBM's Journey Management Library™ (IBM JML™), are useful in helping airlines understand what impact new technologies, such as self-service kiosks, voice recognition check-in, smart cards, electronic ticketing, and radio frequency devices, will have on bottlenecks, personnel needs, and customer service levels.

1 EVOLUTION OF JOURNEY MANAGEMENT

Remember the old days when we had to queue up at the teller line inside the bank's lobby to withdraw or deposit

cash? Those were the unpleasant days before Automated Teller Machine (ATM) technology made it possible to redefine the process. No more queues. Fast service, anytime, anywhere.

Remember the old days when we had to queue up at the counter inside a car rental location to check out or check in our rental car? Those were the unpleasant days before mobile and self-service technologies made it possible to redefine the processes. No more queues. Fast service, high customer satisfaction.

Remember the old days when we had to queue up at the airline check-in line inside the airport terminal lobby and wait, and wait? That was just this morning.

Have you noticed that airports seem a little more crowded lately and lines at the ticket, check-in, and security locations are longer? That's because the number of flights especially into and out of hub-and-spoke airports is increasing, disgorging dramatically more passengers into an airport system that has expanded little in recent years.

Are the airlines and airport authorities exploiting modern technology to improve the passengers' flow through the airport? Is the journey of the passenger effectively managed to high levels of satisfaction? The answer to these critical questions is not always what it should be. While airlines recognize that the adoption of new technologies can achieve higher levels of service, they have a difficult time quantifying the service level and the economic impact of interactions between new technologies and process changes.

In the Fall of 1996, IBM Research and IBM's Worldwide Travel and Transportation Industry Solution Unit began exploring the application of simulation modeling techniques to the airport terminal congestion problem. The "Journey Management" project was formed to address the need for a tool to allow airlines and airport authorities to deliver a positive experience to airline passengers as they proceed through airport processes. The resulting "IBM Journey Management Library" is a set of building blocks and templates, for use with a simulation tool, to describe airline processes (e.g. check-in) and related new technologies. The IBM JML can be efficiently reused both to model multiple airport environments under variable local conditions and to serve as the core engine for the expansion of simulation models into other related airport activities, such as baggage handling and ramp services.

To begin the project, we assembled a team of IBM experts in simulation technology and the travel industry business to form the nucleus of the project. We then selected a simulation tool to be used as the technology base for the project. The selection criteria were based on range of functionality, ease of use, and flexibility, and are described in more detail in the next section.

Having secured necessary knowledge and technology, we took a further step to engage an airline partner who would fully participate in the project. We wanted a partner who would provide in-depth insight into the business and operational aspects of passenger processes at the airports, and who would be able to supply the rather extensive set of statistical and operational data required for construction of the model. We approached several airlines worldwide and presented our Journey Management Library idea and the business objectives we intended to achieve.

The reaction was always extremely positive confirming our belief that simulation modeling, enhanced by the availability of a JML, was essential to the integration, coordination, and optimization of information technology into journey management processes. In addition, the ability to test and evaluate alternative solutions before venturing into "real life" prototyping and investing in new technologies was seen by us and the airlines as a major, fundamental benefit providing the very important bridge between proposed ideas for operational improvement and their implementation.

Air Canada was the airline that responded with the greatest interest and enthusiasm. The leadership, knowledge, and skills provided by their Operations Research and Business Innovation Solutions (ORBIS) organization was most impressive. We all agreed that we would form a close partnership in this venture. After evaluating potential alternative environments, Toronto's Lester B. Pearson Terminal 2 was selected as the best candidate for modeling. The terminal operations for domestic passenger processing at that facility provided the

greatest variations of interactions between passengers and Air Canada's processes where process capabilities were both integrated and segregated in the form of check-in, ticketing, and baggage handling. Domestic departures operations were also determined to be the best source of significant amounts of reliable information in the form of collected statistical data, quality assurance, and contemporary databases. Starting in early 1997 the Journey Management Library project was on its way to success.

2 TEMPLATE DEVELOPMENT APPROACH

The initial step in the development of the Journey Management Library was to select a simulation tool. Air Canada and IBM identified a set of comprehensive requirements. The four most important requirements in priority order are ease of use, graphics and animation, speed, and portability.

- **Ease of Use:** User-friendly to multiple types of users: business process analysts, planners, and operations research experts throughout the organization. Must have an open architecture so that spreadsheet data can be easily imported and exported.
- **Graphics:** State-of-the-art animation for visualization; ability to import CAD drawings
- **Speed:** Very good performance running on a personal computer
- **Portability:** Implement on a personal computer running Windows 95®

The other requirements include:

- **Flexibility:** Easily extensible
- **Data Manipulation:** Automatically fit distributions to historical data
- **Simulation Depth:** Powerful functionality
- **Analysis of Information:** Perform automated analysis so that each alternative is running in parallel in multiple split screens simultaneously
- **Scenarios:** Perform "what if" scenarios easily
- **Reporting:** Comprehensive, easy-to-interpret reports with excellent graphing capability
- **Performance of Runs:** High degree of automation for conducting multiple runs
- **Presentation:** Easy-to-understand results
- **Hardware Needs:** Personal computer, not a mid-range workstation
- **Full Service Support:** High quality and responsive technical support
- **Perception of Use:** Easy, portable, yet sophisticated with a short learning curve

As a result of the need to comply with these requirements, we assessed the suitability of several simulation tools for development of the Journey Management Library. The following five-step approach

was used for the tool evaluation. First, a literature search was conducted to identify possible candidates. Second, Dunn and Bradstreet reports on the simulation companies were obtained to ascertain their financial viability. In some instances where the company was privately held, the information available was incomplete.

Third, a two-day visit with each candidate simulation company was arranged. The first day was devoted to understanding the business aspects of the company such as company history, number and role of employees, product offerings, marketing channels, business partners, major customers, and future development strategies and directions. The second day was devoted to understanding the technical aspects of the simulation tool. On the second day, a tutorial session was conducted and then a problem scenario was posed to the vendor, who was then asked to model the scenario on the fly. The purpose of this exercise was to assess the ease or difficulty in creating and debugging models and to evaluate the flexibility of the tool in handling a problem specific to a non-manufacturing domain. Many of the simulation tools on the market have origins in the manufacturing domain and thus the terminology and slant of some tools are more tailored for manufacturing problems. Fourth, past and current users were contacted to obtain insight on their experiences with using the candidate tools. Fifth, and finally, we created models to gain first-hand experience using the tools.

We concluded that Arena® from Systems Modeling Corporation most closely met our requirements for a simulation tool. Arena is well established in Operations Research groups of major airlines and small package delivery companies for modeling operations. Arena is a proven tool for manufacturing simulation and has been used extensively in IBM. Together Air Canada and IBM agreed to proceed forward in developing the Journey Management Library using Arena.

The development approach for the JML has five phases. Phase 1 involves the selection of the simulation tool. Phase 2 involves creating, validating, and testing a simulation model for a specific problem domain, in particular passenger-oriented processes for a specific airline at a specific airport. Once the model is validated, the simulation results are analyzed. Phase 3 involves defining functional specifications and a high-level design for the template based on the experience gained in Phase 2 and generalizing it for any airline or any airport. Phase 4 involves low-level design, development, and component, functional verification, and systems integration testing of the template. Phases 3 and 4 are iterative phases because design decisions and their associated development implications influence implementation. Phase 5 involves transferring the template and skills to the IBM Travel Industry Consulting organization worldwide for use in helping their customers implement advanced solutions.

Phases 2 through 5 are described in more detail in the next section.

3 EXPERIENCE

3.1 Baseline Simulation Model Description and Study Results

The scope of the baseline simulation model of Air Canada's domestic passenger processing functions consists of these processes: ticketing, economy passenger check-in, premium passenger (e.g., first class, elite frequent flyers) check-in, special assistance (e.g., unaccompanied minors, people requiring wheelchairs), special services (e.g., oversized baggage, pets), and gate control (e.g., gate check-in, coupon lift, close-out / reconciliation). The intent of this journey management model is for use in analyzing the impact of introducing advanced information technology capabilities and evaluating their improvement on customer service.

In the simulation model, the key entities are passengers that move through a set of processes and activities that consume resources. Constructing a suitable model of this airport passenger service process presents a number of challenges in the application of simulation technology.

In many simulation models, specifying a parameterized distribution such as the Poisson process with a given rate easily captures the entity arrival process. However the dependence of passenger appearance on the flight schedule prohibits using this approach. In our model a set of flight pre-departure events was generated at a fixed time interval before the departure time of each flight in the schedule. During the simulation, each of these flight pre-departure events in turn simultaneously kicks off the generation of each passenger on the flight. Each passenger entity is then assigned a terminal appearance event time based on the appropriate distribution of time ahead of flight. The pre-departure event is also used to key the timing of process activities.

Another challenge in this simulation effort was to accurately capture the complexity of the passenger mix and its impact on the requirements for airport services. For example, a different distribution of number of bags needed to be applied to business and leisure passengers. Such distinctions were further broken down by type of travel (domestic versus regional) and even time of day. Immediately upon generation and prior to terminal appearance, each passenger type, as determined by the flight-boarding forecast, is assigned some key attributes, for example originating or connecting. These attributes work with the processing logic to model the flow of the passenger through the process.

A different challenge involved incorporating the resource schedules to model the assignment of agents to

counters. Both full-time and part-time agent schedules are phased in and out over the course of the day to maximize productivity by approximating the peaks and valleys in passenger activity. The result is a resource profile that can vary significantly in each fifteen-minute interval throughout the workday. The model dealt with this complexity in two ways. The first was to take advantage of the modeling tool's ability to group individual resources into workgroups. Secondly, in the course of the study, a method of transforming agent schedules from manpower planning worksheets into simulation resource downtime schedules was devised. This allowed the modification of resource schedules to be accomplished outside of the simulation interface using either a text editor or spreadsheet application.

Another resource-related modeling challenge was making adjustments in the allocation of resources to activities based on observations of the system. For example, one step of the processing logic is to serve regular customers "unless you see a line forming" at the priority counter. Human behavior of this kind is difficult to model as a rule or procedure. In the model, this procedure was handled by giving priority passengers priority access to a "swing" counter. The definition of the resources for the swing counter then needed to be modeled in more detail and separately from the other counters. Such balance decisions will likely continue to be difficult to capture in process modeling regardless of the type of simulation technology.

Air Canada's industrial engineering and quality control organizations provided input data to the model from both current observations and historical patterns. After validating the model with actual data collected for the day of May 2, 1997, we conducted multiple simulation runs for each day of the week of July 7-13, 1997. The runs used forecasted data as input and collected performance measures for all major processes. The measures included peak and average wait times, peak and average number of passengers waiting in line, resource utilization, etc.

The primary objective of these runs was to assess whether predefined standards for passenger service levels were attained. Ticketing standards stipulate that 80% of passengers should wait in queue less than five minutes. Similar standards that 90% of economy check-in passengers wait less than five minutes and 90% of premium check-in passengers wait less than two minutes also hold.

As such, each run took a snapshot of system conditions at each instance when a passenger experienced a service level that did not meet Air Canada's standards. These conditions include time of day, type of passenger, number of passengers in queue, wait time, resources availability and resources utilization.

After analyzing all collected statistics, we focused on investigating conditions where wait time exceeded Air

Canada's targets. Those areas for which the target service levels appeared to be inconsistent were the ticketing process and the economy check-in process. Output from the model indicated that a minimum of 87% and a maximum of 93% of all passengers waiting in the ticketing queue and a minimum of 81% and a maximum of 93% of all passengers waiting in the economy check-in queue waited less than the target 5 minutes.

However, a detailed analysis of the ticketing counter process showed that those passengers whose wait time exceeded the service standard experience a consistent and significant clustering of excessive waiting time during a period of about one hour in the morning. A closer scrutiny of the clustering revealed that almost 60% of those passengers whose wait time exceeds 5 minutes waited more than twice the desired standard with about 20% of passengers waiting between 25 and 30 minutes. Hence, the ticketing process represents an opportunity to investigate the integration of self-service kiosks to improve the throughput.

In contrast, a more detailed data analysis at the economy check-in process portrayed a different picture. In this case, passengers whose wait time exceeds 5 minutes seldom do so by more than 7 minutes. This type of observation provides a base for further simulations that seek to integrate new technology enablers into streamlined processes.

3.2 Journey Management Library Template Description

A functional specification for the Journey Management Library template was developed based on the knowledge gained from the simulation study described in Section 3.1. The template provides a simple user-friendly interface, an interface to outside data sources, a visual representation of the activities taking place within the model, an easy to understand representation of results, and on-line help and user documentation. A tutorial and training course have also been developed to accompany the template, thereby facilitating the technology transfer to the IBM Travel Industry and its customers. The Journey Management Library template consists of custom designed simulation modules that represent portions of the airline passenger processes. Template modules are classified into three main groups: data modules, logic modules and process modules.

1. Data modules define system information that is critical to either the passengers or the processes in the model. Data modules are placed in the model once and define and control the basic parameters of the model. Each of these data modules is linked to an interface to allow the information to be imported and/or entered easily. Visual Basic for Applications® was used to build the interface to the data modules. Excel 97® is the standard data repository.

2. Logic modules allow the user to define passenger flow through the model. Most of the logic modules in the template describe the actions in one type of area in the actual system, such as physical locations like security. In addition to these high level modules, other lower level logic modules are included to allow the modeling of more advanced logic. Logic modules may be used in a model multiple times and are connected to each other in such a way as to describe the logical flow of passengers throughout the system.
3. Process modules define tasks to be performed in the model. A process is defined once, but may be referenced in multiple locations in the model. Passenger Process modules define specific passenger activities, for example, Issue Ticket, Issue Boarding Pass, Accept Baggage, Clear Security, Clear Immigration, Clear Customs, Gate Check-In, & Boarding Control.

The template includes two separate modules with flight specific data. The Flight Schedule module contains standard information for each flight like airline code, flight number, scheduled departure time, aircraft type, and flight type. The Carrier Specific Data module contains other flight specific data like assigned gate number, estimated departure time, number of first class passengers, number of business class passengers, and number of economy class passengers.

The Arrival Pattern modules define the percentage of passengers who arrive during defined time intervals prior to the flight departure. There can be different arrival patterns based on passenger type, time of day, and flight type. Passengers can be categorized as either originating or connecting.

The Passenger Definition module assigns values to passenger attributes. The attributes include passenger status, value to the airline, ticket status, ticket type, and payment type.

The Aircraft Parameters module contains aircraft type specific information that is needed in the template. This information includes the gate open and close time, the aircraft boarding time, the gate close-out time, and the number of gate agents assigned for check-in and boarding. Figure 1 depicts the IBM JML Aircraft Parameters dialog module.

Service Location modules represent physical areas in the system where passengers are serviced. A terminal check-in counter or security checkpoint are examples of service locations.

Decision Location modules represent points in the system where passengers choose among various routing options. These decisions may be based on passenger attributes, system status, or random chance.

Gate Area modules represent areas in the system where passengers go through gate processes. Gate check-in and boarding are examples of gate areas.

The Resource Schedule module defines a staffing schedule for service locations, gate check-in counters, or boarding areas. The staffing schedule controls the availability of the resources required to support the processes at these locations.

3.3 Follow-on Simulation Study for Baggage Handling System

Based on the successful baseline simulation study results described in Section 3.1, Air Canada and IBM engaged in a follow-on study to model the domestic baggage handling system at Toronto Airport. The scope was expanded to include five baggage handling processes: domestic check-in and domestic-to-domestic connections, RapidAir check-in and RapidAir-to-domestic connections (RapidAir is Air Canada's shuttle service between Toronto and Montreal and Toronto and Ottawa), Transborder connections to departing domestic flights (Transborder flights are those flights between Canada and the United States), international connections to departing domestic flights, and "curbside check-in" from Special Services for passengers who have purchased a ticket at Ticketing and drop their bags at Special Services. The intent of this follow-on journey management model is to understand the capacity of the baggage handling system and to evaluate ways of enhancing service for passengers by minimizing the number of passengers who arrive at their destination without their bags.

In the simulation model, as depicted in Figure 2, the key entities are passengers and bags that move through a set of processes and activities that consume resources. Section 3.1 describes the many challenges of modeling domestic passenger processes. The model was further complicated by including additional types of passengers (e.g., RapidAir, Transborder connections, International connections), each with their own arrival pattern that has to be applied against the flight schedule. Additional challenges are introduced when applying simulation technology to baggage handling processes.

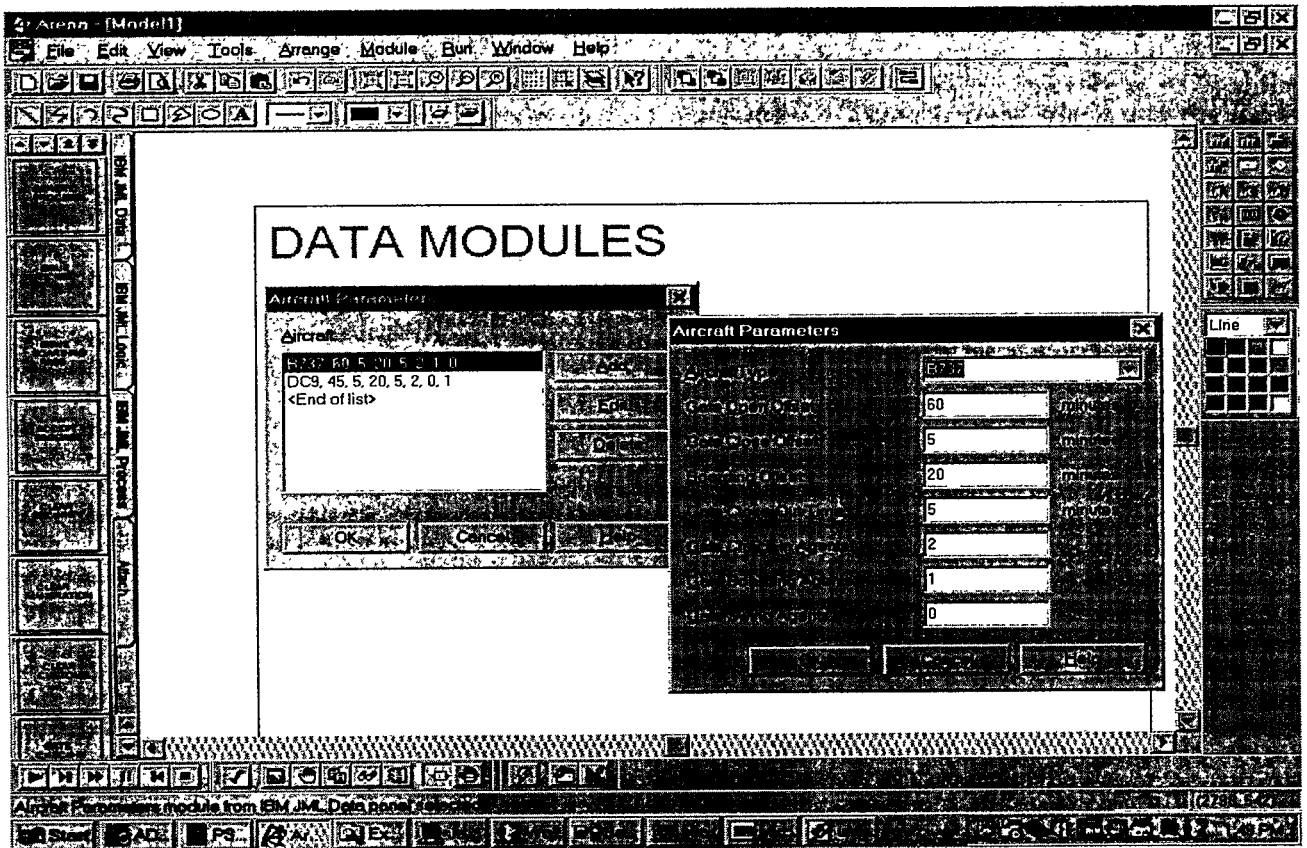


Figure 1: IBM JML Aircraft Parameters Dialog Module

For example, it is important to accurately represent the mix of passengers and their varying needs for airport services. A different distribution of bags needs to be applied not only to business and leisure travelers, but also to domestic passengers, shuttle passengers, and connecting Transborder and International passengers.

Another challenge is to capture the material handling aspects of the system. The model needs to incorporate the distances and speeds of the conveyor segments, the failure rates of the inspection stations where the bar-coded baggage tags are scanned for destination, and the parameters to account for conveyor system jams and slips. Once a bag has been scanned successfully, it is “pushed” down a chute to a pier. Each chute is dedicated to serve one or more destinations. At the end of the pier, the bag is then placed into a cart depending upon its priority (e.g., connections, economy bags, and first class bags).

The capacity of a cart varies based upon the type of aircraft(s) it serves. A tractor then “runs” a series of carts out to the airplane for loading. Each tractor is dedicated to one or more piers. Parameters for modeling tractor velocity and travel distance to the gates must also be incorporated.

In addition to modeling the assignment of agents to counters as described in Section 3.1, scheduling resources is further complicated by modeling the assignment of baggage handlers and tractor runners to piers and also the availability of carts and tractors. Schedules for both full-time and part-time baggage handlers and drivers are phased in and out over the course of a day to maximize productivity. Rules representing the frequency of tractor runs and the time of the last tractor run to ensure on-time aircraft departure also need to be modeled.

4 CONCLUSIONS

The IBM JML is a decision support application that provides relevant and timely information. As an interactive

and flexible management tool, the IBM JML enables resource planners, business process experts, and operations research analysts to solve complex planning tasks in order to provide the highest level of service to its customers and

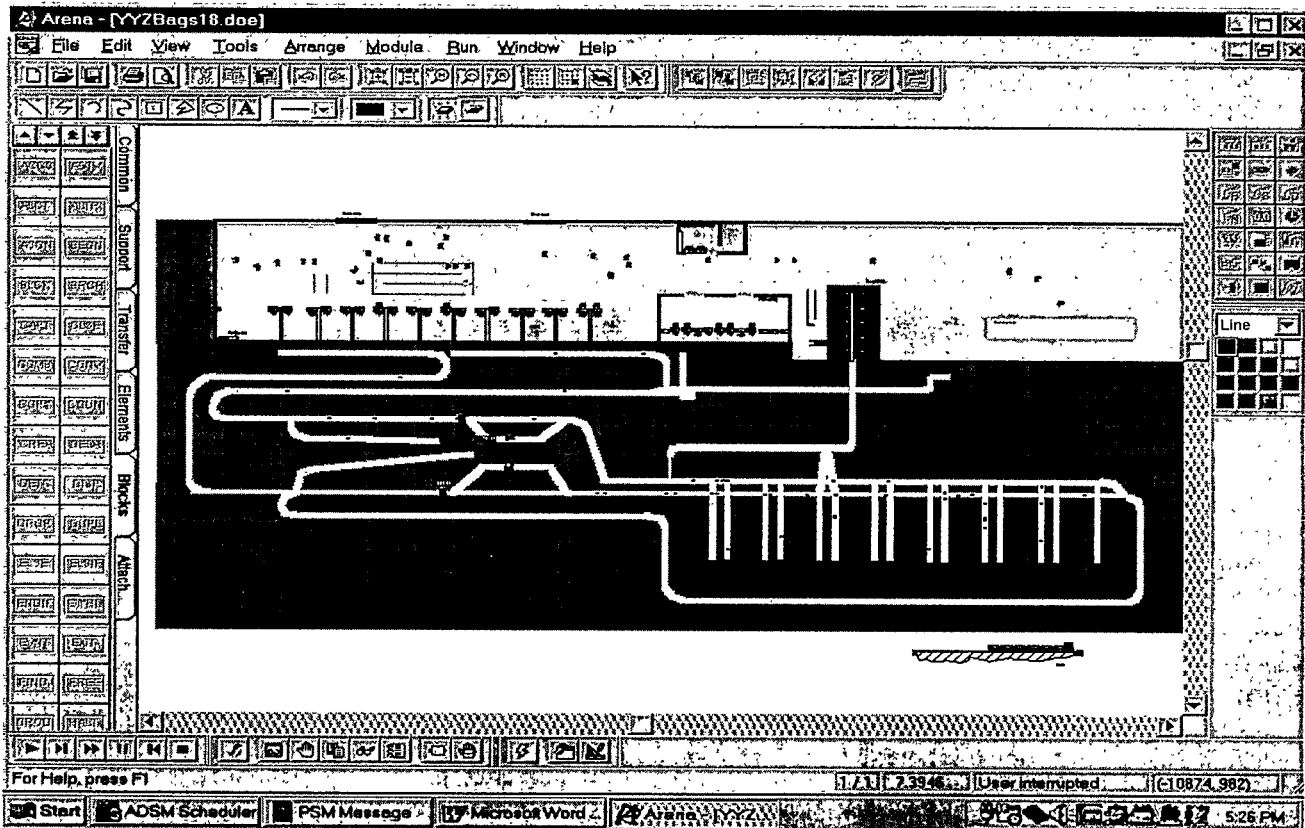


Figure 2: Air Canada Simulation Model

enhance productivity at airports. Specifically, the IBM JML can be used to benchmark the use of several customer service technologies, such as voice recognition, smart cards, or self-service kiosks against internal and industry performance measurements to identify which solutions perform the best under various scenarios, on a desktop workbench, before making actual investments in staffing or equipment.

Because the template can operate as a stand-alone module representing a single process or integrated with other templates to examine multiple processes across functional areas, the IBM JML template can be used in the future by both airlines and airport authorities to, amongst other things:

1. Examine baggage handling operations from terminal check-in to the air field;
2. Examine the impact of security and customs regulations on passenger movements and terminal resource allocation;

3. Examine the management of air cargo warehousing and handling operations; and
4. Examine the travel patterns of passengers to and from retail and food & beverage concessions within the terminal building.

The IBM JML, given its ease of use, allows airlines and airport authorities the ability to easily represent multiple service configurations and quantifiably (e.g. either by economic or statistical measures) choose between alternatives. The value to the organization is that the template can be quickly assimilated, re-used, and repeated with minor parametric changes by other field locations and used to improve customer service and enhance productivity.

The IBM JML also has applicability to other travel-related service providers. In the competitive travel and transportation environment, rail, lodging, rental car, and cruise line companies are planning and preparing for ways to handle the increased volumes of passengers as the millennium approaches.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the help of Air Canada's Operations Research and Business Innovation Solutions Department in Montreal, the Baggage Department and Quality Assurance Team at Toronto Airport, and especially Patrick Bitauld, Bob Blanch, Elena Fanucchi, Jim Ohlsson, Greg Trites, and Michel Turcotte. The authors also acknowledge the help of Ranga Anbil, Sugato Bagchi, Brenda Dietrich, Russell Rushmeier, and Bill Tulske from IBM Research and Ken Burch, Gary Cross, Claude Guay, Anthony Palella, and Ian Smith from the IBM Travel and Transportation Industry Solution Unit.

CREDITS

IBM Journey Management Library and IBM JML are trademarks of the IBM Corporation. Arena is a registered trademark of Systems Modeling Corporation. Microsoft, Windows 95, Visual Basic for Applications, and Excel 97 are trademarks or registered trademarks of Microsoft Corporation.

REFERENCES

Bitauld, P., K. Burch, S. El-Taji, E. Fanucchi, M. Montevecchi, J. Ohlsson, A. Palella, R. Rushmeier, and J. Snowdon (1997), "Journey Management," *OR/MS Today*, Vol. 24, No. 5, pp. 30-33.

AUTHOR BIOGRAPHIES

JANE L. SNOWDON specializes in mathematical optimization, simulation, and business process reengineering in IBM Research's Mathematical Sciences Department. She has over 15 years of experience at IBM in project management, technical, and marketing roles in the travel, transportation, and manufacturing sectors. Dr. Snowdon holds a Ph.D. from Georgia Tech, an M.S. from the University of Michigan, and a B.S. from Penn State University, all in Industrial and Systems Engineering.

SOAD EL-TAJI specializes in operations research in Air Canada's Operations Research and Business Innovation Solutions Department. She has over 7 years of experience at Air Canada. Ms. El-Taji holds a B.Sc. degree in Mathematics and a minor in Computer Science from the American University in Cairo, Egypt.

MARIO MONTEVECCHI specializes in information technology strategic planning, system design, product development, project management, and business re-engineering in IBM's Travel Industry Practice. He has over 30 years of experience at IBM and has worked with most major airlines and related travel organizations in the

Americas, Europe, and Asia Pacific. Mr. Montevecchi holds a Ph.D. degree in Petroleum Engineering from the University of Bologna.

EDWARD A. MACNAIR specializes in modeling contention systems in IBM Research's Mathematical Sciences Department. He has more than 30 years of experience at IBM and has worked in the areas of modeling systems and model tool development. Mr. MacNair holds a M.S. in Operations Research from New York University and a B.A. in Mathematics from Hofstra University.

C. ADAM CALLERY specializes in strategic planning for airport and airline operations and in the development of management technologies in IBM's Travel and Transportation Industry Solutions Unit. He has over seven years of experience in the airport and airline management field having worked for a major international airline and as a management consultant for major airlines and airports. Mr. Callery holds a M.B.A. in Business Administration from the University of North Carolina and a B.S. in Chemical Engineering from the Illinois Institute of Technology.

SCOTT A. MILLER specializes in simulation model development, analysis, and support in the Consulting Services Division of Systems Modeling Corporation. He has seven years of experience consulting in the transportation, steel, communications, electronics, manufacturing, and service industries. Mr. Miller holds B.S. and M.S. degrees in Industrial Engineering from the Pennsylvania State University.