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Airport-Airspace Simulations

A New Outlook

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Airport-Airspace Simulations
A New Outlook

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Introduction

Saleh A. Mumayiz
Illgen Simulation Technologies, Inc.

The third workshop on airport modeling and simulation—Airport Simulation: A New Outlook—was organized by the TRB Committee on Airfield and Airspace Capacity and Delay (A1J05) on January 11, 2002. Proceedings of this workshop is documented in this Circular, which complements those published by TRB for the previous two workshops:

- *Transportation Research Circular E-C035: Airport-Airspace Simulations for Capacity Evaluation*, published August 2001, and
- *Transportation Research Circular E-C036: Airport Modeling and Simulation for Environmental Analyses*, published March 2002.

This workshop built on what was presented and discussed in the previous two by providing state-of-practice of airport and airspace modeling and simulation tools, techniques, and analytical procedures. This workshop also included one-on-one computer demonstrations by the individual presenters of the state-of-the-art of the industry.

This workshop provided a hands-on practical environment and a forum to present and discuss new and innovative simulation tools and techniques that would improve the utility of airport and airspace simulations to users and enhance quality of results. Presentations, discussions, and demonstrations facilitated the exchange of facts and thoughts on the benefits and advantages of implementing these new simulation techniques as technical analysis and decision-making tools. Experiences of the presenters were shared with the workshop participants on the technical content, data requirements, analysis methods, and results from case studies as demonstrated and discussed. The workshop was conducted in an interactive manner with balanced representation of speakers comprised of simulation developers, simulation users, academic researchers, airport managers/operators, airspace planners and operations analysts, and airport consultants.

The attendants of this workshop represented a wide spectrum of experts in this field from the United States and internationally. They included airport managers, aviations planners, airport engineers, aviation/airport consulting firms, university and aviation center researchers, state aviation and airport authorities, and airport-airspace planners from federal and state aviation agencies.

ACKNOWLEDGMENTS

The TRB Committee on Airfield and Airspace Capacity and Delay, and the workshop organizing committee would like to express appreciation and gratitude to the individuals who contributed to the organization and success of this workshop. Acknowledgement is extended to Joseph Breen and Nancy Doten of the TRB staff for their tireless efforts and attentive involvement in the different stages of organization. Special appreciation goes to the speakers and moderators of the workshop for their time and effort in ensuring the success of this activity.

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MORNING SESSION

Modeling the Performance of the National Airspace System

George L. Donohue
Manqin Luo
Chun-Hung Chen
George Mason University

Reza Holland
The Boeing Corporation

OBJECTIVE

The objective of this study is to provide insight into the relative predictions of models that are used to predict parameters of interest to air transportation systems. These parameters include traffic flows, delays, controller workload, and system safety. All of these models make a large number of assumptions that are inevitably buried in the computer code and are usually only known to the code developer. These invisible assumptions can have a large effect on the predicted values of important parameters. Rarely are the outputs of these models compared to actual operational data or to each other for a comparable set of inputs and for a comparable range of input variables.

Models are very expensive to develop and document. In the long run, they are even more expensive to use. The training and knowledge that model/computer simulation users require is extensive. Upon extensive review of the literature (and personal familiarity with a number of the models) we have found that the selection of a model to conduct system sensitivity analysis should be made with great care.

BACKGROUND AND PRESENT STATE OF KNOWLEDGE

Models of aircraft operating at airports and in controlled airspace are increasingly being used to evaluate air transportation congestion and new procedures and technology designed to increase safety and capacity. Models such as SIMMOD (FAA's airport and airspace simulation model) and the Total Airspace and Airport Modeler (TAAM) are used to simulate aircraft at the airport and in the near airspace around the airport. Eurocontrol and FAA also use the European Reorganised ATC Mathematical Simulator (RAMS) model for some of these studies. The MITRE Corporation and the Logistics Management Institute (LMI) have developed two large-scale system models. Defense Contract Management Agency Process Action Team (DPAT) and LMI Network Model (LMINET) both model the system as a network of queues but these models treat the queues somewhat differently and the airport arrival departure parato frontiers are estimated independently. All of these models are in active use and claim a degree of validity based upon reasonable predictions and care in development. To our knowledge, none of these models incorporates the non-linear feedback loop, known as central flow control, nor finite queue restrictions. Recent study has shown that both U.S. and European ground delay programs are becoming a major ingredient in total system delays. Also, none of these models properly represent adverse weather (a major ingredient in system delay) or private aircraft operations, which represent over 25% of U.S. air traffic control (ATC) positive control operations and the majority of all U.S. flight operations. New models are being developed under National Aeronautics and Space Administration (NASA) funding to understand the rapid growth of private aircraft operations in the United States (perhaps as a partial response to safety concerns and growing congestion of the commercial hub-and-spoke system).

Many studies have been done by SIMMOD but it is slowly losing popularity due to lack of FAA support and the difficulty of maintaining legacy FORTRAN code. TAAM has more features, simulates more airspace, and has a more modern code structure. It is expensive to acquire, however, and takes a considerable amount of training and data preparation to operate.

EVALUATION METHODS AND PROCEDURES

The FAA Consolidated Operations and Delay Analysis System (CODAS) and Aviation System Performance Metrics (ASPM) databases were selected to provide national airspace (NAS) performance metrics for code comparison. This data is obtained from the major airline Out-Off-On-In data and is believed to be the most accurate data available for IV&V comparisons. Some differences are found between CODAS and ASPM files for the same days and the reason for these differences is unresolved. The CODAS database has been replaced by the ASPM database. The Official Airline Guide (OAG) is used as input to all of the models being evaluated in this study. Comparison with Enhanced Traffic Management System data indicate that the OAG is rarely if ever flown. This is probably due to the increased use of flight cancellations as a response to hub-and-spoke congestion and systemic over-scheduling of hub airports leading to unacceptable delays and the potential loss of network schedule integrity. The NAS is a stochastic system and all of the models should be run in their Monte Carlo Mode. The models are not user friendly for operation in this mode and the analysis can be quite time consuming.

TAAM was selected for evaluation of airport and terminal airspace controller workload studies. Eurocontrol recently completed an extensive IV&V comparison of TAAM to SIMMOD and RAMS. It was found to provide a reasonably accurate prediction to actual European airport and airspace operations. Comparison of TAAM to Dulles International Airport (IAD) performance in this study found a similar result. TAAM was used to simulate IAD performance under a wide range of arrivals and departures in order to compute the 3-D arrival-departure-delay response function. It is believed that these airport response surfaces would be a better input to DPAT and LMINET system models in the future.

DPAT is still under evaluation. Comparison with good weather, 3-day, midweek averaged hourly delay data at major hub airports shows reasonable agreement. It is observed that DPAT tends to overestimate delays at the end of the delay. This may be due to the lack of an airline air operations center flight cancellation loop in the model logic. Work is underway in using the DPAT model to compute the network non-linear response function to a 20% increase in systemwide airport capacity increase.

LMINET is the next model to be evaluated for network performance characterization. The Traffic Organization and Distribution Model Analyzer (TOPAZ) model (developed by the National Aerospace Laboratory) is planned to be used to estimate the safety–capacity relationship that may be affected by operating airports at high operational workloads.

Click here to see Donohue's slide presentation.

MORNING SESSION

Total AirportSim
A New Generation Airport Simulation Model

TUNG X. LE
LeTech, Inc.

This presentation will focus on the new airport simulation model, called Total AirportSim—computer software that can model various aspects of total airport operations connecting airside and landside, literally from the airspace to the curb.

The model has been developed gradually and implemented over the years together by LeTech and the International Air Transport Association (IATA). LeTech first developed the Airspace/Runway Module back in 1996. In 1997, IATA joined in the development, where the Gate Module was developed in 2000 and the Terminal Passenger Flow Module in 2001. These three main modules of the model will be presented with their special features and capabilities as well as their sub-modules that help make up the system.

Total AirportSim is written in C++ and composed of more than 400,000 lines of code. Short descriptions of the three modules are:

1. Airport/runway. This module fully supports SIMMOD-like format and is compatible with FAA's SIMMOD version 2.3+, and includes an Integrated Noise Model (INM) 6.x interface. It is composed of network editor, event generator, simulation engine, and animation and reporting capabilities.
2. Gate. This module functions as the interface between the terminal and runways, essentially forming the link connecting the airport landside (terminal and groundside) and the airside (runway and airspace).
3. Passenger terminal. This module uses discrete event simulation logic in real or fast time to represent passenger flows and capture the operational and spatial characteristics of this sub-system. Passenger flows are driven by flight schedules, channeled throughout the terminal spatial layout, and subjected to the required facilitation procedures and other operational requirements. The module adopts flexible and diverse passenger path routing algorithms with graphical editor and computer-aided design capabilities. Features also include area/speed/density calculations, level of service (LOS) evaluation, different queue formations, concessions' activities, links to ground transportation, visitor-passenger associations, baggage operations, and several other features.

Click here to see Le's slide presentation.

TRACS: Terminal, Roadway, and Curbside Simulation

A Total Airport Landside Operations Analysis Tool

BELINDA HARGROVE
ERIC MILLER
TransSolutions

TransSolutions has developed an airport-planning tool to assess the effect of demand and operational changes on the airport system. TransSolutions leads the aviation industry in the use of discrete-event simulation analysis to improve the design and operation of airport facilities. Using state-of-the-art-modeling tools, TransSolutions evaluates terminal passenger flow, baggage systems, airport ground service equipment movements, and terminal curbside roadway systems. TRACS—Terminal, Roadway, and Curbside Simulation—now integrates a suite of TransSolutions' airport planning products into one tool.

TRACS is a flexible-planning tool that can be linked to other simulation products. TransSolutions has linked TRACS with both SIMMOD and CORSIM, FHWA's model of urban arterial and freeway systems. By integrating SIMMOD, TRACS, and CORSIM, TransSolutions has provided clients with a comprehensive assessment of terminal performance and its interaction with the airspace, airfield, and roadways systems. Over 80% of the world's largest airports have benefited from TransSolutions' technology through better investment decisions based on objective, accurate facility performance data.

TRACS

- Provides one framework capable of evaluating interactions of passengers, their baggage, and ground vehicles—ensuring the traveler's entire journey through the airport system is accurately evaluated.
- Provides comprehensive output statistics to evaluate in detail any part of the airport system.
- Applies a 24-hour day-of-operations schedule to characterize planning day demand. This approach ensures that key interactions, which affect facility performance, are not overlooked as in average peak-hour analyses.
- Affords a seamless animation of the curbside roadway, terminal, baggage system, and apron activities to see the performance of proposed facility designs. The animation shows vehicles arriving via the roadways to the curbside and the entire passenger process: groups exiting vehicles at the curb, proceeding into the terminal, processing at ticket counters and security inspection stations, and traveling to their gate.
- Has been rigorously validated in more than 200 studies over 10 years. These efforts have compared TRACS results to videotaped data collection, time and motion studies, passenger intercept studies, and client-supplied data. Real-world results were compared to model outputs and shown to be statistically the same, providing our clients with confidence in the model results.

This presentation will include an overview of TRACS and several examples of TRACS analyses at airports around the United States, including airport access roadway construction phasing, terminal layout sizing and design, security equipment requirements and location, curbside drop-off/pick-up, and customs/immigration facilities. Three of the modules within TRACS are highlighted below:

Curbside Roadways

Developed by a team including traffic engineers, the TRACS module evaluates curbside vehicle traffic including curbside geometry, transportation-mode curbside assignment, single and double parking with drop-off location preference, recirculation, curbside check-in operations, valet parking operations, toll plaza operations, pedestrian crosswalks, vehicle queues, and delays caused by congestion.

Output statistics:

- Overall system travel.
- Processing and delay time for each individual vehicle.
- Number of vehicle trips by transportation mode and time of day.
- Number of vehicles queued by time of day for each roadway entrance, exit, or merge point.
- LOS analysis by roadway segment.

Terminal Passenger Flow

TRACS models individual passenger processing through terminals including ticketing, international departure processing, security inspection, detailed corridor congestion, restroom utilization, concessions, holdroom waiting and processing, baggage claim, international arrival processing, baggage recheck, and people movers including elevators, escalators, moving sidewalks, and airport trains.

Output statistics:

- Overall system travel.
- Processing and delay time for each individual passenger or passenger group.
- Number of passengers queued by time of day for each processing point.
- Maximum occupancy statistics/code analyses for terminal areas.
- LOS analysis by terminal processing area.
- First and last bag delivery statistics.

Baggage Systems

TRACS models baggage delivery systems and related operations including gate delivery systems, centralized bagroom systems, manual make-up systems, aircraft loading and unloading, tug-and-cart deliveries, and ramp connection strategies. Detailed system processing areas include: baggage check-in at curbside, ticket counter or remote positions, online and interline transfers, international recheck, early bag storage, all system inputs and merge points, manual encoding, explosive detection screening systems, sortation matrices, and default/late bag processing.

Output statistics:

- Baggage delivery time.
- Processing and delay time for each individual bag.
- Number of late bags.
- Queue conveyor requirements.
- Cart staging requirements.
- Default and early bag handling requirements.
- Input and mainline capacity requirements.
- Baggage claim requirements.

Click here to see Hargrove and Miller's slide presentation.

OPAL

Optimization Platform for Airports Including Landside

KONSTANTINOS G. ZOGRAFOS
Athens University of Economics and Business

The OPAL concept—Optimisation Platform for Airports including Landside—has two main objectives. The first is to develop a concept for a computational, integrated, and distributed platform for modeling, evaluating, and optimising total airport operations, both landside and airside, simultaneously. The second objective is to develop a common platform, which has the form of a facility for integrated simulation with different airport performance models. At the top of these objectives, OPAL aims at giving a proof of this concept for six selected European airports by connecting models with respect to pre-specified scenarios. Selected European airports that will constitute the preliminary validation sites for the innovative OPAL are Amsterdam Schipol Airport, Frankfurt Airport, Madrid Barajas Airport, Barcelona International Airport, Palma de Malloraca Airport, Toulouse-Blagnac Airport, and Athens International Airport.

OPAL enables the assessment of the performance of a total airport. Effects of changes to the total airport infrastructure, technologies, and procedures and processes at airports can be analyzed in combination with contemporary and future traffic-flow scenarios. These effects can be expressed in terms of performance measures, such as:

1. Capacity,
2. Congestion and delays,
3. LOS,
4. Punctuality,
5. Safety,
6. Efficiency, and,
7. Cost-effectiveness.

Through its simulation and evaluation capabilities, OPAL supports decision making by airport authorities, airlines, air traffic service/ATC providers, and governments. The platform supports searching for solutions to problems faced at airports because it allows the user to perform "what-if" studies, and to search for improvements or optimal solutions. In particular, decisions on possible changes in infrastructure, technologies or procedures, and processes are supported. Because the platform allows decision makers to analyze effects of investments beforehand, it exhibits a strong capability of strategic planning and airport resource allocation.

OPAL provides decision support in the form of a facility for distributed simulation into which several airport performance models can be integrated. To evaluate scenarios for a given airport, a set of validated models for this airport is required. Developed model configurations will be stored in a model configuration repository, which is connected to OPAL. This integrated platform will incorporate models that have been developed with tools like TAAM, SIMMOD, MACAD (Mantea Airfield Capacity and Delay Model), WITNESS (landside model), PowerSim, SLAM (Simple Landside Aggregate Model), TOPAZ, and Arena. Similarly, the set of airport validation sites are stored in an airport repository, while the corresponding scenarios and airport studies to be conducted per airport are stored in a respective scenario repository.

The contextual use of OPAL is illustrated in an abstract level in the context diagram presented in Figure 1. A user accesses OPAL for the evaluation of a certain scenario or airport study (e.g., capacity, safety, cost/benefit). After the appropriate model configuration has been selected from the model-configuration repository, the scenario can be executed by the platform. Then, the results of the particular scenario are available to the user through the OPAL distributed platform.

To specify the use of the platform in more detail, Figure 2 illustrates in a sequential manner the full execution of an airport scenario study by the proposed OPAL platform. After the user has accessed OPAL, the user first has to select an airport from the airport repository. Thereafter, the user has to select from the model configuration repository the particular model configuration accruing to the specific scenario and airport site. Results of the execution of the particular scenario are finally obtained by the remote user through the distributed environment initiated by OPAL.

The objective of this presentation is twofold: 1) to introduce the concept of total airport analysis, and 2) to explain the architecture proposed for the integration of analytical and simulation models in simultaneously studying airside and landside operations.

The ever-increasing growth in air traffic demand shows the vulnerability of the entire air transport infrastructure. The airports are becoming the prime and foremost choking points within the air transport system. At present airport stakeholders lack insight in the integrated set of airport processes and the individual process interdependencies in order to cope with this growth. Therefore there is an urgent need for a platform that will allow decision makers and analysts to evaluate the efficiency of the entire airport complex simultaneously.

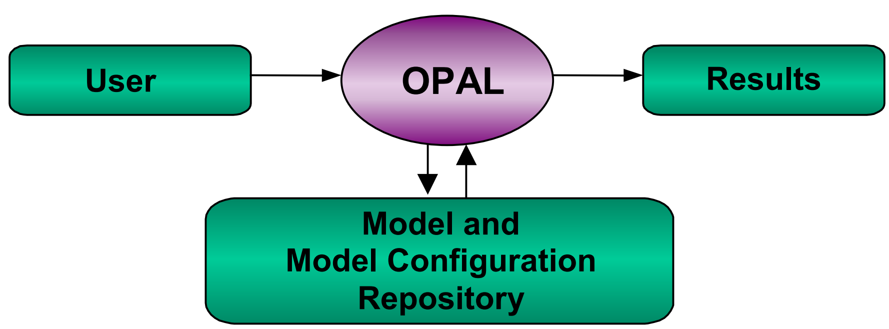

FIGURE 1 Conceptual diagram of OPAL.

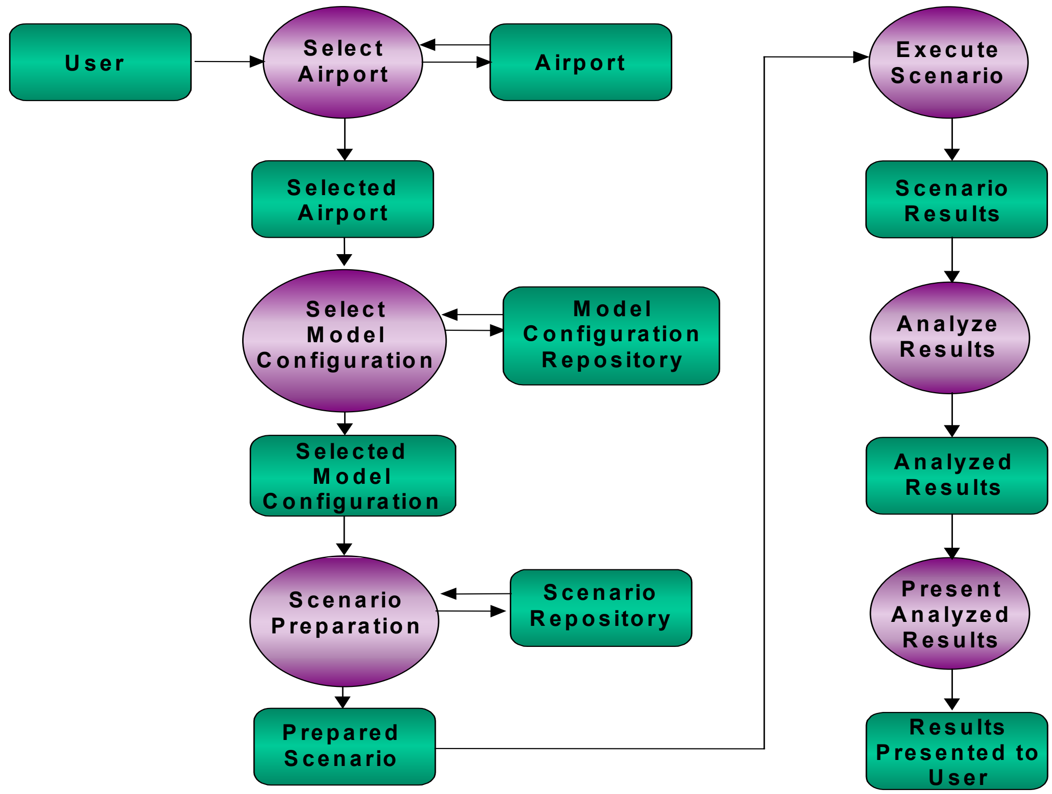

FIGURE 2 More detailed context diagram of OPAL.

OPAL provides a decision-support aid for total airport performance analysis that allows the integration of existing tools in order to model and evaluate simultaneously airport airside and landside capacity and delays. In addition OPAL provides the ability to integrate capacity and delay results with other models analyzing the environmental, safety, and cost-benefit impacts of airport operations.

OPAL consists of the following components:

- A central database that enables the use of common data elements and the communication of the tools and models integrated into the platform.
- A human machine interface that enables access to and visualisation of the input data and results.
- The model base that consists of currently available state-of-the-art airport analysis models and tools that can be integrated in OPAL. The models and tools themselves are not part of the platform. The integration flexibility of OPAL allows the inclusion of any simulation and analytical model provided that it complies with OPAL database specifications.
- A diagnosis tool that identifies the bottlenecks in the entire airport complex.
- An optimisation tool that enables the user to optimise airport configuration given a scenario, the models used, and an optimisation criterion.
- Data converters that enable the integrated models and tools to read and write from the central database of the platform.

- Scenario Manager that provides the functionality of evaluating a scenario and optimizing total airports through a set of networked analytical and simulation models.

The overall architecture of OPAL is presented in Figure 3. The model base of OPAL consists of the following modules: capacity and delay, safety, environment, freight, and cost-benefit. Figure 4 presents the analytical and simulation models that are currently integrated within each module. The OPAL platform exhibits various innovative and useful capabilities.

- Integrates data and entities (i.e., simulation and analytical models) referring to both airside and landside.

Analyzes independently, but also in combination, the airside and landside elements of an airport. Supports decisions associated with the assessment of the technical design and infrastructure of the total airport. Supports decisions related to the strategic and operational decision-making level for both airside and landside. Performs environmental and safety analysis of airside.

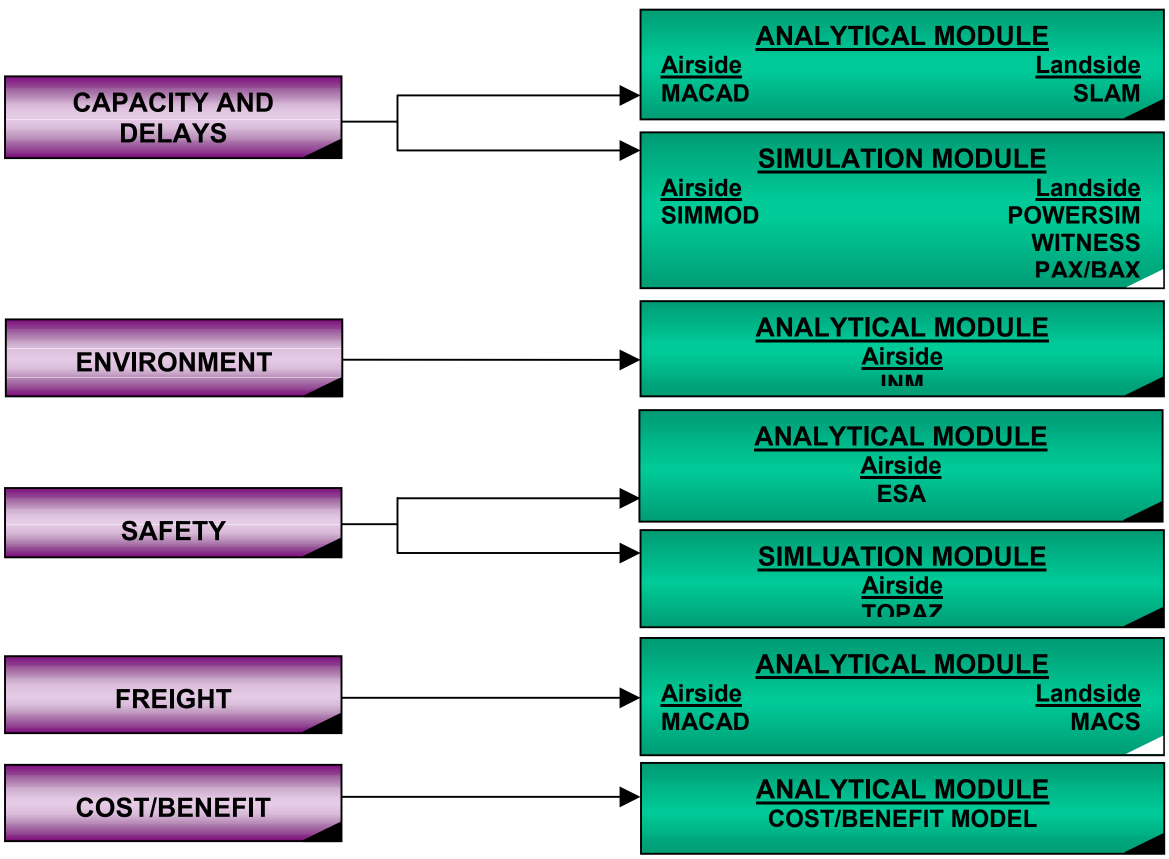

FIGURE 3 Description of the models integrated within OPAL.

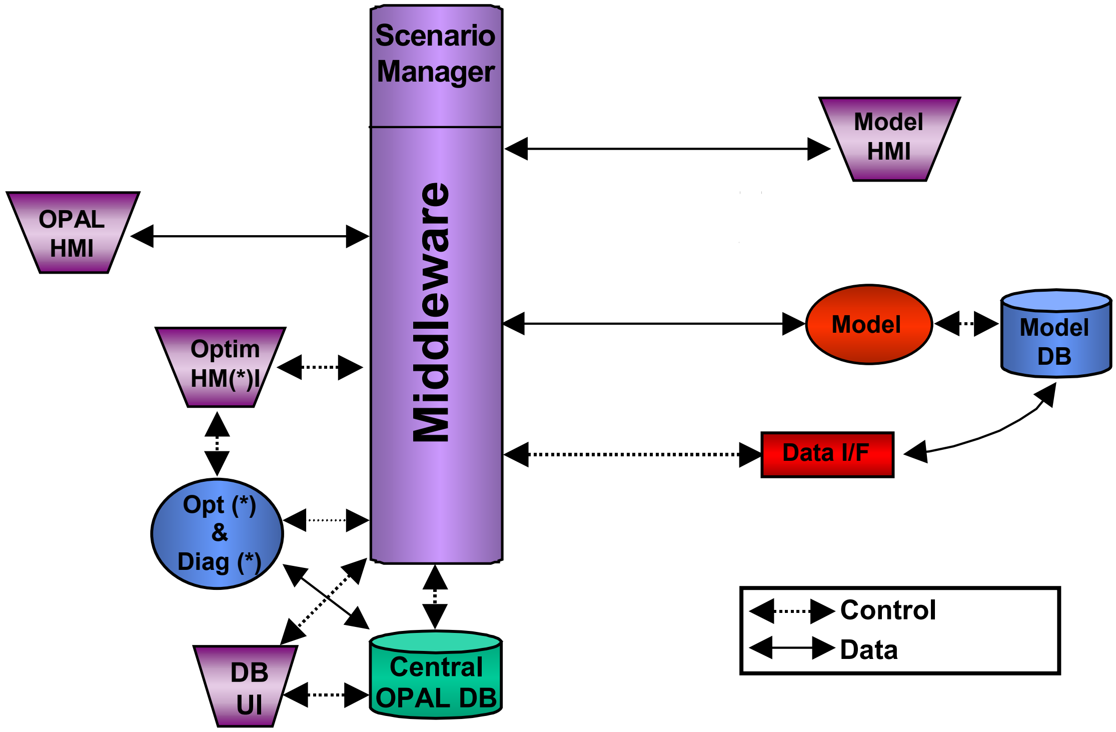

FIGURE 4 Architecture of OPAL.

- In addition, OPAL is able to support cost-benefit analysis.

The OPAL concept will be tested at six major European airports: Amsterdam Schiphol, Athens, Frankfurt, Madrid Barajas, Palma de Mallorca, and Toulouse-Blagnac, for selected combination of tools and performance indicators.

ACKNOWLEDGMENTS

The OPAL project is funded by the European Commission, Directorate General for Energy and Transport, under the 5th RTD Programme on Competitive and Sustainable Growth.

Click here to see Zografos' slide presentation.

MORNING SESSION

Integrated Safety Analysis

Probabilistic Risk Assessment Using Markov Reliability Analysis and Operational Simulation

PETER F. KOSTIUK
SHAHAB HASAN
Logistics Management Institute

Despite the events of this past September (2001) and the associated slow down in air travel, the long-term outlook for air travel demand is still for tremendous growth. How the NAS is able to cope with the expected increase in traffic and provide the needed capacity and throughput is an open-ended question. However, it is at least as important for the aviation community to consider the safety implications of this increased air traffic. Thus there has been recent emphasis on not only new technologies and procedures to increase capacity but also on ensuring that the overall safety level of the NAS is maintained or, better yet, increased.

One research program devoted to increasing the safety level of the NAS is NASA's Aviation Safety Program (AvSP). As part of their research, the AvSP has looked into the use of probabilistic risk assessment methods. LMI is supporting this work by developing a unique modeling capability which features two parallel but complementary analysis chains: Markov reliability analysis and operational simulation. Our basic algorithm for estimating safety is

$$P(Accident) = P(Hazard) \times P(Failure) \times P(Accident|Failure\ and\ Hazard)$$

where

P(Accident)	= the probability of an accident,
P(Hazard)	= the total probability of a hazardous condition,
P(Failure)	= the probability of a failed piece of equipment or human function, and
P(Accident|Failure and Hazard)	= the conditional probability of an accident given a failure when a hazard exists.

The baseline condition for an individual hazard is the probability of an accident when no failure occurs:

$$P(Accident) = P(Hazard) \times P(Accident|Hazard)$$

Markov reliability analyses provide the *P(Failure)* values. To obtain these values, we break down a given technology into its basic components and how those components interact, including hardware, software, and human participants. By quantifying data about the failure modes and rates of the components we can ascertain and aggregate information about how likely the system will be in a normal, degraded, or failed mode of operation and what redundancies or backups exist.

Information and results from the reliability analysis are then used in the second area of concentration, which is an operational simulation. Simulations are used to estimate the *P(Accident|Failure and Hazard)*. For each technology area, we devise an operational scenario in which the technology will be utilized.

By using Monte Carlo methods and explicit failure injection (based on the reliability analysis), we can examine how the technology benefits will manifest as well as what operational and implementation details need to be explored further.

Use of the LMI models and methodology will allow NASA to gain a better understanding of their safety technology portfolio and identify drivers of safety early in the design process. The presentation will provide an overview of the methodology and a brief demonstration of the operational simulation for a basic scenario in which Synthetic Vision technology is used to perform terrain avoidance.

Click here to see Kostiuk and Hasan's slide presentation.

AFTERNOON SESSION

VTASim

A New Paradigm to Model Airport Operations

ANTONIO TRANI
HOJONG BAIK
Virginia Polytechnic Institute and State University

This presentation discusses the Virginia Tech Airport Simulation model (VTASim). The model is a research tool developed under FAA sponsorship to understand advanced airport surface automation concepts including intelligent dynamic traffic routing, data link, and controller workload issues.

The model incorporates algorithms for solving airport operational problems that arise in ATC systems within the airport area. Specifically, the model is suited to study the Network Assignment Problem (NAP) for taxiway operations, and a simulation model for the evaluation of current or proposed ATC system in detail. Individual aircraft parameters are considered in the model. For example, approach speeds and taxiing behaviors are unique to each aircraft type.

VTASim uses a hybrid simulation framework to mimic the aircraft and controller actions around the airport. A first-order longitudinal control aircraft following model is used to schedule aircraft movements on the airport network (NAP). This process considers aircraft interactions and resolves conflicts. Pilot–ATC interactions are modeled as well to study the effects of controller voice frequency constraints (or data link constraints) into the airport flow rates. Ultimately, measures of airport capacity for a given level of delay can be obtained from the model.

The NAP uses a quasi-dynamic assignment scheme, which is based on the incremental assignment technique. This quasi-dynamic assignment method assumes that the current aircraft route is influenced by the previous aircraft assigned to the network. This simplified assumption obviates the need for iterative rerouting procedures to reach a pure equilibrium state, which might not be achievable in practical taxiway operations.

The simulation model is designed to have the capability for reproducing not only the dynamic behavior of aircraft, but also incorporates communication activities between controllers and pilots. These activities are critical in ATC operations, and in some instances, might limit the capacity of the facility.

The model is a research tool developed in C++ that could be used by decision makers to study effects of advanced airport automation in delay and capacity measures of effectiveness.

AFTERNOON SESSION

New Research in Airspace Simulation Tools

MultiCenter Modeling Using Traffic Reroute Analysis Capabilities

THOR ABRAHAMSEN
MITRE-CAASD

In spring 2001, Cleveland (ZOB) Air Route Traffic Control Center (ARTCC) requested that a set of proposed changes to current routing be evaluated by measuring user and airspace impacts and by providing controllers a visualization of new traffic flows. The reroutes proposed by ZOB spanned multiple centers and required consideration of existing and modified altitude restrictions. At the time of the request, there was no single tool that could accurately model the reroutes and generate the specified metrics. The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) initiated an effort to integrate several existing tools and build new components as needed to meet the needs outlined by ZOB, resulting in a modeling capability that could be used to analyze reroutes across multiple centers. The combination of these tools is known as TRACS (Traffic Reroute Analysis Capabilities).

While it was still under development, TRACS was used to provide preliminary results for other airspace studies that focused on reroutes. As of the time this document was published, various studies had been integrated into a single large analysis involving the following seven centers:

- ZOB,
- Indianapolis ARTCC,
- Chicago ARTCC,
- Atlanta ARTCC,
- Jacksonville ARTCC,
- Memphis ARTCC, and
- Washington ARTCC.

As additional reroutes are identified, they can be incorporated into the same framework, building on the existing set of proposals to allow examination of cumulative impacts. TRACS is extendable to any number of centers and reroute definitions.

TRACS COMPONENTS

The set of programs that were integrated to form TRACS include:

- MapInfo: A commercial off-the-shelf product used to help identify candidate city-pairs whose routes will be changed.

- User Request Evaluation Tool's Algorithmic Evaluation Capability (AEC): A tool developed by CAASD and used in TRACS to create four-dimensional (4-D) trajectories of current and proposed routing.
- Sector Design and Analysis Tool (SDAT): A tool developed by the FAA, used to calculate user and airspace metrics.
- TAAM: A commercial off-the-shelf product used to visualize the proposed traffic flows.

These applications are linked by a collection of custom-built pre- and post-processors to form the complete set of analysis capabilities known as TRACS.

FORM OF TRACS RESULTS

TRACS allows for the exploration of proposed reroutes that span multiple centers. For example, an analyst can use TRACS to compare baseline and proposed

- Unimpeded flight times and distances along routes,
- Sector counts (typically calculated in hourly and 15-min intervals),
- Arrival and departure fix loading, and
- Conflicts.

TRACS PROCESS OVERVIEW

The process for conducting an en route study using TRACS can be viewed as being composed of four different phases. The basic goal in a reroute analysis is to create two different traffic files: one representing the current airspace design and routes (Baseline); the other representing the routes and altitude restrictions proposed by the flights (Alternative). The proposed route changes usually impact only a subset of the overall traffic in an ARTCC, and TRACS treats the unmodified flights differently than the rerouted flights. Specifically, the process involves starting with a traffic file [preferably system analysis recording (SAR) data with both tracks and flight plans] and splitting it into two parts: (a) non-rerouted flights and (b) flights to be rerouted. The flights to be rerouted are formatted as flight plans using the proposed reroutes, and then input into AEC along with any new altitude restrictions. The 4-D trajectories produced by AEC are formatted as SDAT track data and combined with the non-rerouted flights from the original traffic file in SDAT. The resulting SDAT file represents the Alternative traffic file and is depicted in Figure 1. The process is repeated using the current flight plans for the rerouted flights as input to AEC. The SDAT file that incorporates this information with existing track data represents the Baseline traffic file.

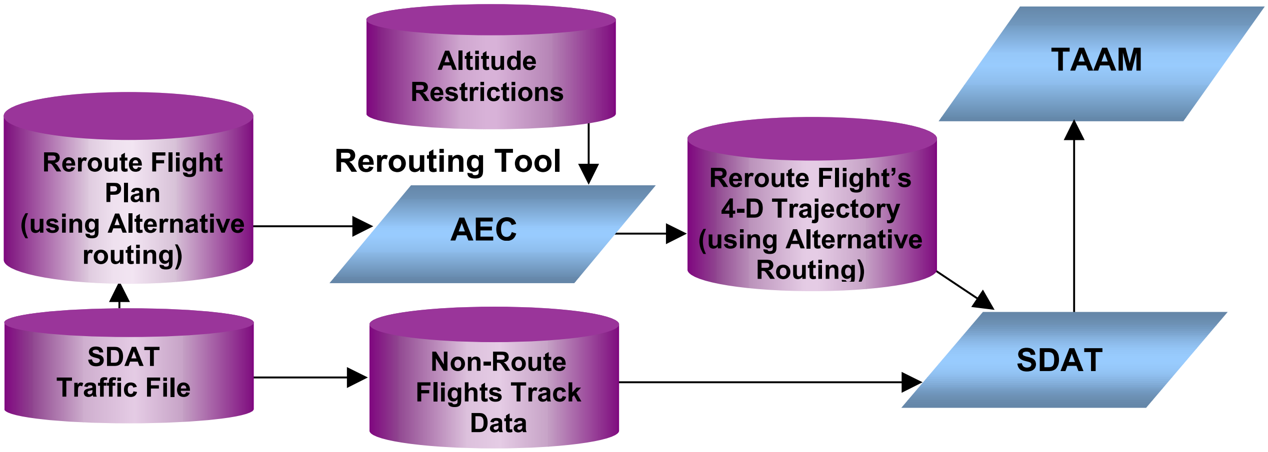

FIGURE 1 TRACS process diagram.

Click here to see Abrahamsen's slide presentation.

AFTERNOON SESSION

Benefits of User Interaction and 3-D Viewing for Airport Simulation

EVERETT JOLINE
Aviation Simulations International, Incorporated

The traditional use of airport simulation has usually been to perform capacity/delay evaluations of alternative airport improvements. Some additional uses that have achieved prominence lately are the use of such modeling to plan for situations that do not necessarily occur every day, such as the planning of deicing operations, or to plan for the introduction of new larger aircraft, such as the A380. Airport simulation has also proved useful for demonstrating how proposed new airport features would be used, and for convincing the public that certain new features would not be harmful to the environment.

The aim of this presentation is to show how the use of advanced techniques for user interaction and 3-D graphics can enhance the value of simulation modeling for the above uses. Examples will be shown of various applications of these techniques as used for the study of a number of different airports. The model used for these demonstrations is the Airport Machine (AM) simulation model (AM2D/AM3D) developed by Aviation Simulations International.

It is important to note that the technology incorporated today in an ordinary desktop computer has not always been available and is continually evolving. When we first became involved in airport simulation back in the 1970s it was necessary to use large IBM mainframe computers. Even then, however, we recognized the need for being able to view the dynamic simulation output rather than to just rely on printed statistics, so we found ways of drawing 16-mm films using very expensive microfilm plotters that were available only at government labs.

When PCs first became available in the 1980s we were quick to adopt them because of the great potential for user interaction and for viewing of the simulation operation. Perhaps the greatest value of these techniques has been in the assuring of simulation validity. Not only is it necessary to view in detail the operation of a model when changes are made to the computer code, it is also necessary to view the operation whenever the model is applied to a new airport configuration, or in fact, whenever changes are made to any input data.

Graphics, produced real time as the simulation runs, are also of much greater value than graphics produced by post-processing of recorded data since it enables real-time interaction by the simulation user, or even by an air traffic controller.

The evolution of the AM model from DOS to Windows during the 1990s also made it possible to use menu selections to incorporate the multiple steps in the simulation process into a single program, while using just one monitor. The old DOS version required use of several ancillary programs, and two monitors, to perform the data editing and route generation steps before running the simulation itself.

The technology of computer graphics for the PC has also continued to advance in synchronism with the computer itself. Just in this last year graphics chips that incorporate hardware transform and lighting that make possible the use of much more complex and detailed

3-D objects and aircraft without reducing the frame rate have become available. Thanks to the popularity of computer games, the latest GeForce3 chips by Nvidia and the Radeon 8500 chips by ATI make possible better graphics, at consumer price levels, than was available on specialized computers that cost over $50,000 a few years ago. In fact, graphics boards using these chips sell for only one-tenth the cost of the board that we used for the DOS version of the AM model during the 1990s.

Now the users of the AM model are also free to customize the graphics as they see fit, by adding 3-D airport buildings, painting the aircraft liveries to identify the airline, or using orthogonalized aerial photos for the background surface.

This presentation shows slides and short videos that will illustrate some of these interaction and 3-D benefits discussed above. An example using a wide taxiway at Frankfurt will illustrate how some of the A380 issues might be addressed. Examples of the planning for deicing operations at Vancouver Airport, Baltimore-Washington International Airport, and Stockholm-Arlanda Airport will illustrate the value of these features for deicing studies. Finally a Boston area video will show the value of 3-D viewing for the demonstration of environmental impact reduction.

Click here to see Joline's slide presentation.

AFTERNOON SESSION

Developing Annual Airport Use Information With Simulation Modeling Data

MATTHEW H. LEE
Landrum & Brown

Annual calculations of airport taxiway and airspace route usage can be based on data samples generated by airfield and airspace simulation modeling. The modeler faces two challenges in developing these data sets. First, quality assurance and control on large and complex data sets is difficult to efficiently accomplish at the level of detail required, and second, combining simulation data with data from other sources requires reorganization of data and often requires enhancement of simulation data to re-introduce real-world variability.

Landrum & Brown developed the Taxiway Layout Analyzer (TLA) to assist modelers in evaluating and using detailed taxiway information from simulation models. METRON has developed the Airspace Design Tool (ADT) to assist modelers in developing noise analysis data sets from multiple data sources including simulation models. Each of these programs creates an analysis environment that allows modelers to quickly assess the quality of the simulation runs or to graphically summarize complex model network information. These tools work with both SIMMOD and TAAM.

The TLA provided critical information that allowed the city of Cleveland to value engineer the taxiway network that supports a new runway at Cleveland Hopkins Airport. Traffic loading information confirmed the necessity of having partial dual parallel taxiways between the close parallel runways, but did not prove the necessity of providing a complete dual taxiway system. TLA proved to be an important tool for validating taxiway network parameters such as speed limits and directions of flow for studies at Detroit Metropolitan Airport (1999 and 2001 using SIMMOD) and for Chicago's O'Hare International Airport (2001 using TAAM).

The ADT was the primary tool used to construct the Noise Integrated Routing System data for noise assessments of airspace changes in the Chicago region. While SIMMOD simulations provided a significant portion of the data required, additional analysis in the ADT environment was required to re-introduce system variability that simulation models do not address. In addition, they combine simulation data with manually constructed data sets and radar information from the Automated Radar Terminal System and SAR. The FAA is currently using ADT with TAAM (with technical support from Landrum & Brown and METRON) for two eastern region airspace redesign efforts.

Use of both tools identified relatively simple changes to the state of the art of airfield and airspace simulation modeling data that would improve the realism of modeling by introducing more variability in aircraft performance. The graphical user interfaces of these tools provide modelers more "at a glance" validation capability to improve modeling accuracy and productivity.

Click here to see Lee's slide presentation.

AFTERNOON SESSION

Airport Simulation for Rapid Decision Making
TAAM for Dallas/Fort Worth International Airport

JAMES M. CRITES
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EVERT MEYER
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The Dallas/Fort Worth International Airport (DFW) Board is currently conducting an airfield/airspace study to determine the most appropriate methods of increasing airfield capacity and reducing aircraft delays at DFW. This presentation will demonstrate the model and present some of the results of the study, focusing on the speed and flexibility that enabled the project team to rapidly simulate multiple future scenarios during different weather conditions and at different demand levels. Specific objectives of the study include:

- Understanding and quantifying the potential impacts of regional jet aircraft on airport capacity;
- Identifying and evaluating methods for increasing airfield/airspace capacity, especially departure capacity; and
- Reaching consensus with key stakeholders regarding the most appropriate capacity enhancement methods.

Due to the complexity of DFW's airfield and airspace system and the large capital and operating costs at issue, fast-time computer simulation has been and continues to be critical to the successful evaluation of most major capacity enhancement options. At the same time, considering the multiplicity of potential capacity enhancements identified in the study including alternatives for a new west runway, perimeter taxiways, runway-use restrictions, new departure procedures, and various weather and fleet mix scenarios, more than 100 simulation experiments had to be evaluated within a relatively short time frame.

Because of the importance of simulation over the years, a significant investment has been made in SIMMOD by DFW airport. However, in order to achieve its objectives within a reasonable time frame, the airport decided to investigate TAAM as an alternative simulation tool to meet the needs of the study. In addition, there had been significant and compelling advances in the TAAM model in recent years and the FAA and two major carriers at DFW are now also TAAM users.

Compared with SIMMOD, TAAM was expected to have a similar baseline set-up period, but then enable much more rapid calibration and alternatives development. Using TAAM, the project team developed and calibrated a baseline DFW model within 2 months, and evaluated all future scenarios within approximately a 6-month time frame. During one particular 3-week period, six alternatives requiring 18 simulation experiments were completed. It became clear that TAAM's alternative development time was significantly less than SIMMOD, and that it was possible to increase the number of runs available within the current project budget allowing the airport to investigate many alternatives that would otherwise have to be eliminated.

Other benefits included improved consensus building and cooperation and data exchange with key airline tenants. TAAM's superior graphics and its ability to allow interaction during real-time simulation makes it a much more useful tool for achieving consensus with controllers, pilots, and other stakeholders. Since the model supports fast-time animation with the ability to perform virtual reality, 3-D perspective playback, operations, and procedure visualization is much more convincing than with SIMMOD or other current simulation models.

DFW was the first airport to introduce independent parallel triple approaches, and will be the first to implement independent parallel quadruple approaches. Considering its position on the leading edge with respect to air traffic capacity and technology, DFW's use of state-of-the art simulation tools is crucial. When dealing with new procedures and complex interactions, TAAM appears to provide the flexibility, power, and speed that is required for a large and complex airport such as DFW.

Click here to see Crites and Meyer's slide presentation.

APPENDIX

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