ACRP Problem No. 12-07-01

Application of Queuing Theory to Airport Related Problems

ACRP Staff Comments: No comments offered.

TRB Aviation Group Committees Comments: AIRFIELD AND AIRSPACE CAPACITY AND DELAY CMTE - Not Recommended: A terminal planning spreadsheet was already developed by an earlier ACRP project. For airside, ACRP Project 03-17, Evaluating Airfield Capacity, is developing high-level models.
AIRPORT TERMINALS AND GROUND ACCESS CMTE - We recommended approval. Queuing theory techniques are well known in the operations research community and academic circles, but their application to airport problems involves practical considerations that are less well understood, particularly by many airport planning staff and consultants. This is likely to require more resources and a longer project duration than envisaged in the problem statement. A toolbox of sophisticated analytics for use by non-statisticians would be of value to the airport operators.

Review Panel Comments: **Not recommended** — There are already many good queuing models available for both terminal and airside planning, so this effort would be of limited value.

AOC Disposition: No funds allocated. No discussion.

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I. PROBLEM TITLE: Application of Queuing Theory to Airport Related Problems

II. RESEARCH PROBLEM STATEMENT -

Airport operations involve numerous queuing situations, for example:

Airside	**Terminal**	**Ground Transportation**
Aircraft runway departures	Check-in counters	Parking payment
Aircraft arrivals	Kiosks	Cell phone parking pick up
Aircraft de-icing	Security Screening	Taxi dispatch
	Immigration Control	
	Baggage Claim	

Often analysis of these queuing processes is made complex because there may be multiple servers, because there may be certain forms of queue assignments (priority lines) and because upstream queues meter flows to those downstream. Because of this complexity, analysts often resort to the use of sophisticated discrete event digital simulation models. This practice has become more common as computer technology (memory size, computing speed) has improved.

Reliance solely on computer simulation models however has numerous drawbacks. The models demand huge data input, particularly detailed planning day schedules involving many critical assumptions which become disguised in the process yet can have a critical bearing on the model results. To be properly used these simulations also demand time consuming and laborious exercising (i.e. multiple runs) to develop the required output distributions such as maximum and average queue lengths and the attendant variances. Often however this required rigor is not evident in the analysis performed. In short, these simulation models while somewhat glamorous in terms of the attractiveness of the outputs, particularly when presented graphically, should be considered only one of a stable of available analytic techniques when tackling airport problems..

Fortunately two alternative analytic options are available, these being (a) deterministic queuing models, and (b) probabilistic queuing theory. Application of these techniques can provide the desired planning information much more readily, without the limitations posed by the many assumptions as is often the case with simulation. The intent of this guidebook is to provide an overview of non-simulation queuing analysis as applied to typical airport planning problems. Such a guide will assist airport planners carry out analysis of typical airport related queuing problems without the need for recourse to expensive and sometimes risky computer simulation.

These techniques will likely be particularly applicable to sketch planning analysis ands one off problem solutions..

III. **OBJECTIVE**

To prepare a guidebook for the application of queuing theory to the analysis of airport related problems. This guide will present the range of applicable queuing models available , the theory behind each, the required input data, expected output information and all underlying assumptions, validity tests and known limitations.

IV. RESEARCH PROPOSED -

1. Carry out an extensive literature search on the application of deterministic and probabilistic queuing theory to airport related queuing problems.

2. Prepare an inventory of useful queuing analysis techniques with a thorough documentation of their strengths and short-comings and select those deemed most helpful in each of the previously mentioned airport queuing situations.

3. For each of the selected techniques, prepare a primer on the theory underlying the technique, the required inputs (i.e. arrival distribution, service time distribution, etc.) and the model outputs (i.e. average queue length, maximum queue length, etc.).

4. For each of the selected queuing techniques describe the input data requirements and the data collection process. Particular attention should be paid to any pitfalls associated with collecting the data such as an upstream process distorting the results (rendering invalid the basic assumptions regarding randomness or distribution properties). Methods for verifying that the form of the input data distributions conforms to the assumptions of each of the analytic techniques should also be included.

5. Where practical simple computer spreadsheet tools should be prepared to assist with the application of the queuing technique and display for the analytic results.

6. For each technique selected, any available tests on the validity of the results should also be documented.

7. Finally, example applications of each technique should be done for a range of appropriate airport situations to assist users in effectively employing the guidebook.

V. ESTIMATE OF THE PROBLEM FUNDING AND RESEARCH PERIOD

It is estimated that:

Recommended Funding: this project will cost $250,000.00

Research Period: and will require twelve months to complete.

This research project will be of greatest interest to transportation consulting firms with strong analytic capabilities and/or academic institutions with strong industrial engineering research capabilities.

Institutions with limited experience with airport related problems but who have strong backgrounds in the application of queuing theory should also be encouraged to compete for this project. In other words, the real value in this study may not be in documenting existing best practices but rather may be found in applying the rich field of industrial engineering queuing theory to the realm of airport queuing problems.

VI. URGENCY AND PAYOFF POTENTIAL

The continual changes being introduced with airline check in processes (e.g. curbside, kiosks, etc) , security screening processes (e.g. full body scanners, priority lines, etc.), and customs and immigration (e.g. e-PIL, NEXUS, etc.) airport planners are in need of simplified tools to respond to the demands for information. The analytic tool box to be developed in this project would greatly aid in providing the required answers cheaply and quickly concerning passenger service experiences and space requirements and in so doing improve the entire airport planning process.

VII. RELATED RESEARCH

The Airport Passenger Terminal Planning and design Guidebook Volume 2 Spreadsheet Models and User's Guide (ACRP Report 25) presents a number of deterministic queuing models used in the sketch planning and sizing of airport terminal facilities.

VIII. PERSON(S) DEVELOPING THE PROBLEM

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3/15/2011
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IX. PROCESS USED TO DEVELOP PROBLEM STATEMENT

This problem statement arise from my long personal experience planning and developing airports including leading the $4.4 billion renewal and expansion of Toronto-Pearson International Airport completed in 2006. This experience has been augmented through the comments provided on the draft by key staff at Toronto-Pearson International Airport in the Strategic Planning and Operations Branches

X. DATE AND SUBMITTED BY

Submitted by:

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14 February, 2012