is summed for the entire airport community to yield a single number descriptor, the total level weighted population, and it is that number which the model uses to quantify impact.

The model has been used in a number of studies to date. For example, a general aviation airport in Florida was considering a number of runway alternatives to accommodate additional traffic forecasted into the year 2005. Three alternatives in addition to maintaining the status quo were considered. The status quo and the three change alternatives were analyzed with this model. It was found that for that particular airport, the noise minimal runway orientation would result in the equivalent of something over one dB in equivalent source noise reduction over the status quo.

More dramatic results were obtained when ground track optimization was considered at a major midwestern airport. There is an algorithm in the model which can determine the ground tracks which fly over the smallest number of people in a given airport community. It is called the shortest path algorithm because it finds the shortest path through population space from the runway to a community exit point. When it was assumed that aircraft were flying population minimal tracks as compared with conventional ground tracks, a reduction in level-weighted population was predicted equivalent to something in excess of 4 decibels reduction in source noise for each airplane flying in the fleet. At a small regional airport, alternative runway use rates were considered. Runway use rates were found which did not violate wind constraints, and yet resulted in an overall reduction in the noise impact in the community equivalent to more than three decibels equivalent source noise reduction.

The Environmental Protection Agency (EPA) has used this model to look at the 70 largest airports in the United States to consider the effects of soundproofing all homes inside the 65 dB contour. The costs of such a countermeasure were large, and it was important to be able to quantify the benefits. The soundproofing program was predicted to achieve the equivalent of approximately 3 dB per aircraft source noise reduction.

Concluding Remarks

The purpose of this paper is not to make a particular point about the degree of noise impact associated with a given operating scenario but simply to point out the types of scenarios which could be evaluated at a given airport. There are other operating scenarios as well that could be studied.

The noise model described in this paper can be used to quantify the benefits associated with a number of noise abatement operating scenarios. Sometimes a particular operating scenario will be found to have significantly less benefit than assumed, but such a null result can also be useful by indicating that a particular change may not be effective. The model can, therefore, indicate if a proposed countermeasure will be effective at all, and if so, how much more or less effective than competing countermeasure proposals. An informed decision can then be made, based on both the cost of the countermeasures, and a quantitative indication of the benefit.

APPLICATION AND VALIDATION OF A MODEL FOR PREDICTING AIRCRAFT AND AIRPORT COMPATIBILITY

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Abstract

Aircraft/airport interface problems can be predicted in initial design stages. A methodology has been developed to analyze and predict potential and known effects of aircraft or airport design. Central to the methodology is a generalized prediction model. In this investigation, the model was applied to a specific dramatic situation. A questionnaire was devised and used to ascertain how well historic information when applied to the model agreed to known impacts identified by the questionnaire. The results are that the overall analysis methodology and the prediction model are effective in reproducing "potential" problems in compatibility of an historic case. The high correlation of the validation should substantiate the workability and capability of the prediction model to analyze problems in compatibility in an efficient and meaningful way.

Introduction

Achievement of compatibility between aircraft and airports requires consideration of many factors pertaining to the configuration and operation of both aircraft and airports (1). Methodology is required to systematically analyze these factors in such a way that design and operational impacts within the interface can be predicted and evaluated in a meaningful and efficient manner.

There are strong motivations for doing these prediction analyses from a systems point of view. First, the comprehensive nature of potential problems can be overlooked if a total systems perspective is not maintained. Second, if prior knowledge of potential compatibility problems can be achieved, essential goals within the industry can also be achieved in an optimum way. For example, if one considers that profitability, service and safety are key air transport goals, prior knowledge of potential safety problems, operational constraints, and/or hidden operational costs will enhance the achievement of goals and improve decision making outcomes. In the age of deregulation, these motivations may be most critical to the industry's health and well being or very survival. Additionally, these analyses must consider addressing both existing compatibility problems and evaluating proposed alternative configurations or operations.

To fill a void in aircraft and airport compatibility analysis techniques, a systems approach has been recently developed which has at its core a generalized prediction model (2). It will be referred to as the Virginia model. The acceptability of the prediction model for application to real-world problems requires that the workability and capability of the overall methodology be demonstrated and that the validity of the prediction model be assessed.

The purpose of this paper is to report on a first effort to validate the Virginia model (3). In this investigation, the model was applied to a specific dramatic situation which arose from a past experience. A primary objective was to ascertain how well predicted impacts agreed with the opinion of knowledgeable specialists involved in that situation.

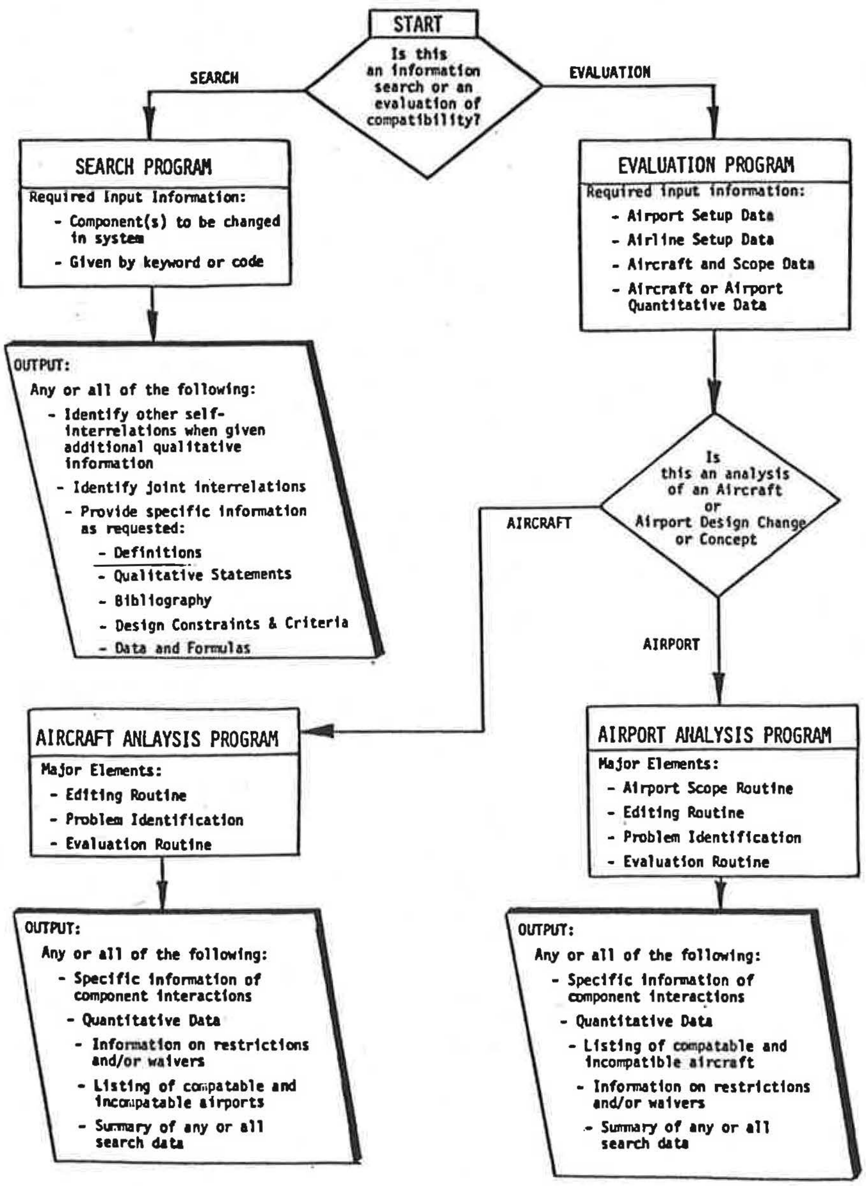
The specific situation examined was the introduction of the Boeing 747 by United Air Lines into the Chicago O'Hare Airport. Using the model, compatibility problems were predicted using preliminary B-747 characteristics and airport/airline data circa 1964-1967. Subsequently, opinions, via a questionnaire, were obtained from selected individuals who worked for either the airline or the airport at the time of the B-747 introduction.

Methodology

A brief word must be said concerning background information which is pertinent to the discussion which follows. First, the analysis methodology will not be described in any detail here. The essential elements of the methodology and the prediction model have been previously outlined (2) and are published in Transportation Research Board Circular 247. However, a brief overview of the process is essential to a better understanding of the validation example. Second, the explanation of the example presented here has been abbreviated from the original documentation (3). It is important, therefore, to view this paper as a summary and refer to the original work for any additional documentation that may be required.

The methodology can be viewed as Phase I -- Problem Identification, of a large-scale systems methodology (4). Central to the methodology are two analysis procedures or programs. Each program is made up of logic steps which are amenable to interactive computer programming and manipulations. A simplified flow chart of the analysis methodology is given in Figure 1.

Figure 1. Flow chart of the analysis methodology.



The program of primary concern is the evaluation program. The main objective of this program is to assist the analyst in identifying potential compatibility problems in a detailed and comprehensive way. The subject of this paper concerns the prediction model of the evaluation program. Specifically, an aircraft design will be applied to the model. The potential compatibility problems identified by the model will then be compared to actual problems which have been identified by questionnaire. Although the comparative analysis is qualitative in nature, it does reasonably substantiate the validity of the model. Further, the manipulation of the model was performed manually, even though some elements of the methodology are computer programmed. Full implementation of the methodology and prediction model will require additional software development and significant data acquisition.

The Validation Example. It was felt that since the model is capable of being site specific, airline specific in its analyses, the validation example should reflect this fact. Also, the example should be one that is intuitively dramatic. Therefore, the Boeing 747 Jumbo Jet was selected because it represented a rather substantial design change from existing aircraft at the time of its preliminary design. The Chicago-O'Hare Airport was selected because of its early operations of that aircraft and its close proximity to the author. United Air Linces, Inc., was selected as the air carrier, again because of its early operation at O'Hare and the proximity of its corporate offices to the author. It must be noted that these selections turned out to be most valuable; not only because of the tremendous cooperation received from the parties involved, but also in the quality of the effort put forth by everyone. The author is greatly indebted to all who participated.

The scenario which was developed for the example was quite simple. The B-747 would be analyzed using airport/airline data circa 1964-1967 and the preliminary aircraft design data. This was done in order to answer the question: "What compatibility problems will be generated by the Boeing 747 design concept at the Chicago-O'Hare Airport if United Air Lines introduces that aircraft there?"

Input/Output Input data to the model contained 133 pieces of aircraft data. This comprised approximately 85 aircraft characteristics and operating parameters. This data is given by Table A2 of the Appendix.

The problem identification algorithm of the model begins by performing a search which compares the characteristics of the candidate aircraft with aircraft that are currently or have been operating at the selected airport. This search involves use of the Official Airline Guide (OAG) schedules and an airport and aircraft data bank. If the OAG search indicates that the candidate aircraft should be acceptable at a given airport because a more restrictive aircraft has already operated there, then a search of the airport data bank is made to see if there were any waivers or restrictions on that operation. If so, these are noted as such in the entry for that airport for that aircraft characteristic. This may represent a potential problem area. For the 747 case, the OAG files from 1964 to 1968 were "searched" limited to UA, air carrier and ORD, airport. This search produced the following aircraft listing for UA:

UA Aircraft at ORD

Douglas DC-8-10, -20, -55, -61, -62;
DC-7; DC-6B; DC-3
Boeing 720, 727-100
SUD Caravelles
Vicker Viscounts

From this aircraft listing, the airport/aircraft characteristic table is generated which provides the data on various elements for the candidate aircraft, and gives the differential (in the same units) by which the candidate aircraft exceeds the value of the same element for the most restrictive aircraft which has used that airport by that airline.

For the analysis of the B-747, the information given by this table was used in the following way:

1. Aircraft elements were ranked from high to low priority using the incremental percentages.

2. Elements were then divided into groups using the following criteria:
   Group 1 - elements where incremental changes were 100 percent or more
   Group 2 - 50 to 99 percent incremental change
   Group 3 - less than 50 percent incremental change

The results of the problem identification algorithm were then tabulated for each grouping. Each operation produced an "Aircraft/Airport Characteristics Table". Table A3 of the Appendix is an example of a Group 1 set. Note that only a portion of that table is used for illustrative purposes. In actuality, Group 1 table produced 69 aircraft/airport interactions. In total, the three groups when combined produced 327 interactions.

At this point, the prediction model has identified "the potential problems which may occur if the B-747 were introduced by United at the Chicago-O'Hare facility." Under actual conditions, the user is free to analyze the OUTPUT in any number of different ways. Therefore, the analysis of OUTPUT is essentially user-dependent. For the validation example, each of the "Aircraft/Airport Characteristics Tables" was treated separately beginning with Group 1 which should contain some of the more significant compatibility problems. Then Groups 2 and 3 were "analyzed". The results of this stepwise analysis showed that 109 airport components or functions were potentially impacted by the B-747 design.

It should be noted that of the 109 potentially impacted airport components at the Chicago-O'Hare airport, the final analysis determined that 67 elements "are likely to have problems." These are summarized in Table 1. Twenty-three of those elements were determined to have known compatibility problems which "will" require design changes if the B-747 is introduced. The other 44 were listed as implied problems which are essentially created by the known problems. Interestingly, aircraft elements in all three incremental percentage groups affected at least one airport component in the final problem set.

Verification by Questionnaire. For purposes of verifying the problems identified by the model, a compatibility questionnaire was devised. Six persons were selected from United Air Lines and the

Department of Aviation, City of Chicago, to participate in answering the questionnaire. The participants' areas of interest are summarized by the listing of present job titles below:

Retired airline captain
Vice president
Station planning manager
Operating manager-ramp operations
General manager of operations-O'Hare Airport
Director of maintenance-O'Hare - retired.

In the final analysis, four questionnaires were answered and returned. One person was interviewed.

Actually, the participants had been highly recommended by persons within the corporation, not so much for their present position and interests as much as for where they were in the company during the preliminary design stages and later introduction of the B-747 at O'Hare. Therefore, this author is confident that some of the best people at United were chosen to participate in this validation exercise.

The comparative analysis for verification was straightforward. First, the problems identified by the model were summarized by totaling all responses into one summary giving equal weight to all participants. Other information was arranged in like manner. The results are given in Table 2 starting with the problem areas airside and continuing toward gate and other landside areas. The analytical results are listed as well. For purposes of quantifying the model OUTPUT, known problems were given an arbitrary three points. Implied problems were simply totaled using interaction data found in Table 1; each supported interaction or delta factor equaled one point. For example, the airport component AP0117 "Traffic Control Procedures - Spacing(4D)" received two points because the aircraft component AC0190 "Wake Turbulence" delta factor (found in the original documentation) was 128 percent greater than any aircraft using O'Hare Airport. In addition, an interaction AC0190/AP0123 "A/C Separation Requirements" was identified by the model. Thus, a point was given to each potential problem for a total of two points.

Table 1. List of known or implied compatibility problems, B-747 example.

	PROBLEM	REMARKS
A. KNOWN PROBLEMS		
0325	RUNWAY SHOULDER DESIGN	Shoulder needs to be stabilized
0334	TAXIWAY/RUNWAY EXIT GEOMETRY	Fillets will have to added
0337	TAXIWAY SHOULDER DESIGN	Same as AP0325
0346	APRON TAXILANE/TAXILANE SEPARATION	Apron taxilanes need changing
0351	HOLDING BAY DIMENSIONS	Holding Bays need widening
0360	OVERPASS STRUCTURES	Engine overhang and blast will effect ground traffic under bridge structure
0621	TERMINAL TAXILANE/TAXILANE SEPARTN	Taxilanes need changing in gate areas
0622	TAXILANE TO BUILDING SEPARATION	Taxilane C.L. to building distances must be increased by 40 feet.
0623	TAXILANE TO PARKED A/C SEPARATION	Taxilane centerline needs changing
0625	PARKED A/C TO A/C SEPARATION	A change in parking configuration required
0710	NUMBER OF GATES	Parallel parking looses 6 gate positions
0730	A/C GATE SPACE REQUIREMNTS	Gate space area increased by 61%
0932	HOLDROOM CAPACITY	Holdroom capacity must be increased by 130 %
0933	PAX/VISITOR RATIO CAPACITY	Visitor capacity at gate must be increased by 130%
0937	DEPLANING PAX FLOW/DOOR OPENING	Three loading bridges required to meet existing flow rates
1610	A/C SERVICE EQUIPMT DESIGN	Ground start cabilitiy increased by 185%
	AC1220/AP1611	Gate heating/cooling increased by 196%
	AC1230/AP1650	Ground towing capacity increased by 165%
	AC/AP1141/AP1472 AC1142/AP1473	Baggage container conveyance equipment redesigned
	AC1040/AP1681	Food service truck requires redign
1663	MAINTENANCE HANGER-DOOR HEIGHT	Hanger door needs to be increased by +15 feet
1664	MAINTENANCE HANGER-OVERALL DEPTH	Hanger depth needs to be increased by+70 feet
1340	HORIZONTAL LOCATION OF CONNECTORS	If parallel parking is maintained then connector locations must be changed
1350	VERTICAL LOCATION OF CONNECTORS	Loading bridges must be modified to reach 3 feet higher
B. IMPLIED OR PROBLEMS BY INFERENCE		
0117	TRAFFIC CONTROL PROCED- SPACING(4D)	See AC0190 Δ ,AC0190/AP0123
0123	A/C SEPARATION REQUIREMENTS	See AC0190/AP0123
0321	RUNWAY WIDTHS AND SLOPES	Implied from AC0810/AP0325,AC0870/AP0325
0331	TAXIWAY WIDTHS AND SLOPES	Implied from AC0810/AP0337,AC0812/AP0337
0336	FILLET RADII	Implied from AC0710,AC0720 Δ ,AC0710/AP0336,AP0334
0370	RUNWAY/TAXIWAY SURFACE DEBRIS	See AP0325,AP0337
0511	RUNWAY APPROACH CAPACITY	See AP0117 above
0513	AIRPORT OVERALL CAPACITY	Implied from AP0117,AP0511
0611	APRON TAXILANE WIDTHS	See AP0621 above
0612	TAXILANE TURN RADII	See AP0336 above

Table 1 (continued).

PROBLEM		REMARKS
B. IMPLIED OR PROBLEMS BY INFERENCE (CON'T)		
0613	APRON/GATE SIGHT DISTANCES	Implied from AC0411
0720	PARKING CONFIGURATION @ GATE POSTN	See AP0710 above
0740	APRON LAYOUT	Implied from AP0710 and AP0720 above
0760	MANEUVERING AREAS AT GATE POSTN	See AP0730,AP0336 and AP0612
0770	TERMINAL/TAXILANE CONFIGURATION	See AP0621,AP0622,AP0623,AP0625 above
0830	A/C SERVICE VEHICLE RIGHTS/WAY	Implied from AP1610,AP0730 and Histogram
0910	TAXILANE CAPACITY	Implied from AP0621,AP0622,AP0623 and AP0625
0920	GATE CAPACITY	See AP0710 above
0931	PAX FLOW RATES	See AP0932,AP0933 and AP0937
0932	CONCOURSE FLOW RATES	See AP0931
0936	LOADING BRIDGE FLOW RATES	See AP0931
1050	JOINTING OF CONCRETE PAVEMTS	By definition of AP1050
1060	DESIGN OF OVERALAYS ON PAVEMT	Implied by AP0325,AP0337,AP0321 and AP0331 above
1070	PAVEMT SURFACE DESIGN	Implied by AC0730,AC0740 and AC0711 Δ factor
1130	SNOW REMOVAL REQRMNTS	Implied by AC0810 Δ factor
1213	VISUAL APPROACH SLOPE INDICATOR	Implied by AC0441,AC0411 Δ factor
1214	HEIGHT INFORMATION - LIGHTING	See AP1213
1215	HEIGHT INFORMATION - MARKINGS	Same as AP1214
1223	RUNWAY LIGHTING AND SIGNS	Implied by AC0441 and AC0411 Δ factors
1231	TAXIWAY LIGHTING AND SIGNS	Same as AP1223
1240	APRON LIGHTING AND MARKINGS	Same as AP1223
1312	PAX ASSEMBLY SPACE REQRMNTS	See AP0932
1320	NUMBER OF LOADING BRIDGES/RAMPS	See AP0937
1330	CONFIGURATION OF BRIDGES TO TERM	Implied from AP0710,AP1340 and AP1350
1380	CONCOURSE DESIGN- WIDTH	See AP0932 above
1390	CONCOURSE DESIGN- HEIGHT	See AP1350 Above
1420	BAG./CARGO FLOW RATES	Implied from AC1140,Ac1150,AC1170 Δ factors
1430	CONTAINER FLOW RATES	See 1420 above ,Also AP1610
1440	BAGGAGE INBD/OUTBD CAPACITY	See 1420 above
1450	BAGGAGE INBD OFFLOADING POINTS	:See 1420 above
1460	COLLECTING AREA CAPACITY	Same as AP1440
1470	BAG.CONVEYANCE EQUIPMNT DESIGN	See problem AC1141/AP1472 and AC1142/AP1473
1510	AIRPORT FUEL STORAGE FACILITY	Implied from AC0920 Δ factor
1520	FUEL SERVICE EQUIPMNT DESIGN	Implied from AC0940,AC2211, AC2212,AC2221 Δ factors
1630	SERVICE EQUIPMNT RIGHTS/WAY @ GATE	Same as AP0830 above
1640	INPAVEMNT UTILITY SERVICE LOCATION	Implied from AP0720,AP0740
1670	MAINTENANCE RAMP - TOTAL AREA	Implied from AP1663 and AP1664
1680	FOOD SERVICE KITCHEN CAPABILITY	Implied from AC1060 Δ factor
1710	JET BLAST PROTECTION	Implied from AC0812 Δ factor and AP0325,AP0337
1912	PASSENGER PROCESSING DELAY-OVERALL	See AP0932, AP0933,and AP0937

The correlation determination between the model and the questionnaire was more subjective in nature. Perhaps tracing through two correlation examples will be most beneficial in clarifying this part of the analysis. As indicated in Table 2, AP0321 "Runway Widths and Slopes" received a negative majority vote on the questionnaire as being a problem. On the other hand, the analysis of the model determined that six points should be given to the problem. Since the mean value of the total points scored was 3.97, the model would indicate that a significant potential problem exists. It follows then that the correlation is poor between the questionnaire and the model. However, AP0337 "Taxiway Shoulder Design" received a unanimous positive vote on the questionnaire and five points from the model; therefore, an excellent correlation was given. Degrees of "poor", "fair", "good", "very good", "excellent", and "none" were then assigned in the analysis in essentially the same way.

Discussion of Results

Of the 125 potentially impacted airport components listed on the questionnaire, fifty-four components were listed as problems (majority response). The model agreed with fifty-three of the fifty-four, or 98.1 percent concurrence. However, the model identified five additional problems that the majority of respondents indicated were not problems. But the point must be made that all five model problems are listed as implied problems. On the other hand, no known problem was listed as not being a problem by the respondents. Interestingly, twelve components received a 50/50 split response to problem identification. The model identified those same components as five problematic and seven nonproblematic. The model appears to be split as well. The concurrence between the questionnaire and model on nonproblems was 80.3 percent.

In addition, if one assigns a numerical grade to each identified problem in the correlation determination such that "excellent" equals five and "poor" equals one, with a "none" being scored zero, the "grade point average" of the model is 3.06. This would indicate not only high correlation, but that the correlation has high quality.

In only one instance did the model say "no problem" and the majority of the respondents indicate that there was a problem. That particular airport component was AP1931 - Personal Security

Checks. The reason for this discrepancy can be explained in that for the time period that the analysis was made (circa mid-1960s), boarding passengers were not subjected to personal security checks. Therefore, no problem was identified by the model. The security check problem, of course, became a major problem, especially during peak periods, for passenger boarding wide-bodied aircraft.

The qualitative assessment is that the model is effective in reproducing potential compatibility problems of a historic case given necessary system design characteristics and parametric data. Obviously, there are limitations to the model's capability. Runway length, for instance, was not listed as a known problem because aircraft already in United's fleet had longer runway requirements than the B-747 design concept. Yet, two respondents indicated a major problem here. One of those respondents gave 30 chips out of 100 toward that problem having a major impact on the company and its operation at O'Hare. Upon closer examination

Table 2. Comparative summary.

AIRPORT COMPONENT		Questionnaire							Analysis	
		COMPATIBILTIY PROBLEM ?		CLASSIFICATION MINOR–SERIOUS					NO. of INTERACTIONS	CORRELATION
CODE XXXX	NAME	Y	N	1	2	3	4	5	(Points)	
0111	TERMINAL CONTROL AREA DIMENSIONS		4							
0113	CONTROLSECTOR CONFIGURATION		4							
0114	HOLDING PATTERN LOCATIONS		4							
0115	NAVIGATIONAL FIXES		4							
0117	TRAFFIC CONTROL PROCED. - SPACING(4 D)	4				2			2 (2)	GOOD
0118	AIR TRAFFIC FLOW CONTROL	1	3							
0121	TOWER INSTRUCTIONS AND PROCEDURES		4							
0123	AIRCRAFT SEPARATION REQUIREMENTS	4				1	1		1 (1)	FAIR
0131	GROUND FLOW CONTROL	2	2			1	1			
0132	GRD. CONT. AIRC. SPACING AND SEPARATION	1	3							
0133	GRD. CONTROL POSITION IDENTIFICATION		4							
0210	AIRPORT SITE SELECTION		4							
0221	AIRPORT TOTAL ACREAGE	1	3							
0231	AIRPORT AIR QUALITY		4							
0232	AIRPORT NOISE QUALITY	1	3		1					
0240	FAR PART 77 - AIRPORT CLEAR ZONES		4							
0321	RUNWAY WIDTHS AND SLOPES	1	3						6 (6)	Poor
0322	RUNWAY SIGHT DISTANCES		4							
0323	RUNWAY LONGITUDINAL PROFILE	1	3							
0324	RUNWAY LENGTHS	2	2				2			

of this discrepancy in the model, it was found that O'Hare Airport in 1967 did not have a cross-wind runway that was suitable for the B-747 at maximum gross weight. Therefore, cross-wind runway limitations were, in fact, a compatibility problem. This, of course, was not a limitation solely of the B-747 but was a general problem for aircraft already operating at O'Hare. Had restriction data been available for the case study, the runway length/direction compatibility problem would likely have been identified as a restriction, therefore, a problem.

Therefore, the limitations to the model seem to be related to data availability much more than a substantive flaw in the model. In fact, a sensitivity analysis would reveal that a ±1.5 percent variation in FAR takeoff field length data would have identified the runway length problem. Thus, data tolerance sensitivity analysis can be seen as a very worthwhile process in the overall analysis. In this case study, since the analysis was performed manually, time did not allow for such a manipulation.

Tabel 2 (continued).

AIRPORT COMPONENT		Questionnaire: Compatibiltiy Problem ?		Questionnaire: Classification (Minor → Serious)					Analysis: No. of Interactions	Analysis: Correlation
CODE XXXX	NAME	Y	N	1	2	3	4	5	(points)	
0325	RUNWAY SHOULDER DESIGN	4					3		2 (4)	Good
0326	RUNWAY BLAST PADS	1	3							
0328	RUNWAY SAFETY AREAS		4							
0329	RUNWAY CLEARWAYS		4							
3211	RUNWAY STOPWAYS		4							
1012	RUNWAY PAVEMENT THICKNESS	2	2	1	1					
1050	JOINTING OF CONCRETE PAVEMENT	3	1		2				1 (1)	Fair
1060	DESIGN OF OVERLAYS ON PAVEMENT	4				2	1		2 (2)	Good
1070	PAVEMENT SURFACE DESIGN	4				2	1		1 (1)	Fair
1110	RUNWAY DRAINAGE SLOPES	1	3							
1120	RUNOFF INLET GRATES AND FRAMES		4							
1130	SNOW REMOVAL REQUIREMENTS	2	2			2			2 (2)	Fair
1140	WATER RUNOFF REQUIREMENTS		4							
1211	RNWY ALIGNMENT GUIDANCE-LIGHTING		4							
1212	RNWY ALIGNMENT GUIDANCE-MARKINGS		4							
1213	VISUAL APPROACH SLOPE INDICATOR	2	2			2			2 (2)	Fair
1214	HEIGHT INFORMATION - LIGHTING	1	3						2 (2)	Poor
1215	HEIGHT INFORMATION - MARKINGS		4						2 (2)	Poor
1221	THRESHOLD LIGHTING DESIGN	1	3							
1222	RNWY THRESHOLD MARKINGS	1	3							

Conclusions

Three conclusions can be drawn from the model application to date. First, the overall analysis methodology and the prediction model are effective in reproducing potential problems in compatibility of an historic case. Second, the validation substantiates the workability and capability of the Virginia model. Third, although the assessment of performance is qualitative in nature, a more comprehensive validation would seem worthwhile once the methodology is fully implemented. In any case, this first effort is significant and does suggest that full implementation is a desirable outcome.

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Table 2 (continued).

AIRPORT COMPONENT		Questionnaire: COMPATIBILTIY PROBLEM ?		CLASSIFICATION (MINOR → SERIOUS)					Analysis: NO. of INTERACTIONS	CORRELATION
CODE XXXX	NAME	Y	N	1	2	3	4	5	(points)	
1223	RUNWAY LIGHTING AND SIGNS	3	1						2 (2)	Good
1224	RUNWAY MARKINGS	1	3							
0331	TAXIWAY WIDTHS AND SLOPES	3	1			2	1		3 (3)	Very Good
0332	TAXIWAY SIGHT DISTANCES		4							
0334	TAXIWAY/RUNWAY EXIT GEOMETRY	4			2				1 (3)	Very Good
0335	LOCATIONS OF EXIT TAXIWAYS		4							
0336	TAXIWAY FILLET RADII	4			2				1 (1)	Fair
0337	TAXIWAY SHOULDER DESIGN	4				2	2		2 (5)	Excellent
0338	HIGH SPEED EXIT DESIGN	1	3							
1231	TAXIWAY LIGHTING AND SIGNS	1	3	1						
0341	TAXIWAY TO TAXIWAY SEPARATION		4							
0342	TAXIWAY TO RUNWAY SEPARATION		4							
0343	RUNWAY TO RUNWAY SEPARATION		4							
0344	SEPARATION TO OTHER VEHICLE PATHS		4							
0351	HOLDING APRONS- MANEUVERING SPACE DIMENSIONS	4			1				6 (9)	Excellent
0352	AIRCRAFT STORAGE SPACE CAPACITY	2	2							
0360	OVERPASS STRUCTURES DESIGN	4					2	1	6 (9)	Excellent
0370	RUNWAY/TAXIWAY SURFACE DEBRIS	1	3	1					2 (2)	Poor
0431	HOLDING BAY LOCATION/CONFIGURATION	3	1	1						None
0440	RUNWAY DIRECTIONS		4							

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Table 2 (continued).

AIRPORT COMPONENT		Questionnaire							Analysis	
		COMPATIBILTIY PROBLEM ?		CLASSIFICATION MINOR				SERIOUS	NO. of INTERACTIONS	CORRELATION
CODE XXXX	NAME	Y	N	1	2	3	4	5	(points)	
0511	RUNWAY APPROACH CAPACITY	4				2			2 (2)	Good
0512	RUNWAY OCCUPPANCY TIME		4							
0513	AIRPORT OVERALL CAPACITY	3	1			2	1		1 (1)	Fair
0514	RUNWAY ACCEPTANCE RATES TO TAXIWAYS	1	3							
0521	AIRPORT TAXIWAY CAPACITY		4							
0611	APRON TAXILANE WIDTHS	2	2			2			2 (2)	Poor
0612	TAXILANE TURN RADII	1	3	1					1 (1)	Poor
0613	APRON SIGHT DISTANCES	2	2			1			2 (2)	Fair
1913	AIRCRAFT/AIRPORT DELAY	1	3							
1944	AIRPORT ACTIVITY - AIR CARRIER ANNUAL OPERATIONS	2	2	1		1				
0621	TAXILANE TO TAXILANE SEPARATION	3	1						3 (6)	Excellent
0622	TAXILANE TO BUILDING SEPARATION	4				2			7 (10)	Excellent
0623	TAXILANE TO PARKED A/C SEPARATION	4				2			4 (7)	Excellent
0625	PARKED A/C TO A/C CLEARANCES	4			2				2 (5)	Excellent
0630	APRON OVERALL DIMENSIONS	1	3							
1240	APRON LIGHTING AND MARKING		4						2 (2)	Poor
1932	APRON SECURITY AND SAFETY CHECKS		4							
0710	NUMBER OF GATE POSITIONS	3	1		2				3 (6)	Excellent
0720	PARKING CONFIGURATION AT GATE POSITION	4		1	1				3 (3)	Very Good
0730	AIRCRAFT GATE SPACE REQUIREMENTS	4			2				10 (13)	Excellent

Table 2 (continued).

AIRPORT COMPONENT CODE XXXX	NAME	Questionnaire: COMPATIBILITY PROBLEM? Y	N	CLASSIFICATION MINOR–SERIOUS 1	2	3	4	5	Analysis: NO. of INTERACTIONS (points)	CORRELATION
0740	APRON/GATE LAYOUT	4			2				10 (10)	Excellent
0770	TERMINAL/TAXILANE CONFIGURATION	3	1		1	1			2 (2)	Good
1911	OPERATION - TERMINAL/ACCESS DELAYS	2	2							
0830	SERVICE VEHICLE RIGHTS OF WAY		4						20 (20)	Poor
0910	OVERALL TAXILANE CAPACITY	3	1		2				1 (1)	Fair
0920	OVERALL GATE CAPACITY	3			1				1 (1)	Fair
1610	AIRCRAFT SERVICING EQUIPMENT DESIGN	3			1				21 (24)	Excellent
1620	AIRCRAFT SERVICE EQUIPMENT STAGING	3			1				1	None
1630	SERVICE EQUIPEMENT RIGHTS OF WAY-GATE	3			1				2 (2)	Good
1640	INPAVEMENT UTILITY SERVICE LOCATIONS								2 (2)	Good
1510	AIRPORT FUEL STORAGE FACILITIES	3					2		2 (2)	Good
1520	FUEL SERVICING EQUIPMENT DESIGN	3		1	1				1 (1)	Fair
1530	FUEL SERVICE VEHICLE RIGHTS OF WAY	1	2							
1650	TOWING TUG CAPABILTIY	3			1				2 (5)	Very Good
1660	MAINTENANCE HANGER DESIGN	3				1			4 (10)	Excellent
0934	CONCOURSE FLOW RATES	3				2	1			None
0931	PASSENGER FLOW RATES AT CHECK-IN	3				3			4 (4)	Excellent
0936	LOADING BRIDGE FLOW RATES	3			3				1 (1)	Fair
0937	PASSENGER FLOW RATES AT A/C DOOR	3			3				1 (3)	Good
1912	PASSENGER PROCESSING DELAY - OVERALL	3			2	1			3 (3)	Good

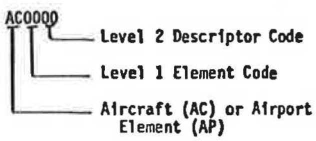
Table 2 (continued).

AIRPORT COMPONENT		Questionnaire							Analysis	
		COMPATIBILTIY PROBLEM ?		CLASSIFICATION MINOR — SERIOUS					NO. of INTERACTIONS	CORRELATION
CODE XXXX	NAME	Y	N	1	2	3	4	5	(points)	
1670	MAINTENANCE RAMP - TOTAL AREA	2	1			1			2 (2)	Good
1680	FOOD SERVICE -KITCHEN CAPABILITY	3				2			2 (2)	Good
1710	JET BLAST PROTECTION	4							4 (4)	Excellent
1720	APRON/RAMP ENGINE NOISE PROTECTION		3							
1320	NUMBER OF LOADING BRIDGES AND RAMPS	2	2						5 (5)	Poor
1330	CONFIGURATION OF BRIDGES TO TERMINAL		3							
1340	HORIZONTAL LOCATION OF CONNECTORS		3							
1350	VERTICAL LOCATION OF CONNECTORS		3							
1370	CONCOURSE DESIGN - LENGTH		4							
1380	CONCOURSE DESIGN - WIDTH	3				2			3 (3)	Very Good
1390	CONCOURSE DESIGN - HEIGHT		4							
1312	PASSENGER ASSEMBLY SPACE REQUIREMENTS	3				2			1 (1)	Fair
1730	INSIDE TERMINAL NOISE PROTECTION		4							
0932	HOLDROOM CAPACITY	3			1	1			1 (4)	Excellent
0933	PASSENGER/VISITOR CAPACITY	1							1 (4)	Excellent
1931	PERSONAL SECURITY CHECKS	3								None
1420	BAGGAGE/CARGO FLOW RATES	3				2			1 (1)	Fair
1430	CONTAINER FLOW RATES	1				1			2 (2)	Good
1440	BAGGAGE INBOUND/OUTBOUND CAPACITY	1				1			1 (1)	Good
1450	BAGGAGE INBOUND OFF-LOADING POINTS	1				1			1 (1)	Good
1460	COLLECTING AREA DIMENSIONS	2				1			3 (3)	Good
1470	BAGGAGE CONVEYANCE EQUIPMENT DESIGN	3				2			1 (1)	Fair
1480	BAGGAGE/CARGO CONTAINER SIZE	1	1	1						
1810	FIRE PROTECTION/EXTINGUISH CAPABILITY	1	3							
1820	EMERGENCY MEDICAL CARE		3							
1830	EMERGENCY VEHICLE SPECIFICATIONS		3							

APPENDIX

Some detailed information is provided in this appendix to the paper. It is helpful to have some knowledge of the general categories of aircraft and airport design characteristics used by the Virginia model. Therefore, the Level I categories of the aircraft/airport interaction matrix have been summarized in Table A1. Also, the description of the element code number is given here in Figure A1.

Figure A1. Element code number description.



AC0000/AC0000 - Aircraft Self-Interaction
AC0000/AP0000 - Aircraft/Airport Joint Interaction
AP0000/AP0000 - Airport Self-Interaction

Table A1. Summary of Level 1 categories of the aircraft/airport interaction matrix.

TABLE A1

<u>Level 1</u> **Aircraft Elements of Aircraft/Airport Interaction Matrix**

AC0100	Aerodynamic Design and Functions
AC0200	Aircraft Velocity and Distance Requirements
AC0300	Aircraft Control and Stability
AC0400	Aircraft Geometry
AC0500	Aircraft Structures
AC0600	Aircraft Weights
AC0700	Landing Gear System
AC0800	Propulsion System
AC0900	Fuel System
AC1000	Passenger System
AC1100	Baggage and/or Cargo System
AC1200	Auxiliary Power Requirements
AC1300	Misc Gate Service Requirements
AC1400	Lighting System
AC1500	Radio/Navigation Systems
AC1600	Instrumentation Capability
AC1700	Operating Scenarios
AC1800	Aircraft Departure/Arrival Mix
AC1900	Aircraft Separation
AC2000	Flight Crew Operation Procedures
AC2100	Aircraft Service Procedures; Overall
AC2200	Aircraft Ground Servicing Points
AC2300	Aircraft Classification
AC2400	Human Factor Considerations

<u>Level 1</u> **Airport Elements of Aircraft/Airport Interaction Matrix**

AP0100	Air Traffic Control
AP0200	Airport Setting
AP0300	Airport Geom. Design-Airside
AP0400	Airport Config.-Airside
AP0500	Airport Capacity-Airside
AP0600	Apron Geom. Design
AP0700	Apron-Gate Configuration
AP0800	Apron Vehicle Circulation
AP0900	Airport Capacity-Apron/Term.
AP1000	Structural Design of A/P Pavement
AP1100	Airport Drainage/Snow Removal
AP1200	A/P Lighting
AP1300	Term. Area Des.-Pax Handling
AP1400	Term. Area Des.-Baggage/Cargo
AP1500	Aircraft Fuel Servicing System
AP1600	General A/C Servicing
AP1700	Jet Blast and Noise Protection
AP1800	Airport Emergency Service
AP1900	General Operations and Safety Requremnts

A description of the OUTPUT information given by Table A3 is given below in Figure A2.

Figure A2. Output information given by Table A3.

Table A2. Input data, Boeing 747 example.

TABLE A2' - Input Data
Boeing 747 Example

AC0120	WING LOADING AT TAKEOFF	LBS./FT2?	129.1
AC0130	WING LOADING AT LANDING WEIGHT	LBS./FT2?	102.5
AC0140	THRUST LOADING	LBS./LBS.S.TH.?	3.94
AC0150	ASPECT RATIO	?	6.96
AC0160	WING SWEEPBCK IN FLIGHT	DEGREES?	37.5
AC0180	WING AREA	FT2?	5500
AC0190	WAKE TURBULENCE	RADIANS/SEC?	16
AC0111	HORIZONTAL TAIL AREA	FT2?	1820
AC0112	VERTICAL TAIL AREA	FT2?	1077
AC0115	WING DIHEDRAL	DEGREES?	7
AC0210	APPROACH VELOCITY	MPH?	168
AC0220	TOUCHDOWN VELOCITY	MPH?	148
AC0260	STALL SPEED	MPH?	129
AC0213	FAR TAKEOFF DIST REQUIREMTS	FT?	10,400
AC0216	FAR LANDING DISTANCE	FT?	6750
AC0410	WING SPAN	FT?	195.7
AC0420	OVERALL LENGTH	FT?	229.1
AC0430	OVERALL HEIGHT	FT?	64.2
AC0440	FUSELAGE HEIGHT	FT?	34.1
AC0450	FUSELAGE OVERWING	FT?	18.1
AC0470	WING HEIGHT ABV GROUND	FT?	18.0
AC0480	HORIZTL TAIL HEIGHT ABV GRD	FT?	29.5
AC0411	COCKPIT CUT-OFF ANGLE	DEGREES,FT?	18.5,66.5
AC0412	HORIZONTAL TAIL SPAN	FT?	72.8
AC0413	FUSELAGE WIDTH	FT?	21.3
AC0414	FUSELAGE LENGTH	FT?	225.1
AC0510	WING STRUCTURE	FT?	6.8
AC0520	FUSELAGE STRUCTURES	RATIO?	10.56
AC0610	AIRCRAFT GROSS WEIGHT	LBS.?	710,000
AC0620	LANDING WEIGHT	LBS.?	564,000
AC0650	MAX.FUEL WEIGHT	LBS.?	316,300
AC0710	WHEEL TREAD DIMENSIONS	FT?	36.1
AC0720	WHEEL BASE DIMENSIONS	FT?	84.0
AC0730	NO. TIRES MAIN GEAR	?	16
AC0740	TIRE CONFIGURATION	S,D,DT OR DDT?	DDT
AC0760	LANDING GEAR IMPACT	LBS./STRUT V.?	141,000
		LBS./STRUT H.?	46,500
AC0780	MIN.TURNING RADIUS	FT?	151
AC0711	TIRE PRESSURE	PSI?	217
AC0713	EQUIVLNT SINGLE WHEEL LOAD	LBS.?	62,000
AC0714	WHEEL SPACG/WHEEL GROUP	FT X FT.?	3.6,4.8
AC0715	MIN PAVEMT WIDTH 180 TURN	FT.?	131
AC0716	NOSE WHEEL TURN ANGLE	DEGREES?	70
AC0810	ENGINE LOCATION/DIST TO A/C CL		
		DIFFERENT LOCATIONS Y OR N?	Y
		MOST INBRD: NO. OF ENGINES?	2
		DISTANCE: FT.?	39.7
		NEXT OUTBRD:NO.OF ENGINES?	2
		DISTANCE: FT?	69.8
		NEXT OUTBRD:NO. OF ENGINES?	0
AC0820	ENGINE LOCATION/DIST.OTHR A/C	MIN.FT.?	26.2
AC0830	ENGINE HEIGHT ABV GROUND		
		DIFFERENT LOCATIONS Y OR N?	Y
		MOST INBRD: NO. OF ENGINES?	2
		MEAN DISTANCE:FT?	3.7
		NEXT OUTBRD:NO. OF ENGINES?	2
		MEAN DISTANCE:FT?	6.0
		NEXT OUTBRD:NO. OF ENGINES?	0
AC0840	ENGINE AIR INLET LOCATION		
		DIFFERENT LOCATIONS Y OR N?	Y
		MOST INBRD:NO. OF ENGINES?	2
		MEAN DISTANCE:FT?	4.5
		NEXT OUTBRD:NO. OF ENGINES?	2
		MEAN DISTANCE:FT?	6.8

Table 2 (continued).

AC0870	ENGINE THRUST/EXHAUST VELOCITY	FT/SEC?	138
AC0880	ENGINE THRUST/EXHAUST VEL 10	FT/SEC?	140
AC0812	ENGINE BRKAWY THRUST REQRMNTS	FT/SEC?	125
AC0813	ENGINE SERVICE REQRMNTS	NO.?	12
AC0814	ENGINE NOISE PRODUCTION	EPNdB?	100
AC0816	ENGINE T.O. THRUST /H.P.	LBS.?	180,000
AC0817	ENGINE THRUST REVERSING	LBS.?	117,000
AC0818	ENGINE OVERALL WIDTH	FT?	7.8
AC0819	ENGINE LOCATION FROM NOSE		
	DIFFERENT LOCATIONS Y OR N?		Y
	MOST FORWRD:NO. OF ENGINES?		2
	DISTANCE:	FT.?	77.5
	NEXT REARWRD:NO.OF ENGINES?		2
	DISTANCE:	FT.?	105.2
	NEXT REARWRD:NO.OF ENGINES?		0
AC0920	A/C FUEL CAPACITY	U.S.GAL?	47,210
AC0940	FUELING POINTS -NO./LOCAT	? ,FT.?	2,46
AC1020	SEATING CAPACITY/MULTI LEVEL	PAX.?	450
AC1030	NUMBER AND LOCATN OF DOORS		
		NO.?	2
	LOCATION	FT.?	31.2
		NO.?	2
	LOCATION	FT.?	61.7
		NO.?	2
	LOCATION	FT.?	100.5
		NO.?	2
	LOCATION	FT.?	133.7
		NO.?	2
	LOCATION	FT.?	180.9
		NO.?	0
AC1040	CABIN FLOOR HEIGHT ABV GRD	FT.?	17.7
AC1050	NUMBER OF AISLES AND X-OVERS	?, ?	2,8
AC1060	FOOD SERVICING SYSTEM	MAX.NO.MEALS?	460
AC1070	POTABLE WATER SERVICING	U.S.GAL.?	330
AC1080	LAVATORY SERVICE	U.S.GAL.?	461
AC1090	CABIN CLEANING	FT2?	3316
AC1011	NUMBER OF GALLEYS	?	4
AC1012	NUMBER OF LAVATORIES	?	10
AC1014	PAX CABIN VOLUME	FT3?	27,860
AC1110	BAG./CARGO DOORS -NO./LOCAT		
		NO.?	1
	LOCATION	FT.?	43.7
		NO.?	1
	LOCATION	FT.?	147.9
		NO.?	0
AC1120	BAG./CARGO FLOOR HEIGHT	FT.?	10.3
AC1130	BAG./CARGO MOVING SYS.IN A/C	Y OR N?	Y
AC1140	BAG./CARGO CONTAINER SIZE	FT3?	350
AC1141	CONTAINER WIDTH	FT.?	5.03
AC1142	CONTAINER HEIGHT	FT.?	5.33
AC1143	CONTAINER LENGTH	FT.?	15.5
AC1150	MAX. CARGO WEIGHT	LBS.?	105,000
AC1170	MAX. BAG./CARGO VOLUME	FT3?	5250
AC1210	ELECTRICAL POWER REQRMNTS	AMPS/KW?	85
AC1220	GATE HEAT/COOLING REQRMNTS	BTU/HR?	367,500
AC1230	A/C GRD START REQRMNTS	ELEC OR AIR?	AIR
	PRESSURE:	PSI?	40
	AIRFLOW:	LB/MIN?	500
AC1240	GROUND TOWING REQRMNTS	LBS.PULL?	33,000
	WHEEL LOAD:	LBS.	42,000
AC1330	AIRFRAME DEICING REQRMNTS	FT2?	12,115
AC1730	GROUND CONTROL OPERATION	OWN OR TOW?	OWN
AC1760	EMERGENCY OPERATIONS	EXITS?	11
AC1810	A/C SIZE DIFFERENTIAL	1,2,3 or4?	1
AC1910	WIDE-BODIED A/C SEPARATION	Y OR N?	Y
AC2010	LANDING PHASE-OPERTN PROCED	AUTO? Y OR N?	Y
AC2110	GATE OCCUPANCY TIME	MIN.?	60
AC2120	GATE UTILIZATION FACTOR	?	.5
AC2210	IN-GRD SERVICING PTS-DIST/NOSE	FT.?	106
AC2211	IN-GRD SERVICING PTS-DIST/CL	FT.?	46
AC2212	IN-GRD SERVICING PTS-HEIGHT	FT.?	16
AC2220	SERVICING FROM VEHICLES-NO.PTS	?	16
AC2221	SERVICING FROM VEHICLES-HEIGHT	FT.?	17.5
AC2230	STAGING OF SERVICING	NO.?	7

Table A3, Group 1, Table Set C, B747 example.

AC CODE	CHARACTERISTIC	AC VALUE		DELTA
AC1230	A/C GROUND START REQRMNTS	40,500		
	A/P ORD/UA			--,400
	AC/AP AP0830 SERVICE VEHICLE RIGHT/WAY		S	
	AP1610 A/C SERVICE EQUIPMT DESIGN		QS	
	AP1620 A/C SERVICE EQUIPMT STAGING		S	
AC0817	ENGINE THRUST REVERSING	117,000		
	A/P ORD/UA			91,800
	AC/AP AP0335 LOCATION OF EXIT TAXIWAYS		M	
	AP0324 RUNWAY LENGTH		M	
	AP0512 RUNWY OCCUPANCY TIME REQRMNTS		M	
AC1070	POTABLE WATER SERVICING	330		
	A/P ORD/UA			230
	AC/AP AP0830 SERVICE VEHICLE RIGHT/WAY		S	
	AP1610 A/C SERVICE EQUIPMT DESIGN		QS	
	AP1620 A/C SERVICE EQUIPMT STAGING		M	
AC1011	NUMBER OF GALLEYS	4		
	A/P ORD/UA			2
	AC/AP AP0830 SERVICE VEHICLE RIGHT/WAY		M	
	AP1620 A/C SERVICE EQUIPMT STAGING		M	
AC0111	HORIZONTAL TAIL AREA	1820		
	A/P ORD/UA			1202
	AC/AP AP0324 RUNWAY LENGTH		W	
	AP0327 FAR TAKEOFF FIELD LENGTH		W	
AC1014	PAX CABIN VOLUME	27,860		
	A/P ORD/UA			17,780
	AC/AP AP1610 A/C SERVICE EQUIPMT DESIGN		W	
AC1150	MAXIMUM CARGO WEIGHT	105,000		
	A/P ORD/UA			64,055
	AC/AP AP1460 COLLECTING AREA CAPACITY		M	
	AP1610 A/C SERVICE EQUIPMT DESIGN		M	