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TRANSPORT MODELLING SYSTEM
USER REQUIREMENTS DOCUMENT

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TITLE:

TRANSPORT MODELLING SYSTEM
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Abstract:

This note brings together the requirements for a computer fast-time aviation oriented Transport Modelling System from over a hundred user organisations world wide. It is planned to be the basis for the production of such a system.

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1. INTRODUCTION

1.1 Identification and Scope

A number of organisations concerned with aviation transport systems modelling launched an initiative in an attempt to define a system that could satisfy the different modelling requirements that exist today whilst at the same time would remain flexible enough to be able to accommodate any future extensions and new features.

Following initial discussions at the Eurocontrol Centre in June 1994 it was decided to establish a Functional and Operational Requirements Users Group. Through discussions it was planned that a Users Requirements Document (URD) be produced which would then be passed onto the Simulations Technology Sub-Group (S.Mathewson).

The purpose of this document is to specify as many known user requirements as possible for a Fast Time Simulator System. It will thus contain requirements already available in existing models as well as new user requirements.

Another purpose of this document is to describe a simulation model that will be flexible and allow the user to switch on/off those functions applicable/not applicable to their needs. The user will be able to tailor the simulation model to fit their requirements with minimum effort. The system shall be user friendly towards the user and provide suitable documentation on how to use the optionality feature.

1.2 Document Organisation

The document is presented in fifteen Sections including Section One, the Introduction. This first chapter includes a glossary of acronyms and a list of known existing Fast Time Simulation Models.

In Section Four, Ground Movements, the main requirements for simulating the manoeuvring area at an airport are outlined.

In Section Five, Runway Management, the main requirements for simulating the management of runway operations and runway allocation are detailed.

In Section Six, TMA Simulation Requirements, the central components to simulating airspace and TMA features are set out.

In Section Seven, Human Factors, the need for workload statistics is outlined.

In Section Eight, Variability Requirements, the dynamic requirements of the model are given.
Sections Nine through to Fifteen outline various other requirements requested by users.

1.3 Glossary of Acronyms

ACAS	Airborne Collision Avoidance System
ACC	Air traffic Control Centre
AIP	Aeronautical Information Publication
APATSI	Airport/Airspace Traffic System Interface
APP	Approach Centre
ATC	Air Traffic Control
ATZ	Air Traffic Zone
CRDA	Converging Runway Display Aid
FIFO	First In First Out
IAF	Initial Approach Fix
IFR	Instrument Flight Rules
INM	Integrated Noise Model
MDI	Minimum Departure Interval
MUFTIS	Model Use and Fast Time Simulators
OAG	Official Airline Guide
SID	Standard Instrument Departures. Each SID specifies the procedures to be followed by aircraft taking off from an airport. Each SID is defined by a sequence of Navigation Points. Altitude restrictions and other ATC constraints may be associated with each Navigation Point in the SID.
STAR	Standard Arrival Routes. Each STAR specifies the procedures to be followed by aircraft landing at an airport. Each STAR is defined by a sequence of Navigation Points. ATC constraints may be associated with each Navigation Point in the STAR.
TWR	Tower Control
VFR	Visual Flight Rules

1.4 Fast Time Simulators and Tools

The MUFTIS project (report available from the European Commission) provided a list of the following fast time simulators and tools:
Airport Machine, ASIM, ATSAM, DORATASK, EAM, FATCAT, Goethe Sport, MSF, NASPAC, RAMS, SIMMOD and TAAM.

2. SIMULATION DATA

The model will include data access and preparation facilities with the possibility of planning variations or randomised scenarios. Clear, detailed documentation will be provided.

The model will provide a set of databases to assist with simulation data collection. These databases will include: airport layouts; schedules (e.g. OAG); aircraft performances and navigational data, such as, en-route and TMA details and route structures. Where inclusion of commonly used databases is not practical due either to volume or update rates of the databases, the model will provide utilities for extracting data from these databases.

It will be possible to simulate hubbing structures at an airport by using various strategies provided for flight linking and delay procedures.

It shall be possible to perform strategic planning. The model will allow the user to allocate resources by means of various criterion or parameters. For example: a passenger flow option, where it will be possible to establish a control strategy determined by passenger demand (e.g. no aircraft of less than 30 passengers will be allowed to operate during the peak hour).

3. TRAFFIC SAMPLES

The model will provide the opportunity to define future traffic samples. It will also be possible to simulate a civil, military traffic mix. The inclusion of helicopter operations shall be available. The model will sustain VFR operations within the aerodrome's traffic circuit in addition to IFR operations and operations within the manoeuvring area.

4. GROUND MOVEMENTS

4.1 Gates and Stands

- The ability to specify complex gate and stand characteristics.

It shall be possible to define a detailed stand allocation and gate specifications using user defined categories. Gate priority assignment will be available and will be linked to the towing feature (see 4.5 page 5). The model shall be able to assign a gate to an aircraft when the aircraft arrives on the apron or when enters the airspace.

Gate Holding procedures, delaying an aircraft at its gate, will be linked to Holding Area procedures (see 4.6 Holding Area page 5)

In order to utilise existing gate models which provide the user with the necessary tools to specify preferences e.g. aircraft size, adjacent gate restrictions, dedicated/preferred user gates, flight sector restrictions, security/frontier control restrictions or gate closures; the model will interface with such models (see 10 page 15).

4.2 Request and Start-Up Times:

- The ability to specify request and start-up times in a way that closely reflects the actual procedure in use today.

The model will have a Request and Start-Up Times feature. This feature will be flexible and accept a varying level of detailed information. It will closely resemble the real world departure slot time allocation procedure.

4.3 Pushback Slot Times:

- The ability to specify pushback slot times in a way that closely reflects the actual procedure in use today.

It shall be possible for different pushback slot time procedures to be modelled, as this procedure can vary between airports.

4.4 Departure Slot Times:

- The ability to specify departure slot times in a way that closely reflects the actual procedure in use today.

Departure Slot Time is highly important within the operations of airfield logic, restricting the movement rate of departures and, more accurately, reflecting delays in the Holding Area (see 4.6 Area page 5). This feature will be dynamically linked to many other features e.g. stand demand.

4.5 Push backs

- The ability to specify detailed push-back characteristics to both gates and aircraft types.

It will be possible to specify push back characteristics to a gate, a group of gates or according to aircraft type or airline. This feature will be linked to the Gate feature (see 4.1 Gates and Stands page 4). The user will be able to model Push backs deterministically or stochastically.

4.6 Holding Area

- The ability to specify a holding area for aircraft awaiting either departure or an available gate.

This facility will model departure holding areas and arrival holding areas. Or, alternatively, multi-holding areas that can be used exclusively by departures or arrivals.

The model will also model parking areas, both long-term and short-term.

If required, departures, after leaving their gate, will be routed to the Holding area as part of the departure sequence prior to be routed to the runway. This will allow the gate to be freed and not remain blocked longer than necessary.

If required, arrivals will be routed to the Holding Area whilst awaiting an available gate.

Rules for applying this feature will be case based (e.g. if an arrival is early then it will be sent to the Holding Area). It will also be linked to Gate Holding procedures (see 4.1 Gates and Stands page 4) so as to ensure efficient usage of the Holding Area and to prevent it from becoming saturated.

Holding procedures differ from airport to airport due to individual layouts, the feature will attempt to be flexible and reflect this.

The model should provide outputs that measure the time spent by aircraft, individually and collectively, in a Holding Area.

4.7 Taxiways

- The ability to specify complex taxiway characteristics.

Taxiways are the links between runways and gates. The model will support the following functionality:

Aircraft sizes are changing rapidly; thus it will be possible to assign aircraft to particular taxiways.

A taxiway will be blocked should an aircraft with a wide wing span be on an adjacent taxiway.

Multiple occupancy of a taxiway will be modelled and will be governed by aircraft size (e.g. a taxiway will be able to take one B747 or two A320s).

Taxiways will be assigned both physical and usage attributes. The usage attributes will be linked to the Weather Variabilty feature (see 8.2 page 14).

Runway usage or approach distance could sterilise a taxiway or vice versa. These would be extreme cases that would be clearly defined.

Taxiways will be assigned priorities according to both airline and aircraft type, as will taxiway speed limits/ranges.

Taxiways may be unidirectional accommodating both arrivals and departures or bi-directional only according to user defined requirements. Automatic conflict resolution will be available on taxiways.

4.8 Towing and Towed Aircraft

- The ability to specify detailed towing and towed aircraft characteristics to both gates and aircraft types.

It will be possible to specify towing and towed aircraft characteristics to a gate, a group of gates or according to aircraft type or airline. Specifying characteristics relating to taxiway will also be possible (i.e. specifying occupancy time, speed restrictions, positioning etc.). This feature will be linked to the Gate feature (see 4.1 Gates and Stands page 4) and the Taxiway feature (see 4.7. Taxiways page 6). The user will be able to model Towing and Towed Aircraft deterministically or stochastically.

4.9 Rules for Cul-de-Sacs

- The ability to specify handling strategies and procedures manoeuvring aircraft within the Cul-de-Sacs.

Cul-de-Sacs shall be modelled with detailed features, such as priority ascribed according to gate, airline or aircraft model. It will be possible to specify strategies and procedures for handling start-ups, pushbacks, towing etc.

4.10 De-Icing

- The ability to simulate the de-icing of an aircraft before departure both at the gate and on the de-icing pad.

The model will include a de-icing feature. As the temperature plays a major role in determining the time needed for de-icing; this feature will be linked to Weather Variability (see 8.2 Weather Variability page 14). The feature will also be linked to departure procedures as aircraft need to be de-iced a specified time before departure should the aircraft be delayed beyond this time they need to return to a secondary de-icing area (may in practice be the originally assigned primary de-icing area). It will be possible to model different methods of de-icing fluid procedures.

It will also be possible to de-ice arrivals, if required.

4.11 Vehicle Movements

- The ability to model non-aircraft vehicle movements at an airport.

The model shall include a vehicle movements option, where the user will be able to include non-aircraft vehicles (e.g. tugs and buses) in the simulation. It will be possible to determine the effect these non-aircraft vehicles have on aircraft movements. It will be possible to specify different types of non-aircraft vehicles and their inter-dependencies.

4.12 Resource Requirements

- The ability to specify sets of critical elements.

Critical elements such as tugs and a usage time for the resource to model restriction of aircraft movement due to the lack of availibility of the resource. Required modelling arrivals to gates, departures from gates and towing as sepcified by the user.

5. RUNWAY MANAGEMENT

5.1 Runway Allocation

- The ability to allocate an arrival or a departure to a specific runway and then be able to switch to another runway, if warranted.

The model will allow a runway to be allocated before the start of the simulation and for it to be changed during the simulation run. It will also be modelled with stochastic variability and for deterministic use.

The model will support all combination of runway dependencies.

The feature will be linked to Weather Variability (see 8.2 Weather Variability page 14) and Diurnal Variability (see 8.1 Diurnal Variability page 14)

In the case of multiple runway usage, departures will use the set of SIDs assigned to each runway. It could be that the flight is allocated a runway which can then be changed during the simulation; the flight would then use the SID assigned to the runway. The flight would be allocated a runway according to the combination of runways used and could be governed by a set of rules which is in turn governed by the weather or by diurnal preferences. A decision on whether to do runway allocation according to individual flights or according to SIDs will have to be taken. There will also be user defined preferences as to which runway is assigned to each flight based on features ranging from taxiing distances to strategic airborne deconfliction within the TMA.

5.2 Detailed procedures for departure line-ups, reaction times and roll level

- The ability to define complex procedures for departure line-ups, reaction times and roll distance.

The model will define separate features for departure line-ups, reaction times (time taken to move from the departure queue to the departure point on the runway) and roll distance.

These features will be modelled for either deterministic or stochastic use. Detailed definition (e.g. according to individual aircraft) or more general definition (e.g. according to aircraft groupings) will available.

5.3 Departure Selection

- The ability to select a departure from a runway hold.

The model shall optimally select an aircraft, using a variety of methods, from the Holding Area by considering departure routings, wake vortex, speed etc. in order to minimise delay. This selection could also be supplanted by a FIFO system.

It will also be possible for the user to define a runway hold area from which the Departure Controller could select aircraft.

5.4 Multiple Line-ups

- The ability to model multiple line-ups on a runway.

It will be possible to model multiple line-ups on a runway i.e. more than one aircraft on the runway ready for take-off.

5.5 Take-off

- The ability to model different take-offs.

It will be possible to specify more than one take-off position according to both aircraft type or group.

5.6 Intersection Take-offs

- The ability to define multiple departure queues that can be operated simultaneously.

It will be possible to model more than one departure queue. The model will restrict the maximum number of aircraft assigned to a runway to three. Aircraft will be routed through the Holding Area (see 4.6 Holding Area page 5) and re-sequenced to different line-up points. It will be possible to specify more than one take-off intersection.

5.7 Runway Arrival and Departure Occupancy and Exits

- The ability to specify the length of time an arrival or a departure will occupy the runway and its exit details.

This feature will be both deterministic and stochastic in character. A number of management procedures for determining runway occupancy will be available. It will be possible to specify different touchdown points and exit choice by either terminal location or airline.

It will be possible to specify a particular exit or a range of possible exits points. The model will allow for the specification of different touchdown points and exit choice to be by either terminal location, airline or user defined conditions. It will be possible to apply a stochastic distribution for the use of the runway exits (e.g. by category; category 1 = 25 % first exit, 50% second exit, 25 % third exit).

The stochastic option will allow blocking times to be assigned through linking with Weather Variability (see 8.2 Weather Variability page 14) and Diurnal Variability (see 8.1 Diurnal Variability page 14).

5.8 Landing Roll

- The ability to model a variety of landing rolls.

It will be possible assign landing roll characteristics in detail according to individual aircraft, aircraft group, landing position etc.

5.9 Runway Crossing

- The ability to manoeuvre an aircraft across a runway.

The model shall allow for the allocation of a single or multiple crossing point and for one or more aircraft to cross the runway at the same time. It will be possible to assign crossing time according to runway operation, crossing location or aircraft type.

This feature will be linked to Arrival and Departure Sequencing (see 6.8 page 12).

5.10 Mixed Mode Runway Operations

- The ability to optimally allocate arrival streams and departures to the same runway.

The model will have the ability to differentiate between the competing demands of the arrival stream and the departure queues so that optimal use of the mixed mode runway is achieved. This will include applying user defined parameters and weightings to reflect how the model should prioritise the demand.

5.11 Runway Backtracking and Taxiing

- The ability to model taxiing and/or backtracking on a runway.

The model will provide a runway backtracking/ taxiing option that enables the user to model aircraft taxiing along part or all of the runway; entering and leaving the runway at specified points. It will also enable the user to turn and backtrack an aircraft (arrival or departure) at any specific point on the runway. The option should permit turn and backtrack or taxiing or both as required by the user.

5.12 Land and Hold Short Operations

- The ability to run crossing runways independantly with land and hold short procedures either for all operations or a subset based on the landing aircraft type..

5.13 Two arrivals on the same runway

- The ability to land a heavy (larger) aircraft to be followed by a smaller without having to have the initial aircraft clear the runway to an exit.

6. TMA SIMULATION REQUIREMENTS

6.1 Arrival Procedures

- The ability to model detailed arrival procedures.

The model will include the application of detailed arrival procedures that would be able to simulate the new APATSI procedures and techniques, such as, land after, CRDA and reduced separation on final approach etc.

6.2 Departure - Departure Separations

- The ability to specify departure - departure separations.

The model will take into account wake vortex separation, runway separation restrictions, MDI restrictions, pilot reaction times, diverging and non-diverging SID structures and speed variations along the SIDS when applying departure - departure separations. It will also take into account runway dependencies.

6.3 Radar Vectoring

- The ability to model the tromboning procedure for arrivals.

The model will provide a tromboning feature that closely reflects the procedures currently in use both in functionality and in its visual display.

6.4 SIDS, STARS, IFR and VFR Approach Procedures

- The ability to define SIDS, STARS and a variety of approach procedures within the simulation model.

It will be possible to input SID and STAR profile restriction information (following the AIP format) directly into the model as well as in the initial data preparation phase. STARs end at the IAF from which point IFR approach procedures are applied, the model will facilitate this detail.

A variety of approach procedure shall be available within the model. It will also be possible to change procedure by vectoring.

6.5 Profiles

- The ability to model a flight profile according to the level of detail required by the user.

The simulation model shall accurately model 4D flight profiles for as many aircraft types as required, including user defined aircraft types. Take-off and descent angles will be variable and not uniform. Aircraft turns will be modelled precisely.

6.6 Conflict Detection and Resolution - ACAS

- The ability to perform conflict detection and resolution using ACAS.

The simulation model shall incorporate advanced conflict detection algorithms combined with a resolution system. Resolution will be multi-fold using vectors, level changes, speed manipulation, path stretching or air/ground holding - in order to represent actual air traffic practices.

6.7 Stacks

- The ability to model holding stacks for arrivals.

The simulation model shall provide the modelling of holding stacks. Aircraft will be stacked in holding patterns, when necessary, and then released back into normal operations when directed. User defined stack management will also be possible. Stacks should be dynamic so that the user can define capacity and altitude, etc., in order that the model can offer 1st and 2nd choice stacks.

6.8 Arrival and Departure Sequencing

- The ability to specify complex and synchronised sequencing schedule for arrivals and departures.

The model will provide a number of arrival and departure sequencing options. It will be possible to spread out arrivals to get departures out, to spread out departures to get arrivals in or to ‘bunch’ arrivals to be interspersed with large gaps. The feature will allow for the application of MDI.

It will be possible to specify user defined sequencing algorithms / systems. Linking to an external sequencer will also be available.

7. HUMAN FACTORS - DIFFERENT CONTROLLER WORKLOAD

- The ability to calculate different controller workload estimation.

An aircraft can pass through the responsibility of many different controllers from the moment it departs its point of origin until it arrives at its point of destination.

The model will emulate the actions of the different controllers within the simulated airspace. From this, the model shall provide statistics of the relative workload placed upon the actual control staff dealing with the flows of traffic within the simulation, in whatever permutation required.

The different controller positions could be defined as follows:

(a) Air traffic Control Centre (ACC), the area related to the FIR and sectors. The model will emulate the actions of the controllers responsible for each sector and those of the Flight Data Preparation (see below).

(b) Approach Control (APP), the area related to the TMA. The model will emulate the actions of the APP Controllers:
- Arrival Controller: responsible for arrivals handed over by the ACC Controller, hands on to the Director or directly on to Tower Control.
- Departure Controller: responsible for departures handed over by Tower Control, hands on to ACC.
- Director: accepts arrivals from the Arrival Controller, sequences the arrivals for final approach before handing on to Tower Control.
- Flight Data Preparation: (this person is not necessarily an air traffic controller), collects the data required by the Planning Controller.
- Planning Controller: is in communication with Tower Control and the ACC to give the planned route for each aircraft.

(c) Tower Control (TWR), related to the Air Traffic Zone (ATZ). The model will emulate the responsibilities and actions of the control tower at an airport, including those of the Flight Data Preparation (see above).
- Apron Control: responsible for all aircraft on the apron, hands aircraft to or accepts them from Ground Control.
- Ground Control: responsible for all aircraft movement along the taxiways, either accepts aircraft from Runway Control and then passes it on to Apron Control or accepts aircraft from Apron Control and hands them on to Runway Control.
- Tower Control: responsible for all aircraft on the runway and in the ATZ. Hands aircraft on to Departure Control after take-off unless bad weather dictates that Departure Control take responsibility for the aircraft from the runway. Accepts aircraft from the Director and, once they are landed, hands over to Ground Control.

8. VARIABILITY REQUIREMENTS

8.1 Diurnal Variability

- The ability to model diurnal variability.

The model will allow for diurnal variability which will reflect the dynamic traffic demands and related operations within a user defined period of up to any 24h period.

8.2 Weather Variability

8.2.1 Weather Conditions

- The ability to model various weather conditions.

The model will model a variety of weather conditions (which would closely resemble real weather systems) that will have a direct impact on the procedures used within the simulation, such as, runway allocation or separations.

8.2.2 Wake Vortex linked to a dynamic weather system

- The ability to determine a wake turbulence flag by not only aircraft model type but also by the prevailing weather conditions.

It will be possible to set dynamic wake turbulence directly linked to the Weather Conditions (see 8.2.1 Weather Conditions page 14) used in the simulation. The model will also facilitate wake vortex relationships between aircraft operating on different runways e.g. closely spaced parallels.

9. ORIENTATION REQUIREMENTS ORIENTATED TOWARD PROCEDURAL CHANGES

- The ability to model strategic and tactical changes.

The model will provide options for assisting with both constructional changes (e.g. a new runway) and ATC procedural changes.

10. INTERFACE REQUIREMENTS

Note: All interfaces shall be user friendly and simple to use.

10.1 User interaction

- The ability for user interaction.

The model will provide a suitable interface that will support user interaction during all stages of the simulation allowing a mixture of both fast-time and real-time simulation. The ability to select and display reports and graphs simultaneously with the animation will be possible.

10.2 Noise Contours

- The ability to calculate noise contours.

The simulation model shall provide a suitable interface between itself and noise contour tools (e.g. INM).

It will also be possible to reproduce flight tracks/profiles if required.

10.3 Existing Tools

- The ability to interface with existing modelling tools.

The model will interface with existing tools, such as NAPA a gate modelling tool. It will be able to integrate with other models. The inclusion of user defined code / programs will be possible. The interface between existing tools and the model shall be two-way i.e. import and export to/from other models.

11. REPORTING REQUIREMENTS

11.1 Delay Statistics

- The ability to calculate delay statistics.

The relative amount of delay accumulated by user defined scenarios (e.g. delay is reduced by adding a taxilink or by altering ground circulation or movement procedures.) will be reported on in detail.

11.2 Fuelburn statistics

- The ability to calculate estimated fuelburn statistics.

User friendly fuelburn reports will be available along with the necessary documentation.

11.3 Time Gain Reports

- The ability to calculate time gain reports.

The model shall be able to measure the different time gains according to the scenarios under simulation. This will be of benefit to airlines who might put more stress on time gained than on fuelburn.

11.4 Annualisation of results

- The ability to calculate annualised results.

The model will assist with the evaluation of the simulation's financial impact by calculating annualised results that will be corrected for any traffic sample bias.

11.5 Cost Analysis

- The ability to formulate a cost analysis.

The model will provide a facility for formulating a cost analysis of delays incurred.

11.6 Revenue Analysis

- The ability to quantify revenue from overflying aircraft.

The model shall provide a function, similar to Eurocontrol CRCO, where scenarios could be compared in terms of possible revenue.

11.7 User Defined Reports

- The ability to formulate user defined reports.

It shall be possible to generate user defined reports in a simple standard format, possibly using a suitable package (e.g. Excel, Access) which reads and analyses simulation output.

12. ADMINISTRATIVE REQUIREMENTS

12.1 Audit trails for changes to input files

- The possibility of audit reports of changes to input files.

The model will provide an audit report detailing changes made to the input files during the simulation.

12.2 Version Control

- The possibility of version control for the simulation model.

Version control will be a feature, all changes and additions to the model will be recorded, reported on and controlled. The version number, release date, date of run, etc. shall be held in a file. The model will also keep a record of the data used so that it is possible to re-create a run from its output.

13. DOCUMENTATION REQUIREMENTS

- The possibility of specific, detailed, tailored documentation for the user.

Documentation will be available for each version. It will include: who created the version, the contact person, all data changes, why these changes were made, what the benefit will be and how to use any new feature. The documentation shall be detail specific, not a general explanation. It shall also include, at least, one fully developed and documented example for each simulation problem that could be encountered whilst using the simulator (e.g. Ground Movements, Runway Management, TMA simulation .....)

14. RESOURCE REQUIREMENTS

One of the aims of the model will to provide a scaleable and portable product that can be used on various platforms (PC and Workstation). The model will aim to be user friendly with a realistic animation. The model will be developed in and will use standard or common tools e.g. language, data base, graphics...

15. VERIFICATION, VALIDATION AND TESTING REQUIREMENTS

A Verification, Validation and Test Plan will be implemented. The resultant report will be made available to the users.