

NTM Rail Crowding Model

Version 11 Software Functional Requirements Specification

December 2007

Prepared for:

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1 Introduction

- 1.1 This document describes the software functional requirements for the calculation of rail crowding penalties for the NTM.
- 1.2 The calculations will be implemented within a revised release of the NMF.
- 1.3 The revised release of the NMF will include a new MOIRA Crowding Penalty application (MOIRA-CP) that will 'wrap around' the MOIRA Batch Processor and which will calculate the crowding penalties.
- 1.4 The performance requirement for the RCM is an average of 1 hour per iteration (where the RCM is run for 9 iterations). This will be achieved if the data on the NMF database is maintained so there is a minimum of data on the NMF database.

2 Data Preparation

- 2.1 A number of reference data tables will be created for the use in new application. All will be held as csv files inside the Demand folder in the NMF directory.
- 2.2 Crowding costs will be sourced from the PDFH – June 2005 (table B5.1).

Table B5.1: Recommended Crowding Penalties for Passengers (p / min)

Load Factor		Leisure		Business		Commuting		1st Class London	
		London	Non London	London	Non London	London Inner	London Outer		
		50%	Sit	0.0	0.0	0.0	0.0	0.0	0.0
60%	Sit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	Sit	0.2	0.17	2.4	0.7	0.0	0.0	0.0	0.0
80%	Sit	0.4	0.35	4.7	1.3	0.0	0.0	0.0	0.0
90%	Sit	0.8	0.52	9.2	1.9	0.0	0.25	0.4	6.0
100%	Sit	1.1	0.70	13.7	2.5	0.6	0.50	0.8	12.1
110%	Sit	1.5	1.20	18.2	3.6	1.2	0.75	1.2	-
120%	Sit	1.8	1.70	22.7	4.6	1.8	1.00	1.6	-
130%	Sit	2.2	2.20	27.2	5.7	2.4	1.25	2.0	-
140%	Sit	2.5	2.70	31.7	6.7	3.0	1.50	2.4	-
150%	Sit	-	-	-	-	3.6	-	-	-
160%	Sit	-	-	-	-	4.2	-	-	-
100%	Stand	22.0	22.0	100.0	48.0	12.0	12.0	6.5	-
120%	Stand	26.4	26.4	120.0	50.5	13.0	13.0	7.5	-
140%	Stand	30.8	30.8	140.0	53.0	14.0	14.0	8.5	-
160%	Stand	-	-	-	-	15.0	15.0	9.5	-

Note: All values are in 2000 quarter 4 prices and incomes.

- 2.3 The table prepared for input to the software will include costs for load factors in 10% increments between 50% and 200% (inclusive); also 250% and 300%. In the preparation of the table, costs for load factors of greater than 160% will be assumed to be equal to those for 160%. But the table will be held as a CSV format file enabling ITEA to update it offline.
- 2.4 Costs for intermediate load factors will be obtained by linear interpolation. A maximum load factor will be assumed equal to the highest value shown in the

table (in this case 300%). Crowding costs for load factors less than those shown in the table will be assumed to be zero.

2.5 All passengers will be assumed to be Standard Class. Therefore total passenger numbers will include First Class passengers and total vehicle capacity will include First Class seating.

2.6 The Crowding Cost table will have fields as below:

CROWDING COSTS

Accommodation	Char(1)	Sit or Stand (I or A)
Journey Purpose	Char(1)	Business, Leisure or Commuting (B, L or C)
Train Type	Char(1)	Non London, Inner London or Outer London (N, I or O)
Load Factor	Integer	
Crowding Cost per Min	Real	Pence per minute

2.7 The Peak Types table will define for each Service Code 4th digit whether trains of those Service Codes should be considered as Peak or OffPeak.

PEAK TYPES

Service Code 4th Digit	Char(1)	
Peak Type	Char(1)	Peak or OffPeak (O or P)

Within NMF the 4th digit determines the peak type of the train. NMF has 7 different peak types (eg AM Peak; PM Peak; AM Shoulder Peak) – for this application these 7 peak types need to be mapped to 2 types, ie Peak and OffPeak.

2.8 The Values of Time table will define for each Origin, Destination, Journey Purpose combination the Value of Time at 2000Q4 prices as derived from the equation in the PDFH – June 2005 (section B3.8.3).

VALUES OF TIME

NMF Origin Zone	Char(3)	3 Letter Code
NMF Destination Zone	Char(3)	3 Letter Code
Journey Purpose	Char(1)	Business, Leisure or Commuting (B, L or C)
Value of Time	Real	Pence per minute

2.9 The Station Areas table will define for each NMF Station whether it is in Zone 1 (London); Zones 2-6 (InBoundary) or outside Zone 6 (OutBoundary).

STATION AREAS

NMF Station	Char(3)	3 Letter Code
Travelcard Zone	Char(1)	London, InBoundary or OutBoundary (L, I or O)

3. Interface: NTM to NMF

- 3.1 Data will be loaded from the Rail Group database into the revised NMF.
- 3.2 The revised NMF will run on a application server separate but connected to the NTM application server with links to the Rail Group database.
- 3.3 The Cost Management Interface (CMI developed by ITEA in house) will pass the required input parameter settings to the NMF via a text file held inside the Demand folder in the NMF directory.

The Input Parameters.ini file will comprise the following in any order:

- NTM Forecast Year;
- NTM Scenario Name;
- NTM Iteration Number;
- RDI File Location – location for the 2 separate Zonal Uplift files generated by the RDI : one each for Scotland and for GB, terminated by a \ character;
- Cost Uplift – to be specified (typically 10%, represented as 1.1);
- NTM Output Location - location to which the Output File will be saved to, terminated by a \ character.

The list will be preceded by the line:

[NTM]

- 3.3a If the contents of the ini file are invalid, then an error log file will be generated (as per 3.6 below). The ini file will be deemed invalid if:
 - The NMF Forecast Year is not an integer > 2005, or does not correspond to one of the years set-up for the Study;
 - The NTM Scenario Name is blank or greater than 100 characters;
 - The NTM Iteration Number is not an integer > 0;
 - The RDI Files do not exist in the location specified;
 - The Cost Uplift is not a float > 0;
 - The NTM Output Location does not exist and cannot be created;
 - It contains blank lines in addition to the final carriage return;
- 3.3b If one of the parameters in the ini file is duplicated, the first will be used, and subsequent entries will be ignored.
- 3.4 The NTM Scenario Name will be set by the user and the CMI will pass the name to the NMF. This name will be picked up by the NMF and used to name folders/outputs etc for each specific NTM run.
- 3.5 On each iteration n (including iteration 1) the RDI part of the NTM will output 2 CSV format files of uplifts between NTM zones which will be used by the NMF to create revised matrices of revenues and journeys. The Zonal Uplifts file will have fields as below:

ZONAL UPLIFTS

NTM Origin Zone	Integer	Zone Number
NTM Destination Zone	Integer	Zone Number
Uplift Percent (Full)	Real	Value of 100%, represented as 1.1 would Double the Revenue and Double the Journeys
Uplift Percent (Season)	Real	Value of 100%, represented as 1.1 would Double the Revenue and Double the Journeys
Uplift Percent (Reduced1)	Real	Value of 100%, represented as 1.1 would Double the Revenue and Double the Journeys
Uplift Percent (Reduced2)	Real	Value of 100%, represented as 1.1 would Double the Revenue and Double the Journeys
Uplift Percent (Misc)	Real	Value of 100%, represented as 1.1 would Double the Revenue and Double the Journeys

- 3.6 An additional text file (“RCMComplete.txt”), generated by the NMF and saved to the NTM Output Location, will record whether the processing successfully ran to completion. Should an error occur, a file named “RCMError.log” will be written with the error message to the NTM Output Location. If the NTM Output Location does not exist it will be created – if it cannot be created a standard error message will be displayed (not an error file as described above).
- 3.7 The command-line parameters for the NMF when running as the Rail Crowding Model are:

<NMF.exe Filepath and Name, in quotes > /NOSPLASH <NMF User Name, e.g. ITEA> <NMF Password, e.g. ITEA> <Database name, e.g. NMFV1.world> <Study Id> <Filepath and Filename of ini file, in quotes>

Note that any strings containing space characters will be expected to be surrounded by quotations, e.g. “C:\Program Files\NMF\NTM\”

For example:

“C:\Program Files\NMF\1.4.0.280\NMF.exe” /NOSPLASH ITEA ITEA
NMFV1.world 1126 “C:\Program Files\NMF\NTM\NTM.ini”

- 3.8 If the Study Id is invalid, then an error will be generated, and written to the error log. The Study Id will be deemed invalid if:
- The Study Id is not an integer > 0;
 - The Study Id corresponds to a study that does not exist;
 - The Study Id corresponds to a study not owned by the current user (as defined by the NMF User Name in the command line parameters)
 - There exist NMF demand results for that Study, or the Study on which the RIFF results will be based.

4. Revisions to the NMF

- 4.1 RIFF Lite will be run as required to create base revenue and journeys for each Origin, Destination, Ticket Type combination. These revenue and journeys values will be calculated as per paragraphs 5.7 to 5.11 of the NMF Functional Requirements v1 [ref 1]. The values will be stored in the NMF database.
- 4.2 The NMF Study will have a parameter saved to the NMF database that indicates whether RIFF Lite needs to be run again, or if not the results of which existing NMF Study should be used instead.
- 4.3 Whether an NMF study uses Proxy Seats or Actual Seats will be saved as a field on the Study so that it persists between runs. The control for setting this value will be moved from the Run page to the Study page within the NMF user interface, and the setting for a study will be added to the list of run information that is displayed in the NMF reports.
- 4.4 For each NTM iteration n (including iteration 1) the NMF will create revised semi-unconstrained revenue and journeys values by uplifting the base values for each Origin, Destination, Ticket Type combination by the appropriate percentage from the Zonal Uplifts file. A mapping of NTM Zone to NMF Zone exists in the NMF database.

5 Data Transfer: NMF to MOIRA-CP

- 5.1 As part of any NMF run a timetable is exported as an SPG file format to the Demand folder in the NMF directory ready for import into MOIRA. The name of this file will be taken from the NTMScenarioName parameter in the Input Parameters file.
- 5.2 The process will be amended to also output a CSV format file containing a record for every Stock Type in the SPG file and giving the corresponding number of seats (Proxy Seats or Actual Seats as defined by the NMF Study ID). The Stock Type file will have fields as below:

STOCK TYPE

Stock Type	Char(16)	As found in SPG file
Number of Seats	Integer	1 to 2000

- 5.3 Market Mix data will be output from the NMF as a CSV format file. The Market Mix file will have fields as below:

MARKET MIX

NMF Origin Zone	Char(3)	3 Letter Code
NMF Destination Zone	Char(3)	3 Letter Code
Ticket Type	Char(1)	Full, Reduced or Seasons (F, R or S)
Share (Business)	Real	0 to 100%
Share (Leisure)	Real	0 to 100%
Share (Commuting)	Real	0 to 100%

The shares for each Origin, Destination, Ticket Type combination will sum to 100%.

- 5.4 Annual revenue and journeys (for Monday-Sunday) will be output from the NMF as a CSV format file. For Origin, Destination, Ticket Type combinations with zero journeys no record will be output. The Flow Demand file will have fields as below:

DEMAND

NMF Origin Zone	Char(3)	3 Letter Code
NMF Destination Zone	Char(3)	3 Letter Code
Ticket Type	Char(1)	Full, Reduced or Seasons (F, R or S)
Annual Revenue	Integer	Pounds
Annual Journeys	Integer	Number of Journeys

- 5.5 The Stock Type, Market Mix and Flow Demand files will be output to the same location as the SPG file. They will have the same names as the SPG file but will be further identified with (Stock Type), (Market Mix) or (Flow Demand) respectively.
- 5.6 All 4 files will be output by the NMF in NTM iteration 1. In subsequent iterations only the Flow Demand file will be output.

6 Calculation of Crowding Penalties

- 6.1 The new MOIRA-CP application will calculate the crowding penalty by Origin, Destination, Journey Purpose and Peak Type (Peak, OffPeak and All Day). This application will: (a) read the SPG timetable and other output files from the NMF; (b) launch the MOIRA Batch Processor to process the timetable; (c) use the MOIRA output files to calculate crowding penalties; (d) create an Output File to interface to the NTM.

- 6.2 The MOIRA-CP application will be called from the NMF (ie not directly from the NTM) with parameters:

OR32 NMF XXXX SPGFileName InputParametersFileName

where *SPGFileName* is the SPG filename and *InputParametersFileName* is the Input Parameters filename (see 3.3) both including their path and extension (and enclosed in double quotes if the names contain a space).

- 6.3 The MOIRA-CP application will use the Flow Allocations, Times by Stop and Generalised Journey Times (binary format) files output by MOIRA:

Flow Allocations: C:\MOIRA\LDrunnum.TMP

Times by Stop: \$root\$\USER\OR32\STrunnum.BIN

Generalised Journey Times: \$root\$\USER\OR32\GTrunnum.BIN

where \$root\$ is the top level folder in which MOIRA is installed and *runnum* is the 6 digit reference number of the run. These files have fields as below:

FLOW ALLOCATIONS

NMF Origin Zone	Char(3)	3 Letter Code
NMF Destination Zone	Char(3)	3 Letter Code
Ticket Type	Char(1)	Full, Reduced or Seasons (F, R or S)
Train Number	Integer	
Stop Number where Passenger gets On	Integer	Sequence number on train
Stop Number where Passenger gets Off	Integer	Sequence number on train
Journeys Allocation Percent	Real	0 to 100%

For each Origin, Destination, Ticket Type combination the table shows the allocation of journeys to pairs of stops on trains. For example 3% of the journeys on Blackpool-Brighton (Full Fare) might travel on the 0810 Glasgow-London between Preston and Watford.

TIMES BY STOP

Train Number	Integer	
Stop Number	Integer	Sequence number on train
NMF Station	Char(3)	3 Letter Code
Arrival Time	Integer	Minutes past midnight
Departure Time	Integer	Minutes past midnight
Service Code	Integer	LENNON 4 digit code
Stock Type	Char(16)	As found in SPG file

GENERALISED JOURNEY TIMES

NMF Origin Zone	Char(3)	3 Letter Code
NMF Destination Zone	Char(3)	3 Letter Code
Ticket Type	Char(1)	Full, Reduced or Seasons (F, R or S)
GJT (Total)	Real	Minutes
GJT (Journey Time Component)	Real	Minutes
GJT (Frequency Component)	Real	Minutes
GJT (Interchange Component)	Real	Minutes

- 6.4 Because all 3 files are independent of the revenue and journeys, the MOIRA Batch Processor will only be launched on NTM iteration 1.
- 6.5 For each record in the Times by Stop table, the number of Passengers On and Passengers Off will be found by summing appropriate records from the Flow Allocations table combined with corresponding numbers of Journeys from the Flow Demand file (factored from annual Monday-Sunday to single day Monday-Friday). For each record in the Trains by Stop table the Number of Passengers on Departure (OTD) will then be calculated using the equation below:

$$OTD(This\ Stop) = OTD(Previous\ Stop) - Passengers\ Off + Passengers\ On$$

At the same time a new table will be created giving, for each pair of stops of each train, the numbers of passengers travelling on the train between the pair of stops. The Loads by Stop table will have fields as below:

LOADS BY STOP

Train Number	Integer	
Stop Number On	Integer	Sequence number on train
Stop Number Off	Integer	Sequence number on train
Passengers	Integer	Number of passengers

For example on the 0810 Glasgow-London, in total 62 people might get On the train at Preston and then get Off the train at Watford.

6.6 For each record in the Times by Stop table the Stock Type table will be used to lookup the Number of Seats on Departure (Seats). The Load Factor will then be calculated using the equation below:

$$\text{Load Factor} = \text{OTD}/\text{Seats}$$

6.7 For each Train in the Times by Stop table the Stop Locations will be checked to determine if the train is Non London, Inner London or Outer London - using information from the Station Areas table in combination with the rules below:

Non London: does not call at any station within Zone 1;

Inner London: calls at least at one station in Zone 1 and all calls are at stations within Zones 1-6;

Outer London: calls at least at one station in Zone 1 and at least one station not in any of Zones 1-6;

6.8 For each Stop of each Train the 4 digit of the Service Code will be checked against the Peak Type table to determine whether, from the Stop, the Train is Peak or OffPeak.

6.9 A new table will be created derived from the Times by Stop tables. The Details by Stop table will have fields as below:

DETAILS BY STOP

Train Number	Integer	
Train Type	Char(1)	Non London, Inner London or Outer London (N, I or O)
Stop Number	Integer	Sequence number on train
Peak Type	Char(1)	Peak or OffPeak (P or O)
Arrival Time	Integer	Minutes past Midnight
Departure Time	Integer	Minutes past Midnight
Ons	Integer	Number Passengers Getting On
Offs	Integer	Number Passengers Getting Off
OTD	Integer	Number Passengers on Departure
Seats	Integer	Number of Seats on Departure
Load Factor	Integer	Percent Load Factor on Departure

6.10 For each record in the Details by Stop table the percent of passenger boarding at the Stop who will be seated on departure from each subsequent Stop will be calculated. For each pair of stops A, B (where B is after A) the Loads by Stop table will be used to find the number of passengers still on the train on

departure from B who boarded the train at stop A. The percent of passengers who boarded at stop A who are seated on departure from stop B is then given by the equation:

$$\text{Percent Seated} = (\text{Seats} - \text{Boarded before A}) / \text{Boarded at A}$$

where Boarded at A and Boarded before A refer to numbers of passengers still on the train on departure from stop B. Values of below 0% or above 100% will be set to 0% or 100% as appropriate (including set to 100% if zero passengers boarded at A). The results of the calculation will be written to the Percent Seated table with fields as below:

PERCENT SEATED

Train Number	Integer	
Stop A Number	Integer	Sequence number on train
Stop B Number	Integer	Sequence number on train
Percent Seated	Real	0 to 100%

For example if 62 people get on the 0810 Glasgow-London at Preston and there are 31 available seats and then 100 more seats become available at the next stop Crewe then the percent seated (of those boarding at Preston) will be 50% at Preston and 100% at Crewe.

This table will have at most (n-1)! records for a Train with n Stops. But once 100% of passengers are seated no further records will be stored. Given that most trains do not experience crowding, for most trains the number of records will be simply (n-1) – not n because passengers do not get On at the final Stop. For very crowded trains some passengers will never get a seat and therefore the percent seated will never reach 100%. Note the implicit assumption that passengers who have been standing the longest get priority for available seats.

6.11 For each record in the Flow Allocations table the crowding cost will be calculated by considering each pair of Stops on the Train between the Stop where the passenger gets On and the Stop where the passenger gets Off.

6.12 For each pair of Stops, Stop1 and Stop2:

$$\text{Lapse Time} = \text{Departure Time}(\text{Stop2}) - \text{Departure Time}(\text{Stop1})$$

except that when Stop2 is the Stop where the passenger gets Off then the lapse time will be based on the arrival rather than the departure time at Stop2. The arrival and departure times will be derived from the Times by Stop table.

6.13 $\text{Sit Cost} = \text{Crowd Cost per Min}(\text{Sit}, \text{Load Factor}, \text{Journey Purpose}, \text{Train Type})$

$$\text{Stand Cost} = \text{Crowd Cost per Min}(\text{Stand}, \text{Load Factor}, \text{Journey Purpose}, \text{Train Type})$$

where the Crowd Cost per Min values are derived from the Crowding Costs table; the Load Factor and the Train Type are derived from the Details by Stop table; and the Journey Purpose is derived from the Market Mix table. Load Factors of above the maximum value in the input table will be assumed to be equal to this maximum value.

6.14 $\text{Cost} = \text{Sit Cost} * \text{Percent Seated} + \text{Stand Cost} * (100 - \text{Percent Seated})$

$$\text{Cost}(\text{Stop1 to Stop2}) = \text{Cost} * \text{Lapse Time} * \text{Journeys} * \text{Journeys Allocation Percent}$$

where the Percent Seated values are derived from the Percent Seated table; Journeys from the Flow Demand file and Journeys Allocation Percent from the Flow Allocations file.

- 6.15 For each Origin, Destination, Journey Purpose combination the costs will be summed for Peak, OffPeak and All Day (where All Day is Peak plus OffPeak combined) to create the Flow Costs table with fields as below:

FLOW COSTS

NMF Origin Zone	Char(3)	3 Letter Code
NMF Destination Zone	Char(3)	3 Letter Code
Journey Purpose	Char(1)	Business, Leisure or Commuting (B, L or C)
Crowding Cost (Peak)	Real	Pence
Crowding Cost (OffPeak)	Real	Pence
Crowding Cost (All Day)	Real	Pence

- 6.16 The Flow Costs table will be combined with the Flow Demand, Generalised Journey Times and Values of Time tables to create a CSV format Output File with fields as below. In this process crowding costs (pence) will be converted to crowding penalties (minutes) using Values of Time; and to 'per passenger' by dividing by Journeys from the Flow Demand file. The crowding penalties will be uplifted by the Cost Uplift parameter (typically 10% because we are dealing with average train loads - see 'Crowding Penalties for Average Train Loads' section beneath the table in the PDFH). The name and location of the file will be as specified by the NTM Scenario Name and NTM Output location parameters.

OUTPUT FILE

NMF Origin Zone	Char(3)	3 Letter Code
NMF Destination Zone	Char(3)	3 Letter Code
Journey Purpose	Char(1)	Business, Leisure or Commuting (B, L or C)
Revenue	Integer	Pounds
Journeys	Integer	Number of Journeys
GJT (Total)	Real	Minutes
GJT (Journey Time Component)	Real	Minutes
GJT (Frequency Component)	Real	Minutes
GJT (Interchange Component)	Real	Minutes
Crowding Penalty (Peak)	Real	Minutes per Passenger
Crowding Penalty (OffPeak)	Real	Minutes per Passenger
Crowding Penalty (All Day)	Real	Minutes per Passenger

- 6.17 On abnormal termination MOIRA-CP will create *SPGFileName.log* (containing details of the error) in the same folder as the original SPG file, to be picked up by the NMF (see 3.6). Otherwise no file will be produced.

CONTROL SHEET

Project/Proposal Name: NTM RAIL CROWDING MODEL

Document Title: Version 11 Software Functional Requirements Specification

ISSUE HISTORY

Issue No.	Date	Details	
2	01 Oct 07	MOIRA application	
5	08 Oct 07	NMF alterations included	
8	12 Oct 07	DfT comments considered	
9	15 Oct 07	Complete for sign-off	
10	18 Dec 07	Updates during development	Note that

intermediate issue / version numbers are for internal review within DeltaRail.

REVIEW

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DISTRIBUTION

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REFERENCES

Reference Number	Document
1	NMF Version 1 Functional Requirements Specification, Issue 4