Using OS MasterMap® Integrated Transport Network (ITN)™ Layer with ArcGIS

An ESRI (UK) White Paper
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Appendix I – Feature Dataset Schema
1 Introduction

The OS MasterMap® Integrated Transport Network Layer™ (ITN) is an integral part of the OS MasterMap® product set, along with Topography, Address, and Imagery layers. Ordnance Survey’s vision of ITN is to provide a detailed overview of Great Britain’s transport infrastructure as a single common multi-modal dataset to meet a variety of business needs, from navigation to asset management, from traffic analysis to accessibility studies.

Unique identifiers (TOID®) associated with each link and node provide a reference for traffic-flow analysis at crucial junctions, and allow organisations to attach their own data. Examples might be points of interest, traffic incidents or average speeds.

Like other OS MasterMap layers, ITN contains ‘themes’. The themes of ITN currently available are:

- Road Network – a network representing the roads in Great Britain; and
- Road Routing Information (RRI) – data to be associated with Road Network features that can affect a driver’s choice of route, including height and vehicle type restrictions, traffic calming, turn restrictions and one-way roads.

ArcGIS® and related products from ESRI (UK) comprise an industry-leading Geographic Information System (GIS) that provides all the tools necessary for making the most of OS MasterMap data, including ITN Layer.

OS MasterMap ITN, however, is structured in a very particular schema, designed with data delivery efficiency in mind. Working with this data schema is eminently possible but can seem complex to casual GIS users. This document provides guidance on how best to use ArcGIS with the ITN Layer to maximum effect.

It is anticipated that most users will initially want to use ITN for general cartographic representation, asset management and routing applications. This document, therefore, focuses on these implementations.
2 Overview

This section covers basic information about OS MasterMap Integrated Transport Network (ITN) data, as well as a brief overview of the ESRI® and ESRI (UK) software products that can be used with it.

2.1 OS MasterMap ITN Layer

The ITN Layer replaces its predecessor, OSCAR™. Like the other vector OS MasterMap products, ITN is delivered in digital files directly from Ordnance Survey in Geographic Markup Language (GML) format, a type of XML. Software is required to interpret and load the ITN GML into a geographic database (See Section 2.2).

Like the other OS MasterMap products but unlike OSCAR, ITN is delivered ‘to order’ for individual customers through Ordnance Survey’s on-line ordering service, and according to OS MasterMap data publication dates (available from Ordnance Survey). This means that Ordnance Survey ‘cut’ the data from the most recent publication date for a particular customer only when they receive an order; they also do the same when updates are requested. This contrasts with the ‘published tile’ push-delivery model for OSCAR.

The customer’s ITN order can be combined within the same GML delivery as the Topography and Address Layers for the same order, or can be split into separate GML files. Either way, the physical delivery of the GML files is made on CD/DVD through the post, or via FTP download (if the total file volume is below the maximum limit, currently 400Mb).

Once an initial delivery (called “Initial Load”) is taken by a customer, the database can subsequently be kept current through the Ordnance Survey Change-only Update (CoU) system on a time interval that suits the customer. CoU provides only those features that have changed in the data holding since the customer’s last delivery.

Alternatively, customers can choose to reload ITN each time. This is a more realistic proposition than it would be for the OS MasterMap Topography Layer, because ITN is much less voluminous.

[Note: At the time of writing of this paper, ESRI/ESRI (UK) software does not support full automatic integration of CoU for ITN Layer; only full re-loads are supported by the software. A future release of Productivity Suite for ArcGIS will support this feature.]


The ITN Layer shares much in common with the Topography Layer. ESRI (UK) have published a white paper, *Loading and Managing OS MasterMap Topography Layer*, that describes in more detail the nature of OS MasterMap itself, its relationship to ESRI software, and guidelines and principles for loading and management. Much of this information applies equally to ITN. This white paper can be found on the ESRI (UK) website:

2.2 Analysing ITN Data

Within ArcGIS, routing processes are performed with the Network Analyst extension. Network Analyst enhances ArcGIS capabilities by adding:

- Routing
- Closest facility
- Service area analysis
- Advanced network management and creation

Network Analyst can be used for a number of analyses, from classic point-to-point routing to advanced time-based delivery models across millions of features. Using the advanced features in the new Network model, users can do even more with their data.

The product delivers advanced features of the Network Model including:

- Closest Facility
- Complex multi-part turns
- Dynamic impedance
- Global weights
- Scaleable to multi-users
- Exact and hierarchical routing
- Network barrier support

Network-based spatial analysis is available for ArcGIS Desktop (ArcView, ArcEditor or ArcInfo), ArcGIS Engine and ArcGIS Server. For desktop users, ArcGIS Network Analyst provides a rich environment with easy to use menus and tools, as well as the robust functionality available in the geoprocessing environment for modelling and scripting. ArcGIS Engine and ArcGIS Server users can employ the APIs of the optional Network Extension to provide customized network solutions in a deployed custom application or as a server-based application. These, essentially, allow the full range of features of ArcGIS to be used in a variety of distributed ways.

ArcView 3.x Network Analyst users will find all their familiar tools available in ArcGIS Network Analyst. In addition, ArcGIS Network Analyst has improved the core functionalities and added new features. ArcGIS Network Analyst requires ArcView, ArcEditor, or ArcInfo.

2.3 Preparing ITN Data for Use in ArcGIS

All ESRI and ESRI (UK) software products can work with ITN data once it is imported into a geodatabase. “Working with data”, however, has two aspects: the data loading and management; and then the use in analysis. The analysis use of ITN data is in areas such as cartography, routing, and asset management. Because of the complex nature of the ITN schema, it is in these areas that it is perceived that customers require some guidance. This paper therefore focuses on products and methods useful for these application areas.

ArcGIS, as a full-featured GIS, is the centrepiece of the suite of applications and therefore this document will make use of terms and concepts that reference it in various ways.

ESRI (UK)’s Productivity Suite for ArcGIS Extension can be used to process the OS MasterMap ITN Layer GML data, provided by Ordnance Survey in a compressed “gz” file format. Productivity Suite for ArcGIS is a new extension for ArcGIS Desktop that replaces MapManager and a number of other
ESRI (UK) software products. Productivity Suite V1.1 and higher also provide the OS MasterMap ITN Data Preparation tool, which processes the OS MasterMap ITN Layer beyond the initial data load.

ESRI’s Data Interoperability Extension (“Interop”) also reads OS MasterMap, including the OS MasterMap ITN Layer. Interop, however, is especially suited for ‘direct-read’ (reading directly without first loading into a database) of the gz files, and for use within Geoprocessing Models created in ArcGIS. This is very useful for previewing the data within ArcCatalog or ArcMap before loading; however, it is less suited for complete ‘management’ of an OS MasterMap database, partly because it has no capacity for incorporating Change-only Update, and partly because it doesn’t do any interpretation of the schema without user intervention. Because Productivity Suite for ArcGIS is built specifically for wizard-based implementation of OS MasterMap layers and automatic integration of CoU, this product is recommended to most users and is the focus of this document.

The result of the initial import process with Productivity Suite is a relational model of the OS MasterMap ITN data which, as has been mentioned, is supplied originally in GML format. This schema is very rich, but also potentially complex for users. The Productivity Suite OS MasterMap ITN Data Preparation tool helps users to become immediately productive with OS MasterMap ITN data.

There are a number of benefits in using the OS MasterMap ITN Data Preparation tool to prepare the data for general display and query in ArcMap, including:

- Extracting features into separate Feature Class with attribution, e.g., gates, rising bollards, bridges over roads, motorway junctions, mini roundabouts, ferries etc.
- Assigning a range of attributes to the road Feature Class, including road labels (used to label the roads on the map), road type (e.g., A Road, B Road, etc) and various restriction information fields.

Furthermore, in order to perform analysis on the data using the ArcGIS Network Analyst extension, a Network Dataset must be created on this data. The OS MasterMap ITN Data Preparation tool can perform the following tasks in preparation for use with Network Analyst:

- Create and build a Network Dataset for use with routing operations and other network analysis.
- Create restriction attributes in the Network Dataset, which model one way, no entry, no turn, mandatory turn and vehicle access restrictions.
- Assign hierarchy levels in the Network Dataset for routing that favours primary roads over local roads.
- Assigns nominal road speeds for calculating travel times.

OS MasterMap ITN data is delivered from Ordnance Survey with or without Road Route Information (RRI). This document assumes that RRI has been included.

### 2.4 References


### 3  Data Loading and Management

This section provides a quick guide to loading OS MasterMap ITN data. ESRI (UK) Productivity Suite for ArcGIS V1.1 or above provides the tools necessary to load the data into a geodatabase and prepare it for use with Network Analyst and general symbolisation in ArcMap. Previous versions of Productivity Suite and ESRI (UK)’s former product MapManager 9.1.2 or above can also be used for the initial step of converting to a geodatabase but do not include a tool for processing the ITN data beyond the initial data load.

The data is loaded into a Geodatabase from GML data containing ITN Layer, provided by Ordnance Survey in gz file format. These files can be read directly from the Ordnance Survey CD/DVD, or can be first copied onto local storage media.

Depending on the choices made by the user at the time of placing the OS MasterMap order with Ordnance Survey, the GML files delivered may contain only ITN or may also contain OS MasterMap Topography Layer and OS MasterMap Address Layer. OS MasterMap Converter and MapManager handle both of these situations.

GML files are normally delivered in ‘chunks’, which usually represent 5km-square areas of coverage; however, some users will choose to take ‘non-geographic chunks’, which are divided according to equal file size.

Please refer to the Ordnance Survey web site or ESRI (UK)’s *Loading and Managing OS MasterMap Topography Layer* white paper for more detailed discussion of OS MasterMap, GML files, chunks, and delivery and processing options.

#### 3.1  Convert OS MasterMap ITN Data to a Geodatabase

The following sequence shows steps which can be taken to load OS MasterMap ITN data into a Geodatabase. OS MasterMap Converter is accessible from the Productivity Suite Data Conversion toolbar in ArcCatalog or from the Windows Program menu. Figure 3-1 shows the OS MasterMap Converter start up screen. Click Next to continue.
The user is then presented with the option to create a new profile or use an existing profile containing parameters from a previous data load (Figure 3-2).

The following step allows the user to select the OS MasterMap ITN data files to be loaded. One or multiple files can be selected at this stage (Figure 3-3). Some customers will be delivered the data in 5km x 5km chunks, grouped in directories according to 100km Ordnance Survey grid tiles. These directories can be processed serially or together by creating stacked profiles, or by first copying all of the files to one directory on local storage media.

This step also gives the option to apply a Change-Only Update. For OS MasterMap, ITN data do not tick this option.
Figure 3-3 - OS MasterMap Converter Source Data Step

The following stage is important as it controls the configuration of the geodatabase into which the data is loaded (Figure 3-4). There are options here to load the data into an existing personal geodatabase or ArcSDE database; or alternatively a new personal geodatabase can be created. To create a new ArcSDE database, refer to the ArcSDE user guide. Please note that Productivity Suite for ArcGIS V1.1 does not support file-based geodatabases.

At this stage a prefix can be added to the default table names. For example, if the prefix was specified to be ITN_ then the RdLk table (which stores road links) would be called ITN_RdLk. The purpose of the prefix is to help the users identify quickly within ArcCatalog (for example) which Tables and Feature Classes belong to ITN (as opposed to Topography Layer, for example).

Figure 3-4 - OS MasterMap Converter Storage Step

The next screen allows the user to select the directory locations for the working folders and log files (refer to Figure 3-5).
There are four loading options available for ITN data loading. It is advised that the default options are used. These will check for old and duplicate versions of the features and process them as necessary.

![Figure 3-5 - OS MasterMap Converter Options Step](image1)

Figure 3-5 shows the selection options for OS MasterMap features. This section allows the user to specify which layer of OS MasterMap is loaded. If the GML files only contain ITN data, better performance will be gained by making sure that all of the non-ITN items are **unticked**. Ensure that the ITN checkbox is ticked before moving on.

![Figure 3-6 - OS MasterMap Converter Features To Process Step](image2)

The profile options allow the profile to be saved at this stage, and also controls which profiles can be processed. It is possible to save a number of profiles and then process them all in one go. For this quick-start guide, use the default selection on the form shown in Figure 3-7.
Figure 3-7 - OS MasterMap Converter Profile Options Step

Clicking Next from the Profile Options step (Figure 3-7) will start the loading process running (Figure 3-8). All ITN files added earlier in the process will then be loaded, with progress information being updated on the screen.

Figure 3-8 - OS MasterMap Converter Processing Step

Upon completion of the loading process the user will be presented with the screen shown in Figure 3-9. This gives the user the opportunity to inspect the log file.
3.1.1 Loading Additional Files

The documented sequence of events in the previous section covers the initial loading of ITN data. However, if the user wants to add data to that which has been previously loaded then some amendments to the flow are required. The steps covered from Figure 3-1 to Figure 3-3 are the same.

When setting the database options (as shown in Figure 3-4) ensure that the same database is used. At this step choose Create New for the prefix option, but use the same prefix as before. For example, if a prefix called ITN_ was used then re-enter this information.

The rest of the steps will remain the same.

3.2 Prepare ITN Data for Network Analyst and General Display within ArcMap

The following section outlines the preparation of ITN data for use with Network Analyst and general display within ArcMap using the OS MasterMap ITN Data Preparation tool. This tool is available with Productivity Suite for ArcGIS V1.1 or higher.

Before using this tool, ensure that the ITN data has been imported into a Geodatabase using OS MasterMap Converter and the Geodatabase contains all original tables and attributes, rather than a reduced version. If a Network Dataset is required, also ensure the ArcGIS Network Analyst Extension is installed and enabled.

The OS MasterMap ITN Data Preparation tool is accessible from the Productivity Suite Data Conversion toolbar in ArcCatalog or from the Windows Program menu. Figure 3-10 shows the ITN Data Preparation wizard start up screen. Click Next to continue through the wizard.
On the next step, the user is presented with the option to create a new profile or use an existing profile containing parameters from a previous data preparation process (Figure 3-11).

The following step allows the user to select the Geodatabase and prefix of the Feature Classes containing raw schema ITN data converted using OS MasterMap Converter (Figure 3-11). The Check Data Consistency option is selected by default. This option checks whether all the relevant ITN tables exist.
The following stage controls the configuration of the geodatabase into which the data is loaded (Figure 3-13). Similar to the OS MasterMap Converter, there are options to load the data into an existing personal geodatabase or ArcSDE database; alternatively, a new personal geodatabase can be created.

At this stage a prefix can be added to the default table names. For example, if the prefix specified was ITN then the RoadLink table (which stores roads) would be called ITN_RoadLink.

The next screen allows the user to select the option to create a Network Dataset, which can be used by Network Analyst (Figure 3-14). If you intend to perform routing or other network analysis, ensure this item is selected. It is also recommended to leave the Build Network option selected unless manual
modifications to the Network Dataset are intended prior to any network analysis. Otherwise, the Network Dataset will need to be built manually in ArcCatalog before performing network analysis.

There is an option at this stage to create default hierarchy levels in the Network Dataset. The hierarchy will favour primary roads over local streets when routing analysis is performed. This assumes that primary roads, such as A roads, are faster and may result in less complicated navigation instructions. This option may not be relevant for some purposes, such as routing for slow vehicles. However, even if a hierarchy attribute has been created, this option can be disabled in analysis when it is not appropriate. For further information on hierarchy, please refer to Section 6.2.

This step also allows the user to select the directory locations for the log file.

![Processing Options](image)

**Figure 3-14 – OS MasterMap ITN Data Preparation Tool Processing Options step**

The OS MasterMap ITN Data Preparation tool will insert a road label field into the road links Feature Class, which can be used to label the roads on the map. A road can sometimes have more than one name. This typically occurs when there is a local name and a road number assigned to a road. The following step allows the user to choose the preferred road label to use (Figure 3-15). The road label field will be set as the default label and also as the default street name source for driving directions when routing.

This stage also provides the option to insert an additional field containing road names and a field containing road numbers. These fields may be useful if the individual information is not going to be provided in the road label field.
Figure 3-15 - OS MasterMap ITN Data Preparation Tool Road Naming Options step

Figure 3-16 shows the network features that can optionally be created. If the data will be used for vehicle routing, ensure that ‘Turn features’ is selected.

Figure 3-16 - OS MasterMap ITN Data Preparation Tool Network Features step

The next step (Figure 3-17) shows the road restrictions that can optionally be created. All of these restrictions are recommended if the data will be used for vehicle routing. For further information on restrictions, please refer to Section 6.1.
The following stage assigns nominal road speeds (Figure 3-18). The user can choose a simple option for setting road speeds or a more detailed option by specifying the sub-categories of each road type, e.g., A road – slip road, A road, dual carriageway etc.

For information about road speed statistics in Great Britain and Northern Ireland please refer to the following websites:


- Department of Health, Social Services and Public Safety: Average Travel Speeds in Northern Ireland - [www.dhsspsni.gov.uk/paperspeeds.pdf](http://www.dhsspsni.gov.uk/paperspeeds.pdf)

When setting nominal speeds, ensure appropriate speeds are set for any vehicle types for which analysis will later be undertaken. If the Network Dataset will be used for routing vehicle types of different speeds, additional speed sets should be created for other vehicle types. For example, one speed set can be created for heavy goods vehicles while another is created for other vehicles.

For further information on how speeds are used in network analysis, please refer to Section 6.3.
Figure 3-18 - OS MasterMap ITN Data Preparation Tool Road Speeds step

The following step allows the profile to be saved (Figure 3-19).

Figure 3-19 – OS MasterMap ITN Data Preparation Tool Save Profile step

Clicking Finish from the Profile Options step (Figure 3-19) will start the loading process running (Figure 3-20).
Upon completion of the process, the user will be presented with the screen shown in Figure 3-21. This gives the user the opportunity to inspect the log file.
4 Displaying and Querying ITN Data

4.1 Network Features

While working through the ITN Data Preparation wizard, the user has the option to generate various network features, as outlined in Section 3.2. The features generated by the tool and a summary of main attributes are listed in Table 4-1 below. This list does not include the Network Dataset and Turn Feature Classes, which are discussed in Section 6.
### Feature Classes

<table>
<thead>
<tr>
<th>Feature Classes</th>
<th>Summary of Main Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Links</td>
<td>• Road name / number&lt;br&gt;• Road descriptive term (e.g., A road) and nature (e.g., Dual&lt;br&gt;carriage way)&lt;br&gt;• Flags to indicate:&lt;br&gt;  o Primary route&lt;br&gt;  o Trunk road&lt;br&gt;  o Passes under a bridge&lt;br&gt;  o Traffic calming&lt;br&gt;  o Rising bollards&lt;br&gt;  o Gate&lt;br&gt;  o Restrictions, including one way, no entry, vehicle restrictions, turn restrictions&lt;br&gt;  o Partial restrictions&lt;br&gt;  o Date time restrictions&lt;br&gt;  o Restriction exception information for various vehicle types and uses</td>
</tr>
<tr>
<td>Bridges</td>
<td>• Maximum height</td>
</tr>
<tr>
<td>Rising Bollards</td>
<td>• Distance from start of the road link to the bollard location</td>
</tr>
<tr>
<td>Gates</td>
<td></td>
</tr>
<tr>
<td>Motorway Junctions</td>
<td>• Name of the junction</td>
</tr>
<tr>
<td>Ferry Terminals and Links</td>
<td></td>
</tr>
<tr>
<td>Traffic Calming</td>
<td></td>
</tr>
<tr>
<td>Mini Roundabouts</td>
<td></td>
</tr>
<tr>
<td>Partial Restrictions</td>
<td>• Nature of restriction</td>
</tr>
</tbody>
</table>

Table 4-1 – Summary of Feature Classes and main attributes generated by the Productivity Suite OS MasterMap ITN Data Preparation tool

### 4.2 Symbology

To help with displaying ITN data, a number of OS MasterMap sample layer files are provided on the installation media for Productivity Suite for ArcGIS V1.1 or above. This includes a sample Road Links layer file based on ‘OS MasterMap User Guide Part 2 - Technical Specifications’.

The installation media also contains an ArcMap style file, which includes symbols that can be used to represent ITN road routing and other traffic-related information. Once the style file has been added to
ArcMap, these symbols can be selected from the standard ArcMap Symbol Selector dialog (see Figure 4-1). Instructions for using the style file are also included on the installation media.

Figure 4-1 – Example of some of the symbols included in the ITN style file provided with the Productivity Suite for ArcGIS installation media
5 Network Analysis Overview

One of the many uses for OS MasterMap ITN data is routing. The ArcGIS Network Analyst extension can be used to provide intelligent routing. The extension also has other network solvers to spatially analyse a network, including service area, closest facility and OD cost matrices.

This section provides a simple example on how to perform point-to-point routing on a network built from ITN data. For further information on the capabilities of Network Analyst refer to the Network Analyst tutorial which is supplied with the extension. Additionally, information can be found in the ArcGIS help.

The Network Analyst extension has its own toolbar and a window to output network analysis information. From the toolbar the user has the option to create a new route. Upon doing so, the user can then set (digitise or load) the start and end points for a route (and any intermediate points). There are also analysis settings that can be configured so that any available parameters such as restrictions can be switched on. After this information has been set the network can be solved to show the route between the locations (see Figure 5-1 example below).

The following steps show how to perform a simple best route analysis.

1. Start ArcMap.
2. Enable the Network Analyst extension from the Tools > Extensions menu.
3. Add the ITN Network dataset to the map.
4. If not already present, add the Network Analyst toolbar from the View > Toolbars menu.
5. On the Network Analyst toolbar, click the Network Analyst dropdown menu and click New Route. A new route layer will be added to the table of contents.
6. Open the Network Analyst Window by clicking the Network Analyst Window button.
7. Add the start and end locations for a route (and any intermediate locations). Stops can be manually added to the map. To do this, select Stops in the Network Analyst Window and then click the Create Network Location tool on the Network Analyst toolbar. Click on the map where the stop locations are required. Alternatively, stops can be added by loading locations from a point Feature Class. To accomplish this, right-click Stops in the Network Analyst Window and click Load Locations. Click the browse button and choose a point feature class. Click Add and then click OK.
8. Route parameters, including restrictions, impedances, and hierarchy, can be set in the Analysis Settings tab of the route layer properties. This dialog is accessed by double-clicking the route analysis layer in the table of contents. Please refer to the following Section 6 for more information about network analysis parameters.
9. Calculate the route by clicking the Solve button on the Network Analyst toolbar.
Figure 5-1 – A simple example of a route calculated with Network Analyst using an ITN Network Dataset
Network Attributes

Network attributes are properties of network elements that control the transversability over the network. When finding a route in Network Analyst, network attributes, such as restrictions, hierarchy and impedances, help to provide a model that more closely resembles the real-world situation. Please be aware, however, that while ITN routing information attempts to reflect the real-world manifestation as much as possible, road routing information is modelled in the simplest possible way with priorities given to certain restriction types. For example, a turn restriction may not be modelled because a one way restriction takes precedence and has the same ultimate effect.

Network element attributes can be queried in ArcMap using Network Identify tool on the Network Analyst toolbar (Figure 6-1).

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Along</th>
<th>Against</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>ITN_FixedLinks</td>
<td>Restricted</td>
</tr>
<tr>
<td>OneWay</td>
<td>Traversable</td>
<td>Restricted</td>
</tr>
<tr>
<td>TurnRestrictions</td>
<td>Traversable</td>
<td>Traversable</td>
</tr>
<tr>
<td>MandatoryTurnRestrictions</td>
<td>Traversable</td>
<td>Traversable</td>
</tr>
<tr>
<td>InferredTurnRestrictions</td>
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<td>Traversable</td>
</tr>
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<td>26.1279173162247</td>
</tr>
<tr>
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</tr>
<tr>
<td>DefaultSpeeds</td>
<td>0.0476381496176</td>
<td>0.0476381496176</td>
</tr>
</tbody>
</table>

Figure 6-1 - Querying network element attributes using the Network Identify tool

The following sections describe the network analysis parameters that may be included when creating the Network Dataset with the OS MasterMap ITN Data Preparation tool. Please note that the attributes included in the output Network Dataset will depend on the options that were chosen while working through the wizard.

6.1 Restrictions

There are four types of restriction attributes created by the OS MasterMap ITN Data Preparation tool:

- Inferred turn restrictions, which include no entry and vehicle access restrictions
- Turn restrictions, i.e., prohibited turns
- Mandatory turn restrictions
- One way restrictions

Each restriction created by the OS MasterMap ITN Data Preparation tool is described in more detail in the following sections. These attributes are used to model restriction information that affects a driver’s choice of route. The restrictions can be applied when performing various network analyses.

Figure 6-2 illustrates two different routes solved between the same start and end point. The first route (a) has been generated without setting the Network Analyst solver to use the ITN Network restrictions. The second route (b) has been generated with all of the ITN Network restrictions set and produces a different result that avoids a ‘No Entry’ restriction. Whilst the first route would be suitable for a walker, a vehicle would need to take the second route.
The following steps describe how to apply restrictions when performing best route, service area, closest facility and OD cost matrices:

1. Ensure the analysis layer is present. If necessary, start a new analysis (e.g., best route). Please refer to Section 5 for more information on performing network analysis.

2. Double click the analysis layer in the table of contents to view the layer properties.

3. On the Analysis Setting tab, check the restriction check boxes to use in the analysis.

4. Click OK to save the settings.

On the Network Analyst toolbar, click the Solve button to generate results that use the restrictions.
Figure 6-2 – Best route: (a) with no restrictions applied; and (b) with restrictions applied.
6.1.1 Inferred Turn Restrictions

The OS MasterMap ITN Data Preparation tool models vehicle access restrictions and no entry restrictions by creating inferred prohibited turns from the original data. For example, where a driver approaches a junction with a no entry or access restriction to the street on the left, this is modelled in the Network Dataset as a prohibited left turn. The model is created in this way because no entry and access restrictions are not supported in Network Analyst.

The inferred turn features are stored in a Turn Feature Class named InferredTurnRestrictions. This Feature Class attribute table includes a TurnSource field, which indicates the specific type of restriction. The Network Dataset includes InferredTurnRestrictions as a restriction attribute.

Vehicle Access Restrictions

Vehicle restriction information indicates vehicles that can access a road link (see Figure 6-3 example) and vehicles that cannot (see Figure 6-4 example). Additional information about the vehicle restriction can be identified from the RoadLinks Feature Class attribute table. The AccessLimited field indicates vehicles that can access a road link and the AccessProhibited field indicates vehicles that cannot. These two fields are assigned a value of ‘Y’ if there is an environment, vehicle and/or date and time qualifier that limits/prohibits access to all or some vehicles for all or part of the day or year. Additionally, there are a number of exception fields, e.g., ExceptBuses, that indicate exceptions to the access restriction. Please refer to Section 6 for more information about modelling restrictions with exceptions.

Figure 6-3 – Example of a vehicle restriction where access is limited to buses and bicycles

Figure 6-4 - Example of a vehicle restriction where access is prohibited to heavy goods vehicles
No Entry Restrictions

No entry restrictions can also be identified from the Road Links Feature Class NoEntry field. The attribute values are described in the following table.

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>No entry at the start of the line as digitised</td>
</tr>
<tr>
<td>-</td>
<td>No entry at the end of the line as digitised</td>
</tr>
<tr>
<td>N</td>
<td>There is no ’no entry’ restriction</td>
</tr>
</tbody>
</table>

6.1.2 Turn Restrictions

Prohibited turns are modelled as features in a Turn Feature Class named TurnRestrictions. The Network Dataset includes this as a restriction attribute, so the relevant roads links will not entered from the direction specified.

6.1.3 Mandatory Turn Restrictions

The OS MasterMap ITN Data Preparation tool models mandatory turn restrictions by creating inferred prohibited turns from the mandatory turns in the original data. For example, where a driver approaches a T junction with a mandatory left turn, this is modelled in the Network Dataset as a prohibited right turn. The model is created in this way because mandatory turns are not supported within Network Analyst.

The inferred turn restrictions, which model mandatory turns, are stored in the MandatoryTurnRestrictions Turn Feature Class. The Network Dataset includes MandatoryTurnRestrictions as a restriction attribute.

6.1.4 One Way Restrictions

One way road links are modelled in the Network Dataset with a ‘OneWay’ restriction attribute, so they can only be traversed from one end to another and not in the reverse direction.

One way roads and directions can also be identified from OneWay field in the Road Links Feature Class. The attribute values are described in the following table.

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Permitted flow is against the direction of digitisation of the line</td>
</tr>
<tr>
<td>+</td>
<td>Permitted flow is in the direction of the digitisation of the line</td>
</tr>
<tr>
<td>N</td>
<td>There is no one way restriction; flow can occur in either direction</td>
</tr>
</tbody>
</table>
### 6.2 Hierarchy

The OS MasterMap ITN Data Preparation tool optionally creates a hierarchy attribute in the Network Dataset. Hierarchy models a user preference for taking primary roads, such as motorways and A roads, over local roads. For example, if routing from an address in one city to an address in another city, the solver will begin by finding a route that ascends to a higher hierarchy until it finds a primary road. The route will continue to use the primary roads until it gets closer to the end point. The solver will then descend the hierarchy, using local roads to the destination.

Hierarchy can be used when performing best route, closest facility and OD cost matrix analyses. Provided the hierarchy attribute option was chosen in the ITN Data Preparation wizard when the network was created, hierarchy will be used by default when network analysis is performed. Alternatively, hierarchy can be disabled to create an exact route.

The Network Dataset supports three levels of hierarchy: primary roads; secondary roads; and local roads. As the default hierarchy levels set by the OS MasterMap ITN Data Preparation tool provide more than three levels of hierarchy, these levels can be grouped as required. For more information about choosing the appropriate hierarchy range values, see the ESRI white paper *Hierarchical Routes in ArcGIS Network Analyst* at [http://support.esri.com](http://support.esri.com).

The following steps describe how hierarchy can be applied to best route, closest facility and OD cost matrix analyses:

1. Ensure the analysis layer is present. If necessary start a new analysis (e.g., best route). Please refer to Section 5 for more information on performing network analysis.

2. Double click the analysis layer in the table of contents to view the layer properties.

3. On the Analysis Setting tab, check the Use Hierarchy check box.

4. View the hierarchy ranges by clicking the Ranges button.

The following hierarchy levels are set by the OS MasterMap ITN Data Preparation tool:
<table>
<thead>
<tr>
<th>Hierarchy Level</th>
<th>Road Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motorway</td>
</tr>
<tr>
<td>2</td>
<td>A Road</td>
</tr>
<tr>
<td>3</td>
<td>B Road</td>
</tr>
<tr>
<td></td>
<td>Minor Road</td>
</tr>
<tr>
<td></td>
<td>Local Street</td>
</tr>
<tr>
<td>4</td>
<td>Alley</td>
</tr>
<tr>
<td></td>
<td>Pedestrianised Street</td>
</tr>
<tr>
<td></td>
<td>Private Road - Publicly Accessible</td>
</tr>
<tr>
<td></td>
<td>Private Road - Restricted Access</td>
</tr>
<tr>
<td>5</td>
<td>All others</td>
</tr>
</tbody>
</table>

If the default hierarchy ranges are used, hierarchy levels 2 and 3 are grouped together, i.e., A Roads will be grouped with B roads, minor roads and local streets. To choose a different range level, select the Use Custom Ranges option. Use the up/down arrows to change the level of the primary or local roads. For example, to group A roads in the primary roads with motorways, increase the Up To value to 2.

5. Click OK to return to the Layer Properties dialog box.

6. Click OK to save the settings.

7. On the Network Analyst toolbar, click the Solve button to generate results that use the restrictions.

### 6.3 Impedances and Travel Times

At the time of writing, Ordnance Survey does not provide speed restriction information with ITN data. Therefore, to model travel time impedances, the OS MasterMap ITN Data Preparation tool assigns nominal road speeds. A speed attribute is created in the Network Dataset for every speed set that has been defined by the user in the ITN Data Preparation wizard. A length attribute is also created in the Network dataset. Road speed is used in conjunction with length to calculate travel time when finding routes.

**Warning:** Please be aware that assigning nominal average speeds to road classifications can only provide a rough estimation of real-world road speeds. It is limited by the lack of speed limit information on roads and inability to differentiate between urban and rural areas. This may in turn lead to inappropriate routes being recommended when using speed impedances in network analysis.

The speed and length cost attributes can be applied when performing various network analyses, including best route, service area, closest facility and OD cost matrices. The network analysis will minimise the cost (impedance) during the calculation of the best route. The analysis layer can be set to find the shortest route by minimising the distance or the fastest route by minimising the travel time (see Figure 6-5).

The following steps describe how impedance and travel times can be applied to network analysis:

1. Ensure the analysis layer is present. If necessary start a new analysis (e.g., best route). Please refer to Section 5 for more information on performing network analysis.
2. Double click the analysis layer in the table of contents to view the layer properties.

3. On the Analysis Setting tab, choose whether to minimise the travel time (speed set) or the distance (length) by selecting the relevant option from the Impedance drop-down list.

4. If performing route or closest facility analyses, directions can be displayed in ArcMap after the generation of a route. On the Directions tab, choose whether to display the time in the Directions Window and which speed set to use for the calculations.

5. Click OK to save the settings.

6. On the Network Analyst toolbar, click the Solve button to generate results that use the restrictions.
Minimises travel time by taking faster A road rather than slower minor roads.

Figure 6-5 – Best route: (a) with distance impedance; and (b) travel time impedance applied.
7  Restriction Exceptions

The ITN network model generated by the OS MasterMap ITN Data Preparation tool creates constant restrictions to all vehicles at all times. However, in some cases routing information specifically does not apply to certain vehicles or at certain times of the day or year. For example, an access restriction may not apply between 6pm to 8am, or no entry restrictions may apply to all vehicles except buses.

Date and time restriction exceptions can be identified by a flag in the Road Links Feature Class table. However, the complexity of the date time qualifiers means that it cannot be modelled simply.

Vehicle restriction exceptions, on the other hand, can be more easily adapted in the network model for any vehicle types of interest. This can be achieved by modifying the restriction attributes in the Network Dataset. It can apply to any vehicle types and vehicle uses with exceptions, including:

- Abnormal Loads
- Access
- All Vehicles
- Authorised Vehicles
- Buses
- Coaches
- Cycles
- Dangerous Goods
- Disabled
- Emergency Access
- Emergency Vehicles
- HGVs
- LGVs
- Loading And Unloading
- Local Buses
- Mopeds
- Motor Cycles
- Motor Vehicles
- Official Business
- Patrons
- Pedestrians
- Permit Holders
- Petrol Tankers
- Public Transport
- Residents And Guests
- School Buses
- Service Vehicles
- Taxis
- Towed Caravans
- Tracked Vehicles
- Wide Loads
- Works Traffic
Figure 7-1 illustrates a route solved (a) prior to modifying the restriction attributes in the Network Dataset and (b) after modifying the restriction attributes. Route (b) takes a slightly faster path after lifting the restrictions, which did not apply to buses or cyclists.

![Figure 7-1 - Best route: (a) with all restrictions applied; and (b) with bus restriction exception.](image)

### 7.1 Exceptions to Inferred Turn Restrictions

Inferred turns comprise No Entry, Access Prohibited, and Access Limited restrictions. Unwanted restrictions can be removed from the model as described below.

1. Ensure the computer is licensed for the appropriate version of ArcGIS desktop product. The following procedure involves modifying the Network Dataset and therefore requires an ArcEditor or ArcInfo licence.
2. Start ArcCatalog and make sure the Network Analyst extension is enabled.
3. In ArcCatalog, right-click on the Network Dataset in the ArcCatalog tree and select Properties.
4. In the Network Data Properties dialog, click the Attributes tab to enable it.
5. Select InferredTurnRestrictions attribute and click Evaluators button.

6. In the type field, select the Field option.

7. In the Field Evaluators dialog, VB script code is required to evaluate whether the restriction applies. A sample script is provided below.

```vbscript
Dim tChar
Dim tExceptions(31)
Dim useRestriction

  tExceptions(0) = 1 'AbnormalLoads
  tExceptions(1) = 2 'Access
  tExceptions(2) = 3 'AuthorisedVehicles
  tExceptions(3) = 4 'Buses
  tExceptions(4) = 5 'Coaches
  tExceptions(5) = 6 'Cycles
  tExceptions(6) = 7 'DangerousGoods
  tExceptions(7) = 8 'Disabled
  tExceptions(8) = 9 'EmergencyAccess
  tExceptions(9) = 10 'EmergencyVehicles
  tExceptions(10) = 11 'HGVs
```
tExceptions(11) = 12 'LGVs

tExceptions(12) = 13 'LoadingUnloading

tExceptions(13) = 14 'LocalBuses


tExceptions(14) = 15 'Mopeds


tExceptions(15) = 16 'MotorCycles


tExceptions(16) = 17 'MotorVehicles


tExceptions(17) = 18 'OfficialBusiness


tExceptions(18) = 19 'Patrons


tExceptions(19) = 20 'Pedestrians


tExceptions(20) = 21 'PermitHoldesrs


tExceptions(21) = 22 'PetrolTankers


tExceptions(22) = 23 'PublicTransport


tExceptions(23) = 24 'ResidentGuests


tExceptions(24) = 25 'SchoolBuses


tExceptions(25) = 26 'ServiceVehicles


tExceptions(26) = 27 'Taxis


tExceptions(27) = 28 'TowedCaravans


tExceptions(28) = 29 'TrackedVehicles


tExceptions(29) = 30 'Vehicles


tExceptions(30) = 31 'WideLoads


tExceptions(31) = 32 'WorksTraffic


tExceptions(31) = 32 'WorksTraffic


useRestriction = True

For Each tChar In tExceptions
    If tChar <> Empty Then
        If Mid([Excepts] , tChar, 1) = "N" Then useRestriction = False
    End If
Next

The script requires modification to ensure that it only include the vehicles or uses that are relevant. The
lines in the code relating to vehicles/uses (i.e., tExceptions(0) = 1 'AbnormalLoads to tExceptions(31) = 32 'WorksTraffic) that are not relevant should be suppressed by deleting these from the script. An example script for school buses is given below.

Dim tChar

Dim tExceptions(31)
Dim useRestriction


tExceptions(24) = 25 'SchoolBuses

useRestriction = True

For Each tChar In tExceptions
    If tChar <> Empty Then
        If Mid([Excepts] , tChar, 1) = "N" Then useRestriction = False
    End If
Next
8. Type ‘useRestriction’ in the Value field and then verify the logic is correct.

9. Save and close the Field Evaluators, Evaluators and Network Dataset Attributes dialogs by clicking OK.

10. Right-click on the Network Dataset in the ArcCatalog tree and select Build.

### 7.2 Exceptions to Turn Restrictions

To remove turn restrictions for a particular vehicle where exceptions occur, follow the steps above for Inferred Turn Restrictions.

### 7.3 Exceptions to Mandatory Turn Restrictions

To remove mandatory turn restrictions for a particular vehicle where exceptions occur, follow the steps above for Inferred Turn Restrictions.
8 Commercial Attributes

Ordnance Survey can provide information on weight and width restrictions as a supplement to the existing Road Routing Information features. Weight and width restrictions represent restrictions such as weak or narrow bridges. Because this information is typically of most interest to commercial users, Ordnance Survey refers to this data as ‘commercial attributes’.

The attributes are not, at the time of writing, part of existing RRI features. They are supplied in a separate CSV file and do not have TOIDs themselves. The attributes have x,y coordinates and can be referenced to Road Links or Road Nodes through a TOID reference field.

The following sections describe how commercial attribute information can be included in the RoadLinks layer and built into the Network Dataset. For further information about commercial attributes and a description of the data model, refer the documentation accompanying the data provided by Ordnance Survey.

8.1 Loading into Geodatabase

1. Start ArcCatalog.

2. In the Catalog tree, right-click on the commercial attributes CSV file supplied by Ordnance Survey, point to Create Feature Class and click From XY Table.

3. In the Create Feature Class From XY Table dialog box, select the x,y fields: “CoordX” and “CoordY”.

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5. Click the Output browse button. Choose the relevant database type from the Save As Type drop down list and navigate to the storage location of the ITN Network Feature Classes. Click Save.

6. Click OK.

8.2 Adding Attributes To Road Links

1. Start ArcMap and add the RoadsLinks and CommercialAttributes Feature Classes to the map.

2. Join the CommercialAttributes table to the RoadLinks table, using the RoadLinkToid and refRoadLink fields.

3. Once joined, create a new field in the RoadLinks table for flagging commercial restrictions, e.g., hasCommercialRestriction.

4. To add a weight restriction attribute, create a new double data type field to hold this information, e.g., WeightRes.

5. Create additional fields in the RoadLinks table if required to hold any other information of interest from the CommercialAttributes table.
6. Select features from RoadLinks where the joined refRoadNode field from CommercialAttributes is false ("F"). This selects all records that reference RoadLinks rather than RoadNodes.

7. For all selected records, calculate the values of the newly created hasCommercialRestriction field to be equal to “Y”.

8. For all selected records, calculate the values of the newly created WeightRes field to be equal to values of the maxGrossWeight field in the CommercialAttributes table.

9. Repeat the above step for any other new fields created to hold information of interest from the CommercialAttributes table.
8.3 Adding Attributes to Network Dataset

Once the commercial attributes have been added to RoadLinks, the data may be built into the Network Dataset to be used in routing and other network analysis. The way in which this is done will depend on the specific purpose and the type of information that is required in the network model. An example of adding weight restrictions to the Network Dataset is provided in Section 9.3.
9 Network Analysis Use Examples

This chapter provides some simple examples of preparing and performing network analysis for some possible uses of the ITN data. To perform routing operations and other analysis with Network Analyst, a Network Dataset is required. Please refer to Section 3 for information about data loading and creating the Network Dataset.

9.1 Bus Routes

9.1.1 Preparing the Data

The ITN network model generated by the OS MasterMap ITN Data Preparation tool creates constant restrictions to all vehicles at all times. Because some restrictions may do not apply to buses, these can be removed from the Network Dataset as described in Section 7.

9.1.2 Planning Optimal Routes

Network Analyst allows the user to find optimal routes for the given bus stops. Section 5 outlines the basic steps of finding a best route.

If loading the stop locations from an existing bus stop Feature Class, it is recommended that the following options are set:

- To ensure stops are approached only from the left side, set the CurbApproach property to "Left side of vehicle".
- A field holding the bus stop name or address is selected in the Name Field drop-down list.
Before solving the route, set up the parameters for the route analysis layer. The parameters listed below are suggested for performing best route analysis with a bus. These can be set on the Analysis Settings tab of the Analysis Layer Properties dialog.

- Speed is the selected impedance. Setting a speed impedance will calculate the fastest route rather than the shortest in distance.
- Time windows option is unchecked (unless relevant and time window data is available for the bus stops). Time windows are used if some stops cannot be visited at certain times of the day.
- All restrictions are selected to ensure road restrictions are respected.
- Reorder stops option is checked.
- Allow U-turns nowhere to avoid tight turns.
- Output true shape type to show the exact shape of the route during analysis.
- Select Use Hierarchy option to favour primary roads over local roads rather than finding the exact route regardless of the road type. Hierarchy may or may not be appropriate, depending on the bus route area and type of bus. See Section 6.2 for further information on hierarchy.
- Ignore Invalid Locations is unchecked to ensure that no bus stops are left out of the analysis.

### 9.1.3 Planning New Bus Stops

**Effect on the Route**

To view the effect of a new bus stop on the route, the new stop can be added to the stops layer – by either adding the locations directly to the display or adding the location to a bus stops Feature Class and reloading the stops. Once the location has been added, a new route can be generated (as illustrated in the example shown in Figure 9-1).
Bus Stop Service Area

Network Analyst allows service areas to be generated around a network location. A service area differs from basic ‘as the crow flies’ radial buffer as it encompasses accessible streets that are within a specified impedance. In this way, service areas can be used to indicate the number of people within walking distance of the new bus stop. An example is illustrated in Figure 9-2.

Service area analysis has a similar work-flow process to best route analysis. New service areas can be started by selecting the option from the Network Analyst toolbar menu. The new bus stop would need
to be added to the Facilities layer. Before solving the analysis, set the parameters in the analysis layer settings. The following settings are recommended for this purpose.

- Length (in metres) of the impedance
- Default breaks set to the number of metres to walk to the bus stop
- Direction towards facility
- Allow U-turns everywhere
- No restrictions

9.2 **Height Restricted Vehicles**

To find routes for vehicles such as lorries, which need to avoid low level bridges, a bridge height restriction can be added to the Network Dataset. An example of route analysis with height restrictions is illustrated in Figure 9-3.
Figure 9-3 – Best route: (a) with no height restrictions applied; and (b) with height restrictions applied.
Adding a bridge height restriction to the Network Dataset is described below.

1. In ArcMap, join the Bridges table to the RoadLink table by linking the RoadLinkToid fields.

2. Once joined, create a new field in the RoadLinks table for maximum height.

3. In the RoadLinks table, select where Bridge.MaxHeight is not null and calculate the values of the newly created height field table to be equal to values of the MaxHeight field in the joined Bridges table.


5. In ArcCatalog, right-click on the Network Dataset in the ArcCatalog tree and select Properties.

6. In the Network Data Properties dialog, click the Attributes tab to enable it.

7. Click the Add button and create a new height attribute with a restriction usage type and click OK.
8. On the Network Dataset Properties dialog, select the height restriction attribute and click the Evaluators button.

9. Select the RoadLinks attribute for the From-To Direction and click the Properties button.
10. Enter the following value ‘[<FieldName>] < [Height]’, e.g., ‘[MaxHeight] < 3.5’ and then verify the logic is correct.

11. Click OK to save and close the Field Evaluators dialog.

12. Select the RoadLinks attribute for the To-From Direction and click Properties and enter the same value in the Field Evaluator dialog.

13. Save and close the Field Evaluators, Evaluators and Network Dataset Attributes dialogs by clicking OK.

14. Right-click on the Network Dataset in the ArcCatalog tree and select Build.

### 9.3 Weight Restricted Vehicles

To find routes for vehicles that need to avoid weight restricted roads, a weight restriction can be added to the Network Dataset. An example of route analysis with weight restrictions is illustrated in Figure 9-4. In this example, an attribute parameter has been used for the weight restriction, which allows the vehicle weight to be evaluated against the maximum gross weight from the OS Commercial Attributes data.

Note: At the time of writing, the creation of parameters for Network Datasets attributes is not supported with personal geodatabases but is supported with ArcSDE and file geodatabases.
Avoiding weight restricted bridge

Figure 9-4 – Best route: (a) with no weight restrictions applied; and (b) with weight restrictions applied for vehicle weight of 10 tonnes.
Adding a weight restriction with a vehicle weight evaluator is described below.

1. Following the instructions described in Section 8, create a new weight restriction field in the RoadLinks table calculated from maxGrossWeight field in the CommercialAttributes table.

2. Close ArcMap.

3. In ArcCatalog, right-click on the Network Dataset in the ArcCatalog tree and select Properties.

4. In the Network Data Properties dialog, click the Attributes tab to enable it.

5. Click the Add button and create a new maximum weight attribute with a Descriptor Usage Type and Double Data Type. Click OK.

6. On the Network Dataset Properties dialog, select the maximum weight descriptor attribute and click the Evaluators button.

7. Change the RoadLinks From-To Direction to a Field Type and set the Value as the weight restriction field (which was added to the RoadLinks in Step 1).

8. Repeat the above step for the RoadLinks To-From Direction.

9. Click OK to save and close the Field Evaluators dialog.

10. On the Network Dataset Properties dialog, click the Add button and create a new weight attribute with a Restriction Usage Type. Click OK.
11. On the Network Dataset Properties dialog, select the weight restriction and click the Parameters button.

12. On the Add Parameters dialog, click Add and create a vehicle weight parameter of a Double Type. Click OK.

13. Click OK to save and close the Weight Parameters dialog.

14. On the Network Dataset Properties dialog, select the weight restriction and click the Evaluators button.

15. Select the RoadLinks From-To Direction, set the Type to VB Script Type and click the Properties button.

16. In the Script Evaluators dialog, enter a script in the Pre-Logic VB Script Code which will evaluate whether a restriction will apply based on the vehicle weight and maximum bridge weight. A sample script is provided below:

```vbnet
res = false
vw = ParameterValueByName("VehicleWeight")

if vw > 0 then
    maxw = Edge.AttributeValueByName("MaxWeight")
    if maxw > 0 then
```

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res = vw > maxw
end if
end if

17. Enter the appropriate variable name in the Value field. If using the sample script provided above, enter ‘res’.

18. Click OK to save and close the Script Evaluators dialog.

19. Repeat steps 15 to 18 for the RoadLinks To-From Direction.

20. Click OK to save and close the Evaluators dialog.

21. Right-click on the Network Dataset in the ArcCatalog tree and select Build.

### 9.4 Closest Fire Station

#### 9.4.1 Preparing the Data

Because some restrictions that have been created in the Network Dataset do not apply to emergency vehicles or emergency access, these can be removed as described in Section 7. If applicable, height restrictions may also be added to the network model, as described in Section 8.2.
9.4.2 Finding the Closest Facility

Network Analyst allows best routes between facilities and incidents to be generated. Closest facility analysis has a similar workflow process to best route analysis. New closest facilities can be started by selecting the option from the Network Analyst toolbar menu. The fire station locations need to be added to the Facilities layer and the location of interest needs to be added to the Incidents layer. Before solving the analysis, set the parameters in the analysis layer settings. The following settings are recommended for this purpose.

- Speed impedance
- No default cut off value
- Travel from facility to incident
- Allow U-turns nowhere to avoid tight turns.
- Output true shape
- Use hierarchy to favour primary roads over local roads rather than finding the exact route regardless of the road type.
- All restrictions

Figure 9-5 illustrates a solved closest facility route. The map shows that there is a shorter distance to a fire station to the west of the incident location. However, because restrictions, speed impedance and hierarchy have been applied to the analysis, the route has favoured taking an A road to a fire station north of the incident.
9.5 Service Area of Stores

As demonstrated with bus stops in Section 8.1.3, Network Analyst allows service areas to be generated around a network location. Service areas can be also used to indicate the number of customers within a specified travel time of stores.

New service areas can be started by selecting the option from the Network Analyst toolbar menu. The store locations need to be added to the Facilities layer. Before solving the analysis, set the parameters in the analysis layer settings. The following settings are recommended for this purpose.

- Speed impedance (to find the fastest route)
- Default breaks set to the number minutes travel time
- Direction towards facility
- All restrictions
Figure 9-6 illustrates a solved service area analysis. Once the service area is generated, the customers in each service area can be counted, using the tools within ArcMap.

Figure 9-6 – Finding customer service areas for stores
Appendix I – Feature Dataset Schema

RoadLinks Line Feature Class:

The RoadLinks Feature Class represents the general alignment of the road carriageway, where the only option for a vehicle is to travel along the link or leave the road network for example onto a petrol station forecourt or onto private land. A road can consist of one or more Road Link features (lines).

Geometry source: Road Link (RdLk)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoadLinkTOID</td>
<td>Road Links Topographic Identifier</td>
<td>RdLk.TOID</td>
</tr>
<tr>
<td>DescTerm</td>
<td>Descriptive term, e.g., Motorway, A Road.</td>
<td>RdLk.DescTerm</td>
</tr>
<tr>
<td>RoadLabel</td>
<td>Cartographic label for the road link. The wizard provides option to make this one of:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Road Name</td>
<td>RRN.Name</td>
</tr>
<tr>
<td></td>
<td>• Road Name or Number if no name</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Road Name concatenated with Number</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• All Road Names concatenated together in formatted string</td>
<td></td>
</tr>
<tr>
<td>RoadName</td>
<td>The primary name of the road (first one in the ITN data)</td>
<td>RRN.Name</td>
</tr>
<tr>
<td>RoadNumber</td>
<td>Road number, e.g., A302</td>
<td>RRN.Name</td>
</tr>
<tr>
<td>PrimaryRoute</td>
<td>Indicates that the Road Link is part of a primary route</td>
<td>‘Y’ where Road.DescTerm = ‘Primary Route’</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>OneWay</td>
<td>One way and direction</td>
<td>RRIDL.DirectedLinkOrientation where ENVQ.Qualifier = ‘One Way’</td>
</tr>
<tr>
<td></td>
<td>“-” Permitted flow is against the direction of digitisation of the line</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“+” Permitted flow is in the direction of the digitisation of the line</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“N” There is no one-way restriction, flow can occur in either direction</td>
<td></td>
</tr>
<tr>
<td>NoEntry</td>
<td>Indicates that the link is no entry</td>
<td>RRIDL.DirectedLinkOrientation where ENVQ.Qualifier = ‘No Entry’</td>
</tr>
<tr>
<td></td>
<td>“+” No entry at the start of the line as digitised</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“-” No entry at the end of the line as digitised</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“N” The link does not have a no-entry restriction</td>
<td></td>
</tr>
<tr>
<td>Nature</td>
<td>Nature of the road, e.g., dual carriageway or single</td>
<td>RdLk.DescGroup</td>
</tr>
<tr>
<td>AccessProhibited</td>
<td>Indicates whether access to the road link has any prohibitions</td>
<td>‘Y’ if there is any of the following qualifiers on the Road link:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vehicle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• DateTime</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and that qualifier prohibits access to some or all vehicles for all or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>part of the day or for all or part of the year</td>
</tr>
<tr>
<td>AccessLimited</td>
<td>Indicates whether access to this Road Link is limited to particular types of</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vehicle</td>
<td>See above.</td>
</tr>
</tbody>
</table>
<pre><code>              |                                                                             |                                                                         |
</code></pre>
<table>
<thead>
<tr>
<th>ExceptAbnormalLoads</th>
<th>Indicates whether there is an exception to a restriction for the specific vehicle type/usage</th>
<th>For Access Limited restrictions: ‘Y’ if VQ.ExceptFor = false and VQ.Qualifier is as described by attribute name. For all other restriction types: ‘Y’ if VQ.ExceptFor = true and VQ.Qualifier is as described by attribute name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExceptAccess</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptVehicles</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptAuthorisedVehicles</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptBuses</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptCoaches</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptCycles</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptDangerousGoods</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptDisabled</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptEmergencyAccess</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptEmergencyVehicles</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptHGVs</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptLGVs</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptLoadingUnloading</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptLocalBuses</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptMopeds</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptMotorCycles</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptMotorVehicles</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptOfficialBusiness</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptPatrons</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptPedestrians</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptPermitHolders</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptPetrolTankers</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptPublicTransport</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptResidentsGuests</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptSchoolBuses</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>ExceptServiceVehicles</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptTaxis</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptTowedCaravans</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptTrackedVehicles</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptWideLoads</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>ExceptWorksTraffic</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>HasBridge</td>
<td>Indicates that the Road Link passes under a bridge</td>
<td>Y’ if EnvQ.Qualifier = ‘Bridge Over Road’</td>
</tr>
<tr>
<td>HasTrafficCalming</td>
<td>Indicates that the Road Link has traffic calming</td>
<td>‘Y’ if EnvQ.Qualifier = ‘Traffic Calming’</td>
</tr>
<tr>
<td>HasBollards</td>
<td>Indicates that the Road Link has rising bollards</td>
<td>‘Y’ if EnvQ.Qualifier = ‘Bollards’</td>
</tr>
<tr>
<td>HasGate</td>
<td>Indicates that the Road Link has a gate</td>
<td>‘Y’ if EnvQ.Qualifier = ‘Gate’</td>
</tr>
<tr>
<td>HasPartialRestriction</td>
<td>Indicates that the Road Link has a partial restriction</td>
<td>Derived from RPRI and RPLI</td>
</tr>
<tr>
<td>HasDateTimeRest</td>
<td>Indicates that the Road Link has a date time restriction qualifier</td>
<td>Derived from RLI/RPLI and DTQ</td>
</tr>
<tr>
<td>TrunkRoad</td>
<td>Indicates that the Road Link is a trunk road</td>
<td>‘Y’ if Road.DescTerm = ‘Trunk Road’</td>
</tr>
<tr>
<td>HasTurnRestriction</td>
<td>Indicates that the Road Link has a turn restriction</td>
<td>Related EnvQ.Qualifier = ‘No Turn’</td>
</tr>
<tr>
<td>HasMandatoryTurnRestriction</td>
<td>Indicates that the Road Link has a mandatory turn restriction</td>
<td>Related EnvQ.Qualifier = ‘Mandatory Turn’</td>
</tr>
<tr>
<td>HasInferredTurnRestriction</td>
<td>Indicates that the Road Link has an inferred turn restriction</td>
<td>Related EnvQ.Qualifier = ‘No Entry’ or ‘Access Limited To’ or ‘Access Prohibited To’</td>
</tr>
</tbody>
</table>

**Bridges Point Feature Class**

The Bridges point Feature Class represents location of bridges under or over roads.

Geometry source: Route Link Information (RLI)

Extraction query: Related EnvQ.Qualifier = ‘Bridge Over Road’ or ‘Bridge Under Road’

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoadLinkTOID</td>
<td>TOID of the Road Link that the bridge</td>
<td>RdLk.TOID</td>
</tr>
</tbody>
</table>
RisingBollards Point Feature Class:
The RisingBollards point Feature Class represents location of rising bollards on roads.
Geometry Source: Route Link Information (RLI)
Extraction query: Related EnvQ.Qualifier = 'Bollards'

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLITOID</td>
<td>TOID of Road Link Information</td>
<td>RLI.TOID</td>
</tr>
<tr>
<td>RoadLinkTOID</td>
<td>TOID of the Road Link in which the bollard is located</td>
<td>RdLk.TOID</td>
</tr>
<tr>
<td>DistFromStart</td>
<td>Distance from start of the Road Link where the bollards are located</td>
<td>RLI.DISTANCEFROMSTART</td>
</tr>
</tbody>
</table>

Gates Point Feature Class:
The Gates point Feature Class represents gates on roads.
Geometry Source: Road Route Information (RRI)
Extraction query: Related EnvQ.Qualifier = 'Gate'

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoadLinkTOID</td>
<td>TOID of the Road Link in which the gate is located</td>
<td>RdLk.TOID</td>
</tr>
<tr>
<td>RLITOID</td>
<td>TOID for the RLI describing the gate</td>
<td>RLI.TOID</td>
</tr>
</tbody>
</table>

PartialRestrictions Line Feature Class:
The PartialRestrictions line Feature Class represents restrictions related to part of a road link in the road network. Examples of partial restrictions include: an access restriction such as pedestrianised area that may be used by vehicles at specific times and only applies to a few hundred metres of a RoadLink feature; and an access restriction such as a bus lane in one direction only or a one-way street that applies to a portion of a RoadLink feature.
Geometry source: Road Link (RdLk)
Derived using the sections of Road Links between the restriction points from the Road Partial Route Information (RPRI) and Road Partial Link Information (RPLI) Feature Classes.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road LinkTOID</td>
<td>TOID of the Road Link that the restriction applies to</td>
<td>RdLk.TOID</td>
</tr>
<tr>
<td>RestrictionTOID</td>
<td>TOID of the partial restriction information that the describes the restriction</td>
<td>RPRI.TOID or RPLI.TOID</td>
</tr>
<tr>
<td>Restriction</td>
<td>Nature of the restriction, e.g., an access restriction or a one-way restriction</td>
<td>EnvQ.Qualifier</td>
</tr>
</tbody>
</table>

**MotorwayJunctions Point Feature Class**

The MotorwayJunctions point Feature Class represents junctions along motorways.

Geometry source: Information Point (InPt)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>InPtTOID</td>
<td>TOID of the Information Point</td>
<td>InPt.TOID</td>
</tr>
<tr>
<td>JunctionName</td>
<td>Name of the junction</td>
<td>InPt.JunctionName</td>
</tr>
</tbody>
</table>

**FerryNodes Point Feature Class:**

The FerryNodes point Feature Class represents where a ferry terminates.

Note: Only ferry nodes that participate in FerryLinks are included in this Feature Class.

Geometry source: FerryNodes (FyNd)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>FerryNodeTOID</td>
<td>TOID of the Ferry Node</td>
<td>FyNd.TOID</td>
</tr>
</tbody>
</table>

**FerryLinks Line Feature Class:**

The FerryLinks line Feature Class contains ferry links for vehicular ferries, providing a logical connection between two Ferry Node features.

Note: Only ferry links which have geometry are included in this table.

Geometry source: FerryLinks (FyLk)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOID</td>
<td>TOID of the Ferry Link</td>
<td>FyLk.TOID</td>
</tr>
<tr>
<td>Node1</td>
<td>TOID of start node</td>
<td>FyLk.Node1</td>
</tr>
<tr>
<td>Node2</td>
<td>TOID of end node</td>
<td>FyLk.Node2</td>
</tr>
</tbody>
</table>
**Traffic Calming Line Feature Class:**
The TrafficCalming line Feature Class represents Road Links in which traffic calming measures exist.
Geometry source: Road Links (RdLk)
Extraction query: Related EnvQ.Qualifier = ‘Traffic Calming’

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoadLinkTOID</td>
<td>TOID of the Road Link</td>
<td>RdLk.TOID</td>
</tr>
<tr>
<td>RestrictionTOID</td>
<td>TOID of the RLI that describes the</td>
<td>RLI.TOID</td>
</tr>
<tr>
<td></td>
<td>calming</td>
<td></td>
</tr>
</tbody>
</table>

**Mini Roundabouts Point Feature Class**
The MiniRoundabouts point Feature Class represents mini roundabouts.
Geometry source: RoadNode (RdNd)
Extraction query: Related EnvQ.Qualifier = ‘Mini Roundabout’

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoadNodeTOID</td>
<td>TOID of the Road Node</td>
<td>RdNd.TOID</td>
</tr>
<tr>
<td>RNITOID</td>
<td>TOID of the Road Node Information</td>
<td>RNI.TOID</td>
</tr>
</tbody>
</table>

**Turn Restrictions Turn Feature Class**
The TurnRestrictions Turn Feature Class models prohibited turns. The Network Dataset includes these features as a restriction attribute, so the relevant roads links will not entered from the direction specified.
Geometry Source: Road Link (RdLk)
Extraction query: Related EnvQ.Qualifier =’No Turn’,

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>AltID#</td>
<td>TOID of the related Road Link</td>
<td>Road Link.TOID</td>
</tr>
<tr>
<td>TurnType</td>
<td>Type of turn</td>
<td>ENVQ.Qualifier</td>
</tr>
<tr>
<td>Excepts</td>
<td>Indicates whether there is an</td>
<td>‘Y’ if VQ.ExceptFor = true and VQ.Qualifier as described by attribute name.</td>
</tr>
<tr>
<td></td>
<td>exception to the restriction for the different vehicle types and uses.</td>
<td></td>
</tr>
</tbody>
</table>

Refer to the “Turns in the Network Dataset” topic in the “Extensions: Network Analyst: Network Dataset Concepts” section of the ArcGIS Desktop Help for a description of the Turn Feature Class schema.
**Mandatory Turn Restrictions Turn Feature Class**

The MandatoryTurnRestrictions Turn Feature Class models mandatory turns. The Network Dataset includes these features as a restriction attribute, so the relevant roads links will not entered from the direction specified.

Geometry Source: Road Link (RdLk)

Extraction query source: Related EnvQ.Qualifier = ’Mandatory Turn’

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>AltID#</td>
<td>TOID of the related Road Link</td>
<td>Road Link.TOID</td>
</tr>
<tr>
<td>Excepts</td>
<td>Indicates whether there is an exception to the restriction for the different vehicle types and uses.</td>
<td>‘N’ if VQ.ExceptFor = true and VQ.Qualifier is as described by attribute name</td>
</tr>
</tbody>
</table>

Refer to the “Turns in the Network dataset” topic in the “Extensions: Network Analyst: Network Dataset Concepts” section of the ArcGIS Desktop Help for a description of the Turn Feature Class schema.

**Inferred Turn Restrictions Turn Feature Class**

The InferredTurnRestrictions Turn Feature Class models no entry, access limited and access prohibited restrictions. This Feature Class attribute table includes a TurnSource field, which indicates the specific type of restriction. The Network Dataset includes InferredTurnRestrictions as a restriction attribute so these roads will not be entered from the end(s) specified.

Geometry Source: Road Link (RdLk)


<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>AltID#</td>
<td>TOID of the related Road Link</td>
<td>Road Link.TOID</td>
</tr>
<tr>
<td>TurnSource</td>
<td>Indicates type of restriction, e.g., &quot;Access Limited&quot;</td>
<td>ENVQ.Qualifier</td>
</tr>
<tr>
<td>Excepts</td>
<td>Indicates whether there is an exception to the restriction for the different vehicle types and uses.</td>
<td>For Access Limited restrictions: ‘N’ if VQ.ExceptFor = false and VQ.Qualifier is as described by attribute name. For all other restriction types: ‘N’ if VQ.ExceptFor = true and VQ.Qualifier is as described by attribute name</td>
</tr>
</tbody>
</table>
Refer to the “Turns in the Network Dataset” topic in the “Extensions: Network Analyst: Network Dataset Concepts” section of the ArcGIS Desktop Help for a description of the Turn Feature Class schema.

**ITN Network_Junctions Point Feature Class**

The ITNNetworkJunctions point Feature Class contains road nodes which signify the beginning or end of road link. Road nodes are formed at the start or end of a road, or where a road junction occurs. This Feature Class participates in the ITN Network Dataset.

Geometry Source: Road Nodes (RdNd)

**ITN Network Network Dataset**

The ITNNetwork Dataset is an ITN Network, which can be used by Network Analyst for routing operations and other network analysis. The dataset is sourced from the RoadLinks and ITNNetworkJunctions Feature Classes. It incorporates a connectivity model and a number of network attributes that helps model impedances, restrictions, and hierarchy for the network.

Geometry Source: Road Links (RdLk)