

RW Net 4.28

A Network Analysis System SDK

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Part I

User Manual

1 User Manual

1.1 Introduction

RW Net 4.28

RW Net is a general purpose routing library. It is flexible enough to be used together with almost any GIS system available and it will also work together with most programming tools on the market.

RW Net uses it's own format for storing street networks and included are functions for [importing](#)^[27] street databases from most common GIS formats. This topological format is targeted towards routing purposes and is described [here](#)^[17]. RW Net always loads the topological network into memory before doing any calculations.

The basic structure in the topological network is a one-to-one relationship, where the first link in the network matches the first record in your GIS file, second link matches second record etc. This makes the network files very compact and fast to use.

All attribute information (road class, one-way information etc.) is held in a separate data structure which can easily be updated without having to re-create the topological network.

1.2 Feature matrix

Features

| | Standard | Pro |
|--|------------------|-----------------------|
| Network size | 500,000 links | 100,000,000 links |
| Import ^[27] | Single file only | Multiple files |
| Import formats | MIF, SHP, TAB | MIF, SHP, TAB, events |
| Import from ^[36] SQL database (MS SQL, Oracle, PostGIS) | | Yes |
| Node-2-node routing | Yes | Yes |
| Matrices (*) | Yes | Yes |
| Spatial searches ^[71] | Yes | Yes |
| Max list length (*) | 300 items | No limit |
| Shortest / fastest / cheapest route | Yes | Yes |
| 32 road classes | Yes | Yes |
| Geographic & projected coordinates ^[10] | Yes | Yes |
| Alpha parameter ^[97] for improved speed | Yes | Yes |
| Output to MIF, SHP, KML, GML, CSV, DBF, array, GeoJSON | Yes | Yes |
| Output to TAB on win32/win64 | Yes | Yes |
| Turn restrictions | Yes | Yes |
| Limits ^[9] (max weight, width etc.) | Yes | Yes |
| Dynamic segmentation | Yes | Yes |
| Driving directions ^[103] (*) | Yes | Yes |
| Travelling salesman optimization ^[134] (TSP) (*) | Symmetrical | Asymmetrical too |
| Nearest N facilities ^[79] (*) | Yes | Yes |
| Isochrone functions - link based (*) | Yes | Yes |
| Isochrone functions - voronoi ^[109] based (*) | Yes | Yes |

| | | |
|---|-------------------------|-----|
| Export of network [48] | Yes | Yes |
| Topological checks (subnets [96], missing snap [7], parallel links [58], cul-de-sac [47], overpasses [7] etc.) | Yes, up to 10,000 links | Yes |
| Encryption of network files [29] | | Yes |
| Smoothing of isochrones [114] | | Yes |
| Hierarchical routing [7] | | Yes |
| Approach based routing [100] | | Yes |
| Multi-threaded calculation [9] | | Yes |
| TSP with curb approach [137] | | Yes |
| Mixed Rural Postman Problem (arc routing) | | Yes |
| Join links [69] | | Yes |
| Clustering [127] | | Yes |
| Minimum Spanning Tree [94] | | Yes |
| Weighted Center of graph [93] | | Yes |
| Traffic Assignment [102] | | Yes |

Functions marked with (*) only accepts 300 items in Standard version.

1.3 System requirements

Available for:

- .NET (fully managed)
- .NET Silverlight
- Delphi XE2 - XE3 - XE4 - XE5 - XE6 - XE7 - XE8 - 10 - 10.1 - 10.2 (32/64-bit)
- [DLL](#) [13] for 32-bit MapInfo / MapBasic 7.5 - 15.0
- [DLL](#) [13] for 64-bit MapInfo / MapBasic 15.2.2 -

Some versions are only available in Pro version - see [license terms](#) [21].

All versions are fully self-contained and 100% "native" on each their own platform (no "wrappers").

RW Net 4 is 100% Unicode enabled.

The older RW Net 2 also includes versions for older Delphi compilers.

1.4 Quick overview

A normal setup includes these steps:

1. Import geographic coordinate data into RW Net's own format with class [TImport](#) [27]
2. Import attribute information such as street names, one-way information etc. with class [TImportAttributes](#) [32]
3. Open the generated files with class [TNetwork](#) [38]
4. Perform spatial searches with class [TSpatialSearch](#) [71] or
5. Perform isochrone calculations (one-to-many, matrices etc.) with class [TCalc](#) [75] or
6. Perform one-to-one route calculation with class [TRouteCalc](#) [96]

Routes can be exported to a lot of standard formats using one of the [TGISwrite](#) [115] classes. Several of the functions write directly to one of the GIS formats.

Drivetime isochrones

A typical use of the software is the calculation of drivetime isochrones, showing how far you can get in 5, 10, 15 minutes etc.

We have explained the various options in more detail [here](#)^[17].

Optimization

Matrices can be used in one of the TSP classes ([TTSP](#)^[134] and [TTSPcurb](#)^[137]) to perform an optimization of the sequence.

[TOptimizer](#)^[127] is used for creating territories according to various criteria: Load, size etc.

1.5 Network terminology

Terminology used to describe the various elements of a street network:

A *link* consists of several connected vertices (2 or more, blue squares on the map below). The first vertex of a link is called the *from-node* and the last vertex is called the *to-node*. See function [Link2FromNode](#)^[53] and [Link2ToNode](#)^[53].

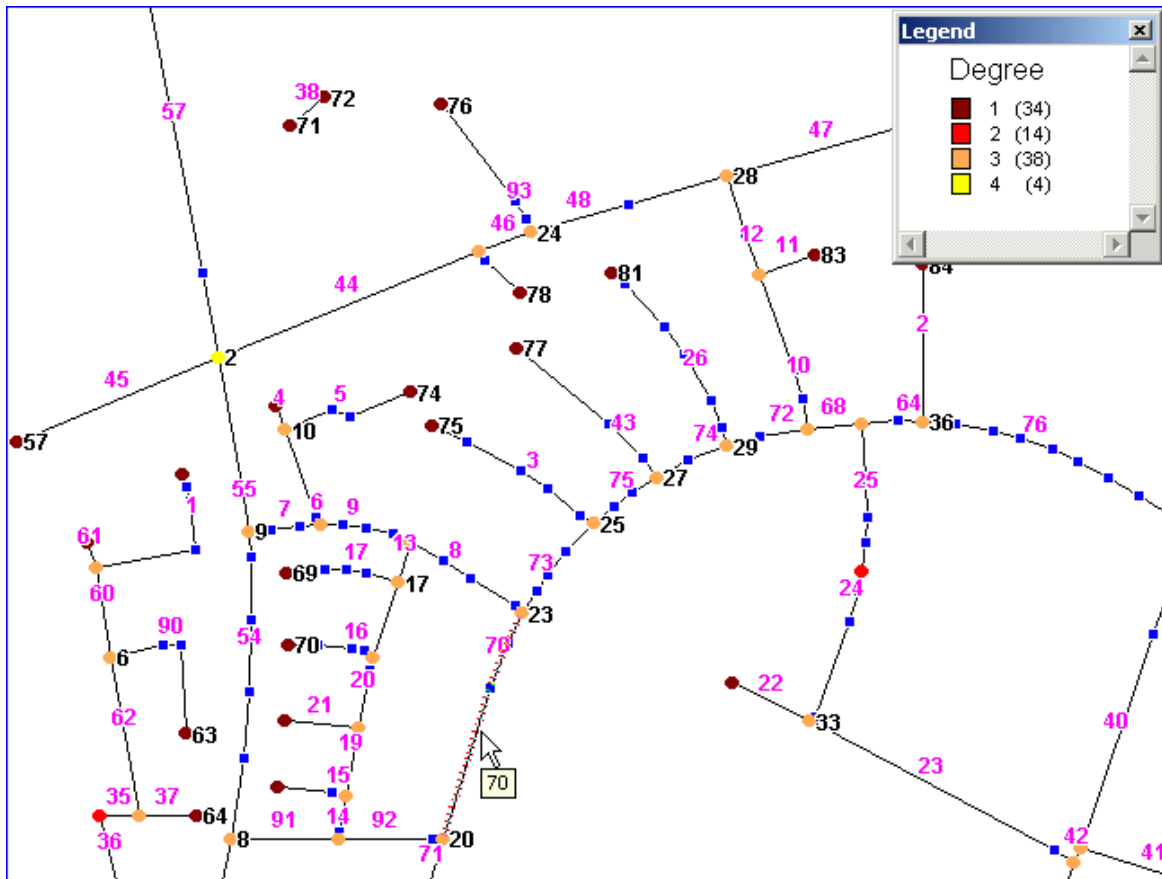
Most of the nodes share coordinates with nodes of other links. The number of links sharing a node is referred to as the degree of the node. You should normally never reach more than 10. See function [Degree](#)^[47].

A node is also called an *intersection* - even if the degree is 1 or 2. A link where one of the nodes has degree 1 is called a *dangling* link. A node with degree 2 is called a *pseudo-node* (see function [Join](#)^[69]). The red node on the map is such a pseudo-node.

A link is identified by its internal ID (Magenta text on the map: 1, 2, 3), which corresponds to the record ID's of the input dataset used by function [TImport.execute](#)^[30].

A node is identified by its ID (Black text on the map: 1, 2, 3). Node ID's are primarily ordered by degree in descending order and secondarily by x-coordinate in ascending order. Node ID's are assigned during network import and can not be controlled by the user.

A *location* is a position on a link: e.g. 50% along link 70 - counted in the same direction as that the link has been digitized in. This appr. matches the cursor on the map below. Locations are used when doing dynamic routing. The percentage needs to be between 0 and 1 (both included).



1.6 Link information

1.6.1 Attributes

The attribute for each link in the network play a key role in defining how the link is used in the routing calculations. This is defined through a bit-pattern:

1. Road class, 0-31 (5 bits)

These have no predefined meaning, but their value can be translated into a drive time using function [CalculateTime](#)^[44]

2. Hierarchy (*), 1-5, (3 bits, 32-64-128, bit 5-7)

A topological hierarchy can be used for speeding up [TRouteCalc](#)^[96] calculations.

0 is also allowed, if you don't use the hierarchy at all.

See further explanation here: [Hierarchy](#)^[7].

3. No-drive through (*), true/false (1 bit, 256, bit 8)

This can be used to define areas, where you are not allowed to drive through to get to the target.

Applies to [TRouteCalc](#)^[96] calculations.

See [TNetwork.NoDriveThroughCheck](#)^[56], [TNetwork.NoDriveThroughInit](#)^[56] and [TRouteCalc.NoDriveThrough](#)^[88]

4. One-way, To-From direction not allowed, (1 bit, 512, bit 9)

5. One-way, From-To direction not allowed, (1 bit, 1024, bit 10)

If both bit 9 and 10 are set, the link is closed for driving.

6. Roundabout, true/false (1 bit, 2048, bit 11)
Can be used in creating driving directions.

7. Non-driving link, such as a ferry or car-train, true/false (1 bit, 4096, bit 12)
Can be used in creating driving directions.

8. True if not allowed to make U-turns at the From-end of the link. (1 bit, 8192, bit 13)

9. True if not allowed to make U-turns at the To-end of the link. (1 bit, 16384, bit 14)

10. SkipInSearch (*), true/false (1 bit, 32768, bit 15)
For use with function [NearestLocation](#)^[73]
See [SkipLinks2BitArray](#)^[61] and [TSpatialSearch.SkipLinks](#)^[75]

(*): Changed from RW Net 2.

An example:

A road of class 4, which can only be travelled in the direction of digitization: $4 + 512 = 516$.

1.6.1.1 Hierarchy

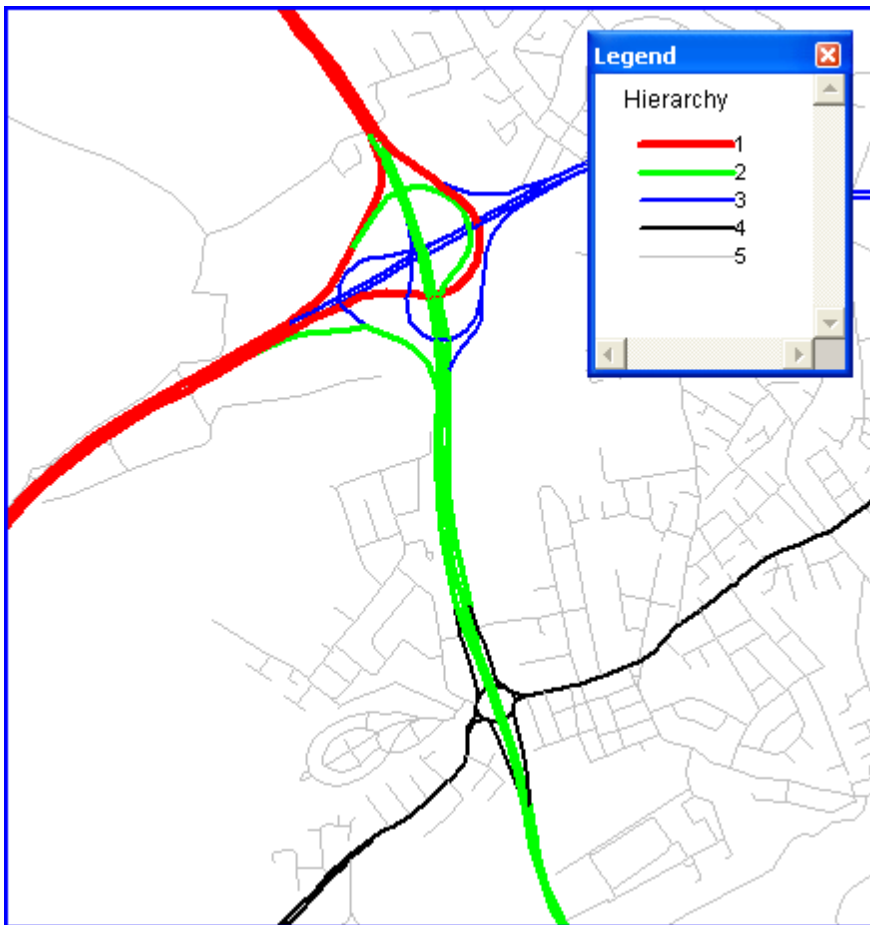
Some street databases has special attributes for the most important streets, the ones being used as part of long routes.

This will typically be motorways, but can also be ferries, bridges and some minor streets which are required to have a connected network.

The advantages of restricting routes to these more important streets are:

- Much faster point-2-point route calculations for long routes ([TRouteCalc](#)^[96]).
- Simpler routes, which doesn't make short-cuts via minor roads to make a long route a little shorter / faster.

The map below shows an example from TomTom Multinet data with 5 layers of importance (hierarchies):



RW Net 4 uses a method where the calculation of the route is restricted to level 1..X as soon as level X has been reached on the route unless you are within a certain distance Y of the final target. Then additional levels are included in the search again.

For the algorithm to work properly the parameter Y has to be supplied for levels 2 to 5. Level 1 (the top level) is of course always included in the search. The best values for these parameters depend on the geometric properties of the network and how the hierarchy attribute has been setup.

If you have less than 5 levels in your data source - 3 for instance - use levels 1, 2 and 3.

If you choose small parameters values, a smaller part of the network is considered when you get close to the target and this improves calculation speed.

The downside is you risk not finding the target at all (!), because there are no major streets within the limits you have defined.

The solution to this problem is to re-calculate without the hierarchy setting or just use a more relaxed setting (larger parameter values).

Such re-calculations are costly and when choosing parameters it is important to find a balance between normal, fast calculations and the slow re-calculations.

Functions for working with hierarchies:

[TNetwork.Hierarchy](#)^[53] For getting / setting hierarchy for a single link
[TRouteCalc.Hierarchy](#)^[99] For enabling / disabling hierarchy for a calculation
[TRouteCalc.SetHierarchy](#)^[107] For defining parameters for the hierarchy - suggestions for TomTom and Naveq databases

1.6.2 External ID

Each link can have an associated external ID as opposed to the internal ID (1, 2, 3...). The external ID can be either string based, integer (0..2147483647) or int64 (0.."really big") based.

The advantage is an external ID can be constant over time and globally unique - even when working with a subset of a larger database.

RW Net includes functions for translating between internal and external ID, but otherwise all functions uses internal ID for input / output.

1.6.3 Limit

Besides the routing options available as part of the [attribute](#)^[6] bit pattern, it is also possible to define 2 other kind of route restrictions for links in the network:

1. A scalar quantity such as a maximum weight, height, width etc. If the limit for a certain link in the network is 100 and you calculate a route for a vehicle with a value >100, that link will be avoided in the route. It is mandatory to scale your limits into the 1-255 interval.
2. A **bit pattern** for defining special links such as ferries, toll roads etc. which you may want to avoid in your routing. If the limit for a link is 3 = 0000011 it may mean it is both a ferry and a toll "road" (most ferries are not free, so that seems logical). If your value has either bit 1 or 2 set, that link will be avoided in the route. It is possible to define 8 such bits within each limit.

For both types, a link value of 0 means no limitations at all.

A maximum of 9 such limitations can be created.

See [TImportAttributes](#)^[32], [TNetwork](#)^[38] and [TCalc.SetLimit](#)^[67].

1.6.4 Road name

It is possible to have a road name for all links. Multiple sets can be created so a link can have the name "Main Street" in one setup, but "Main Street, Smalltown" in another setup. Or use different languages.

Road names are stored using Unicode and always converted before output, depending upon the chosen file format and codepage.

Road names can be used in [driving directions](#)^[103] and in functions [ExportLinks](#)^[48] and [Join](#)^[69].

1.7 Turn restrictions

There are 2 types of restricted turns:

- Banned turns
- Delayed turns

Normally you will be using banned turns only, since for most normal routing purposes, setting different road speeds for road classes are sufficient for giving a realistic route choice.

Generally you can change choice of route A LOT by using wrong values for delays, so take care.

All methods about turn restrictions has an index parameter, which points to one of the turn indices, created by [CreateArrayTurn](#)^[46].

If you add a turn restriction, where one of the links making up the restriction is already marked as one-way, it is skipped.

1.8 Coordinate units

Two kind of coordinate units are supported:

- Spheric / Latitude-longitude (global / local)
- Cartesian / Projected (local)

When working with spheric coordinates, all distance calculations are performed using great circle distances and the Earth is considered a perfect sphere with radius 6378.13 km.

When working with Cartesian coordinates, all distance calculations are performed using straight Pythagoras formula. Several different Cartesian units are supported.

Global projections such as [Web Mercator](#) and more are not supported. They use meters as coordinate unit, but the scale factor depends upon the latitude.

If you use it, you will not get any error messages, but the lengths will come out wrong, when you are not on Equator.

It is worth noting, that RW Net *never* performs any transformation between coordinate systems. It always works with the native coordinates of the base dataset used when creating the network. It will return strange results, if you set the coordinates as spheric, while they are really meters or vice-versa. It is YOUR responsibility to make sure this is correct.

See also [TCoordinateUnit](#)^[156]

1.9 Coordinate system

When [importing](#)^[27] from a GIS street database, information about the coordinate system is stored in the INI file.

This is used for generating output files with class [TGISwrite](#)^[115] - either internally or by the user.

Depending on the output formats you plan to use, this information is needed:

| | |
|---------------|------------------------------|
| TAB / MIF | Coordsys clause |
| SHP | PRJ file |
| GML / GeoJSON | EPSG code |
| KML | Always uses lat/long, WGS 84 |

These should be set before importing.

1.10 Units

RW Net 4 uses metrical units almost everywhere in the setup:

- Distances: Km
- Speeds: Km/h
- Time: Minutes

The exception is miles & mph can be used in a few output-to-file functions, where the output is directly aimed at end-users:

[TCalc.MatrixOut](#)^[85]
[TCalc.MatrixDynOut](#)^[85]
[TDrivingDirections](#)^[103]
[TRouteCalc.NearestNDyn](#)^[97]

See [TCalc.DistanceUnit](#)^[77] and [TDrivingDirections.DistanceUnit](#)^[105] if you prefer miles.

1.11 File structure

When a network is imported, several binary files are created on disk, which together define the topological network. This gives a short description of the content of the various files:

| Filename | Mandatory | Encrypted | Explanation |
|-------------------------|-----------|-----------|---|
| Attribute.bin | | X | Attributes of links |
| Coord.bin | X | X | Coordinates of all intersections (start / end node) |
| Coord3.bin | X | | Coordinates of the rest of the vertices |
| Coord3i.bin | X | X | Index into Coord3.bin |
| Index1.bin & index2.bin | | | Index for conversion between link id (1, 2, 3..) and external id. |
| Length.bin | X | X | Length of all links in the network |
| Limit?.bin | | X | Information about limits on links such as max heights etc. |
| Link.bin & node.bin | X | X | Information about link-node relationship ("topology") |
| Roadname??.bin | | | List of possible road names, Unicode |
| Roadnumber??.bin | | | Index into roadname??.bin |
| Rwnet_config.ini | X | X | INI file, text format |
| Spatialindex.bin | | | Spatial index of both links and nodes |

Turn restrictions can be stored in files with flexible naming.

If you set the [Encryption](#)^[29] property, files marked as such in the table will be encrypted during creation and decrypted during load.

1.12 Password protection

You need to enter a password when using a non time-limited version of RW Net.

Call method `InitPassword` for any of these classes after instantiation:

[TImport](#)^[27], [TNetwork](#)^[38], [TTSP](#)^[134], [TTSPcurb](#)^[137]

It is sufficient to supply the password *once* in an application.

1.13 Progress events

Progress events are available for these methods:

[TImport.execute](#)^[30] (+)
[TImportAttributes.execute*](#)^[32] (+)
[TImportSQL.executeMSSQL](#)^[37] (+)
[TImportSQL.executePOSTGIS](#)^[38] (+)

[TNetwork.AttributeSave](#)^[43]
[TNetwork.ExportLinks](#)^[48]
[TNetwork.ExportLocationList](#)^[49]
[TNetwork.ExportNodes](#)^[49]
[TNetwork.Join](#)^[69]
[TNetwork.ObjectCheck](#)^[56]
[TNetwork.Open](#)^[57]
[TNetwork.ParallelLinks](#)^[58]
[TNetwork.TurnImportTXT](#)^[65]

[TSpatialSearch.FindNonConnected](#)^[71]
[TSpatialSearch.FindNonConnectedNodes](#)^[72]
[TSpatialSearch.FindOverPasses](#)^[71]
[TSpatialSearch.SplitAndSnap](#)^[75]

[TCalc.MatrixOut](#)^[85]
[TCalc.MatrixDynOut](#)^[85] (+)
[TCalc.SubNet](#)^[96]

[TRouteCalc.MatrixDynCurbIsoChrono](#)^[100]
[TRouteCalc.MatrixDynCurbRoute](#)^[100]
[TRouteCalc.SubNetEx](#)^[101]

[TTSP.execute](#)^[135]
[TTSPcurb.executecurb](#)^[137]

[TVoronoi.execute](#)^[112]

Assign the `OnProgress` event to follow progress and eventually cancel the calculations. The events steps from 0 to 100 and as a minimum for every 2 seconds.

(+): Cancel request is supported in these methods. Check property `Cancelled` afterwards to check if the user cancelled.

1.14 MapBasic DLL

The rwnet4.dll is aimed for use with MapInfo / MapBasic.

Since MapInfo is a single user application, we have made several changes to make development easier.

Rather than doing Create/Free methods, we use pre-allocated objects.

Objects are referenced either indirectly (single instance) or by their index (multi instance).

Classes referenced indirectly:

- [TCalc](#)^[75] / [TRouteCalc](#)^[96]
- [TDrivingDirections](#)^[103]
- [TGISwrite](#)^[115]
- [TImport](#)^[27]
- [TImportAttributes](#)^[32]
- [TNetwork](#)^[38]
- [TOptimizer](#)^[127]
- [TRandom](#)^[150]
- [TRoadClassSpeed](#)^[151]
- [TRoadClassTurnCost](#)^[151]
- [TRoute](#)^[163]
- [TSpatialSearch](#)^[71]
- [TStepList](#)^[148]
- [TTrafficList](#)^[148]
- [TTSP](#)^[134]
- [TTSPcurb](#)^[137]
- [TVoronoi](#)^[109]

Classes / types referenced by index (handle):

| | Number of instances | Null-element |
|---|---------------------|--------------|
| TApproachArray ^[155] | 2 | |
| TBitArray ^[149] | 3 | Yes |
| TCostArray ^[157] | 2 | Yes |
| TCurbMatrix ^[157] | 1 | |
| TFloatPointArrayEx ^[158] | 2 | |
| TIntegerArray ^[159] | 2 | |
| TIntegerList ^[148] | 2 | Yes |
| TLocationList ^[148] | 2 | Yes |
| TMatrix ^[160] | 2 | |
| TStringList ^[151] | 2 | Yes |
| TWordArray ^[165] | 2 | |

If null-element is true, you can pass 0 as index / handle, when you want to pass nil as parameter.

Function naming convention

TImport.Execute becomes TImport_Execute.

TCalc.IsoCost becomes TCalc_IsoCost.

etc.

Some method names have been shortened due to max length = 31 characters.

[TCalc](#)^[75] and [TRouteCalc](#)^[96] are both referenced as TCalc.

All definitions can be seen in the rwnet4.def file along with a sample application, covering key areas. MapInfo 15.2.2 and onwards require "ALIGN1" for custom data types.

If you are using an older mapbasic version, just remove it from the def file.

Warning: You can not combine older mapbasic compilers with MapInfo 15.2.2+, if you are also using any of the custom data types.

Password initialization

Call method "[InitPassword](#)^[12]".

Codepage

Since RW Net 4 is Unicode enabled and Mapbasic isn't, it is required to do an internal conversion in all function calls involving strings.

This is handled automatically through a global variable, which sets the codepage you are using in MapBasic.

Default is the system codepage.

Methods: [GetCodepage](#) / [SetCodepage](#).

GIS output format

There is a global variable for output format, which is [gfMITAB](#)^[158] by default.

This means it is skipped from all function calls having a gisformat parameter.

Methods: [GetGISformat](#) / [SetGISformat](#).

Colours are read/set in MapInfo colour format (RGB <> BGR), while the .NET and VCL versions uses windows colour scheme.

Error handling

If an error happens when calling a method, you can use one of these 2 functions to test it:

[GetLastExceptionClass](#)

[GetLastExceptionMessage](#)

The messages are cleared after each successful method call.

Progress Events

These can all be turned on/off by calling [ShowProgress](#) with 0/1 as parameter.

The progress is then shown with a built-in dialog.

Missing functionality compared with VCL / .NET version

- [GISarray](#)^[78] output as format
- Direct access to [TPolyGeneration](#)^[150]

1.15 Data Sources

At RouteWare [website](#) you will find a list of street data providers for various parts of the world. Data from these providers usually have a topological correct structure, which means they are almost ready to be used in RW Net.

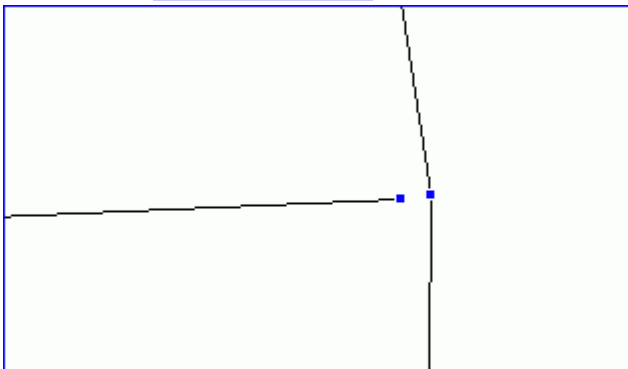
But how should your own street data look like, in order to be used in RW Net?

- *They need to snap*
- *They need to split at intersections*
- *The network should be plane unless there is an overpass*
- *You should avoid subnets (islands)*
- *You should avoid very long links, which have a negative impact on speed of certain calculations*

Below is shown some examples on networks, which are NOT correct, but all look correct unless you check out the details:

Example 1: Missing snap at an intersection

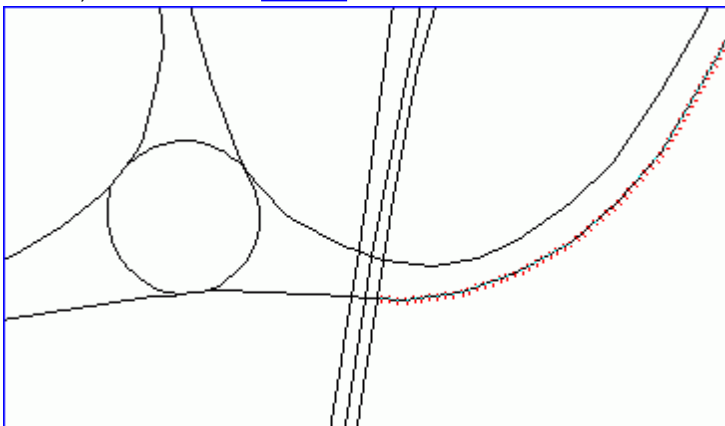
This means the network doesn't connect and the movement to / from the disconnected section, isn't possible. In the example below, the gap is just 1 meter and can't be seen at normal zoom levels. Use function [FindNonConnected](#)^[71] to detect these situations.



Example 2: Split at overpass / underpass

This means a lot of impossible turn movements are suddenly made possible. This is a typical problem with TIGER data.

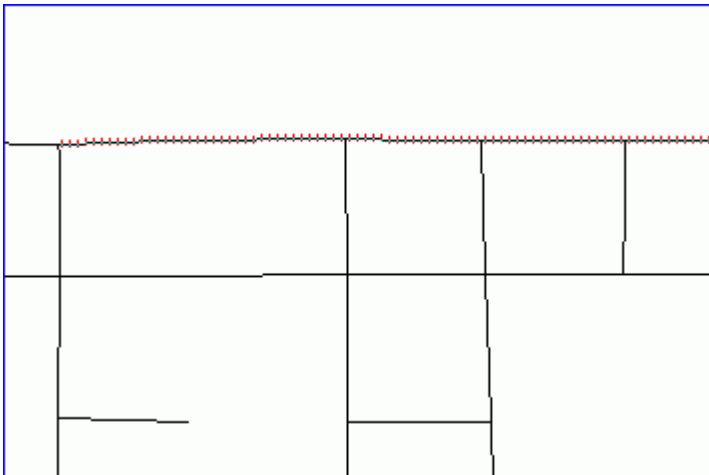
There is no single logical check to detect these situations, it is a simple shortcoming of the data source, if there are no [Z-levels](#)^[17].



Example 3: Doesn't split/break at intersections

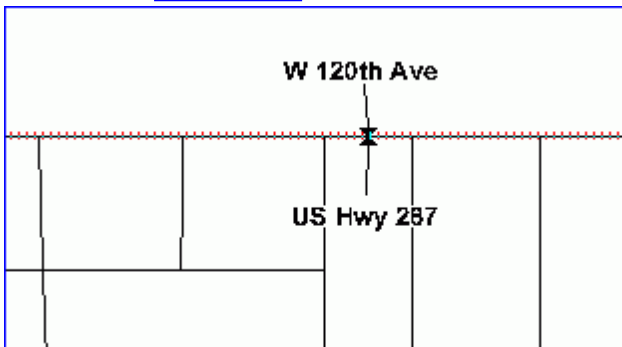
This means turns are not possible at most intersections.

Use function [Split](#)^[75] or [FindNonConnected](#)^[71] to detect where this is most likely an issue.

**Example 4: Double digitization with two street names, here name + route number**

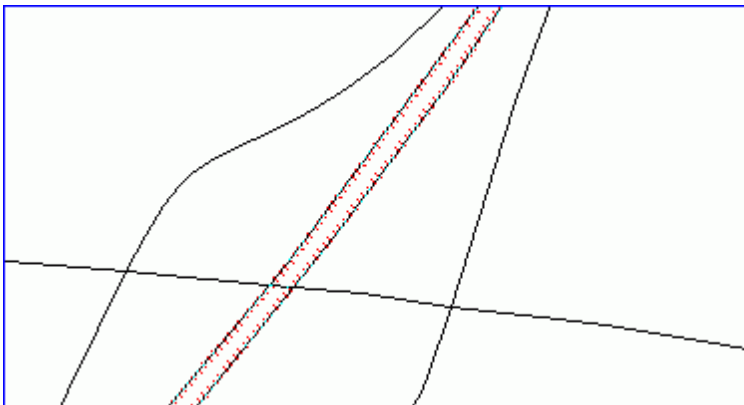
Not a really big problem, but the result of a route calculation may include one of the two streets in a more or less random fashion.

Use function [ParallelLinks](#)^[58] to detect such situations.

**Example 5: Multi sectioned polylines**

Polylines with more than 1 section are ignored. They will not be part of any route, since there is no logical start/end of the link.

These will be reported during network import in either [ImportErrorList](#)^[30] or in the [network_report.txt](#)^[29].



1.16 Z-Levels

Z-level is an integer from -9 to 9, which specifies the vertical level of streets: One number for the start of the link (Z-from) and one for the end of the link (Z-to).

The information is used during the [import](#) process to adjust coordinates slightly (10 cm) to prevent nodes at different Z-levels to have the same coordinates. The modification is only applied, if Z-level<>0.

It is commonly found in commercial street databases (HERE, TomTom, ITN etc.).

If your dataset contains fromnode and tonode for the links instead of Z-level information, use [ExternalNodeId2ZLevels](#) for a transformation.

1.17 Isochrones - overview

Generating nice-looking isochrones has always been a key functionality of routing software and RW Net 4 offers several methods, which are shown below.

As you will see, generating the same N km isochrone with different methods do not give the exact same output.

That is also why we generally do not recommend using the isochrones for point-in-polygon analysis as a way of finding out which customers are less than N km away.

Rather use the various matrix functions for finding distance between multiple points. This also allows you to include the off-road part in the calculations.

This table gives an overview of the key differences between the methods:

| | DriveTimeSimple | DriveTimeSimple(Dyn) | Voronoi | IsoLinkDriveTime(Dyn) | IsoLinkDriveTime | Alpha shapes |
|-----------------------|---------------------------------|--------------------------------------|-------------------------|---------------------------------------|----------------------------------|------------------------------|
| Input | 1 node | 1 location | nodes & locations | 1 location | nodes | nodes & locations |
| TPolyGeneration input | | | Yes | | | Yes |
| Speed of calculations | 15 ms | 36 ms | 47 ms | 78 ms | 109 ms | 125 ms |
| Holes | | | Yes | | | |
| Islands | | | Yes | | | Yes |
| Doughnut mode | Yes | Yes | Yes | | | |
| Smoothing | Yes | Yes | Yes | | | |
| Shown on map as: | Blue line | (not shown) | Yellow polygon | (not shown) | Black network | Brown line |

Alpha shapes and DriveTimeSimple(Dyn) all tries to follow the perimeter of the network, which can be reached from the starting point(s).

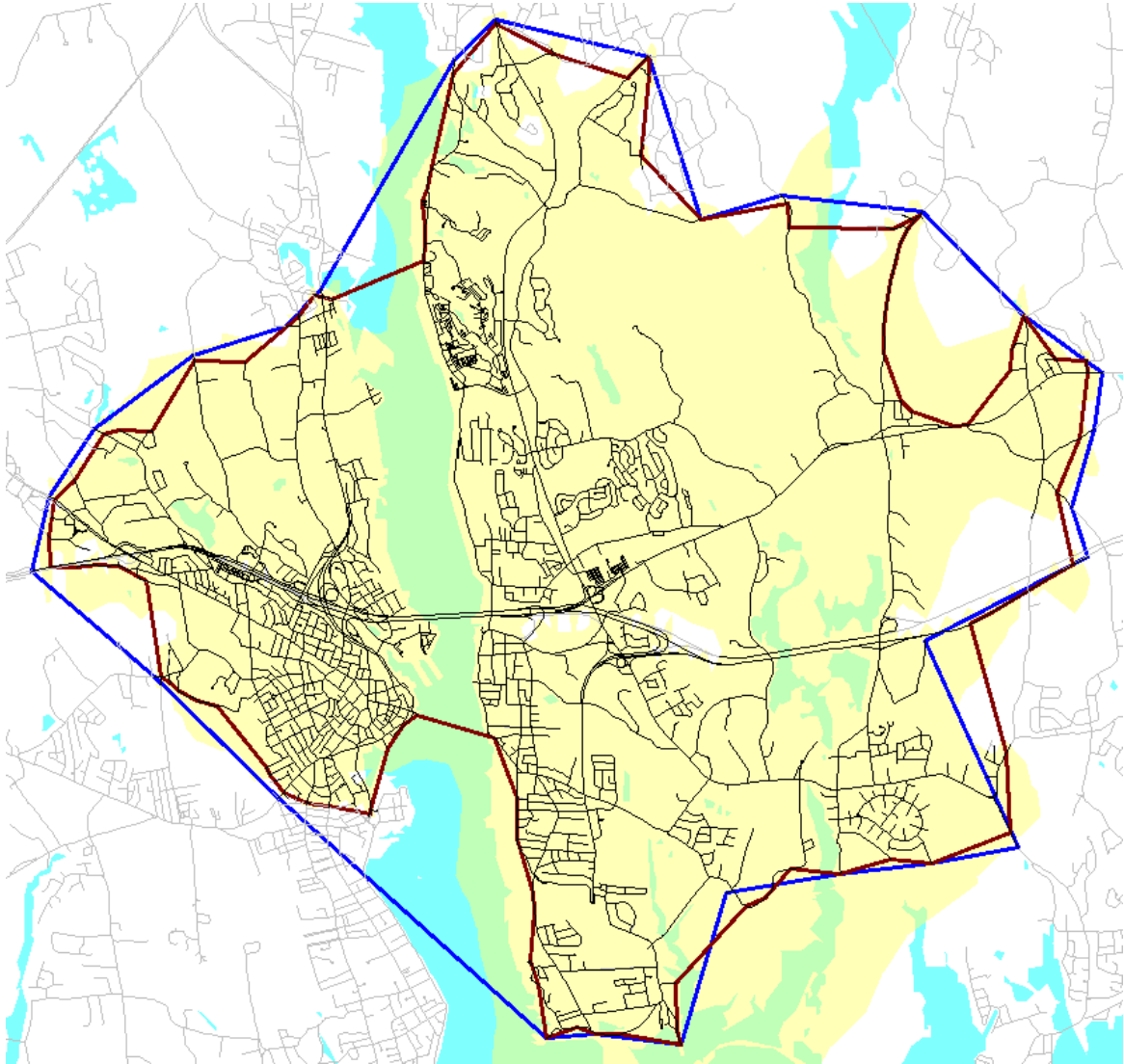
They do not take into consideration any unreachable parts of the network (the grey lines), so they may get included in the output polygon anyway.

Voronoi on the other hand follows the line between what can be reached (black network) and what can not be reached (grey network).

Alpha shapes can not be calculated in doughnut mode, since 2 polygons may actually be intersecting, due to the way they are calculated.

IsoLinkDriveTime(Dyn) is the most accurate, so for comparison it is included. But it is a much different kind of output.

Timings above are for the 7 km isochrones shown below with [addnodes = 0.3 km](#)⁸³:



1.18 Check List

Sometimes a calculation returns a different result (route) compared to what you expected or you get no route at all. Both situations are due to issues somewhere in the network and these can be hard to locate.

This is a list of things to check:

- Look inside network_report.txt (generated when calling [TImport.execute](#)^[30]):
 1. Are you using the latest version of RW Net?
 2. Is the coordinate unit detected correctly?
 3. Should Z-level information have been applied?
 4. Do some of the objects have errors?
 5. Is the average object length realistic?
- Check for network errors. See also [data sources](#)^[14].
- Reduce the setup as much as possible:
 1. Call [Open](#)^[57](false,false,0) (removes one-way restrictions)
 2. Set Turnmode = false, when creating TCalc instance
 3. Set [Hierarchy](#)^[99] = false
 4. Skip [Limits](#)^[89]
 5. Use [SetShortest](#)^[90]
 6. Set [Alpha](#)^[97] = 0
 7. Set [NoDriveThrough](#)^[88] = false

If this solved the problem, enable these again one by one, until it fails. Then you know where to look.

- Create maps in your GIS identifying the problem:
 1. Look at basic map for no physical connection (missing bridge / ferry etc)
 2. Create a thematic map of one-way directions and closed links
 3. Create a thematic map of attribute field
 4. Create a thematic map of hierarchy attributes etc.
 5. Call [TurnExportGIS](#)^[65] to view turn restrictions
 6. Call [FindNonConnected](#)^[71] from RW Net Pro
 7. Call [SubNet](#)^[96] from RW Net Pro

If you have multiple points (Matrix or TSP function), it can be tricky to locate which point makes the trouble. One method is to calculate with 2 points first. If that works OK, try with 3 points, then 4 points etc, until the problem pops up. Now the problem is usually somewhere near the last point being added.

1.19 Changes from RW Net 2

New functionality

Full Unicode support

Improved .NET support (Compact Framework and Mono for instance)

Nodes can be "closed" in point-to-point routing

Links can be "closed" in point-to-point routing (No-Drive-Through bit)

Complex turn restrictions

Automatic identification of left/right turns

Travelling salesman optimization with support for curb approach

Travelling salesman optimization with time windows

Output to array format instead of files on disk (known from RW NetServer 3)

Minimum spanning trees

Improved functionality

Better developer experience (more OOP)
 Improved flexibility
 Much faster spatial searches
 Overall calculation speed

Changes in behaviour

Loop links are not allowed by default.
 Networks with loop links do not work in route calculations (TCalc, TRouteCalc, TDrivingDirections).
 Starting 1-1-2012.
 Percentages in locations can now also be exact 0 or 1. No need to use 0.0001 or 0.9999
 Side in locations are defined differently
 The attribute field is differently defined for a few of the bits ("mode" is gone)
 Alpha parameter is by default 1 (enabled)

Changes in setup

File format is different with an INI file introduced (can be replaced with an event if desired). Even though some file names may be the same, the content may be changed
 Road names are now stored in Unicode format, making import/export easier
 Coordinate system is normally detected automatically during import
 Coordinate system don't have to be specified when opening network, since it is stored in the INI file
 Routes modes are now shortest, fastest or cheapest - it used to be shortest or fastest/cheapest
 Distances, speeds etc. are in km (SI-unit). Miles can only be used in a few output-to-file functions
 Password for initialization is now also needed in the Delphi versions.

Functions removed

Isogrid
 NWcreateCGF
 ResultFile & ResultSave
 RouteSave
 All functions listed as obsolete in RW Net 2 documentation
 COM version

Functions renamed

AirDistNode: [DistanceBetweenNodes](#)^[47]
 AirDistPos: [DistanceBetweenPoints](#)^[47]
 AttributeCreate(2): [ExecuteAttribute](#)^[34]
 AttributeLoad: [Open](#)^[57]
 Assignment: [TrafficAssignment](#)^[102]
 CloseLink: [OneWaySet](#)^[57]
 Coordinate2Location: [NearestLocation](#)^[73]
 Coordinate2LocationSimple: [NearestLocationSimple](#)^[73]
 Coordinate2Node: [NearestNode](#)^[73]
 CulDeSac: [CulDeSac](#)^[47] & [SubNetEx](#)^[101] & [Bridges](#)^[99]
 District: [District](#)^[131]
 ExternidImport: [ExecuteExternalidInt](#)^[34] / [ExecuteExternalidString](#)^[35]
 ExternIDfindID: [Link2ExternalID](#)^[54]
 ExternIDfindIndex: [ExternalID2Link](#)^[50]

FindCloseNodes: [FindNonConnected](#)^[71]
 GetLinkDist: [LinkLength](#)^[53]
 GetOpenStatus: [OneWayGet](#)^[56]
 IsoLink2: [IsoLinkDriveTime](#)^[80]
 IsoLink2Dyn: [IsoLinkDriveTimeDyn](#)^[82]
 IsoLink4: [IsoLinkServiceArea](#)^[82]
 IsoPoly2: [TVoronoi](#)^[109] with mode = vmIsoChrono
 IsoPoly3: [TVoronoi](#)^[109] with mode = vmSimple
 IsoPoly4: [TVoronoi](#)^[109] with mode = vmServiceArea
 LimitCreate: [ExecuteLimit](#)^[35]
 LimitLoad: [OpenLimit](#)^[57]
 LimitLoad_bitpattern: [OpenLimit](#)^[57]
 Linkmax: [Linkcount](#)^[53]
 NetworkCenter: [CenterNode](#)^[93] / [Cluster2](#)^[129] / [Cluster3](#)^[130]
 NetworkLength: [Length](#)^[53]
 NodeCreate: [ExportNodes](#)^[49]
 NodeLinkCheck: [FindNonConnected](#)^[71]
 Nodemax: [Nodecount](#)^[55]
 NodeX, NodeY: [Node2Coordinate](#)^[55]
 NWcreate: [TImport.execute](#)^[30], [ExportNodes](#)^[49], [ObjectCheck](#)^[56]
 NWload: [Open](#)^[57]
 NW3Dnodes: [ExternalNodeId2ZLevels](#)^[50]
 Overpasses: [FindOverPasses](#)^[71]
 RoundAbout: [AttributeGetBit](#)^[42](link, 11)
 RouteList: [TDivingDirections](#)^[103]
 UnusedLinks: [UnusedLinks](#)^[96]
 Valency: [Degree](#)^[47]

Functionality not added yet

CPP / MRPP & EulerRoute
 FindRoundAbout
 HierarchyCheck1
 HierarchyCheck2

1.20 License Terms

Platforms

A license gives access to available versions as listed in the schema below. Within the first year licenser has access to updates and new versions.

| | Standard | Pro |
|----------------------------|----------|-----|
| Delphi XE | | Yes |
| Delphi XE2 - XE8, 32 bit | Yes | Yes |
| Delphi XE2 - XE8, 64 bit | | Yes |
| .NET | Yes | Yes |
| .NET Silverlight | | Yes |
| DLL for MapInfo / MapBasic | | Yes |

Support

A license gives access to support as listed below for the first year:

| | | |
|---------------------------|---------------------|---------------------|
| | Standard | Pro / Standard site |
| E-mail support | ASAP after 24 hours | ASAP |
| Telephone / Skype support | | Yes |

E-mail support includes answering questions, which do not involve writing source code of >10 lines. Only persons with a license can receive support.

After first year, support and maintenance can be extended for one more year at a time.

Deployment / distribution

This table lists how deployment of applications is allowed for different versions of RW Net:

| | | |
|---|---------------------------------------|---------------------------------------|
| | Standard | Pro |
| Deployment of desktop applications | Only within own organization | Allowed |
| Deployment of server application | See website for price | See website for price |
| Deployment of TImport 27) functionality | See website for price | See website for price |

It is a server application if:

- The application has an API, which makes the routing functionality accessible from other applications or
- The routing functionality is available from other computers through a network (web service, REST, cgi etc.)

General terms

Licensors is allowed to use RW Net for as long as he/she doesn't violate this license.

Licensors is not allowed to:

- Distribute applications outside it's own organization, which competes directly with RouteWare's own applications: RouteFinder, RW NetServer and FleetEngine.
- Wrap up RW Net in component-like structures and distribute it.

If licensors holds a personal license, he/she can either:

- 1) Have only 1 named person using RW Net on as many computers as he/she like or
- 2) Install it on 1 physical computer (doesn't include terminal services, citrix and similar setups) and let several persons use it from there (support is still only given to 1 person)

If licensors holds a site license, it allows an unlimited number of persons at licensors site to use RW Net at the same time. Ask RouteWare for enterprise-wide licenses.

Licensors of RW Net are issued a personal [password](#) 12) to activate the software. This password must not be readable to end-users of deployed applications. It is the responsibility of licensors to ensure that this is taken care of.

The usual legal stuff

All copyrights belong to RouteWare (Uffe Kousgaard).

Disassemble or reverse engineering of RW Net binaries are not allowed.

Licensors is not allowed to install RW Net on a network drive or shared drive except for backup

purposes.

Licensor is not allowed to sell or in any other way hand over the right to use the software to any other party.

RouteWare is not responsible for any problems, direct or indirect, which RW Net may cause - no matter what the reason may be.

Any problem / error will be corrected as fast as possible within normal business hours. If RouteWare is not able to correct problems, which to a severe degree affect the functionality of the software, a refund is made, which matches the degree to which the software doesn't function properly. This refund is based on what the licensor has paid within the last 12 months and cannot exceed this amount.

Updated Jan 2014

Part II

Main Classes

2 Main Classes

2.1 TImport

These classes (TImport & TCustomImport) are used for importing the main geography part of a network.

Using this class in applications that you deploy to other users, requires an additional runtime license. See [license terms](#).

TImport

[Add](#)

[AddFiles](#) (only available in RW Net Pro)

[Execute](#)

[ZfromField & ZtoField](#) *

TCustomImport (only available in RW Net Pro)

[Execute](#)

[OnImportLink](#) *

Shared properties / methods:

[AllowLoops](#) *

[CoordinateUnit](#) *

[CoordSys](#) *

[Directory](#) *

[EPSG](#) *

[Encryption](#) * (only available in RW Net Pro)

[MaxNodesPerCell](#) *

[PRJ](#) *

[SkipSpatialIndex](#) *

[CreateReport](#)

[ImportErrorList](#)

[LinkCount](#)

[MaxDegree](#)

[MBR](#)

[NodeCount](#)

[StartTime](#)

[StopTime](#)

[TotalLength](#)

* = Properties that may be set before calling [execute](#). Default values are sufficient in most cases.

2.1.1 Add

Call this method to add a single file to the list of files for processing by [Execute](#) method.

Adding a TAB file requires that the corresponding MAP and ID files are also present.

Adding a SHP file requires that the corresponding SHX file is also present.

Adding a MIF file requires no further files.

You can not mix different file types.

Extended TAB files from MapInfo 15.2 (64-bit) and onwards ("NATIVEX") are supported.

Syntax: Add(filename: string)

In RW Net Standard you can only add 1 file in total. If you add another one, the previous one gets removed from the list.

2.1.2 AddFiles

This method can be used to [add](#)^[27] multiple files at a time.

Syntax: AddFiles(files: [TStringList](#)^[157])

Only available in RW Net Pro.

2.1.3 AllowLoops

This property can be used to define if loop links are allowed in datasets. A loop link is one, where the first and last vertex is the same.

If AllowLoops is false (default), loop links will be [reported](#)^[30] during the import process.

If AllowLoops is true, the existence of any loop links will prevent the use of [TRoute](#)^[163], [TRouteCalc](#)^[96] and [TDrivingDirections](#)^[103].

We recommend that loop links are split into 2 links in advance.

Databases without loop links: TomTom, Navteq, OSM, ITN and Meridian 2.
Databases with loop links: NVDB and DAV.

Type: Boolean

2.1.4 Cancelled

You can check this read-only property after calling [Execute](#)^[30].
If true, the user stopped the process.

Type: boolean

2.1.5 Clear

This method will clear the list of files.

2.1.6 CoordinateUnit

Coordinate unit will automatically be detected for MIF and TAB files.
For SHP files it will happen automatically if a PRJ file exists.

For other situations, it should be set by the user or an error will be raised during import.

Default: cuUnknown

Type: [TCoordinateUnit](#)^[156]

2.1.7 CoordSys

This string property is a MapInfo coordinate clause.

If you import from a MIF or TAB file, it property will automatically be set during execution.

You can set it manually, if you plan to export to MIF or TAB using [TGISwrite](#)^[115] or one of the other functions writing to GIS files.

Otherwise it will be set to a default value (Non-Earth coordsys) that matches [CoordinateUnit](#)^[28] and the coordinates in the file.

Type: String

2.1.8 CreateReport

Call this method after calling execute to generate a report on the import process. This is similar to the report from RW Net 2.

Filename is always network_report.txt and it is stored in the same folder as the other bin files.

Syntax: CreateReport

2.1.9 Directory

This property points to where the output files are stored.

Default: Current directory.

Type: String

2.1.10 EncryptionKey

You can set this property if the imported files should be encrypted to prevent other users from using the files. Encrypting makes it harder, but can't fully prevent the very determined and skilled user from getting to your data.

Default value is 0 (no encryption). You can only set it in RW Net Pro.

Type: Int64

2.1.11 EPSG

The EPSG code should be set before importing, if you plan to export to GML files later on.

Default value is 4326 (Lat/Long, WGS84).

Type: Integer

2.1.12 Execute

Call this method when you have defined all input parameters. This is what does the main job.

Syntax: Execute

2.1.13 FailOnDifferentCoordSys

This property is used for controlling import of multiple TAB or MIF files.

If true (default), it will stop when different CoordSys' are encountered.

Type: Boolean

2.1.14 ImportErrorList

This read-only property keeps a list of problematic links in the input data source, found during import process. Content of the list is also written to the [report](#)^[29].

Type: [TImportErrorList](#)^[147]

2.1.15 LinkCount

This read-only property returns the total number of links after calling [execute](#)^[30].

Type: Integer

2.1.16 MaxDegree

This read-only property returns the maximum degree of the network after calling [execute](#)^[30].

Type: Integer

2.1.17 MaxNodesPerCell

This property can be used to define how detailed the spatial index should be. Set the value before importing.

A higher value decreases the size of the file and memory foot print, but reduces speed of spatial searches.

Default value is 50. Minimum value is 25.

Type: Integer

2.1.18 MBR

This read-only property reports the minimum bounding rectangle (MBR) after import

Type: [TFloatRect](#)^[158]

2.1.19 NodeCount

This read-only property returns the total number of nodes generated after calling [execute](#)^[30].

Type: Integer

2.1.20 OnImportLink

In class TCustomImport assign this event to read custom data:

Parameters:

- 1) Link is automatically increased by one every time.
- 2) Vertices: This is a list of vertices (coordinates).
- 3) VertexCount: Indicates the number of vertices on the list. The list may be longer than actual number of elements.
- 4) Zfrom, Zto: [Z-levels](#)^[17] for the link.
- 5) LastLink: Set this to true, when you have reached the last link to be read.

All links will be traversed twice. Depending upon your source of data, it may be faster to extract to a MIF file first.

Syntax: OnImportLink(link: integer; var vertices: [TFloatPointArray](#)^[158]; var vertexcount: [TVertexCount](#)^[164]; var Zfrom, Zto: integer; var LastLink: boolean)

2.1.21 PRJ

This string gets updated during the import process, if a PRJ file exists along with a SHP file and no coordinate unit has been specified.

Type: String

2.1.22 SkipSpatialIndex

This property allows you to skip creation of the spatial index during import to save time and disk space.

Spatial index is needed by [TSpatialSearch](#)^[71].

The spatial index can not be created later on, unless you re-import the data.

Default: false

Type: Boolean

2.1.23 Starttime

This read-only property reports when importing started.

Type: TDateTime

2.1.24 Stoptime

This read-only property reports when importing stopped.

Type: TDatetime

2.1.25 TotalLength

This read-only property returns the total length for all links after calling [execute](#)^[30].

Type: Double

2.1.26 ZfromField & ZtoField

These 2 properties are used for describing [Z-level](#)^[17] in input data.

The 2 properties refer to the field ID in the same way as it is being done in class [TImportAttributes](#)^[32]. First field has index 0.

For TAB files, the execute command will automatically look for .DAT files.
For MIF files, the execute command will automatically look for .MID files.
For SHP files, the execute command will automatically look for .DBF files.

Set both values ≥ 0 to apply.

Default: -1

Type: Integer

2.2 TImportAttributes

This class is for importing attribute information for the links in the network.

| | File-based | Event-based |
|--------------------------|---|--|
| Attributes | ExecuteAttribute ^[34] | ExecuteAttributeEvent ^[34] |
| External ID's (integers) | ExecuteExternalidInt ^[34] | ExecuteExternalidIntEvent ^[35] |
| External ID's (strings) | ExecuteExternalidString ^[35] | ExecuteExternalidStringEvent ^[35] |
| Limits | ExecuteLimit ^[35] | ExecuteLimitEvent ^[35] |
| Road names | ExecuteRoadname ^[36] | ExecuteRoadnameEvent ^[36] |

Before calling any of the file-based methods above, call function [Add](#)^[32] to add a list of files to import from. Supported file formats include DBF, DAT, MIF and CSV.

If you rather want to import using events, use one of these procedures mentioned in the column with event-based methods.

2.2.1 Add

Call this method to add a single file to the list of files for processing by one of the execute methods.

You can add DBF, DAT, MID and CSV files, but not mix different file types.

If you use CSV files, remember to set [CodePageCSV](#)^[33]. Codepage for other file types gets auto-detected: DAT files from their TAB counterpart and MID files from their MIF counterpart. DBF gets detected from the internal header.

Syntax: Add(filename: string)

In RW Net Standard you can only add 1 file in total. If you add another one, the previous one gets removed from the list.

2.2.2 AddFiles

This method can be used to [add](#)^[32] multiple files at a time.

Syntax: AddFiles(files: [TStringList](#)^[157])

Only available in RW Net Pro.

2.2.3 Cancelled

You can check this read-only property after calling one of the execute functions, except for the event based ones.

If true, the user stopped the process.

Type: boolean

2.2.4 Clear

This method will clear the list of files.

2.2.5 CodepageCSV

When reading from CSV files, set this property to the codepage used.

Default: Codepage of the local system.

Type: [TCodePage](#)^[155]

2.2.6 CodepageDBF

When reading from DBF/DAT files, set this property to the codepage used. Normally leaving it to 0 is sufficient, but DBF files from OpenStreetMap uses UTF-8, which isn't supported natively by DBF format. In that case set it to 65001.

If set to 0, it uses the codepage byte inside the file header. If that byte is 0 too, it uses the codepage of the local system.

Default: 0.

Type: [TCodePage](#)^[155]

2.2.7 Directory

This property points to where the output files are stored.

Default: Current directory.

Type: String

2.2.8 EncryptionKey

You can set this property if the imported files should be encrypted to prevent other users from using the files. Encrypting makes it harder, but can't fully prevent the very determined and skilled user from getting to your data.

Default value is 0 (no encryption).

Type: Int64

Only available in RW Net Pro.

2.2.9 ExecuteAttribute

Call this procedure to import attribute information from one or more files.

Specify fieldindex (0-based) or fieldname for fk = fkDBF. If fieldname is specified, it takes precedence.

Syntax: ExecuteAttribute(fieldindex: integer; fieldname: string; fk: [TFileKind](#)¹⁵⁷)

2.2.10 ExecuteAttributeEvent

Assign event OnReadAttribute for importing attributes. When the last record has been reached, set lastrecord = true.

TAttributeReadEvent = procedure(Sender: TObject; link: integer; var attribute: word; var lastrecord: boolean);

Syntax: ExecuteAttributeEvent

2.2.11 ExecuteExternalIDInt

Call this procedure to import external ID information from one or more files, when the field is an integer field.

If the value read doesn't fit into an [integer](#)¹⁵⁵, specify useint64 = true and an [int64](#)¹⁵⁵ will be used instead.

Int64 formatted files can only be opened with RW Net 4.18 or newer.

Specify fieldindex (0-based) or fieldname for fk = fkDBF. If fieldname is specified, it takes precedence.

Syntax: ExecuteExternalidInt(fieldindex: integer; fieldname: string; fk: [TFileKind](#)¹⁵⁷; useint64: boolean)

2.2.12 ExecuteExternalIDIntEvent

Assign event OnReadExternalIDInt for importing external ID's that are integer based. When the last record has been reached, set lastrecord = true.

Specify useint64 = true and [int64](#)^[155] will be used for storage instead of [integers](#)^[155], allowing much bigger numbers.

TExternalIDReadIntEvent = procedure(Sender: TObject; link: integer; var externalID: int64; var lastrecord: boolean)

Syntax: ExecuteExternalIDIntEvent(useint64: boolean)

2.2.13 ExecuteExternalIDString

Call this procedure to import external ID information from one or more files, when the field is a string field.

Specify fieldindex (0-based) or fieldname for fk = fkDBF. If fieldname is specified, it takes precedence.

Syntax: ExecuteExternalidString(fieldindex: integer; fieldname: string; fk: [TFileKind](#)^[157])

2.2.14 ExecuteExternalIDStringEvent

Assign event OnReadExternalIDString for importing external ID's that doesn't fit in an integer. When the last record has been reached, set lastrecord = true.

TExternalIDReadStringEvent = procedure(Sender: TObject; link: integer; var externalID: string; var lastrecord: boolean)

Specify the maximum width of the strings to be read.

Syntax: ExecuteExternalidStringEvent(width: integer)

2.2.15 ExecuteLimit

Call this procedure to import limit information from one or more files.

Specify fieldindex (0-based) or fieldname for fk = fkDBF. If fieldname is specified, it takes precedence.

Syntax: ExecuteLimit(fieldindex: integer; fieldname: string; fk: [TFileKind](#)^[157])

See also [LimitFileIndex](#)^[36]

2.2.16 ExecuteLimitEvent

Assign event OnReadLimit for importing limits. When the last record has been reached, set lastrecord = true.

TLimitReadEvent = procedure(Sender: TObject; link: integer; var Limit: byte; var lastrecord: boolean)

Syntax: `ExecuteLimitEvent`

2.2.17 ExecuteRoadname

Call this procedure to import road names from one or more files.

Specify `fieldindex` (0-based) or `fieldname`. If `fieldname` is specified, it takes precedence. If reading from MID file, it will automatically lookup the codepage from the MIF file.

Syntax: `ExecuteRoadname(fieldindex: integer; fieldname: string; fk: TFileKind[157])`

2.2.18 ExecuteRoadnameEvent

Assign event `OnReadRoadname` for importing road names. When the last record has been reached, set `lastrecord = true`.

`TRoadNameReadEvent = procedure(Sender: TObject; link: integer; var name: string; var lastrecord: boolean)`

All links will be traversed twice. Depending upon your source of data, it may be faster to extract to a CSV file first.

Syntax: `ExecuteRoadnameEvent`

2.2.19 LimitFileIndex

When calling [ExecuteLimit](#)^[35] or [ExecuteLimitEvent](#)^[35] this property is used in the naming of the output file.

Allowed interval is 1 to 9.

Default: 1

Type: integer

2.2.20 RoadNameFileIndex

When calling [ExecuteRoadname](#)^[36] or [ExecuteRoadnameEvent](#)^[36] this property is used in the naming of the output file.

Allowed interval is 1 to 99.

Default: 1

Type: integer

2.3 TImportSQL

This class can be used to import directly from a GIS enabled database. MS SQL Server, Oracle and PostgreSQL ("PostGIS") all offers storage of gis data, directly inside the database.

We have implemented it for all three and for:

- .NET

- 32/64 bit DLL
- Delphi XE7 - XE8 - 10 - 10.1 - 10.2.

You can reuse the majority of the shared properties from [TImport](#) [27] with this class ([CreateReport](#) [29], [NodeCount](#) [31] etc.).

This class is available with Pro only.

For .NET you need

- MS SQL: [Microsoft.SqlServer.Types.dll](#)
- Oracle: [Oracle.ManagedDataAccess.dll](#)
- PostgreSQL: [Npgsql.dll](#)

For the DLL version it is all compiled into the DLL.

For the VCL version you need to have [UniDAC Pro](#) installed too (version 6.4.15+ is required).

2.3.1 ExecuteMSSQL

This is the main method and is a single call to do all the processing.

The first six parameters always need to be set.

For the rest at least one need to be set. This way you can create just the attribute.bin file or similar if you have the rest in advance.

If geography is true, the field with the geography is automatically detected. For the remaining the fieldname need to be set.

It will automatically look for a MapInfo mapcatalog with additional meta information.

Example set of parameters for a table "roads" that has been uploaded to a local MS SQL Server Express database.

| Parameter | Value |
|------------|------------------------|
| Server | "127.0.0.1\SQLEXPRESS" |
| Database | "GIS1" |
| Username | "GIS_user1" |
| Password | "secret_code" |
| Tablename | "roads" |
| Geography | true |
| Attribute | "attribute4" |
| Roadname | "streetname" |
| Externalid | "ID" |
| Limit | "" |
| ZFrom | "ZFromLevel" |
| ZTo | "ZToLevel" |

Syntax: ExecuteMSSQL(Server, Database, Username, Password, TableName: string; geography: boolean; attribute, roadname, externalid, limit, ZFrom, ZTo: string);

2.3.2 ExecuteORACLE

This method is similar to the one for [MSSQL](#)^[37].

2.3.3 ExecutePOSTGIS

This method is similar to the one for [MSSQL](#)^[37].

2.3.4 LimitFileIndex

When calling [ExecuteMSSQL](#)^[37] this property is used in the naming of the output file.

Allowed interval is 1 to 9.

Default: 1

Type: integer

2.3.5 RoadNameFileIndex

When calling [ExecuteMSSQL](#)^[37] this property is used in the naming of the output file.

Allowed interval is 1 to 99.

Default: 1

Type: integer

2.4 TNetwork

This is the main class that holds all the information about the street network, while the other classes ([TSpatialSearch](#)^[7], [TRouteCalc](#)^[96], [TCalc](#)^[75]) link to this, when doing calculations. Whatever you define here, is shared by all the other classes linking to it.

Besides holding the core network (geometry, topology, spatial index), it also allows you to work with other types of information: Attributes, time / speed, cost, road names, turn restrictions, limits etc.

This is a list of available methods / grouped by area: (*) = Pro only.

Basic opening & closing of the network

[Directory](#)^[47]

[EncryptionKey](#)^[48]

[LinkLimit](#)^[54]

[Open](#)^[57]

[Close](#)^[45]

Geometry & topology

These are generally fairly simple lookup functions returning information requiring little processing.

[CoordinateUnit](#)^[45]

[CoordinateWindow](#)^[46]

[CulDeSac](#)^[47]
[Degree](#)^[47]
[ExtractSection](#)^[51]
[GetGISSection](#)^[52]
[Length](#)^[53]
[Link2FromNode](#)^[53]
[Link2ToNode](#)^[53]
[LinkCount](#)^[53]
[LinkLength](#)^[53]
[Location2Coordinate](#)^[54]
[Location2CoordinateList](#)^[54]
[LoopLink](#)^[54]
[LoopLinks](#)^[55]
[MaxDegree](#)^[55]
[MBR](#)^[55]
[Node2Coordinate](#)^[55]
[Node2Link](#)^[69] (*)
[NodeCount](#)^[55]
[SwapList](#)^[62]

Attributes

See this introductory chapter on [attributes](#)^[6]

[AttributeGet](#)^[42]
[AttributeGetBit](#)^[42]
[AttributeSave](#)^[43]
[AttributeSet](#)^[43]
[AttributeSetBit](#)^[43]
[AttributeSetBits](#)^[43]
[AttributeSetSkipInSearchBit](#)^[43]
[Hierarchy](#)^[53]
[OneWayGet](#)^[56]
[OneWaySet](#)^[57]
[OpenAttributes](#)^[57]
[NoDriveThroughInit](#)^[56]
[NoDriveThroughSet](#)^[56]
[RoadClass](#)^[59]
[SwapOneWay](#)^[62]

Time

Time is defined as minutes and is the criteria for routing in [fastest](#)^[89] mode

[CreateArrayTime](#)^[46]
[CalculateTime](#)^[44]
[ReadTime](#)^[59]
[GetTime](#)^[52]
[SetTime](#)^[61]

Speed

Internally speed is always stored as time for each link, so if you change one, you also change the

other.

[ReadSpeed](#)^[59]
[GetSpeed](#)^[52]
[SetSpeed](#)^[61]

Cost

Use cost, when you want a more flexible routing criteria than just time or distance.

[CreateArrayCost](#)^[46]
[CalculateCost](#)^[43]
[ReadCost](#)^[59]
[GetCost](#)^[52]
[SetCost](#)^[61]

Turn restrictions

See this introductory chapter on [turn restrictions](#)^[9].

[CreateArrayTurn](#)^[46]

[TurnAutoProcess](#)^[62]
[TurnImportBin](#)^[65]
[TurnImportTxt](#)^[65]

[TurnRestriction](#)^[67]
[TurnRestrictionComplex](#)^[67]
[TurnStandard](#)^[67]
[TurnMandatory](#)^[66]
[TurnReset](#)^[66]

[TurnExportBin](#)^[65]
[TurnExportGIS](#)^[65]
[TurnExportTxt](#)^[65]

Road Names

These are mostly used when creating driving directions.

[OpenRoadName](#)^[58]
[Link2RoadNameID](#)^[54]
[Link2RoadName](#)^[54]
[RoadName2RoadNameID](#)^[59]
[RoadNameID2RoadName](#)^[60]
[RoadNameMaxWidth](#)^[60]
[CloseRoadNameFile](#)^[45]

External ID

See this introductory chapter on [external ID](#)^[9].

[ExternalID2Link](#)^[50]

[Link2ExternalID](#)^[54]

Limits

See this introductory chapter on [limits](#)^[9].

[OpenLimit](#)^[57]

[GetLimit](#)^[52]

[SetLimit](#)^[61]

TRoute methods

Methods operating on a [TRoute](#)^[163] instance (output from route calculation).

[GetGISSectionRoute](#)^[52]

[RouteLength](#)^[60]

[NoDriveThroughCheck](#)^[56]

Check functions

These are functions for verifying input. They are used internally by most of the other methods, so you generally don't need to call them on your own.

[CheckCoordinate](#)^[44]

[CheckExternOpen](#)^[44]

[CheckLink](#)^[44]

[CheckLocation](#)^[44]

[CheckLocationList](#)^[44]

[CheckNode](#)^[45]

[CheckNodeList](#)^[45]

[CheckOpen](#)^[45]

[CheckTurnIndex](#)^[45]

Export

Methods for exporting data to a GIS file, so you can view the actual data.

[ExportLinks](#)^[48]

[ExportLinksFullSplit](#)^[49]

[ExportLocationList](#)^[49]

[ExportNodeList](#)^[49]

[ExportNodes](#)^[49]

[ExportPolyGeneration](#)^[49]

[ExportTrafficList](#)^[68] (*)

[TurnExportGIS](#)^[65]

Advanced methods

These are more complex methods doing various sorts of calculations / analysis.

[Direction](#)^[47]

[DistanceBetweenNodes](#)^[47]

[DistanceBetweenPoints](#)^[47]

[DistanceToLink](#)^[48]
[DistanceToLinkSimple](#)^[48]
[DistanceToNode](#)^[48]
[DownStream](#)^[68] (*)
[ExternalNodeId2ZLevels](#)^[50]
[Join](#)^[69] (*)
[Matrix](#)^[55]
[MatrixDyn](#)^[55]
[ObjectCheck](#)^[56]
[ParallelLinks](#)^[58]
[Select](#)^[60]
[Split](#)^[62]
[Trace](#)^[70] (*)
[UpdateAlphas](#)^[67]
[UpStream](#)^[71] (*)

GIS output

These 5 properties all define various settings, used when generating GIS output. See [TGISwrite](#)^[115] class.

They are automatically populated when the network is opened.

[Codepage](#)^[45]
[CompactMIF](#)^[45]
[CoordSys](#)^[46]
[EPSG](#)^[48]
[PRJ](#)^[58]

When calling [GISOutputInit](#)^[53] it also inherits these values.

[GISarray](#)^[52] is for storing output, when you have chosen array as output format.

Random places

When you just need some random input data for testing.

[RandomPoint](#)^[58]
[RandomNode](#)^[58]
[RandomLocation](#)^[58]

2.4.1 AttributeGet

This function returns the [attribute](#)^[6] for the link.

Syntax: AttributeGet(link: integer): word

2.4.2 AttributeGetBit

This function returns the [attribute](#)^[6] value for a single bit of the link.

Syntax: AttributeGetBit(link: integer; bit: byte): boolean

Example: AttributeGetBit(link,11) returns true if link 11 has been marked as a round-about link.

2.4.3 AttributeSave

If you have made changes to the attributes, you can save the whole content as a new attribute.bin file. It will use the folder as specified by [Directory](#)^[47] and overwrite an existing file.

Syntax: AttributeSave

2.4.4 AttributeSet

This method will change the whole [attribute](#)^[6] of a link.

Syntax: AttributeSet(link: integer; value: word)

2.4.5 AttributeSetBit

This method will change an [attribute](#)^[6] bit of a single link. Bit is a value from 0 to 15.

Syntax: AttributeSetBit(link: integer; bit: byte; value: boolean)

2.4.6 AttributeSetBits

This method will change an [attribute](#)^[6] bit for all links, according to BA. Bit is a value from 0 to 15.

BA should have one more elements than [LinkCount](#)^[53], since Links are 1-based and [TBitArray](#)^[149] is 0-based.

Syntax: AttributeSetBits(bit: byte; BA: [TBitArray](#)^[149])

2.4.7 AttributeSetSkipInSearchBit

This method will set the SkipInSearch bit for all closed links (both oneway bits set). For open links, the bit is cleared.

Syntax: AttributeSetSkipInSearchBit

2.4.8 CalculateCost

This will update a Cost array index as a linear combination of length and time:

$$\text{Cost}(*, \text{costindex}) = \text{weightlength} * \text{Length}(*, \text{timeindex}) + \text{weighttime} * \text{Time}(*, \text{timeindex})$$

Syntax: CalculateCost(costindex: integer; weightlength, weighttime: TCost; timeindex: integer)

Call [CreateArrayCost](#)^[46] in advance to allocate the index.

Timeindex points to one of the arrays defined through [CreateArrayTime](#)^[46]. If weighttime = 0, value of timeindex is ignored.

If both weights are <> 0, we recommend setting weighttime = 1. This ensures the values can be interpreted as time easily and be used together with turn delays if needed.

2.4.9 CalculateTime

This will calculate time on all links, by looking up the speed in the RCS array, based upon the road class [attribute](#)^[6]:

$$Time(*,index) = Length(*) / RCS(attribute(*)) * 60$$

Call [CreateArrayTime](#)^[46] in advance to allocate the index.

See also [TCalc.MaxSpeed](#)^[86].

Syntax: CalculateTime(index: integer; RCS: [TRoadClassSpeed](#)^[151])

2.4.10 CheckCoordinate

This will check if a coordinate is valid.

If using degrees / radians / grads there are natural limits for valid values (-180 to 180, -90 to 90 etc).

For all coordinate units the [coordinatewindow](#)^[46] is used for checking that P is within a certain bounding box of the street network.

By setting CoordinateWindow < 0, this part of check is disabled.

Syntax: CheckCoordinate(P: [TFloatPoint](#)^[158])

2.4.11 CheckExternalOpen

This method checks if the [external ID](#)^[9] has been opened through [Open](#)^[57].

Syntax: CheckExternalOpen

2.4.12 CheckLink

This will check if a link number is valid, i.e between 1 and [LinkCount](#)^[53]. At the same time [LinkLength](#)^[53] has be <> 0.

Syntax: CheckLink(link: Integer)

2.4.13 CheckLocation

This will check if a location number is valid, i.e link is between 1 and [LinkCount](#)^[53] and percent is between 0 and 1.

Syntax: CheckLocation(loc: [TLocation](#)^[160])

2.4.14 CheckLocationList

[Checks](#)^[44] all elements in LL:

Syntax: CheckLocationList(LL: [TLocationList](#)^[148])

2.4.15 CheckNode

This will check if a node number is valid, i.e between 1 and [NodeCount](#)^[55].

Syntax: CheckNode(node: Integer)

2.4.16 CheckNodeList

[Checks](#)^[45] all elements in NL:

Syntax: CheckNodeList(NL: [TIntegerList](#)^[148])

2.4.17 CheckOpen

This method checks if the network has been opened through [Open](#)^[57].

Syntax: CheckOpen

2.4.18 CheckTurnIndex

This checks if index is valid for referencing sets of Turn restrictions. See [CreateArrayTurn](#)^[46].

Syntax: CheckTurnIndex(index: integer)

2.4.19 Close

This method closes the network and releases all memory related to it. This includes arrays setup using CreateArray* functions, all roadname files etc.

Syntax: Close

2.4.20 CloseRoadNameFile

This method closes a single roadname file and releases the memory related to it.

Syntax: CloseRoadNameFile(FileNumber: integer)

2.4.21 Codepage

Property Codepage: [TCodePage](#)^[155]

2.4.22 CompactMIF

Property [CompactMIF](#)^[120]: boolean

2.4.23 CoordinateUnit

Read-only property. Is set when calling [Open](#)^[57].

Type: [TCoordinateUnit](#)^[156]

2.4.24 CoordinateWindow

This property controls [checking of coordinates](#)^[44] when entered into functions that accept coordinates.

It is used in checking if coordinates are within the [Minimum Bounding Rectangle](#)^[55] + X % of the street network. This will prevent situations where you by mistake swap x and y coordinate or use lat/long coordinates when the street network was in a projected coordinate system or vice versa.

Use a negative number to skip checking.

An example: If the coordinate should be between 0 and 50 and CoordinateWindow = 20 (default), then only coordinates between -10 and 60 will be accepted.

Type: double

2.4.25 CoordSys

This property is set when calling [Open](#)^[57].

Property CoordSys: string

2.4.26 CreateArrayCost

Call this method to allocate room for n cost arrays. Cost arrays can be used, when you want to a route that isn't shortest or fastest, but rather some other expression.

Syntax: CreateArrayCost(n: integer)

2.4.27 CreateArrayTime

Call this method to allocate room for n time arrays. Time arrays are primarily used for fastest path routing. Multiple arrays can be setup for different uses (vehicle types, time of day etc).

Default value is 60 km/h.

Syntax: CreateArrayTime(n: integer)

2.4.28 CreateArrayTurn

Call this method to allocate room for n turn arrays. Each array is a list of turn restrictions / turn delays.

When calling [Open](#)^[57], this is automatically initialized for 1 array, so normally it isn't needed to call at all.

Syntax: CreateArrayTurn(n: integer)

2.4.29 CulDeSac

This read-only property returns true if a link is part of a Cul-De-Sac / dead end link. See also [NonCulDeSacNodes](#)^[56].

A link is defined as a cul-de-sac, if you can't get back without making a U-turn.
If you can get back without making a U-turn, but only using the same link, it is a [bridge](#)^[99].

Syntax: CulDeSac[Index: Integer]: boolean

2.4.30 Degree

This method returns the degree of a node. See [network terminology](#)^[5] for details.

To iterate through the links connected to a node, use function [Node2Link](#)^[69].

Syntax: Degree(node: integer): integer

2.4.31 Direction

Returns the turning angle (0-359) at node2 when moving from link1 to link2 via node2. This is based on the exact coordinates of the polylines and the node.

Link1 and link2 must both be connected to node2. Specifying node2 may seem superfluous, but is required since link1 and link2 could be parallel links.

Straight on is 0, to the left is 90, backward is 180 and to the right is 270.

Syntax: Direction(link1,node,link2: integer): integer

2.4.32 Directory

This property defines the location of all binary files used by RW Net. Default directory is the current path.

Type: string

2.4.33 DistanceBetweenNodes

Calculates the as-the-crow-flies distance between two nodes.

Syntax: DistanceBetweenNodes(node1,node2: integer): double

2.4.34 DistanceBetweenPoints

Calculates the as-the-crow-flies distance between P1 and P2.

Syntax: DistanceBetweenPoints(P1,P2: [TFloatPoint](#)^[158]): double

2.4.35 DistanceToLink

This method calculates the distance from P to link.

It returns this information:

- Percentage along the link (0 .. 1)
- Side of the link (-1: Left or 1: Right)
- Distance
- Coordinates of location on link

Syntax: DistanceToLink(P: [TFloatPoint](#)^[158]; link: integer; out percent: double; out side: integer; out distance: double; out Pnew: [TFloatPoint](#)^[158])

See also [DistanceToLinkSimple](#)^[48] and [NearestLocation](#)^[73].

2.4.36 DistanceToLinkSimple

This method calculates the distance from P to link.

Syntax: DistanceToLinkSimple(P: [TFloatPoint](#)^[158]; link: integer): double

See also [DistanceToLink](#)^[48] and [NearestLocationSimple](#)^[73].

2.4.37 DistanceToNode

This method calculates the distance from P to a node.

Syntax: DistanceToNode(P: [TFloatPoint](#)^[158]; node: integer): double

2.4.38 EncryptionKey

Set this property before calling [Open](#)^[57], if your data are encrypted.

Type: int64

2.4.39 EPSG

This property is set when calling [Open](#)^[57].

property EPSG: integer

2.4.40 ExportLinks

This method will export the currently open network, including external ID, limit and roadname information where available.

LL can be used if you want to split some of the links. Typically setup LL using [FindOverPasses](#)^[71] or [SplitAndSnap](#)^[73].

If you prepare LL on your own, remember to call these 2 methods after filling in the list: RemoveDuplicates and RemoveStartEndPos.

BA can be used to specify a selection - a subset of the links.

LL and BA can both be nil.

Syntax: ExportLinks(filename: string; GF: [TGISformat](#)^[158]; LL: [TLocationList](#)^[148]; BA: [TBitArray](#)^[149])

2.4.41 ExportLinksFullSplit

This method will export the currently open network, including external ID, limit and roadname information where available.

All links are split into short sections, between vertices. See map here: [network terminology](#)^[5] (blue dots). The method is good for preparing [OpenStreetMap](#) data for use in RW Net. Use method [Join](#)^[69] with topology=2 on the exported dataset and possibly also [FindOverPasses](#)^[7] function.

BA can be used to specify a selection - a subset of the links. BA can be nil.

Syntax: ExportLinksFullSplit(filename: string; GF: [TGISformat](#)^[158]; BA: [TBitArray](#)^[149])

2.4.42 ExportLocationList

This method will export LL, so it can be viewed externally. As a minimum the coordinate part of the items need to be filled in.

Use [Location2CoordinateList](#)^[54] for this, if only the location is filled in.

Syntax: ExportLocationList(filename: string; GF: [TGISformat](#)^[158]; LL: [TLocationList](#)^[148])

2.4.43 ExportNodeList

This method will export NL, so it can be viewed externally.

Syntax: ExportNodeList(filename: string; GF: [TGISformat](#)^[158]; NL: [TIntegerList](#)^[148])

2.4.44 ExportNodes

This method will export the nodes of the currently open network. Nodes are styled according to the degree (MIF, TAB format only):

- 1: Big red dot
- 2: Little black dot
- 3: Medium blue dot
- 4+: Medium magenta dot.

Syntax: ExportNodes(filename: string; GF: [TGISformat](#)^[158])

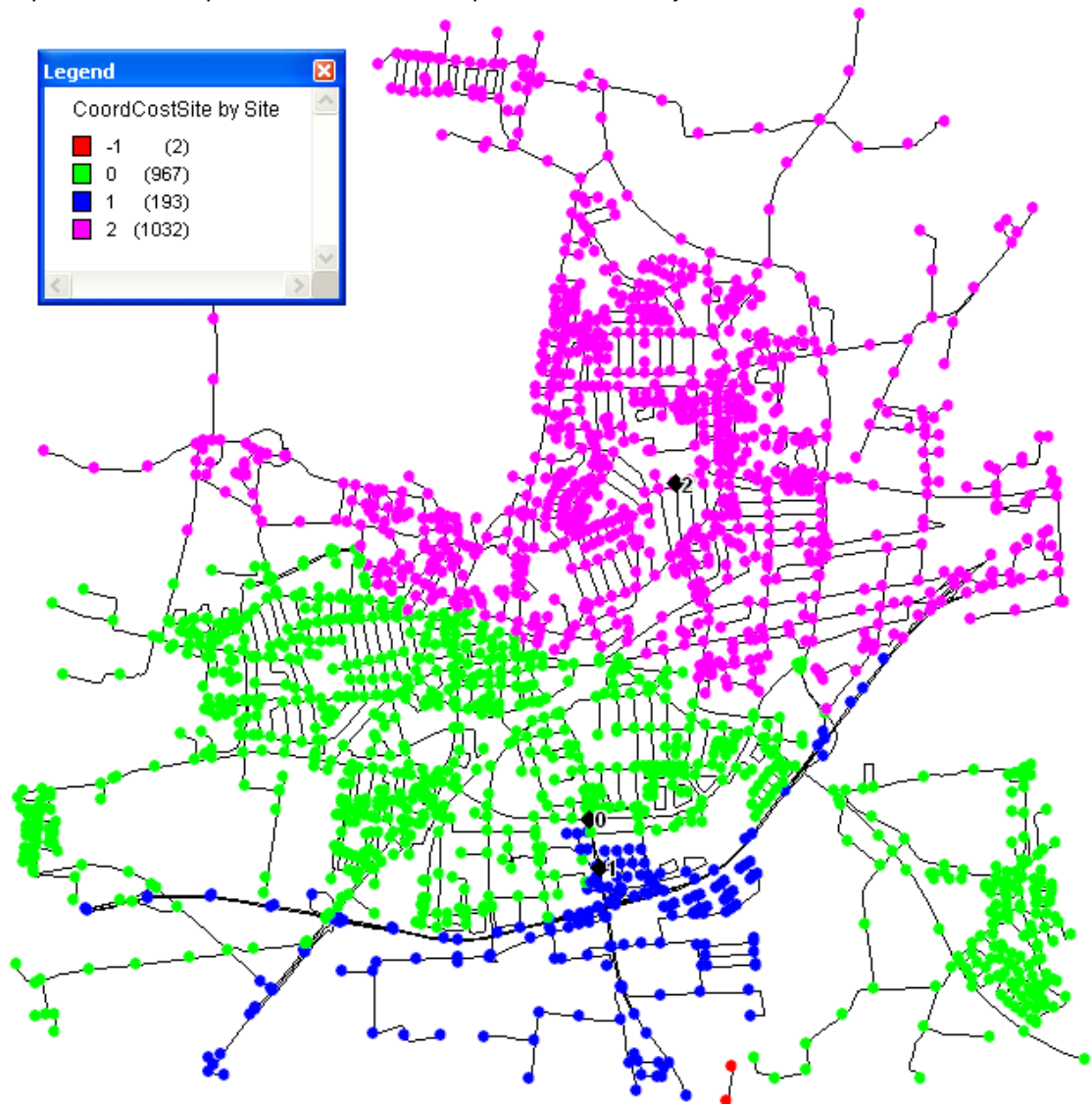
2.4.45 ExportPolyGeneration

This function is mostly for debugging purposes. It allows you to export the content of PG to 2 GIS files, so both facilities (startpoints) and the main data (CoordCostSiteList) are shown. Files called StartPoints and CoordCostSite are generated as specified in the same folder as the main network files.

Syntax: ExportPolyGeneration(filename: string; GF: [TGISformat](#)^[158]; PG: [TPolyGeneration](#)^[150])

Example: `ExportPolyGeneration("test", gfSHP, PG)` will generate files `test_startpoints.shp` and `test_coordcostsite.shp`.

Example with 3 start points and thematic map of nearest facility:



2.4.46 ExternalID2Link

This method translates an [external ID](#) into the internal ID.

Syntax: `ExternalID2Link(id: string): integer`

2.4.47 ExternalNodeID2ZLevels

In most datasets Z-levels are used to describe when streets intersect at different levels such as with bridges.

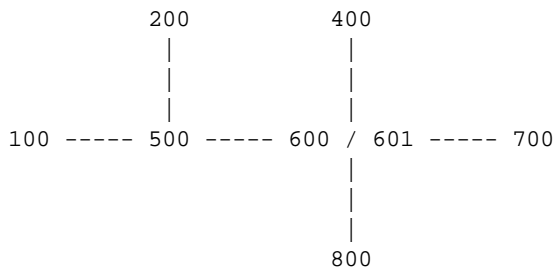
However, some use external node numbers instead to indicate that a shared coordinate belongs at

different levels.

In this example we have 6 links with these fromnode and tonode values:

- 1: 100 - 500
- 2: 200 - 500
- 3: 400 - 601
- 4: 500 - 600
- 5: 600 - 700
- 6: 601 - 800

As can be seen on the simplified map below, node 600 and 601 is really the same coordinate, but since the external node is different, they have different Z-levels.



This method helps you translating from external node numbers to Z-levels for the links.

After you have imported and opened a network, create a text file like this:

```
100,500
200,500
400,601
500,600
600,700
601,800
```

After calling the function you will get an output file with pairwise Z-levels like this:

```
0,0
0,0
0,1
0,2
2,0
1,0
```

Once applied to your dataset, you can import it again, this time declaring [Z](#)^[32] during import.

Syntax: `ExternalNodeId2ZLevels(InputFile, OutputFile: string; GF: TGISFormat[158]);`

2.4.48 ExtractSection

This method can be used to extract a part of a whole link. Start calling [GetGISSection](#)^[52]

Start and stop should be from 0 to 1 and if stop<start the order of the coordinates is swapped.

Example: `ExtractSection(list,1,0)` will return the whole list in reverse order.

Syntax: `ExtractSection(list: TFloatPointArrayEx[158]; start,stop: TPercent[162]): TFloatPointArrayEx`



2.4.49 GeoJSON

When using [gfGeoJSON](#)^[158] as output format in functions like [ExportNodes](#)^[49] etc, this read-only property holds the output.

Property GeoJSON: string

2.4.50 GetCost

This method returns cost for a single link and array index.

Syntax: GetCost(index,link: integer): [TCost](#)^[157]

See also [CreateArrayCost](#)^[46], [CalculateCost](#)^[43] and [SetCost](#)^[61]

2.4.51 GetGISSection

This method returns a list of coordinates for a link in the network.

Syntax: GetGISSection(link: integer): [TFloatPointArrayEx](#)^[158]

2.4.52 GetGISSectionRoute

This method returns a list of coordinates for a whole route.

Syntax: GetGISSectionRoute(route: [TRoute](#)^[163]): [TFloatPointArrayEx](#)^[158]

2.4.53 GetLimit

Returns limit (0-255) for the specified limit and link. You need to have called [OpenLimit](#)^[57] in advance to setup the memory.

Syntax: GetLimit(LimitID,link: integer): byte

2.4.54 GetSpeed

Returns speed for the specified array index and link.

Syntax: GetSpeed(index,link: integer): [TCost](#)^[157]

2.4.55 GetTime

Returns time (minutes) for the specified array index and link.

Syntax: GetTime(index,link: integer): [TCost](#)^[157]

2.4.56 GISarray

When using [gfArray](#)^[158] as output format in functions like [ExportNodes](#)^[49] etc, this read-only property holds the output.

Property GISarray: [TGISarray](#)^[122]

2.4.57 GISoutputInit

This function can be used to create a TGISwrite object.

Please see [Feature Matrix](#)^[3] for supported formats in your version.

Syntax: GISoutputInit(filename: string; GF: [TGISformat](#)^[158]): [TGISwrite](#)^[115]

2.4.58 Hierarchy

This array property can be used to get or set the hierarchy of a link. A hierarchy is a value from 1 to 5. See [attributes](#)^[6].

If the hierarchy hasn't been set, it returns 0.

Property Hierarchy[Index: Integer]: integer

2.4.59 Length

This returns the length of the complete network.

Syntax: Length: [TCost](#)^[157]

2.4.60 Link2FromNode

Returns the number of the node at the start of the link. This is where digitizing has started.

Syntax: Link2FromNode(link: integer): integer

2.4.61 Link2ToNode

Returns the number of the node at the end of the link. This is where digitizing has ended.

Syntax: Link2ToNode(link: integer): integer

2.4.62 LinkCount

Return the highest link-number in the currently loaded network, which should equal to the number of links in the corresponding GIS-network.

Syntax: LinkCount: integer

2.4.63 LinkLength

This function returns the length of the link.

If the value is 0, it means the link isn't valid for routing. Please go back and check the result of the import process.

Syntax: LinkLength(link: integer): [TCost](#)^[157]

2.4.64 LinkLimit

Returns the maximum number of links according to your license. See [feature matrix](#)^[3] (network size).

Syntax: LinkLimit: integer

2.4.65 Link2ExternalID

This method returns the [external ID](#)^[9] from the internal ID.

Syntax: Link2ExternalID(link: integer): string

2.4.66 Link2RoadName

This method returns the roadname for a specific link and RoadFileID. The [roadfile](#)^[58] should have been opened in advance.

Syntax: Link2RoadName(RoadFileID,link: integer): string

2.4.67 Link2RoadNameID

This method returns the roadnameID for a specific link and RoadFileID. The [roadfile](#)^[58] should have been opened in advance.

A roadnameID is an integer, that corresponds to a roadname. It is more compact than a roadname and it is faster to do comparisons using roadnameID's.

RoadnameID's can be translated to road names this [way](#)^[60].

Syntax: Link2RoadNameID(RoadFileID,link: integer): integer

2.4.68 Location2Coordinate

This method translates a location into a set of coordinates, with the ability to offset it to one of the sides of the link. When offset is positive, it will be on the right side of link, negative means left side. This is the same setup as [DistanceToLink](#)^[48] uses for side.

Syntax: Location2Coordinate(loc: [TLocation](#)^[160]; offset: double): [TFloatPoint](#)^[158]

2.4.69 Location2CoordinateList

Same as [Location2Coordinate](#)^[54], just for a whole list. LL is updated with the coordinates.

Syntax: Location2CoordinateList(LL: [TLocationList](#)^[148]; offset: double)

2.4.70 LoopLink

This function returns true if a link is a loop link.

Syntax: LoopLink(Index: Integer): boolean

2.4.71 LoopLinks

This function returns true if any link in the network is a loop.

Starting from 1-1-2012, networks with loop links will not work in [TCalc](#)^[75], [TRouteCalc](#)^[96] and [TDrivingDirections](#)^[103].

Syntax: LoopLinks: boolean

2.4.72 Matrix

This method calculates a matrix of distances between all combinations of nodes in NL. Distance uses as-the-crow fly distances. If extra is true, the matrix will have an additional row and column, allowing for special optimization in class [TTSP](#)^[134].

Syntax: Matrix(NL: [TIntegerList](#)^[148]; extra: boolean): [TMatrix](#)^[160]

2.4.73 MatrixDyn

This method calculates a matrix of distances between all combinations of locations in LL. Distance uses as-the-crow fly distances. If extra is true, the matrix will have an additional row and column, allowing for special optimization in class [TTSP](#)^[134].

You should have called [Location2CoordinateList](#)^[54] in advance.

Syntax: MatrixDyn(LL: [TLocationList](#)^[148]; extra: boolean): [TMatrix](#)^[160]

2.4.74 MaxDegree

Returns the maximum degree in the network. This is typically 5-6.

Syntax: MaxDegree: integer

2.4.75 MBR

Returns the minimum bounding rectangle of the currently loaded network. Is set when calling [Open](#)^[57].

Syntax: MBR: [TFloatRect](#)^[158]

2.4.76 Node2Coordinate

Returns the coordinates of a node.

Syntax: Node2Coordinate(node: Integer): [TFloatPoint](#)^[158]

2.4.77 NodeCount

Return the highest node-number in the currently loaded network. The [import](#)^[27] process assigns node numbers automatically, this can not be controlled by the user.

Syntax: NodeCount: integer

2.4.78 NoDriveThroughCheck

This function checks if [NoDriveThrough](#)^[88] bit is set for any link on the route and the logical area is different from that of the first and last link on the route.

Returns true if the route isn't valid.

Syntax: NoDriveThroughCheck(route: [TRoute](#)^[163]): boolean

2.4.79 NoDriveThroughInit

If you change the [NoDriveThrough](#)^[6] bit for some of the links after loading the network, you should call this function again to have various internal datastructures reset.

Syntax: NoDriveThroughInit

2.4.80 NoDriveThroughSet

This function checks if [NoDriveThrough](#)^[88] bit is set for any link in the network.

Syntax: NoDriveThroughSet: boolean

2.4.81 NonCulDeSacNodes

This function returns a list of all nodes, that are not completely surrounded by [CulDeSac](#)^[47] links.

It can be used together with function [Nearest](#)^[87] to move from a node in a CulDeSac area.

Syntax: NonCulDeSacNodes(NL: [TIntegerList](#)^[148])

2.4.82 ObjectCheck

This method checks individual objects for issues. I.e. not definite errors, but just issues.

It looks for:

- Duplicate nodes
- Self-intersecting objects
- Objects with sharp turns (set turn_angle parameter to define threshold, 90 is a good value)

Returns the number of objects with issues.

Syntax: ObjectCheck(filename: string; GF: [TGISformat](#)^[158]; turn_angle: integer): integer

In standard version you are limited to networks with <10000 links.

2.4.83 OneWayGet

This method returns information about one-way status for a link.

0: No restrictions

512: Travel only allowed in the direction of digitization

1024: Travel only allowed in the opposite direction of digitization
1536: Closed

Syntax: `OneWayGet(link: integer): word`

2.4.84 OneWaySet

This method sets information about one-way status for a link.

0: No restrictions
512: Travel only allowed in the direction of digitization
1024: Travel only allowed in the opposite direction of digitization
1536: Closed

Syntax: `OneWaySet(link: integer; value: word)`

2.4.85 Open

This method opens a street network and loads all information into memory. Files are loaded from [Directory](#)^[47] property.

If `attributes` is true, `attribute.bin` is also opened.

Set `coord3cache` to true, unless you have limited RAM.

Set `spatialindex` to true, if you want to load the spatial index and use [TSpatialSearch](#)^[71] methods.

ExternalID parameter:

0: Do not open
1: Open, but no caching
2: Open, cache index
3: Open, cache index + keys

Syntax: `Open(attributes, Coord3Cache, spatialindex: boolean; externalid: integer)`

2.4.86 OpenAttributes

This method (re)opens the attributes file. Files are loaded from [Directory](#)^[47] property.

Syntax: `OpenAttributes()`

2.4.87 OpenLimit

Use this method to open limit files. File number should refer to the naming of the file, while LimitID is from 1 to 9. It is important to open them in sequence or the routing restrictions will not work. For instance open limitID 1 and 2, but not 4 or higher.

Syntax: `OpenLimit(FileNumber, LimitID: integer; bitpattern: boolean)`

See also [Limits](#)^[9], [LimitFileIndex](#)^[36], [GetLimit](#)^[52], [SetLimit](#)^[61] and [TCalc.SetLimit](#)^[89].

2.4.88 OpenRoadName

This method opens a [roadname](#)^[9] file, previously setup through import.

Specify the number of the file (1..99) and if it should be cached. It is only relevant to cache if you plan to generate MANY driving directions.

Syntax: OpenRoadName(RoadFileID: integer; cache: boolean)

2.4.89 ParallelLinks

Identifies group of links, which start and end at the same two nodes. These might give problems in some networking algorithms ("emme/2" for instance).

RW Net has no problem with parallel links, unless you want to apply a turn restrictions from one parallel link to another and only want it at one of the 2 nodes they have in common.

The function returns the number of parallel links found.

The generated GIS file contains fields for:

- Link: Original link ID
- Group: 1, 2, 3
- SameLength: Logical value, which is true if all links in the group has the same length. This usually means the same link has been digitized twice.

Syntax: ParallelLinks(filename: string; GF: [TGISformat](#)^[158]): integer

In Standard version you are limited to networks with <10000 links.

2.4.90 PRJ

This property is set when calling [Open](#)^[57].

property PRJ: string

2.4.91 RandomLocation

Returns a random location.

Syntax: RandomLocation(r: [TRandom](#)^[150]): [TLocation](#)^[160];

2.4.92 RandomNode

Returns a random node.

Syntax: RandomNode(r: [TRandom](#)^[150]): integer;

2.4.93 RandomPoint

Returns a random point on the network.

It is a coordinate within 10 meters of a location.

Syntax: RandomPoint(r: [TRandom](#)^[150]): [TFloatPoint](#)^[158];

2.4.94 ReadCost

This method allows you to read speed for all links from a single DAT or DBF file.

Specify the full filename, including path.

Fieldindex is 0-based.

If fieldname is defined, fieldindex is ignored.

If cost is 0 or negative for any link, it is ignored.

Syntax: ReadCost(index: integer; filename: string; fieldindex: integer; fieldname: string);

2.4.95 ReadSpeed

This method allows you to read speed for all links from a single DAT or DBF file.

Specify the full filename, including path.

Fieldindex is 0-based.

If fieldname is defined, fieldindex is ignored.

if mph=true, all speeds are assumed to be in mph and multiplied by 1.609 when read from the file.

If speed is 0 or negative for any link, it is ignored.

Syntax: ReadSpeed(index: integer; filename: string; fieldindex: integer; fieldname: string; mph: boolean);

2.4.96 ReadTime

This method allows you to read speed for all links from a single DAT or DBF file.

Specify the full filename, including path.

Fieldindex is 0-based.

If fieldname is defined, fieldindex is ignored.

If time is 0 or negative for any link, it is ignored.

Syntax: ReadTime(index: integer; filename: string; fieldindex: integer; fieldname: string);

2.4.97 RoadClass

This array property can be used to get or set the road class of a link. A road class is a value from 0 to 31. See [attributes](#)^[6].

Property RoadClass[Index: Integer]: integer

2.4.98 RoadName2RoadNameID

This method translates a roadname into the corresponding roadname ID.

Syntax: RoadName2RoadNameID(RoadFileID: integer; roadname: string; ignorecase: boolean): integer

2.4.99 RoadNameID2RoadName

This method returns roadname for a roadname ID.

Syntax: RoadNameID2RoadName(RoadFileID,RoadNameID: integer): string

2.4.100 RoadNameMaxWidth

This method returns the maximum width for an open roadfile and for a specific codepage. This can be used when writing to a [TGISwrite](#)^[115] output with fixed field width, such as DBF, SHP, MIF and TAB.

Syntax: RoadNameMaxWidth(RoadFileID: integer; Codepage: TCodePage): integer

2.4.101 RouteLength

This method returns the length of a route.

See also [RouteCost](#)^[88] and [RouteTime](#)^[89].

Syntax: RouteLength(Route: [TRoute](#)^[163]): [TCost](#)^[157]

2.4.102 SaveLimit

Enter topic text here.

2.4.103 Select

This method can be used for selecting from the street network.

Output is stored in BA. New selections are set and added to any previous selections in BA.

Roadclass_min and roadclass_max specifies the interval for selections. Use 0 and 31 to ignore.

Hierarchy_min and hierarchy_max specifies the interval for selections. Use 0 and 5 to ignore.

You can specify a RoadFileID and RoadNameID to select a specific roadname. Use 0 to ignore.

For each of the bits 8 - 15 in the [attribute](#)^[6] you can specify the value 0 or 1. Use 2 to ignore.

Syntax: Select(BA: TBitArray;
roadclass_min,roadclass_max,hierarchy_min,hierarchy_max: integer;
RoadFileID,RoadNameID: integer;
bit8,bit9,bit10,bit11,bit12,bit13,bit14,bit15: byte)

2.4.104 SelectLimit

This method can be used for selecting from the street network.

Output is stored in BA. New selections are set and added to any previous selections in BA.

It selects all links where LimitID is in the range limit_min to limit_max.

Syntax: SelectLimit(BA: [TBitarray](#)^[149]; LimitID: integer; limit_min,limit_max: byte);

2.4.105 SelectLinksWithLimits

This method can be used for selecting from the street network.

Output is stored in BA. New selections are set and added to any previous selections in BA.

It selects all links with a limit defined. If `includeoneway` is true, it will also select links where both [oneway bits](#)^[6] are set (512 + 1024).

Syntax: `SelectLinksWithLimits(BA: TBitArray[149]; includeoneway: boolean);`

2.4.106 SetCost

This method sets cost for a single link and array index.

Syntax: `SetCost(index,link: integer; cost: TCost)`

See also [CreateArrayCost](#)^[46], [CalculateCost](#)^[43] and [GetCost](#)^[52]

2.4.107 SetLimit

This method sets limit for a single limitID and link. You need to have called [OpenLimit](#)^[57] in advance to setup the memory.

This doesn't change any file on disk.

Syntax: `SetLimit(limitID,link: integer; value: byte)`

2.4.108 SetSpeed

Sets speed for the specified array index and link. Internally it is the corresponding time, that is stored.

See also [MaxSpeed](#)^[86].

Syntax: `SetSpeed(index,link: integer; speed: TCost[157])`

2.4.109 SetTime

Sets time (minutes) for the specified array index and link.

Syntax: `SetTime(index,link: integer; time: TCost[157])`

2.4.110 SkipLinks2BitArray

This procedure will copy bit 15 from the [attribute](#)^[6] to a bitarray, for use in spatial searches.

Syntax: `SkipLinks2BitArray(BA: TBitArray)`

2.4.111 Split

This method will create entries in LL for all links in the network and for every x km.

Example: If the value of distance parameter is 1 km and a link is 3.6 km long, entries will be created like this:

Evenout = false: 1, 2 and 3 km (3 entries)

Evenout = true: 0.9, 1.8 and 2.7 km (3 entries)

No entries are created for links shorter than 1 km.

Call [ExportLinks](#)^[48] afterwards to have the network saved, but with shorter links.

Syntax: Split(distance: [TCost](#)^[157]; evenout: boolean; LL: [TLocationList](#)^[148])

2.4.112 SwapList

This method swaps the order of coordinates in the variable.

Syntax: SwapList(var list: TFloatPointArrayEx)

2.4.113 SwapOneWay

This method swaps all oneway restrictions, so they point in the opposite direction. If both [oneway bits](#)^[6] (9 and 10) are set, nothing happens.

It can be used to calculate isochrones from many-to-one, by first swapping the restrictions, doing it one-to-many and then swapping back again.

This is for instance relevant, when doing a drivetime isochrone and it is more important how fast you can get TO the center (example: hospitals), rather than getting FROM the center (example: fire stations).

Call [TurnSwap](#)^[67] too, if you have turn restrictions.

Syntax: SwapOneWay

2.4.114 TurnAutoProcess

This method allows to automatically detect turns and add turn delays through out your network.

You can either use the built-in rules for adding delays for T-junctions and normal junctions, or override these with events.

In any case, it should be specified if traffic is right- or left-hand. Left-hand is known from UK, Ireland, Australia, New Zealand, Japan, India, South Africa etc.

It should also be specified if any nodes should be skipped completely. This could be nodes / junctions which are part of ramps or use traffic lights, so you want to set up different rules.

We suggest calling [TurnExportGIS](#)^[65] once you have called TurnAutoProcess to see what it actually gives in minutes.

This method is quite slow for large networks, so use it with care.

Events

When using the events you will just get a list of links back, making up the intersection. This includes intersections or nodes with degree > 2.

The list is ordered in the same way as is shown on the small maps below.

T-junctions:

TTurnTEvent = procedure(Sender: TObject; node, link1, link2, link3: integer)

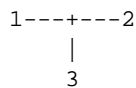
Normal junctions:

TTurnEvent = procedure(Sender: TObject; node: integer; links: [TIntegerArray](#)^[159])

Built-in rules

Delays for each road class in the network is supplied as a [TRoadClassTurnCost](#)^[151] object. For all links in each intersection the delay is then looked up, based upon their road class. If a turn involves crossing multiple traffic flows in the intersection, these are added together as can be seen here:

For a T-junction, where 1-2 is the main road:



Delays for right-hand traffic:

From 3 to 1: $1.5 * (\text{delay1} + \text{delay2})$

From 3 to 2: delay1

From 2 to 3: delay1

Other turns: No delay

Delays for left-hand traffic:

From 3 to 1: delay2

From 3 to 2: $1.5 * (\text{delay2} + \text{delay1})$

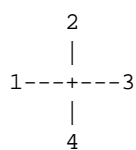
From 1 to 3: delay2

Other turns: No delay

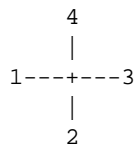
Main road is determined from geometry: The link combination closest to a straight line is the main road.

For a normal intersection, where 1-3 is the main road:

Left-hand traffic



Right-hand traffic



From 1 to 4: delay3

From 2 to 1: $1.5 * (\text{delay1} + \text{delay3} + \text{delay4})$

From 2 to 3: delay1

From 2 to 4: $1.5 * (\text{delay1} + \text{delay3})$

From 3 to 2: delay1

From 4 to 1: delay3

From 4 to 2: $1.5 * (\text{delay1} + \text{delay3})$

From 4 to 3: $1.5 * (\text{delay1} + \text{delay2} + \text{delay3})$

Other turns: No delay

Main road gets detected from the delays. Largest delay means main road.

If opposing roads, 1-3, can't be identified as the main road, the intersection is skipped. This happens if for instance 1-2 has the largest delay.

If the delay for all 4 roads is the same:

Delays for right-hand traffic:

Right turns: delay1

Straight ahead: $2 * \text{delay1}$

Left turns: $4.5 * \text{delay1}$

Delays for left-hand traffic:

Left turns: delay1

Straight ahead: $2 * \text{delay1}$

Right turns: $4.5 * \text{delay1}$

For intersections with >4 links:

No processing occurs. You can use the events instead.

Syntax: TurnAutoProcess(index: integer; LeftHandTraffic: boolean; RCTC: [TRoadClassTurnCost](#)^[151];
SkipNodes: [TBitArray](#)^[149])

2.4.115 TurnClear

This method clears turn restrictions for the specified index.

Syntax: TurnClear(index: integer)

2.4.116 TurnExportBin

This method saves all turn restrictions to a file on disk, which can later be loaded with function [TurnImportBin](#)^[65].

Bin files always use link ID as references.

Specify a full filename, preferably with along this pattern "turn*.bin" (makes it easier to recognize the file).

Syntax: TurnExportBin(index: integer; filename: string)

2.4.117 TurnExportGIS

This method writes all turn restrictions to a TGISwrite, so it is easier to graphically view the turn restrictions.

Specify a full filename.

Syntax: TurnExportGIS(index: integer; filename: string; GF: [TGISformat](#)^[158])

2.4.118 TurnExportTXT

This method saves all turn restrictions to a text file on disk, which can later be loaded with function [TurnImportTXT](#)^[65]. Internal link ID's are used in the output.

Specify a full filename.

Syntax: TurnExportTxt(index: integer; filename: string)

2.4.119 TurnExportTXT2

This method saves all turn restrictions to a text file on disk, which can later be loaded with function [TurnImportTXT](#)^[65]. External link ID's are used in the output.

Specify a full filename.

Syntax: TurnExportTxt2(index: integer; filename: string)

2.4.120 TurnImportBin

This method loads turn restrictions from a file on disk, created by [TurnExportBin](#)^[65]. It doesn't clear the list first.

Specify a full filename.

Syntax: TurnImportBin(index: integer; filename: string)

2.4.121 TurnImportTxt

This method loads turn restrictions from a text file on disk. Supply a full filename, including folder. It doesn't clear the list first.

The format is one or more lines, where each line stores one restriction with parameters stored in

space separated format. Different types of restrictions are possible:

- 0: Simple Turn restriction, 2 external link ID's + 1 cost value
- 1: [Simple Turn restriction](#)^[67], 2 link ID's + 1 cost value
- 2: [TurnStandard](#)^[67], coordinates for node
- 3: Mandatory turn, 2 external link ID's
- 4: [Mandatory turn](#)^[66], 2 link ID's
- 5: Complex Turn restriction, >2 external link ID's + 1 cost value
- 6: [Complex Turn restriction](#)^[67], >2 link ID's + 1 cost value

File example:

```
// Comment
0 A4003234 A4003127 -1
1 456 230 -1
2 -77.024098 38.902711
3 A4003234 A4003127
4 456 230
5 A4003279 A4003234 A4003127 -1
6 89 456 230 -1
```

Lines starting with // are ignored as comments.

The [ITN converter](#) will create turn restriction files in this format.

If you use turn restrictions with external ID's (type 0, 3 and 5), make sure you have called [Open](#)^[57] with externalID>0 or you will get an error code returned.

Type 0, 2, 3 and 4 gets translated into one or more type 1 during import and type 5 gets translated into type 6 during import.

Syntax: TurnImportTxt(index: integer; filename: string)

2.4.122 TurnMandatory

This method defines that turns from link1 is only allowed if the next turn is link2.

Internally this is translated into a number of turn restrictions. These are only applied at the end of link1, where it is actually possible to connect to link2.

If link1 and link2 are parallel links, you will get an error.

Syntax: TurnMandatory(index: integer; link1,link2: integer)

2.4.123 TurnReset

Clears the list of turn restrictions.

Syntax: TurnReset(index: integer)

2.4.124 TurnRestriction

This method defines a restriction on turns from link1 to link2.

cost < 0: Turn prohibited

cost = 0: Remove turn restriction

cost > 0: Additional cost related to the turn (= delay).

If link1=link2 the restriction (a U-turn) is skipped. See here how to apply [U-turn restrictions](#)^[92]. It is not possible to have delays for U-turns, they can only be either allowed or banned.

If link1 and link2 are parallel links, a turn restriction is added at both nodes. Prevent this by breaking up one of the links.

Syntax: TurnRestriction(index,link1,link2: integer; cost: [TCost](#)^[157])

2.4.125 TurnRestrictionComplex

This is the same method as [TurnRestriction](#)^[67] except up to 6 links can be defined as making up the restriction. If you need more than 6 links, use [TurnImportTXT](#)^[65] instead.

Syntax: TurnRestrictionComplex(index,link1,link2,link3,link4,link5,link6: integer; cost: [TCost](#)^[157])

2.4.126 TurnStandard

Adds turn restriction on standard 4-degree intersection, which means no turns are allowed - only driving straight through. The method also works for nodes with higher, but still even degree.

Syntax: TurnStandard(index,node: integer)

2.4.127 TurnSwap

This method swaps the direction of all turn restrictions for the specified index.

Use it in combination with [TNetwork.SwapOneWay](#)^[62], where you can read further details.

Syntax: TurnSwap(index: integer)

2.4.128 UpdateAlphas

Alpha is a parameter used internally by [TRouteCalc](#)^[96] to direct routes faster towards the target.

After changing speed, time or cost and before calculating routes with [TRouteCalc](#)^[96], you should call this method.

For shortest path routing with TRouteCalc, the method is not required.

Syntax: UpdateAlphas

2.4.129 Write

These methods are for writing results from various calculations directly to a DBF or DAT file. DAT is part of a MapInfo TAB file and similar to a DBF file.

All 4 variations below allow you to write to gfDecimal, gfFloat, gfInteger, gfSmallInt and gfLogical fields.

In any case values are written so they best possibly are stored in the underlying field.

Values which are too big, makes it raise an error, such as storing 100000 in a SmallInt field (valid range -32767 to 32767).

If you try to store a number in a Logical field, all values >0 are treated as True.

Length of TIntegerArray, TCostArray and TBitArray need to match the number of records in the file.

TIntegerList is treated as a list of records marked as True. If you have reset=true at the same time, all other records are marked as false.

Fieldindex is 0-based. If you specify fieldname, it is used instead of fieldindex.

Syntax:

Write1(filename: string; fieldindex: integer; fieldname: string; value: [TIntegerArray](#)^[159]);

Write2(filename: string; fieldindex: integer; fieldname: string; value: [TCostArray](#)^[157]);

Write3(filename: string; fieldindex: integer; fieldname: string; value: [TBitArray](#)^[149]);

Write4(filename: string; fieldindex: integer; fieldname: string; value: [TIntegerList](#)^[148]; reset: boolean);

2.4.130 Pro Methods

2.4.130.1 DownStream

This method can be used for tracing in an oriented network. It will start from a link and trace in the forward (downstream) direction as long as there is only one directed link from the next node (unique direction for flow). Links without direction are ignored. You can use direction 512 / 1024 as in a normal street network.

This method is only useful for utility networks, such as sewers, water pipes etc. It has little relevance for street networks.

Output linklist is in the order of flow, starting with the input link.

Syntax: DownStream(link: integer; linklist: [TIntegerList](#)^[148])

See also [Trace](#)^[70] and [UpStream](#)^[71]

2.4.130.2 ExportTrafficList

This method will export TL, so it can be viewed externally.

If lines = false:

Output is shown as point objects with origin / destination records shown as "O" and "D".

If lines = true:

Output is shown as lines connecting origin and destination.

Syntax: ExportTrafficList(filename: string; GF: [TGISformat](#)^[158]; TL: [TTrafficList](#)^[148]; lines: boolean)

2.4.130.3 Join

This will identify neighbouring links and join them in groups. The grouping can be defined by setting 3 parameters, where at least one of them need to be <> "ignore":

Topology

0: Ignore it

1: Connected

2: Intersection to intersection (intersection: Node with [degree](#)^[47] >= 3)

3: Intersection to intersection, but ignoring cul-de-sac links

RoadFileID

0: Ignore roadname

N: Split when roadname changes

Attributes:

False: Ignore attributes

True: Split according to attributes

Result is stored in IA array: Indices with the same value belong to the same group.

Result can also be written to a TGISwrite output, if filename is specified. If GF = gfArray, just set filename to something.

Using parameter combination (0,0,false) is not allowed, since it would join ALL links into one large object.

When using topology=2, joins that would result in loops, are avoided.

Normally it used with these parameters, when the output is to be used for routing:

Topology = 2

RoadfileID >0, if the network is to be used with driving directions.

Attributes = true.

If turn restrictions are defined, they are exported to a file with ".turn" as extension with the updated link ID's as reference.

Syntax: Join(filename: string; GF: [TGISformat](#)^[158]; topology,RoadFileID: integer; attributes: boolean; var IA: [TIntegerArray](#)^[158])

2.4.130.4 Node2Link

This method returns the ID of the links connected to a node.

Iterate through the links this way:

```
for index = 1 to Degree[47](node)
  print node2link(node,index)
next
```

Syntax: Node2Link(node,linkindex: integer): integer

2.4.130.5 Trace

This method can be used for tracing in a network. It will start from a link and trace in all directions until a node is reached that is marked with True in the Valves input parameter.

Oneway restrictions are ignored.

This method is only useful for utility networks, such as sewers, water pipes etc. It has little relevance for street networks.

Output parameter ValvesReached shows which of the valves was reached.

Output parameter LinksReached shows which of the links was reached.

Syntax: Trace(link: integer; Valves, ValvesReached, LinksReached: [TBitArray](#)^[149])

See also [DownStream](#)^[68] and [UpStream](#)^[71]

Example:

Input:

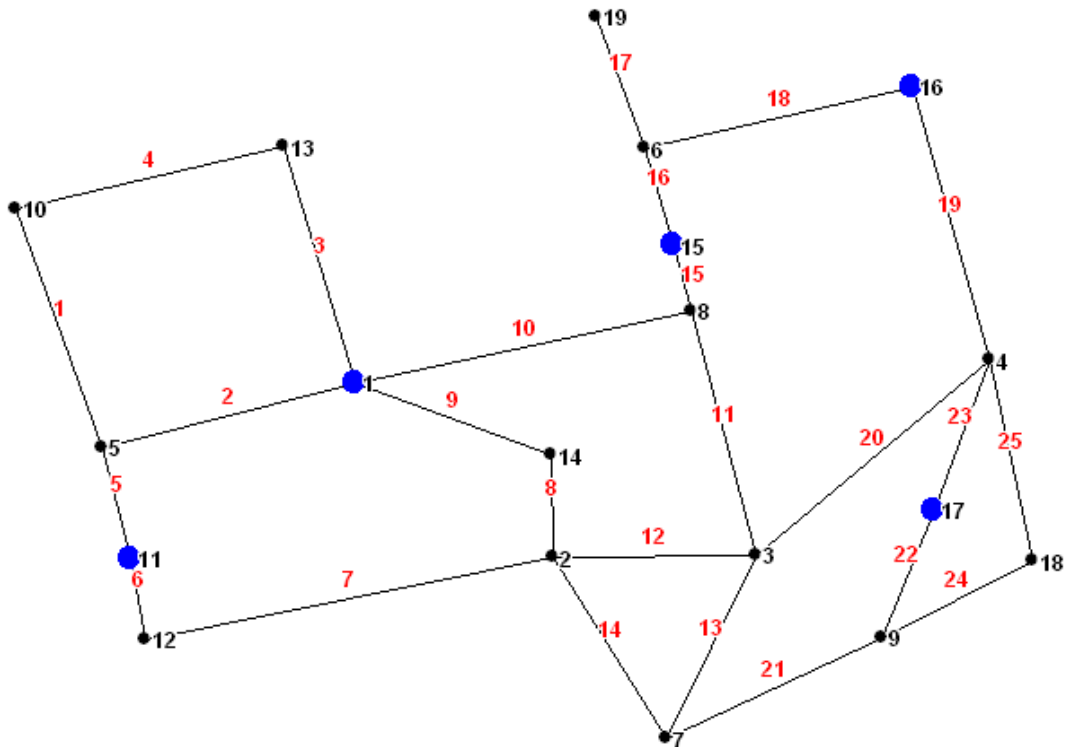
Start link: 1 (red labels)

Valves: 1, 11, 15, 16, 17 (blue dots)

Output:

ValvesReached: 1, 11

LinksReached: 1, 2, 3, 4, 5.



2.4.130.6 UpStream

This method can be used for tracing in an oriented network. It will start from a link and trace in the reverse (upstream) direction, branching if required. Links without direction are ignored. You can use direction 512 / 1024 as in a normal street network.

This method is only useful for utility networks, such as sewers, water pipes etc. It has little relevance for street networks.

Upstream links are marked as true in the output, including the input link.

Syntax: UpStream(link: integer; links: [TBitArray](#)^[146])

See also [DownStream](#)^[68] and [Trace](#)^[70]

2.5 T SpatialSearch

This class is for making spatial searches in the network. Generally as either searching for nodes or links (locations).

On top of this, various topological checks can also be performed: [FindNonConnected](#)^[71], [FindOverPasses](#)^[71] and [Split](#)^[75].

When opening the [network](#)^[57], make sure parameter "spatialindex" is true.

2.5.1 Create

When creating an instance of T SpatialSearch, it is required to specify a network.

Syntax: Create(NW: [TNetwork](#)^[38])

2.5.2 FindOverPasses

This method finds where 2 links intersect and add these locations to LL (LL is not cleared first). Two entries are added every time, one for each link.

There should only be overpasses, where there is also a bridge / tunnel in real life.

You can call [ExportLinks](#)^[48] afterwards if you want to split the links where an overpass was found.

The FindOverPasses algorithm makes sure that exactly the same coordinates are used for both pairs of links, so snap is guaranteed if you call TImport on the resulting output from ExportLinks. See also [SplitAndSnap](#)^[75].

Syntax: FindOverPasses(LL: [TLocationList](#)^[148])

In standard version you are limited to networks with <10000 links.

2.5.3 FindNonConnected

This method performs a topological check:

It checks if there within a radius of all nodes in the network are links, which are not connected to the node.

Usually set radius = 0.005 km or an even smaller value.

Output is a TGISwrite with fields for node and link numbers and the distance from the first node to the node / link. Visually a line is drawn.

It returns the number of records in the result. If no records at all, then no file is generated.

Syntax: FindNonConnected(filename: string; GF: [TGISformat](#)^[158]; Radius: double): integer

In standard version you are limited to networks with <10000 links.

2.5.4 FindNonConnectedNodes

This method performs a topological checks:

It checks if there within a radius of all nodes in the network are other nodes, which are not directly connected to the first node.

Usually set radius = 0.005 km or an even smaller value.

Output is a TGISwrite with fields for node and link numbers and the distance from the first node to the node / link. Visually a line is drawn.

It returns the number of records in the result. If no records at all, then no file is generated.

Syntax: FindNonConnected(filename: string; GF: [TGISformat](#)^[158]; Radius: double): integer

In standard version you are limited to networks with <10000 links.

2.5.5 GeoJSON

When using [gfGeoJSON](#)^[158] as output format in functions like [FindNonConnected](#)^[71] etc, this read-only property holds the output.

Property GeoJSON: string

2.5.6 GISarray

When using [gfArray](#)^[158] as output format in function [FindNonConnected](#)^[71], this read-only property holds the output.

Type: [TGISarray](#)^[122]

2.5.7 NearestLink

This function will locate which link you are driving on, when both GPS coordinate and bearing (0-359) are known.

0 = North, 90 = East, 180 = South, 270 = West.

This is especially useful, when there are many intersecting roads or two parallel roads.

Specify a search radius, such as 0.025 km, since it uses [SelectLinks](#)^[74] internally.

The result is returned as a list of possible matches, with the best guess at the top of the list.

Syntax: function NearestLink(P: [TFloatPoint](#)^[158]; Bearing, SearchRadius: double): [TGPSSMatchList](#)^[147];

See also [NearestLocation](#)^[73]

2.5.8 NearestLocation

This locates the nearest location from P.

It returns this information:

- Location
- Side of the link (-1: Left or +1: Right)
- Distance
- Coordinates of location on link

A typical use is converting large amounts of GPS coordinates into network locations. An example of performance is:

A street network with 200,000 links, latitude/longitude coordinates: 2000 calcs per sec (using an AMD A6-5400K)

Larger street networks makes it slightly slower, while using projected coordinates makes it faster. Setting [MaxVerticesPerCell](#)^[30] at a lower value than default can also make it slightly faster.

Syntax: NearestLocation(P: [TFloatPoint](#)^[158]; var Loc: [TLocation](#)^[160]; var side: integer; var distance: double; var Pnew: [TFloatPoint](#)^[158])

See also [DistanceToLink](#)^[48], [NearestLocationSimple](#)^[73] and [SkipLinks](#)^[75].

2.5.9 NearestLocationSimple

This finds the nearest location from P.

Syntax: NearestLocationSimple(P: [TFloatPoint](#)^[158]): [TLocation](#)^[160]

See also [DistanceToLinkSimple](#)^[48], [NearestLocation](#)^[73] and [SkipLinks](#)^[75].

2.5.10 NearestLocationSimpleList

Same as [NearestLocationSimple](#)^[73], except it processes LL.

Syntax: NearestLocationSimpleList(LL: [TLocationList](#)^[148])

2.5.11 NearestNode

This locates the nearest node from P. Returns distance to the node too.

Syntax: NearestNode(P: [TFloatPoint](#)^[158]; var node: integer; var distance: double)

2.5.12 NearestVertex

This locates the nearest vertex from P.

It returns this information:

- Link

- Index of vertex (0-based)
- Distance

Syntax: NearestVertex(P: [TFloatPoint](#)^[158]; var link, index: integer; var distance: double)

See also [GetGISSection](#)^[52]

2.5.13 SelectLinks

This method selects all links within a radius from P.

Result is returned as a list of links in List and as a bit pattern in BA.

Syntax: SelectLinks(P: [TFloatPoint](#)^[158]; Radius: double; List: [TIntegerList](#)^[148]; BA: [TBitArray](#)^[149])

See also [SkipLinks](#)^[75].

2.5.14 SelectLinksArray

Same as [SelectLinks](#)^[74], but result is only returned in the array.

Syntax: SelectLinksArray(P: [TFloatPoint](#)^[158]; Radius: double; BA: [TBitArray](#)^[149])

2.5.15 SelectLinksList

Same as [SelectLinks](#)^[74], but result is only returned in the list.

Syntax: SelectLinksList(P: [TFloatPoint](#)^[158]; Radius: double; List: [TIntegerList](#)^[148])

2.5.16 SelectNodes

This method selects all nodes within a radius from P.

Result is returned as a list of nodes in List and as a bit pattern in BA.

Syntax: SelectNodes(P: [TFloatPoint](#)^[158]; Radius: double; List: [TIntegerList](#)^[148]; BA: [TBitArray](#)^[149])

2.5.17 SelectNodesArray

Same as [SelectNodes](#)^[74], but result is only returned in the array.

Syntax: SelectNodesArray(P: [TFloatPoint](#)^[158]; Radius: double; BA: [TBitArray](#)^[149])

2.5.18 SelectNodesList

Same as [SelectNodes](#)^[74], but result is only returned in the list.

Syntax: SelectNodesList(P: [TFloatPoint](#)^[158]; Radius: double; List: [TIntegerList](#)^[148])

2.5.19 SkipLinks

This property defines if any of the links should be skipped in methods [NearestLocation](#)^[73] and [SelectLinks](#)^[74].

Default: nil

Type: TBitArray

2.5.20 SplitAndSnap

This methods performs a search around nodes with degree <3. If any location on a link is found in the search, and the link is not connected to the original node and not a node at the same time (i.e. start or end of the link), the location is added to LL (LL is not cleared first). The same coordinate is also added to LL, with the original node as reference together with special codes, that can be handled by [ExportLinks](#)^[48], so links can be split and updated correctly for exact snap in future [TImport](#)^[27] runs.

You can also choose to call [ExportLocationList](#)^[49] to visually check and edit, where issues has been found.

The method returns the number of positive searches. LL holds ~2-3 times as many items.

Syntax: SplitAndSnap(Radius: double; LL: [TLocationList](#)^[148]): integer

In standard version you are limited to networks with <10000 links.

2.6 TCalc

This class is used for one-to-many route calculations, the [Dijkstra](#) algorithm is used. Use [TRouteCalc](#)^[96] for one-to-one route calculations.

Typical sequence when using TCalc is like this:

Call [SetTime](#)^[61] and/or [SetCost](#)^[61] if you want to calculate more than just length of routes.

Define which criteria you want and call the corresponding method: [SetShortest](#)^[90], [SetFastest](#)^[89] or [SetCheapest](#)^[89].

The [SkipLinkList](#)^[90] can be used to ignore certain links in the route calculations.

Eventually set [MaxCost](#)^[86], if you want to create a smaller isochrone than otherwise.

[MaxSpeed](#)^[86] can be used to override the speed for the network, in case of slow vehicles.

[NoDriveThrough](#)^[88] can be set to avoid areas, where you are not allowed to drive through ("no access").

Finally call one of the actual isochrone methods, possibly followed by additional query methods:

If you just want cost:

- [IsoCost](#)^[79] or [IsoCostList](#)^[79] or [IsoCostListN](#)^[79] > [NodeCost](#)^[88] or [LinkCost](#)^[84]
- [IsoCostDyn](#)^[79] or [IsoCostListDyn](#)^[79] or [IsoCostListNDyn](#)^[80] > [NodeCost](#)^[88] or [LinkCostDyn](#)

- [IsoCostDynApproach](#)^[93] > [LinkCostDynApproach](#)^[94]

If you want cost and the route:

- [IsoCost](#)^[79] or [IsoCostList](#)^[79] > [RouteFind](#)^[88] > [RouteCost](#)^[88], [RouteLength](#)^[60] and / or [RouteTime](#)^[89]
- [IsoCostDyn](#)^[79] or [IsoCostListDyn](#)^[79] or [IsoCostListNDyn](#)^[80] > [RouteFindDyn](#)^[88] > [RouteCost](#)^[88], [RouteLength](#)^[60] and / or [RouteTime](#)^[89]
- [IsoCostDynApproach](#)^[93] > [RouteFindDynApproach](#)^[95] > [RouteCost](#)^[88], [RouteLength](#)^[60] and / or [RouteTime](#)^[89]

Matrix methods: (to [TMatrix](#)^[160])

- [Matrix](#)^[55]
- [Matrix2](#)^[84]
- [MatrixDyn](#)^[55]
- [MatrixDyn2](#)^[85]

Matrix methods: (output to GIS files)

- [MatrixOut](#)^[85]
- [MatrixDynOut](#)^[85]
- [MatrixPOut](#)^[86]

Other methods:

- [Nearest](#)^[87]
- [NearestDyn](#)^[87]
- [NearestOpen](#)^[87]
- [NearestOpenDyn](#)^[87]

Methods for isochrones (see also [here](#)^[17]):

1. [DriveTimeSimple](#)^[77]
2. [IsoPoly](#)^[83]
3. [AlphaShape](#)^[92] (Pro only)
4. [IsoLinkDriveTime](#)^[80]

It is worth noting that Cost in TNetwork is different from Cost in TCalc:

- In TNetwork it is a generalized cost for a single link (or turn delay), much similar to the length or time of a link.
- In TCalc it is the result of a route / isochrone calculation from a starting point to somewhere else. The cost can be either distance ([SetShortest](#)^[90]), time ([SetFastest](#)^[89]) or "cost" ([SetCheapest](#)^[89]), depending upon which criteria has been set up.

2.6.1 Create

When creating an instance of TCalc, it is required to specify a network and if turnmode should be true or false.

Syntax: Create(NW: [TNetwork](#)^[38]; Turnmode: boolean)

2.6.2 DecimalsDist

When generating file output, you can use this property to define number of decimals in distances. A negative number means up to 10 decimals.

Default: -1

Type: smallint

2.6.3 DecimalsTime

When generating file output, you can use this property to define number of decimals in time and time spans.

A negative number means up to 10 decimals.

Default: -1

Type: smallint

2.6.4 DistanceUnit

When generating output, you can use this property to use miles in the output.

This affects [MatrixOut](#)^[85], [MatrixPOut](#)^[86], [MatrixDynOut](#)^[85], [IsoLinkDriveTime](#)^[80] and [IsoLinkDriveTimeDyn](#)^[82]. But no other methods !!

Default: duKm

Type: [TDistanceUnit](#)^[157]

2.6.5 DriveTimeSimple

This is a simpler version of the [voronoi](#)^[109] based method for drivetime isochrones. It uses a single node as center.

Angle should be in the range 0 to 45, with 0 giving the convex hull. Small values make the isochrone follow the network more closely and larger values makes it closer to the convex hull.

Depending upon the exact layout of the street network, small parts of what is actually reachable, may end up outside the polygon, because the calculation is node-based.

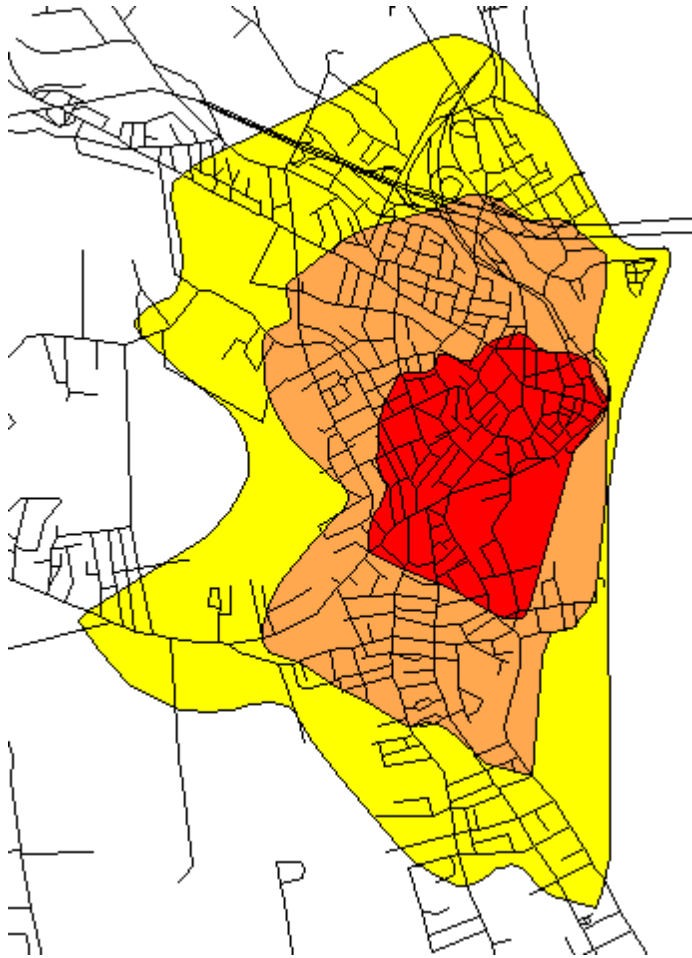
[Smoothing](#)^[96] can be enabled, but may give degenerate results when combined with multiple steps.

If you run this method in turnmode, certain smaller details next to actual turn restrictions may come out wrong.

Syntax: DriveTimeSimple(filename: string; GF: [TGISformat](#)^[158]; node: Integer; Steps: [TStepList](#)^[148]; angle: double; doughnut: boolean);

See also [Isochrones - overview](#)^[17]

Example with 1-2-3 km, angle = 3 degree, doughnut = true and smoothing = (5,3,5):



2.6.6 DriveTimeSimpleDyn

This method uses the same principle as [DriveTimeSimple](#)^[77], but follows the perimeter of [IsoLinkDriveTimeDyn](#)^[82] and uses a location as starting point.

This makes it slower and more accurate than [DriveTimeSimple](#)^[77].

Syntax: `DriveTimeSimpleDyn(filename: string; GF: TGISformat[158]; location: TLocation; Steps: TStepList[148]; angle: double; doughnut: boolean);`

2.6.7 GeoJSON

When using [gfGeoJSON](#)^[158] as output format in functions like [MatrixOut](#)^[85] etc, this read-only property holds the output.

Property GeoJSON: string

2.6.8 GISarray

When using [gfArray](#)^[158] as output format in functions like [MatrixOut](#)^[85] etc, this read-only property holds the output.

Type: [TGISarray](#)^[122]

2.6.9 IgnoreOneway

Set this property to true, if you want to ignore one-way restrictions in the route calculations.

Default: false

Type: boolean

2.6.10 IsoCost

This method calculates an isochrone from the node. The size of the isochrone can be restricted by setting [MaxCost](#)^[86].

Syntax: IsoCost(node: integer)

2.6.11 IsoCostDyn

This method calculates an isochrone from the location. The size of the isochrone can be restricted by setting [MaxCost](#)^[86].

An error will be raised if location is on a loop link. Check with [LoopLink](#)^[54] function in advance.

Syntax: IsoCostDyn(Loc: [TLocation](#)^[160])

2.6.12 IsoCostList

This method calculates an isochrone from node, which extends until all nodes in NL has been reached. If [MaxCost](#)^[86] has been set, it may stop sooner.

Syntax: IsoCostList(node: integer; NL: [TIntegerList](#)^[148])

2.6.13 IsoCostListDyn

This method calculates an isochrone from the location, which extends until all locations in LL has been reached.

An error will be raised if location is on a loop link. Check with [LoopLink](#)^[54] function in advance.

Syntax: IsoCostListDyn(Loc: [TLocation](#)^[160]; LL: [TLocationList](#)^[148])

2.6.14 IsoCostListN

This method calculates an isochrone from node, which extends until the first N nodes in NL has been reached.

If [MaxCost](#)^[86] has been set, it may stop sooner.

Result is returned in IL as a sorted index into NL. Length of IL may be < N, if not all nodes in NL is reached.

Example:

NL = {100, 200, 300, 400, 500, 600}

N = 3

```

cost(100) = 32
cost(200) = 45
cost(300) = 103
cost(400) = 77
cost(500) = 80
cost(600) = 10

```

Output: IL = {5, 0, 1}
 Cost of index 5, 0 and 1 is 10, 32 and 45.

Syntax: IsoCostListN(node: integer; NL, IL: [TIntegerList](#)^[148]; N: integer)

2.6.15 IsoCostListNDyn

Same method as [IsoCostListN](#)^[79], just using locations instead:

An error will be raised if location is on a loop link. Check with [LoopLink](#)^[54] function in advance.

Syntax: IsoCostListNDyn(Loc: [TLocation](#)^[160]; LL: [TLocationList](#)^[148]; IL: [TIntegerList](#)^[148]; N: integer)

2.6.16 IsoCostMulti

This method calculates an isochrone from a list of facilities (NL, nodes), identifying which facility is nearest. No more than 65535 nodes are allowed in the list.

For each facility you can define if there is an offset, i.e. a cost>0 value that is added to the cost. This can for instance be used to create drivetime regions around a number of fire-stations, which has different start times. Set parameter to nil, if offset=0 for all facilities.

You can set MaxCost if you only want smaller isochrones in your calculations.

BestCost returns the cost to the nearest facility.
 BestFacility returns an index into NL. If value is 65535, it means the node wasn't in reach of any facility.

Both have as many elements as there are nodes.

You can not combine this method with subsequent calls to [RouteFind](#)^[88], [LinkCostDyn](#)^[84], [NodeCost](#)^[88] or any other methods. You should only use the two output parameters as result.

Syntax: IsoCostMulti(NL: [TIntegerList](#)^[148]; Offset: [TCostArray](#)^[157]; var BestCost: [TCostArray](#)^[157]; var BestFacility: [TWordArray](#)^[165])

2.6.17 IsoLinkDriveTime

This method shows the distance from one more centers (nodes) to each location on a street network.

Internally it uses [IsoCostMulti](#)^[80] and shares the NL and Offset parameters with this method.

StepList is a number of cost values, indicating which values are used as steps in generating the output. For instance steps 1, 2 and 3 will generate steps 0-1, 1-2 and 2-3.

SL is a list of identifiers for the output. As many as there are items in NL. If SL=nil, you will get

0,1,2... identifiers instead.

Output is a polyline theme and the polylines are dynamically segmented to show the exact position where it changes, which center is the nearest. Polylines are oriented so they point away from the center.

If you run this method in turnmode, certain smaller details next to actual turn restrictions may come out wrong.

Syntax: `IsoLinkDriveTime(filename: string; GF: TGISformat156; NL: TIntegerList148; Offset: TCostArray157; StepList: TStepList148; SL: TStringList151)`

See also [Isochrones - overview](#)¹⁷¹

Example:



2.6.18 IsoLinkDriveTimeDyn

The same as [IsoLinkDriveTime](#)^[80], except it uses a single location as center.

Syntax: IsoLinkDriveTimeDyn(filename: string; GF: [TGISformat](#)^[158]; loc: [TLocation](#)^[160]; Offset: [TCost](#)^[157]; StepList: [TStepList](#)^[148])

2.6.19 IsoLinkServiceArea

This method shows which center (node) is the nearest on a street network.

Internally it uses [IsoCostMulti](#)^[80] and shares the NL and Offset parameters with this method.

Output is a polyline theme and the polylines are dynamically segmented to show the exact position where it changes, which center is the nearest. Polylines are oriented so they point away from the center.

If you run this method in turnmode, certain smaller details next to actual turn restrictions may come out wrong.

Syntax: IsoLinkServiceArea(filename: string; GF: [TGISformat](#)^[158]; NL: [TIntegerList](#)^[148]; Offset: [TCostArray](#)^[157])

Example:



2.6.20 IsoPoly

This method is for calculating input to the [voronoi](#)^[109]-based methods for drivetime isochrone, service areas etc.

Main input is two lists with nodes and locations. If you only have nodes or locations, set the other list parameter to nil. No more than 65535 items are allowed in the lists in total.

The lists contain your facilities or just a single facility. Isochrones are calculated for each of them and the output keeps track of which node / location was the nearest and cost. This is done for all nodes in the network.

For each facility you can define if there is an offset, i.e. a cost>0 value that is added to the cost. This can for instance be used to create drivetime regions around a number of fire-stations, which has different start times. Set parameter to nil, if offset=0 for all facilities.

Addnodes can be used to define if the calculation should be done for additional locations along long links. If the value of addnodes is, say 1 (km), and a link is 3.6 km long, additional nodes will be inserted at 0.9, 1.8 and 2.7 km in the output. No additional nodes are added if the link is shorter than 1 km.

[MaxCost](#)^[86] & MBR can both be used to define if the isochrone should be restricted in size. If [MaxCost](#)^[86]=0 and MBR=cFRNull, the whole network is covered.

If you run this method in turnmode and with addnodes<>0, certain smaller details next to actual turn restrictions may come out wrong.

See also [IsoPolyFast](#)^[83], [IsoPolyRandomization](#)^[83] and [Isochrones - overview](#)^[17].

Syntax: IsoPoly(NL: [TIntegerList](#)^[148]; LL: [TLocationList](#)^[148]; Offset: [TCostArray](#)^[157]; addnodes: [TCost](#)^[157]; MBR: [TFloatRect](#)^[158]): [TPolyGeneration](#)^[150]

2.6.21 IsoPolyFast

This function is the same as [IsoPoly](#)^[83], except the MBR parameter is replaced with a buffer parameter.

Internally the function automatically calculates MBR from the items in NL and LL, [MaxCost](#)^[86] and buffer. This makes it much faster and the recommended solution for preparing input for drive time polygons.

Buffer should be specified in km. Suggested values are 2 km for urban areas and 10 - 20 km in rural areas (for [voronoi](#)^[109] calculations).

If you use the output for [Alpha shapes](#)^[92], then buffer = 0 is sufficient.

Syntax: IsoPolyFast(NL: [TIntegerList](#)^[148]; LL: [TLocationList](#)^[148]; Offset: [TCostArray](#)^[157]; addnodes, buffer: [TCost](#)^[157]): [TPolyGeneration](#)^[150]

2.6.22 IsoPolyRandomization

Set this property to true, if you want to add a very small randomization to the coordinates output from the [IsoPoly](#)^[83] methods.

This is sometimes needed if you are using low values for the addnodes parameter due to numerical

instabilities in the

Default: false

Type: boolean

2.6.23 LinkCost

[TurnMode](#)^[92] = false:

Returns the maximum cost of the two end nodes of the link.

[TurnMode](#)^[92] = true:

Link>0: Returns the cost of going to the ToNode of the link.

Link<0: Returns the cost of going to the FromNode of the link.

Syntax: LinkCost(link: integer): [TCost](#)^[157]

2.6.24 LinkCostDyn

Returns the cost of getting to a specific location of a link.

This method can be used after a call to either [IsoCost](#)^[79] or [IsoCostDyn](#)^[79] function.

Syntax: LinkCostDyn(loc: [TLocation](#)^[160]): [TCost](#)^[157]

2.6.25 Matrix

This method calculates a matrix, based upon the nodes in NL.

Eventually set extra = true for use with [TTSP](#)^[134] - see explanation in [TTSPmode](#)^[164].

Set symmetric = true, if you can do with a symmetric matrix. This makes calculations faster. But it is not recommended if you have oneway restrictions in the network.

If you want to do a N x M matrix rather than N x N, use [Matrix2](#)^[84].

Syntax: Matrix(NL: [TIntegerList](#)^[148]; extra,symmetric: boolean): [TMatrix](#)^[160]

2.6.26 Matrix2

This method calculates a matrix, based upon the nodes in NL1 and NL2. Calculations are fastest if NL1 is the smallest list.

See also [Matrix](#)^[84].

Syntax: Matrix2(NL1, NL2: [TIntegerList](#)^[148]): [TMatrix](#)^[160]

2.6.27 MatrixBuffer

When calculating matrices for a small area in a big street network, it is possible to speed up calculations by restricting calculations to the relevant part + a buffer.

Experience show a factor 2 can be obtained in the best case.

If the buffer gets specified too small, you risk not finding the correct route or even not finding a route at all.

We recommend using 5 km for urban areas, in more rural areas use a larger value.

If you use 0 or a negative value, the whole network is considered (default).

Applies to: [Matrix](#)^[55], [Matrix2](#)^[84], [MatrixDyn](#)^[55], [MatrixDyn2](#)^[85], [MatrixOut](#)^[85], [MatrixDynOut](#)^[85] and [MatrixPOut](#)^[86].

Default: 0 km

Property MatrixBuffer: double;

2.6.28 MatrixDyn

Same method as [Matrix](#)^[84], just with locations instead of nodes:

Syntax: MatrixDyn(LL: [TLocationList](#)^[148]; extra, symmetric: boolean): [TMatrix](#)^[160]

2.6.29 MatrixDyn2

Same method as [Matrix2](#)^[84], just with locations instead of nodes:

Syntax: MatrixDyn2(LL1, LL2: [TLocationList](#)^[148]): [TMatrix](#)^[160]

2.6.30 MatrixDynOut

Same method as [MatrixOut](#)^[85], just with locations instead of nodes.

It also adds an additional parameter `nearestopen`, which updates locations in LL1 and LL2 where needed by making calls to [NearestOpenDyn](#)^[87].

If you want to use [MaxCost](#)^[86] at the same time, use [NearestNDyn](#)^[97] instead.

Syntax: MatrixDynOut(filename: string; GF: [TGISformat](#)^[158]; LL1, LL2: [TLocationList](#)^[148]; SL1, SL2: [TStringList](#)^[151]; dist, time, cost, directdist, symmetric, routeobject, nearestopen: boolean)

2.6.31 MatrixOut

This method calculates a matrix, based upon the nodes in NL1 and NL2.

SL1 and SL2 contains strings, identifying the records. This can be as simple as the record ID or another text.

SL1 and NL1 need to hold the same amount of items.

SL2 and NL2 need to hold the same amount of items.

Optionally SL1 and SL2 can be nil, then list index is used in the output.

If SL1 or SL2 contains all integers, the field type in the output is generated accordingly.

Dist, time, cost and directdist can be set to false/true to determine which fields should be included in the output.

Set `routeobject = true`, if you want the route to be part of the output.

If `symmetric` is true, NL2 should be the same as NL1 and only combinations in one direction between members in NL1 is part of the output.

If [threads](#)^[91] > 1, symmetric is ignored / is always false.

If you want to use [MaxCost](#)^[86] at the same time, use NearestN instead.

Output files can get very big if you have many items in the lists, especially if routeobject is also true. See the notes about [TGISwrite](#)^[115].

Syntax: MatrixOut(filename: string; GF: [TGISformat](#)^[156]; NL1,NL2: [TIntegerList](#)^[148]; SL1,SL2: [TStringList](#)^[151]; dist, time, cost, directdist, symmetric, routeobject: boolean)

2.6.32 MatrixPOut

Same method as [MatrixDynOut](#)^[85], just with positions instead of locations. This means you should use the coordinate of [TLocationList](#)^[160] items, rather than the locations.

It also adds an additional parameter offroadspeed (km/h), which allow you to include the offroad part in the output. If speed=0, then it is skipped.

Another additional parameter is skiplinkbit which determines if the skiplinkbit from the attribute field, is used in the spatial search.

If nearestopen is "active" for a specific element (i.e. another element is used as the starting point, rather than the nearest), then the offroad part is skipped.

If you want to use [MaxCost](#)^[86] at the same time, use [NearestNP](#)^[98] instead.

Syntax: MatrixPOut(filename: string; GF: [TGISformat](#)^[156]; LL1, LL2: [TLocationList](#)^[148]; SL1, SL2: [TStringList](#)^[151]; dist, time, cost, directdist, symmetric, routeobject, nearestopen: boolean; offroadspeed: double; skiplinkbit: boolean)

2.6.33 MaxCost

This property can be used to restrict the size of isochrones, nearest N calculations etc. Various Matrix functions are not affected by MaxCost. Unit is whatever is used as cost criteria: Cost, time or distance.

Default: 0

Type: [TCost](#)^[157]

2.6.34 MaxSpeed

This property can be used to limit the speed of all links in the network, if you are calculating for a vehicle that can not go as fast as is otherwise possible.

It only affects the route choice when working in [Fastest](#)^[89] mode.

Default: 0

Type: [TCost](#)^[157]

2.6.35 Mlpen

Setting this property allows you to control the line style of the output of these methods:

[MatrixOut](#)^[85], [MatrixPOut](#)^[86], [MatrixDynOut](#)^[85], [NearestNDyn](#)^[97], [NearestNP](#)^[98],
[TrafficAssignment](#)^[102] and [TrafficAssignmentDyn](#)^[102].

When you call it from the MapBasic DLL, the color is in MapInfo style (BGR), otherwise it is ordinary windows style (RGB).

Type: [TMlpen](#)^[161]

2.6.36 Nearest

This method will locate the nearest item in NL, calculated from a node. It returns the index of the item.

If returning -1, nothing was found.

Syntax: Nearest(node: integer; NL: [TIntegerList](#)^[148]): integer

2.6.37 NearestDyn

This method will locate the nearest item in LL, calculated from the location. It returns the index of the item.

If returning -1, nothing was found.

Syntax: NearestDyn(Loc: [TLocation](#)^[160]; LL: [TLocationList](#)^[148]): integer

2.6.38 NearestOpen

This method will find the nearest open node, from a starting node. An open node is one where at least one of the connected links is open for driving.

Syntax: NearestOpen(node: integer; var NearestNode, NearestLink: integer; var cost: [TCost](#)^[157])

2.6.39 NearestOpenDyn

This method will find the nearest open link and node, from a starting location. An open node is one where at least one of the connected links is open for driving.

Obstacles it ignores while doing so:

- 1) Oneway restrictions
- 2) Limits
- 3) Links being skipped
- 4) NoDriveThrough setting

Syntax: NearestOpenDyn(Loc: [TLocation](#)^[160]; var NearestNode, NearestLink: integer; var cost: [TCost](#)^[157])

2.6.40 NodeCost

Returns the cost for a single node. This requires that an isochrone has been calculated previously.

Syntax: NodeCost(node: integer): [TCost](#)^[157]

2.6.41 NoDriveThrough

This property controls if the [attribute](#)^[6] bit for NoDriveThrough areas should be respected in calculations.

Default: false

Type: boolean

2.6.42 RouteCost

This method returns the cost of a route, according to how Cost has been [setup](#)^[89].

See also [RouteTime](#)^[89] and [RouteLength](#)^[60].

Syntax: RouteCost(route: [TRoute](#)^[163]): [TCost](#)^[157]

2.6.43 RouteFind

This method will return a TRoute list to a node, if a route / isochrone has already been calculated from another node.

2 examples with the same functionality:

```
TCalc.IsoCost(node1)
cost = TCalc.NodeCost(node2)
route = TCalc.RouteFind(node2)
```

```
cost = TRouteCalc.Route(node1,node2)
route = TCalc.RouteFind(node2)
```

[IsoCost](#)^[79] method is faster if you have many calculations to do for the same node1. But class [TRouteCalc](#)^[96] offers more fine-tuning options.

Syntax: RouteFind(node: integer): [TRoute](#)^[163]

2.6.44 RouteFindDyn

This method will return a TRoute list to a location, if an isochrone has already been calculated from another location.

2 examples with the same functionality:

```
TCalc.IsoCostDyn(location1)
cost = TCalc.RouteFindDyn(location2,route)
```

```
cost = TRouteCalc.RouteDynEx(location1,location2,route)
```

[IsoCostDyn](#)^[79] method is faster if you have many calculations to do for the same location¹. But class [TRouteCalc](#)^[96] offers more fine-tuning options.

Syntax: RouteFindDyn(Loc: [TLocation](#)^[160]; var route: [TRoute](#)^[163]): [TCost](#)^[157]

2.6.45 RouteTime

This method returns the time (minutes) of a route, according to how Time has been [setup](#)^[89].

See also [RouteCost](#)^[88] and [RouteLength](#)^[60].

Syntax: RouteTime(route: [TRoute](#)^[163]): [TCost](#)^[157]

2.6.46 SelectClosedLinks

This method can be used for selecting from the street network.

Output is stored in BA. New selections are set and added to any previous selections in BA.

It selects all links which are closed for the current setup, according to limits.

If includeoneway is true, it will also select links where both [oneway_bits](#)^[6] are set (512 + 1024).

Syntax: SelectClosedLinks(BA: TBitArray; includeoneway: boolean);

2.6.47 SetCheapest

This sets the calculation target to be cost. At the same time it can be specified if turn restrictions should be included.

Syntax: SetCheapest(turncosts: boolean)

2.6.48 SetCost

This defines which cost array should be used in [cheapest](#)^[89] route calculations.

Default: 0 as index

Syntax: SetCost(index: integer)

2.6.49 SetFastest

This sets the calculation target to be time. At the same time it can be specified if turn restrictions should be included.

Syntax: SetFastest(turncosts: boolean)

2.6.50 SetLimit

This allows you to restrict routing to links where a limit exists. See [Limit](#)^[9] for further details.

LimitID is from 1 to 9 and value is from 0 to 255.

Default is value = 0, i.e. no restriction.

Syntax: SetLimit(LimitID: integer; value: byte)

2.6.51 SetShortest

This sets the calculation target to be distance. At the same time it can be specified if turn restrictions should be included.

If they are included, only restrictions (<0) are applied. Delays (>0) are ignored.

Default: SetShortest(false)

Syntax: SetShortest(turncosts: boolean)

2.6.52 SetSkipLinkList

You can set up a list of links that should be excluded in routing.

Default: no list

See also [SetSkipNodeList](#)^[101].

Syntax: SetSkipLinkList(list: [TBitArray](#)^[149])

2.6.53 SetTime

This defines which time array should be used in [fastest](#)^[89] route calculations.

Default: 0 as index

Syntax: SetTime(index: integer)

2.6.54 SetTurn

This defines which turn restriction array should be used, when turncosts = true in [SetCheapest](#)^[89], [SetFastest](#)^[89] or [SetShortest](#)^[90].

Default: 0 as index

Syntax: SetTurn(index: integer)

2.6.55 SkipCulDeSacOptimization

This property controls if cul-de-sac optimization should be skipped during route calculations, increasing calculation time by 25-30%.

It can be used to make sure [RouteDynApproach](#)^[100] calculations gives the same result as [IsoCostDyn](#)^[79] followed by [RouteFindDyn](#)^[88] - even in rare situations.

Default: false

Type: boolean

2.6.56 SmartInit

When doing short routes / small isochrones in very large networks (>2 million links), we have added this feature, which allows the routing engine to only initialize the network as it works its way through it, by using the spatial index for determining when new areas are visited.

It can improve performance by a factor 2-5 in such cases. The advantage disappears when length of routes reaches app. 50 km. For very long routes, it is even a disadvantage.

Default: false

Type: boolean

2.6.57 Starttime

This property is used for defining when a route calculation starts. Not implemented yet.

Type: [TCost](#)^[157]

2.6.58 Threads

Set this property to decide how many threads are used when calling these methods:

[IsoCostMulti](#)^[80]
[IsoLinkDriveTime](#)^[80] (*)
[IsoLinkServiceArea](#)^[82] (*)
[IsoPoly](#)^[83]
[IsoPolyFast](#)^[83]

[Matrix](#)^[84]
[Matrix2](#)^[84]
[MatrixDyn](#)^[85]
[MatrixDyn2](#)^[85]
[MatrixDynCurbIsochrone](#)^[100]

[MatrixOut](#)^[85] (*)
[MatrixDynOut](#)^[85] (*)
[MatrixPOut](#)^[86] (*)

Methods that involve writing a lot to disk (*), do not always benefit much from running multi-threaded. Some fileformats are even slower in multi-threaded mode.

The setting only applies in RW Net Pro. Valid values are 1 to 16. Default is 1. We do not recommend using higher than the "number of cores - 1".

When running with multiple threads, additional TCalc objects are created internally. This means a much higher amount of memory is allocated. This is especially something to be aware of with large street networks.

Progress events for these functions are disabled when threads > 1.

Type: integer

2.6.59 TimeFormatAsString

When set as true, time values in matrix output is generated in a human readable format, rather than minutes.

Examples:

4m 30s

3h 23m 05s

999h 00m 02s

Max value is 999 hours.

It affects: [MatrixOut](#)^[85], [MatrixDynOut](#)^[85], [MatrixPOut](#)^[86], [NearestNDyn](#)^[97], [NearestNP](#)^[98], [RoutePairs](#)^[98] and [RoutePairsP](#)^[99].

Default: false

Type: boolean

2.6.60 Turnmode

This read-only property returns if the object was [created](#)^[76] with turnmode enabled.

Type: boolean

2.6.61 UTurnAllowed

Defines if U-turns are allowed when Turnmode = true.

False: All U-turns are banned.

True: All U-turns are allowed, unless banned through [attribute](#)^[6] settings.

U-turns are always allowed on [cul-de-sac](#)^[47] links.

Default: false

Type: boolean

2.6.62 Pro methods

2.6.62.1 AlphaShape

Alpha shapes is one of many ways to create isochrones around a set of points. It requires the presence of alphashape.dll or alphashape64.dll.

See also [Isochrones - overview](#)^[17]

Syntax: AlphaShape(PG: [TPolyGeneration](#)^[150]; SL: [TStepList](#)^[148]; Includelands: boolean; filename: string; GF: [TGISFormat](#)^[158]);

2.6.62.2 CenterNode

This method finds the center node of a network, the one which minimizes this expression:

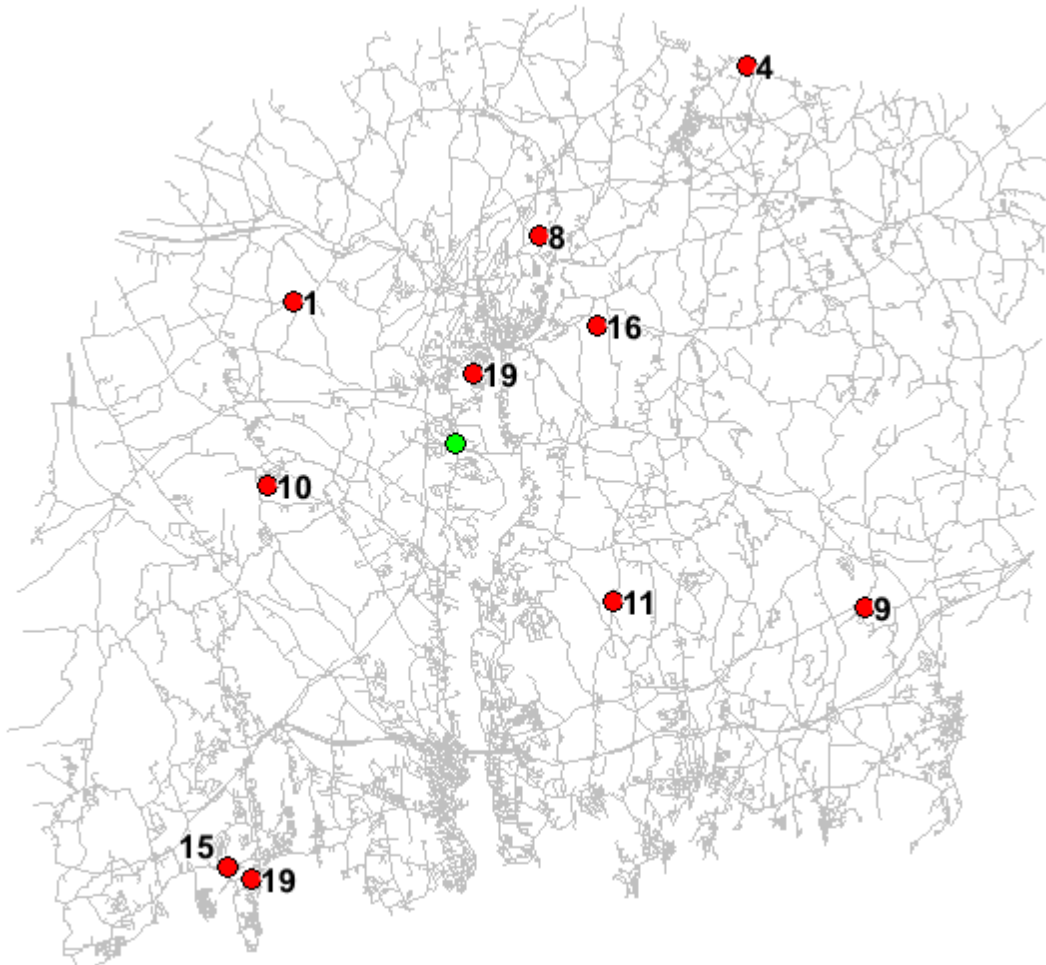
$$\sum \text{Weight}(\text{node}) * \text{distance}(\text{node}, \text{CenterNode})$$

Parameter `nodeweights` need to have as many elements as [NodeCount](#)^[55] + 1 and contain 0's or positive weights.

The method is aimed at having not too many elements > 0 or it gets slow.

Syntax: `CenterNode(var nodeweights: TCostArray[157]): integer;`

Example with 10 nodes with weights and the green centernode:



2.6.62.3 IsoCostDynApproach

This method calculates an isochrone from the location, but with a specific approach. The size of the isochrone can be restricted by setting [MaxCost](#)^[86].

An error will be raised if location is on a loop link. Check with [LoopLink](#)^[54] function in advance.

Requires [turnmode](#)^[92] = true !

Syntax: [IsoCostDynApproach](#)(Loc: [TLocation](#)^[160]; Approach: [TApproach](#)^[155])

2.6.62.4 IsoCostListDynApproach

This method calculates an isochrone from the location, but with a specific approach. It stops when all items in LL has been reached.

An error will be raised if location is on a loop link. Check with [LoopLink](#)^[54] function in advance.

Requires [turnmode](#)^[92] = true !

Syntax: [IsoCostListDynApproach](#)(Loc: [TLocation](#)^[160]; LL: [TLocationList](#)^[148]; Approach: [TApproach](#)^[155])

2.6.62.5 LinkCostDynApproach

Returns the cost of getting to a specific location of a link and with a specific approach. This method can be used after a call to [IsoCostDynApproach](#)^[93] method.

2 examples with the same functionality:

```
TCalc.IsoCostDynApproach[93](location1,approach1)
cost = TCalc.LinkCostDynApproach(location2,approach2)
```

```
cost = TRouteCalc.RouteDynApproach[100](location1,location2,approach1,approach2)
```

If location1.link = location2.link you will have to use the TRouteCalc method.

Syntax: [LinkCostDynApproach](#)(loc: [TLocation](#)^[160]; approach: [TApproach](#)^[155]): [TCost](#)^[157]

2.6.62.6 MST

This method calculates a [minimum spanning tree](#) for the network, using [Prims algorithm](#). Result is stored in links as 1's if the link is part of the tree.

By default length is used as cost, but by calling [SetFastest](#)^[89] or [SetCheapest](#)^[89], you can change to another criteria.

Oneway restrictions are not taken into account, neither is limits or the [SkipLinkList](#)^[90].

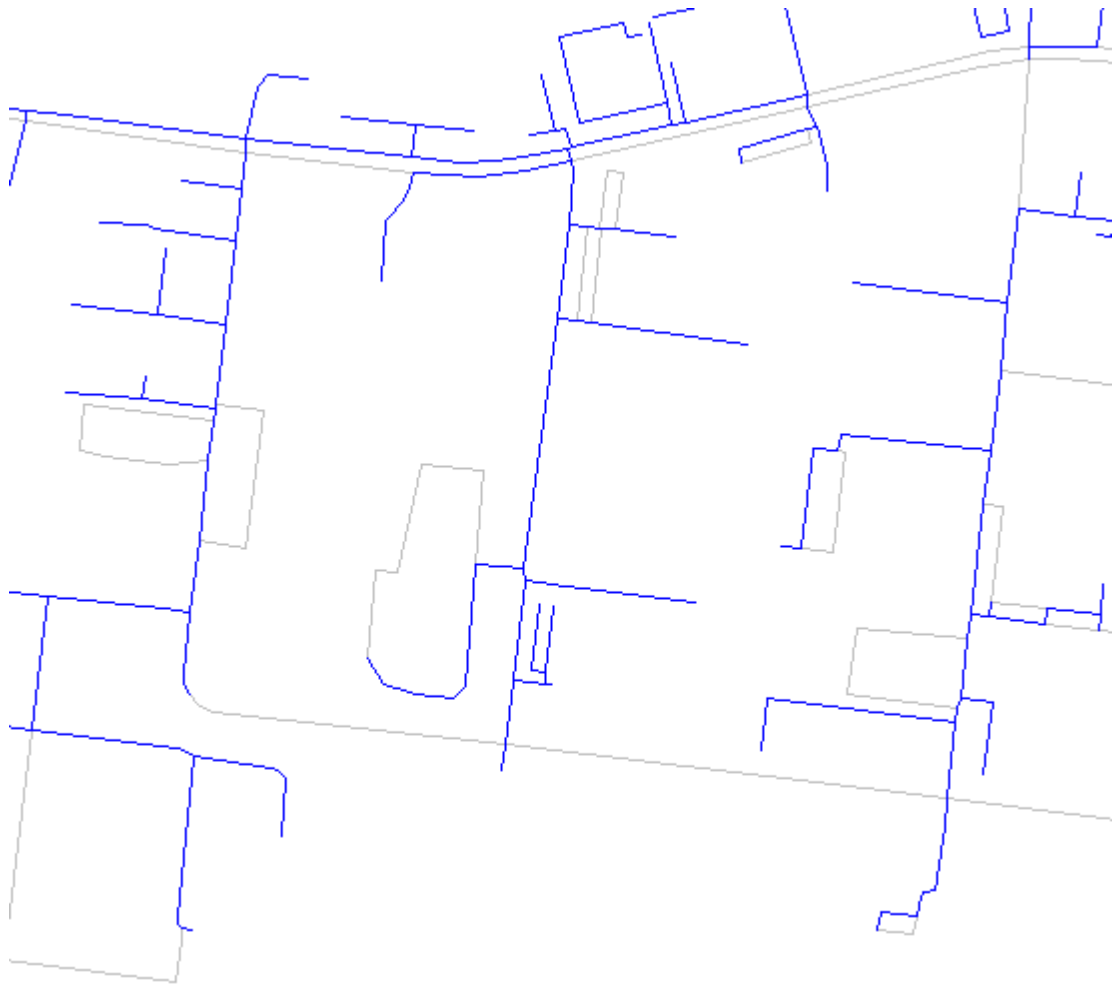
Performance examples:

13,500 links: 0.5 sec

200,000 links: 165 sec

Syntax: [MST](#)(links: [TBitArray](#)^[149]);

Example output, subset of larger network:



2.6.62.7 RouteFindDynApproach

This method will return a TRoute list to a location, if an isochrone has already been calculated from another location.

2 examples with the same functionality:

```
TCalc.IsoCostDynApproach[93](location1,approach1)  
cost = TCalc.RouteFindDynApproach(location2,approach2,route)
```

```
cost = TRouteCalc.RouteDynApproachEx[107](location1,location2,approach1,approach2,route)
```

If location1.link = location2.link you will have to use the TRouteCalc method.

```
Syntax: RouteFindDynApproach(loc: TLocation[160]; approach: TApproach[155]; var route: TRoute[163]):  
TCost[157]
```

2.6.62.8 SetSmoothing

Same functionality as [here](#)^[114], but for method [DriveTimeSimple](#)^[77].

Syntax: SetSmoothing(passes, rounded, deviation: integer);

2.6.62.9 SubNet

This method calculates which part of a network is a subnet. A subnet is defined as a part of the network, which isn't connected to the rest of the network. It can typically be an island without a ferry or a similar situation.

This is done with [IgnoreOneWay](#)^[79] set to true temporarily, so one-way restrictions may in fact make even more links in-accessible. See function [SubNetEx](#)^[101] on how to detect such situations.

IA returns the subnet ID for each link, while the method returns the number of subnets.

0 = main net

1, 2, 3... = sub nets

The main net is defined as the part of the network with node 1.

See also [SubNetEx](#)^[101]

Syntax: SubNet(var IA: [TIntegerArray](#)^[158]): integer

2.6.62.10 Tree

This method allows you to calculate a tree from a single starting point, typically used for verification of the street network.

This can be seen as a simpler version of [TRouteCalc.TrafficAssignment](#)^[102]. It only records which links are in use and all traffic is from a single node.

Syntax: Tree(filename: string; GF: [TGISformat](#)^[158]; startnode: integer; var NL: [TIntegerList](#)^[148])

2.6.62.11 UnusedLinks

This method can be used for locating links which are not part of a route between any 2 nodes. This is done using the current cost criteria.

Invalid objects are not marked in the output.

Syntax: UnusedLinks(links: [TBitArray](#)^[149])

2.7 TRouteCalc

This class inherits all properties and methods from [TCalc](#)^[75] and adds methods and properties related to one-to-one route calculations, the [A*](#) algorithm is used.

In particular it adds these properties:

[Alpha](#)^[97] Makes it possible to increase speed of calculations. No further data requirements.
[Hierarchy](#)^[99] Makes it possible to increase speed of calculations, if hierarchical information is available in the [attributes](#)^[6].

[SkipNodeLi](#) Allows you to avoid passing through certain nodes in the network.

2.7.1 [Alpha](#)

This property allows you to speed up calculations. By using 1.0 as value you will still get the actual best route, while increasing the value also increases the risk of getting a route that is closer to a straight line between start and end, but not necessarily the best route.

We recommend not increasing to more than 1.3. That may improve calculation speed with a factor 10 or so: Largest improvement is seen for long routes.

Default: 1.0

See also [UpdateAlphas](#).

Type: [TCost](#)

2.7.2 [NearestNDyn](#)

This method finds the N nearest elements in LL2 for every element in LL1.

Typically LL1 has many elements, such as single addresses.
LL2 has much less elements, typically some centers (schools etc).

Routes are calculated from center to address for optimized speed of calculations. If you want the other direction, call [SwapOneWay](#) before and after calling the function.

If [maxcost](#) is set, it is used as cutoff and less than N elements may be found.

if N=0, then all elements are returned.

SL1 and SL2 can be nil or contain text identifiers for the output.

Dist, time and cost can be set to false/true to determine which fields should be included in the output.

Set routeobject = true, if you want the route to be part of the output (slows down calculations).

Output is a GIS file with one or more of these fields:

1. ID1
2. ID2
3. N
4. Distance
5. Time
6. Cost
7. DirectDist

Syntax: [NearestNDyn](#)(filename: string; GF: [TGISformat](#); LL1, LL2: [TLocationList](#); N: integer; SL1, SL2: [TStringList](#); dist, time, cost, directdist, routeobject: boolean)

2.7.3 NearestNP

Same method as [NearestNDyn](#)^[97], just with positions instead of locations.
This means you should use the coordinate of [TLocationList](#)^[160] items, rather than the locations.

It also adds an additional parameter offroadspeed (km/h), which allow you to include the offroad part in the output. If speed=0, then it is skipped.

If nearestopen is "active" for a specific element (i.e. another element is used as the starting point, rather than the nearest), then the offroad part is skipped.

Syntax: NearestNP(filename: string; GF: [TGISformat](#)^[158]; LL1, LL2: [TLocationList](#)^[148]; N: integer; SL1, SL2: [TStringList](#)^[151]; dist, time, cost, directdist, routeobject, nearestopen: boolean; offroadspeed: double)

2.7.4 Route

Returns the cost of a route from node1 to node2.

You can call [RouteFind](#)^[88] afterwards, if you want the actual route and not just the cost.

Syntax: Route(node1,node2: integer): [TCost](#)^[157]

2.7.5 RouteDyn

Returns the cost of a route from location1 to location2.

See also [RouteDynEx](#)^[98].

Syntax: RouteDyn(loc1,loc2: [TLocation](#)^[160]): [TCost](#)^[157]

2.7.6 RouteDynEx

Returns the cost of a route from location1 to location2, including the actual route.

Syntax: RouteDynEx(loc1,loc2: [TLocation](#)^[160]; var Route: [TRoute](#)^[163]): [TCost](#)^[157]

2.7.7 RoutePairs

This method calculates the route between pairs of elements in LL1 and LL2, which must have the same amount of elements.

Input is the locations of the locationslists.

SL1 and SL2 can be nil or contain text identifiers for the output.

Dist, time and cost can be set to false/true to determine which fields should be included in the output.

Set routeobject = true, if you want the route to be part of the output (slows down calculations).

Output is a GIS file with one or more of these fields:

1. ID1
2. ID2
3. Distance

4. Time
5. Cost
6. DirectDist

Syntax: RoutePairs(filename: string; GF: [TGISformat](#)^[158]; LL1,LL2: [TLocationList](#)^[148]; SL1,SL2: [TStringList](#)^[151]; dist, time, cost, directdist, routeobject, nearestopen: boolean);

2.7.8 RoutePairsP

It is the same as [RoutePairs](#)^[98], except the input is the coordinates of the locationslists and it can handle an offroadspeed.

Syntax: RoutePairsP(filename: string; GF: [TGISformat](#)^[158]; LL1,LL2: [TLocationList](#)^[148]; SL1,SL2: [TStringList](#)^[151]; dist, time, cost, directdist, routeobject, nearestopen: boolean; offroadspeed: double);

2.7.9 Pro methods

2.7.9.1 Bridges

Detects if removing a link from the network, breaks up the network in separate subnets. The problematic links are marked with 1 in the IA array.

CulDeSac links are not marked, since testing for CulDeSac can easily be done with calling [CulDeSac](#)^[47] for all links.

Links with oneway restrictions are not marked, use SubNetEx instead.

The function returns the number of elements set in the array.

See also [SubNetEx](#)^[101]

Syntax: Bridges(var IA: [TIntegerArray](#)^[159]): integer

2.7.9.2 CulDeSacCurb

Detects which links can not be used in curb approach mode ([TTSPcurb](#)^[137]), when U-turns are not allowed. The problematic links are marked with 1 in the IA array.

[UTurnAllowed](#)^[92] and [IgnoreOneWay](#)^[79] should be left to false, to find all problems.

Simple CulDeSac links are not marked, since testing for CulDeSac can easily be done with calling [CulDeSac](#)^[47] for all links.

The function returns the number of elements set in the array.

The difference between the two functions, is this one also locates links where oneway restrictions are the cause of the problems.

Syntax: CulDeSacCurb(var IA: [TIntegerArray](#)^[159]): integer

2.7.9.3 Hierarchy

Set this property to true, if you want to enable hierarchical routing.

Default: false

Type: boolean

2.7.9.4 MatrixDynCurbIsochrone

Same as [MatrixDyn](#)^[85], but including curb approach, for use with [TTSPcurb](#)^[137].

This version is fastest if you have more than ~10 items in LL.

See also [MatrixDynCurbRoute](#)^[100].

Requires [turnmode](#)^[92] = true !

Syntax: MatrixDynCurbIsochrone(LL: [TLocationList](#)^[148]; extra: boolean): [TCurbMatrix](#)^[157]

2.7.9.5 MatrixDynCurbRoute

Same as [MatrixDyn](#)^[85], but including curb approach, for use with [TTSPcurb](#)^[137].

This version is fastest if you have less than ~10 items in LL.

See also [MatrixDynCurbIsochrone](#)^[100].

Syntax: MatrixDynCurbRoute(LL: [TLocationList](#)^[148]; extra: boolean): [TCurbMatrix](#)^[157]

2.7.9.6 RoadNameTest

This function tests the roadname as part of the driving directions. The theory is, if a road name occur more than once on a route, it may be an error and the links between the 2 occurrences might have the wrong name in the database. An example:

Link 1, 2, 3: Main Street

Link 4, 5: Old Road

Link 6, 7: Main Street

Here link 4 and 5 should probably have had the name Main Street as well. The function will report such instances and then leave it to the user to decide, if any edits should be performed.

RoadFileID defines the database with road names to use with the function and NumOfRoutes defines how many random routes to calculate as part of the test.

The fields in the generated GIS file are linkID, count of links that should be changed in the same way (2 in the example above), present roadname and suggested roadname. Generally, a low number of links to be changed, indicates a higher likelihood, that it is a required change. Using a filter of count<20 is a good idea, before viewing the output. Roundabouts are always skipped in the output.

Syntax: RoadNameTest(filename: string; GF: [TGISformat](#)^[158]; RoadFileID, NumOfRoutes: integer);

2.7.9.7 RouteDynApproach

Returns the cost of a route from location1 to location2, but with specific approach at both locations.

See also [RouteDynApproachEx](#)^[101].

Syntax: RouteDynApproach(loc1,loc2: [TLocation](#)^[160]; Approach1,Approach2: [TApproach](#)^[155]): [TCost](#)^[157]

2.7.9.8 RouteDynApproachEx

Returns the cost of a route from location1 to location2, but with specific approach at both locations. Actual route is also included in the output.

Syntax: RouteDynApproachEx(loc1,loc2: [TLocation](#)^[160]; Approach1,Approach2: [TApproach](#)^[155]; var Route: [TRoute](#)^[163]): [TCost](#)^[157]

2.7.9.9 SetHierarchyLevel

Sets the 4 hierarchy parameters for use in hierarchical routing. Values should be expressed in km.

Input requirement: h2 >= h3 >= h4 >= h5 >= 0.

By default all parameters are set to infinite, meaning no hierarchy is applied.

We have executed tests with TomTom (net2class field) and HERE (func_class field) databases and recommend these values:

| | Km |
|--------|----------------|
| HERE | 145, 90, 40, 7 |
| TomTom | 80, 40, 20, 10 |

HERE tests were executed on UK data with a large number of random routes. Compared to not using a hierarchy, calculations were 11 times faster.

For short routes (<50 km) there is only little difference between using a hierarchy or not, while calculation of longer routes (>400 km) in the UK may be as much as 20-40 times faster (HERE).

We have not had time to test TomTom so accurately yet, so the values above are just a good starting point.

Syntax: SetHierarchyLevel(h2, h3, h4, h5: double)

2.7.9.10 SetSkipNodeList

You can set up a list of nodes that should be excluded in routing.

Default: no list

See also [SetSkipLinkList](#)^[90].

Syntax: SetSkipNodeList(list: [TBitArray](#)^[149])

2.7.9.11 SubNetEx

Detects if a route between any 2 nodes can only be found when going in one of the directions. The links with the problematic one-way restrictions are identified and marked with 1 in the IA array. If any links are marked, it means the whole network isn't strongly connected.

The function returns the number of elements set in the array.

See also [SubNet](#)^[96] and [Bridges](#)^[99]

Syntax: SubNetEx(var IA: [TIntegerArray](#)^[159]): integer

2.7.9.12 TrafficAssignment

This method is for assigning traffic to a street network.

Key input is TL, which holds traffic as volume between two pairs of coordinates. All traffic is allocated to the street network, using the all-or-nothing principle. For each link it keeps track of the total volume in both directions.



The map shows traffic from the red dot to all the blue dots. Width of line corresponds to volume.

Errors is used for keeping track of records within TL for which no route could be calculated. If Errors is unassigned, no records are marked.

Output contains these fields:

1. Link ID
2. Volume in forward direction
3. Volume in reverse direction

See also [TrafficAssignmentDyn](#)^[102]

Syntax: TrafficAssignment(filename: string; GF: [TGISformat](#)^[158]; TL: [TTrafficList](#)^[148]; var Errors: [TIntegerList](#)^[148])

2.7.9.13 TrafficAssignmentDyn

This is the same method as [TrafficAssignment](#)^[102], but it uses dynamic segmentation which means volumes are assigned to partial links and locations are used internally, instead of nodes.

Output contains these fields:

1. Link ID
2. Start percent
3. End percent
4. Volume in forward direction
5. Volume in reverse direction

Syntax: TrafficAssignmentDyn(filename: string; GF: [TGISformat](#)^[158]; TL: [TTrafficList](#)^[148]; var Errors: [TIntegerList](#)^[148])

2.8 TDrivingDirections

This class can be used for creating driving directions (turn left/right etc), but also simpler setups aimed at just mapping. Output goes to a [TGISwrite](#)^[115] instance.

The 4 main methods:

[Route](#)^[106], [RouteList](#)^[106], [RouteDyn](#)^[106] and [RouteListDyn](#)^[106].

Route calculation properties

[SortedIndex](#)^[107] allows you to visit the location in a different order than natural. Typically as a result from [TTSP](#)^[134] / [TTSPcurb](#)^[137] calculations.

[RoundTrip](#)^[106] should be set, so it matches [TTSP.mode](#)^[164] if used in combination with [TTSP](#)^[134] / [TTSPcurb](#)^[137].

[OffRoadSpeed](#)^[105] can be used with RouteDyn and RouteListDyn, when coordinates are present in the LocationList.

[SideInArray](#)^[107] and [SideOutArray](#)^[107] can be used to define approach, when used in combination with [TTSPcurb](#)^[137].

They can also be populated by calling [CalcSideInOutArray](#)^[104], if sequence is known.

Output properties

The key property controlling the kind of output is [ConcatenationMode](#)^[104].

These 7 properties control if each field should exist in the output or not:

[Cost](#)^[104], [Dist](#)^[105], [Time](#)^[108], [Speed](#)^[107] and [DirectDist](#)^[104].
[TotalCost](#)^[108], [TotalDist](#)^[108] and [TotalTime](#)^[109]

DirectDist, Dist and TotalDist are always possible, while Cost, Speed and Time require that the parent [TRouteCalc](#)^[96] is set up correctly (see [SetTime](#)^[90] and [SetCost](#)^[89]).

DirectDist, Speed, cost and total cost are disabled by default. The rest are enabled.

These 3 properties control a possible time stamp field in the output:

[StartTime](#)^[108], [StopTime](#)^[108] and [TimeStampFormat](#)^[108].

[RoadFileID](#)^[105] is used for defining which road names should be used.

[Vialist](#)^[109] is for including a textual description of the locations / nodes.

Driving directions properties

These properties are only relevant for mode [cmDrivingDirections](#)^[156]:

[POI](#)^[105]

[RoundAboutCounting](#)^[106]

[SharpTurn](#)^[107]

[TurnText](#) ^[109]

2.8.1 Create

When creating an instance of TDrivingDirections, it is required to specify a TRouteCalc instance.

Syntax: Create(Calc: [TRouteCalc](#) ^[96]);

2.8.2 CalcDirectDist

This property contains the direct length of a route after calling [RouteDyn](#) ^[106] / [RouteListDyn](#) ^[106]. Unit is km or miles, according to [DistanceUnit](#) ^[105].

Type: [TCost](#) ^[157]

2.8.3 CalcSideInOutArray

This method is for preparing [SideInArray](#) ^[107] and [SideOutArray](#) ^[107] with optimum values (avoiding U-turns as much as possible), when the elements in LL is already in the correct sequence.

It will test all possible combinations, so calculation time increases if LL has many elements or the elements are far apart.

As an example 100 locations takes 3 second, while 500 locations take 13 secs on the sample street network.

It should be used before calling [RouteListDyn](#) ^[106].

Syntax: CalcSideInOutArray(LL: [TLocationList](#) ^[148])

Only available in the Pro version.

2.8.4 ConcatenationMode

This key property controls the kind of output performed when calling one of the methods.

Default: cmDrivingDirections

Type: [TConcatenationMode](#) ^[156]

2.8.5 Cost

This property controls if cost should be part of the output.

Default: false

Type: boolean

2.8.6 DirectDist

This property controls if directdist should be part of the output. Format of field is determined by [DistanceUnit](#) ^[105] and [DecimalsDist](#) ^[77].

Default: false

Type: boolean

2.8.7 Dist

This property controls if dist should be part of the output. Format of field is determined by [DistanceUnit](#)^[105] and [DecimalsDist](#)^[77].

Default: true

Type: boolean

2.8.8 DistanceUnit

When generating output, you can use this property to use miles & mph instead of km & km/h.

Default: duKm

Type: [TDistanceUnit](#)^[157]

2.8.9 OffRoadSpeed

This property can be used to define the speed while moving from the exact coordinates (which are off road) to the nearest link.

It can only be used in combination with method [RouteListDyn](#)^[106]. The LL parameter need to have both coordinates and locations defined internally. This is done by adding coordinates first and then use [TSpatialSearch.NearestLocationSimpleList](#)^[73].

If it is 0 and ConcatenationMode = cmCompactOffRoad, it is the same as using cmCompact.

A typical value would be 5 km/h, for walking speed.

Default: 0

Type: [TCost](#)^[157]

2.8.10 POI

It is possible to define a list of POI (Points-Of-Interest), that you want included in the output. For each link part of the result, it is checked if it contains any POI.

POI may be roadside signs, petrol stations etc. They are not possible during roundabouts.

Default: nil

Type: [TPOIList](#)^[148]

2.8.11 RoadFileID

This property is used to describe which [roadname](#)^[58] file is used for the driving directions.

If ConcatenationMode = cmDrivingDirections, it needs to be set.

If ConcatenationMode = cmSeparate, it can be set and shall then be included in the output.

For other modes, the roadname is not part of the output.

Default: 0

Type: integer

2.8.12 RoundAboutCounting

This property controls how exit links are counted as part of driving directions in roundabouts.

False: Only exit links are counted

True: All links are counted

Default: false

Type: boolean

2.8.13 RoundTrip

This property controls if the output should be generated as a round trip (A-B-C-A) or not (A-B-C).

If you call method [Route](#)^[106] or [RouteDyn](#)^[106] (2 points only), you may like to set it to false first.

Default: true

Type: boolean

2.8.14 Route

Same method as [RouteList](#)^[106], just with 2 nodes and no need to setup a list of nodes.

Syntax: Route(output: [TGISwrite](#)^[115]; node1,node2: integer)

2.8.15 RouteDyn

Same method as [RouteListDyn](#)^[106], just with 2 locations and no need to setup a list of locations.

Syntax: RouteDyn(output: [TGISwrite](#)^[115]; loc1,loc2: [TLocation](#)^[160])

2.8.16 RouteList

This method calculates a route between all the nodes in NL and writes the result to output.

Syntax: RouteList(output: [TGISwrite](#)^[115]; NL: [TIntegerList](#)^[148])

2.8.17 RouteListDyn

This method calculates a route between all the locations in LL and writes the result to output.

See also [OffRoadSpeed](#)^[105].

Syntax: RouteListDyn(output: [TGISwrite](#)^[115]; LL: [TLocationList](#)^[148])

2.8.18 SharpTurn

If this property is >0, it is possible to trigger a turn description in the output even when the street name doesn't change, but the road makes a clear turn at an intersection. Just define how sharp the turn should be. Suggested value is 60-75 degrees. This only applies to sharp turns at intersections - not halfway down a link.

Default: 0

Type: Integer

2.8.19 SideInArray

Set this property in combination with [TTSPcurb](#)^[137] optimization, to control how locations are approached (in-bound).

Default: nil

Type: [TApproachArray](#)^[155]

Only available in the Pro version.

2.8.20 SideOutArray

Set this property in combination with [TTSPcurb](#)^[137] optimization, to control how locations are approached (out-bound).

Default: nil

Type: [TApproachArray](#)^[155]

Only available in the Pro version.

2.8.21 SortedIndex

This property controls the order of the nodes / locations in the output. This is typically the output from [TTSP.SortedIndex](#)^[136].

Alternatively you can setup your own `TIntegerArray`. It should be zero-indexed and contain all values from 0 to Count-1 only once, starting with 0.

Default: nil

Type: [TIntegerArray](#)^[159]

2.8.22 Speed

This property controls if speed should be part of the output. Format of field is determined by [DistanceUnit](#)^[105].

Default: false

Type: boolean

2.8.23 StartTime

This property defines when time stamps start in the output and is defined as a fraction of a day.

Default: 0

Type: [double](#)^[155]

2.8.24 StopTime

This property defines when time stamps stops in the output and is defined as a fraction of a day. If [StartTime](#)^[108] <> 0, it is ignored.

Default: 0

Type: [double](#)^[155]

2.8.25 Time

This property controls if time should be part of the output. Format of field is determined by [DecimalsTime](#)^[77].

Default: true

Type: boolean

2.8.26 TimeStampFormat

This property controls the format for time stamp in the output. Works in connection with [StartTime](#)^[31] and [StopTime](#)^[108].

Default: tfSkip

Type: [TTimeStampFormat](#)^[163]

2.8.27 TotalCost

This property controls if total cost should be part of the output.

Default: false

Type: boolean

2.8.28 TotalDist

This property controls if total dist should be part of the output. Format of field is determined by [DistanceUnit](#)^[105] and [DecimalsDist](#)^[77].

Default: true

Type: boolean

2.8.29 TotalTime

This property controls if total time should be part of the output. Format of field is determined by [DecimalsTime](#)^[77].

Default: true

Type: boolean

2.8.30 TurnText

If this property is defined an additional field is added to the output with textual description of the turns instead of just the values from 0 to 379.

Default: nil

Type: [TTurnTexts](#)^[152]

2.8.31 ViaList

This is for including textual descriptions and / or a fixed service time for each of the locations.

Default: nil

Type: [TViaArray](#)^[164]

2.9 TVoronoi

This class is used for generating Voronoi polygons and Delaunay triangulations. A detailed description of these can be seen in Wikipedia: [Voronoi](#) & [Triangulation](#)

The primary target is calculation of service areas and drivetime isochrones.

The sample application shows how to do it for isochrones and service areas. The other modes are done in a similar fashion.

You can also use the class independently from the routing functions, if you create and populate the PolyGeneration parameter on your own.

Properties relevant for each mode:

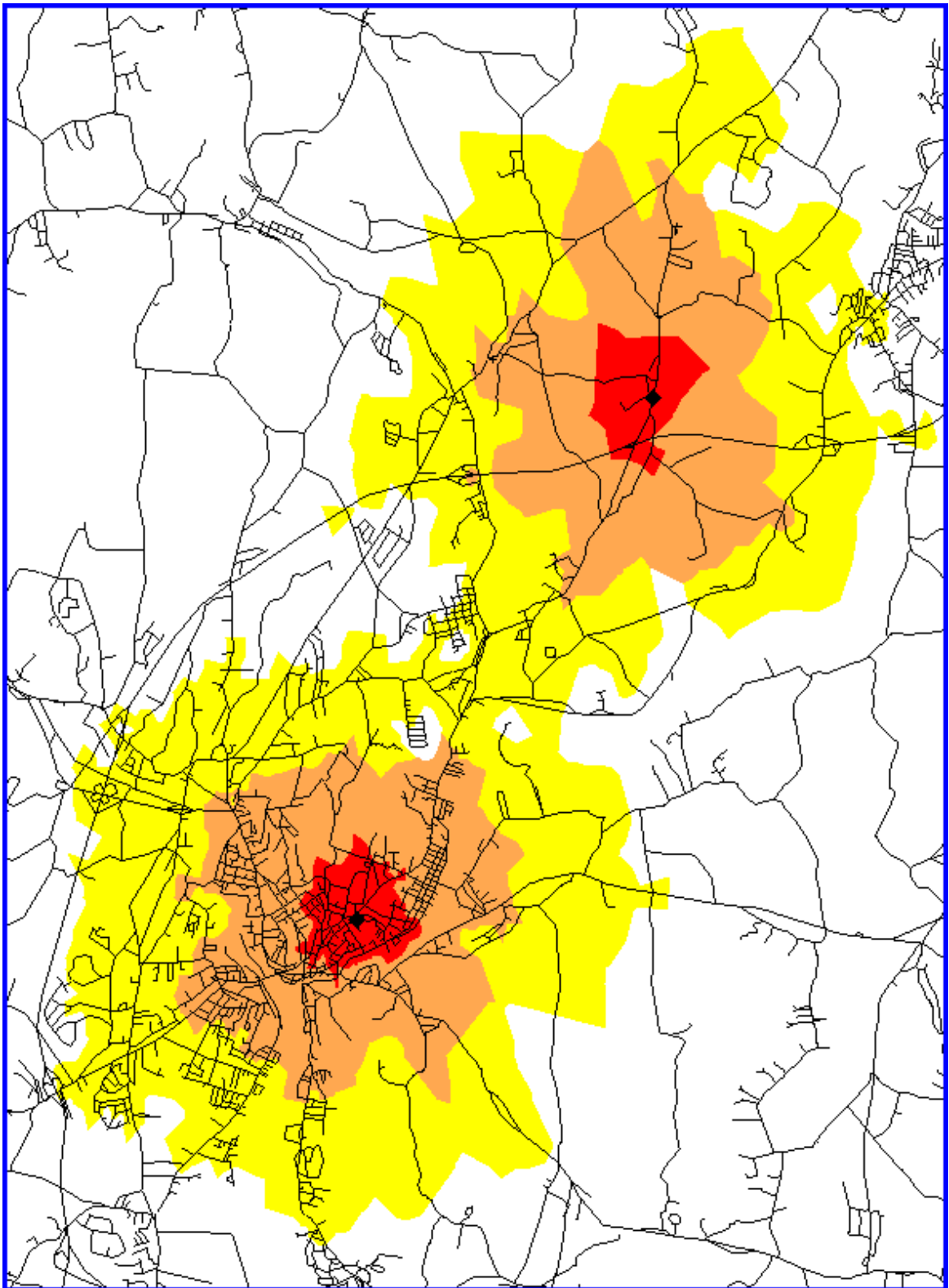
| Mode | GISwrite ^[112] | PolyGeneration ^[114] | Slope ^[115] | Zfieldname ^[115] | Doughnut ^[112] | ID ^[113] | IncludeHoles ^[113] | IncludeIslands ^[113] | StepList ^[115] | Smoothing ^[114] |
|-----------------------|---|---|--|---|---|-------------------------------------|---|---|---|--|
| vmTriangulationLine | X | X | X | X | | | | | | |
| vmTriangulationSimple | X | X | X | X | | | | | | |
| vmSimpleLine | X | X | | | | | | | | |
| vmSimple | X | X | | | | | | | | |
| vmIsochrone | X | X | | | X | | X | X | X | X |
| vmServiceAr | X | X | | | | X | X | X | | |

| | | | | | | | | | | |
|----|--|--|--|--|--|--|--|--|--|--|
| ea | | | | | | | | | | |
|----|--|--|--|--|--|--|--|--|--|--|

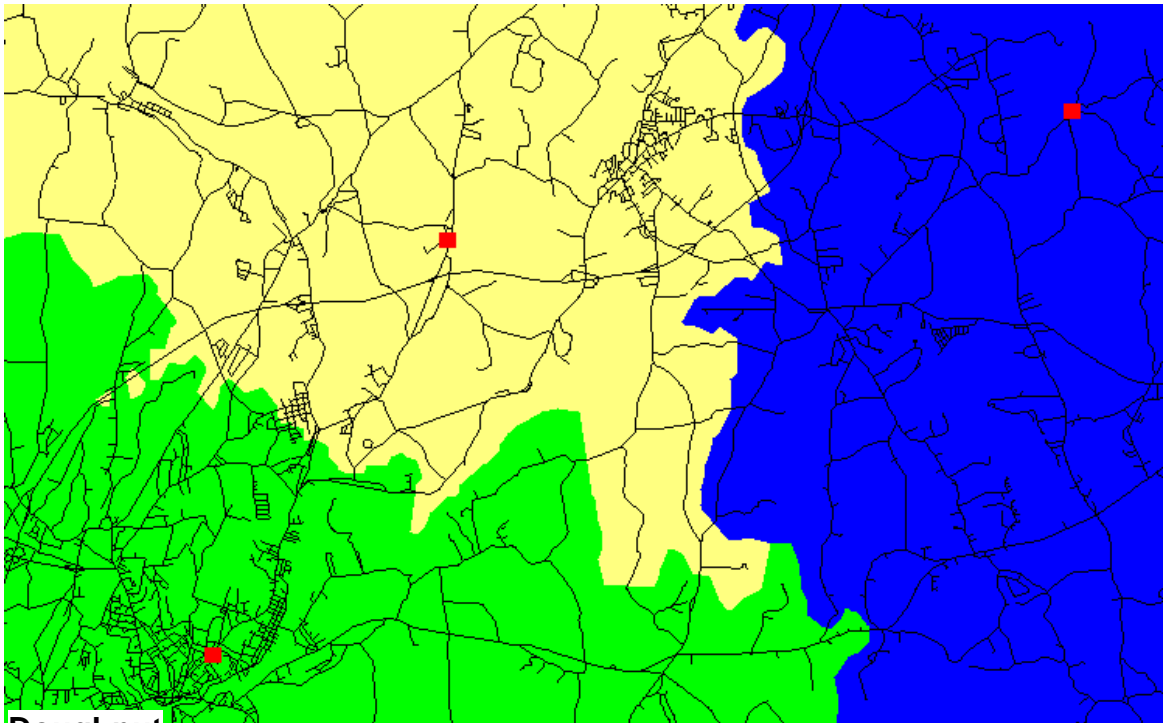
GISwrite, PolyGeneration and StepList need to be set.

Slope, Zfieldname, Doughnut, Includelands and IncludeHoles have default values and can be left unchanged.

Example of drivetime isochrone:



Example of service area calculation:



2.9.1 Doughnut

This property controls if output is generated as doughnut when mode = vmlsoChrono.

Example: If [StepList](#)^[115] holds values 1, 2 and 3, you will get these 3 records in the output, depending upon the value:

| false | true |
|-------|-------|
| 0 - 1 | 0 - 1 |
| 0 - 2 | 1 - 2 |
| 0 - 3 | 2 - 3 |

Non-doughnut polygons (false) are overlapping.
Doughnut polygons (true) are not overlapping.

Default: true

Type: boolean

2.9.2 Execute

This is the main method for starting calculations.

Syntax: execute: integer

2.9.3 GISwrite

This is a reference to a TGISwrite instance, for holding output from the calculations.

Default: nil

Type: [TGISWrite](#)^[115]

2.9.4 ID

This property can be used in `vmServiceArea` mode to have an ID field, rather than the default 0,1,2... values.

The list need to contain as many elements as you have Startpoints in [PolyGeneration](#)^[114].

Default: nil

Type: [TStringList](#)^[157]

2.9.5 IncludeHoles

This property controls if holes are allowed in the output, when `mode`^[114] = `vmIsoChrone` or `vmServiceArea`.

These two maps, show the same 1 km isochrone with `IncludeHoles` = true and false:



Default: true

Type: boolean

2.9.6 IncludIslands

This property controls if islands are included in the output, when `mode`^[114] = `vmIsoChrone` or `vmServiceArea`.

It is an island if there is no center inside it.

< sample map goes here >

Default: true

Type: boolean

2.9.7 Mode

This key property controls the kind of calculation and output performed when calling [execute](#)^[112].

Default: `vmIsoChrono`

Type: [TVoronoiMode](#)^[164]

2.9.8 PolyGeneration

This holds the main data used for the calculations.

Default: `nil`

Type: [TPolyGeneration](#)^[150]

2.9.9 SetSmoothing

This method allows you to smooth the output when [mode](#)^[114] = `vmIsoChrono`. Call it before calling [Execute](#)^[112].

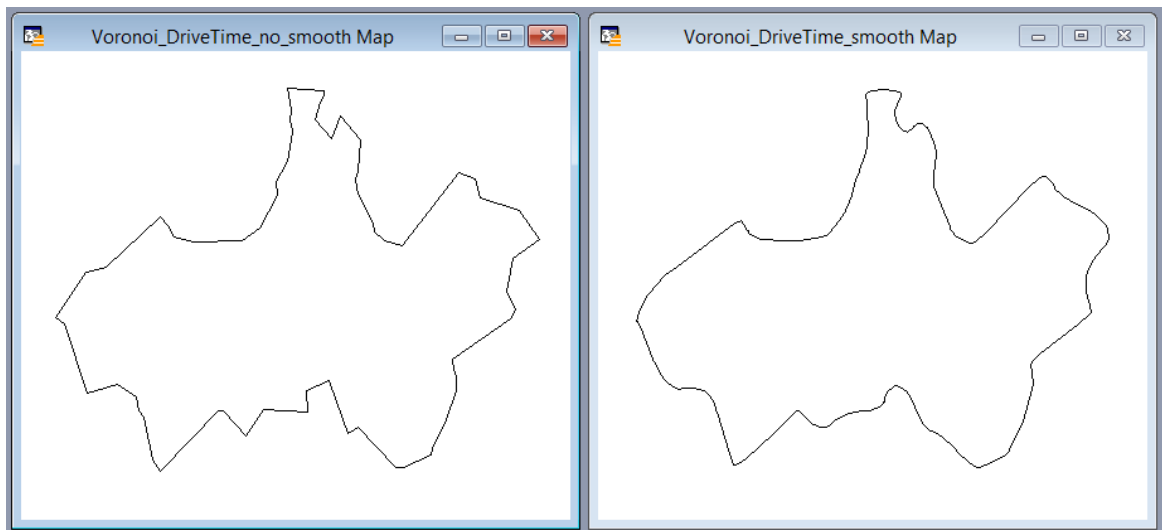
It is worth noting that the generated polygons do not get any more accurate, but may look more "visually" attractive on a map.

The number of nodes in the generated polygons will increase significantly, so use the function with care.

Recommendations:

- Call it with only 1 [step](#)^[115]. With ≥ 2 steps there is a risk of unwanted overlaps.
- Leave [doughnut](#)^[112] = `false` or you risk gaps between rings.

Example without and with settings (5,3,5):



Parameters and valid values:

Passes (1..5) defines how smoothed the output gets. A typical value is 3-4.

Rounded (3..6) defines how close the output fits the original input. 3 means any sharp angles almost disappear, while 5-6 for instance maintains the original look closer.

Deviation (0..15) allows you to remove some of the added nodes again to keep the total number of nodes lower without changing the look of the generated polygon too much.

Deviation is expressed in degrees. 1 degree will remove very few nodes, while 4-5 degrees will be good for most applications.

(0,0,0) is default value and means no smoothing at all. Use it for resetting.

Syntax: `SetSmoothing(passes, rounded, deviation: integer; coord: TCoordinateUnit156);`

2.9.10 Slope

This is the slope of the triangulations. X, Y and Z (Cost) need to be in the same unit for it to work.

Default: false (which means not calculated in output)

Type: boolean

2.9.11 StepList

This property is used to define the steps used in mode `vmIsoChrono`. See [Doughnut](#)¹¹² too.

Default: nil

Type: [TStepList](#)¹⁴⁸

2.9.12 Zfieldname

Change this property if you want a different fieldname for the Z (cost) value. This is only relevant for the triangulation modes.

Default: "Cost"

Type: string

2.10 TGISwrite

This class is used for generating output from calculations. Typically as a GIS file with coordinates, but CSV and DBF files are also possible.

It is mostly used internally, but made available to users too. There is less error checking in this class, so you are to a higher degree responsible for what you are doing, if you use it directly. The sample uses it several times.

This table lists the 8 classes, which all has the same interface:

| | Contains geographic data | Style information | File components | 2 GB limit |
|----------------|--------------------------|-------------------|-----------------|------------|
| TGISwriteArray | X | | | |

| | | | | |
|------------------|---|---|-------------------------|---------------|
| TGISwriteCSV | | | CSV | |
| TGISwriteDBF | | | DBF | X |
| TGISwriteGeoJSON | X | | GEOJSON | X (if string) |
| TGISwriteGML2 | X | | XML, XSD | |
| TGISwriteKML2 | X | | KML | |
| TGISwriteMIF | X | X | MIF, MID | |
| TGISwriteMIF8 | X | X | MIF, MID | |
| TGISwriteMITAB | X | X | TAB, MAP, ID, DAT | X |
| TGISwriteSHP | X | | SHP, SHX, DBF, PRJ, CPG | X |

Despite most of the file formats can hold mixed [object types](#)^[162] (SHP being the exception), we only support using a single object type.

Array

This is not file based opposed to the other formats. Not suited for very large datasets or you may hit an out-of-memory error.

CSV

This always uses , as field delimiter, no matter regional settings. First line in the file contains the field names.

DBF

Stores codepage information in byte 29 in the header. This is standard, but not all software reads the information.

GeoJSON

If you don't specify a filename for output, the content is stored in a string property called GeoJSON instead.

GML2

2.1.2 format.

KML2

2.2 format.

You should only use KML if your coordinate system is already lat/long, WGS84.

MIF8

The new UTF-8 formatted MIF file for MapInfo 15.2 (64-bit) and up.

MITAB

Requires MITAB.DLL or MITAB64.DLL on the path.

SHP

CPG file is a simple text file with the codepage number. ArcGIS can read this information.

2.10.1 AddField

Call this method to add fields after creating the [header](#)^[121].

Syntax: AddField(Fieldname: string; Field: [TGISField](#)^[156]; Width, decimals: byte)

SHP / DBF do not support field names with more than 10 characters.

Width should be specified for fChar and fDecimal.

Width is a maximum of 254 for fChar in DBF, MIF, SHP and MITAB.

For KML and GML there is no limit and width is ignored.

Decimals should be specified for fDecimal.

2.10.2 Adding objects

There are 5 ways to add objects:

- [AddPoint](#)^[118]
- [AddPoint2](#)^[118]
- [AddLine](#)^[118]
- [AddLine2](#)^[118]
- [AddObject](#)^[118] followed by [AddSection](#)^[118] / [AddSection2](#)^[119]

In all methods the attributes for the object is added as a comma-delimited string.

Always use , as delimiter.

Always use . as decimal point.

Char fields with " inside, needs to have it escaped with "".

Number of elements in the string must match the number of fields, except for CSV and MIF where the content is written directly to the file.

When using gfChar fields, use Unicode and " around the text.

When using gfDate fields, use this format: YYYYMMDD

When using gfLogical fields, use this format for true: "T", "t", "Y", "y" or 1.

When using gfTime fields, use this format: HHMMSSsss (where sss = millisec, required !)

When using gfDateTime fields, use this format: YYYYMMDDHHMMSSsss (where sss = millisec, required !)

For SHP/DBF files, gfTime and gfDateTime are stored as text.

For TAB files, use of gfTime or gfDateTime means a version 9.00 file is generated.

Example:

A dataset consists of 9 fields, one of each type:

gfChar, gfInteger, gfSmallInt, gfDecimal, gfFloat, gfDate, gfLogical, gfTime, gfDateTime

Attribute string: "test_text",1234567,123,123.45,123.45,19991231,1,123456000,19991231123456000

19991231123456000 = 31st of Dec 1999, 12:34:56.000

2.10.2.1 AddPoint

This adds a single point to the dataset.

Syntax: AddPoint(X, Y: double; Attrib: string)

2.10.2.2 AddPoint2

This adds a single point to the dataset.

Syntax: AddPoint2(P: [TFloatPoint](#)^[158]; Attrib: string)

2.10.2.3 AddLine

This adds a simple line to the dataset.

Syntax: AddLine(X1, Y1, X2, Y2: double; Attrib: string)

2.10.2.4 AddLine2

This adds a simple line to the dataset.

Syntax: AddLine2(P1, P2: [TFloatPoint](#)^[158]; Attrib: string)

2.10.2.5 AddObject

This adds the first part of a polyline / region object to the dataset.

Syntax: AddObject(NumParts: integer; MultiPolygon: boolean; Attrib: string)

After calling this method you should call [AddSection](#)^[118] or [AddSection2](#)^[119] as many times as stated in NumParts parameter.

If NumParts is 0, you will get an ungeocoded object in the dataset (works with point objects too). This is valid for all the formats, but we have seen some software not being able to deal correctly with SHP files with ungeocoded objects.

If you write to region output, have multiple outer rings and use GeoJSON, set MultiPolygon to true. For other situations, value do not matter.

NumParts can not be higher than 32000 for MIF and TAB formats.

2.10.2.6 AddSection

Call this method to add the actual coordinates in SegList:

Syntax: AddSection(Index: integer; var SegList: [TFloatPointArrayEx](#)^[158])

For polyline datasets, the index parameter has no effect and you can just set it to 0.

For region / polygon objects it is important to store information about outer / inner rings (holes) correctly and different file formats has different requirements:

GML, KML, MITAB

Direction of coordinates: No requirements

Should be stored as first 1 outer and then N inner polygons.

This can be followed by further outer/inner sequences.
Index should be 0, 1, 2, 3 Change sign, if it is an outer polygon.

SHP

Direction of coordinates for outer polygons: Clockwise.
Direction of coordinates for inner polygons: Anti-clockwise.
Order of polygons and index parameter doesn't matter.

MIF and Array

No requirements

Common set of rules for all file formats

Direction of coordinates for outer polygons: Clockwise.
Direction of coordinates for inner polygons: Anti-clockwise.
Should be stored as first 1 outer and then N inner polygons.
This can be followed by further outer/inner sequences.
Index should be 0, 1, 2, 3 Change sign, if it is an outer polygon.
First and last coordinate should be the same for polygons or an error is raised.

2.10.2.7 AddSection2

Call this method to add a simple line object:

Syntax: AddSection2(Index: integer; X1, Y1, X2, Y2: double)

2.10.3 Brush

This property applies to regions in TAB / MIF output.

Default: [BrushDefault](#)^[160]

Type: [TMIBrush](#)^[160]

2.10.4 Close

Call this method to close the file, when you are done writing.

2.10.5 Codepage

This property describes the codepage used, when MIF, TAB, SHP, DBF and CSV files are generated.

KML and GML always uses UTF-8.

Array format uses native Unicode.

If you use MIF as format and set codepage = 65001 (UTF-8), it is the same as choosing MIF8 as format.

Default: System default codepage.

Type: [TCodePage](#)^[155]

2.10.6 CompactMIF

This property describes if MIF files should be written in a compact form, without any object drawing styles ([Brush](#)^[119], [Pen](#)^[121] or [Symbol](#)^[122]).

Default: False (meaning style is included by default).

Type: boolean

2.10.7 Coordsys

This property is used when writing MIF and TAB files.

Default: CoordSys Earth Projection 1, 104 (Lat/Long, WGS84).

Type: String

2.10.8 Drop

This method will close and delete any generated files.

2.10.9 EPSG

The EPSG property should be set if you write to GML or GeoJSON.

Default: 4326 (Lat/Long, WGS84).

Type: [Integer](#)^[155]

2.10.10 Filename

Fill in this property for all file types, except Array format.

Type: String

2.10.11 GeoJSON

When writing to GeoJSON format, this string contains the output.

Type: string

2.10.12 GISarray

When writing to array format, this object contains the output.

You should create the (empty) object first and then assign it to the TGA property.

Type: [TGISarray](#)^[122]

2.10.13 GreatCircleDist

This property should be set if your output is lat/long coordinates and you want to add additional nodes for every X km, so that the output is shown in your GIS application as great circles between start and end. A typical value could be 500 km, so this is only for very large objects.

It is the users responsibility only to use it with lat/long data or nonsense output may be generated.

Default value is 0.

Type: [double](#)^[155]

2.10.14 MITAB_supported

This function returns true, if writing to TAB is supported. This means if the library can find the relevant mitab.dll or mitab64.dll, depending upon the platform.

Type: boolean

2.10.15 OptimizePLinesSections

This property describes if consecutive matching polyline segment should be joined before output.

Default: False.

Type: boolean

2.10.16 Pen

This property applies to polylines and regions in TAB / MIF output.

Default: [PenDefault](#)^[161]

Type: [TMIPen](#)^[161]

2.10.17 PRJ

This property is used when writing the PRJ file in a SHP file collection.

Default:
GEOGCS["GCS_WGS_1984",DATUM["D_WGS_1984",SPHEROID
["WGS_1984",6378137,298.257223563]],PRIMEM["Greenwich",0],UNIT
["Degree",0.017453292519943295]]

(Lat/Long, WGS84).

Type: String

2.10.18 StartHeader

Call this method when you are ready to create a new file.

As a minimum these properties should have been set in advance:

Array: [IGA](#)^[120]

CSV, DBF, KML2: [Filename](#)^[120]
GML2: [Filename](#)^[120], [EPSG](#)^[120]
MIF, MITAB: [Filename](#)^[120], [Coordsys](#)^[120]
SHP: [Filename](#)^[120], [PRJ](#)^[121]

Syntax: StartHeader(NumFields: integer; ObjectTypes: [TObjectTypes](#)^[162])

After calling this method you should call [AddField](#)^[116] as many times as stated in NumFields parameter.

2.10.19 Symbol

This property applies to style of points in TAB / MIF output.

Default: [SymbolDefault](#)^[167]

Type: [TMISymbol](#)^[167]

2.10.20 WrittenRecords

This read-only property keeps track of how many records has been written, since calling [StartHeader](#)^[121].

If no records has been written after a process, you can safely call method [Drop](#)^[120] to delete the empty files.

Type: [integer](#)^[155]

2.11 TGISarray

This class holds output information from TGISwriteArray.

The sample application shows how to iterate through the whole data structure.

2.11.1 OT

Information about the object type in the array.

Type: [TObjectTypes](#)^[162]

2.11.2 MBR

Minimum bounding rectangle for the whole array.

Type: [TFloatRect](#)^[158]

2.11.3 Field

This is a list of fields in the array.

Field: array of [TFieldInfo](#)^[123]

2.11.3.1 TFieldInfo

```
TFieldInfo = record
  FieldType: TGISField[158]
  Width, decimals: byte
  Name: string
end
```

2.11.4 Rec

This is the actual data in the TGISarray

Rec: array of [TRec](#)^[123]

2.11.4.1 TRec

This is each record in the TGISarray:

```
TRec = record
  Attr: array of Variant (array of Object in .NET version)
  Coord: array of TFloatPointArray[158]
end
```

Attr is the attribute information for the object. Length of array is the same as that of [Field](#)^[122].

Coord is the lists of coordinates making up the object. Multiple lists are required for regions with holes for instance. See [AddSection](#)^[118] for details.

2.11.5 RecCount

The number of records in the array. [Rec](#)^[123] may have room for more records, since it is extended in size in steps.

Type: [Integer](#)^[155]

2.11.6 Clear

Call this method to clear all memory allocated.

Part III

Optimization classes

3 Optimization classes

Optimization classes are not part of all levels:

RW Net Standard & Pro:

[ITSP](#)^[134]

RW Net Pro

[TOptimizer](#)^[127]

[ITSPcurb](#)^[137]

3.1 TOptimizer

This class holds various optimization methods:

- [Cluster1](#)^[128]

This is when customers should be grouped into clusters of a uniform load. Minimizing geometric size of clusters.

- [Cluster2](#)^[129]

This is when customers should be grouped into a number of clusters. Minimizing total distance between cluster center and customers.

- [Cluster3](#)^[130]

This is when customers should be grouped into a number of clusters. Minimizing the maximum distance between cluster center and customers (minimax strategy).

- [District](#)^[131]

This is when customers should be assigned to existing centers with a capacity. Minimizing distance between centers and customers.

See also [TCalc.CenterNode](#)^[93] to locate center of a single cluster.

3.1.1 Assignment

This property is read-only and holds the result of a calculation.

Property Assignment: [TIntegerArray](#)^[159];

3.1.2 Capacity

This describes capacity of each center.

Property Capacity: [TCostArray](#)^[157];

3.1.3 Center

This property is read-only and holds the result of a calculation.

Property Center: [TIntegerArray](#)^[159];

3.1.4 Cluster1

This function solves the problem of clustering customers (with [demands](#)^[131]), so [load](#)^[133] within the cluster is lower than sCapacity and geometric size of cluster is minimized.

Cost is defined through a [matrix](#)^[134], which can be calculated by [TCalc.Matrix](#)^[84], [TCalc.MatrixDyn](#)^[85], [TNetwork.Matrix](#)^[55], [TNetwork.MatrixDyn](#)^[55] or on your own.

Demand should be a much smaller number than sCapacity. Otherwise the algorithm isn't very good at finding a solution.

If Demand parameter is nil (not set), the algorithm assumes 1 for all customers. See also [Swap](#)^[134].

The function returns number of clusters. Property [Center](#)^[127] holds information about which customer is the center of the cluster.

| Property | Dimension |
|---------------------|-----------------------------|
| Demand | No of customers |
| Matrix | No of customers x customers |
| Assignment (output) | No of customers |
| Center (output) | No of clusters |
| Load (output) | No of clusters |

Sample calculation time (demand = 1 for all customers):

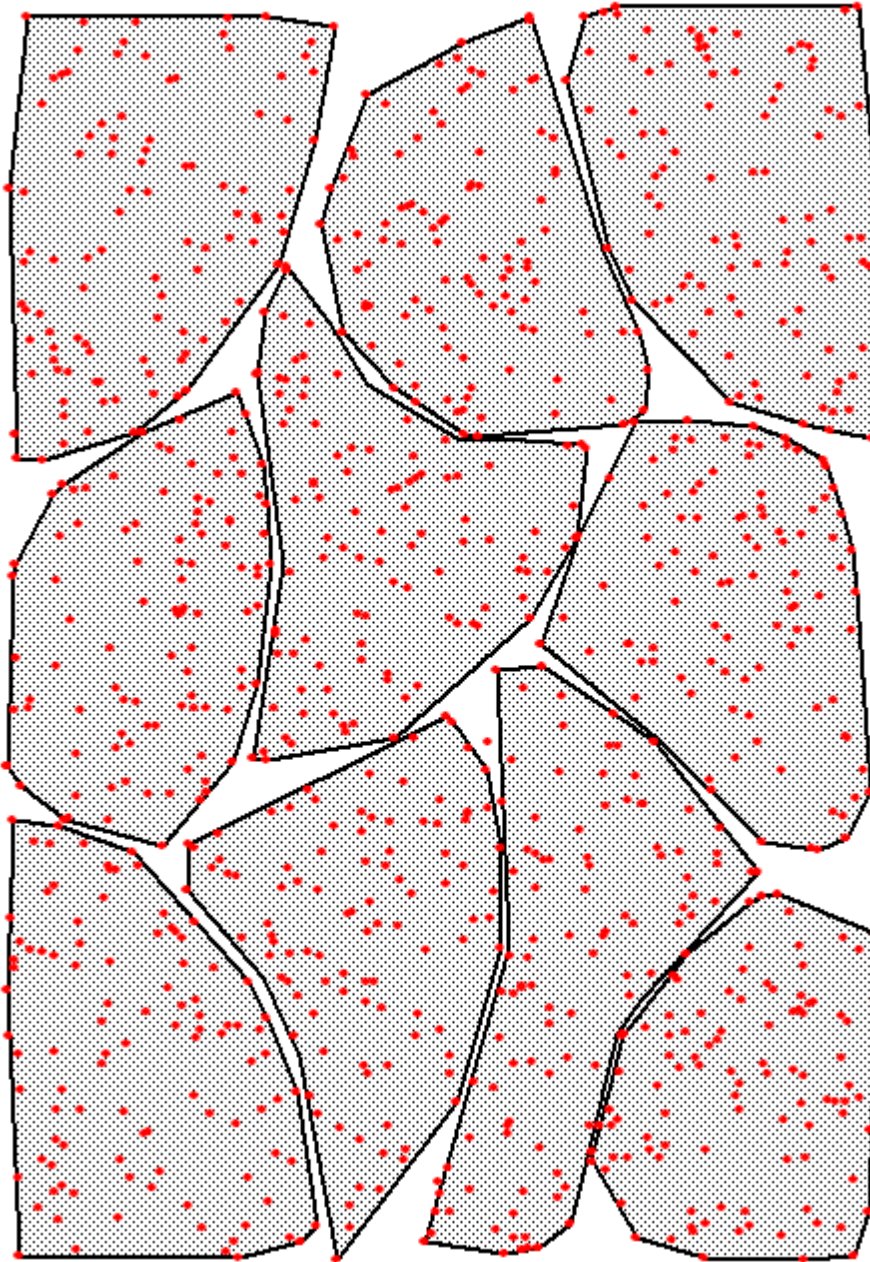
| Customers | Clustersize | No of clusters | Calculation time (msec) |
|-----------|-------------|----------------|-------------------------|
| 100 | 10 | 10 | ~0 |
| 1000 | 100 | 10 | 31 |
| 1000 | 10 | 100 | 250 |
| 10000 | 1000 | 10 | 2500 |
| 10000 | 100 | 100 | 22219 (22 sec) |
| 10000 | 10 | 1000 | 219656 (~ 4 minutes) |

With 50000 customers the matrix has reached a size of 10 GB - to give an indication of the largest instances that can be handled.

On win32 the limit is appr. 25000 customers.

Syntax: Cluster1(sCapacity: TCost): integer;

This is an example with 1000 customers and 10 clusters. Clusters are here highlighted as polygons:



3.1.5 Cluster2

This function solves the problem of clustering customers (with weights defined through [demands](#)^[131] property), so total distance between cluster center and customers is minimized.

Cost is defined through a [matrix](#)^[134], which can be calculated by [TCalc.Matrix](#)^[84], [TCalc.MatrixDyn](#)^[85], [TNetwork.Matrix](#)^[55], [TNetwork.MatrixDyn](#)^[55] or on your own.

If Demand parameter is nil (not set), the algorithm assumes 1 for all customers.

You can also call the function with NCluster = 1, if you just want to find the weighted center.

The function do not return any values, but populates these properties:

- Property [Assignment](#)^[127] holds a number in the range 0 .. NCluster-1 about the cluster ID.
- Property [Center](#)^[127] holds information about which customer is the center of the cluster.

| Property | Dimension |
|-------------------------|-----------------------------|
| Demand (used as weight) | No of customers |
| Matrix | No of customers x customers |
| Assignment (output) | No of customers |
| Center (output) | No of clusters |

Sample calculation time:

| Customers | No of clusters | Calculation time (msec) |
|-----------|----------------|-------------------------|
| 100 | 10 | 32 |
| 1000 | 1 | 16 |
| 1000 | 10 | 47 |
| 1000 | 100 | 31 |
| 10000 | 10 | 3219 |
| 10000 | 100 | 3532 |
| 10000 | 1000 | 2422 |
| 20000 | 100 | 11891 |
| 20000 | 1000 | 8391 |

Syntax: Cluster2(NCluster: integer);

3.1.6 Cluster3

This function solves the problem of clustering customers, so maximum distance within each cluster between center and customers is minimized.

Cost is defined through a [matrix](#)^[134], which can be calculated by [TCalc.Matrix](#)^[84], [TCalc.MatrixDyn](#)^[85], [TNetwork.Matrix](#)^[55], [TNetwork.MatrixDyn](#)^[55] or on your own.

You can also call the function with NCluster = 1.

The function do not return any values, but populates these properties:

- Property [Assignment](#)^[127] holds a number in the range 0 .. NCluster-1 about the cluster ID.
- Property [Center](#)^[127] holds information about which customer is the center of the cluster.

| Property | Dimension |
|---------------------|-----------------------------|
| Matrix | No of customers x customers |
| Assignment (output) | No of customers |
| Center (output) | No of clusters |

Sample calculation time:

| Customers | No of clusters | Calculation time (msec) |
|-----------|----------------|-------------------------|
| 100 | 10 | ~0 |
| 1000 | 1 | 16 |
| 1000 | 10 | 47 |
| 1000 | 100 | 31 |
| 10000 | 10 | 7031 |
| 10000 | 100 | 3968 |
| 10000 | 1000 | 3281 |
| 20000 | 100 | 19469 |
| 20000 | 1000 | 13750 |

Syntax: Cluster3(NCluster: integer);

3.1.7 Demand

This describes demand of each customer.

Property Demand: [TCostArray](#)^[157];

3.1.8 District

This function solves the problem of assigning customers (with [demands](#)^[131]) to centers (with [capacities](#)^[127]), so total [load](#)^[133] is within the capacity and cost of travel is minimized for all customers.

Cost is defined through a [matrix](#)^[134], which can be calculated by [TCalc.Matrix2](#)^[84], [TCalc.MatrixDyn2](#)^[85] or on your own.

Normally you will have many more customers than centers.

Demand should be a much smaller number than capacity. Otherwise the algorithm isn't very good at finding a solution.

Optimum results can only be achieved if demand is the same value for all customers. Such as 1.

If Demand parameter is nil (not set), the algorithm assumes 1 for all customers.

The function returns the cost of the solution.

The heuristics parameter can take two values, 1 and 2. With method 1 you will typically get the lowest overall cost values, while method 2 gives "nicer" looking solutions, but requires more time to get the solution.

We recommend trying both and pick the result you prefer.

| Property | Dimension |
|----------|---------------|
| Capacity | No of Centers |

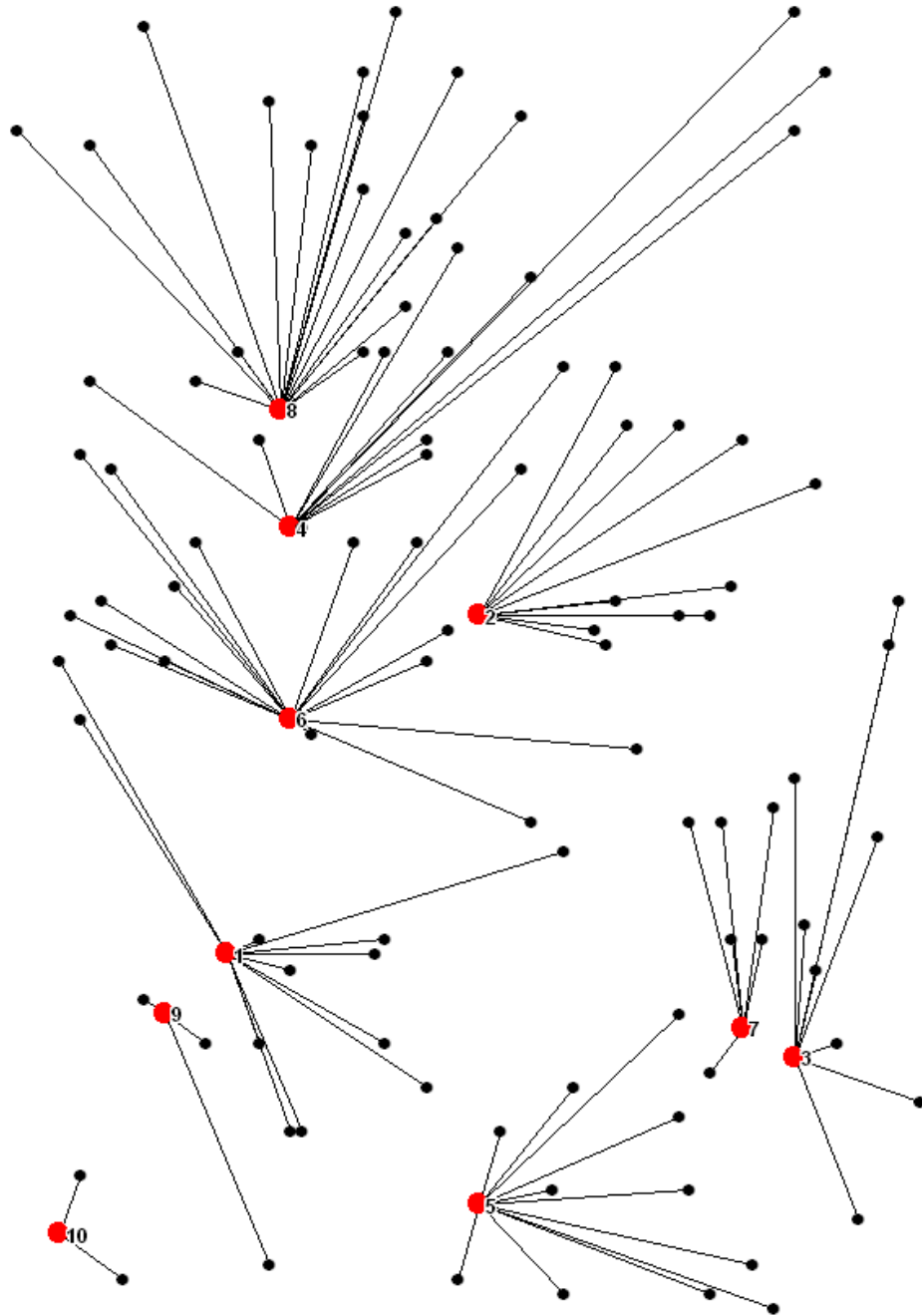
| | |
|---------------------|----------------------------|
| Demand | No of Customers |
| Matrix | No of Centers x Customers |
| Assignment (output) | No of Customers |
| Load (output) | No of Centers |
| Unassigned | No of unassigned customers |

Sample calculation time (demand = 1 for all customers, random center capacity, but sufficient in total):

| Customers | No of centers | Calculation time - heuristic 1 | Heuristic 2 |
|-----------|---------------|--------------------------------|-------------------|
| 100 | 10 | 16 ms | 16 ms |
| 1000 | 10 | 719 ms | 734 ms |
| 1000 | 100 | 1109 ms | 860 ms |
| 5000 | 10 | 220 sec (~ 4 minutes) | 19 sec |
| 5000 | 100 | 169 sec (~ 3 minutes) | 240 sec (4 min) |
| 5000 | 1000 | 15 sec | 3754 sec (62 min) |

Syntax: District(heuristic: integer): [TCost](#)¹⁵⁷;

This is an example with 100 customers, assigned to 10 centers with varying capacity. Customers and centers are connected with lines to make the result easier to view:



3.1.9 Load

This property is read-only and holds the result of a calculation, how much demand were assigned to each center.

Property Load: [TCostArray](#) 157;

3.1.10 Matrix

This is the input to the optimization, describing cost of matching centers and customers.

Property Matrix: [TMatrix](#)^[160];

3.1.11 Swap

Set this to make the [Cluster1](#)^[128] function perform additional steps of swapping and improving quality of solution a lot.

This makes it slower and should only be used with uniform [demand](#)^[131].

Property Swap: boolean;

3.1.12 Unassigned

This property is read-only and reports how many customers wasn't assigned to a center in the [District](#)^[131] method.

Property Unassigned: integer;

3.2 TTSP

This class is for [travelling salesman](#) optimization.

There is support for asymmetric matrices in the Pro version. This is especially important if you have many places in dense urban areas with many one-way restrictions.

In the Standard version, the input matrix is made symmetrical before optimization.

The algorithm uses random permutations, but you can control the randomness using the [RandSeed](#)^[136] property.

Typically you will get the true optimum solution for instances with up to ~100 places to visit. With >100 places the quality of the solution degrades slowly.

Set properties [PercentWithoutImproveStop](#)^[136], [MinCalcTime](#)^[136] and [TimeLimit](#)^[137] to control for how long time the optimization should continue.

Recommended values give a fairly good solution for up to 600 places.

With more places, increase the time values further.

With a faster CPU than 2013-standard, you can decrease the time.

With multiple threads, you can also decrease the time.

Generally test how much time is really needed for your setup, if you are going to do similar calculations for the same area, many times.

Set [Mode](#)^[136] before running the [optimization](#)^[135].

It is also possible to monitor [progress event](#)^[12], and eventually ask the algorithm to stop earlier. When using PercentWithoutImproveStop, the progress may decrease when a new improvement is found.

After the optimization has finished, you have access to [cost](#) [135] and optimized [sequence](#) [136] (key result).

3.2.1 Cost

This read-only property holds the cost of the calculated sequence. It gets updated during execution too, if you monitor [progress events](#) [12].

Property Cost: [TCost](#) [157]

3.2.2 Execute

This procedure starts the actual optimization.

Prepare the matrix using

- [TNetwork.Matrix](#) [55] or [TNetwork.MatrixDyn](#) [55] (for as-the-crow fly distances)
- [TRouteCalc.Matrix](#) [84] or [TRouteCalc.MatrixDyn](#) [85] (for real routes)

Eventually call [MatrixPreProcess](#) [135] to refine processing.

See also [ExecuteFull](#) [135].

Syntax: Execute(mat: [TMatrix](#) [160])

3.2.3 ExecuteFull

This works the same way as [Execute](#) [135], except it testes all possible combinations.

Calculation time increases fast as the dimension of the matrix increases. Just 10 elements means more than 3 million combinations (10!) and a calculation time of appr. 1 sec. With 12 elements you are reaching a couple of minutes.

Use it for testing if the solution found by Execute is the best possible. It almost always is with just 10 elements.

Syntax: ExecuteFull(mat: [TMatrix](#) [160])

3.2.4 MatrixPreProcess

Very often an optimization will result in some links being traversed more than once (either in the same or opposite directions). If there are multiple locations along that same link, it won't matter if the locations are visited first or second time the link is traversed. At least not from an optimization point of view. But for humans it feels most natural if all stops along the same link is just after each other.

This method will update the matrix, so short and long distances between locations are preferred to two medium distances. It essentially takes the square-root of the normalized cost: $\text{Matrix}^* = \text{sqrt}(\text{Matrix}^* / \max(\text{Matrix}^*))$.

Example: Costs 0.25 + 0.75 has the same total as 0.5 + 0.5. After processing we will now see that $\text{sqrt}(0.25) + \text{sqrt}(0.75) < \text{sqrt}(0.5) + \text{sqrt}(0.5)$, so 0.25 and 0.75 are preferred to 2x 0.5.

Syntax: MatrixPreProcess(var mat: [TMatrix](#) [160])

3.2.5 MinCalcTime

This property controls the minimum amount of msec, the optimization phase runs.

Recommended value: $N * 50$, where N = dimension of problem.

Default: 2000

Property MinCalcTime: integer

3.2.6 Mode

This describes how the optimization is performed.

Default value: tspRoundTrip

property Mode: [TTSPmode](#)^[164]

3.2.7 PercentWithoutImproveStop

This property controls when the optimization should stop.

If for instance the value is 50% and last improvement was after 20 sec, then it will stop after 30 sec, if no further improvements happened inbetween.

Assuming [MinCalcTime](#)^[136] < 30 sec and [TimeLimit](#)^[137] > 30 sec.

Default: 100.

Property PercentWithoutImproveStop: integer

3.2.8 RandSeed

This property controls which seed is used for the optimizations, so the same calculation can be run again, if needed. Or different one.

Default: 1

Property RandSeed: integer

3.2.9 SortedIndex

This read-only property holds the optimized sequence after calculation has ended.

Property SortedIndex: [IntegerArray](#)^[159]

3.2.10 Threads

This property defines how many threads are being used in the optimization phase.

The main advantage is reaching a slightly better solution in shorter time, since you can usually get an equally good solution running with threads=1 for longer time. I.e. no wonders from multiple threads !

It has little or no effect on problems with dimension < 100.

Default: 1 (can only be changed in Pro version)

Property Threads: integer

3.2.11 TimeLimit

This property controls the maximum amount of msec, the optimization phase runs.

Recommended value: $N * 600$, where N = dimension of problem.

Default: 10000

Property TimeLimit: integer

3.3 TTSPcurb

This class is similar to TTSP, except it also takes curb (kerb) approach and U-turns into consideration.

It shares these methods / properties with TTSP: [Cost](#)^[135], [MinCalcTime](#)^[136], [Mode](#)^[136], [PercentWithoutImproveStop](#)^[136], [RandSeed](#)^[136], [SortedIndex](#)^[136], [Threads](#)^[136] and [TimeLimit](#)^[137].

After the optimization has finished, you have access to [cost](#)^[135], optimized [sequence](#)^[136], [Sideln](#)^[138] and [SideOut](#)^[138].

Known issue:

Using this method with only 3 elements may not always give the optimum result. This shall be fixed.

See also [CulDeSacCurb](#)^[99]

3.3.1 ExecuteCurb

This procedure starts the actual optimization.

Prepare the matrix using [MatrixDynCurbIsochrone](#)^[100] or [MatrixDynCurbRoute](#)^[100]

Eventually call [MatrixPreProcess](#)^[138] to refine processing.

UTurnCosts should either be:

= 0: Allowed

> 0: Allowed, but at an additional cost

< 0: Turn not allowed.

To avoid U-turns, use a high cost or negative value.

DesiredSide:

See the sample on how to setup the array. It can basically be apIgnore or apReverse / apForward.

The 2 last ones depend upon left / right driving.

Syntax: ExecuteCurb(mat: [TCurbMatrix](#)^[157]; UTurnCosts: [TCostArray](#)^[157]; DesiredSide: [TApproachArray](#)^[153])

3.3.2 ExecuteCurbFull

This works the same way as [ExecuteCurb](#)^[137], except it testes all possible combinations.

Calculation time increases fast as the dimension of the matrix increases. Just 10 elements means more than 3 million combinations (10!) and a calculation time of appr. 1 sec. With 12 elements you are reaching a couple of minutes.

Use it for testing if the solution found by Execute is the best possible. It almost always is with just 10 elements.

Syntax: ExecuteCurbFull(mat: [TCurbMatrix](#)^[157]; UTurnCosts: [TCostArray](#)^[157]; DesiredSide: [TApproachArray](#)^[155])

3.3.3 MatrixPreProcess

Same method as [TTSP.MatrixPreProcess](#)^[135], just with a different parameter.

Syntax: MatrixPreProcess(var mat: [TCurbMatrix](#)^[157])

3.3.4 Sideln

This function returns from which side a location should be approached (in-bound).

Syntax: Sideln(index: integer): [TApproach](#)^[155]

3.3.5 SidelnArray

This read-only property returns from which side all locations should be approached (in-bound). Can be used together with [TDrivingDirections.SidelnArray](#)^[107]

Type: [TApproachArray](#)^[155]

3.3.6 SideOut

This function returns from which side a location should be approached (out-bound).

Syntax: SideOut(index: integer): [TApproach](#)^[155]

3.3.7 SideOutArray

This read-only property returns from which side all locations should be approached (out-bound). Can be used together with [TDrivingDirections.SideOutArray](#)^[107]

Type: [TApproachArray](#)^[155]

3.4 TTSPwindow

NOTE: You should use the special FleetEngine license instead of this class, since it is about to be removed starting from version 4.16

This class is similar to [TTSP](#)^[134], but with some extra features:

- You can define one time window per job
- You can define a break
- Supports a matrix larger than the number of jobs, but using an index
- Can optimize for time (driving & waiting) or distance or a combination
- Standby jobs

There is only support for [TTSPmode](#)^[164] = tspRoundTrip.

If no time windows are defined, the algorithm uses the normal [TTSP](#)^[134] class internally.

Breaks and standby jobs are different in the sense, a standby job is within a time window and there can be many of them. The break on the other side is more flexible and is generally assigned where it fits the best with the desired time for the break. Both breaks and standby jobs can take place anywhere.

Unit for time is minutes and for distance it is km, but strictly speaking it can be anything as long as you stick to the same everywhere. Since unit for time is an integer, you may need to use seconds if much accuracy is needed.

3.4.1 Create

When creating a new instance, state how many jobs you have.

Syntax: Create(N: [integer](#)^[155])

3.4.2 Execute

This function starts the actual optimization and returns a code:

```
0: No error
-1: Total of all work times do not fit in the whole day
-2: Break is not within the planning period
-3: Job N1[139] can not be reached from starting point within time window
-4: Job N1[139] can not reach end point within time window
-5: Job N1[139] & N2[140] overlap including drivetime between them
-6: Length of the best plan exceeds the length of the planning period
-7: No route found when testing all possibilities
-8: Jobs with time windows do not fit
-9: Jobs without time windows do not fit
-10: Resource ID has illegal value
-11: Matrix ID has illegal value
```

Output is best understood by reading the sample code and looking at the generated file.

Syntax: Execute: [integer](#)^[155]

3.4.2.1 N1

This property is set if the [execute](#)^[139] method returns error code -3, -4 or -5.

Property N1: [integer](#)^[155]

3.4.2.2 N2

This property is set if the [execute](#)^[139] method returns error code -5.

Property N2: [integer](#)^[155]

3.4.3 JobCount

This read-only property is set when you call [create](#)^[139].

Property JobCount: integer

3.4.4 Input

When defining input, you should as a minimum set these properties:

[DistMatrix](#)^[140], [Jobs](#)^[140], [TimeMatrix](#)^[141] and [WorkStop](#)^[142].

The rest has default values, which are acceptable for many setups.

3.4.4.1 BreakStart

This is when the break starts, in minutes after midnight.

Default: 0

Property BreakStart: [TTime](#)^[163]

3.4.4.2 BreakTime

This is the length of the break, in minutes.

Default: 0 (meaning no break)

Property BreakTime: [TTime](#)^[163]

3.4.4.3 DepotMatrixID

This is the index for the depot into the [distmatrix](#)^[140] and [timematrix](#)^[141].

Default: 0

Property DepotMatrixID: [integer](#)^[155]

3.4.4.4 DistMatrix

This is a matrix of distances.

Property DistMatrix: [TMatrix](#)^[160]

3.4.4.5 Jobs

This is the main property with information about jobs. The array is automatically setup when you create the instance, but you still have to setup each individual job.

The array gets updated during optimization, so it is also part of the output.

Property Jobs: [TJobsArray](#)^[160]

3.4.4.6 MaxDepth

If [JobCount](#)^[140] <= MaxDepth, an exhaustive search is performed, so the optimum solution is found. Maximum value is 20.

Default: 8

Property MaxDepth: [integer](#)^[155]

3.4.4.7 MaxIterations

This controls how many iterations are executed for non-exhaustive searches.

Default: 100 x [JobCount](#)^[140].

Property MaxIterations: [integer](#)^[155]

3.4.4.8 TimeMatrix

This is a matrix of time.

Property TimeMatrix: [TTimeMatrix](#)^[163]

3.4.4.9 WeightDriveDistance

This is the weight on drive distance in the optimization.

Default: 0

Property WeightDriveDistance: [Double](#)^[155]

3.4.4.10 WeightDriveTime

This is the weight on drive time in the optimization.

Default: 1

Property WeightDriveTime: [Double](#)^[155]

3.4.4.11 WeightWaitTime

This is the weight on wait time in the optimization.

Default: 1

Property WeightWaitTime: [Double](#)^[155]

3.4.4.12 WorkStart

This property defines when the planning period starts.

Default: 0

Property WorkStart: [TTime](#)^[163]

3.4.4.13 WorkStop

This property defines when the planning period ends. Should be larger than [WorkStart](#)^[141].

Default: 0

Property WorkStop: [TTime](#)^[163]

3.4.5 Output

Output is best understood by reading the sample code and looking at the generated file.

The [Jobs](#)^[140] property is also part of the output.

All the output properties are read-only.

3.4.5.1 BestCost

This is the total cost, after optimization has finished.

Property BestCost: [TCost](#)^[157]

3.4.5.2 BestDist

This is the total distance, after optimization has finished.

Property BestDist: [TCost](#)^[157]

3.4.5.3 BestDriveTime

This is the total drive time, after optimization has finished.

Property BestDriveTime: [TTime](#)^[163]

3.4.5.4 BestStart

This is the starting time for the planning period, after optimization has finished.

Property BestStart: [TTime](#)^[163]

3.4.5.5 BestStop

This is the stopping time for the planning period, after optimization has finished.

Property BestStop: [TTime](#)^[163]

3.4.5.6 BestWait

This is the total waiting time, after optimization has finished.

Property BestWait: [TTime](#)^[163]

3.4.5.7 FirstDriveDistToNext

This is the distance from the depot to the first job.

Property FirstDriveDistToNext: [TCost](#)¹⁵⁷

3.4.5.8 FirstDriveTimeToNext

This is the time from the depot to the first job.

Property FirstDriveTimeToNext: [TTime](#)¹⁶³

3.4.5.9 SortedIndex

This is the key result of the optimization, that is the sequence of jobs.

Property SortedIndex: [IntegerArray](#)¹⁵⁹

Part IV

Helper Classes

4 Helper Classes

These are classes that primarily are for input / output from the main classes.

4.1 TBaseList

Various generic lists are used throughout RW Net, see the sub-chapters for implementations:

TBaseList

This is a basic, unsorted list. T is the list item.

method Add(Item: T): Integer
method Clear
method Delete(Index: Integer)
method Extract(Index: Integer): T
method Insert(Index: Integer; Item: T)
property Capacity: Integer
property Count: Integer (read-only)
property Items[Index: Integer]: T

TBaseListSort adds these methods to TBaseList:

method IndexOf(Item: T): Integer
method RemoveDuplicates (calls Sort internally)
method Sort
property ReverseIndex: Boolean
property ReverseItems[Index: Integer]: integer (read-only)
property Sorted: Boolean (read-only)

4.1.1 TCoordCostSiteList

This is an implementation of [TBaseListSort](#)^[147]

List item: [TCoordCostSite](#)^[158]

4.1.2 TGPSTMatchList

This is an implementation of [TBaseListSort](#)^[147]

List item: [TGPSTMatch](#)^[159]

4.1.3 TImportErrorList

This class is an implementation of [TBaseList](#)^[147] with errors that gets recorded during data [import](#)^[27]
:

List item: [TImportError](#)^[159]

4.1.4 TIntegerList

This is an implementation of [TBaseListSort](#)^[147]

List item: integer

Adds two methods:

- 1) RemoveBlanks, which removes items that are 0.
- 2) SetFromBitArray, which creates a list of "true" elements in the [TBitArray](#)^[149].

4.1.5 TLocationList

This is an implementation of [TBaseListSort](#)^[147].

This is a list of not just [TLocations](#)^[160], but also a corresponding [TFloatPoint](#)^[158]. Depending upon how the list is being used, the requirements regarding the location and coordinate part may be different.

See also [Location2CoordinateList](#)^[54] and [NearestLocationSimpleList](#)^[73].

List item: [TLocationListItem](#)^[160]

Additional methods:

Add1(Item: [TLocation](#)^[160]): integer

Add2(link: integer; percent: [TPercent](#)^[162]): integer

Add3(P: [TFloatPoint](#)^[158]): integer

Add4(Item: [TLocation](#)^[160]; P: [TFloatPoint](#)^[158]): Integer

RemoveStartEndPos. Removes all items, where percent = 0 or percent = 1.

4.1.6 TPOIList

This is an implementation of [TBaseListSort](#)^[147].

List item: [TPOI](#)^[162]

4.1.7 TStepList

This is an implementation of [TBaseListSort](#)^[147]

List item: [TCost](#)^[157]

Adds function Max, which returns the largest item.

4.1.8 TTrafficList

This class is an implementation of [TBaseList](#)^[147] for use in [traffic assignment](#)^[102].

List item: [TTraffic](#)^[163]

Only available in Pro

4.2 TBitArray

This class is simply an array of boolean values, but with additional functions built-in.

It is more or less similar to BitArray in .NET and TBits in VCL.

4.2.1 Bits

This property allows you to get or set individual bits in the array.

Property: Bits[Index: Integer]: Boolean

4.2.2 CountFalse

This method returns the number of false in the array.

Syntax: CountFalse: integer

4.2.3 CountTrue

This method returns the number of true's in the array.

Syntax: CountTrue: integer

4.2.4 P_And

This calculates logical *and* with the B parameter.

Syntax: P_And(B: TBitArray)

4.2.5 P_Not

This calculates logical *not* of the whole array. I.e. switches all values between false and true.

Syntax: P_Not

4.2.6 P_Or

This calculates logical *or* with the B parameter.

Syntax: P_Or(B: TBitArray)

4.2.7 SetAll

Sets all elements to the specified value

Syntax: SetAll(Value: boolean)

4.2.8 SetAllFalse

Sets all elements to false.

Syntax: SetAllFalse

4.2.9 SetAllTrue

Sets all elements to true.

Syntax: SetAllTrue

4.2.10 SetFromIntegerArray

This sets the size automatically and assigns to true, when the elements of IA is different from 0.

Syntax: SetFromIntegerArray(IA: TIntegerArray)

4.2.11 Size

This properties specifies the size of the array. If the array is extended, new elements are initialized to false.

Property Size: Integer

4.3 TPolyGeneration

This class is normally only used as a place holder for output from [IsoPoly](#)^[83] / [IsoPolyFast](#)^[83] method, which is used as input to [TVoronoi](#)^[109].

[IsoPoly](#)^[83] creates the instance, but you should free it on your own.

It can be exported using [ExportPolyGeneration](#)^[49] for viewing of the content.

It contains 2 public fields, which can be accessed directly:

CoordCostSiteList: [TCoordCostSiteList](#)^[147]
StartPoints: [TFloatPointArray](#)^[158]

4.4 TRandom

This is for generating pseudo random numbers, but implemented as a class so you have full control and can use it in threads too.

It is also independant of the compiler used.

It uses the same formula as used in Delphi:

http://en.wikipedia.org/wiki/Linear_congruential_generator

4.4.1 NextDouble

Returns a number, $0 \leq x < 1$.

Syntax: NextDouble: double;

4.4.2 NextInt

Returns an integer, $0 \leq x < \text{value}$.

Syntax: NextInt(value: integer): integer;

4.4.3 Randomize

Initializes the random number generator from the compiler built-in random seed generator.

Syntax: Randomize;

4.4.4 SetSeed

Define your own seed, so you repeat a certain sequence of random numbers.

Syntax: SetSeed(value: Int64);

4.5 TRoadClassSpeed

This class is used for storing a set of speeds related to each [road class](#)^[6].

It is a fixed array of doubles with index 0 to 31. Default value is 60 km/h. Only values >0 are allowed.

It can be accessed directly using its index.

It has a single method for loading from an INI file in the same format as used by FleetEngine and RouteWare Studio.

Default speed is 60 km/h for undefined classes.

If mph=true, all speeds are multiplied by 1.609 when read from the ini file. Fractional speeds are allowed, always use . as decimal separator.

Syntax: LoadFromINI(filename, section: string: mph: boolean);

Example: LoadFromINI('c:\fleetengine.ini' , 'Net1');

```
[net1]
Speed1 = 110
Speed2 = 90
Speed3 = 71.5
etc.
```

4.6 TRoadClassTurnCost

Same as [TRoadClassSpeed](#)^[15], except valid range is >=0 and default value is 0. Unit can be anything, but we recommend minutes.

Used in [TurnAutoProcess](#)^[62].

4.7 TStringList

This parameter is slightly different, depending on the platform:

- .NET: List<string>
- Delphi: TStringList

4.8 TTurnTexts

This is a pre-populated array of strings, which you can use when generating [driving directions](#)¹⁰³.

All elements are accessible for reading / writing through property `Items[]`, so you can modify them for your own liking.

Default values are in English.

| Degrees | Text |
|-----------|------------------------------|
| 0 - 22 | Straight on |
| 23 - 67 | Slight turn to the left |
| 68 - 112 | Turn to the left |
| 113 - 157 | Sharp turn to the left |
| 158 - 202 | U-turn like |
| 203 - 247 | Sharp turn to the right |
| 248 - 292 | Turn to the right |
| 293 - 337 | Slight turn to the right |
| 338 - 360 | Straight on |
| 361 | Take exit 1 from roundabout |
| 362 | Take exit 2 from roundabout |
| 363 | Take exit 3 from roundabout |
| .. | .. |
| 379 | Take exit 19 from roundabout |

Part V

Simple types

5 Simple types

These types are the simple ones, without a constructor / destructor.

5.1 Single

A single is a 4-byte floating point number. It is generally used for costs, distances etc. in RW Net.

5.2 Double

A double is a 8-byte floating point number. It is generally used for coordinates.

5.3 Word

Word means a 2-byte unsigned integer (uint16).
Range: 0 to 65,535.

5.4 Integer

Integer means a 4-byte signed integer (int32).
Range -2,147,483,648 to 2,147,483,647.

5.5 Int64

Int64 means a 8-byte signed integer.
Range: -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807.

This is typically used when working with unique identifiers in databases like TomTom, Navteq and OpenStreetMap.

5.6 TApproach

Enumeration: (apIgnore, apForward, apReverse)

5.7 TApproachArray

Array of [TApproach](#)^[155]

5.8 TCodePage

On .NET: Same as System.Text.Encoding

On other platforms: [Word](#)^[155]

See also [Wikipedia](#)

5.9 TColor

Same as [integer](#)^[155] on .NET

5.10 TConcatenationMode

This enumeration describes the various modes for [TDrivingDirections](#)^[103] output:

| | |
|---------------------|--|
| cmVeryCompact | The whole result as one record |
| cmCompact | All segments between two locations as one record |
| cmCompactOffRoad | As above, but with off road segments separately |
| cmDrivingDirections | As driving directions |
| cmSeparate | With all segments as separate records - very detailed and includes link ID |

5.11 TCoordCostSite

This type is used as input to voronoi generation.

```
TCoordCostSite = record
    Cost: TCost[157]
    Site: Integer[155]
    P: TFloatPoint[158]
end;
```

If site = 65535 it means no nearest facility was in reach.

5.12 TCoordinateUnit

This enumeration informs about the coordinate units in use. It can only be set before [importing](#)^[27] a dataset.

Geographic coordinates:

cuRad (radians, -pi - +pi, -pi/2 - +pi/2)
 cuDeg (degrees, -180 - +180, -90 - +90)
 cuGrad (grads, -200 - +200, -100 - +100)

Projected coordinates (SI units):

cuMm
 cuCm
 cuDm
 cuM
 cuKm

Projected coordinates (non-SI units):

cuPoint
 cuInch
 cuLink
 cuFt
 cuSurveyft
 cuYard
 cuChain

cuRod
cuMiles
cuNmi
cuUnknown

Data using geographic coordinates are checked during import for valid range.

By far the most usual ones are cuDeg and cuM.

5.13 TCost

This is used for cost, time, turn delays and speed of routes, links etc.

Alias for [Single](#)^[155]

5.14 TCostArray

Array of [TCost](#)^[157]

5.15 TCurbMatrix

A 3D array of [TCost](#)^[157] elements.

See [TTSPCurb](#)^[137] and [MatrixDynCurbRoute](#)^[100] / [MatrixDynCurbIsochrone](#)^[100].

5.16 TDistanceUnit

Enumeration: (duKm,duMiles)

5.17 TErrorCode

An enumeration:

| | |
|---------------------|--|
| ecDeleted | Object is deleted |
| ecNotGeoCoded | Object is not geocoded |
| ecNotPolyLine | Object is not a (poly)line, but type <value> (value only for SHP/TAB file) |
| ecMultiSection | Object has <value> sections |
| ecZeroOrOneVertices | Object has only <value> vertices |
| ecLoopLink | Object is a loop link |
| ecTooManyVertices | Object has >65535 vertices |

Not all error codes are possible for both TAB, MIF and SHP files.

5.18 TFileKind

Enumeration: fkCSV, fkDBF

Use fkCSV when working with comma-separated files, such as CSV and MIF
Use fkDBF when working with DBF and DAT files.

5.19 TFloatPoint

This is a record describing a point:

```
TFloatPoint = record
  x,y: double[155]
end
```

If you are working with spherical / geographic coordinates, use x for longitude and y for latitude.

5.20 TFloatPointArray

Array of [TFloatPoint](#)^[158]

5.21 TFloatPointArrayEx

```
TFloatPointArrayEx = record
  Pnt: TFloatPointArray[158]
  Count: Integer
end
```

Count keeps track of how many positions in Pnt is in use.

5.22 TFloatRect

This is a record describing a rectangle:

```
TFloatRect = record
  xmin,ymin,xmax,ymax: double[155]
end
```

5.23 TGISField

Field type identifier:

Enumeration: (gfChar, gfInteger, gfSmallInt, gfDecimal, gfFloat, gfDate, gfLogical, gfTime, gfDateTime)

5.24 TGISFormat

GIS format identifier:

Enumeration: (gfMIF, gfDBF, gfSHP, gfCSV, gfArray, gfMITAB, gfGML2, gfKML2, gfGeoJSON, gfMFAL, gfMIF8)

gfMFAL is not available for .NET.

Output from gfGeoJSON is also stored as a string on the calling object:

[TNetwork.GeoJSON](#)^[52]
[TSpatialSearch.GeoJSON](#)^[72]
[TCalc.GeoJSON](#)^[78]
[TGISwrite.GeoJSON](#)^[120]

5.25 TGPSMatch

This record type is used for storing results for possible matches from function [TSpatialSearch.NearestLink](#)^[72]

```
TGPSMatch = record
  Loc: TLocation[160]
  Distance: double
  DifBearing: double
  Reverse: boolean
  OneWayMismatch: boolean
end;
```

Distance is in km. The smaller, the better

DifBearing is in degrees. The smaller, the better.

Reverse: True, if the record is for driving in the opposite direction of digitization.

OneWayMismatch: True, if the road is oneway and it doesn't match the bearing.

5.26 TImportError

```
TImportError = record
  fileindex: integer, 0-based, refers to items in list of files[28]
  linklocal: integer, 1-based, refers to a link inside a file
  link: integer, 1-based, refers to total sequence of links (internal ID)
  errorcode: TErrorCode[157]
  value: integer
end
```

5.27 TIntegerArray

Array of [integer](#)^[155]

5.28 TJob

This record is used when defining a job, as part of [TTSPwindow](#)^[138] class.

It consists of 2 parts, input and output.

ServiceTime must fit within the time window, i.e. ServiceTime <= WindowStopTime - WindowStartTime

If Standby is true, the job has no "location" (MatrixID is ignored) and the length of the job includes drivetime before and after standby period.

Also the timewindow need to be specified and is used as total period (worktime is also ignored).

Output is best understood by reading the sample code and looking at the generated file.

```
TJob = record
  // input
  ServiceTime: TTime[163] // minutes, default 0
  WindowStartTime: TTime[163] // timestamp, default 0
  WindowStopTime: TTime[163] // timestamp, default 0
  MatrixID: integer[155] // default index+1
```

```

StandBy:          Boolean    // default false

// output
Wait:             TTime163    // minutes
BreakBefore:     TTime163    // minutes
BreakAfter:      TTime163    // minutes
StartTime:       TTime163    // timestamp
DriveTimeToNext: TTime163    // minutes
DriveDistToNext: TCost157    // distance
end

```

5.29 TJobsArray

Array of [TJob](#)¹⁵⁹

5.30 TLocation

See [network terminology](#)⁵ for details.

```

TLocation = record
  link: integer
  percent: TPercent162
end

```

5.31 TLocationListItem

```

TLocationListItem = record
  loc: TLocation160
  P: TFloatPoint158
end

```

5.32 TMatrix

A 2D array of [TCost](#)¹⁵⁷ elements.

When used in optimizations it need to be square.

5.33 TMIBrush

This is used for defining region style in TAB / MIF files.

```

TMIBrush = record
  pattern: TMIBrushPattern161
  fg_color : TColor156 (foreground)
  bg_color : TColor156 (background)
end

```

Predefined TMIBrush constants:

```

BrushDefault: Black outline, white fill
OutlineOnly: Black outline, no fill

```

5.34 TMIBrushPattern

This describes a MapInfo pattern from 1 to 71. How they look can be seen in MapInfo's documentation.

Type: [Integer](#)^[155]

5.35 TMILinePattern

This describes a MapInfo line pattern from 1 to 118. How they look can be seen in MapInfo's documentation.

Type: [Integer](#)^[155]

5.36 TMIPen

This is used for defining polyline and region linestyle in TAB / MIF files.

```
TMIPen = record
  Width: TMIPenWidth[161]
  pattern: TMILinePattern[161]
  Color: TColor[156]
end
```

Predefined TMIPen constants:

PenDefault: Solid narrow line

PenInvisible: Invisible line (used by regions)

5.37 TMIPenWidth

This describes a MapInfo line width from 1 to 2047. See MapInfo's documentation for further documentation.

Type: [Integer](#)^[155]

5.38 TMISymbol

This is used for defining polyline and region linestyle in TAB / MIF files.

```
TMISymbol = record
  Shape: TMISymbolNo[162]
  Color: TColor[156]
  Size: TMISymbolSize[162]
end
```

Predefined TMISymbol constant:

SymbolDefault: Small black dot

5.39 TMISymbolNo

This describes a MapInfo symbol style from 31 to 67. How they look can be seen in MapInfo's documentation.

Type: [Integer](#)^[155]

5.40 TMISymbolSize

This describes a MapInfo symbol size from 1 to 48. See MapInfo's documentation for further documentation.

Type: [Integer](#)^[155]

5.41 TObjectTypes

Enumeration:

| | |
|----------|------------------|
| otNone | No object |
| otPoint | Point |
| otPline | Polyline |
| otRegion | Region / Polygon |

5.42 TPercent

See [network terminology](#)^[5] for details.

Alias for [double](#)^[155]

5.43 TPOI

TPOI is used for "Points-Of-Interest" that can be included in [driving directions](#)^[103]. Name and location fields should be self-explanatory, while approach parameter can be used, if a POI can only be seen when driving in one direction.

If you know the coordinates of a POI, use [TSpatialSearch.NearestLocation](#)^[73] to get both location and side of road.

This table shows how to translate from side to approach, if we assume a POI is only visible in the same side of the road as the vehicle is moving:

| Side | Right-hand driving | Left-hand driving |
|------------|--------------------|-------------------|
| -1 (left) | apReverse | apForward |
| +1 (right) | apForward | apReverse |

If a POI is visible when driving in both directions, just set Approach to apIgnore.

```
TPOI = record
  Name: string
  Location: TLocation[160]
  Approach: TApproach[155]
end
```


5.44 TRoute

A TRoute describes a sequence of links and nodes, together making up a route between 2 nodes or 2 locations:

If there are one less links than nodes: Between 2 nodes (and percent1=percent2=0)

If there are one less nodes than links: Between 2 locations

```
TRoute = record
  nodes: TIntegerArray[159]
  links: TIntegerArray[159]
  percent1,percent2: TPercent[162]
end
```

If a link number is negative it is travelled in the reverse direction.

5.45 TTime

This is used in class [TTSPwindow](#)^[138] for setting timestamp.

Alias for [integer](#)^[155]

5.46 TTimeMatrix

A square 2D array of [TTime](#)^[163] elements. Used in [TTSPwindow](#)^[138] class.

5.47 TTimeStampFormat

This enumeration describes the format for time stamps in [TDrivingDirections](#)^[103]:

| | |
|----------|---|
| tfSkip | Skip in output |
| tf24hour | 24 hour format: "23:59" |
| tf12hour | am/pm format: "11:59 PM" |
| tfFloat | Floating point number for your own formatting (fraction of a day). It may be >1, but not negative. Example: 0.25 = "6:00 AM" = "6:00" |

5.48 TTraffic

This type is used for a volume of traffic between coordinates P1 and P2 in [traffic assignment](#)^[102].

```
TTraffic = record
  P1,P2: TFloatPoint[158]
  Volume: TVolume[164]
end
```

Only available in Pro

5.49 TTSPmode

This enumeration describes the various modes for TSP optimization:

| | |
|--------------|---|
| tspRoundTrip | This is the classic round trip mode |
| tspStartEnd | This starts at the first item in the list and ends at the last item |
| tspOpenEnd | This starts at the first item, but can end at any item |
| tspOpenStart | This can start anywhere, but ends at the list item |
| tspOpen | This can start and end anywhere |

When optimizing for all other modes but tspRoundTrip, set extra = true in methods [Matrix](#)^[55] and [MatrixDyn](#)^[55].

5.50 TVertexCount

This is used for the number of vertices on a link.

Minimum is 2 (first and last).

Maximum is 65535.

It is the same as a 2-byte unsigned integer ([word](#)^[155]).

5.51 TVia

This type and corresponding [TViaArray](#)^[164] can be used when creating [driving directions](#)^[103].

Field *name* is a textual description and *time* is the time in minutes it takes to make the stop.

```
TVia = record
  Name: string
  Time: TCost
end
```

5.52 TViaArray

array of [TVia](#)^[164]

5.53 TVolume

This is used in traffic volumes in TTraffic for [traffic assignments](#)^[102].

Alias for [single](#)^[155]

Only available in Pro

5.54 TVoronoiMode

This enumeration describes the various modes for [voronoi](#)^[109] output:

| | |
|-----------------------|--|
| vmTriangulationLine | Basic triangulation, as line output |
| vmTriangulationSimple | Basic triangulation, as polygon output |
| vmSimpleLine | Basic voronoi, as line output |
| vmSimple | Basic voronoi, as polygon output |

| | |
|---------------|---------------------|
| vmIsochrone | Drivetime isochrone |
| vmServiceArea | Service area |

5.55 TWordArray

Array of [Word](#)¹⁵⁵