An Assessment of 'FlowRound' for Signalised Roundabout Design.

1.0   Introduction

This critique is based upon recent use by White Young Green signal engineering staff. The comments made do not cover all of the software's features, but are meant only as general remarks.

2.0   Traditional Lane-Flow Analysis

2.1   *Manual Lane-Flow Diagrams.*

Traditionally, in order to accurately model the circulating and approach flows at roundabouts, 'Lane-Flow' diagrams are produced. This is a manual process to trace traffic through the junction, determining the flow in each lane at each stop-line. This process highlights asymmetrically loaded circulating lanes that reduce the capacity of signalised roundabout nodes. The principal factors that affect this are origin-destination flows and layout.

The manual method can, and usually does, involve many repetitive calculations to get the correct result. However, that's only for a single O-D matrix; the operation has to be repeated (ad-nauseum) for each flow group or design option.

Some designers write spreadsheets to calculate lane flows as an alternative to the manual method. While a well written spreadsheet will undoubtedly reduce simple arithmetical errors and be useable for multiple flow groups, a modified or new spreadsheet has to be produced for each site, or design option. More complex spreadsheets may introduce the potential for errors in formulae when they are changed for different layouts.

2.2   *Design Issues*

The Lane-Flow method is essential to correctly model roundabouts with good lane discipline (roundabouts with spiral markings, for example) and where circulating links are not too long. However, this method may be overly robust for assessing extremely large roundabouts where there will be a reasonable degree of weaving and merging, e.g. an urban gyratory system.

In practice, good roundabout lane layouts will be dependant on maximising balanced traffic distribution over all entry and circulating lanes, particularly at critical nodes. Indeed, in some cases it may be desirable to change the road markings or layout of roundabout entries to create more balanced circulating lane flows at key circulating stop-lines. It can be seen in figure 1 that, whilst traffic flows on the entry arms are reasonably balanced, the individual lane flows on the circulating arms are not.
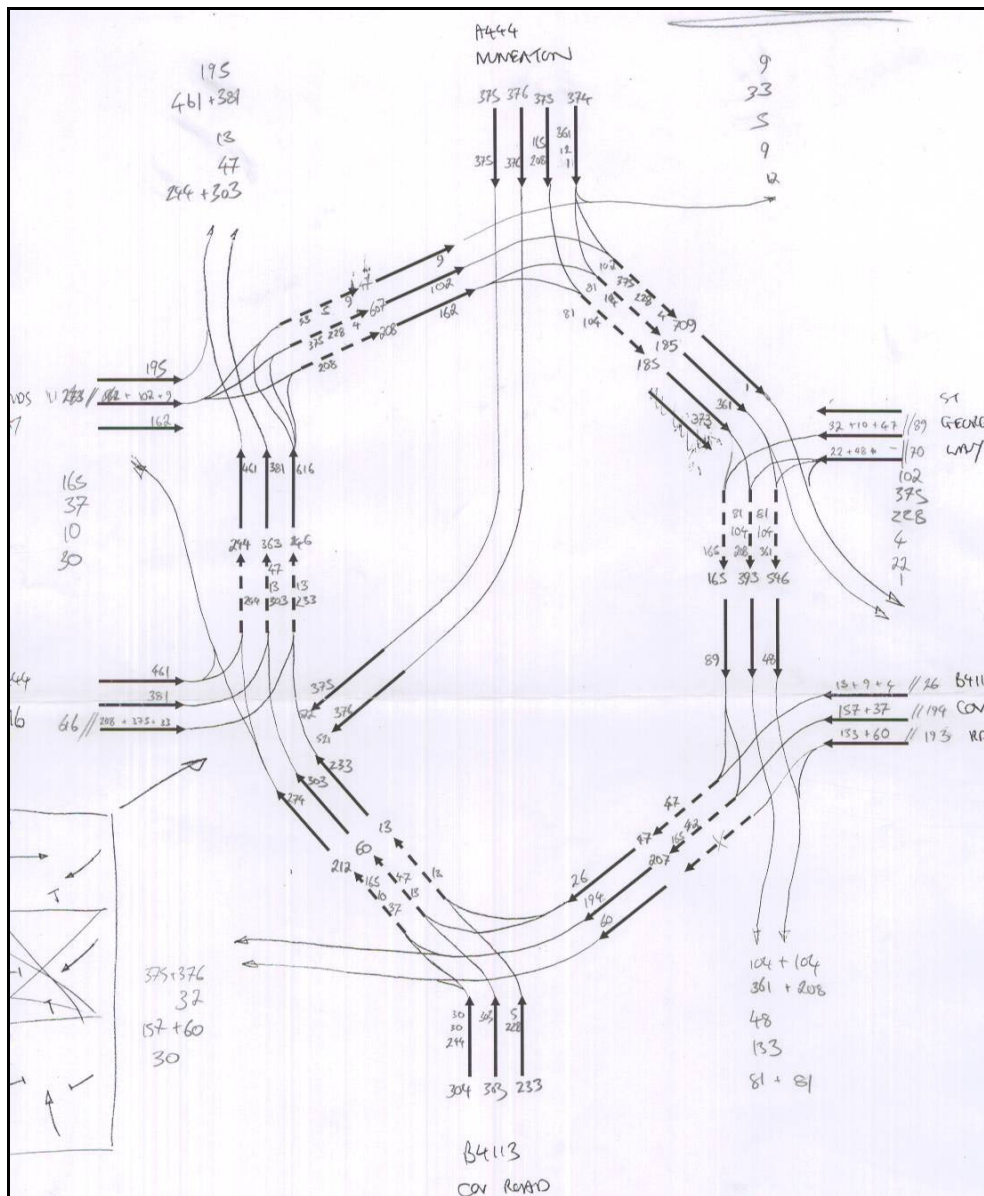

Figure 1 – A Manual Lane-Flow diagram.

2.0 What is 'FlowRound?'

2.1 *Overview*

The FlowRound programme uses exactly the same principles as the manual method, but goes a long way to simplify and largely automate the process. It is a graphical design tool that allows quick and relatively simple production of lane-flow diagrams of multi-lane roundabouts. The model is easily modified to generate different lane flows for assorted design options and flow groups. What's more, the results are (of course) arithmetically accurate, readily understood and more suitable for presentations. The programme is only at beta testing stage (evaluation only) and it is acknowledged that certain features may well improve in the final issue.

2.2 *Applications*

The use of FlowRound is not restricted to roundabouts either. WYG have used this software to analyse other highway networks. The software can be used for the robust analysis of any network where good lane discipline is expected, though merging and weaving can be simulated if required.
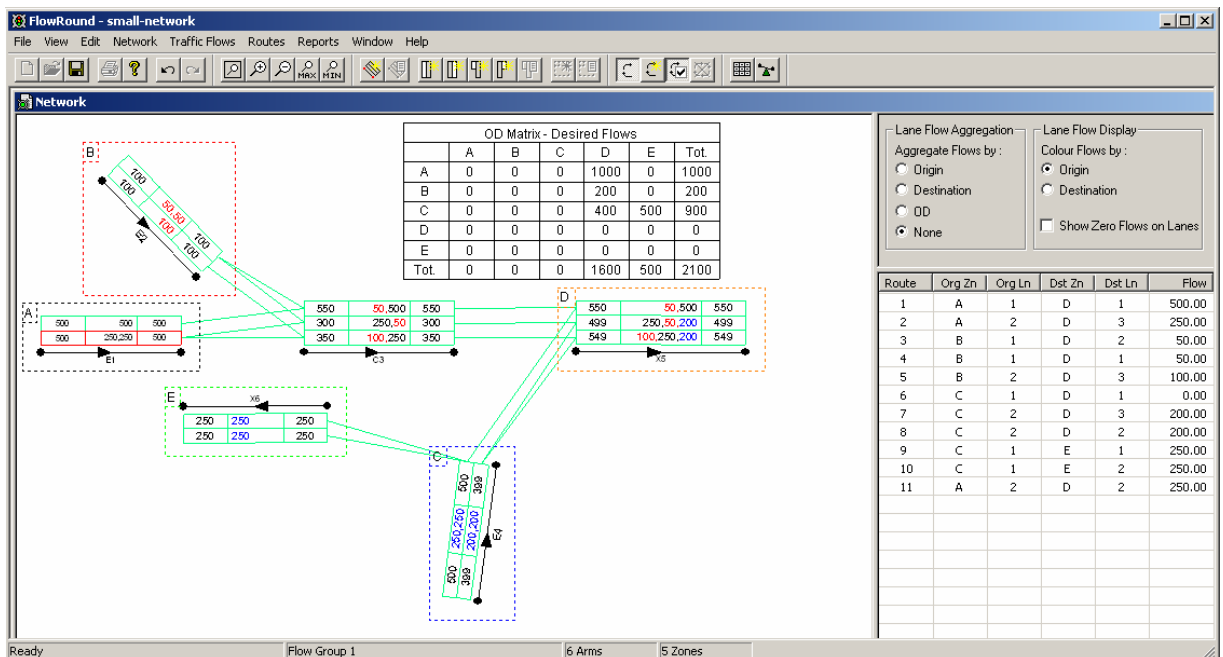

Figure 2 – A simple FlowRound network.

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3.0 **Programme Features, Functionality and Hierarchy**

3.1 *Functionality*

FlowRound has similar functionality to other JCT software such as TranEd and Linsig for Windows ™.

3.2 *Hierarchy*

Figure 3 illustrates the network features. They can be created in the following sequence:

a) Create and position **Arms**: These are normally numbered sequentially, although their arm number can be changed.

b) Edit **Lanes**: The initial number of lanes on an arm is 2. The user can change the number of lanes on each arm.

c) Create **Connectors**: By clicking on the exit of a lane on an arm and dragging to the entry of the next lane (or visa-versa), a connector is generated. Connectors define possible lane-to-lane choices , and therefore 'Routes' can be identified. As connectors are added, the programme logically defines each arm as an 'Entry', 'Connector / Circulating', or 'Exit'.

d) **Zones**: The Zones for the O-D matrix need to be applied to the model in order for traffic to be allocated to each lane around the model. A Zone can have a single entry arm, a single exit arm, or both. The colour of zones can be user defined.

3.3 *Features*

Once all data has been input and the base network defined, the user can build all the possible routes by selecting a single button. The user can then calculate the lane allocations by using the 'Balance Lane Flows on All Entry Arms' button. Manual alterations can be made by entering a precise flow for a particular route (lane-flow component) through the network and this figure locked, then the network flows re-balanced with the new fixed element taken into account in the calculation.

FlowRound assumes that balancing entry flows will mimic typical driver behaviour as motorists will choose an appropriate approach lane depending on prevailing queue lengths and lane destination possibilities. Thereafter flows are assigned across the possible routes.   This technique ensures that flows are not artificially balanced across entry and circulating lanes, as this could be seen as 'cheating', especially when the layout does not lend itself to such a scenario.

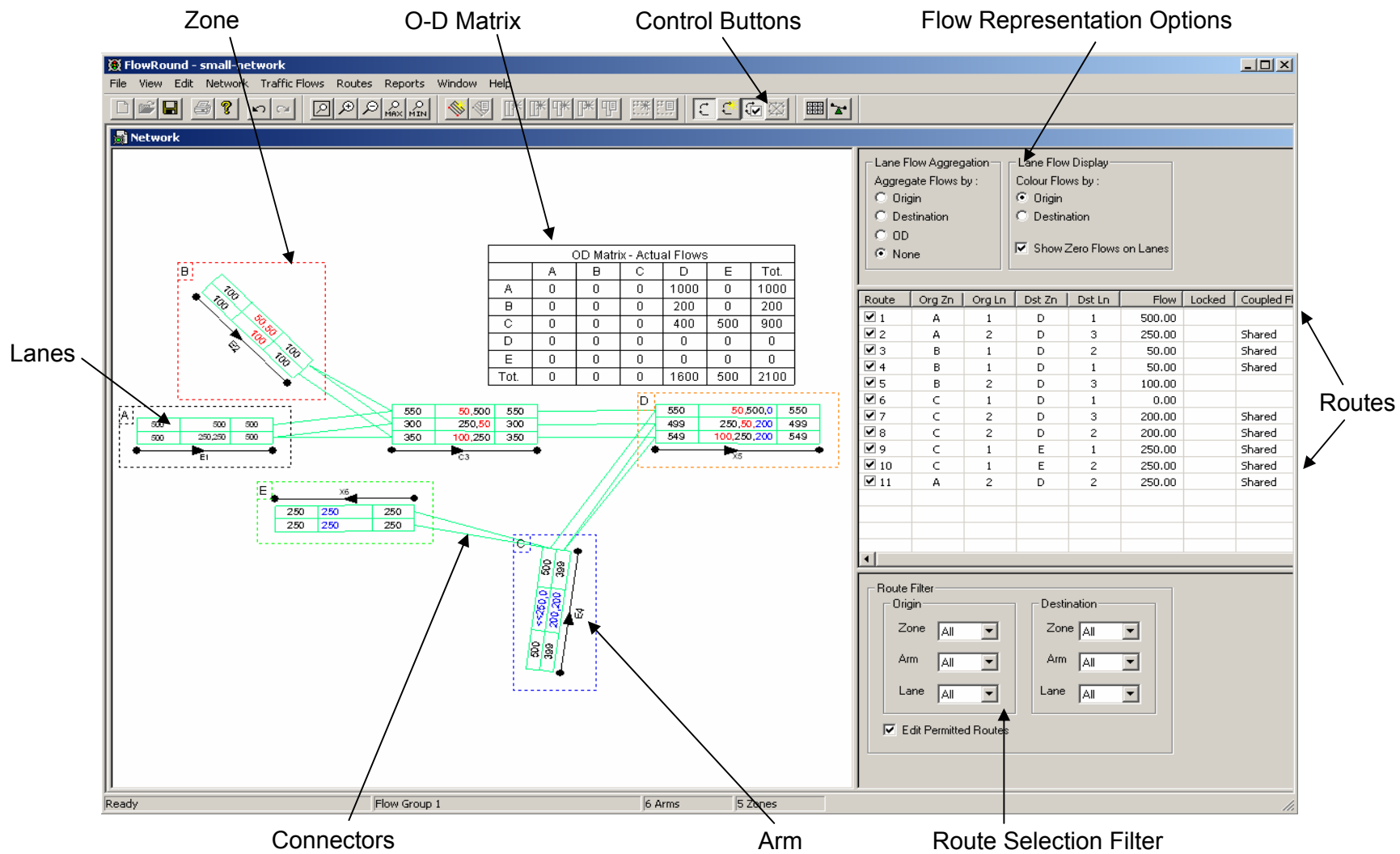# The FlowRound Programme Window

Figure 3

FlowRound splits each lane flow down by route, e.g. a lane flow of 100 might be split into 20 for Zone C and 80 for Zone D. These split flows, or lane-flow components, are colour coded by origin zone or exit zone as required by the user. This is very useful when coding TRANSYT networks with main and shared circulating links as the origin or destination of these lane-flow components can be easily identified.

From all of the options described above, the user can reasonably accurately assess an existing signalised roundabout or network. Additionally, this can be a powerful design tool allowing the engineer to change route choice through the junction by changing the number of lanes and position of lane connectors.

3.4   *Capacity Assessors*

A Capacity Assessor can be added to a pair of entry arms (entry and circulating for roundabouts) and an upper limit defined that if exceeded, will cause the assessor box to change from black to red. The assessor works on a combination of the 2 most heavily trafficked lanes on each approach. This limit might be set at approximately 1400 pcu/hr for a combination of any 2 lanes the user does not wish to exceed 90% degree of saturation, where a junction is running at a 60s cycle, with 5 second intergreens and with saturation flows of 1800 pcu/hr. This could be tailored to approximately represent 75% of circulating flow and 90% of entry flow at roundabouts. However, the actual usefulness of this 'fixed ceiling' method is limited, and is at best only a ready-reckoner. It would be better to incorporate a simple capacity calculator where an arm's single lane saturation flow and maximum degree of saturation is specified along with a generic, network wide, intergreen value.

4.0   Problems and Suggested Enhancements

Even though FlowRound is only at beta stage, it has been used by White Young Green for the analysis of several signalised roundabouts.

4.1   *Delete all connectors*

It would be an advantage if the user was able to delete all connectors by pressing a single button, rather than deleting each connector individually. When designing complex multi-lane signalised roundabouts it is quite easy to get a little confused, or simply to design a less-than-ideal layout. The facility to be able to re-define all lane connectors would be a welcome addition (with a confirmatory 'do you really want to do this?' message please).

4.2   *Circular route issues*

A Circular Route in FlowRound is essentially turning right to turn left. While some more cunning drivers may do this under certain traffic conditions, it is clearly not the norm, and should not be assumed to be a genuine manoeuvre in the model. When building signalised roundabout models, it is a reasonable assumption that the designer will allocate an arm for all entries, exits and circulating links, as seen in the example below.
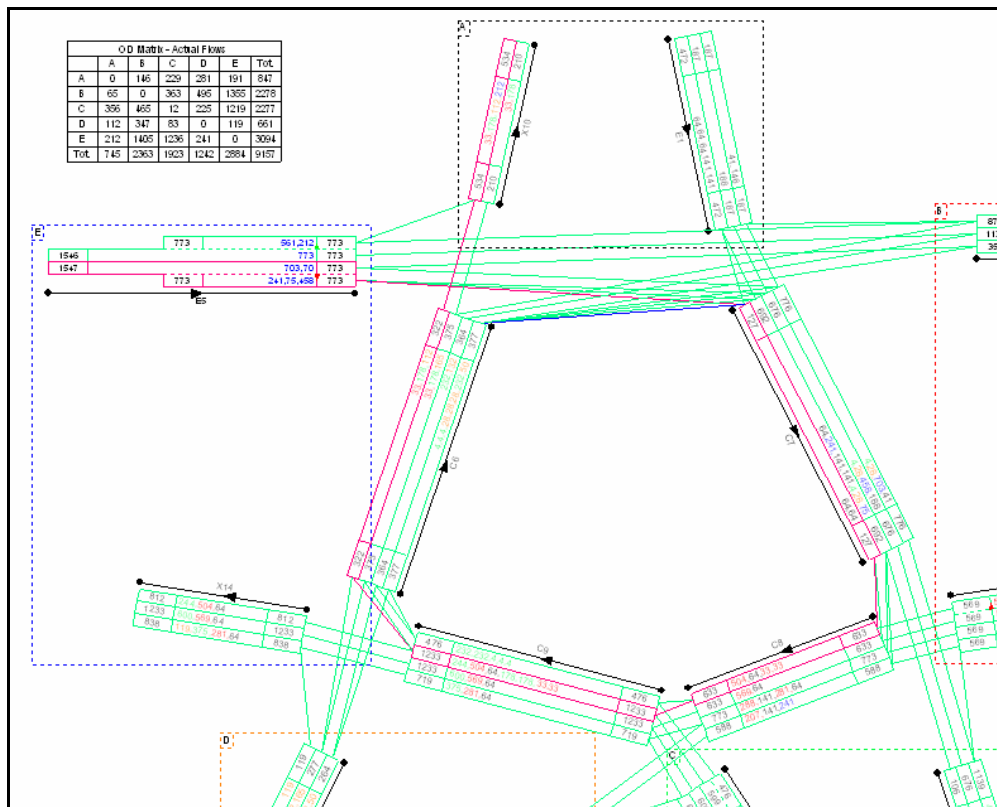

Figure 4 – Example of a Circular Route (red)

The problem is that when the 'Make Any Existing Circular Routes Non-permitted' option is chosen, the programme does not detect a circular route with the above configuration. It therefore, utilises these circular routes to achieve balanced flows. There are 2 solutions to this issue:

a)   As the user scrolls down the routes (to the right of the window – fig.3) they are highlighted on the layout, lane to lane, entry to exit. When the user identifies a circular route, the permitted flow can be locked at 0, effectively removing it from the calculation. Alternatively, there is also an option to disable editing of that route. This operation has to be completed for every possible circular route.

b) An intermediate arm (fig.5) is inserted between the approach and exit arms in the conflict area. The programme can now detect that a flow passes through the same arm twice and the removal of circular routes described above works.
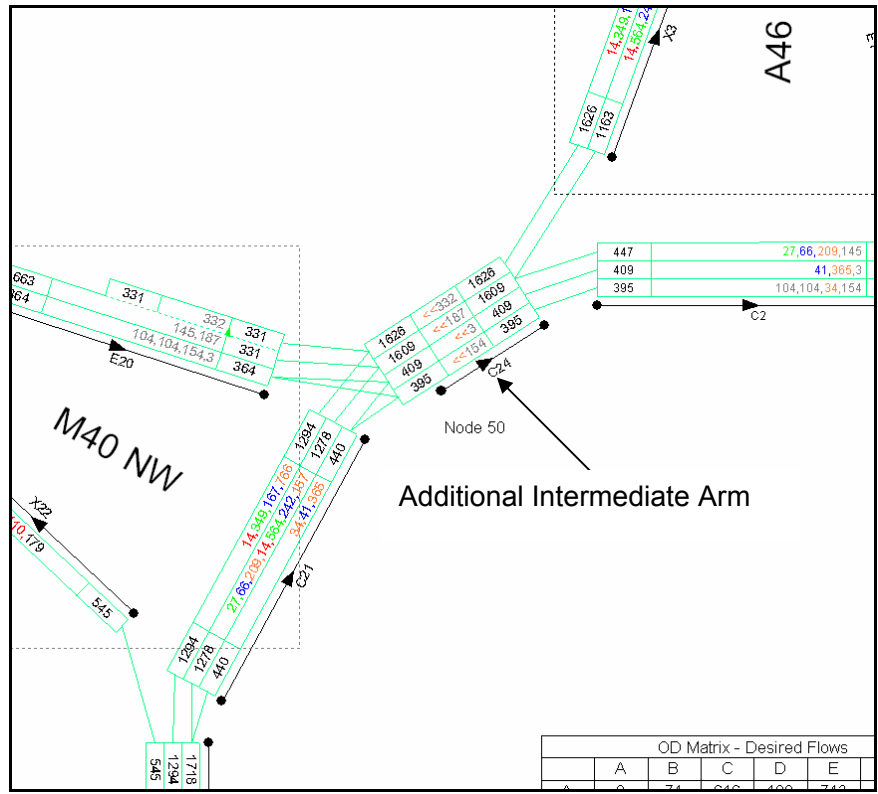

Figure 5 – Intermediate Arm to Detect Circular Routes

4.3 *Other Issues*

- It may be desirable, if the user requires, to 'weight' particular lanes of roundabout entries rather than use the default distribution which seeks to equally balance flows. For example, this could allow a 60 /40 split if exit merge conditions discouraged use of the offside lane. This could be achieved by having a facility to group certain lanes within an arm and alter the distribution of traffic between them.

- There should be a feature to allow a maximum or target lane flow. This could then trigger warnings when individual lane flows are exceed practical limits. A maximum lane flow would also be useful when modelling flare lanes when the expected maximum usage is known.
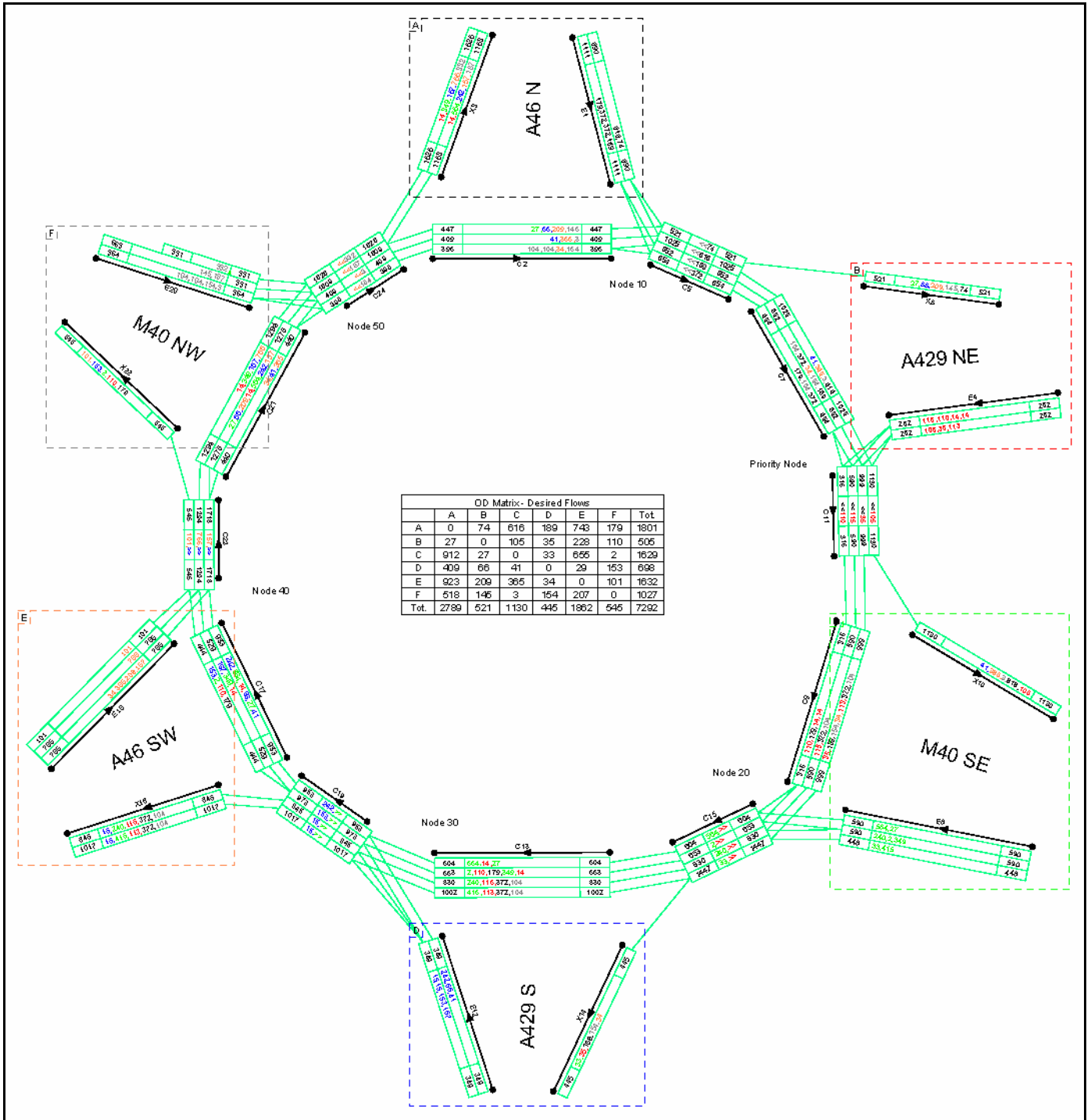
The OD Matrix table in the figure reads:

OD Matrix - Desired Flows							
	A	B	C	D	E	F	Tot.
A	0	74	616	189	743	179	1801
B	27	0	105	35	228	110	505
C	912	27	0	33	655	2	1629
D	409	66	41	0	29	153	698
E	923	209	365	34	0	101	1632
F	518	145	3	154	207	0	1027
Tot.	2789	521	1130	445	1862	545	7292

Figure 6 - A worked example – M40 Junction 15

5.0   Conclusion

FlowRound is effective design software, offering significantly reduced design times and presentation quality graphics.   As has been demonstrated, FlowRound is a considerable improvement upon the traditional methods of Lane-Flow calculations.

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