Technical Note

Project:	M4 Junction 17 Improvements Outline Business Case (Major Road Network Fund)		
Subject:	Addendum to Appraisal Specification Report		
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Date:	24/02/2022	Project No.:	5205278
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Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
1.0	ASR Addendum	EN	NW	SP	AM	24/02/22

Client signoff

Client	Wiltshire Council
Project	M4 Junction 17 Improvements Outline Business Case (Major Road Network Fund)
Project No.	5205278
Client signature / date	

1. Introduction

1.1. Background

Wiltshire Council is seeking funding from the Major Road Network (MRN) fund for improvements to M4 Junction 17. An Outline Business Case (OBC) is being prepared for submission to the Department for Transport (DfT). In line with DfT guidance, an Appraisal Specification Report (ASR) was produced setting out the proposed approach to transport modelling and economic appraisal. The ASR (WC_M4J17-ATK-GEN-XX-RP-TB-000002) was originally issued to DfT in June 2021.

1.2. Purpose of this ASR Addendum

Following initial development of the proposed modelling and appraisal approach, it became apparent that the approach required modification in order to provide a sufficiently robust and representative appraisal of the scheme impacts. This addendum note to the original ASR therefore sets out a revision to the methodology to be employed in the assessment of economic benefits of the scheme. The revision encompasses:

- A new modelling and appraisal process for user impacts; and
- An adjusted approach to dependent development appraisal to that which was proposed in the original ASR.

The methodology set out in this addendum supersedes that which had been proposed in the original ASR document. All other elements of the original ASR remain unchanged.

The revised methodology presented within this addendum was discussed and agreed in principle with DfT representatives at a meeting held on 3 December 2021.

2. Development of Appraisal Process

2.1. Review of Appraisal Process and Use of Transport Modelling

The initial transport appraisal of economic impacts, as described in the body of this document, identified that limitations of the strategic modelling methods used to inform the appraisal resulted in what appeared to be a significantly understated reflection of the impact of the proposed scheme.

Meanwhile, the operational modelling (which was not used to inform the appraisal but was prepared to provide assurance that the scheme will provide sufficient capacity based on the planning horizon), indicated a substantially different impact on junction performance.

Based on the findings of these two modelling approaches, a review has been undertaken to consider the strengths and the limitations of each method, and the impact these may have on the appraisal.

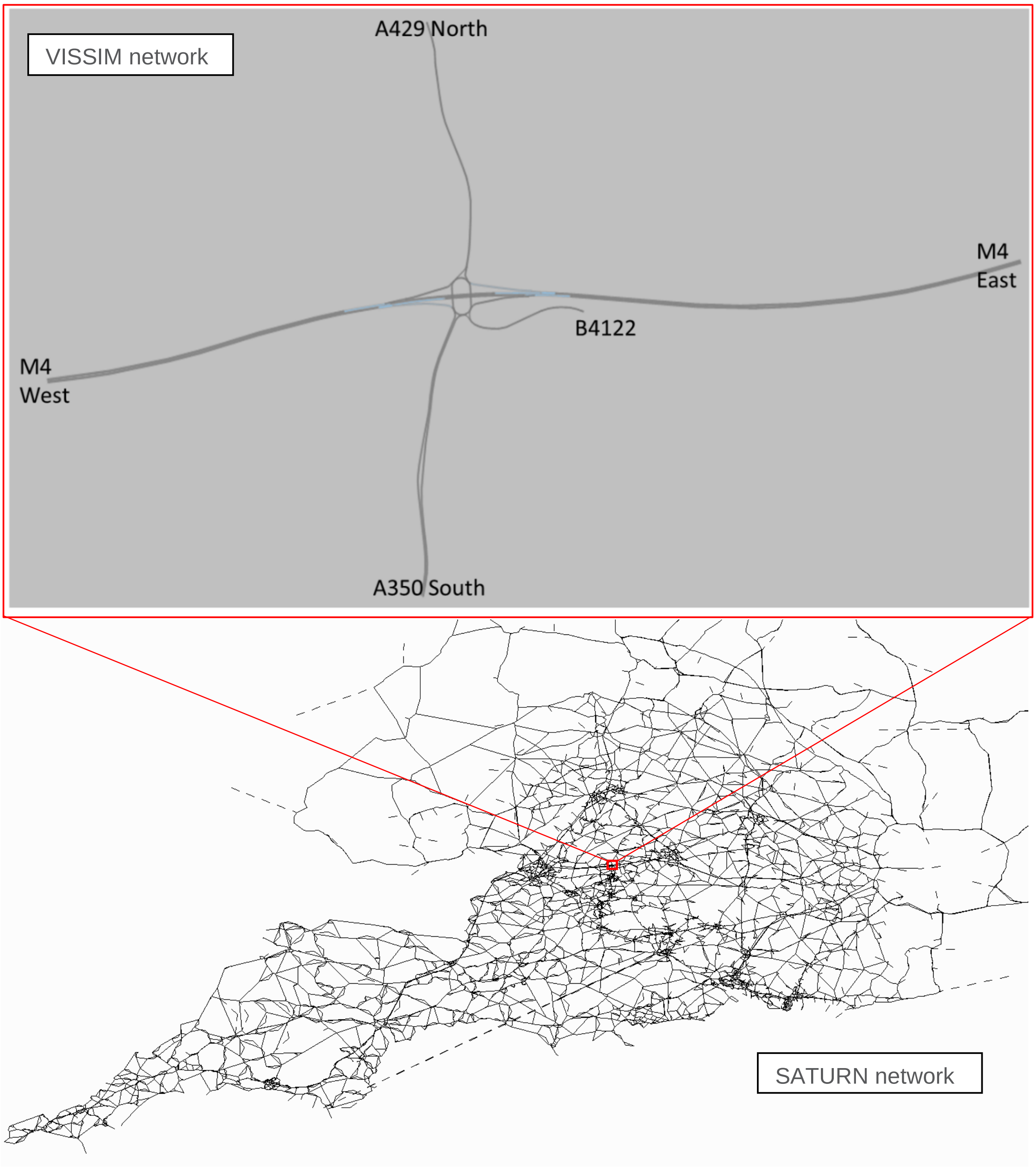
2.2. Model Structure and Limitations

To help clarify some of the differences between the two elements of modelling described above, some key differences are summarised. Figure 2-1 indicates the scale and scope of the two models. The operational model, developed in VISSIM is presented first. This represents only M4 Junction 17 and the area in the immediate vicinity, not extending as far as the nearest junction in any direction.

The southern extent of the network of the strategic model, prepared in SATURN, is presented below the VISSIM network. An indication is provided of how the two networks relate to each other.

The large difference in scale of these models results in variations in how detail is used to represent traffic behaviour. While the VISSIM model provides a high level of detail in how traffic moves across Junction 17 itself, no assessment is included of how trips travel to or from the junction. The SATURN model conversely provides a lower level of detail at Junction 17, with network representation becoming increasingly less detailed in areas further away from the proposed scheme. The wider scope of this model enables assessment of how traffic makes end to end journeys to capture both rerouting impacts and indirect impacts on other traffic.

Figure 2-1 - Model Layouts



Key advantages and limitations in representation of the M4 Junction 17 scheme of each of the modelling methods, with respect to using each model to inform the economic appraisal, are set out in Table 2-1.

Table 2-1 - Advantages and Limitations of Modelling Approaches for Application to Economic Appraisal

Modelling Platform	Advantages	Limitations
SATURN approach	• Technically more recognised approach, with representation of complete journeys. • Able to capture strategic rerouting.	• Complexity of interaction of traffic from different arms of the junction is not well represented in SATURN. • Poor representation of peak hour flows, due to use of average peak period. • Potential for model noise in the outskirts of the modelled area to distort benefits.
VISSIM approach	• More suited to representation of detailed junction interactions. • Retains a degree of consistency with operational assessment.	• Less conventional approach to appraisal for a strategic network improvement. • Limited ability to capture potentially significant re-routing impacts, or knock-on impacts on other parts of the network. • Re-routing could complicate the rule of a half calculation. • Not fully developed for appraisal. Additional work required to add to existing modelling.

With respect to the final limitation listed in Table 2-1, the original purpose of developing the VISSIM model was to assess the operational performance of the scheme and ensure sufficient capacity would be provided to meet the demand requirement up until at least the design year for the scheme. As a result models have been developed only for the most busy periods of the AM and PM peaks in the design year.

To provide a robust economic appraisal, the SATURN modelling was developed to also cover the opening year of the scheme and included an average interpeak hour.

2.3. Refinement of Appraisal Process

2.3.1. Approach

With awareness of the modelling limitations set out in section 2.2, each element of the modelling was refined and developed from its initial state to overcome these so far as possible.

2.3.2. Limitations of SATURN Assessment

As part of the initial appraisal process based on SATURN, measures have been taken to mitigate the described weaknesses so far as is possible. A benefit masking process has been developed to minimise the potential impacts of model noise, providing improved confidence that the captured benefits are directly related to the network changes introduced as part of the proposed scheme.

However, to improve the representation of the variation in flows across the peak period would require significant reconstruction, calibration and validation of the model. The limitations on the ability of the software to represent highly detailed interactions across the junction cannot be resolved while using this software alone.

2.3.3. Limitations of VISSIM Assessment

The VISSIM modelling would provide a solution to both problems described above relating to detail of flow profiles and traffic interactions. Flow input to VISSIM is introduced at 15-minute intervals throughout the 3-hour peak periods, based on recorded flow patterns, while the software is designed specifically for detailed representation of interacting flows of traffic at a localised level.

A refinement of the VISSIM modelling was therefore developed to replicate conditions in the SATURN model, in terms of do-minimum network provision and demand to exclude those elements which had been considered dependent on the scheme.

From a technical perspective, the key challenge relating to use of VISSIM for the economic appraisal is the exclusion of the wider network, meaning that only a short section of each trip is captured, rather than measuring impacts on origin to destination movements. This causes certain complications which are detailed below:

- Changes in journey times across the junction between DM and DS scenarios will result in a proportion of traffic diverting, so that it passes through the section of the network represented by VISSIM in either the DM or DS scenarios, but not in both. VISSIM alone will not capture these impacts, as it has been configured to use the same demand inputs in both DM and DS scenarios.
- Such variations in flow in the DS scenario would result in changes to the forecast journey times.
- Just as flows through Junction 17 would be affected by changes to journey times between DM and DS scenarios, flows across the wider strategic network would also change. This will affect journey times outside of the VISSIM network and result in (dis)benefits for traffic which are entirely outside the scope of VISSIM.
- Changes to flows across the VISSIM network between DM and DS would represent changes in trip numbers as changes in demand, when in fact those diverting trips will still be made but simply following a different route. As benefits are calculated using the rule of a half, this may result in a distortion to the calculation of user benefits. E.g. if a trip diverts around Junction 17 in DM to avoid delays, but passes through Junction 17 in DS the calculation of benefit should be measured as:

  GJT benefit = 0.5 x (DM demand + DS demand) x (DM time – DS time)

  Where:

  DM demand = 1 and DS demand = 1
  as for simplicity this example is focussed on a single trip

  DM time = DM time around Junction 17

  DS time = DS time through Junction 17

  However, if using only VISSIM, the inputs to this calculation (for diverted trips) would be:

  DM demand = 0

  DS demand = 1

The scheme is most likely to result in an increase in flow through the junction, as delays are mitigated. However, the difference in journey time across the junction between DM and DS scenarios is likely to be greater than the actual difference between DM and DS journey times for a given trip, as the DM diversion route would only be used if it were quicker than the DM time through the junction. This is illustrated in Figure 2-2.

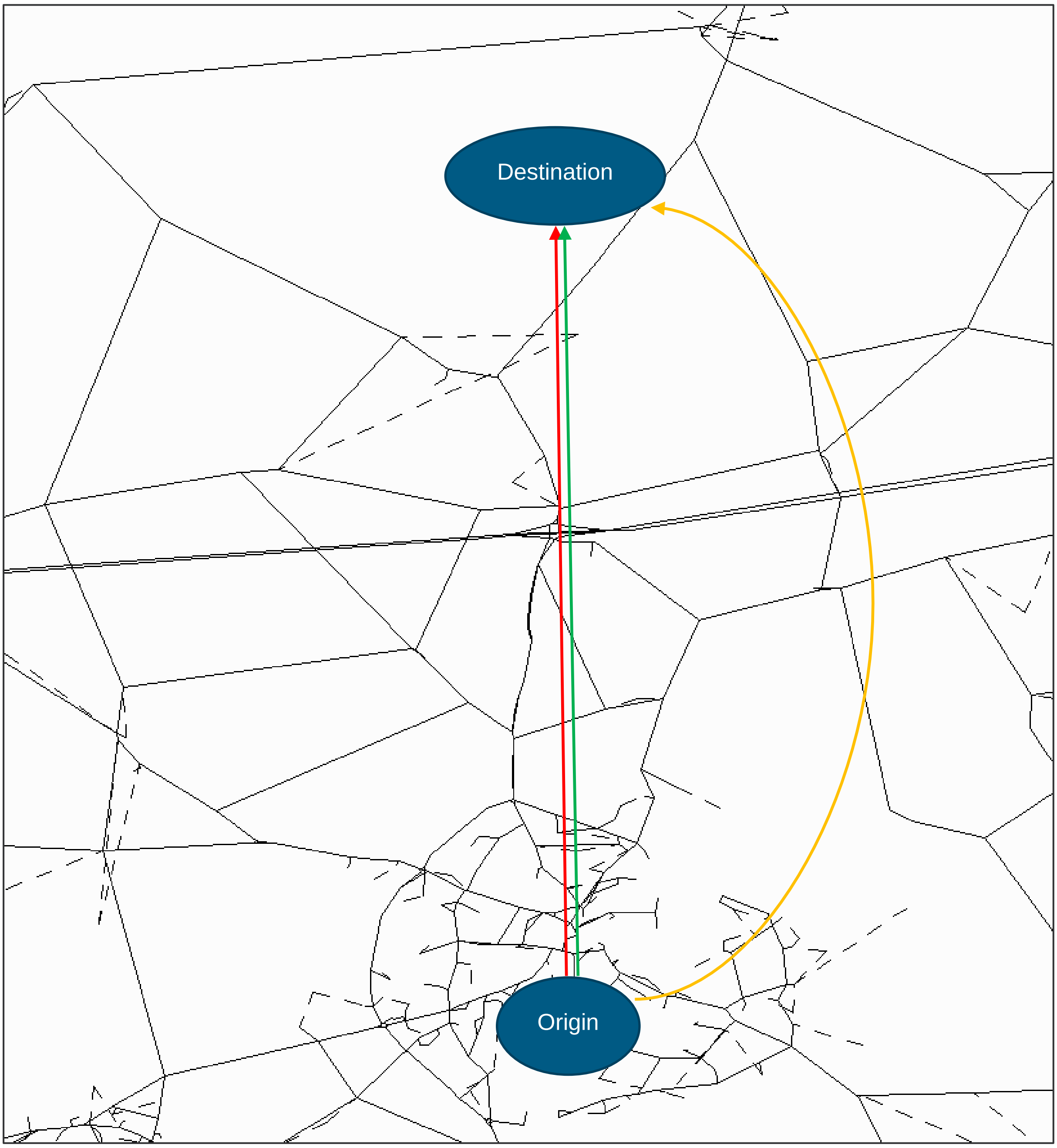
For a trip between the indicated origin and destination, the lines indicate the following:

- Red = DM journey via Junction 17
- Orange = DM journey not via Junction 17
- Green = DS journey via Junction 17

In the DM scenario, if the diversion around Junction 17 gives the faster journey time then the majority of trips will follow the orange route. If the scheme reduces congestion at Junction 17 so that it becomes quicker to follow this route rather than the diversion, then the benefit per trip will be the difference between the orange route in DM and the green route in DS. This difference will be less than that between the red route in DM and the green route in DS, which is what VISSIM would measure.

Therefore, this difference in application of the rule of a half between SATURN and VISSIM would be expected to result in an over-estimate of benefits if based on VISSIM alone.

Figure 2-2 - Application of the Rule of a Half in VISSIM



2.4. Hybrid Modelling

As neither the SATURN modelling nor VISSIM modelling alone provides robust assessment of user benefits, an alternative hybrid method, making use of information from both models has been considered most reliable. This will draw on VISSIM's ability to accurately reflect the performance of traffic as it passes across Junction 17 and its detailed time profile of flows, while building in SATURN's ability to represent rerouting options across the wider network and the effects of this rerouting on other traffic.

In order to provide the most robust assessment based on a combination of the two models, a level of interaction between them is required. For this to operate effectively it is necessary that the models are developed to be as consistent as possible.

In terms of network representation, the models already had a high level of consistency, in that the full VISSIM network was reflected by existing links in the SATURN model. The key difference effecting traffic behaviour was the scale of delay for trips entering Junction 17, with entries from the A350 and A429 most affected.

2.4.1. Interaction between Models

To better reflect this aspect of the junction performance, a series of tests were undertaken to understand how increasing delays would affect travel behaviour. These involved introducing a time penalty to the relevant arms in the SATURN model to represent the additional expected delay.

At the upper end of this scale, the delays forecast by the existing VISSIM model were applied, while at the lower end of the scale no additional delay was applied. Incremental steps between these two points were also modelled to evaluate the extent of rerouting caused as delays increase.

The VISSIM model for the 2036 AM peak with no rerouting applied had forecast delays of around 15-minutes for trips entering Junction 17 from the A429 or the A350. Tests in SATURN were conducted applying delays to these arms of 2, 5, 10 and 15 minutes. Table 2-2 indicates the scale of diversion away from Junction 17 resulting from each of these tests.

Table 2-2 - Testing of Scale of Diversion at M4 J17

Additional delay applied at A350 and A429	Reduction in flow at A350	Reduction in flow at A429
0 minutes	0%	0%
2 minutes	8%	15%
5 minutes	56%	61%
10 minutes	75%	80%
15 minutes	93%	94%

These results indicate the most significant shift in behaviour of traffic occurs between the 2 minute and 5-minute delay points. As further delay is added, more traffic continues to divert away from the junction, but the rate of diversion slows. The equilibrium point, at which traffic diverting away from the junction will result in reductions to delay, which in turn will lead to lower levels of diversion appears very likely therefore to occur at or around the 5-minute delay level.

Further examination of these iterative tests indicated that a proportion of traffic diverting away from the A350 as a result of the added delays was choosing to use the B4122 entry to Junction 17 instead. Similarly, to the A350 and A429, this route displays very little delay in SATURN, but is somewhat more congested in VISSIM, though to a lesser extent than the other arms. To balance this effect of diversion from the A350 to the B4122, a further test was performed in SATURN in which, in addition to the 5-minute delays added to the A350 and A429 a 3-minute delay was applied to the B4122. This resulted in flows on the B4122 being comparable to those forecast with no additional delays applied, effectively balancing the impact of the 5-minute delay added to the A350.

2.4.2. Hybrid Model Process

Based on the analysis above the following process for preparation of modelling inputs to the economic appraisal and calculation of user benefits has been developed.

Modelling Process

1. Forecast Trips Modelled in Demand Model
2. Trips Assigned to Strategic Network in SATURN
3. Forecast flows passed from SATURN to VISSIM and assigned to network – at this stage no rerouting is possible.
4. Delay forecast at Junction 17 in VISSIM is passed to SATURN in the form of delay added on key links. This informs a range of delay scenarios modelled in SATURN with VISSIM delay forecasts providing the upper limit.
5. Review undertaken of delay scenarios to identify which of the SATURN models is considered the most representative (as summarised in 2.4.1).

6. Demand from selected delay scenario fed back into VISSM and re-assigned.
7. Confirm that performance of selected SATURN scenario (steps 4 & 5) and VISSIM model (step 6) indicate comparable performance. If this is not the case return to Step 5.

Appraisal Process

A. The selected scenario from step 4, based on review at step 5, is used to inform two TUBA assessments:
   i. Based on the entire SATURN network
   ii. Based on only the Junction 17 section of the network, as represented in VISSIM
B. Item 6 is used to inform a further TUBA assessment to capture in detail the benefits for movements across Junction 17.
C. Item B forms the core of the economic assessment. Impacts across the remainder of the network, including any impacts of rerouting to or from Junction 17 are captured based on

Strategic and Rerouting Benefit (excluding Junction 17) = A(i) – A(ii)

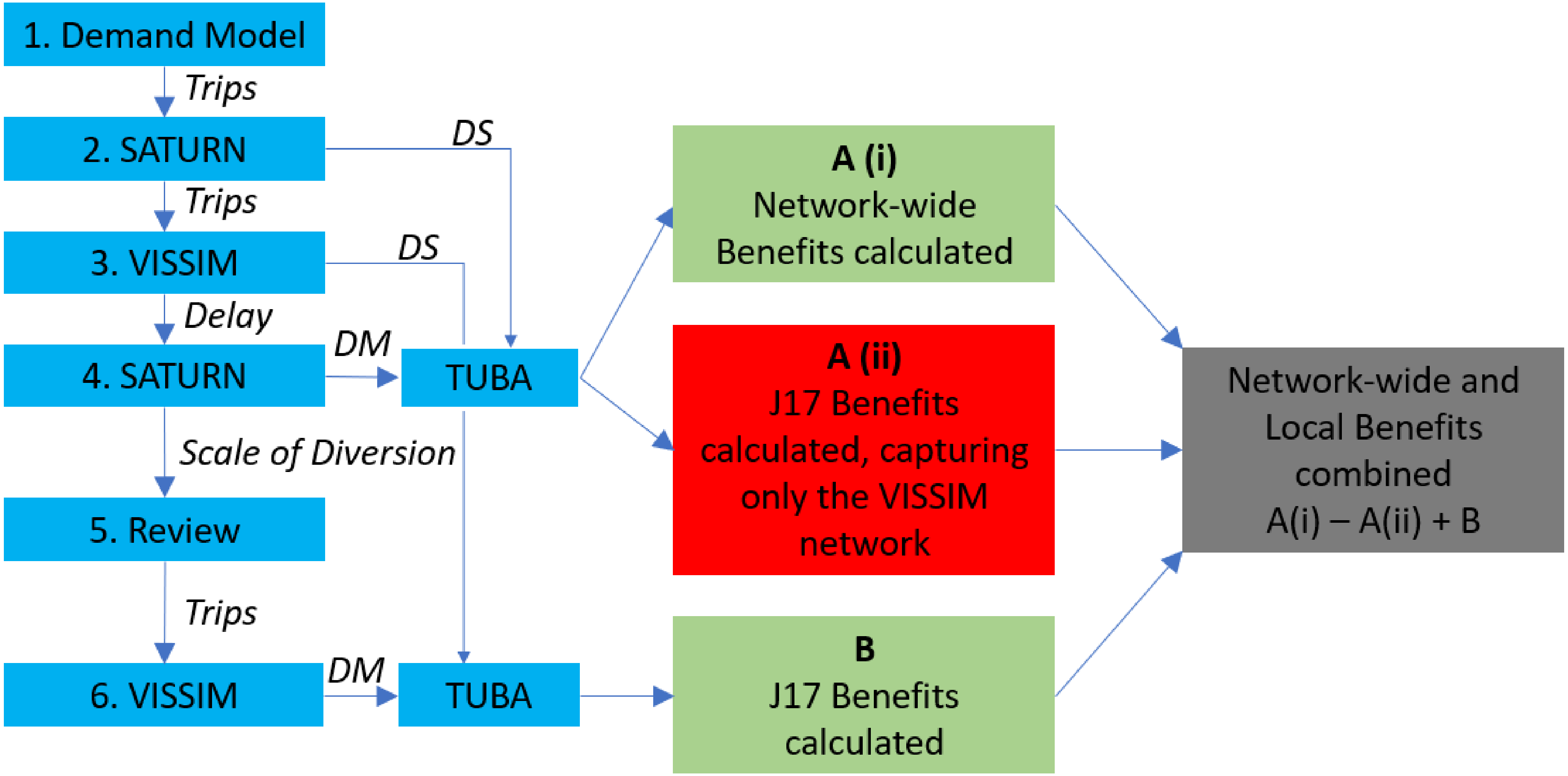
Therefore, the total benefit is measured as:

Total Benefit = B + A(i) – A(ii)

This process is set out in Figure 2-3.

Based on this methodology, the benefits captured through item A(ii) will be used to avoid any double counting, so that the process used to capture benefits using VISSIM outputs is mirrored using outputs from SATURN.

Figure 2-3 - Proposed Hybrid Appraisal Process



3. Application of Revised Modelling and Appraisal Approach

Review of the existing modelling has been undertaken to establish what will be the most appropriate and proportionate approach to preparation of the assessment described above. The following areas have been considered.

3.1. Forecast Years

Forecast years which had been developed for the two models included:

- Opening year of 2024 (SATURN & VISSIM)
- Design year of 2036 (SATURN & VISSIM)
- Horizon year of 2051 (SATURN only)

VISSIM has not been tested for 2051 and the additional growth in traffic is likely to lead to more extreme delay scenarios, with sensitivity of performance of the scheme to the ability of traffic to divert becoming a greater factor in the assessment of performance. A conservative and proportionate approach has therefore been taken to assess the benefits up until the 2036 forecast year and assume no further growth in user benefits beyond that point.

3.2. Do Minimum and Do Something Scenarios

The purpose of the approach set out in Figure 2-3 is to bring together the much higher levels of delay forecast by VISSIM and the rerouting forecast by SATURN in a single system which provides an equilibrium between the two elements. The determining factor which established the requirement for such a process was the large difference in delays forecast by the two models.

However, this large difference in delays is apparent only in the Do Minimum VISSIM model. Even at the busiest times the Do Something network can comfortably support the levels of forecast demand provided by SATURN, without using the above process of rerouting demand. This supports the original purpose of the VISSIM operational modelling, which was to ensure that the proposed design would be sufficient for the forecast traffic growth up to the design year.

With only minimal (positive and negative) differences in delay in the Do Minimum scenario between the SATURN and VISSIM models, passing the delays in VISSIM back to SATURN would have only a marginal effect on rerouting.

Therefore, it has not be considered proportionate to follow the process above for modelling of the Do Minimum scenarios. These scenarios have instead been based on Step 2 SATURN modelling and Step 3 VISSIM modelling for the purpose of appraisal.

The input to the appraisal for the Do Something scenarios, where the delay variations between the two models is much more significant are based on Step 4 SATURN modelling and Step 6 VISSIM modelling as described above.

3.3. Time Periods

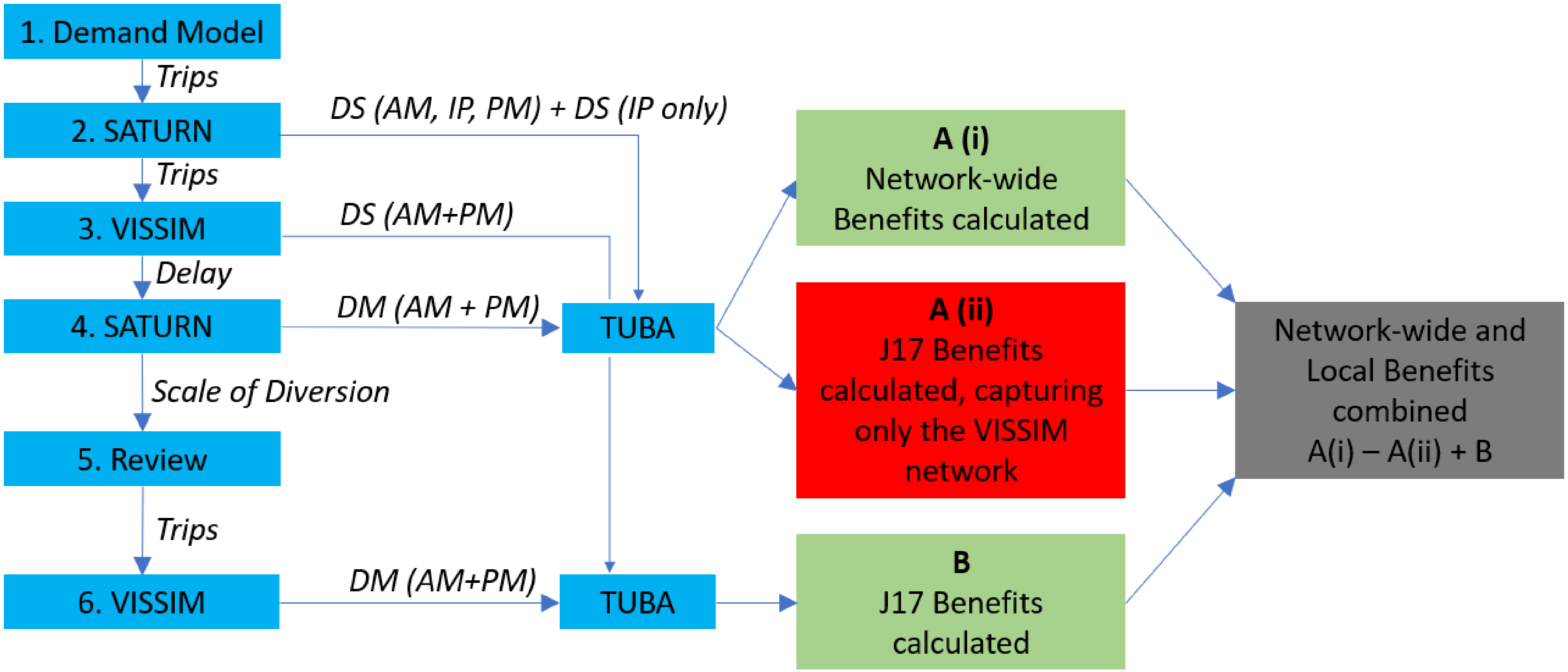
SATURN modelling has been developed for the average AM and PM peak periods and an average interpeak period, while VISSIM has considered only the AM and PM peaks. Analysis of the interpeak flows has shown that traffic levels remain at a largely consistent level between the end of the AM peak and the start of the PM peak.

Therefore, the interpeak period has not undergone additional modelling in VISSIM, but will draw on the outputs of the final 15 minute period of the AM peak period and the first 15 minute period of the PM peak period from the Step 6 VISSIM models.

Unlike VISSIM, the SATURN outputs are not able to isolate changes in performance by 15-minute intervals, so this approach cannot be taken to capture benefits over the wider network. It is likely, based on modelling undertaken so far, that delays in the interpeak scenario will be low and benefits small. Therefore, similarly to the modelling of Do Minimum scenarios discussed above, Stage 2 SATURN models will be used to inform the wider network element of the interpeak period analysis.

Figure 3-1 provides additional detail of how the modelled scenarios and time periods will flow through the appraisal process.

Figure 3-1 - Proposed Hybrid Appraisal Process by Time Period (2024 and 2036)



3.4. Sensitivity Testing

High and Low growth scenarios will be assessed to provide an indication of the sensitivity of the scheme to the uncertainty in future travel demand. These scenarios have been modelled in SATURN, but it has not been considered proportionate to undertake the highly detailed assessment set out above for each of these scenarios as well.

Modelling for the scenarios has been developed in SATURN and an appraisal of how the impacts of the scheme compare between growth scenarios will be assessed based on this modelling alone. For this purpose, an additional TUBA assessment for the core growth scenario will be prepared, so that this can be compared on a like-for-like basis with the low and high growth scenarios.

Due to the lower detail represented in the modelling of Junction 17 this approach is considered to be less precise in terms of absolute performance but will provide a suitable indicator of how variable performance of the junction may be.

It may be helpful to draw on other elements of modelling, such as rates of growth between forecast years, within the more detailed methodology to imply a reasonable range of uncertainty for the low and high growth scenarios.

3.5. Delays During Construction

The approach to assessing the impacts of delays during the construction period has been determined according to the level of detail currently available for traffic management plans.

The traffic management will be determined by the contractor and therefore at this stage only relatively high-level assumptions can be made. The main factors in the traffic management which are likely to influence the level of disruption for users are:

- Carriageway closures (single or dual lane);
- Works undertaken during peak periods; and
- Duration of works.

For the purposes of this indicative assessment, it will be assumed that:

- Works will require temporary lane closures, such that 1 lane remains operational on all merges and diverges at all times of day.
- Lane closures will remain in place for a period of 6 months.
- The mainline M4 carriageway will not require any traffic management.

The impact of such traffic management is likely be that significant rerouting of traffic away from the junction will occur during peak hours. It is therefore considered most appropriate that the assessment of impacts be undertaken using the SATURN model.

For reasons of proportionality, a combined SATURN and VISSIM approach will not be undertaken at this stage, due to lack of certainty of the traffic management measures themselves. Once these measures have been determined by the contractor the the method of assessment of these impacts at FBC should be proportionate to the costs to the users.

This will be modelled using the opening year DM model in SATURN.

3.6. Summary

As has been set out, it has been identified following initial assessment that certain limitations exist in the process of capturing economic impacts of the M4 Junction 17 scheme under the originally proposed method, resulting in a low level of accuracy. An alternative method, drawing on both VISSIM modelling to capture changes in delays across the junction itself and SATURN modelling for more strategic impacts relating to diversion of traffic, has been developed to provide a more refined measure of these two types of impacts of the scheme, with interaction between the two models used to establish a feedback relationship between the elements.

While this approach is expected to significantly increase accuracy in representation of the user benefits the methodology goes beyond standard approaches set out in guidance. Therefore, additional detailed review of the findings will be undertaken to ensure results are both plausible and consistent across scenario tests.

Due to the complexity of the proposed assessment method, a proportionate approach has been proposed for its application. The core elements of assessment will undergo the most precise modelling, while more comparative elements, those generating lesser impacts and those for which detailed specifications are yet to be developed, will be based on a simplified and more conventional modelling approach.

4. Dependent Development

Upon review of the scheme impacts, performance of the transport network in the DM scenario and the scale and type of development supported, it has been considered disproportionate to undertake the assessment approach set out in Section 5 of the ASR. This revision to approach also reflects changes to the planned development in the immediate vicinity of the junction, with planned expansion of the Dyson development site to the north-west of Junction 17 having been withdrawn.

It has been identified that a proportion of the traffic which will be generated by the Future Chippenham development will travel via Junction 17 and therefore improvements to the junction will be of benefit to these trips and so the upgrade will add value to the development. However, with the scale of development now reduced, the primary benefits of the scheme will relate to journey time savings rather than land value uplifts (LVUs). Therefore, owing to the complexity of modelling required to capture LVUs with a requirement for multiple scenarios to be represented, the focus of the assessment has been revised to accurately assess the journey time benefits based on the approach above, with development impacts considered qualitatively rather than being monetised.