THE QUADRO 2021 MANUAL
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PART 1

ECONOMIC CONCEPTS IN QUADRO

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1.   THE QUADRO METHOD

1.1   QUADRO can be used to appraise an individual maintenance task that is being planned in the near future or it can be used to appraise maintenance strategies over the whole life of an existing or new road. These could involve not only different sequences and types of work on the carriageway, but also alternative methods for handling the traffic, appropriate to the requirements of the work.

1.2   It might be helpful at the outset to define a number of terms that are used throughout this manual:

   Maintenance job: a maintenance job is defined as a maintenance activity in a particular year, at a particular site, and with particular traffic management arrangements. The principal types of maintenance job for which QUADRO is relevant are; reconstruction, overlay, resurfacing, carriageway repairs, surface dressing and major patching. A task which extends from one year to the next, or which involves different phases each with significantly different provision for traffic, or different levels of traffic, will need to be modelled as two or more jobs.

   Maintenance profile: this is the total major maintenance expenditure on a defined stretch of an existing or new road over the economic appraisal period, usually 60 years. It takes the form of a series of maintenance jobs over time. Only maintenance jobs as defined above should be included. Cyclic maintenance such as verge maintenance, sweeping and gully emptying, should be excluded, as should routine maintenance works which do not cause a significant traffic delay and which are generally low cost.

   Alternative maintenance profiles: alternative maintenance profiles for any given stretch of road are different profiles of maintenance expenditure that are all consistent with meeting the highway authorities' maintenance obligations. For example, alternatives might be 10 yearly resurfacing of a road, compared with reconstruction every 20 years.

   'Do-Minimum' scheme: the 'Do-Minimum' is the existing road(s) that exist without the new road scheme.

   'Do-Minimum' maintenance profile: this is the profile of major maintenance jobs that are expected on the existing road(s) if the new road is <u>not</u> built. Note that there may be alternative 'Do-Minimum' maintenance profiles. If QUADRO is being used by maintenance engineers to optimise maintenance works for an existing road where there is no new road under appraisal, they will be interested in alternative 'Do-Minimum' maintenance profiles only.

   'Do-Something' scheme: the 'Do-Something' scheme is the new road proposal that is being evaluated. Note that there will often be more than one 'Do-Something' option.

   'Do-Something' maintenance profile: this is the maintenance profile of major maintenance jobs that are expected on the new road and the existing road(s) in the network if the new road is built. Note that there may be alternative 'Do-Something' maintenance profiles for each 'Do-Something' option.

1.3   The basic 'building block' in QUADRO is the individual maintenance job. QUADRO is essentially a program that costs, in total works and road user terms, individual jobs and then sums the series which forms the maintenance profile. The items of cost of an individual maintenance job are illustrated in Table 1/1.

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TYPE OF COST	FALLS ON
Works cost	Central or Local Government
Delay time cost	Road users
Accident costs	Road users and Government
Vehicle operating costs	Road users

Table 1/1: Costs Arising from Road Maintenance

1.4   The QUADRO user supplies the data on the works cost of the maintenance job. The user also specifies the road network, including the diversion route and works site layout during maintenance works, and the traffic flows on the network without the maintenance works. When considering new schemes it is essential that these traffic flows are compatible with those used elsewhere in the economic assessment. The program calculates any diversion of the traffic flow during the works from the route being maintained to the diversion route, and then costs the total extra time, vehicle operating cost and accidents on both the main route and the diversion route during the works. This extra cost is calculated as the difference between the total user cost with and without the maintenance job. The costs associated with delays resulting from breakdowns and accidents in the work site are also estimated. QUADRO assumes a fixed trip matrix with and without the maintenance works. That is to say, it assumes that no journeys will be suppressed or redistributed during the maintenance period.

1.5   The program calculates delays and accidents in units such as vehicle-hours or numbers of accidents, and then converts these into monetary costs using the same values of time, vehicle operating costs and accident costs as used in COBA User Manual.

1.6   The program adds the extra road user costs imposed by the maintenance job to the works cost, all defined in average 2010 prices, and then discounts them from the year of the maintenance job to a common base year (normally 2010).

1.7   This same procedure is applied to each maintenance job in a maintenance profile. Of course, the works cost will differ for each job, and so will the traffic flows (due to traffic growth), duration of works, site layout during maintenance, etc. Having calculated the total works and user cost for each of the jobs in the profile, the program then sums the profile to give a total discounted cost over the economic assessment period. Where there are alternative profiles, the program calculates the total discounted cost of each profile. The optimum profile for the 'Do-Minimum' and each of the 'Do-Something' options can then be identified and is that profile which has the minimum discounted total cost.

1.8   The size of the network evaluated with QUADRO can vary according to the user's needs. Each individual job is related to a particular stretch of road and, of course, a sequence of jobs over the economic assessment period can be analysed for that particular stretch. However a longer route can be assessed by specifying a number of jobs, one for each subsection of the route, and for each of these jobs a QUADRO network will be defined by the user. These subsections are independent however; QUADRO cannot model any interactions that might take place between a series of contemporary maintenance jobs on a long length of road. For new schemes the assessment should normally be restricted to that length of old road which is directly replaced by the new road (for example, distance between terminal junctions), together with the new road.

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2. DEFINING THE OPTIONS FOR APPRAISAL

2.1   The first stage in a QUADRO appraisal is to define the options that are to be appraised. This varies according to whether QUADRO is being used to evaluate individual maintenance jobs or maintenance profiles; and according to whether it is being used to evaluate maintenance work in its own right, or maintenance work as it affects the appraisal of new trunk road schemes.

2.2   The most simple level of use is the evaluation of individual jobs, for example, when one is assessing proposals for a maintenance contract in the near future. The alternative options may differ in terms of duration of contract, traffic arrangements (for example, length of site, hours of working), and so on, or may differ more radically in terms of comparing a full scale maintenance contract with a more modest proposal which would involve further maintenance works at a later date. The general rule when evaluating individual jobs is to start with the cheapest possible option consistent with minimum maintenance requirements, and then compare this with higher cost solutions. The highest cost solution may turn out to be preferable when all costs are taken into account, because it avoids a further round of maintenance works and delays at a later date.

2.3   It can be seen that in assessing an individual job, the maintenance engineer may well be drawn into considerations of a life-cycle nature. The next stage of complexity in the use of QUADRO is the explicit comparison of alternative maintenance profiles for an existing stretch of road. This will normally be carried out at an earlier stage in the maintenance planning for a trunk road, when the engineer is comparing the merits of, for example, frequent but low cost jobs with infrequent but high cost jobs. Once again the general rule is to start with the maintenance profile that meets minimum requirements at lowest works cost.

2.4   The discussion so far in this section has been directed at maintenance engineers who use QUADRO to evaluate maintenance jobs *per se*. The other main use of QUADRO is in scheme appraisals where traffic-related maintenance costs of the 'Do-Minimum' and 'Do-Something' options are compared. This can be for two reasons: because it has a bearing on the overall justification for the 'Do-Something', or because it may affect its standard. Before embarking on such an analysis, the user should consider carefully whether a detailed assessment of traffic-related maintenance costs is worthwhile. It might be fairly obvious that maintenance works and delays in the 'Do-Minimum' and 'Do-Something' are not likely to be significantly different, or that the standard proposed is robust for a wide variety of conditions. Where this is <u>not</u> the case, the user should consider the 'Do-Minimum' and 'Do-Something' options in turn. For each option, the user should specify the likely alternative profiles of major maintenance works. QUADRO can then be used to assess for each of the 'Do-Minimum' and 'Do-Something' options, which profile has the least cost in overall delay and works cost terms. These minimum overall cost profiles will normally be the preferred profiles, one for each of the 'Do-Minimum' and 'Do-Something' options. They are then input to the economic evaluation as part of the overall assessment of the new scheme. In some cases there may be only one feasible profile per 'Do-Minimum' and 'Do-Something' option for QUADRO to cost.

2.5   When the maintenance implications of the 'Do-Minimum' and 'Do-Something' networks are being considered, only those parts of the network which have changes in traffic flow which are sufficiently large to affect significantly the level or timing of traffic-related maintenance works or traffic delays at maintenance works need to be assessed. When traffic flow changes are smaller, there is unlikely to be any change in the traffic-related maintenance requirements or delays. Thus where QUADRO is used as part of the economic evaluation, the QUADRO analysis will usually be restricted to a small number of links in the total road network.

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3. DISCOUNTING, THE PRICE BASIS AND TREATMENT OF TAXATION

3.1   This section briefly reviews the principles of discounting, prices and the treatment of taxation used in QUADRO.

3.2   When evaluating maintenance works which occur at different periods of time it is necessary to take account of the fact that people generally put a higher value on having benefits today rather than next year, and similarly they prefer to defer costs where possible. This is expressed in formal terms in economic appraisal by the use of a technique called 'discounting'. This process can be thought of as the opposite of compound interest. Consider a maintenance profile for a particular stretch of road. The maintenance engineer has estimated that three major maintenance jobs will be necessary, that is, resurfacing costing £X in 10 years time, reconstruction costing £Y in 20 years time and a further resurfacing costing £Z in 40 years time, £X, £Y and £Z being at current day prices. The sum of these in undiscounted terms is (£X + £Y + £Z). However, as society generally puts a lower value on later costs, the costs have to be discounted to form what is called the present value of the cost stream, as follows:

$$\text{Present Value of Costs (PVC)} = \frac{£X}{(1+r)^{10}} + \frac{£Y}{(1+r)^{20}} + \frac{£Z}{(1+r)^{40}}$$

where r is the discount rate, expressed as a fraction.

3.3   The Green Book (HM Treasury, 2018) gives the guidance for public sector bodies on how to appraise proposals before committing funds to a policy, programme or project. The book defines a discount rate of 3.5%, plus the change to a 3% discount rate 30 years after the current year. In order to carry out the discounting process, it is necessary to define the current year (2021 by default in QUADRO) and a base year to which costs are discounted. This latter year is known as the Present Value Year and is 2010 by default in QUADRO.

3.4   When comparing costs incurred at different points in time, it is also necessary to express costs in constant prices. In QUADRO all costs (both user and works) are expressed in average 2010 prices. The present value of a maintenance job or profile is thus said to be 'in average 2010 prices discounted to 2010'.

3.5   However, if the user wants to express QUADRO results in up-to-date prices, the costs should be adjusted using the Treasury's GDP Deflator series from the WebTAG databook. The updating should be done manually in the following way. Suppose the submission is in 2013 and the latest GDP deflator for 2013:

   i)   QUADRO PVC = £2.0m in average 2010 prices and discounted to 2010;

   ii)   at 2013 prices, $\text{PVC} = \dfrac{£2.0m \times 105.70 \text{ (2013 GDP deflator)}}{100 \text{ (2010 GDP deflator)}} = £2.11m$, discounted to 2010

   iii)   at 2013 prices and discounted to 2013, $\text{PVC} = 2.11 \times 1.035^3 = £2.34m$.

3.6   Where undiscounted works or delay costs are quoted in submissions, they should be updated similarly by multiplying the undiscounted costs at average 2010 prices in QUADRO by the ratio of the latest GDP deflator divided by the 2010 GDP deflator as at ii) in paragraph 3.5 above.

Treatment of Taxation

3.7   In order to take account of the impacts of a project across different modes of travel, it is necessary to describe

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the impacts using a calculus of willingness-to-pay (WTP), as opposed to a calculus of social costs and benefits (SCB). In addition, the values placed on impacts can be reported in the perceived costs, factor costs and market prices unit of account, converted as appropriate from factor costs using the indirect tax correction factor. These methods and unit of accounts merely affect the presentation of results and not the fundamental principles of appraisal. In particular, the results using a WTP calculus show clearly how different groups are affected by the project, whilst previously resource costs and benefits were aggregated and consequently masked transfer payments. A fuller discussion of the conversion between the factor cost and market price units of account is given in TAG Unit A1.1 (Ref 0.7).

3.8   To ensure compatibility, an adjustment must be made for indirect taxes in the economy. These are <u>transfers</u> between members of society (for example, consumers to Government), rather than <u>costs</u> to society as a whole. QUADRO works in the factor cost unit of account (for time and VOC). However, it gives outputs (for time and VOC) in factor costs and also presents them in market prices. Further information can be found in the COBA user manual) (Ref 0.6).

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4.   SINGLE YEAR AND 60 YEAR APPRAISALS

4.1   Where QUADRO is used to appraise maintenance profiles, the appropriate time span for the profile is normally 60 years, starting at the opening year of the new road scheme under appraisal. When maintenance profiles are being considered outside the context of a new road scheme, then the time span usually starts from the date of the first maintenance job. This time horizon is consistent with that used in other economic appraisal methods.

4.2   Historically QUADRO used the 'low' set of traffic and economic growth assumptions by default. 'High' growth was selected by using KEY 003. In the latest version of QUADRO, the low and high defaults are the same and are consistent with the central traffic growth in the DfT Road transport forecasts 2018 Scenario 1 (Ref 5.6). KEY 003 is therefore no longer relevant. In addition, the economic parameters, namely the values of time, vehicle operating costs and accident costs are common to both growth assumptions and are based on those recommended in the TAG Unit A1.1.

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