1. INTRODUCTION: AN ONGOING RELOCATION OF SCHOOLS, CAUSING SAFETY CONCENS

Schools are subjected to all kinds of change, which may have consequences for their location. The most important ones are:
- changes in demand, as may be caused by demographic shifts and an increase in participation or by developments in consumer preference, which may be especially influential where there are no school districts as is the case in The Netherlands,
- changes in the school system or in teaching methods as such, which require amalgamations of schools. i.e. larger school buildings or a different layout of school buildings and precincts,
- changes in required or aspired facilities, with consequences for the adequacy of the location,
- physical deterioration of buildings, demanding large scale reconstruction, which is impossible at the present location. That location might be the subject of a profitable redevelopment enterprise too,
- economizing on the cost of education, especially those of buildings, facilities and staff.

During the last decade of the 20th century the relocation process was intensified with economizing and changing demand as dominant motives. In the meantime the school system was reorganized as well, without much funding for new school buildings. It implied that physical changes took place only slowly. Nowadays the change is dominated by the ongoing replacement of inadequate school buildings, and the agglomeration of schools to improve facilities and educational diversity.

The working unit of the first author studied school transportation impacts and solutions for these intensively for about a decade. Most of the studies were undertaken on assignment of three national ministries (Education, Physical Planning and Transport) and three provinces (counties). For the Ministry of Education school closures in primary education were the subject of three studies. The most important one was designing an approach for assessing the acceptability of closure of individual schools from the combined perspectives of accessibility and cost, i.e. the cost of overcoming accessibility problems.
The method was developed quite carefully, afraid as we were to be accused of helping the ministry in closing down village schools. We asked all three national traffic safety associations, now united in 3VO, whether they would appreciate such a method. The Pedestrian Association didn’t. ‘Safe Traffic Netherlands’ (VVN) encouraged the idea: ‘good, then we can use it too’. ‘Stop child murder’ had developed a method herself.

The method was based on an extensive study of possible standards for individual traffic and road variables and a search for similar methods. Danish standards proved to be helpful as were exercises with the ‘Stop child murder’ and a Finnish method (de Boer, a.o., 1987).

In the next section (2) the method is discussed in sufficient detail to understand its character and the procedure followed. See for more detail de Boer 1988.

In the following section the extensive test of the method on 42 cases is described concisely.

The subject of section 4 is the outcome of an after study made by TU Delft in 2004, undertaken to find out what happened with the 42 locations assessed in 1987. It might be regarded as a second test.

Figure 1. ‘Harm Schreur’ public school at St. Jansklooster, closed conform our assessment for the Province of Overijssel

2. DEVELOPING A METHOD

2.1. Accessibility, distance, time and safety

Hitherto accessibility and safety have been talked of rather loosely and seemingly interchangeable, but of course accessibility is the larger concept. Distance is an important factor in accessibility, affecting travel time and safety because of duration of exposure. For this reason, and because it is easily measurable, it is often used as a criterion for closing down schools: the larger the distance to the next school, the
lower the minimum of pupils allowed. However, distance is too unreliable an indicator of danger. Short routes in urban areas may be less safe than longer ones in rural areas for instance, although German standards for providing schoolbus transportation assume the contrary (see Satzungen 2005). One might however assume that long distances are inherently too unsafe for young children (8-10 years) to go to school on their own. This is internationally acknowledged in distance standards for (reimbursement of) pupil transport. One practical limit for safety evaluation therefore is such a widely accepted standard. In The Netherlands the standard is 4 to 6 km for the whole primary school (4-12 years), but in Germany (5-10) only 2 km (!).

If for any reason a shorter journey to school is still found to be too unsafe, distance and time are important factors in assessing traffic improvements or transport alternatives: detours, waiting times and comparatively long-lasting journeys might make these unacceptable for the children and therefore useless.

We have taken this into account in our system, but it will be ignored in the remaining part of the paper, as will be the safety of the bus-stop and of the direct school-environment. This is because the safety assessment of routes is the most important element of the method.

### 2.2 A simple theory on the safety of school routes

It is quite impossible to investigate the danger of a new school-route by analysing accidents and conflicts, not only because it is not yet a school route, but also because this approach requires too much lime and money for decision-making on closures. Investigating subjective safety will not do. It is too subjective for a debate and is in any case seen as too emotional by the educational authorities. One is therefore left with indicators, measurement of factors, like bad sight, that are proven to be causes of danger. Danger may be caused by three different elements: by the value taken on by an individual variable, by the combination of values of different variables in individual traffic situations, and by a succession of high situational scores along a route. It is quite obvious that a school-route may be rejected in its present state because at one or more places critical values of certain variables are exceeded. The idea of small children having to cross without protection roads with speeds exceeding 100 km/hour is unthinkable. It is essential that the degree of protection offered by facilities such as pavements should be specified. It is quite obvious too, that a situation in which only one variable reaches a high value, is less dangerous than one in which more of them are reaching critical values. Unfortunately it is not really possible to predict the level of danger resulting from the interaction of variables in a situation (apart from the relation between restricted visibility and speed).

Therefore a simple device is needed for defining an overall-score on the variables and setting a lower maximum on 'average scores' than on individual ones. This appraisal should of course also do justice to the three fundamentally different route elements: following a road, crossing it and going across crossroads.

It is perhaps somewhat less obvious, that confrontation with a sequence of unsafe traffic situations is a further addition to danger and to the unacceptability of a school-route. However, there is no doubt that the accident risk is increased by repeated exposure to similar (or dissimilar) danger. This implies that one situational score which is acceptable as such may be rejected as an average for a route. The device for setting a lower maximum on this average had preferably be the same one as in
the previous stage in order to minimize the arbitrariness of the whole. The reduction should also be dependent upon the number of unsafe situations en route: the more the less acceptable.

2.3. **Translation into an assessment procedure**

The procedure starts with defining a school route to the new school location. This may be the most likely route or an optimal one to be advised to children and their (accompanying) parents. In case of closure, and redistribution of the children about more than one school, more routes will have to be defined. In the method the **route from the old location to the new one** is chosen as a proxy for the set of routes of individual children. If this is clearly incorrect it should be adapted or a number of different ones should be defined.

Our research showed that the number of road and traffic factors which were acknowledged to cause danger proved to be surprisingly small. Furthermore it proved to be possible to design generally accepted minimum values for these factors, at least in Dutch circumstances. It should be possible in other conditions as well, but the values might be different. These standards, concerning for instance speed and volume of motorized traffic, constitute the basis for the method.

If, on the route to an alternative school, the score on one of these factors exceeds this standard anywhere, the route is considered not acceptable in its present state. Danger however is not only a matter of unsafe factors. Danger can be increased by combinations of factors in situations or by a succession of dangerous situations along a route. This implies that combinations of acceptable values may be unacceptable: acceptable factors combining into unacceptable situations, acceptable situations combining into unacceptable routes. To take account of this, some form of multi criteria analysis is required.

The level of acceptability for situations was defined, after weighing factors, as two third of the summarized maximum factor scores, scores which were normalized for this purpose. For the combination of situations along the routes the acceptable mean 'situation-score' is defined at an ever lower level as the number of situations increase. In practice this implies, that on the basis of indisputable factor-criteria (like no unprotected crossing on roads carrying more than 10.000 cars a day) an assessment of routes can be made resulting in a rejection of even moderately unsafe situations. The outline of the whole procedure is shown in figure 1.

The school route is divided into a series of different road and traffic situations. For each of these all relevant variables are measured, and the results confronted with the maximum acceptable values. If one of these values exceeds the norm, then the possibility of traffic measures within a certain budget is investigated. The Dutch Ministry of Education defined that budget as roughly 50.000 Euro per annum, or half of the savings of the intended closure. If a traffic measure is not affordable, because a costly measure like a long pedestrian tunnel is required, the possibility of a transport solution is investigated. For modest numbers of children this is an affordable solution.
Variables and values
The most important variables found in the international literature are traffic volume, speed and visibility. A number of road variables are no doubt relevant though mentioned somewhat less often in literature. These are the total length of the journey, the length of a stretch of road (one situation) followed, the width of a road (for cyclists to ride on, for pedestrians to cross in one time) and the presence of separate facilities for these, either for riding on or for walking and crossing.

Traffic volume contributes to the chance of conflicts for children cycling on the road and for children crossing. The latter will take more risk with higher volumes because of long delays. A value of 2000 motor-vehicles a day we held to be acceptable, a value of 10,000 vehicles completely unacceptable.

Speed is a self-evident contributor to frequency of conflicts (children have difficulties estimating speeds!) and to their gravity. Accepted speed: 30 km per hour, rejected speed 80 km (the maximum allowed on Dutch roads apart from motorways). Danger increases rapidly above 50 km. per hour. For pedestrians walking along a road 30 km. is the maximum without footpaths.

Visibility is an absolute requirement for crossing. The length of the sight lines needed depends upon the highest speeds registered.
Crossing distance is important for the acceptability of gaps in the traffic flow. A distance of 3 metres is acceptable, one of 12 metres unacceptable. This might be considered rather strict in comparison with the previous criteria. Yet wide roads are generally resented, and the problem can be solved easily by making an island in the middle, and by restricting locally the space for riding and parked vehicles.

Width of the road has an impact on the safety of cyclists, narrow (4 m. and less) and wide ones (7.5 m and more) allowing for higher velocities of car traffic because in either case they will be confronted with traffic in one direction only, which moreover cannot cause many conflicts any more. In these cases the traffic volume registered is taken only half as serious, like (for crossing) in the case of a resting-place in the middle of the road.

Length of a stretch of road (one continuous situation) is of relevance because of the duration of exposure which is only partly outweighed by adaptation to the situation.

Total length of the school-route Some kind of distance limit is required. In our system of criteria 4 km. was chosen because it is the traditional criterion for pupil transport in The Netherlands.

Facilities, which have been mentioned frequently must of course be taken into account. Footpaths, separate bikeways, tunnels and bridges are sufficient measures along or across the road respectively. Other measures like traffic lights must somehow be given a danger reduction value. These are relevant when judging more than one variable i.e. for judging situations.

Situations: integrating variables in a calculus and punishing extreme scores
A major problem of assessing safety on the basis of indicators, or constructing a general acceptability criterion for situations or even routes, is incomplete knowledge about the interaction of variables. Only some of these could be expressed with reasonable reliability in one real value: combining speed, intensity and crossing-distance may yield a certain chance, a mean delay for a sufficient gap in the traffic flow. The general problem though cannot be solved this way. The only way out is to choose some form of multi-criteria analysis. As a rule these are used to combine different arguments, which cannot be integrated into one. The most limited form is a presentation of all facts in one table, the most far-reaching one a translation into a monetary balance. In this case multi-criteria analysis is to be used for arguments leading to one kind of conclusion: a degree of safety being acceptable or not. Arithmetic simplicity is required because of the limited level of knowledge. A numerical score is nevertheless preferable as an outcome for the sake of clarity. Of course the outcome is nothing more than the result of the best possible combinatorial reasoning and agreement on limits.

The first step to be made is expressing all variables in a similar way. This can be done most easily by normalizing them: assigning a score of 0 to the lowest possible value (e.g. zero motor-vehicles) and a score of 1 to the highest possible one (10.000 or more), and assigning intermediate scores to intermediate values on a proportional base, or on a disproportional one if necessary, as in the case of speeds.

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The next step is to weigh variables. For crossing for example speed may be thought to be of more importance than traffic volume.

The third step is to assign correction values to special circumstances like width of the road and facilities present in the situation.

The fourth step is designing a formula to calculate a summary score. Given the previous steps this is rather easy. The formulas we made are presented in figure 3. Different formulas are used for longitudinal, transversal and cross-road-problems. In fact the latter case is only crossing one arm of a cross-road. Crossing a second arm requires separate assessment because conditions can be quite different there.

An equal maximum score for different types of situation is a prerequisite for constructing a route score. The maximum score for every type of situation is decided by intensity, speed and (crossing) distance. Correction factors may increase or decrease the score. The figure in the denominator limits the possible score to 1 (L and T) or 1.5 (C).

### Longitudinal

- Intensity
- Velocity
- Width of road in $c_w$
- Distance in $c_d$
- Facilities in $c_f$

$$L = \frac{((I_i * c_w) + V_i) * c_d * c_f}{2} < 0.66$$

### Transversal

- Intensity
- Velocity
- Crossing distance
- Sight line
- Facilities

$$T = \frac{((2 * V_i) + I_i + C_i) * c_s * c_f}{4} < 0.66$$

### Arms of cross-roads

- Intensity
- Velocity
- Crossing distance
- Sight line
- Facilities

$$A = \frac{(V_a + I_a + C_a) * c_s * c_f * c}{3} < 0.66$$

Figure 3 Criteria for different types of situation ($c = correction factor$)

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The maximum score accepted for any given situation is 0.66, which implies that problems in crossing at crossroads are punished more heavily than other elements of the route. The reason for this is the large degree of complexity at crossroads. Defining a 0.66 standard was of course difficult because of its arbitrariness. After a few exercises and practical tests we decided to choose this very simple standard. It implies that no route with a traffic speed of 80 km/h and 10,000 vehicles will be accepted. Transversal combinations of for instance 60 km/h and 6500 vehicles per hour or 50 and 9500 vehicles are however accepted but only for (impossibly) narrow roads (see figure 3). The moderating effect is evident but these combinations indeed are still looking rather dangerous. It should not be forgotten though that only one such situation will be tolerated on any one route.

![Figure 4](image-url) The acceptable velocity of traffic on a road to be crossed related road width and traffic volume.

**Routes: integrating situational scores in a calculus and punishing rather modest scores**

The question of how to make a route-assessment was now quite simple. A route is a succession of situations, some of which are innocent or at least completely acceptable (score 0) and some of which are less acceptable (scores 0.0 to 0.65). The unacceptability of the route increases with the number of less acceptable situations. A route with only one such situation (0.65 e.g.) should be judged less rigorously. It is logical to use, in the case of a 'normal' number of 'less acceptable situations', the same two-thirds weighting as for single situations, which means that for a somewhat longer route only 0.66 x 0.66 or less than 0.44 of the original variable score will be tolerated.
3. A PRACTICAL PROCEDURE PRODUCING A TRANSPORT SOLUTION?

In a first round the new school route may be explored superficially to find the places where critical values of individual variables might be exceeded. If after measurement this proves to be the case, further assessment is superfluous. Instead the possibility of counter-measures and of a transport alternative will have to be considered. If a transport solution is feasible (public transport might even be suitable in its present state!) closure is acceptable, because all known and as yet unknown problems are solved at once. A traffic solution, like a traffic bump is inevitably local in character and in the next step, assessment of situations lower values may be required even at the same spot let alone at other spots. Again a broad inspection will produce a list of potentially unacceptable situations, for which measurement of all variables is required this time. The search for solutions is then repeated, and in case non-transport ones are proposed and in the case that no problems have yet been found the third, and most extensive analysis begins. Yet even then it is not necessary to scrutinize the entire route because parts of it may prove to be acceptable at first sight (footpath or bikeway present e.g.), after a simple calculus (cul-de-sac) or after a brief measurement: very low volumes and speeds.

The traffic solution alternative might be thought to be preferable because it gives the children an opportunity for an independent journey to school. In a procedure like this assessment can be stopped if a reasonable transport alternative exists or can be organized. Finding a traffic solution on the level of single variables is no guarantee for acceptable situations or routes and therefore more analysis has to be done. In this case however the tendency towards transport solutions is partly fictitious and partly real: the purpose of this method is to judge closability of a location and not specific accessibility measures; it is meant to prevent the worst danger, which makes transport alternatives, which ideally prevent confrontation with danger, preferable for longer distances.

Of course the results have no absolute value. The method does, however, distinguish schools that cannot be closed and schools that cannot be defended from closure, at least from the perspective of traffic safety. Without doubt there is a grey area in between, requiring further research.

4. EVALUATION AND IMPLEMENTATION

The Ministry of Education was interested less in the structure and content of the method than in its results. For it the question was above all: how many schools could be closed upon application of the method, and, more specifically, what would be the net-result in financial terms, resulting from savings on schools and costs for traffic and transport.

We took a stratified sample of 42 out of nearly 600 schools which were too small, regarding three characteristics of individual schools: size (decisive for transport cost), distance (decisive for transport need) and geographical position (important for traffic-measures). A great part of the cases were taken from a list of the (non-expert)
Educational Inspection indicating schools causing "very serious" or "insurmountable' accessibility problems upon closure. These proved upon application of the method hardly to differ from the other cases, which in itself proved the utility of an objective method.

An estimated 25% of all schools could be closed down without causing accessibility problems at all. Another 25% would cause so much problems that closure would hardly be attractive from a financial perspective, i.e. it would cost at least half as much as the mean savings per school. The remaining 50% might be closed after taking affordable measures. Especially the smaller rural schools could be readily closed utilizing pupil transport. The larger urban schools, for which transport is more expensive and less effective proved to be more difficult.

On the basis of these outcomes a simple cost benefit analysis was made for all 600 schools, assuming that the outcomes of the 42 cases were representative. The cost of closures was calculated to be 9 million Euro per annum (present level) and the benefits for the ministry 40 million.

The method and its results were presented and were received not unfavourably. In the mean time the ministry however had decided to design more lenient pupil- and distance criteria in order to get rid of 'special circumstances' in decision making, amongst those traffic safety. The responsible under-minister did not want to be accused of neglecting safety altogether and asked us to make a guide for creating a safe journey to a new school intended for local use.

Figure 5. The school with the Bible at Holkerveen with the proud chairman of the school board.

Our defense of his school for the Union of Protestant School boards was ineffective.
Nevertheless the method was used by some provinces for assessing the acceptability of closures of public schools. It was used too for supporting appeals against closing decisions at the Council of State, the national administrative court. We had to pass sentence on a number of primary schools on assignment of a province. We defended a number of other schools at the Council of State on assignment of a national Protestant school union.

5. REVISITING THE 42 SCHOOL LOCATIONS

The study of the 42 cases was in fact confidential, just a test of a method. The report of the study did not mention the locations. Only a few were treated in order to demonstrate the method. The schools were not informed about the assessment nor were the school authorities.

We were interested to know what happened to these schools and especially whether the decisions about these schools were in line with our judgment. Figure 4 shows the result of our search.

In the figure three categories are distinguished: schools which according to our assessment could be closed, schools which could be closed after taking affordable measures and schools which could not be closed.

Looking at the indication ‘closed’ the distribution of the number of factual closures is correct: for the three categories 73%, 45% and 22% respectively. This may be regarded as a satisfactory outcome in two slightly conflicting senses: the method was right and the authorities took the right decision even without knowing our assessment.

Considering the indication ‘open’ the distribution is less satisfactory though: 9%, 41% and 22%. It is explained with the two other categories: ‘satellite/dislocation’ and ‘other school’.

Closure of a school, i.e. dissolving an institution by discontinuing government finance, is not the same as discontinuing education at a certain location. In one decade (1990 – 2000) the Ministry of Education reduced the number of primary schools by 15%. At the same time it introduced a number of changes in its policies towards schools as institutions and as locations.

Nowadays the school as an institution is allowed satellites (and the required additional finance) under traditional criteria: minimum pupil numbers and minimum distance. It is allowed an increasing budgetary freedom as well. This created the freedom to maintain unofficial locations, called dislocations as well.

Local government has been made responsible for school buildings, for which it receives finance on the basis of pupil numbers and geography. It can change the location of a school only in agreement with the institution.

Both the institutional freedom of the school and the shortage of municipal finance explain of the categories ‘between’ closed and open.
42 cases

- could be closed: 11
  - satellite or dislocation: 1
    - closed: 8
    - open: 1
  - other school: 1

- could be closed after measures: 22
  - satellite or dislocation: 1
    - closed: 10
    - open: 9
  - other school: 2

- could not be closed: 9
  - satellite or dislocation: 3
    - closed: 2
  - other school: 2
    - open: 2

Figure 6 The acceptability of school (location) closures as assessed, confronted with factual closures.

6. CONCLUSIONS

I proved to be possible to design a normative method on a multi criteria basis to assess the acceptability of a new school route. The method as such was accepted by important parties, but only modestly for official decision making. This is likely to have been caused partly by the relative complexity of the method and partly by the social and administrative distance between official from the department of education and those from the traffic department.

The regional body for traffic safety in the Province of Friesland offered three municipalities a 50% subsidy for developing a physical plan of schools, i.e. for the relocation of schools. The major ones amongst which the regional capital, Leeuwarden, refused because the education department had sufficient problems in deciding about remaining buildings and staff.

The outcomes of the assessment and of decision making on schools are strikingly similar in the sense that the method identifies sustainable school locations.
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