# THE IMPLEMENTATION OF SCOOT IN THE CITY OF NIJMEGEN IN THE NETHERLANDS

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## INTRODUCTION

Trying to reach a new and better balance between the conflicting interests of transportation on one side and the environment on the other side is the challenge of the Second Transport Structure Plan (1), which is approved by Parliament. This plan has three main objectives: improve access to urban centres and reduce congestion, contain the growth of vehicle kilometrage and improve environmental conditions and traffic safety.

Real-time control systems are considered as possibilities to come to a better utilization of the urban and interurban networks. It was decided to implement such a system in Nijmegen in order to assess the traffic performance of an on-line optimized real-time control system against the existing control system. This paper describes the implementation and plans for the evaluation of SCOOT in Nijmegen. It was explicitly decided not to develop a new real-time control system, but to consider the possibilities and applicability of an existing system. The SCOOT system was chosen because it's: an operational system, successfully applied in the United Kingdom and other countries, and still under development.

Nijmegen was chosen because intersections and controlprograms are relatively simple and fixed time coordinated in Nijmegen, in contrast with the situation in other cities in The Netherlands in which most intersections are programmed individually and public transport has priority. Moreover it was chosen because: its isolated position (no influence from other cities), its functioning as a link in the rural network, its radial construction of streets, which assures that the traffic is directed through a few congested arterials, and in Nijmegen already a traffic management system was available.

## FEASIBILITY STUDY

The project started in 1990 with a feasibility study. In this study (2) the different steps for the realisation of the project 'SCOOT in Nijmegen' have been considered. Discussions with the people involved resulted in: a first definition of the intersections to be included in the SCOOT-network, a global estimation of the costs and an inventory was made of the existing hardware, new hardware and training, necessary for a successful implementation. It was also decided to maintain the existing hardware in order to be able to compare SCOOT against the existing traffic management schemes.

The SCOOT-network defined is 40 intersections wide. They were equipped with controllers of three different suppliers, including 10 old-fashioned controllers which were short-listed for replacement. Most controllers were already connected with the control room by the existing cable network. In The Netherlands there is no valid communication standard. So the feasibility study showed that the following items were needed to add the SCOOT-system to the existing system in Nijmegen:

- an UTC central computer for the kernel;
- OTU's in 40 controllers;
- two types of dedicated interfaces in the local controllers to communicate with the OTU;
- some additional cables;
- early replacement of 10 controllers;
- (re)programming of two types of controlprograms to respond to SCOOT-messages;
- a SCOOT-database for the network;
- validation of the links in the database;
- training for the Dutch engineers;
- fine-tuning of the system.

Also, TRANSYT-runs were made to see whether or not introduction of SCOOT in Nijmegen could have positive effects on delays and stops.

The feasibility study resulted in a proposal for the implementation of a SCOOT-system in Nijmegen. Based on this proposal, the Ministry of Transport decided to start the implementation.

## CALL FOR TENDER

At the end of 1990, most of the work on the call for tender was completed. Before the set up of the specifications, several examples of British call for tenders were studied. The Dutch standard of specification of traffic controllers was used as a basis. An appendix, containing the commonly used British items, was added. The final call for tender was compiled of a British part and a Dutch part, that matched with each other. The call for tender was a full specification of the system and its components: the central computer

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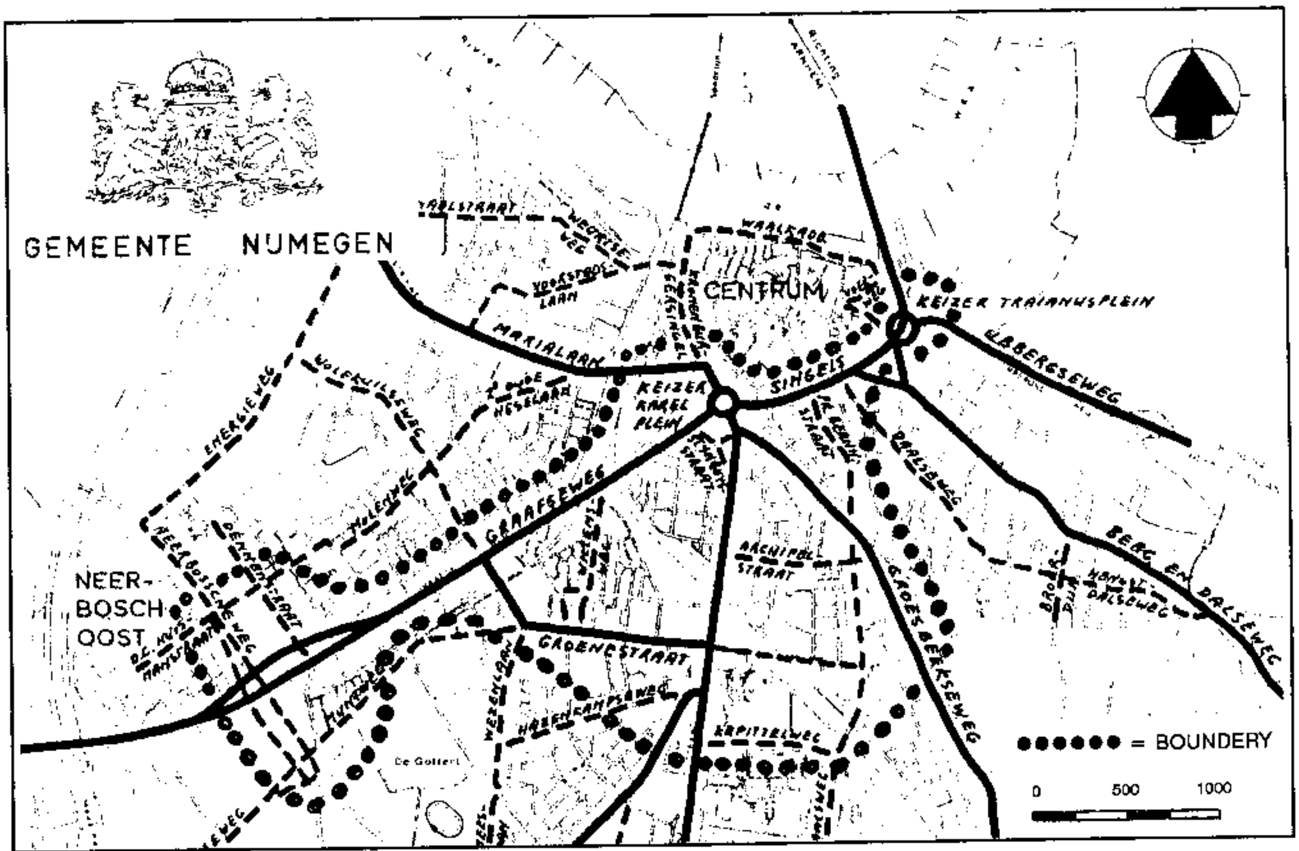


**Figure 1.** The area under SCOOT-control in Nijmegen

and its necessary facilities, the location of the detectors, all necessary cableworks, placement of the OTU's, all necessary UTC- and SCOOT-software, documentation of the system and the software, training, etc.

In the first months of 1991, four suppliers of traffic controllers, active on the Dutch market were invited to compete for this specification. At that moment in time all suppliers were already negotiating with British suppliers. Criteria for selection were the potential of a specific system to demonstrate the possible positive effects and the ability for the local traffic engineers to become familiar with the system. According to the normal procedures, the job was awarded to ASCOM-HASLER, in cooperation with GEC.

## IMPLEMENTATION

For several reasons parts of the work to be done, were not included in the specification. Because the controllers of different suppliers had to be connected with the SCOOT-system, the interfacing between SCOOT and the controllers was carried out by the supplier of the local controller. Also, the replacement of the controllers was done separately, according to the local procedures of the city of Nijmegen.

The work on (re)programming the existing controllers to respond to the SCOOT-system was carried out by the city of Nijmegen and the consultant. Work on the initial Database, validation and fine-tuning of the system was carried out by the consultant.

According to the initial schedule, the hard- and software should be delivered in August 1992, while the validation had to result in an operational SCOOT-system in November 1992. The hard- and software was completed almost in time, but the validation work was delayed. There were several reasons for that, but the main reason was that the amount of work involved in fine-tuning was underestimated. Most effort had to be put in solving relatively few complex traffic situations, specific for the situation in Nijmegen.

Another reason for the delay was the roving terminal. It causes some difficulty, due to the quality of the cellulair phone network in The Netherlands. At several sites it prevents detailed comparison of the SCOOT model with traffic behaviour on street.

The Transport Research Laboratory (TRL) was invited to help with fine tuning the system and to ensure that SCOOT was implemented and operated in a good way (3). Finally, all the efforts resulted in an operational SCOOT-system from 15 october 1993 until now on.

### Some overall characteristics

The SCOOT-network of Nijmegen is divided into four regions. Region 1 is the biggest and the most complex region with 29 intersections. This region contains all the main roads of Nijmegen connecting to the roundabout Keizer Karelplein. The regions 2, 3 and 4 are smaller, relatively simple in control strategy and contain respectively 5, 4 and 3 intersections.

In region 1, SCOOT operates within a cycletime range from a minimum of 72 to a maximum of 88 seconds. The minimum is defined by the most complex four stage intersections in the region. Longer cycletimes are not permitted for politcal reasons. In the other regions, the cycletime may vary from 48 to 80 seconds.

The sequence of stages on the intersections in the SCOOT-network is the same as it is under fixed-time control. This stage sequences have proven to be adequate for fixed time coordinated control under different circumstances. Where demand dependency exists, the local controllers are programmed to recognize these demand dependent windows, and to react in the way SCOOT expects: they switch to the demand dependent stage when there is a demand, and otherwise stay or switch to the next stage.

There are several intersections in the Nijmegen network with exclusive control for all traffic movements. These intersections have a four-stage logic. Validation caused some extra difficulties. Left-turning traffic also uses the detector for straight ahead traffic. A correction of the saturation occupancy was needed. Also the validation of the stages for filter links was critical. As these stages are controlled by the filter logic, an increase of left turning traffic only gives a longer green-phase in the next cycle. On intersections with a short left-turn lane this leads to the possibility that left turning traffic blocks the link straight ahead.

Another complication was that the speed of left turning traffic varies more: some drivers are considerably slower than the average, which leads to an appreciable amount of green time being wasted. By using a "safe" journey time (below the average) and by carefully choosing the link start and end lag, the time window during which SCOOT looks at a detector to determine filter demand, was altered in order to control the filter links in a satisfactory way.

**Keizer Karelplein**

The Keizer Karelplein is the pivot on which everything hinges. The roundabout has six entries from which five are signalled. Traffic on the roundabout has to give way to traffic entering the roundabout.

It has not been possible to install SCOOT-detector loops such that normal SCOOT-control could be provided, so there is no direct information about the circulating traffic. Traffic leaving the roundabout is measured on the detectors on the exit links of the roundabout, using the filter-logic. The entry links to the roundabout have SCOOT-loops on the normal position: near the first intersection upstream.

After normal validation of the links entering and leaving the roundabout, we had to make some extra changes in the SCOOT-database to help SCOOT control the splits and offsets on this roundabout in a reasonable way.

**Split-control.** The volume of traffic leaving the roundabout (during stage 2 and 4), measured by a filter loop, has been used as an approximation for the circulating traffic. Traffic can also exit during stage 3, when traffic also enters the roundabout. To enable the split optimiser to optimise, the database has been set up in such a way that SCOOT gets the suggestion that traffic does not exit during stage 3. So an artificial conflict has been introduced between the entering and exiting traffic which results in less green for traffic entering the roundabout.

**Offset-control:** The offsets at the roundabout have to be carefully controlled for two reasons. The first reason concerns bicycles. Because of political priorities in Nijmegen, and because it is unsafe to change the bicycle signals to red as the main bicycle platoon is crossing or just approaching the stopline, a good bicycle progression is necessary. The second reason is vehicle progression. Without this there much chance of the roundabout locking up. Under fixed time control, good offsets had been chosen for both bicycles and vehicles. Under SCOOT control the offsets for bicycle stages are fixed and the same as the original offsets. The resulting vehicle offsets are acceptable within the normal range of stage lengths.

**Gating**

The network has two main entries. Originally a gating mechanism was already in operation. It controls the traffic volumes in such a way that the network doesn't get congested during peak hours. Under SCOOT-control, the gating mechanism of version 2.4 is used for this purpose.

A complication in the specification of the gating mechanism was the fact, that both gating sites are complex intersections that required two controllers to logically control one intersection. Alterations had to be made to the hard- and software of the local controllers. The implementation of the gating mechanism is described below.

Basically, the gating site is a two stage controlled intersection. The link entering the city (the gated link), is controlled in the same stage as the link exiting the city. Because this link may not be affected by the gating mechanism, this stage is divided into two stages. In addition, the third stage controls the side roads. In normal operation the second stage, controlling the exit link only, is always at its minimum. When the gating mechanism is in effect the length of this stage varies depending the length of the first stage.

In order to fine-tune the gating mechanism we had to experiment with the critical gating saturation of the bottleneck link. During these experimentations, the gating mechanism proved to be quit powerful. During peak hours, the green times on the link entering the city varies between 16 (the minimum), 20 or 24 seconds, within a 88 seconds cycle. In comparison, during off-peak hours de green phase of the gated link varies between 24 and 36 seconds, in a cycle of 88, 80 and sometimes of 72 seconds. The green phase of the bottleneck link is under gated circumstances highly saturated, so no green time is wasted and oversaturation occurs only when there are some very slow vehicles in the platoon.

**Bus priority**

Under fixed time control, there is a local bus priority facility at one intersection that forces the left turn stage for inbound buses, whenever the main road stage is running. Under SCOOT control the left turn stage is forced before and after the main road stage. This does not give as much priority to buses as the fixed time plan does. Because we do want the bus to have the same priority under SCOOT control, we will change the application in such a way that bus priority will be locally implemented in the controller. As the SCOOT system will not know that the bus stage is running, the saturation occupancy factors and the link start lag and end lag parameters will be adjusted accordingly.

At present, the feedback of the green bits to the SCOOT kernel is inhibited until the enhancement of the feedback logic where a demand dependent stage can occur within another stage, as we have been told by TRL.

**EXPERIENCE TO DATE**

The system is in operation since October 1993. In Nijmegen traffic management and control is the responsibility of the townplanning department. Two engineers are able to operate the system. The police department is responsible for the operational control. They have the opportunity to command the system, but in practise the townplanning department operates the system. The electricity department has the technical management of local controllers, cables, loops and OTU's in hand. ASCOM-HASLER does the maintenance of the central computer. Finally the fire-brigade may operate a button to force a green wave for a turn out.

There is no central control room in Nijmegen and all these people have different interests in the operation of the system. They feel that at present, compared with current PC-technology, the user interfaces are of a low level and not user-friendly.

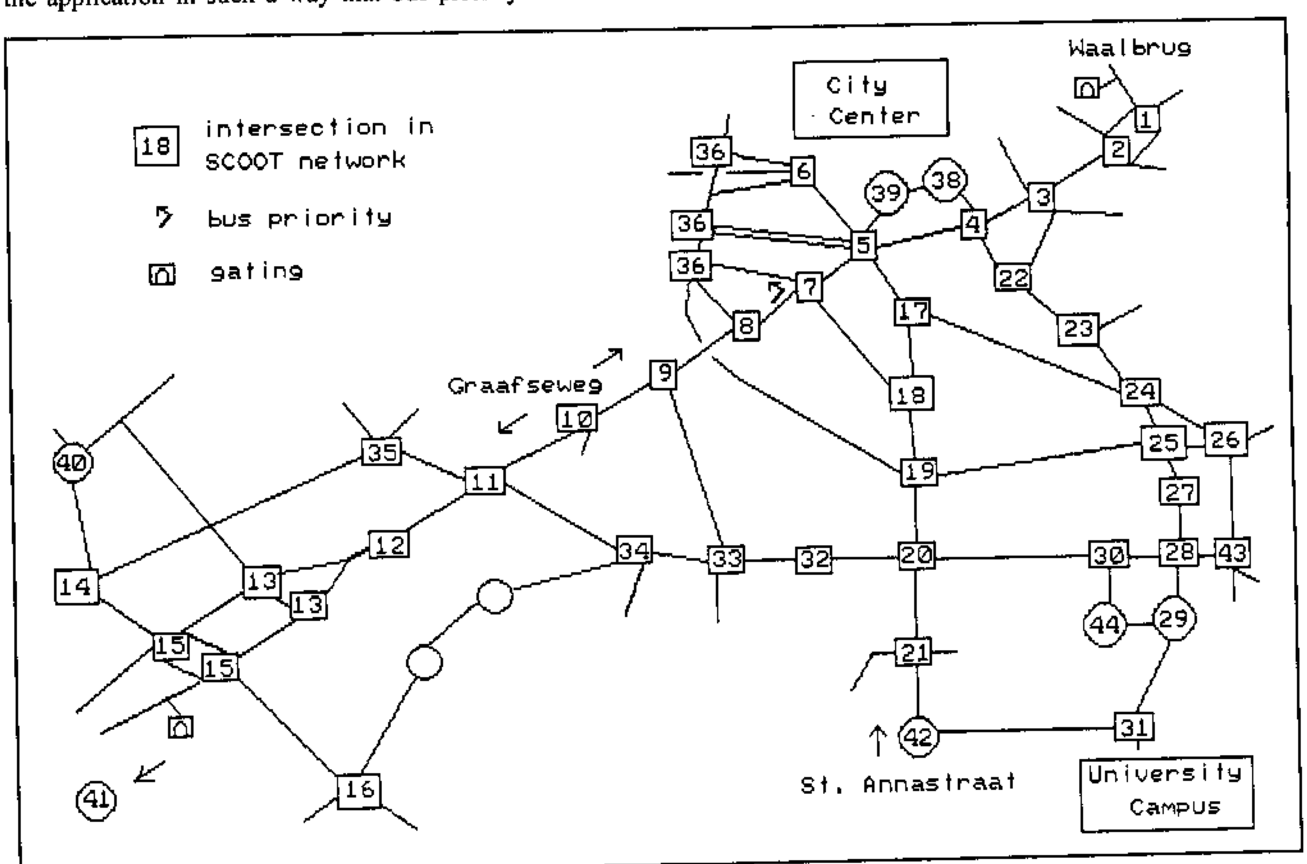


**Figure 2.**Schematic SCOOT network in Nijmegen

**Technical**

Failures are rare. The communication lines are in good condition and detectors are operating well. The interfaces with the existing controllers appear to be quite good.

**Non congested operation**

Since the SCOOT-system came in operation, it didn't require much attention which is good. There are no complaints from public transport and police. The gating appears to operate well. The system is able to deal with high traffic loads.

**Congested operation**

A subject of special attention is how to handle congestion under SCOOT-control. At present, we do not yet have enough experience in handling congestion with SCOOT to tell whether SCOOT is working properly under these circumstances.

We do know that the Nijmegen network is very sensitive to congestion: an unusual event on a link of one of the main roads, such as a vehicle breakdown, can cause serious problems and can result in a jam on the roundabout. To help to prevent congestion, the congestion importance factors on all links leaving the roundabout are set to the highest possible value. In addition, the congestion link facility is used to make filter links respond to congestion on its parallel straight ahead link. Also the maximum queue check inhibit has been set to on for all these links. This results in all congested intervals on these links to be treated as real congestion.

After consultation of TRL, we decided to install special loops on the roundabout to detect congestion and use their information as an extra safeguard against congestion on the roundabout. These loops require the programming of an algorithm in the local controllers on the roundabout. The resulting signal will be send to the SCOOT system, in order that it can take the actions needed to recover from the congestion by using the gating mechanism.

## EVALUATION

Parallel with the implementation phase the evaluation phase was started. In June 1992 an evaluation plan was completed (4). The plan describes a complete set of measurements to assess the system with respect to the effects on the traffic, but also with respect to the management and maintenance of the system.

The most important part of the evaluation consists of the measurement of journey times through the network, not only for passenger cars, but also for public transport. On strategic locations in the network (nine locations in both directions) observers will record the number of the license plates and time of passage of private cars and busses. From the City Centre to the University campus, there is a lot of bicycle traffic. On that route journey times for bicycles will be measured. This will be done by cycling the route several times per period. They will do that on thirteen days with the system operating under SCOOT-control and on thirteen days with the system operating under 'normal' control. In this way it is possible to calculate journey times for certain periods of the day and to compare SCOOT-control with 'normal' control.

With the help of so called SCOOT-messages the aspect delay will be analyzed. This applies to normal traffic as well as to bicycles and pedestrians that cross certain intersections. Other important aspects are the number of stops and the queue length. These aspects will be measured on eight locations in the network, including those locations where the gating mechanism will be active.

On the basis of travel times and number of stops a global analysis of the environmental effects, for both types of control, will be done.

Concerning the evaluation of the management and maintenance of the system, attention will be paid to the financial aspects of the system and also to the use of the system. This will be done by interviewing the persons involved with the management and maintenance of the system.

The measurements will take place in the first half of 1994. Results are expected to become available at the end of 1994. The results will be used for decisions on future possibilities for real-time traffic control in urban areas in The Netherlands.

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