AB
Storstockholms
Lokaltrafik

SES

In central Stockholm

by Sten Sedin, traffic engineer, Stockholm transport.

The TRUNK NETWORK FOR BUSES in central Stockholm

by Sten Sedin, traffic engineer, Stockholm transport.

During 1992 a political agreement was reached concerning the infrastructure in the Stockholm Region. The agreement consisted of three parts:

- New ringroads
- Improving the environment
- Investments in Public transport

A trunk network for buses in the innertown was one way to meet an increasing demand of accessibility. A sum of 400 Million SEK (~ 44 M EURO) was set aside for the Trunk network and 340 Mk (SEK) for new busses.

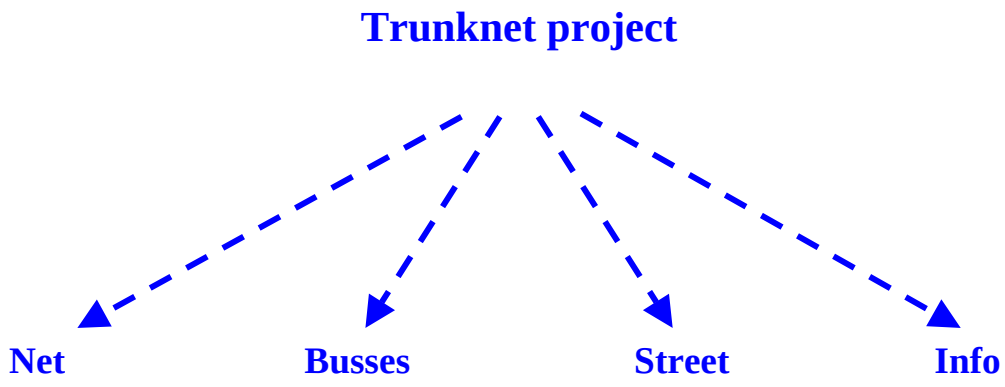
In order to reach a good average speed, the busses in the trunk network should be allocated reserved buslanes and buspriority at signal-controlled intersections. This should be possible by reducing cartraffic with 25% through a system of toll-stations where the drivers had to pay to get in to the innertown. A real-time informationsystem was also included in the agreement. The trunk network was to be regarded as the ” metro of the street” and new installations were to be designed to facilitate the future development of trolley bus or tram services. Local routes served by smaller busses with no special priority and short distances between bus stops also supplemented the trunk network.

- **Average speed should be improved from 13 to 18 km/h (incl. time at bus stops).**
- **Comfort and convenience should be improved**
- **The net should be easily understandable and orientated.**

Keywords: **Speed, comfort, convenience, clarity and stability**

How did we work?

The Public transport, AB Storstockholms Lokaltrafik, (SL) started four working groups in close contact with Stockholm town. We divided the work in four separate parts as shown below.

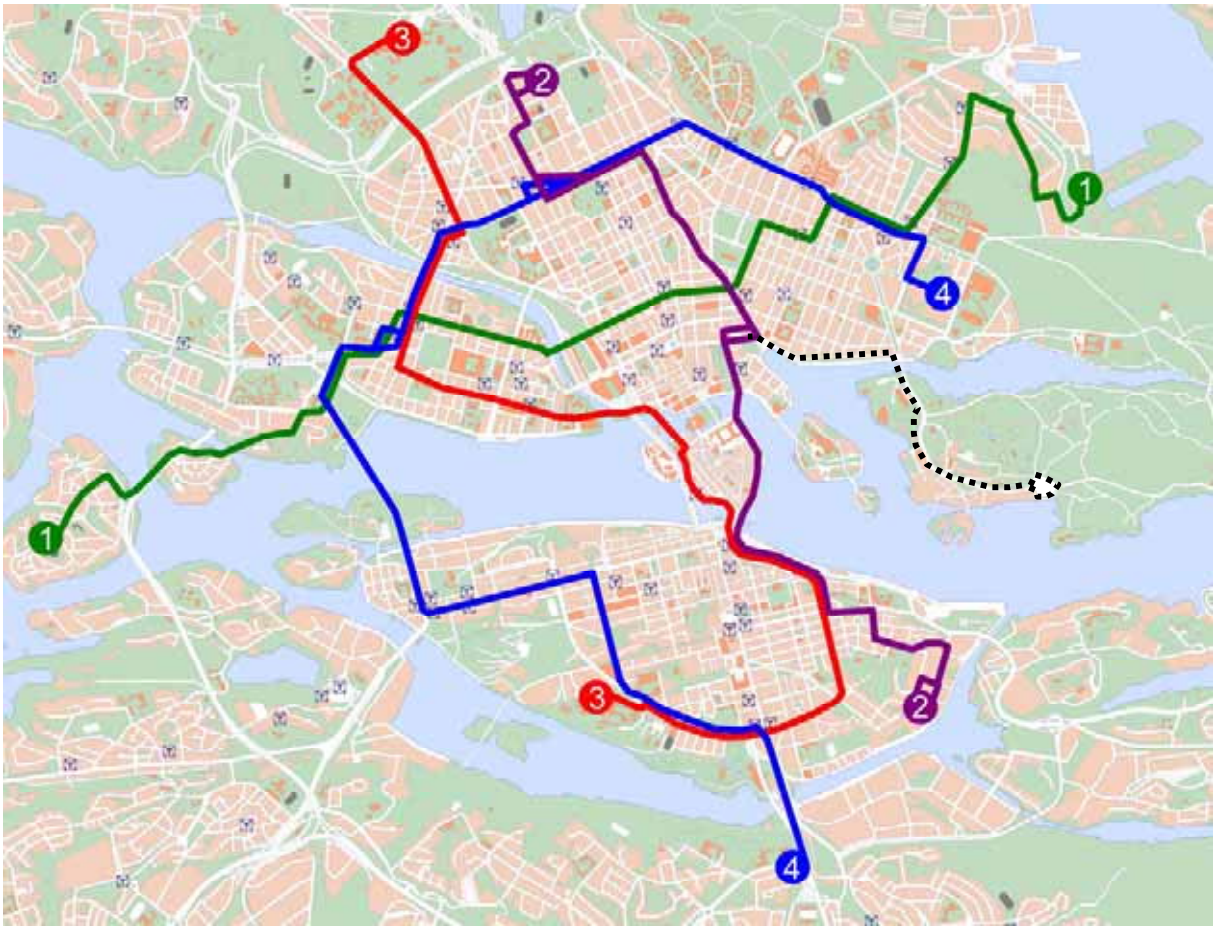


1. The Net

The Trunknet should work in close contact with the Metro and cover parts of the innertown where there is quite a distance to reach the metro. To make the net clear and visible there was certain demands:

- Only 5 bus lines with simple numbers 1 - 5.
- The busses should be orientated to drive on main routes.
- The busses were painted blue to make a difference compared to our other busses, which is red.
- Increasing the distance between bus stops to 400-500m.
- The regularity should be 5 min all day.
- Accepting passengers to get on/off the bus in all doors and thereby reducing stopping time at bus stops.
- Local routes served by smaller buses with no special priority and short distances between bus stops should supplement the Trunknet.

The net was designed to complement the metro and cover areas without any metrostation.



The Trunknet system was originally consisting of five lines. Line nr. 4 was started in –98, Line nr. 1 and 3 in –99 and Line nr. 2 is going to start in June –04. There will probably not be any Line nr. 5 due to the fact that we can't get a good accessibility. Today a light rail tram is operating a part of this line (black dotted line above).

Line 1. A line that is passing the City centre. The length of the route is 21 km (11 + 10). There are 3,5 km buslanes, 35 traffic signals and 65 bus stops along the route. The amount of travellers before starting Line 1 in –92 was about 25.000/day.

Line 2. Is going to be started in June –04 and is about 16 km long (8+8), has 36 traffic signals, 40 bus stops and 6,3 km buslanes. The amount of travellers today is about 25.500/day.

Line 3. A line that is going from one big hospital to another partly passing the City centre. The length of the route is 19,3 km (9,6 + 9,7). There are 6,3 km buslanes, 44 traffic signals and 50 bus stops along the route. The amount of travellers before starting the Line in –92 was about 26.000/day.

Line 4 A sort of a circle line going around the City centre. The length of the route is 23,4 km (11,7 + 11,7). There is 8-km buslanes, 63 traffic signals and 60 bus stops along the route. The amount of travellers before starting the Line in –92 was about 32.000/day.

Line 5 is, as we see it now, not going to be started due to the fact that we can't get a good accessibility in some of the streets.

The changing figures after the Trunknet lines started is presented in the result part in this article.

Keyword Clarity

In order to make the net visible the idea was to mark the lanes and also paint the line number. You should easily find the net and even understand the line nr. just to have a look on the street.

(The busses were actually painted blue).

2. Busses The demands for the new Trunknet busses were:

- Best possible environment bus. In our case no diesel, but ethanol busses.
- Articulated busses, 18m long so that a lot of passengers could travel more comfortably. The Trunknet bus has room for 110 persons compared to our ordinary 12m long ones, which holds 70.
- Low floor bus to make entrance and alighting easier
- Acceptance to step in to the bus in all doors in order to reduce time at bus stops. So far SL only has accepted entrance through the front door.
- Blue painted to increase clarity
- Easy remembered linenumber 1 – 5.
- Automatic announcements of next stop and place to change via loudspeaker and digital sign in the ceiling.

All the busses were equipped with busscomputor, dataradio and DGPS –antenna to be able to fulfil the requirements.

The articulated bus SL bought was a Scania ethanol. Today we have 73 busses in the Trunknet. We also have ordered 28 new busses for line number 2. These busses will not be Scania but Volvo and MAN driven by biologic gas (methanol).

Behind the blue trunk net bus you can see an ordinary red bus

3. Measures in the street – the demands were:

- Improved speed from 13 to 18 km/h (incl. bus-stop time)
- Comfortably ride for the passengers
- Easy to find the Trunknet
- Short-changing distances between subway and other bus lines.
- Traffic safety.

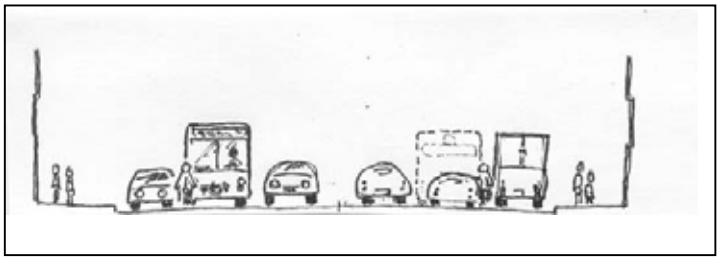
In order to fulfil the requirements we worked with the following measures:

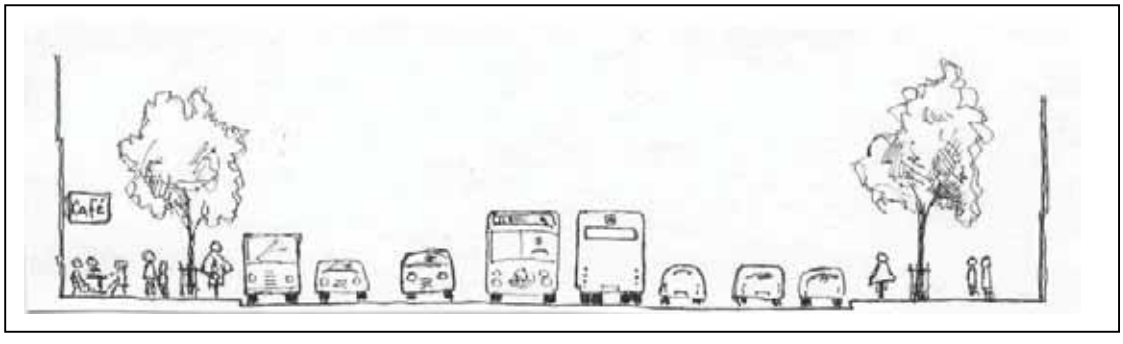
- **Bus lanes**

One of the most important measures to improve speed

Stockholm has no wide streets. They are between 18 up to 30 m. this causes problem when you try to introduce a bus lane. There are a lot of other wishes upon a street. For ex. Trees, cafés, bicycle lanes, cartraffic lanes, loading place and so on. If you could satisfy all the needs the street would have to be about 42m wide. So there is really a battle of the streets going on.

Our 24m street compared to a 42m street





- **Buspriority in traffic signals**

Together with bus lanes, buspriority signals are vital for bus accessibility.

Totally there is about 140 traffic signals in the Trunk net.

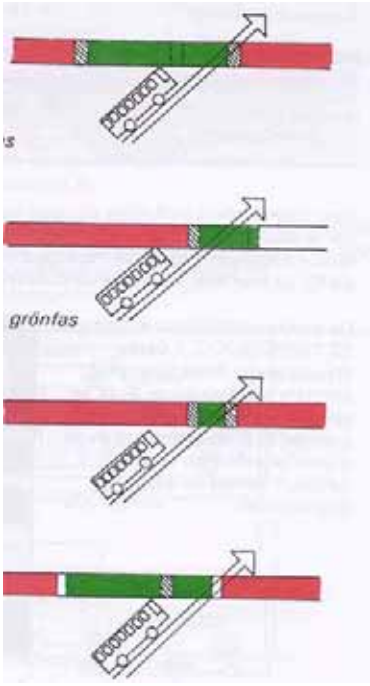
Today we have about 70 modern buspriority traffic signals along the three lines we started.

We use dataradiocommunication to reach the signals and it is the same equipment we use in the information system. The reason for using dataradiocommunication instead of ordinary loops is costs and reliability.

The cost of bus a priority in an intersection in Stockholm where busses will arrive from four different directions is about 1 M SEK. With dataradio you can cut this down to half. This is because you don't have to dig for placing the loops in the streets. We also could notice that a lot of our earlier loops was out of order because all the digging in the streets that is always happening in Stockholm.

We use four different strategies in the signal steering to get bus priority.

1. Prolonging the current green phase.
2. Place the ordinary green phase earlier.
3. Extra green phase.
4. Go back to green shortly after normal green phase.



As you can see we also show if a bus is detected with a little bus detector lamp. The distance from detector point to traffic signal should be at least 250 m

The green and blue dots mark a buspriority-signal.

The black ones were not done yet in 2000 which is the date of the map.

- **Other measures**

Bus-stops

We try to build the bus stop so that the pavement is extended. This gives us a lot of advantages:

- The bus can draw up at the kerb without having to make awkward manoeuvres.
- Waiting passengers have plenty of room.
- Motorist will not so easily park at the bus stop and obstruct the bus.
- There will be room enough for a rain shelter.
- Passengers will have an easier alighting since the bus doesn't have to make a turn in to the kerbstone.

As shown in the picture there is also tactile concrete paving stones for the disables. The roadway in the bus stop is made of red concrete to clearly show that this is a Trunknet bus stop and also to bear the weight of the articulated bus axles, which can be higher than the normal bus. There is a regulation in Stockholm inner town of 10 tons max and the Trunknet bus will sometimes exceed this limit so we had to have a special permit to drive these busses.

4. The Information system

In the traffic agreement was also an information system. We started out testing such a system in –92 and after procurement the German Company INIT in Karlsruhe got the contract to provide the system in Dec -95. The Contract was for the first part was 21,3 M SEK and had a lot of options for coming needs.

The first stage completed in –98 were:

- 85 buses with information systems
- 30 bus priority signal intersections
- 60 equipped bus-stops

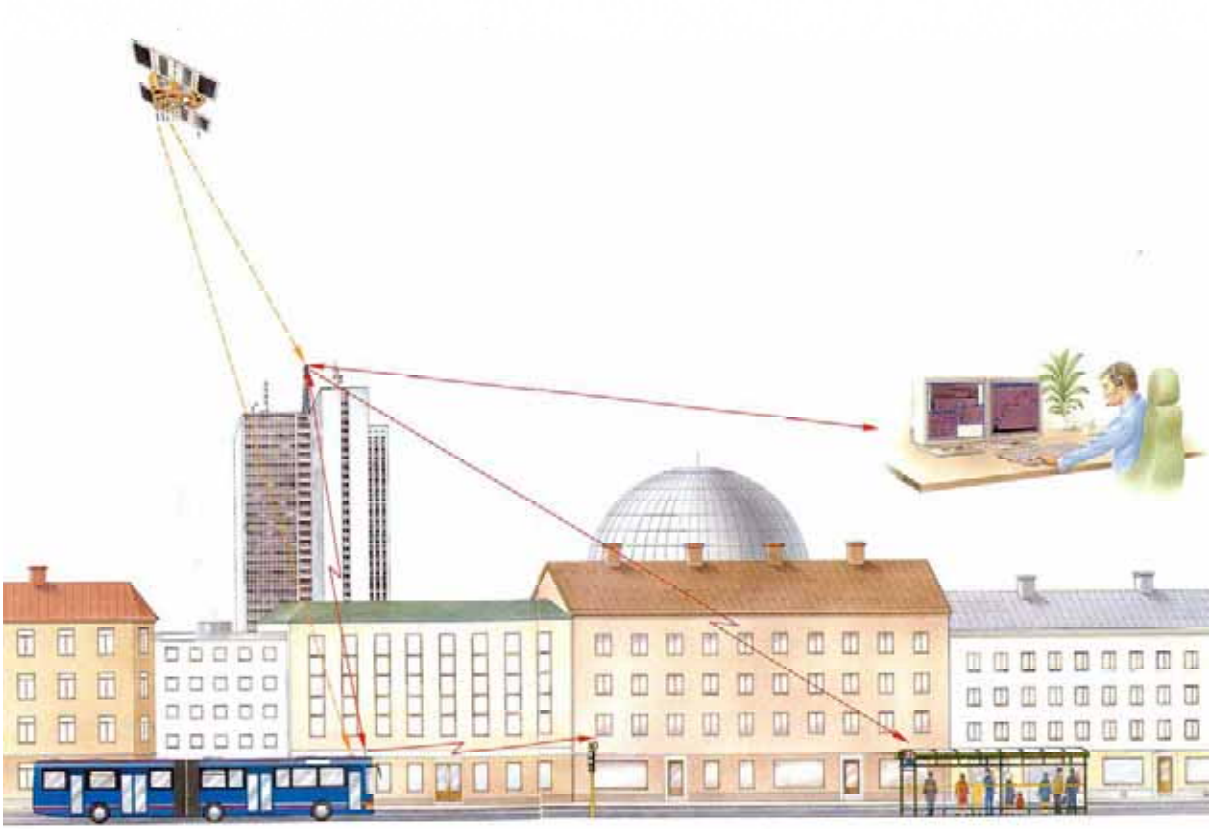
Later stages:

115 buses with information systems

110 bus priority signal intersections

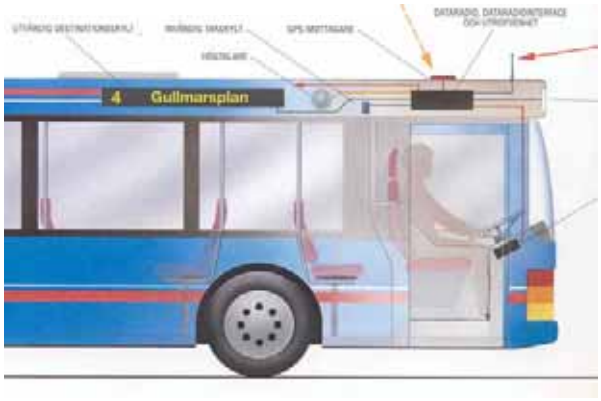
140 equipped bus-stops

The positioning of the buses is done via DGPS. The bus communicates with a central computer, a radiobase –station, signal crossings, bus stops and the traffic- depot. The traffic planner at the depot can see in real-time on his screen where all the buses are. The database is calculating the arrival at each bus stop and this information is shown as ”min till the bus will arrive”. The bus communicates directly with each signal intersection via the bus dataradio.

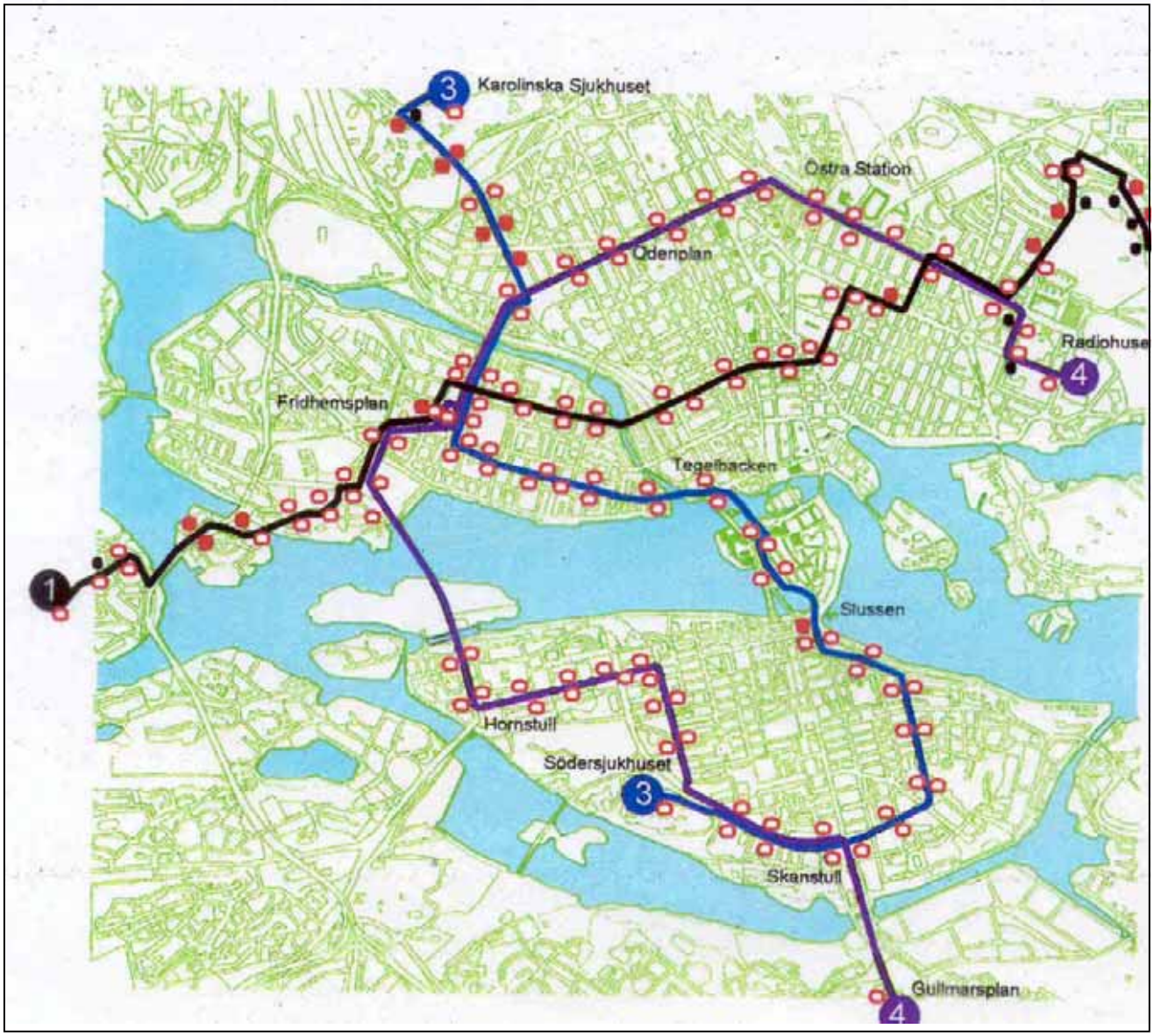


In the bus the system consist of:

- Bus computer
- Dataradio
- GPS antenna
- Automatic digital sign in the ceiling
- Automatic speech system
- Connections to the odometer, destination signs



The bus stops are equipped with digital signs in the rain shelters or at poles.



The fig shows the equipped bus stops year 2000 (red ring).

RESULTS

In may 2000 we made an investigation whether we had reached the aims that put up for the Trunk net.

- **Average speed should be improved from 13 to 18 km/h (incl. time at bus stops).**
- **Comfort and convenience should be improved**
- **The net should be easily understandable and orientated.**

The Keywords were: **Speed, comfort, convenience, clarity and stability**

Accessibility, bunching and speed

One of the most important conditions which should give room for the Trunk Net was that the car traffic should be reduced by 25% by ring roads and car-toll stations. This has not been realised. The car traffic has instead increased from 541.000 to 570.000 cars/day in the inner town. As a consequence we have not been permitted to build out our buslanes were we need them, because that would effect the car traffic to much, and therefore we have not reached our target concerning speed and accessibility for the buses. Today we have about the same speed as when we started about 15 km/h in peak ours. This has also effected the bunching which maybe is a bigger problem than speed. It is important that the buses arrive with about the same time space between them. When buses bunch You will get long periods with no buses coming and then suddenly two or three. This is partly caused by the bad accessibility. Perhaps the forthcoming test of a car tolls system that Stockholm now is planning will give us better possibilities to raise our accessibility.

In the figures below You can compare the situation before (-92) and after (-99) for each line. Red colour is a speed under 15km/h; Yellow between 15 – 18 km/h and the green one is over 18 km/h

Linje 1

1992

Linje 1

1999

Linje 3

1992

Linje 3

1999

Linje 4

1992

Linje 4

1999

Bus-stop time
When we started the project we had the idea that the passengers should be permitted to enter the bus in all doors. This has not been realised because SL sales department was afraid that we would get a lot of ”free” riders. Therefore we have not been able to reduce the bus-stop time as we planned. Due to the fact that the new buses doors is a little wider and it’s a low-floor bus, the entrance is quite easy and therefore the bus –stop time has not been extended.

Passengers
In spite of the lack of an improved speed the results of the amount of travellers has been promising as you can see in the table below.

Passenger entrance/day	1992	1999
Line 1	24.700	36.000
Line 3	26.300	37.600
Line 4	32.300	63.600

Clarity and understandable
The idea of a special painting with markings along the net to show the lines was not accepted by the town planning architects. The only thing that we were allowed to mark was the red colour in the pavement at the bus stops. The blue colour of the Trunknet-buses and the simple line-numbers were however measures that contributed to better clarity. The information system and the special bus stops also made the net easier to find and understand.

Comfort and convenience
In order to know how our passengers felt about the Trunknet system we made an investigation on one of the lines (line 4). The results are shown below.

Questions, *what Do You think about the:*	**Satisfied %**	**Not satisfied %**
The automatic digital ceiling sign which shows next stop	93	2
The route	93	2
The automatic speech of next bus-stop in the bus	90	4
The bus in general	88	2
Easy to find the bus-stops	87	1
The frequency	86	5
Articulated bus instead of the usual one	85	6
The automatic digital signs which shows ”min” till the next bus will arrive at the bus-stop	79	11
The cleaning of the buses	77	6
The equipment of the bus	77	9
The comfort	75	11
The temperature and ventilation	70	9
The accessibility	65	9
The drivers way of handling the bus	62	5
Was there a seat free for You	39	19

Comment: The new Trunknet-buses we now order have AC.

We also asked the following questions:

Has the Trunknet-bus replaced another way of travelling?

- Often 37%
- Sometimes 35%
- Seldom/never 28%

What kind of transportation has the Trunknet-bus replaced?

- Another bus 39%
- Metro 56%
- Car 5%

Has your travelling time changed?

- Increased 15%
- No changes 45%
- Reduced 40%

As a result you can state that the majority of our passengers are satisfied with the Trunknet and the bus in spite of the bad accessibility.

Costs

The traffic agreement broke down 1998 owing to the fact that there was a political disagreement. The town and SL then decided to carry on and share the costs 50% each. Up to the year 2003/-04 we have together spent 302 M SEK.

Besides SL has bought 73 Trunknet-buses at a sum of 177,5 M SEK.
Street measures + buses up till now is = 480 M SEK

Summary

Accessibility	**The target was not achieved**
Comfort and quality	**The target was achieved**
Clarity and understandable	**The target was achieved**