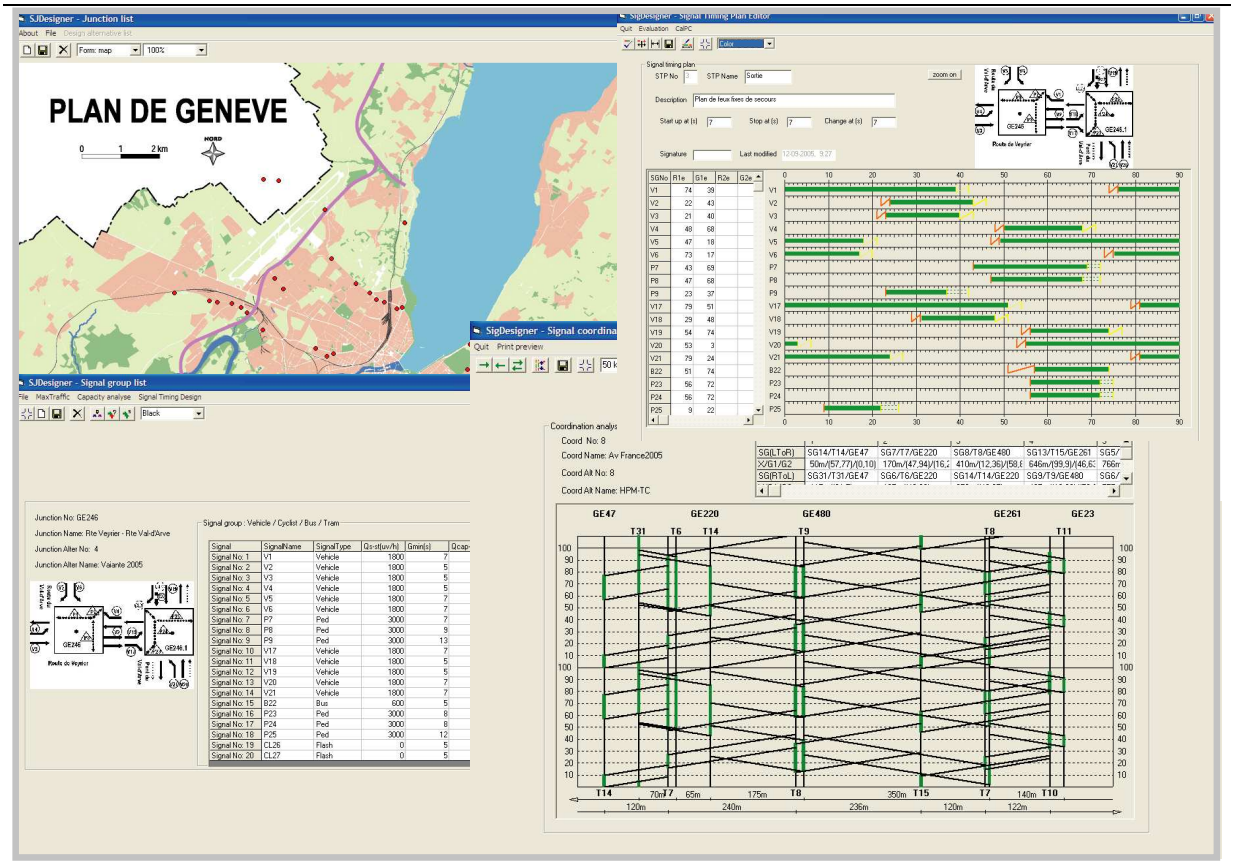

SJDesigner: A powerful tool for signalised junction design

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Abstract

Signalised junction design takes a very important role in the intelligent traffic control and management. A signalised junction design usually consists of junction geometry design and its detail signal design. The objective of a signalised junction design is to find an optimum design alternative that fits best with the well defined traffic control objects. For a signalised junction, many junction geometry design alternatives may be developed. For each junction geometry design alternative, there are also many signal design alternatives. Therefore, there exists a lots of signalised junction design alternatives for a given signalised junction. In order to find an optimal signalised junction alternative surely and correctly, a computer tool is very necessary. Based on author's more than ten years experiences in real projects and studies on signalised junction design and signal design, a useful tool for signalised junction geometry design and its signal design, named as SJDesigner (Signalised Junction Designer) is developed. It can be used in a signalised Junction geometry design, a junction signal design and signal coordination design of different signalised junctions. This software is project-management oriented software. The main printable results are: (1) capacity analyse results of the junction geometry design, (2) the definition of all signals and inter-green matrix of signals, (3) signal timing plans and their evaluations and (4) time-space-diagrams of signal coordination. All the printable results are well organised and can be directly included in the technique report of the project. SJDesigner may also export a junction design and its signal design data to a file witch can be read as a basic data for the junction traffic controller ITSignal. Some further developments are suggested.

Keywords

Signalised junction design – Junction geometry design – Junction signal design –Signal coordination –Intelligent traffic control –Signalised junction capacity

1. Introduction

Signalised junction design takes a very important role in the intelligent traffic control and management. A signalised junction design usually consists of junction geometry design and its detail signal design. The objective of signalised junction design is to find an optimum design alternative that fits best with the well defined traffic control objects.

Signalised junction design process is shown in figure 1. Based on the junction geometry plan, traffic data and well defined traffic control objects and constrains, different junction design alternatives may be developed (1 and 2). Each junction design alternative consists of a junction geometry plan with a clear lane utilisation's definition (go to / come from), signal definition, the definition of conflict matrix between signals and basic control strategies. Each junction design alternative should be evaluated and evaluation results should be compared with the traffic control objects (3). If the evaluation results show the junction design alternative does not match with the traffic control objects, the alternative may be rejected or modified (2). If the evaluation results show the junction design alternative fit the traffic control objects, the alternative then can be accepted. Its detail signal design can be done and different signal design alternatives may be developed (4).

A junction signal design alternative usually consists of a matrix of inter-green, detail control strategies and one or more (fixed time and / or actuated) signal timing plans or actuated signal operation logics (with or without taking account of signal coordination with adjacent signalised junctions). Each signal design alternative should be evaluated and evaluation results should be compared with the traffic control objects (5). If the evaluation results show the signal design alternative does not fit with the traffic control objects, the signal design alternative may be rejected or modified (6). If there is no signal design alternative that can fit with the traffic control objects, then this junction design alternative should be rejected or modified (2).

If the traffic control objects include an intention of signal coordination with adjacent junctions, the signal coordination design should be made. By applying the signal timing plans obtained in the signal design of all the coordinated junctions (7), the time – distance diagrams may be produced and signal coordination may be evaluated. The evaluation results should be compared with traffic control objects (8). If signal coordination results don't fit the traffic control objects, the signal design alternative may be rejected or modified (6). If there is no signal design alternative that can fit the traffic control objects, then this junction design alternative should be rejected or modified (2).

The recommended signalised junction alternatives should be the junction design alternatives and their detailed signal design alternatives those fit well with the traffic control objects.

For a signalised junction, many junction design alternatives may be developed. For each junction design alternative, many signal design alternatives may also be developed. Therefore, there exists a lots of signalised junction design alternatives for a given signalised junction. As a signalised junction design result not only depends on the signal design but also depends on the junction geometry design, so a good combination of a junction geometry design and its signal design may give the best result. In the practice, often several iterations are needed to propose the final recommended signalised junction design.

In order to find an optimal signalised junction alternative quickly and accurately, a computer tool is very necessary. Based on author's more than ten years experiences in real projects and studies on signalised junction design and signal design, a useful tool for signalised junction geometry design and its signal design, named as SJDesigner (**S**ignalised **J**unction **Designer**) is developed. This software is project-management oriented software. It can be used in a signalised junction design geometry design, a junction signal design and signal coordination design. As shown in figure 2, when SJDesigner is stared, user can do signalised junction design or signal coordination design.

If the signalised junction design menu is selected, the database of existing designed signalised junctions will be selected and the signalised junctions in the database can be shown in a city map or in a list. An existing signalised junction can be selected, by click it in the city map or in the junction list. A new signalised junction can also be created if the signalised junction to be studied is not in the database. A double-click on the existing junction, the list of the junction design alternatives will be shown. Modification on existing design alternatives or creation of a new design alternative may be done.

If the signal coordination design menu is selected, the database of existing signal coordination designs will be selected and all the signal coordination in the database can be shown in a list. Existing signal coordination can be selected by click it in the coordination list. New signal coordination can also be created if the signal coordination to be studied is not in the database. By double-clinking a signal coordination design, the list of its signal coordination alternatives will be shown. Modification on existing signal coordination alternatives or creation of a new signal coordination alternative may be done.

Figure 1 Signalised junction design process

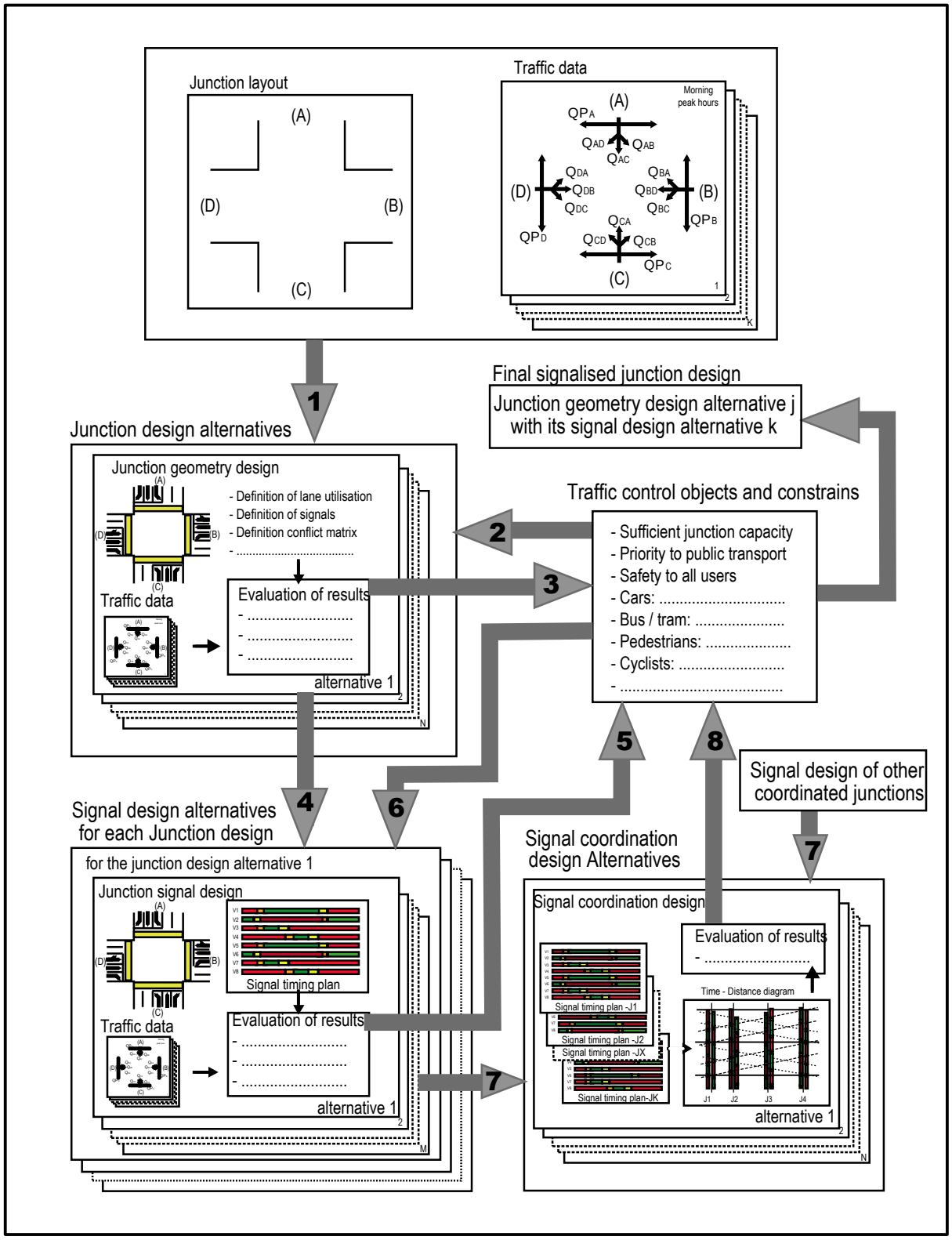
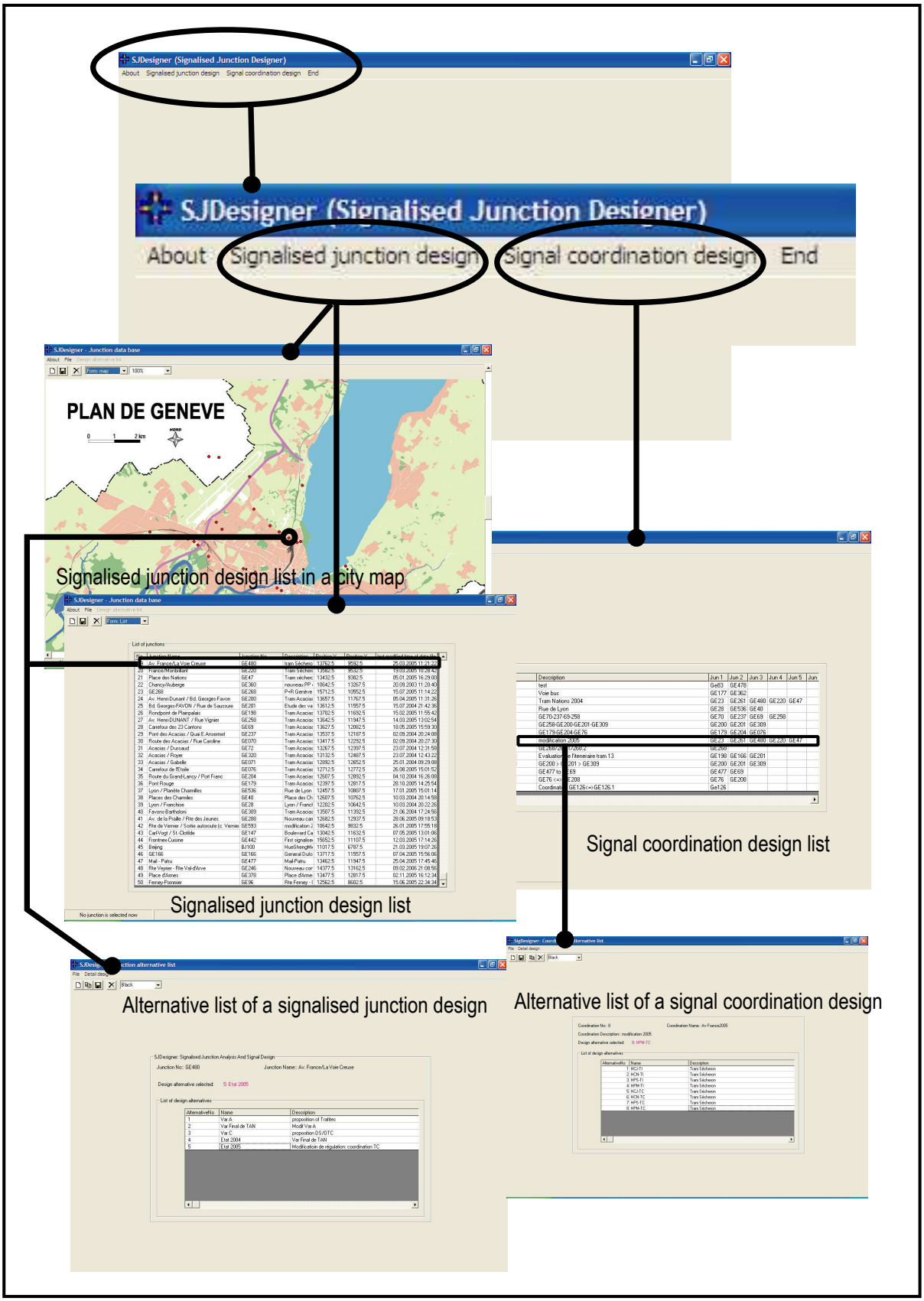


Figure 2 SJDesigner: Signalised junction design and signal coordination design



2. Junction geometry design

Junction geometry design is quite important in the signalised junction design as junction capacity is only determined in the junction geometry design. If the CU (capacity used in %) of a junction design for the design traffic data is less than 100%, then there exist a signal timing design so that all signals have enough greens and all the traffic arriving at junction should pass the junction in the same cycle (hypotheses: conflict signals respecting the mean intergreen and traffic for each signal arrives at junction uniformly). On the contrary, If the CU (capacity used in %) of a junction design for the design traffic data is higher than 100%, i.e. junction is saturated, there is no signal design alternative who can distribute enough green for all signals (same hypotheses as above). Signal design can only have influence on the distribution of green length and green start point for each signal.

SJDesigner is a quite useful tool to develop and evaluate junction design alternatives.

Each junction may have up to 15 design alternatives. Each junction geometry design alternative consists of

- a junction geometry plan with a clear lane utilisation's definition (go to / come from)
- signal definition
- definition of conflict matrix (or inter-green matrix) between signals
- traffic flow data for junction design purpose.
- some basic control strategies

Each junction design may have up to 32 signals and 10 sets of traffic data.

A signalised junction design alternative may be developed as shown in figure 3. Where the junction layout editor is used to import the junction layout (based on junction lane utilisation plan). The signal group editor is used to define signals. The conflict matrix editor is used to define if any two signals are conflict or not and the mean inter-green of conflict signals. The traffic data editor is used to input traffic volume for each signal.

The junction design alternative can be analysed by the Junction design analyser as shown in figure 4. By applying different designing traffic flow data (such as morning / evening peak hours traffic data) and assumptions on cycle length, mean inter-green as well as minimum green length of each signal, SJDesigner can give following main useful results:

(1) Key traffic movements which determine the junction capacity for a given traffic design data[2],

(2) Junction capacity used in percentage without taking account of exit capacity limit[1],

(3) Junction capacity used in percentage with taking account of exit capacity limit[2],

(4) Benefits if intelligent signals control is used for certain traffic movements[2],

(5) Priority performance index for transit (bus or tram) movements[1],

(6) Estimated green length (critical movement green, free green and shared green) of each signal and the capacity used in percentage for each signals.

If junction consists of sub-junctions, the results ((1) to (4)) for each sub-junction will be obtained.

Figure 3 development of a junction geometry design alternative

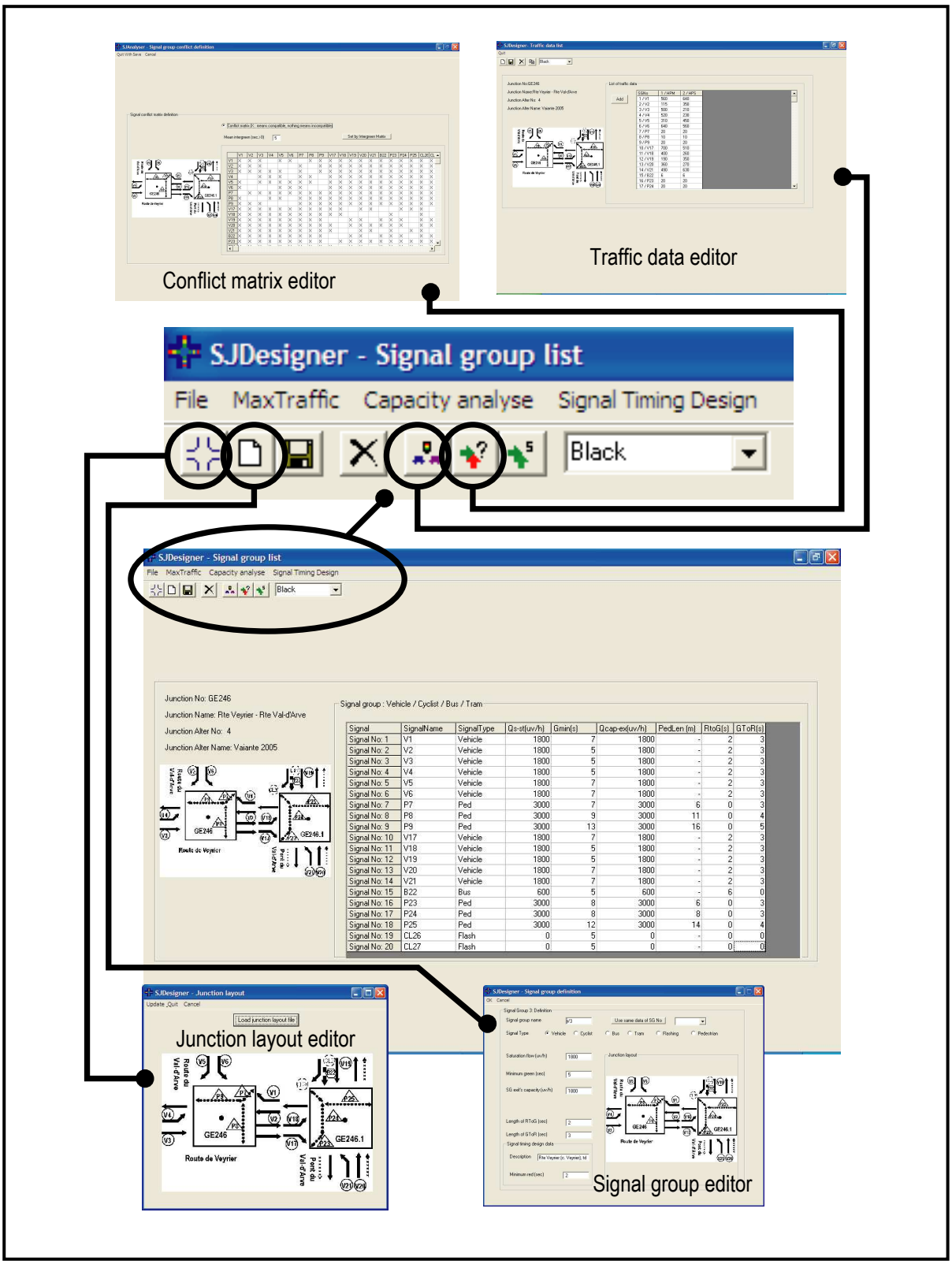
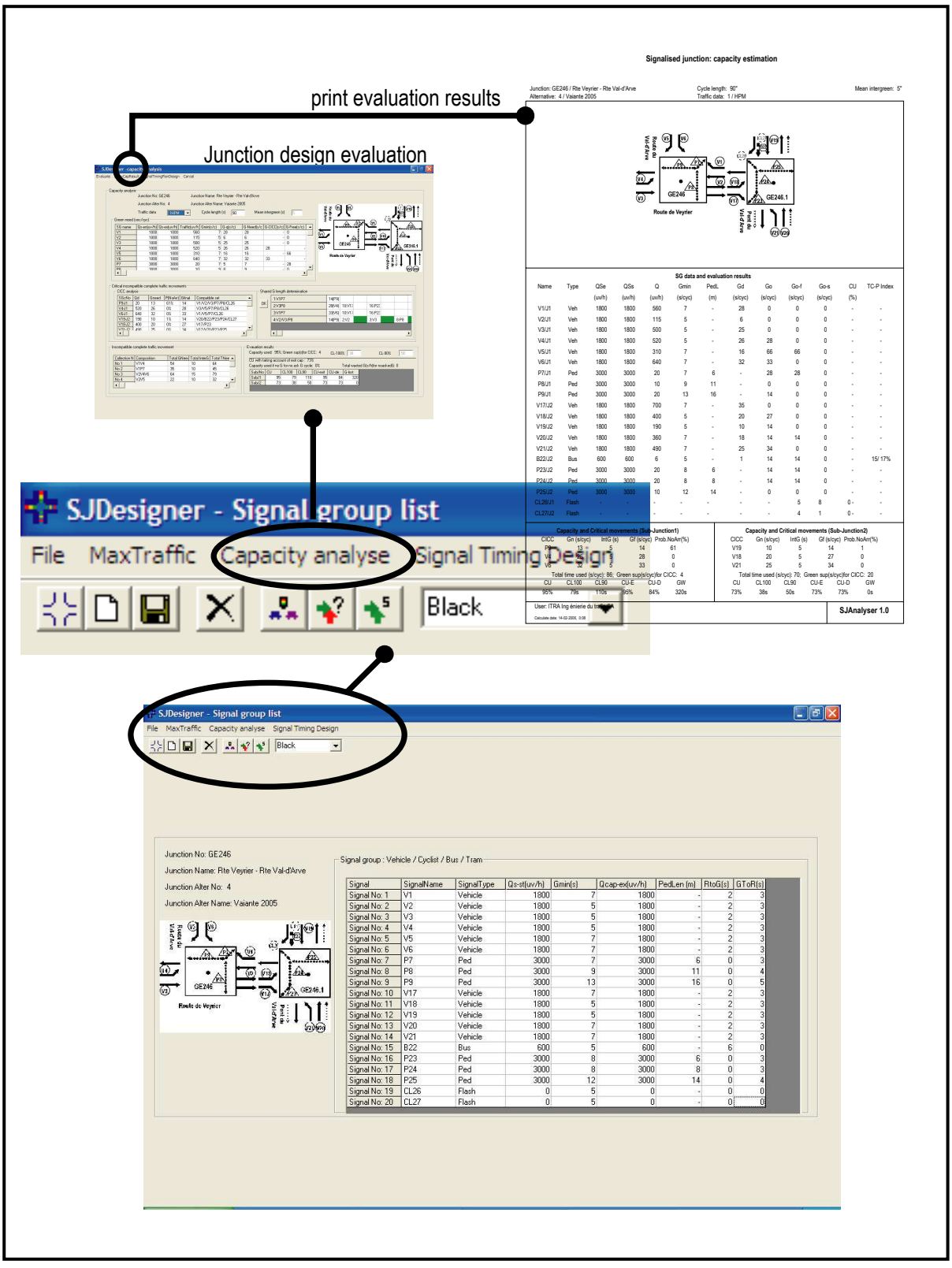


Figure 4 Evaluation of a junction geometry design alternative



Signal	SignalName	SignalType	Qs-st(uv/h)	Gmin(s)	Qcap-ex(uv/h)	PedLen (m)	RtoG(s)	GToR(s)
Signal No: 1	V1	Vehicle	1800	7	1800	-	2	3
Signal No: 2	V2	Vehicle	1800	5	1800	-	2	3
Signal No: 3	V3	Vehicle	1800	5	1800	-	2	3
Signal No: 4	V4	Vehicle	1800	5	1800	-	2	3
Signal No: 5	V5	Vehicle	1800	7	1800	-	2	3
Signal No: 6	V6	Vehicle	1800	7	1800	-	2	3
Signal No: 7	P7	Ped	3000	7	3000	6	0	3
Signal No: 8	P8	Ped	3000	9	3000	11	0	4
Signal No: 9	P9	Ped	3000	13	3000	16	0	5
Signal No: 10	V17	Vehicle	1800	7	1800	-	2	3
Signal No: 11	V18	Vehicle	1800	5	1800	-	2	3
Signal No: 12	V19	Vehicle	1800	5	1800	-	2	3
Signal No: 13	V20	Vehicle	1800	7	1800	-	2	3
Signal No: 14	V21	Vehicle	1800	7	1800	-	2	3
Signal No: 15	B22	Bus	600	5	600	-	6	0
Signal No: 16	P23	Ped	3000	8	3000	6	0	3
Signal No: 17	P24	Ped	3000	8	3000	8	0	3
Signal No: 18	P25	Ped	3000	12	3000	14	0	4
Signal No: 19	CL26	Flash	0	5	0	-	0	0
Signal No: 20	CL27	Flash	0	5	0	-	0	0

3. Junction signal design

Junction signal design is mainly to determine the green start point, end point and conditions to open / to close for each signal with respecting the inter-green of conflict signals.

For a given junction geometry design alternative, its signal design alternatives may be developed as shown in figure 5. Firstly, a matrix of inter-green used for all signal design alternatives should be calculated and the calculated results can be inputted by the Intergreen Editor. Each junction signal design alternative consists of control strategies and one (fixed time and / or actuated) signal timing plan or actuated signal operation logics (with or without taking account of signal coordination with adjacent signalised junctions).

There are three methods to produce a signal timing plan:

-Create a part of signal timing plan based on the key movements (by the Junction design analyser). Then use signal timing plan editor to complete the signal timing plan.

-Input green intervals for each signals by signal timing plan editor

-Copy an existing signal timing plan and modify it by the signal timing plan editor

The signal timing plan editor has following functions:

-Check error about conflict with inter-green matrix and minimum green length,

-Displace entire signal timing plan,

-Change cycle length.

Any Signal timing plan developed and verified by SJDesigner respect certainly the inter-green matrix and minimum green length defined.

The verified signal timing plan can then be evaluated. The main results are

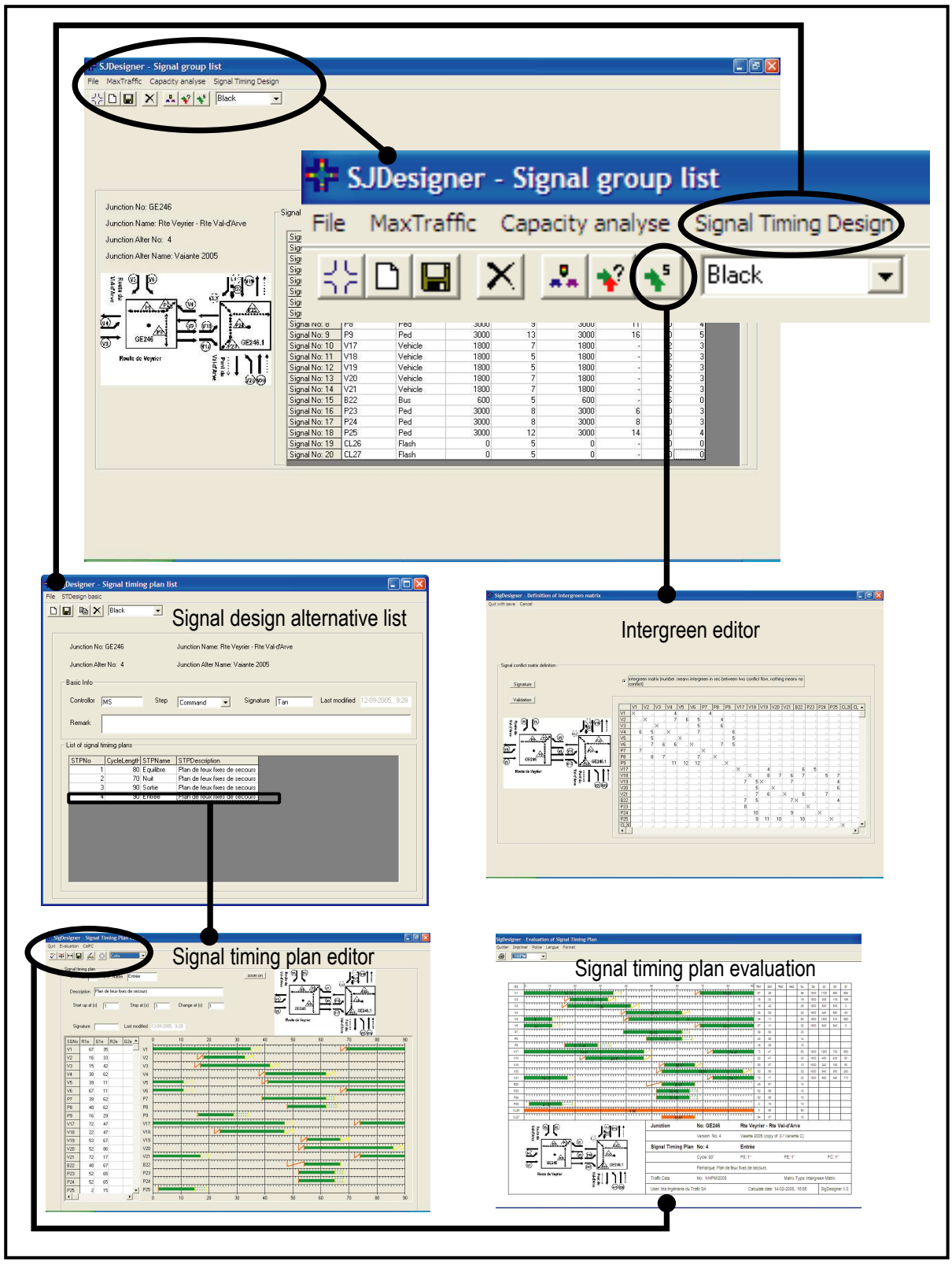
-the green start / close point and green length of each signal

-the maximum number of cars can pass the junction in one hour for each signal for cars

-the reservation of capacity of car signal (difference of cars who want to pass and who can pass for each car signal).

SJDesigner can export the junction design and signal design data to a file witch can be read by ITSignal Controller[5] (figure 6). There are the types of base data file:

Figure 5 Junction signal design and its evaluation



-Base data for fixed-time oriented control,

-Base data for stage oriented control,

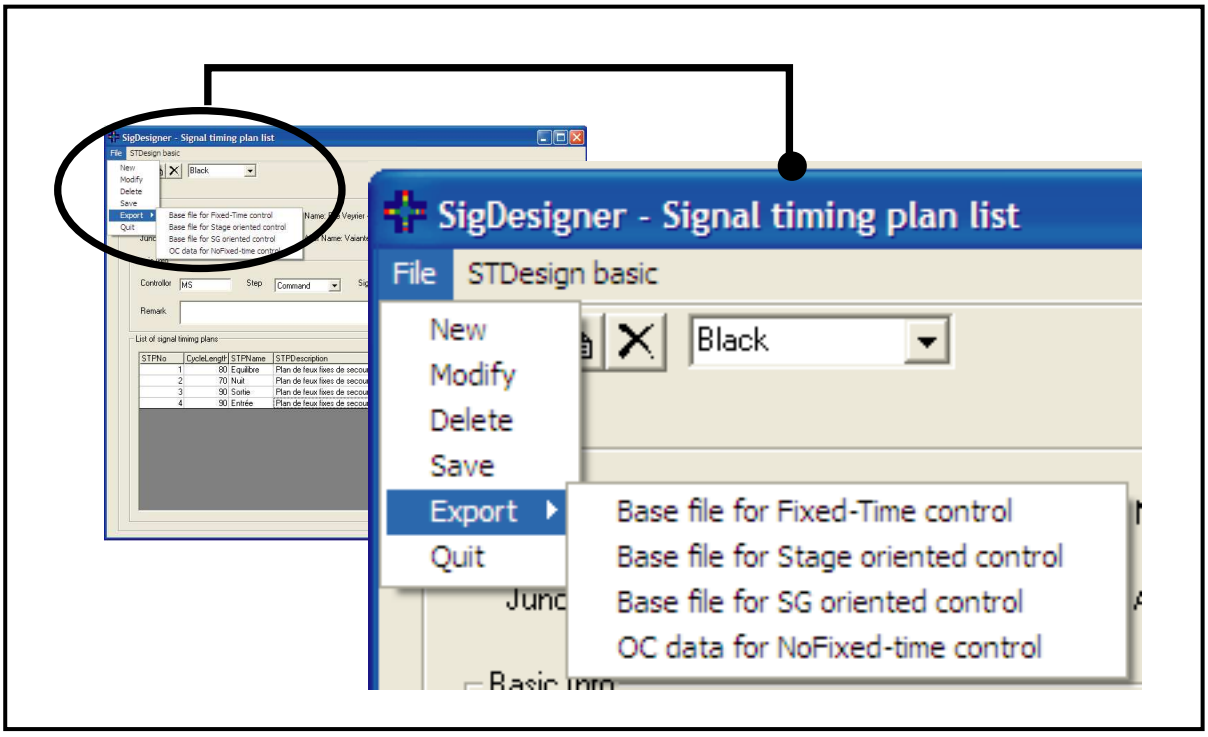
-Base data for signal group oriented control.

SJDesigner can also export a part of estimated traffic actuated control parameters for signal group oriented control, such as OC (open / close interval) parameters.

The generated data file then can be read and completed by ITSignal Controller's programming tool[6].

SJDesigner is a quite useful tool to develop traffic-actuated control logics in the signal design. For example, to develop some control logics for priority to public transport, two alternatives signal designs may be developed, one has a single green per cycle for bus signals, and the second has double green per cycle. By comparing these two signal design alternatives, the impact of double green of bus on private traffic is then easily identified quantitatively and some good traffic-actuated control logics may be proposed. By the help of simulation and analysing its real signal recording data by SigRecAnalyser[4], the signal design with traffic actuated logics may be tested and validated.

Figure 6 Export of signalised junction design data for junction controller



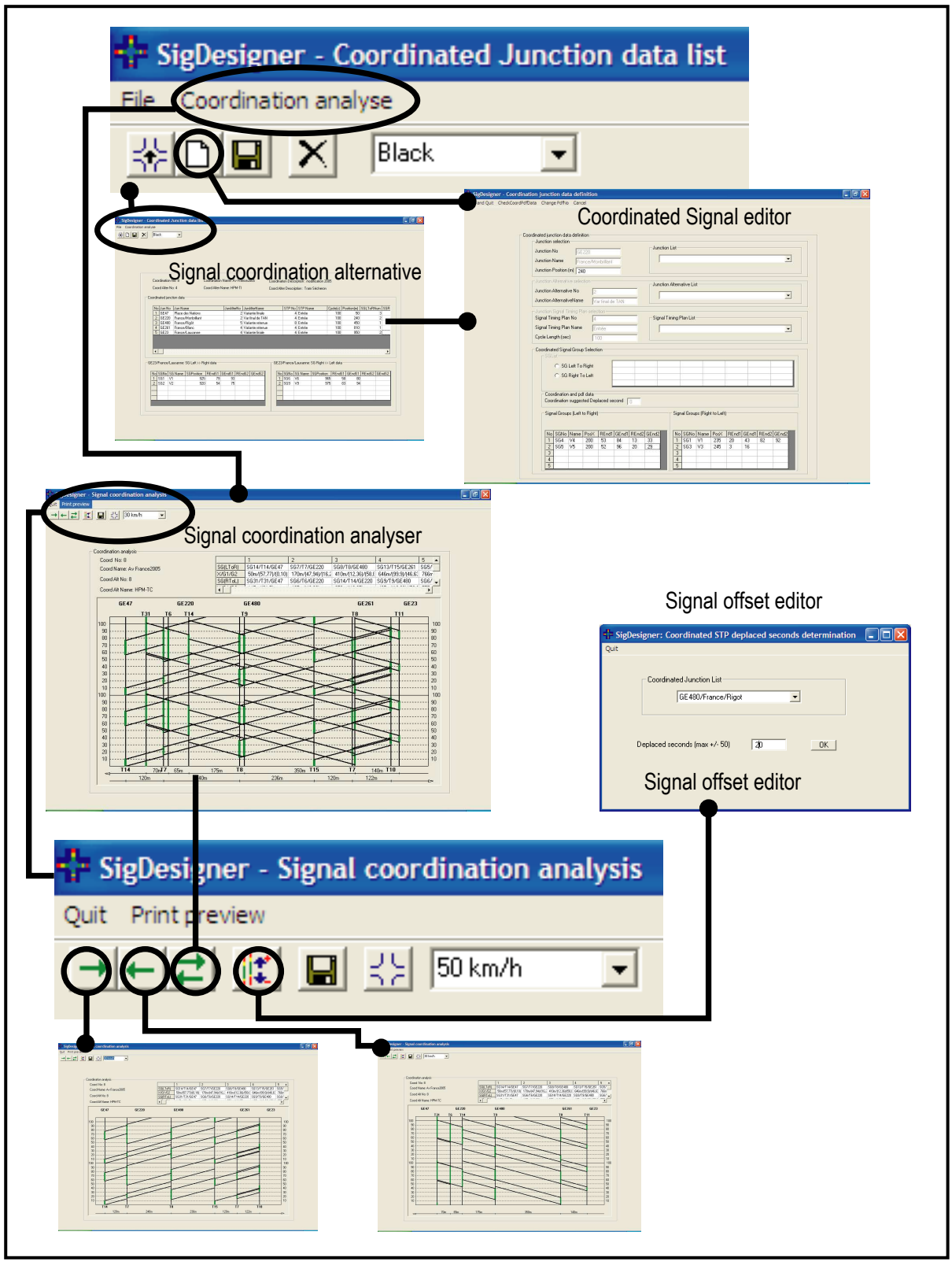
4. Junction signal coordination design

Signalised junction design (junction geometry design and its signal design) described above is the design without taking account of signal coordination with adjacent junctions. It means that green start / stop points of each signal are not take account of green start / stop points of adjacent signalised signals. If signals of adjacent junctions should be taken account of, the signal coordination design should be done.

SJDesigner can be used for the signal coordination design as shown in figure 7. By the SJDesigner, different signal coordination alternatives can be easily developed and analysed. First, a coordinate route of coordinated signalised junctions (based on their signal design data, one way or two ways) should be defined in each alternative by the coordinated signal editor. Then the signal coordination can be analysed by the help of the signal coordination analyser (time-space diagrams) for a desired coordination speed. The signal coordination may be optimised by adjusting the offset between adjacent signalised junctions by the help of the junction offset editor and the signal coordination analyser. The signal timing plans related may be updated by applying the final offset to its original signal timing plans. If the signal coordination results are not satisfied, the junction signal design or even junction design should be modified or rejected.

SJDesigner is a quite useful tool to analyse the priority for public transport in a main road with a coordinated control system. For example, two alternatives for the same adjacent signalised junctions in the main road may be developed, one is the signal coordination design for cars, and the second is for public transport. By analysing these two signal coordination alternatives, some good traffic-actuated control logics may be proposed. These control logics are often benefic to public transport and will minimise the impact of priority of public transport on private traffic. By the help of simulation, the signal coordination design may be tested and validated.

Figure 7 Signal coordination design



5. Summary and further development

SJDesigner is a powerful tool in the signalised junction design with the object to find an optimum signalised junction design alternative that fit best the will-defined control objectives.

By the help of SJDesigner, junction geometry design alternatives may be easily developed and evaluated. Then junction signal design alternatives of selected junction design alternatives can then be easily developed and evaluated. In this way, many signalised junction alternatives can then be analysed and compared and the best design alternative can be determined. To taking account of its adjacent signalised junctions, a signalised junction design should be verified or improved by a signal coordination study by the help of SJDesigner.

Continually beneficing experiences from real signalised junction control projects and new knowledge on intelligent traffic control, SJDesigner will be improved constantly. Further efforts for finding an evaluation method on signal coordination design are being done in order to answer the following questions: if signal coordination of two adjacent junctions is necessary? How to measure quantitatively the necessity of signal coordination? What is the relation between signalised junction capacity, distance between adjacent signalised junctions and their signal coordination?

6. References

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