TRAFFIC SIMULATION OF ROUNDABOUTS IN SWITZERLAND

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ABSTRACT

In Switzerland, roundabouts enjoy a large and growing popularity. As a self-organizing system, they replace more and more the traditional traffic light systems. This article focuses on the modeling and simulation of a double tracked roundabout near Lucerne (Switzerland). The simulation results were used for decision purposes; in order to find out whether a single or double tracked roundabout should be used there. All simulations were done with the simulation language SIMSCRIPT II.5.

1 INTRODUCTION

One important question in roundabout design is its traffic capacity. In Switzerland, every roundabout is a bit different, due to the fact that they have to be fitted into an already existing road structure.

Although standard formulas exist for the calculation of a roundabouts capacity, they do not really take into account the influence of pedestrians, bicycles and other specialities. Static formulas also lack of transparency.

2 SINGLE AND DOUBLE TRACKED ROUNDABOUTS

Figure 1 shows a map of the planned object (see arrow), which is located close to the well-known City Lucerne.

Figure 2 shows the single tracked proposal and Figure 3 the double tracked proposal whereas the latter more cost intensive is, due to the differences caused by pedestrian and bicycle tracks. It was expected that a simulation analysis could answer the following questions:

1. Which roundabout is able to handle a forecasted traffic load of 3500 vehicles per hour for the year 2007 without queuing up entering vehicles?
2. What are the influences of forecasted amounts of bicycles and pedestrians?

Figure 1: Planned Location of the Roundabout, Located Close to Lake Lucerne (at right in the picture)

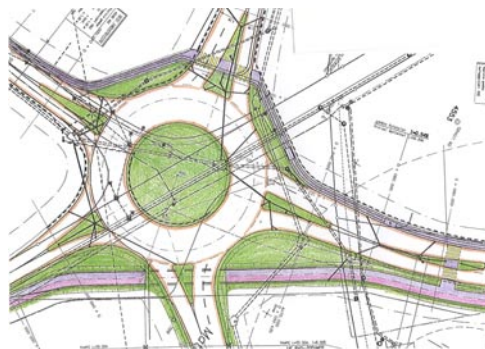Figure 2: Single Tracked Roundabout with Multiple Pedestrian Crosswalks

Figure 3: Double Tracked Roundabout with Special Tracks for Pedestrians and Bicycles

3   MODELING OF ROUNDABOUTS

The basic idea was to use a knot-based network, where every knot must have its own behavior for the vehicles. This principle works well on single tracked roundabouts and traffic light systems but in double tracked systems the behavior gains more complexity. Each vehicle must have the opportunity to change the lane as the situation makes it necessary.

Although the Touring Club of Switzerland (TCS) gives recommendations how to correctly drive a roundabout (Figure 4), the common driving behavior is a different one. Observations on roundabouts in Switzerland have shown that drivers tendentially try to stay on the outer lane caused by the fact that you could get caught on the inner lane.
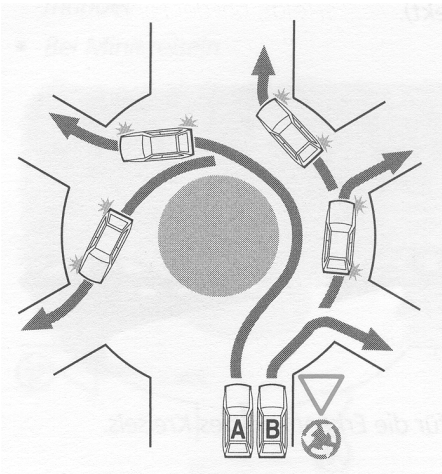

Figure 4: Example of the Ideal Driving Behavior for a Double Tracked Roundabout Recommended by the "Touring Club of Switzerland"

Therefore, it was obvious that the simulation model had to give response for the ideal as well as for the common case.

3.1 Building a Network

Figure 5 shows the carefully hand selected knots of the double tracked roundabout. On both lanes, the knots are spreaded so that their distance to the next one takes always 5 meters.

According to the connections shown in Figure 5, the network allows the vehicles to change lanes. Fortunately, the angle of a vehicle changing its lane is only within a certain range. Therefore, every knot has no more than three destinations, which can be chosen by a vehicle.
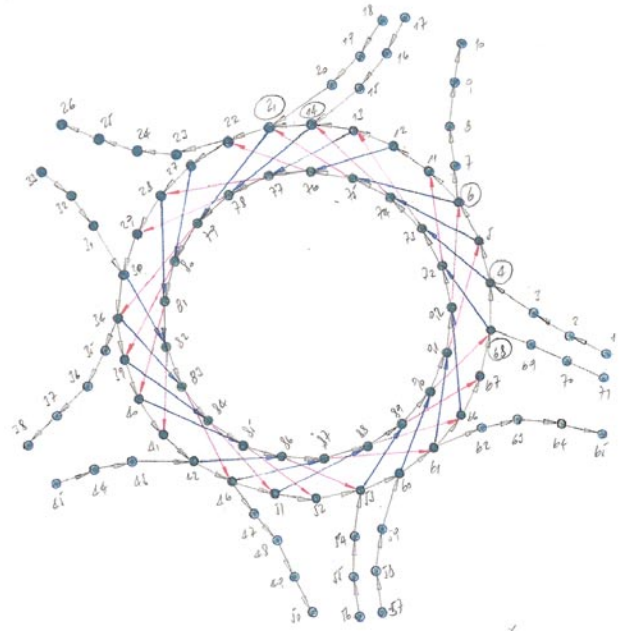

Figure 5: Network of the Double Tracked Roundabout, Each Knot Represents a Control Unit of Approximately 5-Meter Distance

3.2 Implementation of Decision Logic

The process-oriented simulation language SIMSCRIPT II.5 was chosen for the simulation. Every knot of the network is modeled as an individual SIMSCRIPT process. The behavior of a process includes certain decisions. These are tested sequentially:

1. Select next knot, depending on the status of the selectable knots and of the driving strategy (common or TCS-recommended).
2. Test collisions with vehicles already driving to the selected knot.
3. Stop or drive, depending on the vehicle of the next knot. Also set speed and distance to the next knot depending on the vehicle on it.

Figure 6 illustrates this on a vehicle controlled by process knot number four. The vehicle has chosen number 73 as the next destination and therefore must test for possible collisions as the highlighted arrows in the picture indicate it.

The software MASTER was used for writing the SIMSCRIPT II.5 simulation program. This expert driven front-end reads the file of the graphical representation of the network (see Figure 8), which can be made with the flowchart software "ABC-Graphics Suite 2", and writes the appropriate source code in SIMSCRIPT II.5. As it is only
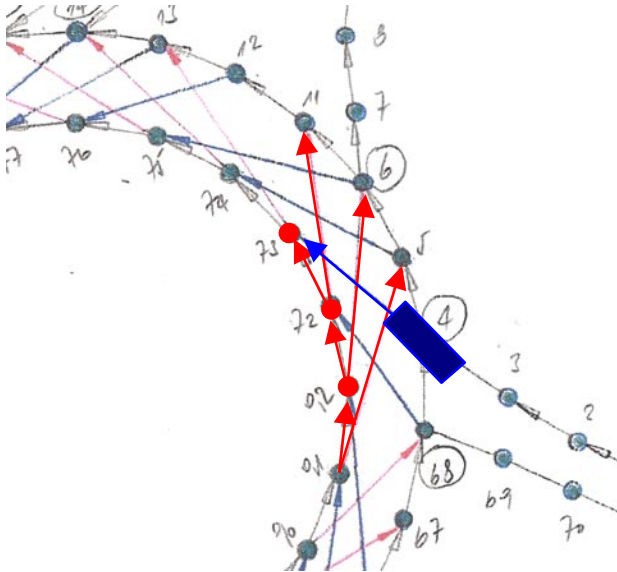
Figure 6: Example Illustrating Possible Traffic Collisions For Vehicle on Process Knot Number 4

an automated rough solution, some specific corrections are still necessary.

For example, the SIMSCRIPT II.5 code for process number 68 (see Figure 6) looks like this:

```
Process P68 given .object

    let ProcessStatus(68)=busy
    set speed given 68 and .object
let pull.time=SpeedP(68) *
              XFaktor(68,.object)

    If Crossing(.object)=activ
        let Pcrossing(68)=busy
    always
    If Einfahrt(.object) is not "Nord"
     Activate a LockProcess now
    always

    pullmove from location

     Forever
        do
        If ProcessStatus(4)=passiv and
           Einfahrt(.object) is not "Nord"
            Activate a P4 giving .object
                                  now
           leave
        always

        ........

        If ProcessStatus(72)=passiv and
           ProcessCrossing(72)=passiv and
           ProcessCrossingx(5)=passiv
```

```
           let Crossing(.object)=activ
           Activate a P72 giving .object
                                     now
           leave
        always

           suspend
    loop

    wait FZAbstand units

End
```

Figure 7 shows the simulation environment of SIMSCRIPT II.5. Every process can be opened there and corrected as necessary. Splitting up the source code automatically into single processes is an implemented feature of the SIMSCRIPT II.5 program.

Figure 8 shows a graphical representation of the processes, which control the vehicles. The whole model has another set of processes for pedestrians and bicycles, which are not shown here. The large appearing processes work as sources and sinks for vehicles. The circles represent queues for entering vehicles.

In order to make the model as realistic as possible, the following behavior have been included, mainly:

- Every vehicle, pedestrian and bicycle has its own desired velocity. There is a parameter in the model, which defines the min-max values. Of course, the vehicles velocity in the model depends on the vehicles predecessor as well.
- The time-based driving distance of the vehicles, which depends on the velocity of the vehicles.
- The time-slice, which allows a vehicle to enter into the circle without having a collision with an approaching vehicle.
- Behavior for selecting and crossing lanes. Can be "recommended by TCS" or "tendency to drive in right lane".
- Jostle behavior for vehicles not able to change immediately. This behavior is important when a vehicle on the inner lane wants to leave the circle and due to heavy traffic is not able to do it. The jostling vehicle then enforces its precedence.
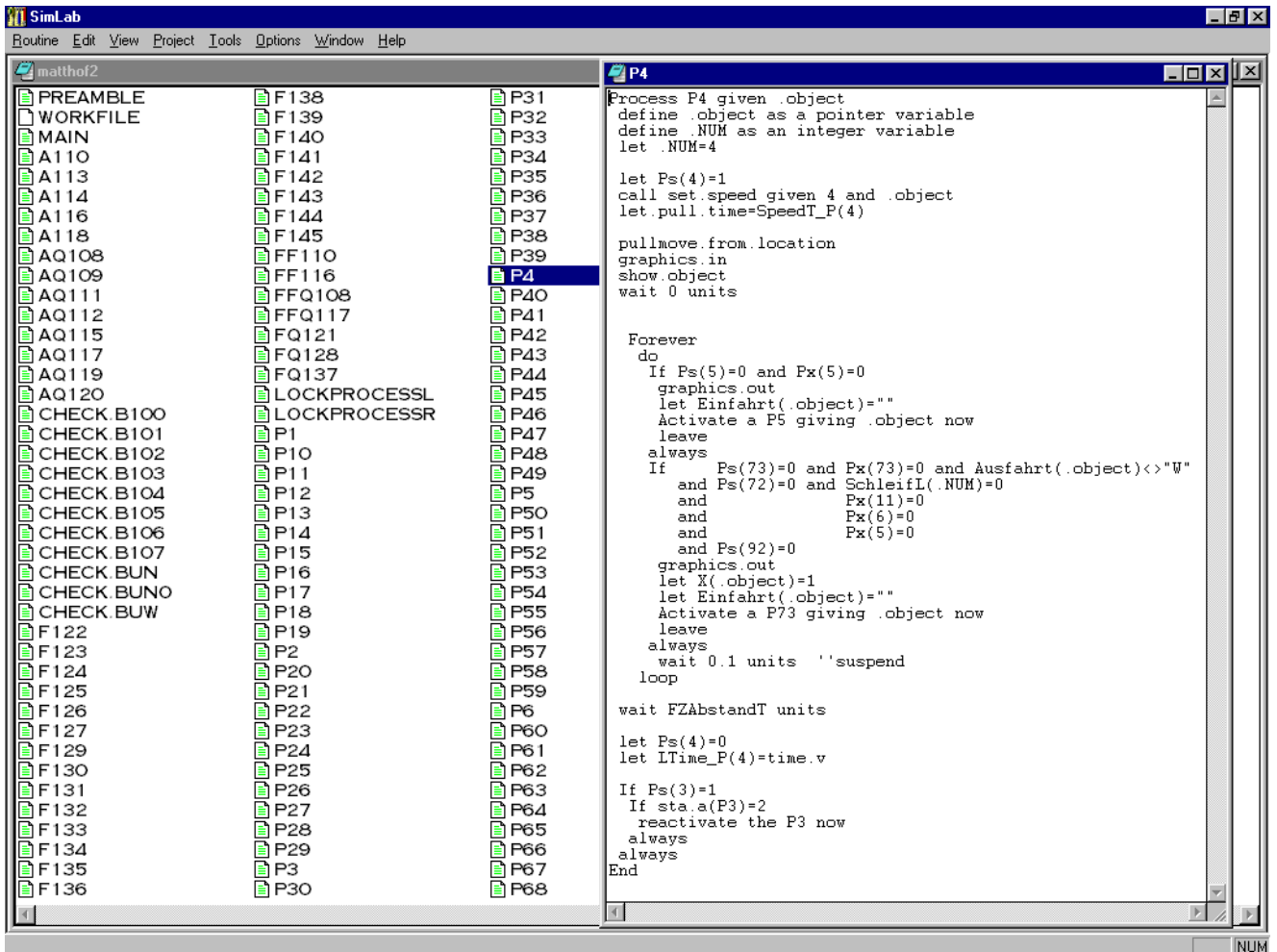- Pedestrians always have precedence. This is a traffic regulation in Switzerland.

Figure 7: SIMSCRIPT II.5 Working Environment with Process P4 Opened for Editing Simulation Code
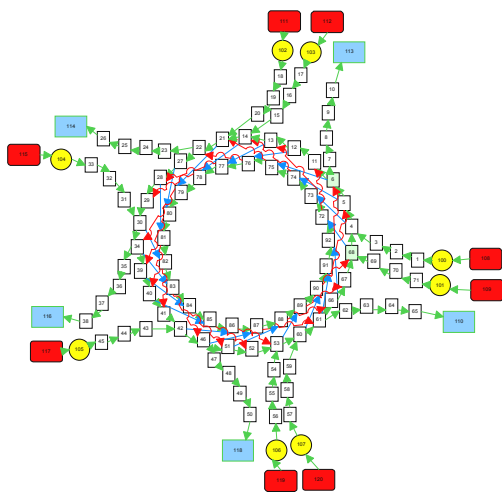

Figure 8: Graphical Process Representation of the Double Tracked Roundabout Made with the Flowchart Software ABC Graphics Suite 2

4   SIMULATION RESULTS

Figure 9 shows an animation screenshot. The animation allows the user to see the traffic conditions and also supports verification and validation of the simulation model. The simulation model records the desired traffic data like queue-length, waiting times and volumes (see Figure 10).

Table 1 shows the simulated upper limit of the traffic volume for the single and double tracked roundabout.

The maximum capacity can be measured as the volume of vehicles leaving the roundabout while simultaneously overloading the input and therefore producing traffic jam at the inputs. A more interesting scenario is to find the maximum traffic volume where no or just a few vehicles have to wait. In this case, the single tracked roundabout allows a traffic volume of 3500 vehicles per hour whereas the double tracked roundabout in TCS-mode has a capacity of 5700 vehicles per hour.
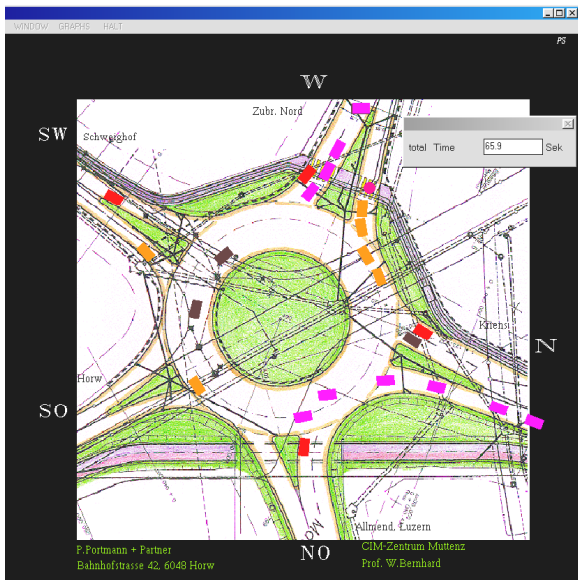
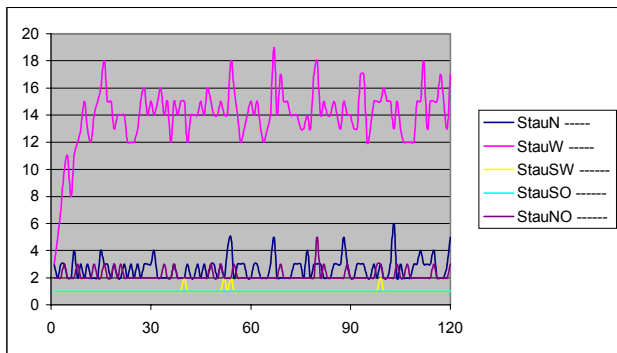Figure 9: Animation Screen Shot of the Double Tracked Roundabout with TCS-Recommended Driving Behavior

Figure 10: Simulation Result, Amount of Waiting Vehicles Versus Time (example)

Table 1: Maximum Traffic Volume, Comparison of Single and Double Tracked Roundabout and Different Driving Behavior

Tracks	Drive Mode	Max.Cap. (Veh/h)	Traffic Inner Lane
2	TCS	5831	41 %
2	Tend. Right	5237 +11%	33 %
1	-	+34% 3903 +49%	-

5   SUMMARY

An important aspect of the work performed is the transparency the simulation brought to the customer by having an animated model of the planned roundabouts. Also, the simulation model allows to include specific details like pedestrians and other influences not taken into consideration in standard formulas.

At the beginning of the project, it was uncertain if the behavior of a driver in a double tracked roundabout could be modeled realistic enough. It stated out that the knot-based concept is very powerful to control a vehicle according to the specific location. Just a handful of rules are enough for a satisfactory driving behavior.

Modeling a network with a large amount of knots can be very time-consuming. The automatic (source) code generation provided by the system MASTER can make the modeling process more effective.

In Switzerland, special traffic designs exist where roundabouts are directly combined with traffic lights. In such cases where formulas are rare or even not available, the simulation and animation can develop its full strength.

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