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TECHNIQUE OF SUBSTANTIATION OF A PLANNING DECISION AT MODERNIZATION OF CIRCULAR CROSSINGS ON THE BASIS OF FORECASTING LOSSES IN TRAFFIC

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The task of a choice of optimal planning decision at modernization of circular intersection is considered. The proposed criterion of optimisation – losses in road traffic, which evaluates as well the variants of road traffic organization and parameters of loading as the road conditions and specificity of conflict interaction at an intersection. From the alternatives possible it has been chosen a grounded choice of a planning decision.

Keywords: *losses in road traffic, circular crossings, planning decision, optimisation of intersection's parameters*

As it is known circular crossings take a middle position between controlled and non-controlled junctions. Such crossings are self-controlled. Their use reduces the quantity of accidents with injured till 50% in comparison with junctions of standard configuration (it is not important whether it is controlled junction or non-controlled). More over their use reduces the quantity of conflict points (just only less dangerous points of confluence and deflection remain), due to central traffic island liquidates conflict areas in which the most severe accidents occur. Correctly designed junctions with circular motion almost entirely exclude the presence of severe accidents with injured (as the practice shows, the quantity of such accidents is no more than 1–3 a year).

It is also significant as the scheme of circular motion provides larger carrying capacity than usual schemes. The possession by circular motion of self-controlling properties provides a constant continuous traffic flow with definite speed (depending on the configuration and the diameter of central traffic island) in contrast to controlled junction (the principle of movement sequence requires full stopping of traffic flow, requires day and night and week adaptation of traffic light cycles and etc.).

From the point of view of psycho physiologic peculiarity of a driver, the movement by one direction inside the circle doesn't require the psychological effort that takes place when it is necessary to watch the movement of the other directions while waiting the interval of entering a junction.

It is observed the reduction of ecological losses on circular crossings because of smooth fall of speed of traffic flows (the quantity of braking, stopping and accelerations reduces).

11 circular crossings are used in hard-loaded main points in Minsk. At the same time some crossings have till 6–7 streets on which the organization of movement of the main traffic flows is possible with the circular motion only.

But some circular crossings (due to peculiarities of design: diameter of the circle, carriageway width, radiuses of adjacent of streets, total design) exhaust all their carrying capacities. There often traffic jams (blocking till 20 minutes) form in time of morning and evening picks on the hard-loaded directions.

One of such intersection in Minsk is Bangalor Square – crossing of Bogdanovicha, Orlovskaya, Sarganova Streets with the partial controlling of movement. The peculiarity of this intersection is also that from the one side it borders on the area of existing building, and pedestrian crossing cannot be replaced underground because of plenty of engineering services. In this connection the problem of optimisation of a planning decision with the saving of geometrical characteristics of junctions and the presence of conflict traffic flows is actual (Fig. 1).

According to the existing planning decision, the controlling on the junction fulfils from two entrances by the principle “the circle is main” and from the other two entrances in the partially controlling mode: in the beginning – controlled pedestrian crossing, then by the principle “the circle is main”.

The main delays and stops of the traffic occur while entering the circular crossing (70%). Additional delays and stops of traffic (20%) occur because of two closely located pedestrian crossings (across Bogdanovicha Street from the side of Kulman Street and across Surganova Street from the side of Kuibysheva Street). At the entrances where controlled pedestrian junctions are located the traffic flow mainly stops not less the two times: the first time in front of the traffic light, the second time in front of the circular crossing.

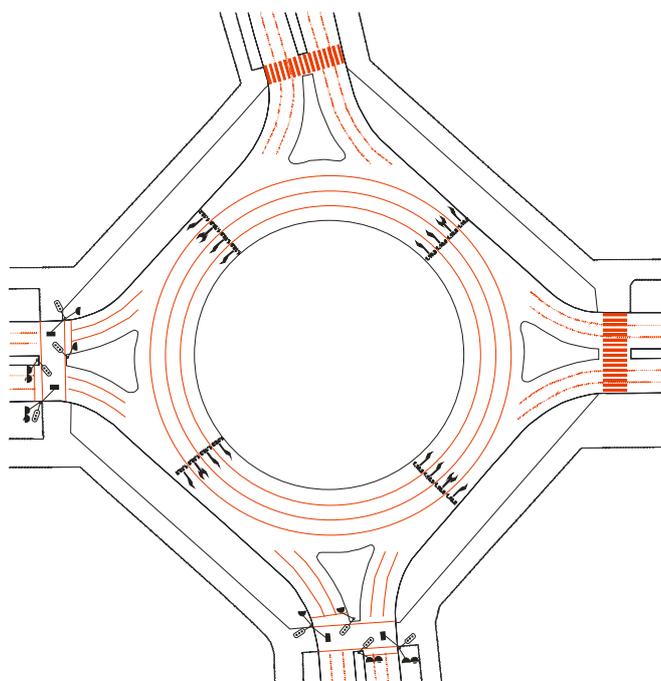


Figure 1. Existing intersection planning

Uncontrolled pedestrian junctions are located on the two entrances but because of low pedestrian flows the delays and stops of traffic are not significant.

Very often as a result of closely located controlled pedestrian crossing on Bogdanovicha Street the queue of vehicles moving from the circular crossing to the exit of intersection grows when red light is on. While queue is growing the adjacent entrance from the side of Orlovskaya Street is being blocked. And while the grows of queue before the exit from the intersection has not been reduced, the traffic flow, moving from Orlovskaya Street has not possibility to enter the intersection because of vehicles stopped by traffic light which move to the exit of the circular crossing.

Synchronous switching on and switching off of green lights for traffic on Surganova and Bogdanovicha Streets leads to increasing of quantity of vehicles on the circular crossing in front of the entrance on Surganova Street. Traffic flow from Surganova Street has to miss at first transit and left-turning flows from Bogdanovicha Street and only at remaining time of permitting light can enter the circular crossing.

While moving on the circular crossing on 3 and 4 traffic lanes the drivers ungrounded must move left only. Actually cars from these carriageways moves right and left that leads to great amount of accidents at the circular crossing and as the result to the appearance of jams. The first traffic lane is not used almost neither cars not trolley because that caused of large overrun, low speed on the carriageway, difficulty while enter the traffic flow and the presence on it traffic entering to the circular crossing.

The average speed of cars moving on the circular crossing is about 40 km/h. The time of moving (excluding delays and stops) in the straight direction 4 sec, in the left-turning direction is 21 sec.

The peculiarity of cartogram of intension of movement is presence of left-turning flow of high intension (till 600 cars per h) from Orlovskaya Street to Bogdanovicha Street and the same right-turning flow in the back direction.

The losses caused by delays and stops of traffic and pedestrian are 1300000 c.u/year. The advantages of the existing organization of traffic movement:

1. The possibility of junction to operate when traffic lights are absent.
2. The possibility of using the ground-based pedestrian crossings in 2 phases.
3. The accidents with injured are practically absent.
4. Good operating in the conditions of large right-turning and left-turning flows.

The disadvantages of the existing organization of traffic movement:

1. The large quantity of accidents with material damage (about 250 accidents per year).
2. Overrun of transit and left-turning flows of all directions.
3. The low speed at crossing the intersection because of movement on the circle.
4. Impossibility of coordination on either street.
5. The presence of additional delays and stops on the conventional second and stop-lines of the part of turning flows.
6. Periodical arising of jams while lighting the permitting signals.
7. The high level of loading a t the entrances (0,8–0,9).

For the designing and substantiation designing variants by Research-and-development centre of the University are experimental investigations: of intense (Fig. 2) and structure of traffic and pedestrian flows on the crossings (by means of investigation of correspondences in working days and days-off with interval of 2 h); vehicles' location; time of crossing the intersection in the basic directions (transit and left-turning), conflict interaction of traffic flows while entering the circular crossing (the investigation of movement speed when coming to the place of confluence traffic flows which move on the circular crossing and entering the circle); conflict interaction and conflict simultaneity, etc.

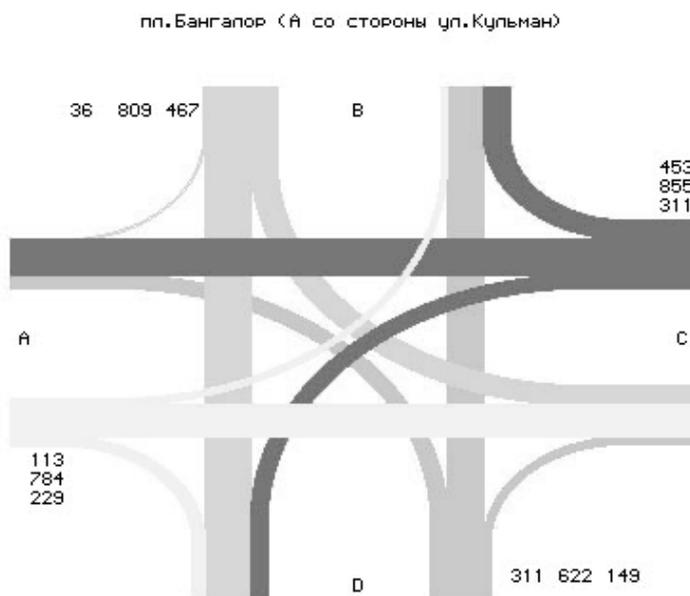


Figure 2. Cartogram of movement intensity

When the further researches were conducted it was taken the intense for the prospect (5 years). The evaluation of the decisions proposed is made by the criteria of minimizing of losses in road traffic. On the basis of experimental data obtained the accidental, ecological and economic losses are evaluated.

Further the following organizing and planning decisions are considered: the coordination of work of controlled pedestrian crossings (Fig. 3 a); total control on the entrances (turbine) (Fig. 3 b), cut of central traffic island along the most loaded street (Bogdanivicha Street) (Fig. 3 c), the total cut along two streets (analogue – Pritytskogo Square) (Fig. 3 d) and standard intersection (analogue – intersection of Lynkova and Pritytskogo Streets) (Fig. 3 i).

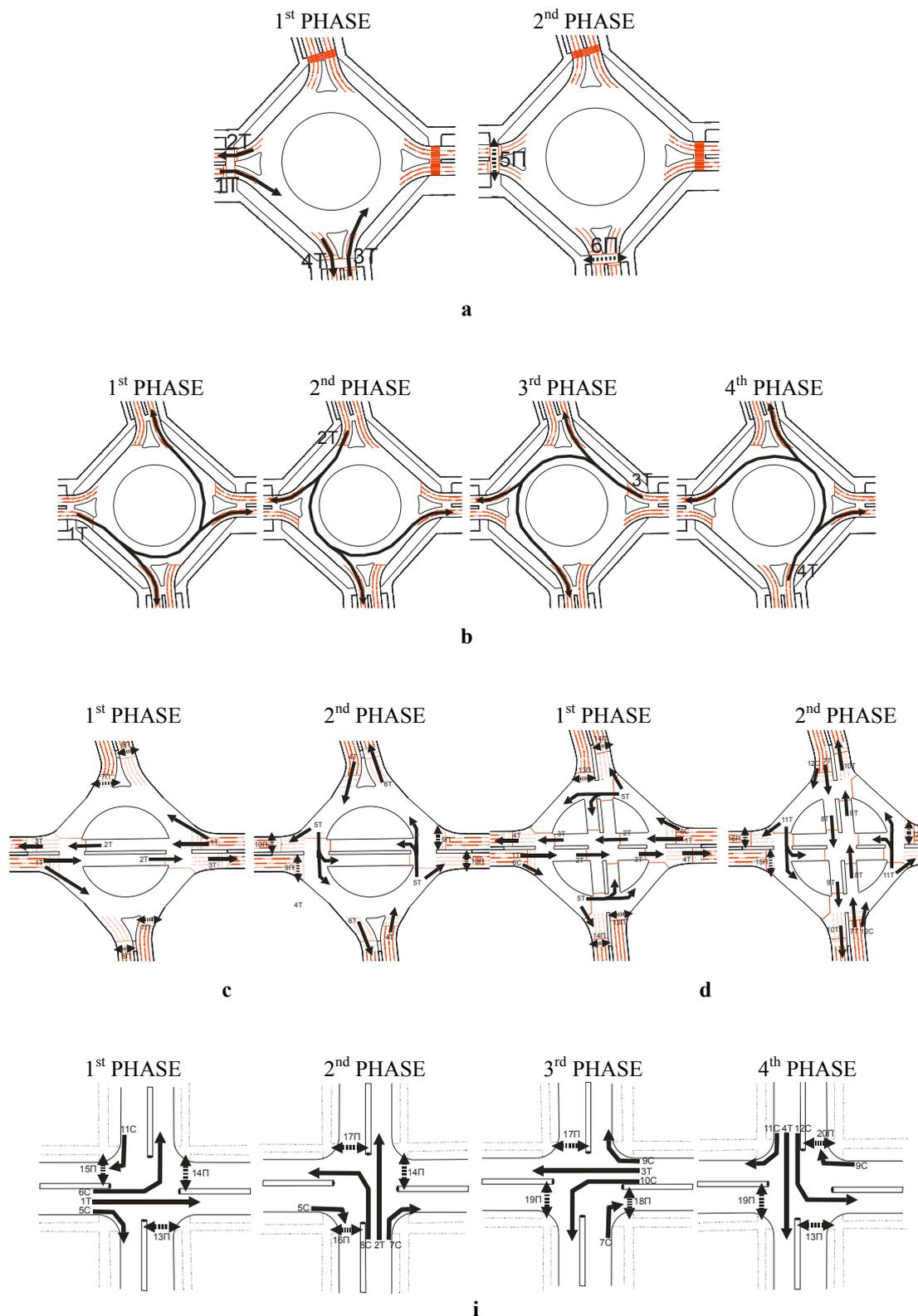


Figure 3. Variants of alternative decisions

Signal cycles, which have the following parameters, are composed for each of the variants (Fig. 4–7). For each variant it was considered the cycle with length of 84 sec, because on the main streets Bogdanovicha, Surganova, Orlovskaya there is a coordinated control with length of the cycle of 84 sec. And as one of the conditions for the coordination is the equality of cycles of all the traffic signals that compose in the coordinated main street, it was taken the present cycle for the objective decision.

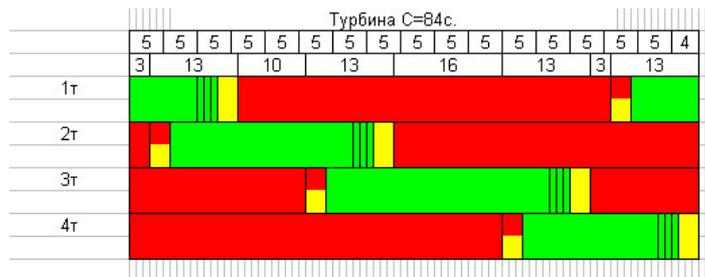


Figure 4. The diagram of the signal lights' cycle for a variant "Turbine"

The distinctive feature of the proposed planning decision (Fig. 5) is full changing of junction type. It is designed a car fax with all turns permitted instead of a circular intersection.

It is necessary the existence of 5 carriageways on the each entrance and 4 carriageways on each exit for the functioning of such junction. At the same time the control must take place in 4 phases because of presence of large left-turning flows from every entrance:

a) traffic from each entrance move without conflicts in every direction at the same phase. Pedestrians cross the street without conflict in two stages;

b) traffic from each entrance moves without conflicts in every direction at the same phase. The right-turning traffic moves also in next phase in conflict with pedestrians. Pedestrians cross the street in two stages: one carriageway without conflict and another carriageway with conflict with right-turning traffic in the next phase.

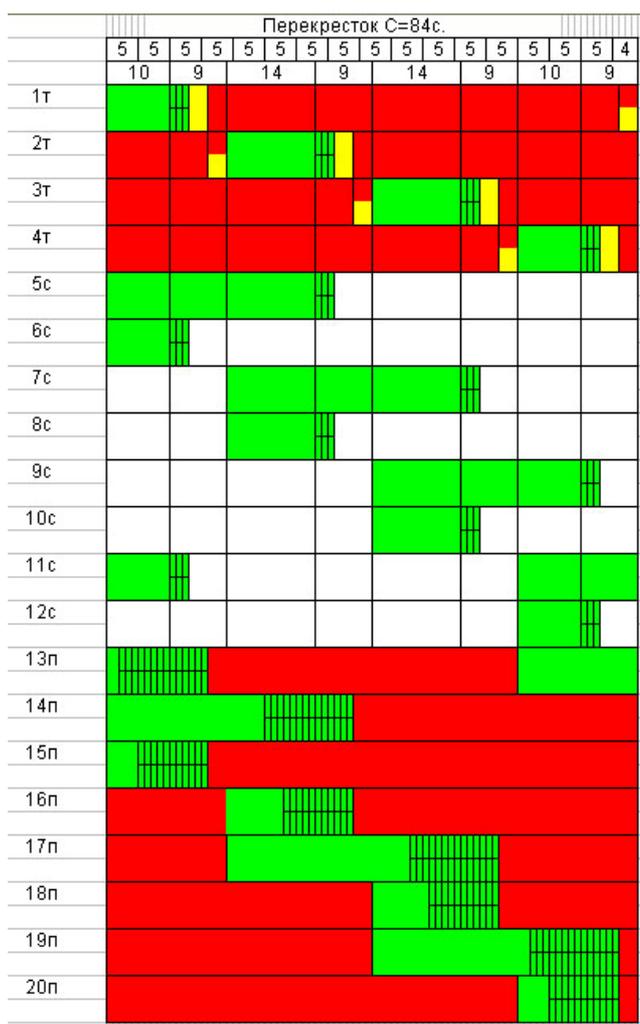


Figure 5. The diagram of the signal lights' cycle for a variant "the Standard crossroads"

The losses of the delays and stops of traffic and pedestrians at the given planning decision are 15000000 c.u. annually.

But at the same time with advantages (absence of overrun from each entrance; speed of movement on the junction can be equal to speed of movement at the entrance; possibility of use of ground pedestrian crossings in 2 stages; absence of additional delays and stops on conditional second stops-lines, etc.), are available also essential disadvantages – necessity of trouble-free work traffic signals; a 4-phase cycle of regulation and, hence, a high level of loading on entrances (0,8–0,9); limitation of use of trolleybus transport on all directions because of characteristics of a contact network; the big width of an intersection and approaches to it; predicted reduction of accidents is 10–20 % in comparison with existing planning decision, but weight of accidents raises in 2,5 times.

The distinctive feature of the variant "the cut along one highway" is that it includes elements of a usual and circular intersection (Fig. 3, c and 6). Central traffic island is cut along one of crossed highways, forming itself a circle cut in the middle. Movement of transit transport on this street (main) is carried out directly in a cut of central traffic island, and left-turning transport moves on a circle riding around of central traffic island. Movement of transit transport from other street (minor) is carried out on a circle in riding around of central traffic island, and left-turning transport first moves a circle up to a cut, and then cars to a cut, and routing passenger transport and trucks on a circle riding around central traffic island. In order such a planning decision to function it is necessary to provide signal control, at the same time coordination of signals of a traffic light inside crossroads is very important.

The choice of a direction of a cut of a circle depends on the intensity of movement transit and left-turning flows. At the cartogram of movement's intensity the cut of central traffic island must be carried out along Bogdanovicha Street.

On each entrance there are 4 traffic lanes for movement on each direction, inside a circle the 3 traffic lanes are arranged, and the width of traffic islands remains former. Pedestrian crossings are arranged in 2 stages on the L-shaped trajectory. In case of arrangement of bus-stops on Bogdanovicha Street, in front of the intersection there will be a necessary to start up transit trolleybus movement not in the cut, but on the circle. In case of switching off the traffic signals it is necessary that movement on the circle is the main, and on the cut is secondary. Such regulation is necessary, because it is more difficult for the traffic flow moving on the circle to overcome two-direction moving, than for the transport flow moving in a cut to overcome one-direction moving.

Losses from delays and stops of traffic and pedestrians at the given planning decision make up 1100000 c.u./year. In case of coordination of movement on Bogdanovicha Street losses will make up 750000 c.u./year.

An unconditional minus is: Complexity of coordination on the second street; on one street it is better by condition of movement, than another; overrun of transit flows on a minor street and left-turning flows of the main; low speed of crossing the intersection by transport because of movement on a circle; presence of additional delays and stops on conditional second stops-lines at a part of transit and all turning flows.

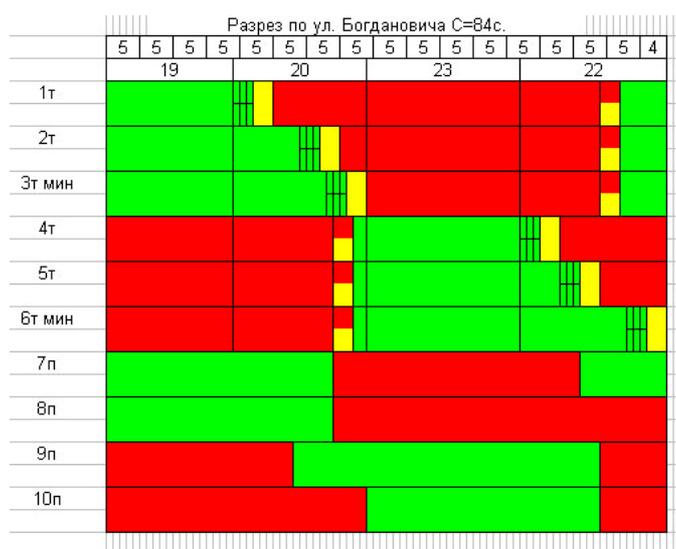


Figure 6. Diagram of the signal lights' cycle for the variant "Cut along the one street"

The distinctive feature of the variant in which central traffic island is cut along both highways, is that it also includes elements of usual and circular crossroads. Central traffic island is cut on two crossed highways, forming usual crossroads inside and elements of circular crossroads outside. Movement of transit transport on highways is carried out directly in a cut of central traffic island, and left-turning transport first on a circle up to a cut, and then cars to a cut, and routing passenger transport and trucks on a riding around central traffic island. For functioning of such a planning decision it is necessary to organize traffic signal control, at the same time the coordination of signals of a traffic light inside the crossroads is very important.

On each entrance 4 traffic lanes are arranged: 1-st – to the right, 2-nd – directly and to the right, 3-rd and 4-th – is direct. On each exit 4 traffic lanes are arranged: 1-st – for turning transport as a transitive-speed traffic lane, and also for accommodation on it of bus-stops of routing passenger transport; 2-nd, 3-rd and 4-th – for transit transport. There are 3 traffic lanes in each direction and between them a dividing strip, dedicated constructively or as traffic lane marking of the former width, inside the circle. The size of central traffic island increases due to reduction of quantity of carriageways (by one) for movement on a circle. On the circle 3 traffic lanes are arranged: 3-rd – on the left in a cut, 2-nd – on the left in a cut and is direct on a circle, 1-st – is direct on a circle.

Losses from delays and stops of transport and pedestrians at the given planning decision make up 1000000 c.u./year. In case of coordination of movement on one of streets losses will make 650000 c.u./year. In case of coordination of movement on two streets losses will make 350000 c.u./year.

The given decision possesses the best parameters for the further application of planning project.

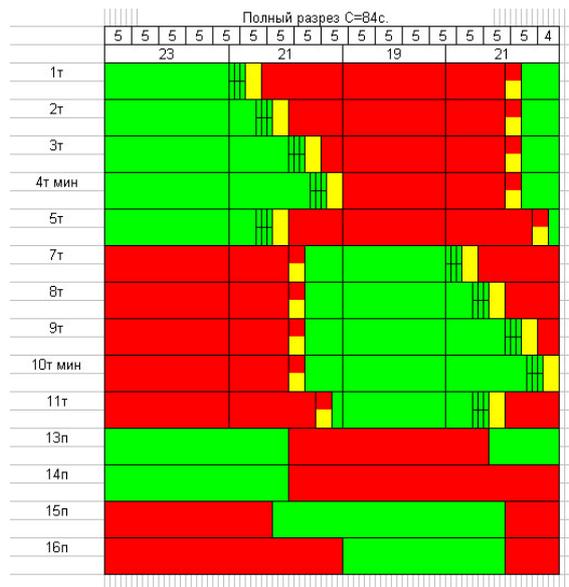


Figure 7. Diagram of the signal lights' cycle for the variant «Cut along two streets»

Some decisions are visualized in program complex TV_VISION (Fig. 8–10).



Figure 8. Traffic and pedestrian movement under the existent variant



Figure 9. Traffic and pedestrian movement on the standard intersection



Figure 10. Traffic and pedestrian flows when central traffic island is cut along the high-street

In case of coordination of movement on Bogdanovicha Street losses will make up 750000 c.u./year. Advantages of planning decision proposed: absence of the overrun of transit transport on Bogdanovicha Street and also decrease of overrun of left-turning flows from Orlovskaya and Surganova Streets; speed of movement of transit transport on a junction on Bogdanovicha Street can be equal to speed of movement at the entrance to it; the possibility of use of ground pedestrian crossings in 2 stages; smaller predicted accident rate (by 60–70%) in comparison with the existing planning decision; the possibility of coordination of a transit direction along Bogdanovicha Street; the optimum level of loading on entrances (0,5–0,8).

There are also some disadvantages of the decision proposed: complexity of coordination on the second street; necessity of trouble-free work of traffic signal; the conditions of movement on one street are better than on another one; overrun of transit flows on a minor street and left-turning flows of the main street; low speed of transport crossing one street due to movement on a circle; presence of additional delays and stops on conditional second stops-lines of a part of transit and all turning flows.

Thus, it has been chosen planning decision, which will be realized as the building project (the executor: Minsk Engineering Project). It is significant, that preservation of a circular crossroads specificity will give considerable advantages (including reduction in accident rate) when switching-off the signal control system.