# Improvement of the west road corridor for accessing the new hospital of Lucca (Italy)

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## Abstract

This paper deals with the study of a road corridor in the historical city of Lucca (Tuscany, Italy) following the transfer of the city hospital to a new location, which took place in May 2014. Lucca is surrounded by a ring road and the road corridor study was related to alleviating the problems actually experienced by ambulances travelling from the urban ring road to the new hospital. The corridor road length is about 1.5 km (i.e. 0.93 miles), and there are seven different intersections along the corridor, spanning from signalized to two-way stop controlled and roundabouts. SIDRA INTERSECTION 6.0 (NETWORK version) was used to analyze the two scenarios; namely, the "present situation" and the "design situation" to verify the effectiveness of some proposed local changes and intersection improvements. The analyses indicated that "Level of Service D" (the target value required in the urban field) could be achieved for the "design situation" while "Level of Service F" was indicated for the "present situation". The analysis results strongly supported the design proposal of improving the west road corridor for accessing the new hospital of Lucca. This is particularly important considering that ambulances are the most crucial users of the road corridor. The analyses also showed that significant improvements could be made to traffic performance in the road corridor in general, including environmental benefits in terms of reduced fuel consumption and emissions. This study has been possible thanks to SIDRA INTERSECTION 6.0 (NETWORK version) that showed its capability of modelling both single intersections and the road corridor.

*Keywords: road corridor evaluation, SIDRA INTERSECTION 6.0 software, roundabout analysis, network analysis and comparison.*

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## 1 Introduction

The purpose of this study was to analyze a road corridor in the city of Lucca (Tuscany, Italy) following the transfer of the city hospital from the old location to the new one that took place in May 2014 (as shown in Figure 1).

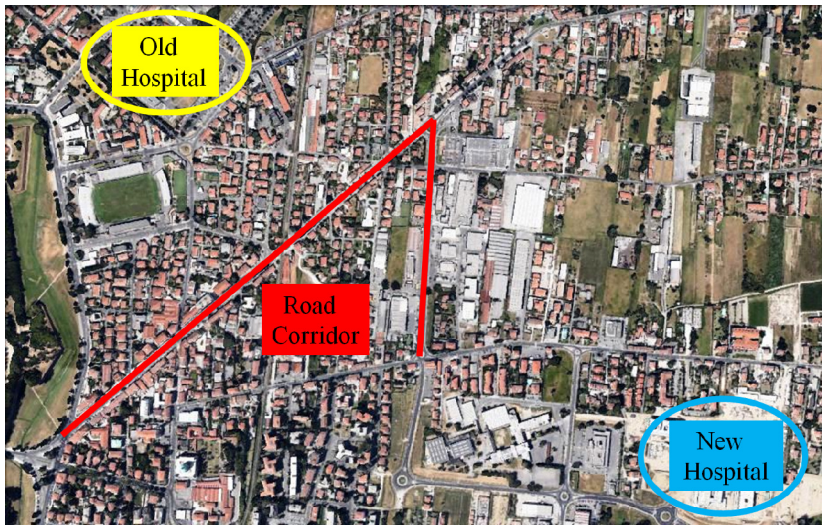


Figure 1: Aerial view of the considered area.

The historical city of Lucca is surrounded by a ring road and the problem has been to study the road corridor that ambulances have to use to travel from the urban ring road to the new headquarters hospital. We used SIDRA INTERSECTION 6.0 (NETWORK version) to study two scenarios, namely the "present situation" and the "design situation", to verify the effectiveness of some proposed changes. We developed this study using the HCM 2010 Roundabout Capacity Model option in SIDRA INTERSECTION [1] and following the instructions suggested by NCHRP Report 772 [2], but also taking into account other international studies [3, 4].

## 2 The SIDRA INTERSECTION 6.0 software

The word SIDRA is an acronym for Signalised and unsignalised Intersection Design and Research Aid.

SIDRA INTERSECTION 6.0, released in April 2013, introduced the biggest changes in the 30-year history of the software. Three major elements of change were network modelling capability, movement classes, and data and modelling by origin–destination movements. Major data structure and user interface changes were implemented as a result. Further major enhancements have been introduced through software updates after the initial release.

Table 1: HCM 2010 capacity model.

| *HCM 2010 capacity model* | | | | | |
|---|---|---|---|---|---|
| | $t_f$ (s) | $t_c$ (s) | *A* | *B* | $C_e$ (pc/h) |
| *Single lane roundabout* | | | | | |
| HCM 2010 | 3.19 | 5.19 | 1130 | 0.001 | 1130*exp((-1*10^-3)*$V_c$) |
| NCHRP 572 | 3.20 | 5.10 | 1125 | 0.000972 | 1125*exp((-0.972*10^-3)*$V_c$) |
| California | 2.50 | 4.90 | 1440 | 0.00101 | 1440*exp((-1.01*10^-3)*$V_c$) |
| North Tuscany | 2.64 | 3.83 | 1364 | 0.00070 | 1364*exp((-0.70*10^-3)*$V_c$) |
| *Left lane of two-lane roundabout* | | | | | |
| HCM 2010 | 3.19 | 4.29 | 1130 | 0.00075 | 1130*exp((-0.75*10^-3)*$V_c$) |
| NCHRP 572 | 3.40 | 4.50 | 1059 | 0.000778 | 1059*exp((-0.778*10^-3)*$V_c$) |
| California | 2.30 | 4.80 | 1565 | 0.001014 | 1565*exp((-1.014*10^-3)*$V_c$) |
| North Tuscany | 2.59 | 3.85 | 1390 | 0.000710 | 1390*exp((-0.70*10^-3)*$V_c$) |
| *Right lane of two-lane roundabout* | | | | | |
| HCM 2010 | 3.19 | 4.11 | 1130 | 0.0007 | 1130*exp((-0.7*10^-3)*$V_c$) |
| NCHRP 572 | 3.10 | 4.20 | 1161 | 0.000736 | 1161*exp((-0.736*10^-3)*$V_c$) |
| California | 2.20 | 4.40 | 1636 | 0.000917 | 1636*exp((-0.917*10^-3)*$V_c$) |
| North Tuscany | 2.63 | 3.64 | 1369 | 0.000646 | 1369*exp((-0.646*10^-3)*$V_c$) |

In this study, we used the following relevant settings:

- HCM 2010 Roundabout Capacity Model option was applied;
- Capacity adjustments for queue spillback were calculated by the program;
- P.H.F. = 1, because we used on-site traffic surveys as demand flows;
- Desired speed = 50 km/h along the corridor;
- Parameters A and B of the HCM 2010 Roundabout Capacity Model were calibrated for North Tuscany locations (as shown in Table 1).

## 3 Present situation

The corridor length is about 1.5 km (i.e. 0.93 miles). There are seven different intersections along the corridor, spanning from signalized to two-way stop controlled and roundabouts. Different geometric characteristics as well as traffic flows and origin–destination movements for these intersections were entered in SIDRA INTERSECTION 6.0 to obtain realistic modelling of the area. The intersections that are part of the road corridor in the "present situation" are shown (numbered) in Figure 2. These are described in more detail below.

Traveling along the corridor in a W–E direction you can find the following intersections:

- Intersections n° 1-2-3 are assembled in "Piazzale Don Aldo Mei" (Figure 3): This forms a big square close to the city renaissance walls (in this area, there is the city door "Porta Elisa") presenting a critical area because of closely spaced signalized intersections. The first intersection is controlled by a "give way" sign, then there are two signalized intersections with pedestrian crossings on all approaches managed by traffic lights.


Figure 2: Road corridor full map with highlighted intersections.

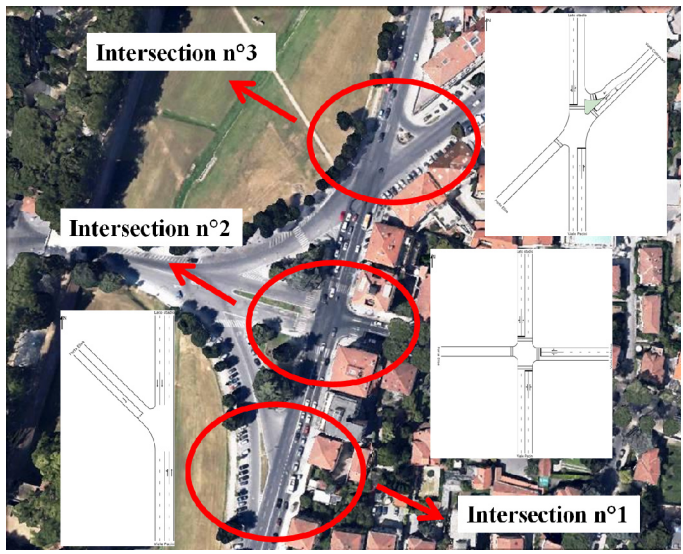


Figure 3: Intersections n°1-2-3 and the SIDRA layout pictures.

- Intersection n°4 (Figure 4): This is a four-way signalized intersection with pedestrian crossings on all approaches managed by traffic lights.
- Intersection n°5 (Figure 5): This is a roundabout with two circulating lanes in front of each branch.

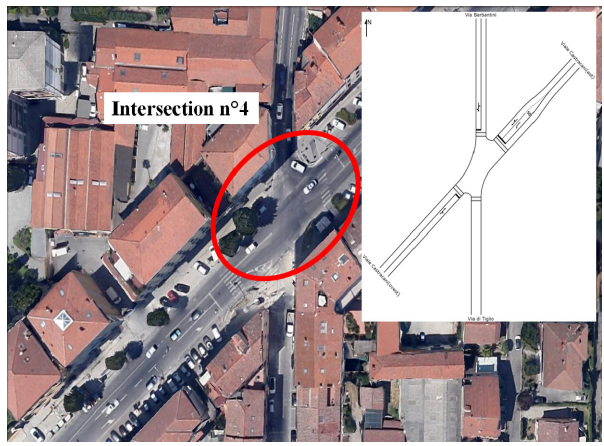


Figure 4: Intersection n°4 and the SIDRA layout picture.


Figure 5: Intersection n°5 and the SIDRA layout picture.

- Intersection n°6 (Figure 6): This is a stop controlled intersection of the main street and a secondary street. An important aspect of this intersection is that, when you arrive at the stop line on Via di Tempagnano (the street to the right in Figure 6), you can only turn right, while if you are on the north approach going towards the south, turning left into Via di Tempagnano is banned. However, generally users do not respect this rule and cause significant queuing on the north approach. Left turns from the north approach were included in the model.
- Intersection n°7 (Figure 7): This is a roundabout with two circulating lanes in front of the west approach, and one circulating lane in front of north, south and east approaches. As seen in Figure 7, there is also a problem of lack of fastest trajectory deflection in the W–E direction treated in the "design situation".

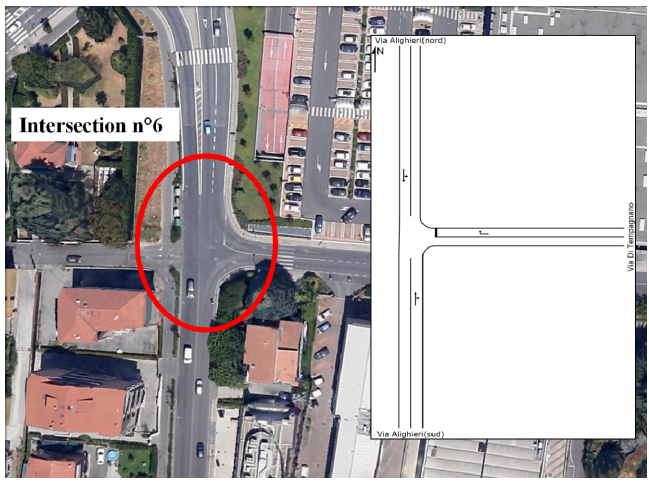


Figure 6: Intersection n°6 and the SIDRA layout picture.

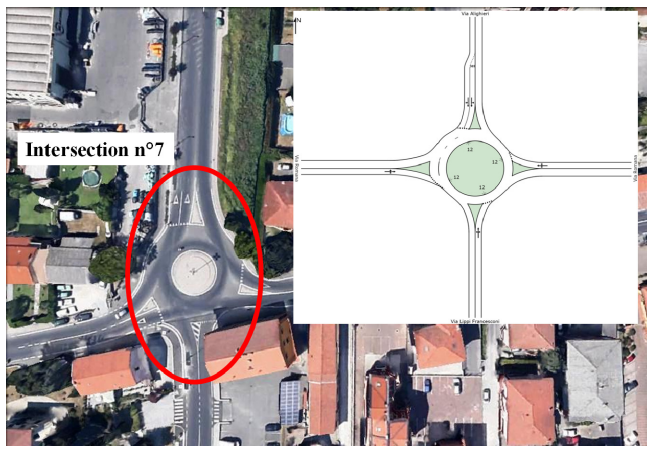


Figure 7: Intersection n°7 and the SIDRA layout picture.

## 4 Design situation

The "design situation" includes some changes to improve traffic conditions in the road corridor. The changes introduced to intersections in the "design situation" are described below.

### 4.1 Porta Elisa's roundabout

This is the main change introduced in the design situation. The roundabout shown in Figure 8 is to replace three intersections including traffic lights at "Piazzale Don Aldo Mei" (shown in Figure 3) [5–7].

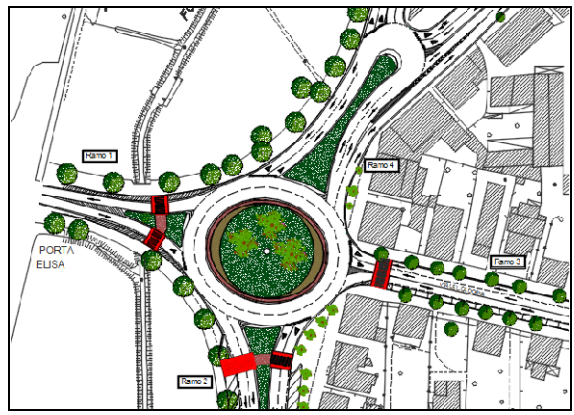


Figure 8: Porta Elisa's roundabout.

The main geometric characteristics of the roundabout are:
- Major axis = 69.00 m;
- Minor axis = 61.00 m;
- Central island diameter = 39.00 m;
- Circulating road width = 9.00 m;
- Number of circulating lanes = 2.

Close to the roundabout, there is a traffic island which has the form of a raindrop and that allows northbound traffic to turn right on Viale Castracani to enter the corridor or go straight on the urban ring road.

### 4.2 Traffic island at the intersection n°4

On Viale Castracani, at the location of intersection n°4, a traffic island (length 60 m, or 180 feet) is to be placed to eliminate left turns from Viale Castracani and Via Barbantini. This last and Via di Tiglio will be one-way exit roads as seen in Figure 9. Other changes include a staggered pedestrian crossing and parking areas [8]. As a consequence of these changes, the existing traffic lights will be removed.

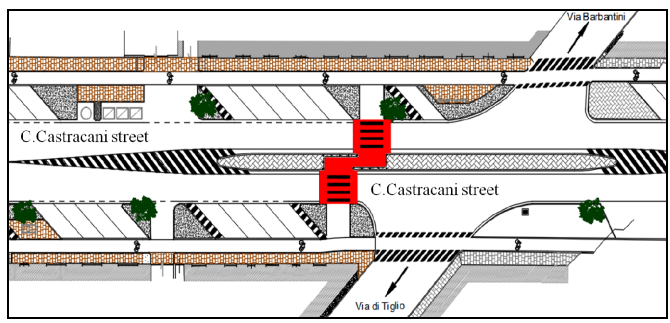


Figure 9: Traffic island.

### 4.3 Roundabout at the intersection n°6

A new roundabout is to replace the stop controlled intersection [5–7] with the objective of improving traffic conditions, especially because of queues caused by left turns on Via Di Tempagnano (Figure 10).

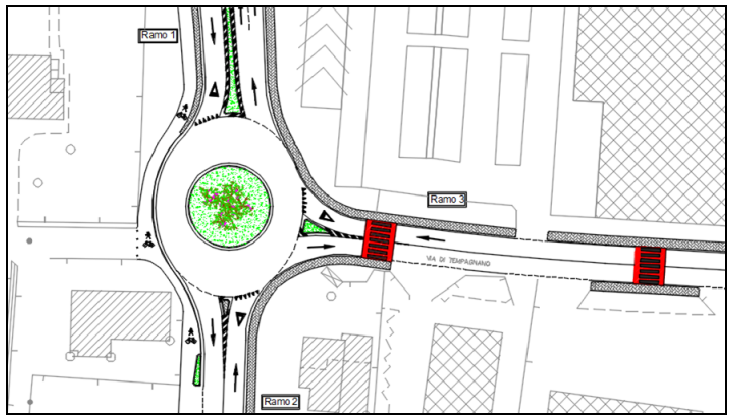


Figure 10: Roundabout at intersection n°6.

The main geometric characteristics of the roundabout are:
- Major axis = 33,00 m;
- Minor axis = 27,00 m;
- Central island diameter = 15,00 m;
- Maximum circulating road width = 8,50 m;
- Minimum circulating road width = 5,50 m;
- Number of circulating lanes = 2 (north/south approach); 1 (east approach).

### 4.4 Roundabout at intersection n°7

To improve the geometric configuration of the existing roundabout, the south side of the central island is to be extended because of the need to solve the problem of fastest trajectory deflection in the W–E direction obtaining the new layout (shown in Figure 11).

## 5 Results

We modelled the two networks representing the present situation and design situation by specifying O–D movement definitions and other parameters required by the software. We obtained some very interesting results analysing the two networks as well as analysing individual intersections.

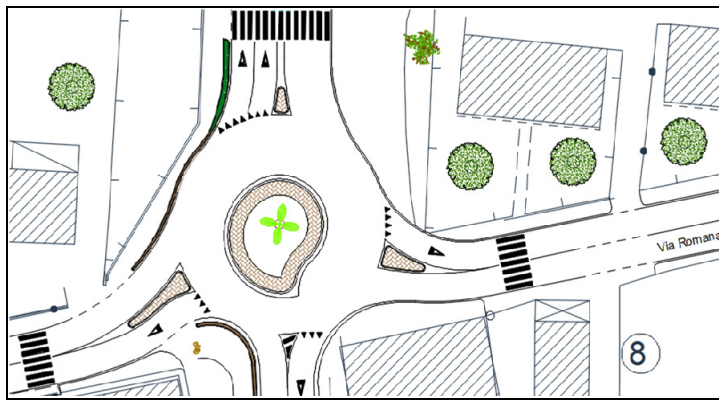


Figure 11: New layout of the intersection n°7.

Individual intersection analyses were carried out to discover measures that produced best improvements of traffic conditions in terms of queue length and average delay, especially on some particular approaches. The comparison between the two different networks is depicted in Figures 12 to 14. These three figures, drawn from SIDRA INTERSECTION 6.0 outputs, show improvements in some critical points of the two networks as well as the roads in the adjacent areas both in terms of both queue lengths and approach Levels of Service.

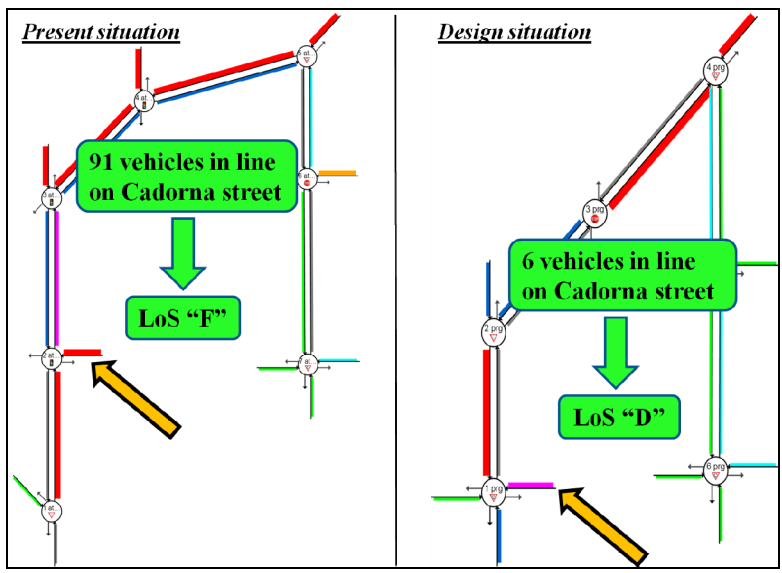


Figure 12: Intersection n°2 – east approach.

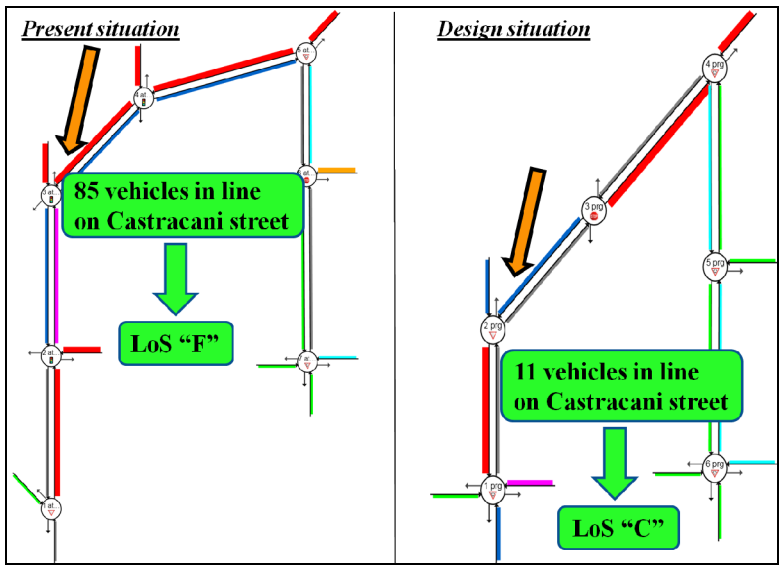


Figure 13: Intersection n°3 – north–east approach.

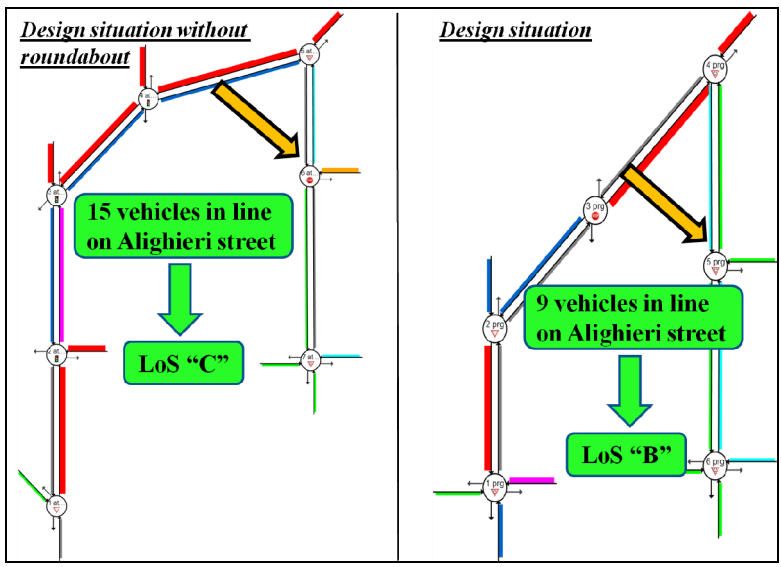


Figure 14: Intersection n°6 – north approach.

Figure 14 is related to the design network but without a roundabout at the intersection n°6 (left), compared with the full changed network as previously described in "design situation" (right).

A summary of results is presented in Table 2. This highlights the comparison of the most important network output parameters for the two networks representing the present situation and design situation.

Table 2: Network output comparison.

| Network Performance (Vehicles Only) - Hourly Values | | | | | |
|---|---|---|---|---|---|
| Performance Measure | Units | Network A PRESENT SITUATION | Network B DESIGN SITUATION | Difference Network B - Network A | % Difference Diff / Network A |
| Network Level of Service | | LOS F | LOS D | NA | NA |
| Travel Time Index | | 0.07 | 3.99 | 3.92 | 5868.0 |
| Speed Efficiency | | 0.11 | 0.46 | 0.35 | 333.0 |
| Congestion Coefficient | | 9.43 | 2.18 | -7.25 | -76.9 |
| Travel Speed (Average) | km/h | 5.3 | 23.0 | 17.7 | 333.0 |
| Degree of Saturation | | 3.383 | 1.178 | -2.205 | -65.2 |
| Cost (Total) | $/h | 12801.12 | 4503.49 | -8297.63 | -64.8 |
| Fuel Consumption (Total) | L/h | 1504.5 | 824.5 | -680.0 | -45.2 |
| Fuel Economy | L/100km | 31.9 | 13.7 | -18.2 | -56.9 |
| Carbon Dioxide (Total) | kg/h | 3535.6 | 1937.5 | -1598.1 | -45.2 |

## 6 Conclusions

As seen in Table 2, “Level of Service D” is obtained in the “design situation”, which is the minimum value required in urban field, whereas “Level of Service F” is obtained in the “present situation”. Substantial improvements are indicate in all performance measures.

Therefore, the results of the modelling effort strongly support the design proposal of improving the west road corridor for accessing the new hospital of Lucca. This finding is emphasized considering that ambulances are the most crucial users of the road corridor.

Our analyses also showed that improved traffic conditions in the corridor could be obtained only considering the proposed road corridor improvements as a whole.

In relation to vehicular traffic along roads in the adjacent areas, SIDRA INTERSECTION indicated various improvements under the design situation, especially in terms of reduced queue lengths.

Currently, the works for building the large roundabout of Porta Elisa are in progress. We are pleased to think that such a practical result is also due to our detailed modelling effort.

## Acknowledgement

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## References

[1] TRB, *Highway Capacity Manual* 2010, N.R.C., Washington D.C.
[2] TRB, *NCHRP 772: "Evaluating the Performances of Corridors with Roundabout"*.
[3] Akçelik, R. An assessment of the Highway Capacity Manual 2010 roundabout capacity model. *International Roundabout Conference*, Transportation Research Board, Carmel, Indiana, USA, 2011.
[4] Akçelik, R. Lane-Based Micro-Analytical Model of Roundabout Corridor. Paper presented at the *CITE 2013 Annual Meeting*, Calgary, Alberta, Canada, 2013.
[5] Pratelli, A. Dispense del corso di Teoria della Circolazione: "progetto delle intersezioni a rotatoria", (Edizione marzo 2001), TEP, Pisa.
[6] Pratelli, A. Rotatorie di nuova generazione, TEP, Pisa.
[7] Pratelli, A. Annotazioni di viabilità urbana, TEP, Pisa.
[8] Bollettino Ufficiale CNR n. 60 del 28.08.1978.