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Measure Evaluation Results

BOL 5.1 Urban Traffic Safety Plan

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Executive Summary

With regards to road safety issues, in 2003, the Road Safety Plan was approved on the city level. The Plan focused on detailed technical issues and addressed a range of strategic activities to implement. Among other aspects, the plan enabled to identify black spots (places where the number of accidents is particularly high) and provided a comparative analysis of the number of urban accidents with other cities in Italy. Mayor steps were realised and statistical data on casualties up to 2005 reached the provisional outline. Furthermore, in 2005 the Municipality of Bologna endorsed EU and national initiatives which aimed at halving the number of road casualties (people killed and seriously injured) by 2010. To achieve this goal, a context-oriented and integrated approach is required and therefore significant efforts had to be done to elaborate a long-term city-scale strategy, involving all parties, including citizens and key-partners.

The frame of the MIMOSA project offered a great opportunity to the city of Bologna to pursue these efforts and the measure 'Urban Traffic Safety Plan' was elaborated with the aim at testing the efficiency of infrastructural and non-infrastructural actions elaborated in the frame of the Road Safety Plan. One of the main activities was thus the implementation of 30 km/h speed limit areas as an innovative pilot project. Thereby, the measure is related to two other MIMOSA measures which shared the common high level objective to improve road safety: BOL 5.2 'Safer Road to School' and BOL 8.5 'Stars: Automatic Enforcement of Traffic Lights'.

This measure was divided in two tasks:

Task 1: Implementation of traffic calming actions (2008 - 2012) Prior to enforcing the 30 Km/h area, road works were undertaken to improve the traffic regulations and re-design the infrastructure for crossroads and pedestrian crossings in the focused area of via Garavaglia. The central part of the area was transformed into a public garden and exclusively accessible to pedestrians. In 2012 work began for the 30 Km/h zone in this area.

Task 2: Road safety plan application (2008 -2012) Several activities were conducted during the MIMOSA period with the focus on road safety improvement including the implementation of IT systems for traffic light crossing enforcement, optimising traffic light design, completing technical analyses of the Variable Message Signs (VMS) for speed display (signs giving drivers their real time speed). Subcontractors which were selected by the Municipality in the frame of tender procedures were in charge of these activities. Additional activities were carried out by the Municipality among which the building of intermediate traffic islands to protect pedestrian crossings and the installation of new traffic lights at pedestrian crossings were the most prominent. During the entire process, continuous monitoring of 'black spots' was carried out to update the database of accidents and injuries and fine tune actions based on the current situation.

The impact evaluation focused on traffic levels and traffic flows in the 30 km/h area. Since the measure is related to two other MIMOSA measures aiming at reducing accidents rate in Bologna, a bundled indicator was selected to measure the accident rates on the city level. The **key results** showed that the activities related to traffic calming and safety were successful. A reduction of 46% of accidents at crossings was observed after the implementation of traffic islands (comparing data before the interventions and at the end of the measure) and a reduction of 34% of accidents was measured at intersections where traffic lights were implemented. Furthermore, the bundled indicator (accidents, people injured and killed throughout the Municipality of Bologna included in the analysis) showed a significant reduction: 21.1% fewer accidents from 2010 to 2007 (the last year without any Mimosa measures) and 21.65 fewer people injured over the same period. Concerning the

pilot area a reduction of 26% reduction in traffic flows with steady traffic levels demonstrated that this new 30 km/h regulation does not reduce the access quality.

During the preparation phase for the infrastructural interventions at the identified 'black spots' (redesigning and modifying crossroads, changes to traffic patterns, renewing traffic lights) and the 30 km/h zone, the most important **barrier** the Municipality faced was the excessive bureaucracy. The application of new and more restrictive tender procedures for public works assignment and the opposition of the Cultural Heritage Department (when road works impacted on existing assets) had to be overcome through several preparatory meetings.

On the other hand, the constructive partnership between Municipality offices and the police department chiefs and the RER (Emilia-Romagna Region) has been a continuous **driver** for this measure. In combination with the availability of new technologies, these drivers became a powerful combination to achieve the measure's objectives. This new technology included the STARS device, implemented under Measure 8.5, and information panels for vehicle speed detection. These devices helped deter speeding and other behaviours violating the highway code.

From the experience of Bologna, **it is highly recommended** to invest preliminary resources in the elaboration of a detailed plan to investigate traffic conditions and road safety issues. Firstly, a preparatory plan provides a focused analysis of the current situation for each selected areas and therefore guide the elaboration of appropriated and context oriented traffic calming measures. Secondly, the preliminary plan is the main guide to pursuing the goal of improving road safety in case of political changes or of lack of a leading role, as it happened in Bologna

The lack of leading role raised difficulties in the implementation of the measure. **The main insight learnt in the process** was the relevance of continuing, extensive cooperation between the three different public partners within the local administration: Municipal Police office, Mobility office and Public Works office. Good internal cooperation is essential to ensure the transfer of relevant information for the decision-making and ensures continuous and coherent public communication during the process. Transfer of information between the several public administration departments is also crucial for the elaboration of "tailored" interventions and for the identification of challenges which required specific focus and resources.

Despite the city-scale interventions and the changes asked to citizens in their mobility behaviors, the public opposition was low during the process. This can be explained by the intensive and continuous public communication addressed to citizens during the entire process: citizens were always up-to-date on the progress of the measure through website and communication campaign and the objectives of improving safety were clearly explained from the earliest stage of the measure. As a result of this positive feedback, the 30 km/h pilot project was already extended to two other areas: in via Sacco and via Vanzetti. Thereby, the high acceptance among citizens during the process can be seen as one of the successful steps towards a long-term road safety strategy in Bologna.

A Introduction

A1 Objectives

The Measure's objectives were:

- (A) High level / longer term:
 - (1) To improve road safety
- (B) Strategic level:
 - (2) To improve safety and security in the municipality of Bologna
- (C) Measure level:
 - (1) To halve the number of road casualties (people killed and seriously injured) with respect to 2008
 - (2) To test the effectiveness of a combination of infrastructural/non-infrastructural actions
 - (3) To demonstrate the effectiveness of a pilot 30 km/h speed limit area in reducing traffic flows

A2 Description

In the challenge for road safety, the Municipality of Bologna endorsed EU and national efforts aimed at halving the number of road casualties (people killed and seriously injured) by 2010. To reach this goal the Municipality carried out several ongoing, innovative measures, and will continue to do so in the future.

Ordinary approaches and designing a simple set of infrastructural actions in specific areas are inadequate to achieve such an ambitious goal. The great relevance of this issue required an innovative approach, addressing efforts toward extensive for the long term.

The Road Safety plan adopted in 2003 responded to these requirements with a scientific and detailed focus. It detected black spots (places where the number of accidents is particularly high) and compared the number of urban accidents with other cities.

Therefore, based on inputs from the Road safety plan, with this Measure the Municipality intended to implement and test several infrastructural/non-infrastructural actions. The aim was to improve road safety and check the effectiveness of the actions in the distinctive scenario of Bologna. The core of the Measure therefore included two complementary approaches. These were **accident reduction**, in which traffic engineering work was done (e.g traffic lights, traffic islands, changes to road sections) to reduce the number and severity of accidents; and **spatial accessibility of vulnerable road users**, in which action was taken to promote the mobility of vulnerable users.

As regards **the first approach**, the Municipality assessed traffic engineering work done in places where accidents tend to occur to pedestrians (black spots for weaker users) in order to reduce the risk of accidents. Traffic islands and traffic lights at pedestrian crossings were analysed. **For the spatial accessibility approach**, the Measure considered implementing a pilot 30 Km/h speed limit area. The aim was to introduce a new traffic calming measure in a particular area through:

- parking places review;
- mini roundabouts;

- chicanes;
- redesigning curb extensions;
- pedestrian refuges and/or small islands in the middle of the roads;
- speed bumps and/or tables.

B Measure Implementation

B1 Innovative Aspects

The innovative aspect of the Measure was:

New conceptual approach - The innovative feature of the Measure is the extensive 30 km/h speed limit area and the integration of the road safety plan with an extensive deployment of ITS control systems.

B2 Research and Technology Development

RTD work was aimed at investigating the state-of-the-art of the planned interventions with particular reference to:

- **interventions at black spots:** the Plan includes measures to improve the quality of the infrastructures and reduce the number of road accidents at the first 30 black spots (those with the highest accident rates). Of the 30 black spots where infrastructural and road safety interventions were planned, 15 have been realized or are underway. The remaining 15 interventions are at different levels of planning and realization;
- **protection for vulnerable users:** with reference to safety analysis of fatal accidents (from 1999 to 2004), 6 of the 11 zones requiring where structural interventions have been realized;
- **other work was carried out to protect pedestrian crossings:** 7 road segments were equipped with traffic islands, 12 road crossings with traffic lights. The 30 km/h zones were planned.
- **speed control:** 20 STARS stations were set up. STARS is a system for red light crossing control and automatic enforcement, consisting of a camera in a protective device (see Measure 8.5).

Accidents, casualties and injuries “before” and “after” the various interventions between June 2004 and April 2008 were analyzed to show the efficacy of each kind of intervention:

- traffic islands, analysis of the 7 road segments: via Zanardi, via Felsina, via Dante, via Barca, via Barbieri Francesco, via Ferrarese, via Panzini;
- creation or completion of crossings with traffic lights; analysis of 12 road crossings (the total analysis included the time and date of the accident, the type, deaths occurring within 24h, deaths occurring within 30 days and the vehicles involved): Pietra-Emilia, Murri Parisio, Tocana Mascagni, Toscana Camaldoli, Emilio Lepido Salute, Zanardi Poste, Don Sturzo, San Donato Repubblica, San Donato Zacconi Beroaldo, Salvemini Einaudi La Malfa, Quercia Matteotti, Silvani Calori;
- STARS: 24 road intersections are monitored by the STARS system in Bologna, corresponding to 15 video-monitored crossings (see Measure 8.5).

Further analysis was made of accidents occurring in sections where no interventions were made in order to verify the influence of STARS on crossings equipped with traffic lights.

TABLE B2.1: Analysis of interventions realized between June 2004 and April 2008 (*)

	Type of intervention		accidents	casualties	Injuries
1	Protection of pedestrian crossings with traffic islands (1)	Before iune 2004	31	2 (2)	37
		After the intervention - june 2004	23	0	27
		Δ %	-25.8%	-100%	-27%
2	Pedestrian crossings equipped with traffic lights (isolated and to support intersections which already had traffic lights (2)	Before iune 2004	35	0	48
		After the intervention - june 2004	22	1	36
		Δ %	-37.14%	-	-25%
3	STARS	Before iune 2004	84		137
		After the intervention - june 2004	42		54
		Δ %	- 0%		-60.58%
(1)the number of accidents/injuries refers not only to pedestrians but all types of road accidents					
(2) pedestrians injured on pedestrian crossings					

(*) data of accidents available to April 2008

Source: Municipality of Bologna

For the categories of interventions 1 and 2, it can be seen that, even though they were mainly designed to support pedestrians, they also produced benefits for general traffic conditions. This is probably because they led to a reduction in speed and a better detection of the conflict spots between the different road users. At traffic lights where STARS is installed, there was a 50% reduction in accidents and a 61% reduction in injuries. In 2009 the number of fatal accidents in Bologna increased (24 accidents were recorded).

Considering that all areas of Bologna vary in terms of road characteristics, poles of attraction and traffic flows, it was not possible to use control sites to compare the results. The RTD activity representing the state-of-the-art of the planned intervention was a substantial element of the Measure implementation. It was needed to direct future decisions regarding the next set of interventions.

B3 Situation before CIVITAS

The Municipality of Bologna drew up an Urban Traffic Safety Plan in 2005. According to the Italian National Road Safety Plan and the EU White Paper on Road Safety, several actions were planned to halve the number of fatalities and seriously injured road users by 2010. As part of the PGTU (Piano Generale del Traffico Urbano, Urban Traffic Plan), the Plan focused its attention on urban road accidents, where the Municipality, owner of the roads, has exclusive competence for intervention. The Plan frames the phenomenon of traffic accidents in this period, consisting of:

- comparison of urban accidents with other cities;
- detection of black spots, places where the number of accidents is very high.

The Plan also included a comparison with 15 other Italian cities with more than 200,000 inhabitants. It emerged that Bologna had the fifth highest rate of accidents per 1,000 inhabitants and the fourth highest rate of fatal accidents per 1,000 inhabitants.

This comparison with other cities of similar dimensions and inhabitants showed that Bologna needed to improve its position, by reducing the number of accidents.

In order to achieve the goal of reducing the rate of road accidents by 50%, the Safety Plan comprised 4 groups of interventions, divided as follows.

1. Traffic Engineering to reduce road accidents. Bologna's Safety Plan identified "black spots" with the highest rate of accidents. A black spot is a term used in road safety management to denote a place where road traffic accidents have historically been concentrated. For the first 30 black spots (those with the highest rates of accident rates and fatalities) the Safety Plan provided measures to improve the quality of the infrastructure and reduce the number of road accidents.

2. Protection of vulnerable road users. Pedestrians, bicyclists and motorcyclists are the most vulnerable road user groups. If they are involved in a crash, they are at greater risk than vehicle occupants and bear the greatest burden of injury. Hence they require extra attention, with measures that reduce crash and injury risks. The Plan included interventions for these issues, aiming at developing measures to improve both safety and mobility for vulnerable road users. The aim was to present measures within an implementation framework. The main focus was on standardizing infrastructural interventions for the safety and mobility of vulnerable road users. These can be summed up as follows:

- monitored traffic lights at intersections;
- new roundabouts;
- grade-separated intersections and crossings;
- traffic islands;
- 30 km/h zones.

3. Education – Awareness, with two complementary approaches:

- accident reduction, in which measures were taken to reduce the number and severity of accidents;
- accident prevention, i.e. the application of measures to prevent accidents from taking place in the future, mostly deployed via information and education policies.

The Plan included policies aimed at improving the safety and mobility of vulnerable users, such as the Safer Road to School (see Measure 5.2)

4. Enforcement. The Plan also included a "Piano della Vigilanza" (Control Plan), which includes all the measures and actions required to make the interventions effective. The Control Plan covers:

- speed control devices (automatic speed traps were installed in Viale Panzacchi and speed barriers in Via Stalingrado);
- alcohol checks: before the Plan was implemented, alcohol checks were only used after an accident. Under the Plan checks are carried out to prevent accidents, in conjunction with the Highway Police Department. Every Saturday night a patrol checks drivers and records offences. Breathalysers need annual revision, which is done in Rome. The alcohol tests are disposable and they are a very useful preliminary tool in deciding whether to use a breathalyser;
- accident database: the Municipality of Bologna has a good database of accidents thanks to the work of the Municipal Police Department.

An important part of the activities was realised. Statistical data on casualties up to 2005 was in line with the provisional outline, but the road to achieving the planned goal required future efforts from all parties involved, including the general public and stakeholders.

Therefore, the Measure intended to test the infrastructural/non-infrastructural actions designed to improve road safety and check their effectiveness in the distinctive scenario of Bologna. Particular attention was paid to demonstrating an innovative pilot for a 30 km/h speed limit area under the Measure, with advice from other Mimosa partners.

B4 Actual Implementation of the Measure

The measure was split up in the following task:

Task 1- Implementation of traffic calming actions (from 2008 to 2012)

- Planned work for the 30 Km/h area in via Garavaglia was partially completed (end of 2008).
- The first phase of the work for the 30 Km/h area in via Garavaglia was completed. It consisted of changes to traffic regulations and re-designing the infrastructure for crossroads and pedestrian crossings. A central part of the area was refurbished with a new public garden and it was pedestrianised (2010).
- Based on the experience gained from the first 30 km/h area in via Garavaglia, in 2001 the executive plan was completed for another 30 km/h area (in via Sacco and Vanzetti in conjunction with Emilia Romagna Region (outside Mimosa).
- In 2012 a second phase of the work began for the 30 Km/h area in via Garavaglia.
- Work began for the 30 km/h area in via Sacco and Vanzetti, outside MIMOSA.

Task 2. - Road safety plan application (from 2008 to 2011)

- IT systems were introduced for red light crossing enforcement and the traffic light design was optimised (2008-2009).
- The first technical analyses were completed for the Variable Message Signs (VMS) at speed advising stations and the tender was awarded (2009).
- The Municipality of Bologna carried out the following categories of work to improve road safety and rationalise road use:
 - protection of pedestrian crossings with new intermediate traffic islands.
 - Work was completed on installing new traffic lights at pedestrian crossings. The final activities to activate them are underway.
- VMS were installed for speed display signs (information panels for vehicle speed detection). The panels are designed only for information and awareness purposes; they are not yet used for enforcement (2010).
- In 2011, 17 new traffic lights were installed (outside Mimosa) at crossings and pedestrian crossings in order to improve road safety in these areas.

Task 3 -Data collection for evaluation and supervision of safety topics (from 2008 to 2012)

- 'Black spots' were continuously monitored to update the accident and injuries database and fine tune interventions based on the actual situation. Interventions were carried out at black spots based on the findings so far.

B5 Inter-Relationships with Other Measures

The focus of the Measure 5.1 is part of the Municipality's general strategy, via the Urban Traffic Safety Plan, to improve road safety and mobility. It is therefore possible to consider this Measure in a more general context, including the effects of the following measures:

- 5.2 Safer Road to School;
- 8.5 Stars Automatic Enforcement of Traffic Lights.

Nonetheless, every measure mentioned above has its own target, objective and domain. Measure 5.1 refers especially to vulnerable users and interventions to improve safety at crossings. Measure 5.2 concerns safer roads to school, and thus is aimed at young people. Measure 8.5 focuses on reducing improper driver behaviours at crossings equipped with STARS technology. For these reasons, all the measures mentioned above have their own indicators which show the measure impacts in the selected domain of application.

It is true that all the measures pursue the common objective of improving road safety. In this sense, the number of accidents recorded throughout the Municipality of Bologna can be assumed as a bundled indicator, summarising the general improvements to road safety to which these three measures are certainly contributing.

C Impact Evaluation Findings

C1 Measurement Methodology

C1.1 Impacts and Indicators

In order to evaluate the achievement of the Measure objectives, the following indicators were selected to monitor the level of road safety and security (pedestrians and cyclists in particular), through the reduction in accidents, injuries and casualties. Considering that the number and severity of accidents also depends on traffic volumes and vehicle speeds, the use of indicators such as vehicle flows and speeds makes it possible to measure the effects on road safety conditions which change people's accessibility perceptions (to shops, services, places of residence...). The greater the traffic flows and vehicle speeds, the lower the perceived quality conditions of accessibility.

TABLE C1.1.1: Common core indicators

Evaluation area	Evaluation category	Core indicator	Indicator	Source of data
1	Transport	Core indicator 20	No. of injuries and casualties due to accidents at specific black spots	Statistics from Municipal Police
5	Transport	Core indicator 21/22	Flows in new 30 km/h speed limit area	Loop detectors

TABLE C1.1.2: Measure Indicators

Evaluation area	Evaluation category	Typology	Indicator	Source of data
2	Transport	Congestion levels	Flows in 30 km/h speed limit area	Average flows before/after
3	Transport	Congestion levels*	Speed in 30 km/h speed limit area	Average speed before/after

* Average speed can be related to congestion level: the higher the average speed, the less frequently congestion is seen (the assumption is primarily true for areas with speed limits, where the maximum speed is no higher than 30 km/h).

TABLE C1.1.3: Bundled indicator

Evaluation area	Evaluation category	Typology	Indicator	Source of data
4**	Transport	Transport safety	No. of injuries and casualties due to accidents throughout the Municipality**	Statistics from Municipal Police

**Bundled indicator (5.1 - 5.2 - 8.5)

Indicator 1 'Number of injuries and casualties due to accidents at specific black spots'

The chance of being involved in a traffic accident provides a direct contribution to measuring the quality of life. Fatalities and injuries caused by traffic accidents are one of the most important social costs associated with transport systems.

Accident rates are known to vary with the quality of road infrastructure, vehicle technology, driver behaviour, traffic regulations, vehicle density, enforcement, etc. While policies must

address each and every aspect, this indicator provides an aggregated measure of the overall policy performance with regard to safety.

This indicator is particularly important because the numbers of accidents, fatalities and casualties provide an important view of the traffic safety situation. They are normally recorded by city police departments. The focus is on the number of transport accidents causing injury and the resulting number of fatalities and casualties. The underlying reasons for an accident can vary considerably and they are not directly addressed by this indicator.

The control site approach was taken into consideration but not followed, considering that all crossings are different in terms of road characteristics, traffic conditions, the number of people involved, the main factors/fatalities causing accidents and their consequences (casualties and injuries). For these reasons they are not comparable in a significant way.

Transport safety is defined as the number of recorded transport injury accidents and the resulting number of casualties caused by any means of transport. A recorded injury accident is any transport incident causing casualty or injury recorded by the police.

Frequency: Measurements were taken before and after the interventions, and every year thereafter during the Mimosa project to check on the results. In order to reduce short-term influences (yearly changes), the yearly measurements were replaced by average figures, considering the values of a three-year period where the central value is the year of reference. For example, casualties for 2010 are the average of 2009, 2010 and 2011.

Unit: data was collected on the number of accidents, fatalities and casualties at crossings where interventions were planned. It is important to note that safety interventions were done in different years. This aspect implies that there is not only a single year before the interventions and only one year after. The analysis considers two different time periods for each crossing: one before the implementation of the Measure and one after, independently of the year when it was implemented. Data collected in this way can be used to compare safety improvements at every crossing regardless of the Measure's different times of application.

Domain: as reported in point A2 above, the analysis of safety improvements, considered 19 spots in the Municipality of Bologna where safety needs are addressed with traffic islands or traffic lights. These spots are detailed in the Safety Plan and described below in point C.1.2.

Indicator 2 'Average flows in 30 km/h speed limit area' This indicator concentrates on spatial accessibility (in terms of reductions in local pollution, public health, safer, more accessible and attractive urban public spaces) as a consequence of reduced external traffic demand. It assesses the extent to which spatial accessibility changes before and after the implementation of the Measure.

This parameter therefore focuses on spatial dimensions, disregarding other accessibility factors such as economic ones (price of using the service in relation to personal income).

Frequency: Measurements were taken before the Measure implementation and at least once at the end of the Measure. In order to have a valid comparison for the measurements, they will be carried out over a period with the same conditions (weekday, same month, same weather conditions, etc.).

In order to reduce errors of measurement, they were taken over a 3-day period on week days in November. The daily measurement was replaced with an average figure, considering the mean values of a of a three-day period (called "Average weekday").

The measurement was taken using pneumatic road tube counters and a magnetometer sensor classifier, allowing automated traffic data collection, vehicle classification and speed estimation (for specific detail of instruments used for data collection, see References E(2)).

Unit: vehicles/day

Domain: 30km/h zone: via del Giorgione.

Indicator 3 'Average speed in 30 km/h speed limit area' The safety and mobility of vulnerable road users are critical to improving social inclusion in general.

Even if there is not a proven close connection between speed and urban safety, since urban safety depends on different factors such as road infrastructures, traffic levels and driver behaviours, it is known that driving speed is a determining factor for observation. The faster one is driving, the narrower the field of vision and the less one notices the environment.

Studies in others cities show that decreasing speeds from 50 km/h (the maximum speed on urban roads) to 30 km/h reduces vehicles' stopping distances by more than half. It also increases the driver's angle of view and helps cut acceleration/deceleration phases with a decrease in accidents, injuries, casualties and noise in 30 km/h areas. A pedestrian hit by a vehicle travelling at 50 km/h has only a 30% chance of surviving. If the accident happens at a speed of 30 km/h, the probability increases to 90% (source: BFU – Swiss Council for Accident Prevention).

This data should therefore be considered a rough indicator for improving safety in an area where a speed limit is in force.

Frequency: A measurement was taken before the Measure implementation and at least once at the end of the Measure. In order to have a valid comparison for the measurements, they were taken over a period with the same conditions (weekday, same month, same weather conditions, etc.). The measurements were taken during the "3-day period" described for indicator 2.

Unit: km/h

Domain: 30km/h zone: via del Giorgione

Indicator 4 'Number of accidents, injuries and casualties throughout the Municipality'

This indicator extends the size of indicator 1 to the whole of the Municipality, considering locations where no interventions were planned/made. Its objective is to check on the results of the Municipality's efforts to improve safety.

This indicator is a result of many features which are not connected or closely related to the Mimosa project (e.g. areas where no mitigation measures are implemented, or might be easily influenced by other casual circumstances). Measures 5.2 (Safer road to school) and 8.5 (Stars), contributing to improve urban safety, also influence the indicator. As a consequence it can be considered a "bundled" indicator.

Unit: number of accidents, injuries and casualties throughout the Municipality.

Domain: Municipality of Bologna

Indicator 5 'Flows in new 30 km/h speed limit area'

This indicator collects data on average daily flows in the new speed limit zone in via Garavaglia. Data takes into account roads inside the new regulated zone as well as nearby roads. This kind of approach provides an understanding of the consequences of the new project in a larger area. It is common knowledge that any effective traffic project impacts a wider area than the one subject to changes.

Unit: Average daily flow, morning peak (8 am-9 am) and afternoon peak (6 pm – 7 pm).

Domain: 30km/h zone, via Garavaglia.

C1.2 Establishing a Baseline

Between June 2004 and April 2008 the Municipality of Bologna carried out interventions under its Urban Traffic Safety Plan to improve road safety and rationalize road use.

All interventions were defined on the basis of the number of accidents occurring (the higher the number of accidents, the more urgent the intervention was). The initial situation was described in the Road Safety plan, with analysis and figures on road design, accidents and recurring driver behaviours. This document represents the preliminary phase for the evaluation process.

Indicator 1 ‘Number of injuries and casualties due to accidents at specific black spots’

The baseline is the state-of-the-art before the implementation of the interventions.

The interventions were divided up into 2 groups:

- Protection of pedestrian crossings with traffic islands. As part of Bologna’s Urban Traffic Safety Plan, seven road segments were equipped with traffic islands in Bologna. Baseline data regards the number of accidents, injuries and fatalities before Measure implementation.
- Protection for pedestrians with new traffic lights (isolated and in support of intersections which already had traffic lights). Within the Urban Traffic Safety Plan, 12 pedestrian crossings were equipped with traffic lights (some of them already existed, others were added). The Baseline takes into account data from before the safety interventions.

Indicator 2 ‘Average flows in 30 km/h speed limit area’ The domain of this indicator is an area which has been turned into a 30km/h zone. The baseline is before the implementation of the Measure. The measurement was taken between 27th and 29th November 2001; the average values are a mean of these three week days.

Indicator 3 ‘Average speed in 30 km/h speed limit area’ The domain of this indicator is an area which has been turned into a 30km/h zone. The baseline is before the implementation of the Measure. In order to reduce errors of measurement, the daily measurement was replaced with the average of a period of three days (from November 27th to 29th 2001). Measurements were taken using pneumatic road tube counters and a magnetometer sensor classifier, enabling automated data traffic acquisition, vehicle classification and speed estimation.

Indicator 4 “Number of accidents, injuries and casualties throughout the Municipality”

The number of accidents, injuries and casualties is continuously monitored by the Municipality of Bologna. For the Baseline, the trend of values between 1991 and 2008 was considered. Only accidents with injuries and/or casualties were included.

The Baseline shows a significant increase of over 35% in the number of accidents and injuries between 1993 and 2000, compared to a reduction in the number of vehicles registered in Bologna (see References (3)). The situation seems to have stabilize in 2000.

C1.3 Building the Business-As-Usual Scenario

The trend of accidents, injuries and casualties before Mimosa underlines the stabilization of values during the last few years before 2008 (accidents between 5700-5800 units). The Business as usual scenario is considered as the state-of-the-art before 2008. It is therefore

assumed that if the Measure had not been implemented, accident data would not change regarding indicator 4 (for the whole of the Municipality) and, as a consequence, indicator 1 (only the crossings indicated in the Urban Safety Plan). For indicators related to the limited speed zone (numbers 2, 3 and 5), the BaU scenario coincides with the 'before' situation.

C2 Measure Results

C2.1 Economy

Not applicable

C2.2 Energy

Not applicable

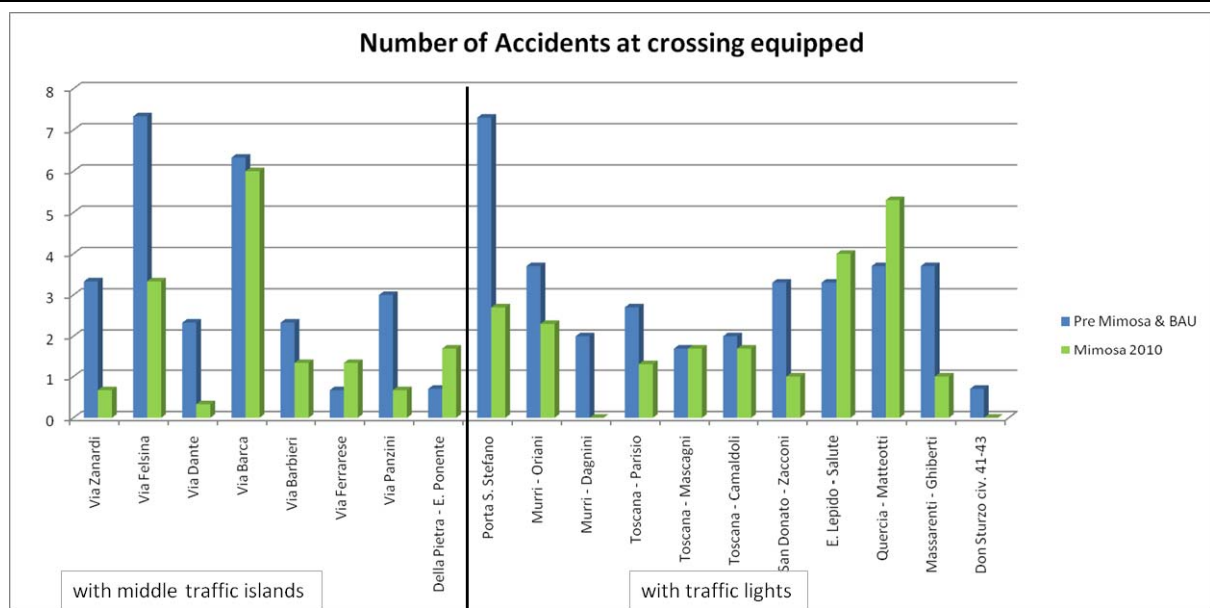
C2.3 Environment

Not applicable

C2.4 Transport

Indicator 1 'Number of injuries and casualties due to accidents at specific black spots'. Indicator 1 records the number of accidents, casualties and injuries at crossings equipped with **traffic islands and traffic lights**. The tables below compare results obtained before and after the Measure. The average value is calculated for the first three years before installation and the average values for the last three years of activity 2010 (average from 2009 to 2011). This approach uses different years to compute the average of the 'before' situation, since not all crossings were equipped in the same year. It is nonetheless a good method of investigating the Measure results because it compares the scenario without the Measure to the results obtained when the Measure was in force. Trends of values for each crossing from the first year of analysis to 2010 (average from 2009 to 2011) are available in the references (4). Tables with detailed picture of behaviour of every single crossing are available in the references (point 5)

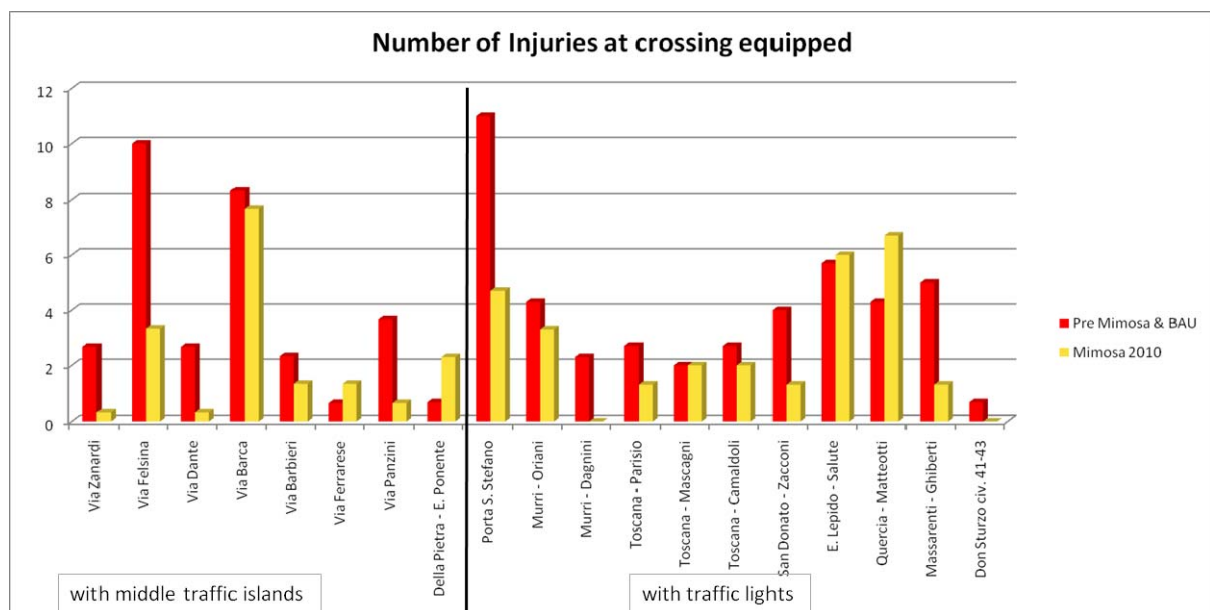
FIGURE C2.4.1: Comparison between accidents at crossings with traffic islands and with traffic lights before (*) and after interventions



* Values of three years before the crossing was fitted out were considered as Pre Mimosa & BaU data.

Source: Statistics Department, Municipality of Bologna

FIGURE C2.4.2: Comparison between injuries at crossings with middle traffic island and traffic lights before and after interventions



Source: Statistics Department Municipality of Bologna

Indicator 1 shows two kinds of data for a complete picture of what happened (injuries, accidents, and casualties are available in the References). The most important item of data for safety evaluation is the number of accidents.

The figures on accidents indicate the safety level in absolute and comparable terms for the crossroads observed. Casualties (and injuries) complete the analysis, giving detail of the severity of the events. Paradoxically, only one accident may have occurred at a crossing in three years (safety should be considered excellent), but during this event many people might

have been injured or died. In this case it is very important to add the value of this data in order to evaluate the severity of the event.

Comparison between average data before and after Mimosa shows an essential improvement in safety at crossings equipped with traffic islands. The sum of accidents in the 7 locations decreased from an average of 25.32 to 15 (more than 40%). The same consideration can be made for crossings with traffic lights, where accidents decreased from 34.68 to 22.67 (more than 34%). Probably this sharp results have been influenced from other safety measures implemented in the Municipality too. One for all is STARS, the automatic system to punish illegal behaviour at crossing. The STARS system was installed alternately at the most critical junctions with traffic lights. Motorists, not knowing where the STARS system was active, changed their driving habits and showed an increased caution at all intersections.

The 'before' and BaU data comes from different years because it considers the average of three years before the crossing was equipped. Considering that the implementation of the Measure takes many years to be completed, this is the only way to analyze the efficacy of the Measure itself. The results show the unquestionable effectiveness of the project.

Indicator 2 'Average flows in 30 km/h speed limit area' . After the implementation of the speed limit area, a new measurement campaign was carried out using the same conditions as the baseline measurements. Measurements were taken using pneumatic road tube counters and a magnetometer sensor classifier. Daily measurements were replaced with the average from a three-day period (November 24th to 26th, 2009).

TABLE C2.4.1: Comparison between average daily flow before and after Mimosa interventions

30 km/h speed limit area - VIA DEL GIORGIONE					
TYPES OF VEHICLE		Pre Mimosa (2001)	Mimosa (2009)	Mimosa vs. Pre Mimosa or BAU	
		vehicles	Vehicles	vehicles	vehicles (%)
Cars	Inwards	5.555	7.629	+2.074	+37,3 %
	Outwards	875	1.640	+765	+ 87,4%
Vans	Inwards	365	452	+87	+ 23,8%
	Outwards	151	160	+9	+ 6,0%
Bus-Truck	Inwards	155	111	-44	-28,4%
	Outwards	75	77	+2	+ 2,7%
TOTAL	Daily flow	7.176	10.069	+2.893	+ 40,3%

Source: Municipality of Bologna

Interventions to improve safety in the 30 km/h zone are an excellent way of regulating speed and driver behaviour without denying access to the area .

A comparison between average daily flow pre and post Mimosa shows a sensible increase in flows (+40.3%) and a significant reduction in heavy flows (trucks, buses). This result indicate as the measure worked as forecasted: people are still use the area, but no longer the heavy

traffic which has been successfully banned. Results demonstrate as the safety implementation pursued through a sharp reduction of velocity did not deny the accessibility of the area.

Indicator 3 'Average speed in 30 km/h speed limit area'

TABLE C2.4.2: Comparison between average daily speed before and after Mimosa interventions

30 km/h speed limit area - VIA DEL GIORGIONE				
MEAN SPEED		Before (2001)	After (2009)	Δ (2009-2001)
Average speed (Km/h)		42,41	40,73	- 1,68
	Inwards	41,89	41,05	- 0,84
	Outwards	45,27	39,33	- 5,94
% speed > 50 Km/h		11,30%	6,70%	- 4,6%
h 6:00 – 22:00	Inwards	9,90%	6,60%	- 3,3%
	outwards	19,10%	7,10%	-12,0%
% speed <40 Km/h		64,50%	71 80%	+ 7,3%
h 6:00 – 22:00	Inwards	66,54%	70,77%	+ 4,2%
	Outwards	53,62%	76,15%	+ 22,5%

Source: Municipality of Bologna

Data can be considered statistically significant with a significance level of 1% (X2-test), for more details see references (5)

A comparison between data from before and after the Mimosa project shows a significant reduction in average speeds. This demonstrates the efficacy of the speed management interventions adopted.

Indicator 4- Bundled 'Number of accidents, injuries and fatalities throughout the Municipality'

TABLE C2.4.3: Bundled indicator results

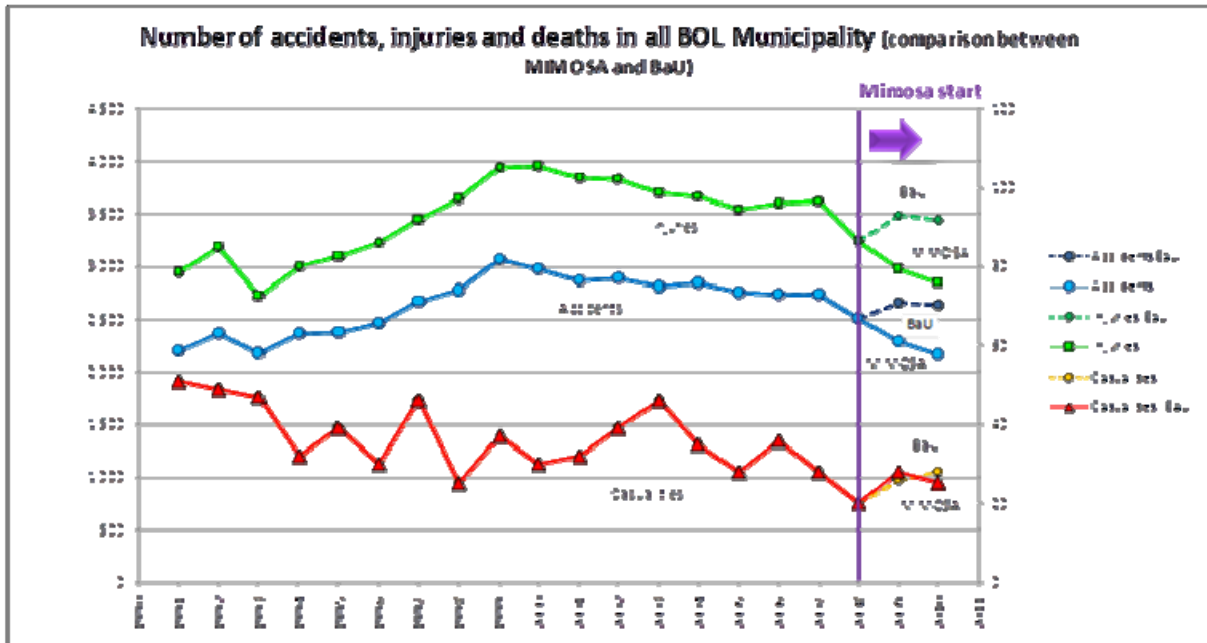
Year	Accidents with injuries or casualties (1)	Number of casualties	Number of people injured	Pedestrians involved		
				Casualties	Injuries	Total
2009	2.288	26	2.976	9	344	353
2010	2.164	28	2.843	9	329	338

Source: ISTAT. ISTAT Data is only available after many months; for this reason the last available data is 2010. (1) Data discards accidents with no injuries or casualties

Data on accidents during 2009 and 2010 shows a significant reduction in values compared to 2007, the last year without the Mimosa Measure (2,743). There was a 16.5% reduction between 2007-2009 and a 21.1% reduction between 2007-2010. Results from bundled indicators showed a significant improvement of safety in the entire Municipality. Obviously

the results are not exclusively from the material interventions in the urban network, instead they stressed the positive effects of measures aiming at a general changing in drivers behaviors, which improve the safety on all Municipality roads.

FIGURE C2.4.3: Number of accidents, injuries and fatalities throughout the Municipality, results



Indicator 5 ‘Flows in new 30 km/h speed limit area’

The results of indicator 5 are given in the table below. The data shows that the project did not affect the accessibility of the area, with a small decrease in the total average daily flow in the last three years. There was a significant fall in the flow in Via Garavaglia (more than 25%), and as an obvious consequence roads near the 30 km/h area saw an increase in the number of vehicles. In this phase of the analysis it is important to underline that data was not collected in the same month. There are more rainy days in October than May and presumably more people used their own vehicles instead of other modes of transport (e.g. walking, moped or bicycle). However, it is clear that the new 30 km/h area did not damage the accessibility of the zone and presumably increased safety for more vulnerable people. As demonstrated by the Study by the Swiss Council for Accident Prevention (see point C.1.1), there is a close connection between speed and user safety, especially in urban areas).

The behaviour of flows underlines another important aspect. When an intervention is planned with a wide impact for vehicle users, it is important to put forward an alternative route so as not to damage the accessibility of a zone.

TABLE C2.4.4: Comparison between pre – post Mimosa traffic flow in the 30 km/h zone (via Garavaglia)

Roads inside 30 km/h zone		Pre Mimosa BaU (October 2007)			Mimosa (May 2010)			Differences between Mimosa- Bau & Pre Mimosa	
		Daily	8'9	18'19	Daily	8'9	18'19	Daily	%
Garavaglia sud	0	2.829	284	167	0	0	0	-2829	-100,00%
Garavaglia nord --> A. Moro/fiera	1	2.524	293	157	954	89	92	-1570	-62,20%
Garavaglia nord --> Salvini/villa	2	3.212	183	256	2.569	198	193	-643	-20,02%
Salvini	3	3.707	224	308	1.138	103	75	-2569	-69,30%
Della Villa	4	1.504	87	125	1.502	108	135	-2	-0,13%
MICHELINO	5	1.297	142	86	2.381	287	158	1084	83,58%
ZACCONI	6	6.081	474	577	7.126	611	615	1045	17,18%
TOTAL		21.154			15.670			-5.484	-25,92%

TABLE C2.4.5: Comparison between pre – post Mimosa traffic flow for roads near 30 km/h zone

Roads near 30 km/h zone		Pre Mimosa BaU (October 2007)			Mimosa (May 2010)			Differences between Mimosa – Bau & Pre Mimosa	
		Daily	8'9	18'19	Daily	8'9	18'19	Daily	%
GALEOTTI Mickiewicz --> Repubblica A	A	14.775	1.425	1.124	13.573	1.340	966	-1202	-8,14%
REPUBBLICA* S. Donato --> Rasi/Marini	B	13.364	1.180	888	13.000	1.223	904	-364	-2,72%
ARTIGIANO Beroaldo --> Ristori C	C	12.322	899	921	12.429	903	916	107	0,87%
S.DONATO Artigiano --> Andreini	D	10.499	672	785	11.826	816	843	1327	12,64%
ANDREINI --> S. Donato / Ferravilla	E	6.926	625	523	6.886	686	488	-40	-0,58%
FERRAVILLA --> S. Donato/Andreini	F	6.148	407	469	5.510	379	472	-638	-10,38%
S.DONATO Ferravilla --> Michelino	G	11.593	895	847	11.094	771	745	-499	-4,30%
S.DONATO Garavaglia --> Salvini	H	8.666	709	650	11.636	896	828	2970	34,27%
S.DONATO** Repubblica --> Lavoro	I	12.418	1.024	943	11.647	1.065	838	-771	-6,21%
BEROALDO S. Donato --> Artigiano	J	5.784	408	498	4.774	352	411	-1010	-17,46%
A. MORO ** Repubblica --> Serena	K	6.832	479	504	5.870	518	403	-962	-14,08%
EUROPA** Fiera/ Michelino nord	L	16.821	1.165	1361	17.529	1288	1428	708	4,21%
FIERA** Michelino -->Garavaglia	M	14.783	1.476	913	16.608	1781	1271	1825	12,35%
A.MORO Garavaglia --> Serena	N	11.766	993	846	13.957	1472	1021	2191	18,62%
TOTAL		152.697			156.339			+ 3.642	+ 2,39%

Source: Municipality of Bologna

C2.5 Society

Not applicable

C3 Achievement of Quantifiable Targets and Objectives

No.	Target	Rating
1	To halve the number of road casualties (people killed and seriously injured) with respect to 2008	**
2	To test the effectiveness of a combination of infrastructural/non-infrastructural actions	*
3	To demonstrate the effectiveness of an innovative pilot for a 30 km/h speed limit area in reducing traffic flow levels	*
NA = Not Assessed; O = Not Achieved; * = Substantially achieved (at least 50%) ** = Achieved in full; *** = Exceeded		

The first objective can be considered to have been achieved in full with reference to the Measure results. The installation of traffic lights and traffic islands improved safety at crossings. Traffic lights reduced accidents by 34% and injuries by 30%. The introduction of traffic islands almost halved the number of accidents.

The second objective is demonstrated by the results obtained from the bundled indicator. This also considers the contribution of other road safety improvement measures acting on different drivers (e.g trying to introduce correct driving behaviours and more sustainable habits).

With reference to the third objective, good results also came from the 30 km/h limited zone. The creation of an area with a particularly low speed limit did not compromise the accessibility of the zone. A comparison between pre and post intervention data shows that flows were substantially unchanged in the surrounding area, but that there was a significant reduction in flows in the limited speed area (-25% in via Garavaglia). Improving the quality of life for residents of via Garavaglia has not restricted their daily habits.

The aforementioned results demonstrate the efficacy of the Measure and the possibility of extending it to other urban contexts.

C4 Up-Scaling of Results

Since the Road Safety Plan already has an urban application, up-scaling is not possible. The Municipality continuously checks its territory to identify critical points requiring structural investments (traffic lights, traffic islands and limited speed zones). The Planning activity is as important as the interventions themselves, in terms of focused interventions. Following this approach, a second phase of work for the 30 Km/h area in Via Garavaglia and Via Vanzetti represented an upscale of the Measure.

C5 Appraisal of Evaluation Approach

The approach used made it possible to evaluate the Municipality's efforts to improve safety, initially concentrating on crossings where effective interventions were planned and realized.

The evaluation of the 30 km/h zone in Via del Giorgione only used old data for comparison. It must therefore be noted that many factors might have influenced during the results over the years. An improvement to the evaluation would be to consider more recent years or more than the two campaigns carried out.

The evaluation of the 30 km/h zone in Via Garavaglia was carried out in two different periods, the first in October and the second in May. This approach does not allow for a unique evaluation of the project since these two months are characterised by completely different weather conditions influencing people's mobility choices (autumn has many rainy days, while there are a lot of sunny days in spring).

In order to improve the evaluation (which is already complete), future similar projects could also evaluate the opinion of residents of the 30 km/h area as regards increased safety conditions, their perception of the area's accessibility or their opinions of the project itself.

C6 Summary of Evaluation Results

The key results are as follows:

- **Key result 1** – 46% reduction in accidents at crossings with traffic islands and a 34% reduction in accidents at crossings equipped with traffic lights.
- **Key result 2** – 21.1% fewer accidents from 2010 to 2007 (the last year without any Mimososa measures) and 21.65 fewer people injured over the same period throughout the Municipality of Bologna (bundled indicator)
- **Key result 3**- Thanks to the introduction of the 30 km/h speed limit area under the Measure, there was a 26% reduction in recorded flows.

C7 Future Activities Relating to the Measure

Another 30 km/h area will be introduced in the coming months in via Sacco and via Vanzetti (outside MIMOSA).

The **monitoring of 'black spots'** will be continued to update the accident and injuries database and fine tune interventions based on future situations.

D Process Evaluation Findings

D1 Deviations from the Original Plan

None

D2 Barriers and Drivers

D2.1 Barriers

Preparation phase

Based on input from the safety plan, during the preparation phase the infrastructural interventions began at the black spots (redesigning and modifying crossroads, changes to traffic patterns, renewing traffic lights) and work was planned for the 30 km/h zone. In this phase the most important barriers the Municipality faced were:

Excessive bureaucracy– the application of new and more restrictive tender procedures for public works assignment and the opposition of the Cultural Heritage Department (when road works impacted on existing assets).

Overall barriers

Lack of economic resources for all planned interventions and road equipment.

Political changes- There was a lack of political will in Bologna for a year and a half. The problem was solved in May 2011 with the election of a new mayor. As in the case of most Measures in Bologna, political changes slowed down the deployment process.

D2.2 Drivers

During the Measure development, the Municipality drew on several overlapping conditions to stimulate the entire process. The drivers used during the different phases are described below.

Overall drivers

A constructive partnership – there was a constructive partnership between Municipality offices, guaranteed both by Municipality managers and police department chiefs. This provided useful data and constant cooperation with RER (Emilia-Romagna Region) with a common commitment.

New technologies – new technologies became available, facilitating the achievement of the Measure objectives. This included the STARS device, implemented under Measure 8.5, and information panels for vehicle speed detection. These devices helped deter speeding and other behaviours violating the highway code.

New funds – new funding from outside the MIMOSA project made it possible to realize some of the road works foreseen by the PGTU.

D2.3 Activities

Preparatory meetings – the main activities in the preparation phase consisted of several meetings with the people involved in the Measure. The aim was to define all preconditions for implementing the planned work (details, decisions and permits). These activities were also

necessary to overcome the aforementioned difficulties related to public works assignments, ones which risked hampering the entire process.

Carrying on with activities following the PGTU – Despite the lack of political will, the Municipality continued to follow the PGTU guidelines and completed the following of interventions to improve road safety and rationalize road use: building new traffic islands, completing the installation of new traffic lights, installing VMS for speed display signs. These activities were undertaken to overcome the second barrier presented above. Thanks to these guidelines, all the planned interventions were completed.

New Accurate planning activities- Since the Municipality was able to carry out some road works using funds from outside MIMOSA, the planned funds were moved to strengthen communication and evaluation activities, promoting project actions and evaluating their impacts. This activity relates to the third driver presented above.

A new executive plan in cooperation with RER- Emilia Romagna Region – Following the successful experience of the 30 km/h area in Via Garavaglia, an executive plan was completed for another 30 km/h area in conjunction with RER- Emilia Romagna Region (outside MIMOSA). This activity relates to the second driver presented above.

D3 Participation

D3.1 Measure Partners

The Municipality of Bologna– COBO. The Municipality (including several offices, such as the police department for data collection) planned all interventions to be implemented within the Measure. It carried out the planned work and is collecting all evaluation data, always following the baselines from the PGTU (road safety plan).

D3.2 Stakeholders

Car drivers and motorists. The Measure includes several interventions designed to increase safety and reduce accidents. Car drivers' and motorists' mobility habits have been changed and are now controlled. To obtain the general public's support, their needs were always managed. People were always informed not only about the new rules but primarily about the reasons for the interventions: to increase their safety and protect vulnerable users.

Vulnerable users: (pedestrians, cycling/walking groups and the general public): these people are the direct beneficiaries of the Measure and those who can benefit from an improvement to their quality of life.

Residents in the areas covered by the interventions who can benefit from increased safety levels.

D4 Recommendations

D4.1 Recommendations: Measure Replication

Invest in a preliminary plan - Cities interested in implementing this kind of intervention must always invest preliminary resources in a detailed plan to investigate traffic conditions and safety topics. Firstly, a preparatory plan makes it possible to investigate the requirements of each area and choose the best traffic calming action. Secondly, in case of political

changes/the lack of a leading role (as happened in Bologna), it is the main guide to pursuing the goal of improving road safety.

D4.2 Recommendations: Process (Related to Barrier-, Driver- and Action Fields)

Extensive cooperation- Any plan must co-ordinate the different participants involved from a technical and organizational point of view. The main insight learnt in the process is the importance of continuing, extensive cooperation between the 3 different participants from inside the Municipality: Municipal Police offices, Mobility offices and Public Works offices. This guarantees integrated information management which supports all decisions and ensures the continuity and reliability of the process for the general public. . In particular, having access to detailed data makes it possible to plan “tailored” interventions (different kinds) and focus the available resources on the main problems.

Invest in communication and information activities – Despite of the level of interventions and changes to mobility behaviors affecting the whole of Bologna, the Municipality did not face any public opposition. This is because citizens were always kept up-to-date and the objective of improving safety was always communicated. A website and communication campaign are very important in order to obtain the support of the people involved.

F Annex

(1) The Municipality of Bologna manages accident data in a cartographic database, where every location (road or crossroad) is characterized with its own information: number of accidents, fatal accidents, index of death/injury, number of weak users involved. This approach allows Mobility planners to classify all points in Bologna's network where accidents have occurred and find possible solutions to improve safety

(2) Pneumatic tubes are hollow rubber tubes stretched across the portion of the roadway where vehicle counts are needed. One end of the tube is attached to a traffic counter and the other end is plugged to prevent air leakage. This means that pneumatic tubes are axle counters and they operate with a pressure hose sensor: the road traffic counter will increment by +1 each time tyres cross over the pressure hose. Counts are finally retrieved by the traffic counter for data collection, which will automatically divide the counts by 2 considering that a car will increment the counter by +2, once for the front tyres and once for rear tyres. The tubes are typically 1.3mm in diameter and they work on all types of motorized vehicles, including motorcycles and motorbikes.

Magnetometer sensors were used to collect speed and vehicle classification data, besides flows data. By collecting classification data it is possible to further determine what types of vehicle usage there is as well as speed and details. The magnetometer sensors detect distortions in the Earth's magnetic field as a vehicle (ferrous metal) passes over the magnetometer, making use of the principle that ferrous vehicles collect and distort the fairly uniform magnetic field lines that shroud the Earth. The sensor element and the recording electronics are built as a single unit. This unit, designed to be very low profile, is mounted in the middle of the lane where traffic data acquisition is needed. By incorporating two sensors in the same unit with a reasonable spacing, speed, direction and vehicle length can be measured. It exhibits good detection rates, even in very slow or stopped traffic conditions; however, counting accuracy is not as good as other technologies. It cannot detect motorcycles or motorbikes.

(3) Vehicles registered in the Municipality of Bologna

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999
Vehicles	244.380	249.349	246.095	231.500	231.190	215.990	213.423	215.907	216.884

2000	2001	2002	2003	2004	2005	2006	2007	2008
214.701	214.670	213.776	212.202	206.411	204.177	201.275	199.254	197.561

Source: A.C.I (Automobile Club d'Italia). A.C.I. is a public administration (a federation of 106 local clubs) which promotes, controls, and regulates the automobile sector.

(4) Accidents, casualties and injuries occurring at each crossing equipped with traffic islands during the period of analysis (the highlighted value refers to the year the equipment was fitted).

TRAFFIC ISLANDS				
<i>Via Zanardi</i>		accidents	casualties	injures
2003 - 2005	2004	3,00	0,33	3,67
2004 - 2006	2005	3,33	0,67	2,67
2005 - 2007	2006	2,67	0,67	2,00
2006 - 2008	2007	1,33	0,33	0,33
2007 - 2009	2008	1,00	0,00	0,67
2008 - 2010	2009	1,00	0,00	0,67
2009 - 2011	2010	0,67	0,00	0,33

<i>Via Felsina</i>		accidents	casualties	injures
2004 - 2006	2005	8,00	0,00	10,33
2005 - 2007	2006	7,33	0,00	10,00
2006 - 2008	2007	6,00	0,00	7,67
2007 - 2009	2008	4,33	0,00	5,00
2008 - 2010	2009	2,67	0,00	3,00
2009 - 2011	2010	3,33	0,33	3,33

<i>Via Dante</i>		accidents	casualties	injures
2003 - 2005	2004	1,67	0,00	1,67
2004 - 2006	2005	2,33	0,00	2,67
2005 - 2007	2006	1,67	0,00	2,00
2006 - 2008	2007	1,67	0,00	2,00
2007 - 2009	2008	0,33	0,00	0,33
2008 - 2010	2009	0,67	0,00	0,67
2009 - 2011	2010	0,33	0,00	0,33

<i>Via Barca</i>		accidents	casualties	injures
2004 - 2006	2005	5,67	0,00	8,33
2005 - 2007	2006	6,33	0,00	8,33
2006 - 2008	2007	6,00	0,00	7,67
2007 - 2009	2008	6,33	0,00	7,33
2008 - 2010	2009	6,00	0,00	7,33
2009 - 2011	2010	6,00	0,00	7,67

<i>Via Barbieri</i>		accidents	casualties	injures
2002 - 2004	2003	4,00	0,00	5,00
2003 - 2005	2004	2,33	0,00	3,00
2004 - 2006	2005	2,33	0,00	2,33
2005 - 2007	2006	2,67	0,00	3,00
2006 - 2008	2007	3,00	0,00	3,67
2007 - 2009	2008	2,67	0,00	3,33
2008 - 2010	2009	2,33	0,00	2,67
2009 - 2011	2010	1,33	0,00	1,33

Via Ferrarese		accidents	casualties	injures
2004 - 2006	2005	1,67	0,00	1,67
2005 - 2007	2006	0,67	0,00	0,67
2006 - 2008	2007	0,67	0,00	0,67
2007 - 2009	2008	1,00	0,00	1,00
2008 - 2010	2009	1,33	0,00	1,33
2009 - 2011	2010	1,33	0,00	1,33

Via Panzini		accidents	casualties	injures
2004 - 2006	2005	2,67	0,00	3,67
2005 - 2007	2006	3,00	0,00	3,67
2006 - 2008	2007	3,00	0,00	3,33
2007 - 2009	2008	2,00	0,00	2,00
2008 - 2010	2009	1,33	0,00	1,33
2009 - 2011	2010	0,67	0,00	0,67

Accidents, casualties and injuries occurring at each crossing equipped with traffic lights during the period of analysis (the highlighted value refers to the year the equipment was fitted).

CROSSINGS EQUIPPED WITH TRAFFIC LIGHTS				
<i>Della Pietra - E. Ponente</i>		accidents	casualties	injures
2003 - 2005	2004	1,00	0,00	1,00
2004 - 2006	2005	0,67	0,00	0,67
2005 - 2007	2006	0,33	0,00	0,33
2006 - 2008	2007	0,67	0,00	0,67
2007 - 2009	2008	1,33	0,00	1,67
2008 - 2010	2009	1,33	0,00	2,00
2009 - 2011	2010	1,67	0,00	2,33

<i>Porta S. Stefano</i>		accidents	casualties	injures
2005 - 2007	2006	10,67	0,00	14,33
2006 - 2008	2007	7,33	0,00	11,00
2007 - 2009	2008	5,67	0,00	9,00
2008 - 2010	2009	3,33	0,00	6,00
2009 - 2011	2010	2,67	0,00	4,67

<i>Murri - Oriani</i>		accidents	casualties	injures
2005 - 2007	2006	5,33	0,00	5,67
2006 - 2008	2007	3,67	0,00	4,33
2007 - 2009	2008	3,67	0,00	4,67
2008 - 2010	2009	3,33	0,00	4,33
2009 - 2011	2010	2,33	0,00	3,33

<i>Murri - Dagnini</i>		accidents	casualties	injures
2005 - 2007	2006	1,67	0,00	2,00
2006 - 2008	2007	2,00	0,00	2,33
2007 - 2009	2008	1,33	0,00	1,67
2008 - 2010	2009	1,00	0,00	1,00
2009 - 2011	2010	0,00	0,00	0,00

<i>Toscana - Parisio</i>		accidents	casualties	injures
2005 - 2007	2006	3,67	0,00	4,33
2006 - 2008	2007	2,67	0,00	2,67
2007 - 2009	2008	2,33	0,00	2,33
2008 - 2010	2009	1,67	0,00	1,67
2009 - 2011	2010	1,33	0,00	1,33

<i>Toscana - Mascagni</i>		accidents	casualties	injures
2004 - 2006	2005	1,00	0,00	1,00
2005 - 2007	2006	1,67	0,00	2,00
2006 - 2008	2007	1,67	0,00	3,33
2007 - 2009	2008	3,00	0,00	4,67
2008 - 2010	2009	2,67	0,00	4,33
2009 - 2011	2010	1,67	0,00	2,00

<i>Toscana - Camaldoli</i>		accidents	casualties	injures
2004 - 2006	2005	1,33	0,00	1,67
2005 - 2007	2006	2,00	0,00	2,67
2006 - 2008	2007	2,00	0,00	3,67
2007 - 2009	2008	3,00	0,00	4,67
2008 - 2010	2009	2,67	0,00	4,33
2009 - 2011	2010	1,67	0,00	2,00

<i>San Donato - Zacconi</i>		accidents	casualties	injures
2004 - 2006	2005	2,67	0,00	3,00
2005 - 2007	2006	3,33	0,00	4,00
2006 - 2008	2007	3,33	0,00	4,00
2007 - 2009	2008	3,00	0,00	3,67
2008 - 2010	2009	0,67	0,00	0,67
2009 - 2011	2010	1,00	0,00	1,33

<i>E. Lepido - Salute</i>		accidents	casualties	injures
2003 - 2005	2004	3,33	0,00	4,67
2004 - 2006	2005	3,33	0,00	5,67
2005 - 2007	2006	2,67	0,00	6,33
2006 - 2008	2007	1,33	0,00	4,33
2007 - 2009	2008	1,00	0,00	3,67
2008 - 2010	2009	2,00	0,00	3,00
2009 - 2011	2010	4,00	0,00	6,00

Quercia - Matteotti		accidents	casualties	injures
2001 - 2003	2002	2,33	0,00	3,00
2002 - 2004	2003	3,67	0,00	4,33
2003 - 2005	2004	3,67	0,00	5,33
2004 - 2006	2005	3,67	0,00	5,00
2005 - 2007	2006	3,33	0,00	5,00
2006 - 2008	2007	2,33	0,00	3,33
2007 - 2009	2008	3,67	0,00	5,00
2008 - 2010	2009	3,67	0,00	4,67
2009 - 2011	2010	5,33	0,00	6,67

Massarenti - Ghiberti		accidents	casualties	injures
2004 - 2006	2005	4,33	0,00	5,67
2005 - 2007	2006	3,67	0,00	5,00
2006 - 2008	2007	3,00	0,00	3,67
2007 - 2009	2008	3,00	0,00	3,67
2008 - 2010	2009	2,00	0,00	2,33
2009 - 2011	2010	1,00	0,00	1,33

Don Sturzo civ. 41-43		accidents	casualties	injures
2003 - 2005	2004	0,67	0,00	1,00
2004 - 2006	2005	0,67	0,00	0,67
2005 - 2007	2006	NA	NA	NA
2006 - 2008	2007	NA	NA	NA
2007 - 2009	2008	NA	NA	NA
2008 - 2010	2009	NA	NA	NA
2009 - 2011	2010	NA	NA	NA

Source: Statistics Department, Municipality of Bologna

(5) Significance test: the **Chi-square test** or **χ^2 test** is any statistical hypothesis test in which the sampling distribution of the test statistic is a chi-squared distribution when the null hypothesis is true, or any in which this is *asymptotically* true, meaning that the sampling distribution (if the null hypothesis is true) can be made to approximate a chi-squared distribution as closely as desired by making the sample size large enough. 9,210 represents the minimum value to obtain a significance level of 1%. The high results are due to the high number of values considered in the test. Following the test, the reported differences between data pre and after Mimosa can be considered statistically significant with a significance level of 1%; this means that there is probability of 99% when the null hypothesis is true. In particular the tests results are:

(*) All vehicles

$\chi^2 = 148,89 > 9,210$

Degree of freedom = 2

(**) Inwards

$\chi^2 = 57,81 > 9,210$

Degree of freedom = 2

(***) Outwards

$\chi^2 = 176,29 > 9,210$

Degree of freedom = 2

The high results obtained in the test are due to the high number of values considered; in general these tests are applied for smaller samples. For high values like these the significance could have been directly assumed.

TABLE: Comparison between accidents, casualties and injuries at crossings with traffic islands before (*) and after interventions

CROSSINGS EQUIPPED WITH TRAFFIC ISLANDS									
Location	Pre Mimosa & BAU (3 years average before*)			Mimosa 2010 (2009 – 2011, 3 years average after)			Mimosa VS. Pre Mimosa or BAU		
	accidents	casualties	injuries	accidents	casualties	injuries	accidents	casualties	injuries
Via Zanardi	3,3	0,7	2,7	0,7	0,0	0,3	-2,7	-0,7	-2,3
Via Felsina	7,3	0,0	10,0	3,3	0,3	3,3	-4,0	0,3	-6,7
Via Dante	2,3	0,0	2,7	0,3	0,0	0,3	-2,0	0,0	-2,3
Via Barca	6,3	0,0	8,3	6,0	0,0	7,7	-0,3	0,0	-0,6
Via Barbieri	2,3	0,0	2,3	1,3	0,0	1,3	-1,0	0,0	-1,0
Via Ferrarese	0,7	0,0	0,7	1,3	0,0	1,3	0,7	0,0	0,7
Via Panzini	3,0	0,0	3,7	0,7	0,0	0,7	-2,3	0,0	-3,0
TOTAL AVERAGE	25,3	0,7	30,3	13,6	0,3	15,0	-11,7	-0,3	-15,4

* Values of three years before the crossing was fitted out were considered as Pre Mimosa & BaU data.

Source: Statistics Department, Municipality of Bologna

TABLE: Comparison between accidents, casualties and injuries at crossings with traffic lights before and after interventions

CROSSINGS EQUIPPED WITH TRAFFIC LIGHTS									
Location	Pre Mimosa & BAU (3 years average before*)			Mimosa 2010 (2009 – 2011, 3 years average after)			Mimosa VS. Pre Mimosa or BAU		
	accidents	casualties	injuries	accidents	casualties	injuries	accidents	casualties	injuries
Della Pietra - E. Ponente	0,7	0,0	0,7	1,7	0,0	2,3	1	0	1,7
Porta S. Stefano	7,3	0,0	11,0	2,7	0,0	4,7	-4,7	0	-6,3
Murri - Oriani	3,7	0,0	4,3	2,3	0,0	3,3	-1,3	0	-1
Murri - Dagnini	2,0	0,0	2,3	0,0	0,0	0,0	-2	0	-2,3
Toscana - Parisio	2,7	0,0	2,7	1,3	0,0	1,3	-1,3	0	-1,3
Toscana - Mascagni	1,7	0,0	2,0	1,7	0,0	2,0	0	0	0
Toscana - Camaldoli	2,0	0,0	2,7	1,7	0,0	2,0	-0,3	0	-0,7
San Donato - Zacconi	3,3	0,0	4,0	1,0	0,0	1,3	-2,3	0	-2,7
E. Lepido - Salute	3,3	0,0	5,7	4,0	0,0	6,0	0,7	0	0,3
Quercia - Matteotti	3,7	0,0	4,3	5,3	0,0	6,7	1,7	0	2,3
Massarenti - Ghiberti	3,7	0,0	5,0	1,0	0,0	1,3	-2,7	0	-3,7
Don Sturzo civ. 41-43	0,7	0,0	0,7	N.A	N.A	N.A	N.A	N.A	N.A
TOTAL AVERAGE	34,7	0	45,3	22,7	0	31	-12,0	0	-14,3

Source: Statistics Department Municipality of Bologna