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ITS and Traffic Control System of Munich: Technical Measures and Benefits

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Abstract

The current substantial implementations of the ITS technology in the Traffic Control System of Munich, manages efficiently to deliver improved services in terms of traffic flow, capacity and safety. This paper investigates those technically intelligent measures taken by Munich's Traffic Control Centre (TCC) in association with of all the private and public organizational, economic and social sources. Moreover, the focus of this research is to highlight the benefit and impact of these measures on account of which the reader of the paper could easily evaluate the efficiency of measures implemented on current traffic. Towards the end, the current challenges of extending the application of ITS is briefed. Furthermore, several future opportunities have been addressed which are being deeply studied by the Traffic Control System of Munich for further implementation into the city's transport. In a nutshell, this paper tries to cover major running ITS applications in almost each and every type of city's traffic control system viz. urban traffic control, motorway traffic control, ring road control, commuting traffic control. The measures and their benefits are observed in light of the goals set by the government for intelligent traffic management. Based on the insight that the intelligent traffic control is a necessity and not just need, we can find many areas of further research.

Keywords: *ITS; Traffic Control System; Munich TCC; SimTD.*

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1 Introduction

1.1 General Definition

ITS integrate telecommunications, electronics and information technologies - in short, 'telematics' - with transport engineering in order to plan, design, operate, maintain and manage transport systems. This integration aims to improve safety, security, quality and efficiency of the transport systems for passengers and freight, optimizing the use of natural resources and respecting the environment [1].

1.2 Background

With enormous development in city's traffic control system, Munich carries third largest traffic in Germany. Intelligent Transport System is therefore vitally important for managing the current and future transport systems of Munich effectively and sustainably. The capital city of Munich and its region follow a cooperative transportation management approach. The Road Traffic Division is responsible for traffic lights, local traffic control, traffic management, and driver registration. Munich has a 1.35 million population in an area of 370 square km. In the outer region of ring highway, there are 2.4 million people in the region of 5,500 square km. There are 2,200 km of roads in the city, while the region comprises 3,800 km of roads [2]. However, ITS is a newly advanced and fast growing area and the standard of knowledge varies across different European cities including Munich.

1.3 Traffic Scenario in Munich

The volume of traffic on Bavaria's roads is on the increase particularly in Munich. The results are a reduction in road safety, deterioration in traffic flow and a rise in environmental pollution. These problems cannot be solved merely by widening existing roads or by building new roads and railways. In order to improve road safety, reduce environmental pollution and increase transport efficiency, there is a need to use the innovative opportunities offered by modern transport technology and telecommunications and that's what Intelligent Transport System fulfills.

Therefore, the state of Bavaria including city of Munich has already started by introducing intelligent techniques in traffic control systems on motorway sections throughout Bavaria [3]. As a consequence, changes in various social and political conditions played an important role in the forecast of city's traffic from base year 2000 to 2015. The modal split is shown in the figure 1 below which is self-explanatory that how mode shares among transport is varying from the base year to forecasted year as a consequence of ITS applications in TCS.

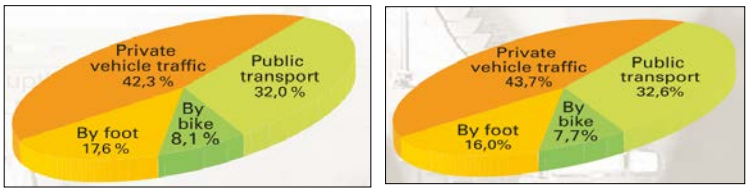


Figure 1: Modal Split (% of Person Trips), year 2000 & 2015(L-R), Munich [3]

2 Objective and Methodology

2.1 Objective and Research Focus

Objective:

The primary objective of the study is to highlight the various ITS applications which have been scoped to the traffic control system of Munich. Covering various modes of transport and means of commuting involving ITS applications, they have been compared from their past performances.

This paper assesses whether the implications of ITS in the current traffic control system of Munich addresses their goals and purposes efficiently. Hence this research work sums up to a one point emphasis as below and answering this question is the main objective of this paper.

Research Focus:

How are the ITS technical measures benefitting Traffic Control System of Munich?

2.2 Goals and Scope of ITS Bavaria

Goals:

The need to monitor and run the goals set by the state of Bavaria and city of Munich, converged all stakeholders from politics, administration, economy and science to support forming an open forum called ITS Bavaria. It is responsible for the looking over the fulfilment of certain goals in terms of ITS as listed below.

- Promotion of Transport Telematics,
- Improvement of an integrated and networked mobility,
- Increase Road Safety,
- Making transport environmentally responsible & economical,
- Informing the people on traffic telematics.

Scope of ITS application:

In a metropolitan city like Munich, it is no surprising that it has wide scope of ITS applications in the current traffic management system. They are broadly categorized as under;

- Motorway Control System (for Autobahns / Expressways),
- Urban Traffic Control, UTC (for urban road environment),
- Public Transport Control (for buses, trams, U-Bahn, S-Bahn, Regional Bahn etc),
- Munich Airport Traffic control (for Franz Josef Strauss Airport).

2.3 Methodology of the study

In this section, the methodological framework adopted for the study has been briefed. To have the former objective fulfilled a detailed information about the measures to improve traffic control system of Munich in light of ITS has been enlisted and briefed. With each measures, corresponding benefits are found. These benefits will then be observed and compared with the goals of ITS Bavaria in discussion segment to find out if the measures applied fulfils the goals or not. In the due course, general challenges and some future opportunities in the study field, which are within the scope of the city of Munich and globally, will be also be studied one by one. Eventually, many member organizations operating within the city of Munich are within the reach. Their involvement in the development work of better ITS strategies for the city's benefit and welfare are discovered.

3 Measures and Benefits of Using ITS in TCS: Munich

3.1 Traffic Signal Control with Inductive Detectors

Traffic Signal Control is possibly seen as the longest established ITS application used within the urban environment of Munich. Although, initially traffic signals did not really include any intelligence, but with the advancement in computer sciences, intersection control has become more specific concern since the 1980's [4]. It is more than just a tool that typically separates conflicting movements at an individual intersection.

Measures:

The signal system in Munich contains microprocessor modules that enable modal-based, artificially intelligent control by using data acquisition from inbuilt inductive loops and detector under the road bed. Currently Munich has 1106 numbers of such signal systems at most of the urban intersections [5].

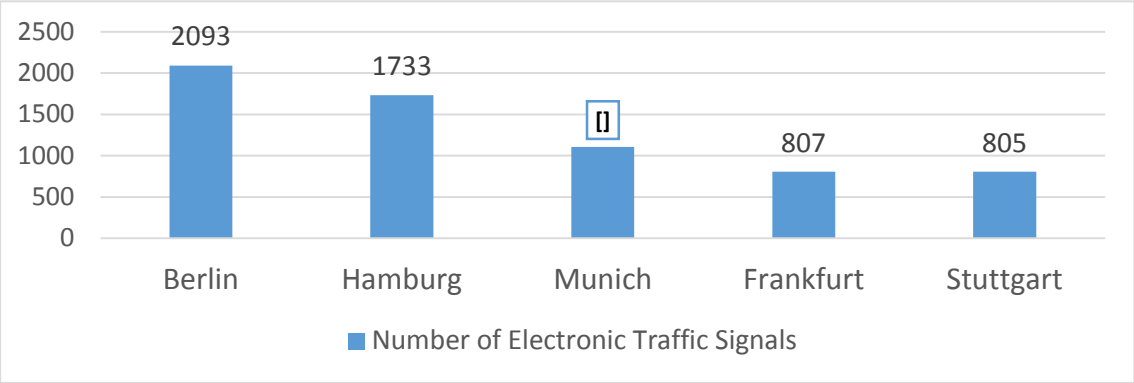


Figure 2: Number of Traffic Signal Control in various German cities including Munich [5]

Benefits:

The consequences are the development of features such as prioritisation of public transport in which it recognise buses, trams etc. for avoiding stopping delays at signals.

That further helps avoiding queue length generation behind the buses and trams. As such the traffic throughput at individual arms of intersection has been optimised [4].

3.2 The MOBiNET Approach

Munich follows the MOBINET (Internet of Mobility) approach which is part of the next generation advanced transport telematics. It started in the current decade and the system is financed by the European Community. The project focuses on multimodal transportation management, innovative transport technologies, and novel mobility services. The structure of MOBINET includes a data network and urban and regional centres. This structure aims at:

- Optimization of traffic in the primary road network.
- Provision of multimodal information services to shift demand to public transport.
- Application of innovative concepts for a mobile society [2].

Benefits:

The following table [2] shows the segmental benefits of ITS strategy used with MOBiNET approach on Munich's Traffic Control System.

Table 1: Measures and Benefits of MOBiNET approach in Traffic Control System, Munich

S. No.	Measure Segment	Advantage and Benefits
1	Intermodal Choice	Managed parking spaces
		Improved public transport
		Reorganized buses to U-Bahn stations
		Provision of more direct links on the U-Bahn
		Alternate routing signage
		Provision of information signs
2	Dynamic Message Signs (DMS)	Congestion on the network for drivers to choose ultimate routing
		Variable Speed Message Signs
3	Information Services	Urban information (city information, events)
		Shortest route algorithms
4	Public Transport Information	Electronic timetables
		Integration of various systems
		Parking information including available spaces
		Information on recreation and leisure

3.3 Traffic Control Centre (Verkehrsrechnerzentralle, VRZ)

The Munich Traffic Control Centre, TCC is the part of MOBiNET. The new TCC is equipped with Intelligent Transport System techniques and is located in the police headquarters of Munich, where traffic connections were earlier made to the traffic signals. The more numbers of traffic lights, detectors and cameras for traffic in roads and pedestrian areas have been installed from earlier numbers 1000 and 77 respectively [2]. The image below shows the upgradation of Munich TCC from year 2008 to year 2015.

Figure 3: Upgradation of Traffic Control Centre from 2008 to 2015, Munich [2]

Benefits of new TCC:

- Cooperation among state, city, transit, and rail.
- Information on pre-trip and en-route information, transportation alternatives.
- Optimization of personal choice of means of transport.

With the latest control system, not just roads but even tunnel information can be accessed and conveyed. There are no video camera images on the web for social usage. The Munich police at the police headquarters can accesses these information for taking control over critical situation of traffic. They are sensitive to this because of security concerns and public welfare.

3.4 Motorway Control Centre

When the city is already advancing in the field of ITS, it is not anymore surprising to know that Munich has its own separate department for motorway traffic specifically under TCC. This is for further enhanced improvement of traffic flow on the motorways originating and passing through Munich and its region. The scope of ITS measures in Motorway control is quite wide and thus they are shortly listed below and shown in following figures from figure 4 to figure 7;

- Network Control System.
- Section Control System.
- Interchange Control System.
- Traffic Control via Information.

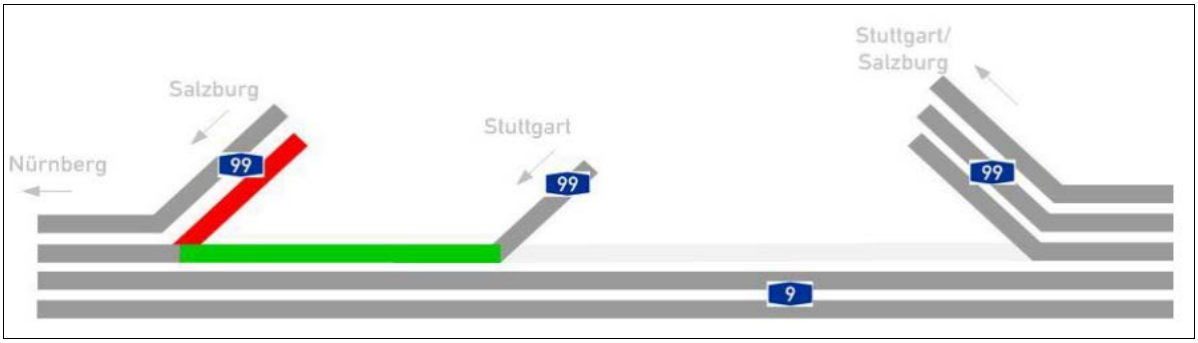


Figure 4: Variable Lane Allocation for Interchange Control system, Munich [6]

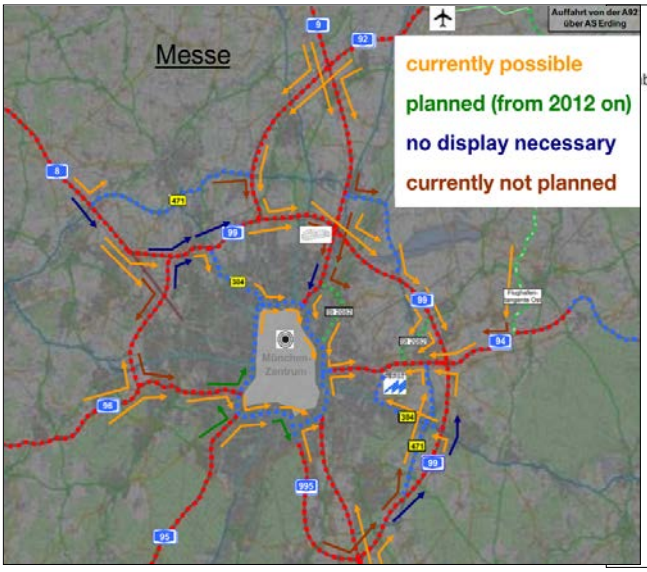


Figure 5: Network Control System, Munich [6]

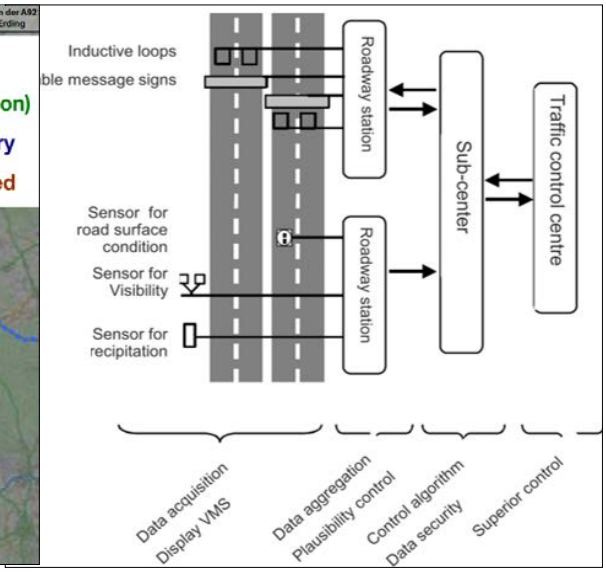


Figure 6: Section Control System, Munich [6]

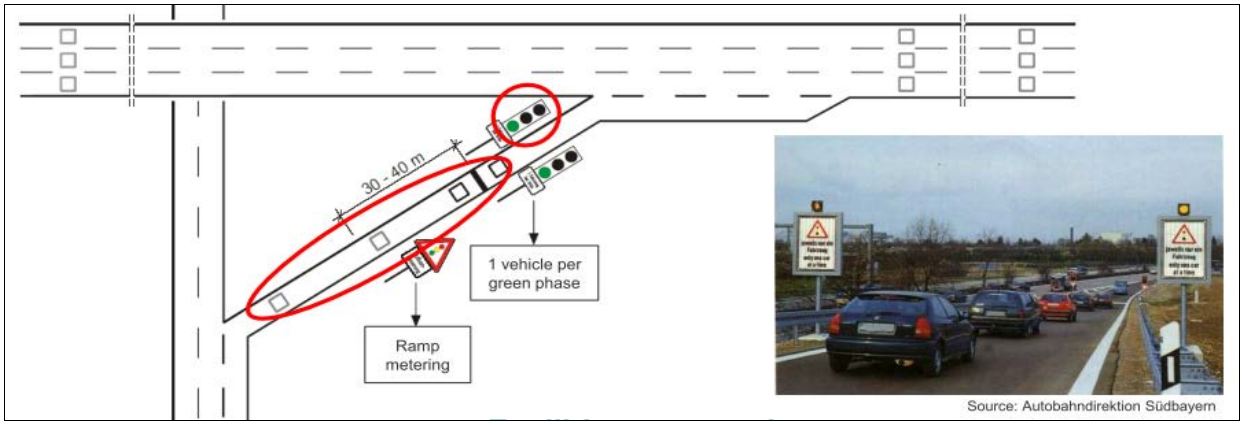


Figure 7: Ramp Metering, Interchange Control System, Munich [6]

Measures and Benefits:

- It uses rain monitors, fog monitors and speed detectors for safe and secure ride.
- Speed enforcement is performed with radar mounted on the DMS.

- Other detection includes loops, radar/ultrasonic.
- The system has 58 weather stations, 120 visibility (fog) meters, 452 sensor loops, and 93 video cameras [2].
- Ramp metering enforces speed limits and it encourages traffic to merge through different speeds in different lanes.
- Data are read every minute in the system.
- Manual settings can be accommodated, such as an emergency call.
- The electronic signs can be changed manually or automatically.
- The DMS algorithm uses variable speed per lane, speed of cars and volume of traffic.

3.5 BMW-ITS Applications (for Ring Road Control)

BMW is one of the leading partner in MOBINET. It is responsible for the main road optimization. Almost all the highways towards Munich end at the Middle Ring. It is around 30 km in length, mostly grade-separated highway out of which only about 25 intersections are signalized. Speed limit is of 60 km/h [2]. It circumscribes the Munich CBD and thus it is of extraordinary importance for the traffic throughout the inner city.

Problematic Situations:

The middle ring road has uneven saturation levels, resulting in frequent bottlenecks and delays, ultimately causing air and noise pollution and low safety levels. This results in high volume rise over 157,000 vehicles/day (Average Daily Traffic) during peak hours [2].

Measures:

With ITS technique, the problematic data are simultaneously collected, simulated and calibrated into a simulation model for development of various ITS scenarios. The best scenario is then integrated into problematic situations which aims to improve the overall traffic system's performance. This is achieved by:

- Harmonizing the traffic flow on the ring road and its major radials.
- Maintaining the system's capacity throughout the peak periods.
- Overcoming the adverse effects of traffic congestion.
- Simulating, evaluating, and ranking the different ITS scenarios for the best package of adaptive control systems.

Benefits:

The results of best package contains the following control systems with various spatial impacts and benefits to the motorists as listed in Table 2 and shown in Figure 8.

Table 2: Measures and Benefits of BMW ITS Application for Ring Road Control, Munich

S. No.	Segment	Impacts	Benefits
1	Area wide	Dynamic and collective information sign (RING-INFO)	Better traffic allocation within the network
2	Section based	Adaptive signal control (BALANCE)	Intermodal and traffic dependent junction control
		Variable lane assignment	Optimal use of existing capacity resources
3	Local	Ramp metering	Access ramps to optimize traffic flow in weaving areas
		Actual traffic conditions	Situation alert to drivers
		Congestion information from the motorist's entrance point onto the ring road	Information to drivers before entering the ring road.

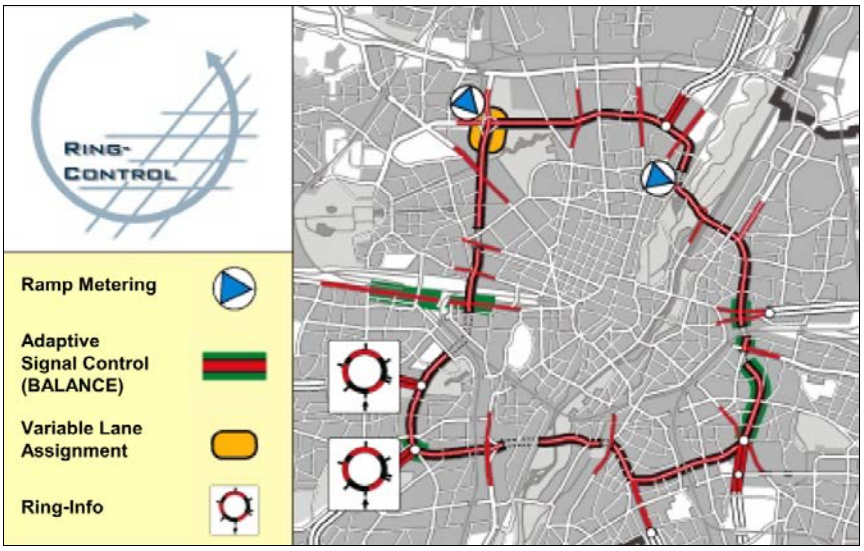


Figure 8: ITS Measures for Ring Road Control, Munich [2]

3.6 BMW i for Munich

For daily commuters, under "BMW i" scheme, BMW has started environment friendly vehicles which can be rented at every independent stations. This discourages private transport usage and cuts off the trip distance and thus reduces continuous on road traffic by significant margin. Currently there are around 500 vehicles at almost all district locations of Munich [7].

Benefits:

- Reduced trips with "Drive Now" and "Park Now" schemes.

- Improved mobility.
- Environmental friendly vehicles.

3.7 BMW Telematics

The navigation unit of BMW uses icons instead of text to provide information to drivers. Messages are generated by acquiring data from the traffic information center and other sources. The data are then forwarded to the message processing center at the Bavarian Regional Center and then to the German Automobile Association for transmission to the car [2]. BMW also has a beacon warning system along motorways (including Munich) that lights red beacons along the road when there is an incident ahead (warning). BMW is also investing in dynamic routing and expects a revenue stream from this venture.

3.8 Bayern-Info Application

Apart from MVG app, the city has smart and portable app for its people. Bayern-Info is an internet based online information system for real time traffic information to commuters and motorists in Bavarian region. The Traffic control centre provides traffic forecasts and real-time dynamic information. The application automatically collects traffic data from detectors, floating cars, traffic counts, and weather data with the preprogramed algorithms. Other information is provided by police headquarters, the German Automobile Association, TV and radio. It has flexibility for service providers to add value-added data to safe guard fair usage policy.

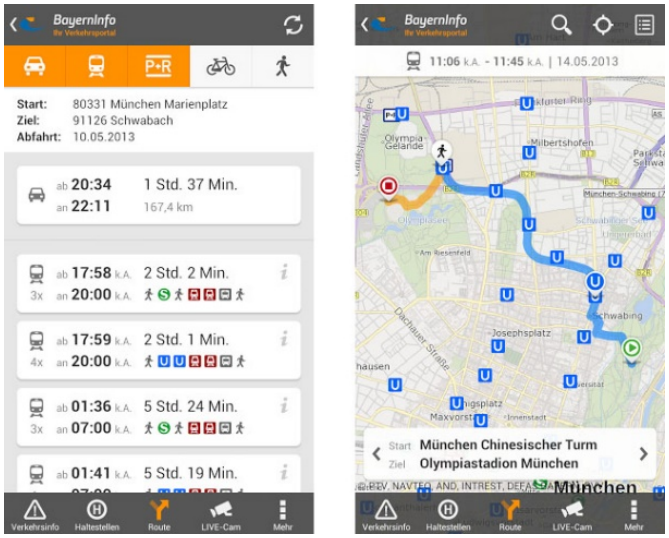


Figure 9: Bayern Info App [8]

Benefits:

With all the support from various departments of the city of Munich and state of Bavaria, it has following benefits for the customer using the application;

- Mobile app can be installed into the cell phones, PDAs and tablets.

- Personalized and customized information.
- Congestion, incidents, and delays are factored in and changes can be sent out to people.
- Contains Rail and Public Transport electronic time tables and itinerary booking options.
- Integrated and automated connections among various systems and modes available.
- Park-and-ride information shows where, when and number of parking spaces available.
- Live Camera images can be accessed.
- Route search with cycling and walking can be found instantly.

4 Challenges and Opportunities

Despite of numerous ITS implementations on traffic control system of Munich, there are still some challenging projects which needs to be highlighted here, and still a lot of ongoing and future scope in the improvement process of the city's traffic management system.

Such some challenging activities and projects in Munich are:

- Munich Automated Underground Parking System, Germany (€11.35 mio).
- COMFORT / TABASCO, for researching traffic control (€15 mio).
- Infoten / CORVETTE, for researching traveler information (€10 mio).
- Motiv / INVENT, for researching control and information (€20-30 mio). [2]

4.1 Future Cooperative systems - Communicating Cars Technology

The direct communication between vehicles among each other and between vehicles and infrastructure (including traffic management centres) leads to a reduction of dangerous situations and a better traffic quality through enhanced and faster information exchange. This is based on the Car-to-X (V2X) technology. The work on this is being carried out in conjunction with other projects like SimTD, in most of the major cities of Germany including Munich at Technical University of Munich [9].

The car-to-x technology (V2X) is now ready for market [10]. The first planned stretch is a corridor between Rotterdam and Vienna, via Frankfurt/Main and Munich. The system was planned for year 2015, and was supposed to record the traffic situation at road works and issue the relevant warnings to drivers. The results are provided in next section 4.2 of this paper.

4.2 SimTD Project

The project SimTD has brought all mega giants of the industry together for one implementation of one technology "Car-to-X" and was initiated by the Association of the Automotive Industry (VDA). The German automobile manufacturers companies like Daimler, BMW, Volkswagen, Opel, Ford, Audi, and suppliers like Siemens, Bosch and Continental are prime members in the project. It is also supported by the German Telekom as a global telecommunication provider.

As mentioned in previous section, the first trial test finished recently and the results were studied in Munich. The test results has clearly shown that there is increased safety, efficiency and comfort on the road. [10].

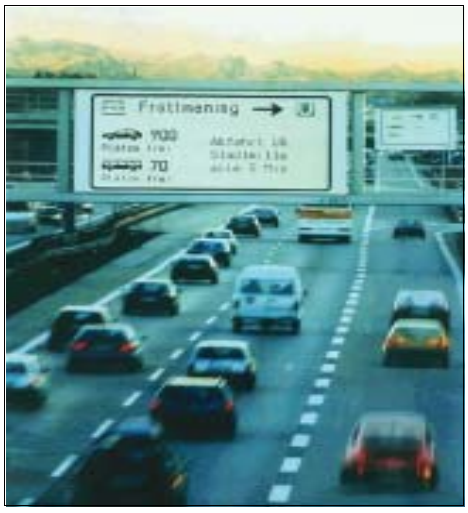
4.3 Other Future ITS Projects in Munich TCC

In Munich, numerous research and studies are being carried on ITS - the most advanced technology of today's era in the field of Traffic Control System. Their impacts and benefits are only partially seen and yet to be researched on wider scale. Some of them are listed below.

- Electric Trucks on Munich roads.
- Audi Hotspot (currently only in Audi A1 city car, A6, A7 & A8). [8]

5 Discussion

After studying all the measures and their relevance towards the ITS goal fulfilment, various such benefits have been identified. For example, DMS are used to tell motorists what is happening up ahead and to provide parking information (park-and-ride) when the sign is not used for traffic management as shown in Figure 10. Another benefit is the reduction of traffic accidents, as shown in Figure 11 below.



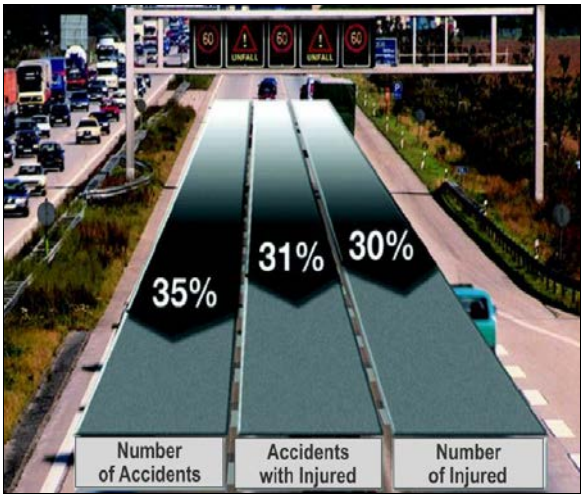


Figure 10: Multimodal DMS, Munich [2] **Figure 11:** ITS Results in Reduction of Traffic Accidents, Munich [6]

In light of the current development in ITS field within the Munich region, it can be said that Munich is already running a multi-modal integrated traffic system. Since most of the benefits meet the goals of ITS Bavaria, it can be clearly illustrated that it is working efficiently till now until the results of future opportunities are not seen practically.

Political support for ITS is very important and that's how the city of Munich has made their way out on the leaderboard in terms of ITS application to its own traffic management system. One such example of deep support is the powerful statement by the Lord Mayor of Munich:

"No one has claimed that intelligent transport technology alone will solve the problems linked to increasing levels of traffic. Quite the reverse is true. But to believe that we can do without intelligent traffic management systems, when we are up to our necks in traffic and transport problems, that is an illusion!" [2].

6 Conclusion

6.1 Research Outcomes

The research finds ITS technology to be playing major role in helping improve TCS of Munich in regards of traffic flow, travel time, information and safety, hence fulfilling goals of ITS Bavaria.

6.2 Recommendation

After studying all the measures and their benefits, the author of the paper is further encouraged to investigate the other way impact of ITS application. Continued focus on research work is highly recommended to keep check on with such an advancing next generation technology.

6.3 Limitations of the Study

Although the research has reached its aim and fulfilled its objective, there were some unavoidable limitations. Only a little amount of detailed research articles are available on this yet growing field. Moreover, some of the technical facts and figures were available only in local language and quite difficult to be included in its original form into the paper.

6.4 Concluding Remarks

Looking at the numerous benefits and impacts, the research concludes that the implementation of all the ITS technologies were not just need of the city's traffic control system but was a necessity of the current and next generation. That's how a city becomes sustainably developed when it has an eye check on the next generation needs, while fulfilling current needs. The outcomes of the study directly relates to the focus of research and it is clearly understandable from the benefits that Munich is marching towards a complete smart city. The idea of writing the paper was according the methodology. Accordingly, all the relevant information were collected from various sources and presented at one place. Consequently, it is discovered that there is huge interdependency among most of the measures. For example, in case of integration of two modes of transport, viz. metro bus and U-Bahn train lines, it is only possible with intelligent traffic signal system, which makes connecting station function as per the timetable. This and many other correlations among measures and benefits can be made out of this paper by the reader.

Acknowledgment

I owe a great many thanks to the support and guidance provided by Dr Birgit Vierling, Program Coordinator, for granting me several opportunities in learning process of scientific paper writing, since the beginning.

The add-on being the topic of the research about home city of Munich for which I was regularly poured with ITS knowledge by the faculty members, especially Dr. Fritz Busch, Chair of Traffic Engineering and Control. I am sincerely grateful to all the authors, researchers and scientists whose work on the topic helped me to write the paper. Lastly, I witnesses the transition of personal and professional development I've had in the due course of masters which makes me feel motivated to write further more in the near future.

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