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Copyright HIL-Tech Ltd.: Active Traffic Management and Dynamic Road Markings; Lit Pavement Markings, Safely Expanding Road Infrastructure Capacity, Without Building More Roads!

Enclosed is a write up on our concept for expanding road capacity, without building new roads. We would like to suggest that our daylight visible LEDlineSunDV™ could not only be used at high accident locations to improve road safety, but could also be tried as a method for temporarily increasing the capacity of a road during rush hours. When traffic is moving slowly, extra lanes could be created by narrowing the road lanes, thus safely helping to reduce today's gridlock around cities.

Apart from contributing to the environmental pollution and ill health, air pollution alerts, road rage and lost productivity; how much does a society lose in time, money and wasted fuel etc, due to today's ever-lengthening traffic jams? The answer according to experts; is that society pays huge amounts for traffic congestion.

According to the Texas Transportation Institute's (TTI) Annual Mobility Report, 2010, which tracks the costs of traffic immobility in 90 - 100 urban areas, estimates of the wasted time and gas, being paid by drivers stuck in today's traffic jams are;

- **"Congestion costs continue to rise: measured in constant 2009 dollars, the cost of congestion has risen from $24 billion in 1982 to $115 billion in 2009.**
- **The total amount of wasted fuel in 2009 topped 3.9 billion gallons – equal to 130 days of flow in the Alaska Pipeline.**
- **Cost to the average commuter: $808 in 2009, compared to an inflation-adjusted $351 in 1982.**
- **Yearly peak delay for the average commuter was 34 hours in 2009, up from 14 hours in 1982.**

The Researchers recommended a balanced and diversified approach to reducing traffic congestion – one that focuses on more of everything. Their strategies include:

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- **Get as much use as possible out of the transportation system we have.**
- **Add roadway and public transportation capacity in the places where it is needed most.**
- **Change our patterns, employing ideas like ridesharing and flexible work times to avoid traditional "rush hours."**
- **Provide more choices, such as alternate routes, telecommuting and toll lanes for faster and more reliable trips.**
- **Diversify land development patterns, to make walking, biking and mass transit more practical.**
- **Adopt realistic expectations, recognizing for instance that large urban areas are going to be congested, but they don't have to stay that way all day long.**

More information about the Urban Mobility Report can be found at http://mobility.tamu.edu" The above is the Copyright Texas Transportation Institute

Moreover, these statistics do not include the associated health costs society suffers from the concentrated pollutants and particulate matter (smog) caused by the ever-increasing traffic jams with longer and longer commutes. There is no costing for the health issues of motorists breathing in concentrated congestion traffic pollution, or when it drifts over residential neighbourhoods what happens there when the pollutants are breathed in by the sick, elderly and young. There is also an anxiety component to increasing traffic jams, road rage being just one manifestation. Therefore, the costs to the today consumer and society are much, much worse.

Which brings up the question, does it have to be this way, and are there no solutions other than continuing the gross environmental damage by continually building new roads to try to keep up with burgeoning traffic growth.

The TTI researcher's first recommendation was; **"Get as much use as possible out of the transportation system we have."** In other words**,** an immediate answer to help severe traffic congestion is to use society's already built infrastructure more efficiently and effectively. This can be done by temporarily creating narrower extra lanes during rush hour traffic, thus dramatically increasing a road's capacity and a cities ability to handle rush hour traffic. For this, policy needs to be changed and the concept researched.

Active Traffic Management: What are needed are Intelligent Transportation Solutions, (ITS) and Dynamic Road Markings (DRM), where today's already built and available infrastructure is used much more efficiently. These solutions should be used in addition to the other side of the transportation equation; to convince people where possible to use mass transit.

We are dealing with the premise, to develop a system that uses the present already built infrastructure more efficiently, by creating temporary narrower extra lanes, as well as using a freeway's hard shoulders, for maximum possible road capacity increase.

These types of solutions could dramatically increase the carrying capacity of road, bridges and tunnels, at a fraction of the cost of building new roads, bridges or tunnels. In addition, using Active Traffic Management, DRM, would immediately increase road capacity compared to awaiting the sometimes 15 – 20 years of; planning and engineering; environmental assessments; the capital funding; and finally the construction of the new road infrastructure. Thus, these types of systems would rapidly expand a Department of Transportation's road capacity, and should allow Departments of Transportation to recover the lanes when needed for emergencies and emergency vehicles; the best of both worlds!

Dynamic Road Markings (DRM), Safely Reducing Traffic Gridlock, yet Still Ensuring Highway Safety. A number of countries are looking at this as a possible way forward in preventing gridlock and the FHWA is interested and wants to hear from any State interested in a trail of these concepts.

There are two basic scenarios for increasing road capacity;

1. **For The Maximum Possible Gain in Road Capacity:** Here, a combination of overhead VMS signs and lit in-pavement markings would be used to create the extra lanes. Made with sunlight visible markings, lit LEDlineSunDV^{TM}, changeable lane markings would be narrowed when traffic speeds were reduced by traffic congestion to say 30kh (20mph) and returned to normal once higher traffic speeds resumed. This would maximize the increase in any road's capacity, since it does not depend on having hard shoulders to be use.

2. **The Easiest Gain in Road Capacity: Using hard shoulders however, does not however maximize road capacity gain.** If a road has hard shoulders, then the easiest way to gain road capacity is to use the hard shoulders, either both sides, or only the outside lane. (Note: many older roads do have hard shoulders, so Departments must look at narrowing the lanes to increase road capacity.)

1. For the Maximum Increase in Temporary Extra Road Capacity Gain; This is achieved by creating more, narrower temporary extra lane/s for increasing a road's capacity to handle rush hour traffic: (This needs research).

Here the lit temporary lanes would be made slightly narrower than the usual lane width, when traffic is moving at speeds of say less than 30kh (20mph) (during rush hours), therefore allowing space for extra lanes. The more lanes that could be created the more significant would be the increase in a road's capacity to handle traffic and the greater would be the decrease in traffic congestion.

The number of extra lanes would depend on the road's width, however, if combined with the temporary use of the hard shoulders (if there are any) could allow for the creation of perhaps

two or even more extra lanes each way! Any city achieving this would effectively be turning back the traffic congestion clock by perhaps 20years or more, when traffic volumes were much less. In such scenarios, traffic congestion should be immediately halved or perhaps even more and motorists, neighbourhoods and the environment, would all benefit from the decrease in wasted time and gas, and the lowering of pollution as traffic congestion becomes much less. Therefore, this is a major way for increasing the capacity of any city's major highways, drastically reducing a city's gridlock.

Before moving to the mechanics of the systems there are two suggestions;

- To differentiate the system from standard white painted lines, these types of changeable lit markings should utilize a different color like yellow LEDs, as a cautionary color.
- All truck traffic in rush hours must travel on the inside slow lane, which would be narrowed the least.

The largest possible and universal increase in road capacity requires narrower temporary extra lanes during peak traffic times. Here LEDlineSunDV^{TM} would provide the Dynamic Road Markings (DRM) rush hour variable lane guidance system.

There are again two scenarios; A) all road lane markings would be of the Active Traffic Management DRM variety and the appropriate lit lane would be switch on or off at will depending on traffic volumes and speed; B). The standard painted lane markings would remain and would be ignored by motorists when the active traffic management DRM lit markings were switched on. However, the painted markings would again provide the usual standard lane guidance, once these lit markings were switched off. This is the least cost solution and has and is been tested in Holland.

1A). Here, all road markings would be of the active road management kind and which markings were turned on would be dependent on traffic speeds / volume. For traffic speeds of say less that 30KMH (20MPH), the narrower lanes would be turned on and they would provided the lane line guidance. Once traffic speeds increase above the selected cut off point, (the 30KMH (20MPH)), then the narrower lanes would start to flash, indicating to motorists, that the lanes were about to change to the standard wider lanes. Any overhead signs would help this process explaining what was happening. There would need to be motorist education on this point.

The process of moving to the lit wider standard lane lines, could start then start with the outside higher speed lanes, and would proceed to the inside low speed lanes, with the wider lit lanes being switch on, and the narrower lit lanes being turned off.

1B). In this scenario, the standard painted markings on the road would remain. However, during rush hours, the lit narrower lane marking system would be switch on and motorists would follow the lit guidance lanes, ignoring the painted lane markings. (Motorists everywhere are familiar with construction sites, where there are often many painted pavement markings that are lest on the road that make no sense, so are routinely ignored during the construction.) This is the system being trialed in Holland and uses half the amount of lit DRM markings so is less costly.

2. To Use the Hard Shoulders of the Freeways; either both, (adding most capacity), or utilizing only the outside lane hard shoulder.

Both emergency freeway hard shoulder lanes are seldom needed all of the time. When traffic congestion was much less, it was considered desirable to keep emergency freeway lanes open at all times, on a just in case basis. However, given the present budget constraints, environmental lobby, limited road expansion and ever-growing traffic gridlock, can any State or Country now really afford this policy? Since no Country, State or Province can afford to provide the capital to build the road infrastructure to handle today's traffic, it is politically, financially and environmentally impossible; therefore, there is no longer a case for keeping emergency lanes open on a just in case basis all the time.

To recover a hard shoulder in case of emergency, a combination of overhead and in-pavement lit guidance lighting might be the least best and safest method to utilize a hard shoulders, since both can then warn motorists when not to use the emergency lane hard shoulder.

Again, there are two scenarios;

2. A. To use both the emergency lane hard shoulders on both sides of the road to expand highway capacity.

2. B. To use just the fast lane emergency hard shoulder

2 A. **Whilst the outside hard shoulder is relatively easy to use, with a combination of overhead signs and in-pavement lighting, (see option B), the inside hard shoulder has both the exits and entrances to the freeway to cope with, as well as allowing motorists to run through the intersection.** To achieve the cross junction running for the inside hard shoulder, there would need to be both overhead signs and DRMs, which move the pavement markings to the right configuration when needed to provide the necessary guidance. The Highways Authority in the Netherlands has successfully trialed inside hard shoulder running since 1999 and Germany since 1999 – 2000. The UK , which often only has hard shoulders on the inside of their motorways, are also interested in this area to expand their road's capacity

2 B. **The easiest to instigate road capacity expansion also provides for the least highway capacity gain.** Here, the inside emergency lane is always available as an emergency lane and is kept open for distressed vehicles and only the outside hard shoulder is used for road capacity expansion and is then retrieved for emergency use when needed. We believe that temporarily using the outside emergency lane / hard shoulder as a normal part of the road during rush hours, will help to alleviate some gridlock, but does not maximise road capacity increase. Its practicality and safety is already clearly evidenced by the closures of lanes during construction often necessitating the use of the outside hard shoulder. When major serious road repairs occur, such closures can sometimes go on for years, yet motorists use these hard shoulders and narrower lanes at construction site, without apparent difficulty.

The ability to use the outside lane / emergency road shoulder would be further helped if there was a way to notify motorists when the outside emergency lane was needed and that it was changing back from a rush hour lane to an emergency lane only. Daylight visible

LEDlineSunDV™ could do this by marking the edge of the hard shoulder perhaps every 12m (40ft). When lit; vehicles can use the lane. When not lit, the hard shoulder is only available for emergencies and emergency vehicles.

The following details how this extra lane solution can be quickly retrieved and be available for use for emergency vehicles and emergencies only: When the in-pavement lights and perhaps some over head signs are switch on, the hard shoulder emergency lane could be used as a normal lane, however;.

- When the in-pavement LEDlineSunDV™ lights start flashing all vehicles must exit back into the normal lanes to allow emergency vehicles priority. Any overhead signs would also inform motorists when the hard shoulder can or cannot be used.
- If the LEDlineSunDV™ is off, (a failsafe solution in case of power failures) then the emergency lane / shoulder remains solely for emergency / distress vehicle use only.

If one wished, added indicators such as pre-positioned red crosses and / or merge arrows could be placed within the emergency shoulder lane to further indicate that the lane was closed to regular traffic and any overhead signs could be set also to indicating that the lane was reverting to an emergency lane status only. **Note: Again, the system would function on a failsafe basis, since no lit lines or lights would automatically mean that the emergency lane had reverted to being an emergency lane only and was only available for emergency vehicles or vehicles in distress.** Therefore, the increase in the capacity of the road would be accomplished without compromising road safety. **At any time a Department wished, the emergency lane could be recovered and revert back its traditional use for emergency and distress vehicles use only.**

Such a flexible system would allow for emergency vehicle access at any time, yet also allow the lane to be used during rush hours. An ITS / DRM system could be programmed to automatically customize itself to any detected traffic problems, automatically closing the lane to general traffic and opening it to emergency vehicles, adjusting itself on an instant by instant basis to traffic requirements.

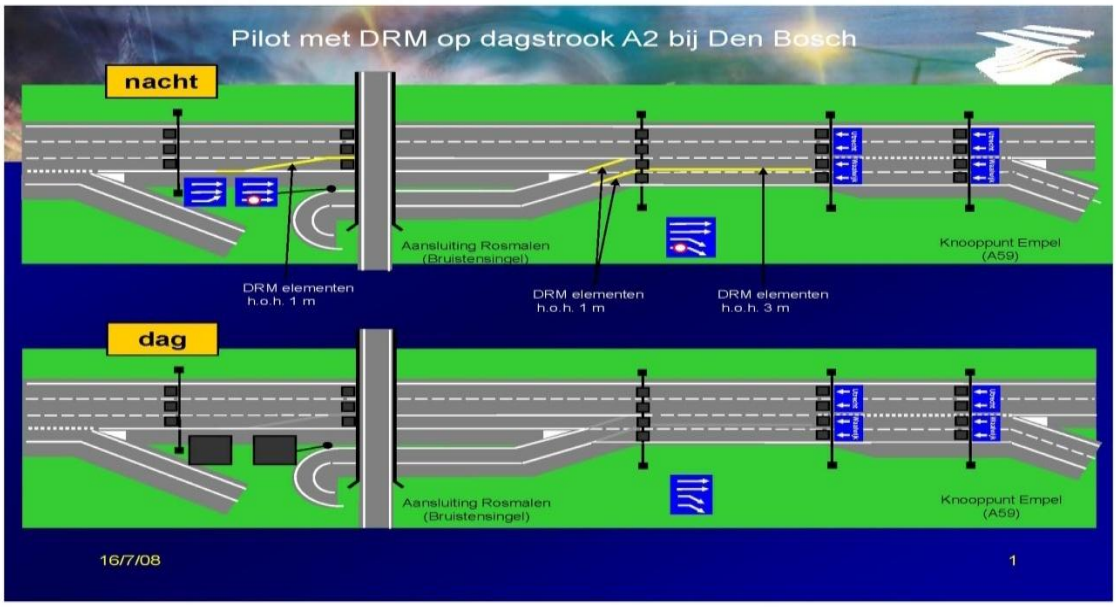
Indeed, if the system was sectionalized and coordinated with other ITS solutions, sensors/ cameras etc., only the lit LEDline® edging sections, prior to the emergency, would be turned off. And any prepositioned red X etc if any, would be turned on This way, motorists prior to the accident would have clear indications that there was an emergency ahead and that the lane was now closed to all traffic. Those after the detected incident would continue to use the lane and would not necessary know that there was a problem, but the extra capacity would be available to move vehicles away from the accident site.

There would of course be a need for public education on the issue, however since the system should be self-intuitive, this would not take too long.

The following is an example of Dynamic Road markings from the Netherlands Department of Transportation, where such road markings have been in use since 1999;

As can be seen in the first figure, vehicles moving from the left, by the bridge, have to merge to

the left as the road ahead is reserved for vehicles entering directly onto the 3rd lane of the freeway. When the Dynamic Road Markings (DRM) is turned off, vehicles can drive straight through and the entering lane merges as usual.



Here is an example of cross junction running. The bottom figure first shows the entrance lane is directly to the 4th lane, below the hard shoulder, allowing vehicles to run through the junction. Whilst when turned off, the vehicles are directed normally to the 3rd lane beyond the hard shoulder.

Mass Transit Priority Lanes: Another area where lit in-pavement markings would help would be to have a temporary extra lane used only by mass transit busses, this way the carrying capacity of the road would remain the same for other vehicles, but the extra buss lane would allow for quick mass transit, encouraging drivers to use the buss.

Presently, in many areas, exclusive buss lanes are being used or considered as a way of reducing traffic congestion and introducing mass transit into areas without mass transit. The use of an exclusive lane obviously allows busses to speed through the traffic to their destination, the hope being that drivers viewing this will give up their cars for the "Speedybus™ "

Extra buss lanes however are not easily accomplished, since roads often cannot easily be widened. Also, widening such roads is a major undertaking, which is very disruptive and is an expensive operation, which often causes more traffic chaos and congestion, whilst construction proceeds.

Unless costly specialized lanes are being built for the busses, the alternative, when roads cannot be widened, is to take and use a lane exclusively for busses during rush hours. This means that the carrying capacity of that road which loses a lane, is severely reduced, again creating more traffic jams, which inevitably propagates onto other highways and roads heading in the same direction, causing them to become choked with traffic, further spreading the traffic jams and exhaust air pollution.

Reducing Road Capacity Is The Wrong Way To Go, Especially When There Is An Alternative:

We believe that by using daylight visible LEDlineSunDV™, an exclusive buss lane can be created both without reducing the capacity of the road and without adding or building additional infrastructure; a huge cost savings. Creating the extra lanes with LEDlineSunDV™ and light is relatively easy, certainly much less costly than building exclusive buss lanes and at the same time, it maintains the present carrying capacity of the road for all the other vehicles, a win / win solution.

Given a successful trial, such a system would enormously expand a city's highway capacity, helping the rush hour gridlock, without compromising safety, for relatively little investment.

Other Dynamic Applications: At night, sequencing LEDline® sections might be able to modify driving behavior, reducing drivers speed. Posted speed signs are often ignored, therefore, if proven, speed bumps and the police and the LEDline® might be one of the few practical effective controls for reducing excessive speed. Policing is expensive and speed bumps on high speed roads would be hazardous, so having a marking system which can fool drivers into thinking they are moving too fast, may be the most practical and least expensive of the alternatives.

Marking Buss Only Lanes Right of Ways: Many cities are trying to improve mass transit by having buss only lanes at certain times of the day. These types of lanes can be confusing to other motorists, especially if the times for the "buss only lanes" change because of changing schedules

of say a large football arena, where large numbers of people congregate at a stadium then after the match leave. It is here that LEDline® can be of help, changing the pavement markings for the tidal flow, either into or out of a stadium area and special buss lanes can be lit and designated with say an in-pavement "X" in the center of the lane to show other motorists that the lane is now exclusive for busses. Such markings also help enforcement agencies, since the times when the lane is exclusively for busses, is intuitive and obvious to other motorists, so transgressors can be easily prosecuted. A possible bonus for this system if the in-pavement lights were centrally controlled, would be that the system could be switched on to help emergency vehicles arrive sooner at a destination.

Modifying Driver Behavior to Reduce Speed: At night, the system could possibly be used to modify a driver's behavior and make drivers slow down at construction sites and other areas where it is installed, especially during bad weather, by not only providing the guidance, but with lit segments sequence towards the driver, different sections at differing speeds. We believe that such a system would provide excellent guidance, but induce hesitation and slight confusion to the drivers, who feeling uncomfortable and unsure of their speed would slow down. As such, this system is one of the few devices, which could possibly modify a driver's behavior on the road.

Controlling Speed during Key Conditions: Depending on traffic congestion, or perhaps bad weather conditions, such as fog, traffic lane speeds could be lit with sections of LEDline® sequentially lighting at the posted or Department of Transportation set speeds. Anyone overtaking the light would be speeding, easily seen and be ticketed

The Zipper Effect, Merging Two Lanes of Traffic Into One: The sequencing lines could be positioned / offset so that merging lanes and vehicles traveling at the same speed of the lit sections could then be positioned alternately to merge two lanes down to a single lane, (a zippered effect), or the lines could be set so that there was space between each vehicle so another could merge into the gap. This is under trial in Holland.

Possibly Modifying Driver Behavior to Reduce Speed at Construction Sites: Construction sites have a problem with vehicles traveling at speed, as the construction site road ways are usual narrow, have temporary road surfaces and can be congested and cluttered with equipment. Also construction sites by their nature are frequently changed, so the route is often unknown, so the site is hazardous to speeders. Most importantly, speeding in such sites is hazardous to the workers at the site. And, since construction often occurs at night, the danger to construction workers is even higher at this time when motorists have limited visibility.

Normally at night, when approaching a construction site, drivers are often confused and hesitant and many initially slow down, however, once they are used to the environment, they tend to speed up again.

The solution is to provide them with excellent guidance, but not have them feel comfortable with that guidance. This can be accomplished by having the key guidance elements LEDline® constantly changing in unpredictable fashions. It is postulated that installing LEDline® sections and having them sequencing towards the drivers, would make them feel as though they are speeding, so they slow down. (The effect would be similar to having painted markings come

closer and closer together, but being dynamic would be more effective). As we understand it, having painted markings closer and closer together often works at first, then as locals get used to the different markings, they tend to ignore them and speed again. However, since LEDline® can be dynamic, people might not get used to the system so quickly, especially if different sections randomly changing and move towards the driver at different speeds.

The dynamic aspect of the guidance even though it shows the way, thus introduces the unpredictable, uncomfortable element, increasing the driver's concentration and hesitation. As such, we believe that this will modify the drivers' behavior and get them to slow down. This has yet to be tried in North America, should work, since there apparently has been a study done in Scandinavia in a tunnel with sequencing incandescent bulbs. The sequencing lights apparently kept motorists speeds down.

Dynamic Rail / Road Crossing Markings: Red LEDline® could be used on the poles of railroad crossings signs and be placed in the road / rail area to flash when trains approach.

Pedestrian Crossing (crosswalks): When placed on either sides of a crosswalk, for increased pedestrian safety, the system could be used to highlight the crosswalks from a distance. More importantly, with the semi-directional LEDlineDV™ on either side of the crosswalk facing in towards the crossing, the system should side light any pedestrians using the crossing, which should allow drivers to see any pedestrians using the crossing from a distance. How brightly or uniformly lit the pedestrians would be, depends on the number of units installed and type of LEDs used. With today's extra bright LEDs few LEDline® units would be needed.

To improve pedestrian safety, the system could also be used to highlight pedestrian islands, so motorists avoid them.

Tunnel Safety and Guidance: The system would also be helpful for guidance for vehicles in tunnels, as well as providing emergency in-pavement safety backup lighting. Pre-positioned road closed crosses and merge arrows could keep traffic moving should one lane become blocked.

Single-point Urban Interchange (SPUI): Guiding motorists and helping to keep safely the opposing vehicles separated.

The Federal Highways Authority (FHWA) USA: The FHWA in the USA has ruled that the LEDline® units meet the criteria for Raised Pavement Markers, as per the MUTCD section 3B.11 to 3B.14, so any US State there can now use them in this capacity as per the MUTCD for these applications. And, it has been similarly approved for use by CALTRANS.

Road Benefits:

Given its use on high accident locations, LEDline® should dramatically improve safety and reduce road accidents, which will improve traffic flow, reducing gridlock and significantly improving and increasing road efficiencies! If it saves just one accident, compared to the cost of the accident LEDline® will have paid for itself. And, installed to create temporary extra lanes during rush hours; compared to the cost of building new lanes or even worse new roads;

LEDline® will rapidly pay for itself by reducing the gridlock. It would even more rapidly pay for itself if the extra lanes are used as a toll road / lane, as this would allow municipalities to provide extra lanes during rush hours and get funds back for doing so.

In conclusion: Any cities freeways / main highways have huge unused capacity already built into them, waiting to be used. If there was a successful trial and LEDlineSunDV™ proved that it could provide the necessary guidance, the use of this existing capacity would dramatically help any city's rush hour gridlock, safely improving the capacity and efficiency of any road at a fraction of the cost of building new highways or customized exclusive buss lanes.

HIL-Tech Ltd. is looking for projects for our daylight visible LEDlineDV™ and LEDlineHB™, and sunlight visible LEDlineSun™; especially in areas with endemic bad weather such as fog, snow whiteouts, heavy rains or dust storms. LEDline® would be extremely helpful in improving safety at locations with; high accident rates; in work zones; for severely congested roads at rush hours; all areas where it could rapidly demonstrate the systems ability to help prevent accidents, improve road safety, and increase road capacity and efficiency, thereby reducing traffic congestion.

I hope this is of interest and I look forward to talking to you.

Yours sincerely,

N.D. Hutchins
Director