



A COMPREHENSIVE SURVEY OF EMERGING TECHNOLOGY FOR NEW YORK METROPOLITAN AREA



Technical Memorandum 1: Comprehensive Literature Review

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1 Summary

This report summarizes the major findings from Task 1 of the project - Comprehensive literature review. The review covered three broad NYMTC goals of (i) congestion reduction and management, (ii) safety and security systems, and (iii) air quality improvement and environmental impact mitigation. Both national as well as international studies have been included. The studies have been classified into sub-categories under each of the above broad categories. These classifications were based on transportation goals of NYMTC. Therefore they have been classified together as "Goal driven". On the other hand, several studies were focused on particular technologies instead of specific goals. These technologies have been classified as "Technology driven". Every "Goal driven" study is further classified into sub-categories under the three broad goals listed above. In addition few studies mainly focused on assessment/evaluation of a technology; these have been classified as "Assessment" studies.

The most important technologies are summarized under each category below.

Congestion reduction and management:

1. Current major trends include congestion pricing and the use of ATIS.
2. However significant scope for improvement exists in these technologies including distance-based pricing and active travel guidance systems using vehicle-to-vehicle communication and VII systems.

Safety and Security:

1. Among safety systems crash avoidance systems hold immense promise. These systems will utilize sensors to detect vehicle, environment, and driver characteristics and determine crash possibilities using intelligent algorithms.
2. Pedestrian safety systems that alert driver of presence of pedestrians in their path or pedestrian detection systems at pedestrian crossing.
3. Biometric identification

Air Quality Improvement:

1. Use of bio-fuels and hybrid vehicles are recommended in the short-term;
2. In the longer term hydrogen fuel vehicles may offer better benefits. However currently the operational costs and lack of institutional support hinder the use of hydrogen fuel on a large scale.

The above systems for achieving different goals are enabled because of developments in diverse technologies. These technologies include wireless communication systems, advanced sensors, electronic payment, and biometric identification among others.

The entire literature has been entered as an MS Access database. Several additional fields of information such as year of publication, applicability of study/technology to different modes and freight, brief descriptions and URL if the study is available online are created on the database. The database also has an easy to use search form that can be used to select specific studies of interest. Further, the results as well as the entire database can be viewed in convenient report formats. A brief description of the database and its functionalities are included in this report.

2 Comprehensive Literature Review: Methodology

The primary goal of this project is to conduct a comprehensive survey and assessment of the emerging and promising technology that are likely to impact the transportation performance in the NYMTC region. Task 1 of the project is a comprehensive review of existing literature. Since the scope of the project is very broad at this stage, the literature review was carried out in several stages. The “Goal driven” studies were categorized broadly into three main goals of (i) congestion reduction and management, (ii) safety and security systems, and (iii) air quality improvement and environmental impact mitigation. Within each of the categories, sub-categories were identified. List 1 below provides a complete list of the sub-categories investigated.

List 1 List of Categories and Sub-categories

Congestion Reduction and Management

1. Congestion pricing
2. Electronic freight management
3. Highway system improvements
4. Incident management
5. Intelligent Transportation Systems (ITS)
6. Inter-modal transfer technologies
7. Parking management
8. Pedestrian and bicycle systems
9. Transit system improvements
10. Travel Demand Management
11. Traveler Information Systems

Safety and Security Systems

1. Collision Avoidance
2. Crash Assessment
3. Driver Condition Warning
4. Emergency response
5. Freight security
6. Lane Change and Merge Collision Avoidance
7. Pedestrian safety
8. Road Departure Collision Avoidance
9. Vehicular safety technology
10. Weather and Safety
11. Work Zone Safety
12. Grade Crossing

Air Quality Improvement and Environmental Impact Mitigation

1. Fuel based
2. Hazardous materials safety
3. Infrastructure based
4. Vehicle based

The sub-categories in List 1 were used as keywords to search in several transportation databases and search engines. List 2 is a near-complete list of the databases and search engines used in the search.

List 2 List of Databases and Search Engines

Link: Brief Description

<http://ntlsearch.bts.gov/tris/index.do> : National Transportation Library

<http://database.path.berkeley.edu/reports/index.cgi> : UC-Berkeley, PATH database

<http://library.ctr.utexas.edu/index.html> : Center for Transportation Research, U-Texas

<http://www.mtl.mit.edu/researchgroups/itrc/itrc.html> : ITRC, MIT

<http://www.civitas-initiative.org/main.phtml?lan=en> : European Commission

<http://www.ertico.com/> : Intelligent Transport Systems and Services in Europe

<http://www.calccit.org/itsdecision/> : ITS Decision Web site

www.google.com : For general search such as news articles, company profiles

Several studies were focused on specific technologies or the evaluation of technologies. These were grouped under separate perspectives – “Technology Driven” and “Assessment”. However, these studies were categorized along the same lines as shown in List 1.

3 Comprehensive Literature Review: Brief Description of Studies

The studies were entered into Microsoft Access database program. The database generates a report of all the studies listed with brief descriptions of each study. This is presented in Appendix 1.

Here we present a brief summary of the technologies. The references to particular studies are through the unique identification number of the study in the database.

The studies have been grouped based on three perspectives: Assessment, Goal-driven, and Technology-driven. Assessment perspective deals with evaluation of technologies (for example, cost-benefit analysis). Goal-driven perspective deals with a system of technologies that work together to achieve a policy goal (for example, congestion pricing). Technology-driven studies are those that describe a particular technology in detail which have potential applications in possibly several transportation objectives.

3.1 Goal-driven Perspective

The goal-driven perspective was further sub-divided into three main categories: Congestion Reduction and Management, Safety and Security systems, and Air Quality Improvement and Environmental Impact Mitigation.

Technology use for **Congestion Reduction and Management** (CRM) goals is more prevalent. Foremost of the strategies for CRM is **travel demand management (TDM)**. This will be elaborated in this section. Several different TDM strategies exist including congestion pricing, telecommuting, Carshare, and improved transit options (for a more detailed review of TDM strategies please refer to: <http://www.vtpi.org/tdm/>).

Congestion Pricing

Among the most successful demonstrations of *congestion pricing* is the London Congestion Charging scheme (G74). In order to support the existing congestion charging scheme

Transport for London conducted a two stage evaluation of future technologies that could be implemented. They concluded that DSRC-based technologies are feasible to operate in an urban environment however distance-based charging may not be practical. The United Kingdom is also exploring the feasibility of a nation-wide road user charging scheme (G51). Several challenges are identified that include both political as well as technical challenges. Other countries where congestion pricing or some form of road pricing has been considered include Japan (G50), France (G45), Singapore (G39), and Norway (G40).

Several alternate technologies are available for enabling congestion pricing. These include dedicated short-range communication (DSRC), wide-area communication based systems, and video-based license plate recognition software (G80). The primary disadvantages of DSRC based systems are the speed restrictions on vehicles while passing the tag readers and the lack of direct enforcement on violating vehicles. Wide-area communication systems use a combination of GPS technology for tracking and GSM/DSRC technology for communication. The advantage of wide-area communication systems is the capability for distance-based and zone-based charging. However difficulties with determining exact location using GPS in densely-built urban areas have hindered its implementation (G75, G76).

Ukkusuri et al. (314) present a comprehensive synthesis and an evaluation framework for congestion pricing technologies. They compare different congestion pricing technologies: manual toll booths, automatic number plate recognition, DSRC, GPS, Infrared communications, and RFID. The technologies were compared along four main characteristic measures: economic, operational, impacts/integration/flexibility, and other measures such as credibility, availability of suppliers, and privacy. The technology evaluations were carried out using ELECTRE IV algorithm. The main insights from their study include:

- (1) Given the performance measures, RFID is the best technology to implement, though this does depend on the desired pricing scheme.
- (2) The subjective rankings of enforcement and privacy have significant impacts on the ultimate technology rankings. The implication from this insight is that technology that handles these issues better is more readily accepted and useful.
- (3) GPS will become the preferred technology if its cost, reliability and privacy issues are adequately addressed.

Telecommuting

Telecommuting is yet another example of TDM strategy that is being successfully implemented. Though telecommuting was considered as early as 1980s and was considered a failure in the mid 90s (Technology Review, Vol 98, Iss 5), rapid advances in communication and computing technology in the last decade have made telecommuting an attractive TDM strategy. Choo, Mokhtarian, and Salomon (Transportation, Vol 32, 1) develop aggregate time-series models to examine the impact of telecommuting. Their models suggest that "telecommuting reduces VMT, with 94% confidence. Together with independent external evidence, the results suggest a reduction in annual VMT on the order of 0.8% or less. Even with impacts that small, when informally compared to similar reductions in VMT due to public transit ridership, telecommuting appears to be far more cost-effective in terms of public sector expenditures." Advances in video-conferencing and Internet and the growing transportation congestion problems have made telecommuting more attractive. Dedicated organizations (www.telcoa.org) and companies (www.telecommutect.com) have sprung up to support telecommuting initiatives. Other than driving alone, telecommuting is the only commute mode that has gained market share

since 1980 (322). In 2005, 4.5 million Americans telecommute on most work days, roughly 20 million telecommute at least once per month, and 45 million once a year (322).

Electronic freight management powered by advances in freight identification and tracking technology can contribute towards CRM. Electronic freight management allows both shippers and transportation enforcers to better monitor the freight technology movement and thereby identify problem areas and identify solutions. In addition “intelligent freight technologies are used to improve freight system efficiency and productivity, increase global connectivity, and enhance freight system security against common threats and terrorism. These technologies are currently deployed in several areas: 1) asset tracking, 2) on-board status monitoring, 3) gateway facilitation, 4) freight status information, and 5) network status information” (L16).

Highway system improvements are a direct method towards congestion mitigation. Technologies that are used for highway system improvements include advanced signal management (G94, W2), freeway and arterial performance measurement (G7) and the use of the performance measurement in access management (G2). A traffic responsive signal control plan (G94) was successfully installed, verified, and demonstrated in three cities (Chania, Southampton, and Munich) in United Kingdom. The United Kingdom has also demonstrated the use of motorway access management strategies recently (G2).

Besides direct improvements to highway systems and auto-use disincentive measure of congestion pricing, CRM objectives may also be achieved through **improved transit service**. An important and tested strategy for transit service improvement is transit signal priority (TSP). The FTA has prepared a handbook about Transit Signal Priority implementation (G65). Another study has shown the need for a ‘bundle’ of technologies to encourage transit use. This study (G21) recommends the use of exclusive bus lanes and ITS technology in addition to signal priority to encourage transit-oriented development. A key issue with transit ridership is the ease of access to transit. Researchers at PATH, University of California, Berkeley (G34) demonstrate the use of “shared-use, low-speed mode vehicles, smart parking management systems, electronic lockers, and power supplied by hydrogen fuel cell” to address the issue of ease of access to transit.

Advanced Traveler Information Systems

The above studies focused on directly influencing the travel environment thereby inducing favorable travel choice shifts. Often, inefficient travel choices are a result of lack of adequate information. **Advance Traveler Information Systems** seek to ameliorate congestion by providing the road users with appropriate information. Several studies discuss the implementation of ATIS (L17, L36, L27) however the overall architecture and the true potential of TIS remains to be realized. Current implementations primarily focus on a centralized architecture and passive guidance where only information on network state is provided to individuals. A centralized architecture is both expensive and has scalability problems. An alternative emerging architecture involves decentralized vehicle-to-vehicle communication based architecture. Further, a decentralized architecture enables information to be delivered to each vehicle separately thereby allowing for active guidance where information on alternative routes, modes, and departure times can be delivered to each individual in real-time. The benefits from such architecture have not yet been fully understood though the opportunity remains promising. Recently the focus has been on Vehicle-Infrastructure Integratoin (VII). VII involves combining information from both vehicle and infrastructure sources and to use it to improve the operational capabilities of both vehicle and infrastructure systems (G29). A recent research effort involving Caltrans, California PATH and DaimlerChrysler RTNA demonstrated two VII services: one in traffic

data probes and another with safety, using real cars and on Caltrans roadways (G24). Vehicle-Infrastructure integration and the use of decentralized vehicle-to-vehicle communication systems hold immense potential to operationalize truly real-time travel guidance systems. Besides the above applications, information systems also play a direct role in demand management (L23) and in improving toll charge information dissemination and collection process (L49).

Safety systems' is the third category under which goal-driven technologies were reviewed. Among safety systems the technologies reviewed were collision avoidance systems, driver condition warning systems, and pedestrian safety systems. All of these systems incorporate some sort of sensor technology, intelligent algorithms to compute likelihood of crash, and communication or automatic remedial action to ensure safety. Collision avoidance systems comprised vehicle-vehicle collision avoidance systems (W9), crash warning system interface (W20), lane change and merge collision avoidance (W11, W12), and road departure crash warning systems (W14, W19). The most advanced of these collision avoidance systems take into account: (i) the trajectory of the vehicle with respect to vehicles in the vicinity and the road environment, (ii) road conditions including pavement deterioration, curvatures, and presence of water/ice/foreign material on the surface, and (iii) the driver and passenger characteristics including details such as the eye gaze direction and alertness of the driver.

Driver condition warning systems seek to alert the driver in the case of lack of vigilance or in the event of impending accidents/emergency. The AWAKE project in Europe (W4) demonstrated a driver condition warning system based on diagnosis of driver's lack of vigilance in real-time. The diagnosis is based on both driving behavior (lane violation, speed) and physiological diagnosis (driver's eyelid activity, grip pressure etc.).

Pedestrian safety systems are either in-vehicle sensor and warning systems that alert driver of presence of pedestrians in their path or pedestrian detection systems at pedestrian crossing that switch pedestrian signal to walk mode in their presence. The former help avoid pedestrian-vehicle crashes by alerting the driver and pedestrians of a possible collision while the latter discourages pedestrians violations at signals.

Air quality improvement studies were classified into two different approaches: fuel-based technology and vehicle-based technology. Among fuel-based technology the most promising were the use of Hydrogen-fuel and bio-fuel. The European Commission conducted a comprehensive study (W26) on using Hydrogen as an alternative source of fuel. Besides outlining the expectations from using Hydrogen in transportation, the study also examined the feasibility of hydrogen supply infrastructure and demonstrated examples on buses (W27). The hydrogen bus trials were carried out for a two-year period and the total system availability was 80% which is lower than diesel or CNG bus fleet. However, the main emphasis of the demonstration project was to show the technology is workable.

The Alternative Fuels Study report (W69) tabled at the Congress by the US DOT presents a comprehensive picture of current practices and future trends of alternative fuels in the US. The study concluded that there are clear and immediate benefits from alternative fuels:

“In the longer term, depending on the source of the hydrogen, vehicles powered by hydrogen in fuel cells or internal combustion engines may ultimately be cleaner than other alternative fuel or diesel engines. Further, electric transit vehicles offer performance and noise reduction benefits and emit no exhaust gases, but their net environmental benefit depends on controlling emissions from

the fuel used to generate electricity. Finally, hydroelectric, wind and solar generation of electricity produces no emissions, and so may become the optimal power source for hydrogen fuel cells or electric vehicles of all kinds.”

However, they also report that “Every alternative fuel reviewed in this study imposes some combination of increased capital costs, operating costs, technical challenges, or institutional issues as compared to diesel fuel.” The use of alternative fuels still requires considerable government backing in terms of favorable institutional changes and wide spread use to realize economies of scale. In the short-term substituting diesel with alternative bio-fuels and/or using hybrid mix of fuels appears to be the best strategy. However, in the longer term switching to hydrogen fuel may be more efficient and cleaner alternative.

Besides fuel-based technologies, air quality improvements can also be realized from vehicle-based changes. Both car manufacturers and the government have taken initiatives to ensure reduction in emission in vehicles. In the United Kingdom, a Clean Vehicles Task Force (W18) was established to encourage the manufacture and purchase of vehicles which are “cleaner, quieter, more fuel-efficient, and less resource intensive”. Another vehicle-based initiative involves the use of electric vehicles and hybrid vehicles. The governmental agencies could play a lead role in encouraging their use. For example, in Italy, the Municipality of Reggio Emilia (W29) is currently using electric cars for municipal services and home assistance to elderly and disabled persons. In 1996, the technology review magazine (Technology Review, Vol 99, Issue 1, p30) examined the prospect of electric vehicle usage in the United States. The article identified several economic disadvantages of electric vehicles and emphasized the need to promote alternate technologies such as the Hybrid Vehicles. Hybrid vehicle sales have increased an average of 72 percent a year for the past five years and since 1999 the hybrid vehicles have saved close to 230 million gallons of fuel in the United States (source: The National Renewable Energy Labs).

3.2 Technology-driven perspective

Several diverse technologies were reviewed from this perspective. While most of the technologies had specific application or goal focus, few of them were more general and had a wide application potential. The technologies are presented sequentially here.

Adaptive ramp metering algorithms: advances in traffic sensors, communication, and control algorithms have enabled the implementation of adaptive ramp metering strategies. Researchers at PATH, University of California at Berkeley design and implement an adaptive ramp metering algorithm (G10). Evaluation of their algorithm on simulation platform yields 8.4% savings in total travel time on a 14.1 mile long freeway section.

Wireless communication systems: sensors with wireless communication capabilities have transformed traffic data collection methods. A guidebook (319) for selecting between alternative technologies for wireless communication is available. Newer architectures are also being developed with vehicles playing the part of communication transfer nodes also referred to Vehicular Ad-hoc Networks (VANET). L61 is an example of application of VANET for providing safety and commercial services. Rahman and Hengartner (322) report the use of VANETs for automatic vehicle crash event recording and communication to enable quick response and accurate data for investigators to reconstruct the events. Another VANETs project is the Cooperative Vehicle-Infrastructure Systems (CVIS, www.cvisproject.org). CVIS is a major new European research and development project

aiming to “design, develop and test the technologies needed to allow cars to communicate with each other and with the nearby roadside infrastructure.” Besides the technological advances, the CVIS project is also focusing on “key ‘deployment enablers’ such as user acceptance, data privacy and security, system openness and interoperability, risk and liability, public policy needs, cost/benefit and business models, and roll-out plans for implementation.”

Electronic vehicle identification and toll collection technologies: Vehicle identification is an important component for automated toll collection. Several alternatives exist for electronic vehicle identification. Persad et al. (316, 317) reviews industry standards, performance, and costs of electronic vehicle identification technologies. Electronic vehicle identification also enables accurate determination of traffic and demand parameters when data is collected between successive identification stations.

Electronic payment technologies include the use of magnetic swipe cards and ‘smart cards’. While magnetic swipe cards have been in use for over four decades, smart cards have gained acceptance only in the past 5 years. Smart cards are made of plastic, similar to a credit card, and contain microprocessors and memory chips with wireless communication capabilities (G66). Smart cards have been used in a range of applications including toll and parking payments, internet access, mobile commerce. Adoption of smart cards by transit agencies allow for partnerships with toll and parking systems, employers, universities, financial institutions, telecommunication companies (G66). However, transit system managers are often uncertain about the costs and, particularly, the benefits of moving to smart cards; this is especially the case for the often complex interoperable smart cards systems (G22). A recent successful implementation of smart cards is Transport for London’s Oyster Card (G73). The smart card alliance (<http://www.smartcardalliance.org/>) provides updates on the advances in the state-of-the-art and state-of-practice in Smart Cards. The Alliance membership includes over 150 U.S.-based and international organizations.

The reduction in cost of sensor technologies coupled with advances in nanotech and wireless communication are enabling the widespread deployment of sensors in road networks. However the surfeit of information generated needs to be managed and knowledge extracted from the data. Battelle (G60) identifies innovative approaches including innovative contracting methods, standards, training for data collection, data sharing between agencies and states, and advanced traffic detection techniques. Malik and Russell (G4) discuss new traffic sensor technology for motion based grouping, vehicle classification, and tracking. Ritchie et al (G8) present field investigation of vehicle re-identification techniques and detector technologies. Cheung and Varaiya (G18) summarize a three-year research project in the prototype design, analysis and performance of wireless sensor networks for traffic surveillance, using both acoustic and magnetic sensors. They report that magnetic sensors are superior to the acoustic sensors.

Machine vision (W56, W54) provides intelligence to vehicles and is very useful in developing vehicle safety systems and automated vehicle systems. Automated vehicle systems are also being developed at PATH in University of California, Berkeley (G5).

Biometric identification technology is a promising technology with applications in enhancing security in transportation. The European Commission funded a study (G46) on assessing the impact of Biometrics on society: the study highlight a number of key issues to be taken into account when considering the large-scale implementation of Biometric technologies. The report also addresses the social, legal, economic and technological challenges of four

biometric technologies - face, fingerprint, iris and DNA. The study also identifies the vulnerability of biometric technologies and points to the need to include biometric identification as only a part of an overall identification and authentication process. An important implementation issue raised in the report is the possible use of biometric identification to enhance privacy: biometric identification eliminates the need for individuals to reveal their identity at the point of screening. Among the different biometric technologies the major advantage and limitation are: face recognition – can be performed from a distance but identity may be stolen since faces are on public display; fingerprint – best known but an estimated 5% are not able to enroll satisfactorily; Iris – high level of accuracy however not everyone is comfortable with the technology and are unclear where to focus when providing a sample; DNA identification – highly accurate but expensive, time consuming and requires skilled human intervention (G46).

Bus rapid transit systems are emerging a cheaper mass transit alternative compared to light rail. SmartBRT (G6) is a tool for modeling and simulating hypothetical transit systems, especially Bus Rapid Transit technologies and policies. The tool has the capability to evaluate new technologies and policies that haven't been fully explored. Personal Rapid Transit (PRT) is emerging as a potential personal transit option in urban areas. However, the viability report (G1) of PRT in New Jersey concludes that PRT systems are "approaching but not yet ready for public deployment". Successful transit usage also requires the dissemination of real-time information. Countdown (G71) and London Underground Metro information system (G63) are example of transit information systems implemented in the United Kingdom. More recently in the US there has been an increased awareness on the use of tracking and communication technologies for Transit. Termed "Virtual Mass Transit" (<http://www.state.sc.us/irc/minutes/080698.html>), the system can "track all mass transit infrastructure, vehicles and routes across the state. Such a system could lower transportation costs by sharing resources between mass transit systems, such as using school buses during non-school times for city or county recreational use, and for collecting and dispatching vehicles in case of a natural disaster."

3.3 Assessment Perspective

Most studies on assessment focused on cost-benefit analysis. In particular, several studies (G48, G49, G47) examined the benefits of implementing ITS. These studies estimate returns of \$6.30 to \$12.20 for every dollar invested in ITS. Though the returns are high the results are only based on simulation studies and not on field-evaluation.

On the other hand, studies on safety (W65, W36) were more concerned with assessment based on objective evaluation of more direct consequences (crash reduction, success rate percent) instead of benefit-cost ratios. Often when dealing with safety and environmental issues, assessment based on direct objective measures could provide a better evaluation framework than dollar equivalent. Dealing with a direct objective measure also allows stakeholders to make subjective inferences on cost-benefit values. This eliminates bias that may be introduced due to imposed false values.

Another assessment method for technology involves the use of attitude and preference surveys (G22, G28). Often in computing cost-benefit values, an important component to the success of any technology – the end-user acceptance is ignored. Attitude and preference surveys provide a better understanding on the degree of acceptance of a technology. Besides providing a stand-alone assessment measure, these surveys can also better inform economic cost-benefit analysis.

The above assessment methods assume a reasonable level of maturity of the technology. In some cases, the technology may still be under development and only experts working on the technology and policy analysts who may implement the technology towards achieving the policy goals, may have sufficient knowledge to assess the technology. The best assessment technique in such cases involves group decision making or voting. Several techniques exist in the literature on group decision making; these include Delphi techniques, Analytic Hierarchy Process, ELECTRE IV, and prediction markets.

3.4 Summary

To summarize the review, several different technologies have been applied to achieve different objectives. The most important technologies are summarized under each category below.

Congestion reduction and management:

1. Current major trends include congestion pricing and the use of ATIS.
2. However significant scope for improvement exists in these technologies including distance-based pricing and active travel guidance systems using vehicle-to-vehicle communication and VII systems.

Safety and Security:

1. Among safety systems crash avoidance systems hold immense promise. These systems will utilize sensors to detect vehicle, environment, and driver characteristics and determine crash possibilities using intelligent algorithms.
2. Pedestrian safety systems that alert driver of presence of pedestrians in their path or pedestrian detection systems at pedestrian crossing.
3. Biometric identification

Air Quality Improvement:

1. Use of bio-fuels and hybrid vehicles are recommended in the short-term;
2. In the longer term hydrogen fuel vehicles may offer better benefits. However currently the operational costs and lack of institutional support hinder the use of hydrogen fuel on a large scale.

The above systems for achieving different goals are enabled because of developments in diverse technologies. These technologies include wireless communication systems, advanced sensors, electronic payment, and biometric identification among others. While the literature review has focused on technologies that have been developed and prototyped, it is reasonable to assume that several technologies currently under development may become available for the public to use within the next 10 years. The synthesis of emerging technologies including technologies that are currently under development will be the focus of task 2.

4 Overview of Database

The database includes interactive forms and summary report templates to help the user navigate better. An interactive form (Fig 1) appears as soon as the database is opened.

The user can select one of three options available: View Entire Report, Enter New Studies, and Search Database. The view entire report option displays the report shown in Appendix 1. The report automatically updates any new studies that will be entered in the future. The report presents studies sorted based on the Perspective, Category and Sub-category. At present, the database has over 230 studies (18 under Assessment perspective, 116 under Goal Driven perspective, and 104 under Technology Driven perspective).

The second button, Enter New Studies, brings up another form (Fig 2) that allows the user to enter new studies to the database.

Figure 1: Main form in Database

Technology Scan Project - Literature Review

A COMPREHENSIVE SURVEY OF EMERGING TECHNOLOGY FOR NEW YORK METROPOLITAN AREA

Literature Review Database Main Form

This database is part of deliverable 1 in the "Comprehensive Survey of Emerging Technology for New York Metropolitan Area" project. A national as well as international review of relevant literature have been carried out and compiled into this database.

What would you like to do?

- To view the entire database as a report, click View Entire Report button
- To enter new studies, click the Enter New Studies button
- To search for specific studies, click the Search Database button

View Entire Report Enter New Studies Search Database

Figure 2: Enter New Studies form

literature_list

Title: Design, Field Implementation and Evaluation of Adaptive Ramp Metering Algorithms

Authors: Horowitz et al.

Year: 2005

Institution: Research Institution

Journal: California Partners for Advanced Transit and Highways (PATH). R

Perspective: Technology Driven

If Technology Driven...

Technology_Type: Ramp Metering Algorithm

Goals_Enabled: []

If Goal Driven...

Category: []

Sub-category: []

Technology_Enablers: []

Mode: All Road Traffic

Is technology/study applicable to freight transportation? []

What type of assessment: []

Record: 2 of 228

The third button brings up a search form (Fig 3). The user can input the study reference ID to look-up a particular study or use specific keywords, author names and publication years

to select a subset of relevant literature. The search results are displayed in the form of a report.

Figure 3: Search Form

The screenshot shows a web browser window titled "Search Form". The page content includes the logo of Rensselaer Polytechnic Institute (1824) on the left and the NYMTC logo on the right. The main heading is "A COMPREHENSIVE SURVEY OF EMERGING TECHNOLOGY FOR NEW YORK METROPOLITAN AREA". Below this is the "Literature Review Database Search Form". The form has the following fields:

- Enter Reference ID: [text input]
- OR
- Main category: [dropdown menu]
- Keyword(s): [text input] in [dropdown menu (set to 'Title')]
- Author(s): [text input]
- Range of publication: [dropdown menu (set to '1995')] to [dropdown menu (set to '2007')]

A "Submit!" button is located below the range of publication field. At the bottom, a hint reads: "Hint: To obtain better results, use wildcard entries. Type Cong* to search for all words starting with Cong (congestion, congestion pricing, congress etc). Type B?ll to search for Bill, Bel, or Ball."

5 PROJECT STATUS REPORT APPROVALS

Prepared by _____
Principal Investigator

Approved by _____
Project Manager

6 APPENDICES

See attached file: Appendix 1.pdf which is the Access Database of TM1
