



A COMPREHENSIVE SURVEY OF EMERGING TECHNOLOGY FOR NEW YORK METROPOLITAN AREA



Technical Memorandum 3: Screening of Emerging Technologies

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1 Summary

In task 2, a comprehensive, initial list of emerging technologies to improve transportation systems was prepared. In task 3, the technologies identified in task 2 are screened based on preliminary criteria that include: a) relevance to NYMTC, and b) subjective estimate of economic and technical feasibility. The screening process will be a two-stage process where in the first stage the most appropriate goals of NYMTC will be screened, and in the second stage the technologies useful for achieving the goals will be screened.

The report outlines the list of technologies obtained from task 2. A total of forty-six technologies were identified. In order to obtain a better understanding of the forty-six technologies listed above, a survey of existing studies was carried out. Information was gleaned from these existing studies and a database was constructed to store the information. The database allows easy access to the information and allows the user to organize the information in convenient formats.

The decision making process for screening the technologies was done in two stages. In the first stage the most appropriate goals or policies that are relevant to NYMTC was screened, and in the second stage the economic and technical feasibility of technologies useful for achieving the goals was assessed. Two internet accessible surveys were created for the purpose of obtaining input from the Regional Transportation Plan committee members. The details of the survey and the results are presented in the report.

The final section summarizes the results of the surveys. There were 14 total responses. An important result from the survey is the ranking of the different policy sub-categories. Energy consumption is the highest ranked policy sub-category followed by transit-system improvements. Highway system improvements, transportation demand management strategies (including telecommuting), ITS, and highway safety are ranked next. These rankings will be used as weights to rank each of the specific technologies from the comprehensive list to obtain a shortlist for task 4.

The feasibility assessment questionnaire was completed by 7 respondents including two outside experts. Feasibility assessment included both technical and economic feasibility. We present the average rating for the technical and economic feasibility and also provide a joint weighted measure. The technologies are ranked based on this weighted measure. The top 5 technologies in terms of the joint feasibility measure are GPS, HD video conferencing, machine vision, ultra-low sulfur diesel, and biodiesel fuel.

2 Details on Technologies

In task 2, a comprehensive, initial list of emerging technologies to improve transportation systems was prepared. In task 3, the technologies identified in task 2 are screened based on preliminary criteria that include: a) relevance to NYMTC, and b) subjective estimate of economic and technical feasibility. The screening process will be a two-stage process where in the first stage the most appropriate goals of NYMTC will be screened, and in the second stage the technologies useful for achieving the goals will be screened.

2.1 List of Technologies

The list of technologies identified in task 2 is presented in List 1 below. Broadly, the technologies were divided into the following seven technology domains:

- a) Nanotechnology
- b) Energy and Fuel technology
- c) Communication technology
- d) Computing and Internet technology
- e) Transportation, Vehicular and Automotive technology
- f) Sensors
- g) Freight technology

List 1 List of Technologies

Nanotechnology

- 1. Nano-sized batteries
- 2. Nano Fuelsaver
- 3. Fuel-cell Nano Catalyst
- 4. Nanosensors
- 5. Carbon-based nano-fibres
- 6. Nanocoating of metallic surfaces
- 7. Nanoparticle-reinforced materials
- 8. Nanomaterials in pavements
- 9. Automatic healing materials

Energy and Fuel technology

- 10. Hydrogen Fuel
- 11. Biodiesel Fuel
- 12. Ethanol Fuel
- 13. Methanol Fuel
- 14. Natural gas
- 15. Propane
- 16. Biogas Fuels
- 17. Biobutanol Fuels
- 18. Hydrogenation-Derived Renewable Diesel
- 19. P-Series
- 20. Ultra-low sulfur diesel
- 21. Electric-driven vehicle

Communication

- 22. Dedicated Short Range Communications (DSRC)
- 23. Wide area wireless communication *
- 24. Ultra high-speed Internet *
- 25. Vehicular Ad Hoc Networks (VANETs)

Computing and Internet Technology

- 26. Collaboration software *
- 27. Augmented Reality *
- 28. Personal travel assistant
- 29. HD video conferencing *
- 30. Advanced route guidance systems
- 31. Adaptive ramp metering

Transportation, Vehicular, and Automotive Technology

- 32. Small wheeled transport
- 33. Hybrid vehicles
- 34. Personalized rapid transit (PRT)
- 35. Automated vehicles
- 36. Flying cars
- 37. Waterbridge

Sensor Technologies

- 38. GPS
- 39. Radio Frequency Identification (RFID)
- 40. MEMS sensors
- 41. Smart Cards
- 42. Machine Vision
- 43. Biometric Identification

Freight Technology

- 44. Automated Guided Vehicles
- 45. Automated Container Transport system
- 46. Pick-up centers

Note: *The technologies relevant to telecommuting have been marked with a **

A total of forty-six technologies were identified. Several of these technologies (automatic healing materials, nano catalysts, augmented reality, flying cars etc.) have only been demonstrated in small-scale laboratory experiments while a few of the technologies (for example: VANETs, PRT, guided vehicles) have been prototyped or tested in limited field experiments. Few other technologies (GPS, RFID, Hybrid vehicles etc.) have been in use for several years now but newer advances will enable wide-spread adaptation. Figure 1 below presents the approximate timeline and cost/benefit category for each of the technologies. Each cell in the figure represents a particular timeline-cost/benefit category. For example, the technologies in the top-right cell are those that are still in the conceptual stages and have excellent cost/benefit estimates.

2.2 Database with Details on Technology

In order to obtain a better understanding of the forty-six technologies listed above, a survey of existing studies was carried out. Information was gleaned from these existing studies and a database was constructed to store the information. The database allows easy

access to the information and allows the user to organize the information in convenient formats.

Timeline	Conceptualized	Automatic healing materials Ultra high-speed net Augmented Reality Flying cars	Nano-size battery VANETs	Automated container transport system
	Demonstrated	Fuel-cell nano-catalyst DSRC Carbon nano-fibers Personal rapid transit Automated vehicles Machine Vision	Nano Fuel Saver Wide area wireless Personal travel asstt. Adaptive ramp meter Biometric identification	Collaboration software Pick-up centers
	Developed	Hydrogen fuel HD Video conferencing	Nanosensors Electric-driven vehicle Advanced route guidance systems Small-wheel transport	Biodiesel / Ethanol Propane / Natural gas Hybrid vehicles GPS, RFID Smart Cards
		Poor	Promising	Excellent
Cost/Benefit				

Figure 1 Timeline – Cost/Benefit Categorization of Technologies

The details for each technology include: features, timeline, costs, applications to transportation, and challenges. The features field describes the technology in detail including the components and capabilities of the technology. The timeline provides a subjective estimate of the level of maturity of the technology and the time to implementation. Costs provide estimates of the implementation and operational cost and economic benefits from the technology. Given the uncertainty involved and the fact that these technologies are still under development, in most cases the costs are rough estimates. The next field identifies the potential application of the technology to transportation domain. What are the different benefits arising from the technology in terms of congestion reduction and management, air quality improvement, safety and security etc. is also discussed in the database. Finally, the field corresponding to ‘challenges’ lists the main hurdles to the development of the technology. In addition to these details the database has provision for additional information with regard to how effective the technology is towards meeting specific policies or goals. This is a rating and will be carried out as part of task 4 in order to short-list the technologies.

3 Decision Making Process

The decision making process for screening the technologies was done in two stages. In the first stage the most appropriate goals or policies that are relevant to NYMTC were screened, and in the second stage the economic and technical feasibility of technologies useful for achieving the goals were assessed. Two online surveys were conducted for the purpose of obtaining input from the Regional Transportation Plan (RTP) committee members. The details of the survey and the results are presented in the following sections.

3.1 Scope Assessment Survey

The scope assessment survey was divided into two sections. In the first section five broad transportation goals were presented and the respondents were asked to rate the importance of each transportation goal on a scale of 1 to 5 (5 being very important and 1 representing not important). Figure 2 below presents a screenshot of the first section of the survey.

Technology Scan Project - Scope Assessment Questionnaire

On a scale of 1-5, rate importance of each of the following five broad objectives to your organization:
(1-Not important, 5-Very important)

Broad Objective	Not important					Very important	
	1	2	3	4	5		
Congestion reduction and management technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safety systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Security systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Air quality improvement technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other environmental impact minimization technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Continue...

Figure 2 First Section of Scope Assessment Survey

The primary purpose of the above questions was to gauge the importance of each of the broad objectives to the different participating agencies across different counties in the NYMTC region. A secondary purpose was to reduce the burden of response by reducing the number of questions in the section 2 based on the response in section 1. For example if a respondent indicated that Security is not an important goal (rating ≤ 2) for their organization, section 2 did not have any questions pertaining security.

Having obtained input on broad transportation goals, the second part of the scope assessment survey divided each of the broad goals into several sub-categories. List 2 below presents all the sub-categories that were included. The respondent was asked to rate the importance of each sub-category in a scale of 1 (Not important) to 5 (Very important). Figure 3 below presents a screenshot of the survey 2.

Congestion reduction and management technology

Sub-objective	Not important				Very important	
	1	2	3	4	5	
Highway system improvements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	
Transit system improvements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	
Pedestrian and bicycle system improvements	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Transportation demand management strategies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Intelligent transportation systems (ITS)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Access management strategies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Parking management strategies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Traffic incident management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Work zone management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Road weather management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
Planned special events traffic management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

For the sub-objectives you have rated as important ('4' or '5'), please list any advanced technologies that your organization considers promising (use commas to separate multiple entries):

Technology for Highway system improvements:

Technology for Transit system improvements:

Figure 3 Second Section of Scope Assessment Survey

In addition to the rating of the sub-categories, the section also collected information on promising (from the organization’s perspective) future technologies to meet each of these sub-categories. This additional information was sought only from those respondents who rated a sub-category as very important (≥ 4). These rankings will be used as weights to rank each of the specific technologies from the comprehensive list to obtain a shortlist for task 4. The results from this survey are summarized in Section 4.

3.2 Feasibility Assessment Survey

The feasibility assessment survey was the second internet survey administered to obtain input from RTP committee members. The purpose of this survey was to obtain subjective inputs on the technical and economic feasibility of each of the forty-six technologies in List 1. For each technology and for each of the two categories of feasibility (technical and economic), the respondent was requested rate on a scale from -4 (Highly infeasible) to 4 (Highly feasible). A snapshot of the questionnaire is shown in figure 4.

The feasibility assessment questionnaire was completed by 7 respondents including two outside experts. Feasibility assessment included both technical and economic feasibility. We present the average rating for the technical and economic feasibility and also provide a joint weighted measure. The technologies are ranked based on this weighted measure. The results of this survey are presented in figure 5.

List 2 List of Sub-categories

Congestion Reduction and Management

1. Highway system improvements
2. Transit system improvements
3. Pedestrian and bicycle system improvements
4. Transportation demand management strategies
5. Intelligent Transportation Systems (ITS)
6. Access management strategies
7. Parking management strategies
8. Traffic incident management
9. Work zone management
10. Road weather management
11. Planned special events traffic management

Traffic Safety Technology

1. Auto passenger safety
2. Pedestrian and biker safety
3. Vehicle safety
4. Highway safety
5. Emergency medical services
6. Traffic management

Security Technology

1. Transit security
2. Highway security
3. Freight security

Air Quality Improvement

1. Vehicle based technology
2. Fuel technology
3. Transportation infrastructure technology

Environmental Impact Mitigation

1. Noise pollution
2. Energy consumption
3. Wildlife habitat loss
4. Water and land pollution

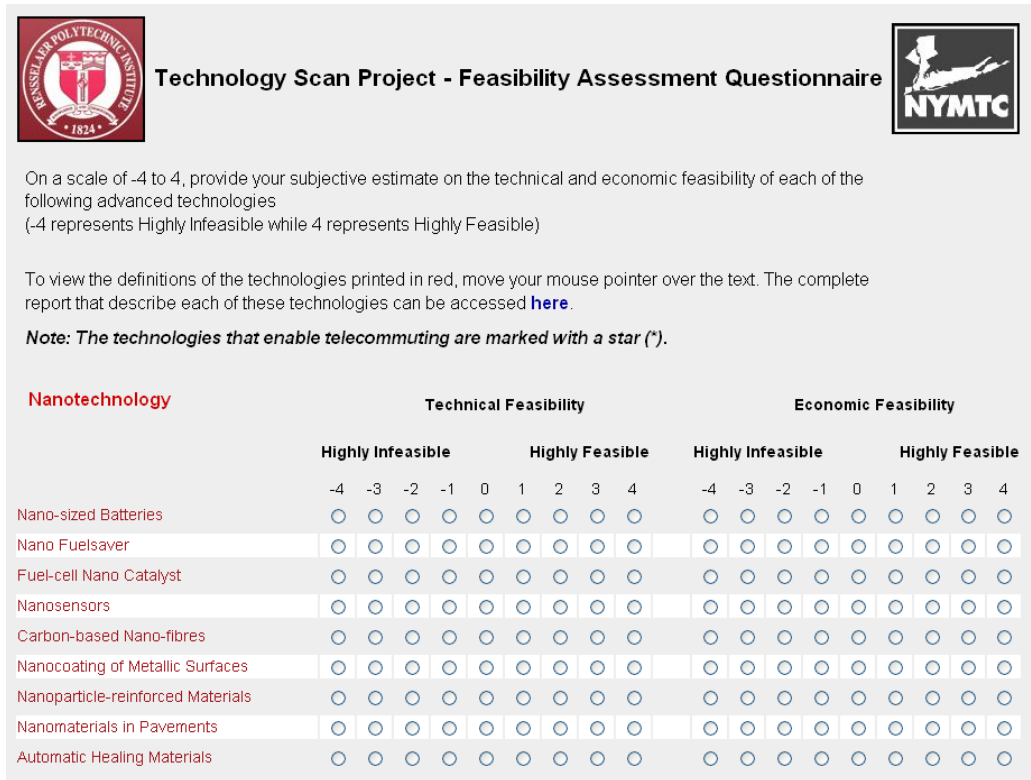


Figure 4 Feasibility Assessment Survey

4 Results from Survey Response

In this section, we present the results of the scope assessment survey. There were 14 total responses. These responses were from the following organizations: Westchester County, Rockland County, NYC Dept. of City Planning, MTA, Nassau County Planning Commission, Suffolk County DPW-Transportation Division, New York City DoT (4 responses), New York State DoT (4). However, only nine of the respondents completed all sections of the survey.

The figures in the Appendix provide pie-chart representations of importance ratings from all the responses for each sub-category of goals.

An important result from the survey is the ranking of the different sub-categories. The table below presents the rankings of the sub-categories based on all the responses.

As expected energy consumption is the highest rated policy sub-category followed by transit-system improvements. Energy is an important policy category particularly because of rising gas prices in the country. In addition, transit related technology is important since NY metropolitan region has one the highest ridership in the country. Highway system improvements, transportation demand management strategies (including telecommuting), ITS, and highway safety were ranked next. These rankings will be used as weights to rank each of the specific technologies from the comprehensive list to obtain a shortlist in task 4.

Table 1 Rankings of Sub-categories		
<u>Rank</u>	<u>Goal/Policy Sub-Category</u>	<u>Total Points</u>
1	Energy consumption	43
2	Transit system improvements	42
3	Highway system improvements	41
3	Transportation demand management strategies	41
3	Intelligent transportation systems	41
3	Highway safety	41
7	Pedestrian and bicycle system improvements	40
7	Pedestrian and biker safety	40
7	Traffic management	40
7	Transit security	40
7	Air Quality Improvement: Vehicle based technology	40
7	Air Quality Improvement: Fuel technology	40
7	Air Quality Improvement: Transportation infrastructure technology	40
14	Road weather management	39
14	Water and land pollution	39
16	Access management strategies	38
16	Traffic incident management	38
16	Emergency medical services	38
16	Highways security (including bridges and tunnels)	38
16	Noise pollution	38
21	Auto passenger safety	37
22	Vehicle safety	36
23	Work zone management	35
23	Freight security	35
25	Parking management strategies	34
26	Planned special events traffic management	33

Note: 9 total responses.

The feasibility assessment survey results are presented in figure 5. A total of 7 respondents completed the technical feasibility component of the survey while the economic feasibility component was completed by 6 respondents. Figure 5 presents three measures of feasibility: economic, technical, and weighted joint measure. The technologies are ranked based on the weighted measure. The top 5 technologies in terms of the joint feasibility measure are GPS, HD video conferencing, machine vision, ultra-low sulfur diesel, and biodiesel fuel.

In terms of the broad categories, three technologies (biodiesel, biogas, and ultra-low sulfur diesel) from energy and fuel technology category are ranked in the top ten, three (GPS, RFID, machine vision) from sensor technologies, two (HD video conferencing, personal travel assistant) from computing and internet technology, wide-area wireless communication from communication technologies, and hybrid vehicles from transportation technologies. None of the freight technology and only one nanotechnology are present in

the top twenty. The rankings are along expected lines. Alternative energy sources are important both from economic and environmental perspective. The sensor technologies have a wide range of application including in pricing, route guidance, and safety. These technologies have also reached considerably levels of maturity and its wide-spread adoption is very likely over the next ten years. On the other hand, technologies that are still under development such as nano-materials and flying cars have been ranked low in terms of feasibility.

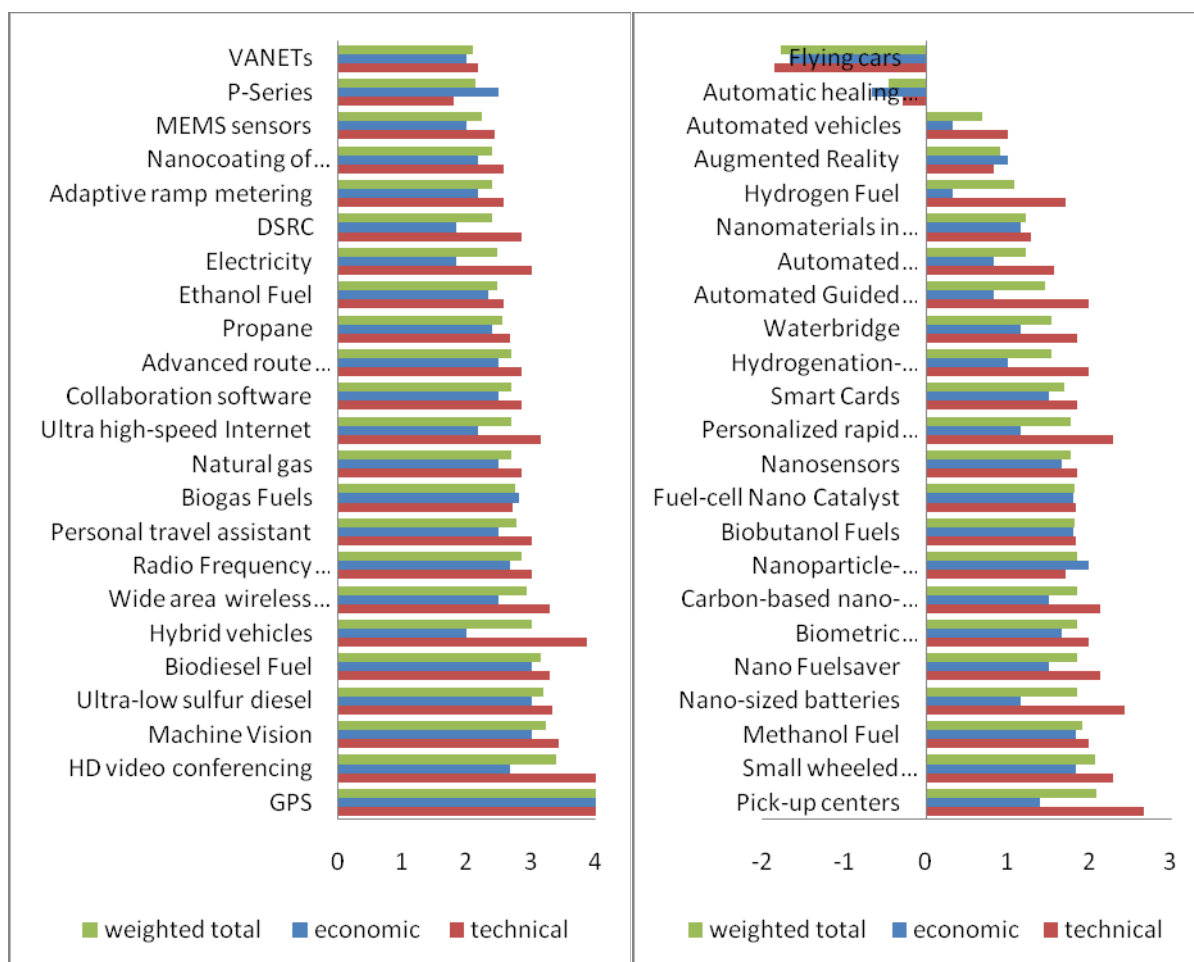
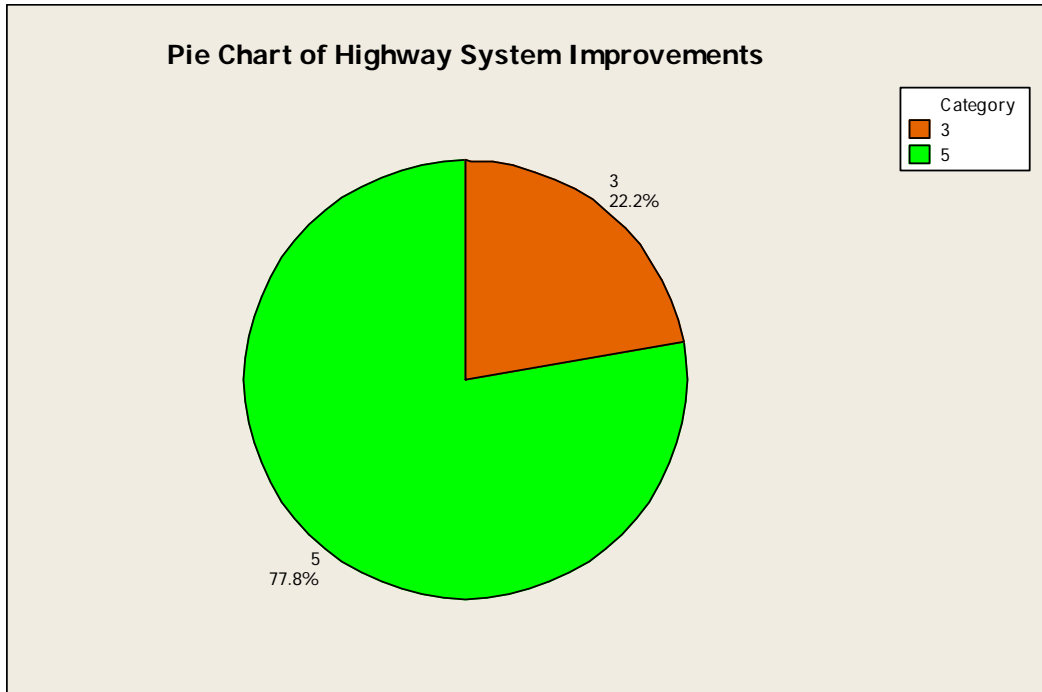


Figure 5. Feasibility Assessment Survey Results (7 respondents)

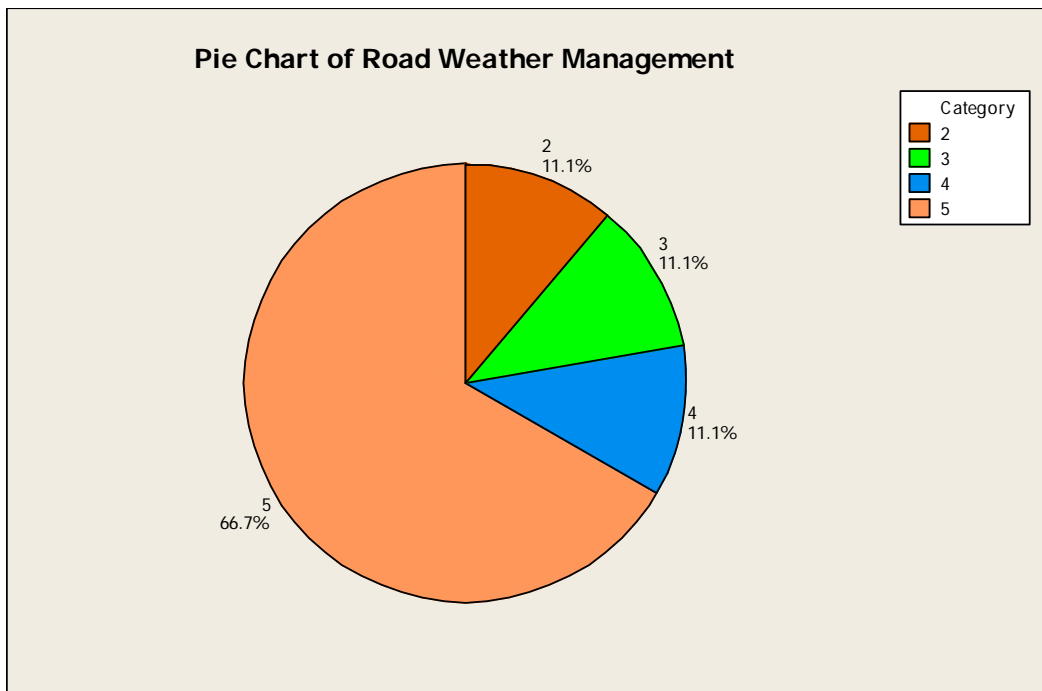
HD video conferencing (ranked 2), wide area wireless communication (7), ultra-high speed internet (12), and collaboration software (13) are four telecommuting technologies in the top twenty. Telecommuting will play an important role in substituting work-related trips in the future. The above technologies will enable a rapid acceptance of telecommuting by both employers and employees.

In summary, the rankings for the sub-categories and the economic and technical feasibility of the technologies obtained in task 3 will be taken as input to determine the shortlist of most relevant and likely technologies in Task 4.

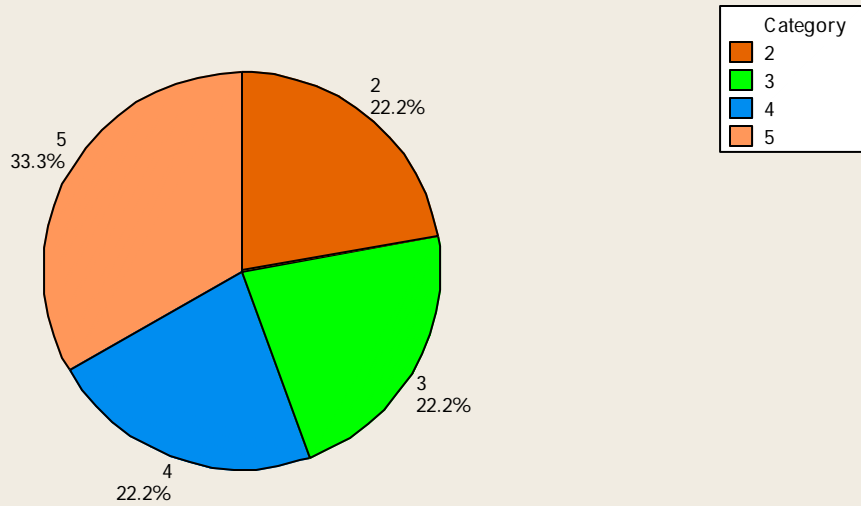
5 Appendix – Importance of Sub-category of Goals/Policies



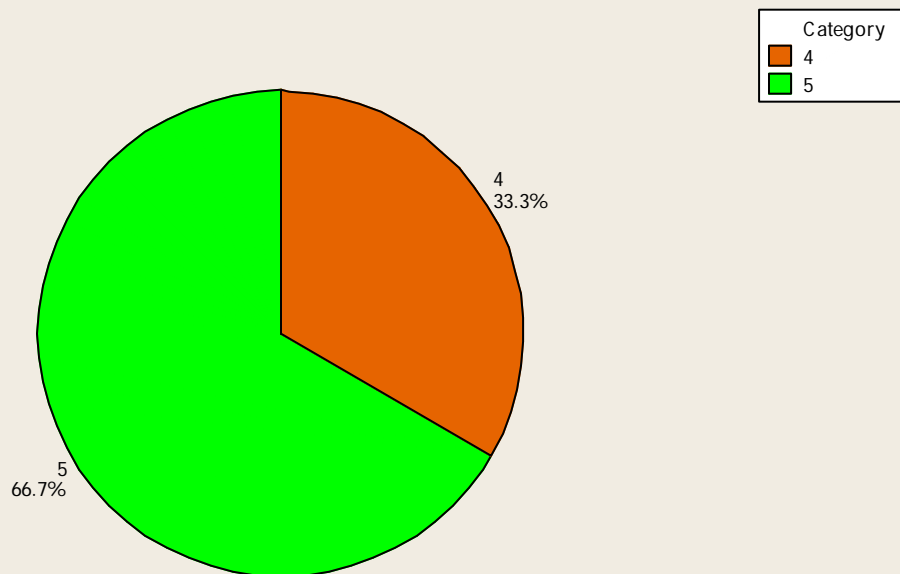
Note: 1 – Not Important and 5 – Very Important



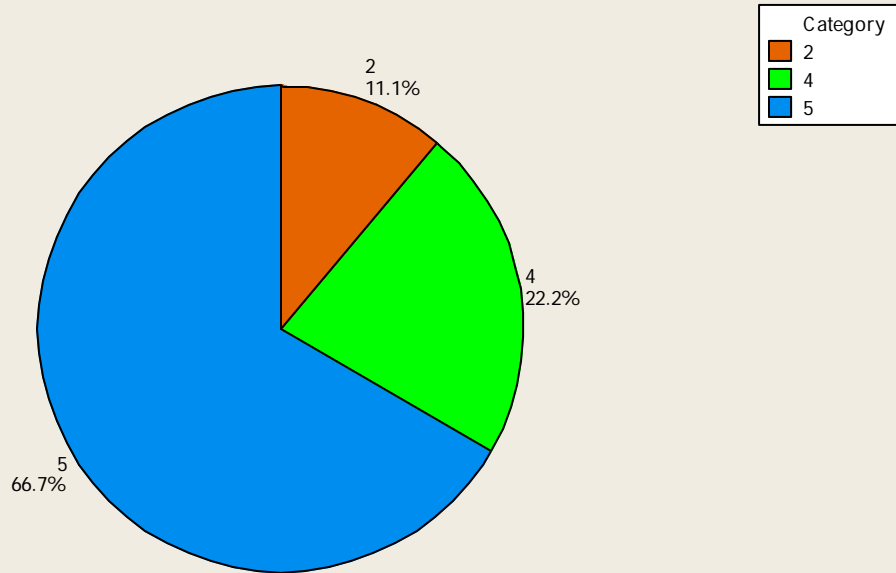
Pie Chart of Planned special events traffic management



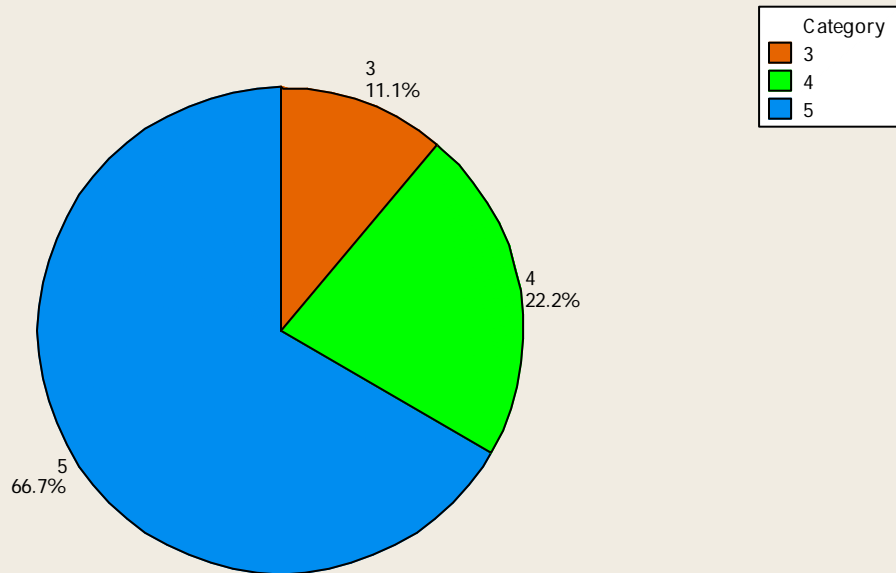
Pie Chart of Transit System Improvements



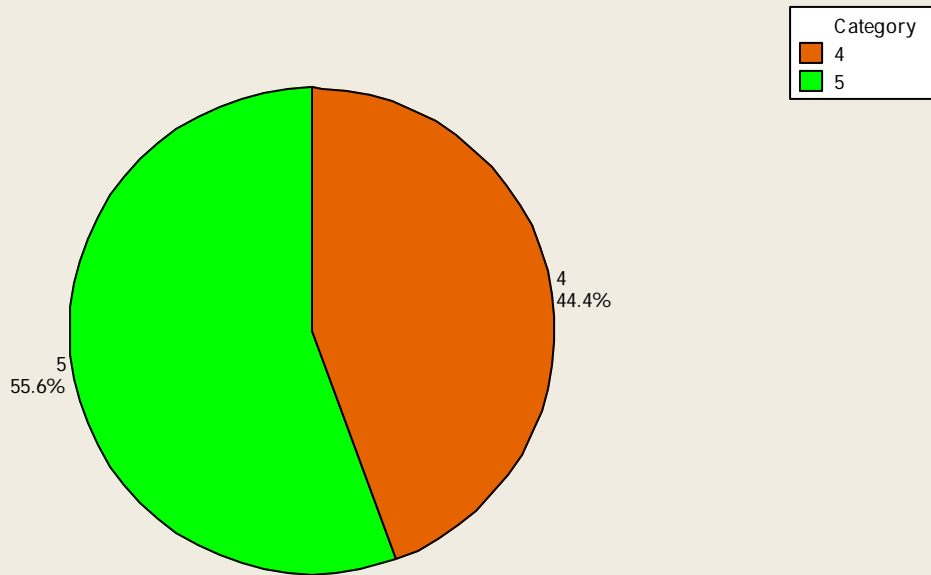
Pie Chart of Pedestrian and Bicycle Systems



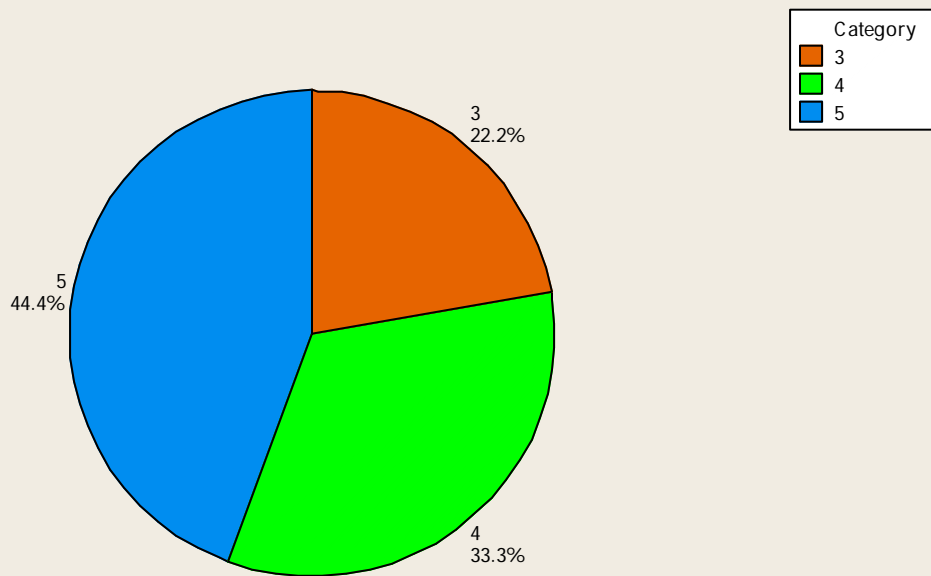
Pie Chart of Transportation Demand Management



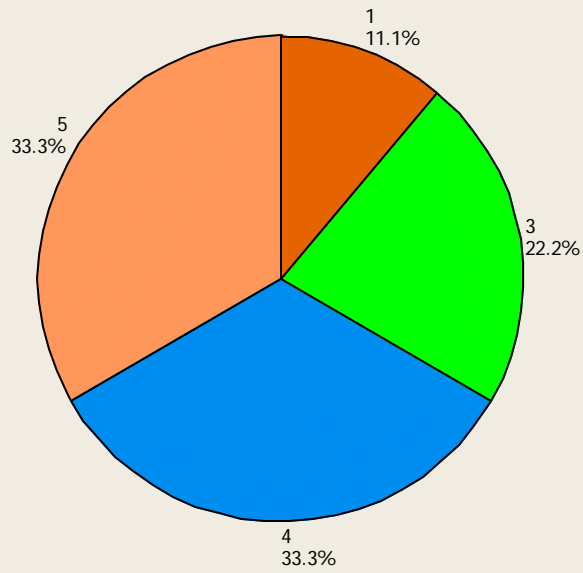
Pie Chart of Intelligent Transportation Systems



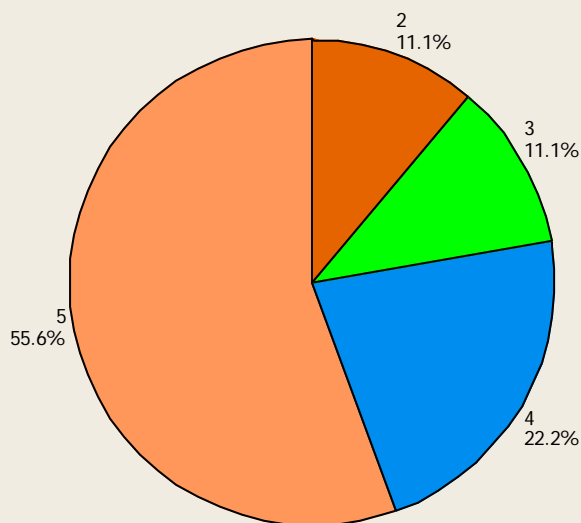
Pie Chart of Access Management Strategies



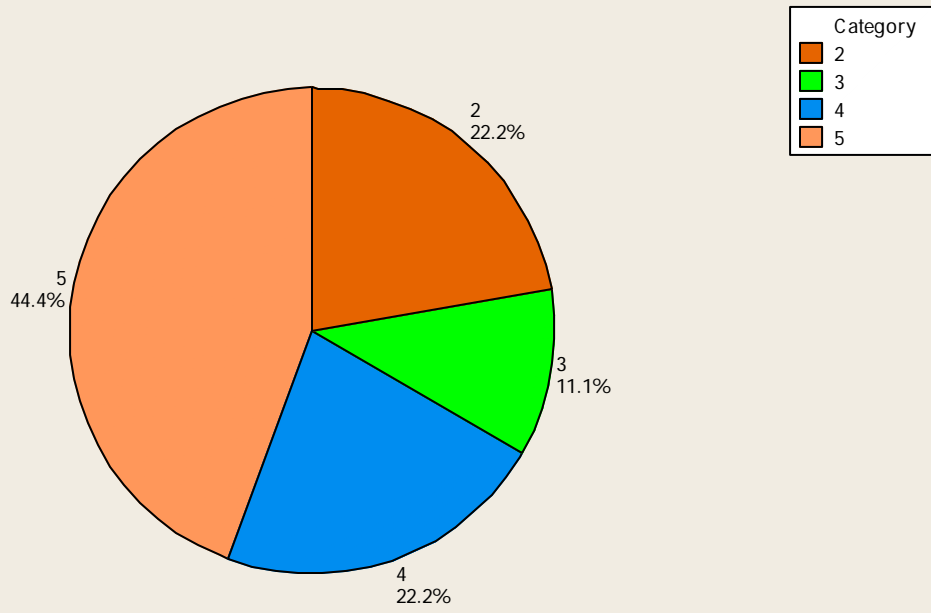
Pie Chart of Parking Management Strategies



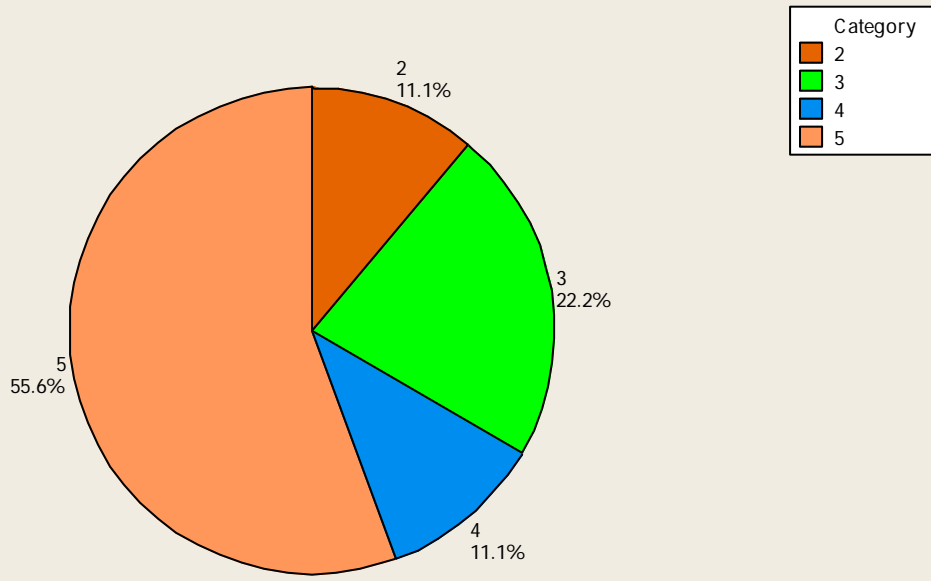
Pie Chart of Traffic Incident Management



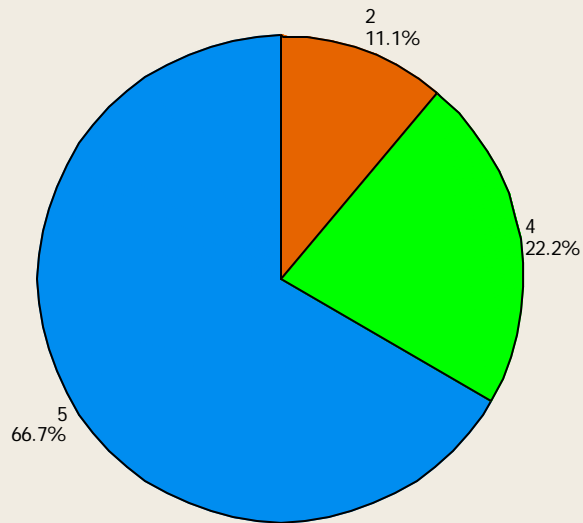
Pie Chart of Work Zone Management



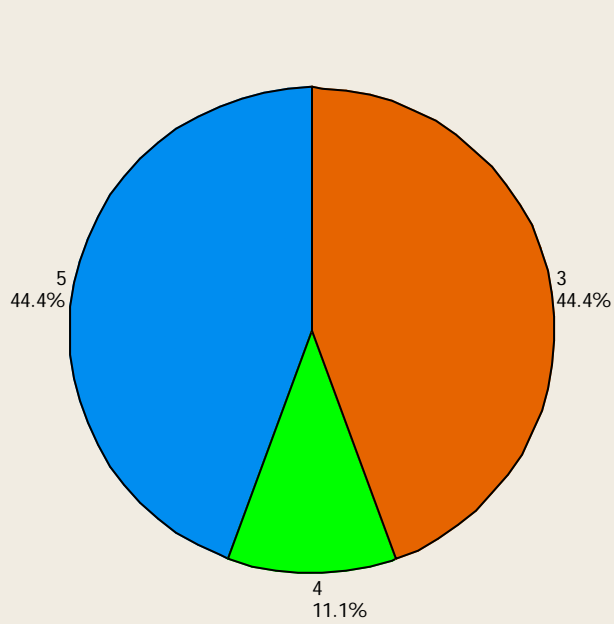
Pie Chart of Auto Passenger Safety

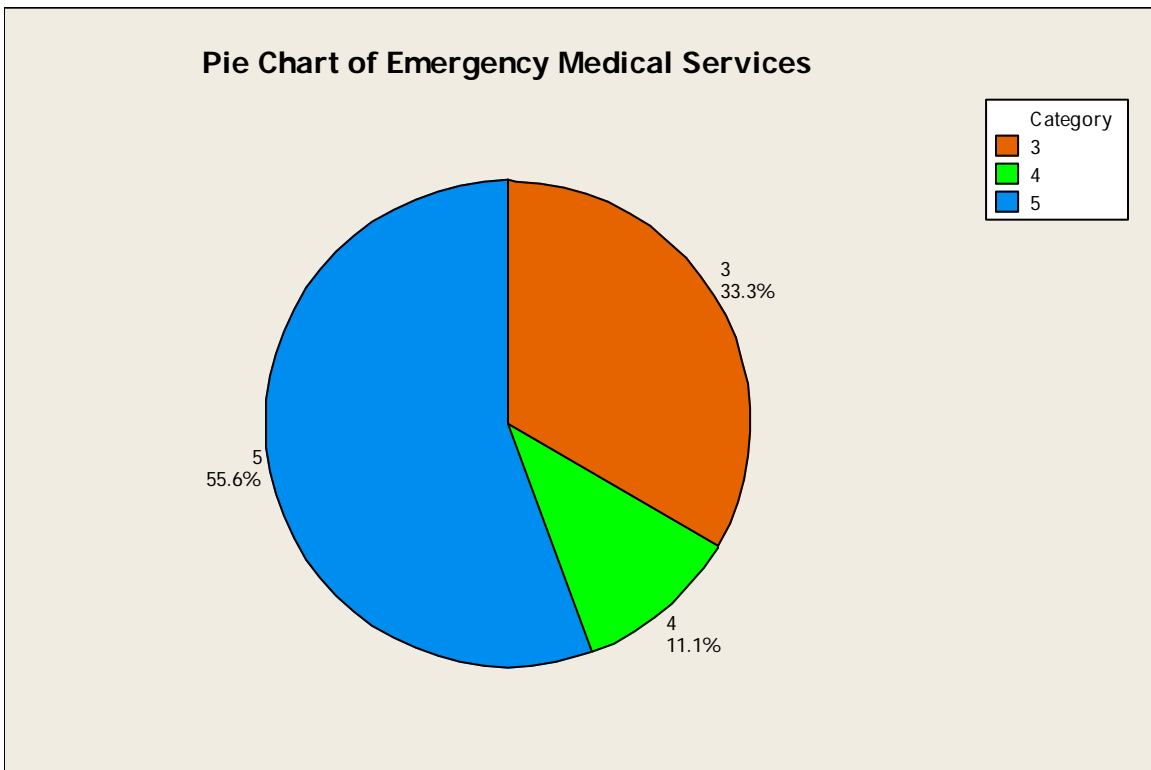
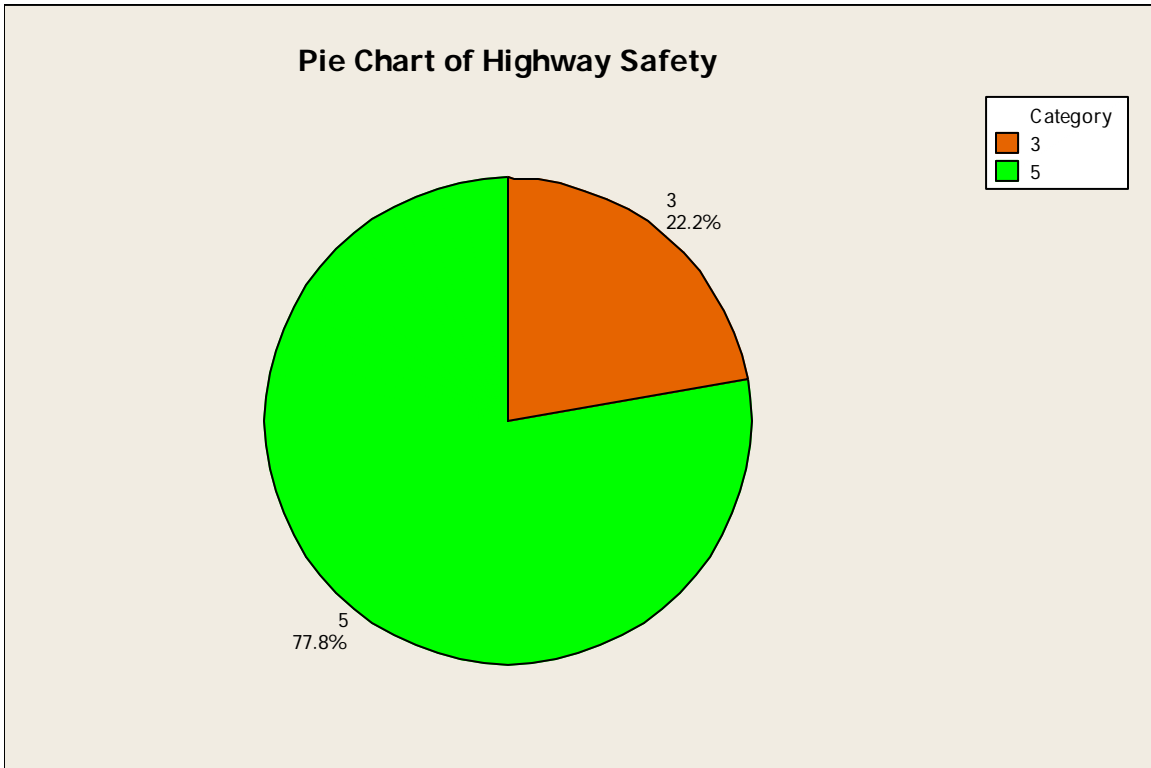


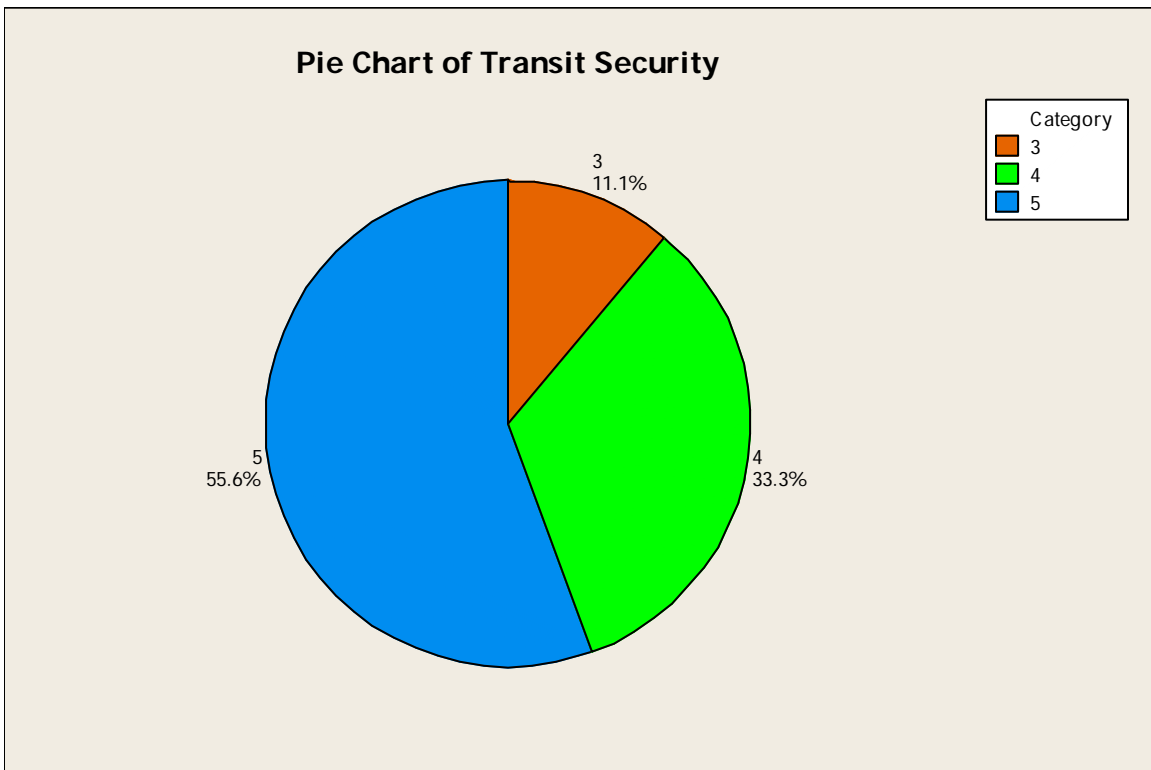
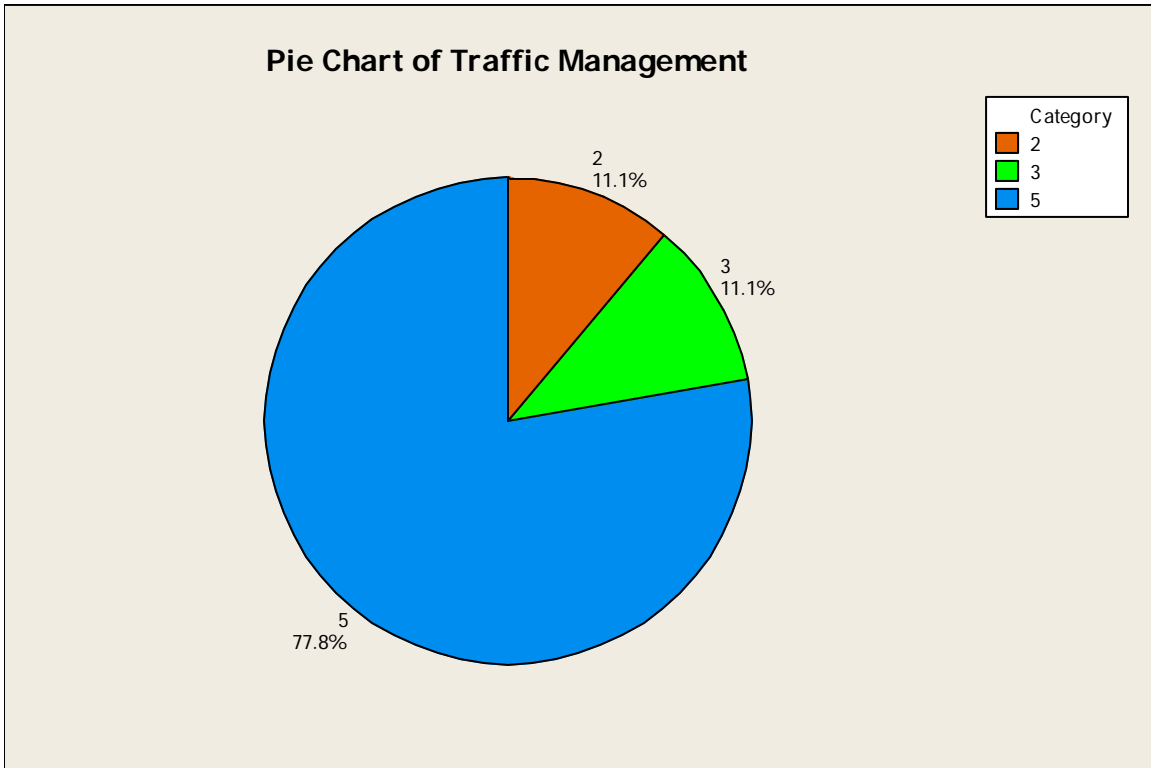
Pie Chart of Pedestrian and Biker Safety



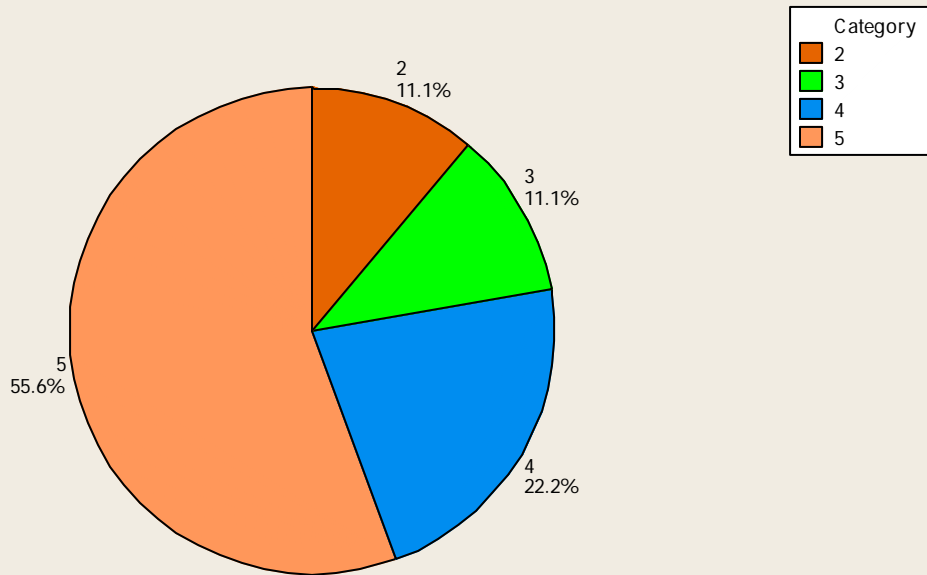
Pie Chart of Vehicle Safety



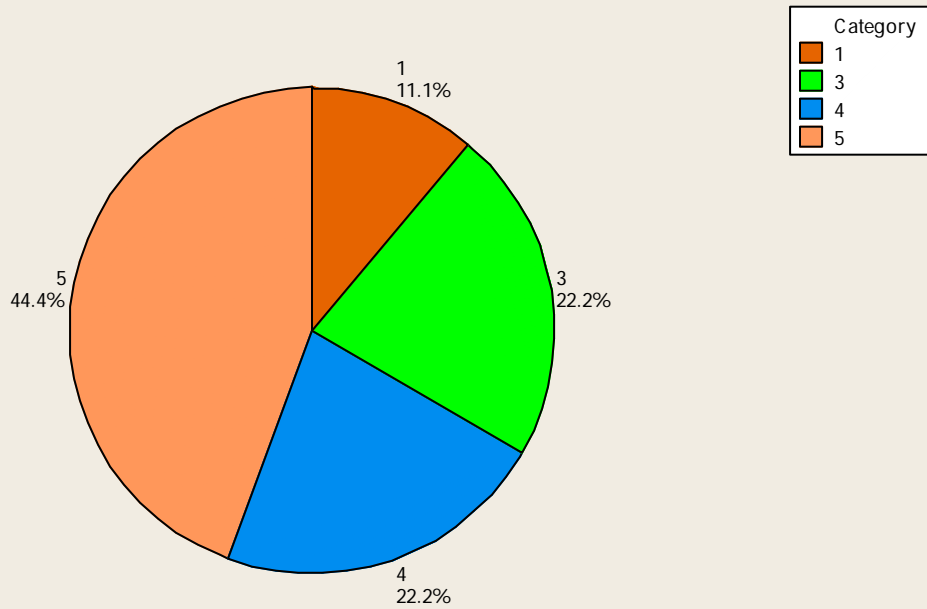




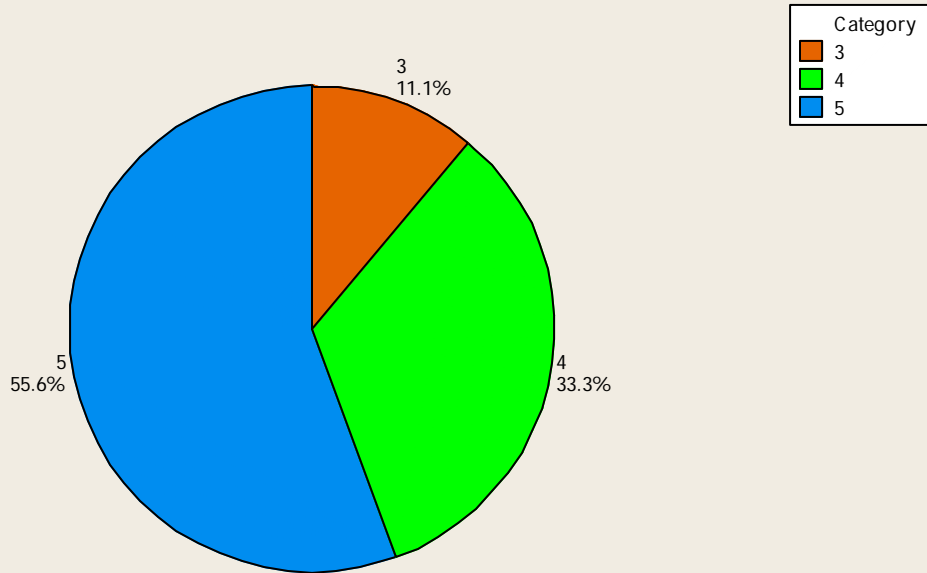
Pie Chart of Highways Security (including bridges and tunnels)



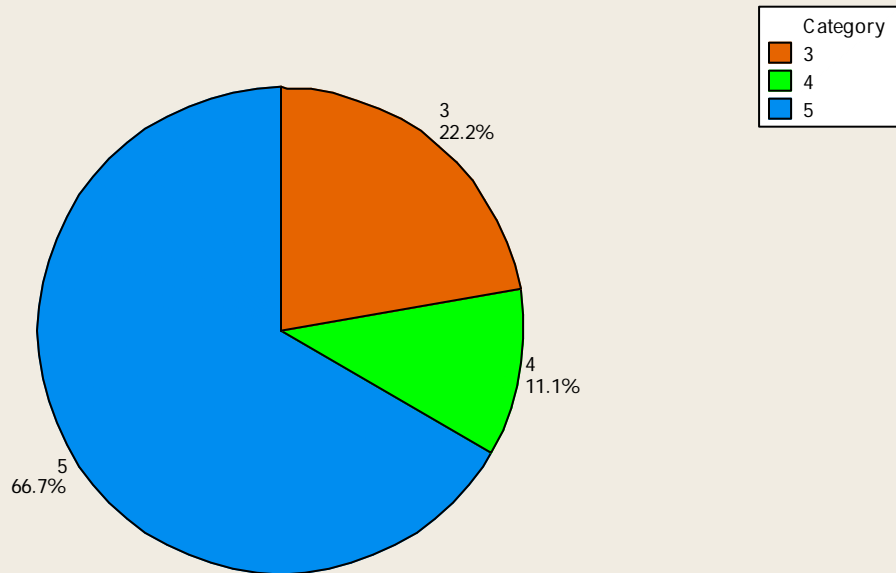
Pie Chart of Freight Security



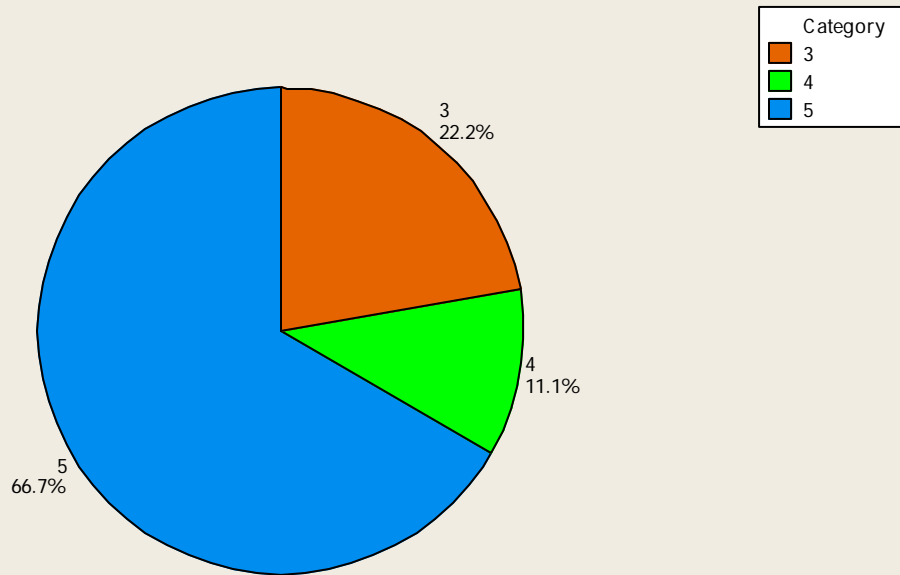
Pie Chart of Vehicle Based Technology



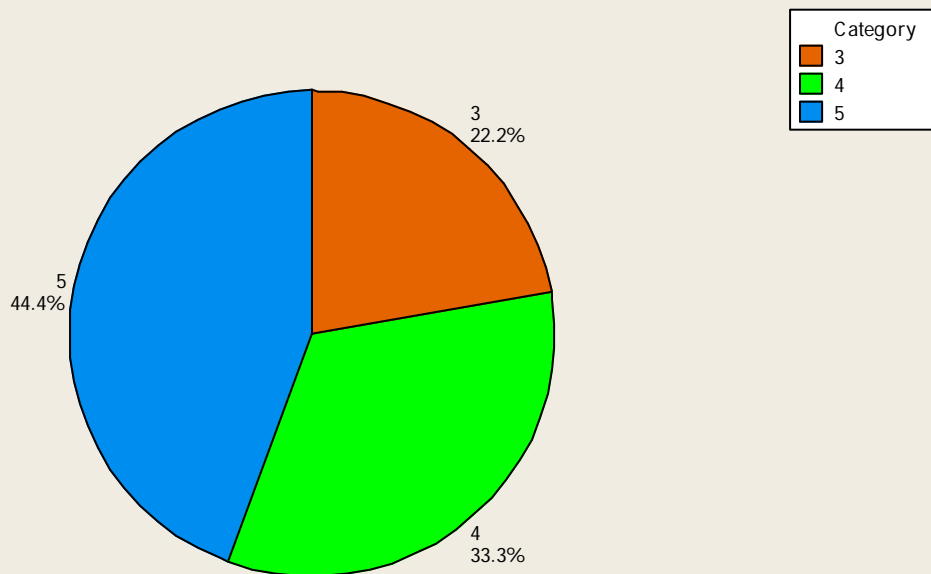
Pie Chart of Fuel Technology

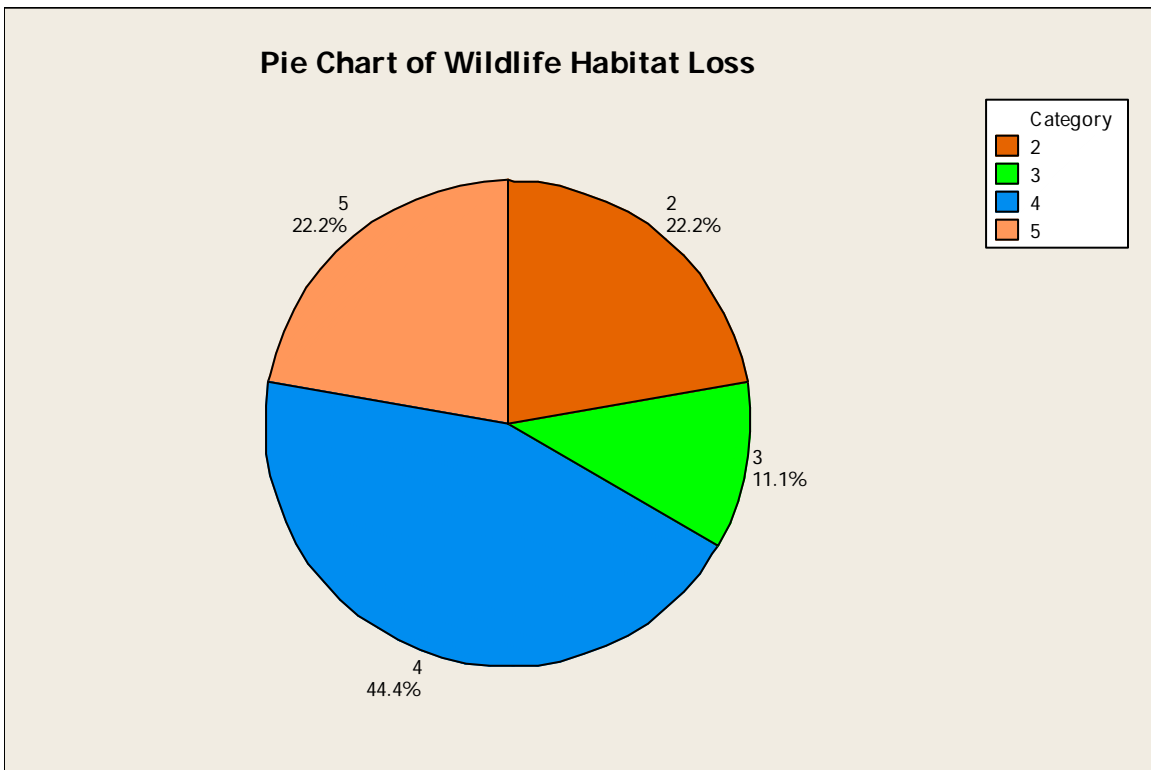
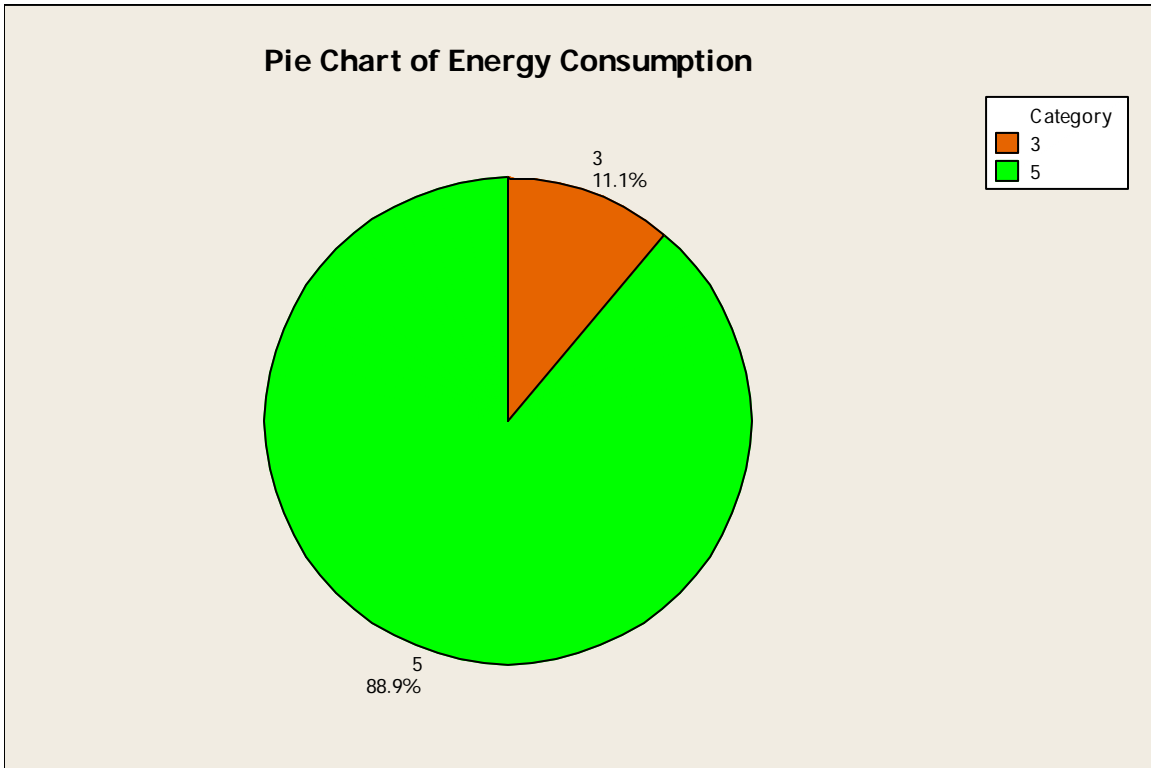


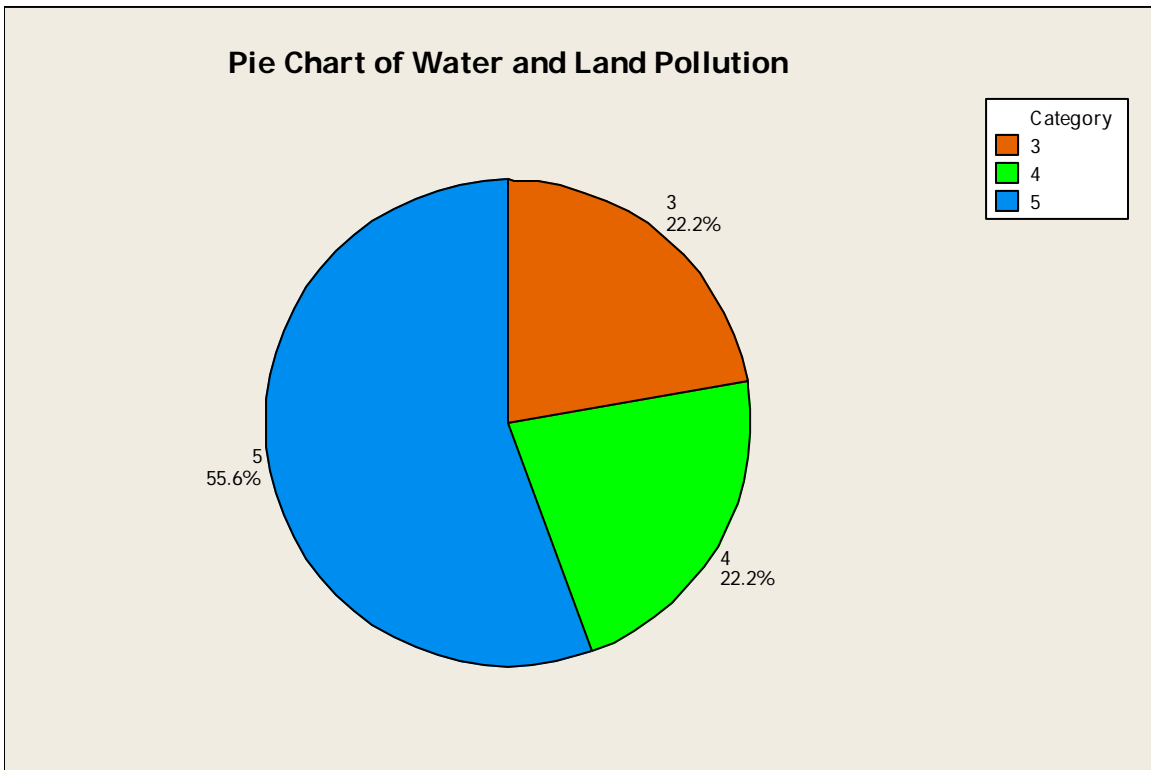
Pie Chart of Transportation Infrastructure



Pie Chart of Noise Pollution







6 PROJECT STATUS REPORT APPROVALS

Prepared by _____
Principal Investigator

Approved by _____
Project Manager