PLANNING OF A SECONDARY ROAD NETWORK FOR LOW SPEED VEHICLES IN SMALL OR MEDIUM-SIZED CITY: USING GOOGLE EARTH

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ABSTRACT
In response to the growing environmental concern, the use of low speed vehicles (LSVs) on public roadways is gradually increasing in recent years as a short-range alternative to fossil-fueled autos. Primarily designed for protected environments and gated communities, LSVs have a maximum speed limit of 25 mph and are not subjected to the same Federal Motor Vehicle Safety Standards required for regular passenger cars. This paper presents a comprehensive planning methodology for the development of a secondary low speed roadway network primarily intended for use by LSVs that can be applied to small or medium-sized cities with closely located activity spaces. Typically, small or medium sized cities have limited planning or construction resources, therefore the objective was to develop the low speed network based on the existing road system of the city, with minimal infrastructure modifications. The City’s Transportation Plan and public opinion on route preference were integrated with the road analysis tool of Google Earth to accomplish the network development process. Public involvement in the process through a survey provided valuable insight on users’ route choice behavior; whereas the roadway inventory by City’s Transportation Planning document and Google Earth helped to evaluate city’s actual transportation infrastructure and also helped to analyze the factors influencing LSV users’ route preference behavior. The developed low speed roadway network is expected to provide safe and efficient connectivity from neighborhood areas to major activity centers of the city by LSVs, while minimally affecting the safe operations of regular automobiles.
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1. INTRODUCTION
In response to the growing environmental concern, the concept of Low Speed Vehicles (LSVs) has emerged as a new mode of urban transportation. These vehicles offer the benefits of zero tailpipe emission, reduced greenhouse gas emission, less energy consumption, low noise and low maintenance over conventional motor vehicle. According to a report by U.S. Department of Energy (DOE) published in 2001, each LSV can prevent the consumption of 329 L (87 gal.) of gasoline, and consequently the emission of 570 ton of GGE per year (1). Therefore, the use of LSVs on public roadways is gradually increasing in recent years as a short-range alternative to fossil-fueled autos (2). Specially, in multi-car households, people find it desirable and economical to substitute a conventional passenger car with a LSV for local commuting and personal errands due to their energy efficiency and lower operating cost.

On June 17, 1998, the National Highway Traffic Safety Administration (NHTSA) officially included “Low-speed vehicles” as a motor vehicle category of the Federal Motor Vehicle Safety Standards (FMVSS) and defined LSV in 49 CFR 571.3 (3). According to the definition in this rulemaking, “Low-Speed Vehicle (LSV) is a four-wheeled motor vehicle whose attainable speed in 1 mile is more than 20 mph and not more than 25 mph on a paved level surface and has a gross vehicle weight rating (GVWR) of less than 3000 lbs.” This group includes neighborhood electric vehicles (NEVs), and speed-modified golf cars whose top speed is greater than 20 mph, but not more than 25 mph. FMVSS 500 requires LSVs to be equipped with headlights, taillights, brake lights, turn signals, seat belts and other safety features. However, these vehicles do not have to meet all the federal motor vehicle safety standards required for conventional passenger car. Also, a study conducted by the University of California noted that such vehicles are typically shorter in length, width and wheelbase than the American Association of State Highway and Transportation Officials (AASHTO) designed passenger cars, and they also have slower acceleration (4). Therefore, while LSVs use the same right-of-way with higher-speed regular traffic on public roads, they impose potential risks to the occupants of LSVs due to the speed differential and the different physical features of the two classes of motor vehicles (2).

As LSVs continued to become more numerous on public roads, there is a need to investigate the impacts of their use to ensure the safety of the traveling public on the roadways, but at the same time, LSVs also need a user-friendly infrastructure that would take into account of their inherent physical features and lower crash protection characteristics. Stein et al. discussed about developing a new roadway infrastructure and modifying traffic control devices to safely accommodate LSVs on roadways used by larger vehicles and fast-moving traffic (4). However, development of a completely new LSV infrastructure by modifying the existing road network in the city would be very expensive, time consuming and in many cases, not feasible due to adjacent land use characteristics. For example, provision of separate LSV path by either increasing the total road width or narrowing the lane width is not always feasible, especially when there is a bike lane beside the major through traffic lane on roads. Also acquisition of new land for expanion of the road width is very expensive and often not possible for majority of the roads within the city. Therefore, instead of developing a completely new infrastructure for LSVs, a parallel or secondary low speed roadway network needs to be identified and developed in addition to the primary road network within the city. The purpose of this secondary road network is to provide safe and continuous links between neighborhood areas and all major activity centers of the city to be used by human and non-human powered low speed vehicles. This study attempted to develop this secondary low speed road network based on the existing road infrastructure of the city, making any special infrastructure change of the roads, as minimal as possible. To accomplish this network development process, the City’s Transportation Plan and LSV users’ route preference feedback obtained from a survey were integrated with the road analysis tool of Google Earth. Google Earth helps the planner to identify the actual road condition during the planning process, and it is also very accessible. Usually the analysis of routes assumes the concept that travelers use some form of minimum-cost or minimum-distance path from their origin to destination
(5). But the use of Google Earth assisted the planner to develop the low speed network not only based on travel time or distance between origin and destination, but also considering other roadway factors important for making route choice decision.

2. **PLANNING OF THE LOW SPEED NETWORK**

The objective of this research is to develop a low cost and easily adaptable planning methodology for the low speed route network in a small or medium sized city based on the city’s existing road network. Typically, small and medium sized cities have limited planning resources, and also limited scope of new infrastructure establishment. Therefore the methodology did not propose any new road construction or design modifications for the existing roads that would be used as the potential link of low speed network. In cases where it was not possible to provide any connectivity to certain part of the city through its low speed route, this research recommended some mitigation criteria to resolve the connectivity gaps. It is important to note that planning of a LSV network is different from the planning of regular motor vehicle networks. For regular motorized traffic, trip distribution and assignment is relatively straightforward as it is influenced by impedance factors such as travel distance and vehicle-flow capacity constraint (6). In case of LSVs, several other factors influence the route choice behavior of the users. Some of these factors include the motor vehicle speed, the percentage of heavy vehicles in the traffic stream, the perceived hazard of sharing the roads with regular motorized traffic, and roadway geometrics, such as number of lanes, vertical elevation etc. Therefore, all these factors need to be considered in the planning of low speed network. These factors are categorized into two groups - link-level and route-level factors. The link-level factors considered in this research included roadway classification, geometric configuration of roads such as the number of lanes, percentage of heavy vehicles, barriers, and elevation difference. Route level factors can be better valued when they are accumulated over the entire route (7). These factors are distance, number of stops, intersection type, accessibility, and safety.

To date, the research could find almost no studies that examined the route planning of LSVs on public roadways. Although not exactly similar, LSV has some features analogous to bicycles and other non motorized vehicles, such as zero tailpipe emission, lower crash protection than motor vehicle, lower speed than regular traffic, alternative mode for cars to travel etc. Therefore, the literature related to the route choice, travel behavior and network development for bicyclist were also studied in this research. These included the AASHTO Guide for the Development of Bicycle Facilities, Wisconsin Rural Bicycle Planning Guide, the Comprehensive Plan of the City of Corvallis, Bicycle Planning Guide by Virginia Department of Transportation etc. (8, 9, 10, 11). The literature review helped to assess different factors that might influence LSV users’ route choice decision.

This planning process followed the concept of activity-based travel model instead of the conventional four-step planning model to develop the network, because of the fact that the activity-based model deals at the individual or disaggregates level. This model represents an individual’s demand for activity and travel as an activity pattern and set of tours, where a tour can be defined as a sequence of trip segments originated from home and ends at home (12). This is different from conventional transportation planning which uses large aggregated areal units like cities or traffic analysis zones (TAZs) as the unit of analysis (13). Therefore, the conventional model does not reflect the individual LSV user’s activity pattern within the micro-environment, whereas micro-environment analysis is important for LSV trips instead the aggregated traffic zone analysis. Hence, this planning methodology followed the concept of activity-based model, where linear transportation segments or corridors were used as the basic unit of analysis. The output of this model is an origin-destination matrix. In this research, home was considered as the origin of the trip and all other activity centers were considered as the destination of the trip. In general, all origin-destination points were considered as the nodes of the network, while all the connecting streets of these nodes were considered as the links of the network. Trips were made through the link from one node to another. Figure 1 represents the schematic diagram of this step-by-step planning methodology.
2.1 Study Area
This planning methodology was applied to the study area that represents a small or medium sized city with closely spaced activity centers and neighborhoods that are in need of a road network to accommodate the safe movement of LSVs. The City of Corvallis in Oregon was selected for that purpose; since there are a number of LSV, electric vehicles and non-motorized vehicles using the public roadways. Also the concept of urban sprawl is not applicable for this city. It is the home of Oregon State University (OSU) with a city population of 55,370. The city was awarded as one of the best college towns in U.S. by the American Institute for Economic Research’s annual College (AIERC) Destinations Index. The grid pattern neighborhood areas and the activity centers are closely located in the city. The current planning documentation for the existing trip generation characteristics of the city revealed that a significant portion of the trips are home-based shopping or other. The city downtown and OSU are the most significant trip origin and destinations points and are within about a five-mile or less distance from the neighborhood areas. In addition, the trip generation characteristics showed that as the city grows, there is a high potential for mixed-use development, allowing each area to have elements of housing, employment, schools, and shopping activities. This would potentially result in shortening the length of daily trip made by city dwellers. The City also aims to provide energy efficient alternative sustainable transportation mode to its residents, as directed in the City Comprehensive Transportation Plan. All these characteristics provided a good base for developing a secondary low speed road network within the city.

2.2 Vision and Objective
The vision of this secondary low speed network planning was to provide a safe, efficient and continuous operating path for LSVs throughout the city. This low speed network was developed using mostly the neighborhood streets and collector streets of the city in order to provide these vehicles a safe and direct access to homes and activity centers of the city. The ultimate vision of this planning methodology was to achieve the sustainable transportation goal of the city.

2.3 Public Involvement in Developing the Plan
The opinion of the local community groups, LSV advocates, and other interested citizens should be included from the beginning of the planning process. This helps to assess users’ route preferences for driving LSV, and also to set goals and objectives in the planning effort. Moreover, incorporating public opinion during the development of the network plan also helps to generate a basis for supporting the alternative transportation within the city.

A revealed preference (RP) survey was conducted to identify different factors that influence LSV users’ route choice behavior. Those factors were considered thereafter in developing the network. RP survey measures users’ route choice preference by presenting an actual choice environment and reveals the travel behavior of an individual user by providing the direct report of his actual trips. However, the survey conducted in this research was fiscally and time constrained, therefore the sample size was limited since not all the LSV owners in the city were identified or contacted.

However, the survey conducted with a group of LSV users, did provide some important insight into the trend of route preference characteristics as well as the user characteristics. It should be noted that the results of this survey did not represent all the LSV users of the country, but a particular group in the region of Corvallis. The survey revealed that users prefer to drive LSVs on neighborhood roads with posted speed limit of 25 mph or less. When the posted speed limit of roads exceeds beyond 35 mph, users found it unsafe to drive LSVs on those roads and did not prefer to drive on 45 mph posted arterial streets. This finding is consistent with many State laws regarding LSVs operation on public roads, which describes that LSVs can be driven on public roadways with speed limit of no more 35 mph.

The survey results indicated that the leading factors to motivate people driving LSVs in the city area were high gas prices, environmental concerns, shorter travel distance, health and age. In contrast, heavy traffic volumes, high speed traffic, the presence of heavy vehicles and uphill grades negatively influenced the operation of LSVs. Participants also reported that pavement condition and...
continuity were also important for their route selection. The public opinion collected through this survey helped to identify some valuable aspects impacting the route choice behavior of LSV users. All these factors were considered in the network development phase to ensure a safe and convenient LSV driving path, and also to enhance the overall acceptability of the network to its users.

2.4 Review of the Transportation Development Plan of City

The City of Corvallis maintains a comprehensive transportation planning framework, documented as “Corvallis Transportation Plan” and this was reviewed to obtain detailed information on the land use pattern and traffic characteristics of the city. Describing the functional classification of the roadway, the plan provided a detailed description of the existing roadways system running inside the city and addressed different issues associated with the current road system. Overall, the city transportation plan serves as a policy tool for the decision makers and municipal authorities to evaluate the existing transportation system of the city, and to analyze the effects that any development, specific transportation and land use decisions, and other social phenomena will likely have on it, and finally initiate proper steps to resolve any issue related to this system. In this planning methodology, City’s Transportation Plan was consulted to make inventory of city’s existing road system, such as the functional class of roadways, speed limit, traffic volume etc.

2.5 Application of Google Earth mapping tool

The planning methodology was developed primarily for small and medium sized cities that often have limited planning resources, and the mapping tool, Google Earth was used in this methodology. It is widely available software and planners can easily access this software from their computer. Google Earth presents a comprehensive map with legends depicting different activity centers in the city. The “Google Street View” option allows the planner to virtually walk on the street and analyze different road characteristics, which includes the number of lanes in each direction, presence of curbs, shoulders or medians, the types of traffic control system present on roads etc. Planners can also assess the type of adjacent land use by “Satellite View” that provides an indication of the functional classification of streets- whether it is a collector or neighborhood street. All these characteristics significantly affect the route choice behavior of the LSV users. The Google Earth roadway analysis provides planners with a simple tool to evaluate different roadway characteristics and assess the factors influencing LSV users’ route preference behavior. This helps planners to select potential routes from the existing roadway network.

2.6 Analysis of the current roadway system

A comprehensive analysis of the existing road system included the identification of the roadway posted speed limit, the functional classification, the roadway geometrics as well as potential barriers that may obstruct the regular movement of LSVs. All these important factors were then combined together to select potential routes for low speed network. The City Transportation Plan, feedback from the survey and the Google Earth mapping tool were used simultaneously to analyze the road system. This process included the three important steps: i) identification of the activity centers, ii) inventory of the current roadway system, and iii) identification of the potential barriers.

2.6.1 Identification the Activity Centres

The activity centers in the city were identified by the “Point of Interest (POI)” option of Google Earth. Figure 2 shows the map of Corvallis city with different activity centers displayed on it. After identifying the activity centers within the city, a detailed mapping effort was conducted to link these activity centers as much as possible to facilitate an easy and continuous travel of LSVs within the city.

2.6.2 Inventory of Existing Road System

The existing roadway system of the city was used as the base of low speed network in this planning methodology. The potential links between different activity centers were chosen from the existing road network based on the road speed limit, traffic characteristics and roadway geometric features. Data on roadway speed limit and roadway functional classification were collected from the City’s
Transportation Plan. At the same time, the physical characteristics of the roads were analyzed by Google Earth. Different roadway features that influence the operation of LSVs are described below.

Types of Roadways: The functional classification of roadways is very important for this low speed network development. Generally the speed limit and traffic volume in freeways and arterials are very high in contrast to collector and neighborhood streets. Also, the primary purpose of collector and neighborhood streets is to provide vehicle access to different activity centers inside the city. Therefore, the aim of this study was to avoid the freeways and arterial streets, and use collector and neighborhood streets of the city as much as possible, to develop the low speed network. Detailed information on the roadway functional classification for the Corvallis city was collected from city’s Transportation Planning document.

At the same time, to assess roadway type, Google Earth mapping tool was used as it displays the names and position of major highways, county roads, and city streets running inside the city. Google Earth also indicates the state highways and some of the arterial streets by solid yellow line in the city map. These high-speed roads were identified by simultaneously consulting the City Transportation Plan and Google Earth to screen those out in network development phase.

Roadway Speed Data: According to NHTSA, LSVs have maximum attainable speed of 25 mph. After analyzing the safety issues of these vehicles conducted by the authors in another study, it was recommended that the operation of LSVs should be limited to public roadways with a posted speed limit of 25 mph. A speed differential is created when LSVs are operated with the regular traffic operating at higher speeds on public road, which poses potential safety risk for the occupants of LSVs. Also, almost 35 states in the U.S., including Oregon have specified the roadway speed limit of maximum 35 mph where LSVs can be operated. Therefore, roadway speed data is an important factor to develop the low speed network. In this study, the roadway speed data for the Corvallis city was derived from City’s Transportation Plan.

Traffic Volume: Motor vehicle traffic volume on the roads considerably impacts LSV users’ trip experience. Higher motor vehicle traffic substantially creates weight differential as well as speed differential for LSVs. This increases the probability of potential conflicts between LSV and motor vehicles. The Street view imagery of Google Earth was used to assess the traffic volume of the road. Simultaneously, city’s Transportation Plan was also consulted to obtain the traffic volume data of city roadways.

Number of Lanes: Number of lanes is an important consideration for developing the low speed network. It was observed from the survey that LSV users prefer roadways with no more than two lanes in both directions. When the number of lanes in two directions increases to more than two, the perceived risk of operating LSVs on those routes also increases. This is due to the reason that, usually with increasing number of lanes, traffic volume and roadway speed limit also increase. Also, users do not feel comfortable when any vehicle, heavier and faster than LSVs overtake them. Therefore, the roadways with more than two lanes, one in each direction, were avoided as possible in the development of LSV network. The number of lanes in every direction of the roadway was identified by using The “Satellite View” option of Google Earth. This view also helped to identify the presence of bike lanes on the road.

Heavy Vehicles: The presence of buses and trucks on the road poses a negative impact on the route choice behavior of LSV users. Heavy vehicles in the traffic stream creates significant weight differential that poses potential risk to the LSV users. The “Transportation” option in the “Layer” panel of Google Earth indicates the streets in the city carrying heavy vehicles by showing the icon of ‘Bus Stops’. This was an important information for this study because it was assumed that the most percentage of heavy vehicles running on the city streets at regular basis is City Buses, which might
significantly create weight differential for LSVs. Therefore, using this information, the routes with city buses were identified to avoid as a link of the low speed network.

**Hilliness:** The route preference of the LSV users obtained from the survey revealed that users prefer flat terrain to drive LSVs than hilly terrain. Despite the facts that hilly terrain often offers visual and scenic view, users try to avoid routes with hilly terrain. One probable reason might be higher energy consumption while driving LSV from flat to hilly terrain. Also for some of the LSV models, the speed drops by half on the uphill grades ($i$). The LSV performance on hills is limited by the design of the electric motor, vehicle weight and batteries. LSV’s operators are similar to bicycle riders who self select terrain depending on the “motor” or physical condition of the operator. Hence, most hilly routes were avoided in developing the low speed network. The ‘elevation’ option of the Google Earth map window displays the elevation of any point on earth. Integrating the information on elevation obtained from Google Earth with the route information provided by the local LSV users, the routes of higher elevation were identified to screen out during network development.

**Types of Intersection:** This is an important factor in the planning of low speed network. After analyzing the safety issues related to LSVs conducted by the authors in another study, it was recommended that these vehicles should be restricted to crossing higher-speed roads at four-way stops or signal-controlled intersections (2). Therefore, the low speed network needs to be planned to minimize the number of crossings of high-speed intersections of arterials or major collector roads. The physical and functional characteristics of the intersections were identified by analyzing with Google Earth and also by consulting the City Transportation Plan.

**Continuity:** Continuity is most meaningful when accumulated over the entire route (15). From users’ feedback, it was evident that they have a strong preference for continuous low speed routes to different activity centers of the city. Therefore, the connectivity gaps in the low speed road network should be carefully identified and appropriate measures should be taken to provide a possible solution. Connectivity gaps in the network were identified from local users’ feedback in the survey and also by analyzing with Google Earth “Satellite” view option.

**Accessibility:** One of the major characteristics of a good road network is to ensure accessibility to all the destination points. According to Handy, “Accessibility can be defined as a way of describing the opportunities for participating in activities, such as, work, shopping, recreation, available to residents of a given place” (16). It is determined by the connectivity between activity centers as provided by the transportation systems. Therefore, the low speed network needs to be planned in a way so that it provides accessibility between the residential neighborhood and all other activity centers within the city. Major connectivity gaps need to be identified as described above and proper measures should be proposed to mitigate those gaps in order to ensure accessibility to the major destination points of the city.

### 2.6.3 Identification of the potential barriers:

In the early stage of the planning process, potential obstacles or barriers that may hinder the regular movement of LSVs, need to be identified. These may include physical barriers or local regulatory aspects, such as high-speed intersection, that might potentially obstruct the safe passage of low speed vehicles. Different types of barriers are summarized below.

**Physical Barriers:** This type of barriers includes mountainous terrain, some traffic calming devices, multiuse paths etc. Traffic calming devices such as bollards or high bumps placed at neighborhood streets to control regular motor vehicles may sometimes create problems for the smooth passage of LSVs. Also, multiuse paths are not recommended for driving LSVs since they are physically separated from the motor vehicle traffic and are dedicated for pedestrian and bicycle traffic.
Therefore, LSVs on multiuse paths might pose speed and weight differentials for multi use path users. All these barriers need to be identified in order that they are minimized in the network.

**Infrastructural Barriers:** In many cases, high-speed roadways surround neighborhoods or activity centers. These high-speed roads create barriers to the access of LSVs and other non-motorize road users to those activity centers. In addition, LSVs are more vulnerable to risks than conventional motor vehicles. Therefore, motor vehicle high crash locations in the city are also of safety concern for LSVs (10). These high crash locations need to be identified possibly from local users’ feedback and from the city’s traffic engineering reports. The low speed network needs to be designed in a way such that LSVs do not have to cross these high crash locations.

After identifying these potential barriers in the existing roadway system as much as possible, appropriate measures were recommended to eliminate, overcome or bypass those barriers. When the elimination of barriers was not possible, a convenient alternative route was proposed for the movement of LSVs.

3. NETWORK DEVELOPMENT

Once the inventory of the existing roadway system was completed and all the potential origin and destination point of the city were identified, low speed network was developed by following a two steps procedure: i) Connecting the origin and destination points, and ii) Recommendation to fill up the connectivity gaps.

3.1 Connecting the Origin and Destination Points

The “Add Path” option in Google Earth allows the planner to depict a path by drawing lines on the city map. This option was used to depict the links between different origin and destination points to develop the network. Again, the different color-coding property of these lines helps the user to distinguish the routes of different characteristics on the low speed network map. The step-by-step procedure to develop the network through Google Earth is described in the following section.

- First, the city boundary was defined on city map using “City Boundaries” option of Google Earth.
- All the State Highways and major arterials running through the city, such as US 20, OR 34, OR 99W (3rd & 4th St.) and US 20/OR 34, were identified by their solid bold yellow line representation on Google Earth city map and thereafter avoided as a link of the proposed network. Figure 3 displays some of these State highways and city arterials. The Corvallis Comprehensive Plan was consulted to identify additional arterials that were not marked by yellow lines on Google map and was discarded as well. Also, by analyzing the type of adjacent land use by Google Earth, the functional types of roadways were assessed. For example, neighborhood streets can easily be assessed by adjacent residential houses and low traffic volume, whereas arterial streets are characterized by the adjacent commercial establishments and high traffic volume.
- Efforts were made to develop the network based on city’s minor collector and neighborhood streets with posted speed limit of no more than 25 mph. In general these roadways are two lane roadways. However, to provide connectivity to some major activity centers of the city, some arterials and major collectors with speed limit more than 25 mph, but no more than 45 mph, were needed to be included as a potential route in the low speed network. To distinguish the higher speed routes on the network, those were marked by red lines, whereas orange lines on the network marked the regular routes with 25 mph or less speed limit, as illustrated in Figure 3.
- Routes that include heavy vehicles, in particular city buses were avoided as much as possible in developing the network. However, it is often not possible to avoid all such roads especially for a college town like Corvallis. Therefore, some bus routes were included in the low speed network. However, bus routes included in the network were selected in a way so that those
have comparatively lower bus volume as well as lower motor vehicle traffic volume. Included bus routes were marked by purple color, as shown in Figure 3.

- Efforts were made to propose alternative routes for the hilly routes. However, many routes with higher vertical elevation, especially in the northwest end of the city could not be avoided in order to provide complete accessibility of LSVs to all parts of the city. Those included hilly routes were marked with blue color, as depicted in Figure 3, in order to distinguish those easily from other routes of the network.

- The network was initially developed so that the potential routes of network ran through every residential street. However, when it was not possible to include every neighborhood street in the low speed network, attempts were made to include every alternate neighborhood street in the network. This approach was adopted in order to provide access to almost every part of the city by LSVs, and also to give people more incentive to use energy efficient LSVs for their daily regular trip.

- For the city of Corvallis, the potential obstacles that created connectivity gaps in the network were identified, which included mostly some hilly routes and high-speed roadways with higher traffic volume.

### 3.2 Recommendations for Connectivity Gaps

It was not always possible to eliminate the natural barrier, such as hilly terrain. Alternative routes were proposed in such cases. The bicycle community is a good source of information for avoiding hilly routes. For the case of man-made barriers, various mitigating steps can be adopted to eliminate or avoid both physical and regulatory barriers. For example, in this case study, it was proposed that the local authority should amend the on-road regulations, such as posted speed limit for a specific high speed roadway of the city in order to provide access to LSVs to certain part of the city. Also, when a restricted use roadway in the city that provided access to only agricultural vehicles presented a barrier to the movement of LSVs, it was recommended that the operational classification of the restricted roadway be amended to accommodate LSVs and all the other roadway users including bicycles and pedestrians, but not high speed regular motor vehicles. Some regulatory signs can also be placed that would state the authorization of LSVs but prohibition of other motorized vehicles on those roads. This particular roadway’s restricted use has been modified and new connectivity options for LSVs now exist. In some cases, it was also recommended to adopt corridor management plan to resolve the issues with access control, multiple driveways and provide LSV access to the activity centers. Finally, to resolve the connectivity issues of low speed road network in the city, it was recommended that the city transportation agencies, municipal authority, stakeholders and the community people should work together to develop and implement the mitigation strategies.

### 4. IMPLEMENTATION OF THE DEVELOPED LOW SPEED NETWORK

Once the low speed road network was developed, it was recommended that the local authorities collaborate with other road authorities, local LSV operators as well as users of other transportation modes in the city to implement this network. Different short term and long term projects can also be adopted to implement this network. For example, the “Three Es (education, encouragement and enforcement) Program” can be introduced to develop public concern about the safety of LSVs and benefits of using LSVs network. Again, as the low speed network will be a new concept to the community, the community members can be provided with the map of low speed network along with the legend sheet containing symbols of different attraction points. A web site can also be maintained that will contain the complete information of low speed route, local LSV program in the city, multiple benefits of using LSV etc. At the same time, the urge for adequate funding sources is also mentioned for the proper implementation and maintenance of the network.

### 5. CONCLUSION

In the recent era when energy crisis and greenhouse gas (GHG) emission are the most severe issues the world is experiencing, LSVs can potentially contribute to reduce the scale of severity of these
issues. LSVs alone clearly are not the solution of all transportation problems, but these vehicles can significantly reduce the automobile dependency and increase livability in the community. However, LSVs have inherent safety risks associated with their use on public roadways due to their lack of crash protection features. To ensure safe operation of LSVs as well as other road users, this research proposed a comprehensive framework to develop a secondary road network in a small or medium sized city that has not experienced the concept of urban sprawl. Primarily intended for use by LSVs, this low speed routes would provide a secondary transportation network to many types of other road users who may prefer traveling on lower speed roadways. As small cities usually do not have extensive planning or construction resources, this network was developed completely on the basis of existing roadway system, mostly using the low speed neighborhood and collector streets. To accomplish that, Google Earth based road analysis was integrated with City Transportation Plan that helped to explore city’s actual transportation infrastructure; whereas the public involvement in the process provided valuable insight on users’ route choice behavior and also helped to identify the connectivity gap throughout the network. Therefore the low speed network presented here is expected to serve as a complete guide for the LSV users’ that would provide a safe and efficient connectivity to all major activity centers and neighborhood areas of the city, as much as plausible. In addition, the planned low speed routes did not interfere with the existing bike lane on the roads. Therefore, this network is also expected to assist the city authority to reach the multimodal transportation system goal for the city.

6. RECOMMENDATIONS

As an outcome of this research, it is recommended that the State and Local government should limit the on-road operation of LSVs to the roads having maximum-posted limit equal or less than the maximum operating speed of the LSVs, which is 25 mph in most cases. This would ensure the safety of LSV occupants and all other road users. Also, to get a broader picture of LSV usage more feedback should be collected from LSV users all over the community before the network is developed, which could not be accomplished in this study as mentioned in section 2.3. Opinions from motorists’, pedestrians’, bicyclists’, law enforcement officers’ and other stakeholders’ should also be accumulated regarding these small LSVs sharing the roadway and also on the developed low speed network. As, LSVs and the low speed route network is a comparatively new concept to the community, adequate publicity should be made to make people informed of this network. It can be accomplished through local TV channels, newspapers, public meetings and erected billboards during the establishment of the network within the city. A before-after study should also be conducted after implementing the low speed network to evaluate the overall impact of LSVs and their route network on the community. In summary, municipal authorities should work together with the related stakeholders, local LSV operators and users of other transportation modes to establish the low speed network and resolve the connectivity gaps of this network, thereby promote LSVs as a safe, green and alternative transportation mode in the city.
REFERENCE:


LIST OF FIGURES

FIGURE 1: Schematic Diagram of the proposed Planning Process for Low Speed Road Network

FIGURE 2: Location of different activity centers in the City of Corvallis

FIGURE 3: Secondary Low Speed Road Network
FIGURE 1: Schematic Diagram of the proposed Planning Process for Low Speed Road Network
FIGURE 2: Location of different activity centers in the City of Corvallis
SOURCE: Google Earth
FIGURE 3: Secondary Low Speed Road Network
SOURCE: Google Earth