High Voltage Transmission Line (HVTL) Right-of-Way Usage for Transportation Facilities

FEASIBILITY STUDY

FINAL REPORT

April, 2002

Maryland Department of Transportation

Office of Planning & Capital Programming

Acknowledgements:

The study team would like to thank the following individuals for their efforts in making this report a reality. Their attendance at team meetings, their technical expertise and their prompt replies when asked for comments made this feasibility study possible.

Maryland Department of Transportation:

- ***Marsha Kaiser – Director, Office of Planning and Capital Programming***
- ***Paul Oberle – Office of Planning and Capital Programming***
- ***Michelle Hoffman – Project Manager, Office of Planning and Capital Programming***

Maryland Power Company Representatives:

- ***Allegheny Power – Alan Fleissner, General Manager of Engineering and Construction Projects***
- ***Baltimore Gas and Electric (BGE) – George Niles, Transmission Engineering***
- ***Conectiv – Richard Galster Jr., Transmission and Distribution Planning***
- ***Potomac Electric Power Company (PEPCO) – Ron Marth and George Carlisle, Substation and Transmission Office***
- ***Southern Maryland Electric Company (SMECO) – Richard Hendershot, System Engineering Manager***

Maryland State Highway Administration:

- ***Joseph Bissett - Statewide Utility Engineer, Office of Construction***
- ***John Ney - Highway Design Division***
- ***Dennis Yoder, Office of Planning and Preliminary Engineering***

Maryland Transit Administration:

- ***Michael Bartholf - Deputy Administrator***
- ***Henry Kay - Director, Office of Planning***

Executive Summary

Executive Summary

Finding locations for new transportation corridors has grown more difficult as Maryland becomes more developed and available land in urbanized areas becomes scarce. Beginning with a proposal to the Montgomery County Council, the Maryland Department of Transportation agreed to conduct a study that would determine the feasibility of using existing high voltage transmission line (HVTL) corridors for transportation purposes as well. This involved locating a transportation facility in a corridor that often has very different characteristics from a traditional transportation alignment. Important considerations include the types of HVTL structures and corridor dimensions in comparison with various design requirements for different transportation modes. Because of the variability of these factors in Maryland, the study does not identify specific HVTL corridors for adaptation to transportation use. Rather, the study concludes with recommendations based upon general feasibility and lists the local conditions that would either favor or preclude joint use of HVTL corridors with transportation facilities.

In Maryland, five power companies transmit electricity on separate and individually maintained HVTL rights-of-way. The HVTL corridors vary in geographic location and transmission line voltage. The land within an HVTL corridor is either owned outright by the power company or purchased through an easement. Some common layouts of corridor width and structure location within the corridor are used as a starting point for further feasibility study. Footprints of towers on the ground as well as the necessary safety clearances, based on voltage and transportation type, reveal available portions of the corridor viable for transportation use.

Standards and guidelines for power structures vary by utility company. There is little precedent for guidelines regarding how power companies accommodate transportation along their rights-of-way or vice versa. The Maryland State Highway Administration (SHA) has a Utility Policy that outlines acceptable amounts of impact for HVTL structures in highway rights-of-way; however, it does not address sharing rights-of-way for long parallel sections. The necessary clearances and functionality stated in the Utility Policy would need to be achieved with no negative impact on the capability of the HVTL corridor as required by the power company's needs. Any improvements that would require modifications to the HVTL structures would require compensation to the Power Company and extensive modification could rapidly diminish any of the initial cost savings by using previously existing rights-of-way.

Design criteria for different modes of transportation are similarly documented. In addition to highway improvements, busways, light rail, sky train[1], and high speed rail (including Maglev technology) options are also considered along with each of their unique requirements. The possible combinations of these modes in several typical HVTL corridors are presented in the body of the report.

The Issues and Consequences chapter addresses the different design philosophies for HVTL and transportation corridors. HVTL corridors are not sensitive to elevation and can span many obstacles. Transportation corridors, however, need to have even grades and smooth transitions and often must go around major geographical obstructions. Maintenance of facilities is an issue

[1] A hybrid of light-rail and metro transit technology on elevated track and stations.

for both transportation facilities and utilities in the event of an incident or emergency. Safety concerns and sufficient clearance from the base of HVTL towers are also a major concern. Limiting the access to the towers causes an extra burden on the power company to maintain its property and could also preclude future expansion of the HVTL corridor to meet growing electrical demand. Costs increase and the ability to adapt transportation to an HVTL corridor decrease when the terrain is mountainous or there are multiple steep slopes. Examples of successful joint use occur in Louisiana where the land is flat and power companies benefit from having paved access to their structures. Within Maryland, there are numerous examples where HVTL and transportation share a corridor, but not over large distances where a previously existing HVTL corridor is adapted to transportation use.

The study reached five primary recommendations. The first recommendation is that only short segments of HVTL corridors should be utilized. Long distance use of HVTL corridors for transportation purposes is unlikely since a long HVTL corridor has a higher probability of rapid changes in direction or obstacles not easily negotiated by a transportation facility. A second recommendation is for low speed transportation options in HVTL corridors. Lowering operating speeds offers increased flexibility through less rigid design requirements and higher safety margins. Additionally, lower speed highway and transit modes have more tolerance for the grades and uneven ground that characterize an HVTL corridor in rolling terrain. A third recommendation calls for the use of guided transportation vehicles. Guided technology offers a higher safety margin and vehicles can operate closer to structures, thus better utilizing narrow HVTL corridors. A fourth recommendation is for a wide HVTL corridor on level terrain. The width of HVTL corridors analyzed within this report generally varied from 150 feet to 250 feet. Corridors less than 250 feet, afford little room for roads or rail to negotiate obstacles. Level terrain is important, as transportation facilities often require cuts or fills through rolling terrain, which may be incompatible in an HVTL and require costly retrofits. The fifth and final recommendation is for HVTL corridors with steel poles supporting the transmission wires. Steel poles have a smaller footprint on the ground and can offer increased buffer space between the base of the structure and the transportation facility. The recommendations are general in nature further study would be required for a particular corridor within Maryland. Even after a candidate HVTL corridor has been identified, the report emphasizes that only with an appropriate transportation mode and under a special set of circumstances would joint use likely be feasible.

In summary, the overall recommendations of this study for those conditions that would best support the implementation of a transportation facility within an existing HVTL corridor are as follows:

- Utilization of short HVTL corridor segments instead of long segments
- Lower speed
- Guided transportation systems
- Wider corridors with level terrain
- Steel poles used as HVTL structures

Table of Contents

List of Figures

Figure	**Title**	**Page**
II-1	Power Company Jurisdictions within Maryland	5
II-2	Steel Pole Detail - Dual Circuit (Tangent Structure)	8
II-3	Steel Pole Detail - Dual Circuit (Angle Structure)	9
II-4	Dual Steel Tower Scenario	11
II-5	Clearances from Transportation Facilities	15
III-1, III-1a, III-1b	4-lane w/ Duel Steel Pole Scenario	23
III-2, III-2a, III-2b	Rail w/ Dual Steel Pole Scenario	26
III-3, III-3a, III-3b	Combined w/ Dual Steel Pole Scenario	29
III-4, III-4a	4-lane w/ Triple Steel Pole Scenario	32
III-5, III-5a	Rail w/ Triple Steel Pole Scenario	34
III-6, III-6a	Combined w/ Triple Steel Pole Scenario	36
III-7, III-7a	150’ Corridor	38
V-1	Map of Jefferson Parish, LA	48
V-2	Map of the King of Prussia Corridor, PA	49
V-3	Baltimore Light Rail – Westport Station	53
V-4	Map of the Norfolk Southern Main Rail Line, PA	54
V-5	MD Route 3, Crofton	57
V-6	MD Route 32	60
V-7	Southbound MD 170, Odenton (Lattice Tower)	62
V-8	MD 170, Odenton (Steel Pole)	63
B-1…B-14	Typical Sections Pursued but Dropped	B-1

List of Tables

Table	**Title**	**Page**
II-1	Clearance Comparison per Power Company	14
III-1	SHA Vertical Clearances	17
IV-1	Total Cost Estimate Ranges	46
VI-1	Recommendations for Transportation in HVTL Corridors	66
VI-2	Transportation Options Comparison Matrix	71

Table of Contents

Section	**Page**
I. Introduction	**1**
Introduction / Project Purpose	1
Scope Summary	2
II. Statewide HVTL Characteristics	**4**
Maryland Power Companies	4
Typical Corridors	4
Typical Tower Structures	6
Standards and Guidelines	13
III. Transportation Options	**16**
Overview	16
Maryland State Policy	16
Federal Policy	17
Transportaion Design Criteria	19
Design Criteria for Highways	19
Design Criteria for Transit	20
Hypothetical Corridors	21
Typical Sections	22
IV. Issues and Consequences	**40**
Types of Issues	40
Potential Costs	44
V. National and Statewide Examples of Shared Corridor Use	**47**
Joint Transportation and HVTL Use Corridors	47
Transportation Facilities with HVTL Crossings	58
VI. Recommendations	**65**
General (Mode, Length, Safety, Environment)	65
Corridor Configuration	68
Transportation Mode	68
Geographical Region	69
Utiltiy Company	69
Additional Conclusions	70
APPENDICES	
APPENDIX A Meeting Minutes	A-1
APPENDIX B Typical Sections Pursued but Dropped	B-1

I. Introduction

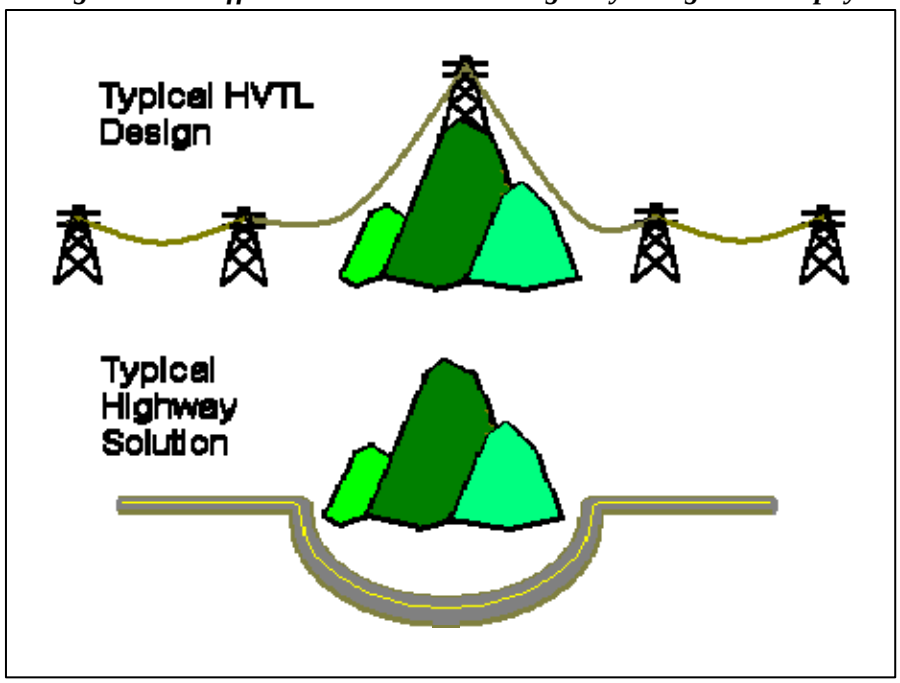
I. Introduction

Introduction / Project Purpose

As Maryland becomes more urbanized, there is a need to identify new strategies for locating transportation facilities. The traditional approach of purchasing an exclusive use right-of-way has become cost prohibitive. As a result, the Maryland Department of Transportation (MDOT) is interested in alternative ways to locate transportation facilities when the cost and availability of land would otherwise prevent the outright acquisition of a new transportation right-of-way. The goal of this study is to analyze the feasibility of using HVTL rights-of-way for transportation purposes while maintaining the utility companies' ability to maintain a safe, reliable, and economic electric supply. This general feasibility approach involves examining the different design philosophies of HVTL and transportation corridors and determining the conditions that would favor joint use.

The selection of transportation and HVTL corridors is based upon many factors. Transportation corridors are very sensitive to elevation changes and every effort is made to minimize grades. HVTL corridors use straight alignments where possible and are much less dependent on elevation differences. An HVTL corridor also has the ability to span certain obstacles or obstructions, while a transportation corridor often needs to go around such impediments (see Figure I-1). Across Maryland, there are many different HVTL structure configurations, each based upon specific conditions. The line voltage, number of circuits, available span lengths, and number of angles in the line route all determine types of poles and towers and their placement within the corridor. Transportation facility design is impacted by many factors including design speed, method of vehicle guidance, vehicle performance, and safety. This variability requires a broad examination of transportation requirements and HVTL corridor conditions across Maryland.

Figure I-1 - Differences in HVTL and Highway Design Philosophy



This study was initiated by MDOT subsequent to interest outlined by the Montgomery County Council, based upon a proposal submitted by Mr. Byrne Kelly, the principal of a Takoma Park planning and landscape architecture firm. Study recommendations identify the combinations of HVTL corridors and transportation modes that are most compatible and the circumstances that make the economic and environmental benefits of using HVTL rights-of-way superior to other rights-of-way for transportation purposes.

HVTL corridors are networked throughout the State of Maryland. The corridors are managed and maintained under the jurisdiction of five separate utility companies. A 'high voltage' transmission line is defined as one with an electrical phase-to-phase voltage in excess of 69,000 volts (69kv) or higher. The lines are located primarily above ground and supported by various types of tower structures. The corridors range in right-of-way width from 50 to 500 feet, with overall corridor width dependent upon the voltage of the electricity in the line. Higher voltages require more physical separation both within and along the corridor for safety considerations and this may necessitate larger corridor widths. The utility company may either own the corridor right-of-way in fee simple or be granted easements from the property owners in which to place their lines and structures. Likewise, higher voltages require more physical separation both within and along the corridor for safety considerations and this necessitates larger corridor widths.

The original intention of the study was to look at several specific corridors within Maryland and to recommend which corridors may be viable for transportation use. It was soon realized, however, that it would be difficult to base corridor specific feasibility of joint HVTL and transportation on only a few examples. Other concerns that arose included heightened public sensitivity towards the study of specific corridors, possibly raising public concerns and creating perceptions that transportation facilities were indeed being planned and designed within these corridors. As a result, the study was refined to look at general feasibility across the State. First, the study investigated the characteristics of various HVTL corridors in Maryland. The second phase included an analysis of various transportation options that could potentially utilize an HVTL right-of-way. Following these two steps, the study identified issues and consequences of for combined usage through discussions with stakeholders. Finally, the study concluded with recommendations concerning general feasibility of various transportation options in different corridors. The recommendations steer any future study of corridor specific implementation to the most promising candidates of transportation options based upon the HVTL corridor conditions. Throughout the study, national and statewide examples were gathered to represent some of the various possibilities for joint use, highlighting their practical benefits and issues.

Scope Summary

To prepare this feasibility study, the following activities were undertaken:

- Gather information and create a database of local and national examples of transportation facilities that were either built within HVTL corridors or contain HVTL issues, such as crossings, easements, etc.
- Initiate a Technical Advisory Committee, comprised of representatives from the statewide power companies and the transportation modal administrations, to serve as a 'two-way' sounding board throughout the study.
- Develop typical sections for several transportation modes and analyze the impact of locating these sections within generic HVTL corridors.
- Develop a comprehensive list of the issues associated with using HVTL rights-of-way for transportation use.

- Determine the anticipated difficulties that will arise through constructability concerns, applying to both the utility and transportation infrastructure.
- Summarize the above-mentioned tasks and key project activities and offer recommendations for possible transportation facility design concepts for different HVTL corridor types, geographical regions, and power company jurisdictions within a final report.

In developing typical sections, the study analyzed HVTL corridors of 150 and 250-foot right-of-way width, which included standard placements of towers within each type of corridor. To further reduce the complexity and number of typical sections to generate, transportation design criteria were established from the onset of the study. Design criteria identified the safety and performance requirements of certain transportation options that must be satisfied within the limits of an existing HVTL right-of-way.

This report can be used as a tool during the alternatives development phase of a transportation planning project and aid in determining whether or not to consider an HVTL corridor as a viable alternative for study through the project planning development process.

II. Statewide HVTL Characteristics

II. Statewide HVTL Characteristics

Maryland Power Companies

The electrical power transmission lines, steel structure and corridors dispersed throughout Maryland are owned, designed and maintained by five power companies, all with specific jurisdictions (see *Figure II-1*). The companies are listed and briefly described below:

- ***Allegheny Power (The Potomac Edison Company)*** – Within Maryland, Allegheny Power serves Maryland's westernmost counties and small portions of Montgomery, Howard and Carroll counties. Its jurisdiction also extends into Pennsylvania, West Virginia, Virginia and Ohio.

- ***Baltimore Gas and Electric (BGE)*** - Includes all or part of the nine counties within central Maryland, including Baltimore City.

- ***Conectiv*** – Serves all the Maryland Eastern Shore counties, Cecil County and part of Harford County, all of Delaware and the southern portion of New Jersey.

- ***Potomac Electric Power Company (PEPCO)*** – Serves the majority of Prince George's and Montgomery counties and the entire District of Columbia.

- ***Southern Maryland Electric Cooperative (SMECO)*** - Serves Charles, St. Mary's and Calvert (except the northeastern tip) Counties, and the southernmost portion of Prince George's County.

Representatives from the five power companies have been involved with the study since its inception in 2001. They met five times as part of the Technical Advisory Committee (TAC) and contributed ideas and voiced comments and concerns throughout the study. Other members of the TAC included utility experts from SHA's Offices of Construction and Highway Development, a representative from SHA's Office of Planning and Preliminary Engineering, representatives from the Maryland Transit Administration (MTA), and representatives from MDOT's Office of Planning and Capital Programming.

The TAC meetings were quite helpful and provided the groundwork for this report.

Typical Corridors

Each power company serves a different geographic region and coverage area throughout Maryland. The result is that each company's HVTL corridor characteristics vary. The density of the power company's network affects corridors when customers are located at large distances from generating facilities. For efficient transmission, this necessitates longer HVTL corridors that require increased right-of-way width for safety clearances. Typically, corridor width increases as the transmission line voltage increases. The final step in delivering electricity to customers involves localized and low voltage power distribution lines to residential or retail/business communities. These lines, with their lower voltage and safety requirements, often utilize an existing transportation right-of-way and run along existing arterial roadways and collector streets. See the Transportation Options section for typical section sketches.

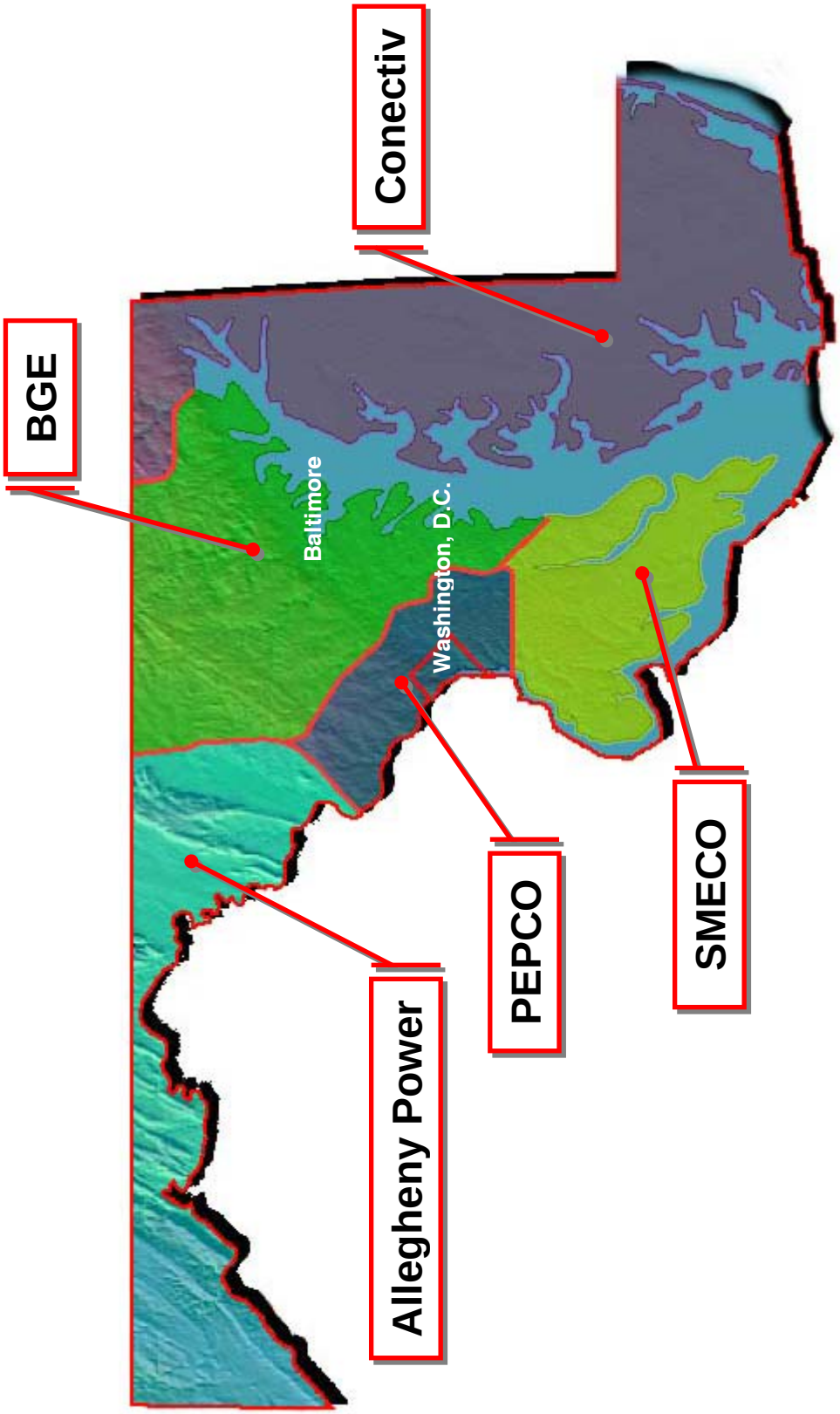


Figure II-1 Power Company Jurisdictions within Maryland

the wires that must be maintained. Also, it usually means the HVTL structures must be built stronger to carry the increased weight of lines carrying the higher voltage.

Other factors affecting HVTL structures include the span lengths, the available land, and the number of angles in the transmission line route. The severity of the angle is a very important criterion in transmission line design. It takes a stronger or more stable structure to support the wires turning an angle versus a tangent section. *Photo 1* shows a pole supporting wires turning an angle. Its construction is much sturdier than the pole shown in *Photo 2*, which is along a straight segment.

The strength to support heavier wires and span large distances dictate that HVTL structures be of substantial construction. For these reasons, usually only the lighter, lower voltage lines (typically less than 100 kv) are considered for wood structures. In the past, the only choice other then wood poles was the steel (lattice) tower configuration. Beginning about 40 years ago, tubular steel poles were manufactured to replace steel (lattice) towers. These steel poles provided sufficient strength while occupying less space at the ground level. Initially, steel poles were very expensive and used sparingly, but improved manufacturing and design processes have now made this type of structure more economical and its use has increased throughout the State.

Figures II-2 and II-3 are detailed sketches of a typical steel pole structure with 230kv dual circuits. *Figure II-2* shows the dimensions for a pole within a tangent section of the corridor. *Figure II-3* shows the dimensions of a pole used to support wires with medium and heavy angles.

Photo 1 - Large Steel Pole / Tower

This pole is 4 feet in diameter and is designed to withstand higher loads since the transmission lines and conductors form an angle. The voltage carried by this pole is 115 kv.

Photo 2 - Steel Pole in Tangent Section

The steel poles carrying 115kv transmission lines shown here are along the edge of the public right-of-way for MD 3, near Crofton, Maryland. The pole diameter is 3 feet.

Lattice towers are the most common structures found in Maryland's HVTL corridors. As shown in *Photos 3 and 4*, lattice towers have a much larger footprint than steel poles. This is due to the lattice tower's expanded base. The size of the structure footprint is important in determining the viability of implementing a transportation facility within the HVTL corridor right-of-way.

The base of a lattice tower is generally square and ranges from 16 feet per side to over 40 feet per side. The size depends on the height of the tower (the higher the tower, the wider the base) and the loading on the tower from the weight of transmission lines.

Photo 3 - Dual Lattice Tower Configuration

This photo shows the dual lattice tower configuration, one of the most common HVTL corridor configurations in Maryland. Figure II-4 describes the dimensions and spacing at this location.

Photo 4 – Single Lattice Tower Configuration

This is an example of a single lattice tower configuration. It has a narrower corridor due to the single row of towers.

The exact shape and placement of transmission wires can vary among lattice towers. This depends on the amount of support needed for the particular transmission wire circuitry. As evidenced by *Photo 5*, this tower was designed to handle only one horizontal row of transmission wires.

Photo 5 – 'Short and Wide' Lattice Tower

This corridor carries 230kv wires within BGE's jurisdiction. The base members of these structures are similar to those of the 'common' lattice towers, but the difference is that this tower widens at the top.

When the lattice towers need to be upgraded to handle higher loads (more circuits, higher voltage, etc.), they are often replaced with steel poles. Eventually there will be more steel poles than lattice towers throughout Maryland, especially if corridors are upgraded to handle 500kv transmission lines. Currently, there are very few 500kv HVTLs in Maryland, which typically connect power plants to main substations.

Photo 6 - Steel Poles Supporting 500kvWires

Photo 6 shows typical steel pole structures within 500kv corridors.

Photo 7 - 500kv Corridor

Photo 7 shows the same corridor, as in Photo 6, crossing a limited access highway (MD 3 in Crofton).

Photo 8 – Multiple Steel Poles

The steel poles in this photo need to provide extra support for the 500kv transmission wires due to the angle in the corridor. Absent any angles, fewer poles would be needed.

Standards and Guidelines

Each power company has their own general design standards and guidelines that are based in part on the National Electrical Safety Code (NESC). The purpose of the NESC is to provide the minimum accepted standards and guidelines for the practical safeguarding of persons during the installation, operation, and maintenance of electric supply and communication lines and associated equipment. Naturally, these safeguards would need to be extended to the vehicles using any transportation facilities placed in the vicinity of the HVTLs.

The NESC contains the basic provisions that are considered necessary for the safety of employees and the public under specified conditions. The NESC is not intended to be used as a design specification or an instruction manual. Individual power companies develop their own design standards and guidelines.

Table II-1 on the following page summarizes each power company's general guidelines for HVTL spacing and clearance requirements between transmission line structures and transportation facilities. NESC guidelines are also shown for comparison reasons. The horizontal clearances between the structure and the roadway facilities are generally determined on a case-by-case basis, depending on the transportation facility's design speed, types of protection barriers, and MDOT's fixed object safety standards. The vertical clearance categories are determined by the transmission line voltages.

See *Figure II-5* for a three-dimensional visual representation of the clearance locations.

Table II-1 - Safety Spacing/Clearance Guidelines in Maryland

	Allegheny Power	BGE	Conectiv	PEPCO	SMECO	NESC minimums
Horizontal Clearance from tower base to the edge of hwy. shoulder or rail track	15’	30’	25’	35’ preferred	MDOT req.+ barrier	Not specified
Horizontal Clearance between the vertical projection of the overhead conductor to the edge of hwy. shoulder or rail track	Not given	Not given	Not given	10’	Not given	8.7’
Horizontal Clearance from tower base to excavation work (blasting, grading, etc.)	Not given	40’	25’	Not given	Not given	Not given
Vertical Clearance between 115kv – 138kv conductor wires to the highway surface	25’	Exceed NESC	Exceed NESC	Not given	Exceed NESC	20.6’[1]
Vertical Clearance between 230kv conductor wires to the highway surface	27’	Exceed NESC	Exceed NESC	35’	Exceed NESC	22.4’[1]
Vertical Clearance between 500kv conductor wires to the highway surface	35’	Exceed NESC	Exceed NESC	Not given	Exceed NESC	27.9’[2]
Vertical Clearance between 115kv – 138kv conductor wires to the rail track surface	33’	Exceed NESC	Exceed NESC	Not given	Exceed NESC	28.6’[1]
Vertical Clearance between 230kv conductor wires to the rail track surface	35’	Exceed NESC	Exceed NESC	35’	Exceed NESC	30.4’[1]
Vertical Clearance between 500kv conductor wires to the rail track surface	43’	Exceed NESC	Exceed NESC	Not given	Exceed NESC	35.9’[2]

[1]The NESC computes minimum vertical clearances by adding 0.4 inches of clearance for each kilovolt over 22kv, up to 470kv. This spacing is added to the overall minimum clearance of 18.5 feet over highways, and 26.5 feet for rail tracks. For example, to calculate the additional clearance above 18.5 feet for a 230kv line spanning a highway, multiply the 230 kv * 105% (to obtain maximum operating voltage); then 242kv * √3 (this give the voltage to ground), then you would multiply (140kv-22kv) * (0.4”) * (1 foot/12”).

[2]The formula for determining additional spacing for transmission lines above 470kvkv is more complicated than for lines less than 470kv.

<u>Note</u>: Transmission wires naturally sag between tower connections due to the span length between towers and the downward force of gravity. However, the sag distance (drop in elevation at the low point of the wire) can vary depending on a number of factors. They include the conductor wire material, conductor wire tension, current flow, temperature, and precipitation (especially ice). For spans upwards of 1000 feet, the sag increase can be as much as 6.5 feet closer to the ground.

III. Transportation Options

III. Transportation Options

Overview

Transportation options or typical sections were developed as part of this study with the purpose of demonstrating the feasibility of implementation within existing HVTL corridors, or incorporated within the design of new HVTL corridors. The study team was unable to evaluate all possible scenarios due to almost unlimited number of typical sections that could be applied, particularly since the HVTL corridor vary tremendously. Modal options include heavy rail and light rail transit lines, general-purpose or managed highway lanes, and bus rapid transitways (BRT).

In developing these transportation options, the guidelines set forth by the five power companies and the National Electrical Safety Code (NESC) were important requirements. The power companies currently work with the Department of Transportation while designing their infrastructure improvements within or near transportation corridors. The power companys' designs must gain the approval of the administration, which owns rights to the transportation corridor or facility before any implementation can take place. This often requires complicated agreements for design, maintenance, and operations.

The next section discusses an example policy set forth by the Maryland State Highway Administration (SHA), regarding guidelines for utility lines adjacent to or crossing state highway facilities.

Maryland Utility Policy

The Maryland Department of Transportation, State Highway Administration's Utility Policy (SHA Utility Policy) regulates utility occupancy in SHA highway rights-of-way. This policy was developed in 1989, following a declaration by the Federal Highway Administration (FHWA) that granted approval authority of longitudinal occupancy of utility installations within highway rights-of-way to the state governments.

Potential impacts of HVTL installations upon the functions of a highway include the disruption of traffic flow, safety, and provisions for maintenance and future expansion of the highway. These impacts are addressed in several broad categories of regulation contained in the SHA Utility Policy, including:

- Obstruction of, or interference to, the operation of a State highway.
- Maintaining State highway safety during access and maintenance of utility installations.
- Utility design specifications and minimum construction standards within State highway right-of-way.
- Cost responsibility for any required modifications or relocation of utility facilities as required by State highway regulations.

Of most concern to utility companies currently enjoying unrestricted access to their facilities are the following safety precautions set forth by the SHA Utility Policy[1]:

[1] SHA Utility Policy, 1989. Page 2-4.

- Utilities will take precautions to protect the traveling public. No lane closures during the peak hours will be allowed. In some cases, it may be necessary to perform the work during off peak times or at night.
- Private automobiles and non-essential construction vehicles shall not be parked on SHA rights-of-way.
- Mud and debris tracked or spilled on the roadway shall be removed promptly.
- Appropriate protective measures, approved by the SHA, including warning signs and barricades, may be necessary around excavations or construction sites.

In general, the SHA Utility Policy states that longitudinal utility lines, whether above ground or underground, are not permitted within the right-of-way of existing highways. Wireless telecommunication installations are permissible within expressway rights-of-way and the requirements governing this use could also apply to highway locations around pre-existing HVTL structures. The priority order of utility structure location within expressway rights-of-way is stated as follows:

1) Vehicle access to the site can be obtained from outside the through roadway and connecting ramps.
2) Within interchanges, vehicle access can be obtained from the right hand side of the diagonal ramps.
3) Within interchanges, vehicle access can be obtained from the left hand side of the diagonal ramps.
4) Vehicle access can be obtained from the outside shoulder of the mainline.
5) Vehicle access can be obtained from the inside shoulder (median side) of the mainline.

Arterial and collector highways do not require such strict location criteria. In general, a lower design speed of the highway allows for more flexibility in utility structure placement and affords an extra margin of safety that helps to reduce some concerns regarding access to, and the maintenance of, the structure itself.

Federal Policy

Federal-aid policy states that a lack of sufficient right-of-way width to accommodate utilities outside the roadside border, in and of itself, is not a valid reason to preclude highway facilities and utility structures to coexist. In fact, the policy only presents guidelines rather than a fixed requirement for horizontal separation. Vertical separation is explicitly governed by State policy. However, these minimum clearances are less than the NESC and power companies' guidelines. For longitudinal lines, the following minimums must be maintained:

Table III-1 - Vertical Clearances (SHA)

Minimum Vertical Clearance (feet)	Transmission Lines
18	Guy wires and secondary power wires below 750V.
20	750V – 22kv
21	22kv – 50kv
21 feet plus 0.4" per kv in excess of 50kv	50kv – 470kv

When the state agency lacks authority over the right-of-way, Federal policy dictates that an agreement must be reached with the utility such that the degree of protection to the highway is at least equal to the protection provided by the State agency's utility accommodation policy. In this case, SHA requirements must be upheld in any agreement reached with a utility company for the use of utility right-of-way for highway purposes. The specifics of these requirements can be referenced in the SHA Utility Policy[2].

Federal participation for funding the replacement and modification costs incurred by the utility company is available under certain conditions. Replacement right-of-way costs may be provided when the portion of the utility's existing right-of-way is transferred to the State Highway Administration (SHA) at no cost to the project. When relocation work is shared between SHA and the utility company, a written agreement stating the shared responsibilities of each entity is required for Federal-aid. The provisions of the FHWA's regulations covering reimbursement for utility work is for actual costs incurred to functionally restore a utility's existing operating facilities prior to the commencement of the highway project. The utility's financial and productive situation is to be maintained as if the highway project had not occurred. Where possible, this would not require construction of a replica facility, rather that the utility service is to be made whole by restoring the existing functions of the impacted facilities.

Use and occupancy agreements are used to establish the terms and conditions under which utility and highway installations co-exist. Federal-aid policy[3] stipulates what such an agreement must include, with the following being critical to this study:

- The State agency standards for accommodating utilities. Since all of the standards will not be applicable to each individual utility installation, the agreement at a minimum must describe the requirements for location, construction, protection of traffic, maintenance, access restriction, and any special conditions applicable to each installation.
- The extent of liability and responsibilities associated with future adjustment of the utilities to accommodate highway improvements.
- The action to be taken in case of noncompliance with the requirements.

[2] Maryland State Highway Administration, Utility Policy
[3] Federal-Aid Policy Guide, 23 CFR 645 A, Sec. 645.213

Transportation Design Criteria

Introduction

The design criteria for any transportation facility will ultimately determine the feasibility of its use in an HVTL corridor. The criteria determine the accuracy and the specification of the design and establishes the physical constraints that must be applied. Depending on the type of transportation facility or mode certain guidelines apply. Examples include the size and characteristics of the design vehicle, method of operation, the intended level of service, as well as the number of people expected to use a transportation facility. "Design criteria" are more specific. Some examples include the lane or track width, grades, sidewalk width, maximum and minimum superelevation (banking), maximum travel speed, maximum structure width or span, and horizontal and vertical clearances. Environmental considerations are vital since permits are needed and environmental documents must be approved before a facility is ultimately constructed. Also, the designs must be reasonable and practical from an economic standpoint.

Design Criteria for Highways

AASHTO Design Standards

The American Association of State Highway and Transportation Officials (AASHTO) publishes a design criteria standards manual, entitled: 'A Policy on Geometric Design of Highways and Streets', approximately every five years. It aids state highway administrations in the design of their facilities. The following is a list of the primary guidelines that were used to develop the highway options for this study (assuming a fully access-controlled, 4-lane highway).

- The ideal 4-lane highway consists of two, 12-foot traffic lanes in each direction, separated by a wide grassy median. If a wide median (54 feet or wider) is not feasible, then roadside barriers need to be implemented. AASHTO guidelines state that an 8-foot wide outside shoulder is the minimum, but it ultimately depends on the anticipated amount of traffic. Also, in some cases an 11-foot wide travel lane can be used, but the percent of truck usage has to be low.
- Design speed for urban and rural expressways vary from 40 mph to 70 mph, respectively. Terrain has a major influence on the selection of a design speed. This study uses a 'rolling' terrain with a design speed of 60 mph.
- With a 60 mph design speed, the minimum radius of horizontal curvature is approximately 1,350 feet. Therefore, if a HVTL corridor makes an abrupt turn, adjacent rights-of-way may need to be purchased to 'round-out' the curve.
- Grades depend on the type of terrain as well as the type of highway vehicle. For a 60 mph highway, a 4% maximum grade is used for rolling terrain, and up to 6% for freeways in mountainous terrain. A maximum grade of 5% is used in this study.
- A 16-foot vertical clearance should be provided for any bridge structure spanning the entire roadway width. Some additional clearance has to be taken into consideration for future resurfacing of the under passing roadway.

Design Criteria for Transit

Light Rail

The design speed of a light rail system depends on the type of vehicle and the type of terrain. It is normal for a light rail vehicle to operate between 40 and 50 mph along restricted access rights-of-way. The horizontal curves can be tighter than that required for a 60 mph freeway because the operating speed is controlled and can be lowered to a safe speed while maneuvering curves. The maximum grade for a long, sustained segment is 4%, but up to 6% for short segments of less than 2,500 feet between the crests and sags. At light rail stations, grades can vary from a desirable 0.5% to a maximum of 2.5%, but this is also dependent on the type of rail vehicle. Track spacing for two-way service varies based on vehicle specification, superelevation, and terrain. Using this standard, minimum track spacing of 12.25 feet center to center would be acceptable. A more desirable track spacing of 14 feet center to center would be used. Vertical clearance depends on the type of vehicle as well. Light rail vehicles receiving power from overhead wires require a clearance of 15 feet from the top of the rail to the overhead wire.

Busways

The design guidelines for busways are similar to light rail. However, busways can accommodate steeper grades and tighter turns. For this report, we will group them together. Of note, is that busways are flexible and can be either exclusive alignments or shared with highways.

High Speed Rail / Maglev

The design constraints are much more stringent for high-speed rail options. Included in this category is Amtrak and local commuter rail services (MARC, etc.), SkyTrain and Magnetic Levitation (Maglev).

Basic design requirements for high-speed rail systems are listed below:

- Speed – The design speed of high speed rail lines primarily depend on the type of vehicle that will be utilizing the tracks. For many existing commuter rail lines, the tracks are shared with freight trains and in most cases were initially designed for the lower speeds associated with the freight lines, which would mean tighter horizontal curves. Even though commuter train systems (Amtrak, MARC, etc.) are capable of speeds in excess of 100 mph, they would be limited to the maximum design speed used when the tracks were initially built. The design speed for commuter rail using new tracks implemented within HVTL corridor rights-of-way would depend on the lengths of the tangent sections and the severity of the corridor angles. The scenario would change quite drastically though, if a Maglev line were to be implemented, with speeds reaching 240 mph.
- The minimum horizontal curve radii increases almost exponentially as the design speed of the facility increases. Therefore, for tracks that are designed to carry a Maglev train designed for 240 mph, it may take over a mile to complete a single curve.
- Grades – Similar to the speed, the grade depends on the type of vehicle that will be used. Generally, a maximum grade is about to 2% to maintain speeds, but there are exceptions. In fact, the Maglev could travel on a maximum 10% grade. Other heavy rail systems, such as the Washington Area Metropolitan Transit Authority's Metrorail line, have segments with grades as high as 4.5% where operating speeds must be lowered. At

station locations, the maximum grades are reduced to a desirable grade of 0.35%. This would be the same for surface, underground and raised platforms station.

- Track Spacing – The minimum track spacing between the centerlines of parallel tracks is 14 feet, but can be up to 15 feet due to the size of rail cars used.
- Vertical Clearance - Vertical clearance depends on the type of structure, and the type of vehicle. Vertical clearance is usually measured from the top of a rail to the bottom of a structure. A preferable minimum vertical clearance for a heavy rail corridor is usually 22 feet. In some cases, such as the Washington Area Metrorail (a fixed structure in an open environment), the minimum clearance is as little as 13 feet. Vehicles that require overhead contact wiring would require additional vertical clearance.

SkyTrain is a rail system built primarily on an elevated guideway consisting of concrete pylons. It has been in use in other countries besides the United States for over 20 years. SkyTrain is faster and more environmentally safe than most existing rail lines since it runs exclusively on electricity, therefore producing no harmful emissions. Even though SkyTrain systems travel at speeds in excess of 50 mph, they are relatively quiet compared to other rail systems, and much quieter than a diesel truck. As an automated system, SkyTrain runs more frequently and efficiently than other transit systems, with as little as a 75-second gap separating trains. Because it operates along a dedicated guideway separate from the road system, SkyTrain does not interfere with highway traffic operations. The cost to design and construct a SkyTrain system is between $30 million and $40 million per-mile, dependent upon a number of factors. This cost incorporates approximately $20 million per-mile of concrete elevated guideway, $5 million to $7.5 million per station, various “cut and cover” tunnel and related structures along the line, and other miscellaneous items.

Maglev is a newer technology incorporating an electromagnetic, non-contact levitation and propulsion system that is an alternative to traditional wheel-on-rail trains with a system that lifts, guides and propels the vehicle along a guideway at speeds up to 240 mph. Still in its planning stages in the Baltimore/Washington corridor, it could be implemented within the next 10 to 12 years. Test tracks have been built in Europe and the results are positive thus far. The cost to design and construct a Maglev system is between $70 million and $80 million per-mile, incorporating the same elements and contingencies as the SkyTrain system.

Hypothetical Corridor(s)

Based on the above criteria, typical sections were developed for a variety of potential HVTL corridor configurations. The purpose of this was to create a template to evaluate the typical section through a hypothetical HVTL corridor, consisting of the common tower configurations and corridor widths found in Maryland. The results help the study team determine what impacts the transportation typical section would cause to the HVTL infrastructure and what cost might be necessary to mitigate these impacts.

Two HVTL right-of-way widths were analyzed; 150 feet and 250 feet. Each corridor width was analyzed along an actual 5-mile tangent section that exists within Maryland. Several tower configurations were hypothetically considered within each corridor width with upwards of 3 large steel poles and two wooden poles per corridor. This would serve to represent a future ‘full build-out’ scenario, or most highly constrained HVTL corridor.

Topographically, these corridor(s) represent the terrain found in a typical HVTL corridor throughout almost all counties west of the Chesapeake Bay. Several of the towers are placed on hills while the transmission wires span ravines and valleys. To stay within the guidelines set forth by both AASHTO and the SHA / MTA, it was realized that several large cuts and/or fills would be required, along with retaining walls to protect the foundations of the towers. Otherwise, to move one tower is to move or affect the system of towers. Vertical profiles were created under each scenario, noting that the grade requirements for highways, light-rail systems and BRT were all quite similar, but highly constrained for the heavy rail option.

Typical Sections

The following series of figures (*Figures III-1 through III-7A*) represents the various combinations of typical sections with corresponding 'elevation' sketches illustrating the projected clearance distances. Note that several other typical sections were developed and initially analyzed, but were found to be less desirable than the sections evaluated here. Some proved impractical while others violated the standards and policy guidelines for highway and HVTL use (these typical section figures can be found in *Appendix B*). An explanation of the reasons why those typical sections were not carried for further analysis is also in *Appendix B*.

Ownership of the corridors varies by power company. PEPCO is the only company in Maryland that purchased and continues to own the land rights (with a few exceptions) for their HVTL corridors. BGE owns roughly half of their HVTL corridor rights-of-way. SMECO, Allegheny Power and Conectiv have limited land rights through easements from private property owners. Essentially, the amount of land purchased or obtained through easements depends on the land area needed to construct, operate, maintain, and expand the HVTL corridor.

ALLEGHENY POWER

Allegheny Power's typical HVTL corridors vary dependent upon the transmission voltage. For 500kv corridors, the right-of-way widths are typically 200 feet and the primary structures used are steel (lattice) towers. For 230kv corridors, the right-of-way width is usually 125 feet and the structures can be steel lattice towers, steel poles, or multiple wood 'H' frame structures. For 138kv corridors, the right-of-way width is usually 100 feet, and the steel structures can be steel poles, steel towers, or multiple wood 'H' frame structures.

BGE

There are several types of HVTL corridors within BGE's jurisdiction. The corridors vary in width and contain several different types of structures. Voltages carried in the various corridors include 115kv, 230kv and 500kv. BGE has examples of shared use corridors in its system, including shared right-of-way with Amtrak along the Northeast Corridor and a short corridor shared with the Baltimore Light Rail Transit (LRT).

CONECTIV

Conectiv's corridor easements are typically 150 feet wide and have long tangent segments due to the flat topography and a larger percentage of available land, primarily with agricultural land-uses. Most corridors have at least one wood pole H-frame line in the center of the easement.

PEPCO

PEPCO's 230kv corridors are typically 250 feet wide. The width of 500kv corridors varies. Most of the corridors have dual steel (lattice) towers. PEPCO's ultimate build-out scenario for 230kv corridors is a triple steel pole configuration with the third line of structures constructed along the centerline of the corridor. The corridors also have lower voltage transmission lines, primarily wooden poles carrying 69kv lines, near the edge of the corridor. Due to PEPCO's high service demand within the Washington Metropolitan region, many of the existing 230kv corridors already include one or more 69kv lines along the edge of the corridor.

SMECO

SMECO's only HVTL corridor is a 230kv line with an average right-of-way width of 150 feet. Within this corridor, there is a single line of steel poles down the centerline of the corridor, with wooden poles carrying lower voltages approximately 25 feet from the corridor edge. The opposite side of the corridor will be used for future expansion needs, possibly dualization of the wooden poles.

Typical Tower Structures

Statewide, there are various structure configurations for HVTL corridors. Different utilities use different configurations depending on the specific conditions in the corridors. The differences are due to factors such as line voltage, the number of circuits, the current capacity required and the line route. In general terms, the higher the voltage, the larger the required safety area surrounding

IV. Issues and Consequences

IV. Issues and Consequences

Types of Issues

The study identifies several issues and concerns related to the utilization of HVTL rights-of-way for transportation facilities, especially compared to potential rights-of-way in undisturbed areas. Utility company representatives and highway officials have also identified issues and concerns. The issues represent the specific interests of the stakeholders but can also have a broader effect upon the likelihood of an HVTL corridor being selected for use as a transportation corridor. These issues may be an advantage, a disadvantage, or even both, dependent upon the stakeholder. A generalized collection of issues have been prepared and their effects, based upon the individual stakeholders, summarized below:

Access Issues:

- **HVTL rights-of-way generally do not run in areas of high transportation demand.** Most HVTL corridors are in rural or low-density areas. The areas where HVTL corridors exist generally do not generate travel demand sufficient to support transit service or a highway. The corridor may not easily connect with the existing transportation network. And due to safety concerns associated with development near HVTLs, it could be difficult to target growth to the corridor.

- **Easier access for maintenance equipment to towers and lines.** If a transportation facility is in the HVTL corridor, it should facilitate the power company's ability to bring maintenance workers and equipment from its storage facility to the structures and lines. Many HVTL corridors have rugged terrain and the addition of a graded, paved road would facilitate access. Having a better and quicker means of access would also be beneficial in emergencies.

- **Power line maintenance could become less time efficient.** In many cases today, rights-of-way are already accessible for the power companies' maintenance needs, including the use of access agreements with adjacent property owners. A paved corridor could result in quicker access times, but the time savings could be reduced because of the additional time needed to restrict and control traffic so that maintenance activities can be performed in a safe manner for workers and the general public.

- **Traffic Impacts.** Maintenance and repair of the HVTL and associated structures could impact traffic flow on the transportation facility.

- **Loss of private property owners' individual crossing rights.** When HVTL rights-of-way have been purchased by the utility companies in fee simple, most adjacent property owners have been granted crossing rights. In a number of cases, adjacent property owners are allowed to continue to use the land for agricultural purposes. Should a transportation facility be constructed in the corridor, the adjacent property owners' rights would be eliminated. Multiple parcels along a corridor require extensive title searches to determine the property owners affected and negotiation and compensation with these adjacent property owners for this loss. This could slow down any land acquisition process, which would cause this issue to be categorized as an economic issue as well.

Safety Issues:

- **Increased hazards for transportation facility users.** Constructing a transportation facility in an HVTL corridor increases the number of hazards a transportation user would encounter on the facility. The towers are fixed object hazards that drivers could hit. Towers or parts of towers could fall onto the facility, which could cause delays and accidents. If severed or faulted wires come into contact with the facility, users could experience fatal or severe electrical shock.

- **Increased risk to workers during construction and maintenance of the transportation facility.** Using large trucks and construction equipment, such as construction cranes, around HVTLs increases the possibility of a worker being killed or severely injured by electrical shock. A truck or crane could touch, or simply come too close, to the transmission line and cause an electrical shock. Death or severe burns and injuries happen instantly if contact is made with an electrical transmission line. However, the risk for electrical shock is minimal if sufficient clearance is maintained.

- **Impacts on emergency response times.** Depending on power wire converge, a medi-vac helicopter may not be able to land in the corridor. This could increase medical response times as compared to those on other transportation facilities. However, the improved access provided by the transportation facility could provide shorter medical response times over current times to power company employees maintaining the lines.

Environmental Issues:

- **Reduced need to clear forested and wooded areas.** Many HVTL rights-or-way have been substantially cleared of trees to allow clearance for power line sag and sway. This would reduce the need to clear the right-of-way for transportation uses. If a transportation facility is constructed in an HVTL corridor, the incremental negative effects of the transportation facility on water quality, wetlands, air quality, flora and fauna could be similar to or less than in the impacts of a facility constructed in undisturbed woodlands.

- **Negative aesthetic characteristics of the facility.** The sight of the towers, poles and transmission lines could decrease the visual appearance of the transportation facility for some users.

- **Brownfields redevelopment opportunities.** Many HVTL corridors meet the broad definition of a “brownfield” - vacant or underutilized property with real or perceived contamination. If a transportation facility was constructed within a brownfield, it could make better use of the vacant or underutilized property.

- **Environmental Permitting.** Because HVTL corridors are previously disturbed, the number of environmental permits required may be less than for a corridor that is not disturbed. If the number of permits is the same as a disturbed corridor, it may be easier to obtain new permits. However, in order to obtain Federal funds for the project, wetland, tree conservation and sediment and erosion control permits would still be necessary. Although it has not been proved, the potential association between electromagnetic fields (EMF) and certain types of cancer could cause possible permitting issues.

Socio-Economic Issues:

- **Reduced socio-economic and community impacts.** Due to buffer width requirements for HVTL towers and lines, and depending on the design of the transportation facility, homes could be located further from the facility. For example, if a four-lane roadway were located in the center of a 250-foot wide HVTL right-of-way, there would be approximately 100 feet between the edge of pavement and the adjacent property line. This results in a greater distance than typical HVTL scenarios utilized in a majority of highways and arterials.

- **Localizes the effect on people.** Utilizing HVTL rights-of-way should simplify social-economic issues with adjacent property owners and the surrounding public, since the HVTL corridors are generally an accepted land-use within the community. The implementation of a transportation facility would alter this use, but the effects to this change would be less than if the use was previously an environmental conservation area for example.

- **Creates an incremental impact, instead of new impact.**

- **Concentrates linear land uses.**

Cost Issues:

- **Faster, less costly land acquisition process.** If the HVTL corridor right-of-way were owned primarily by the power company, the government would need only deal with one property owner opposed to potentially hundreds. Land acquisition could be resolved in one negotiation and be a minimization of eminent domain issues, speeding the acquirement process. In addition, where adjacent property owners have been granted crossing or agricultural rights, significant negotiations may be needed to eliminate these rights.

- **HVTL and transportation facility geometry.** Depending upon the topography of the HVTL corridor, the cost of building a transportation facility could either increase or decrease accordingly. If the corridor is flat and straight, such as many Maryland HVTL corridors, construction costs may decrease. If the corridor traverses mountainous areas, low-lying wetlands or includes 90-degree turns, construction of the facility could be quite costly. In addition, to ensure safe clearances between power and transportation functions are maintained, it may be necessary to make significant and expensive modifications to the existing power facilities.

- **Limited expansion opportunities.** If a transportation facility is built within the HVTL right-of-way, there will be limited space available to construct additional HVTL towers. Future expansion would require the power companies to purchase additional rights-of-way. This process may be a disadvantage to both power companies and Maryland citizens as the demands upon available electricity increase.

- **Relocation of other utilities.** Within several HVTL corridors, easements have been granted to utility companies for gas and phone lines and fiber optic cables. Construction,

Potential Costs

Developing accurate implementation cost estimates for various transportation options is not possible because they are within hypothetical corridors with unknown variables and a large number of assumptions about the corridors have been made. To prepare a detailed cost estimate, a specific corridor must be selected and an environmental inventory be conducted. This study estimates costs using a 'cost-per-mile' approach. For example, the average ***base*** cost for building a new 4-lane divided freeway ranges between $5 million-per-mile on flat terrain and $6 million-per-mile over mountainous terrain. The base cost excludes "intangibles" such as right-of-way acquisition, structures, utilities, signing, lighting, marking, beautification, preliminary engineering, contingency, and overhead. Because the base cost typically covers earthwork, paving and drainage, base costs would be similar for any highway improvement, regardless of whether it is located within an HVTL corridor. It is the intangibles that create the cost differences. Building a transportation facility in an HVTL corridor will reduce some of the base-cost exclusions, but will increase others.

Cost savings can occur through a simplified right-of-way purchasing process if the power company owns the land and would be willing to allow areas of dedication or to enter into joint usage agreements. Clearing and grubbing costs would be significantly lower, and reforestation mitigation and other environmental costs would be minimized. The light poles and overhead sign lighting associated with interchanges should be easier to construct because of the land has already been cleared. However, even though the transportation facility is located in an electricity corridor, the power for the lights cannot come directly from the HVTL's because the voltages are too high. A separate, lower voltage electrical line would need to be used. Some HVTL corridors already have lower voltage lines within them, and in those cases, costs would be reduced.

The primary additional costs associated with building a transportation facility in an HVTL corridor occur if the terrain is mountainous with multiple steep slopes or there are impacts to avoid with grading. This is because bridges will need to span ravines and retaining walls and barriers will need to be constructed to protect the towers and provide sufficient clearances. The average cost for a bridge is $100 per square foot. Retaining walls cost approximately $50 per square foot. Depressing the transportation facility through the crests to eliminate high grades and to increase safety clearances will increase construction costs and take longer to build as the HVTL structures would need to be protected or moved.

Another cost associated with building a transportation facility in the HVTL right-of-way is relocating existing HVTL towers or poles if they are impacted by the transportation facility. The redesign, relocation or modification of an existing steel lattice towers or large steel pole can cost between $100,000 and $400,000 per structure. In addition, it is not uncommon to find that the relocation or modification of one tower creates the need to relocate or modify the adjacent towers until the transmission lines can be set at a constant tension throughout the tangent section of the corridor. If given the choice between relocating towers or constructing new ones, the power companies would rather construct new, large steel poles adjacent to the existing line because it will be easier to build and will allow for future expansion. Burying the conductor wires is an option, but the cost can be up to 10 times more expensive than relocating the lines above-ground. The increased cost is due to design complexity, cost of materials, electrical arching prevention and construction of casing pipes filled with oil to insulate the wires. Because of the extreme costs and safety requirements associated with insulating 500kv transmissions lines, they cannot be placed underground.

To determine the estimated implementation costs, the study adds the base cost-per-mile for a particular transportation facility to the cost-per-mile increase associated with using the HVTL corridor that occurs and subtracts the cost-per-mile savings associated with using the HVTL corridor. *In general, the cost savings equal the additional costs, leaving little difference between the costs of implementing a transportation facility within an HVTL corridor versus an undisturbed corridor*. However, this finding could vary depending on the specific characteristics of the HVTL corridor. If the corridor's right-of-way is mountainous, is owned by several property owners, and has restrictive tower and/or pole placement, then the cost to construct the transportation facility could be more than 50% greater than building in an undisturbed corridor. Conversely, if the HVTL corridor is owned by one power company, the power lines and structures do not need to be relocated and some environmental mitigation has taken place as part of the HVTL construction, it could cost 50% less to build the transportation facility in the HVTL than in an undisturbed corridor.

Table IV-1 is a cost comparison matrix that breaks down the costs between the various transportation options and corridor configurations.

which would require the relocation or avoidance of these utilities, could impact both maintenance and building costs of the transportation facility.

- **Additional tower protection.** Possibilities exist that vehicles may collide with the stationary power towers, requiring increased protection at the tower base. Examples of such include additional protective fencing and barriers at ground level, or constructing retaining walls.

- **Possible power line relocation.** If a transportation facility built in an HVTL right-of-way requires expansion, the costs associated with the relocation of the power lines would be incurred by the taxpayers.

- **Vertical clearance Constraints.** Design of the transportation facility must take into account the maximum wire sag between towers. Wire sag could limit the allowable vertical clearance of vehicles.

Miscellaneous Issues:

- **Electrical interference.** Electromagnetic Interference (EMI) is the disturbance or electrical noise electromagnetic fields within HVTL's can cause to vehicular radios, cell phones or other electronic devices. The EMI range is dependent on climate and a number of weather variables. For instance, it is such a problem in Hawaii that a "Faraday Shield" was designed and implemented to abate the interference on vehicles traveling along Interstate H-3 , but at high costs.

- **Reciprocity Concerns.** If a transportation facility is built in a HVTL corridor, how will fair compensation be determined? Can the utility companies be compensated for aggravation and loss of time associated with routine HVTL maintenance? Does allowing transportation facilities in existing HVTL corridors create a precedent for allowing HVTL's in existing transportation corridors? These questions illustrate the types of concerns that need to be resolved once the physical and environmental concerns about constructing transportation facilities in HVTL corridors are addressed. Answers will need to be researched thoroughly and possibly with input from lawyers.

V. National and Statewide Examples

V. National and Statewide Examples of Shared Corridor Use

Joint Transportation and HVTL Use Corridors

This section documents examples of power lines and transportation facilities sharing the same corridor. The examples highlight the circumstances that made joint use possible and may not represent typical HVTL and transportation design standards. However, the examples provide opportunities to learn about the types of projects and level of integration possible and to find out the case-specific circumstances that made joint use feasible. The examples cover two types of joint-use corridors. The most common type of joint use corridor is one in which the HVTL use comes in to the corridor after the transportation facility exists. Because of strict guidelines regarding placement of HVTL structures, the safety and operation of the transportation facility is not diminished by the combined use. The second type of joint use corridor – and the one that is the primary concern of this study – is a corridor in which the power company uses the right-of-way and the transportation facility is built after the HVTL line is in place. There are a limited number of examples of this type of joint use corridor, especially over long distances. A final type of corridor would be the design and construction of the HVTL and highway uses together from the outset. However, there are no examples of this type of activity in the United States.

HVTL Corridors Adapted for Transportation Use

The following examples show HVTL corridors adapted to allow for transportation uses in the corridor. The examples illustrate how different transportation modes can be accommodated in close proximity to HVTL structures. Because the examples have unique topography, political will and engineering, the findings they present may not be applicable to conditions in Maryland.

JEFFERSON PARISH, LOUISIANA

In Jefferson Parish, Louisiana, several roads have been constructed almost entirely within existing Louisiana Power and Electric Company's (LaPALCO) HVTL rights-of-way.

- Lapalco Blvd. 8 miles, 4-lane open section, partial control of access.
- Power Blvd. 4 to 6-lane open and closed sections, partial control of access
- Gretna Blvd. 2 to 4-lane residential street, no controls of access
- Stumph Blvd. 4-lane closed section, no controls of access (industrial land use)
- Dickory Avenue 4-lane open and closed section, no controls of access

The highways were designed and built in a way that allows the existing single tower configuration to remain in place as part of the highway median. LaPALCO supported the highway projects because the towers did not have paved access roads for HVTL maintenance and the LaPALCO vehicles were frequently getting stuck in the low-lying, wet terrain.

Photo 18

Trains pass directly beneath and through lattice HVTL towers. I-76 is visible to the right. Both modes share corridor space for approximately ¼ mile.

Photo 19

Even though this lattice structure has a wider base than the one from the above photograph, both, permit two tracks to pass beneath. They also have sufficient vertical clearance (minimum of 22 - feet) to allow double stack container trains.

MD 3 in Crofton

These highways have proved to function safely beside the HVTL's and some of the roads are programmed for widening improvements.

- Power Blvd. (Vet.-W.Espl.) Widen from 4 to 6 lanes
- Lapalco Blvd. (Barataria-Destrehan) Widen from 4 to 6 lanes
- Lapalco Blvd. (Westwood-Barataria) Widen from 4 to 6 lanes

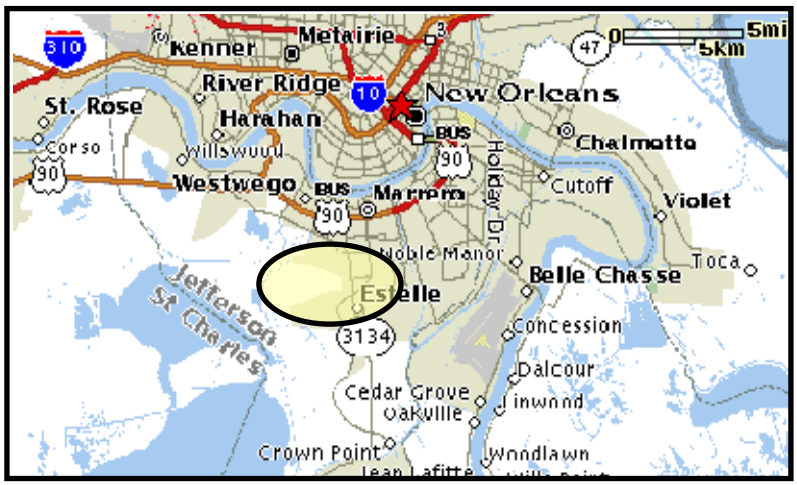


Figure V-1 - Jefferson Parish HVTL Corridor Location.

Photo 9 - Lapalco Blvd. westbound

The outside shoulder of Lapalco Blvd., with oncoming traffic. The towers are in the median. Notice the utility piping bridging over a stream crossing.

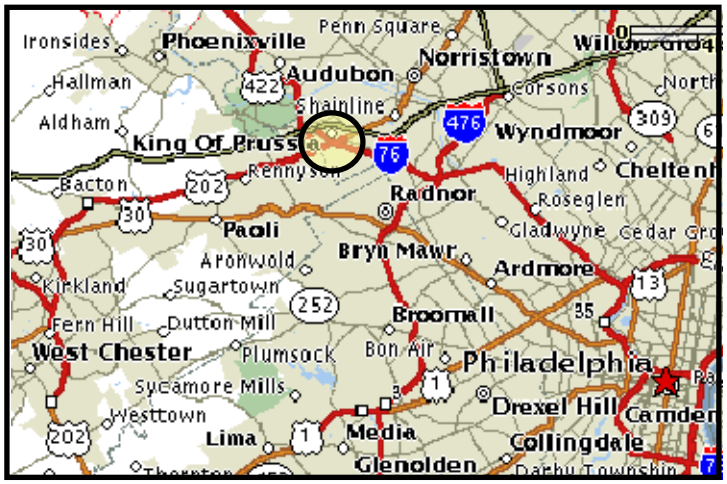
Photo 10 - Lapalco Blvd. eastbound

Lapalco Blvd., looking along the outside edge of pavement.

KING OF PRUSSIA, PENNSYLVANIA

An HVTL corridor near King of Prussia, PA (Figure V-2) provides an example of a using a short segment of an existing HVTL corridor to build a new highway interchange. The surrounding region was completely developed, and the ¾-mile segment needed to connect three major highways was only available along an HVTL right-of-way. This new construction highlights the use (see Photos 11 and 12) of an HVTL corridor to enhance highway connectivity. The exiting steel lattice towers were replaced with steel poles in the joint-use section to provide more flexibility in highway and ramp design.

Figure V-2 - King of Prussia Corridor
I-76, US 202, US 422 Interchange



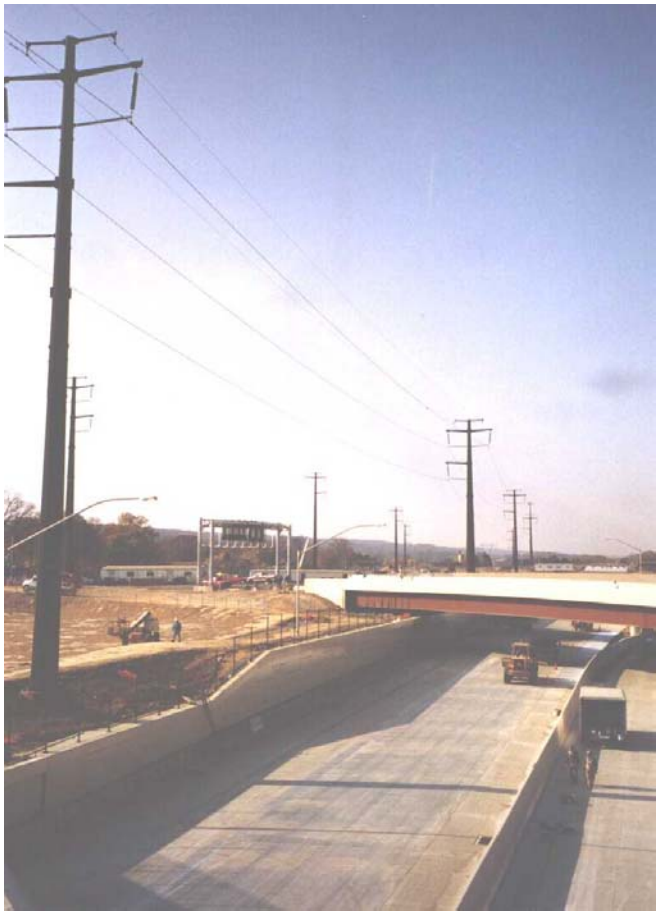


Photo 11

This photo shows that a cut slope and retaining wall is utilized to maintain sufficient vertical clearance between the overpass and the power lines.

Photo 12

Here, *a service road intersection lies directly adjacent to a steel pole. The service road runs at times through the middle of the corridor and between the two lines and also along the outside of the pole bases. The corridor width is generous, at approximately 400' across.*

BALTIMORE LIGHT-RAIL TRANSIT SYSTEM

The Baltimore Light Rail Transit system provides an excellent example of implementing rail transit in close proximity to HVTL structures. In the mid-to-late 1980's, the Maryland Transit Administration (MTA) constructed a light rail line between Westport and Baltimore Highlands that utilized the existing HVTL corridor. Part of the corridor was originally owned by CSX for rail freight purposes, but portions of it were bought by BGE for HVTL's. The light rail tracks run between double circuit steel poles for a short segment near the Westport Stop (see Photos 13 through 17) and run parallel to the poles for a longer segment near Baltimore Highlands Stop.

Initially, BGE was opposed to building the rail line because it was concerned about potential conflicts with HVTL maintenance activities. However, funding and strong political support allowed the transit system to be built. Access to and maintenance of the HVTL structures has been arranged at the least possible inconvenience of either MTA or BGE in the extremely tight quarters illustrated in the following photos. Using the HVTL corridor allowed the light rail line to be built without disrupting adjacent properties while preserving a critical HVTL corridor into the city.

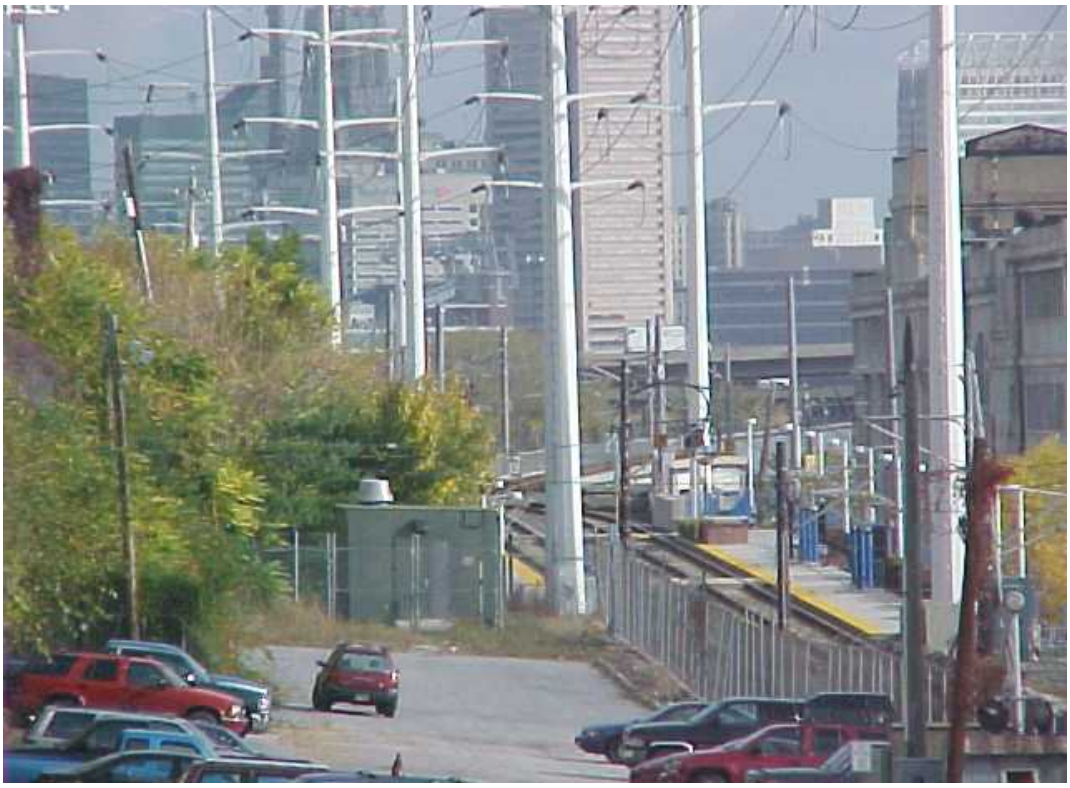


Photo 13

Looking north toward the Westport Station. The train lines are located between the two sets of HVTL towers.

Photo 14

The towers afford little horizontal clearance for passing trains in this view from Westport station.

Photo 15

A steel and concrete barrier provides the steel pole with protection from northbound trains (see Figure V-3).

Photo 16
Another view of the steel pole shown in Figure 1. It has a 52-inch diameter with an 8 ft diameter concrete base.

Photo 17
Looking across tracks at the steel pole and concrete barrier adjacent to the southbound track.

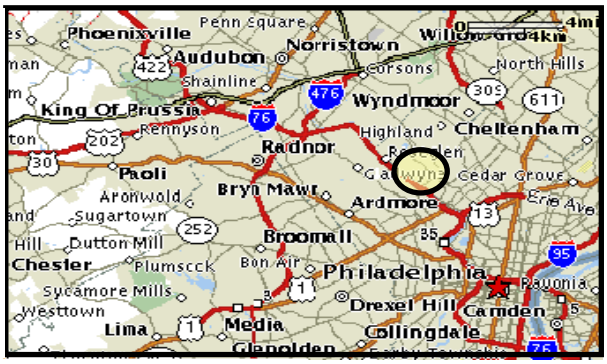
<u>Transportation Corridors Adapted for HVTL Use</u>

There are many more examples of transportation corridors being used for HVTL use, than HVTL corridors being used for transportation purposes. Transportation corridors have higher design standards than HVTL design standards. This is because of vehicle performance limitations and safety considerations. A result of the higher design standards is that it is easier to develop an HVTL in a transportation corridor than the other way around.

Philadelphia, PENNSYLVANIA

Topography limited the space available for an HVTL corridor along the Schuylkill River approaching Center City (see Figure V-4). Along this particularly narrow point, both the local power company and the Pennsylvania Department of Transportation were able to utilize the same segment of this corridor in very close proximity. The topography and constraints of the corridor required specially engineered structures to be used. (See Photos 18 and 19). The corridor had been initially purchased to construct a rail freight line in the late 1800's.

Figure V-4 - Norfolk Southern Main Line



Whereas the Baltimore LRT located within segments of a previously existing HVTL corridor, it is far more common for utility companies to locate within existing transportation corridors. An example from Maryland is along MD 3 near Crofton. The Maryland Department of Transportation State Highway Administration (SHA) has specific policy that governs the placement of such utility structures within highway rights-of-way. The SHA Utility Policy indicates the necessary clear zone required for safety reasons beside highways. These standards are represented by the horizontal separation between road and steel poles, while in this example the transmission line is located just outside the highway right-of-way on private land. The need for increased safety buffers along highways contrasts with the Baltimore Westport LRT example, where tight spacing was allowable between poles and light rail vehicles. The horizontal clearances are shown in detail in Figure V-5.

Photo 20

Looking south along MD 3 southbound lanes. The 2.5-foot diameter steel poles carry transmission lines of 115,000 volts.

The previous examples are either functional facilities or are very near completion. Locally, there are several projects in the planning stages that could potentially have joint-use HVTL implications. These projects would provide the most immediate application of the recommendations of this HVTL study. Descriptions of some example projects within Maryland and West Virginia are provided below.

- ***The Baltimore-Washington Maglev Project***

  This Federally funded study is evaluating several high-speed rail alignments to connect Baltimore and Washington. One alignment utilizes for several miles an HVTL right-of-way that has a dual configuration of steel and lattice towers. All alternatives are still under evaluation and no date has been set for an alternate to be chosen.

- ***College Park Connection from I-95 (2012 Olympics)***

  SHA's Regional Planning Office is conducting this study. One of the options is utilizing the HVTL right-of-way that extends south from the I-95/I-495 interchange towards College Park and beyond.

- ***Northeast Baltimore Corridor Study***

  This feasibility study was conducted by MTA to explore opportunities to extend rail transit from downtown Baltimore to the White Marsh area. Several alternatives looked at using the HVTL corridor that connects northeastern Baltimore City and the White Marsh Area. This project has recently been funded for further study

- ***West Virginia Route 9***

  West Virginia Division of Highways initiated this study based on a future highway alignment shown in the adopted local Master Plan. As part of the NEPA evaluation process, other alignments were evaluated. While the study was being conducted, Allegheny Power built HVTL's within the master plan alignment. Joint usage is still a possibility since no highway alignment has been selected.

Transportation Facilities with HVTL Crossings

Maryland has many examples of transportation facilities and HVTL structures crossing.

The study team took some trips to the field to investigate HVTL crossings of existing transportation facilities in order to witness the clearance distances between the HVTL towers, transmission lines and highway / rail track. The purpose was to determine if there were any issues associated with these crossings that may help to develop an understanding of joint-usage possibilities.

One observation was discovering how many HVTL crossings there are within Maryland, and realizing how close some of the tower structures are to the edge of highway / rail track. The following paragraphs and photos represent key examples of these crossings and how they hinder future expansion possibilities for the transportation facility.

MD 32 – ANNE ARUNDEL COUNTY

This 115,000-volt transmission line corridor crosses MD 32 several times and runs parallel to the roadway for several miles (see Photo 21 through 23). One key observation was the close proximity of one of the towers situated in the median of MD 32, near the National Security Agency. The HVTL corridor crosses at a skewed angle in this instance.

Photo 21

The photographer is looking west along the median barrier of westbound MD 32. The HVTL tower is a lattice tower with a square base of 30 feet on each side. There is 19-foot horizontal clearance between the concrete base of the tower and the face of steel barrier.

Photo 22

This photo shows another view of the lattice tower shown in Photo 21. This view is from the outside of MD 32 westbound, looking towards the eastbound lanes. (See Figure V-6 for a plan view sketch.)

Photo 23

The HVTL Corridor is parallel to MD 32, south of the freeway. Note that the closest two lattice towers have extended heights to accommodate a long span and still maintain minimum vertical clearance distances between the transmission wire midpoint sag and the ground elevations.

MD 170 – ODENTON

This HVTL corridor crosses MD 170 at a skewed angle, near the town of Odenton. Note how the transmission wires span from a lattice tower to a steel pole in the distance; refer to Photo 24 below. The observation here is how close the towers are to the curbs, with no barriers. This was accepted most likely due to the lower design speed of 35mph along MD 170, which caused less of fixed object hazard risk. The sidewalk is even closer to the towers.

Photo 24

Looking north along the MD 170 southbound lanes. The steel (lattice) tower is 15 feet from the travel lane. (See Figure V-7 for a plan view sketch.)

Photo 25

Looking north along the sidewalk adjacent to the northbound lanes of MD 170. The diameter of the steel pole is slightly more than 4 feet. The distance between the base of the pole and the travel lane is 9.5 feet. (See Figure V-8 for a plan view sketch.)

Photo 26

A closer look at the wide steel pole adjacent to northbound MD 170.

I-95 / I-495 INTERCHANGE – COLLEGE PARK

This is feasible and practical since the towers / poles can be places within the acres of underutilized land areas between the ramps and travel lanes of these major interchange configurations (see Photo 27).

Photo 27 - *Large HVTL structures within the I-95/I-495 interchange*

Photo provided by Bryne Kelly

There are several completed or ongoing transportation studies in Maryland with HVTL corridor right-of-way impacts, primarily due to perpendicular crossings HVTL crossings under study in the region include:

- ***MD 43 – Middle River Extension (Baltimore County)***

  This project led by SHA is in Final Design. To accommodate maximum sag conditions, the transmission line height need to be at least 30-feet over the proposed highway. BGE is working with SHA to adjust tower and transmission line heights. Preliminary cost estimates for tower and transmission line modifications and relocations are approximately $600,000.

- ***MD 33 – St. Michael's Bypass (Talbot County)***

  This project led by SHA almost made it through Final Design before the project was canceled due to an inability to obtain environmental permits. Some HVTL rights-of-way were purchased from, but will now be sold back.

- ***US 301 – Waldorf Upgrade / Bypass Study (Charles County)***

  The eastern bypass alternative for Waldorf crosses an existing HVTL corridor several times and runs either within or alongside the corridor for several hundred yards. This alternative is still being evaluated and a Public Hearing on the alternatives is scheduled for 2002.

Appendix B

Typical Sections Pursued but Dropped

Appendix B

The following typical sections (Figures B-1 through B-14) were considered but dropped because of design and implementation difficulties and potential safety hazards for users of the transportation facility. Minimum horizontal clearances not being met and not having enough available land between HVTL structures to even place the transportation facility, excluding the additional buffer areas required for safety, were the overriding issues. Otherwise, only a two-lane highway or a single-track rail line could fit. For the case of the full build-out (three steel poles, with diameters representing the maximum concrete base or footer), a two-lane highway "inside configuration" had to be used, satisfying a 15 foot clearance requirement on both sides. For rail transit, an inside and outside configuration was considered, but that hinders HVTL maintenance activities. Any "split rail option" (outside configuration) will complicate transit system operations, primarily at stations. Any inside configuration for a full build-out scenario would serve as the 'worst-case' option from a transportation facility user's viewpoint, as well as for HVTL maintenance operations. For a dual steel pole structure scenario, some specific designs can be accommodated. For example, a four-lane highway "inside configuration" could fit between the HVTL structures, but it would limit any possibility for future expansion to the highway or to the HVTL, unless the entire HVTL structures are relocated.

Safety and aesthetics are also important. An additional concrete median barrier used to separate opposing traffic flows could present a safety issue if the required shoulders were unable to fit within the right-of-way. The dual steel lattice tower scenario represents the configuration with the least amount of available land between the towers for transportation facility implementation. Any transportation system had to be located on the "outside" of the these towers.

TABLE VI-2 Transportation Options Comparison Matrix

	HIGHWAY			RAIL			
Corridor / Structure Configuration	**2-Lane Highway**	**4 Lanes Highways /Expressways**	**4 Lanes Expressway with Rail Option**	**Light Rail / Busway**	**Heavy Rail (AMTRAK / MARC)**	**SkyTrain**	**Maglev**
250' Corridor Dual Steel (Lattice) Towers	**Good Horizontal Clearance** Minor HVTL Maint. Access Issues **Construction Less Costly**	**Does Not Meet Clearance Req. w/out Barriers** **Structure within median** **HVTL Maint. Access Issues** **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** **Structure(s) within median(s)** **Major HVTL Maint. Access Issues** **Construction More Costly**	**Good Horizontal Clearance** Minor HVTL Maint. Access Issues **Construction Less Costly**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **No difference in Construction Costs, unless there are vertical clearance issues**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **Construction more costly, especially when HVTL structures are located on crests**
250' Corridor One Steel (Lattice) Tower, One Steel Pole	Good Horizontal Clearance Minor HVTL Maint. Access Issues Construction Less Costly	**Does Not Meet Clearance Req. w/out Barriers** **Structure within median** **HVTL Maint. Access Issues** No difference in Construction Costs	**Does Not Meet Clearance Req. w/out Barriers** **Structure(s) within median(s)** **HVTL Maint. Access Issues** No difference in Construction Costs	**Good Horizontal Clearance** Minor HVTL Maint. Access Issues **Construction Less Costly**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **No difference in Construction Costs, unless there are vertical clearance issues**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **Construction more costly, especially when HVTL structures are located on crests**
250' Corridor Dual Steel Poles	**Best Horizontal Clearance** Minor HVTL Maint. Access Issues **Construction Less Costly** **Best Vertical Clearance**	**Does Not Meet Clearance Req. w/out Barriers** **Structure within median** Minor HVTL Maint. Access Issues No difference in Construction Costs	**Does Not Meet Clearance Req. w/out Barriers** **Structure(s) within median(s)** **HVTL Maint. Access Issues** No difference in Construction Costs	**Good Horizontal Clearance** Minor HVTL Maint. Access Issues **Construction Less Costly**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **No difference in Construction Costs, unless there are vertical clearance issues**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **Construction more costly, especially when HVTL structures are located on crests**
250' Corridor Triple Steel Poles (Full Buildout)	**Good Horizontal Clearance** Minor HVTL Maint. Access Issues **Construction Less Costly**	**Does Not Meet Clearance Req. w/out Barriers** **Structure(s) within median** **HVTL Maint. Access Issues** **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** **Structure(s) within median(s)** **Major HVTL Maint. Access Issues** **Construction More Costly**	**Good Horizontal Clearance** Minor HVTL Maint. Access Issues **Construction Less Costly**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **No difference in Construction Costs, unless there are vertical clearance issues**	**Does Not Meet Clearance Req. w/out Barriers** Minor HVTL Maint. Access Issues **Construction more costly, especially when HVTL structures are located on crests**
150' Corridor (Full Buildout)	**Good Horizontal Clearance** Minor HVTL Maint. Access Issues **Construction Less Costly**	**Considered, but Dropped *due to lack of available space between structures***	**Considered, but Dropped *due to lack of available space between structures***	**Good Horizontal Clearance** **Existing low-voltage Wooden Poles to be Relocated or Altered** **HVTL Maint. Access Issues** **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** **Existing low-voltage Wooden Poles to be Relocated or Altered** **HVTL Maint. Access Issues** **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** **Existing low-voltage Wooden Poles to be Relocated or Altered** **HVTL Maint. Access Issues** **Construction More Costly**	**Does Not Meet Clearance Req. w/out Barriers** **Existing low-voltage Wooden Poles to be Relocated or Altered** **Construction more costly, especially when HVTL structures are located on crests**

NOTES:

Color coding - - **Blue is positive,** Green is Neutral, **Orange is sligtly negative,** and **Red is negative**

Costs are based on the positive or negative percentage values shown in Figure IV-1