LRSDP
Long Range Strategic Deployment Plan
FINAL

Office of CHART and ITS Development
State Highway Administration
7491 Connelley Drive
Hanover, MD 21076 -1701
(800) 543-2515
www.chart.state.md.us

2013

LRSDP
Long Range Strategic Deployment Plan
FINAL

Preface and Executive Summary

Office of CHART and ITS Development
State Highway Administration
7491 Connelley Drive
Hanover, MD 21076 -1701
(800) 543-2515
www.chart.state.md.us

2013

Long Range Strategic Deployment Plan

This report was developed and finalized in September of 2013 by the Maryland State Highway Administration's Office of CHART and ITS Development; with support from Telvent USA, LLC and Sabra, Wang and Associates, Inc.

Preface

In the following scenario the main character is a typical Maryland commuter, whose commute is seamless and informed as a result of the technologies and services provided by CHART. While it is unlikely that all of the incidents outlined in the following scenario could occur in a single day for most Maryland residents, the scenario aims to portray the potential of the CHART program impacting the lives and day-to-day travel of Maryland citizens beyond the many benefits it already provides.

6:30 AM

A Maryland Commuter who lives in Frederick wakes up to begin her daily weekday routine on the Friday before a three-day holiday weekend. Already on her mind, however, is the important client presentation she has in Baltimore in the afternoon, and how much she needs to get done in the office beforehand. Also on her mind is the family vacation awaiting her over the extended weekend.

7:45 AM

She gets the kids up and off to school before she hurries out the door for work by 7:45 AM. She checks her cell phone as the garage door opens to see what her commute looks like this morning.

The MD 511 notification service for which the Commuter recently registered provides personalized travel information for her commute routes between Frederick and Northern Bethesda. The service sends email messages to her phone alerting her of news regarding accidents, construction, bad weather, or congestion occurring along her route to work.

In the CHART Statewide Operations Center (SOC) in Hanover, MD, operators closely watch traffic conditions in anticipation of holiday travel. The traffic simulation system is forecasting heavy traffic to begin 30 minutes before normal this morning, specifically along major Interstates. Commuters are leaving for the office early so they can get a head start on the holiday weekend by leaving work a little earlier in the afternoon. The CHART operators utilize an automated traffic management system to disseminate information to travelers to provide them improved decision support for route and mode choice.

CHART Strategy 5.16.1
Develop Software to Provide Transportation Network Simulation and Prediction Capabilities

CHART Strategy 3.16.2
Develop Traveler Information Software

7:55 AM

Our Commuter is on her way to work, on I-270 just South of Frederick, when a traffic alert pops-up on her in-vehicle display via her Bluetooth enabled cell phone. “Great,” she thinks, “what’s in store for me now?” She touches a button on her steering wheel and a text-to-speech system reads the email for her:

HEAVY TRAFFIC ON I-270 SB ROUTE, DELAY ESTIMATED AT 25 MINUTES, CONSIDER ALTERNATE ROUTE

“That’s 10 minutes more than usual,” she thinks before realizing it must be due to the upcoming holiday. “I’m going to see how it looks ahead before I get off the interstate,” she decides.

CHART Strategy 3.16.1
Exchange/Integrate Traveler Information Data with/from Other Public Agencies

8:00 AM	*CHART operators are now busy coordinating with several county traffic operations centers- to give sufficient green traffic signal time to the estimated number of vehicles that will soon be diverted from the interstate.*	**CHART Strategy 4.16.1** *Develop Software to Manage Arterial Traffic and Integrate Arterial Traffic Management Data* **CHART Strategy 5.10.1** *Integrate Traffic Signal System Data*
8:10 AM	Our Commuter reaches the I-270 southbound overhead electronic message sign at Exit 13, on which she frequently relies for traffic information. The sign reads: TRAVEL TIME TO I-495 37 MINUTES, CONSIDER MD 355 ALTERNATIVE She decides to take the advice and exits onto the alternative route. Even though our Commuter recognizes that a large portion of traffic is doing the same, she is unaware of the level of coordination that is taking place to get traffic off the Interstate exit ramp and through the MD 355 corridor.	**CHART Strategy 3.9.1** *Additional Dynamic Message Signs (DMS)*
8:50 AM	Despite the heavy congestion, the Commuter arrives to work on time, having been delayed a total of 20 minutes – within the window for which she typically plans. Relieved that she didn't lose any of her much-needed preparation time, she begins to get ready for the client presentation in Baltimore at 1:00 PM.	
10:50 AM	*The CHART incident detection system has identified a probable accident on northbound I-95, just north of MD 198, between Washington D.C. and Baltimore. CHART operators use roadside cameras to verify the accident. They also use the images to start coordinating with the appropriate public safety agencies and other resources to remove the vehicles involved so normal traffic flow can be restored as quickly as possible. The CHART system disseminates information about the incident to a variety of agencies and information outlets.*	**CHART Strategy 1.1.1** *Additional Closed Circuit Television (CCTV)* **CHART Strategy 2.16.1** *Develop Incident/Emergency Management and Computer Aided Dispatch (CAD) Central Software*
11:15 AM	Our Commuter is already slightly behind schedule to depart for Baltimore, but checks the CHART web site for current information on traffic and construction. She understands that three minutes spent checking road conditions now may save her 15 minutes or more of travel time. She sees there is a three-car accident on northbound I-95, and the traffic flow map shows that traffic is slow approaching the accident location. The commuter logs into the CHART website with her user-ID, allowing her to easily click on her origin as "work" and then enter her destination address for the meeting. The CHART system calculates the fastest route based on current transportation conditions. The preferred route is shown as the Baltimore-Washington (B-W) Parkway, which would bypass the I-95 accident scene and growing backup – resulting in a 75-minute travel estimate. The second option	**CHART Strategy 3.8.1** *CHART Web Site Enhancements/Development* **CHART Strategy 3.16.2** *Develop Traveler Information Software* **CHART Strategy 3.16.1** *Multi-modal Traveler*

	is to use the MARC train departing at 11:45 from Greenbelt – estimated at 85 minutes; the third being to brave I-95, which is estimated at 95 minutes. Taking the train would get her to the meeting on time and allow her to prepare while on the train, but she would have to come back to the Park-n-Ride to get her car rather than driving directly home from Baltimore to get a head start on the holiday weekend traffic. She decides to try driving the B-W Parkway. Knowing that conditions may change by the time she reaches the exit to use the MARC or I-95, she requests to be paged on her cell phone if they become better than the B-W Parkway option.	*Information Data Repository/Clearinghouse*
11:30 AM	On her way, our Commuter receives the page she had worried about – the CHART website had now calculated that travel time along the B-W Parkway was exceeding the 85 minutes it would take to use MARC. "Everyone's using the Parkway," she realizes, "I'm not going to get there in time to prepare." She decides that taking the train will be the only way to adequately prepare for this important client presentation, even though it means the family will have to leave later than expected. Just to be sure, she calls 511 Traveler Information from her cell phone to double check on the MARC train schedule and status to see if it's running on time, which it is. Approaching the Greenbelt exit off the Beltway, she also checks the roadside message sign to ensure the Park-n-Ride lot has spaces available. "Well, at least I'll have plenty of time on the train to get ready for this meeting . . . and call my husband to let him know I'll be getting home late," she realizes.	**CHART Strategy 5.8.1** *Statewide 511 Service* **CHART Strategy 4.12.1** *Support for Deployment of Traffic Management Infrastructure at Inter-modal Transfer Points and Major Parking Facilities*
12:55 PM	Having a relaxing, yet productive, train ride, our Commuter arrives at her 1:00 pm Baltimore meeting on time and well prepared.	
3:45 PM	After a good meeting and upon returning to Greenbelt, the Commuter checks the status of her route home using a traffic flow map displayed on a CHART traveler information board at the Park-n-Ride center. She sees that her "back roads" route will be better right now because of the early congestion levels. She is hoping that she will not arrive home too late, as holiday traffic to the beach will be heavy and travel time could be lengthy.	**CHART Strategy 3.8.4** *Electronic Traveler Information Board* **CHART Strategy 1.2.1** *Additional Traffic Detectors*
5:00 PM	*CHART is busy with the combined holiday and commute rush. The dynamic toll lane fares have been updated along major Interstates, and coordination between CHART and multiple other transportation organizations is at a peak.*	**CHART Strategy 4.11.4** *Support Deployment of Dynamic Toll Lanes*
5:30 PM	The Commuter arrives home by 5:30 pm and helps her husband pack the kids into the family car to leave for Ocean City by 6:00. She is relieved to hear her husband has already checked and confirmed their preferred travel route with their minivan's in-vehicle route guidance subscription service from the family home computer.	

6:30 PM	The family – just under way – hits heavy traffic in Gaithersburg. The route-guidance system helps by directing them along roads where current delay levels are minimal.	
7:10 PM	The in-vehicle route-guidance device indicates traffic conditions are still heavy along US 50 heading east and that HOT lanes are currently charging the highest level toll. Nonetheless, they decide to use the toll lanes. While they will pay extra due to the holiday and traffic volumes, the route-guidance system reports an estimated 25 minutes saved in travel to Ocean City.	**CHART Strategy 3.16.1** *Multi-modal Traveler Information Data Repository/Clearinghouse*
8:00 PM	Using the toll lanes allows the Commuter and her family to make good time, but, as if the day has not been hectic enough, a tire goes flat on their van along US 50, just east of the Bay Bridge. They call #77 from their cell phone to request assistance because they do not feel safe changing the tire on the roadway shoulder. Other cars have been slowing down to avoid the family van, and this slowdown is beginning to cause a backup. Within 10 minutes, the family sees a CHART Emergency Traffic Patrol (ETP) vehicle approaching with flashing safety lights and a traffic arrow panel mounted on the rear. The ETP responders help with the tire change, which restores traffic flow to normal conditions and enables the family to proceed much more quickly and safely than they otherwise would have.	**CHART Strategy 2.5.4** *Extend CHART Traffic Patrol*
11:00 PM	The Commuter and her family arrive safely at their vacation destination, and are pleased with their travel time considering the heavy traffic and flat tire. They look forward to a full three-day weekend.	

Executive Summary

A Texas Transportation Institute (TTI) report indicated that in 2011 traffic congestion cost $818 per auto commuter, an annual delay of 38 hours, and 19 gallons of wasted fuel per peak-hour traveler. Average yearly costs in the Baltimore and Washington, D.C. urban areas were estimated at $908 and $1,398 per auto commuter, respectively. The total cost of congestion for 498 urban U.S. cities studied was $121 billion (in 2011 dollars).

Resources for new infrastructure construction have become scarcer in the current economic climate. As highways have become more congested, attention has been focused on strategies to optimize existing infrastructure to move traffic. Applying a range of such operations strategies can decrease the congestion and delay, increase travel time reliability and improve safety.

The Coordinated Highways Action Response Team (CHART) is Maryland's operations element for the state's transportation program. Its mission is *to improve mobility and safety for the users of Maryland's highways through the application of ITS technology and interagency teamwork.* CHART is a joint effort of the Maryland Department of Transportation (MDOT), Maryland State Highway Administration (MDSHA), Maryland Transportation Authority (MDTA), and the Maryland State Police (MSP), in cooperation with federal, other state, and local agencies.

CHART began in the mid-1980s as the "Reach the Beach" initiative and is now a multi-discipline and multi-jurisdiction program. Its activities have extended not just to the busy Baltimore-Washington Corridor, but into a statewide program.

CHART accomplishes its mission by focusing on mitigation of non-recurring congestion that occurs due to events such as crashes, breakdowns, construction, weather, etc. According to the FHWA, non-recurring congestion is the cause of about 50 percent of highway congestion. Recurring congestion – generally caused by high volumes on highways with limited capacity – accounts for the other fifty percent.

Table E-1 provides an overview of the two types of congestion, some of their causes, as well as the two different types of strategies to mitigate those causes.

Table E-1 - Types of Congestion with Usual Mitigation Strategy

Type of Congestion	Representative Causes of Delay	Mitigation Strategy
Recurring	Infrastructure capacity shortfalls	Capacity increases
	Interchange bottlenecks	
	Weave and merge friction	
	Non-optimized traffic signal timing*	Transportation Systems Operations and Management
Non-recurring	Breakdowns and crashes	
	Construction work	
	Weather	
	Vehicle mix	

* Note that while non-optimized signal timing will lead to recurring congestion, it is addressed through better operations and management, not new capacity.

The University of Maryland has developed a yearly assessment of the CHART program since 1999. The CHART program – sometimes in conjunction with other programs and agencies – has made a beneficial difference, especially in the incident management arena. In the year 2010 alone, the CHART program's focus on non-recurring congestion returned $1.375 billion in savings from fewer delayed vehicle hours to Maryland travelers, reduced average incident durations by 28% between 2004 to 2010, and significantly lowered emissions levels. These benefits continue to accrue year-after-year and, in fact, are growing over time. The most recent evaluation report released in 2013 shows sizeable benefits of the CHART program for the 2012 analysis period:

- Overall reduction of travel delay of 28.48 million vehicle-hours, saving consumers 5.59 million gallons of fuel.
- Trip cost savings due to delay reduction were estimated at $908.13 million in travel time and $21.01 million in fuel.
- Reduction in vehicle emissions (hydrocarbons, nitric oxide, etc.) due to CHART operations was estimated at $32.56 million.
- The benefits of CHART far outweighed the allocated capital and operational costs – for every dollar invested, the CHART program returned $31.63 in benefits.

Looking Forward – The Potential of CHART

CHART continues to take a structured approach to planning, implementing and integrating new strategies to move the operations program forward.

The CHART Non-Constrained Deployment Plan (NCDP), developed in 2005 and updated in 2008, provided a roadmap for the future including advanced technology deployments, software development, integration, and improvements to coordination with other states and local agencies. This document, the Long Range Strategic Deployment Plan (LRSDP), is an update of the 2008 NCDP and carries forward all the elements of the NCDP. It can be viewed as a palette of ITS deployment projects for inclusion in future CHART planning for years to come. The key improvement in the LRSDP is in addition to the total cost estimates for the projects, it provides budgetary and deployment scheduling information for individual projects.

Qualitatively, beyond existing benefits, additional benefits that will be experienced through extending CHART's programs based on strategies and associated projects within this Plan include:

- More efficient, useful, and personalized traveler information through enhancements to the 511 service
- Increased real-time traffic management and traveler information services through use of the latest technological tools
- Increased safety, mobility, and reliability due to coordinated management of commercial vehicles and hazardous material shipped along roadways
- Increased safety along freeways, at work zone locations, and at highway/rail crossings
- Increased mobility at inter-modal transfer points
- Increased adverse weather and emergency management, as well as evacuation services
- More secure, sustainable and redundant transportation management services
- Safer and quicker management of roadway incidents at multi-jurisdictional locations
- Increased mobility on arterials/surface streets, tolled roadways, and event/work zone locations

Planning Structure

The CHART Long Range Strategic Deployment Plan is composed of a series of Elements, Objectives, Strategies, and Projects. The LRSDP Elements are consistent with the six program Elements defined by CHART within the MDSHA planning framework. Table E-2 lists the six Elements, and provides total capital cost estimates for each.

Objectives within this Plan offer the CHART program a specific target for the six program Elements. They provide a high-level description of the sort of operations that will need to take place, and the underlying purpose behind those operations. In this manner, the Objectives were used as the primary basis to build the various deployment Strategies. The 17 LRSDP Objectives are displayed in Table 3, along with associated total capital cost estimates.

Using the Objectives as a foundation, the LRSDP Strategies were developed. This Plan presents ITS deployment Strategies as a group of functional benefits and associated activities that CHART will undertake in order to achieve the operational capability defined in the Objective. The LRSDP Strategies are provided in Section 3.1, along with associated priority ratings.

The LRSDP Projects give a physical description of what needs to be deployed to realize the functionality outlined by the Strategies. As such, each Project will primarily support the implementation of a specific deployment Strategy. A list of Project names is provided in Section 3.2, along with associated capital cost estimates.

The Appendices provide detailed information, including detailed Project definitions and profiles, project deployment status and their corresponding yearly capital and operations and maintenance costs with assumptions.

Cost Estimate for LRSDP Implementation

The Consolidated Transportation Plan (CTP) allocation for CHART for fiscal years 2012-2017 shows expenditures of $21 million in capital costs and $9.4million in operations and maintenance costs in 2012. At the current level, funding for the CHART program will be approximately $182 million over the next six years. In comparison, funding for MDSHA capital costs is budgeted at $4.6 billion for the same six-year period in the 2012-2017 MDOT CTP. The share of funding devoted to Transportation Systems Operations and Management tends to be relatively small compared to new construction. Given the difficulty in keeping pace with congestion through new construction, focusing additional

attention on the operations and management part of the congestion solution through increased funding could pay large dividends.

Capital cost estimates for implementing the LRSDP for CHART's six traditional program elements are reflected in Table E-2. All cost estimates within the LRSDP are in current dollars, and not adjusted for inflation.

Table E-2 Capital Cost Estimates by Traditional CHART Elements

CHART Element	Total Capital Cost Estimate
Traffic and Roadway Monitoring (TRM)	**$76,017,000**
Incident Management (IM)	**$31,753,000**
Traveler Information (TI)	**$96,752,000**
Traffic Management (TM)	**$33,072,000**
Systems Integration and Communication (SIC)	**$42,071,500**
Emergency and Weather Operations (EWO)	**$23,200,000**
LRSDP Total Capital Cost Estimate	**$302,865,500**

Table E-3 shows the above capital cost estimates for the 17 Objectives that are defined within the LRSDP.

Table E-3 Capital Cost Estimates by CHART LRSDP Objectives

Number	Objective	Total Capital Cost Estimates
1	Enhance CHART's ability to visually monitor highway conditions.	$41,748,000
2	Enhance CHART's ability to collect automated traffic data from traffic detection sites.	$22,275,000
3	Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data and reduced infrastructure requirements.	$26,490,000
4	Enhance CHART's ability to monitor travel conditions during inclement weather.	$1,640,000
5	Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.	$28,542,000
6	Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	$660,000
7	Enhance CHART's severe weather and emergency management operations.	$15,550,000
8	Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	$27,690,000
9	Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.	$69,900,000
10	Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.	$5,813,000
11	Utilize current technology and strategies to optimize flow of traffic on access controlled highways.	$25,945,000
12	Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	$239,000
13	Enhance ability to manage traffic and increase safety near and within work zones and event locations.	$2,600,000
14	Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	$6,798,000
15	Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.	$ -
16	Develop additional capabilities within the CHART Operating System Software.	$21,162,000
17	Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices.	$5,813,500
NCDP Total Capital Cost Estimates		**$302,865,500**

* Objective 15 does not have a capital cost estimate because it only consists of Strategies in which CHART is acting in a supporting role to another agency initiative (see Section 2.4.3). In these supporting roles, CHART may incur little or no capital costs.

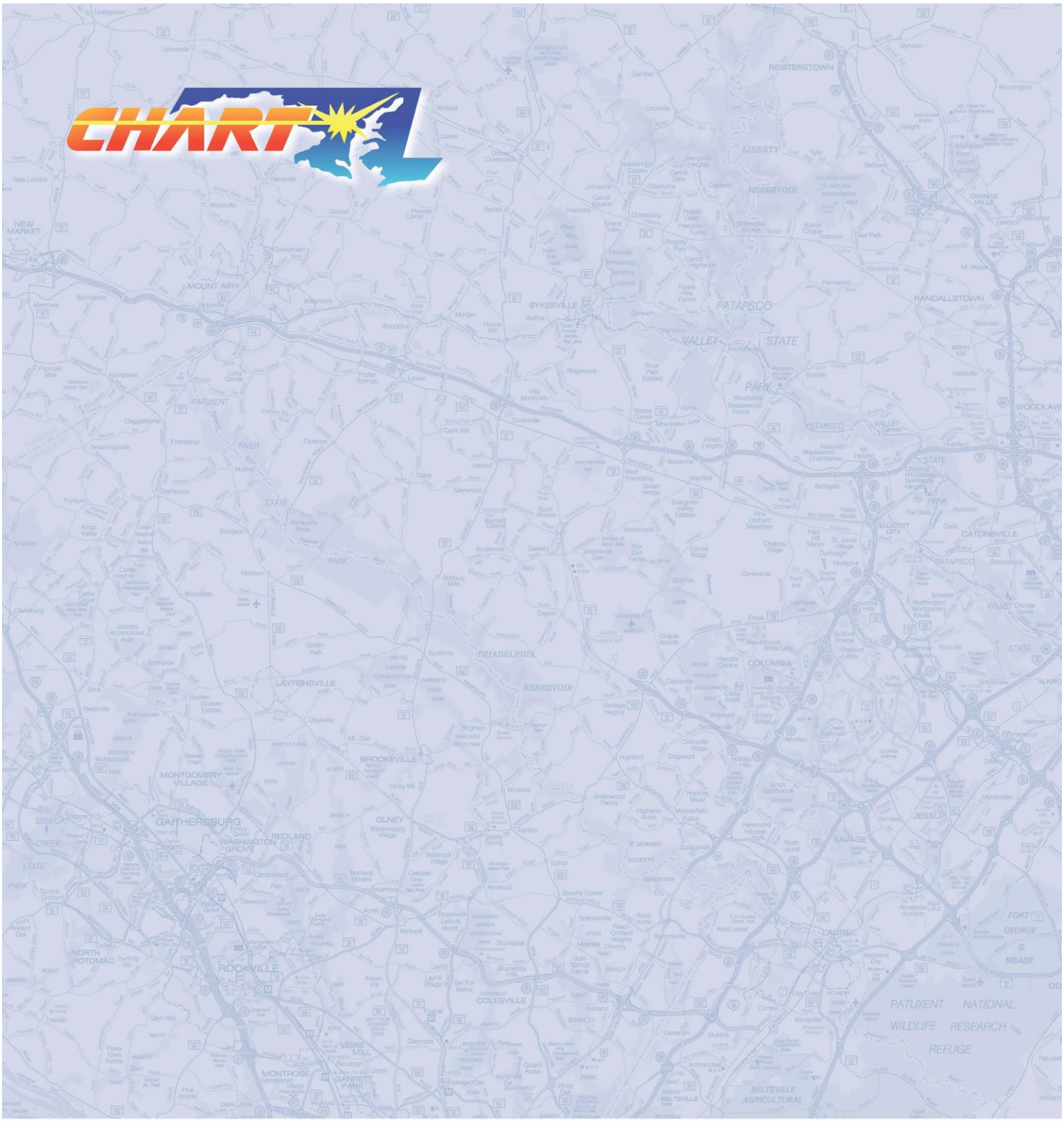
The total cost of the LRSDP is reflected in Table E-4 below.

Table E-4 – CHART LRSDP Total Cost Estimates

CHART LRSDP Costs	Total Cost Estimate
Capital Cost	$302,865,500
Pre-deployment (Studies and Engineering) Costs	$28,065,250
20-year Operations and Maintenance Costs	$491,726,749
20-Year Recurring Communications and Software Licensing Cost	$18,427,320
Total	**$841,084,819**

In short, costs of implementation (approximately $303 million capital costs, and $28 million pre-deployment costs), 20-year operations and maintenance (approximately $492 million) and 20-year recurring costs (approximately 18 million), of the complete capital plan within the CHART LRSDP is a small percentage of the estimated $51.4 billion in needed statewide highway construction improvements. However, the CHART program represents MDSHA's primary contribution to managing and operating existing roads, addressing approximately half of what causes congestion, delay, and lack of reliability for Maryland travelers.

THIS PAGE LEFT INTENTIONALLY BLANK



SHA
State Highway Administration
Maryland Department of Transportation

Martin O'Malley
Governor

Anthony G. Brown
Lt. Governor

Melinda B. Peters
State Highway Administrator

James T. Smith
Secretary of Transportation

Leif A. Dormsjo
Deputy Secretary for Planning and Project Management

Wilson H. Parran
Deputy Secretary for Administration and Operations

LRSDP
Long Range Strategic Deployment Plan
FINAL

Report

Office of CHART and ITS Development
State Highway Administration
7491 Connelley Drive
Hanover, MD 21076 -1701
(800) 543-2515
www.chart.state.md.us

2013

Long Range Strategic Deployment Plan

This report was developed and finalized in September of 2013 by the Maryland State Highway Administration's Office of CHART and ITS Development; with support from Telvent USA, LLC and Sabra, Wang and Associates, Inc.

Table of Contents

Tables

Figures

1. Introduction

Transportation operations involve the application of ITS technology solutions to transportation challenges as well as close interagency cooperation and coordination to implement improved mobility and safety. Specifically, operations solutions are used to efficiently manage recurring and non-recurring congestion (e.g., crashes, breakdowns, construction, and weather).

The Coordinated Highways Action Response Team (CHART) is the highway operations element of Maryland's ITS Program. CHART is a joint effort of the Maryland Department of Transportation (MDOT), Maryland State Highway Administration (MDSHA), Maryland Transportation Authority (MDTA), and Maryland State Police (MSP), in cooperation with other federal, state, and local agencies.

CHART's mission was defined early in the program's development, and is still applicable today:

> ***CHART strives to improve mobility and safety for the users of Maryland's highways through the application of ITS technology and interagency teamwork.***

The CHART program relies on communication, coordination, and cooperation among agencies and disciplines, both within Maryland and with neighboring states, to foster the teamwork necessary to achieve its mission. CHART's mission is consistent with MDSHA's overall mission, which is to ***efficiently provide a safe, well-maintained, reliable highway system that enables mobility choices for all customers and supports Maryland's communities, economy and environment***.

The genesis of CHART can be traced back to the mid-1980s, when a program known as "Reach-the-Beach" was initiated to help improve travel to and from Maryland's Eastern Shore and the urban areas of Baltimore and Washington. "Reach-the-Beach" developed into a multi-jurisdictional and multi-disciplinary initiative that extended into the Baltimore-Washington Corridor and provided the foundation for a statewide ITS program.

The supportive technologies underlying CHART are rapidly changing, requiring a proactive approach to respond to, and anticipate changes. In addition, CHART management needs to capitalize on opportunities for cooperation with a wider and more diverse group of public agencies and private organizations, to better fulfill its mission.

A requirement within the MDOT organizational planning process is for each responsibility center to contribute its portion within the MDOT capital plan, which CHART does on a yearly basis. However, unlike the majority of other MDSHA programs, CHART is based on concepts, strategies, and technologies that have only become available within the past twenty years. This has led to a planning process that is comparatively more iterative and potentially more dynamic than other MDSHA offices, and which must be updated as customers' requirements of the CHART program evolve along with the transportation improvement technologies it deploys.

Because CHART needs to be in continuous pursuit of the latest advancements in ITS, it is essential that corresponding planning efforts to identify the ever-changing user needs, as well as the strategies that are available to meet those needs occur. There have been several planning efforts that consider the extension of the CHART program past conventional incident management and highway operations in order to take on more diverse transportation challenges by employing various innovative ITS solutions.

There are, however, numerous transportation operations and technology applications that can significantly enhance the CHART program but are beyond what is considered feasible when taking into account today's institutional and resource constraints. It is important to consider the potential of these deployments in order to depict an ideal or model target for the CHART program. In this manner, the CHART program will be more compatible with tomorrow's transportation system user needs, as well as prepared for deploying the latest ITS solutions.

2. Plan Overview

The LRSDP builds on the previous efforts of the 2008 NCDP to paint a picture of transportation-related solutions that are available for future implementation in order to improve safety and mobility for travelers in Maryland. This plan will serve as a resource to support CHART's project planning and programming process.

2.1 Purpose

The broad purpose of the LRSDP is to identify priorities, costs, and approaches for the MDSHA to continue the process of deploying ITS technology throughout the state. The LRSDP presents a "menu" of ITS projects (Appendix D) for periodic deployment with associated deployment costs that span a planning timeline of twenty (20) years.

Projects in the plan address six major CHART planning areas (called Elements), which are Traffic and Roadway Monitoring, Incident Management, Traveler Information, Traffic Management, Systems Integration and Communication, and Emergency Weather Operations. The intended effect of these projects is to improve safety and mobility, increase traveler situation awareness, and promote and support transportation sustainability.

The LRSDP differs fundamentally from previous NCDPs by including planned deployment timelines and budgets for each project presented in Appendix D. The LRSDP provides a means for:

- Identifying new projects to be added to future MDOT CTPs, and CHART Deployment Plans as part of CHART's project planning and programming process (See Figure 2).
- Portraying the possibilities of future program operations to decision-makers.
- Providing a consolidated CHART vision for future deployments and operations.

2.2 LRSDP within the CHART Planning Process

This section describes (1) CHART's ITS Project Deployment Process and (2) CHART's Project Planning and Programming Process and how the LRSDP fits within this Planning and Programming process.

CHART's ITS Project Deployment Process, depicted in Figure 1, is cyclical and follows, at a high-level, a Systems Engineering process. This process is

overseen and directed by the CHART Board of Directors and begins with needs. The process continues with the following steps:

- **Planning/Stakeholder Input**: Gathers stakeholder inputs to explore project concepts and feasibility through feasibility studies and Concept of Operations documents.
- **Design:** Uses the Concept of Operations to develop requirements and detailed design.
- **Construction**: Implements all pieces of the project such as installation of field devices and development of software and hardware.
- **Acceptance Testing**: Tests and validates individual components of the system and the system as a whole for functionality according to requirements.
- **Network Integration**: Integrates the system into the CHART network for operations to begin.
- **Operations and Maintenance**: Operates the system as part of daily operations and subsequently performs routine and emergency maintenance throughout the life of the system.

Figure 1 – CHART ITS Project Deployment Process

CHART's Project Planning and Programming Process is depicted in Figure 2. It begins with the identification of potential projects from multiple MDSHA and CHART planning documents, denoted as inputs to the programming process. These inputs include the following:

Maryland Statewide ITS Architecture: Identifies planned and existing interconnects and information flows among systems operated by transportation agencies in Maryland. The Maryland Statewide ITS Architecture fulfills a United States Department of Transportation (USDOT) requirement for MDSHA Office of CHART and other participating stakeholders to receive federal funding for ITS projects. The documentation and associated system diagrams define functionality and information exchanges. As such, the CHART program bases capital improvement projects on planned system functionality and information exchange defined in the Maryland Statewide ITS Architecture.

Baltimore and D.C. Regional Operation Coordination Committees (ROCC): A collection of representatives from agencies that have a stake in transportation operations within the Baltimore-Washington Metropolitan region. It identifies multi-agency transportation coordination issues throughout the region, defines projects and needed resources to address those issues, and to generally foster regional cooperation in transportation operations. CHART has historically provided staff coordination and resources for various projects that originated in the ROCC – primarily related to regional incident management initiatives.

Other MDSHA Office Projects with ITS Applications: MDSHA offices, other than CHART, that have ITS deployment projects. In these cases, the Office of CHART often provides preliminary planning and design services to identify characteristics of a deployment (e.g., location and viewing angles of a camera), as well as the needed system hardware, power, and communication services to integrate the deployment into the CHART system. It should be noted that these projects only involve CHART resources for planning and integration support and do not typically require capital expenditures or overall project management services from CHART.

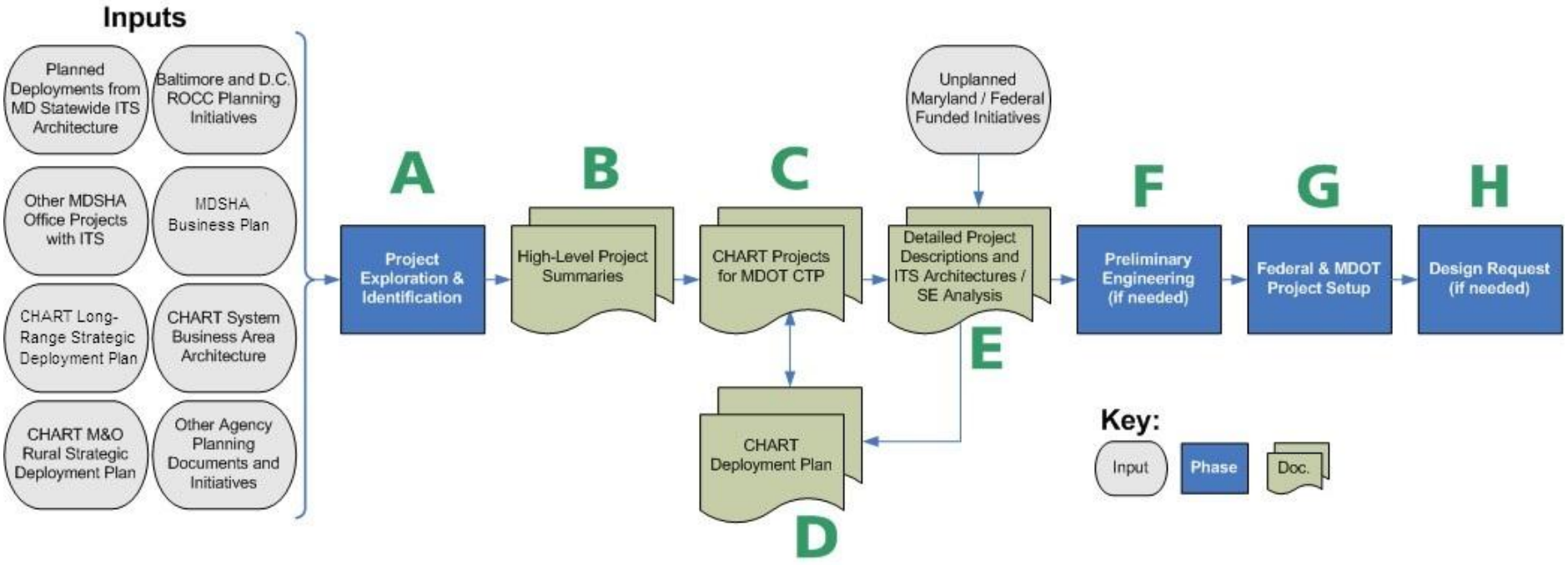


Figure 2 – CHART Project Planning & Programming Process

Note that in Figure 2 those items denoted by blue boxes represent phases/tasks within the CHART planning process; items denoted by the gray ovals represent inputs into the planning process; and items denoted by the dark green pages represent documents within the planning process. It should also be noted that the lettered notes on the phases/tasks and documents cross-reference the descriptions in the following paragraphs, and are not necessarily in chronological order.

MDSHA Business Plan – The Maryland State Highway Administration's Business Plan defines the MDSHA's Mission, Vision, Values Goals, and Key Performance Areas (KPAs) as they relate to Maryland's highway system operations at customer and institutional levels. This Business Plan is primarily driven by the KPAs, Objectives to meet the KPAs, and performances measures to define progress in achieving the Goals of the KPAs. CHART is responsible for making its contribution to the MDSHA Business Plan and the management of CHART-related KPA objectives and performance measures facilitate the identification of projects for future deployment.

CHART Long Range Strategic Deployment Plan – This document, the CHART Long Range Strategic Deployment Plan (LRSDP) is a 20-year planning document. Its primary purpose is to depict a model of how CHART should be operating twenty years into the future taking into account cost and scheduling constraints related to potential project deployments. The LRSDP provides a tool for CHART to update its Deployment Plan and generate yearly capital plans for annual CTP budget submittal. It achieves this by tracking the latest technologies and operational applications available to the CHART program. The LRSDP uses these technologies to develop projects and present them with their corresponding proposed fiscal year deployment and total cost estimates. Potential projects are identified from project profiles presented in Appendix D.

CHART System Business Area Architecture – The CHART Business Area Architecture (BAA) is a document that defines the current and future CHART system operational vision. This includes: designed business processes for relationships to organizations, technology, and facilities; defined, distributed, and integrated applications and data entities across platforms and locations; a system architecture at the conceptual level for technical infrastructure; and defined, interrelated, and scheduled releases within the business change program. The document is specific to the CHART system and the operation of the system, including software, hardware, and communications infrastructure. It includes a significant amount of needs/requirements related to operational capabilities to be built into the CHART system. These needs and requirements are used as input for identifying CHART projects.

CHART M&O Rural Strategic Deployment Plan – This document defines the Management and Operations/ITS planning and deployment needs of Rural Maryland. It identifies and addresses major issues such as minimizing congestion, improving safety, reducing incident-related delays, providing timely and accurate information to travelers, providing effective transportation resources for emergencies and disasters, and establishing effective transportation operations centers for agency coordination. Additionally, this plan provides a schedule for each project deployment, estimated deployment costs, and cost assumptions.

Other Agency Planning Documents and Initiatives – There are other planning documents and initiatives that provide input into the CHART Project Planning and Programming process. These include, but are not limited to, the following:

- Planning documents or deployment initiatives by other agencies that include CHART support and/or capital deployments
- Internal MDSHA Strategic Plans – often particular to an operational area. These plans define future operational conditions and/or capital deployments.
- Inputs from CHART personnel on operational needs to be met by deployment projects

Unplanned State / Federal-Funded Initiatives – These project exploration and identification inputs occur when special needs or opportunities arise and formal planning processes have not been fully carried to initiate a project. Depicted in Figure 2, projects arising from unplanned state/federal-funded initiatives bypass formal documentation in the MDOT CTP and CHART Deployment Plan and are documented directly within a detailed project description and/or a project-level ITS architecture / SE analysis. The project is then officially programmed in the Federal and/or MDOT project systems.

A – Project Exploration and Identification

This phase in the CHART project planning and programming process involves gathering information from the previously defined planning documents and initiatives. One of the CHART program's objectives is to coordinate with other offices/agencies/partners in order to effectively operate Maryland roadways. CHART has an established place within several forums and processes that involve planning interaction with other agencies (e.g., bordering/regional states, local and county agencies, other state modal transportation agencies, public safety agencies, emergency and medical operational agencies, among others), as well as other offices within MDSHA. Similar to CHART, these partner agencies also have planning processes and documented initiatives, many of

which identify resources that CHART will be responsible for deploying/providing. Therefore, CHART planning efforts need to account for various CHART resources allocated to support other agency initiatives.

In addition to inputs from outside agencies, there are various inputs from within the CHART program that identify operational needs and resources to be deployed through future projects. These include (but are not limited to):

- Planning and/or design documentation developed for specific systems or efforts within the CHART program (e.g., the CHART Business Area Architecture is a planning/requirements document for the CHART II operating platform);
- Input (documented or not) on operational needs from CHART operational staff in CHART centers or in the field; and
- Operations and maintenance data related to the need to replace existing infrastructure that is beyond or reaching its life expectancy.

The Project Exploration and Identification Phase is not necessarily sequential within the overall CHART project planning and programming process depicted in Figure 2. That is, planning inputs can be taken into account at any point within the process. For instance, some planning inputs are impromptu and bypass preliminary planning stages to be entered directly into the project setup phase to receive funding and programming.

B – High-Level Project Summary

After projects are identified, high-level project summaries are developed to be entered into the MDOT Consolidated Transportation Program (CTP) to begin the programming process. These summaries do not require a great deal of resources to produce, and therefore are typically done prior to final decisions on whether/and how the project will be carried out. More detailed project descriptions and preliminary design efforts are completed closer to the point where the project is going to be designed, budgeted for, and programmed into the Federal and/or MDSHA project tracking systems as a formal project.

High-level project summary documentation typically includes:

- Project Title
- Preliminary cost estimate
- Rough scope definition (i.e., a paragraph describing equipment to be deployed, and estimated number of devices)
- Projected implementation schedule (i.e., estimate of when project will be implemented, and duration of project)

- High-level benefits and needs addressed (i.e., paragraph explanation)

C – CHART Projects for MDOT CTP

The Maryland Consolidated Transportation Program (CTP), developed annually by the Maryland Department of Transportation (MDOT), uses the high-level project summaries to develop detailed listings and descriptions of capital projects that are proposed for construction, development and evaluation during the next six-years. The MDSHA and the Office of CHART contribute projects to the CTP, which include budget projections for each project in yearly increments. CHART updates its projects and budgets every year for submittal to the MDOT CTP, showing the latest CHART capital investment six-year projection.

D – CHART Deployment Plan

The CHART Deployment Plan presents capital improvement projects that the MDSHA Office of CHART is responsible for within the six-year MDOT CTP. It is a compilation of projects that either have a high-level or detailed project description. High-level project summaries are included for those projects that do not yet have a detailed project description developed, or those projects that are planned for more distant year deployments. Projects that have started deployment, close to project initiation, or projects close to being programmed as an official project would have detailed project descriptions in the CHART Deployment Plan. The purpose of the Deployment Plan is to document detailed information on CHART projects that will receive funding for the next six years through the CTP. The CHART Deployment Plan directly reflects the CHART Projects that are programmed in the MDOT CTP.

As depicted in Figure 2, after a detailed project description is developed or updated for a project, it becomes an input for the next iteration of the CHART Deployment Plan.

E – Detailed Project Descriptions and ITS Architectures / Systems Engineering (SE) Analysis

This documentation takes place after projects are documented in the MDOT CTP and the CHART Deployment Plan. The Detailed Project Description and ITS Architecture / SE Analysis Phase is required to be carried out prior to a project going through the Preliminary Engineering Phase (if applicable), and eventually entered into the Federal and MDOT Project Setup Phase.

The detailed project descriptions document information that is required by MDOT and MDSHA to begin the project setup process. In general, the detailed project descriptions expand on the information within the high-level project summaries to

include details that are required to secure state funding. Detailed project description documentation typically includes:

- Project title
- Brief project description and/or background
- Project cost estimate
- Detailed scope (e.g., system functionality, location, number of devices, etc.)
- Project tasks and/or milestones
- Project schedule
- High-level benefits and needs addressed
- Project funding source

The project-level ITS architecture and SE compliance documentation is carried out to fulfill the Federal Highway Administration (FHWA) rule on Intelligent Transportation Systems (ITS) Architecture and Standards, which implements section 5206(e) of the Transportation Equity Act for the 21st Century (TEA-21). This final rule/policy requires that ITS projects funded by the Highway Trust Fund conform to the National ITS Architecture. Part of this process includes a project-level architecture, as well as a systems engineering analysis.

The systems engineering analysis is a structured process that is used to help reduce the risk of schedule and cost overruns by accounting for variables affecting the system being deployed. The Project ITS Architecture is based on the results of the SE analysis, and defines specific system data exchanges and functions being deployed by the project. It is developed using applicable information flows documented in the Maryland Statewide Architecture, and once completed, the Project ITS Architecture identifies, in turn, any project-related updates that need to be made to the Statewide Architecture. The following is a more detailed list of what the Project ITS Architecture and systems engineering analysis includes.

Systems engineering analysis documentation includes:

- Identification of portions of the Maryland Statewide ITS architecture being implemented
- Identification of participating agencies roles and responsibilities;
- Requirements definitions;
- Analysis of alternative system configurations and technology options to meet requirements;
- Procurement options;

- Identification of applicable ITS standards and testing procedures; and
- Procedures and resources necessary for operations and management of the system.

The project level ITS architecture is based on the results of the systems engineering analysis, and includes the following:

- A description of the scope of the ITS project;
- An operational concept that identifies the roles and responsibilities of participating agencies and stakeholders in the operation and implementation of the ITS project;
- Functional requirements of the ITS project;
- Interface requirements and information exchanges between the ITS project and other planned and existing systems and subsystems; and
- Identification of applicable ITS standards.

F – Preliminary Engineering (If Needed)

Following the Detailed Project Descriptions and ITS Architecture/SE Analysis phase, preliminary engineering is conducted where all details about the deployment are gathered prior to beginning the final project design.

However, not all CHART projects require preliminary engineering services such as projects that are solely equipment procurement. In general, the most common type of projects that require preliminary engineering services are those where ITS field devices are being deployed in new locations. A preliminary engineering report will be completed to document outcomes from the preliminary engineering phase. These reports typically include the following for each field device location/site:

- Roadway and site characteristics/conditions – county, route, direction of travel, nearest milepost, geographical coordinates, offset of road, etc.
- Landscape features/usage
- Special features
- Personnel conducting survey
- Obstructions
- Power/communications notes on availability or issues
- Comments/suggestions
- Additional reference material, typically including: a map of the location, images of viewing angles (especially for cameras), reference images from site survey

G – Federal & MDOT Project Setup

After preliminary engineering services are performed and documented, the project is documented in the Federal and/or MDOT project tracking systems, which records budget, payments, scheduling, etc. As discussed above, those projects that do not require a project-level ITS architecture and/or a systems engineering analysis, and/or preliminary engineering services may be entered directly into the project setup phase. Typically, much of the documentation conducted in the previous phases is used as inputs to document projects in the Federal and MDOT Project systems.

The USDOT/FHWA project setup utilizes project information from (1) Project-level ITS architecture and (2) Systems Engineering analysis documents.

The MDOT project setup utilizes project information from (1) Detailed project descriptions and (2) Preliminary engineering services

H – Design Request

This phase follows the Federal and MDOT Project Setup and is the last phase within the CHART Project Planning and Programming Process. Once the project is setup in the USDOT/FHWA and/or MDOT project system, it can then move forward with design and deployment. The Office of CHART typically does not conduct design services for many of the projects it initiates through its planning process, and therefore, a design request is submitted by CHART to the Office of Traffic and Safety (OOTS) in order to officially move project design and construction management services to OOTS. This phase also moves the planning and programming process into project design and deployment.

However, not all Office of CHART projects require design service requests. For example, projects that only require procurement of system hardware or software do not require site engineering design. Projects with design services that will be conducted internally by CHART rather than by OOTS would also have no need for design requests.

When completed, the Design Request submitted by CHART to OOTS includes:

- High-level project summary / title
- Project location and limit
- Funding source
- Estimated costs
- Specific device location information (typically accompanied by a map)
- Additional reference material (e.g., preliminary engineering report)

- OOTS design request forms

2.3 Scope

The purpose of the LRSDP is to provide a framework for CHART's future ITS deployments. It includes costs and schedules associated with each project. A breakdown of deployment schedule and costs is included in each project profile and a summary of this information is presented in the deployment matrix in Appendix D.

The LRSDP will provide the CHART planners an array of ITS deployments and initiatives from which to choose. Similar to the NCDP, the LRSDP also has a role in assisting MDOT, MDSHA, and CHART to portray the potential benefit of ITS operations to various decision-makers. In this manner, the LRSDP establishes CHART's commitment to expanding its functionality by using the latest available solutions based on the needs of Maryland travelers.

The following subsections present a discussion of the scope for the LRSDP, which focuses on its unique features in comparison to other CHART planning initiatives.

Deployment Priorities – Deployment Priority is defined in 3 categories, which are presented in terms of Strategies. A Strategy is one of the four planning levels in this plan, which contains projects and is a specific course of action that will be undertaken in order for the deployment Objectives to be achieved. Hence a Strategy's priority is applied to all projects within that Strategy. The priority number provides a distinction between those deployments that are more likely to offer an immediate benefit and those, which due to current constraining factors, will be more feasible in the future. In effect, it broadly categorizes projects based on importance while considering CHART's annual budget as determined by the allocation of the CTP funding. Additionally, priority may convey a sense of urgency to decision-makers to projects that will be immediately influential in meeting program goals.

Deployment Constraints

The planned deployment of the projects presented in this plan are constrained by the following factors:

- Costs constraints – Project deployment costs are allocated to each deployment phase by taking into account CHART's annual budget and sequencing of other projects.

- Time constraints – Implementation schedules (by year) are applied to each project based on CHART's anticipated annual budget, sequencing of other project deployments, and priority.
- Capacity of CHART network components and/or software constraints, and
- Institutional coordination constraints – This refers to CHART's internal logistics at the organizational level that are necessary for the successful implementation of each project such as defining the roles and responsibilities of each CHART department on a project and defining regional needs of travelers.

Considering these constraints in the LRSDP enables the Office of CHART to fill in the "sixth year" capital plan for each annual CTP budget submittal. Applying constraints in the LRSDP enables the CHART program to create a reasonable projection of when and how projects will be implemented to address future user needs, as well as the ITS applications to answer those needs.

Technologies

Due to the nature of this plan, several ITS technologies that facilitate transportation solutions were considered. These technologies include those that are seemingly feasible due to the existing and planned capability of the CHART system or the current operating priorities within the program. Therefore, the Plan provides a depiction of the fully feasible operating potential of CHART because it details existing ITS technologies that can be utilized by CHART considering institutional and resource constraints. The Plan also provides an outlook on technological advancement possibilities in the future.

Table 1 provides an overview of the basic scope of the LRSDP.

Table 1 – CHART LRSDP Scope

Scope Category	Long Range Strategic Deployment Plan
What is the general purpose of the plan?	• Presents CHART's twenty year plan for project deployment • Provides a consolidated CHART vision of future deployments and operations • Considers latest transportation solutions in order to expand CHART's functionality • Facilitates identification of new projects to be added to future MDOT CTPs and CHART Deployment Plans. • Portrays the possibilities of future program operations to decision-makers.
Who is the audience?	• Governor • State Legislature • CHART • MDSHA • MDOT • Local Transportation Agencies • Multi-modal Agencies • General ITS Arena • Public
What is the plan's time span?	• 2019-2038
What planning constraints were considered?	• Budgetary constraints, major factors in determining number of annual deployments. • Deployment timeframe for each project • Existing or significantly developed technology • Institutionally reasonable now or in the future

Table 2 presents how the LRSDP defines ITS deployments.

Table 2 – CHART LRSDP ITS Deployment Definition

ITS Deployment Definition Category	Long Range Strategic Deployment Plan
Costs included for each project?	Yes
Defined timeframe for project deployment?	Yes
Defined priority for project deployment?	Yes
What is the general range of defined deployments?	Office of CHART (only) resources for: • CHART ITS initiatives • Broader CHART ITS initiatives, i.e., support of other agencies' initiatives
What variety of technologies is defined?	• Existing proven technologies, from those that are fully developed to those not fully proven or fully developed • Technologies that extend conventional CHART operations to develop a broad operational perspective of future

2.4 Planning Structure

The planning structure of this plan utilizes four planning levels – *Elements*, *Objectives*, *Strategies*, and *Projects* – that indicate program level goals, high-level objectives of CHART's operations, a calculated course of action for meeting these objectives, and projects identified for deployment between 2019 and 2038.

This planning structure was adopted from that of the 2000 CHART Business Plan, the original benchmark for the development of previous NCDPs from which this LRSDP was developed. This planning structure provides a method of planning that facilitates decision making, improve program performance, simplify resource allocation, increase customer satisfaction, and create public accountability. The Elements, Objectives, Strategies, and Projects included in this plan are described in the following sections.

2.4.1 Elements

Elements are core planning categories of CHART that reflects CHART's mission and vision. There are six Elements in this plan, which are as follows:

1. Traffic and Roadway Monitoring
2. Incident Management
3. Traveler Information

4. Traffic Management

5. Systems Integration and Communication

6. Emergency and Weather Operations

2.4.1.1 Traffic and Roadway Monitoring

The intent of establishing the Traffic and Roadway Monitoring Element is to:

> *Improve highway safety and efficiency by augmenting CHART's ability to rapidly respond to hazardous highway conditions through enhanced traffic and roadway monitoring, including the use of new technology and additional device deployment.*

The LRSDP defines Objectives, Strategies, and Projects within the Traffic and Roadway Monitoring Element that stipulate the continued deployment of monitoring capabilities necessary to enhance incident and traffic management activities, as well as provide the data needed to disseminate information on current traveling conditions. Deployments for significantly extending traffic and roadway monitoring coverage are incorporated in order to ultimately encompass the entire CHART "primary coverage area" (Baltimore, Washington, Frederick, and Annapolis regions), and to do so by utilizing the latest advancements in technology applications. The Plan attempts to reflect the added emphasis of the CHART operations centers in collecting data from increasing numbers of devices in the field. Combination of public and private coordination (e.g., parking monitoring) is outlined as a possibility for the future of transportation system monitoring, as well as enhanced CHART support and deployment for the integration of monitoring operations across modal lines.

2.4.1.2 Incident Management

The intent of establishing the Incident Management Element is to:

> *Quickly and efficiently restore normal traffic flow after an incident by enhancing CHART's incident management program through training of personnel, technology solutions, and teamwork both internally and with other agencies.*

The LRSDP extends the breadth of CHART Incident Management deployments by continuing to consider this functional area as a critical element for the CHART program. This is because managing events that cause non-recurring congestion quickly and safely will remain CHART's cornerstone for providing benefits to the public. Therefore, emphasis on traffic patrol coverage extension and incident

response coordination efforts has been incorporated, as well as increasing technology applications that will enhance incident detection, response and management coordination throughout the state.

2.4.1.3 Traveler Information

The intent of establishing the Traveler Information Element is to:

> *Provide timely and reliable mobility information to the traveling public both prior to travel and en-route through the use of roadside devices, electronic media, and public-private partnerships with information providers.*

Traveler Information deployments within the LRSDP extend the scope of the current CHART Deployment Plan due to this functional area's potential for providing significant benefit to the public. The LRSDP defines how CHART will contribute to traveler information efforts to integrate various agency systems throughout, and beyond, the state. The vision involves collecting an assortment of data types so that congestion, incident, weather, transit, and other forms of traveler information can be easily accessed by the public through a variety of dissemination mediums, eventually transitioning toward a "one stop shop" for statewide traveler information.

2.4.1.4 Traffic Management

The intent of establishing the Traffic Management Element is to:

> *Reduce congestion on highways by employing traffic management strategies to control vehicular movements, increase highway efficiency, and encourage travelers to choose alternative modes of travel.*

The LRSDP expands on the current CHART Deployment Plan to support the Traffic Management Element by defining the implementation of more advanced technologies. These applications will vastly enhance CHART operational control of state freeways and expressways, and do so in harmony with the data collected by field monitoring devices. This Plan also presents deployments, initiatives, and support efforts that will increase CHART's operational involvement with arterial traffic management, specifically in initiating automatic adjustments on surface arterials related to real-time traffic conditions on state freeways/expressways.

2.4.1.5 System Integration and Communications

The intent of establishing the System Integration and Communications Element is to:

Expand the CHART operating system and network to support inter-agency and inter-modal coordination, connectivity and sharing of transportation management information.

Systems Integration and Communications will continue to be the backbone for providing the entire range of CHART services. The LRSDP builds upon the foundation set by the 2008 NCDP by calling for added deployments in software development and systems integration to allow the CHART operating system to communicate with added field devices, as well as new types of technologies that will be introduced in the communications/systems/software arena. The required capacity of the CHART network will need to continue growing as the demand for CHART's operational functionality increases.

2.4.1.6 Emergency and Weather Operations

The intent of establishing the Emergency and Weather Operations Element is to:

Establish a secure and safe transportation system by deploying emergency response equipment and establishing coordinated preparedness and response plans for large-scale natural and man-made disasters, including adverse weather operations, terrorist activities and evacuations.

The LRSDP defines emergency and weather operations to include resources and technology deployments for homeland security, evacuations, adverse weather, and large-scale event coordination. While many of the CHART resources used for incident management will also be used during emergency situations, the LRSDP delineates deployments within the Emergency and Weather Operations Element as those which are typically not used on a day-to-day basis (as is the case for incident management operations). The 2008 CHART NCDP update was the first inclusion of Emergency and Weather Operations as a separate fundamental CHART Element.

2.4.2 Objectives

Objectives are defined as specific targets for fulfilling the intent of each Element. The Objectives represent high-level descriptions of operations required to achieve this. Note that edits or additions were not made to the 2008 NCDP Objectives for the LRSDP update effort.

Table 3 presents the Objectives, and associated color-coding, defined within the LRSDP.

Table 3 – Origin of CHART Objectives

Number	Objective
1	Enhance CHART's ability to visually monitor highway conditions.
2	Enhance CHART's ability to collect automated traffic data from traffic detection sites.
3	Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data and reduced infrastructure requirements.
4	Enhance CHART's ability to monitor travel conditions during inclement weather.
5	Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.
6	Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.
7	Enhance CHART's severe weather and emergency management operations.
8	Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.
9	Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.
10	Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.
11	Utilize current technology and strategies to optimize flow of traffic on access controlled highways.
12	Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.
13	Enhance ability to manage traffic and increase safety near and within work zones and event locations.
14	Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.
15	Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.
16	Develop additional capabilities within the CHART Operating System Software.
17	Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices

2.4.3 Strategies

A Strategy is defined as a specific course of action that will be undertaken in order for the Objectives to be achieved. The LRSDP presents ITS deployment Strategies as a group of functional benefits and associated activities that CHART will undertake in order to achieve the operational capability defined in the associated Objective. A total of 95 Strategies are included in this plan.

There are a few Strategies that are duplicated under more than one Objective. These Strategies are duplicated because the technologies that they will apply are intended to be versatile, and, therefore, are applied to several different types of operations. Within this plan, duplicated Strategies are primarily related to portable trailers with mounted ITS devices such as variable message signs (VMS) and closed-circuit television (CCTV) cameras. Such deployments can be utilized for Objectives related to traffic and roadway monitoring, work zone/event management, incident management, or emergency evacuation.

Support Strategies

Deployments are to be defined in the LRSDP if they are the responsibility of the MDSHA Office of CHART. However, as CHART moves toward increased coverage and coordinated operations with other agencies and MDSHA offices, it becomes essential for CHART to support projects that are initiated and administered outside of CHART. The LRSDP, therefore, includes and defines these efforts because they are carried out using some CHART resources. These deployments are designated as Support Strategies.

In order to more clearly define the level of support that CHART will be providing for other outside ITS initiatives, this Plan uses three categories for Support Strategies:

- Operations support – CHART allocates staff-hours to support other agencies in various tasks including patrols, traffic control operations, and emergency operations.
- Systems support – CHART funds the development of CHART system software and hardware interfaces in order to integrate data/systems/operations that are initiated and/or deployed by another agency.
- Planning/technical support – CHART allocates staff-hours to better coordinate CHART's role within the planning, analysis, and technical development stages of other agency initiatives/deployments.

2.4.4 Projects

Projects are presented as profiles that provide a practicable understanding of what CHART needs to build, develop, integrate, and initiate in order to achieve the functionality of the Strategies. Each Project will primarily support the implementation of a specific deployment Strategy. The 96 defined Projects and associated Objectives and Elements are listed in Section 3.2 – Projects Grouped by Objective.

Some projects are duplicated under more than one Objective, and follow the associated duplicate Strategies (see Section 2.4.3 above for details). These Projects are duplicated because the technologies they will apply are intended to be versatile, and therefore are intended to be applied to different types of operations. Within this plan, duplicated Projects are primarily related to portable trailers with mounted ITS devices such as variable message signs (VMS) and closed-circuit television (CCTV) cameras. Such deployments can be utilized for Objectives related to traffic and roadway monitoring, work zone/event management, incident management, or emergency evacuation. Note that the cost estimates associated with the duplicate Projects are only totaled once so as to not double-count them.

It is important to note that this Plan does not define Projects for Support Strategies, which identify deployments where CHART is responsible for allotting resources for other agencies' ITS initiatives. This is primarily because the LRSDP does not define what other agencies will be implementing, and, therefore, it is difficult to define the resources that CHART will be required to provide for another agency's initiative.

2.4.4.1 Project Categories

To facilitate the development of deployment Projects for the CHART LRSDP, three Project category definitions have been developed: (1) Field and Infrastructure Deployment, (2) Integration and Communications, and (3) Software Development. The notion behind this is to facilitate easy identification of projects by the appropriate parties within CHART because projects within each of these Project "categories", although interrelated, could be (and most probably would be) performed by different personnel groups within CHART.

Field and Infrastructure Deployment

These Projects typically involve any or all of the following activities, depending on whether deployments are for new sites or the replacement of devices at existing sites:

- Device site selection
- Site preparation
- Construction of supporting infrastructure or adaptation of existing infrastructure
- Device purchase
- Device installation
- Incident/emergency management equipment purchase

Most Field and Infrastructure Deployment projects are found in Objectives 1 – 15 in Appendix D

Integration and Communications

These Projects can involve any or all of the following activities, depending on whether the integration and communications are for new sites or replacement/upgrade of devices at existing sites:

- Provisioning the required communications to each device site (e.g., ordering leased circuits)
- Obtaining/procuring the necessary networking/system components
- Configuring the networking/system equipment upon receipt
- Installation of the networking/system equipment
- Configuring the CHART software to identify and accept/process data from each new or re-equipped device site
- Test and validation of communications, device functionality, and data transfer to/from each site

Most Integration and Communications projects are found in Objective 17 in Appendix D

Software Development

These Projects involve developing and enhancing software required to support desired new functionality, including the deployment of new devices. Software development may require both modification and module development for the central CHART system software (e.g., database-related software, Graphical User Interface (GUI) software), as well as the development of device drivers and communications protocol modules for each new (i.e., not already supported by the CHART system) technology device that must be integrated into the central CHART system software.

Most Software Development projects are found in Objective 16 in Appendix D

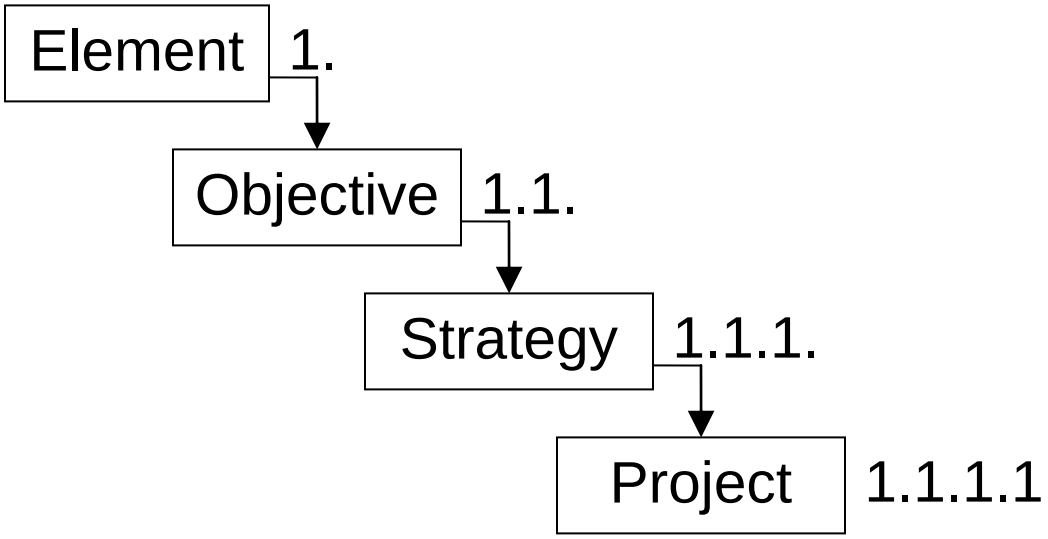
2.4.4.2 Project Definitions

A Project Definition is developed for each project and is made up of eight fields, which include Project Description, Project Scale, Benefits, Technologies, Cost, Related Strategies, Cost Assumptions, 2008 NCDP Reference, and a Deployment Table. These definition fields aim to provide a uniform manner of explaining what the deployment Projects will entail, as well as its importance in fulfilling CHART's goals. The Project definitions and a further explanation of the five fields are included in Appendix D – Project Definitions.

2.4.5 Connectivity and Numbering

The numbering for the LRSDP is consistent with that of other CHART planning initiatives in that it follows the Element (Goal in the Business Plan), Objective, Strategy, and Project hierarchy. Similar to the 2008 NCDP and CHART Deployment Plan, Projects are represented in this Long Range Strategic Deployment Plan, by the fourth number of the numbering series, as indicated in Figure 3 below.

Figure 3 – Long Range Strategic Deployment Plan Numbering Structure/Hierarchy



This numbering scheme permits each Objective to fall under multiple Elements allows each Objective to apply resources, or Strategies, that are associated with all six CHART functional Elements. This flexibility is significant because one of the primary aims of CHART is to integrate its various subsystems together to perform CHART operational functions.

For instance, Objective 13 - Enhance CHART's ability to manage traffic and increase safety near and within work zones and event locations, will require deployments from the Traffic and Roadway Monitoring Element to provide monitoring capabilities at events and work zones; the Traveler Information Element to deploy equipment for relaying information to those traveling at events or through work zones; as well as the Systems Integration and Communications Element in order to establish the necessary systems, software, and communications to accomplish the Objective.

2.4.6 Deployment Priority

Identifying the level of priority for defined deployments is a requirement for the LRSDP. This requirement originates from the widespread need of decision-makers and planners to gain a general understanding of what is most important to the CHART program. Defining priority within the LRSDP is especially important because the Plan includes deployments that may only be feasible in a long-term timeframe. Associating a measure of priority to more distant deployments delineates those deployments that have an immediate importance for CHART implementation efforts.

The LRSDP uses three levels of measurable priority to define the importance of each Strategy. These levels of priority are called "P-levels" and are denoted by a P-1, P-2, or P-3 for all Strategies except Support Strategies. Levels of priority for Support Strategies (i.e., where CHART is providing support to another agency's initiative) are denoted by an "S" to indicate the level of priority for that particular Support Strategy.

- P-1 & S-1: Functionality or deployment that needs to be put in place as soon as possible in order for CHART to achieve its overall operational vision and business model. CHART should currently be in the process of planning for or implementing the means to provide this operation or deployment.
- P-2 & S-2: Functionality or deployment that is critical for CHART to accomplish after P-1 priorities have been addressed in order for CHART to achieve its overall operational vision and business model. CHART should begin planning for the means to provide these functionalities or deployments as soon as possible.
- P-3 & S-3: Functionality or deployment that is within the overall CHART operational vision but will likely be included as part of future business models. CHART should treat these priorities as functionalities and deployments for future planning and deployment.

2.5 Cost Estimates

Cost estimates were developed for the Projects (see Section 2.4.4 – Projects) included within the LRSDP. These costs are intended to provide a "ballpark" funding estimated required for CHART to build on its existing operations to reach the potential of defined Objectives and Strategies within this plan. Note that all cost estimates within the LRSDP are in 2013 dollars, and not adjusted for inflation.

Additional funding – beyond what CHART currently receives – will be required not only for capital costs but also for preliminary studies and engineering prior to

capital deployments, as well as operations and maintenance after deployment. Table 4 provides an overview of the total cost estimates associated with the Long Range Strategic Deployment Plan.

Table 4 – Total LRSDP Cost Estimates

CHART LRSDP Costs	Total Cost Estimate
Capital Cost	$302,865,500
Pre-deployment (Studies and Engineering) Costs	$28,065,250
20-year Operations and Maintenance Costs	$491,726,749
20-Year Recurring Communications and Software Licensing Cost	$18,427,320
Total	**$841,084,819**

2.5.1 Capital Cost Estimates

Capital cost estimates are defined for each Project (Appendix D – Project Definitions and Project Cost and Deployment Schedule). Cost estimates were developed using inputs from the 2008 NCDP, along with the most current historical CHART expenditure data and available standard capital cost data and general ITS implementation knowledge. Deployment costs for the latest available technologies and other tools were assumed for developing the estimates. Also, capital costs are not adjusted for inflation experienced over the time it takes for actual deployment.

The LRSDP cost estimates are based on assumptions that are recorded within each Project Definition (Appendix D – Project Definitions and Project Cost and Deployment Schedule). Most of these assumptions are made to compensate for unknown parameters associated with those implementations that will take place in the more distant future. Any significantly unproven ITS technologies that are still under development are not priced in the cost estimates if it was deemed that there is not a meaningful or accurate basis for doing so.

The LRSDP only defines Strategies that necessitate capital spending, with the exception of the Support Strategies, which include staff resources and support that CHART will provide to other agencies' ITS initiatives (see Section 2.4.3 Strategies). CHART spending for other non-capital elements such as pre-deployment engineering studies, operations, and maintenance is estimated using percentage levels of capital spending, and discussed later in Sections 2.5.2 –

Studies and Engineering Prior to and 2.5.3 – Operations and Maintenance. Funding necessary to carry out Support Strategies is not estimated because it is difficult to define the level of CHART resources required for deployment efforts initiated by other agencies.

The tables below present capital cost estimates in several different ways. Table 5 gives estimate subtotals grouped by Element and sub-grouped by Objective. Table 6 defines capital cost estimates grouped by Objective.

Table 5 – Total Capital Cost Estimates Grouped by Element

Element	Objective	Total Capital Cost Estimates
1 – Traffic and Roadway Monitoring (TRM)	1	$38,872,000
	2	$22,275,000
	3	$6,913,000
	13	$2,050,000
	16	$3,060,000
Element 1 – Subtotals:		**$96,017,000**
2 – Incident Management (IM)	5	$28,542,000
	6	$540,000
	16	$2,671,000
Element 2 – Subtotals:		**$31,753,000**
3 – Traveler Information (TI)	8	$25,200,000
	9	$69,900,000
	16	$1,652,000
Element 3 – Subtotals:		**$96,752,000**
4 – Traffic Management (TM)	11	$25,945,000
	16	$7,127,000
Element 4 – Subtotals:		**$33,072,000**
5 – Systems Integration and Communication (SIC)	1	$2,876,000
	3	$16,730,000
	6	$120,000
	8	$2,490,000
	10	$5,813,000
	12	$239,000
	13	$550,000
	14	$788,000
	16	$6,652,000
	17	$5,813,500
Element – 5 Subtotals:		**$44,127,000**
6 – Emergency and Weather Operations (EWO)	4	$1,640,000
	7	$15,550,000
	14	$6,010,000
Element – 6 Subtotals:		**$23,200,000**
NCDP Total Capital Cost Estimates		**$302,865,500**

Table 6 – Total Capital Cost Estimates Grouped by Objective

Number	Objective	Total Capital Cost Estimates
1	Enhance CHART's ability to visually monitor highway conditions.	$41,748,000
2	Enhance CHART's ability to collect automated traffic data from traffic detection sites.	$22,275,000
3	Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data and reduced infrastructure requirements.	$26,490,000
4	Enhance CHART's ability to monitor travel conditions during inclement weather.	$1,640,000
5	Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.	$28,542,000
6	Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	$660,000
7	Enhance CHART's severe weather and emergency management operations.	$15,550,000
8	Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	$27,690,000
9	Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.	$69,900,000
10	Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.	$5,813,000
11	Utilize current technology and strategies to optimize flow of traffic on access controlled highways.	$25,945,000
12	Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	$239,000
13	Enhance ability to manage traffic and increase safety near and within work zones and event locations.	$2,600,000
14	Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	$6,798,000
15	Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.	$ -
16	Develop additional capabilities within the CHART Operating System Software.	$21,162,000
17	Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices.	$5,813,500
NCDP Total Capital Cost Estimates		**$302,865,500**

* Objective 15 does not have a capital cost estimate because it only consists of Strategies in which CHART is acting in a supporting role to another agency initiative (see Section 2.4.3). In these supporting roles, CHART may incur little or no capital costs.

Table 7 provides total capital cost estimates for LRSDP Projects grouped by one of the three Project categories. These categories – field and infrastructure deployment, integration and communications, and software development – are defined in Section 2.4.4.1 – Project Categories.

Table 7 – Total Capital Cost Estimates by Project Category

Number	Objective	Project Category		
		Field and Infrastructure Deployment Cost	Integration and Communications Cost	Software Development Cost
1	Enhance CHART's ability to visually monitor highway conditions.	$38,872,000	$2,400,000	$476,000
2	Enhance CHART's ability to collect automated traffic data from traffic detection sites.	$22,275,000	$-	$ -
3	Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data, and reduced infrastructure requirements.	$9,760,000	$16,730,000	$ -
4	Enhance CHART's ability to monitor travel conditions during inclement weather.	$1,640,000	$-	$ -
5	Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.	$28,542,000	$-	$ -
6	Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	$660,000	$-	$ -
7	Enhance CHART's severe weather and emergency management operations.	$15,550,000	$-	$ -
8	Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	$24,625,000	$2,490,000	$575,000
9	Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.	$69,900,000	$-	$ -
10	Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.	$-	$5,813,000	$ -
11	Utilize current technology and strategies to optimize flow of traffic on access controlled highways.	$25,945,000	$-	$ -
12	Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	$-	$239,000	$ -
13	Enhance ability to manage traffic and increase safety near and within work zones and event locations.	$2,600,000	$-	$ -

Number	Objective	Project Category		
		Field and Infrastructure Deployment Cost	Integration and Communications Cost	Software Development Cost
14	Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	$6,798,000	$-	$ -
15	Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.	$ -	$ -	$ -
16	Develop additional capabilities within the CHART Operating System Software.	$ -	$ -	$21,162,000
17	Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices.	$2,100,000	$3,713,500	$ -
NCDP Total Capital Cost Estimates		**$249,267,000**	**31,385,500**	**$22,213,000**

* Objective 15 does not have a capital cost estimate because it only consists of Strategies in which CHART is acting in a supporting role to another agency initiative (see Section 2.4.3). In these supporting roles, CHART may incur little or no capital costs.

2.5.2 Studies and Engineering Prior to Project Implementation

The CHART program must consistently take into account the activities and associated resources required to take place before ITS project implementation. That is, the success of a deployment will depend heavily upon the analyses, studies, and engineering reports to determine: 1) if the deployment is, in fact, feasible and beneficial; 2) what exactly to deploy (e.g., type of technology, extent, location); and 3) the best manner in which to carry out the deployment. Because the services to provide planning studies and engineering are not capital costs in the sense of placing a new piece of equipment in the field, they are defined within this Plan as an estimated percentage of capital costs.

Table 8 is a cost estimate for the pre-deployment (studies and engineering) activities required for those capital deployments within this plan. These figures are based on using an estimated 10% of the capital costs estimated for the Projects. The 10% estimate is a figure historically used throughout the ITS arena, as well as within the CHART program, to estimate studies and engineering costs.

Table 8 – Pre-Deployment (Studies & Engineering) Cost Estimates per Element

Element	Pre-Deployment Cost Estimates
Element 1 – Traffic and Roadway Monitoring	$7,295,700
Element 2 – Incident Management	$2,908,200
Element 3 – Traveler Information	$9,452,500
Element 4 – Traffic Management	$2,594,500
Element 5 – Systems Integration and Communication	$3,494,350
Element 6 – Emergency and Weather Operations	$2,320,000
NCDP Total Pre-Deployment Cost Estimate	**$28,065,250**

2.5.3 Operations and Maintenance

Another critical factor in developing a successful ITS program is a strong commitment to efficiently operate and maintain the field devices, system components, communications network, and software that are deployed. For purposes of the LRSDP, operations and maintenance (O&M) costs have been determined as an estimated percentage of capital costs. It is important to note that for the purposes of this Plan, replacing and upgrading ITS components are treated as a separate capital deployment and have associated Strategies and Projects.

Also for the purposes of this plan, maintenance costs for Software Development Projects are defined as a percentage of the original development to provide intermittent "fixes" to initial software. This estimate does not include true software "enhancements", which would require significant programming to add software functionality, and are thus considered a separate project.

The operations and maintenance for those deployments in the field and infrastructure, and integration and communication Project categories are estimated as general systems operations and maintenance. The following expenditures comprise the system operations and maintenance cost estimates:

- **Management staff hours** – full-time labor to manage day-to-day program activities/initiatives, contracts, in-house planning and technical studies, operational/maintenance staff, public outreach, training, coordination with other agencies, and general program decision-making
- **Operational staff hours** – full/part-time and on-call labor to control, configure, provide security, administer, and troubleshoot systems/software/communications electronics and hardware; undergo training; provide patrolling and incident management services along highways; perform other administrative program/office functions

- **Maintenance staff hours** – full/part-time and on-call MDSHA labor or contracted labor to troubleshoot, repair, run diagnostics on, and generally perform upkeep on CHART field devices and system components
- **Operational expenses** – costs related to day-to-day running of facilities and systems, including building use costs, monthly phone and power, and leased communication lines
- **Maintenance expenses/equipment** – costs to supply spare parts, vehicles, equipment, and tools needed to repair CHART field devices and systems components

Table 9 presents estimates for operations and maintenance, as it would be carried out over a projected 20-year deployment period. As previously stated, cost estimates were separated for the different Project categories because operations and maintenance percentages of capital costs will be different for each. O&M cost estimates for Field and Infrastructure deployments, Integration and Communications deployments, and Software Development are 15%, 15%, and 4.6% of capital costs respectively.

Based on information collected throughout the ITS arena, a system operations and maintenance cost of 15% of CHART's capital expenditures is considered appropriate. While this figure could be on the high side, it enables decision-makers to know with greater certainty that the O&M estimates are not under-represented, as is often the case. A 4.6% software cost estimate is based on documented software support estimates for fixing errors to originally developed software (FHWA ITS Joint Program Office – The Road to Successful ITS Software Acquisition, Volume II).

Annual O&M cost of each project was calculated as the sum of O&M costs associated with each fiscal year deployment. The O&M cost associated with each fiscal year deployment is the sum of 15% of the total Capital Cost of that fiscal year multiplied by the remaining number of years to 2038. These fiscal year deployments are presented in the Project Cost and Deployment Schedule in **Appendix D** – Project Definitions and Project Cost and Deployment Schedule. This method uses the principle that equipment deployed in a particular fiscal year will need to be maintained only from the time of deployment to year 2038. For example, if a total of $1.5M of equipment was deployed in year 2025 its annual O&M cost would be $1.5M x 15% = $225,000. The total O&M cost from the time of deployment to year 2038 is $225,000 x 13 years = $2,925,000.

The sum of the annual O&M cost of each project is the total O&M cost of the LRSDP.

Table 9 – Capital and 20-year Operations and Maintenance Cost Estimates per Project Category, Grouped by Objective

Number	Objective	Capital / O&M	Project Category		
			Field and Infrastructure Deployment	Integration and Communications	Software Development
1	Enhance CHART's ability to visually monitor highway conditions.	Capital Cost	$38,872,000	$2,400,000	$476,000
		20-Year O&M Cost	$82,420,200	$6,480,000	$399,832.00
2	Enhance CHART's ability to collect automated traffic data from traffic detection sites.	Capital Cost	$22,275,000	$ -	$ -
		20-Year O&M Cost	$37,084,500	$ -	$ -
3	Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data, and reduced infrastructure requirements.	Capital Cost	$9,760,000	$16,730,000	$ -
		20-Year O&M Cost	$22,641,000	$24,829,500	$ -
4	Enhance CHART's ability to monitor travel conditions during inclement weather.	Capital Cost	$1,640,000	$ -	$ -
		20-Year O&M Cost	$3,124,500	$ -	$ -
5	Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.	Capital Cost	$28,542,000	$ -	$ -
		20-Year O&M Cost	$59,459,700	$ -	$ -
6	Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	Capital Cost	$660,000	$ -	$ -
		20-Year O&M Cost	$1,757,250	$ -	$ -
7	Enhance CHART's severe weather and emergency management operations.	Capital Cost	$15,550,000	$ -	$ -
		20-Year O&M Cost	$27,645,000	$ -	$ -
8	Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	Capital Cost	$24,625,000	$2,490,000	$575,000
		20-Year O&M Cost	$50,299,500	$6,538,500	$462,300
9	Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.	Capital Cost	$69,900,000	$ -	$ -
		20-Year O&M Cost	$73,545,600	$ -	$ -

Number	Objective	Capital / O&M	Project Category		
			Field and Infrastructure Deployment	Integration and Communications	Software Development
10	Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.	Capital Cost	$ -	$5,813,000	$ -
		20-Year O&M Cost	$ -	$8,775,600	$ -
11	Utilize current technology and strategies to optimize flow of traffic on access controlled highways.	Capital Cost	$25,945,000	$ -	$ -
		20-Year O&M Cost	$33,817,500	$ -	$ -
12	Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	Capital Cost	$ -	$239,000	$ -
		20-Year O&M Cost	$ -	$627,375	$ -
13	Enhance ability to manage traffic and increase safety near and within work zones and event locations.	Capital Cost	$2,600,000	$ -	$ -
		20-Year O&M Cost	$6,962,625	$ -	$ -
14	Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	Capital Cost	$6,798,000	$ -	$ -
		20-Year O&M Cost	$14,247,638	$ -	$ -
15	Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.	Capital Cost	$ -	$ -	$ -
		20-Year O&M Cost	$ -		$ -
16	Develop additional capabilities within the CHART Operating System Software.	Capital Cost	$ -	$ -	$21,162,00
		20-Year O&M Cost	$ -	$ -	$15,033,904
17	Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices.	Capital Cost	$2,100,000	$3,713 ,500	$ -
		20-Year O&M Cost	$5,625,000	$9,949,725	$ -
NCDP Total Capital and 20-Year O&M Cost Estimates		**Capital Cost**	**$249,267,000**	**$31,385,500**	**$22,213,000**
		20-Year O&M Cost	**$418,630,013**	**$57,200,700**	**$15,896,036**

* Objective 15 does not have a capital cost estimate because it only consists of Strategies in which CHART is acting in a supporting role to another agency initiative (see Section 2.4.3). In these supporting roles, CHART may incur little or no capital costs.

3. Strategies and Projects

While the previous sections were developed to provide a fundamental background on the document, this section gives more detail in the form of ITS Strategy descriptions and Project planning. Additional detail is contained within Appendix D – Project Definitions. It gives a detailed description of those Projects named in Section 3.2 that will be required to achieve the Strategies within Section 3.1.

3.1 Strategies Grouped by Objective

Table 10 presents the CHART LRSDP Strategies in their entirety, with associated priorities – designated as a 1, 2, or 3 (1 being highest priority). Support Strategies are designated by an "S" in the priority column. Grouping the Strategies by Objectives will associate the Strategies with a more specific purpose for carrying out the ITS deployment it prescribes rather than grouping them by Element at a more general level. Strategies grouped by Element are provided in Appendix B – Strategies Grouped by Element.

Table 10 – CHART Strategy Definitions and Priority, Grouped by Objective

Objective		Element	Strategy		Priority
1	Enhance CHART's ability to visually monitor highway conditions.	1 - TRM	1.1.1	*Additional Closed-Circuit Television (CCTV)* – Deploy CCTV cameras along major state highways in the Baltimore and Washington D.C. regions to provide full visibility of roadways. Continue to extend CCTV camera coverage statewide to include all major state highways, as well as evacuation and Freeway Incident Traffic Management (FITM) routes.	1
			1.1.2	*Replace and Upgrade Existing Closed-Circuit Television (CCTV)* – Replace existing end of life-cycle CCTV cameras with latest technology of existing CCTV infrastructure to continue CHART's ability to effectively monitor roadway conditions by using the latest technological developments.	2
			1.1.3	*Traffic Monitoring at Video Detection Sites* – Deploy roadside infrastructure to enable CHART to access data and images from video detection cameras at signalized intersections.	1
			1.1.4	*Incident Monitoring Cameras on Emergency Response Vehicles* – Deploy camera image or video capture technology on CHART Emergency Response Vehicles to provide near real-time monitoring of field conditions (This Strategy is repeated under Objective 6 as Strategy 2.6.5).	1
		5 - SIC	5.1.1	*Process Video Images for Traffic Information* – Develop "machine vision" technology to facilitate the collection of traditional video detection data (speed, volume, and occupancy), as well as data associated with visual detection of incidents.	1
2	Enhance CHART's ability to collect automated traffic data from traffic detection sites.	1-TRM	1.2.1	*Additional Traffic Detectors* – Deploy new detection sites along major state highways in the Baltimore/Washington D.C. regions to provide full detection at 1-mile spacing of roadways. Continue to extend traffic detection coverage statewide to include major state highways as well as designated evacuation and Freeway Incident Traffic Management (FITM) routes.	1
			1.2.2	*Support for Deployment of Vehicle Passenger Occupancy and Class Determination Detectors* – Support the deployment of detection devices along freeways and expressways with the capability to determine vehicle class types (car, truck type) and a vehicle's passenger occupancy (HOV) in order to provide data for various operations.	S-3
3	Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data, and reduced infrastructure requirements.	1-TRM	1.3.1	*Portable Trailer-mounted Traffic Monitoring Cameras* – Obtain portable camera trailers with wireless communications in order to provide flexible monitoring capabilities at any location. (This Strategy is repeated under Objective 13 as Strategy 1.13.2.)	1
			1.3.2	*Portable Trailer-Mounted Traffic Detectors* - Obtain portable traffic detection trailers with wireless communications, as well as intrusion detection devices, in order to provide flexible safety monitoring, traffic data collection, and queue detection at any location. (This Strategy is repeated under Objective 13 as Strategy 1.13.3.)	1

Objective		Element	Strategy		Priority
			1.3.3	*Traffic Probe Data Collection* – deploy necessary infrastructure – either directly or through partnerships with public or private agencies – to support the collection of traffic probe data through use of various technologies in order to determine traffic flow conditions along freeways and expressways.	1
			1.3.5	*Support Deployment of Traffic Probe Devices in MDOT Vehicles* – Support other agencies in equipping vehicles owned by Maryland Department of Transportation Modals with technology applications that allow traffic flow data to be collected while traveling along roadways.	S-1
		5 - SIC	5.3.1	Integrate Traffic Probe Data – Collect and integrate probe data collected by various technology applications in order to determine traffic flow conditions along freeways and expressways.	1
			5.3.2	*Purchase Data from Traffic Information Providers*- Purchase data and services from private-sector traffic data providers, including real-time and historic traffic flow conditions, traffic counts, traffic volumes, traffic incidents, and other information.	1
4	Enhance CHART's ability to monitor travel conditions during inclement weather.	6-EWO	6.4.1	*Additional Roadside Weather Stations* – Deploy infrastructure at new weather and pavement condition monitoring sites to provide thorough statewide coverage.	1
			6.4.2	*Replace and Upgrade Existing Roadside Weather Stations* – Replace and update the technology at existing weather and pavement condition monitoring sites to assure continued statewide coverage.	1
			6.4.3	*Support for Deployment of Road Surface Monitoring Equipment on MDSHA Vehicles – Support other MDSHA Offices in equipping* Maryland State Highway Administration snowplows with technology applications that collect and transmit road surface condition data as the vehicle travels	S-2
			6.4.4	*Support for Deployment of Automatic Vehicle Location (AVL) on Snowplow Vehicles – Support other MDSHA Offices in equipping* Maryland State Highway Administration snowplows with AVL devices to collect and transmit vehicle location data to support more efficient management of roadway treatment winter operations.	S-1

Objective		Element	Strategy		Priority
5	Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.	2 – IM	2.5.1	*CHART Incident Management Field Equipment* – Continue to purchase the most advanced field equipment (including vehicles, clearance machinery, etc.) to enhance CHART incident management personnel's ability to detect, respond, and clear incidents and emergencies along state highways in all jurisdictions.	1
			2.5.2	*Public Safety Incident Management Equipment* – Provide and transfer equipment to Maryland State Police and other public safety agencies to improve coordination and joint activities with CHART.	1
			2.5.3	*Incident/Emergency Management Training* – Train personnel, both within the CHART program and from other agencies, to familiarize operational and technical staff with the underlying principles of incident/emergency management, ITS applications, and the impacts of congested roadways.	1
			2.5.4	*Extend CHART Traffic Patrol* – Extend CHART traffic patrol program to include coverage in every MDSHA Engineering District.	1
			2.5.5	*CHART Vehicle Depots* – Build CHART vehicle depots in the Baltimore and Washington, D.C. areas to facilitate vehicle management and maintenance.	1
			2.5.6	*CHART Traffic Operations Center (TOC) Expansion* – Extend CHART operational coverage to include deployment of a TOC in every MDSHA Engineering District.	1
			2.5.7	*Freeway Location Signage* – Install mile marker signs at every 0.10 of a mile along all freeways and expressways within the state of Maryland.	1
6	Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	2 – IM	2.6.1	*Automated Vehicle Location (AVL)* on MDSHA Incident/Emergency Vehicles – Deploy Global Positioning System (GPS)-based AVL devices and systems to collect MDSHA incident/emergency vehicle location data, in order to more efficiently manage MDSHA field resources during incidents and emergencies.	1
			2.6.2	*Support for Opening Local Operations Centers* – Support counties and municipalities in their efforts to establish regional ITS programs and operations centers with functions that will be integrated inter-regionally with the CHART SOC.	S-1

Objective		Element	Strategy		Priority
6	Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	2 – IM	2.6.3	*Real-time Data Acquisition Devices* – Equip operational personnel with portable devices that will be used to gather real-time information on CHART field operations.	*1*
			2.6.4	*Wireless Real-time Data Sharing Devices* – Equip remote incident management personnel with portable devices to support the exchange of messages and information to facilitate incident/emergency management field operations.	*1*
			2.6.5	*Incident Monitoring Cameras on CHART Emergency Response Vehicles* – Deploy camera image or video capture technology on CHART Emergency Response Vehicles to provide near real-time monitoring of field conditions (This Strategy is repeated under Objective 1 as Strategy 1.1.4).	*1*
		5 – SIC	5.6.1	*Support Regional Interoperable Incident Management Voice Communications* – Participate in the development of systems and software to establish interoperability between various agencies' voice communication systems to provide uniform communications between incident/emergency response personnel throughout a particular region.	*S-1*
			5.6.2	*Support Regional Incident Management Communication Networks* – Participate in the development and deployment of regional communication networks that access various public safety and transportation management databases, as well as provide real-time messaging capabilities between remote incident/emergency response personnel, in order to facilitate coordination and communications among various agencies responding to incidents and emergencies.	*S-1*
			5.6.3	*Support Integration of Regional Incident Management Systems* – Participate in the development and implementation of regional incident/emergency management networks that integrate independent agency systems in order to more efficiently manage various operations related to the detection, response, and clearance of incidents and emergencies throughout a region.	*S-1*
			5.6.4	*Geo-location Devices on Portable Incident/Emergency Management Equipment* – Equip MDSHA and other agencies' portable field equipment (including device trailers, tow trucks, incident management equipment, and FITM trailers) with geo-location devices in order to dynamically track and update exact locations and current usage status (e.g., direction facing) of field equipment being used for response to incidents/emergencies.	*1*

Objective		Element	Strategy		Priority
7	Enhance CHART's severe weather and emergency management operations.	6– EWO	6.7.1	*Traffic Monitoring Infrastructure Along Evacuation Routes* – Deploy permanent traffic detection and visual monitoring devices along evacuation routes in order to improve CHART operations during severe weather and emergency situations.	*1*
			6.7.2	*Support the Deployment of Bio-hazard/Radiological Detection Devices* – Support for deploying field devices along identified stretches of roadways and/or on critical infrastructure to detect biohazards or abnormal radiation levels and automatically warn CHART and other appropriate agency personnel.	*S-1*
			6.7.3	*Support for Emergency Operations Coordination* – Participate in coordination among transportation and public safety agencies to formulate emergency operations plans that would detail CHART's responsibilities for emergency response operations at the state or national levels. Coordination efforts would include CHART's connectivity with various emergency communication systems that provide a secure means of coordination and communications among responding agencies.	*S-1*
			6.7.4	*Traffic Management Infrastructure for Emergency Operations* – Deploy permanent infrastructure along evacuation routes (e.g., reversible lane signals, and route guidance signs) that will manage increased volumes of traffic using various technology applications.	*1*
			6.7.5	*Satellite Voice Communications for Field Emergency Operations* - Equip remote incident management personnel with portable satellite voice communication units to support redundant and continuous voice communications between field personnel and CHART operations centers during emergency situations.	*1*

Objective		Element	Strategy		Priority
8	Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	3 – TI	3.8.1	*CHART Web Site Enhancements/Development* – Enhance the functionality and traveler information services provided to the public through "CHART on the Web".	*1*
			3.8.2	*Support Regional Advanced Traveler Information Programs* –Support regional programs that manage various sources of transportation data in order to provide a "one-stop shopping" source for the public to access multi-modal traveler information through various media.	*S-1*
			3.8.3	*Support Information Service Provider Partnerships* – Support for partnerships with ISPs, which manage and/or fuse transportation data, and distribute traveler information through various dissemination media.	*S-1*
			3.8.4	*Electronic Traveler Information Board* – Install display units to provide real-time traffic and transportation information at various locations. Such as rest areas, airports, Motor Vehicle Administration (MVA) facilities, and transit transfer points.	*2*
			3.8.5	*AM/FM Side-Band Traffic Alerts* – Deploy necessary infrastructure to provide CHART the ability to broadcast traveler information over AM/FM frequencies using technology that transmits data to vehicles equipped with receivers.	*3*
		5 – SIC	5.8.1	*Statewide 511 Service* – Deploy necessary systems components to initiate a statewide 511 program that collects and manages available transportation-related data throughout the state and distributes information to travelers calling within the state using technologies such as audio-text and voice recognition.	*1*

Objective		Element	Strategy		Priority
9	Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.	3 – TI	3.9.1	*Additional Dynamic Message Signs (DMS)* – Deploy Dynamic Message Signs along major state highways in the Baltimore and Washington, D.C. regions to provide comprehensive traveler information on roadways. Continue to extend DMS coverage statewide to include major state highways, as well as evacuation and Freeway Incident Traffic Management (FITM) routes.	1
			3.9.2	*Additional Highway Advisory Radio (HAR)* – Deploy Highway Advisory Radios along major state highways in the Baltimore and Washington, D.C. regions to provide comprehensive traveler information on roadways. Continue to extend HAR coverage statewide to include major state highways, as well as evacuation and Freeway Incident Traffic Management (FITM) routes.	2
			3.9.3	*Replace and Upgrade Highway Advisory Radio (HAR)* – Update the technology in existing highway advisory radio infrastructure to assure that this service continues to effectively broadcast current traveler information.	1
			3.9.4	*Replace and Upgrade Portable Trailer-mounted Dynamic Message Signs (DMS)* – Replace and upgrade existing portable DMS trailers with the latest technologies and wireless communications in order to provide flexible distribution of traveler information at any location. (This Strategy is repeated under Objective 13 as Strategy 3.13.1.)	1
			3.9.5	*Replace and Upgrade Portable Trailer-mounted Highway Advisory Radios (HAR)* – Replace and upgrade existing portable HAR trailers with the latest technologies and wireless communications in order to provide flexible distribution of traveler information at any location. (This Strategy is repeated under Objective 13 as Strategy 3.13.2)	1
			3.9.6	*Infrastructure to Support In-vehicle Highway Hazard Alerts* – Deploy roadside detectors and short-range communication infrastructure to detect hazardous traveling conditions and exchange communications with traveling vehicles to alert motorists that will be affected.	3
			3.9.7	*Infrastructure to Support In-vehicle Highway Signage Systems* – Deploy short-range communication infrastructure to transmit data to a traveling vehicle in order to allow the motorist to see an in-vehicle display of upcoming static and dynamic signs, as well as other messages pertaining to motorist needs.	3

Objective		Element	Strategy		Priority
10	Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.	4 – TM	4.10.1	*Support Statewide Traffic Signal System Optimization* – Support the development of a signal optimization plan and the deployment of new timings for signal systems operating on MDSHA controlled arterials throughout the state in order to increase traffic flow.	*S-1*
		5 – SIC	5.10.1	*Integrate Traffic Signal System Data* – Integrate the operation of traffic signal systems with SOC operations to automatically employ pre-arranged incident/emergency management timing plans for optimal traffic flow during incidents and emergencies, especially along Freeway Incident Traffic Management (FITM) routes.	*1*
11	Utilize current technology and strategies to optimize flow of traffic on access controlled highways.	4 – TM	4.11.1	*Active Traffic Management System* - Active Traffic Management (ATM) is a strategy that enhances traffic flow based on real-time data and communication of this data to the drivers for well-informed decisions ahead of congestion/incident, thus aiming to reduce primary and secondary collisions associated with congestion. Additional monitoring capabilities added through sensors and detectors would improve response time during the incidents.	*S-2*
			4.11.2	*Trail Blaze Signage* – Deploy infrastructure to provide signage to route vehicles along Freeway Incident Traffic Management (FITM) routes, or other pre-established diversion routes.	*1*
			4.11.3	*Highway Access Alert Systems* – Deploy infrastructure to alert motorists of travel conditions before reaching freeway or expressway access ramps.	*3*
			4.11.4	*Support Deployment of Dynamic Toll Lanes* – Participate in the establishment and operation of High Occupancy Toll (HOT) lanes and other advanced toll lane operations that dynamically toll travelers depending on various parameters (e.g., current congestion level and number of passengers in a vehicle) in order to better manage travel demand and traffic flow.	*S-1*

Objective		Element	Strategy		Priority
12	Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	1 – TRM	1.12.1	*Support Partnerships to Monitor Parking Facilities* – Develop partnerships to monitor parking capacity and other operations at major public parking facilities as well as at recurring event locations, Park 'n' Ride locations, and airports.	*S-2*
		4 – TM	4.12.1	*Support for Deployment of Traffic Management Infrastructure at Inter-modal Transfer Points and Major Parking Facilities* – Develop partnerships and deploy infrastructure to manage traffic flow as well as display real-time information at and approaching major parking facilities, including event parking and Park 'n' Ride facilities, in order to guide motorists to available parking.	*S-1*
		5 – SIC	5.12.1	*Integrate Parking Management Data* – Collect and integrate parking management data from public and private parking institutions in order to improve parking traffic management operations through the CHART Operating System.	*1*

Objective		Element	Strategy		Priority
13	Enhance ability to manage traffic and increase safety near and within work zones and event locations.	1 – TRM	1.13.1	*Work Zone/Event Traffic Monitoring Infrastructure* – Where applicable, deploy permanent infrastructure to support traffic flow detection and video monitoring capabilities at work zones (for continued coverage after completion of construction) and major event locations.	1
			1.13.2	*Portable Trailer-mounted Traffic Monitoring Cameras* - Obtain portable camera trailers with wireless communications in order to provide flexible monitoring capabilities at work zones and event locations. (This Strategy is repeated under Objective 3 as Strategy 1.3.1.)	1
			1.13.3	*Portable Trailer-mounted Traffic Detectors* - Obtain portable traffic detection trailers with wireless communications, as well as intrusion detection devices, in order to provide flexible safety monitoring, traffic data collection, and queue detection at work zones and event locations. (This Strategy is repeated under Objective 3 as Strategy 1.3.2.)	1
		3 – TI	3.13.1	*Replace and Upgrade Portable Trailer-mounted Dynamic Message Signs* (DMS) – Replace and upgrade existing portable DMS trailers with the latest technologies and wireless communications in order to provide traveler information messages at work zone and event locations. (This Strategy is repeated under Objective 9 Strategy 3.9.4)	1
			3.13.2	*Replace and Upgrade Portable Trailer-mounted Highway Advisory Radios* (HAR) – Replace and upgrade existing portable HAR trailers with the latest technologies and wireless communications in order to broadcast traveler information messages within work zone and event areas. (This Strategy is repeated under Objective 9 as Strategy 3.9.5)	1
		5 – SIC	5.13.1	*Geo-location Devices on Portable Work Zone/Event Equipment* – Equip MDSHA and other agencies' portable work zone/event equipment with geo-location devices in order to dynamically track and update exact locations and current usage status (e.g., direction facing) of field equipment being used for work zone or event management.	1

Objective		Element	Strategy		Priority
14	Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	5 – SIC	5.14.1	*Security Measures for CHART Operations Centers and System Infrastructure* – Deploy infrastructure and systems applications that protect against unauthorized access to the CHART network, and user controls within operation center facilities.	*1*
		6 – EWO	6.14.1	*Security Monitoring Equipment for CHART Devices* – Continue to deploy infrastructure and equipment to increase security for CHART field equipment that is accessible to the public and is essential to continuity of CHART operations.	*1*
			6.14.2	*Security Monitoring Equipment for Critical Transportation Infrastructure* – Deploy technology applications that monitor identified critical transportation infrastructure to increase security measures in order to protect against sabotage and destruction.	*1*
15	Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.	1 – TRM	1.15.1	*Support for Highway-Rail Crossing Monitoring Devices* – Support the deployment of devices that detect both automobiles and approaching trains at highway-rail crossings to support various safety alert systems, as well as traffic management systems.	*S-2*
		4 – TM	4.15.1	*Support for Highway- Rail Crossing Safety and Diversion Systems* – Support the deployment of infrastructure to process detection data at identified highway rail crossings and use technology applications to divert approaching traffic, as well as to predict collisions and alert motorists and/or train operators accordingly.	*S-2*
		6 - EWO	6.15.1	*Support for Deployment of Flood Monitor and Warning Systems* – Deploy technology applications at locations identified as prone to flooding, in order to monitor flooding effects on road surface conditions and warn motorists of potential hazards.	*S-2*
			6.15.2	*Support for Deployment of Fog Monitor and Warning Systems* – Deploy technology applications at locations identified as hazardous due to recurring fog conditions, in order to monitor fog effects on traveling conditions and warn motorists of potential hazards.	*S-1*
			6.15.3	*Support for Deployment of High Wind Monitor and Warning Systems* – Deploy technology applications at locations identified as hazardous due to high wind conditions, in order to monitor high wind effects on traveling conditions and warn motorists of potential hazards.	*S-1*

Objective		Element	Strategy		Priority
16	Develop additional capabilities within the CHART Operating System Software.	1 – TRM	1.16.1	*Exchange Closed-Circuit Television Images and Camera Control* – Software module deployment for collecting and integrating video images and camera control interfaces from sources outside of CHART, as well as providing CHART camera images and administered control to outside agencies.	1
			1.16.2	*Develop Traffic and Roadway Monitoring Software* – Software module deployment to provide added functionality to traffic and roadway monitoring operations within CHART software.	1
		2 – IM	2.16.1	*Develop Incident/Emergency Management and Computer Aided Dispatch (CAD) Central Software* – Software module deployment to develop the central CHART system software to collect, integrate and process MAYDAY notification data from outside systems and operations data from multi-jurisdictional public safety and transportation-related agencies responsible for incident/emergency management in order to optimize MDSHA incident/emergency management and dispatch operations throughout the state.	1
			2.16.2	*Develop Incident Prediction Software* – Software module deployment that uses various sources of data as input into an algorithm that processes predictions and probabilities for incidents occurring along stretches of highways where data is being collected.	2
			2.16.3	*Integrate Incident/Emergency Rail System Data* – Software module deployment to collect and integrate incident/emergency data from various Rail Carrier Systems into the CHART Operating System in order to improve incident detection and traffic management at and around highway-rail crossings.	2
		3 – TI	3.16.1	*Exchange/Integrate Traveler Information Data with/from Other Public Agencies* – Software module deployment to request multi-modal traveler information data from various public agencies (within and outside of Maryland) and integrate it into the CHART system, as well as to collect and process multi-modal traveler information data within the CHART system into a pre-determined format for transfer to another public agency's system.	1
			3.16.2	*Develop Traveler Information Software* - Software module deployment to provide added functionality to traveler information distribution and management capabilities within CHART central software.	1
			4.16.1	*Develop Software to Manage Arterial Traffic and Integrate Arterial Traffic Management Data* – Software module deployment to develop CHART's ability to control field devices on principal arterials (especially along FITM routes), and at principal arterial intersections with freeways and expressways and integrate the associated data into the CHART Operating System.	2
			4.16.2	*Develop Traffic Management Software* – Software module deployment to provide added functionality to freeway and expressway traffic management operations within CHART central software.	1
		5 – SIC	5.16.1	*Develop Software to Provide Transportation Network Simulation and Prediction Capabilities* – Utilize simulation algorithms to analyze real-time traffic conditions and predict likely impacts on traffic flows as an operational decision tool.	1

Objective		Element	Strategy		Priority
			5.16.2	*Further Develop Software to Predict Roadway Conditions During Adverse Weather Situations* – Software module deployment to improve the collection and processing of historical and real-time data from weather station field devices and thermal mapping applications in order to predict unsafe conditions along roadways.	1
			5.16.3	*Integrate Traffic Probe Data*– Software module deployment to integrate into the CHART Operating System software traffic probe data collected through use of various technologies in order to determine traffic flow conditions along freeways and expressways and improve various CHART operations.	1
			5.16.4	*Develop Access to Available CVO and HAZMAT Databases* – Initiate Maryland agency connectivity with national and state-level databases that provide information on CVO operators and HAZMAT carrier organizations in order to better respond to incidents and emergencies involving hazardous materials.	1
			5.16. 5	*Software for CHART System Health Monitoring* – Software module deployment to detect, locate, and track all failures, security breaches, and malfunctions within the CHART Operating System, communications network, or field devices.	1
			5.16.6	*Develop Software for Control of Portable Devices* – Software module deployment to provide CHART personnel the ability to control portable field devices through the CHART Operating System.	1
17	Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices.	5 – SIC	5.17.1	*CHART Communications Network Equipment Expansion* – Purchase and install new, and replace and upgrade the technology of existing, switches, multiplexors, routers, hubs, codecs, cabling, modems, and servers to support the continued expansion of the CHART communications network.	1
			5.17.2	*Expand Communications to Local Agencies* – Extend communications to provide CHART data transfer capabilities with local jurisdiction agencies within Maryland.	1
			5.17.3	*SOC Integration and Equipment* – Plan, design, replace and upgrade equipment necessary to support the integration and inter-connectivity of CHART subsystems at the SOC.	1
			5.17.4	*Integrate Field Equipment Installations* – Deploy necessary communications, system components, and software updates to provide wireless and hardwire point-to-point communications to enable CHART data transfer capabilities with newly installed field devices and previously non-integrated legacy systems.	1
			5.17.5	*Deploy Secure Communications Between CHART Operations Centers and Emergency Management Systems* – Deploy secure and redundant communications to allow data transfer between CHART operations centers and various state, local, and federal emergency management agencies' systems to facilitate coordinated emergency management operations.	1

THIS PAGE LEFT INTENTIONALLY BLANK

3.2 Projects Grouped by Objective

Table 11 presents the CHART LRSDP Project names, and includes cost estimates for each Project. The full Project descriptions can be found in Appendix D – Project Definitions. This particular table groups the Projects by Objective, which is intended to provide the reader a specific practicable understanding of what CHART needs to build, develop, integrate, and initiate in order to achieve the operational capability defined in the associated Objective.

Therefore, grouping the Projects by Objectives will associate the Projects with a more specific purpose for carrying out the ITS deployment CHART will build – as opposed to grouping them by Element, which is at a less specific level. Appendix C – Projects Grouped by Element will thereby provide the reader the associated Projects to build the operational potential within each of the six CHART Elements.

THIS PAGE LEFT INTENTIONALLY BLANK

Table 11 – CHART Project Names and Capital Cost Estimates, Grouped by Objective

Objective		Element	Project		Cost ($)
1	Enhance CHART's ability to visually monitor highway conditions.	1 - TRM	1.1.1.1	Deploy Additional CCTV Sites Along Freeways and Expressways	$10,000,000.00
			1.1.1.2	Deploy Additional CCTV Sites Along Arterials	$8,300,000.00
			1.1.1.3	Deploy Additional CCTV Cameras Along Freeway Incident Traffic Management (FITM) Routes	$15,000,000.00
			1.1.2.1	Deploy Replacement CCTV at Existing Sites	$1,620,000.00
			1.1.3.1	Deploy CCTV Cameras with PTZ capabilities on Existing Infrastructure at Signalized Intersections for Signal Operations and Incident Management/Detection	$3,200,000.00
			1.1.4.1	Deploy Cameras on CHART Emergency Response Vehicles for Incident Monitoring	$752,000.00
		5 - SIC	5.1.1.1	Develop Software for Collecting and Processing Video Detection Data	$476,000.00
			5.1.1.2	Integrate "Machine Vision" Technology into CHART	$2,400,000.00
Objective 1 Total Capital Cost Estimate					**$41,748,000**
2	Enhance CHART's ability to collect automated traffic data from traffic detection sites.	1 - TRM	1.2.1.1	Deploy Additional Traffic Detectors	$15,435,000.00
			1.2.1.2	Deploy Additional Traffic Detectors along Freeway Incident Traffic Management (FITM) Routes	$6,840,000.00
Objective 2 Total Capital Cost Estimate					**$22,275,000.00**

Objective		Element	Project		Cost ($)
3	Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data and reduced infrastructure requirements.	1 - TRM	1.3.1.1	Purchase Portable Trailer-Mounted Traffic Monitoring Cameras	$360,000.00
			1.3.2.1	Purchase Portable Trailer-Mounted Traffic Detectors	$1,000,000.00
			1.3.3.1	Deploy Traffic Data Collection Devices with various Probe Technologies	$8,400,000.00
		5 - SIC	5.3.1.1	Integrate MDSHA Traffic Probe Data into CHART	$80,000.00
			5.3.1.2	Integrate Traffic Probe Data from External Sources into CHART	$500,000.00
			5.3.2.1	Purchase Traffic Data and Services from Private-Sector Providers	$16,150,000.00
Objective 3 Total Capital Cost Estimate					**$26,490,000**
4	Enhance CHART's ability to monitor travel conditions during inclement weather.	6 – EWO	6.4.1.1	Deploy Additional Roadside Weather Stations	$500,000.00
			6.4.2.1	Deploy Replacement Roadside Weather Stations at Existing Locations	$1,140,000.00
Objective 4 Total Capital Cost Estimate					**$1,640,000.00**

5	Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.	2 - IM	2.5.1.1	Purchase Incident Management Field Equipment for CHART Personnel	$7,995,000.00
			2.5.2.1	Purchase Incident Management Field Equipment for Public Safety Agencies	$1,282,000.00
			2.5.3.1	Provide Coordination and Resources for Training of Incident/Emergency Management Personnel	$3,261,000.00
			2.5.4.1	Extend CHART Traffic Patrols	$9,029,000.00
			2.5.5.1	Deploy CHART Vehicle Depots	$4,200,000.00
			2.5.6.1	Expand Coverage of CHART Traffic Operations Center (TOC) to all MDSHA Districts and Expand Existing Coverage	$1,325,000.00
			2.5.7.1	Install Mile Marker Signage along all Freeways and Expressways, Statewide	$1,450,000.00
Objective 5 Total Capital Cost Estimate					**$28,542,000.00**
6	Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	2 - IM	2.6.1.1	Deploy AVL Technology in Future CHART Vehicles	$282,000.00
			2.6.3.1	Replace Portable, Real-time Data Acquisition Devices for Operational Personnel	$129,000.00
			2.6.4.1	Deploy Wireless, Real-time Data Sharing Devices for Operational Personnel	$129,000.00
			2.6.5.1	Deploy Cameras on CHART Emergency Response Vehicles for Incident Monitoring	(Cost reported under 1.1.4.1)
		5 - SIC	5.6.4.1	Deploy Geo-Location Devices on Portable Incident/Emergency Management Equipment	$120,000.00
Objective 6 Total Capital Cost Estimate					**$660,000.00**

7	Enhance CHART's severe weather and emergency management operations.	6 - EWO	6.7.1.1	Deploy CCTV Devices along Evacuation Routes	$2,600,000.00
			6.7.1.2	Deploy Traffic Detection Devices along Evacuation Routes	$3,600,000.00
			6.7.4.1	Deploy Traffic Management Infrastructure along Evacuation Routes	$9,350,000.00
Objective 7 Total Capital Cost Estimate					**$15,550,000.00**
8	Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	3 - TI	3.8.1.1	Develop Enhancements for CHART Web Site	$575,000.00
			3.8.4.1	Deploy Electronic Traveler Information Board System	$23,680,000.00
			3.8.5.1	Deploy AM/FM Side-Band Traffic Alert Infrastructure	$945,000.00
		5 - SIC	5.8.1.1	Integrate Traveler Information Data for Statewide 511 Distribution	$2,490,000.00
Objective 8 Total Capital Cost Estimate					**$27,690,000.00**

9	Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.	3 - TI	3.9.1.1	Deploy Additional DMS Along Freeways and Expressways	$3,750,000.00
			3.9.1.2	Deploy Additional DMS Along Arterials at Freeway Interchanges	$62,500,000.00
			3.9.2.1	Deploy Additional HAR Along Freeways and Expressways	$530,000.00
			3.9.2.2	Deploy Additional HAR Sites Along Arterials	$530,000.00
			3.9.3.1	Deploy enhanced HAR at Existing Sites	$530,000.00
			3.9.4.1	Deploy Replacement Portable Trailer-Mounted DMS	$770,000.00
			3.9.5.1	Deploy Replacement Portable Trailer-Mounted HAR	$160,000.00
			3.9.6.1	Deploy Roadside Infrastructure to Support In-vehicle Highway Hazard Alert	$565,000.00
			3.9.7.1	Deploy Roadside Infrastructure to Support In-vehicle Highway Signage Systems	$565,000.00
Objective 9 Total Capital Cost Estimate					**$69,900,000.00**
10	Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.		5.10.1.1	Integrate Traffic Signal Operation Systems into CHART	$5,813,000.00
Objective 10 Total Capital Cost Estimate					**$5,813,000.00**

11	Utilize current technology and strategies to optimize flow of traffic on access controlled highways.	4 - TM	4.11.1.1	Deploy an Active Traffic Management (ATM) System as a Pilot Project	$20,000,000.00
			4.11.2.1	Deploy Trail Blaze Signage for FITM Routes	$1,320,000.00
			4.11.3.1	Deploy Highway Access Alert Systems	$4,625,000.00
Objective 11 Total Capital Cost Estimate					**$25,945,000.00**
12	Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	5 - SIC	5.12.1.1	Integrate Parking Management Systems	$239,000.00
Objective 12 Total Capital Cost Estimate					**$239,000.00**
13	Enhance ability to manage traffic and increase safety near and within work zones and event locations.	1 - TRM	1.13.1.1	Deploy Permanent Traffic Monitoring Equipment at Work Zones	$2,050,000.00
			1.13.2.1	Purchase Portable Trailer-mounted Traffic Monitoring Cameras	(Cost reported under 1.3.1.1)
			1.13.3.1	Purchase Portable Trailer-mounted Traffic Detectors	(Cost reported under 1.3.2.1)
		3 - TI	3.13.1.1	Deploy Replacement Portable Trailer-mounted DMS	(Cost reported under 3.9.4.1)
			3.13.2.1	Deploy Replacement Portable Trailer-mounted HAR	(Cost reported under 3.9.5.1)
		5 - SIC	5.13.1.1	Deploy Geo-location Devices on Portable Work Zone/Event Equipment	$550,000.00
Objective 13 Total Capital Cost Estimate					**$2,600,000.00**

14	Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	5 - SIC	5.14.1.1	Deploy Security Improvement Measures at CHART Operations Centers	$788,000.00
		6 - EWO	6.14.1.1	Deploy Security Monitoring Equipment at Field Device Locations	$3,250,000.00
			6.14.2.1	Deploy Security Monitoring Equipment at Critical Infrastructure Locations	$2,760,000.00
Objective 14 Total Capital Cost Estimate					**$6,798,000.00**
Objective 15 Total Capital Cost Estimate					*
16	Develop additional capabilities within the CHART Operating System Software.	1 - TRM			
			1.16.1.1	Integrate CCTV with CHART Connected Agencies and Agencies not Connected to CHART	$504,000.00
			1.16.2.1	Enhance the Traffic Flow Monitoring Software to Automatically Generate Incident and Congestion Alerts	$631,000.00
			1.16.2.2	Develop Enhancements to the Video Display Software to Enable Mobile Video Camera Access	$104,000.00
			1.16.2.3	Develop Weather and Road Condition Monitoring Software	$448,000.00
			1.16.2.4	Develop Enhancements to the Work Zone/Evacuation Route Monitoring Software	$381,000.00
			1.16.2.5	Develop Security Monitoring Software	$992,000.00
		2 – IM	2.16.1.1	Develop Multi-Jurisdictional CAD Operations Software to Integrate CAD and Incident Information from 911 and In-Vehicle System Centers through RITIS	$519,000.00
			2.16.2.1	CHART Incident Prediction Report Generation	$1,700,000.00
			2.16.3.1	Develop Software for Incident/Emergency Data Exchange for Highway Rail Crossings	$452,000.00

16	Develop additional capabilities within the CHART Operating System Software.	3 - TI	3.16.1.1	Develop Software to Integrate Parking Management Data	$851,000.00
			3.16.2.1	Develop Electronic Traveler Information Board Software	$420,000.00
			3.16.2.2	Develop Software for In-Vehicle Traveler Information	$381,000.00
		4 - TM	4.16.1.1	Develop Software to Incorporate Arterial Traffic Monitoring and Management into CHART	$476,000.00
			4.16.2.1	Develop Software for Operation of Ramp Metering Devices	$1,470,000.00
			4.16.2.2	Develop Software for Operation of Variable Speed Limit Devices	$924,000.00
			4.16.2.3	Develop Software for Operation of Lane Control Devices	$761,000.00
			4.16.2.4	Develop Software for Operation of Queue Detection and Warning Devices	$1,560,000.00
			4.16.2.5	Develop Software for Operation of Traffic Management Devices at Inter-Modal Transfer Points	$1,270,000.00
			4.16.2.6	Develop Software for Advanced Technology Traffic Detectors	$666,000.00
		5 - SIC	5.16.1.1	CHART Real-time Simulation	$1,750,000.00
			5.16.1.2	CHART Offline Simulation and Training	$1,220,000.00
			5.16.2.1	CHART Weather Alert Processing	$436,000.00
			5.16.3.1	CHART TSS Add Mobile Probe Data Device Type	$381,000.00
			5.16.4.1	Develop Software to Interface with CVO and HAZMAT Data Sources	$549,000.00
			5.16.5.1	Enhance Software for Monitoring the Status of CHART	$984,000.00

			5.16.6.1	Develop Software for Portable/Trailer-Mounted HARs	$571,000.00
			5.16.6.2	Develop Software for Portable Data-Collection Devices	$761,000.00
Objective 16 Total Capital Cost Estimate					**$21,162,000.00**
17	Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices.	5 - SIC	5.17.1.1	Deploy Additional CHART Fiber Connections	$2,100,000.00
			5.17.2.1	Integrate Local Agencies and Jurisdictions	$640,000.00
			5.17.3.1	Integrate SOC Subsystems	$345,000.00
			5.17.4.1	Integrate New Field Equipment Locations	$2,030,000.00
			5.17.5.1	Integrate Secure Communications to CHART Sites (Secure Communications Infrastructure will be deployed as Part of Project 5.14.1.1)	$630,000.00
			5.17.5.2	Emergency Backup Voice Communications between TOCs and Regional EOCs	$68,500.00
Objective 17 Total Capital Cost Estimate					**$5,813,500.00**
LRSDP TOTAL CAPITAL COST ESTIMATE					**$302,865,500**

* Objective 15 does not have a capital cost estimate because it only consists of Strategies in which CHART is acting in a supporting role to another agency initiative (see Section 2.4.3). In these supporting roles, CHART may incur little or no capital costs.

THIS PAGE LEFT INTENTIONALLY BLANK

3.3 Benefits of CHART

3.3.1 Role of CHART in Combating Traffic Congestion

Cost of Traffic Congestion

The 2012 version of the Annual Urban Mobility Report – a widely acknowledged study by the Texas Transportation Institute (TTI) – released statistics measured in 2011 that indicate an average yearly cost of $818 per auto commuter (in 2011 dollars), an annual delay of 38 hours, and 19 gallons of wasted fuel per peak-hour traveler due to congestion. The total cost of congestion for the 498 urban U.S. cities studied was $121 billion (in 2011 dollars). Average yearly costs in the Baltimore and Washington, D.C. urban areas were estimated at $908 and $1,398 per auto commuter, respectively.

Nature of Congestion

There are two types of congestion - recurring and non-recurring. Recurring congestion occurs when the number of vehicles traveling on the highways exceeds the capacity those roads were designed to efficiently carry, leading to reduced speeds, and congestion. This type of congestion is referred to as recurring because it tends to occur day-after-day, often at the same times and in the same locations. Non-recurring congestion occurs due to factors such as automobile crashes, breakdowns, construction, special events, and weather conditions. Table 12 below highlights some of the differences between the two types of congestion.

Potential Solutions to Congestion

In general, new construction is viewed as an appropriate response to recurring congestion. However, in the current economic environment, raising highway construction budgets is unlikely. Moreover, new construction does not address non-recurring congestion, which is approximately half of the congestion problem as shown in the FHWA Causes of Congestion graphic (Figure 4). The other part of the perceived solution, which addresses non-recurring congestion, is known as transportation system management and operations. Table 12 provides an overview of the two types of congestion, some of their causes, as well as the different strategies to mitigate those causes. The TTI report also emphasizes that effectively addressing congestion is more than just roadway expansion and broader solutions such as the inclusion of operational treatments are required to more effectively address congestion. The TTI stated that there are five major operational treatments that would be effective in reducing delay by 7% on roadways in the 498 urban areas studied in 2011. They also pointed out that these

treatments are projected to reduce delay by 15% if applied to all major freeways and streets.

Table 12 - Types of Congestion with Usual Mitigation Strategy

Type of Congestion	Representative Causes of Delay	Mitigation Strategy
Recurring	Infrastructure capacity shortfalls	Capacity increases
	Interchange bottlenecks	
	Weave and merge friction	
	Non-optimized traffic signal timing*	Systems operations and management
Non-recurring	Breakdowns and crashes	
	Construction work	
	Weather	
	Vehicle mix	

* Note that while non-optimized signal timing will lead to recurring congestion, it is addressed through better operations and management, not new capacity.

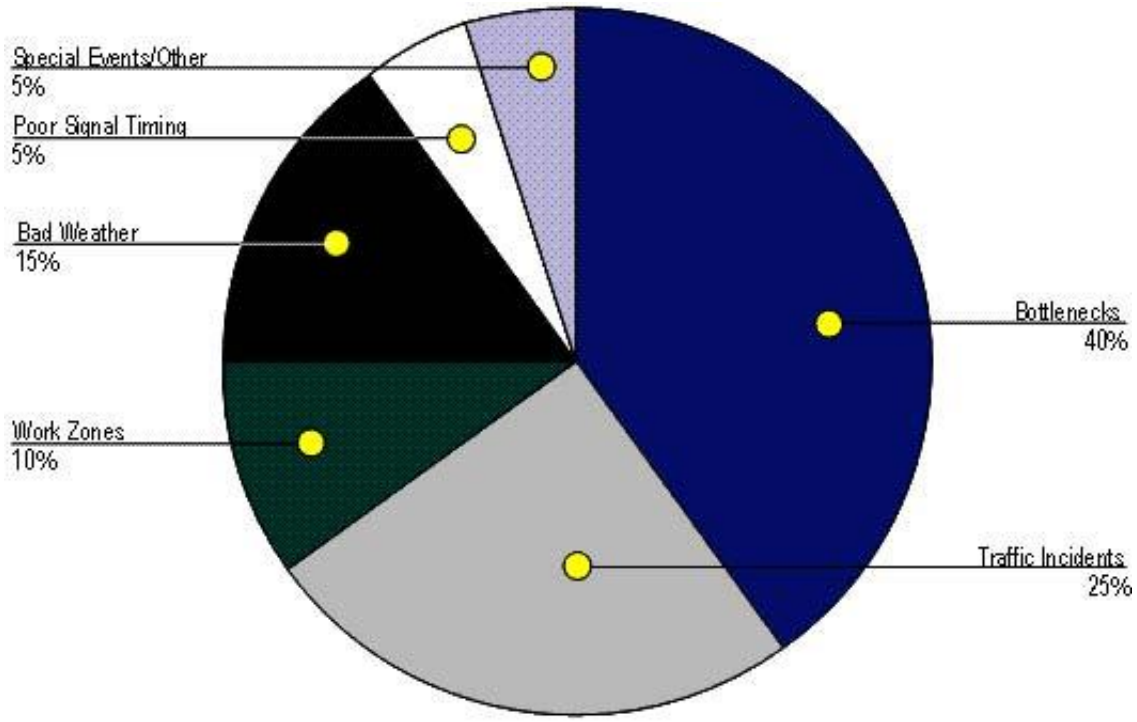


Figure 4 Sources of Congestion[1]

[1] *Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation* http://ops.fhwa.dot.gov/congestion_report/executive_summary.htm

Transportation System Operations and Management

In the past, highways were built and then there was comparatively little emphasis on effectively operating and managing day-to-day traffic on the highway system. As resources for new construction have become scarcer, and as highways have become more congested, attention has been focused on strategies to more effectively move traffic on a day-to-day basis. Some standard operations and management strategies include:

- Adding monitoring capabilities to highways, as well as enhanced traffic detection, so unusual levels of congestion can be quickly determined and addressed
- Improving techniques and coordination for the clearance of vehicles involved in incidents
- Disseminating timely information to travelers so they can make informed travel decisions resulting in a more efficient use of the roadways
- Maximizing the use of road lanes through deployments such as reversible and high occupancy vehicle (HOV) or managed toll lanes
- Installing automatic vehicle location (AVL) systems on highway agency and contractor vehicles to better track use of operating resources
- Stabilizing the flow of vehicles onto expressways through ramp metering
- Better optimizing traffic signal timing plans to provide optimal traffic flows

Applying a range of such strategies as above will collectively decrease levels of congestion and delay, increasing travel time reliability for Maryland travelers.

Supporting transportation management and operations solutions also takes significant steps toward addressing safety. High congestion levels result in more closely spaced vehicles on a roadway, which provides more opportunities for conflict. Another aspect of unsafe travel is secondary crashes – crashes that occur due to conditions produced by an existing crash. Detecting, managing, and clearing accidents from the roadway as efficiently as possible will directly decrease the likelihood of secondary crashes. Also, applications in technology can detect probable weather-related hazards, and better manage the resources to mitigate them.

In Maryland, the CHART program is MDSHA's primary contributor toward enhanced system management and operations. In essence, the CHART program was established to tackle approximately half of the congestion problem that is non-recurring. Other MDSHA programs also contribute, e.g., the Office of Traffic and Safety (OOTS) for traffic signal optimization program. Additional representative agencies that contribute include the Maryland State Police, especially for incident

clearance, and transit agencies to the extent they are able to provide service that reduces highway congestion. As noted below, the CHART program – sometimes in conjunction with other programs and agencies – has made a significant difference, especially in the incident management arena.

Resource Imbalance Between Congestion Solutions in Maryland

As noted in the Nature of Congestion section above, Maryland's CHART program addresses roughly 50% of the delay and lack of system reliability not addressed by the Administration's capital improvements program, and does so in a highly effective manner.

The Consolidated Transportation Program (CTP) allocation for CHART for fiscal years 2012-2017 shows expenditures of $21million in capital costs and $9.4 million in operations and maintenance costs in 2012. At the current level, funding for the CHART program will be approximately $182 million over the next six (6) years. In comparison, funding for MDSHA capital costs is budgeted at $4.6 billion for the same six-year period in the 2012-2017 MDOT CTP.

CHART, being one of multiple programs in management and operations of Maryland's state highway system, is allocated a relatively small share of funding devoted to transportation systems operations and management. Given the difficulty in keeping pace with congestion through new construction, focusing additional attention on the operations and management part of the congestion solution through increased funding could be largely beneficial.

3.3.2 CHART Cost-benefit Evaluation

CHART Benefits in Brief

While described in greater detail below, the CHART program's focus on non-recurring congestion in the year 2012 has:

- Returned $961.69 million in savings from fewer delayed vehicle hours and fuel consumption to Maryland travelers
- Lowered emissions levels

Initial CHART Evaluation

The first CHART program evaluation encompassed data collected from FY 1990 to FY1994. This initial evaluation demonstrated that the benefits of CHART operations, supported by a small (at that time) core of traffic and roadway monitoring devices, exceeded the system's capital, operating, and maintenance costs by a ratio of over 7 to 1. This evaluation compared the estimated reduction

in delay, fuel consumption, and secondary incidents (benefits) to the capital, operating, and systems maintenance costs of the program.

The evaluation was performed at three levels: System-wide, corridor-level, and site-specific, and comparisons were made between the findings and conclusions from each level of evaluation. The findings also concluded that CHART incident management patrols were being used where they were needed most. That is, they were covering the segments of the network that experience the highest number of incidents per mile, resulting in the most non-recurring delay and congestion.

More Recent CHART Evaluations

Since 1999, the Civil Engineering Department of the University of Maryland at College Park has developed a yearly assessment of the effectiveness of CHART with an emphasis on the program's ability to detect and respond to incidents on major freeways and highways (Note: A pilot study was also conducted in 1997 that underpins the later work). These newer evaluation studies benefit from a significant increase in collected data and accuracy due to the implementation of the CHART II Database.

The most updated program evaluation at time of this report (released July 2013) provides statistics and a cost savings analysis for CHART operations carried out in the year 2012, and then compares those figures to previous year analyses. Table 13 shows the total available incident reports for the years 2010, 2011, and 2012 where data was collected to support the Year 2013 evaluation report.

Table 13 – University of Maryland Study – Comparison of Available Data for 2010, 2011, and 2012

Available Records		2010		2011		2012	
		Records	Total (%)	Records	Total (%)	Records	Total (%)
CHART II Database	Disabled Vehicles	29,699	60.6	37,571	62.5	41,243	64.9
	Incidents	19,309	39.4	22,534	37.5	22,328	35.1
Total		49,008	100	60,105	100	63,571	100

Without CHART/MDSHA response units, the average incident duration was approximately 29 minutes, while the average incident duration with CHART was approximately 22 minutes – about a thirty-two percent (32%) reduction in the

average incident duration (see Table 14 below). Of special note, the University of Maryland's statistics show that incident average durations are not only decreasing for incident responses where CHART Patrol vehicles are involved, but also for those where only other agencies (e.g., state police and local public safety) responded. This trend suggests that efficient response to incidents has received increasing attention among all responsible agencies.

Table 14 – University of Maryland Study – CHART Incident Average Duration from 2006 to 2012

Year	CHART Incident Average Duration
2006	23 minutes (32 min. without CHART)
2007	25 minutes (35 min. without CHART)
2008	25 minutes (35 minutes without CHART)
2009	28 minutes (41 minutes without CHART)
2010	28 minutes (47 minutes without CHART)
2011	22 minutes (29 minutes without CHART)
2012	22 minutes (29 minutes without CHART)
Average	**25 minutes (35 minutes without CHART)**

It was also found that secondary incidents, defined as "the number of incidents occurring within two hours after a major incident and within a range of two miles," have been potentially reduced by 218 in 2012. In addition, efficient removal of stationary vehicles and large debris from travel lanes by CHART patrol units may have prevented 429 potential lane-changing-related collisions in 2012, as approaching vehicles under those conditions would have been forced to perform unsafe mandatory lane changes. Thus, the reduction in secondary incidents implies additional savings in travel time, fuel consumption and congestion. This is especially significant toward achieving safety benefits because secondary incidents commonly involve more serious injuries and fatalities than do initial incidents.

Overall, reduction in Year 2012 travel delay due to CHART operations was found to be 28.47 million vehicle hours, saving consumers 5.59 million gallons of fuel for that year.

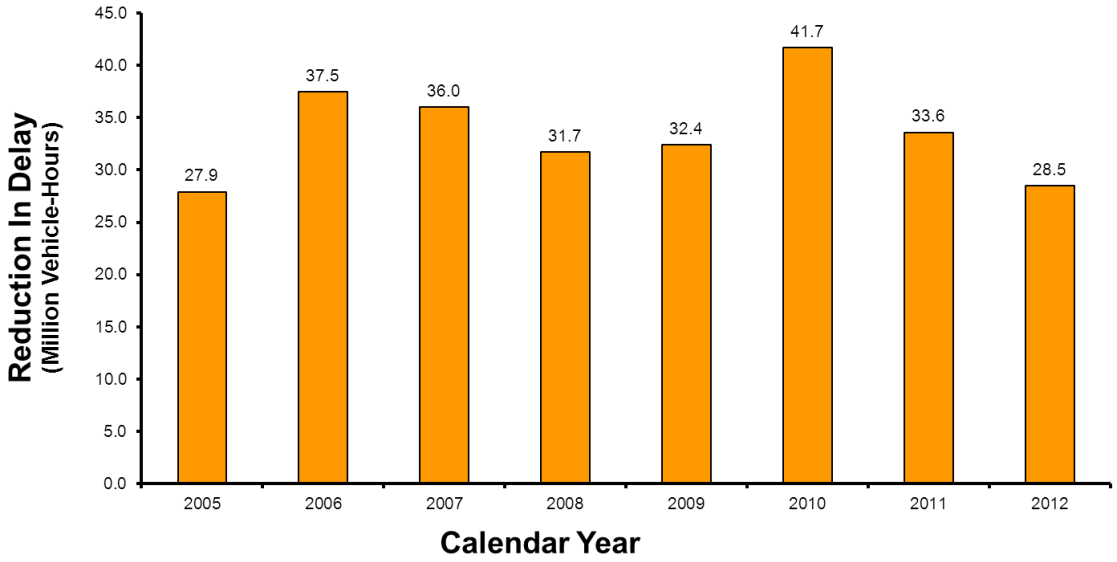


Figure 5 – Yearly Reduction in Delay Resulting from CHART Operations

Using the time value of $29.82/hr (car driver's cost)[2], $20.21/hour (truck driver's cost)[2], $45.40/hour (cargo's cost)[2] and the unit value of $3.69/gallon[2], the total trip cost savings due to delay reduction was estimated to be $908.13 million in traveler time, and $21.01 million in fuel.

Similarly, reductions in vehicle emissions were estimated at 372.20 tons for hydrocarbon (HC), 4,180.40 tons for carbon monoxide (CO), and 178.26 tons for nitric oxide (NO). Using the emission unit savings rates of $6,700/ton, $6,360/ton, $12,875/ton, and $23/metric for HC, CO, NO, and CO2 respectively, the total reduction in emissions due to CHART operations is estimated at $32.56 million. This brings the total savings for CHART operations in 2012 to $961.69 million. Table 15 presents a summary of the Year 2012 findings for the evaluation of CHART incident management operations.

[2] The car driver's cost and fuel price are updated based on the information from the U.S Census Bureau in Year 2012 and the Energy Information Administration in Year 2012, respectively.

Table 15 – University of Maryland CHART 2012 Incident Management Evaluation Findings

Reduction due to CHART		Amount	Unit rate	In Dollars (million)
Delay (million veh-hrs)	Truck	1.66	$20.21/hour (truck driver's cost)	33.44
			$45.40/hour (cargo's cost)	75.15
	Car	26.82	$29.82/hour (car driver's cost)	799.54
Fuel consumption (million gallons)		5.59[3]	$3.69/gal.	21.01
Emissions (tons)	HC	372.20	$6,700/ton	32.56
	CO	4,180.40	$6,360/ton	
	NO	178.26	$12,875/ton	
	CO_2	51,411.95	$23/metric ton[4]	
Total Savings				**$961.69**

Figure 6 presents a yearly cost-to-benefit comparison for CHART operations from 2005 to 2012. This comparison is based on the total user cost savings figures for the yearly University of Maryland evaluations compared with the actual CHART program capital and operations costs. Using the most recent numbers available, the CHART Benefit-Cost Ratio for the year 2012 is as follows:

$$\frac{\textit{Total Savings/Benefit to Highway Users for 2012 (\$961.69 Million)}}{\textit{Total Capital and Operational Costs for 2012 (\$30.40 Million)}} = 31.63$$

As can be seen, the benefits of the CHART program far outweigh the allocated Capital and Operational costs.

[3] The fuel consumption was computed based on the rate of 0.156 gallons of gas per hour for passenger cars from the Ohio Air Quality Development Authority and the rate of 0.85 gallon per hour for trucks from the literature "Heavy-Duty Truck Idling Characteristics-Results from a Nationwide Truck Survey" by Lutsey et al. and the Environmental Protection Agency (EPA).

[4] This value is computed based on the unit rates of 19.56 lbs CO2/gallon of gasoline and 22.38 lbs CO2/gallon of diesel from Energy Information Administration and $23/metric ton of CO2 from CBO (Congressional Budget Office)'s cost estimate for S. 2191, America's Climate Security Act of 2007.
e.g. 4.80(million gallons) * 19.56 (lbs CO2/gallon) / 2204 (lbs/metric ton) * 23($/metric ton)

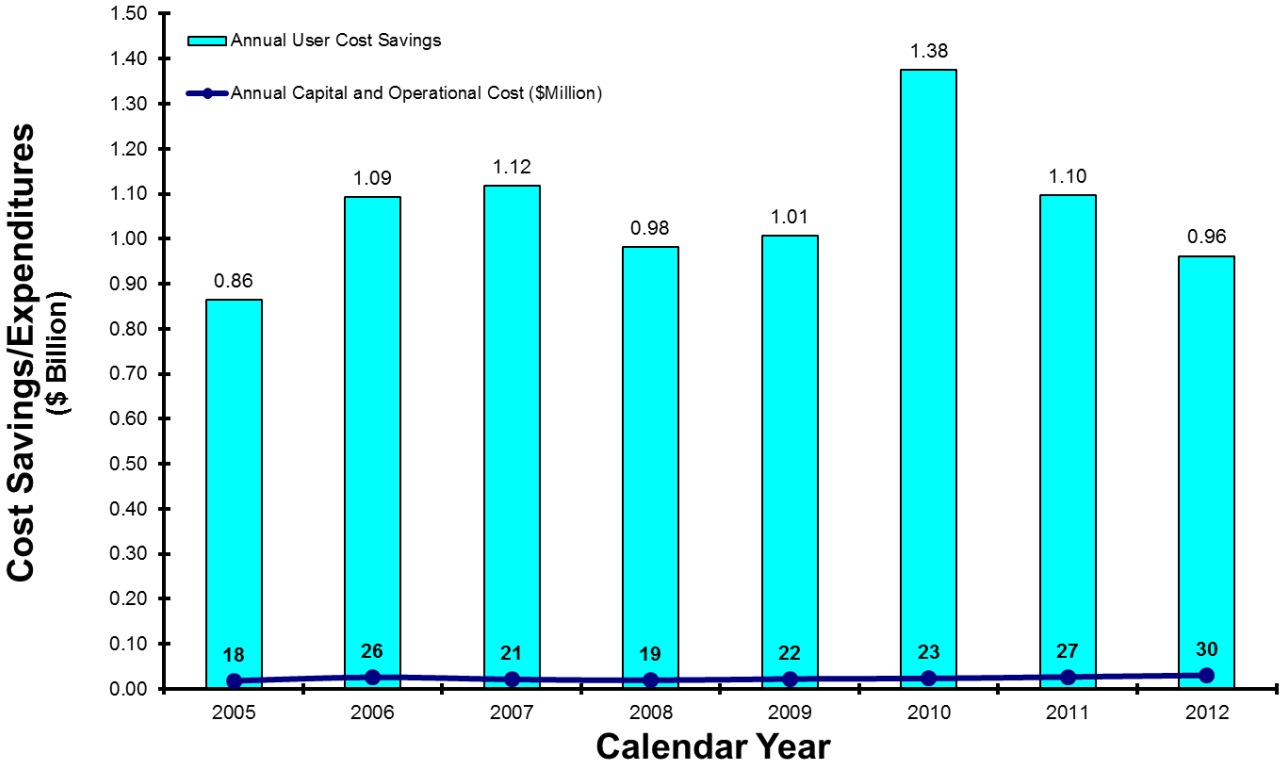


Figure 6 – Comparison of Annual User Cost Savings and CHART Program Operating Cost from 2005 to 2012

3.3.3 Benefits from Implementing the CHART LRSDP

The following section provides examples of qualitative benefits that are currently being experienced by Maryland travelers due to CHART operations, as well as benefits (including economic benefits to the State of Maryland) that will be realized through the implementation of the deployments contained within the LRSDP.

Current CHART qualitative benefits include:

- Access to various sorts of travel information via website and radio, including weather conditions, roadway surface conditions, traffic video images, variable message sign (VMS) postings, location-based traffic speeds, incident reports, lane closures, as well as road work durations and locations
- Decreased delay from non-recurring events (e.g., crashes, breakdowns, construction, weather) on state and other roadways
- Decreased fuel consumption and cleaner air due to fewer emissions

- Safer and quicker management of roadway incidents, and fewer secondary incidents
- Increased security safety along roadways, including during construction, adverse weather, and catastrophic events

In addition to more of the benefits in the above list, potential CHART qualitative benefits introduced by deployments within the 2013 LRSDP are provided in Table 16 below. This table maps specific benefits provided by the NCDP for Maryland travelers.

Table 16 – Potential CHART LRSDP Benefits Mapped to Overall Traveler Benefit

LRSDP Benefit	Increased Traveler Benefit		
	Mobility	Reliability	Safety
More efficient, useful, and personalized traveler information	X	X	X
Improved and increased access to traveler information, including private sector dissemination of information from CHART	X	X	
Consolidated source(s) of traveler information for multi-modal travelers	X	X	
Increased operational management at inter-modal transfer points	X	X	
Increased emergency management and evacuation services			X
More secure and redundant transportation management services			X
Safer and quicker management of roadway incidents/emergencies requiring multi-jurisdictional response	X	X	X
Increased management of traffic flow on highways	X	X	
Increased management of tolled roadways	X	X	
Increased management of, and safety within, scheduled event and work zone locations	X	X	X
Increased safety at highway/rail crossings			X
Increased real-time services due to implementation of latest system technologies	X	X	X
Increased safety, mobility, and reliability due to coordinated management of commercial vehicles and hazardous material shipped along roadways.	X	X	X

Potential CHART qualitative economic benefits to Maryland introduced by deployments within the LRSDP include:

- Increased mobility of employees/goods along Maryland highways benefiting Maryland workers and businesses
- Decreased cost of doing business for motor carriers due to more efficient cargo transport throughout Maryland
- Quicker highway system recovery from emergency situations leading to normal highway operating conditions
- Reduced fatalities and injuries along roadways leading to fewer medical costs for public
- Fewer air-pollution medical effects and thus fewer medical costs

A qualitative summary of Project benefits is included within the Project definitions (Appendix D – Project Definitions) in order to provide an outline of the user-based operational, economic cost-savings, and other benefits that are anticipated to be realized through the implementation of each Project. These anticipated benefits serve as a reference to decision-makers and CHART planning and deployment staff.

LRSDP
Long Range Strategic Deployment Plan
FINAL

Appendices A-D

Office of CHART and ITS Development
State Highway Administration
7491 Connelley Drive
Hanover, MD 21076 -1701
(800) 543-2515
www.chart.state.md.us

2013

Appendix A – Acronyms List

AM	Amplitude Modulated
AOC	Authority Operations Center
API	Application Programming Interface
ASTM	American Society for Testing and Materials
ATIS	Advanced Traveler Information Systems
ATM	Active Traffic Management
ATR	Automatic Traffic Recorder
AVL	Automatic Vehicle Location
BWI	Baltimore-Washington International
C2C	Center to Center
CA	Computer Associates
CAD	Computer Aided Dispatch
CCTV	Closed-Circuit Television
CHART	Coordinated Highways Action Response Team
CORBA	Common Object Request Broker Architecture
COTS	Commercial-Off-The-Shelf
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operations
DATEX-ASN	Data Exchange ASN.1
DEMA	Delaware Emergency Management Agency
DMK	Dynamic Management Kit
DMS	Dynamic Message Sign
DSRC	Dedicated Short-Range Communication
DVR	Digital Video Recording
EOC	Emergency Operations Center
EORS	Emergency Operations Reporting System
ETP	Emergency Traffic Patrols
ERU	Emergency Response Unit
FEMA	Federal Emergency Management Agency
FITM	Freeway Incident Traffic Management
FM	Frequency Modulated
GIS	Geographic Information System
GPS	Global Positioning System
GUI	Graphical User Interface
HAR	Highway Advisory Radio
HIB	Hazard Identification Beacon
HP	Hewlett-Packard
HTML	Hypertext Markup Language
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IP	Internet Protocol
IRIS	Intelligent Roadside Information System

ITS	Intelligent Transportation System
J2ME	Java 2 Micro Edition
JAAS	Java Authentication and Authorization Service
JDBC	Java Database Connectivity
JMX	Java Management Extensions
JSP	JavaServer Pages
LATA	Local Access Transport Area
LED	Light Emitting Diode
LRT	Light Rail Transit
MAA	Maryland Aviation Administration
MDOT	Maryland Department of Transportation
MDTA	Maryland Transportation Authority
MIDP	Mobile Information Device Profile
MMTIS	Multi-modal Traveler Information System
MS/ETMCC	Message Sets for External Traffic Management Center Communication
MDSHA	Maryland State Highway Administration
MTA	Maryland Transit Administration
MVA	Motor Vehicle Administration
NMS	Network Management System
NTCIP	National Transportation Communications for ITS Protocol
ODBC	Open Database Connectivity
OOTS	Office of Traffic and Safety
PEMA	Pennsylvania Emergency Management Agency
POTS	Plain Old Telephone System
PSTN	Public Switched Telephone Network
PTZ	Pan Tilt Zoom
RAID	Redundant Array of Inexpensive Disks
RF	Radio Frequency
RITIS	Regional Integrated Transportation Information System
RLCSS	Reversible Lane Control Signal System
RSVD	Roadside Vehicle Detection
RTMS	Remote Traffic Microwave Sensor
RWIS	Roadway Weather Information System
SAE	Society of Automotive Engineers
SAN	Storage Area Network
SF	Square Feet
SNMP	Simple Network Management Protocol
SOAP	Simple Object Access Protocol
SOC	Statewide Operations Center
SQL	Structured Query Language
SWGI	Statewide Government Intranet
TCP	Transmission Control Protocol
TCPIP	Transmission Control Protocol and Internet Protocol
TMDD	Traffic Management Data Dictionary

TNG	The Next Generation
TOC	Traffic Operations Center
TSS	Traffic Sensor Subsystem
USDOT	United States Department of Transportation
VDEM	Virginia Department of Emergency Management
W3C	World Wide Web Consortium
WAN	Wide Area Network
XML	Extensible Markup Language

THIS PAGE LEFT INTENTIONALLY BLANK

Appendix B – Strategies Grouped by Element

Element		Objective	Strategy		Priority
1	Traffic and Roadway Monitoring	1 - Enhance CHART's ability to visually monitor highway conditions.	1.1.1	*Additional Closed-Circuit Television (CCTV)* – Deploy CCTV cameras along major state highways in the Baltimore and Washington D.C. regions to provide full visibility of roadways. Continue to extend CCTV camera coverage statewide to include all major state highways, as well as evacuation and Freeway Incident Traffic Management (FITM) routes.	1
			1.1.2	*Replace and Upgrade Existing Closed-Circuit Television (CCTV)* – Replace existing end of life-cycle CCTV cameras with latest technology of existing CCTV infrastructure to continue CHART's ability to effectively monitor roadway conditions by using the latest technological developments.	2
			1.1.3	*Traffic Monitoring at Video Detection Sites* – Deploy roadside infrastructure to enable CHART to access data and images from video detection cameras at signalized intersections.	1
			1.1.4	*Incident Monitoring Cameras on Emergency Response Vehicles* – Deploy camera image or video capture technology on CHART Emergency Response Vehicles to provide near real-time monitoring of field conditions (This Strategy is repeated under Objective 6 as Strategy 2.6.5).	1
		2 - Enhance CHART's ability to collect automated traffic data from traffic detection sites.	1.2.1	*Additional Traffic Detectors* – Deploy new detection sites along major state highways in the Baltimore/Washington D.C. regions to provide full detection at 1-mile spacing of roadways. Continue to extend traffic detection coverage statewide to include major state highways as well as designated evacuation and Freeway Incident Traffic Management (FITM) routes.	1
			1.2.2	*Support for Deployment of Vehicle Passenger Occupancy and Class Determination Detectors* – Support the deployment of detection devices along freeways and expressways with the capability to determine vehicle class types (car, truck type) and a vehicle's passenger occupancy (HOV) in order to provide data for various operations.	S-3

1	Traffic and Roadway Monitoring	3 - Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data and reduced infrastructure requirements.	1.3.1	*Portable Trailer-mounted Traffic Monitoring Cameras* – Obtain portable camera trailers with wireless communications in order to provide flexible monitoring capabilities at any location. (This Strategy is repeated under Objective 13 as Strategy 1.13.2.)	*1*
			1.3.2	*Portable Trailer-Mounted Traffic Detectors* - Obtain portable traffic detection trailers with wireless communications, as well as intrusion detection devices, in order to provide flexible safety monitoring, traffic data collection, and queue detection at any location. (This Strategy is repeated under Objective 13 as Strategy 1.13.3.)	*1*
			1.3.3	*Traffic Probe Data Collection* – deploy necessary infrastructure – either directly or through partnerships with public or private agencies – to support the collection of traffic probe data through use of various technologies in order to determine traffic flow conditions along freeways and expressways.	*1*
			1.3.5	*Support Deployment of Traffic Probe Devices in MDOT Vehicles* – Support other agencies in equipping vehicles owned by Maryland Department of Transportation Modals with technology applications that allow traffic flow data to be collected while traveling along roadways.	*S-1*
		12 - Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	1.12.1	*Support Partnerships to Monitor Parking Facilities* – Develop partnerships to monitor parking capacity and other operations at major public parking facilities as well as at recurring event locations, Park 'n' Ride locations, and airports.	*S-2*
		13 - Enhance ability to manage traffic and increase safety near and within work zones and event locations.	1.13.1	*Work Zone/Event Traffic Monitoring Infrastructure* – Where applicable, deploy permanent infrastructure to support traffic flow detection and video monitoring capabilities at work zones (for continued coverage after completion of construction) and major event locations.	*1*
			1.13.2	*Portable Trailer-mounted Traffic Monitoring Cameras* - Obtain portable camera trailers with wireless communications in order to provide flexible monitoring capabilities at work zones and event locations. (This Strategy is repeated under Objective 3 as Strategy 1.3.1.)	*1*
			1.13.3	*Portable Trailer-mounted Traffic Detectors* - Obtain portable traffic detection trailers with wireless communications, as well as intrusion detection devices, in order to provide flexible safety monitoring, traffic data collection, and queue detection at work zones and event locations. (This Strategy is repeated under Objective 3 as Strategy 1.3.2.)	*1*

1	Traffic and Roadway Monitoring	15 - Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.	1.15.1	*Support for Highway-Rail Crossing Monitoring Devices* – Support the deployment of devices that detect both automobiles and approaching trains at highway-rail crossings to support various safety alert systems, as well as traffic management systems.	S-2
		16 - Develop additional capabilities within the CHART Operating System Software.	1.16.1	*Exchange Closed-Circuit Television Images and Camera Control* – Software module deployment for collecting and integrating video images and camera control interfaces from sources outside of CHART, as well as providing CHART camera images and administered control to outside agencies.	1
			1.16.2	*Exchange and Integrate Traffic Monitoring Data with Other Agencies* – Software module deployment for processing traffic monitoring and detection data from CHART devices and sending it to other agencies, as well as receiving and integrating traffic monitoring data from outside sources and integrating it into the CHART Operating System.	1
			1.16.3	*Develop Traffic and Roadway Monitoring Software* – Software module deployment to provide added functionality to traffic and roadway monitoring operations within CHART software.	1

Element		Objective	Strategy		Priority
2	Incident Management	5 - Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.	2.5.1	*CHART Incident Management Field Equipment* – Continue to purchase the most advanced field equipment (including vehicles, clearance machinery, etc.) to enhance CHART incident management personnel's ability to detect, respond, and clear incidents and emergencies along state highways in all jurisdictions.	1
			2.5.2	*Public Safety Incident Management Equipment* – Provide and transfer equipment to Maryland State Police and other public safety agencies to improve coordination and joint activities with CHART.	1
			2.5.3	*Incident/Emergency Management Training* – Train personnel, both within the CHART program and from other agencies, to familiarize operational and technical staff with the underlying principles of incident/emergency management, ITS applications, and the impacts of congested roadways.	1
			2.5.4	*Extend CHART Traffic Patrol* – Extend CHART traffic patrol program to include coverage in every MDSHA Engineering District.	1
			2.5.5	*CHART Vehicle Depots* – Build CHART vehicle depots in the Baltimore and Washington, D.C. areas to facilitate vehicle management and maintenance.	1
			2.5.6	*CHART Traffic Operations Center (TOC) Expansion* – Extend CHART operational coverage to include deployment of a TOC in every MDSHA Engineering District.	1
			2.5.7	*Freeway Location Signage* – Install mile marker signs at every 0.10 of a mile along all freeways and expressways within the state of Maryland.	1
		6 - Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	2.6.1	*Automated Vehicle Location (AVL)* on MDSHA Incident/Emergency Vehicles – Deploy Global Positioning System (GPS)-based AVL devices and systems to collect MDSHA incident/emergency vehicle location data, in order to more efficiently manage MDSHA field resources during incidents and emergencies.	1
			2.6.2	*Support for Opening Local Operations Centers* – Support counties and municipalities in their efforts to establish regional ITS programs and operations centers with functions that will be integrated inter-regionally with the CHART SOC.	S-1
			2.6.3	*Real-time Data Acquisition Devices* – Equip operational personnel with portable devices that will be used to gather real-time information on CHART field operations.	1
			2.6.4	*Wireless Real-time Data Sharing Devices* – Equip remote incident management personnel with portable devices to support the exchange of messages and information to facilitate incident/emergency management field operations.	1

Element		Objective	Strategy		Priority
			2.6.5	*Incident Monitoring Cameras on CHART Emergency Response Vehicles* – Deploy camera image or video capture technology on CHART Emergency Response Vehicles to provide near real-time monitoring of field conditions (This Strategy is repeated under Objective 1 as Strategy 1.1.4).	*1*
2	Incident Management	16 - Develop additional capabilities within the CHART Operating System Software.	2.16.1	*Develop Incident/Emergency Management and Computer Aided Dispatch (CAD) Software* – Software module deployment to develop the CHART system software to process operations data from multi-jurisdictional public safety and transportation-related agencies responsible for incident/emergency detection, verification, response, and clearance in order to optimize MDSHA incident/emergency management and dispatch operations throughout the state.	*2*
			2.16.2	*Develop Incident Prediction Software* – Software module deployment that uses various sources of data as input into an algorithm that processes predictions and probabilities for incidents occurring along stretches of highways where data is being collected.	*1*
			2.16.3	*Integrate Incident/Emergency Rail System Data* – Software module deployment to collect and integrate incident/emergency data from various Rail Carrier Systems into the CHART Operating System in order to improve incident detection and traffic management at and around highway-rail crossings.	*2*

Element		Objective	Strategy		Priority
3	Traveler Information	8 - Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	3.8.1	*CHART Web Site Enhancements/Development* – Enhance the functionality and traveler information services provided to the public through "CHART on the Web".	1
			3.8.2	*Support Regional Advanced Traveler Information Programs* –Support regional programs that manage various sources of transportation data in order to provide a "one-stop shopping" source for the public to access multi-modal traveler information through various media.	S-1
			3.8.3	*Support Information Service Provider Partnerships* – Support for partnerships with ISPs, which manage and/or fuse transportation data, and distribute traveler information through various dissemination media.	S-1
			3.8.4	*Electronic Traveler Information Board* – Install display units to provide real-time traffic and transportation information at various locations. Such as rest areas, airports, Motor Vehicle Administration (MVA) facilities, and transit transfer points.	2
			3.8.5	*AM/FM Side-Band Traffic Alerts* – Deploy necessary infrastructure to provide CHART the ability to broadcast traveler information over AM/FM frequencies using technology that transmits data to vehicles equipped with receivers.	3
		9 - Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.	3.9.1	*Additional Dynamic Message Signs (DMS)* – Deploy Dynamic Message Signs along major state highways in the Baltimore and Washington, D.C. regions to provide comprehensive traveler information on roadways. Continue to extend DMS coverage statewide to include major state highways, as well as evacuation and Freeway Incident Traffic Management (FITM) routes.	1
			3.9.2	*Additional Highway Advisory Radio (HAR)* – Deploy Highway Advisory Radios along major state highways in the Baltimore and Washington, D.C. regions to provide comprehensive traveler information on roadways. Continue to extend HAR coverage statewide to include major state highways, as well as evacuation and Freeway Incident Traffic Management (FITM) routes.	2
			3.9.3	*Replace and Upgrade Highway Advisory Radio (HAR)* – Update the technology in existing highway advisory radio infrastructure to assure that this service continues to effectively broadcast current traveler information.	1
			3.9.4	*Replace and Upgrade Portable Trailer-mounted Dynamic Message Signs (DMS)* – Replace and upgrade existing portable DMS trailers with the latest technologies and wireless communications in order to provide flexible distribution of traveler information at any location. (This Strategy is repeated under Objective 13 as Strategy 3.13.1.)	1

Element		Objective	Strategy		Priority
			3.9.5	*Replace and Upgrade Portable Trailer-mounted Highway Advisory Radios (HAR)* – Replace and upgrade existing portable HAR trailers with the latest technologies and wireless communications in order to provide flexible distribution of traveler information at any location. (This Strategy is repeated under Objective 13 as Strategy 3.13.2)	*1*
			3.9.6	*Infrastructure to Support In-vehicle Highway Hazard Alerts* – Deploy roadside detectors and short-range communication infrastructure to detect hazardous traveling conditions and exchange communications with traveling vehicles to alert motorists that will be affected.	*3*
			3.9.7	*Infrastructure to Support In-vehicle Highway Signage Systems* – Deploy short-range communication infrastructure to transmit data to a traveling vehicle in order to allow the motorist to see an in-vehicle display of upcoming static and dynamic signs, as well as other messages pertaining to motorist needs.	*3*
		13 - Enhance ability to manage traffic and increase safety near and within work zones and event locations.	3.13.1	*Replace and Upgrade Portable Trailer-mounted Dynamic Message Signs* (DMS) – Replace and upgrade existing portable DMS trailers with the latest technologies and wireless communications in order to provide traveler information messages at work zone and event locations. (This Strategy is repeated under Objective 9 Strategy 3.9.4)	*1*
			3.13.2	*Replace and Upgrade Portable Trailer-mounted Highway Advisory Radios* (HAR) – Replace and upgrade existing portable HAR trailers with the latest technologies and wireless communications in order to broadcast traveler information messages within work zone and event areas. (This Strategy is repeated under Objective 9 as Strategy 3.9.5)	*1*
		16 - Develop additional capabilities within the CHART Operating System Software.	3.16.1	*Exchange/Integrate Traveler Information Data with/from Other Public Agencies* – Software module deployment to request multi-modal traveler information data from various public agencies (within and outside of Maryland) and integrate it into the CHART system, as well as to collect and process multi-modal traveler information data within the CHART system into a pre-determined format for transfer to another public agency's system.	*1*
			3.16.2	*Develop Traveler Information Software* - Software module deployment to provide added functionality to traveler information distribution and management capabilities within CHART software.	*1*

4	Traffic Management	10 - Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.	4.10.1	*Support Statewide Traffic Signal System Optimization* – Support the development of a signal optimization plan and the deployment of new timings for signal systems operating MDSHA controlled arterials throughout the state in order to increase traffic flow.	*S-1*
		11 - Utilize current technology and strategies to optimize flow of traffic on access controlled highways.	4.11.1	*Active Traffic Management System* - Active Traffic Management (ATM) is a strategy that enhances traffic flow based on real-time data and communication of this data to the drivers for well-informed decisions ahead of congestion/incident, thus aiming to reduce primary and secondary collisions associated with congestion. Additional monitoring capabilities added through sensors and detectors would improve response time during the incidents.	*S-2*
			4.11.2	*Trail Blaze Signage* – Deploy infrastructure to provide signage to route vehicles along Freeway Incident Traffic Management (FITM) routes, or other pre-established diversion routes.	*1*
			4.11.3	*Highway Access Alert Systems* – Deploy infrastructure to alert motorists of travel conditions before reaching freeway or expressway access ramps.	*3*
			4.11.4	*Support Deployment of Dynamic Toll Lanes* – Participate in the establishment and operation of High Occupancy Toll (HOT) lanes and other advanced toll lane operations that dynamically toll travelers depending on various parameters (e.g., current congestion level and number of passengers in a vehicle) in order to better manage travel demand and traffic flow.	*S-1*

Element		Objective	Strategy		Priority
4	Traffic Management	12 - Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	4.12.1	*Support for Deployment of Traffic Management Infrastructure at Inter-modal Transfer Points and Major Parking Facilities* – Develop partnerships and deploy infrastructure to manage traffic flow as well as display real-time information at and approaching major parking facilities, including event parking and Park 'n' Ride facilities, in order to guide motorists to available parking.	S-1
		15 - Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.	4.15.1	*Support for Highway- Rail Crossing Safety and Diversion Systems* – Support the deployment of infrastructure to process detection data at identified highway rail crossings and use technology applications to divert approaching traffic, as well as to predict collisions and alert motorists and/or train operators accordingly.	S-2
		16 - Develop additional capabilities within the CHART Operating System Software.	4.16.1	*Develop Software to Manage Arterial Traffic and Integrate Arterial Traffic Management Data* – Software module deployment to develop CHART's ability to control field devices on principal arterials (especially along FITM routes), and at principal arterial intersections with freeways and expressways and integrate the associated data into the CHART Operating System.	2
			4.16.2	*Develop Traffic Management Software* – Software module deployment to provide added functionality to freeway and expressway traffic management operations within CHART central software.	1

Element		Objective	Strategy		Priority
5	Systems Integration and Communication	1 - Enhance CHART's ability to visually monitor highway conditions	5.1.1	*Process Video Images for Traffic Information* – Develop "machine vision" technology to facilitate the collection of traditional video detection data (speed, volume, and occupancy), as well as data associated with visual detection of incidents.	*1*
		3 - Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data and reduced infrastructure requirements.	5.3.1	*Integrate Traffic Probe Data* – Collect and integrate probe data collected by various technology applications in order to determine traffic flow conditions along freeways and expressways.	*1*
		6 - Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	5.6.1	*Support Regional Interoperable Incident Management Voice Communications* – Participate in the development of systems and software to establish interoperability between various agencies' voice communication systems to provide uniform communications between incident/emergency response personnel throughout a particular region.	*S-1*
			5.6.2	*Support Regional Incident Management Communication Networks* – Participate in the development and deployment of regional communication networks that access various public safety and transportation management databases, as well as provide real-time messaging capabilities between remote incident/emergency response personnel, in order to facilitate coordination and communications among various agencies responding to incidents and emergencies.	*S-1*
			5.6.3	*Support Integration of Regional Incident Management Systems* – Participate in the development and implementation of regional incident/emergency management networks that integrate independent agency systems in order to more efficiently manage various operations related to the detection, response, and clearance of incidents and emergencies throughout a region.	*S-1*
			5.6.4	*Geo-location Devices on Portable Incident/Emergency Management Equipment* – Equip MDSHA and other agencies' portable field equipment (including device trailers, tow trucks, incident management equipment, and FITM trailers) with geo-location devices in order to dynamically track and update exact locations and current usage status (e.g., direction facing) of field equipment being used for response to incidents/emergencies.	*1*

Element		Objective	Strategy		Priority
5	Systems Integration and Communication	8 - Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	5.8.1	*Statewide 511 Service* – Deploy necessary systems components to initiate a statewide 511 program that collects and manages available transportation-related data throughout the state and distributes information to travelers calling within the state using technologies such as audio-text and voice recognition.	1
		10 - Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.	5.10.1	*Integrate Traffic Signal System Data* – Integrate the operation of traffic signal systems with SOC operations to automatically employ pre-arranged incident/emergency management timing plans for optimal traffic flow during incidents and emergencies, especially along Freeway Incident Traffic Management (FITM) routes.	1
		12 - Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	5.12.1	*Integrate Parking Management Data* – Collect and integrate parking management data from public and private parking institutions in order to improve parking traffic management operations through the CHART Operating System.	1
		13 - Enhance ability to manage traffic and increase safety near and within work zones and event locations	5.13.1	*Geo-location Devices on Portable Work Zone/Event Equipment* – Equip MDSHA and other agencies' portable work zone/event equipment with geo-location devices in order to dynamically track and update exact locations and current usage status (e.g., direction facing) of field equipment being used for work zone or event management.	1
		14 - Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	5.14.1	*Security Measures for CHART Operations Centers and System Infrastructure* – Deploy infrastructure and systems applications that protect against unauthorized access to the CHART network, and user controls within operation center facilities.	1

Element		Objective	Strategy		Priority
5	Systems Integration and Communication	16 - Develop additional capabilities within the CHART Operating System Software.	5.16.1	*Develop Software to Provide Transportation Network Simulation and Prediction Capabilities* – Utilize simulation algorithms to analyze real-time traffic conditions and predict likely impacts on traffic flows as an operational decision tool.	1
			5.16.2	*Further Develop Software to Predict Roadway Conditions During Adverse Weather Situations* – Software module deployment to improve the collection and processing of historical and real-time data from weather station field devices and thermal mapping applications in order to predict unsafe conditions along roadways.	1
			5.16.3	*Integrate Traffic Probe Data*– Software module deployment to integrate into the CHART Operating System software traffic probe data collected through use of various technologies in order to determine traffic flow conditions along freeways and expressways and improve various CHART operations.	1
			5.16.4	*Develop Access to Available CVO and HAZMAT Databases* – Initiate Maryland agency connectivity with national and state-level databases that provide information on CVO operators and HAZMAT carrier organizations in order to better respond to incidents and emergencies involving hazardous materials.	1
			5.16. 5	*Software for CHART System Health Monitoring* – Software module deployment to detect, locate, and track all failures, security breaches, and malfunctions within the CHART Operating System, communications network, or field devices.	1
			5.16.6	*Develop Software for Control of Portable Devices* – Software module deployment to provide CHART personnel the ability to control portable field devices through the CHART Operating System.	1
		17 - Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices.	5.17.1	*CHART Communications Network Equipment Expansion* – Purchase and install new, and replace and upgrade the technology of existing, switches, multiplexors, routers, hubs, codecs, cabling, modems, and servers to support the continued expansion of the CHART communications network.	1
			5.17.2	*Expand Communications to Local Agencies* – Extend communications to provide CHART data transfer capabilities with local jurisdiction agencies within Maryland.	1
			5.17.3	*SOC Integration and Equipment* – Plan, design, replace and upgrade equipment necessary to support the integration and inter-connectivity of CHART subsystems at the SOC.	1
			5.17.4	*Integrate Field Equipment Installations* – Deploy necessary communications, system components, and software updates to provide wireless and hardwire point-to-point communications to enable CHART data transfer capabilities with newly installed field devices and previously non-integrated legacy systems.	1

Element		Objective	Strategy		Priority
		[redacted]	5.17.5	*Deploy Secure Communications Between CHART Operations Centers and Emergency Management Systems* – Deploy secure and redundant communications to allow data transfer between CHART operations centers and various state, local, and federal emergency management agencies' systems to facilitate coordinated emergency management operations.	*1*

Element		Objective		Strategy	Priority
6	Emergency and Weather Operations	4 - Enhance CHART's ability to monitor travel conditions during inclement weather.	6.4.1	*Additional Weather Stations* – Deploy infrastructure at new weather and pavement condition monitoring sites to provide thorough statewide coverage.	1
			6.4.2	*Road Surface Monitoring Equipment on MDSHA Vehicles* – Equip Maryland State Highway Administration snowplows with technology applications that collect and transmit road surface condition data as the vehicle travels.	2
			6.4.3	*Automatic Vehicle Location (AVL) on Snowplow Vehicles* – Equip Maryland State Highway Administration snowplows with AVL devices to collect and transmit vehicle location data to support more efficient management of roadway treatment winter operations.	1
		7 - Enhance CHART's severe weather and emergency management operations.	6.7.1	*Traffic Monitoring Infrastructure Along Evacuation Routes* – Deploy permanent traffic detection and visual monitoring devices along evacuation routes in order to improve CHART operations during severe weather and emergency situations.	1
			6.7.2	*Support the Deployment of Bio-hazard/Radiological Detection Devices* – Support for deploying field devices along identified stretches of roadways and/or on critical infrastructure to detect biohazards or abnormal radiation levels and automatically warn CHART and other appropriate agency personnel.	S-1
			6.7.3	*Support for Emergency Operations Coordination* – Participate in coordination among transportation and public safety agencies to formulate emergency operations plans that would detail CHART's responsibilities for emergency response operations at the state or national levels. Coordination efforts would include CHART's connectivity with various emergency communication systems that provide a secure means of coordination and communications among responding agencies.	S-1
			6.7.4	*Traffic Management Infrastructure for Emergency Operations* – Deploy permanent infrastructure along evacuation routes (e.g., reversible lane signals, and route guidance signs) that will manage increased volumes of traffic using various technology applications.	1
			6.7.5	*Satellite Voice Communications for Field Emergency Operations* - Equip remote incident management personnel with portable satellite voice communication units to support redundant and continuous voice communications between field personnel and CHART operations centers during emergency situations.	1

6	Emergency and Weather Operations	14 - Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	6.14.1	*Security Monitoring Equipment for CHART Devices* – Continue to deploy infrastructure and equipment to increase security for CHART field equipment that is accessible to the public and is essential to continuity of CHART operations.	1
			6.14.2	*Security Monitoring Equipment for Critical Transportation Infrastructure* – Deploy technology applications that monitor identified critical transportation infrastructure to increase security measures in order to protect against sabotage and destruction.	1
		15 - Increase motorist roadway safety, and deploy systems to enhance safety at highway rail crossings.	6.15.1	*Support for Deployment of Flood Monitor and Warning Systems* – Deploy technology applications at locations identified as prone to flooding, in order to monitor flooding effects on road surface conditions and warn motorists of potential hazards.	*S-2*
			6.15.2	*Support for Deployment of Fog Monitor and Warning Systems* – Deploy technology applications at locations identified as hazardous due to recurring fog conditions, in order to monitor fog effects on traveling conditions and warn motorists of potential hazards.	*S-1*
			6.15.3	*Support for Deployment of High Wind Monitor and Warning Systems* – Deploy technology applications at locations identified as hazardous due to high wind conditions, in order to monitor high wind effects on traveling conditions and warn motorists of potential hazards.	*S-1*

Appendix C – Projects Grouped by Element

Element		Objective	Project		Cost ($)
1	Traffic and Roadway Monitoring	1 - Enhance CHART's ability to visually monitor highway conditions.	1.1.1.1	Deploy Additional CCTV Sites Along Freeways and Expressways	$10,000,000.00
			1.1.1.2	Deploy Additional CCTV Sites Along Arterials	$8,300,000.00
			1.1.1.3	Deploy Additional CCTV Cameras Along Freeway Incident Traffic Management (FITM) Routes	$15,000,000.00
			1.1.2.1	Deploy Replacement CCTV at Existing Sites	$1,620,000.00
			1.1.3.1	Deploy CCTV Cameras with PTZ Capabilities on Existing Infrastructure at Signalized Intersections for Signal Operations and Incident Management/Detection	$3,000,000.00
			1.1.4.1	Deploy Cameras on CHART Emergency Response Vehicles for Incident Monitoring	$752,000.00
		2 - Enhance CHART's ability to collect automated traffic data from traffic detection sites.	1.2.1.1	Deploy Additional Traffic Detectors	$15,435,000.00
			1.2.1.2	Deploy Additional Traffic Detectors along Freeway Incident Traffic Management (FITM) Routes	$6,840,000.00

1	Traffic and Roadway Monitoring	3 - Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data, and reduced infrastructure requirements.	1.3.1.1	Purchase Portable Trailer-Mounted Traffic Monitoring Cameras	$360,000.00
			1.3.2.1	Purchase Portable Trailer-Mounted Traffic Detectors	$1,000,000.00
			1.3.3.1	Deploy Traffic Data Collection Devices with various Probe Technologies	$8,400,000.00
		13 - Enhance ability to manage traffic and increase safety near and within work zones and event locations.	1.13.1.1	Deploy Permanent Traffic Monitoring Equipment at Work Zones	$2,050,000.00
			1.13.2.1	Purchase Portable Trailer-mounted Traffic Monitoring Cameras	(Cost reported under 1.3.1.1)
			1.13.3.1	Purchase Portable Trailer-mounted Traffic Detectors	(Cost reported under 1.3.2.1)
		16 - Develop additional capabilities within the CHART Operating System Software.	1.16.1.1	Integrate CCTV with CHART Connected Agencies and Agencies not Connected to CHART	$504,000.00
			1.16.2.1	Enhance the Traffic Flow Monitoring Software to Automatically Generate Incident and Congestion Alerts	$631,000.00
			1.16.2.2	Develop Enhancements to the Video Display Software to Enable Mobile Video Camera Access	$104,000.00
			1.16.2.3	Develop Weather and Road Condition Monitoring Software	$448,000.00
			1.16.2.4	Develop Enhancements to the Work Zone/Evacuation Route Monitoring Software	$381,000.00
			1.16.2.5	Develop Security Monitoring Software	$992,000.00
Element 1 Capital Cost Estimate					**$75,817,000**

Element		Objective		Project	Cost ($)
2	Incident Management	5 - Provide sufficient resources and training to operational personnel, and expand coordination with public safety agencies, to assure the efficient management of incidents and emergencies.	2.5.1.1	Purchase Incident Management Field Equipment for CHART Personnel	$7,995,000.00
			2.5.2.1	Purchase Incident Management Field Equipment for Public Safety Agencies	$1,282,000.00
			2.5.3.1	Provide Coordination and Resources for Training of Incident/Emergency Management Personnel	$3,261,000.00
			2.5.4.1	Extend CHART Traffic Patrols	$9,029,000.00
			2.5.5.1	Deploy CHART Vehicle Depots	$4,200,000.00
			2.5.6.1	Expand Coverage of CHART Traffic Operations Center (TOC) to all MDSHA Districts and Expand Existing Coverage	$1,325,000.00
			2.5.7.1	Install Mile Marker Signage along all Freeways and Expressways, Statewide	$1,450,000.00
		6 - Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	2.6.1.1	Deploy AVL Technology in Future CHART Vehicles	$282,000.00
			2.6.3.1	Replace Portable, Real-time Data Acquisition Devices for Operational Personnel	$129,000.00
			2.6.4.1	Deploy Wireless, Real-time Data Sharing Devices for Operational Personnel	$129,000.00
			2.6.5.1	Deploy on CHART Emergency Response Vehicles for Incident Monitoring	(Cost reported under 1.1.4.1)
		16 - Develop additional capabilities within the CHART Operating System Software.	2.16.1.1	Develop Multi-Jurisdictional CAD Operations Software to Integrate CAD and Incident Information from 911 and In-Vehicle System Centers through RITIS	$519,000.00
			2.16.2.1	CHART Incident Prediction Report Generation	$1,700,000.00
			2.16.3.1	Develop Software for Incident/Emergency Data Exchange for Highway Rail Crossings	$452,000.00
Element 2 Capital Cost Estimate					**$31,753,000**

Element		Objective	Project		Cost ($)
3	Traveler Information	8 - Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	3.8.1.1	Develop Enhancements for CHART Web Site	$575,000.00
			3.8.4.1	Deploy Electronic Traveler Information Board System	$23,680,000.00
			3.8.5.1	Deploy AM/FM Side-Band Traffic Alert Infrastructure	$945,000.00
		9 - Allow the traveling public to make better informed travel decisions by providing information on travel conditions via deployed highway field infrastructure.	3.9.1.1	Deploy Additional DMS Along Freeways and Expressways	$3,750,000.00
			3.9.1.2	Deploy Additional DMS Along Arterials at Freeway Interchanges	$62,500,000.00
			3.9.2.1	Deploy Additional HAR Along Freeways and Expressways	$530,000.00
			3.9.2.2	Deploy Additional HAR Sites Along Arterials	$530,000.00
			3.9.3.1	Deploy enhanced HAR at Existing Sites	$530,000.00
			3.9.4.1	Deploy Replacement Portable Trailer-Mounted DMS	$770,000.00
			3.9.5.1	Deploy Replacement Portable Trailer-Mounted HAR	$160,000.00
			3.9.6.1	Deploy Roadside Infrastructure to Support In-vehicle Highway Hazard Alert	$565,000.00
			3.9.7.1	Deploy Roadside Infrastructure to Support In-vehicle Highway Signage Systems	$565,000.00
3	Traveler Information	13 - Enhance ability to manage traffic and	3.13.1.1	Deploy Replacement Portable Trailer-mounted DMS	(Cost reported under 3.9.4.1)

Element		Objective		Project	Cost ($)
		increase safety near and within work zones and event locations.	3.13.2.1	Deploy Replacement Portable Trailer-mounted HAR	(Cost reported under 3.9.5.1)
		16 - Develop additional capabilities within the CHART Operating System Software.	3.16.1.1	Develop Software to Integrate Parking Management Data	$851,000.00
			3.16.2.1	Develop Electronic Traveler Information Board Software	$420,000.00
			3.16.2.2	Develop Software for In-Vehicle Traveler Information	$381,000.00
Element 3 Capital Cost Estimate					**$96,752,000**

Element		Objective	Project		Cost ($)
4	Traffic Management	11 - Utilize current technology and strategies to optimize flow of traffic on access controlled highways.	4.11.1.1	Deploy an Active Traffic Management (ATM) System as a Pilot Project	$20,000,000.00
			4.11.2.1	Deploy Trail Blaze Signage for FITM Routes	$1,320,000.00
			4.11.3.1	Deploy Highway Access Alert Systems	$4,625,000.00
		16 - Develop additional capabilities within the CHART Operating System Software.	4.16.1.1	Develop Software to Incorporate Arterial Traffic Monitoring and Management into CHART	$476,000.00
			4.16.2.1	Develop Software for Operation of Ramp Metering Devices	$1,470,000.00
			4.16.2.2	Develop Software for Operation of Variable Speed Limit Devices	$924,000.00
			4.16.2.3	Develop Software for Operation of Lane Control Devices	$761,000.00
			4.16.2.4	Develop Software for Operation of Queue Detection and Warning Devices	$1,560,000.00
			4.16.2.5	Develop Software for Operation of Traffic Management Devices at Inter-Modal Transfer Points	$1,270,000.00
			4.16.2.6	Develop Software for Advanced Technology Traffic Detectors	$666,000.00
Element 4 Capital Cost Estimate					**$33,072,000**

Element		Objective	Project		Cost ($)
5	Systems Integration and Communication	1 - Enhance CHART's ability to visually monitor highway conditions	5.1.1.1	Develop Software for Collecting and Processing Video Detection Data	$476,000.00
			5.1.1.2	Integrate "Machine Vision" Technology into CHART	$2,400,000.00
		3 - Employ new technologies to monitor traffic and roadway conditions with greater accuracy, more data and reduced infrastructure requirements.	5.3.1.1	Integrate MDSHA Traffic Probe Data into CHART	$80,000.00
			5.3.1.2	Integrate Traffic Probe Data from External Sources into CHART	$500,000.00
			5.3.2.1	Purchase Traffic Data and Services from Private-Sector Providers	$16,150,000.00
		6 - Employ new technologies to improve CHART's coordination and communications during the management of incidents and emergencies.	5.6.4.1	Deploy Geo-Location Devices on Portable Incident/Emergency Management Equipment	$120,000.00
		8 - Allow the traveling public to make better informed travel decisions by providing travel conditions through various media sources.	5.8.1.1	Integrate Traveler Information Data for Statewide 511 Distribution	$2,490,000.00
		10 - Enhance coordination between CHART and Traffic Signal Operations to optimize signal systems timing in response to conditions.	5.10.1.1	Integrate Traffic Signal Operation Systems into CHART	$5,813,000.00

Element		Objective	Project		Cost ($)
5	Systems Integration and Communication	12 - Employ strategies to improve the efficiency of operations at inter-modal transfer points and parking facilities.	5.12.1.1	Integrate Parking Management Systems	$239,000.00
		13 - Enhance ability to manage traffic and increase safety near and within work zones and event locations.	5.13.1.1	Deploy Geo-location Devices on Portable Work Zone/Event Equipment	$550,000.00
		14 - Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	5.14.1.1	Deploy Security Improvement Measures at CHART Operations Centers	$788,000.00
		16 - Develop additional capabilities within the CHART Operating System Software.	5.16.1.1	CHART Real-time Simulation	$1,750,000.00
			5.16.1.2	CHART Offline Simulation and Training	$1,220,000.00
			5.16.2.1	CHART Weather Alert Processing	$436,000.00
			5.16.3.1	CHART TSS Add Mobile Probe Data Device Type	$381,000.00
			5.16.4.1	Develop Software to Interface with CVO and HAZMAT Data Sources	$549,000.00
			5.16.5.1	Enhance Software for Monitoring the Status of CHART	$984,000.00
			5.16.6.1	Develop Software for Portable/Trailer-Mounted HARs	$571,000.00
			5.16.6.2	Develop Software for Portable Data-Collection Devices	$761,000.00

Element		Objective	Project		Cost ($)
5	Systems Integration and Communication	17 - Build the infrastructure necessary to expand the CHART Network and facilitate regional connectivity between operational facilities and to field devices.	5.17.1.1	Deploy Additional CHART Fiber Connections	$2,100,000.00
			5.17.2.1	Integrate Local Agencies and Jurisdictions	$640,000.00
			5.17.3.1	Integrate SOC Subsystems	$345,000.00
			5.17.4.1	Integrate New Field Equipment Locations	$2,030,000.00
			5.17.5.1	Integrate Secure Communications to CHART Sites (Secure Communications Infrastructure will be deployed as Part of Project 5.14.1.1)	$630,000.00
			5.17.5.2	Emergency Backup Voice Communications between TOCs and Regional EOCs	$68,500.00
Element 5 Capital Cost Estimate					**$42,071,500**

Element		Objective	Project		Cost ($)
6	Emergency and Weather Operations	4 - Enhance CHART's ability to monitor travel conditions during inclement weather.	6.4.1.1	Deploy Additional Roadside Weather Stations	$500,000.00
			6.4.2.1	Deploy Replacement Roadside Weather Stations at Existing Locations	$1,140,000.00
		7 - Enhance CHART's severe weather and emergency management operations.	6.7.1.1	Deploy CCTV Devices along Evacuation Routes	$2,600,000.00
			6.7.1.2	Deploy Traffic Detection Devices along Evacuation Routes	$3,600,000.00
			6.7.4.1	Deploy Traffic Management Infrastructure along Evacuation Routes	$9,350,000.00
		14 - Enhance and expand transportation security measures to better protect systems and infrastructure against attacks and unauthorized usage.	6.14.1.1	Deploy Security Monitoring Equipment at Field Device Locations	$3,250,000.00
			6.14.2.1	Deploy Security Monitoring Equipment at Critical Infrastructure Locations	$2,760,000.00
Element 6 Capital Cost Estimate					**$23,200,000**
LRSDP Total Capital Cost Estimate					**$302,865,500**

Appendix D – Project Definitions and Project Cost and Deployment Schedule

This Appendix is intended to provide CHART management staff with a set of deployable projects to meet the functionality described in the CHART LRSDP Strategies and Objectives. Due to the large size of Appendix D – Project Definitions, it is not included in this primary document and, therefore, available upon request from CHART.

These project profiles provide the Coordinated Highways Action Response Team (CHART) staff a "menu" of projects that can be used to plan its deployment program over a period of approximately twenty years. Projects are organized by CHART "Objective."

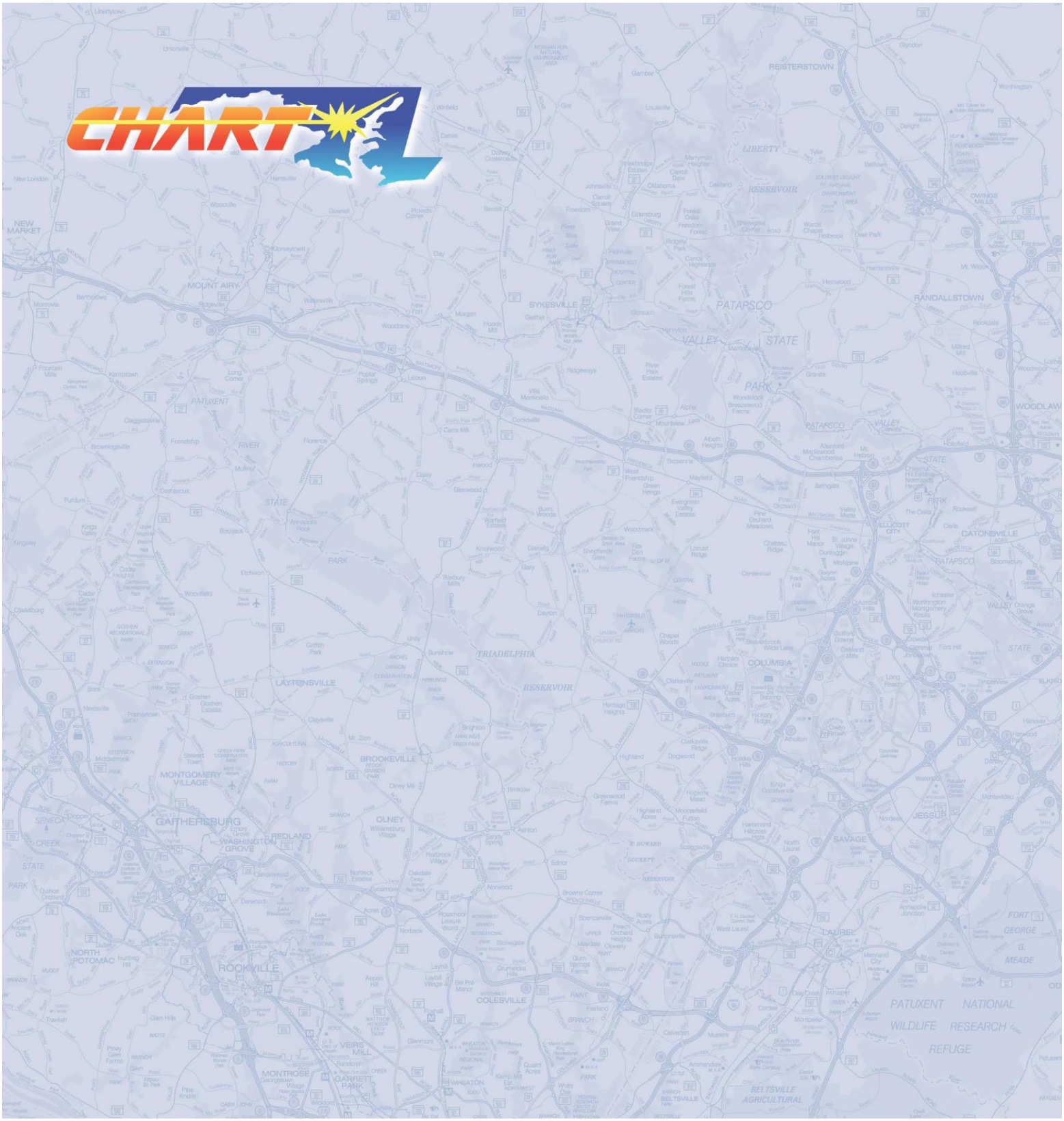
Project Cost and Deployment Schedule

The Project Cost and Deployment Schedule identifies deployment phases of each project and associated costs per phase broken down by fiscal year. This schedule will enable CHART to identify the total estimated funding need per fiscal year for planning purposes and enable CHART to identify projects for deployment that fits its internal annual budget.

Each project is profiled in relation to the following parameters, below:

- **Project Description** – Provides detail on what will be implemented through the Project.
- **Benefits** – Presents qualitative benefits that will be realized through the implementation of the Project.
- **Project Scale** – Describes the level or extent of what the Project will implement. Can be described using measures such as geographical deployment areas, types of roadways, or number of devices.
- **Technologies** – Defines the technologies that will be implemented through the Project, as well as other technologies that will influence the implementation of the Project.
- **Cost** – Presents the estimated cost to implement the Project. (Note: leased communications necessary to operate additional CHART deployments are identified within the Project definitions. These recurring communications costs are included to assist CHART in more specifically identifying costs for these Projects.)
- **Related Strategies** – Provides corresponding Strategies that either will support the deployment of the Project, or be supported because of deployment of the Project.

- **Project Dependencies –** Lists Projects that are interdependent, where it is not feasible (or rational) to deploy the subject Project as a standalone project.
- **Cost Estimate Assumptions** – Presents assumptions that were used to develop the Project cost estimates for Capital, Annual Recurring, and Annual Operations & Maintenance (O&M) Cost.
- **2008 NCDP Reference** – Provides the linking Project number from the 2008 NCDP. If the Project is introduced by the LRSDP (i.e., was not in the 2008 NCDP) the Project is labeled as "New."
- **Deployments –** Identifies the potential phases of project deployment and the allocated budget for each phase.



SHA State Highway Administration
Maryland Department of Transportation

Martin O'Malley
Governor

Anthony G. Brown
Lt. Governor

Melinda B. Peters
State Highway Administrator

James T. Smith
Secretary of Transportation

Leif A. Dormsjo
Deputy Secretary for Planning and Project Management

Wilson H. Parran
Deputy Secretary for Administration and Operations