Hill International

Review and Analysis of Proposed New Haven Rail Maintenance Facility Expansion Project

Table of Contents

Review and Analysis of Proposed New Haven Rail Maintenance Facility Expansion Project

Executive Summary

Hill International, Inc. (Hill) was retained by the State of Connecticut's Office of Policy & Management (OPM) to review and analyze the scope, cost, and budget of the State of Connecticut Department of Transportation (CDOT) New Haven Rail Maintenance Facility Expansion Project. The study was initiated due to concern that the original budget estimate for the project in June 2002 of $331 million Total Program Costs (TPC) was re-estimated in March 2008 at $1.187 billion (3/31/08 Program). Hill's findings and recommendations are as follows:

CDOT Budgets and Estimates

- The 2002 fleet study, used as the basis of the June 2002 estimate of $331 million TPC, was a very preliminary planning study, and inadequate for establishing a project budget.
- Scope increases account for approximately 18 percent of the current estimated costs. In addition, approximately 13 percent of current costs are related to a more definitive, and enhanced, baseline-scope.
- The largest portion of the cost variance between 2002 and 2008 is escalation, caused by an expanded schedule along with dramatic increases in construction cost escalation rates since 2002. Overall, escalation accounts for approximately 32% of the 3/31/08-estimated costs.
- The methods used by CDOT in developing the program TPC estimates have varied considerably between 2002 and 2008, and account for a very large portion of the variance over time.
- No system of configuration control is currently being used. No documentation was found related to a budgetary control mechanism that identifies and tracks elements such as "out-of-scope" items.
- Hill recommends that CDOT consider the following
    - Development of written standardized procedures for the preparation of estimated construction costs and other associated costs for the roll-up of overall program costs. Procedures for handling escalation costs are of particular importance.
    - The use of a program contingency when program budgets are established based upon preliminary planning or design documents.
    - Development of a configuration management system associated with overall program budgets. Elements comprising the scope for a specific budget should be clearly identified and tracked.

Current Program Costs and Cost Containment

- Hill prepared a check estimate of the 3/31/08 Program, including an evaluation of out-year cost, that totals $1.336 billion. This is $150 million higher than the comparable CDOT 3/31/08 Program estimate of $1.187 billion.
- A cost containment proposal was developed based on a functional analysis of the maintenance and operational needs of the rail-yard. After discussion with CDOT and Metro North Railroad (MNR), general agreement was reached on most of the elements of a revised program (proposed 12/05/08 Revised Program), estimated at $1.08 billion. The major revisions are as follows:
    - Upgrade of the existing Interim Running Repair shop as an alternative to building the proposed new Service & Inspection shop.
    - Procurement or lease of an offsite conventional warehouse as an alternative to the proposed onsite High Density Warehouse.
    - Procurement or lease of an offsite at-grade parking facility as an alternative to an onsite Parking Garage.
    - Scaling down the modification work of the proposed Paint & Heavy Repair shop slated to be housed in the existing CSR Shop.
    - Scaling down the size and complexity of the proposed Independent Wheel True facility, similar to a facility currently being used at MNR's Harmon Yard.
- Further cost containment is possible, based on a prioritization of the proposed 12/05/08 Revised Program. Hill broke down the program into three tiers, as follows:
    - **Tier 1 Elements** – Baseline need critical for the maintenance operations of the expanded fleet, estimated at $849 million. Includes as its centerpiece the proposed Component Change Out Shop, other necessary shops, and most of the program's yard track work.
    - **Tier 2 Elements** – Enhancements to Baseline need, estimated at $57 million, consisting of the proposed Car Wash Facility.
    - **Tier 3 Elements** – Other elements that can be either deferred or eliminated, as necessary, estimated at $178. Included in this tier are the Fuel Cells, Pedestrian Bridge, EMU/Program Shop Upgrade, Yard Signal System, further scope reduction of the proposed Paint & Heavy Repair Shop upgrade, and the Final Track Completion.
- Hill's functional analysis indicates that all of the Tier 1 elements will be required to provide the necessary maintenance and storage facilities of the proposed expanded fleet. Elements in Tiers 2 and 3 can be either deferred or eliminated, as necessary. Alternately, if only the Tier 1 scope is selected for funding, a large program budget contingency should be used: at minimum $100 million.

Review and Analysis of Proposed New Haven Rail Maintenance Facility Expansion Project

Section I
Introduction and Project Background

A. Introduction

Hill International, Inc. (Hill) was retained by the State of Connecticut's Office of Policy & Management (OPM) to review and analyze the scope, cost, and budget of the State of Connecticut Department of Transportation (CDOT) New Haven Rail Maintenance Facility Expansion Project. Recent estimated costs for the execution of the proposed project greatly exceed the original budgetary estimates originally conceived in 2002.

The principal tasks associated with Hill's assignment were:

- Examine the original work scope and associated budget and critically evaluate the adequacy of the scoping and accuracy of the original cost estimate (Task 2).

- Review the cost estimates developed by CDOT for each phase of the project and determine what was driving the increases in estimated costs, including escalation, changes in scope, design changes, and other factors (Task 3). This task includes the development of an independent cost estimate for the current scope.

- Review the existing scope and recommend ways to reduce project costs (Task 4). This value engineering exercise includes a review of an existing value engineering study performed by Vanasse Hangen Brustlin, Inc. (Task 6).

- Provide budgeting options based on a cost containment analysis (Task 5).

- Conduct a project risk assessment (Task 1) and assess the reliability of out-year cost estimates (Task 7).

B. Project Background

In 2002, an estimate was prepared by CDOT for the expansion and improvement of the New Haven Rail Facilities to support the maintenance, repair, and storage of CDOT's proposed expanded fleet, which was to include the addition of new series of self-propelled electric passenger cars, or M-8 cars. At that time, the estimated cost for these expansion and improvements was approximately $331 million. Over the next several years, as the design of the proposed facilities progressed, the estimated cost greatly increased, with the most recent cost estimate at approximately $1.2 billion.

Briefly, our understanding of the timeline for this cost estimate growth is as follows:

June 2002: CDOT consultant provides a first estimate of $331 million for improvements to the New Haven Maintenance Facility, based on a preliminary study.

June 2004: CDOT informs the state legislature that the project will cost $350 million.

June 2005: CDOT authorizes design activities to begin.

December 2005: CDOT consultant Parsons Brinckerhoff (PB) is selected to provide engineering design; CDOT meets representatives of Metro-North Railroad and the Federal Transit Administration to discuss the scope of the project.

January 2006: PB was authorized to proceed with program refinement and schematic design using its 2002 study as the basis for design of the program.

June 2006: PB's schematic design report, issued at the design's 10 percent completion mark, estimates the cost of the program at $679 million.

June 2006: CDOT splits the program into two separate programs ("Program 1" and "Program 2") to prioritize both funding and construction. Program 1 is estimated to cost $545 million and Program 2 estimated at $230 million, for a total program cost of $775 million.

April 2007 through December 2007: As design continues in development, various program estimates were prepared by CDOT ranging from $688 million to $730 million.

October 2007: Program 1 design packages were at about 60 percent complete and value engineering is initiated among top-level management at CDOT and Metro-North to identify potential cost savings.

February 2008: Final report of value engineering study provided.

March 2008: Program estimate is again revised, with total cost of programs 1 and 2 at $1.187 billion.

April 2008: Discussions of escalating cost of programs continue with state officials, various lawmakers and top-level CDOT and Metro-North officials; construction of first project in Program 1, the M-8 Acceptance Facility, begins.

Review and Analysis of Proposed New Haven Rail Maintenance Facility Expansion Project

Section II
Programming – Functional Scopes

A. CDOT Scoping History

Plans for the New Haven Rail Maintenance Facility Complex project originated during the development of the New Haven Line Fleet Configuration Analysis, published in June 2002. That analysis and resultant report cited the need to overhaul and expand the New Haven Line's existing rail car fleet of M-2 cars, which dated back to the 1970s and were nearing the end of their useful service life. In addition, increased ridership on the line, and a desire for an improved level of service, also pointed to the need for new railcars.

During the course of the Fleet Configuration Analysis, it became apparent that additional maintenance facilities would be required to store, maintain, and repair the proposed expanded fleet. As such, the Maintenance Facilities project became a byproduct of the Fleet Configuration Analysis.

The original Maintenance Facilities Assessment, known as "Task 4" in the June 2002 Fleet Configuration Analysis, called for improvement to existing facilities as well as the addition of new facilities. Such an identification of maintenance needs was fueled by several factors. First, the expanded fleet (new M-8) cars would be introduced in phases while simultaneously retiring some M-2 cars and refurbishing or overhauling others. This created the need for expanded storage as well as adequate facilities to achieve the overhauls. Second, the magnitude of construction, as well as funding stipulations, mandated that phased construction would be necessary. Accordingly, it was critical that the provision of the maintenance facilities was commensurate with the size of the fleet at any given time.

As planning and execution of the fleet expansion plan has evolved since 2002, the size of the expanded fleet, the New Haven Line's operating plans, and the maintenance facilities being constructed have also evolved. This section reviews the maintenance facility program with respect to maintenance needs as they are now known.

B. Functional Scope Analysis Methodology

Hill's methodology for reviewing the scope of facilities needed to support the New Haven Line fleet begins with a review of the Rail Fleet Management Plan[1], as well as the Operating Plan contained in it, which establishes the need for vehicles. These plans, maintained and provided by Metro-North, also form the basis of need for improved storage and maintenance facilities.

Facilities are needed to store vehicles between periods of operation, or "revenue service." They also provide storage of both spare vehicles and vehicles queued for the shop. The operating plan is used to evaluate how much storage is required at each location. The operating plan also

[1] Metro-North Railroad Rolling Stock Plan December 2006, MTA Metro-North Railroad, December 15, 2006.

provides details on the number of cars that need daily servicing to continue routine rail operations.

The need for each of the maintenance facilities is by utilization. The term “Maintenance Facility” is used in this section to describe any facility that is used to provide periodic servicing (not daily servicing) and inspection, scheduled preventative maintenance, programmed modifications, and unscheduled repairs of all types.

Programming rail car facilities depends, primarily, on meeting four basic operating needs: 1) Storage, 2) Servicing, 3) Inspection, and 4) Maintenance and Repair. Storage refers primarily to track space for trains that are between revenue service periods, although consideration is also given to yard space requirements for spare cars and cars that are out-of-service for maintenance. Shop space is sized to take into account all programmed and mandated maintenance, along with provisions for unscheduled maintenance based on empirical knowledge or past experience.

The following subsection discusses the evolution of the New Haven Line fleet in both size and composition. It also describes the features unique to each vehicle class that impose both requirements and limitations on the facilities.

The remaining subsections will each discuss one of the four operating needs for rail car support: Storage, Servicing, Inspection, and Maintenance and Repair. In each subsection, the evolution of the support facilities is described, beginning with the existing facilities, continuing to the facilities outlined in the 2002 Fleet Configuration Analysis, and finally presenting the improvements as currently proposed for the New Haven Facilities Improvement program.

Hill has analyzed the program improvements and compared each to the facilities needed to support the fleet as planned. A discussion of differences between the programmed needs and the strategies to accomplish those needs is included in each subsection.

1. New Haven Line Fleet

1.1 Fleet Characteristics

The New Haven line is a four-track, high-density passenger railroad that originates in Grand Central Terminal in New York City and operates for the first 14 miles using 700-volt direct current provided by a third rail. The remainder of the main line through to New Haven is electrified using a 12.5-kilovolt overhead catenary system. There are three branch lines off the main line. One of these three branch lines is electrified, and the other two use diesel-powered trains.

CDOT also operates a service called the Shore Line East (SLE) on the Amtrak Northeast Corridor line from New Haven to Old Saybrook. The SLE is a two-track main line which has recently been electrified using a 25-kilovolt overhead catenary system but is currently operated in commuter service using diesel-powered trains.

1.2 Existing Fleet

The existing fleet serving the New Haven line is split into two main categories: diesel-powered trains and electric multiple unit (EMU) trains. Although the primary thrust of the New Haven maintenance improvement project is to service the needs of the EMU fleet, consideration for the storage, servicing, and maintenance of the diesel fleet also is needed.

1.3 Diesel Fleet

There are two predominant types of locomotives in the New Haven line diesel fleet. CDOT owns several General Electric-built Genesis locomotives that are equipped for dual mode service, which means they can operate in “through-train operation”, that is operation through into Grand Central Terminal using the electrified third rail system. The second type of locomotive is diesel powered only, and is used in shuttle services on the branch lines and for the Shore Line East.

Trains for Shore Line East are currently maintained by Amtrak, acting as CDOT’s contractor, at the Diesel Shop in the New Haven Rail Yard. Diesels used on the New Haven line west of New Haven are taken from the pool of Metro-North-owned and CDOT-owned locomotives, and are maintained by Metro-North at Croton-Harmon, New York.

The passenger car fleet on the New Haven line consists of single-level coaches and cab control cars. The fleet used is similarly distributed between the pool of diesel fleet cars maintained by Metro-North at Croton-Harmon and a fleet maintained by Amtrak at New Haven for Shore Line East service. The cars in the Metro-North pool are Bombardier-built aluminum-bodied coaches, in both end-door and (more recently built) center-door versions. The cars maintained by Amtrak at New Haven include 17 Bombardier coaches and 33 stainless steel-bodied, end-door coaches originally built by Mafersa. The Mafersa-built cars are known as VRE cars since they were originally built for the Virginia Railway Express rail commuter service.

1.4 EMU Fleet

The EMU fleet consists of three classes of electric multiple-unit cars arranged as married pairs or triplets. A married pair consists of two cars semi-permanently coupled together with a cab at each end that share common equipment. A triplet consists of three cars semi-permanently coupled together with a cab at each end that share common equipment; the center car has no cab. All New Haven line EMU cars operate from both third-rail and 12.5-kilovolt AC power supplied by the overhead catenary system

The M-2 fleet consists of 240 cars built in the 1970s by General Electric and arranged as married pairs. The M-4 fleet consists of 54 cars built in 1987 by Tokyu Car and arranged as triplets. The M-6 fleet consists of 48 cars built in 1996 by Morrison-Knudsen and also arranged as triplets. Combined, the M-4 and M-6 fleets include 102 cars as triplets.

The M-2, M-4 and M-6 fleets share a common train line and coupler, and are interoperable. These cars also use similar trucks and propulsion systems. Specifically, the propulsion system is essentially two propulsion systems on the same car, one for DC operation and the other for AC operation. The trucks use a 32-inch diameter wheel with tread braking. The traction motors are DC-type motors.

Since an EMU car has propulsion equipment and a control cab, it is considered a locomotive under federal regulations. These federal regulations prescribe the minimum maintenance standards for locomotive maintenance. Working with Federal Railroad Administration, Metro-North has developed a maintenance program under which the existing fleet is inspected every 60 days. Major maintenance is scheduled on an annual cycle and triennial cycle.

1.5 Future Procurement

Following recommendations made in the Fleet Configuration Analysis of June 2002, Metro-North and the CDOT are procuring a new fleet of EMU vehicles designated as M-8. The base order for this procurement is 300 vehicles arranged in married pairs. The exercise of contract options will increase this order to 380 vehicles, including 12 cars to be fitted out as bar cars to replace the existing M-2 bar cars.

The M-8 fleet will not share a common train line or coupler with the existing fleet and can only be operated with this fleet in an emergency mode. Since compatibility is not a requirement, the M-8 fleet can use and take advantage of newer technologies such as network train lines and AC propulsion. The AC propulsion system is the latest technology and offers the New Haven fleet several advantages. First, the AC propulsion system is the only propulsion control system on the car, which negates the need for a complex overlay of systems such as that used on the existing New Haven fleet. Power supplied by either the third rail or the AC overhead catenary system are separately conditioned and provided to the AC propulsion system input. The output of the AC propulsion system is a variable-voltage, variable-frequency power supplied to the AC traction motors. Alternating current traction motors do not have the carbon brushes and open commutators that are found in DC motors and which are maintenance-intensive and a significant source of failures. Second, the trucks are designed to use the larger 36-inch wheel and have disk brakes in addition to tread brakes. Both of these factors significantly reduce the thermal load on the wheel, which can result in less breakage, less maintenance, and longer wheel life. Last, most of the systems on the car are operated by and continuously monitored by computer controls.

The M-8 fleet also differs from the existing fleet in that it can utilize 25-kilovolt power in addition to the 12.5-kilovolt and third-rail power used by the existing fleet. This allows the M-8 fleet to operate on the entire line from Old Saybrook to Grand Central Terminal, and will eliminate the need for diesel powered trains east of New Haven.

Since it utilizes similar technologies, the M-8 is expected to require maintenance and inspection on the same intervals as the existing Metro-North M-7 fleet. The M-7 fleet undergoes periodic inspection on a 92-day interval, with major maintenance on an annual cycle and a 5-year cycle.

1.6 M-8 Fleet Roll-Out

The roll-out of the M8 fleet and subsequent retirement of the M-2 fleet is shown in the following table. During the transition from M-2 to M-8, the fleet size will increase slightly, since the M-2 fleet will only be retired once the M-8 fleet has achieved adequate reliability. Ultimately, the plan is to retain 30 M-2 cars as a reserve for potential ridership increase.

The M-4/M-6 fleet will not be affected by the M-8 rollout. However, the long-term plan is to expand the M-8 fleet and replace the 102 cars in the M-4/M-6 fleet and 30 cars in the M-2 fleet with a new cars that are compatible with the M-8 fleet. It is anticipated that, in the long term, the fleet could be as large as 536 cars.

Quarter	M2/M4/M6 Fleet Size	Cumulative M-2 Retirements	M-8 In-Service	Total Active Fleet
3Q2009	340	0	0	340
4Q2009	340	0	0	340
1Q2010	340	0	8	348
2Q2010	340	0	16	356
3Q2010	340	0	34	374
4Q2010	340	0	80	420
1Q2011	340	0	110	450
2Q2011	314	26	146	460
3Q2011	282	58	178	460
4Q2011	246	94	214	460
1Q2012	210	130	250	460
2Q2012	174	166	286	460
3Q2012	138	202	322	460
4Q2012	132	208	346	478
1Q2013	132	208	350	482
2Q2013	132	208	350	482
3Q2013	132	208	350	482
4Q2013	132	208	350	482
2014	132	208	370	502
2015	132	208	380	512

Table II-1 Fleet Roll-Out and Retirement

2. Storage Yards

2.1 Current Operation

Storage yards are used to store train consists between revenue service periods. The yards are ideally sized to accept the entire train without uncoupling.

On the New Haven line, there are four storage yards to serve the EMU fleet. They are located at New Haven, Bridgeport, Stamford and Grand Central Terminal. Diesel-powered trains can also lay over at these storage yards, as well as at smaller yards in non-electrified territory, such as at Danbury. The size of the New Haven storage yards is directly related to its job as an overnight storage yard.

The primary EMU storage facility at New Haven is called the “60s Yard,” and consists of nine tracks with a total capacity of 123 cars. This yard has just enough capacity to support the existing fleet. The diesel fleet, spare cars, and cars awaiting repair are stored on other smaller tracks throughout the facility.

The yard at Bridgeport is located adjacent to the existing Bridgeport Maintenance-of-Way Facility, and currently has a capacity of 73 cars on five tracks. There are no maintenance facilities at this location.

The yard at Stamford has a capacity of 158 cars, and is served by a maintenance shop. The Stamford Yard also has an exterior car wash.

Grand Central Terminal is also used for overnight lay over for early morning departures in the off-peak direction. For practical purposes, the storage capacity of Grand Central Terminal is not limited. There is no maintenance facility at this location.

2.2 2002 Proposal

The 2002 fleet configuration analysis cited the need for additional storage yards at New Haven. Specifically, the analysis recommended an EMU storage yard with a capacity of 72 cars, consisting of six tracks to hold 12 cars each. A recommendation also was made for a diesel fleet storage yard that would include ten tracks of five cars and one locomotive per track, for a total of 60 vehicles.

2.3 2006 Program

The current facility improvement program includes the construction of additional storage tracks at New Haven. This project is called the West End Yard project (part of Program 1A). The storage yards to be built as part of this project include five tracks with a total capacity of 45 vehicles for diesel fleet and six tracks with a capacity of 66 cars for the EMU fleet.

In Program 2, the yard is to be expanded, with additional storage tracks for both the diesel fleet and the EMU fleet. This project is called the Final Track Completion project.

In another ConnDOT program, the capacity of the yard at Bridgeport will be increased by the electrification of an additional four tracks, which will increase its capacity from 73 to 119 cars.

2.4 Facility Requirements

As mentioned earlier, the sizing of a storage yard is dependant upon the number of trains, and the total number of cars, to be stored. The plans and schedule reviewed are the March 2008 program.

Details used to determine the number of trains and cars is found in the New Haven Line Cycle Sheets. Hill reviewed two suites of cycle sheets. The first was included in the 2006 Metro-North Rolling Stock Plan and a second was prepared and presented during Summer 2008[2].

The Metro-North Rolling Stock Plan included cycle sheets that began with Fall 2006 and continuing annually through 2012, and then for every fifth year beginning with 2015 and continuing to 2030. The cycles were based on the ridership projections in 2006 and the presumed purchase of 342 M-8 cars.

The suite of cycle sheets reflecting the summer 2008 timetable recognized the current procurement of 380 M-8 cars, as well as the demands on the fleet and the storage yards during the phased construction at New Haven. The periods modeled were Summer 2008, Summer 2010, April 2012, and Late 2013, which coincides with the completion of the M-8 car delivery. This plan also recognizes the construction of additional yard tracks at Bridgeport. For this analysis, it was calculated that the West End Yard is to be completed in 2012.

[2] The document titled M-8 Implementation Plan was a handout at a joint CDOT – Metro-North meeting on July 11, 2008.

The table that follows summarizes the yard storage requirements at the New Haven. It does not include the additional storage requirements at Stamford and New Haven for spare cars or for cars awaiting shop time.

Yard		Apr-08	Jul-10	Apr-12	Dec-13
New Haven	EMU	105	113	115	126
	Diesel	32	22	22	0
	Trains	22	21	20	18
	Spots*	123	123	188	188
	Surplus	18	10	73	62
Bridgeport	EMU	46	73	85	92
	Diesel	0	0	0	0
	Trains	6	9	10	10
	Spots	73	119	119	119
	Surplus	27	46	34	27
Stamford	EMU	97	100	130	134
	Diesel	7	0	0	0
	Trains	17	16	18	18
	Spots	158	158	158	158
	Surplus	54	58	28	24
Grand Central Terminal	EMU	20	42	56	56
	Diesel	7	0	0	0
	Trains	4	6	7	7
	Spots**	27	42	56	56
	Surplus	0	0	0	0
New Haven Line	EMU	268	328	386	408
	Diesel	46	22	22	0
	Trains	49	52	55	53
	Total Vehicles	314	350	408	408
	Total Spots	381	442	521	521
	Surplus	67	92	113	113

Note: * At New Haven only EMU spaces are shown.
** At GCT, the number of available spots is equal to the number of required spots.

Table II-2 New Haven Storage Yard Requirements

The trend at New Haven is for fewer trains of a longer length. The actual number of trains dispatched from New Haven decreases from 22 in the current cycle plan to 18 in the 2013 plan. However the number of EMU vehicles in the yard increases from 105 to 126. As stated earlier, the 60s Yard has a capacity of 123 cars on nine tracks and takes advantage of the fact that several tracks can handle two trains of the existing train lengths. With the increase in train size this will, in general, no longer be the case. The six tracks proposed as part of the West End Yard project all have a capacity of at least ten cars, which will provide storage for the longest trains anticipated. The result is that all trains proposed in 2013 cycle plan can be accommodated in these 15 tracks, assuming that a few of the longer tracks in the 60s Yard are used for two trains.

The West End Yard plan also includes five tracks for diesel-powered trains. There are currently six diesel-powered trains dispatched from New Haven. Each of these diesel-powered trains, with one exception, is a shuttle train with four cars or less. The number of diesel trains will decrease to two by 2013. This plan does not acknowledge, however, that the diesel powered service may be instituted between New Haven and Hartford. It also provides for only five of the ten tracks contemplated in the 2002 program. Without consideration of the proposed Hartford service, the five proposed tracks are adequate in the long term for the diesel fleet trains.

As part of the phasing plan, it was planned that the M-8 Acceptance Facility site (a Program 1A project) would be relocated to four tracks in the new West End Yard. Through the 2013 cycle sheet, the possible loss of use of these tracks does not adversely affect the required yard capacity for storage of trains. During the development of this site, some diesel trains may need to be stored in the electrified tracks until Shore Line East services are fully electrified. Upon completion of the M-8 acceptances, there should be ample train storage without the additional tracks proposed for Phase Two.

2.5 Current Program

The current development plan differs from March 2008 plan in that the six EMU storage tracks are to be built on the footprint of Building 10 which currently houses storeroom, support shop, and training facilities. Since many of these facilities are to be relocated into the Component Change Out Shop (CCO), demolition of Building 10 can not be done until the CCO is completed and in service. The entire order of M-8 cars will be delivered prior to the completion of the CCO making the timing of the completion of these storage tracks not related to the delivery of the M-8 cars.

In the interim, Metro-North will use a facility called the “Boneyard”, constructed as a temporary storage yard between 2002 and 2006, to store extra cars on site. Under a separate program, CDOT is funding Metro-North’s construction of 4 additional storage tracks at Bridgeport. Metro-North presented a plan which uses these two storage facilities, along with some utilization of the New Haven Station platform tracks, to provide the necessary storage facilities to handle trains in service as well as spare cars.

3. Servicing

3.1 Routine Servicing

Routine servicing of the EMU trains consists of daily collection of trash and light cleaning, daily exterior and interior inspections, and dumping the toilets. The 60s Yard, which is the existing EMU storage yard, is equipped for toilet dumping at all locations. Cars are scheduled for toilet cleaning at every visit to this facility. The tracks in the EMU portion of the West End Yard are also to be equipped with toilet dumps. There will also be roadways between every other track to facilitate servicing and collection of trash.

The diesel portion of the West End Yard is equipped with lay over power connections to maintain heat and light in the train while the diesel engines are shut down. This scheme reduces noise and saves fuel. There are also drip pans under the locomotive layover spots.

The construction of gravity toilet dumps is an expensive construction feature. It is recommended that the life-cycle cost of constructing gravity toilet dumps be compared with the cost of procuring and using a service vehicle to dump the toilets and having a single discharge

point for unloading this service vehicle. The comparable costs are the construction and periodic cleaning of the fixed gravity toilet dumps as compared to the purchase of a vehicle and its maintenance and periodic replacement. The cost of operating the vehicle is not a factor since, with or without the vehicle, there is a need for a worker to go from toilet to toilet to service them. However, it must be noted that gravity toilet dumps are standard facility in Metro-North yards and are used in the 60s Yard at New Haven, at Stamford, and at Metro-North facilities on the Hudson and New Haven Lines in New York State. Metro-North is insistent on this detail.

3.2 Servicing and Inspection

On Metro-North, the term "Servicing and Inspection," or "S&I," is used to describe the maintenance activities conducted in conjunction with Federal Railroad Administration-mandated inspections. "Servicing" by the more common definition is the routine servicing activity described above, which is performed on a daily basis in the storage yards.

"Servicing and Inspection" describes the inspection, testing, and routine maintenance conducted on a scheduled interval. Routine maintenance tasks include filter changes, lubrication, and testing of other subsystems not specifically mentioned in the FRA regulations.

The maintenance facility requirements for S&I is a configuration that will allow good access to all under-floor and roof-mounted equipment. Married pairs need to be uncoupled from other married pairs on the same track to check couplers. Access is needed to the interior of the car to inspect and test communications equipment, heating and cooling equipment, door systems, and cab equipment. A source of auxiliary power to energize the on-board systems also is required. Shops with raised rail track, including center pits and car-level and roof-level access platforms, are often provided for this work.

Currently the M-2/4/6 fleet is scheduled for S&I on a 60-day cycle, which results in six scheduled visits per year. The plan is that the M-8 fleet will use the same 92-day cycle that is followed by the M-7 fleet. This longer service interval is the result of the increased reliability that is available with the newer technologies. The computer-controlled systems on the M-8 fleet continuously monitor the health of the on-board subsystems. Digital computers are controlled by parameters in their software, and do not require the same periodic testing and adjustment that older technologies require. The end result is not only fewer scheduled visits per year but also less work at each visit.

Although the new fleet is expected to need less work overall and at each scheduled visit, it is assumed that three shifts of labor will continue to man the shop. Three shifts will allow for the completion of minor repairs found during inspection, for interior cleaning, and for movement of the cars in and out of the building. Once per year, per federal regulation, additional items must be inspected or replaced. For the annual inspection, which coincides with a scheduled periodic S&I activity, an additional three-shift dwell is anticipated. If additional scheduled or unscheduled repairs are needed, this work would be performed in the component change-out shop or another shop.

The following table shows average daily inspections for the fleet at five different time periods. It is assumed that scheduled inspections are conducted five days each week, for a total of 250 days per year (allowing for holidays).

	Shifts per Year				Average Inspection Spots			
Year	M-2	M-4/6	M-8/10	Total	M-2	M-4/6	M-8/10	**Total**
2008	5278	2243	0	7521	7.0	3.0	0.0	**10.0**
2010	5278	2243	788	8309	7.0	3.0	1.1	**11.1**
2012	660	2243	5072	7975	0.9	3.0	6.8	**10.6**
2014	660	2243	5828	8731	0.9	3.0	7.8	**11.6**
2020	0	0	8442	8442	0.0	0.0	11.3	**11.3**

Table II-3 Inspections Per Fleet, Per Year

At the time of the 2002 Fleet Configuration Analysis, the only S&I facilities available on the New Haven line were one, three-car track at Stamford and one, four-car track in the MU Shop at New Haven. Adjacent to the MU Shop at New Haven was a two-track Blow Shed, which was used to maintain DC traction motors and other DC motors on the cars. In this shop, the access covers were taken off the DC motors to inspect and change the carbon commutator brushes and to blow out carbon dust from the motor, an activity not done on AC motors.

The 2002 Fleet Assessment, prepared with input from the Yard and Shops Committee, recommended a service and inspection shop consisting of two tracks, each 2 car lengths long, for total capacity of 24 cars. A two-track blow shed, three cars in length, was recommended on the approach to the S&I facility. However at that time, the characteristics of the new fleet were not yet known.

The May 2006 Engineering Report notes that a blow shed would no longer be needed for the M-8 fleet due to the AC motors. The proposed S&I facility was reduced in length from 12 cars to 10 cars due to site constraints. It was anticipated that all cars would receive inspection on a 60-day cycle. At the same time, the Interim Running Repair Shop (IRR) was under construction with two tracks, each six car-lengths long, for a total capacity of 12 cars. The report describes that "the (IRR) shop is being constructed to address the near-term deficit in shop facilities prior to completion of the entire program of improvements." The shop was built with raised rail and pits but without side platforms and roof platforms. It also did not have overhead cranes to service roof-top equipment, except for six jib cranes that were used to service the roof-mounted pantographs.

Reviewing the requirements for S&I, there is space available at Stamford for either a married pair or a triplet. There are also 12 spaces available in the IRR. Per the table above, the maximum average requirement for S&I is 11.6 cars. This requirement is higher in 2014 than 2020 since the M-2/4/6 cars continue to be inspected on a 60-day cycle instead of the 92-day cycle used for the M-8/10 cars. Hill recommends that this requirement can be scheduled using the IRR and one track at Stamford.

As noted in the May 2006 Engineering Report, the blow shed is not needed. Hill also contends that the 20-car capacity S&I shop also is not required or justified by the anticipated long-term workload. With the availability of Stamford and the IRR facility, Hill recommends that the S&I facility be deleted from the work scope.

Hill also recommends that CDOT investigate and install systems to improve the efficiency of the inspection process at the running repair shop, if it is to be used as the permanent S&I shop. Hill's recommends improvements such as are roof-level platforms, additional portable work platforms for access to the car interior, and powered scissors-lifts for additional access to roof-mounted equipment. A monorail crane over each track would be desirable if the building

structure can accommodate it. Since the interim running repair shop is a pre-engineered building structure and this load was not anticipated during design, the building will need significant strengthening to accommodate the added load.

4. Maintenance and Repair

4.1 Maintenance Approach

The characteristics of the vehicle define the maintenance and repair tasks required, and the approach to performing these maintenance tasks defines the facilities required. However, the facilities that are available also have an impact on the approach to maintenance. Therefore, the maintenance approach and the facilities needed for that maintenance need to be jointly optimized.

Before reviewing the adequacy of the planned maintenance facilities, Hill began with by defining the maintenance tasks that need to be accomplished. Routine tasks, beginning with daily cleaning and servicing through periodic servicing and inspections, have been discussed in earlier subsections. All of these activities are geared toward maintaining the vehicle in service.

However, as with all equipment, there are times when worn components need to be replaced and when failed components need to be repaired. These activities also constitute maintenance, in that they are performed to maintain the vehicle and its service. The difference between maintenance and repair is defined as whether the component was replaced before failure (preventative maintenance) or has failed in service (repair). The facilities required to perform either preventive maintenance or repair are, in the case of railway vehicles, the same facilities. The decision to replace components as part of preventative maintenance or to replace on failure is an economic decision that is made weighing the cost of the failure, the cost to repair, and the disruption to operations due to unscheduled versus scheduled work.

Metro-North has embarked on a program called Reliability Centered Maintenance, or RCM. This program does, in fact, attempt to predict the useful service life of a component and to schedule that component for replacement or re-build before the component fails. Shop space needs to be provided to perform this scheduled component replacement work. Similarly, components that fail in-service or during inspections are found to need maintenance also require shop space for their replacement. The shop facilities required are the same, and the overall space requirements and out-of-service time are better controlled with scheduled work as compared to unscheduled repairs. There is a balance to be found, however. If there is a good preventative maintenance program, the vehicle will spend more scheduled time in the shop and less in unscheduled repair. Where preventative maintenance is not a priority, the total time of scheduled maintenance may be less, but unscheduled maintenance is more frequent and typically results in more out-of-service time.

The methodology used to review the adequacy of the facilities proposed at the New Haven Rail Yard attempted to model the experience of the existing fleet as well as the expected maintenance requirements of the proposed fleet. The Critical Systems Replacement (CSR) program on the existing fleet is an attempt to start an effective preventive maintenance program for the fleet; however the data available is the current performance of the fleet. An effective RCM program would make this a conservative estimate. For the proposed M-8 fleet, the estimated maintenance requirements are taken from the experience of the Metro-North M-7 fleet, since the technology being employed in the M-8 fleet is similar. The maintenance experience of the current EMU fleet is not a good predictor of the expected maintenance

requirements of the M-8 fleet since it neither reflects an effective RCM program nor the maintenance requirements of the new technology used on the M-8 fleet. The assumption used in the 2002 and 2006 reports is that the maintenance requirement for the new cars will replicate the maintenance requirement of the existing fleet. Using the current New Haven Line fleet data would significantly overstate the expected maintenance requirements of the new fleet and therefore overstate the maintenance facilities required.

4.2 Maintenance Tasks

The maintenance tasks that need to be performed at New Haven are:

- Running Repair
- Component Change-Out
  - Truck Change-Out
  - Under-floor Equipment Change-Out
  - Roof-mounted equipment Change-Out
- Wheel Truing
- Heavy Repair

4.2.1 Component Change-Out

The centerpiece of the expanded New Haven Rail Yard improvement program is the Component Change-Out shop (CCO). It is proposed that this shop has three tracks, with car hoist equipment that can handle two married pairs on each track. An additional hoist will be added to one of the sets of hoists to enable a triplet to be hoisted for repairs. The shop will be equipped with roof-level platforms and overhead cranes. Turntables and release tracks at floor-level will allow trucks to be moved to the truck shop on the first floor of this building. The cranes and the roof-level platforms are arranged with a mezzanine to facilitate handling the pantographs and roof-mounted air conditioning units of the M-8 fleet. Lift tables can be used to remove under-floor equipment. Forklift trucks can operate at all locations on the shop floor. This facility is capable of accomplishing all routine maintenance on the EMU fleet.

Metro-North has expressed a preference for performing, in the CCO shop, all maintenance on the EMU fleet beyond that done on a scheduled S&I visit. This would include all troubleshooting and interior sub-system work. While it is possible to do running repairs either in the interim running repair building or in the MU Shop, CDOT's planning should take into account that the CCO shop is scheduled to accomplish all of this work.

4.2.2 Truck Change-Out

Wheel-set replacement and truck maintenance is currently performed one wheel-set at a time. Complete truck change can only be done in the CSR shop or at Stamford. A truck repair shop is included in the proposed component change-out shop. The use of the car hoist system there would allow for the rapid change of truck assemblies. Once the trucks are removed, they can be moved to the truck shop using a system of turntables and release tracks.

4.2.3 Under-floor Equipment Change-Out

The change out of under-floor equipment can be quickly accomplished using the car hoist system. Once the car is lifted in the air, mechanics have easy access to under-floor equipment. Once the equipment is disconnected, it can be lowered from the car using a lift table. Forklift trucks then can be used to remove the defective component and to place a replacement

component onto the lift table. Shop mechanics then lift the component in place and reinstall it on the car.

The advantage of using the car hoist for replacement of under-floor equipment is ease of access both for the mechanics and for material handling. The new fleet also is being configured for replacement of subcomponents rather than repair on the car. The combination of these factors is expected to reduce the mean-time-to-repair, which will reduce the expected shop dwell time.

4.2.4 Roof-mounted Equipment Change-Out

The component change-out shop is equipped with overhead cranes that will be able to access both the pantographs and the roof-mounted air conditioning units on the M-8 cars. Since these units are bulky but relatively light, a mezzanine is provided to handle and store these components. The shop space to maintain the components also is nearby. Again, since the M-8 car uses a roof-mounted air conditioning unit, the mean-time-to-repair is less than that spent on maintaining a split air conditioning system as found on the M-2/4/6 fleet. Roof-mounted air conditioning units can be repaired and re-qualified separate from the car, which will eliminate the handling of refrigerant on the shop floor. This, in turn, also reduces the shop dwell time.

4.3 Support Shops

Metro-North has stipulated that all scheduled and unscheduled repairs should be done in the component change-out shop. Hill evaluated whether the component change-out shop has the capacity to support the entire New Haven Line fleet.

Currently, the repair work that will be performed at the component change-out shop is done at four separate locations: the MU shop, the CSR shop, the IRR shop, and Stamford. The CSR shop is now engaged in a scheduled change-out of major subcomponents on the M-2 fleet. It is anticipated that the CSR shop will continue with similar programs on the M-4 and M-6 fleets, meaning that it will be busy with this work through the commissioning of the component change-out shop. All other scheduled and unscheduled repairs and component changes will be done in the MU shop.

Hill created an estimate of the number of visits that each vehicle would need to make for scheduled and unscheduled repairs. Based upon data provided by Metro-North, Hill has estimated that the current EMU fleet underwent an average of 10.9 unscheduled visits per car per year, in addition to its six scheduled visits. Hill also looked at the M-7 cars, which are being used to estimate the M-8's performance, and estimated that they underwent an average of 2.2 unscheduled visits per car per year, in addition to the four scheduled visits. The average shopped dwell per visit is estimated at a duration of two shifts.

Scheduled component change-out for the existing fleet consists of the CSR program and a triennial truck change. No further scheduled work is anticipated, since the cars are scheduled for retirement. For the M-8 fleet, it is assumed that ten shifts per year are dedicated to scheduled major subcomponent change-out or other fleet modifications. In addition, truck change is scheduled after five years of service.

Applying these estimates to the planned fleet and the available shop space, the shop utilization is estimated as shown in the table below:

	Shifts per Year				Average Spots			
Year	M-2	M-4/6	M-8/10	Total	M-2	M-4/6	M-8/10	**Total**
2008	8542	3416	0	11958	8.1	3.3	0.0	**11.4**
2010	5518	6272	830	12620	5.3	6.0	0.8	**12.0**
2012	690	6272	5346	12308	0.7	6.0	5.1	**11.7**
2014	690	3416	6142	10248	0.7	3.3	5.8	**9.8**
2020	0	0	8898	8898	0.0	0.0	8.5	**8.5**

	Spots Utilized for Component Change						
	MU Shop	CSR	IRR	CCO	Stamford	**Total**	Notes
2008	7.4	4.0				**11.4**	4 spots: M-2 in CSR
2010	9.3	2.7				**12.0**	2.7 spots: M-4/6 in CSR
2012	0.7	2.7		8.3		**11.7**	2.7 spots: M-4/6 in CSR
2014	0.7			9.1		**9.8**	
2020	0.0			8.5		**8.5**	

	Total Percentage Utilization (including S&I)						
	MU Shop	CSR	IRR	CCO	Stamford	**Total**	Notes
2008	62%	67%	84%		0%	**59%**	
2010	77%	45%	67%		50%	**64%**	M-4/6 S&I at Stamford
2012	5%	45%	64%	64%	50%	**46%**	
2014	5%	0%	72%	70%	50%	**44%**	CSR used for Heavy Repair
2020	0%	0%	94%	71%	0%	**43%**	MU Shop Abandoned

Table II-4 Shop Utilization Estimate

The percentage table above assumes that the S&I work for the M-4 and M-6 fleets is assigned to Stamford Shop, which is designed to handle triplets. The capacity at Stamford for unscheduled repair and component change is not assigned, but the facility is available to support both local needs and the MU Shop for triennial center-plate inspection on the existing fleet.

As noted earlier, the CSR shop is engaged in component change-out on the existing fleet, and then will be assigned to heavy repair. As such, it will be available to support fleet modification programs. The interim running repair shop is assigned all S&I work, up to and including quadrennial inspections. Although the capacity of the interim running repair shop appears tight in the 2020 scenario, transferring quadrennial inspections to the component change-out shop and performing two inspections per day to Stamford reduces utilization at the interim running repair shop from 94 percent to 73 percent. Work at the change-out shop will see only a three percent increase, rising from 71 to 74 percent capacity.

It is assumed that the MU shop is abandoned with the retirement of the last M-2 cars.

As indicated in the table, above, the utilization of the component change-out shop is shown at 71 percent, based upon 21 shifts. The MU Shop, which currently handles this work, operates under this 21-shift schedule. However, for the sake of comparison, if it is assumed that the component change-out shop works only 15 shifts per week, its utilization increases to 99 percent. However, using that same logic, demand for space in the existing MU shop would to increase to more than 100 percent if it operated on only 15 shifts per week. Therefore, it is expected that the level of utilization of the CCO Shop would be similar to the current level of utilization of the MU Shop. Notably, this does not take into account further advantages presented by an increase in scheduled rather than unscheduled repairs, and the increased maintenance efficiency expected with car hoists at every repair position.

4.4 Wheel Truing

Wheel truing is the process of machining the wheel surface to remove defects or to restore a worn wheel's correct profile. One commonly used method of wheel truing is to use an under-floor machine that is capable of machining the wheel surface without removing the wheel-set from the vehicle. This capability is currently provided at New Haven in the Wheel Mill.

The wheel truing machine in the existing wheel mill was installed in the 1960s. It is a Stanray wheel truing machine that re-profiles the wheels using profiled milling cutters. The wheel mill building also dates from that era. At the time of the fleet configuration analysis, there were two wheel truing machines on Metro-North: one at New Haven and one at Croton-Harmon. In addition to these two machines, there is now a new, double-axle wheel truing machine at Croton Harmon. The new wheel truing machine differs from the others in that it operates as a lathe rather than a milling machine. However, this difference is not of importance.

During the fleet configuration analysis and via the engineering report, the Shops and Yards Working Committee has recommended the inclusion of a second wheel truing machine. With only two wheel truing machines available, the concern about having one machine out of service is understandable. With three machines available, there should be less concern. If there is sufficient capacity at New Haven in a single wheel truing machine, a second machine will not be needed, since it can be backed up by the wheel truing machines at Croton-Harmon.

4.4.1 Shop Capacity Analysis

Utilization of the wheel truing machine was estimated at one visit per year for locomotives and M-8 cars, (four axles per vehicle per year), and two visits per year for the current fleet and diesel hauled passenger cars (eight axles per car per year). Data provided by Metro-North was sampled and confirmed the estimated wheel truing frequency for the existing fleet. Wheel truing on the M-2 fleet averaged 7.2 axles per car per year based upon 5.4 visits per married pair. For the M-4 fleet, the average was 5.7 axles per car per year with 7.0 visits per triplet. For both of these fleets, the assumption of eight axles for car per year is conservative. The productivity assumed was based on the number of axles, although there is a slight penalty in productivity with a high number of visits. No data was made available on M-7 wheel truing after the resolution of the fleet's wheel slip problem. The productivity of the wheel truing operation at New Haven, then, is currently four axles per shift. The following table shows the demand for wheel truing, based upon operation of the wheel truing machine at 15 shifts per week.

	Shifts						Spots							
Year	M-2	M-4 M-6	M-8 M-10	Locos	Coach	Total	M-2	M-4 M-6	M-8 M-10	Locos	Coach	Total	Spots	Util.%
2008	480	204	0	14	94	792	0.6	0.3	0.0	0.0	0.1	1.1	1	106%
2010	480	204	50	14	94	842	0.6	0.3	0.1	0.0	0.1	1.1	1	112%
2012	60	204	322	14	94	694	0.1	0.3	0.4	0.0	0.1	0.9	1	93%
2014	60	204	370	14	94	742	0.1	0.3	0.5	0.0	0.1	1.0	1	99%
2020	0	0	536	14	94	644	0.0	0.0	0.7	0.0	0.1	0.9	1	86%

Table II-5 Wheel Truing Demand

The table above indicates that under current conditions the Wheel Mill is operating slightly over capacity. However, the actual maintenance requirement being slightly less, the Wheel Mill is operating at capacity. Utilization is forecast to remain high throughout the transition from the current fleet to the new fleet. However, the wheel truing capacity of the existing facility is adequate for the long-term fleet if the expected (longer) wheel life is achieved.

The proposed double-axle wheel truing machine should have are production rate that is at least 50 percent higher than the existing machine, since it will true two axles at one set-up. The new machine also will have a sophisticated instrumentation package that will speed the set-up time. No data has been provided on the expected productivity of the new machine; however eight to twelve axles per shift may be possible. Simply doubling the existing productivity using the new machine would provide adequate capacity at New Haven, using ten shifts per week.

The Stanray wheel truing machine is still in production. It has been modernized with sophisticated wheel measuring instrumentation and larger cutter heads. With these improvements, a modern Stanray wheel truing machine could true six axles, possibly eight axles per shift. The current production machine uses the same basic structural components as the existing machine, and it is possible that a new machine could be installed in the existing pit. This scenario also is capable of achieving the needed production using 15 shifts per week in the near term and 10 shifts per week in the long-term.

Data on wheel life on the M-7 fleet has not yet been provided. The M-7 suffered an early problem which required a large number of shoppings for wheel truing. Since the problem has been resolved it appears that the expected wheel life and the expected wheel truing requirements are being met, but it is too early for definitive data. Metro-North is taking the position that the tolerances on wheel diameter required among the wheels in one truck are sufficiently close that a two axle wheel truing machine is needed. The proposed Independent Wheel Truing facility is designed around the two-axle wheel truing machine.

4.5 Heavy Repair

Heavy repair for the purposes of this report is defined as those repairs that are not routine in nature and which require extended dwell times. This is most often the case with derailment or collision damage, in which the car body structure must be repaired. It is also needed for repairs which require extended dwell periods such as the replacement of floor panels. The characteristics required in the shop are its versatility and capacity to handle the widest variety of work. That being said, the heavy repair shop is not expected to perform this work rapidly or to any pre-determined schedule. As a result, the heavy repair shop does not contain facilities or equipment geared to high production, such as car hoists or permanent platforms. A heavy repair facility should have some center pit track, a floor suitable for portable jacks, and power outlets for welding and other equipment. Overhead cranes of high capacity are warranted in the

shop. Due to the specialized nature of this work and the fact that the vehicle is not expected for the next service period, the heavy repair shop would operate five days per week on a single shift.

Although the description in the previous paragraph describes the use of the facility for ad-hoc work, the nature of this type of facility also allows it to be tooled-up for programmed modifications to the fleet that may not be appropriate, in terms of efficiency, for a component change-out shop. Examples of this type of work are the current Critical Systems Replacement program, or a major floor or interior replacement program.

In addition to supporting the EMU fleet, the heavy repair facility is able to support the diesel fleet of locomotives and cars as needed. For example, the space available in the heavy repair facility and the high-capacity overhead crane are important for replacement of diesel locomotive prime movers (the diesel engine itself) or main generators.

4.5.1 Shop Capacity Analysis

The 2002 Fleet Configuration Analysis suggests that have a repair facilities be provided to support into repairs due to accident damage at the rate of one percent of the fleet per year, with an average expected dwell of eight weeks.

All studies of the New Haven Rail Yard have considered the existing two-track heavy repair facility in Stamford among the existing maintenance assets. While this facility might be suitable for the ad hoc heavy repair, it is not suitable for programmed modification work. The existing CSR Shop has three tracks each three car-lengths long and has all of the facilities described above, including portable jacking systems and overhead cranes (one 35-ton crane and a second 35-ton crane with a 10-ton auxiliary hoist). It has been proposed as part of the current program to update this facility to a state of good repair and to retain it as the heavy repair facility. We concur with this recommendation since it will provide both heavy repair and major program capacity at the New Haven yard.

4.6 Painting Facility

Painting facilities have been requested at New Haven yard in both the 2002 and in the 2006 Engineering Report. However the car bodies of the EMU fleet are stainless steel, which does not require painting except for the end bonnet and side striping. The diesel locomotives do have painted carbon steel car bodies, which will require periodic repainting. The passenger cars in the diesel fleet are either aluminum-bodied or stainless steel-bodied cars, which also do not require painting with the exception of side stripes (they do not have fiberglass end bonnets).

Trucks and other components do require painting, however these are best painted during the component repair process and not while installed on the vehicle. Access for painting subcomponents or trucks is better while off the vehicle and the amount of masking is minimized. When done off of the vehicle, a painting facility capable of painting an entire car is not required.

It is recommended that alternatives to a painting facility be investigated. Renewal of the side stripes on aluminum or stainless steel car bodies can be accomplished with the use of decals. It is suggested that methods for refinishing end bonnets using either water based coatings and or decals be investigated. Painting of diesel locomotives could be done at other facilities on either Metro-North or Amtrak. Until alternatives are thoroughly investigated, installation of painting facilities at New Haven is not recommended. Since the cost-benefit analysis has not been done, the cost of the paint booth is included in this report.

CDOT and Metro-North note that they are expecting to continue to require painting facilities. The body band on the new M-8 cars is painted, as is the body band on the existing fleet. Repainting and sealing of the fiberglass end bonnets is also required. For durability Metro-North requires the use of a two-part polyurethane paint which must be applied in a paint booth. It is possible to build a paint booth inside the CSR Shop or the MU Shop with the CSR Shop being recommended.

C. Summary of Facilities Required

Hill's review of the proposal for improved maintenance facilities at the New Haven Yard finds that the proposed component change-out shop, supported by the existing interim running repair shop, the CSR shop, the Stamford shop, and a single wheel truing machine, is capable of maintaining the proposed New Haven Line fleet.

At the end of the New Haven facility improvement program, the New Haven MU is surplus. The Stamford Heavy Repair shop may also be surplus for New Haven Line heavy repair work.

Phase one of the West End Yard, six additional storage tracks, is needed for operations. Further expansion of the yard would need to be justified by an increase in operations significantly above that currently planned.

Review and Analysis of Proposed New Haven Rail Maintenance Facility Expansion Project

Section III
CDOT Budgets and Estimates

This section of our report describes Hill's assessment of the development of the original program budget (Proposal Task 2), and the cost estimates developed during subsequent phases of the project (Task 3.b). In addition, this section presents Hill's assessment of CDOT's project budgeting and cost estimating procedures (Task 8).

A. Evaluation of CDOT Estimating and Budgeting Procedures

To gain an understanding of CDOT's estimating and budgeting procedures, Hill interviewed key CDOT staff and reviewed selected documents provided by CDOT.

1. CDOT Estimating and Budgeting Procedures

Based upon our review, the following is a summary of Hill's understanding of CDOT's estimating and budgeting procedures:

1.1 CDOT Estimating Procedures

- Construction cost estimates are prepared by various CDOT divisions, either by in-house staff or outside consultants. The estimates are vetted and checked by the originating division managers. Other project costs are added in order to determine overall Total Project Costs (TPC). Other costs include construction general conditions, overhead and profit, soft costs, escalation, etc. There is no standard procedure for the application and roll-up of the estimates to Total Project Costs among the CDOT divisions. Funding requests are submitted using a "Capital Funding Request" form.
- As projects are developed from the conceptual design stage through final design, updated estimates are prepared at various milestones. If updated TPC estimates indicate values greater than the initial budget, CDOT typically has the discretion to manage over-variances within its annual capital budget by deferring other projects. Over-variances are vetted internally by CDOT with justifications, including justifications related to scope-drifts, provided by the originating division.
- CDOT has an internal Estimating Unit. The Estimating Unit does not review preliminary estimates. Reviews by this unit are limited to final design estimates (based upon final construction documents), which are used for the purposes of procurement. This unit concentrates its efforts on developing "Contractor's Estimated Bid" values.

1.2 CDOT Budgeting Procedures

New project estimates and revised project estimates are processed as follows:

- Estimates are submitted by written request, as part of a request for new or additional funding.

- Estimates or revised estimates are reviewed at regular monthly Capital Project Management meetings by CDOT senior line managers, project managers, and other stakeholders.

- Decisions on whether to fund the requests are typically made by the CDOT senior line managers (bureau chiefs). Decisions that cannot be handled at their level are made by CDOT's Deputy Commissioner or Commissioner.

Programming the funding requirement is done in the Capital Project Management Plan (CPMP) in the appropriate fiscal year. The priority of the project or revised estimate is discussed with the affected administrator and project managers. (For rail projects, the project managers are assigned from CDOT's Bureau of Public Transportation.) A determination then is made relative to which project can be deferred in the current CPMP to accommodate the new project or revised estimate.

Each month, the CPMP is updated and circulated throughout the Bureau of Public Transportation. Ordinarily, the bureau chief's approval of project estimates and prioritization would occur through expressed or tacit approval of the modified Capital Project Management Plan. Under the department's normal capital programming process, the Office of Policy and Management would not be contacted for additional funding except during the biennial budget process or during a mid-term update. Funding shortfalls are managed to the extent possible within the existing budget authorization by transferring monies from one budget to another based on their relative priorities.

B. Estimating and Budgeting History on New Haven Rail Yard Project

The estimating and budgeting procedures used for the New Haven Rail Yard Improvements project were as follows:

- The project was handled outside the normal process, as it was initiated by Legislative action. The project has a separate "stand-alone" budget authorization, outside the normal biennial CDOT capital budget process.

- The initial request for funding for the New Haven Rail Yard project was in 2004 for $350 million TPC (Total Project Cost). This request was based upon a 2002 estimate of $331 million TPC, with an escalation update to 2004 costs, yielding $350 million. Legislative Act PA 05-04 authorized $965 million for the entire New Haven Revitalization Program. This includes the procurement of a maximum of 342 self-propelled rail cars (EMAs) and the design and construction of the rail maintenance facilities to support these cars. $300 million of the $965 million was budgeted for the rail maintenance facility.

- In June 2006 a 10 percent design estimate was developed by CDOT (approximately $471 million Contractor's Estimated Bid value). This updated estimate was rolled up into Total Program Costs and ranged from $775 million to $1.187 billion TPC.

- The large range of values (between $775 million and nearly $1.2 billion) is due, to a large extent, to variable methods in the application of escalation. The most recent comprehensive TPC estimate, at approximately $1.187 billion, used an escalation rate of 10 percent, and an extended schedule of approximately 15 years. This estimate (dated March 31, 2008), however, does not estimate escalation to the mid-point of construction. This is addressed later in Section IV (Evaluation of Current Program Costs) of this

report. For the purposes of our evaluation, we have assumed that the escalation values in the March 31, 2008 estimate are values at the mid-point of construction.

- Hill has been made aware that the March 31, 2008 $1.187 billion cost estimate does not completely cover all of the costs being accrued against the $300 million budgeted for the rail maintenance facilities. Portions of the costs for the Running Repair Shop, Property Acquisition, and Fuel Facility also are being charged to the Program. These charges were not budget either initially or in subsequent updates. These costs total approximately $27 million, and are not included in the $1.187 million.

C. Evaluation of Program Estimate Growth

Hill's evaluation begins with the original estimated cost, prepared in June 2002, of approximately $331 million TPC, and is used as the baseline estimated value. The end point of Hill's evaluation is the estimate prepared in March 2008 of approximately $1.187 billion. The 2002 estimate was based upon a conceptual study of the maintenance facilities that would be needed to maintain, repair and store the proposed expansion of the EMA fleet to approximately 500 units ("New Haven Line Fleet Configuration Analysis, Connecticut DOT Project Number 300-066, June 2002"). The March 2008 estimate is a composite estimate, based upon various proposed contract packages using program design documents that range in completion from 10 percent to 100 percent.

Table III-1 summarizes the growth of the estimated costs.

Cost Growth Drivers 3/31/08 Estimate	Total Project Costs (TPC)	% of Total	Notes
ORIGINAL 2002 CONTRACTOR'S ESTIMATED BID	$ 331,000,000	27.9%	Estimated Total Project Cost (TPC), 7 yr schedule with 3% Escalation
Escalation overall from 2002 to 2007	$ 126,000,000	10.6%	Accounts for escalation delta due to date of estimates, @ 8%/yr average
SUBTOTAL	$ 457,000,000		
Delta in Markups	$ 96,000,000	8.1%	Accounts for differences in soft cost markups
SUBTOTAL	$ 553,000,000		
Base Scope Design Enhancements & Under-Estimated Elements	$ 158,000,000	13.3%	Accounts for variation in design and omitted items, but sill consistent with original scope
SUBTOTAL	$ 686,000,000		
Delta in Escalation going Forward	$ 260,000,000	21.9%	Accounts for escalation delta due to changes in schedule and escalation rate (from 3% to 10%)
SUBTOTAL	$ 953,000,000		
Additional Scope Elements	$ 217,000,000	18.3%	Elements not included in original scope
TOTAL 3/31/08 ESTIMATE	$1,188,000,000	100.0%	

Table III-1 Growth of Estimated Cost 2002 to 2008

Hill's review of the detailed estimates reveals that there were three principal factors driving the increase in estimated costs:

- Scope growth
- Escalation growth, and
- Growth in percent markups used for miscellaneous costs

1. Scope Growth

The estimated cost for the additional-scope elements accounts for approximately $217 million TPC, which is 18.3 percent of the overall estimated costs. These elements include:

- M-8 Acceptance Facility
- EMU & CSR Shop Improvements
- Metro-North, CDOT, and MTA police offices in the proposed Component Change-Out Facility Building
- New Warehouse Facility
- Pedestrian Bridge
- Parking Garage, and
- Maintenance-of-Way Building

An additional $158 million (13.3 percent of the overall estimated costs) appears to be related to base scope design enhancements and items that were either omitted or under-estimated. The scope enhancement elements are not considered scope growth, as they are consistent with the original scope as presented in the 2002 study. These scope enhancements include:

- An additional 1,600 linear feet of track, and associated catenary systems
- 18 additional switches and associated heaters
- Additional demolition of various structures, due to changes in the physical arrangement of the facilities
- Additional site work in the area of the existing power plant, and
- Increases in the size of some of the proposed facilities

2. Escalation Growth

The June 2002 estimate was based upon a seven-year implementation schedule, starting in 2002 and ending in 2009 (two years to the start of design, plus one year for design, plus four years to complete construction). Escalation was calculated using a 3 percent per year escalation rate.

The actual start of design was in January 2006. In addition, the duration of the project was greatly extended. The March 2008 estimate is based upon an approximately 14-year implementation schedule (starting in 2006 and ending approximately in 2020).

Table III-1, above, shows an escalation value of approximately $126 million, or 10.6 percent of the overall estimated costs. This value represents an adjustment from the original 2002 cost estimate of $331 million. Preparation dates for the estimates used in the March 2008 estimate range from 2006 to 2007. Adding the $126 million to the original $331 million, yields $457 million, and is the approximate escalated value in 2007 dollars. This escalation was calculated using an annual escalation rate of 8 percent, which represents the average escalation rate for the period. Escalation, as used here, represents an increase in the overall selling price, which incorporates both cost and market factors.

Escalation going forward, calculated beginning at the preparation dates for the 2008 estimate (again, ranging from 2006 to 2007) to the corresponding mid-point-of-construction dates (which range from 2010 to 2019), adds another $260 million (or 21.9 percent of the overall estimated costs). This cost was derived from the CDOT March 2008 estimate, which uses an escalation rate of 10 percent per year.

3. Growth in Percent Markups used for Miscellaneous Costs

There are number of cost elements that are estimated as a percentage of the "Contractor's Estimated Bid (CEB)." Elements estimated in this manner are often referred to as "markups." These elements are added to the Contractor's Estimated Bid to arrive at estimated Total Project Costs (TPC). The June 2002 estimate and the March 2008 estimate differ considerably in their estimated costs for the following elements:

- Construction Administration and Inspection (referred to as "Incidentals" by CDOT). This covers the costs for professional services required to oversee and manage the construction effort, including construction management and design services during construction.

- Construction Contingency. Construction contingency is an allowance for potential change orders that may occur during construction.

- Railroad Flagging. Railroad flagging covers the cost for Metro-North's force account labor that is necessary for the flagmen and other safety personnel at the jobsite. Such personnel safeguard the construction workers and ensure coordinated rail yard operations during construction.

- Engineering Services. This includes the costs for all the pre-construction engineering and design services (referred to as "Preliminary Engineering" by CDOT), as well as the costs for the Program Manager.

All of the markups used in the 2008 estimate were higher and, in combination, totaled an approximate 48 percent markup of the Contractor's Estimated Bid. Comparably, the 2002 estimate had a corresponding 20 percent markup of the Contractor's Estimated Bid. Thus, the 2008 estimate uses an additional 28 percent markup of the CEB, accounting for $96 million, or approximately 8 percent, of the current estimated total of $1.187 billion.

Typically, these markups are refined to detailed estimates as the Project is advanced to reflect more complete knowledge. For example, the present estimate assumes a 15% markup for Railroad Flagging based on experience with construction on the New Haven Mainline. The work in this project will be almost all confined to the Yard, implying a much lower level of Railroad Flagging. These costs should be estimated based on present knowledge rather than a percentage.

D. Conclusions and Recommendations

1. Conclusions

Hill's review has yielded the following conclusions:

- The 2002 fleet study, used as the basis of the June 2002 estimate of $331 million TPC, was a very preliminary planning study, and inadequate for establishing a project budget. Additional program contingency would have been appropriate given the limited, preliminary nature of the 2002 program definition.

- By June 2006, upon the completion of the Schematic Design (done at 10 percent design development), the general aspects of the proposed program were better established, and the scope of the program had increased considerably. Scope increases account for approximately 18 percent of the current estimated costs. In addition, approximately 13 percent of current costs are related to a more definitive, and enhanced, baseline-scope.

- Changes in the program implementation schedule account for a large portion of the cost variance between 2002 and 2008, driving up the costs for escalation. This is a result of better definition of the schedule requirements, which have nearly doubled the amount of time required to implement the program. The expanding schedule is coupled with an historic and voluminous change in the construction market, with construction cost escalation rates growing considerably since 2002. Overall, escalation accounts for approximately 32% of the 3/31/08-estimated costs.

- The methods used by CDOT in developing the program TPC estimates have varied considerably between 2002 and 2008, and account for a very large portion of the variance over time. Even after the completion of the Schematic Design in June 2006, the approaches used in developing Total Program Costs (TPC) continued to vary considerably. (During this period the TPC rose from $775 million in 2006 to $1.187 billion in 2008.)

- There does not appear to be a strong system of configuration control with regard to the New Haven Rail Yard budget. This is exemplified by elements of costs that are being accrued against the $300 million budget that were not part of the initial scoping as set forth in 2002. We did not find any documentation related to a budgetary control

mechanism which would provide for a conscious decision-making process that identifies and tracks elements such as “out-of-scope” items.

2. Recommendations

Hill recommends that CDOT consider the following:

- Development of written standardized procedures for the preparation of estimated construction costs (Contractor’s Estimated Bid). We recommend that these procedures include the following:

    - Estimating/Design Contingency: Estimating contingency should be defined. Typically, estimating contingency is used to cover uncertainty about the level of design. We caution against using estimating contingency to cover elements of known scope; that scope that can be reasonably inferred by a review of the design documents.

    - Subcontractor and General Contractor Markups for Overhead and Profit and General Conditions: Clearly establish how these costs are applied.

    - Escalation: Set up a standard procedure for incorporation of the project schedule and estimated escalation rates. This is particularly important on programs of long duration. Typically, escalation is incorporated into the construction cost by projecting the escalation from the date of the estimate to the mid-point of construction for each construction package.

    - Basis of Estimate: A narrative description of the basis of the estimate should accompany each estimate, which describes the nature of the design documents and how the degree of design development relates to the estimating contingency, as well as the assumptions used on labor, equipment and materials for the major elements comprising the estimate.

    - Review by the CDOT Estimating Unit of preliminary estimates used for the development of project budgets. This review should include a quality control/quality assurance function to verify that the estimates conform to the written estimating procedures. The Estimating Unit should have the option of requiring that an independent check estimate be developed. Independent checks of estimates should be performed on large programs of long duration or complex projects with high degrees of price uncertainty.

- Development of written standardized procedures for the roll-up of overall program costs. These procedures should address:
    - Construction Contingency (allowance for extra work): Construction contingency varies depending on the type of construction. Projects that may have a

significant risk for differing site conditions, for example, may require a higher construction contingency.

- Soft Costs: These include engineering, design, construction administration and inspection, railroad flagging (as applicable), program management, etc. Preliminary estimates typically estimate soft costs as a percentage of the estimated construction cost, but as the projects progress, a “bottoms-up” estimate of these costs should be performed (based upon estimated labor hours and associated expenses).

- The use of a program contingency when program budgets are established based upon preliminary planning or design documents. The program contingency should be based upon an evaluation of the overall potential risks posed, particularly those related to scope definition. This can be done as a standard markup that is dependent on the stage of project development (refer to attached, sample, Pro Forma), or determined by a formal risk assessment (e.g., cost at 90 percent Confidence Interval).

- As part of the standard procedure, consider the use of a standard “Pro Forma”. The Pro Forma can be used as a standardized formulation for the compilation and presentation of program costs. A sample Pro Forma- is provided below for consideration.

- Development of a configuration management system associated with overall program budgets. Elements comprising the scope for a specific budget should be clearly identified and tracked. Work Breakdown Structure (WBS) system is typically used to uniquely identify and track scope elements. As discussed above, an overall program contingency can be used, as necessary, to accommodate unforeseen elements as the program design develops. This configuration management system should include a program manager from the technical staff who takes responsibility for managing the approved program budget and schedule.

SAMPLE

PROJECT PRO FORMA

Project Title:	**Component Changeout Building - Blg 01**
State Project ID:	**300-T189**
Estimate Date:	**September 30, 2008**

	COST ELEMENT	% RANGE	% USED		COST
I	**CONSTRUCTION PHASE COSTS**				
	a. Base Construction Costs				
	Estimated Trade Cost			**$**	**162,624,767**
	General Conditions		12.0%	$	19,514,972
	Subtotal			**$**	**182,139,739**
	Design Contingency		15%	$	27,320,961
	Subtotal			**$**	**209,460,700**
	General Contractor OH&P		15%	$	31,419,105
	Base Construction Cost Subtotal			**$**	**240,879,805**
	b. Escalation				
	Date of Estimate		09/30/08		
	Construction Start		03/30/09		
	Construction Completion		04/03/12		
	Midpoint Construction		10/01/10		
		Date Interval (yrs)			2.00
	Escalation to Midpoint @ per year rate of	3% - 10%	10.0%	**$**	**50,660,877**
	c. Contractor's Estimated Bid Amount				
	Base Construction Cost Subtotal			$	240,879,805
	Construction Cost Escalation			$	50,660,877
	Contractor's Estimated Bid Amount			**$**	**291,540,682**
	d. Other Construction Phase Costs				
	Incidentals (Const Admin & Inspection)		12%	$	34,984,882
	Construction Contingency (Allowance for Extra Work)		7%	$	20,407,848
	RR Flagging & Administration		15%	$	43,731,102
	Railroad Force Account Construction			$	4,532,012
	Plus Escalation on RR Force Acct			$	953,155
	Adjusted RR Force Acct			$	5,485,167
	Subtotal Other Construction Phase Costs			**$**	**104,608,999**
	Total Construction Phase Cost			**$**	**396,149,681**
II	**PLANNING & ENGINEERING**				
	Planning, Engineering & Design		12%	$	28,905,577
	Program Management			$	3,948,389
	Subtotal Planning & Engineering			**$**	**32,853,965**
IV	**PROJET/OWNER CONTINGENCY**				
☐	Project Needs Definition	25% - 50%			
☐	Preliminary Design	10% - 15%			
☐	Contract Drawings	5% - 10%			
	Subtotal Project Contingency			**$**	**-**
V	**FINANCIAL EXPENSE**			**$**	**-**
VI	**TOTAL PROJECT COSTS**			**$**	**429,003,646**

Review and Analysis of Proposed New Haven Rail Maintenance Facility Expansion Project

Section IV
Evaluation of Current Program Costs

A. Independent Cost Estimate

Hill performed an evaluation of the estimated costs of the current configuration of the New Haven Rail Yard program (part of Task 3). As part of this evaluation, Hill developed an independent check estimate. The design documents that formed the basis of the check estimate were the same as those used by CDOT for the preparation of its March 31, 2008 estimate. This CDOT estimate, at $1.187 billion, was the most recent comprehensive program-wide estimate available (refer to Section III of this report for a comparison of this estimate to the original budget estimate) and was selected as the focus of Hill's evaluation.

Notably, at the time of the March 2008 estimate, the design packages were at various levels of design, as indicated in Table IV-1.

Program	State Project No.	Design Package	% Level of Design
1A	300-0131	M-8 Acceptance Facility	100%
	300-0137	EMU & CSR Shop Improvements	90%
	300-0138	West End Yard Work	60%
	300-0139	Independent Wheel True Facility	60%
	300-T189	Component Change Out Shop	60%
1B	300-T193	East End Yard	60%
	300-TBD	Car Wash - Foundations Only	60%
	300-TBD	Warehouse	10%
	300-TBD	Main Line Signal System Modifications	30%
2	300-TBD	Final Track Completion	10%
	300-T191	S&I Shop	60%
	300-T191	Pedestrian Bridge	60%
	300-TBD	Parking Garage	10%
	300-TBD	Engineering (MOW) Building	10%
	300-T192	Car Wash Facility	60%
	300-TBD	Paint & Heavy Repair	10%

Table IV–1 March 31, 2008 Estimate Design Documents

Hill reviewed the information contained in the March 2008 design packages, and prepared detailed cost estimates for 15 of the 16 packages listed (the M-8 Acceptance Facility was not estimated as it was already awarded before Hill's assignment). These check estimates then

were compared to the corresponding package estimates in the March 31, 2008 program-wide estimate.

1. Basis of Quantity Take-Off

As expected with any preliminary design documents, some of the design details presented on the drawings and specifications were not fully developed. In these cases, Hill used its knowledge and experience to make reasoned assumptions on the missing design details in an effort to cost out the full scope of the intended design. These assumptions were later checked with CDOT to ensure that they were consistent with the intent of the design. After reconciling with CDOT, adjustments then were made as necessary.

2. Schedule Basis for Escalation

The CDOT March 31, 2008 estimate included escalation, and Hill used the schedule information, as provided, to independently calculate escalation. Hill included escalation to the mid-point of construction, which is the procedure typically used in the industry to account for the cost of escalation on projects of long duration.

Table IV-2 provides a tabulated summary of the milestones used.

Program	Design Package	Construction	
		Start	Finish
1A	M-8 Acceptance Facility		
	EMU & CSR Shop Improvements	10/27/08	10/26/09
	West End Yard	03/30/09	06/06/11
	Independent Wheel True Shop	03/30/09	03/28/11
	Component Change Out Shop	03/30/09	04/03/12
1B	East End Yard	04/16/12	12/22/14
	Rail Carwash Building – FOUNDATIONS	04/16/12	12/22/14
	Rail Carwash Building - BALANCE OF STUCTURE	06/21/18	07/02/20
	Warehouse	05/21/12	01/16/13
	Main Line Signal System Modifications	04/16/12	12/22/14
2			
	Final Track Completion	03/31/15	03/31/18
	Service and Inspection Shop	01/03/17	09/11/19
	Pedestrian Bridge	01/03/17	09/11/19
	Parking Garage	01/04/17	07/30/18
	Maintenance of Way (MOW) Building	03/31/17	12/31/19
	Heavy Repair/Paint Shop	01/03/19	09/25/20

Table IV-2 Construction Schedule Milestones - March 31, 2008 Estimate

3. Basis of Trade Costs (Labor, Materials and Equipment Costs)

Hill used prevailing wage rates as the basis of the cost for construction labor. The wage rates are based upon the current Heavy Rates – New Haven (effective July 1, 2007, and last updated June 02, 2008). Applicable percentages were then added to the various trades for insurance, workmen's compensation, etc.

Pricing for this estimate was developed from numerous sources including, but not limited to, current market material prices, historical data, and previous experience with similar types of construction. Material pricing is based upon costs in the second and third quarters of 2008.

For the electrical trades, Hill used Sauerbier Electrical Unit & Assemblies manual or the NECA standard labor unit manual. Hill used additional reference tools to price the mechanical scope of work, including the MCAA and MCA labor and equipment unit rates.

Pricing for some of the architectural, mechanical, electrical, and specialty items were obtained from regional manufacturer's representatives, as available. Material prices were also obtained from supplier/vendor catalogs and internet sources, recent projects and/or recent estimates.

Construction equipment prices/rates were developed from numerous sources including, but not limited to, current equipment rental rates from regional suppliers, historical data, and the Blue Book for Rental Construction Equipment.

All work is estimated to take place during regular work hours unless otherwise noted and labor cost calculation is based on an eight-hour work day. Production time for the various trades ranges from six to six-and-a-half hours per day, to account for lunch, work breaks, and setup time.

Equipment, small tools, and consumables necessary to perform the work are included in this estimate. Scaffolding and individual man-lifts required to perform the work associated with this package are included within the equipment unit rates.

Adjustments for productivity losses are included in the estimates to account for field conditions that restrict production. The productivity loss percentages vary per estimate, but are typically 20 percent for labor and 10 percent for equipment. These adjustments are explicitly indicated as specific line items in the trade estimate detail, and typically cover restrictions related to working in an active rail yard or an active operating environment. These adjustments include:

- For the Parking Garage and the MOW Building, Hill applied the factors of a 10 percent loss in labor productivity, and a 5 percent loss in equipment productivity.

- For the EMU/CSR Shop Improvements, a 30 percent loss in labor productivity and a 15 percent loss in equipment productivity were used due to the fact that these buildings are being renovated in an active facility and are located around live tracks.

- The Component Change Out Shop uses a 10 percent loss in labor productivity and a 5 percent loss in equipment productivity for working on the north side of the facility adjacent to the active tracks, and a separate 20 percent productivity loss on labor and 10 percent loss on equipment for all pile work.

Trade cost estimates include all sub-contractor field office costs for supervision, temporary facilities, construction material and equipment storage. These costs are added as a percentage and are embedded in each estimated line item.

Markups used for subcontractor overhead and profit are also included in the trade estimate line items. They are 10 percent for subcontractor general conditions and 10 percent for overhead and profit.

Due to current economic conditions, labor, materials, and equipment costs are subject to change. The base trade costs, however, do not include escalation. Escalation is addressed separately.

4. General Contractor General Conditions

Hill was informed that the CDOT trade estimates include the costs of the general contractor's general conditions. In order to compare Hill's trade costs to the corresponding CDOT estimate, an allowance for general conditions must be added to the Hill trade cost (the detailed line items in the Hill trade estimate do not include this markup).

5. Design Contingencies

As typically done on all preliminary estimates, a design contingency is applied to account for incomplete design development. Design contingencies are added as a percentage of the total trade costs (the detailed line items in Hill's trade estimate do not include this markup). For the purposes of comparison to the CDOT March 31, 2008 estimate, the check estimates prepared by Hill use the same design contingencies used by CDOT.

6. General Contractor Overhead and Profit (Fee)

For the purposes of comparison, Hill used the same markups for each estimate as CDOT for general contractor Overhead and Profit. These markups range from 10 percent to 15 percent.

7. Contractor's Estimated Bid Value

The roll-up of costs, starting from Hill's trade cost through the point of the equivalent of the CDOT "Contractor's Estimated Bid," is as indicated on Table IV-3, below:

Description	Formulation	Notes
Hill Trade Cost	TC	Includes all direct trade costs, productivity adjustments, and subcontractor OH&Profit
GC General Conditions (% of TC)	GCs	
Adjusted Trade Subtotal (ATS)	ATS = TC+GCs	Equivalent to CDOT "Raw Cost"
Design Contingency (% of ATS)	DC	
Subtotal 1	Subtotal 1 = ATS + DC	
GC Overhead & Profit (% of Sub-total 1)	OH	
Base Construction Cost Subtotal	BCC = Subtotal 1 + OH	
Escalation	Esc	
Contractor's Estimated Bid	CEB = BCC + Esc	Defined Term by CDOT

Table IV-3 Formulation Summary for Contractor's Estimated Bid Value

8. Other Costs Used in Development of Total Program Costs (TPC)

Other program costs are compiled and added to the Contractor's Estimated Bid to arrive at an estimate of Total Program Costs (TPC). The formulations are modeled after the methods used by CDOT in its March 31, 2008 program-wide estimate. These costs are as follows:

- **Construction Administration & Inspection (Incidentals):** This covers all the soft costs incurred by CDOT and its consultants to administer and inspect construction. For the purposes of comparison, Hill used the same markups as CDOT for each estimate. They range from 0 percent to 21 percent of the Contractor's Estimated Bid value.

- **Construction Contingency:** This element is an allowance set aside for potential extra work during construction. For the purposes of comparison, Hill used the same markups as CDOT for each estimate. They range from 7 percent to 10 percent of the Contractor's Estimated Bid value.

- **Railroad Flagging & Administration:** This covers safety flagmen and associated costs for the coordination of railroad operations with construction activities. For the purposes of comparison, Hill used the same markups as CDOT for each estimate, or 15 percent of the Contractor's Estimated Bid value.

- **Railroad Force Account Construction:** Portions of the construction work will be performed by Metro North force account personnel. This element covers this work. This is an estimated item, based on labor, equipment, and materials costs. Escalation is added to this item, based on the mid-point of construction milestone.

- **Planning, Engineering & Design:** This covers the costs of planning, engineering and design through the development of final construction documents. For the purposes of comparison, Hill used the same markups as CDOT for each estimate, or 12 percent of the Base Construction Cost Subtotal.

- **Program Management** – This covers the costs of Program Management staff for the project. These are estimated values provided by CDOT for each sub-program. Hill prorated the cost of program management between the difference projects based on total project cost (net of program management costs).

9. Check Estimate Summary and Comparison to CDOT Estimate

To compare the Hill check estimates with the corresponding CDOT March 31, 2008 estimates, an adjustment to the CDOT estimate was necessary for escalation. The procedure used by CDOT did not reflect escalation to the mid-point of construction. The adjusted values are shown Table IV-4, below. Table IV-5, which follows, shows a comparison of the CDOT adjusted values versus the corresponding Hill check estimate values. The table also includes a brief description of the nature of the variances.

Program-wide, Hill's estimated costs are approximately 26 percent higher. The largest variances were for the buildings portion of the proposed program, where the Hill's check estimates are significantly higher. The most significant drivers for the variances were:

- Hill identified and priced significant items of scope (design details) that were not explicitly shown on the design drawings and which were not priced by the engineer.

- Hill included allowances for productivity inefficiencies due to the contractors' requirement to work in and around train operations in the yard. To the extent that the construction of scope elements can be removed from the operating environment, this premium can be minimized.

- Hill pricing for steel and piling were significantly higher, based on current market conditions.

Design Package		CDOT 3/31/08 Estimate	CDOT 3/31/08 Estimate With Adjustment for Escalation
M-8 Acceptance Facility		$ 14,813,350	$ 14,813,400
EMU & CSR Shop Improvements		$ 3,615,544	$ 3,624,798
West End Yard Work		$ 76,607,700	$ 84,670,661
Independent Wheel True Facility		$ 28,702,100	$ 30,868,443
Component Change Out Shop		$ 273,805,200	$ 315,129,784
Subtotals Construction Phase Costs		**$ 397,543,894**	**$ 449,107,086**
Engineering & Design (Preliminary Engineering)		**$ 28,636,343**	**$ 28,636,343**
Program 1A Program Manager		**$ 5,580,100**	**$ 5,580,100**
SUBTOTALS PROGRAM 1A		**$ 431,760,337**	**$ 483,323,530**
East End Yard		$ 65,763,200	$ 74,457,292
Car Wash - Foundations Only		$ 4,271,500	$ 4,850,218
Warehouse		$ 22,470,800	$ 26,484,762
Main Line Signal System Modifications		$ 9,463,200	$ 10,560,934
Subtotals Construction Phase Costs		**$ 101,968,700**	**$ 116,353,206**
Engineering & Design (Preliminary Engineering)		**$ 4,644,591**	**$ 4,644,591**
Program 1B Program Manager		**$ 4,935,700**	**$ 4,935,700**
SUBTOTALS PROGRAM 1B		**$ 111,548,991**	**$ 125,933,497**
Final Track Completion		$ 115,979,100	$ 143,821,657
S&I Shop (+Wheel True/Pedestrian Bridge)		266,471,700	$ 309,762,381
Parking Garage		$ 62,312,100	$ 70,546,792
Engineering (MOW) Building		$ 39,820,200	$ 48,805,900
Car Wash Facility		$ 40,519,400	$ 47,292,352
Paint & Heavy Repair		$ 88,827,900	$ 101,358,310
Subtotals Construction Phase Costs		**$ 613,930,400**	**$ 721,587,390**
Engineering & Design (Preliminary Engineering)		**$ 21,117,411**	**$ 21,117,411**
Program 2 Program Manager		**$ 8,923,200**	**$ 8,923,200**
SUBTOTALS PROGRAM 2		**$ 643,971,011**	**$ 751,628,001**
FULL PROGRAM TOTALS		**$ 1,187,280,339**	**$ 1,360,885,027**

Table IV-4 CDOT March 31, 2008 Estimate & Adjustment for Escalation

Design Package	CDOT Estimate 3/31/08 Adjustted		Hill 3/31/08	% Difference	Principal Drivers on Variance
M-8 Acceptance Facility	$ 14,813,400		$ 14,813,400	0%	Package was awarded and in progress; no check estimate prepared.
EMU & CSR Shop Improvements	$ 3,624,798		$ 6,505,741	79%	Variance is from actual bid; $7.04 million based on low bid value; corresponding Hill estimate was $7.8 million approximately 11% higher than actual.
West End Yard Work	$ 84,670,661		$ 96,940,423	14%	Pricing on catenary assemblies and productivity inefficiency
Independent Wheel True Facility	$ 30,868,443		$ 45,834,382	48%	Quantities and pricing on piles; pricing on building envelope assemblies; productivity inefficiencies.
Component Change Out Shop	$ 315,129,784		$ 396,149,681	26%	Quantities and pricing on piles; pricing on steel; scoping on mechanical trades; productivity inefficiencies.
Subtotals Construction Phase Costs	**$ 449,107,086**		**$ 560,243,627**	**25%**	
Engineering & Design	**$ 28,636,343**		**$ 40,470,005**		
Program Manager	**$ 5,580,100**		**$ 5,580,100**		
SUBTOTALS PROGRAM 1A	**$ 483,323,530**		**$ 606,293,731**	**25%**	
East End Yard	$ 74,457,292		$ 86,390,376	16%	Productivity inefficiencies.
Car Wash - Foundations Only	$ 4,850,218		$ 12,188,939	151%	Pricing on piles; productivity inefficiencies.
Warehouse	$ 26,484,762		$ 34,730,678	31%	Scoping assumptions on building.
Main Line Signal System Modifications	$ 10,560,934		$ 13,369,879	27%	Scoping assumptions on sitework and ductbank.
Subtotals Construction Phase Costs	**$ 116,353,206**		**$ 146,679,873**	**26%**	
Engineering & Design (Preliminary Engineering)	**$ 4,644,591**		**$ 6,912,176**		
Program Manager	**$ 4,935,700**		**$ 4,935,700**		
SUBTOTALS PRGRAM 1B	**$ 125,933,497**		**$ 158,527,749**	**26%**	
Final Track Completion	$ 143,821,657		$ 151,928,884	6%	Pricing on trackwork.
S&I Shop	$ 284,539,835		$ 375,159,328	32%	Quantities and pricing on piles; pricing and scoping on steel; productivity inefficiencies.
Pedestrian Bridge	$ 25,222,545		$ 34,528,903	37%	Pricing and scoping on structure.
Parking Garage	$ 70,546,792		$ 76,533,182	8%	Pricing on structure.
Engineering (MOW) Building	$ 48,805,900		$ 62,347,968	28%	Pricing on structure and scoping.
Car Wash Facility	$ 47,292,352		$ 80,291,302	70%	Scoping of structure; pricing on architectural items; productivity inefficiencies
Paint & Heavy Repair	$ 101,358,310		$ 127,466,547	26%	Scoping of renovation work.
Subtotals Construction Phase Costs	**$ 721,587,390**		**$ 908,256,112**	**26%**	
Engineering & Design (Preliminary Engineering)	**$ 21,117,411**		**$ 30,871,005**		
Program Manager	**$ 8,923,200**		**$ 8,923,200**	**0%**	
SUBTOTALS PROGRAM 2	**$ 751,628,001**		**$ 948,050,317**	**26%**	
FULL PROGRAM TOTALS	**$1,360,885,027**		**$ 1,712,871,798**	**26%**	

Table IV-5 - CDOT March 31, 2008 Estimate versus Hill Check Estimate

B. Evaluation of Out-Year Costs

Hill performed a program risk assessment, which is presented in Section V of this report. The risk assessment included an evaluation of escalation for the duration of the proposed program, which extends to the year 2020. Escalation was evaluated for each contract package, based on the commodities that make up the bulk the work (e.g., steel, copper, fuel, labor, etc.), which varies between packages. Generally, escalation was projected to decrease over time.
Table IV-6 provides a tabulated summary of the escalation values used for the out-year cost evaluation.

Program	Design Package	Construction Milestones		
		Start	Finish	Escalation Rate (%/yr)
1A	M-8 Acceptance Facility			N/A
	EMU & CSR Shop Improvements	10/27/08	10/26/09	N/A
	West End Yard	03/30/09	06/06/11	7.1%
	Independent Wheel True Shop	03/30/09	03/28/11	8.0%
	Component Change Out Shop	03/30/09	04/03/12	7.4%
1B	East End Yard	04/16/12	12/22/14	7.0%
	Rail Carwash Building – FOUNDATIONS	04/16/12	12/22/14	7.2%
	Rail Carwash Building - BALANCE OF STUCTURE	06/21/18	07/02/20	2.9%
	Warehouse	05/21/12	01/16/13	7.3%
	Main Line Signal System Modifications	04/16/12	12/22/14	3.7%
2	Final Track Completion	03/31/15	03/31/18	5.2%
	Service and Inspection Shop	01/03/17	09/11/19	5.6%
	Pedestrian Bridge	01/03/17	09/11/19	6.4%
	Parking Garage	01/04/17	07/30/18	7.25%
	Maintenance of Way (MOW) Building	03/31/17	12/31/19	5.2%
	Heavy Repair/Paint Shop	01/03/19	09/25/20	5.8%

Table IV- 6 - Escalation Values for Out-Year Cost (Hill 3/31/08 Program Estimate)

Hill also addressed design and construction contingencies as part of the risk assessment. Table IV-7 presents a comparison of the Hill estimate using values for the contingencies and escalation rates used by CDOT versus the corresponding values derived from the risk assessment.

Item No.	Design Package	Hill 3/31/08 Program with CDOT Pro Forma	Hill 3/31/08 Program with Out-year Cost Assessment	Hill 3/31/08 Program with Out-year Cost Assessment Including Contingencies
1	M-8 Acceptance Facility	$ 14,800,000	$ 14,800,000	$ 14,800,000
2	EMU & CSR Shop Improvements	$ 6,500,000	$ 6,500,000	$ 6,500,000
3	Component Change Out Shop	$ 396,100,000	$ 377,300,000	$ 377,600,000
5	Independent Wheel True Facility	$ 45,800,000	$ 44,600,000	$ 44,000,000
6	Parking	$ 76,500,000	$ 60,800,000	$ 54,000,000
7	Warehouse	$ 34,700,000	$ 31,500,000	$ 27,600,000
9	Pedestrian Bridge	$ 34,500,000	$ 25,000,000	$ 25,300,000
10	Engineering (MOW) Building	$ 62,300,000	$ 40,000,000	$ 35,100,000
12	S&I Shop	$ 375,200,000	$ 252,700,000	$ 247,600,000
13	West End Yard Work	$ 96,900,000	$ 92,900,000	$ 101,200,000
15	East End Yard	$ 86,400,000	$ 75,500,000	$ 77,000,000
16	Main Line Signal System Modifications	$ 13,400,000	$ 10,000,000	$ 10,200,000
18	Paint & Heavy Repair	$ 127,500,000	$ 82,900,000	$ 73,000,000
19	Car Wash - Foundations Only	$ 12,200,000	$ 10,800,000	$ 11,800,000
19	Car Wash Facility	$ 80,300,000	$ 39,300,000	$ 37,500,000
20	Final Track Completion	$ 151,900,000	$ 105,900,000	$ 98,100,000
	Subtotals	**$ 1,615,000,000**	**$ 1,271,600,000**	**$ 1,241,700,000**
	Preliminary Engineering	**$ 78,300,000**	**$ 78,300,000**	**$ 75,700,000**
	Program Manager	**$ 19,400,000**	**$ 19,400,000**	**$ 19,400,000**
	TOTALS	**$ 1,712,700,000**	**$ 1,368,200,000**	**$ 1,335,600,000**

Table IV- 7 - Out-Year Cost Assessment Summary Table

As Table IV-7 indicates, when we applied the escalation values from the risk assessment to the 3/31/08 Program estimate the estimated costs were significantly reduced. The application of the design and construction contingencies had a relatively minor impact on the overall estimated cost.

C. Cost Containment Analysis

1. 12/5/08 Revised Program

The principal focus of our cost containment study involved examining potential scoping alternatives that might have the potential for cost reductions. Priorities were determined via a functional analysis to assess what best meets the objectives of the program. Some modifications to program elements were examined. Based on the functional analysis as presented in Section II of this report, Hill developed a proposed revised program, which was reviewed and vetted with CDOT and MNR. Some changes were made to the initial Hill proposed program and agreement was reached on most of the general elements of a revised program, characterized as the proposed "Revised 12/5/08 Program", as summarized below.

Item No.	Design Package	Hill 3/31/08 Program Estimate w/ Out-year Cost Assessment Including Contingencies	Hill Estimate (12/5/08 Revised Program)	Scope Revisions
1	M-8 Acceptance Facility	$ 14,800,000	$ 14,800,000	None; as awarded.
2	EMU & CSR Shop Improvements	$ 6,500,000	$ 6,600,000	As awarded.
3	Component Change Out Shop	$ 377,600,000	$ 406,900,000	Moved Track 41 & Associated Utilities from WEY package to CCOS package; later start adds about $10 million in escalation
4	Diesel Storage Yard	$ -	$ 6,500,000	Reconfigured scope formerly part of WEY.
5	Independent Wheel True Facility	$ 44,000,000	$ 40,800,000	Reduced scale of building similar to Harmon facility
6	Parking	$ 54,000,000	$ 15,500,000	Deleted onsite garage; replaced with offsite facility procurement & upgrade.
7	Warehouse	$ 27,600,000	$ 18,900,000	Deleted onsite high density warehouse; replaced with offsite (conventional) facility procurement & upgrade.
8	Fuel Cells in CCO	$ -	$ 8,300,000	New scope
9	Pedestrian Bridge	$ 25,300,000	$ 17,800,000	None; earlier start decreases escalation cost
10	Engineering (MOW) Building	$ 35,100,000	$ 1,700,000	Deleted MOW Bldg; replaced with relocation of functions to existing EMU Bldg Annex.
11	Stores Building Demolition	$ -	$ 5,700,000	Reconfigured scope, formerly part of Final Track Completion Pkg.
12	S&I Shop	$ 247,600,000	$ 28,700,000	Deleted proposed new S&I Shop; Existing Interim Running Shop to be upgraded as alternate
13	West End Yard Work	$ 101,200,000	$ 80,700,000	Remainder of reconfigured scope: 6 tracks over former Store Bldg area & associated utilities, plus Subtation and tie-ins. Later start & finish dates (4 yrs) adds additional escalation.
14	EMU/Program Shop Upgrades	$ -	$ 30,200,000	New scope: renovate existing building
15	East End Yard	$ 77,000,000	$ 91,200,000	None; later start adds escalation cost
16	Main Line Signal System Modifications	$ 10,200,000	$ 16,000,000	None; later start adds escalation cost
17	Yard Signal System	$ -	$ 12,700,000	New scope
18	Paint & Heavy Repair	$ 73,000,000	$ 44,900,000	Deleted trackwork & reduced scale of rehab work
19	Car Wash - Foundations Only	$ 11,000,000	$ 14,700,000	None; delayed start adds escalation
19	Car Wash Facility	$ 37,500,000	$ 36,500,000	None; earlier start reduces escalation
20	Final Track Completion	$ 98,100,000	$ 50,500,000	Scope reduced to add only 2 tracks @ WEY, assocaited utilities, & upgrade of Bone Yard traction power
21	Other Program Accruals	$ -	$ 27,000,000	These are out-of-scope elements are already accrued to the program
	Subtotals	**$ 1,241,700,000**	**$ 976,600,000**	
	Engineering & Design (Preliminary Engineering)	**$ 75,700,000**	**$ 87,100,000**	
	Program Manager	**$ 19,400,000**	**$ 20,400,000**	
	TOTALS	**$ 1,335,600,000**	**$ 1,084,100,000**	

Table IV- 8 - Summary Comparison Table 3/31/08 versus 12/05/08 Programs

Component Change Out Shop (CCOS) – The CCOS is the most critical facility in the program. Due to some staging issues, some of the trackwork that was formerly in the West End Yard package was moved to the CCOS package. However, no modifications to the facility building are reflected in the $406.9 million cost estimate (Item 3). The cost of this facility can be reduced if the office space planned for the 4th floor is eliminated. This office space will be used by staff anticipated for expansion of service to Springfield. Since the plan for that expansion is not part of this Project, it is a candidate for cost reduction. There is office space on the 3rd floor for ConnDOT supporting the present operation that could be located elsewhere, but other site-specific uses are also on that floor. Their location off-site is not recommended. The location of ConnDOT office staff at this facility makes the provision of access without the Pedestrian Bridge discussed below more difficult. These employees would be less experienced at crossing tracks at-grade making the Pedestrian Bridge more desirable for their accessing the CCOS from the train station.

Addition of Yards & Rearrangement of Existing Yard Access – This work includes the Diesel Storage Tracks (Item 4), Stores Building Demolition (Item 11), West End Yard Work (Item 13), East End Yard Work (Item 15), Mainline Signal Modifications (Item 16), and Final Track Completion (Item 20). These elements total $252 million. Costs can be reduced further for some of these elements if a single wire overhead traction power system is used as an alternate to catenary overhead presently designed. The catenary is standard for Main-line service but not required for yard service. The Diesel Storage Tracks, Store Building Demolition, and West End Yard Work are the most critical elements, as these facilities are required to provide enough storage of the proposed expanded fleet. The scope of the Final Track Completion (Item 20) is to provide additional operational flexibility in the area of the West End Yard, but our functional analysis indicates that it is not required to meet the basic functions of the proposed expanded fleet.

Rehabilitation of the EMU and CRS Shops – Modification of the EMU Annex shop (Item 10) to accommodate the planned Maintenance of Way (MOW) functions will be at a significantly lower cost than building a new facility as proposed in the 3/31/08 Program. The main part of the EMU building is proposed to be used for car campaign work (programs to rehabilitate part of the car such as the seats for the fleet), and an allowance is provided for a comprehensive rehabilitation the building (Item 14). Alternately, the building can be essentially left as-is with provision of normal routine maintenance, but it is currently very inefficient in maintaining normal interior working temperatures during cold weather. The existing CRS Shop is to be converted into the Paint & Heavy Repair Shop, but the trackwork and the scale of the rehabilitation work has been reduced (Item 18). The scopes and related cost estimates for these elements are highly conceptual, and further work is necessary to define them.

Independent Wheel True Facility – The scope of this facility has been reduced, by decreasing its size, including light weight pre-fabricated sheds on either end of the building to allow enclosure of a three-car consist (Item 5). The proposed facility will be similar in concept to what MNR has currently in-use at its Harmon Yard in New York. A possible alternative is the rehabilitation of the existing wheel true machine, but this option poses significant risk to service.

Service and Inspection Shop Facility – The proposed alternative is to upgrade the existing Interim Running Repair (IRR) shop (Item 12) in order to function as the S&I facility. This is the largest cost containment proposed, with a reduction of cost of over $200 million. The cost of upgrading the IRR is largely dependent on the level of structural reinforcement necessary to support the added functions; further engineering study is required to adequately scope and estimate costs for these upgrades.

Relocation of Function Offsite – The proposed Central Warehouse on-site was to be a high density warehouse with attendant high capital and operation costs. This function is proposed to be moved off-site to a conventional facility; the allowance provided (Item 7) is for the purchase or lease of an existing offsite facility and fit-out of the facility for the railroad's functions. Similarly, the alternative to the proposed Parking Garage is the purchase or lease of at-grade parking facilities (Item 6). The scope and costs of these relocations are very conceptual and additional study is required to fully define them.

Car Wash Facility – No changes are proposed for the Car Wash Facility (Item 19), other than modification on the proposed starts of construction (the foundations package is to be integrated into the main facility package). The facility will contributes indirectly to the maintenance of the fleet and directly to the customer perception of the quality of service. Construction of the Car Wash should be considered if the estimate to complete shows the program stays within budget limits after the major elements of work have been awarded.

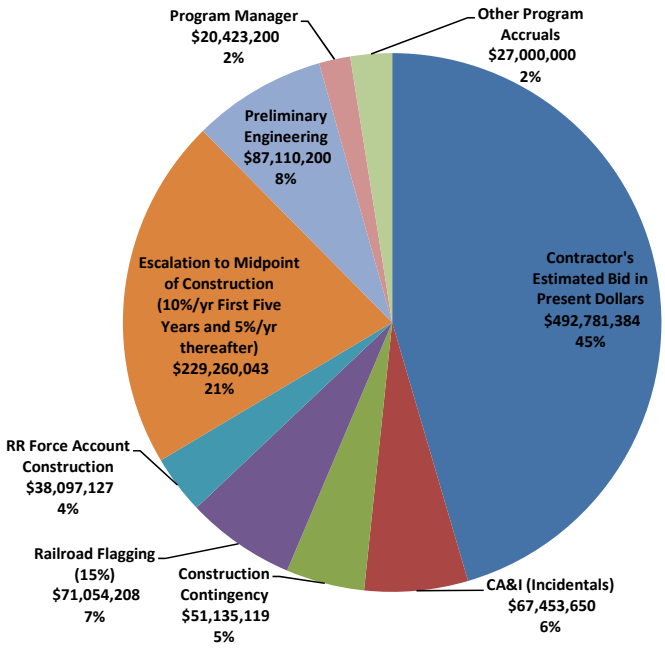
Pedestrian Bridge – Safe passage from Union Station to the yard facilities needs to be provided. The Pedestrian Bridge is the CDOT proposed alternative, consisting of an overhead passage from Union Station to the Component Change Out Shop. Hill considers an at-grade crossings solution more effective for maintenance staff. Office staff located in the Component Change Out Shop would require proper training and qualification for an at-grade-crossing safe-passage operation for those commuting from Union Station (it is expected that the majority of the staff will commute by automobile, park near the building, and not require crossing tracks).

Additional Program Elements – Two additional elements were added to the 12/5/08 Revised Program, the Yard Signal System (Item 17) and the Fuel Cells (Item 8). Hill does not consider these elements critical or necessary for the core maintenance functions of the program.

Out-of-Scope Program Accruals – Hill was informed that other scope elements were cost-accrued against the existing program, including portions of the costs for the Running Repair Shop, Property Acquisition, and Fuel Facility, which were not previously identified as part of the scope of the program (Item 21). These costs must be factored in for a proper accounting of the full cost of the proposed 12/05/08 Revised Program.

New Haven Rail Maintenance Facility Expansion Program

Revised 12/5/08 Program - Distribution of Costs by Category



As discussed above, further study of the proposed reconfigured packages is required to better assess estimated costs of the 12/5/08 Revised Program. In addition, the costs for Preliminary Engineering and Program Management should be estimated in more detail (represents approximately 10% of the estimated total program cost). The cost of Railroad Flagging also represents a substantial portion of the estimated cost (approximately 7% of the total program). Since large portions of the proposed construction, like the Component Change Out Shop, will be largely separated from the yard operations, the amount of estimated railroad flagging may be overstated. A more detailed estimate for this should be performed based on the actual conditions for each proposed package and a management plan executed to control and minimize it use in coordination with the selected package contractors.

2. Budgeting and Cost Containment Recommendations

Hill recommends a contingency management plan to manage cost risks going forward. Escalation, an estimated 21% of the Total Program Cost, represents a major unknown in the present environment. The escalation pressure on the value of materials and equipment appears to be reduced, but uncertainty as perceived by the contractors may still continue to increase bid prices. Due to this and other cost risks going forward, Hill recommends that the proposed 12/05/08 Revised Program be budgeted and structured to allow for additional cost containment. Hill has broken down the proposed revised program into three functional tiers, as follows:

Tier 1 Elements – Baseline need critical for the maintenance operations of the expanded fleet
Tier 2 Elements – Enhancements to Baseline need
Tier 3 Elements – Other elements that can be either deferred or eliminated, as necessary

Item No.	Design Package	Hill Estimate (12/5/08 Revised Program)	Tier 1 – Baseline	Tier 2 – Enhancements	Tier 3 – Other Elements	Comments
1	M-8 Acceptance Facility	$ 14,800,000	$ 14,800,000			Awarded
2	EMU & CSR Shop Improvements	$ 6,600,000	$ 6,600,000			Awarded
3	Component Change Out Shop	$ 406,900,000	$ 386,600,000		$ 20,300,000	Remove 4th floor from CCOS, if schedule permits
4	Diesel Storage Yard	$ 6,500,000	$ 6,500,000			
5	Independent Wheel True Facility	$ 40,800,000	$ 40,800,000			
6	Parking	$ 15,500,000	$ 15,500,000			
7	Warehouse	$ 18,900,000	$ 18,900,000			
8	Fuel Cells in CCO	$ 8,300,000	$ -		$ 8,300,000	Defer or Delete scope from program
9	Pedestrian Bridge	$ 17,800,000	$ 2,000,000		$ 15,800,000	Provide at-grade crossings
10	Engineering (MOW) Building	$ 1,700,000	$ 1,700,000			
11	Stores Building Demolition	$ 5,700,000	$ 5,700,000			
12	S&I Shop	$ 28,700,000	$ 28,700,000			
13	West End Yard Work	$ 80,700,000	$ 80,700,000			
14	EMU/Program Shop Upgrades	$ 30,200,000			$ 30,200,000	Defer or Delete scope from program
15	East End Yard	$ 91,200,000	$ 91,200,000			
16	Main Line Signal System Modifications	$ 16,000,000	$ 16,000,000			
17	Yard Signal System	$ 12,700,000			$ 12,700,000	Delete scope from program
18	Paint & Heavy Repair	$ 44,900,000	$ 22,400,000		$ 22,400,000	Reduce scope to Paint Booth and critical maintenance (e.g., roof overlay); defer or delete remaining scope
19	Car Wash - Foundations Only	$ 14,700,000		$ 14,700,000		Defer scope and execute if funds allow
19	Car Wash Facility	$ 36,500,000		$ 36,500,000		Defer scope and execute if funds allow
20	Final Track Completion	$ 50,500,000			$ 50,500,000	Defer or Delete scope from program
21	Other Program Accruals	$ 27,000,000	$ 27,000,000			
	Subtotals	**$ 976,600,000**	**$ 765,100,000**	**$ 51,200,000**	**$ 160,200,000**	
	Preliminary Engineering	**$ 87,100,000**	**$ 68,200,000**	**$ 4,600,000**	**$ 14,300,000**	
	Program Manager	**$ 20,400,000**	**$ 16,000,000**	**$ 1,100,000**	**$ 3,400,000**	
	TOTALS	**$ 1,084,100,000**	**$ 849,300,000**	**$ 56,900,000**	**$ 177,900,000**	

Table IV-9 - Functional Tiers and Associated Costs

Hill's functional analysis indicates that all of the Tier 1 elements will be required to provide the necessary maintenance and storage facilities of the proposed expanded fleet. Elements in Tiers 2 and 3 can be either deferred or eliminated, as necessary. Alternately, if only the Tier 1 scope is selected for funding, a large program budget contingency should be used: at minimum $100 million.

Elimination of the 4th floor of the CCOS may reduce cost on the order of $20 million, but may delay the start of this critical facility. A decision has to be made now whether to fund the 4th floor build-out.

Review and Analysis of Proposed New Haven Rail Maintenance Facility Expansion Project

Section V
Program Risk Assessment

A. Description of Methodology

The purpose of the risk assessment was to identify and evaluate risk factors and the potential impacts to the cost of the program. The risk assessment represents a "snapshot in time" during the project development process. The Hill snapshot will reflect design and the construction environment status in its current state. Programs that require several years to design, construct, and complete can benefit from annual updating, which allows project owners to identify and monitor the associated risks as conditions change.

Today's traditional understanding of risk is one's potential for loss. No project is without risk. The risks inherent in any project provide the owner with the opportunity to manage it, assign it, insure it, or generate contingency through estimation.

The Hill team conducted reviews and analysis of each design package. The primary risks were identified and the impacted cost drivers were categorized into major segments. The Hill engineers, estimators and project managers (the Project Team) evaluated and estimated the range of uncertainty as it is applies to each cost segment in the risk model. Cost segments were ranged for uncertainty through stochastic methods and compared against the corresponding values using deterministic methods.

1. Risk Identification

A program-wide check estimate was prepared by Hill, as presented in Section IV of this report. The line items in the check estimate were coded into several industry-standard groupings. These groupings allowed sorting of specific categories of costs. Selected categories of costs were then evaluated for risks such as commodity costs variability, completeness of design, constructability, site factors, weather, and productivity.

Hill's estimators evaluated the level of design and developed ranges of uncertainty. Limited constructability reviews were conducted on each design package in order to ascertain the opportunities and limitations on production. Physical constraints were identified and clarified.

Site factors have considerable influence on the overall program cost and scheduling. Hill was informed that some soil and groundwater contamination may be encountered during construction, but the amount and degree of contamination is uncertain. Demolition activities present a number of significant challenges in terms of both staging and removal of debris. Foundation pile installations present significant levels of risk due to the potential for differing site conditions. Construction in the vicinity of an operating rail also presents considerable staging and productivity risks.

The nature of Rail Yard construction requires force account work by specialized railway workers that must be coordinated with the work being performed by the construction contractors. Utility relocation, control switching, and selected rail construction are examples of specialized activities

that must be coordinated. Power shut-down and start-up activities in selected areas of work may have considerable effect on productivity.

Escalation was considered a major risk, as the construction market had been experiencing considerable escalation pressure in the recent past.

2. Risk Measurement

Each cost segment was evaluated and risk ranged by the Project Team. The Risk Model constructed by Hill considered the value of the top trade cost categories constituting the major part of the trade costs. These trade costs were each evaluated and risk ranged for design uncertainty, construction activity uncertainty, and escalation uncertainty. Owner and contractor direct and indirect costs were also evaluated and risk ranged.

Hill evaluated escalation of construction commodities, including labor and equipment. The analysis was performed with the intent of generating supporting data for escalation forecasts for both short and long-term estimate forecasts.

Risk ranging was performed through Team consensus. Upon completion of the analysis of the risk factors impacting the cost segments, Hill convened meetings with estimating staff, economists and statistical professionals to reach consensus on the appropriate levels of risk ranges to apply to each segment and the appropriate statistical distribution to apply to those ranges.

B. The Model

The estimates were analyzed, and essential information was extracted for evaluation. The top 80 percent of the trade contracts for each project were identified and segregated. As an example, the diagram below illustrates top estimated trade costs for the Component Change Out Facility.

Item	Direct Trade Costs
Industrial Equipment Schedule	$ 16,500,000
Structural Metal Framing	$ 17,795,232
Concrete Piles	$ 11,899,177
Sitework	$ 4,475,000
Sitework/Productivity	$ 4,493,017
Sitework/Contaminated	$ 4,469,167
Rail	$ 4,274,858
Fabricated Wall Panel System	$ 3,553,736
Electrical Equipment	$ 5,552,682
Electrical service and distribution	$ 5,065,200
Ductwork	$ 4,386,078
Ground Floor Slab on Grade	$ 3,972,238
Miscellaneous	$ 3,920,651
Site Construction	$ 2,735,380
Piping Systems	$ 2,698,518
CMU Interior Partitions	$ 2,652,792
Fire Protection	$ 2,163,346
Lighting and branch wiring	$ 5,609,796
Membrane Roofing	$ 2,069,902
Windows	$ 1,957,910
Stainless Steel Liner Panel	$ 1,529,850

Item	Direct Trade Costs
Finish Carpentry	$ 1,439,243
Insulation	$ 1,434,417
GWB Assemblies	$ 1,429,982
Demolition	$ 1,428,092
Hydraulic Elevators	$ 1,365,909
Metal Decking	$ 1,357,517
Air Temperature Controls	$ 1,357,000
Secondary transformers	$ 2,518,283
Elevated Floor Slab	$ 1,259,252
Detection and alarms	$ 1,063,529
Rough Carpentry	$ 1,028,031
Concrete Pile Caps	$ 1,087,726
Balance of Scope	$ 34,081,256

TABLE V-1 Top Trades – Component Change-Out

These costs were evaluated by the team to establish ranges of uncertainty as they relate to the design and construction of each trade category. Opinion forms were distributed to personnel, and meetings were held to form a consensus on each trade package. The diagram below illustrates opinions developed for the Car Wash Facility (Balance).

The ranges established by project team were then modeled and simulated 2,000 times for each trade cost category in order to develop a distribution of likely outcomes. The method used for the trade costs was beta-pert simulation. The trade costs were aggregated for the trade costs mean, 10th percentile and 90th percentile of the distribution.

Direct Costs

ITEM		2008 ESTIMATE	2019 PROJECTIONS LOW 10%	ML	HIGH 90%	Monte Carlo
Trade Contract Amounts						
Equipment Schedule		3,000,000	2.50%	10.25%	15.00%	$ 3,373,166
Productivity Adjustment		1,060,810	2.50%	6.05%	7.50%	$ 1,113,993
Concrete Grade Beams		868,959	5.00%	15.50%	20.00%	$ 954,672
Liner Panel		687,874	10.00%	23.60%	25.00%	$ 850,419
Fabricated Wall Panel System		624,400	10.00%	20.75%	25.00%	$ 763,536
Piping Systems		535,901	10.00%	33.90%	35.00%	$ 715,950
Foundation Wall		592,093	5.00%	16.15%	17.50%	$ 679,449
All Locations		402,072	2.50%	20.75%	25.00%	$ 496,240
Concrete Slab on Grade		400,610	5.00%	6.05%	7.50%	$ 425,192
Equipment		332,759	10.00%	18.80%	30.00%	$ 409,864
Miscellaneous (HVAC, FP & Plumbing Items)		257,470	5.00%	13.30%	15.00%	$ 289,309
Thermoplastic Membrane Roofing		227,382	1.00%	10.25%	12.50%	$ 252,246
Catenary		200,679	5.00%	13.30%	14.00%	$ 227,520
Demolition		195,419	2.50%	8.15%	15.00%	$ 212,159
Sitework		193,500	1.00%	15.50%	15.00%	$ -
Precast Structural Concrete		182,242	2.50%	16.15%	20.00%	$ 213,052
Lighting and branch wiring		178,005	5.00%	6.05%	20.00%	$ 196,084
Balance of Scope		2,618,407	15.00%	20.75%	25.00%	$ 3,156,268
TRADE COSTS		**12,548,581**	13,849,655	14,182,465	14,470,993	$ ***14,329,116***
GENERAL CONDITIONS	12%	1,719,494	10%	12%	15%	$ 1,956,737
Design Contingency	15%					
OVERHEAD & PROFIT	15%	2,442,878	7%	8%	12%	$ 2,632,513
ESTIMATE TOTAL		**18,586,958**	18,547,220	18,710,592	18,870,368	$ ***18,918,367***

Table V-2 Top Trade Contracts Risk Model

For escalation, key construction commodities were evaluated based on their history and possible future outcomes. The key commodities included iron and steel, cement, copper and diesel fuel.

Additionally, overall construction material indexes were evaluated for remaining project materials. Labor inflation was also evaluated and forecasted. The diagram below provides a sample of the forecasting of escalation for construction commodities and labor.

Iron Steel
Five Year Projection

2008 Fit Value	244.08

	High	Mid	Low
2008	244.08	244.08	244.08
2009	276.2875	273.26	269.84
2010	311.9524	302.55	281.21
2011	351.0731	331.22	306.58
2012	395.6496	358.51	314.67
2013	439.6819	383.61	314.67

Value of Steel in Component Change-Out Shop:	$	15,443,134.51
Years to Project Midpoint		3

Trend	Year	Index Value	Multiplier	Avg Annual %	Dollar Value
High	4	351.076	1.438375538	14.613%	$ 22,213,026.91
Mid	4	330.916	1.355775849	11.859%	$ 20,937,428.80
Low	4	306.024	1.253793863	8.460%	$ 19,362,507.27

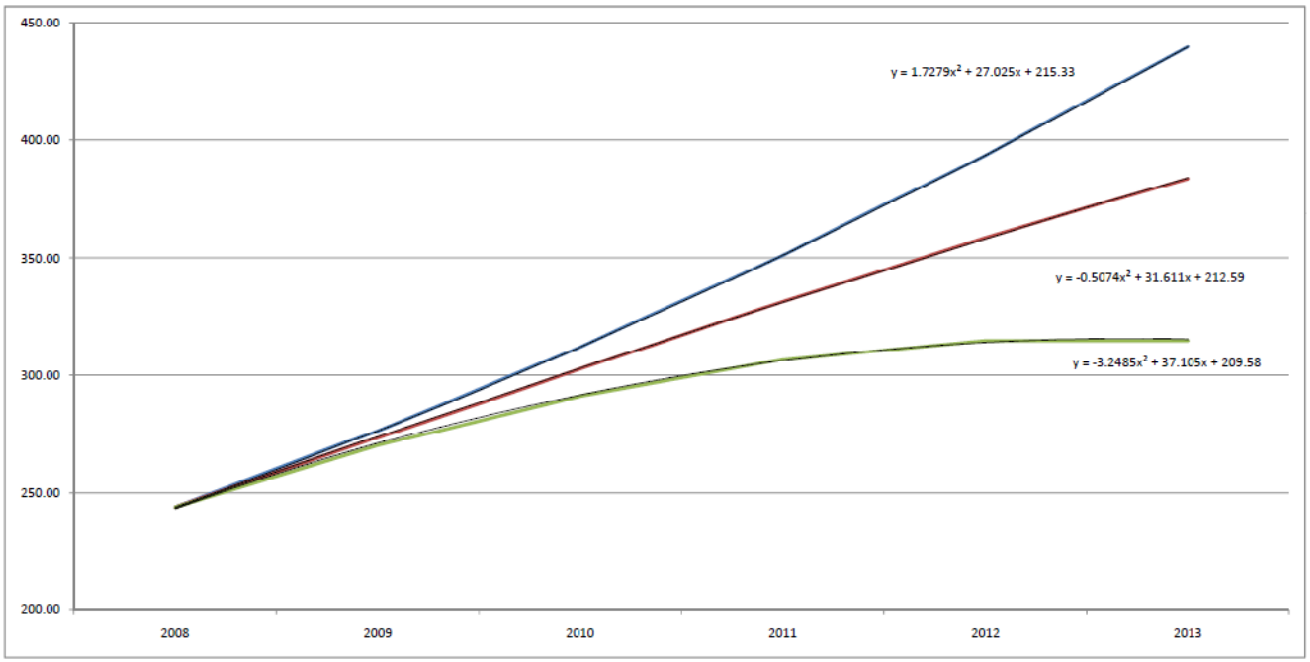


Table V-3 Iron and Steel Escalation Forecast

The top escalation drivers were evaluated for each project and escalated to the mid-point of each project construction schedule. The estimators, economists and statisticians assisted in establishing escalation rates for each top inflation driver.

The escalation ranges established by the project team were then modeled and simulated 2,000 times for each inflation item in order to develop a distribution of likely outcomes. The method used for the trade contracts was beta-pert simulation. The trade contracts were aggregated and values were displayed for the mean, 10th percentile and 90th percentile of the distribution.

Several of the projects included high values of force account work to be performed by Metro North and other specialized rail trades. These costs were also segregated, ranged by the project team and then simulated in the risk model.

Owner direct and indirect costs were also estimated and ranged by estimators and management. Hill used established CDOT mark-ups for construction contingency, incidentals, rail road flagging and administration, and preliminary engineering. These line items were also ranged for uncertainty and simulated. The method used for owner costs was triangular simulation as opposed to beta-pert simulation.

The results of the overall stochastic model were compared to the corresponding values as determined by the deterministic estimate. The table below provides a comparison summary.

				Risk Assessment Values		
Design Package	**CDOT 3/31/08 w/Esc Correction**	**Hill Estimate 3/31/08 Program w/ CDOT Pro Forma**	**Hill 3/31/08 Program Estimate w/Out-year Cost Assessment**	**Hill Most Likely**	**Hill High (90% Confidence)**	**Program Contingency for the 90% Confidence**
M-8 Acceptance Facility	$ 15,909,420	$ 15,909,420	$ 15,900,000	$ 16,000,000	$ 16,000,000	N/A
EMU & CSR Shop Improvements	$ 3,889,836	$ 7,040,459	$ 7,040,459	$ 7,000,000	$ 7,000,000	N/A
West End Yard Work	$ 89,550,805	$ 103,391,970	$ 107,792,438	$ 112,600,000	$ 114,600,000	6.3%
Independent Wheel True Facility	$ 32,830,513	$ 49,316,525	$ 47,318,429	$ 48,800,000	$ 49,300,000	4.2%
Component Change Out Shop	$ 335,562,856	$ 425,055,257	$ 405,809,248	$ 403,900,0000	$ 414,100,000	2.0%
Subtotals	**$ 477,743,430**	**$ 600,713,631**	**$ 583,869,995**	**$ 583,300,000**	**$ 601,000,000**	2.9%
Program Manager	**$ 5,580,100**	**$ 5,580,100**	**$ 5,580,100**	**$ 6,000,000**	**$ 6,000,000**	7.5%
SUBTOTALS PROGRAM 1 A	**$ 483,323,530**	**$ 606,293,731**	**$ 589,450,095**	**$ 594,300,000**	**$ 607,000,000**	3.0%
East End Yard	$ 77,337,030	$ 90,129,721	$ 80,823,284	$ 91,500,000	$ 93,900,000	16.2%
Car Wash - Foundations Only	$ 5,090,218	$ 12,844,639	$ 11,607,291	$ 11,300,000	$ 11,800,000	1.7%
Warehouse	$ 27,716,412	$ 36,769,800	$ 29,392,272	$ 31,900,000	$ 32,700,000	11.3%
Main Line Signal System Modifications	$ 10,854,137	$ 13,847,888	$ 10,629,745	$ 13,200,000	$ 13,600,000	27.9%
Subtotals	**$ 120,997,797**	**$ 153,592,049**	**$ 133,631,068**	**$ 147,900,000**	**$ 152,000,000**	14.8%
Program Manager	**$ 4,935,700**	**$ 4,935,700**	**$ 4,935,700**	**$ 5,000,000**	**$ 5,000,000**	1.3%
SUBTOTALS PROGRAM 1B	**$ 125,933,497**	**$ 158,527,749**	**$ 137,388,292**	**$ 152,900,000**	**$ 157,000,000**	14.3%
Final Track Completion	$ 148,030,657	$ 157,285,593	$ 103,097,815	$ 117,300,000	$ 120,700,000	17.1%

				Risk Assessment Values		
S&I Shop (+Wheel True/Pedestrian Bridge)				$ -	$ -	
S&I Shop	$ 293,604,076	$ 388,468,116	$ 260,443,722	$ 274,000,000	$ 280,800,000	7.8%
Pedestrian Bridge	$ 26,046,595	$ 35,766,253	$ 26,546,184	$ 27,000,000	$ 28,100,000	5.9%
Parking Garage	$ 72,605,096	$ 79,301,488	$ 56,546,025	$ 59,900,000	$ 63,400,000	12.1%
Engineering (MOW) Building	$ 50,121,730	$ 64,431,891	$ 36,973,256	$ 40,100,000	$ 41,200,000	11.4%
Car Wash Facility	$ 48,623,257	$ 82,733,522	$ 39,862,625	$ 42,500,000	$ 43,800,000	9.9%
Paint & Heavy Repair	$ 103,673,390	$ 131,140,255	$ 76,320,945	$ 85,500,000	$ 89,300,000	17.0%
Subtotals	**$ 742,704,801**	**$ 939,127,117**	**$ 599,790,572**	**$ 646,300,000**	**$ 667,300,000**	11.3%
Program Manager	**$ 8,923,200**	**$ 8,923,200**	**$ 8,923,200**	**$ 9,000,000**	**$ 9,000,000**	0.9%
SUBTOTALS PROGRAM 2	**$ 751,628,001**	**$ 948,050,317**	**$ 608,713,772**	**$ 655,300,000**	**$ 676,300,000**	11.1%
FULL PROGRAM TOTALS	**$ 1,360,885,027**	**$ 1,712,871,798**	**$ 1,336,730,635**	**$ 1,402,500,000**	**$ 1,440,300,000**	7.8%

Table V-8 - Comparison Summary – Risk Model versus Deterministic Values

C. Risk Assessment Findings and Conclusions

Hill's assessment results in the following findings and conclusions:

- CDOT's use of a 10 percent annual escalation rate for the 3/31/08 Program appears too high, particularly for the construction packages of with midpoints greater than 5 years from present day. The risk assessment model points to escalation values ranging on the order of 3% to 10%, varying by package depending on the cost divers, but generally decreasing for the longer term packages.
- Escalation is the major driver of cost in the risk model. The design and construction contingency factors simulated in the risk model have an impact also, but do not vary significantly from the corresponding deterministic costs. The deterministic costs are those values using percentages of construction costs based on past experience without statistical analysis.
- Comparing the 90% Confidence values from the risk assessment model to the corresponding values using the deterministic method indicates that package contingencies of approximately 2% to 28% may be appropriate. Overall, program-wide, the P90% indicates that program contingency should be on the order of 8%, based on the 3/31/08 Program.

- For proposed 12/05/08 Revised Program, Hill recommends a minimum of 10% program contingency, overall. This is due to the additional uncertainty introduced by the proposed revisions to the program.

Review and Analysis of Proposed New Haven Rail Maintenance Facility Expansion Project

Section VI
Summary of Conclusions and Recommendations

A. CDOT Budgets and Estimates

- The 2002 fleet study, used as the basis of the June 2002 estimate of $331 million TPC, was a very preliminary planning study, and inadequate for establishing a project budget.
- Scope increases account for approximately 18 percent of the current estimated costs. In addition, approximately 13 percent of current costs are related to a more definitive, and enhanced, baseline-scope.
- The largest portion of the cost variance between 2002 and 2008 is escalation, caused by an expanded schedule along with dramatic increases in construction cost escalation rates since 2002. Overall, escalation accounts for approximately 32% of the 3/31/08-estimated costs.
- The methods used by CDOT in developing the program TPC estimates have varied considerably between 2002 and 2008, and account for a very large portion of the variance over time.
- No system of configuration control is currently being used. No documentation was found related to a budgetary control mechanism that identifies and tracks elements such as "out-of-scope" items.
- Hill recommends that CDOT consider the following
    - Development of written standardized procedures for the preparation of estimated construction costs and other associated costs for the roll-up of overall program costs. Procedures for handling escalation costs are of particular importance.
    - The use of a program contingency when program budgets are established based upon preliminary planning or design documents.
    - Development of a configuration management system associated with overall program budgets. Elements comprising the scope for a specific budget should be clearly identified and tracked.

B. Current Program Costs and Cost Containment

- Hill prepared a check estimate of the 3/31/08 Program, including an evaluation of out-year cost, that totals $1.336 billion. This is $150 million higher than the comparable CDOT 3/31/08 Program estimate of $1.187 billion.
- A cost containment proposal was developed based on a functional analysis of the maintenance and operational needs of the rail-yard. After discussion with CDOT and Metro North Railroad (MNR), general agreement was reached on most of the elements of a revised program (proposed 12/05/08 Revised Program), estimated at $1.08 billion. The major revisions are as follows:
    - Upgrade of the existing Interim Running Repair shop as an alternative to building the proposed new Service & Inspection shop.
    - Procurement or lease of an offsite conventional warehouse as an alternative to the proposed onsite High Density Warehouse.

- Procurement or lease of an offsite at-grade parking facility as an alternative to an onsite Parking Garage.
- Scaling down the modification work of the proposed Paint & Heavy Repair shop slated to be housed in the existing CSR Shop.
- Scaling down the size and complexity of the proposed Independent Wheel True facility, similar to a facility currently being used at MNR's Harmon Yard.

- Further cost containment is possible, based on a prioritization of the proposed 12/05/08 Revised Program. Hill broke down the program into three tiers, as follows:
  - **Tier 1 Elements** – Baseline need critical for the maintenance operations of the expanded fleet, estimated at $849 million. Includes as its centerpiece the proposed Component Change Out Shop, other necessary shops, and most of the program's yard track work.
  - **Tier 2 Elements** – Enhancements to Baseline need, estimated at $57 million, consisting of the proposed Car Wash Facility.
  - **Tier 3 Elements** – Other elements that can be either deferred or eliminated, as necessary, estimated at $178. Included in this tier are the Fuel Cells, Pedestrian Bridge, EMU/Program Shop Upgrade, Yard Signal System, further scope reduction of the proposed Paint & Heavy Repair Shop upgrade, and the Final Track Completion.
- Hill's functional analysis indicates that all of the Tier 1 elements will be required to provide the necessary maintenance and storage facilities of the proposed expanded fleet. Elements in Tiers 2 and 3 can be either deferred or eliminated, as necessary. Alternately, if only the Tier 1 scope is selected for funding, a large program budget contingency should be used: at minimum $100 million.