U.S. Department
of Transportation
**Federal Transit
Administration**

REGION IX
Arizona, California,
Hawaii, Nevada, Guam
American Samoa,
Northern Mariana Islands

201 Mission Street
Suite 1650
San Francisco, CA 94105-1839
415-744-3133
415-744-2726 (fax)

AUG 14 2014

Daniel Grabauskas
Executive Director & CEO
Honolulu Authority for Rapid Transportation
1099 Alakea Street, 17th Floor
Honolulu, HI 96813

Dear Mr. Grabauskas,

Enclosed is the Federal Transit Administration's (FTA) 2014 Risk Refresh Report on the Honolulu Authority for Rapid Transportation's (HART) Honolulu Rail Transit Project (Project). As explained to HART staff in our recent meeting of July 30, 2014, FTA's risk assessment process is designed to evaluate the reliability of the project scope, cost estimate, and schedule with special focus on the elements of uncertainty associated with the effectiveness and efficiency of the project's implementation and within the context of the surrounding project conditions. While at this time the Project remains on schedule and budget, the Report notes HART's proactive management practices particularly since the resumption of construction and addresses the challenges and increasing pressure on the schedule and budget. These include, but are not limited to, past construction delays that have had significant cost impacts on the active design-build contracts with escalation still to be determined and recent cost estimates on future construction packages for eastern segments of the Project. The Report also addresses market concerns regarding the cost of labor amid other concurrent construction projects in the Honolulu market place.

FTA appreciates the time and co-operation extended by HART staff to our project management oversight contractor (PMOC) to assist in the development of the Report. The PMOC, in its independent development of the Report, synthesized available project information, explored and analyzed uncertainties and risks, provided a qualitative and quantitative assessment of ranges of forecasted cost and schedule; described the analytical methods used, considered risk mitigation options and alternatives including use of cost and schedule contingencies; and drew conclusions. The Report also provides recommendations for adjustment to scope, cost, schedule and project management planning activities in order to respond to project risks.

HART's formal response to the recommendations set out in the Report should be provided to FTA within thirty (30) of receipt of the Report. Any questions about the Report should be directed to Bernardo Bustamante, Director of the Office of Program Management and Oversight, at (415) 744-3113, or bernardo.bustamante@dot.gov.

Sincerely,

Leslie T. Rogers
Regional Administrator

Enclosure

PMOC REPORT

2014 Risk Refresh

Honolulu Rail Transit Project
Honolulu Authority for Rapid Transportation (HART)
City and County of Honolulu
Honolulu, HI

July 2014 (FINAL)

PMOC Contract Number: DTFT60-09-D-00012
Task Order Number 5
Work Order Number 9
Project No. DC-27-5140
OPs Referenced: OP 1, OP 32C, 33, 34, 40

Jacobs Engineering Group, Inc., 501 North Broadway, St. Louis, MO 63102
Tim Mantych, P.E., (314) 335-4454, tim.mantych@jacobs.com
Length of Time Assigned: Five Years (November 18, 2009 through November 17, 2014)

TABLE OF CONTENTS

TABLE OF CONTENTS ..... **i**
LIST OF TABLES ..... **ii**
LIST OF FIGURES ..... **ii**
LIST OF APPENDICES ..... **iii**

1.0 EXECUTIVE SUMMARY **4**
1.1 Introduction 4
1.2 PMOC Review 4
1.3 Findings/Recommendations 4
1.3.1 Technical Capacity and Capability (TCC) Review 4
1.3.2 Project Scope Review 5
1.3.3 Project Schedule Review 6
1.3.4 Project Cost Estimate 7
1.3.5 Project Risk and Contingency Review 8

2.0 INTRODUCTION **11**
2.1 Project Sponsor 11
2.2 Project Description 11
2.3 Project Status 13
2.4 Project Budget 13
2.5 Project Schedule 16
2.6 Project Management Oversight Contractor (PMOC) 16
2.7 Evaluation Team 16

3.0 TECHNICAL CAPACITY AND CAPABILITY REVIEW **17**
3.1 PMOC Assessment 17
3.2 PMOC Recommendations 18

4.0 PROJECT SCOPE REVIEW **19**
4.1 PMOC Assessment 19
4.2 PMOC Recommendations 20

5.0 PROJECT SCHEDULE REVIEW **21**
5.1 PMOC Assessment 21
5.2 PMOC Recommendations 21

6.0 PROJECT COST ESTIMATE REVIEW **23**
6.1 PMOC Assessment 23
6.2 PMOC Recommendations 25

7.0 PROJECT RISK **26**
7.1 Purpose 26
7.2 Methodology 26
7.3 Risk Identification 27

7.4 Contract Packaging 27
7.5 Cost Risk Assessment 27
7.5.1 Methodology 27
7.5.2 SCC Adjustments 28
7.5.3 Baseline Beta Values 29
7.5.4 Beta Value Adjustments 32
7.5.5 Cost Risk Analysis 33
7.5.6 Cost Contingency 34
7.6 Schedule Risk Assessment 35
7.6.1 Methodology 35
7.6.2 Schedule Risk Analysis 37
7.6.3 Schedule Contingency 42
7.7 Risk Mitigation 43
7.7.1 Primary Mitigation 43
7.7.2 Secondary Mitigation 43
7.8 Conclusion 44
7.8.1 Cost Risk Analysis 44
7.8.2 Schedule Risk Analysis 46

8.0 APPENDICES 48

LIST OF TABLES

Table 1. PMOC Evaluation Team 16
Table 2. Updated Contract Packages 19
Table 3. Summary of Contract Change Orders (CCO) 24
Table 4. HART Forecast of Change Orders (February 2014) 25
Table 5. Adjusted Stripped BCE 25
Table 6. PMOC Adjustments to HART Estimate $YOE 29
Table 7. Imported Beta Values for Risk Profile 1 30
Table 8. Imported Beta Values for Risk Profile 2 30
Table 9. Imported Beta Values for Risk Profile 3 30
Table 10. Beta Values Risk Refresh 31
Table 11. Risk Model Data 34
Table 12. PMOC Recommended Contingency 34
Table 13. Schedule Contingency Final Design through RSD 42
Table 14. PMOC Recommended Secondary Mitigation 44

LIST OF FIGURES

Figure 1. Project Map Showing Line Segments 12
Figure 2. Project Map 13
Figure 3. Schedule Risk Assessment Process 37
Figure 4. Schedule Risk Assessment Steps and Schedule Types 37
Figure 5. Duration Distribution Type 39
Figure 6. Schedule Risk Scoring Chart 40

Figure 7. Project Completion Date Confidence Level 41
Figure 8. Buffer Float and RSD Analysis 43

LIST OF APPENDICES

Appendix A: List of Acronyms

1.0 EXECUTIVE SUMMARY

1.1 Introduction

The Honolulu Authority for Rapid Transportation (HART) continues to advance development of its Honolulu Rail Transit Project ("Project") in accordance with the Federal Transit Administration (FTA) New Starts requirements.

FTA assigned Jacobs as a Project Management Oversight Contractor (PMOC) on September 24, 2009, for the purpose of monitoring the Project and providing FTA with "information and well-grounded professional opinions regarding the reliability of the project scope, cost, and schedule" of the Project. The PMOC completed a Risk Refresh in 2012 prior to execution of the Full Funding Grant Agreement (FFGA) in December 2012. This report represents an updated Risk Refresh based on information provided by HART as of April 2014.

It should be noted that this assessment is an update of the assessment that was completed in advance of the FFGA. In addition, all legal litigations have been resolved since the last risk assessment. The PMOC reviewed any Project changes, including those changes as a result of litigation period impacts, that may affect the technical capacity and capability of the grantee as well as changes associated with Project's current FFGA scope, schedule, cost estimate, and risk and contingency management.

1.2 PMOC Review

This report represents an update of the PMOC's assessment at time of FFGA of HART's technical capacity and capability as well as an assessment of the Project's current FFGA scope, schedule, cost estimate, and risk and contingency management. This assessment is governed by the following FTA Oversight Procedures (OP):

- OP 21 – Technical Capacity and Capability Review
- OP 32C – Project Scope Review
- OP 32D – Project Delivery Method Review
- OP 33 – Capital Cost Estimate Review
- OP 34 – Project Schedule Review
- OP 40 – Risk and Contingency Review

1.3 Findings/Recommendations

1.3.1 Technical Capacity and Capability (TCC) Review

The PMOC has assessed that the HART organization should be streamlined to be more effective. There is a sense that critical decisions are rendered "by committee", which is not an effective means for management on a capital program of this magnitude. HART should consider identifying a Project Director who serves as the focal point for all capital program decisions. This will eliminate management by committee, expedite critical decisions, and help ensure strong schedule and contract management principles are implemented.

Recommendations

(1) HART should identify a Project Director.
(2) HART must complete the update of the Project Management Plan (PMP).
(3) HART should identify a permanent Risk Manager.
(4) HART and their consultant organization should be streamlined to be more effective (e.g. evaluate need for HART Construction Assistant Deputy; clearly define the roles and responsibilities of HART Project Manager and CE&I Resident Engineer; evaluate need for HART Assistant Project Managers).
(5) HART must update its management plans to include the Assistant Deputy Director positions that weren't included in the most recent updates provided to the PMOC in March 2014.

1.3.2 Project Scope Review

There have been no significant changes to the scope of the Project since execution of the FFGA. The scope of the Project is well-defined and is generally at an appropriate level of completeness. The Project final design phase and construction phase are concurrent to an extent as a result of the hybrid contract packaging strategy that contains work packages for Design-Build (DB), Design-Bid-Build (DBB), and Design-Build-Operate-Maintain (DBOM). The awarded DB contracts are significantly more advanced than other portions of the project and have progressed through most of the design phase and into field construction, which resumed in September 2013. The DBB contracts remain in varying stages of final design.

The following observations were made with regard to the scope review:

- Scope is adequately defined.
- Level of completion varies across contract packages.
- There are still several outstanding issues:
  - Several third-party agreements have yet to be resolved.
  - Final operational analysis must be completed by Ansaldo Honolulu Joint Venture (AHJV).
  - A number of design issues that affect the interface with other contracts must be resolved.
  - HART has developed an extensive Contract Packaging Plan that will require significant management effort to ensure proper interface coordination.
  - There is concern whether bidding competition for the remaining packages will be strong enough to assure pricing within budget.
  - Cost estimates have not yet been prepared for a number of potential Contract Change Orders (CCO).
  - Real estate acquisition to support construction in the City Center Segment will require significant coordination and effort by HART.
  - HART is considering several proposed design changes that may require additional environmental review. It is not anticipated that any of these changes will significantly impact the Project implementation or planned operations. However, each proposed change must be properly vetted by each affected party.

Recommendations

(1) Continue to review and vet all potential Contract Change Orders. Prepare cost estimates for any potential Contract Change Orders that cannot be eliminated at this time.
(2) Continue to review all post-Record of Decision (ROD) changes to ensure they do not have an impact on the environmental documentation, the project scope, or future operations.
(3) Prioritize resolution of required third-party agreements, real estate acquisitions, and coordination between various contractors and designers.

1.3.3 Project Schedule Review

The PMOC reviewed HART's Master Program Schedule (MPS) with a Data Date of February 28, 2014. The PMOC has assessed that the MPS remains achievable but contains little margin for error or delay to critical path and near critical path activities due to schedule compression. HART should also engage tighter management oversight over the Core Systems Contractor especially since they continue to slip critical schedule dates with vehicle design and manufacturing and systems design.

The following observations were made with regard to the schedule review:

- The FFGA Revenue Service Date (RSD) is January 31, 2020.
- HART's target RSD is March 29, 2019 and the MPS includes more than 300 calendar days of buffer float up to the FFGA RSD.
- The adjusted/stripped schedule RSD is February 7, 2019.
- HART MPS consists of the master schedule connected to multiple contractor's schedules. The CSC's AHJV schedule is the only one whose base calendar is a 7-day calendar due to it being mainly a manufacturing and procurement schedule.
- The current MPS contains more logic density and schedule-compression than ever before, which may require more concurrent utilization of resources. It is recommended that HART and consultant staff projections be re-visited as a result of this concurrent utilization.
- Most of the Risk Register items used by the PMOC in the schedule risk analysis are the same as the previous risk refresh.

Recommendations

(1) HART and consultant staff projections should be re-visited as a result of projected concurrent utilization.
(2) HART should require all construction contractors to consistently apply 5-day and 6-day-per-week calendars in lieu of 7-day- per-week calendars.
(3) HART should revise its staffing plan to ensure that schedule compression has not caused excessive staff requirements during peak demand.
(4) HART should withhold partial or full payment of contractor monthly pay applications if the contractors continue failing to submit timely and acceptable Critical Path Method (CPM) project schedule updates.
(5) HART should consider placing a senior level scheduler in the CSC offices to support more aggressive schedule management oversight.

1.3.4 Project Cost Estimate

The FFGA Project Budget is $5.122 billion, including $644 million in allocated and unallocated contingency and $173 million in financing costs. HART has stated that the Project is on budget while acknowledging that there has been pressure on the budget due to the year-long Archeological Inventory Survey (AIS) delay to the project and changing market conditions.

The PMOC evaluated the cost estimates for each Standard Cost Category (SCC) for mechanical soundness and consistency. These mechanical checks are used to determine if there are any material inaccuracies within the estimate. The estimate was found to be mechanically correct in the tabulation of the unit cost, application of factors, and translation to the SCC workbook. The estimate is reflective of the sequencing identified in the MPS.

The following specific observations were made with regard to the cost estimate review:

- The individual Bases of Estimates (BOE) are updated to match contract estimates. However, there was no uniformity across individual BOEs. For example:
    - The application of markups was inconsistent.
    - The application of the General Excise Tax (GET) varied.
    - Escalation rates varied between contracts.
- The cost estimate provided by HART excluded two contracts (MM-937 – ROW Engineering Support Services and MM-964 – Safety & Security Certification Consultant).
- Some components of estimate must be updated (e.g. soft costs, Right-of-way (ROW)).
- There are a number of possible change orders for which no cost has been associated.
- Several adjustments to the cost estimate are recommended.

Once all contingency was stripped, the PMOC incorporated the adjustments into the base cost of the project prior to completing the cost risk analysis. These adjustments totaled $139.5 million:

- Revaluation of ROW and Temporary Construction Easements – $7.4 million
- Costs for added HART/PMC positions – $5.9 million
- MM-937 and MM-964 excluded from cost breakdown provided to PMOC – $6.5 million
- HART adjustment for “Known changes” at time of analysis – $32.5 million
- Potential Changes Identified with no associated estimate – $25 million
- Disagreement in savings for change to 4-Car Trains – $5 million
- Escalation component of delay settlement for WOFH/KHG/MSF – $10 million
- Resolution of disputed Contract Change Orders – $5 million
- HART adjustment for Stations – $23.8 million
    - Westside Stations – $8.9 million
    - Pearl Highlands Transit Center – $10 million
    - Airport Station Group – $5.6 million
    - Dillingham/Kaka’ako Station Group – $0.7 million (Deduct)
- HART adjustment for Airport and City Center Guideway (rescue carts) – $1.4 million
- Westside Stations Group adjustment based on CE&I estimate – $17 million.

In addition, the Net Stripped, Adjusted Estimate includes $177.6 million in forecast Change Orders that had previously been identified by HART.

Recommendations

(1) HART should prepare cost estimates for all identified possible changes (contract change orders).
(2) HART should focus on completion of the Airport & City Center Guideway Estimate to allow time for mitigation if there is a budget issue with this contract.
(3) HART should refresh its ROW estimate to reflect current property costs and include costs for Temporary Construction Easements.
(4) HART should refresh its personnel manpower charts to account for new positions and a refined schedule to verify the cost included in SCC 80 soft costs.
(5) HART should re-baseline its budget following completion of the Risk Refresh activities.
(6) HART should verify that its budgets and any ongoing estimate refresh include adequate funds for escalation.

1.3.5 Project Risk and Contingency Review

The PMOC has performed regular monitoring visits to the project and has refreshed its earlier risk assessment based upon an updated understanding of project risks and updated schedule and cost information provided by HART. In April 2014, the PMOC participated in a risk refresh workshop with HART, the purpose of which was to discuss HART's progress in its risk management efforts, and to discuss PMOC's observations and reflections from PMOC's initial review of HART's updated scope, cost, schedule, and risk information.

For the purposes of its risk refresh, the PMOC considered the project in three separate elements, which are termed here as "risk profiles":

- ***Risk Profile 1*** is associated with currently-contracted direct cost work;
- ***Risk Profile 2*** is associated with yet-to-be-contracted direct cost work; and
- ***Risk Profile 3*** is associated with "soft costs".

Cost Risk Analysis

During the April 2014 risk workshop, information was provided indicating that HART was aware of additional costs that should be included, and which were added by the PMOC as estimate adjustments, along with PMOC's independent estimate adjustments. The PMOC has prepared this risk refresh based upon additional information provided by HART after the workshop. The PMOC found that the HART's risk identification effort, including its risk mitigation activities, generally conforms to its documented processes.

The cost risk assessment recognized general reductions in risk due to advancement of design. However, little additional construction has occurred and so no major changes in construction risk were made. Further, the project delay has caused the bidding effort to occur during an increase in the construction market, which adds market risk to the model. A major influence in the risk for Risk Profile 2 is market risk due to an increasingly strong construction market both at the project location and on the west coast of the U.S.

It is recognized that efforts have been made to recover contingency levels through cost reduction measures, value engineering, and revised project delivery strategies. However, these types of changes are becoming increasingly less likely.

The PMOC basis of the stripped, adjusted estimate for cost risk modeling is as follows:

Project Budget	$5,122
HART Current Available Contingency	$463
Financing	$173
Net Stripped Estimate	**$4,486**
PMOC Adjustments	$139.5
Net Stripped, Adjusted Estimate	**$4,625**

With adjustments of $139.5 million, the current contingency is reduced to $323.5 million (7% of the adjusted, stripped estimate). This level of contingency would be commensurate with a project that is completely bid and has progressed in construction beyond the point of being "in the ground". Considering the project progress to date is 22%, this current level of contingency would only reflect an approximate achievable probability of 42%.

The predicted FTA model outcome is $5,214 million (excluding finance costs). This includes $588 million in recommended contingency (13% of the adjusted, stripped estimate). HART's estimate falls short of the predicted FTA model outcome by $265 million ($139.5 million in recommended adjustments plus $125.5 million in additional recommended contingency). There is a 5.4% difference between HART's project estimate of $4,949 million and the predicted FTA model outcome of $5,214 million.

The recommended estimate represents the median value from the FTA risk assessment model, when adjusted for the specifics of this project. The historic trend indicates 40%-likely to 80%-likely range of $5,101 million to $5,670 million.

The RCMP includes several potential Secondary Mitigation options. However, there is a general lack of detailed development of plans and cost estimates for the items identified in the RCMP.

Recommendations

(1) HART's estimate falls short of the predicted FTA model outcome by $265 million ($139.5 million in recommended adjustments plus $125.5 million in additional recommended contingency). HART should review its project estimate and determine how to reduce costs to close this gap.
(2) The PMOC-recommended amount of secondary mitigation is $195.5 million.
(3) The RCMP must be updated to strengthen risk contingency tracking, custody, and reporting. The RCMP should include an updated contingency draw-down curve that reflects the current contingency balance and more accurate drawdown milestones. Diligence and vigilance must continue to be applied to this effort to avoid a rapid contingency usage that could ultimately leave the project unprotected.
(4) HART should update and continue its tracking of the Secondary Mitigation items,

and develop a process by which those items may be priced by the bidders of the remaining work at the time of bidding. This strategy avoids attempting to trigger Secondary Mitigation after receipt of bids or after contracting, at which point the cost reduction may be significantly reduced due to lack of competitive forces.

(5) Strong controls must be put in place immediately to avoid future rapid contingency reduction. The frequency and the levels of project management to which these statistics are reported should be improved and monitored monthly.

(6) The PMOC and HART should engage in a focused "cost containment workshop" on a monthly basis to monitor the efforts taken to avoid rapid contingency usage.

Schedule Risk Analysis

HART's target Revenue Service Date is March 2019. The FFGA Date is January 31, 2020. The Impacted Risk Model (IRM) distribution range for project completion from the 0% to 100% confidence levels span a 549-day period. The probability percentage points for the IRM are:

- 20% Confidence level completion date: 20-Aug-19
- 50% Confidence level completion date: 17-Dec-19
- 75% Confidence level completion date: 20-Feb-20
- 90% Confidence level completion date : 20-Apr-20
- 100% Confidence level completion date: 31-Jul-20

The probability confidence level for achieving project completion by January 2020, the FFGA RSD, has been reduced by 15-20% since the last Risk Assessment refresh in July 2012. The Schedule Risk Analysis indicates 66-70% probability of completing the project by the FFGA RSD of 31-Jan-20. The schedule risk analyses using the OP40 calculation indicates a recommended RSD of July 13, 2020.

The FFGA RSD of January 2020 can be achieved; however, HART must implement strong schedule and contract management throughout the remainder of the project.

Recommendations

(1) HART should closely monitor the MPS longest critical path and near critical paths as a means to prevent depletion of project total float to achieve RSD by January 2020.

(2) HART should revise its staffing plan to ensure that schedule compression has not caused excessive staff requirements during peak demand during construction.

(3) The PMOC and HART should engage in focused "schedule containment workshops" on a monthly basis to monitor the efforts taken to achieve the FFGA RSD.

2.0 INTRODUCTION

The Honolulu Authority for Rapid Transportation (HART) continues to advance development of its Honolulu Rail Transit Project ("Project") in accordance with the Federal Transit Administration (FTA) New Starts requirements. The Project is intended to provide improved mobility in the highly-congested east-west corridor along Oahu's south shore between Kapolei and the Ala Moana Center.

FTA assigned Jacobs as a Project Management Oversight Contractor (PMOC) on September 24, 2009, for the purpose of monitoring the Project and providing FTA with "information and well-grounded professional opinions regarding the reliability of the project scope, cost, and schedule" of the Project. That effort continues with this update report, which represents the PMOC's assessment of Risk and Contingency Management.

The PMOC completed a Risk Refresh in 2012 prior to execution of the Full Funding Grant Agreement (FFGA) in December 2012. This report represents an updated Risk Refresh based on information provided by HART as of April 2014.

It should be noted that this assessment is an update of the assessment that was completed in advance of the FFGA. In addition, all legal litigations have been resolved since the last risk assessment. The PMOC reviewed any Project changes, including those changes as a result of litigation period impacts, that may affect the technical capacity and capability of the grantee as well as changes associated with Project's current FFGA scope, schedule, cost estimate, and risk and contingency management.

2.1 Project Sponsor

The City and County of Honolulu ("City") is the overarching FTA grantee. The City's Department of Transportation Services (DTS) and HART have executed a Memorandum of Understanding, which delineates each agency's roles and responsibilities so as not to jeopardize the City's standing as an FTA grantee. HART is responsible for the New Starts grants for the Project and may share responsibilities with DTS for grants using Section 5307 or other FTA funding sources.

2.2 Project Description

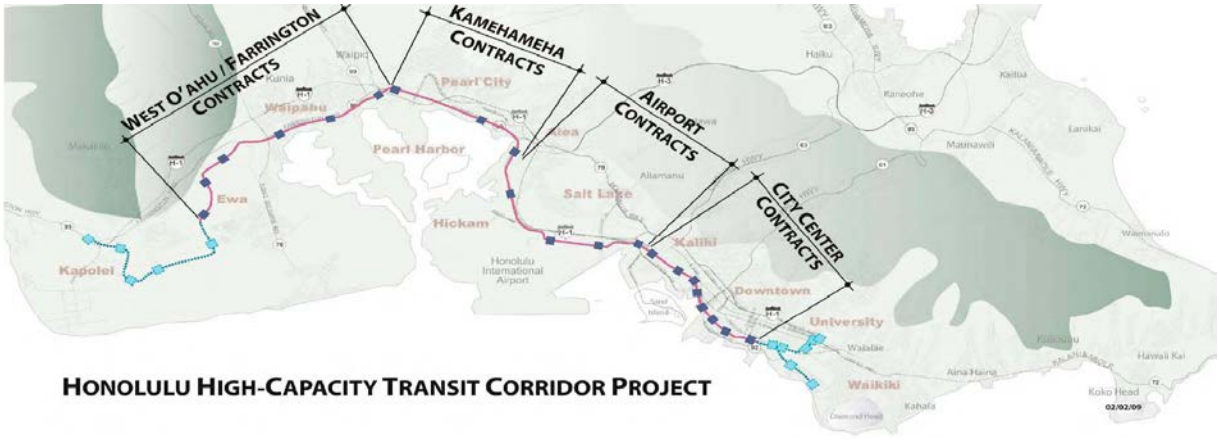
The Project is an approximately 20-mile elevated fixed guideway rail system along Oahu's south shore between East Kapolei and Ala Moana Center. The alignment is elevated, except for a 0.6-mile at-grade portion at the Leeward Community College station. The proposed investment includes 21 stations (20 aerial and 1 at-grade), 80 "light metro" rail transit vehicles, administrative/operations facilities, surface and structural parking, and maintenance facilities. HART plans to deliver the Project in four guideway segments:

- Segment I (West Oahu/Farrington Highway/WOFH) – East Kapolei to Pearl Highlands (6 miles/7 stations)
- Segment II (Kamehameha Highway/KH) – Pearl Highlands to Aloha Stadium (4 miles/2 stations)
- Segment III (Airport) – Aloha Stadium to Middle Street (5 miles/4 stations)

- Segment IV (City Center) – Middle Street to Ala Moana Center (4 miles/8 stations)

HART has combined Segments III and IV into a single guideway construction contract. The Contract Packaging Plan has been updated to reflect this change.

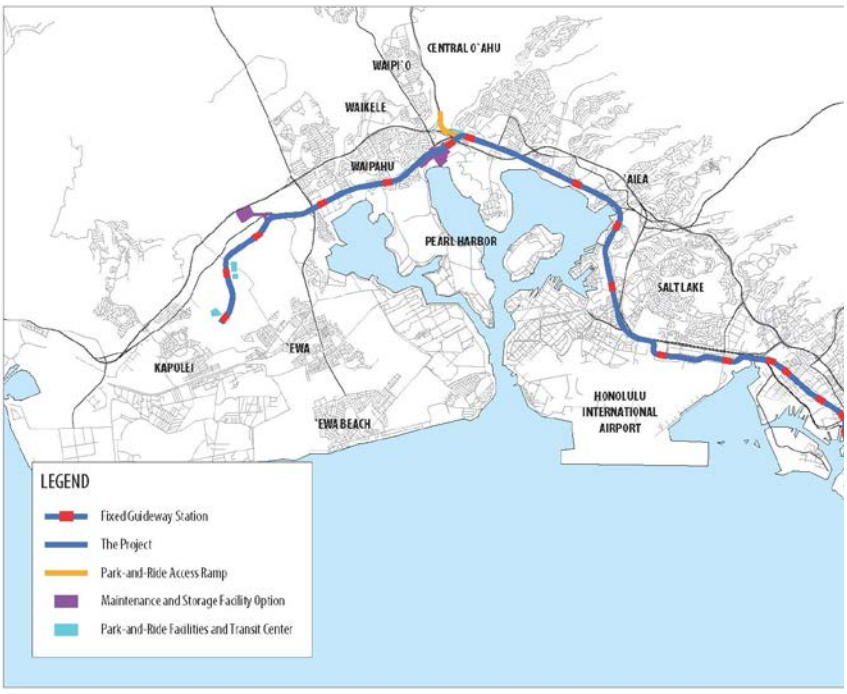
Figure 1. Project Map Showing Line Segments



Additional Project information:

- **Additional Facilities:** Maintenance and Storage Facility (MSF) and parking facilities
- **Vehicles:** 80 vehicles, supplied by the Core Systems Contractor (CSC), which is also responsible for systems design and construction and operations. The CSC is a Design-Build-Operate-Maintain (DBOM) contract.
- **Ridership Forecast:** Weekday boardings – 99,800 (2019); 114,300 (2030).
- **Grantee's Target Revenue Service Date (RSD):** March 2019

Figure 2. Project Map



2.3 Project Status

The Full Funding Grant Agreement (FFGA) was executed on December 19, 2012. Final Design activities are continuing for a large portion of the Project, and construction activities have begun in the West Oahu/Farrington Highway and Kamehameha Highway segments and the Maintenance and Storage Facility.

2.4 Project Budget

The FFGA Project Budget is $5.122 billion in Year-of-Expenditure (YOE) dollars, including $644 million in allocated and unallocated contingency and $173 million financing costs.

Through March 2014, HART expended $904.5 million and reported a balance of $608.2 million in contingency. However, HART's forecast for contingency usage indicated an available balance of $423.8 million.

Table 3. 2014 Adjusted Base Cost Estimate ($M)

SCC	Description	HART Current Budget[1]	Allocated Contingency[2]	Total w/o Contingency[1]	Adjustments[2]	Adjusted BCE
10	**Guideway & Track Elements**	**1,299,822,278**	**162,179,982**	**1,137,642,296**	**75,712,912**	**1,213,355,208**
10.04	Guideway: Aerial structure	1,195,800,651	153,386,755	1,042,413,896	59,258,703	1,101,672,599
10.08	Guideway: Retained cut or fill	6,973,415	537,159	6,436,256	1,165,177	7,601,433
10.09	Track: Direct fixation	90,462,039	7,599,249	82,862,790	14,714,643	97,577,433
10.11	Track: Ballasted	2,923,035	225,160	2,697,875	488,405	3,186,280
10.12	Track: Special (switches, turnouts)	3,663,139	431,660	3,231,479	85,894	3,317,463
20	**Stations, Stops, Terminals, Intermodals**	**483,938,837**	**87,272,569**	**396,666,268**	**16,300,000**	**412,996,268**
20.01	At-grade station	7,420,693	1,309,361	6,111,332	0	6,111,332
20.02	Aerial station	331,162,203	57,998,746	273,163,457	16,300,000	289,463,457
20.06	Automobile parking multi-story structure	79,690,518	13,281,753	66,408,765	0	66,408,765
20.07	Elevators, escalators	65,665,423	14,682,709	50,982,714	0	50,982,714
30	**Support Facilities: Yards, Shops, Admin.**	**113,037,249**	**8,680,192**	**104,357,057**	**23,566,903**	**127,923,960**
30.02	Light Maintenance Facility	8,217,846	631,053	7,586,793	1,713,322	9,300,115
30.03	Heavy Maintenance Facility	42,485,010	3,262,447	39,222,563	8,857,612	48,080,175
30.04	Storage or Maintenance of Way Building	8,541,975	655,943	7,886,032	1,780,899	9,666,931
30.05	Yard and Yard Track	53,792,419	4,130,749	49,661,669	11,215,070	60,876,740
40	**Sitework & Special Conditions**	**1,084,906,182**	**128,616,712**	**956,289,470**	**119,779,617**	**1,076,069,087**
40.01	Demolition, Clearing, Earthwork	32,194,824	4,522,813	27,672,011	843,636	28,515,647
40.02	Site Utilities, Utility Relocation	355,379,490	51,485,547	303,893,943	8,281,622	312,175,565
40.03	Haz. material, contaminated soil removal/mitig	1,400,811	231,903	1,168,908	3,632	1,172,540
40.04	Environmental mitigation	36,144,458	4,188,535	31,955,923	1,534,841	33,490,764
40.05	Site structures (retaining walls, sound walls)	9,752,797	691,423	9,061,374	18,668,873	27,730,247
40.06	Pedestrian / bike access, landscaping	49,302,959	7,429,919	41,873,040	6,389,602	48,262,642
40.07	Automobile, bus accessways (roads, parking)	200,108,610	29,709,250	170,399,360	4,999,842	175,399,202
40.08	Temporary Facilities/other indirect costs	400,622,233	30,357,322	370,264,911	79,057,567	449,322,478
50	**Systems**	**270,399,210**	**24,718,087**	**245,681,123**	**15,861,261**	**261,542,384**
50.01	Train control and signals	115,240,968	10,022,272	105,218,696	5,967,134	111,185,830
50.02	Traffic signals and crossing protection	12,301,603	2,050,267	10,251,336	0	10,251,336
50.03	Traction power supply: substations	33,910,327	2,883,016	31,027,311	1,758,895	32,786,206
50.04	Traction power distribution	35,070,608	3,352,161	31,718,447	4,087,511	35,805,958
50.05	Communications	59,996,794	5,203,351	54,793,443	3,329,076	58,122,519
50.06	Fare collection system and equipment	10,096,140	878,041	9,218,099	522,774	9,740,873
50.07	Central Control	3,782,271	328,980	3,453,791	195,870	3,649,661
	CONSTRUCTION SUBTOTAL (10 - 50)	**3,252,103,757**	**411,467,543**	**2,840,636,214**	**251,220,693**	**3,091,856,907**

SCC	Description	HART Current Budget[1]	Allocated Contingency[2]	Total w/o Contingency[1]	Adjustments[2]	Adjusted BCE
60	**ROW, Land, Existing Improvements**	**219,819,371**	**22,143,624**	**197,675,747**	**7,486,975**	**205,162,722**
60.01	Purchase or lease of real estate	199,347,711	19,987,047	179,360,664	6,830,126	186,190,790
60.02	Relocation of existing households/businesses	20,471,660	2,156,577	18,315,083	656,850	18,971,933
70	**Vehicles**	**209,787,838**	**18,244,821**	**191,543,017**	**20,862,735**	**212,405,752**
70.01	Light Rail	189,081,069	16,443,996	172,637,073	19,790,546	192,427,619
70.06	Non-revenue vehicles	14,267,350	1,240,802	13,026,548	738,758	13,765,306
70.07	Spare parts	6,439,419	560,023	5,879,396	333,431	6,212,827
80	**Professional Services**	**1,178,173,903**	**100,047,774**	**1,078,126,129**	**37,589,728**	**1,115,715,857**
80.01	Preliminary Engineering	124,962,785	6,632,905	118,329,880	9,344,848	127,674,727
80.02	Final Design	232,869,193	32,095,148	200,744,044	12,014,809	212,788,853
80.03	Project Management for Design/Construction	382,704,988	19,570,239	363,134,749	5,877,733	369,012,484
80.04	Construction Administration & Management	174,938,380	13,112,698	161,825,682	94,717	161,920,399
80.05	Professional Liability/Non-Construction Insurance	39,803,072	4,586,756	35,216,316	158,194	35,374,510
80.06	Legal; Permits; Review Fees by other agencies	78,714,481	8,997,171	69,717,310	5,000,000	74,717,310
80.07	Surveys, Testing, Investigation, Inspection	72,964,682	8,640,605	64,324,077	2,432,494	66,756,571
80.08	Start up	71,216,324	6,412,253	64,804,071	2,666,935	67,471,006
	SUBTOTAL (10 - 80)	**4,859,884,869**	**551,903,762**	**4,307,981,107**	**317,160,131**	**4,625,141,238**
90	**Unallocated Contingency**	**88,750,055**	**88,750,055**	**0**	**0**	**0**
90	**Latent Contingency**	**0**	**0**	**0**	**0**	**0**
	SUBTOTAL (10 - 90)	**4,948,634,924**	**640,653,817**	**4,307,981,107**	**317,160,131**	**4,625,141,238**
100	**Finance Charges**	**173,058,243**	**0**			
	TOTAL PROJECT COST (10 - 100)	**5,121,693,167**	**640,653,817**			

[1]Based on data provided by HART as of February 2014.
[2]Includes both HART Forecast Change Orders ($177.65M) and PMOC Recommended Adjustments ($139.51M).

2.5 Project Schedule

The Revenue Service Date (RSD) identified in the FFGA is January 31, 2020. HART's current target date for the start of full revenue operations is March 2019. HART intends to begin partial revenue service from East Kapolei Station to Aloha Stadium Station in June 2017.

2.6 Project Management Oversight Contractor (PMOC)

This report represents an update of the PMOC's assessment at time of FFGA of HART's technical capacity and capability as well as an assessment of the Project's current FFGA scope, schedule, cost estimate, and risk and contingency management. This assessment is governed by the following FTA Oversight Procedures (OP):

- OP 21 – Technical Capacity and Capability Review
- OP 32C – Project Scope Review
- OP 32D – Project Delivery Method Review
- OP 33 – Capital Cost Estimate Review
- OP 34 – Project Schedule Review
- OP 40 – Risk and Contingency Review

2.7 Evaluation Team

The following table presents the PMOC Evaluation Team and their respective roles associated with the assessment of the Project.

Table 1. PMOC Evaluation Team

Name	Firm	Role
Tim Mantych	Jacobs	Program Manager
Bill Tsiforas	Jacobs	Task Order Manager
Keith Konradi	Jacobs	Rail Engineering
Bob Niemietz	Jacobs	Structural Engineering
Allan Zreet	Jacobs	Architect
Charles Neathery	Jacobs	Construction Management, Project Controls, Schedule Risk Assessment
Tim Morris	Jacobs	Cost Estimating
Arun Virginkar	Virginkar and Associates	Vehicles, Systems
Bob Merryman	OR Colan	Real Estate
Dorothy Schulz	Interactive Elements Inc.	Safety and Security
David Sillars	Independent Contractor	Risk Manager

3.0 TECHNICAL CAPACITY AND CAPABILITY REVIEW

The PMOC reviewed HART's organization, policies and procedures in accordance with *OP 21: Grantee Technical Capacity and Capability Review* dated May 2010, to determine whether there had been any significant changes that would affect management of the Project.

3.1 PMOC Assessment

The PMOC previously expressed concern that HART may continue experiencing difficulty attracting and retaining the experienced staff needed for long-term project assignment and permanent HART employment (post-Project) given Hawaii's geographic isolation, salary limits, and high cost of living relative to the mainland. It was recommended that HART adhere to the staffing plan to address the transition of staff during the final design and construction phases for positions currently occupied by PMC staff to HART staff.

The PMOC also recommended that HART must strive to transition the key management positions currently occupied by the PMC and General Engineering Consultant (GEC) as early as possible. This transition is necessary in order for HART to have more ownership and maintain stronger continuing control of the project without having to rely too heavily on the PMC and GEC.

There are currently several key positions that remain vacant. The most critical positions that HART is diligently working to permanently fill include:

- Deputy Director of Construction
- Risk Manager
- Assistant Deputy Directors (5)

HART has improved recruitment and hiring of additional Project staff. HART will use the GEC III to fill the Risk Manager position on an interim basis. However, the Assistant Deputy Directors were not included in the Staffing and Succession Plan recently reviewed by the PMOC.

HART recently submitted the following management plans and procedures for review:

- Resident Engineers Manual for DB (dated March 5, 2014)
- Resident Engineers Manual for DBB (dated March 6, 2014)
- Quality Management Plan (dated March 4, 2014)
- Staffing and Succession Plan (dated March 5, 2014)
- Construction Management Plan (dated March 7, 2014)
- Change Management Plan (dated March 7, 2014 and previously identified as Configuration Management Plan)
- Contract Change Procedure 5CA-11 (dated March 7, 2014)

The PMOC has reviewed these plans/procedures and provided comments to HART. HART is in the process of updating several additional management plans including its Project Management Plan (PMP).

The PMOC has assessed that the HART organization should be streamlined to be more effective. There is a sense that critical decisions are rendered "by committee", which is not an effective means for management on a capital program of this magnitude. HART should consider identifying a Project Director who serves as the focal point for all capital program decisions. This will eliminate management by committee, expedite critical decisions, and help ensure strong schedule and contract management principles are implemented.

3.2 PMOC Recommendations

(1) HART should identify a Project Director.
(2) HART must complete the update of the Project Management Plan (PMP).
(3) HART should identify a permanent Risk Manager.
(4) HART and their consultant organization should be streamlined to be more effective (e.g. evaluate need for HART Construction Assistant Deputy; clearly define the roles and responsibilities of HART Project Manager and CE&I Resident Engineer; evaluate need for HART Assistant Project Managers).
(5) HART must update its management plans to include the Assistant Deputy Director positions that weren't included in the most recent updates provided to the PMOC in March 2014.

4.0 PROJECT SCOPE REVIEW

The PMOC reviewed the Project in accordance with *OP 32C: Project Scope Review* and *OP 32D: Project Delivery Method Review*, both dated May 2010, to determine whether there had been any significant changes regarding the scope of the Project.

4.1 PMOC Assessment

In general, there have been no significant changes to the scope of the Project since execution of the FFGA. The scope of the Project is well-defined and is generally at an appropriate level of completeness. The Project final design phase and construction phase are concurrent to an extent as a result of the hybrid contract packaging strategy that contains work packages for DB, DBB, and DBOM. The awarded DB contracts are significantly more advanced than other portions of the project and have progressed through most of the design phase and into field construction, which resumed in September 2013 following suspension to complete the Archaeological Inventory Survey per the Hawaii Supreme Court ruling. The DBB contracts remain in varying stages of final design. It is advisable to acknowledge the project risks to completing the project on schedule and within budget, given the varying level of completion of the final design documents.

PMOC primarily focused its review on those contract packages that have not yet been bid or have been significantly advanced since time of the FFGA. These contract packages include:

Table 2. Updated Contract Packages

Contract ID	Contract Description
DBOM920	Core Systems Contract (CSC) Design-Build-Operate-Maintain
DBB185	Westside (WOSG, FHSG, KHSG) Station Group Construction
DBB470	Airport Station Group Construction
DBB505	Airport Section Utility Relocation Contract
DBB595	Airport/City Center Guideway Construction + City Center Utility Relocation
DBB580	Dillingham / Kaka'ako (Eastside) Station Group Construction

The drawings for the four line segments present right-of-way plans, drainage plans and details, demolition plans, guideway plans and profiles, typical cross sections, utility plans, roadway plans, signing and striping plans, maintenance of traffic plans, traffic signal plans, street lighting plans, structural drawings, landscaping plans, station drawings, and contact rail installation plans. The West Oahu/Farrington Highway (WOFH), Kamehameha Highway (KHG), and MSF DB contracts have progressed beyond the others as they near completion of final design as they have proceeded into construction.

The following observations were made with regard to the scope review:

- Scope is adequately defined.
- Level of completion varies across contract packages.
- There are still several outstanding issues:
  - Several third-party agreements have yet to be resolved.

- Final operational analysis must be completed by Ansaldo Honolulu Joint Venture (AHJV).
- A number of design issues that affect the interface with other contracts must be resolved.
- HART has developed an extensive Contract Packaging Plan that will require significant management effort to ensure proper interface coordination.
- There is concern whether bidding competition for the remaining packages will be strong enough to assure pricing within budget.
- Cost estimates have not yet been prepared for a number of potential Contract Change Orders (CCO).
- Real estate acquisition to support construction in the City Center Segment will require significant coordination and effort by HART.
- HART is considering several proposed design changes that may require additional environmental review. It is not anticipated that any of these changes will significantly impact the Project implementation or planned operations. However, each proposed change must be properly vetted by each affected party.

4.2 PMOC Recommendations

(1) Continue to review and vet all potential Contract Change Orders. Prepare cost estimates for any potential Contract Change Orders that cannot be eliminated at this time.

(2) Continue to review all post-ROD changes to ensure they do not have an impact on the environmental documentation, the project scope, project cost, project schedule, or future operations.

(3) Prioritize resolution of required third-party agreements, real estate acquisitions, and coordination between various contractors and designers.

5.0 PROJECT SCHEDULE REVIEW

The PMOC reviewed the Project in accordance with *FTA OP 34: Project Schedule Review* dated May 2010 to assess and evaluate HART's project schedule.

5.1 PMOC Assessment

The PMOC reviewed HART's Master Program Schedule (MPS) with a Data Date of February 28, 2014. The following observations were made with regard to the schedule review:

- The FFGA RSD is January 31, 2020.
- HART's target Revenue Service Date (RSD) is March 29, 2019 and the MPS includes more than 300 calendar days of buffer float up to the FFGA RSD.
- The adjusted/stripped schedule RSD is February 7, 2019.
- HART MPS consists of the master schedule connected to multiple contractor's schedules. The CSC's AHJV schedule is the only one whose base calendar is a 7-day calendar due to it being mainly a manufacturing and procurement schedule.
- The current MPS contains more logic density and schedule-compression than ever before, which may require more concurrent utilization of resources. It is recommended that HART and consultant staff projections be re-visited as a result of this concurrent utilization.
- Most of the Risk Register items used by the PMOC in the schedule risk analysis are the same as the previous risk refresh.

The PMOC incorporated the following adjustments to schedule prior to completing the schedule risk analysis:

- Removed/dissolved "buffer" float activities.
- Minor mechanical corrections were made based on results of Schedule Analyzer:
- Removed constraint date(s).
- Added logic and modified lags to reduce excessive float.
- Incorporated logic and relationship/lag adjustments to reduce excessive float.
- Estimate Uncertainty modeling will account for activity duration adjustments.
- No adjustments were made to the calendar library.

In general, the PMOC has assessed that the MPS remains achievable but contains little margin for error or delay to critical path and near critical path activities due to schedule compression. HART should also engage tighter management oversight over the Core Systems Contractor especially since they continue to slip critical schedule dates with vehicle design and manufacturing and systems design.

5.2 PMOC Recommendations

(1) HART and consultant staff projections should be re-visited as a result of projected concurrent utilization.

(2) HART should require all construction contractors to consistently apply 5-day and 6-day-per-week calendars in lieu of 7-day-per-week calendars.

(3) HART should revise its staffing plan to ensure that schedule compression has not caused excessive staff requirements during peak demand.
(4) HART should withhold partial or full payment of contractor monthly pay applications if the contractors continue failing to submit timely and acceptable CPM project schedule updates.
(5) HART should consider placing a senior level scheduler in the CSC offices to support more aggressive schedule management oversight.

6.0 PROJECT COST ESTIMATE REVIEW

The PMOC followed the requirements outlined in the *FTA OP 33: Capital Cost Estimate Review,* dated May 2010, to assess and evaluate changes to HART's FFGA cost estimate.

6.1 PMOC Assessment

The Project Budget is $5.122 billion, including $644 million in allocated and unallocated contingency and $173 million in financing costs. HART has stated that the Project is on budget while acknowledging there has been pressure on the budget due to the year-long Archeological Inventory Survey (AIS) delay to the project and changing market conditions.

The PMOC evaluated the cost estimates for each SCC for mechanical soundness and consistency. These mechanical checks are used to determine if there are any material inaccuracies within the estimate. The estimate was found to be mechanically correct in the tabulation of the unit cost, application of factors, and translation to the SCC workbook. The estimate is reflective of the sequencing identified in the MPS.

Given the various formats of the composite Project Cost Estimate, the PMOC had some difficulty completing the analysis. The current estimate is a combination of an Estimate at Completion (EAC) or Contract tally with allowances of various types for change orders or issues. At present, approximately half of the construction work is awarded and the remaining work is "estimated" from varied sources or entities. Some of the budget costs are based on estimates from the original FFGA but were not updated for this Risk Assessment refresh. The contract change orders, especially for the construction contracts, are at best uncertain as many of the issues do not have an associated agency estimate.

A significant setback occurred with the federal/state lawsuits for most of 2013 and this cost has been partially captured by HART change orders or adjustments included in the PMOC's analysis. However, the net result is that the agency has eroded the project contingency without making any significant progress in the work, construction contract awards, acquisition of right of way, or lessening of the project's risks. The time loss is concerning as the stations, real estate procurement, and east sections of the guideway will be bid in a market that may be less favorable for the owner.

The City Center and Airport Guideways with Utilities will require HART to purchase ROW in the costliest areas of the project with significant utility and construction challenges. The current HART budget relies generally on the FFGA budget for this portion of the work as an update based on more recent engineering was not complete at the time of the risk refresh. The updated estimate for this contract will not be available until June or July 2014. HART is fully aware of the importance of this large contract as it has the potential to require a large share of the contingency if the bids are higher than originally anticipated at FFGA.

Escalation was discussed in general terms at the April 2014 Risk Refresh Workshop, but it is unclear if HART's budget adequately addresses this project risk. Once the contracts are awarded this risk should decline significantly, but the PMOC recommends for the interim that HART verify that its budgets and any ongoing estimate refresh efforts include adequate funds for

escalation.

The following specific observations were made with regard to the cost estimate review:

- The individual Bases of Estimates (BOE) are updated to match contract estimates. However, there was no uniformity across individual BOEs. For example:
  - The application of markups was inconsistent.
  - The application of the General Excise Tax (GET) varied.
  - Escalation rates varied between contracts.
- The cost estimate provided by HART excluded two contracts (MM-937 – ROW Engineering Support Services and MM-964 – Safety & Security Certification Consultant).
- Some components of estimate must be updated (e.g. soft costs, ROW).
- It was unclear how increased costs for the Owner Controlled Insurance Program were handled, but clarification was subsequently provided by HART.
- There are a number of possible change orders for which no cost has been associated (see table below).
- Several adjustments to the cost estimate are recommended.

Table 3. Summary of Contract Change Orders (CCO)

Category	Number
Executed CCOs	108
Pending Changes	22
Probable/Potential Changes	57
Issues/Possible	143
Issues/Possible w/out Estimate*	90
Disputed	10

63% of the Issues/Possible do not have associated cost estimate.

Once all contingency was stripped, the PMOC incorporated the adjustments into the base cost of the project prior to completing the cost risk analysis. These adjustments totaled $139.5 million:

- Revaluation of ROW and Temporary Construction Easements – $7.4 million
- Costs for added HART/PMC positions – $5.9 million
- MM-937 and MM-964 excluded from cost breakdown provided to PMOC – $6.5 million
- HART adjustment for "Known changes" at time of analysis – $32.5 million
- Potential Changes Identified with no associated estimate – $25 million
- Disagreement in savings for change to 4-Car Trains – $5 million
- Escalation component of delay settlement for WOFH/KHG/MSF – $10 million
- Resolution of disputed Contract Change Orders – $5 million
- HART adjustment for Stations – $23.8 million
  - Westside Stations – $8.9 million
  - Pearl Highlands Transit Center – $10 million
  - Airport Station Group – $5.6 million
  - Dillingham/Kaka'ako Station Group – $0.7 million (Deduct)
- HART adjustment for Airport and City Center Guideway (rescue carts) – $1.4 million

- Westside Stations Group adjustment based on CE&I estimate – $17 million.

In addition, the Net Stripped, Adjusted Estimate includes $177.6 million in forecast Change Orders that had previously been identified by HART.

Table 4. HART Forecast of Change Orders (February 2014)

Category	Estimate ($M)
Pending Changes	$35.35
Probable/Potential Changes	$75.89
Issues/Possible*	$66.41
Total	**$177.65**

*Includes $18.1 million in credits that have already been included in HART Cost Estimate (February 2014 HART Budget , ref. MM-900 & MM-901)

Following is a summary of the Adjusted Stripped Base Cost Estimate (BCE):

Table 5. Adjusted Stripped BCE

HART Estimate	$4,307.98
Allocated Contingency	$551.90
Unallocated Contingency	$88.75
Financing	$173.06
TOTAL	**$5,121.69**
Stripped Cost	$4,307.98
HART Forecast CCOs	$177.65
PMOC Adjustments	$139.51
Adjusted Stripped BCE	**$4625.14**
Incurred Costs (as of March 2014)	$904.5

All values in $M

6.2 PMOC Recommendations

(1) HART should prepare cost estimates for all identified possible changes (contract change orders).
(2) HART should focus on completion of the Airport & City Center Guideway Estimate to allow time for mitigation if there is a budget issue with this contract.
(3) HART should refresh its ROW estimate to reflect current property costs and include costs for Temporary Construction Easements.
(4) HART should refresh its personnel manpower charts to account for new positions and a refined schedule to verify the cost included in SCC 80 soft costs.
(5) HART should re-baseline its budget following completion of the Risk Refresh activities.
(6) HART should verify that its budgets and any ongoing estimate refresh include adequate funds for escalation.

7.0 PROJECT RISK

7.1 Purpose

Per FTA Oversight Procedure (OP) 40, PMOC has performed "an evaluation of the reliability of the grantee's project scope, cost estimate, and schedule, with special focus on the elements of uncertainty associated with the effectiveness and efficiency of the grantee's project implementation and within the context of the surrounding project conditions." Through the process of risk and contingency review, the PMOC attempts to aid the grantee in its efforts to better define the project's risks and to provide avenues for recovery should those risks become reality.

The purpose of this report is to provide a refresh of recommendations for adjustments to scope, cost, schedule, and project delivery options and to consider risk identification and risk mitigation options and alternatives, particularly in regard to contingencies, in order to respond to established project risks. This report is produced to establish the Project's ability to complete on time and within the identified budget. This report is based on information provided by HART as of April 2014.

7.2 Methodology

The purpose of this section is to describe the review and evaluation methodology utilized by the PMOC with regards to HART's identification of project risk and its plans for mitigating and managing these risks, including the use of schedule and cost contingencies.

The PMOC is required to synthesize available project information, explore and analyze uncertainties and risks, and provide a qualitative and quantitative assessment of ranges of forecasted cost and schedule. The PMOC reviewed risk mitigation options and alternatives, including use of cost and schedule contingencies.

The risk refresh requires an evaluation of the reliability of HART's project scope, cost estimate, and schedule, with specific focus on the elements of uncertainty normally associated with the implementation of the project. PMOC reviewed scope, cost, and schedule documents and presented these reviews in separate spot reports on each topic. The objective of this refresh is to assess changes in the project risks and uncertainties associated with project conditions and the effectiveness and efficiency of project implementation in identifying and mitigating risks in regard to scope, cost and schedule. This report provides a qualitative and quantitative assessment of the ranges of forecasted cost and schedule and project management planning in order to respond to project risk. The PMOC's refresh is understood to be a critical input to FTA's decision regarding project advancement and funding.

The PMOC has performed regular monitoring visits to HART's project and has refreshed the PMOC's earlier risk assessment based upon an updated understanding of project risks and updated schedule and cost information provided by HART. In April 2014, the PMOC participated in a risk refresh workshop with HART, the purpose of which was to discuss HART's progress in its risk management efforts, and to discuss PMOC's observations and reflections from PMOC's initial review of HART's updated scope, cost, schedule, and risk information.

For the purposes of its risk refresh, the PMOC considered the project in three separate elements, which are termed here as "risk profiles":

- ***Risk Profile 1*** is associated with currently-contracted direct cost work;
- ***Risk Profile 2*** is associated with yet-to-be-contracted direct cost work; and
- ***Risk Profile 3*** is associated with "soft costs."

7.3 Risk Identification

The PMOC has reviewed HART's updated risk register and has found that HART has been reasonably diligent in its efforts to track and revise its risk register through internal project risk tracking processes. In its review of the project's scope, estimate, and schedule, the PMOC did not develop any recommendations for adjustment to HART's risk register.

7.4 Contract Packaging

HART is utilizing both traditional (Design/Bid/Build or DBB) and alternative (Design/Build or DB and Design/Build/Operate/Maintain or DBOM) project delivery methods for the various contracts. The WOFH DB Contract, KHG DB Contract, MSF DB Contract, and the CSC DBOM have all been selected and contracted. The majority of the remaining work (Airport and City Center Guideway and Utilities and stations) is anticipated to be procured utilizing a traditional DBB method. HART is utilizing DB for the Pearl Highlands Station, Parking Structure and H-1 Ramps. To achieve expected market efficiencies and in hope of reducing cost, elements of this work have been consolidated into larger packages than earlier planned.

7.5 Cost Risk Assessment

This section includes the PMOC refresh of the cost risk of the project, based on the PMOC's review of HART's capital cost estimate. This section also describes the Beta Range Factor (BRF) assignments for the SCC Risk Assessment utilized in the FTA Risk and Contingency Review Workbook. Finally, the cost risk evaluation is described and the results are reported.

7.5.1 Methodology

Cost risk evaluation is a combination of the PMOC's professional judgment and objective cost data to summarize and make adjustments to HART's cost estimate. This is in addition to a rational and empirical application of a risk model analysis used to simulate the magnitude of project risk and establish the potential responses to manage the risk. In the context of the project risk evaluation, quantitative risk assessment is utilized in the analysis of risk exposure and the corresponding management of uncertainty. The PMOC utilized the following steps for the cost risk analysis of the project:

(1) The PMOC conducted a cost review of the estimates of the project budget. The results of the PMOC review include an adjusted cost estimate that represents a more likely base cost of the project costs. For the project, HART costs are largely based on detailed and parametric estimating procedures, utilizing industry standards and pricing recently received on contracts for this project.

(2) A Stripped Cost Estimate was then developed from the adjusted cost estimate.

The PMOC removed contingency funds embedded in the adjusted estimate, including both contingencies allocated by SCC and general unallocated contingencies. The PMOC interviewed HART's estimating staff to determine the extent to which latent (hidden) contingencies existed within the estimate, and found no latent contingency to review. The resulting Adjusted Cost Estimate was reported in YOE dollars.

(3) A likely range of costs was then established, utilizing the FTA Risk and Contingency Review Workbook. The Adjusted Cost Estimate for each SCC Cost Element was then established as the lower bound value of the SCC Element Cost Range. The upper bound of the SCC Cost Element range is established through multiplying the lower bound value by a BRF, i.e., upper bound = BRF*lower bound.

(4) For the Project, the Adjusted Estimate was divided between Risk Profiles 1, 2, and 3, as described earlier.

(5) BRF values were established by the PMOC through a process that initially utilized the guidelines indicated in OP 40 and then adjusted the Beta Factors based upon specific project situations and identified risks. An example is that, for the project, the design and market factors for the DB and DBOM work warranted much lower beta factors than other cost categories, since their design and market prices are largely established. With previously developed information from the risk registers, an assessment of appropriate beta factors for the risk worksheet was made. This assessment occurred independently for each Risk Profile.

(6) Once the Beta values were assigned to each portion of work, the resulting Risk Profiles were combined to develop an overall project risk assessment, including establishment of a target budget and recommended contingencies. These results provided a basis for evaluation of HART's budget and contingencies.

7.5.2 SCC Adjustments

The PMOC used its professional judgment as well as evaluation of objective data to develop its assessment of the Project costs and to develop the indicated adjustments. Adjustments noted below include changes proposed by the PMOC as well as changes proposed by HART, largely as a result of the April 15, 2014 Risk Workshop, and includes some minor adjustments due to post-workshop information received from HART. The following indicates adjustments made to the HART estimate; some adjustments were made to each risk profile. See Table 6 for a summary of PMOC/HART adjusted project costs by major SCC. The Adjusted Estimate represents the stripped project cost in $YOE.

Table 6. PMOC Adjustments to HART Estimate $YOE

Standard SCC codes		Base year Dollars		
		Grantee stripped estimate	Establish PMOC/HART Adjustments	Calculate Estimate
SCC	Category	Estimate w/o Contingency	Cost Adjustments	Adjusted Estimate
SCC 10	Guideway	1,200,018	13,337	1,213,355
10.04	Guideway: Aerial structure	1,090,289	11,384	1,101,673
10.08	Guideway: Retained cut or fill	7,455	147	7,601
10.09	Track: Direct fixation	95,867	1,710	97,577
10.11	Track: Ballasted	3,125	61	3,186
10.12	Track: Special (switches, turnouts)	3,283	35	3,317
SCC 20	Stations, Stops, Terminals, Intermodals	396,666	16,300	412,966
20.02	Aerial station, stop, shelter, mall, terminal, platform	273,163	16,300	289,463
SCC 30	Support Facilities: Yards, Shops and Admin Bldgs	125,546	2,378	127,924
30.02	Light Maintenance Facility	9,127	173	9,300
30.03	Heavy Maintenance Facility	47,186	894	48,080
30.04	Storage or Maintenance of Way Building	9,487	180	9,667
30.05	Yard and Yard Track	59,745	1,132	60,877
SCC 40	Sitework and Special Conditions	1,008,190	67,879	1,076,069
40.01	Demolition, Clearing, Earthwork	28,333	183	28,516
40.02	Site Utilities, Utility Relocation	310,517	1,658	312,176
40.04	Environmental mitigation, e.g. wetlands, historic/archeologic, parks	33,114	377	33,491
40.05	Site structures including retaining walls, sound walls	10,027	17,703	27,730
40.06	Pedestrian / bike access and accommodation, landscaping	42,548	5,715	48,263
40.07	Automobile, bus, van accessways including roads, parking lots	173,191	2,209	175,399
40.08	Temporary Facilities and other indirect costs during construction	409,288	40,034	449,322
SCC 50	Systems	258,115	3,427	261,542
50.01	Train control and signals	109,695	1,491	111,186
50.03	Traction power supply: substations	32,329	457	32,786
50.04	Traction power distribution: catenary and third rail	35,295	511	35,806
50.05	Communications	57,335	788	58,123
50.06	Fare collection system and equipment	9,610	131	9,741
50.07	Central Control	3,601	49	3,650
SCC 60	ROW, Land and existing improvements	197,720	7,443	205,163
60.01	Purchase or lease of real estate	179,361	6,830	186,191
60.02	Relocation of existing households and businesses	18,359	613	18,972
SCC 70	Vehicles	199,691	12,715	212,406
70.01	Light Rail	179,981	12,447	192,428
70.06	Non-revenue vehicles	13,581	185	13,765
70.07	Spare parts	6,129	83	6,213
SCC 80	Professional services and Agency costs	1,099,681	16,035	1,115,716
80.01	Preliminary Engineering	125,841	1,833	127,675
80.02	Final Design	211,663	1,126	212,789
80.03	Project Management for Design and Construction	363,135	5,878	369,012
80.04	Construction Administration & Management	161,908	12	161,920
80.05	Professional Liability and other Non-Construction Insurance	35,359	16	35,375
80.06	Legal; Permits; Review Fees by other agencies, cities, etc.	69,717	5,000	74,717
80.07	Surveys, Testing, Investigation, Inspection	65,253	1,503	66,757
80.08	Start up	66,804	667	67,471
	SCC 10-80 total	4,485,627	139,514	4,625,141

The PMOC recommended an adjustment to the base cost estimate in the amount of $139.5 million. Note that no latent contingency adjustments were made from any portion of HART's estimate. Details of the adjustments are discussed Section 6.0 of this report.

7.5.3 Baseline Beta Values

For each risk profile, the starting point for the Beta values in this risk assessment were based on the Beta values imported from the prior, 2012 risk refresh and are shown by major SCC category in the tables below. These values are developed from FTA standards, adjusted in consideration of slight advancements in the stage of project and in consideration of the current level of estimate.

Table 7. Imported Beta Values for Risk Profile 1

SCC	R	D	M	C	Total Beta
SCC 10 - 50	0.00	0.00	0.00	0.38	1.43
SCC 60	0.00	0.25	0.40	0.25	1.95
SCC 70	0.00	0.50	0.10	0.30	1.95
SCC 80.01-08	Not applicable				
R = Requirements Risk	D = Design Risk		M = Market Risk		
C = Construction Risk	Total Beta = 1 + (R + D + M + C)				

Table 8. Imported Beta Values for Risk Profile 2

SCC	R	D	M	C	Total Beta
SCC 10 - 50	0.00	0.25	0.25	0.45	2.20
SCC 60	0.00	0.40	0.80	0.25	2.40
SCC 70	Not applicable				
SCC 80.01-08	Not applicable				
R = Requirements Risk	D = Design Risk		M = Market Risk		
C = Construction Risk	Total Beta = 1 + (R + D + M + C)				

Table 9. Imported Beta Values for Risk Profile 3

SCC	R	D	M	C	Total Beta
SCC 10-50	Not applicable				
SCC 70	Not applicable				
SCC 80.01	Not applicable				
SCC 80.02	0.00	0.14	0.14	0.21	1.54
SCC 80.03	0.00	0.17	0.06	0.40	1.68
SCC 80.04	0.00	0.24	0.31	0.35	1.95
SCC 80.05	0.00	0.08	0.05	0.25	1.43
SCC 80.06	0.00	0.19	0.11	0.39	1.74
SCC 80.07	0.00	0.19	0.23	0.47	1.94
SCC 80.08	0.00	0.42	0.25	0.60	2.32
R = Requirements Risk	D = Design Risk		M = Market Risk		
C = Construction Risk	Total Beta = 1 + (R + D + M + C)				

Beta values for the current project were developed based on a refreshed view of the Scope, Cost, and Schedule risks identified in the project, informed by regular PMOC site visits and project reviews. The Beta values were refreshed from previous Beta assignments by the PMOC team and used for the refreshed final cost risk assessment. Note that the Beta value adjustments occurred independently for each Risk Profile as applicable. These Beta values were assigned as outlined in FTA guidance OP 40, and generally fall within ranges expected for this character of project. Beta values were applied at the second level SCC structure.

Table 10. Beta Values Risk Refresh

SCC	Description	Risk Profile 1	Risk Profile 2	Risk Profile 3
10	**Guideway& Track Elements (Route Miles)**			
10.04	Guideway: Aerial structure	1.33	2.05	-
10.08	Guideway: Retained cut or fill	1.33	-	-
10.09	Track: Direct fixation	1.33	2.05	-
10.11	Track: Ballasted	1.33	-	-
10.12	Track: Special (switches, turnouts)	-	2.05	-
20	**Stations, Stops, Terminals, Intermodals**			
20.01	At-grade station, stop, shelter, mall, terminal, platform	-	2.03	-
20.02	Aerial station, stop, shelter, mall, terminal, platform	-	2.03	-
20.06	Automobile parking multi-story structure	-	2.03	-
20.07	Elevators, escalators	1.33	-	-
30	**Support Facilities: Yards, Shops, Admin. Bldgs.**			
30.02	Light Maintenance Facility	1.33	-	-
30.03	Heavy Maintenance Facility	1.33	-	-
30.04	Storage or Maintenance of Way Building	1.33	-	-
30.05	Yard and Yard Track	1.33	-	-
40	**Sitework& Special Conditions**			
40.01	Demolition, Clearing, Earthwork	1.33	2.10	-
40.02	Site Utilities, Utility Relocation	1.33	2.10	-
40.03	Haz. mat'l, contam'd soil removal/mitigation, ground water treatments	1.33	2.10	-
40.04	Environmental mitigation, e.g. wetlands, historic/archeological, parks	1.33	2.10	-
40.05	Site structures including retaining walls, sound walls	1.33	2.10	-
40.06	Pedestrian / bike access and accommodation, landscaping	1.33	2.10	-
40.07	Automobile, bus, van accessways including roads, parking lots	1.33	2.10	-
40.08	Temporary Facilities and other indirect costs during construction	1.33	-	-
50	**Systems**			
50.01	Train control and signals	1.33	-	-
50.02	Traffic signals and crossing protection	-	2.10	-
50.03	Traction power supply: substations	1.33	-	-
50.04	Traction power distribution: catenary and third rail	1.33	2.10	-
50.05	Communications	1.33	-	-
50.06	Fare collection system and equipment	1.33	-	-
50.07	Central Control	1.33	-	-
60	**ROW, Land, Existing Improvements**			
60.01	Purchase or lease of real estate	-	2.00	-
60.02	Relocation of existing households and businesses	1.95	2.00	-
70	**Vehicles**			
70.01	Light Rail	1.55	-	-
70.06	Non-revenue vehicles	1.95	-	-
70.07	Spare parts	1.55	-	-
80	**Professional Services**			
80.01	Preliminary Engineering	-	-	1.05
80.02	Final Design	-	-	1.25
80.03	Project Management for Design and Construction	-	-	1.35
80.04	Construction Administration & Management	-	-	1.45
80.05	Professional Liability and other Non-Construction Insurance	-	-	1.33
80.06	Legal; Permits; Review Fees by other agencies, cities, etc.	-	-	1.59
80.07	Surveys, Testing, Investigation, Inspection	-	-	1.72
80.08	Start up	-	-	2.32

7.5.4 Beta Value Adjustments

Significant issues noted in the scope, cost, and schedule reviews are reflected in the risk assessment model by means of adjustments to the risk Beta factors (β) applied to each SCC sub-category. These adjustments result in forecasts of ranges of cost for the project. Standard FTA Beta values incorporate an expectation of common risks that occur across transit projects; Beta adjustments below reflect those increases or decreases in risk that differ from risks occurring within standard Beta values.

The following sections present detail regarding the basis for adjustments, reflected previously in Table 6, beyond standard OP 40 Beta value suggestions. The purpose of this listing is to provide information regarding Beta values of note.

SCC Wide Beta Value Changes

System-wide Beta adjustments were made to two Risk Profiles: in Risk Profile 1, a reduction of 0.1 to the Construction Beta was made to recognize the refinement of change order estimates since the last review; and in Risk Profile 2, a Beta increase of 0.10 was made to the Market Beta in recognition of cost pressure due to a tightening of the construction market and a Beta increase of 0.10 was made to the Construction Betas due to concern that many multiple contractors will increase risk due to potential conflicts among the contractors.

SCC-Specific Beta Value Changes

The following issues determined the final resulting Beta values for the SCC sub-categories, which are the Beta values that reflect risk across all four categories of *Requirements*, *Design*, *Market*, and *Construction* risk, including the general Beta value increases previously noted in the section above. Noted below are only those conditions where exceptional changes to the standard Betas were noted. "Normal" risks associated with similar construction are accounted for in the base risk model.

SCC-70 – Vehicles (Risk Profile 1)

- Design Risk
  - 70.01 & 70.07 (β) = 1.55, decrease D to 0.10. Vehicle design work has advanced during the interim period since the last review.

SCC-10 – Guideway (Risk Profile 2)

- Design Risk
  - 10.04, 10.09, & 10.12 (β) = 2.10, decrease D to 0.10. Guideway plans have advanced to approximately the 90% level, and existing guideway work has provided the opportunity to resolve design unknowns.

SCC-20 – Stations, Stops (Risk Profile 2)

- Requirements and Design Risk
  - 20.01, 20.02, & 20.06 (β) = 2.30, increase R to 0.05 and decrease D to 0.30. Discussion continues with property owners that may result in design changes. At the same time, general design has advanced on the stations since the last review.

SCC-40 – Sitework and Special Conditions (Risk Profile 2)

- Design Risk
  - 40.01 – 40.07 (β) = 2.10, decrease D to 0.15. Advanced work in siting and resolving utilities and other site investigations brings more certainty to the design.

SCC-50 – System (Risk Profile 2)

- Requirements and Design Risk
  - 50.02 & 50.04 (β) = 2.10, decrease D to 0.15. Systems design has advanced since the last review.

SCC-60 – Right of Way (Risk Profile 2)

- Design and Market Risk
  - 60.01 & 60.02 (β) = 2.00, decrease D to 0.10 and M to 0.60. This Beta change recognizes that estimate adjustments were made that increase cost. The Beta adjustment here is for potential risk above the estimate adjustment that was made to the stripped estimate.

SCC-80 – Soft costs (Risk Profile 3)

- Design, Market, and Construction Risk: The following changes to the "soft cost" portions of the work all reflect the same reason. Since the last review, much work has been done to resolve staffing and professional services contract issues. Further, the detailed review of the project team staffing also resulted in an increase to the stripped estimate. Therefore, this adjustment recognizes the resulting reduction in risk since the last review.
  - 80.02 (β) = 1.25, decrease D to 0.05, M to 0.05, & C to 0.10
  - 80.03 (β) = 1.35, decrease D to 0.05, M to 0.05, & C to 0.20
  - 80.04 (β) = 1.45, decrease D to 0.10, M to 0.05, & C to 0.25
  - 80.06 (β) = 1.59, decrease D to 0.10 & M to 0.05
  - 80.07 (β) = 1.25, decrease D to 0.19, M to 0.23, & C to 0.25

7.5.5 Cost Risk Analysis

This section presents the PMOC's analysis of the model-based Project Cost Risk Assessment based on the FTA Risk and Contingency Review Workbook (version 4.0), utilizing the project-adjusted BRFs. This workbook is based on the summary organizational structure of the FTA SCC 10 through 80 for the capital cost elements of a project. SCC 90 (contingency) is specifically excluded as a duplicate measure of risk. Risk for SCC 100 (finance charges) is not covered in the standard FTA risk range factors. Project-level risk is an aggregated amount of the risk associated with all of the SCC Ranges.

Using the Beta values in Table 10, a simulation project risk model was developed, as presented later in this report. Table 11 presents the corresponding numeric data results from the risk model.

Table 11. Risk Model Data

YOE Grantee values	Overall	Part 1	Part 2	Part 3
Grantee total estimate/budget (SCC 10-90)	4,948,635	1,804,664	1,943,586	1,200,385
Grantee exposed contingency	463,008	21,784	340,520	100,704
Grantee stripped estimate/budget (SCC 10-80)	4,485,627	1,782,879	1,603,067	1,099,681
YOE PMOC values				
Latent contingency	0	0	0	0
Inflation Adjustment	0	0	0	0
Adjustments	139,514	73,843	49,637	16,035
Adjusted estimate	4,625,141	1,856,722	1,652,703	1,115,716
Model recommendations				
Recommended estimate/budget, incl. contingency	5,213,963	1,989,386	2,018,486	1,206,092
Contingency recommendation amount	588,822	132,664	365,782	90,376
Contingency %	13%	7%	22%	8%
Secondary mitigation target	5,409,551	2,033,453	2,139,987	1,236,112
Secondary mitigation recommended amount	195,588	44,067	121,501	30,020
Secondary mitigation %	4%	2%	7%	3%
Risk analysis				
Lower bound (~0%)	4,625,141	1,856,722	1,652,703	1,115,716
Lower range reporting amount (40%)	**5,100,833**	1,963,897	1,948,208	1,188,728
Contingency target (Conditioned estimate) (50%)	5,213,963	1,989,386	2,018,486	1,206,092
Upper range reporting amount (80%)	**5,670,230**	2,092,185	2,301,923	1,276,122
Upper bound (~100%)	7,586,212	2,523,863	3,492,151	1,570,199

Further analysis of these amounts is provided in other sections below.

7.5.6 Cost Contingency

The PMOC identified YOE $463 million in allocated and unallocated contingency, and found no additional latent contingency. This amount is reflected in Table 12. Further, with known estimate adjustments, that contingency is likely to be currently reduced to $323.5 million.

Table 12. PMOC Recommended Contingency

YOE Grantee values	Overall	Part 1	Part 2	Part 3
Grantee total estimate/budget (SCC 10-90)	4,948,635	1,804,664	1,943,586	1,200,385
Grantee exposed contingency	463,008	21,784	340,520	100,704
Grantee stripped estimate/budget (SCC 10-80)	4,485,627	1,782,879	1,603,067	1,099,681
YOE PMOC values				
Latent contingency	0	0	0	0
Inflation Adjustment	0	0	0	0
Adjustments	139,514	73,843	49,637	16,035
Adjusted estimate	4,625,141	1,856,722	1,652,703	1,115,716
Model recommendations				
Recommended estimate/budget, incl. contingency	5,213,963	1,989,386	2,018,486	1,206,092
Contingency recommendation amount	588,822	132,664	365,782	90,376
Contingency %	13%	7%	22%	8%
Secondary mitigation target	5,409,551	2,033,453	2,139,987	1,236,112
Secondary mitigation recommended amount	195,588	44,067	121,501	30,020
Secondary mitigation %	4%	2%	7%	3%
Risk analysis				
Lower bound (~0%)	4,625,141	1,856,722	1,652,703	1,115,716
Lower range reporting amount (40%)	**5,100,833**	1,963,897	1,948,208	1,188,728
Contingency target (Conditioned estimate) (50%)	5,213,963	1,989,386	2,018,486	1,206,092
Upper range reporting amount (80%)	**5,670,230**	2,092,185	2,301,923	1,276,122
Upper bound (~100%)	7,586,212	2,523,863	3,492,151	1,570,199

The PMOC prepared a risk assessment by Risk Profile as previously described. At this refresh, the PMOC recommends approximately 7% contingency for the Risk Profile 1 (contracted direct cost), 22% for the Risk Profile 2 (uncontracted direct cost), and 8% contingency for the Risk

Profile 3 (soft costs), equating to an overall contingency recommendation of $588.8 million (or ~13%).

7.6 Schedule Risk Assessment

7.6.1 Methodology

The Schedule Risk Assessment is based on the Master Project Schedule with a Data Date of February 28, 2014. As noted in the following discussion, the PMOC conditioned the MPS for use in the risk assessment.

This review focuses on the elements of ***schedule*** uncertainty associated with the effectiveness and efficiency of HART's project implementation, the project scope, and surrounding project conditions.

The OP 40 schedule analysis output data are generated from Oracle's "*Pertmaster Risk Analysis*" software program used by the PMOC. The PMOC risk analysis process conforms to the software user manual and intent of the OP 40 as described below:

There are two kinds of project risk:

- ***Uncertainty risks*** are inherent variability that makes it impossible to predict exactly how long an activity will take. For instance, you can estimate how long it will take within a range of uncertainty, but you can never predict exactly how long.
- ***Risk events*** are events separate from an activity that can disrupt or otherwise impact the activity.

Pertmaster handles risk events by using a Risk Register to enter potential risk events and estimates of the probability and impact of the risks on activity duration, costs, and project quality. Once uncertainty and risk event impact estimates have been entered for all tasks within a project, Pertmaster performs a high number of project simulations using "Monte Carlo" or "Latin Hypercube" sampling of the estimates to select random task duration and cost values for every run-through of the simulation. These simulations generate a range of outcomes that can be used to predict project duration and costs with statistical confidence.

The Critical Path Method (CPM) is the traditional means for determining a project finish date. However, because CPM only determines a single date and does not consider potential risks, results are not always comprehensively reliable. Risk Analysis uses risk inputs to determine a range of project finish dates with more confidence and reliability. The Pertmaster risk analysis is based on the risk management process outlines in Chapter 11 of the Project Management Institute's "*A Guide to the Project Management Body of Knowledge*" and consists of the components shown below. The process is not strictly linear; there may be considerable repetition of certain steps before moving on.

<u>Schedule Review</u>
The purpose of the Schedule Review "Characterization" is to check HART's project schedule, referred to as the Current Probable Schedule (CPS) for logic errors, open-ended tasks, negative lags, start-to-finish links, and other potential problems that could compromise the risk analysis.

This step ensures the integrity of the schedule and improves the chances for a meaningful analysis. If mechanical or fundamental revisions are necessary based upon the schedule characterization, the risk management team makes the necessary adjustments and creates a revised schedule file, called the Adjusted Project Schedule (APS).

Pre-Analysis Check

A rudimentary analysis of the schedule is performed to identify activities that drive project duration and costs. These activities merit the closest attention during subsequent detailed risk analysis.

Build a Risk Model

Estimates for duration, cost, and resource uncertainty for each project task are identified by a specific team of experts relying on industry statistics and experience. The estimate uncertainty duration ranges are incorporated into a copy of the project schedule called the Estimate Uncertainty Model (EUM).

The team then brainstorms a list of potential risk events, evaluates the risk events as to how likely it is that they may occur and the potential impact such occurrences may have. The list of risk events is then entered into a risk register and each risk event is assigned a probability and impact, resulting in a risk degree factor, which is scored by the risk modeling software. At this point, a copy of the EUM is made, to which Pertmaster then applies the uncertainty and maps the risk events to the appropriate tasks to build a risk model, called an Impacted Risk Model (IRM).

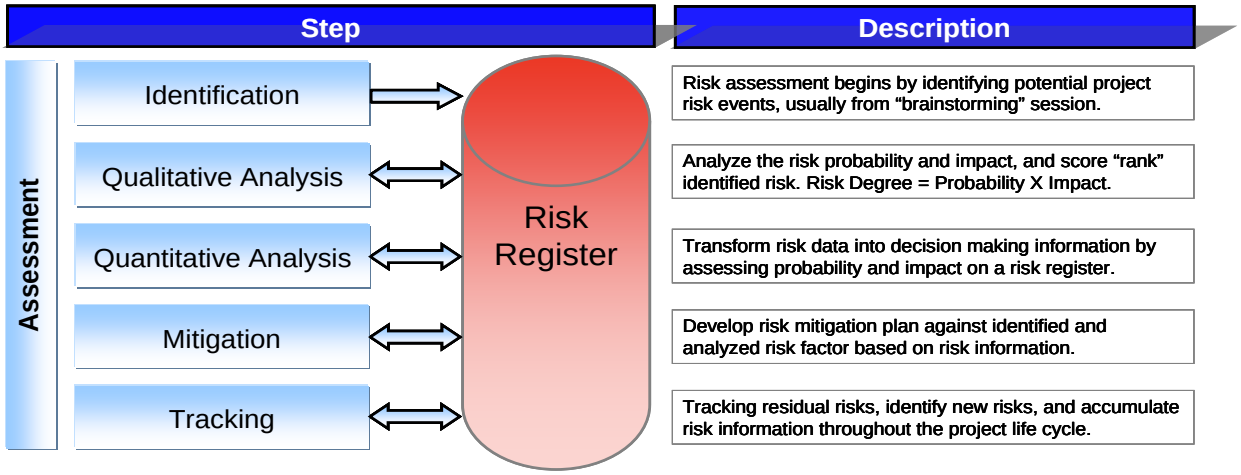
Analyze and Review

A "Monte Carlo" or "Latin Hypercube" sampling analysis is run on the IRM. The risk analysis output can be viewed and evaluated in a wide variety of reports. The review options allow the risk management team to focus on areas of the schedule that pose the greatest risk to the overall program. This helps with the creation of an efficient and cost-effective risk mitigation plan.

Mitigate and Report

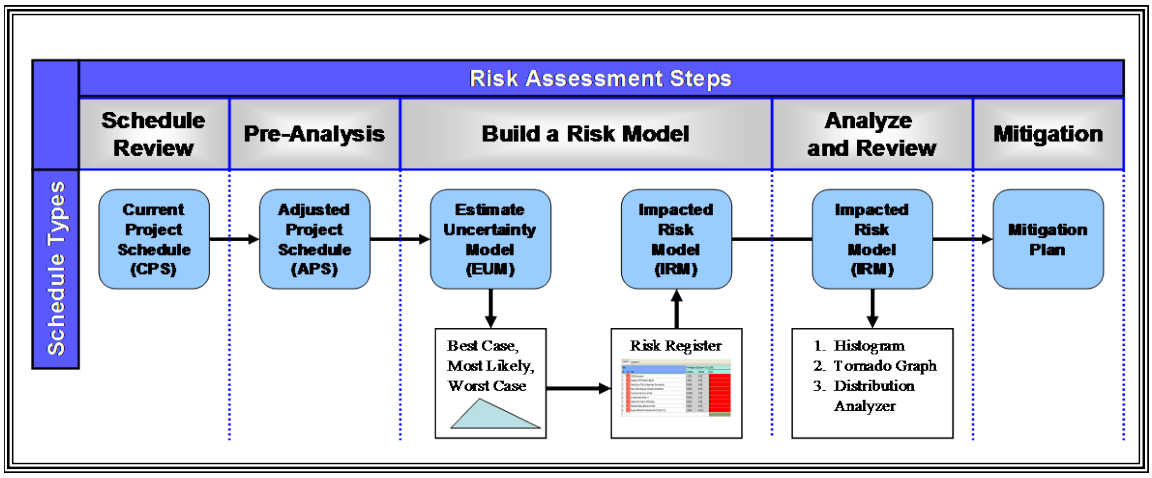
Based on the preliminary analysis, the risk management team reviews and evaluates alternative scenarios with varying reductions to duration, resource and cost uncertainty. Ultimately, the most cost-effective risk mitigation strategy is chosen and formalized into a risk mitigation plan.

Figure 3. Schedule Risk Assessment Process



The figure below describes the various schedules that are created once the PMOC commences the OP 34 review of HART's project schedule, called the CPS. The final product is the IRM, which the PMOC uses for the risk analysis in Pertmaster.

Figure 4. Schedule Risk Assessment Steps and Schedule Types



7.6.2 Schedule Risk Analysis

Project Schedule Review

The PMOC used HART's project schedule file *"FEB 2014 Update - Risk Refresh-04-02-14.xer"* (CPS) to conduct the Schedule Review. The PMOC concentrated its efforts on ensuring that a detailed, mechanical and fundamentally sound schedule was used for both the risk assessment and the contingency analysis. HART and the PMOC collaboratively worked through initial master program schedule development to ensure adequate detail and logic to support the PMOC risk analysis.

The PMOC made a backup copy of the CPS electronic file and made several logic adjustments to

account for poor or missing logic ties and increased some activity detail to better represent the network logic in order to produce a more realistic risk analysis model. The PMOC used the "adjusted" project schedule, herein referred to as the "Adjusted Project Schedule" (APS), to provide more realistic risk assessment and contingency analysis output. The APS is considered most optimistic, as it is stripped of all latent and patent time contingency.

The HART Basis of Schedule stated that all activities in the MPS contained a 4% contingency. Most activities in the MPS utilize a 7-day per week calendar that does not contain non-work periods for weekends or holidays. The PMOC has continually recommended HART use multiple calendars to more accurately represent and distinguish non-work periods. HART stated that it is having difficulty persuading the construction contractors to change their standard work calendar library from 7 days to 5 days.

The PMOC reduced original durations on some longest critical path activities as a means to strip the embedded 4% contingency purported by HART.

The risk analysis adjusts the activity duration distribution ranges in order to establish a reliable and supportable risk analysis calculation, primarily for determining the project completion date.

A summary of the PMOC adjustments are listed below:

- Deleted (stripped) all activities containing "buffer float"
- Minor logic changes were made for activities containing excessive float
- Some longest critical path original durations were shorted to account for built-on time contingency.

Pre-Analysis Check

The PMOC performed a pre-analysis check by applying a quick risk distribution range across all schedule activities and reviewing the confidence level range, duration sensitivity, and criticality index. Preliminary notes and observations were made for specific schedule drivers. Note that the pre-analysis check is performed as a pre-impacted risk analysis, meaning that the schedule does not have risk events incorporated at this point of the risk analysis process.

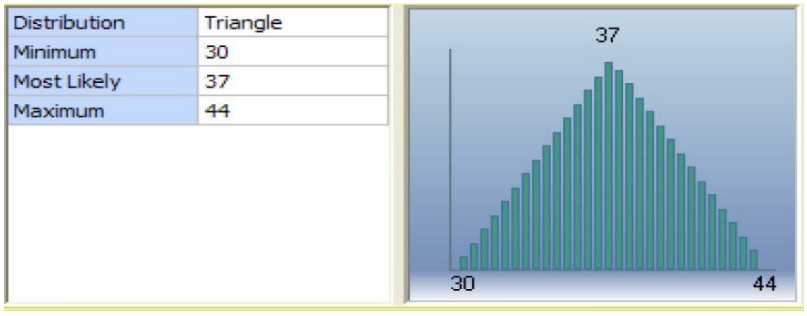
Build a Risk Model "Impacted Risk Plan"

(1) Estimate Uncertainty Model (EUM)

Before running the risk analysis, the PMOC assigned three durations to each activity in the schedule. The three durations for each activity represent best case "minimum", most likely, and worst case "maximum". The PMOC reviewed the activity Original Durations (OD) in the CPS and made an objective determination of the adequacy of each OD. The PMOC used most of the schedule OD durations as the most-likely durations and, in some cases, the PMOC determined that certain activity ODs were overly optimistic. Most of the "maximum" durations the PMOC assigned are 25-30% greater than their ODs, depending on the work task, project phase and task location. Also, some final design and FFGA related activities containing a one-day duration were assigned a worst-case duration of 3 days, or 300% of the original duration. The best-case durations were calculated as 95% of the OD, or "- 5%". This value is low because the EUM is already based on a stripped and "best case" schedule. The value ranges (differences in activity

durations) reflect levels of uncertainty. Based on the three durations, a triangular distribution was assigned to each activity.

Figure 5. Duration Distribution Type



Once the estimate uncertainty process step is complete, the EUM is used to develop the Impacted Risk Model (IRM).

(2) Impacted Risk Model (IRM)

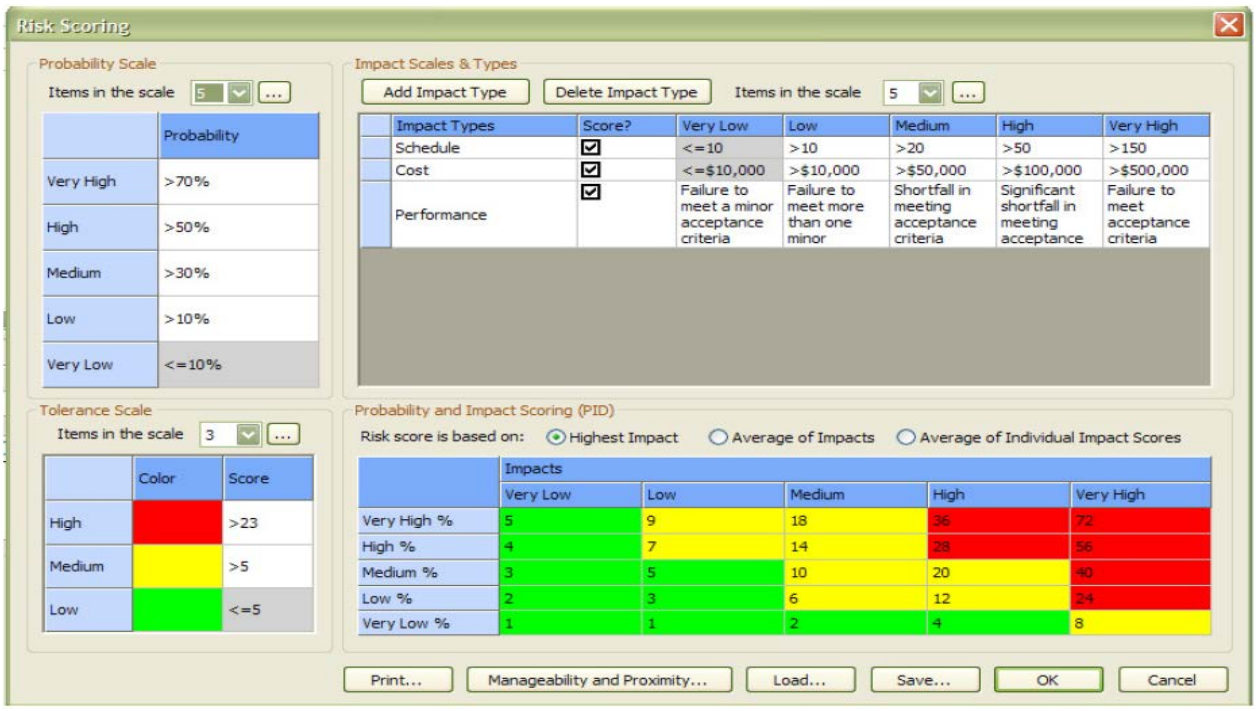
The PMOC conducted a review and evaluation of all risks in the HART Project risk register and the PMOC risk register in order to decide which risk events should be used for the schedule risk analysis (Pertmaster). Once the risks were culled and prioritized, the PMOC assigned the risks events into the longest critical path and into the respective project alignment sections, WOFH/ Kamehameha, Airport and City Center, and the MSF.

Risk events (ID numbers) are used in the risk register to build the risk plan. Many of the risk events are tied to the Airport and City Center section alignment since they are located near downtown and inherently contain more uncertainty than the more westerly, non-critical alignment sections that do not do adversely affect the risk analysis. The PMOC risk events used to perform the Risk Analysis are listed below:

- ROW acquisition delay (Airport/ City Center)
- Utility issues & delays (Airport/ City Center)
- Bidding delays, protests, rebidding required (Airport/ City Center)
- Traffic management and congestion delays (Airport/ City Center)
- Labor Availability Challenges (Airport/ City Center)
- Encounter delays with core systems automation (Airport/ City Center)
- Vehicle manufacturing delivery, startup, testing challenges (Airport/ City Center)

Each risk event was scored based on a risk degree factor. The risk degree factor is calculated by the risk event probability and impact factors. The probability and impact factors for each risk event are objectively determined by the PMOC risk management team. The risk register scoring system prioritizes each risk event by the risk degree factor, see figure below.

Figure 6. Schedule Risk Scoring Chart



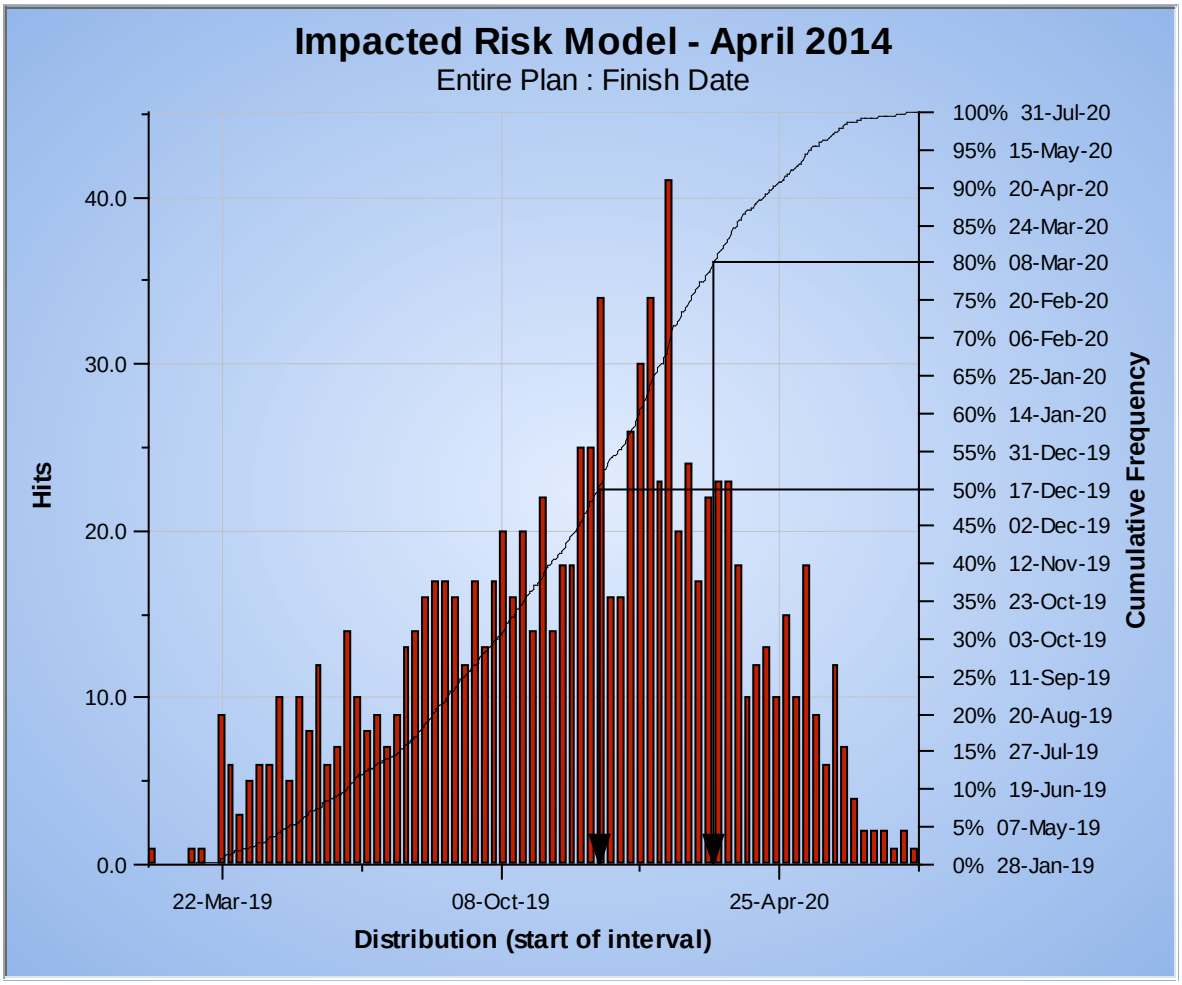
Once the risk events and their risk degree factors are determined, they are incorporated into a copy of the PMOC EUM, resulting in a plan file called the IRM. The IRM is used to produce all of the schedule analysis "output" reports.

Analyze and Review

(1) Summary Results

The PMOC generated a confidence level histogram. The IRM schedule model calculated 1,000 simulations, selecting random durations for each task, to estimate the project completion date within a confidence range. This analysis yields the results shown in the figure below.

Figure 7. Project Completion Date Confidence Level



The IRM distribution range for project completion ranges from the 0% to 100% confidence levels span a 549-day period. The probability percentage points for the IRM are:

- 20% Confidence level completion date: 20-Aug-19
- 50% Confidence level completion date: 17-Dec-19
- 75% Confidence level completion date: 20-Feb-20
- 90% Confidence level completion date : 20-Apr-20
- 100% Confidence level completion date: 31-Jul-20

The risk event results are produced by running a schedule analysis using the IRM which contains qualitative risk events within the software risk register. The true indication of how sensitive each risk event ultimately becomes is not realized until the analysis is performed. For example, a risk event with a very high score does not necessarily mean that it will be highly sensitive to the schedule, as it may only affect non-critical activities containing total float. The schedule drivers that contain the most impact potential contain a high-risk degree and are on the longest critical path or near critical path.

7.6.3 Schedule Contingency

Adjusted Project Schedule (APS)

The APS was used for both the schedule risk assessment and the Contingency Analysis Review. The APS is a backup copy of HART's Master Project Schedule (MPS) with adjustments made to logic, calendars and incorporation of additional activities to better reflect a logical critical path and alleviate excessive float in certain other logic paths. The APS is also stripped of all patent and latent contingency. Because the APS is pre-analysis, not containing estimate uncertainty or risk events, it is considered most optimistic, as it is stripped of all latent and patent time contingency.

Contingency Analysis

The objective of the contingency analysis, pursuant to OP40, is to estimate the minimum amount of schedule contingency required to complete the project on schedule. The FTA guidance states that the contingency recommendations shall be developed using the following assumptions:

- At the Revenue Service Date, schedule contingency requirements have been reduced to a minimum requirement or possibly eliminated.
- At the point of 100% complete with bid, the project should have sufficient schedule contingency available to absorb a schedule delay equivalent to 20% of the duration from Entry into Final Design through Revenue Operations.

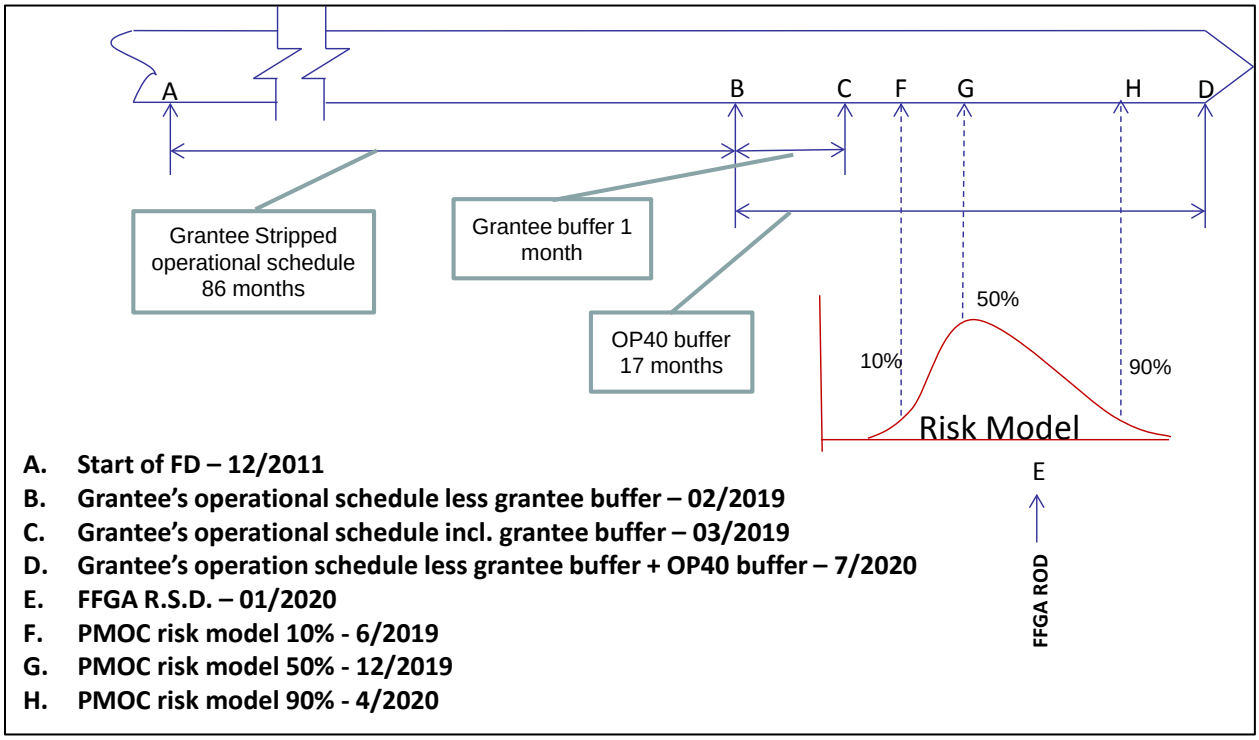
The APS indicates an 86.2-month duration from the start of the APS Final Design through RSD. According to the OP40, the project should contain the equivalent of 20% of this duration as contingency. The result is a contingency buffer total of 17.2 months. The result of adding 17.2 months contingency to the APS RSD (07-Feb-19) is 13-Jul-20 as shown in the table below. The OP 40 buffer float calculation results in an RSD of July 13, 2020, approximately five and a half months beyond the FFGA RSD of January 31, 2020.

Table 13. Schedule Contingency Final Design through RSD

Entry to Final Design	APS RSD	Duration			20% Float Duration			APS RSD 20% Float added to RSD	CPS RSD Date	Additional Float Required (Variance)		
		Dys	Mth	Yrs	Day	Mth	Yrs			Dys	Mth	Yrs
29-Dec-11	07-Feb-19	2,606	86.2	7.1	521	17.2	1.4	**13-Jul-20**	31-Jan-20	163	5.4	.45

The figure below illustrates the same information relative to the PMOC Schedule Risk Analysis IRM dates plotted for the 10, 50 and 90th percentiles represented by letters F, G and H, respectively. The OP40 calculation for buffer float indicates a July 13, 2020 RSD, five and a half months beyond the FFGA RSD date of 31-Jan-20. The FFGA RSD milestone date of 31-Jan-202 falls within the PMOC IRM 60 - 65 percentile. The last risk PMOC assessment conducted in July 2012 indicated an 85 – 90 percentile range for the FFGA 31-Jan-20 date.

Figure 8. Buffer Float and RSD Analysis



7.7 Risk Mitigation

7.7.1 Primary Mitigation

HART developed a risk register with its identification of project risks. Development of a formal Risk and Contingency Management Plan (RCMP) as an integral part of HART's Project Management Plan is expected, including establishment within HART's organization of authority to ensure that the RCMP is well-managed. An acceptable RCMP was submitted on September 27, 2011. Updated versions dated June 29, 2012 and November 1, 2013 were provided to the PMOC later. Primary mitigation is comprised of the management actions defined within the RCMP that will occur to reduce or eliminate current or future identified risks.

7.7.2 Secondary Mitigation

Secondary mitigation consists of pre-planned potential scope or process changes that may be triggered when risk events occur that cause overruns that cannot be resolved by available project contingency. Example events that may incur secondary mitigation include right of way costs that are significantly over the estimate or unexpected geotechnical hazards that are encountered, etc., such that the change is likely to cause a significant over-budget condition and reduction of contingency for future work. Such "triggered" mitigation would enable HART to make cost reductions in a planned and orderly process and preserve contingencies for use later in the project. It is noted that Secondary Mitigation is not to be confused with a value engineering

exercise. Value engineering is a formal, systematic, multi-disciplined process designed to optimize the value of each dollar spent.

Table 14 utilizes model information to estimate required amounts of secondary contingency. The overall secondary mitigation recommendation of $195 million took into consideration all three Risk Profile portions of the project:

- Risk Profile 1 and 2 include $165.5 million in Secondary Mitigation and represent the direct cost portions of the project.
- Risk Profile 3 includes $30 million in Secondary Mitigation and represents the "soft costs" portion of the project.

It is well-recognized that secondary mitigation is difficult to cost-effectively obtain at this stage of design and where portions of the project are already contracted for construction. However, station design continues and may be a source for secondary mitigation, as may other areas of the project.

In its most current RCMP, HART provides a list of potential Secondary Mitigation items whose total value is estimated at $152 million. The nature of these estimates implies that the degree of estimate to develop these values is rather subjective and therefore caution should be applied to relying on the estimated value. However, the general lack of detailed design or estimating for the Secondary Mitigation items precludes strong reliance on the value of the proposed Secondary Mitigation.

Table 14. PMOC Recommended Secondary Mitigation

YOE Grantee values	Overall	Part 1	Part 2	Part 3
Grantee total estimate/budget (SCC 10-90)	4,948,635	1,804,664	1,943,586	1,200,385
Grantee exposed contingency	463,008	21,784	340,520	100,704
Grantee stripped estimate/budget (SCC 10-80)	4,485,627	1,782,879	1,603,067	1,099,681
YOE PMOC values				
Latent contingency	0	0	0	0
Inflation Adjustment	0	0	0	0
Adjustments	139,514	73,843	49,637	16,035
Adjusted estimate	4,625,141	1,856,722	1,652,703	1,115,716
Model recommendations				
Recommended estimate/budget, incl. contingency	5,213,963	1,989,386	2,018,486	1,206,092
Contingency recommendation amount	588,822	132,664	365,782	90,376
Contingency %	13%	7%	22%	8%
Secondary mitigation target	5,409,551	2,033,453	2,139,987	1,236,112
Secondary mitigation recommended amount	195,588	44,067	121,501	30,020
Secondary mitigation %	4%	2%	7%	3%
Risk analysis				
Lower bound (~0%)	4,625,141	1,856,722	1,652,703	1,115,716
Lower range reporting amount (40%)	**5,100,833**	1,963,897	1,948,208	1,188,728
Contingency target (Conditioned estimate) (50%)	5,213,963	1,989,386	2,018,486	1,206,092
Upper range reporting amount (80%)	**5,670,230**	2,092,185	2,301,923	1,276,122
Upper bound (~100%)	7,586,212	2,523,863	3,492,151	1,570,199

7.8 Conclusion

7.8.1 Cost Risk Analysis

During the April 2014 risk workshop, information was provided indicating that HART was aware of additional costs that should be included, and which were added by the PMOC as

estimate adjustments, along with PMOC's independent estimate adjustments. The PMOC has prepared this risk refresh based upon additional information provided by HART after the workshop. The PMOC found that HART's risk identification effort, including its risk mitigation activities, generally conforms to its documented processes.

The PMOC separated the project into three distinct risk profiles to better model the effect of risk upon the project. The cost risk assessment recognized general reductions in risk due to advancement of design. However, little additional construction has occurred and so no major changes in construction risk were made. Further, the project delay has caused the bidding effort to occur during an increase in the construction market, which adds market risk to the model. A major influence in the risk for Risk Profile 2 is market risk due to an increasingly strong construction market both at the project location and on the west coast of the U.S.

It is recognized that efforts have been made to recover contingency levels through cost reduction measures, value engineering, and revised project delivery strategies. However, these types of changes are becoming increasingly less likely.

The PMOC basis of the stripped, adjusted estimate for cost risk modeling is as follows:

Project Budget	$5,122
HART Current Available Contingency	$463
Financing	$173
Net Stripped Estimate	**$4,486**
PMOC Adjustments	$139.5
Net Stripped, Adjusted Estimate	**$4,625**

With adjustments of $139.5 million, the current contingency is reduced to $323.5 million (7% of the adjusted, stripped estimate). This level of contingency would be commensurate with a project that is completely bid and has progressed in construction beyond the point of being "in the ground". Considering the project progress to date is 22%, this current level of contingency would only reflect an approximate achievable probability of 42%.

The predicted FTA model outcome is $5,214 million (excluding finance costs). This includes $588 million in recommended contingency (13% of the adjusted, stripped estimate). HART's estimate falls short of the predicted FTA model outcome by $265 million ($139.5 million in recommended adjustments plus $125.5 million in additional recommended contingency). There is a 5.4% difference between HART's project estimate of $4,949 million and the predicted FTA model outcome of $5,214 million.

The recommended estimate represents the median value from the FTA risk assessment model, when adjusted for the specifics of this project. The historic trend indicates 40%-likely to 80%-likely range of $5,101 million to $5,670 million.

The RCMP includes several potential Secondary Mitigation options. However, there is a general lack of detailed development of plans and cost estimates for the items identified in the RCMP.

Recommendations

(1) HART's estimate falls short of the predicted FTA model outcome by $265 million ($139.5 million in recommended adjustments plus $125.5 million in additional recommended contingency). HART should review its project estimate and determine how to reduce costs to close this gap.
(2) The PMOC-recommended amount of secondary mitigation is $195.5 million.
(3) The RCMP must be updated to strengthen risk contingency tracking, custody, and reporting. The RCMP should include an updated contingency draw-down curve that reflects the current contingency balance and more accurate drawdown milestones. Diligence and vigilance must continue to be applied to this effort to avoid a rapid contingency usage that could ultimately leave the project unprotected.
(4) HART should update and continue its tracking of the Secondary Mitigation items, and develop a process by which those items may be priced by the bidders of the remaining work at the time of bidding. This strategy avoids attempting to trigger Secondary Mitigation after receipt of bids or after contracting, at which point the cost reduction may be significantly reduced due to lack of competitive forces.
(5) Strong controls must be put in place immediately to avoid future rapid contingency reduction. The frequency and the levels of project management to which these statistics are reported should be improved and monitored monthly.
(6) The PMOC and HART should engage in a focused "cost containment workshop" on a monthly basis to monitor the efforts taken to avoid rapid contingency usage.

7.8.2 Schedule Risk Analysis

HART's target Revenue Service Date is March 2019. The FFGA Date is January 31, 2020. The Impacted Risk Model (IRM) distribution range for project completion from the 0% to 100% confidence levels span a 549-day period. The probability percentage points for the IRM are:

- 20% Confidence level completion date: 20-Aug-19
- 50% Confidence level completion date: 17-Dec-19
- 75% Confidence level completion date: 20-Feb-20
- 90% Confidence level completion date : 20-Apr-20
- 100% Confidence level completion date: 31-Jul-20

The probability confidence level for achieving project completion by January 2020, the FFGA RSD, has been reduced by 15-20% since the last Risk Assessment refresh in July 2012. The Schedule Risk Analysis indicates 66-70% probability of completing the project by the FFGA RSD of 31-Jan-20. The schedule risk analyses using the OP40 calculation indicates a recommended RSD of July 13, 2020.

The FFGA RSD of January 2020 can be achieved; however, HART must implement strong schedule and contract management throughout the remainder of the project.

Recommendations

(1) HART should closely monitor the MPS longest critical path and near critical

paths as a means to prevent depletion of project total float to achieve RSD by January 2020.

(2) HART should revise its staffing plan to ensure that schedule compression has not caused excessive staff requirements during peak demand during construction.

(3) The PMOC and HART should engage in focused "schedule containment workshops" on a monthly basis to monitor the efforts taken to achieve the FFGA RSD.

8.0 APPENDICES

Appendix A: List of Acronyms

AHJV	Ansaldo Honolulu Joint Venture
AIS	Archaeological Inventory Survey
APS	Adjusted Project Schedule
BCE	Base Cost Estimate
BOE	Basis of Estimates
BRF	Beta Range Factor
CCO	Contract Change Orders
CPM	Critical Path Method
CPS	Current Probable Schedule
CSC	Core Systems Contract
DB	Design-Build
DBB	Design-Bid-Build
DBOM	Design-Build-Operate-Maintain
DTS	Department of Transportation Services
EUM	Estimate Uncertainty Model
FFGA	Full Funding Grant Agreement
FTA	Federal Transit Administration
GET	General Excise Tax
HART	Honolulu Authority for Rapid Transportation
IRM	Impacted Risk Model
KHG	Kamehameha Highway Guideway
MPS	Master Project Schedule
MSF	Maintenance and Storage Facility
OD	Original Duration
OP	Oversight Procedure
PMOC	Project Management Oversight Contractor
PMP	Project Management Plan
RCMP	Risk and Contingency Management Plan
ROD	Record of Decision
ROW	Right-of-Way
RSD	Revenue Service Date
SCC	Standard Cost Category
TCC	Technical Capacity and Capability
WOFH	West Oahu/Farrington Highway
YOE	Year of Expenditure