# INTEGRATED COST/SCHEDULE RISK MANAGEMENT

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Smithsonian Institution
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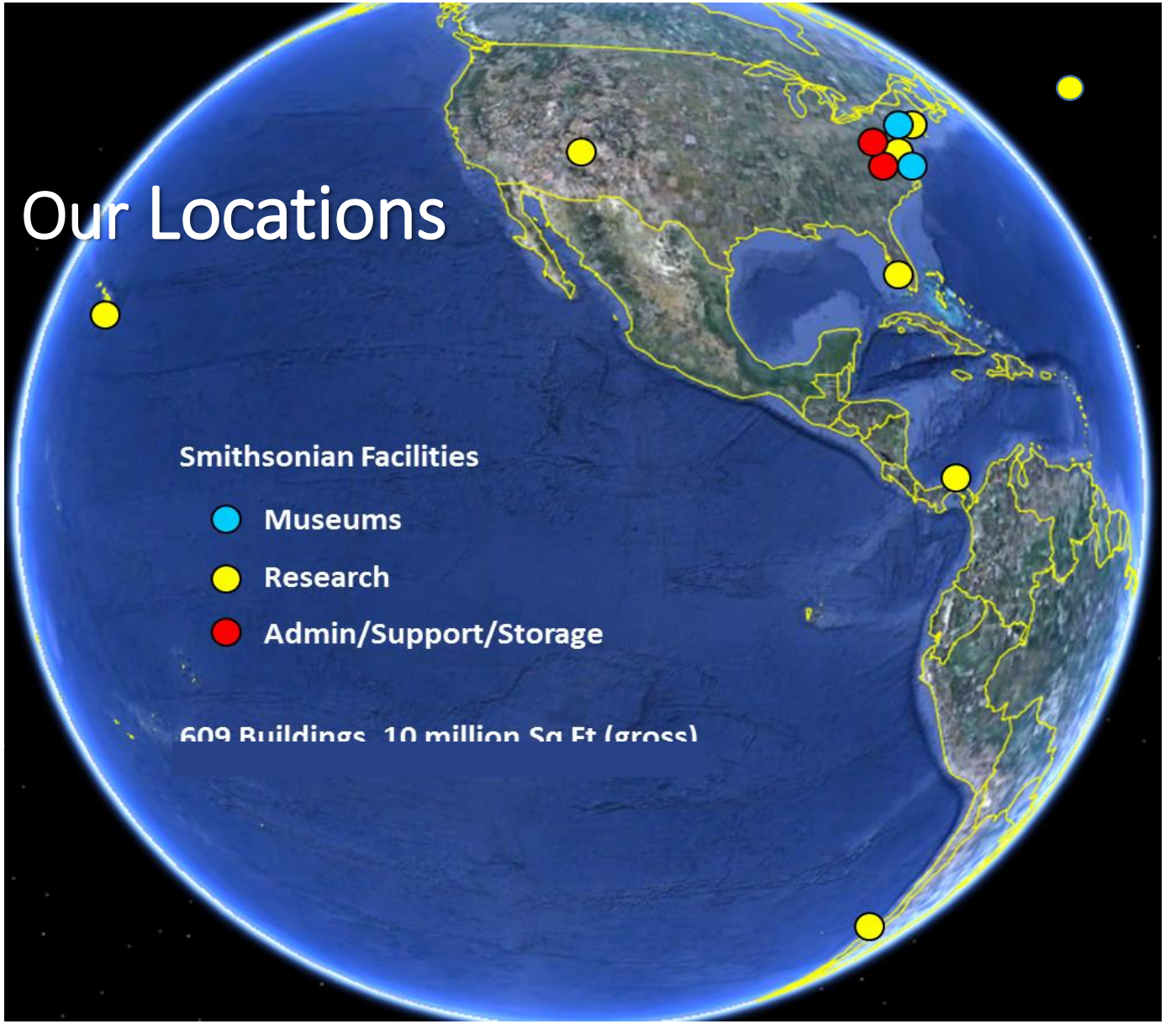
# Smithsonian Around the Globe



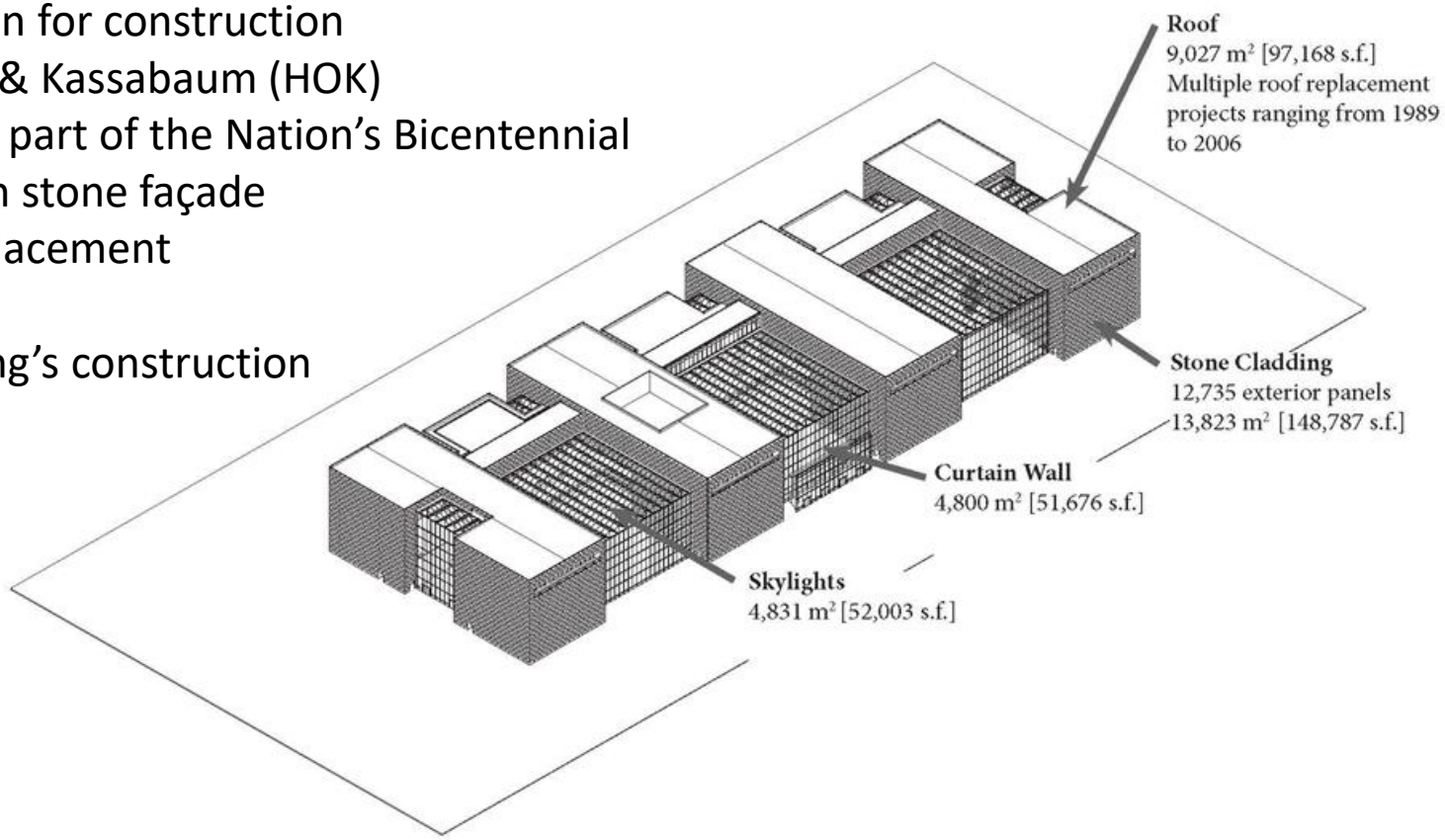
# Smithsonian Facilities By the Numbers

- 19 Museums + 1 Zoo
- 9 Research Centers
- 154 million artifacts
- 2 million library volumes
- 29 million in-person visitors
- 13 million square feet
- 43,000 acres of land
- 28,000 equipment assets
- 13,000 volunteers
- 6,675 employees
- 600 Buildings
- 300 Structures

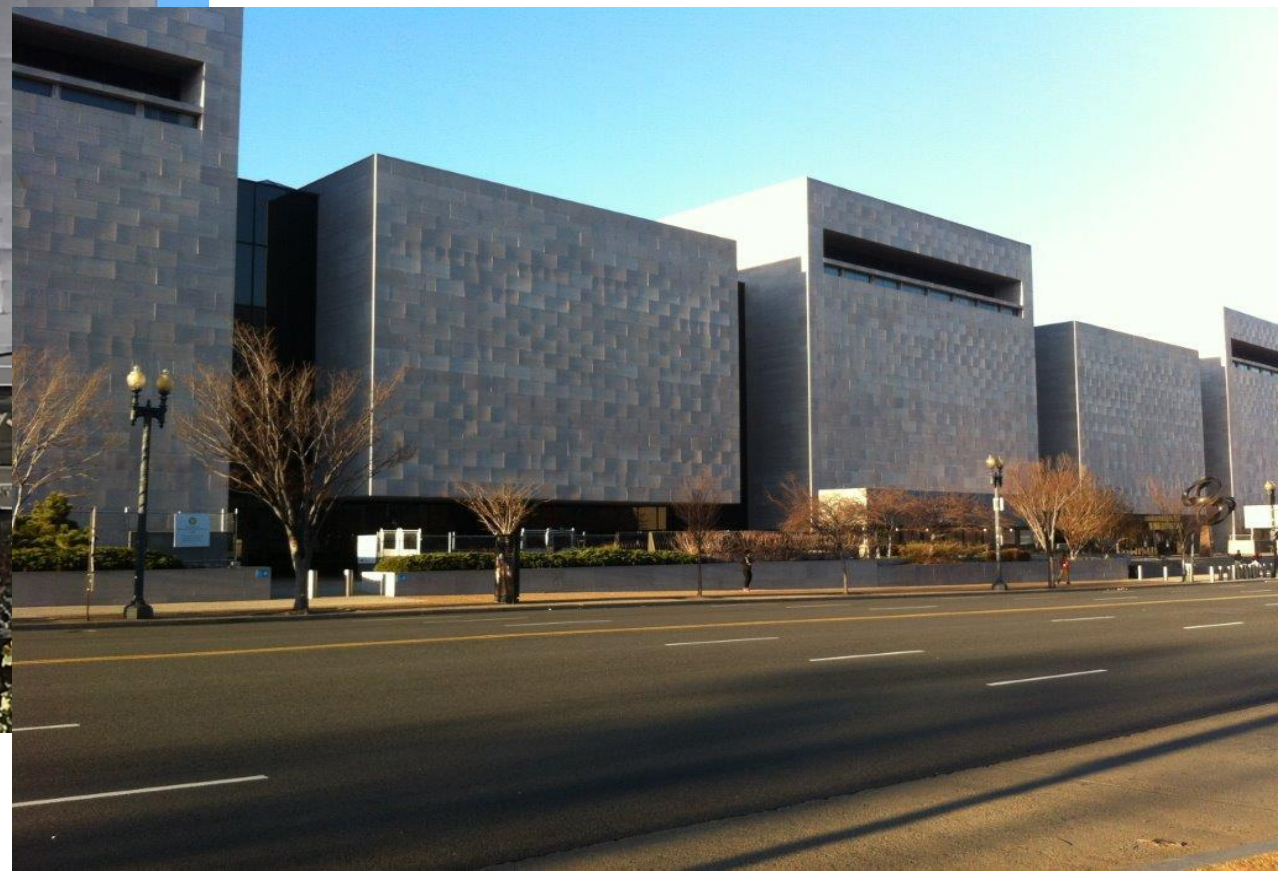
# National Air and Space Museum – Mall Building Facts

**1958** – planned location authorized by President Eisenhower
**1971** – Congress appropriated $41 million for construction
**1972-1973** – design by Hellmuth, Obata & Kassabaum (HOK)
**1976** – opened to the public on July 1 as part of the Nation's Bicentennial
**1995-1997** – last previous major work on stone façade
**1997-2001** – skylight & window wall replacement

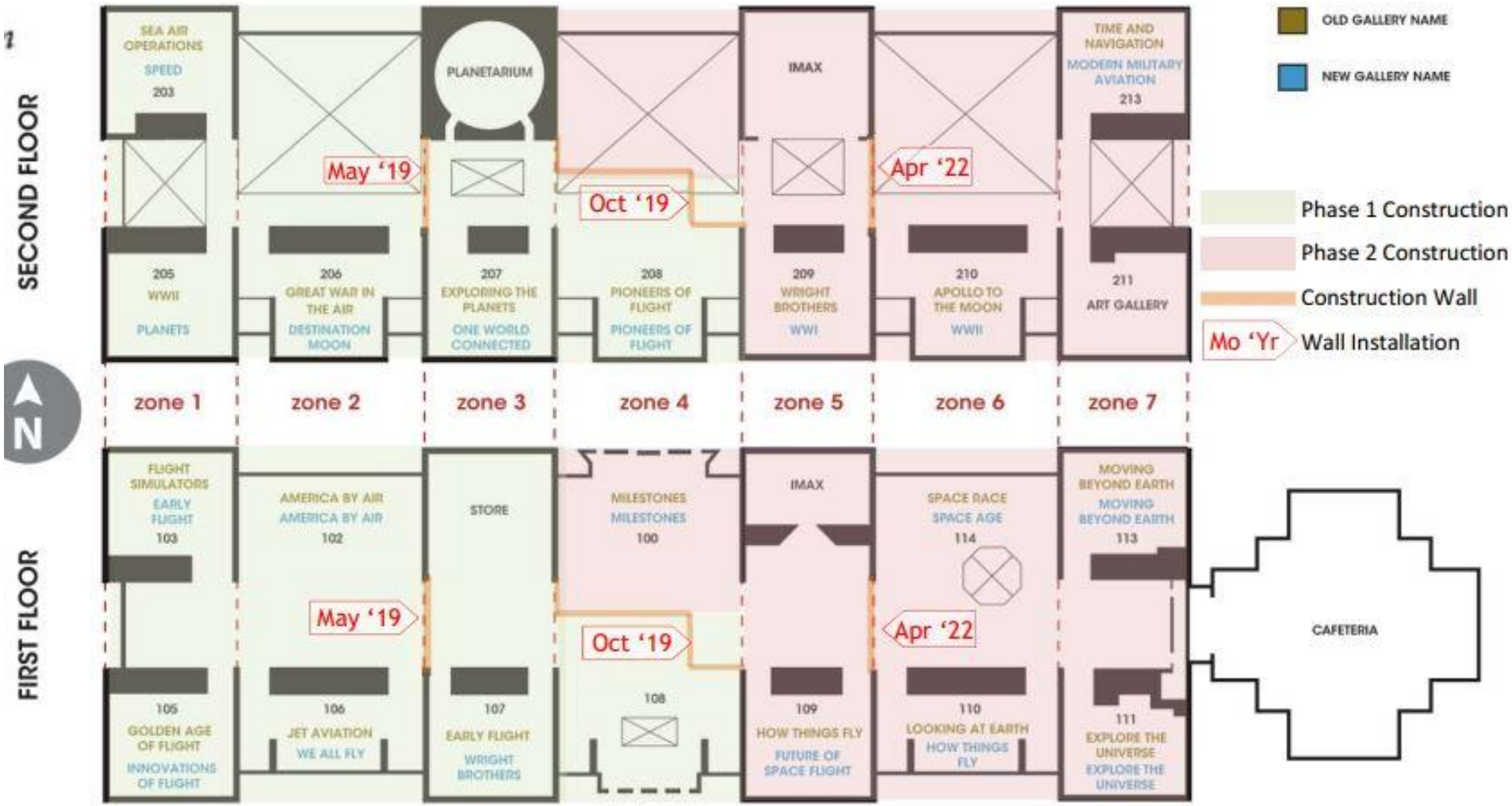
- Mechanical systems date to the building's construction
- Stone façade is primary & exclusive weather barrier
- Building dimensions are (747,877 sf):
  - 209 meters (685 feet) in length
  - 69 meters (225 feet) in width
  - 25 meters (83 feet) in height
- In parallel alignment with National Gallery of Art building on opposite side of the Mall



# The need to address the façade…



# The Challenge



# Logistics

Smithsonian National Air and Space Museum

## Revitalization/Transformation Artifact/Object Summary

Total number of objects to be moved: **2,733**
Total number of artifacts to be moved: **2,430**

- **NASM NMB Artifacts**
  - Total artifacts in NMB: 1,606
  - Moving out of NMB: 768
  - Returning to NMB: 786
  - Not currently on exhibit at NMB: 1,465
  - Protect in Place (PIP): 10
- **Garber Objects**
  - Number coming to NMB for Transformation: 75
- **UHC Objects**
  - Number coming to NMB for Transformation: 1,039
- **Loans for Transformation**
  - Number of loans not renewed from NMB: 202
  - Number of loans renewed from NMB: 86
  - Number of new loans to NASM: 117
  - Number of recalled loans (NASM artifacts): 308
- **Valuable Curatorial Objects (VCOs)**
  - Total number in NMB: 169
  - Number moving out: 108
  - Number returning to NMB: 50

Data As Currently in TMS Database

# Studying the needs

- 2013 Preliminary studies undertaken
  - Envelope Study
  - Feasibility Study
  - Sustainability Study

- Integrated Cost/Schedule Risk Management
  - February 2016 Risk Assessment (Schematic Design)
  - November 2016 Risk Assessment update (35% Design)
  - October 2019 Risk Assessment (GMP Design)

# Assessing the needs

- Pre-requisites for Integrated Risk Management
  - Detailed Cost and Schedule information is required
  - Cost-loaded Critical Path Schedule is Developed
  - Knowledgeable and dedicated subject matter experts
  - Consultant expertise in conducting workshops and analysis
  - Time

# Why Risk Management?

**Best Practices Checklists**







**Probabilistic Risk Management in Design and Construction Projects (Best Prac**

RT-280
2010 - 2012

- Publications: 4
- Presentations: 3
- Tools: 2

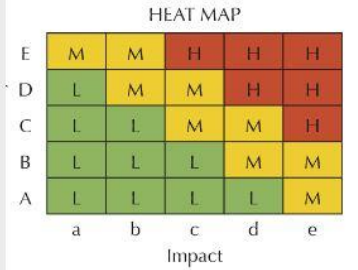
KA: Risk Management

**1 : Level of Risk Management**

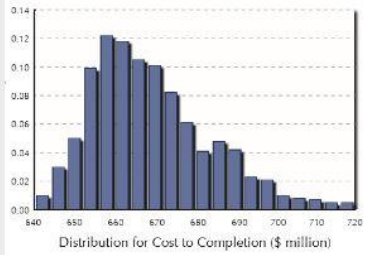
There are 3 processes that organizations can use to implement more advanced project risk management approaches, including probabilistic analysis. This process comprises three levels, each of which offers clear benefits: risk identification, deterministic analysis, and probabilistic analysis.

| Risk | Category |
|---|---|
| Poor soil conditions may require deep foundations, resulting in cost increase. | Cost |
| Utility relocation delay could result in longer schedule. | Schedule |

**Level 1: Risk Identification** is the formal act of identifying risks and opportunities for projects. Typically, this includes the use of a risk checklist and/or the start of a risk register.



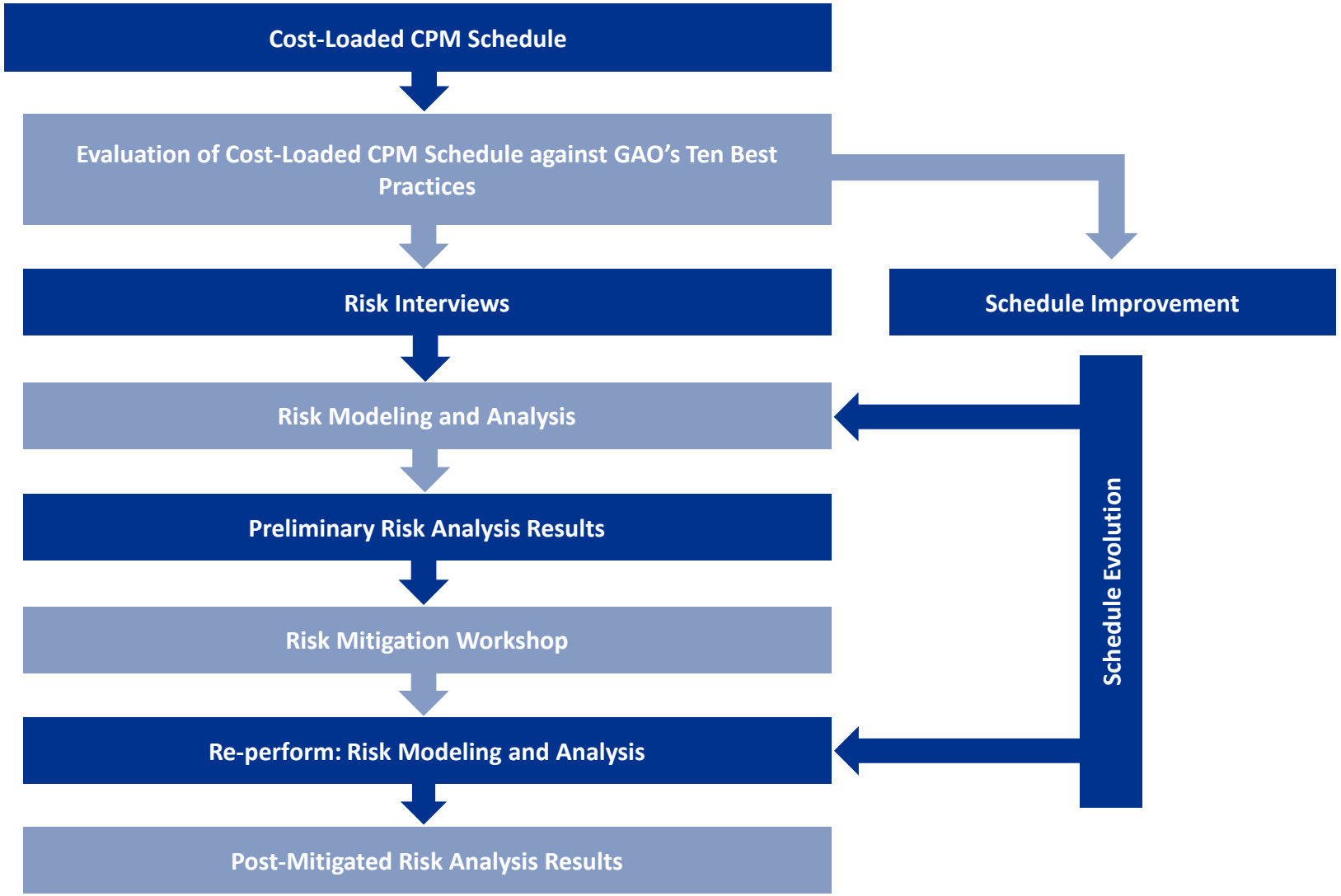

**Level 2: Deterministic Risk Analysis** is the act of analyzing risks through a single-point estimate of potential impacts. Typically, this involves a probability × impact matrix, a prioritized list of risks, and/or an expected value for contingency allocation of schedule or cost.




**Level 3: Probabilistic Risk Analysis** is the act of analyzing risk through probability distribution estimates of potential impact, known as Monte Carlo simulations. Typically, this approach involves cumulative distributions of potential outcomes and determination of the probability of meeting project targets.

Reference: (RS280-1)

# Overview of the Process



# The Costs

| Summary of Risk Analysis Results: Cost Objectives for NASM Project & DCC Storage Module 1 | | | | | |
|---|---|---|---|---|---|
| **No.** | **Program Description** | **SI CWE Budget Amount** | **CPM Summary Schedule Amount** | **Risk Analysis P-80 Value** | **P-80 Budget Shortall** |
| 1 | Total NASM Program Budget without Contingency | $561,492,562 | $561,492,562 | | |
| 2 | NASM Construction Contingency | $114,542,438 | $114,542,438 | | |
| **3** | **Total NASM Program Budget with Contingency** | **$676,035,000** | **$676,035,000** | **$680,432,000** | **($4,397,000)** |
| 4 | DCC Storage Module without Contingency | $53,804,361 | $53,804,361 | | |
| 5 | DCC Storage Module Contingency | $4,199,687 | $4,199,687 | | |
| 6 | DCC Storage Module with Contingency | **$58,004,048** | **$58,004,048** | $63,855,000 | **($5,850,952)** |
| **5** | **Total SI Program Budget with Contingency including DCC** | **$734,039,048** | **$734,039,048** | **$744,287,000** | **($10,247,952)** |

# The Schedule

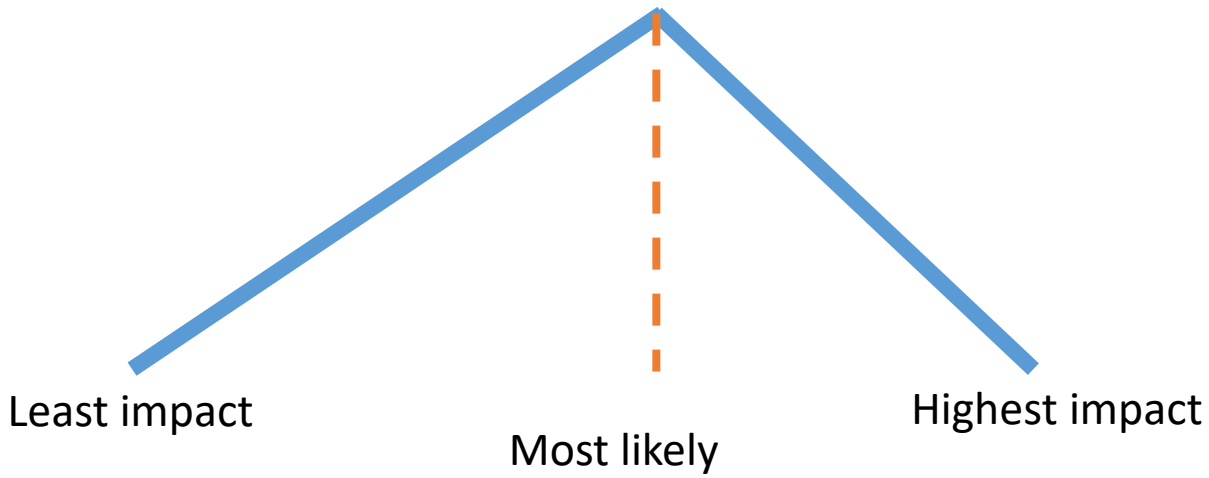
| Summary of Milestone Dates: Planned Sequence from 35% DD and CPM Summary Schedule | | | | |
|---|---|---|---|---|
| **No.** | **Work Scope** | **Planned Timeline[1]** | **35% DD Planned Completion Date[2]** | **CPM Summary Schedule Date[3]** |
| | Temporary Space | Months 0 - 4 | 3/15/2018 | 3/30/2018 |
| **DCC** | **DCC Storage Module** | **19 Months** | | **1/31/20194** |
| Zone 1 | Demount | Months 5 - 9 | 2/15/2019 | 11/5/2018 |
| | Construction | Months 10 - 23 | 1/15/2020 | 1/13/2020 |
| | Remount | | 2/15/2021 | 8/16/2024 |
| Zone 2 | Demount | | 2/15/2019 | 10/30/2018 |
| | Construction | Months 14 - 38 | 1/15/2020 | 1/17/2020 |
| | Remount | | 1/15/2021 | 10/1/2020 |
| Zone 3 | Demount | | 8/15/2019 | 6/8/2021 |
| | Construction | Months 27-41 | 5/15/2021 | 8/10/2022 |
| | Remount | | 12/15/2021 | 11/16/2022 |
| Zone 4 | Demount | | 10/15/2019 | 1/10/2020 |
| | Construction | Months 26-56 | 6/15/2021 | 8/10/2022 |
| | Remount | | 8/15/2021 | 3/2/2022 |
| Zone 5 | Demount | | **5/15/2022** | **6/8/2021** |
| | Construction | Months 35-68 | 7/15/2023 | 8/10/2022 |
| | Remount | | **1/15/2023** | **12/28/2022** |
| Zone 6 | Demount | | **5/15/2022** | **3/24/2023** |
| | Construction | Months 56-75 | 2/15/2024 | 2/2/2024 |
| | Remount | Months 73-84 | **11/15/2024** | **11/29/2024** |
| Zone 7 | Demount | | **2/15/2022** | **12/30/2022** |
| | Construction | Months 56-75 | 2/15/2024 | 3/22/2024 |
| | Remount | Months 71-82 | 9/15/2024 | 1/31/2025 |
| | **Project Construction Completion** | | **2/15/2024** | **10/25/2024** |
| | **Project Final Completion** | | **9/15/2024** | **1/31/2025** |

# The People

| No. | Name | No. | Name |
|---|---|---|---|
| 1 | Ann Powell | 24 | John Bixler |
| 2 | Ann Trowbridge | 25 | Josh Shaw |
| 3 | Barbara Faust | 26 | Josh Stewart |
| 4 | Bill Donnelly | 27 | Juan Puente |
| 5 | Brian Temme | 28 | Ken Johnson |
| 6 | Cecelia Mayer | 29 | Kevin Blanchard |
| 7 | Charles Chandler | 30 | Larry Barr |
| 8 | Charles Obi | 31 | Leora Mirvish |
| 9 | Claire Siedschlag | 32 | Mark Kornmann |
| 10 | Colin MacKillop | 33 | Mary Kfoury |
| 11 | Darick Allan | 34 | Meg Caulk |
| 12 | David Hay | 35 | Meg Caulk |
| 13 | David Voyles | 36 | Michael Kilby |
| 14 | Debbie Nauta-Rodriguez | 37 | Mike Carrancho |
| 15 | Deborah Palazzo | 38 | Mike Henry |
| 16 | Derek Ross | 39 | Rick Flansburg |
| 17 | Doug Hall | 40 | Rob Shaw |
| 18 | Douglass Erickson | 41 | Sarah Billington |
| 19 | Ed Rynne | 42 | Sharon Park |
| 20 | Ed Stroczynski | 43 | Stephen Schluth |
| 21 | Elizabeth Fedowitz | 44 | Susan Lake |
| 22 | Eve Errikson | 45 | Tom Dempsey |
| 23 | Hugh Meehan | | |

# The Workshops

# Projecting the Impacts



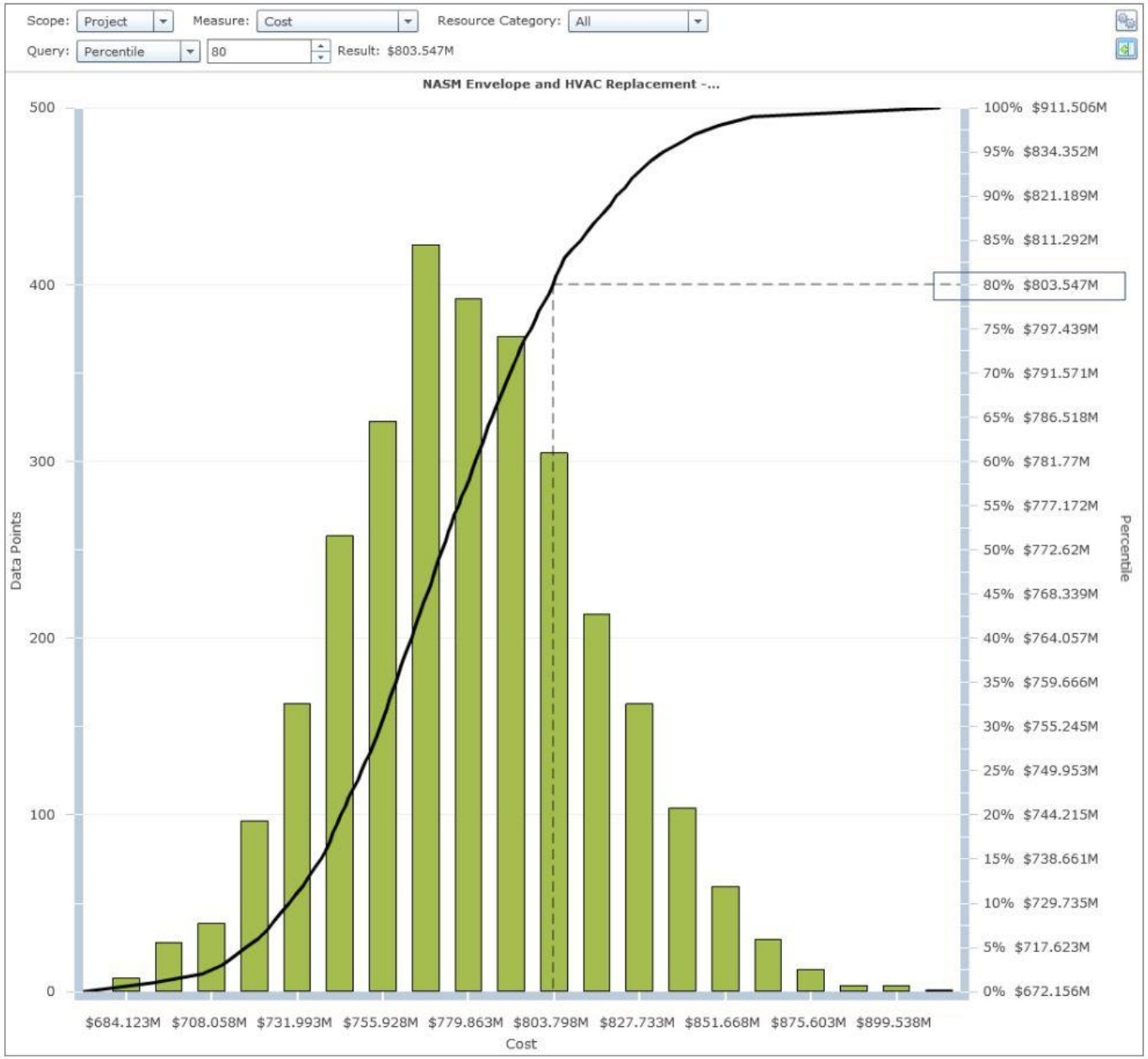
# The Worksheets

| RISK ID | Risk Statement (cause, risk, impact) | Probability | Impact on Time | | | Impact on Cost | | | Activities /Resources Affected | Risk Mitigation Proposed in 2015; Notes; Suggested Mitigations in 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Low | ML | High | Low | ML | High | | |
| 1006 | **Mitigation Proposed (2016, at 35% DD) =======>>** | Reprioritize budget and or scope items within or outside the project.<br>Monitoring of budget line item for supervision and administration.<br>Based on NMAAHC actual SIOH costs of approximately 5% the 5% S&A amount for NASM, if not reduced and if not of excessive duration, should be sufficient. | | | | | | | | Reprioritize budget and or scope items within or outside the project.<br><br>Monitoring of budget line item for supervision and administration. |
| | Post Mitigation Risk Parameters =====>> | 55% | | | | 1.00 | 1.15 | 1.30 | | |
| 1007 | Stone Risk - production/quarry. The yield of the Tennessee Marble company is sill uncertain despite the feasibility (the yield in the new quarry may be less than what's stated or assumed in the estimate). Quality of stone may not match the spec requiring further drilling delaying the production | 50% | 1.20 | 1.25 | 2.00 | 1.05 | 1.10 | 1.25 | Stone Fabricate and Inspect | 1) Prior to purchase, conduct independent drilling/boring at and near quarry to determine extent of vein, quantity, quality, consistency (including battery of lab analyses of the stone). 2) Widen acceptable color range, pending approval by Agencies. 3) Pre-purchase & quarry at least 50% of projected stone to process into blocks for sorting/analysis (100% if possible) to get ahead of the schedule |
| | **Mitigation Proposed (2016, at 35% DD) =======>>** | 1) Project schedule slippage has relieved some of the production pressure on Tennessee pink.<br>2) Si will, either through AE, CM, or CM@risk, conduct independent drilling/boring at and near quarry to determine extent of vein, quantity, quality, consistency (including battery of lab analyses of the stone).<br>3) SI is evaluating other stone and materials for the cladding other than Tennessee Pink<br>4) Widen acceptable color range, pending approval by Agencies.<br>5) Pre-purchase & quarry at least 50% of projected stone to process into blocks for sorting/analysis (100% if possible) to get ahead of the schedule<br>We believe the original probability of 50% was low and that the correct mitigated probability is 50% | | | | | | | | |
| | Post Mitigation Risk Parameters =====>> | 50% | 1.20 | 1.25 | 2.00 | 1.05 | 1.10 | 1.25 | | |
| 1008 | Stone Risk - delivery (included in 1007) | 50% | 1.10 | 1.15 | 1.25 | | | | Not modeled in risk analysis; for **Project Risk Register** | 1) Purchase enough surplus stone blocks to store at quarry to prevent delay in delivery. 2) Identify local storage site for finished panels to accommodate delays in construction schedule. 3) Detail interfaces of exterior wall to allow sequencing flexibility ( i.e. so stone can be installed last). 4) Panelized cladding system helps address deficient panel replacement and related delivery delays. |
| | **Mitigation Proposed (2016, at 35% DD) =======>>** | 1) Project schedule slippage has reduced pressure on delivery schedule, especially early in project<br>2) Introduction of Rain Screen envelope system has lessened stone cladding placement as the critical path<br>3) Potential use of other cladding material can significantly reduce delivery schedule risk<br>4) Purchase enough surplus stone blocks to store at quarry to prevent delay in delivery.<br>5) Identify local storage site for finished panels to accommodate delays in construction schedule.<br>6) Detail interfaces of exterior wall to allow sequencing flexibility ( i.e. so stone can be installed last).<br>7) Panelized cladding system helps address deficient panel replacement and related delivery delays.<br>Risk probability based on the use of Tennessee Pink | | | | | | | | |
| | Post Mitigation Risk Parameters =====>> | 40% | 1.10 | 1.15 | 1.25 | | | | | |
| 1009 | Major design defect or error | 35% | 1.00 | 1.05 | 1.10 | 1.00 | 1.00 | 1.05 | Not modeled in risk analysis; for **Project Risk Register** | 1) Peer reviews are on-going. 2) BIM pre bid clash detection is planned 3) Pre bid mock ups are being planned 4) Validate design through testing and mock ups 5) Design assist/ early contractor involvement being considered. |
| | **Mitigation Proposed =======>>** | Multiple levels of review/ CMc involvement, preview of subs, Peer reviews | | | | | | | | |
| | Post Mitigation Risk Parameters =====>> | 15% | 1.00 | | | | | | | |
| 1010 | Client initiated/requested changes | 80% | 1.05 | 1.10 | 1.30 | 1.05 | 1.10 | 1.30 | Office space, swing space for staff, artifacts | "Change Management Board" has been incorporated in the Project Management Plan (PMP).<br>Engage all parties in discussions early and often. Interview stakeholders before SD410 process to identify needs. Ensure all stakeholders are part of the SD410 process. Provide flexibility in the design to account for changing needs of the staff/Museum/SE. Plan for allocation of staff (HR).<br>Manage/prioritize different agendas; what takes precedence (artifacts, revenue, space). Improve communication from executive team as to what the priority is. Establish/utilize the change management board. |
| | **Mitigation Proposed (2016, at 35% DD) =======>>** | | | | | | | | | |
| | Post Mitigation Risk Parameters =====>> | 70% | 1.05 | 1.10 | 1.30 | 1.05 | 1.10 | 1.30 | | |

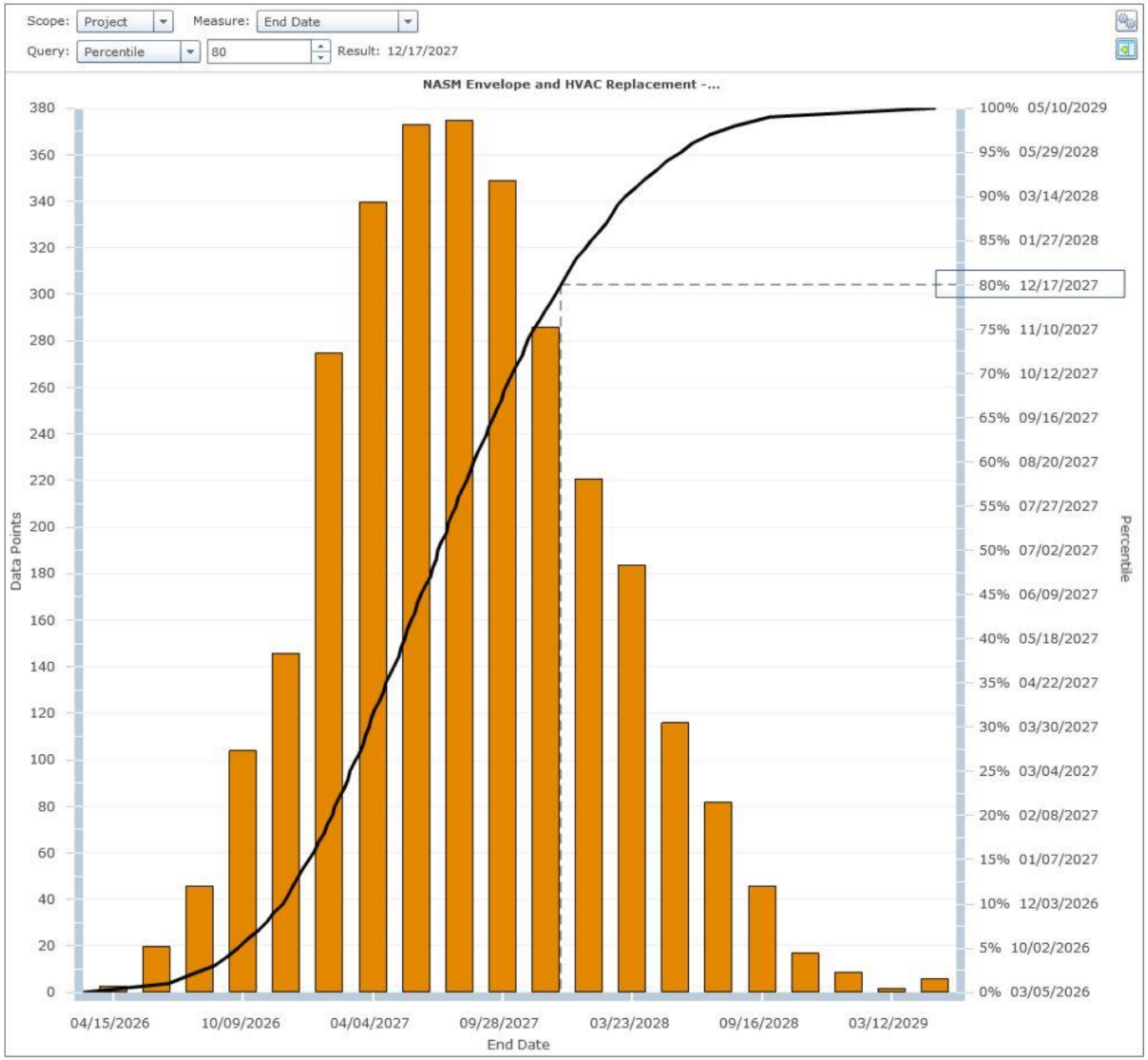
# Developing Mitigations

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1007 | Stone Risk - production/quarry. The yield of the Tennessee Marble company is sill uncertain despite the feasibility (the yield in the new quarry may be less than what's stated or assumed in the estimate). Quality of stone may not match the spec requiring further drilling delaying the production | 50% | 1.20 | 1.25 | 2.00 | 1.05 | 1.10 | 1.25 | Stone Fabricate and Inspect |
| | **Mitigation Proposed (2016, at 35% DD) ======>>** | 1) Project schedule slippage has relieved some of the production pressure on Tennessee pink.<br>2) Si will, either through AE, CM, or CM@risk, conduct independent drilling/boring at and near quarry to determine extent of vein, quantity, quality, consistency (including battery of lab analyses of the stone).<br>3) SI is evaluating other stone and materials for the cladding other than Tennessee Pink<br>4) Widen acceptable color range, pending approval by Agencies.<br>5) Pre-purchase & quarry at least 50% of projected stone to process into blocks for sorting/analysis (100% if possible) to get ahead of the schedule<br>We believe the original probability of 50% was low and that the correct mitigated probability is 50% | | | | | | | |
| | Post Mitigation Risk Parameters =====>> | 50% | 1.20 | 1.25 | 2.00 | 1.05 | 1.10 | 1.25 | |

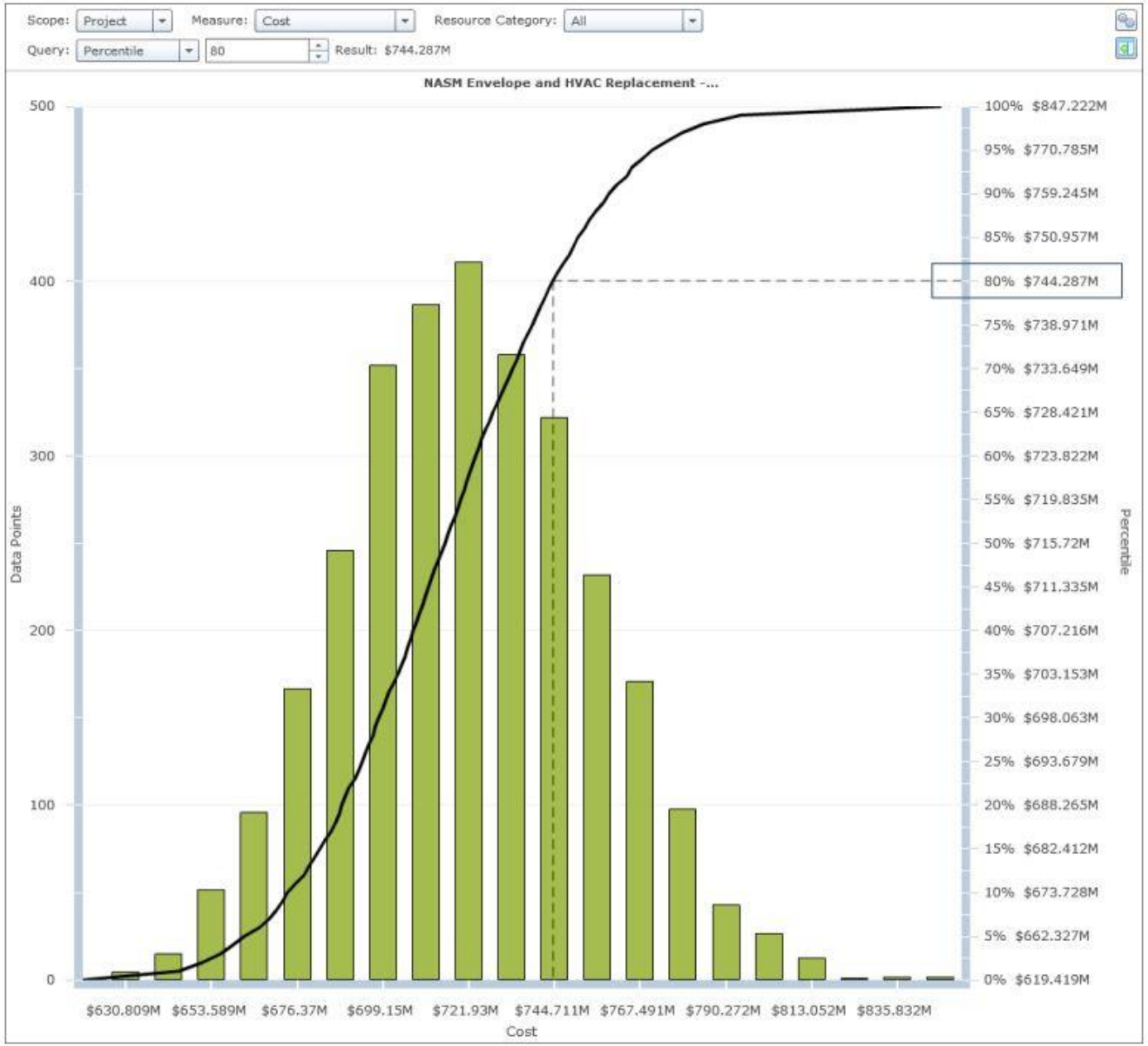
# Cost Confidence Pre-mitigation



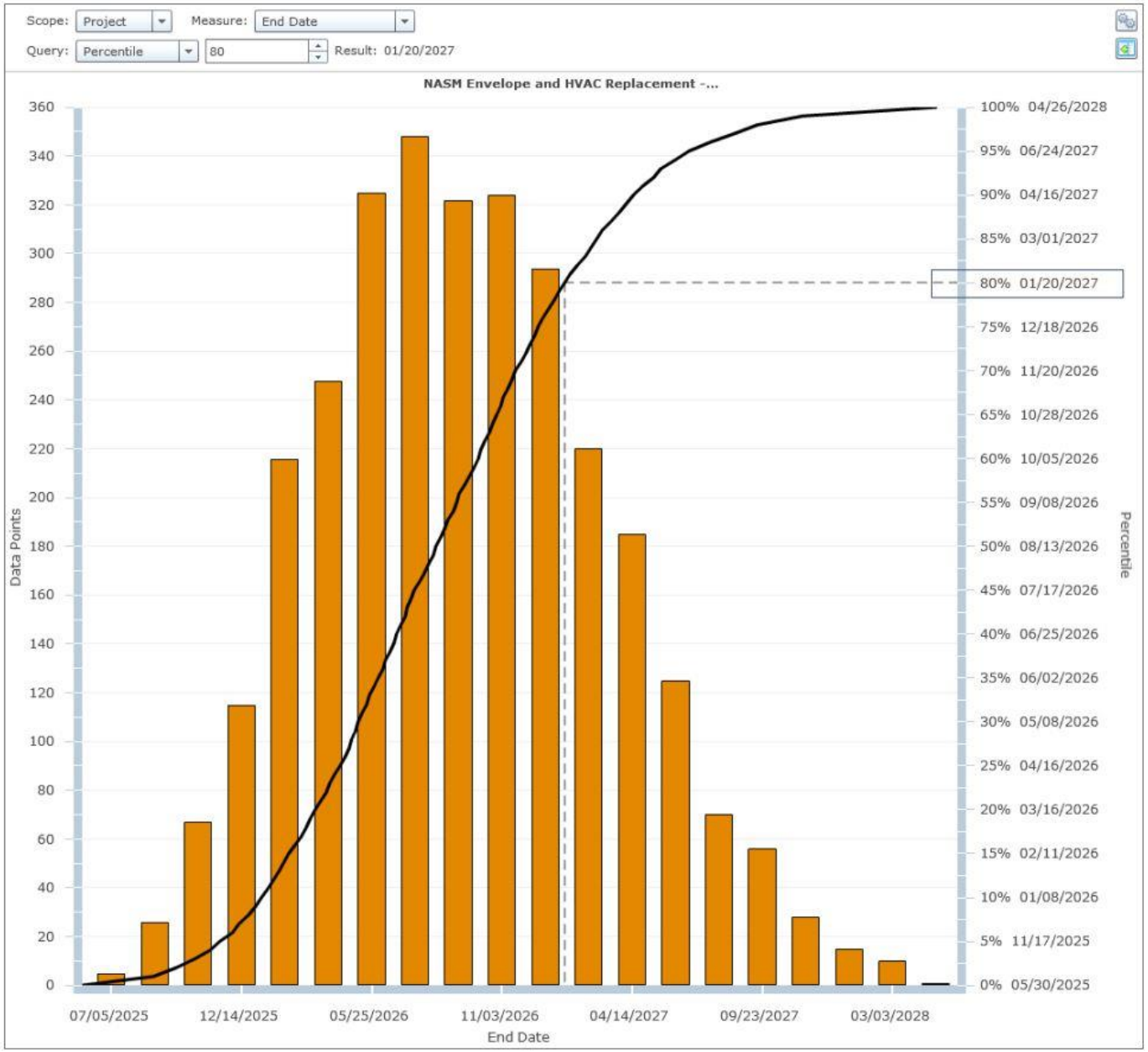
# Schedule Confidence Pre-mitigation



# Cost Confidence Post-mitigation



# Schedule Confidence Post-mitigation



# The Cost Risk Drivers

| Top 20 Cost Risk Drivers | | |
|---|---|---|
| **No.** | **Risk Description** | **Cost Impact** |
| 1 | Resource Uncertainty | $29,467,000 |
| 2 | Client initiated/requested changes | $26,972,900 |
| 3 | Stone Risk - production/fabrication | $11,368,700 |
| 4 | West End is the choke point for everything coming in and out of the building (hazmat, stone, exhibits, artifacts) | $7,188,340 |
| 5 | At the current staffing level in Collections, challenging to properly focus on major projects that include Revitalization, NASM Master Plan, Suitland Master Plan for DCC, UHC-buildout, and building upgrades at Garber | $5,727,580 |
| 6 | Lack of adequate SI "Supervision and Administration" budget | $2,477,810 |
| 7 | Swing Space - Design and Construction of Swing Space Overall Duration (planned duration 11 month may not be adequate) | $2,135,390 |
| 8 | Proposed schedule for re-mount/reinstallation of 10-12 months may be insufficient. | $2,074,530 |
| 9 | Duration Uncertainty | $1,856,730 |
| 10 | Cladding - delayed selection of cladding material (e.g., due to lack of consensus within or outside SI) and its impact on agency review and approval process, issuance of 65% DD, material testing and construction documentation | $1,765,660 |
| 11 | Unforeseen conditions | $1,682,980 |
| 12 | Unintended consequences of perceived good ideas (best intentions) from newer parties brought onboard for various studies might slow the design and construction process; cumulative effect on design completion | $1,655,170 |
| 13 | Changes in senior leadership might impact the project due to the change in priorities | $1,559,170 |
| 14 | DCC - Client requested changes | $1,546,150 |
| 15 | DCC - Unforeseen Conditions | $1,478,650 |
| 16 | Agency reviews may result in additional design changes and time | $1,251,390 |
| 17 | Risk of a large batch of stone falling during construction (due to vibration, etc. - during de-installation) impacting construction - in the construction zone | $1,173,890 |
| 18 | Lack of adequate staff within SI to manage NASM Project | $927,505 |
| 19 | DCC - Delayed or insufficient funding | $617,515 |
| 20 | Current re-mounting schedule has not accounted for additional artifacts, yet to be selected from collection currently outside of Mall Building. | $541,653 |

# The Schedule Risk Drivers

| Top 20 Schedule Risk Drivers | | |
|---|---|---|
| **No.** | **Risk Description** | **Time Impact (days)** |
| 1 | Stone Risk - production/fabrication | 107 |
| 2 | Client initiated/requested changes | 45 |
| 3 | West End is the choke point for everything coming in and out of the building (hazmat, stone, exhibits, artifacts) | 36 |
| 4 | Proposed schedule for re-mount/reinstallation of 10-12 months may be insufficient. | 27 |
| 5 | Duration Uncertainty | 25 |
| 6 | Cladding - delayed selection of cladding material (e.g., due to lack of consensus within or outside SI) and its impact on agency review and approval process, issuance of 65% DD, material testing and construction documentation | 13 |
| 7 | Current re-mounting schedule has not accounted for additional artifacts, yet to be selected from collection currently outside of Mall Building. | 8 |
| 8 | Lack of adequate staff within SI to manage NASM Project | 6 |
| 9 | Swing Space - Design and Construction of Swing Space Overall Duration (planned duration 11 month may not be adequate) | 5 |
| 10 | Unforeseen conditions | 5 |
| 11 | Risk of a large batch of stone falling during construction (due to vibration, etc. - during de-installation) impacting construction - in the construction zone | 5 |
| 12 | Agency reviews may result in additional design changes and time | 4 |
| 13 | At the current staffing level in Collections, challenging to properly focus on major projects that include Revitalization, NASM Master Plan, Suitland Master Plan for DCC, UHC-buildout, and building upgrades at Garber | 3 |
| 14 | Unintended consequences of perceived good ideas (best intentions) from newer parties brought onboard for various studies might slow the design and construction process; cumulative effect on design completion | 3 |
| 15 | Lack of defined schedule for exhibit re-installation will have impact to the construction (also Risk ID 1020) | 1 |
| 16 | Price above Engineer's Estimate | 1 |
| 17 | Resource Uncertainty | 0 |
| 18 | Lack of adequate SI "Supervision and Administration" budget | 0 |
| 19 | Changes in senior leadership might impact the project due to the change in priorities | 0 |
| 20 | DCC - Client requested changes | 0 |

# The Summary Results

| Summary of Risk Analysis Results: Cost Objectives for NASM Project & DCC Storage Module 1 | | | | | |
|---|---|---|---|---|---|
| No. | Program Description | SI CWE Budget Amount | CPM Summary Schedule Amount | Risk Analysis P-80 Value | P-80 Budget Shortall |
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| Summary of Risk Analysis Results for SI NASM Project: Schedule Objectives | | | | | | |
|---|---|---|---|---|---|---|
| No. | Milestones | Planned Timeline* | Planned Date | CPM Schedule Date | Risk Analysis P-80 Date | Risk Analysis P-90 Date |
| 1 | Project Construction Completion | Months 59-76 | 2/15/2024 | 10/25/2024 | 6/10/2026 | 9/2/2026 |
| 2 | Final Remount Exhibit Completion | Months 75-86 | 11/15/2024 | 1/31/2025 | 1/20/2027 | 4/16/2027 |

* Assumes NTP on 11/30/2017

# Follow on actions

- Generated risk register to manage mitigations
- Quarterly review of register and mitigations
- Conducted quarry visits and stone tests
- Made stone selection based on risk analysis
- We've executed as a CM@Risk w/design assist
- Performed Value Engineering exercises
- The museum director hired a Deputy and additional staff including a scheduler
- We've done a bunch of other things (partnering, PMP, BIM PxP)

# OK What if I don't have a $1 billion Project?

- CII Best Practice Provides 3 Tiers
- Provides Spreadsheet Tool
- Tier 1 Identify Risk
- Tier 2 Deterministic Risk
- Tier 3 Probabilistic Risk (Integrated)

# Instructions

## Risk Register Sheet Overview

Below is a list of each sheet and the purpose it serves in creating the final risk register.

| | |
|---|---|
| ***Instructions*** | Provides necessary instructions and definitions for the risk register tool. The sheet serves as a reference and requires no input. |
| ***Input Sheet*** | Defines values for impact and probability. Values are used in deterministic calculations. Default values can be used, if desired. |
| ***Level 1 - Identificatio*** | Risk identification is the first step in the creation of Level 2 Deterministic Risk Analysis. Enter initial risks on this sheet, including risk description, project phase, and category of impact (time or cost). |
| ***Level 2 - Determinist*** | Deterministic risk analysis is the second step in the creation of the Level 2 risk register. Each risk is rated on a qualitative impact and probability scale. In addition, the user can manually enter the expected risk impact and probability value. This sheet will populate the risk mean value (i.e. the most likely case) and overall risk ranking for each identified risk. |
| ***Allocation & Risk Mi*** | This is the last sheet to complete to create the Level 2 risk register. The input focuses on mitigating and monitoring the risks. The user can identify response strategies, assign key individuals, and note potential trigger events. The user can also estimate the cost of mitigation and then re-rank the risks' impacts and probabilities. This sheet will populate the post-mitigated risk mean value (i.e. the most likely case) and give the overall risk ranking for each identified risk. |
| ***Summary*** | This is the final sheet of the Level 2 risk register. The entire sheet is auto-populated on the basis of the data entered in the previous sheets. |

## Initial Data

Initial project data is required to create the risk register. Below, please enter the following approximate values: Project Value (USD), Length of Project (Days), and Value of One (1) Day Delay (in USD). Data will be used in the subsequent sheets to produce the final risk register.

| *Initial Project Data Input* | |
|---|---|
| **Project Value (Unescalated USD)[1]:** | $14,000,000 |
| **Length of Project (Calendar Days)[2]:** | 238 |
| **Value of One (1) Day Delay (USD):** *Example: $10,000* | $5,000 |

[1] Project value should include construction, design, and/or land purchase, depending upon the goals of the risk analysis. Project value should include estimated contingency for this input.

[2] Length of project should be to mid-point of construction and should include construction and/or design, depending upon the goals of the risk analysis.

| **CII Phases** *(Referenced in Risk Identification Sheet)* | |
|---|---|
| Front End Planning | From definition of business need to authorization of total project budget |
| Detail Engineering | From design basis through release of all approved drawings and specifications for construction |
| Procurement | From the procurement plan for engineered equipment through the delivery of engineered equipment to the site |
| Construction | From commencement of foundations or piles to completion of the mechanical system |
| Start-up/Commissioning | From completion of mechanical systems through the transfer of the project to user/operator |

# Input

## INPUT SHEET

***Before completing the subsequent sheets, first complete this input sheet on the basis of the specific project being assessed. Instructions for each input section are located on the right side of this page.***

### Category of Impact

#### Cost

| Description | | Percent of Project Value | | Mean Value |
|---|---|---|---|---|
| | | *L* | *H* | (Dollars) |
| VL | Insignificant Cost increase | 0% | 0% | $0 |
| L | Minimal Cost Increase | 0% | 6% | $420,000 |
| M | Significant Cost Increase | 6% | 12% | $1,260,000 |
| H | Very Significant Cost Increase | 12% | 20% | $2,240,000 |
| VH | Critical Cost Increase | 20% | 40% | $4,200,000 |

#### Schedule

| Description | | Value | | Mean Value | |
|---|---|---|---|---|---|
| | | *L* | *H* | (Days) | (Dollars) |
| VL | Impact recoverable without affecting critical path | 0% | 1% | 1.2 | $5,950 |
| L | Impact recoverable affecting critical path | 1% | 2% | 3.6 | $17,850 |
| M | Critical path affected | 2% | 5% | 8.3 | $41,650 |
| H | Restructuring of project required | 5% | 10% | 17.9 | $89,250 |
| VH | Major restructuring of project required | 10% | 20% | 35.7 | $178,500 |

***Cost Instructions***

*For each description level, in the orange boxes, enter the high (H) percent of project value. Low percent values will automatically populate. Default percent values are provided.*

***Schedule Instructions***

*For each description level, in the orange boxes, enter the high (H) percent of project length. Low percent values will automatically populate. Default percent values are provided.*

### Risk Probability Ranking

| Description | | Value | |
|---|---|---|---|
| | | *L* | *H* |
| vl | Very low likelihood of occurring | 0% | 10% |
| l | Low likelihood of occurring | 10% | 30% |
| m | Medium likelihood of occurring | 30% | 50% |
| h | High likelihood of occurring | 50% | 70% |
| vh | Very high likelihood of occurring | 70% | 100% |

***Probability Instructions***

*For each probability description level, in the orange boxes, enter the high (H) percentage value correspondent to that level. Low percent values will automatically populate. Default percent values are provided.*

### Deterministic Output Rankings

**PxI Heat Map**

| Probability | VL | L | M | H | VH |
|---|---|---|---|---|---|
| vh | | | | | |
| h | | | | | |
| m | | | | | |
| l | | | | | |
| vl | | | | | |

Impact

| Ranking Definition | |
|---|---|
| High | Unacceptable. Major impact on project goals. Different approach |
| Med | Some impact on project goals. Different approach may be required. |
| Low | Minimum impact. Minimum oversight needed to ensure risk |

# Level 1 Identification

| LEVEL 1 - RISK IDENTIFICATION | | | | | | |
|---|---|---|---|---|---|---|
| Item | Status | Date Identified | Brief Risk Description | Detailed Risk Description | CII Project Phases | Category of Impact |
| 62 | Active | 10/04/18 | Construction Security | New OPS cameras may be required to account for new visitor/staff ingress and egress methods | Construction | Cost |
| 63 | Active | 10/23/18 | Visitor Flow | Construction Equipment will interfere with musuem visitation | Construction | Schedule |
| 64 | Active | 10/23/18 | Parking | Contractor personnel parking costs. Limited free parking for construction staff | Construction | Cost |
| 65 | Active | 10/23/18 | Competition method | How we procure the construction could affect the construction cost | Procurement | Cost |
| 66 | Active | 10/23/18 | Sustainable Demolition | Reducing construciton waste stream will be a transferred cost | Construction | Cost |
| 67 | Active | 10/23/18 | Protection / Replacement of gardens | Lots of travel in area and the HMSG has an extensively planted grounds that could be | Construction | Cost |
| 68 | Active | 10/23/18 | Timing of procurement | If this project is competing in a saturated construciton market place prices will be affected | Procurement | Cost |
| 69 | Active | 10/23/18 | Events near site | Not only do museum activities affect construciton but also activity near the HMSG | Construction | Cost |
| 70 | Active | 10/23/18 | Events near site | Not only do museum activities affect construciton but also activity near the HMSG | Construction | Schedule |

# Level 2 Deterministic

| LEVEL 2 - DETERMINISTIC | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Item # | Brief Risk Description | Category of Impact | Pre-Mitigated Risk Ranking | | | | | |
| | | | Most Likely Impact | | Most Likely Probability | | Risk Mean Value (Dollars) | Overall Risk Ranking |
| | | | Qualitative Value | Quantitative Mean Value (Dollars or Day) | Qualitative Value | Quantitative Mean Value | | |
| *Auto* | *Auto* | *Auto* | *Drop Down (Selection Required)* | *Auto (Manual Override)* | *Drop Down (Selection Required)* | *Auto (Manual Override)* | *Auto* | *Auto* |
| 1 | Panel Condition | Cost | Very High | $4,200,000 | Medium | 40% | $1,680,000 | High |
| 2 | Panel Condition | Schedule | Very High | 36 | Medium | 40% | $71,400 | High |
| 3 | Proper Construction Equipment | Schedule | Very High | 36 | Low | 20% | $35,700 | Med |
| 4 | Weather | Schedule | High | 18 | High | 60% | $53,550 | High |
| 5 | Weather | Cost | Medium | $1,260,000 | Medium | 40% | $504,000 | Med |
| 6 | No fall protection | Cost | Medium | $1,260,000 | Very High | 85% | $1,071,000 | High |
| 7 | Adequate Storage for Panels | Cost | Medium | $1,260,000 | Very High | 85% | $1,071,000 | High |
| 8 | Adequate Storage for Panels | Schedule | Medium | 8 | Very High | 85% | $35,403 | High |
| 9 | truction Trailer | Cost | Low | $420,000 | High | 60% | $252,000 | Med |
| 10 | Paver Damage | Cost | Medium | $1,260,000 | High | 60% | $756,000 | Med |
| 11 | Visitor Flow | Cost | Medium | $1,260,000 | High | 60% | $756,000 | Med |
| 12 | Dust Control | Cost | Low | $420,000 | High | 60% | $252,000 | Med |
| 13 | Dust Control | Schedule | Low | 4 | Low | 20% | $3,570 | Low |

Probability - Qualit
Select the approximate probability of the

# Mitigations

| RISK MANAGEMENT | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item # | Brief Risk Description | Response Action/Strategy | Response Action/Strategy Description | Responsible Individual | Cost of Response Action | Monitoring & Updating | | Post-Mitigated Risk Ranking | | | | | | |
| | | | | | | | | Most Likely Impact | | Most Likely Probability | | | | |
| | | | | | | *Trigger Events* | *Risk Resolution Date* | *Qualitative Value* | *Quantitative Mean Value (Dollars or Day)* | *Qualitative Value* | *Quantitative Value* | *Risk Mean Value* | *Risk Mean Value + Cost of Mitigation* | *Overall Risk Ranking* |
| *Auto* | *Auto* | *Drop Down* | *Manual* | *Manual* | *Manual* | *Manual* | *Manual (MM/DD/YY)* | *Drop Down* | *Auto (Manual Override)* | *Drop Down* | *Auto (Manual Override)* | *Auto* | *Auto* | *Auto* |
| 62 | Construction Security | Mitigate | Design Team having forethought of the phasing and ingress and | AE | $0 | Design | 01/01/19 | Low | $420,000 | High | 60% | $252,000 | $252,000 | Med |
| 63 | Visitor Flow | Accept | NA | na | $0 | na | 01/01/19 | High | 18 | High | 60% | $53,550 | $53,550 | High |
| 64 | Parking | Mitigate | Negotiate with city for spaces | PM | $0 | Design | 01/01/19 | Low | $420,000 | Low | 20% | $84,000 | $84,000 | Low |
| 65 | Competition method | Mitigate | More competiation is good | CM | $0 | Construction | 01/01/20 | Low | $420,000 | Very Low | 5% | $21,000 | $21,000 | Low |
| 66 | Sustainable Demolition | Accept | NA | NA | $0 | Construction | 0101/20 | Low | $420,000 | Low | 20% | $84,000 | $84,000 | Low |
| 67 | Protection / Replacement of gardens | Mitigate | Have SG provide the protection | SG | $20,000 | Construction | 01/01/20 | Low | $420,000 | Low | 20% | $84,000 | $104,000 | Low |
| 68 | Timing of procurement | Mitigate | Pick a better time for procurement | CM | $0 | Construction | 01/01/20 | Very Low | $0 | Very Low | 5% | $0 | $0 | Low |
| 69 | Events near site | Mitigate | Getting event schedules early to mitigate impacts | CM | $0 | Construction | 01/01/20 | Very Low | $0 | Very Low | 5% | $0 | $0 | Low |
| 70 | Events near site | Mitigate | Getting event schedules early to mitigate impacts | CM | $0 | Construction | 01/01/20 | Very Low | 1 | Very Low | 5% | $298 | $298 | Low |

# Summary

| RISK REGISTER | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RISK IDENTIFICATION | | | | | | ANALYSIS | | RISK MANAGEMENT | | | | | |
| Item | Status | Date Identified | Brief Risk Description | CII Project Phases | Category of Impact | Pre-Mitigated Risk Mean Value | Pre-Mitigated Risk Ranking | Response Action/Strategy Description | Responsible Individual | Monitoring & Updating | | Post-Mitigated Risk Mean Value | Post-Mitigated Risk Ranking |
| | | | | | | | | | | *Trigger Events* | *Risk Resolution Date* | | |
| 1 | Active | 10/01/18 | Panel Condition | Construction | Cost | $1,680,000 | High | Test Samples. Rigging Hooks for removal techniques | Architect/3rd Party | Award | 10/01/19 | $327,000 | Med |
| 2 | Active | 10/01/18 | Panel Condition | Construction | Schedule | $71,400 | High | Test Samples. Rigging Hooks for removal techniques | Architect/3rd Party | Award | 10/01/18 | $16,660 | Med |
| 3 | Active | 10/01/18 | Proper Construction Equipment | Construction | Schedule | $35,700 | Med | Provide parameters and equipment requirements in the contract documents | KTR | NTP | 10/01/20 | $375,000 | Low |
| 4 | Active | 10/18/18 | Weather | Construction | Schedule | $53,550 | High | Track NOAA data | KTR | NTP | 10/01/19 | $0 | Low |
| 5 | Active | 10/01/18 | Weather | Construction | Cost | $504,000 | Med | Track NOAA data | KTR | NTP | 10/01/20 | $504,000 | Med |
| 6 | Active | 10/01/18 | No fall protection | Construction | Cost | $1,071,000 | High | KTR supplies their own fall protection equipment and plan | KTR | RFP | 01/01/20 | $166,000 | Low |
| 7 | Active | 10/01/18 | Adequate Storage for Panels | Construction | Cost | $1,071,000 | High | Find additional space alternate locationis. Store on Grass racking system | SI | AE Award | 10/01/18 | $84,000 | Low |
| 8 | Active | 10/01/18 | Adequate Storage for Panels | Construction | Schedule | $35,403 | High | Find additional space alternate locationis. Store on Grass racking system | SI | AE Award | 10/02/18 | $3,570 | Low |
| 9 | Active | 10/01/18 | Construction Trailer | Construction | Cost | $252,000 | Med | Contractor buys and installs trailer | KTR | NTP | 10/01/20 | $134,000 | Low |
| 10 | Active | 10/01/20 | Paver Damage | Construction | Cost | $756,000 | Med | KTR required tolay protection | KTR | RFP | 01/01/20 | $184,000 | Low |
| 11 | Active | 10/01/18 | Visitor Flow | Construction | Cost | $756,000 | Med | KTR required to build tunnels | KTR | RFP | 01/01/20 | $184,000 | Low |

# SI Implementation

- SI has piloted on 2 projects, plans for more
- Hirshhorn Envelope Replacement project ~$20 million
- Hirshhorn Vertical Transportation Repair ~$5
- Interviewed approximately 10-15 Subject Matter Experts
- Took approximately 12-20 hours of time

# Benefits

- Got SME's thinking about risks to project
- Identified mitigations and generated risk/mitigation register
- Identified impacts to schedule and cost of project
- Got team thinking about creative solutions
- Achieved a diversified perspective on the project

# Limitations

- Tends to overstate individual cost and schedule impacts (based on inputs)
- Difficult to determine a reasonable cost/duration contingency (no histograms)

# Questions?

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