1. Challenge

2. Solution

3. Final Remarks
1. Challenge

2. Solution

3. Final Remarks
“NYC is welcoming proposals for the expansion of the city’s transportation system.”

- Provide a new line or line extension with a new station
- Deliver a meaningful and executable design
- Should consider the impact on the community and environment
About the Subway

5.7 Million commuters use the subway on an average weekday, and 1.757 Billion commuters use it per year.

There are over 665 miles of mainline track, about 60% of which is underground.

There are 472 total stations, most of which were built before 1940.
1. Challenge

2. Solution

3. Final Remarks
Overview

Project Management
- Cost Estimate
- TBM Duration
- Total Construction Duration Estimate

Architectural
- Visualization
- Floor plan
- Design aesthetics

Structural
- Calculations of load
- Structural components
- Material choices
- Capability against natural disasters

Mechanical
- Heating
- Consumer Ventilation
- Tunnel Ventilation
- Air Conditioning
- Piston Effect
Project Management

Deliverables of this workstream
Project Management

Procurement and Design Method

Benefits of Design Build

- Reduces design time
- Reduces construction calendar
- Fast track schedule
Project Management Cycle

Request for Proposal (RFP)

Design Guidelines (Parameters)

Time

Cost

Location
### Project Management

#### Site Selection

**Student Name:**

<table>
<thead>
<tr>
<th>Project Criteria</th>
<th>%</th>
<th>Team:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>B&lt;sub&gt;A&lt;/sub&gt;</td>
</tr>
<tr>
<td>1. Achieve project objective – People and Planning Benefits</td>
<td>30</td>
<td>Meets RFP requirements</td>
</tr>
<tr>
<td>2. Complexity – Technical Design &amp; Construction</td>
<td>20</td>
<td>Can be designed and built with moderate difficulty</td>
</tr>
<tr>
<td>3. Site selection – Environmental Impacts</td>
<td>20</td>
<td>Negative impact = low #  Positive impact = high #</td>
</tr>
<tr>
<td>4. Site selection – Social Impacts</td>
<td>15</td>
<td>Negative impact = low #  Positive impact = high #</td>
</tr>
<tr>
<td>5. Regional Economic Impact</td>
<td>15</td>
<td>Potential to economic growth beyond what was already there  <em>(higher number expected in less developed area)</em></td>
</tr>
</tbody>
</table>

**Total Weighted Score (C):**

**Example:**

\[
B_{B1} = A_1 \times B_{A1} \\
.7 = .10 \times 7 \\
C = B_{B1} + B_{B2} + B_{B3} + B_{B4} + B_{B5} \\
6.5 = .7 + .6 + 2.4 + 2.4 + .4 \\
B_A \text{ must be a # 1-10!}
\]
Project Management

Tunnel Estimated Construction Cost & Time

Tunnel Option

**Construction Cost Estimate**
- Est. $/mile: $1.3B
- Est. cost for 1 new station and 1 rehabilitated station: $173M

**Construction Schedule Estimate**
- TBM Machine Schedule: 299 days
- Station Construction Schedule: 3 Yrs Max.

**Total Construction Est.:**
3-4 Yrs (w/ overlap of construction)

**Est. Total cost for project:** $4.42B
Architectural
Architectural

SECTION OF THE TRAIN STATION PLATFORM
• Calculated the dead and live loads
• The choice of material that will perform the best in a given project
• Precautions against natural disasters
Drilling and Blasting

Tunnel Boring

Cut and Cover
### Structural

![Structural Diagram](image)

| Attitude position system | Hydraulic thrust system | Motor | Cutter-head |

<table>
<thead>
<tr>
<th><strong>Pros</strong></th>
<th><strong>Cons</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Its faster</td>
<td>- It will get costly; compared to deep cut to cover it would be less</td>
</tr>
<tr>
<td>- Doesn’t interfere with traffic as much</td>
<td></td>
</tr>
<tr>
<td>- Businesses are not affected as badly</td>
<td></td>
</tr>
<tr>
<td>- Wouldn’t interfere with existing pipes and utilities</td>
<td></td>
</tr>
<tr>
<td>- Not as loud as cut and over.</td>
<td></td>
</tr>
<tr>
<td>Columns</td>
<td>units</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Tributary Area</td>
<td>sq ft</td>
</tr>
<tr>
<td>Uniform Load</td>
<td>lb/sq ft</td>
</tr>
<tr>
<td>Load Factor</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td>lb/sq in</td>
</tr>
<tr>
<td>Area Required</td>
<td>sq in</td>
</tr>
<tr>
<td>side 'a' dimension</td>
<td>in</td>
</tr>
<tr>
<td>side 'b' dimension</td>
<td>in</td>
</tr>
<tr>
<td>Area Provided</td>
<td>sq in</td>
</tr>
<tr>
<td>Utilization Ratio</td>
<td></td>
</tr>
</tbody>
</table>
A = 675 sq ft
W = 100 lbs/sq ft

LOAD = A*W = 67500 lbs
As a structural engineer we had the task of determining the excavation techniques as well as the appropriate structural components to use in the project. At the end, we chose boring as the best method to excavate the subway. In addition, we calculated the loading and calculated columns sizes based on architectural layouts.
Deliverables

• Mechanical equipment for ventilation
• Tunnel ventilation system
• Platform and station ventilation systems
Mechanical – Our Problem

The Piston Effect

Subway Ventilation System
(Piston Effect)

Downcast Shaft

Air Intake

Ground surface

Air Exhaust

Upcast Shaft

Subway Tunnel

Driving Direction
When leaving a station, the train creates a sucking effect. In addition, the train also creates a pushing effect.
**Mechanical – Calculations**

**Key:**
- → Tunnel
- • Stations & trains
- • Air Flow
- • Pressure

![Diagram of a tunnel system with labels and calculations.](image)

**Equations:**

- \[ Q = \frac{427.4 \times 420.4}{1500} \]

- \[ A = 284.94 \text{ ft}^2 \]

- \[ 285/5 = 57 \]

- **1500 FPM =** rule of thumb for exit velocity (Feet per minute)

- \[ \frac{11(7.5)^2}{2} = 88.3125 \]

- \[ 88.31 \times 4840 \]

- **60 Grates @ each end of the tunnel**
Mechanical – Solution
Add Subway Grates

• These are commonly used to reduce the Piston Effect, however they must be sized accordingly so that they are efficient and don't cut too much into funds.

• These would be placed on both ends of the station, diminishing the vacuum/sucking effect as well as the pushing force.
Mechanical – Problem

Heating and Cooling of the Platform and Station

Design a ventilation system for heating and cooling the station
1. Challenge

2. Solution

3. Final Remarks
Acknowledgments
Thank You