Urban Tunnelling

Future trends…

- Alleviate serious traffic congestion
- Eliminate a troublesome eyesore
- Create new green and developable space
- Improve mass transportation efficiency

Boston’s “Big Dig”
Newly created parks will transform the city’s physical character and reconnect neighborhoods torn apart by highways and urban decay. It is held that this infusion of urban green space will enhance Boston’s quality of life in a way that no building or tax cut ever could.

Benefits:
- Aesthetics/Open space
- Time
- Accidents
- Air/Noise pollution
- Jobs created

The project will also result in a citywide reduction of carbon monoxide levels by 12%.

Total change in property values (2000 US$)
The Richmond–Airport–Vancouver Rapid Transit Project (the “RAV”), now named the “Canada Line”, is the planned rapid transit connection between downtown Vancouver and central Richmond, with a connection to the Vancouver International Airport. The RAV Project Management Ltd. (RAVC – now InTransitBC) was designated in Feb. 2002 as a subsidiary of the Greater Vancouver Transit Authority (TransLink) responsible for the management and fulfillment of the RAV line construction, and maintenance of public sector obligations under the Public/Private/Partnership (P3) process.

(http://www.canadaline.ca/)
Urban Tunnelling – The Canada Line

Key characteristics of the RAV Project are as follows:

- length of 19.5 km, with an footprint alignment width of approximately 10 m (and a corridor width of approximately 100 m);
- up to 18 stations;
- bridges over the North and Middle arms of the Fraser River;
- ancillary facilities, including an Operation and Maintenance Centre (OMC), a possible concrete batch plant and/or pre-cast facility on Sea Island, and other potential facilities;
- travel time of 25 to 30 minutes from the Airport or central Richmond to downtown Vancouver, depending on the final line configuration;
- approximately 40 million annual boardings anticipated by 2010, increasing to 50 million by 2021;
- construction commencement by late summer 2005; and
- construction completion and revenue service operation by November 2009.

Urban Tunnelling – The Canada Line

In 1999, interest was generated in a rapid transit link to connect Richmond and Vancouver, with a link to serve the Vancouver International Airport and terminal facilities.
• Estimated capital cost of $1.9 billion (2003 $);
• Delivery through a fixed-price “Design, Build, Partially Finance, Operate and Maintain (DBFOM)” contract (awarded to SNC Lavalin/SERCOS - now named InTransitBC);
• Cost overruns will primarily be the responsibility of InTransitBC. In addition, InTransitBC is making an investment of $657 million as part of its obligation under the 35-year performance-based contract.

The key financial characteristics of the Canada Line are:

<table>
<thead>
<tr>
<th>Agency</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government of Canada</td>
<td>$421</td>
<td>$412</td>
</tr>
<tr>
<td>Province of British Columbia</td>
<td>$228</td>
<td>$230</td>
</tr>
<tr>
<td>Vancouver International Airport Authority</td>
<td>$271</td>
<td>$301</td>
</tr>
<tr>
<td>Greater Vancouver Transportation Authority (Translink)</td>
<td>$300</td>
<td>$321</td>
</tr>
<tr>
<td>City of Vancouver</td>
<td>$37</td>
<td>$39</td>
</tr>
<tr>
<td>Total Agency Contributions</td>
<td>$1,230</td>
<td>$1,247</td>
</tr>
</tbody>
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The Canada Line – Preliminary Design

- Elevated guideway through Richmond along No.3 Road;
- Elevated guideway from Bridgeport Station to the Vancouver International Airport terminals;
- Elevated guideway to cross the Fraser River to SW Marine Drive and Cambie Street;

- Cut-and-cover tunnel from 63rd Avenue to 2nd Avenue along Cambie Street;
- Twin-bored tunnel from 2nd Avenue to midway between Georgia and Dunsmuir streets underneath Granville Street;
- Cut-and-cover tunnel from midway between Georgia and Dunsmuir streets to the downtown Vancouver terminus at Waterfront Station.

Much of the Vancouver segment of the line will be underground, with about 75% being built by the “cut and cover” method.
For most of the line, “cut and cover” has been chosen by the SNC team for two basic reasons:

- It allows for shallower tunnels, meaning stations are closer to the surface and more user friendly for those riding the train;

  Cut & cover tunnel construction involves excavating a trench from the surface, and placing pre-cast concrete tunnel segments in the trench. The trench is then backfilled and the road restored.

- It is the best way to ensure the line is built on schedule, and that geotechnical risk is managed.
It is believed that most of the cut & cover tunnel will be excavated in tills with boulders, and in places, some marine sandstones, siltstones and mudstones. However, near Queen Elizabeth park, the tunnel will encounter basalts, which will require blasting.
An Earth Pressure Balanced TBM system will be used. These machines are capable of exerting a balancing pressure against the tunnel face, which will be used to control excavation rates, groundwater inflows and maintain stability of the excavated face.

The procurement of the TBM will commence after the commercial closing. Preliminary discussions and design will take place prior to the commercial closing to identify the specific TBM requirements and the potential manufacturers. The TBM will be capable of achieving, as a minimum, an average advance rate of 10 m per day in the type of ground conditions anticipated, and erection of the segmental lining within the specified tolerances.

The TBM will then move northwards excavating the 1st tunnel.
The TBM will then excavate under False Creek.

Once the TBM reaches the end, it will be lifted out on an exit shaft, transported back to the entry shaft, so that it can excavate the 2nd parallel tunnel.
The Canada Line - Preliminary Design

<table>
<thead>
<tr>
<th>Segment</th>
<th>Vertical Configuration</th>
<th>Horizontal Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>VANCOUVER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterfront of Cordova to south side of Georgia</td>
<td>Underground – side-by-side cut-and-cover tunnels</td>
<td>Centre of Granville Street</td>
</tr>
<tr>
<td>South side of Georgia to Granville near Davie</td>
<td>Underground – twin-bore tunnels</td>
<td>Centre of Granville Street, then east to Davie Street</td>
</tr>
<tr>
<td>Davie near Granville to 2nd Ave</td>
<td>Underground – twin-bore tunnels</td>
<td>Centre of Davie Street, then under False Creek</td>
</tr>
<tr>
<td>2nd Ave to 11th Ave</td>
<td>Underground – side-by-side cut-and-cover tunnels</td>
<td>East side of Cambie Street (beneath north-bound lanes)</td>
</tr>
<tr>
<td>11th Ave to 31st Ave</td>
<td>Underground – stacked cut-and-cover tunnels</td>
<td>East side of Cambie Street (beneath north-bound lanes)</td>
</tr>
<tr>
<td>31st Ave to 37th Ave</td>
<td>Underground – side-by-side cut-and-cover tunnels</td>
<td>East side of Cambie Street (beneath north-bound lanes)</td>
</tr>
<tr>
<td>37th Ave to 63rd Ave</td>
<td>Underground – side-by-side cut-and-cover tunnels</td>
<td>East side of Cambie Street (beneath north-bound lanes)</td>
</tr>
</tbody>
</table>

Activities Under Way or Planned:

- **November 2004**: RAV Line in Service
- **August 2005**: Construction Starts
- **March 2005**: Hydro-Quebec and City of Vancouver sign contract
- **April 2005**: Project Approval

**Projects/Commissions**

- **December 2004**: Project Approval
- **Dec. – Feb. 2005**: Meetings with Downtown and Cambie Business Groups to Provide Project Information
- **Mar. – May 2005**: Preliminary Design & Construction Phase Consultation
- **Mid 2005**: Completion
- **August 2005**: Construction Phase Begins
- **Early 2006 – End 2007**: Cut & Cover Tunnel Construction (Cambie Street)
- **Fall 2006 – Spring 2008**: Cut & Cover Tunnel Construction (Granville M.T. South of Dunsmuir Street)
- **Spring 2006 – Fall 2008**: Bored Tunnel Construction (Granville M.T. South of Dunsmuir Street)
- **November 2009**: RAV Line In Service

*preliminary schedule*
RAVCO is undertaking geotechnical engineering studies to assess general ground conditions, depth of materials, strength characteristics, gradation and grain size and groundwater levels. This study will assist in determining the appropriate construction methodology and foundation design throughout the length of the RAV Project alignment.

**The Canada Line – Preliminary Design**

**T16A Geotechnical Investigations – Vancouver Segment**

Goldco Associates Ltd. completed geotechnical and geophysical investigations along the Vancouver Segment of the RAV corridor which included drilled boreholes, bedrock surface exposure mapping, surface and borehole geophysics, bathymetry, and in situ and laboratory testing. Preliminary environmental screening and chemical testing was also carried out at some borehole locations as part of the investigations. To assess the potential for encountering terms of archaeological significance, an archaeological review of test locations was conducted prior to undertaking the geotechnical investigations.

- **T16B Geotechnical Investigations – Richmond and Airport Segment**
  - Conducted by EBA Engineering Consultants Ltd. (EBA): Land-based investigations along the City of Richmond and Vancouver International Airport segments.

- **T16C Geotechnical Investigations – Fraser River Crossings Segment**
  - Conducted by Klohn Crippen Consultants Ltd. (Klohn Crippen): Investigations for the North Arm and Middle Arm (Murry Channel) crossings of the Fraser River, where bridge structures are being considered.

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**The Canada Line – Term Project**

You will need to form junior “consulting” teams of 4 to 5. Each team will be assigned one of 6 projects related to the RAV tunnelling scenarios:

1. Stability of deep cut & fill trench for double stacked tunnel;
2. Settlements around deep cut & fill trench for double stacked tunnels;
3. Stability of deep cut & fill trench in basalt for double stacked tunnels (near Q.E. Park: between 30th and 37th Ave.).
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You will need to form junior “consulting” teams of 4 to 5. Each team will be assigned one of 6 projects related to the RAV tunnelling scenarios:

5. Stability of twin bored tunnels in water saturated soils/rock beneath False Creek;

6. Minimum pillar width between twin bored tunnels along Granville.

If consulting teams have other ideas or interests, we can discuss alternative projects.

• “Consulting” teams will be expected to collect as much data as possible about their study location (location overview, problem geometry, geology, groundwater conditions, etc.), to use in a series of analyses they conduct using one of the analysis techniques covered in class (limit equilibrium, boundary element, finite element, distinct element, etc.).

• Where data is not available, teams will be required to make engineering estimates and justify the assumptions they make.

• Each team will be required to prepare a professional report and present their findings.