Montreal, November 3, 2016

Anton Dubrau

# The Vision of Montreal's Downtown at the Core of a Poly-Centric City And How to Get there With Public Transit

A Contribution to the Office de la Consultation Publique de Montreal on the "Strategie Centre-Ville".

# 1. Intro

During the consultation process of the OCPM on the “Strategie Centre-Ville”, the city of Montreal proposed to densify the center of Montreal, encourage more people to live downtown, improve transit in particular via the construction of the proposed “REM” system, and to revitalize some former industrial and port areas.

These are all worthwhile and interesting goals, but the proposals appear presented as a set of distinct projects that lack a unifying vision, there doesn’t seem to be a clear regional goal the city of Montreal intends to move towards.

In this document I would like to propose such a vision: the creation of a poly-central city. I would like to explain what I mean by this, and how we can encourage its development using public transit.

Further, I am including a critique of the REM project, which is inadequate to help with these goals. This is mostly due to the low capacity of this light metro system, and the refusal by the CDPQ to share the strategic Mount Royal tunnel with the AMT and VIA as a high-capacity rail access to downtown.

# 2. What is a Poly-Central City?

Before the advent of the automobile, cities were compact and walkable. They had relatively high density, and the relatively small radius of walkability meant that cities were mixed use. With industrialization and early public transit, the sizes of cities started to increase as it was now possible to travel farther, and large factories resulted in some separation of cities into residential and industrial areas. However, the residential areas were still relatively mixed use, providing many services within walking distance.

This is the compact, traditional city.

In North America, the advent of the car changed that. It increased the distances that people could travel to get to work. Coupled with the desire that each person should have a single-family detached dwelling, the cities started to sprawl outwards faster than their population rose, the average density increased. Suburban planning resulted in large single-use areas; many residential areas have few services within walking distance. At the same time, downtowns started to become more dense with single-use office spaces areas. This density increased until the point where the high cost encouraged the proliferation of office complexes in the cheaper suburbs -- now the office buildings are part of the sprawl as well.

A city like this is low density, consists of large single-use area, is heavily dependent on driving, but very walkable, and generally has a large dense central business district which is not human scale.

This describes the sprawling city.

During the last twenty/thirty years, the problem of sprawl has been identified, and there's a movement have people move towards the center again. To again create a more compact city. To make areas more mixed use, and encourage walkability.

The problem is that the existing suburban, lower density areas will not just "go away". It is also unlikely to create a compact, traditional city for a Metropolitan area the size of Montreal. This creates a sort of conflict between those who want to re-urbanify the city and those who want to continue the sprawl. Often this results in the desire to densify everywhere possible, without a clear plan.

As a synthesis of these ideas, in order to combine the advantages of the different models, Montreal should strive for a poly-central city. This is a view of the city as a collection of a large number of towns, each with a proper center of it's own. Each center provides a pocket of density, mixed uses and services. Each center has a certain radius of high density and walkability.

The idea is that it's not necessary to have people live near a dense downtown, they just have to leave near a center with enough density to provide services within walking distance.

The poly-central city is a development pattern that acknowledges that Metropolitan area is going to stay large, that we won't all move back into the inner city. In some sense, it encourages to export the desirable features of the inner city to many areas.

The poly-central city is not a new concept, and it is also very natural that happens already in many places in Montreal. But it should be given a name and it should be explicitly encouraged.

The densification that happens at each 'center' should be focussed on creating a viable community. This means there have to be mixed uses and services. The most efficient way to encourage the creation of these is via the use of transit. Transit generally encourages development.

This means TOD (transit oriented development) should be used together with the development of the transit as an explicit tool for urbanism throughout the region. One has to be careful not to simply build transit lines wherever it is convenient (for example

along highways), then build large condo-complexes next to them. This is a development anti-pattern that will not create the desired outcomes.

## 3. A Transit System for a Poly-Centric City: An S-Bahn

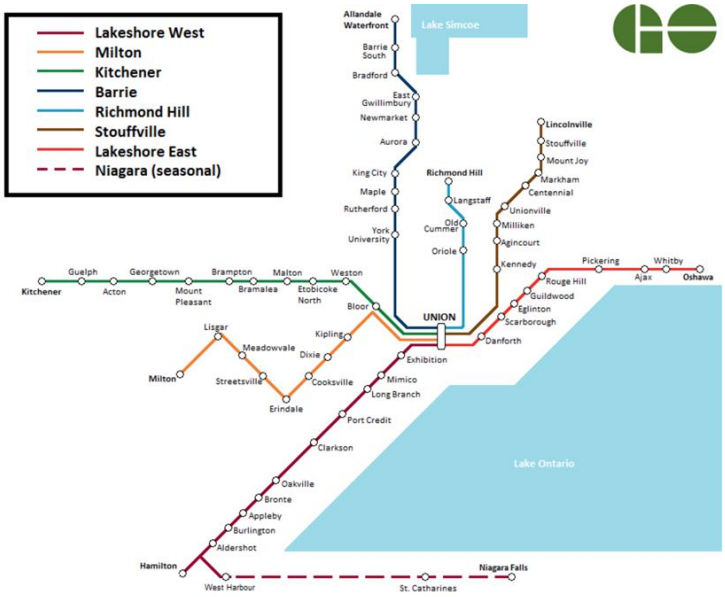
Transit can be used to encourage and help the construction of a poly-central city. Development will often happen naturally near transit stations, especially if service is rapid and frequent.

**Metro**

Generally, Metro lines can provide the right development incentives. But being underground, they are too expensive to build to cover the whole region. In Montreal, the metro can not be extended overground, and it would not be compatible with existing heavy rail due to regulation.

**Commuter Rail**

Another transit mode used in North America, Commuter Rail, allows better coverage of the region. By building more cheaply along existing rail corridors, it is possible to build further out. Unfortunately, commuter rail in North America tends to be anti-urban: stations are often not well placed, and are often build next to large parking lots. Service patterns are usually going downtown in the morning, and away from downtown in the afternoon, with very little other service, meaning that mostly suburban office workers will use the service. Instead of exporting the density along the commuter rail line, they end up encouraging sprawl.




*Go Transit in Toronto*

At the same time, the pan-regional connectivity of commuter rail is often poor. The station distance within the suburbs may be relatively small, but travel between outlying stops is often discouraged due to the ticketing. Within the inner suburbs and the city, there will be very few stops, so the service is often useless for city residents. Lastly, the services tend to terminate downtown, without any through-routing, meaning there will be very little regional connectivity. All this further exacerbates the sprawl-centric nature of traditional North American commuter rail, which thus provides very little incentives to build town centers around the stations. If there is development pressure, it is mostly of the suburban bedroom community type.

*Commuter trains are often large and slow, encouraging low frequency, peak-focussed service and large interstation distances*

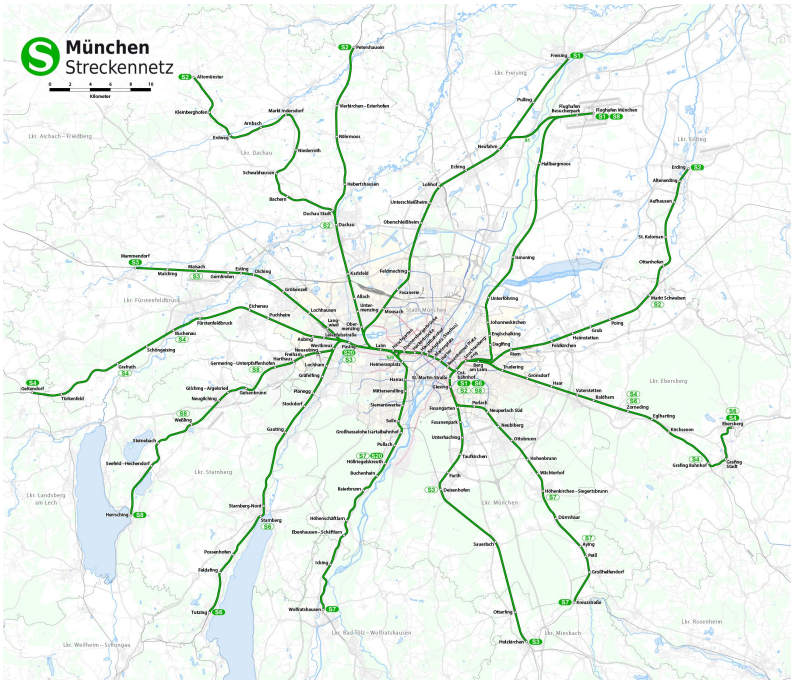
**Meet the S-Bahn or RER**

There is a mode of transit that is a compromise between a metro and commuter rail, it combines many of the positive aspects of both systems. An **S-Bahn** (German: Stadtschnellbahn - rapid city train) or **RER** (Réseau Express Régional) is a transit system that like a metro uses a high capacity trunk line in downtown, usually a tunnel. Outside of downtown, an S-Bahn uses existing rail lines (like Commuter rail) to comparably cheaply cover the whole region.

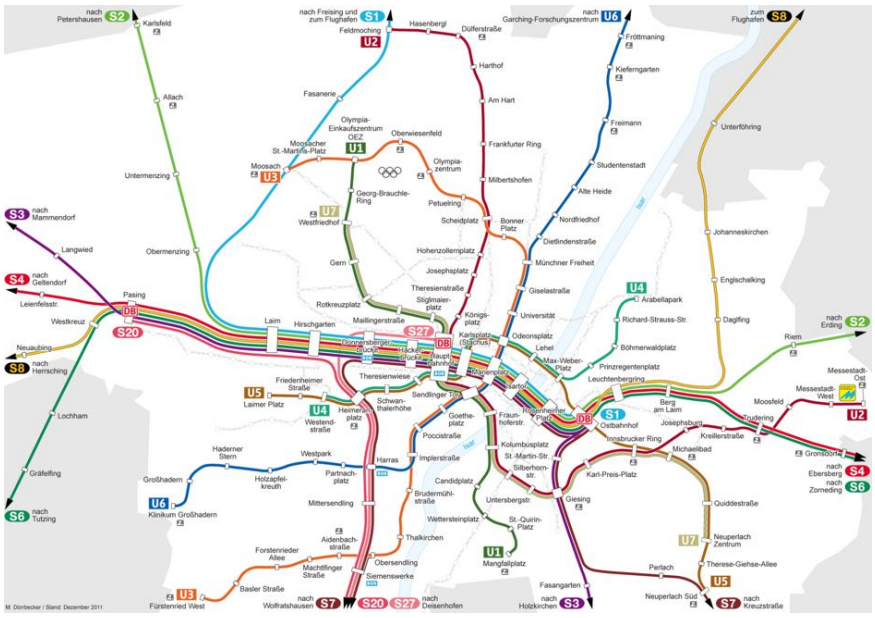
The downtown section acts like a metro, with high frequency of service and small interstation distance. This encourages travel within the city, but also allows travellers from outside to reach multiple possible destinations besides downtown. Having many stations also maximizes the number of transfers to transit lines within the city, making it possible to reach more areas of the city with fewer transfers.

The service is frequent all day long. Note that there is a maximum service frequency on the trunk line, which is generally in the 2min to 3min range. Every branch reduces

the maximum possible frequency, so in outlying areas the frequency may be much lower.




The S-Bahn of Munich. Many lines overlap in the downtown tunnel section, for a frequency of service every 120seconds. About 360km of this network were inaugurated on a single day in 1972, due to the efficiency of construction when re-using existing infrastructure



Munich map of services (S-lines are S-Bahn, U-lines are metro lines). Note the branching of lines

German S-Bahn systems compensate by having fixed interval schedules. If a train comes exactly every 15 minutes, all day long, then passengers will get used to and accept that service, even though the frequency is lower than a metro.

Unlike a commuter rail, S-Bahn vehicles usually appear more like metros. They are usually completely electrified They are generally single level and have many doors. Boarding is usually level. This allows low dwell time, which enables the high frequencies. Unlike metros, however, they tend to have more seating than subways, due to the generally longer trips.


*Electrified rapid-transit-like S-Bahn (left), North American commuter rail (right)*

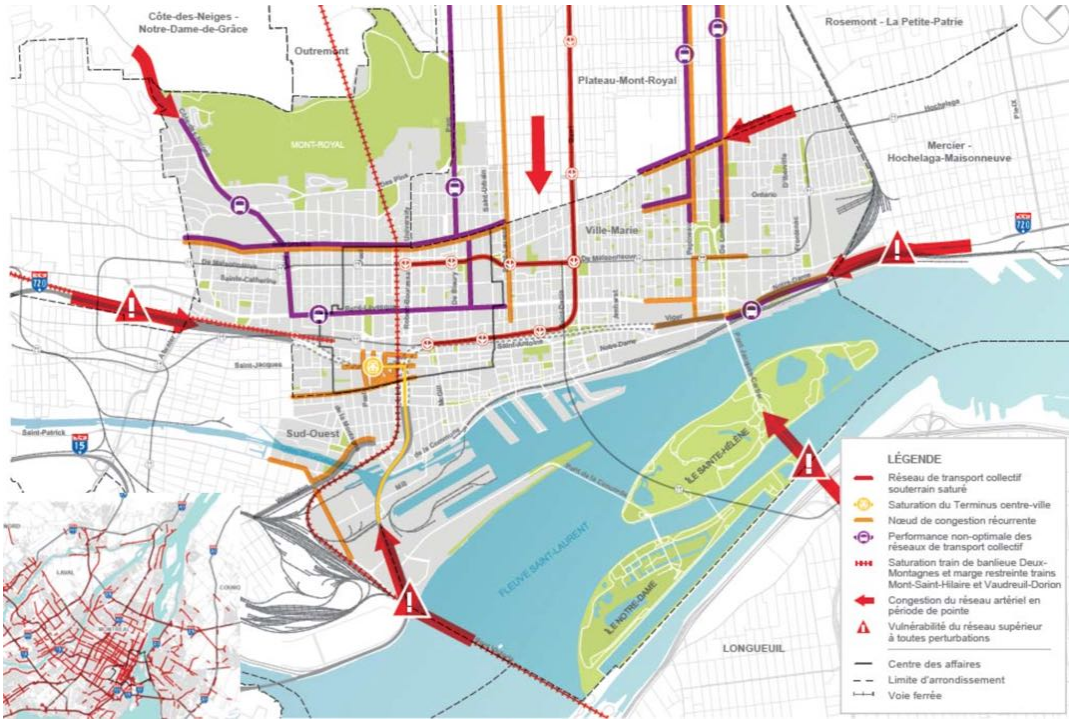
All of these properties allow an S-Bahn system to act like a truly regional rapid transit system that encourages the kind of densification that allows building town centers near stations. This means this mode of transit can be used for urbanism, like many advocate to use a tram.

But unlike a tram which can be used to encourage the development of a neighborhood, an S-Bahn can be used to to encourage development throughout a metropolitan region.

# 4. What would an S-Bahn look like in Montreal?

I believe building an S-Bahn-like transit system can have many positive regional effects. It would allow the creation of a regional transit system, while also increasing the total transit capacity that reaches downtown. By re-using existing rail corridors, there is the opportunity to build a system very cost-effectively.

It can greatly increase the transit capacity reaching downtown. A system like this would not just be complementary to the Metro, it can compete with the metro itself to be the primary transit system of the Metropolitan Area.

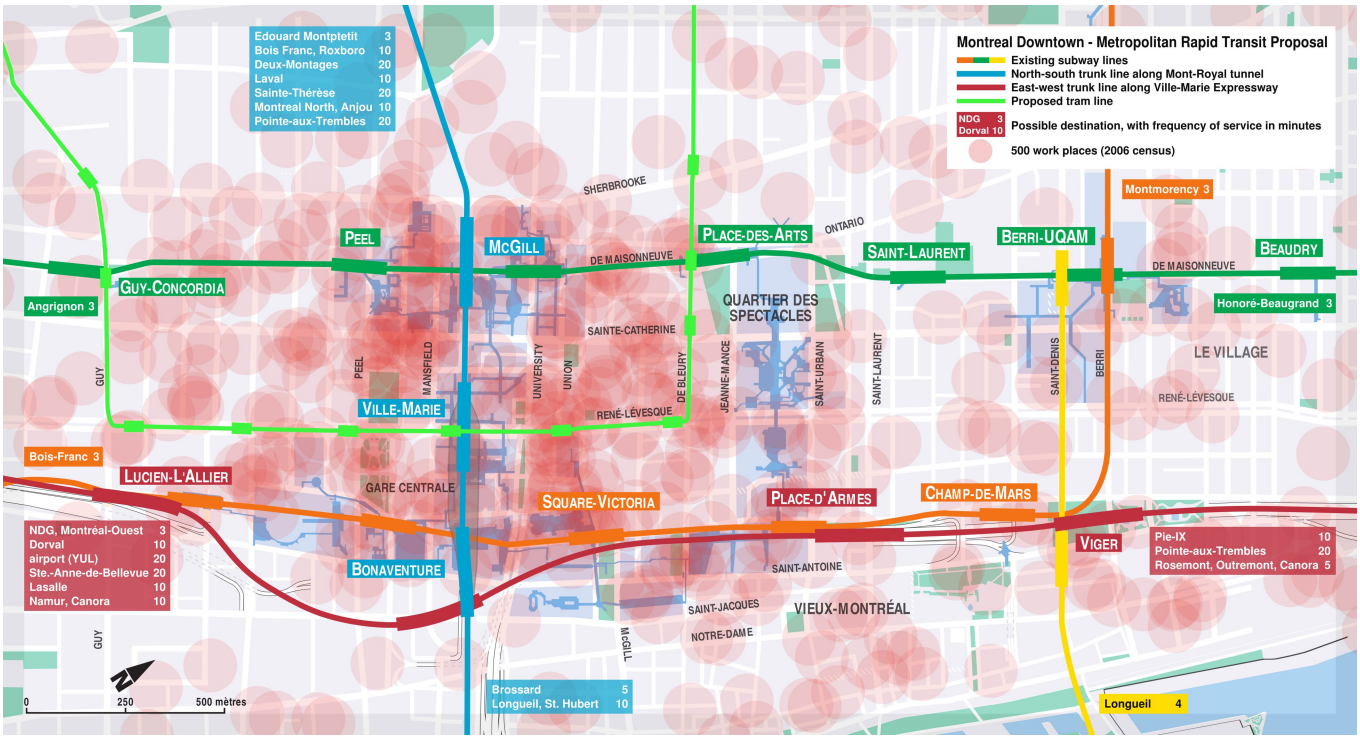



*Many of the transportation challenges facing downtown Montreal can be addressed with an S-Bahn system. Presentation ville de Montreal (5.2.1), page 19*

The main cost of such a system is the trunk line in downtown.

I would propose the construction of an S-Bahn like system that consists of two components: a North-South tunnel and an East-West tunnel.

Both would form trunk lines for many branches that would cover the region. They would both be compatible with heavy rail lines. A map for downtown might look like this:




*Downtown Montreal with two possible S-Bahn tunnels. Note the many possible places each tunnel may connect to. The Frequencies are just given as a possibility. Note the inclusion of a tram line on Rene-Levesque, and an extra station on the Yellow line.*

**North-South Line**

The North-South tunnel already exists today: It is the Mount-Royal tunnel connecting to Gare Centrale. It has the potential to connect to the metro at McGill and Edouard-Montpetit. Proposals to build these stations have been around for a long time.

Outside of downtown, the system can connect

- The Deux-Montagnes line
- The Mascouche line (mostly serving dense areas in Montreal-North)
- The St-Jerome line (mostly serving Ahuntsic and Laval)
- The Mont-St-Hilaire line (serving Longueuil)
- The Champlain Bridge Corridor (serving Brossard)

This idea overlaps a lot with the REM proposal. However, the REM lacks connections to some of the mentioned branches, and has not enough capacity. These issues and potential fixes are discussed below.

**East-West Line**

The East-West Tunnel would be an extension of the Commuter rail lines terminating in Lucien l'Allier. With a downtown tunnel, they would receive a direct connection downtown. Note also that I included the proposal to build a station on the Yellow line in the Old-Port (which has been proposed several times in the past). This could encourage passengers from the South-Shore to transfer there instead of at Berri-Uqam to get downtown, thus relieving the metro.

Outside of downtown, this line could connect on the West to

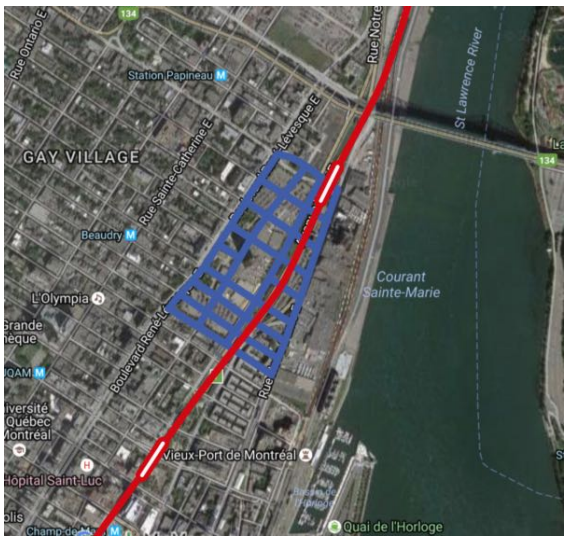
- Multiple new stations between downtown and Montreal-West, which would service dense but underserved areas of NDG
- The Vaudreuil-Hudson line (with a possible connection to the airport)
- The Candiac Line (serving Lasalle)
- A proposed Line to Lachine
- The St-Jerome line, that is, serving Cote-St-Luc, Hampstead, Namur

Outside of downtown, this line could connect on the East to

- The Radio-Canada area and Papineau which are intended to be revitalized by the city of Montreal
- A future possible connection towards the Montreal East along existing rail lines
- A future possible connection around the Plateau towards Rosemont, along the CP Outremont Spur

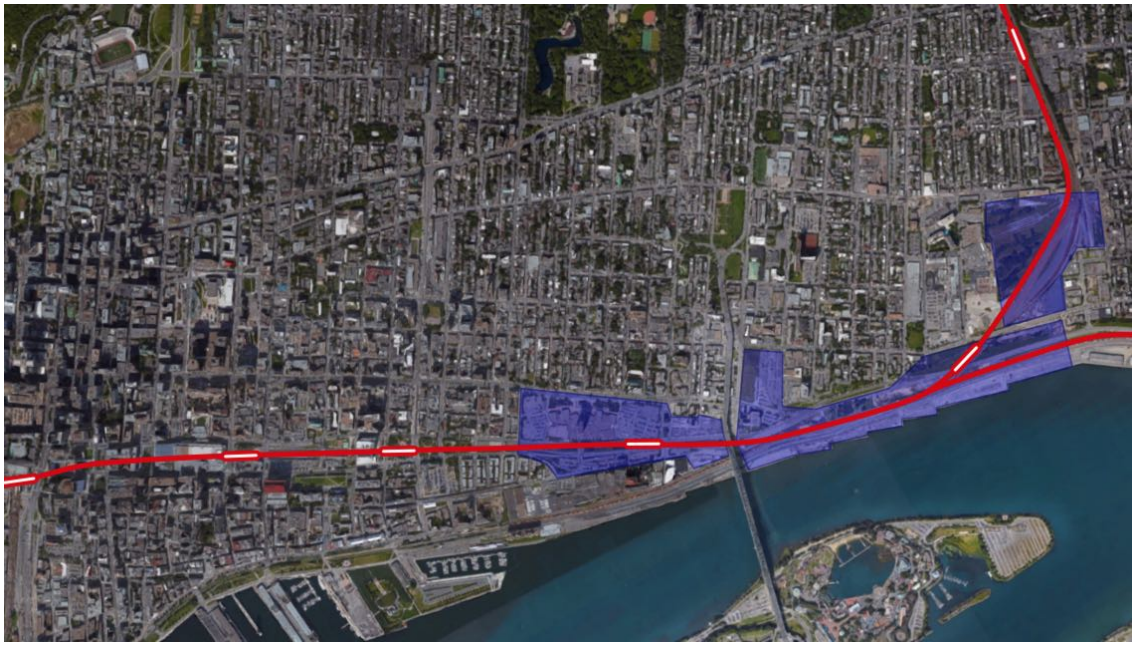
**Revitalization Areas**

This line could be especially interesting to encourage revitalization of the Radio-Canada Area, by imposing a street-grid. With a rapid transit stop, this area could be revitalized much more easily.




*East-West tunnel with stations at Bonsecours and Papineau,*
*With Street-Grid Imposed on Radio Canada Area*

Interesting development opportunities could be encouraged further East Along the St-Laurent River in the area currently occupied by the Port of Montreal, and the CP yards:



*East-West Trunk line, with possible revitalization areas marked in Blue: Radio-Canada, Port of Montreal, CP yards*

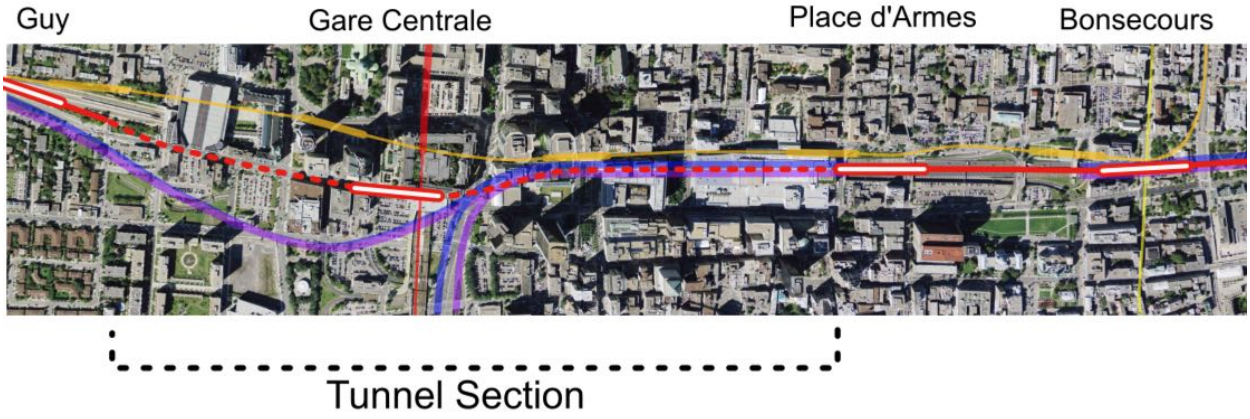
**Papineau Transit Corridor**

Connected to that is the issue of Papineau transit corridor. This street is currently served by the STM line 45. It is a relatively well used transit line, even though it has a large detour when going North from Metro Papineau: due to Papineau being a Soutbound one-way street, the buses have to do a multi-minute detour.

Establishing two-way bus lanes on Papineau between Rachel and Downtown would increase ridership and strengthen the bus corridor. The 45 could also be extended further south to the Radio Canada area and the station proposed on Papineau on the East-West trunk line.

**Cost**

Unlike the North-South corridor, the East-West trunk line does not exist today. There are existing rail lines West of Lucien l'Allier, and East of the Champlain bridge, a total distance of about 3.7km. Most of the corridor is parallel to the A-720 corridor (Autoroute Ville-Marie). It is possible to use the Median at least East of the Palais de Congress, which reduces the tunnel length to about 2km.




A heavy rail tunnel that is 2km long may still be expensive, especially given the complexity due to all the other infrastructure in the area. But it is nevertheless only 2km, so the cost should be manageable. Since this can provide the centerpiece of a network serving hundreds of thousands of people, the cost-benefit ratio may be very strong.

*The A-720 is generally over capacity, because the highway was never extended Eastward. Frequent shutdowns due to construction show that it would be feasible to re-allocate some of its space to a high-capacity rail line.*

# 5. The REM - The North-South S-Bahn?

## 5.1. Intro

At first sight, the REM looks like it matches the vision of a regional transit system proposed in this document, it appears to match the North-South tunnel idea: A trunk line running through downtown, with branches outside of downtown, while electrifying along some commuter rail lines and providing frequent service.

On closer inspection, it turns out the REM project includes several large strategic errors that make this project a bad choice as is. It may create several unresolvable problems for transit in Montreal in the long term:

1) The peak capacity of the proposed system is too low, about half the capacity of a Metro. Maximizing the utility of the existing infrastructure, the Mount Royal tunnel, it would be possible to have a capacity of 40,000 PPHD going downtown (like a metro line), but the REM will only provide at most 24,000 PPHD (at 90s frequencies); the initial system will only have 12,000 PPHD. Today, between the Mascouche line and the Deux-Montagnes line that use the tunnel, the peak capacity is about 10,000 PPHD. 20,000 PPHD is possible with only small modifications to the infrastructure, and if more rail vehicles were purchased. So the public is spending all this money, and handing over infrastructure to a private entity without making enough of a dent in the overall capacities reaching downtown.

2) The REM will block of two very important commuter rail lines from accessing the tunnels directly (St-Jerome line, Mascouche line). These lines pass by high density areas (higher than the areas served by the REM), and are prime candidates to be upgraded to rapid transit standards. These two lines are positioned well to relieve the Orange line. So instead of relieving the Orange line and allowing more people to access downtown, which would strengthen downtown as an employment center and reduce car traffic, the REM may increase crowding on the Orange line down the line, and allow fewer people to reach downtown via transit.

3) The REM system will be incompatible with other rail lines, blocking their access. If the system goes ahead without ensuring compatibility, it is nearly impossible to re-establish compatibility later, meaning this lines will be locked out. Even with compatibility the capacity of the line in the tunnel would be too low to accommodate extra branches.

4) The privatization of all the infrastructure makes a later merging of the lines even less likely, as the public will have no control over transit project anymore.

5) Related to the issue of privatization is the issue that the CDPQ is both planning and financing the line, while at the same time engaged in several nearby real estate projects (two hotels near Gare Centrale, several shopping/office complexes in downtown and at Fairview). A privately planned project is already questionable because it will maximize profit at the expensive of social utility; the real estate connection represents a conflict of interest which exacerbates the issue.

6) Most of the new stations of the REM are along highways, and include a lot of parking. Instead of densification near stations, this will induce sprawl and encourage automobile ownership. Being near pedestrian-hostile highways, most of the stations can not be the centers of towns and neighborhoods, so the development is antithetical to the creation of a poly-central city.

7) The West Island and Airport branches are set up to compete with the existing Vaudreuil-Hudson line, which could serve these areas much better. Having two transit lines compete with each other in low density areas does not make financial sense. It may result in reduction of service on the Vaudreuil-Hudson line, which will have many undesired regional effects.

8) The REM system does not have a good placement of stations in downtown (in particular the Peel Basin & heavily polluted low-density area of the Technoparc Pt-St-Charles). This means it may not help with the revitalization goals in the old port, the griffintown and Pointe-St-Charles, because the stations will not have these areas within walking distance.

9) The transfers between REM and other transit corridors will be very long, in particular the transfer to the Orange line at Gare Centrale, the transfer to the bus/tram corridor on Rene-Levesque, and the transfer to the Green line at McGill.

10) Lastly, by monopolizing the Mount Royal Tunnel, the REM will block VIA rail from using the tunnel for its proposed Quebec City-Montreal high-frequency train. The proposed ‘solution’ is to have the this train terminate at the proposed A-40 station -- a station at the side of a highway in the North of Montreal. With direct access to downtown, this intercity train would strengthen Montreal's downtown as an important employment center. Without direct access to downtown, people will continue to use cars to go to Quebec City.

The end result is a too small increase of transit capacity reaching downtown, the creation of a development pattern that does not encourage densification and the creation of a poly-central city. Instead it will induce sprawl and it will not significantly reduce car traffic to downtown.

This in turn will mean low quality of life in downtown (due to noise and pollution from cars), making it less likely that new residents will want to settle in downtown.

Further, by not maximizing the transit utility (i.e. by sharing the tunnel with the AMT), and by blocking direct access to downtown for the proposed VIA rail line to Quebec City, Montreal's downtown will be comparably weaker as an employment center.

In the following, I would like to explore some issues in more detail, and propose solutions for each of them.

The concerns regarding privatization of transit is further explained in Appendix C. This is an issue that explains some of the overall concerns of the REM project, and explains some of the questionable choices, but it is not immediately connected to the issues facing downtown Montreal.

## 5.2. Low Capacity

Generally, the capacity of a transit line is calculated in "Passengers per hour per direction". This number is obtained by multiplying the number of passengers that can fit at most on the train, by the number of trains per hour.

For example, the REM system may have a frequency of one train every 3 minutes (20 trains per hour), and each train has a capacity of 600 passengers. This yields a capacity of 12,000 PPHD.

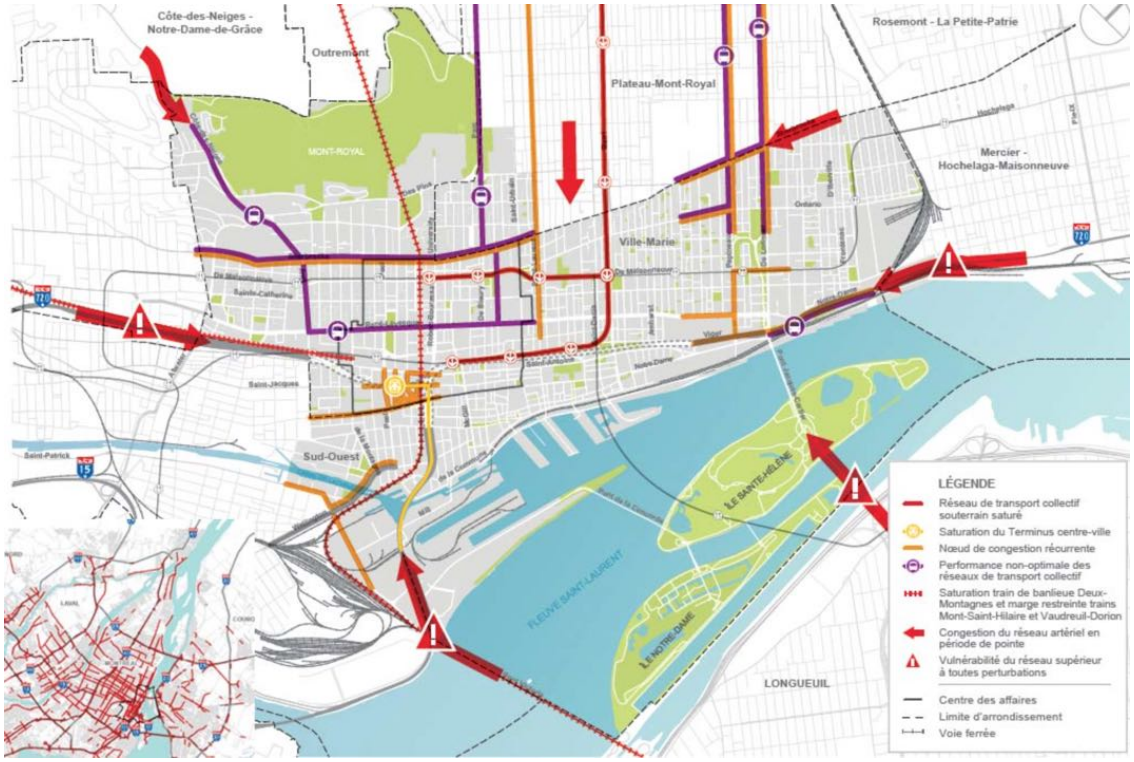
Note that this capacity does not exactly correspond to ridership. Generally, due to uneven crowding over time, and even within the same vehicle, it is basically impossible to actually transport that many passengers per hour. The capacity can be used as a guide to get an idea how many people can be transported, and to compare different lines and plans.

The claim is that the REM system will not provide much more capacity in its initial configuration compared to today. This is largely due to the small vehicles. Compare the REM trains to the Metro trains and the existing Commuter rail trains:


*Capacity of Commuter rail, Metro and REM trains*

This means even if the REM runs at much higher frequency, the capacity may not significantly increase.

To understand the issue of capacity, let us review this traffic issues map from the presentation of the city of Montreal:




*Presentation ville de Montreal (5.2.1), page 19*

The map shows several corridors are overcrowded, including basically all of the transit corridors.

Right now, there are several medium/high capacity lines arriving in downtown Montreal:

- Two Metro lines (Green, Orange line) providing four accesses to downtown with a capacity of 30,000 PPHD-40,000 PPHD each (7,500-10,000 of which is seated)
- The Mount-Royal tunnel, providing a peak capacity of up to 10,000 PPHD (between the Mascouche line and Deux-Montagnes line) during rush hour, 4,000 of which is seated. The theoretical capacity, assuming some infrastructure updates on the Deux-Montagnes line and purchasing of more vehicles, is about 20,000 PPHD.
- The Champlain Bridge corridor. During rush hour, there are up to 178 buses (including 22 articulated buses) per hour arriving/leaving from Terminus Centre Ville. Assuming the capacities of the RTL buses [3], this translates into a capacity of 12,428 PPHD, of which 6,736 are seats.

Note that the Yellow line does not quite reach downtown, so it's capacity is not counted here; as most passengers will transfer onto the Green or Orange line.

The initial REM system (service every 3 minutes) will provide a capacity of 12,000 PPHD, and a seated capacity of 2400 (20% seated capacity of total). The REM will replace the services through the Mount-Royal tunnel and along the Champlain Bridge Corridor.

In the documentation for the REM, there are three possible service levels defined [DA-91], accommodating more and more ridership. The highest service level (3) is not achievable for the initial system, as there won't be enough vehicles.

The seated/standing capacity for the existing systems and the REM is as follows:

| | Existing Systems | Existing Systems & Improvements | REM Service Level 1 | REM Service Level 2 | REM Service Level 3 |
|---|---|---|---|---|---|
| Tunnel Mt Royal total capacity | 10,000 | 20,000 | 12,000 | 13,500 | 24,000 |
| Tunnel Mt Royal Seated capacity | 4,000 | 8,000 | 2,400 | 2,700 | 4,800 |
| Champlain Bridge Total Capacity | 12,428 | ? | 12,000 | 13,500 | 24,000 |
| Champlain Bridge Seated Capacity | 6,736 | ? | 2,400 | 2,700 | 4,800 |

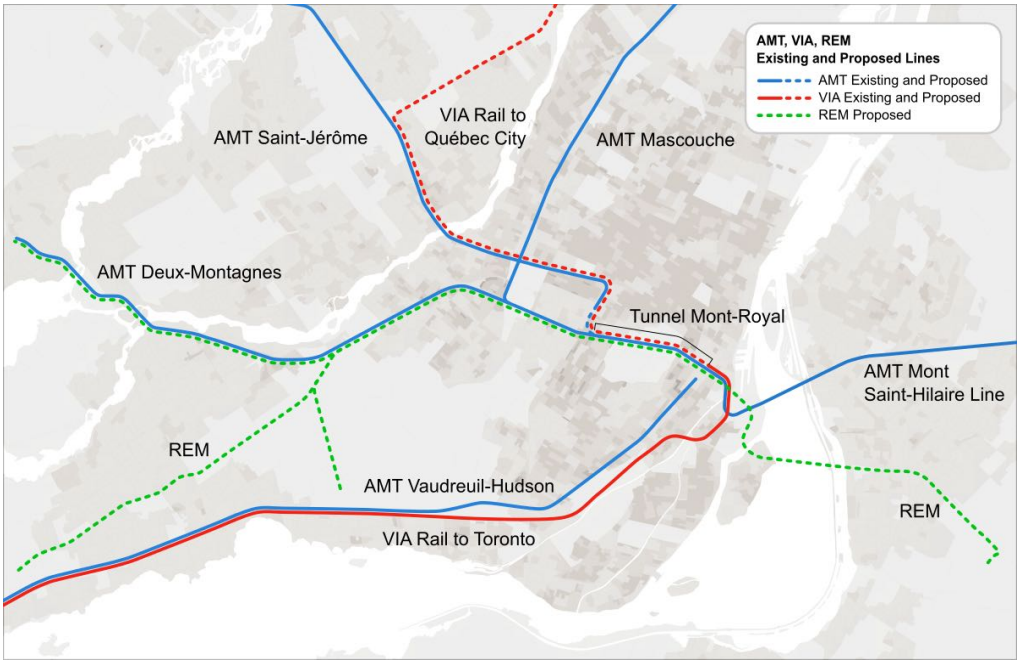
Note how the increase in capacity is surprisingly small, given the very large amount of investment the REM system will represent. Counting the two existing metro lines, the

total maximum theoretical transit capacity that will reach downtown will only increase by about 15%.

## 5.4. Monopolization of Mount Royal Tunnel

Directly connected to the issue of low capacity is the issue of the Monopolization of the Mount Royal Tunnel. VIA, AMT need to access the Mount-Royal tunnel, because it is the only heavy rail connection downtown from the North

VIA, REM & AMT could all use the tunnel, which could provide a high-capacity trunk line through Montreal serving the whole region and cities beyond.

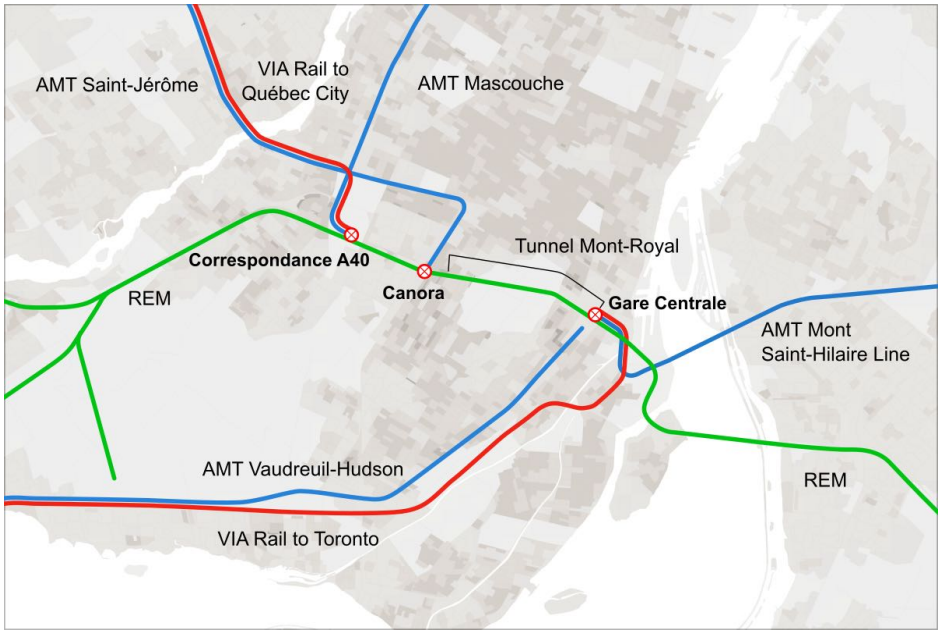



*Various existing and Proposed Rail lines for Montreal*

But the Caisse wants to privatize the tunnel and monopolize it. They insist on converting it to an incompatible technology, citing regulation and the need for frequency.

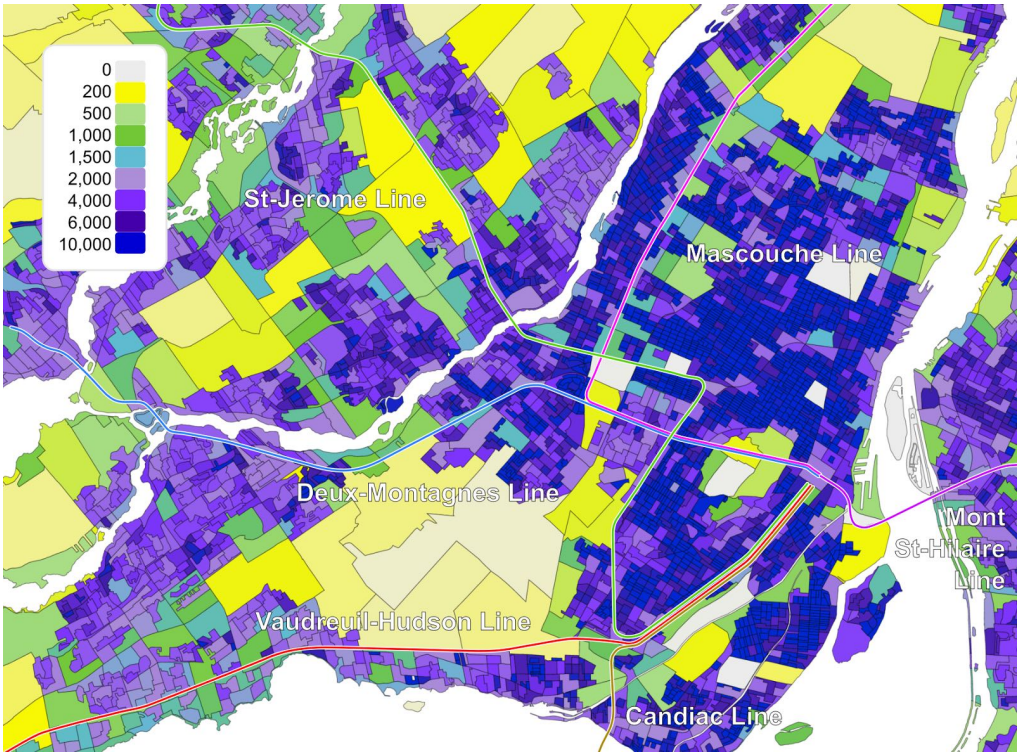
This will cut off the Mascouche line, the St-Jerome line and the proposed VIA rail from accessing downtown directly.

This means we are not building a regional transit system like an S-Bahn. It would require as many lines as possible to connect to the downtown trunk line, which the REM will prevent.



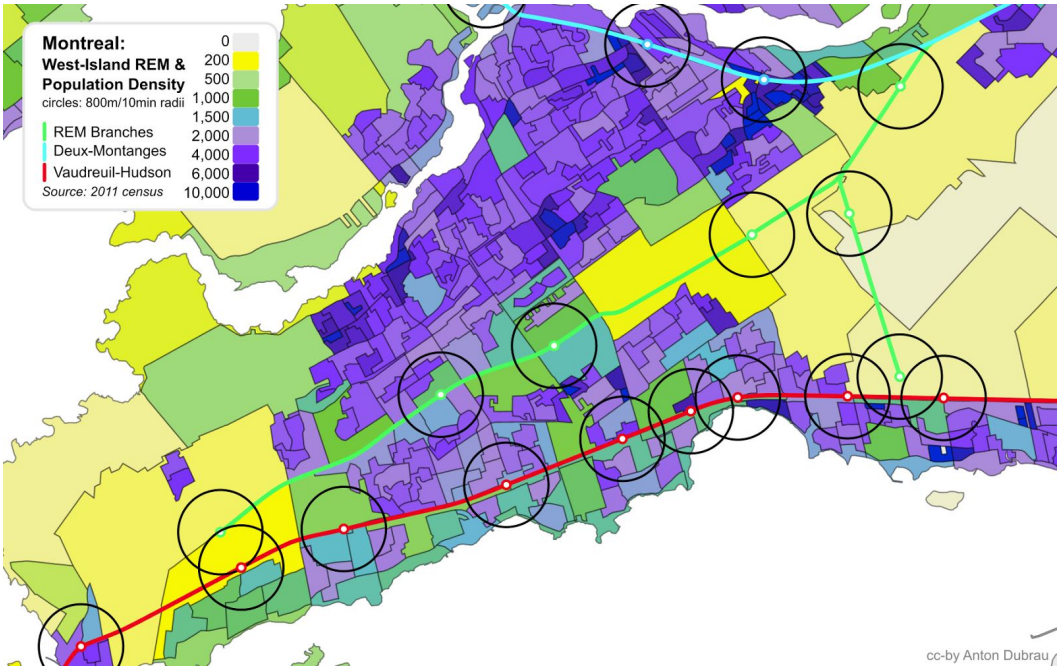

*The result of the REM would be that many lines would be cut off from accessing downtown*

Note that the St-Jerome line and Mascouche line are actually along more densely populated areas. So the REM will monopolize the tunnel to serve branches that are less dense than the lines that are cut off from accessing downtown! This can be seen more clearly in the following density map:

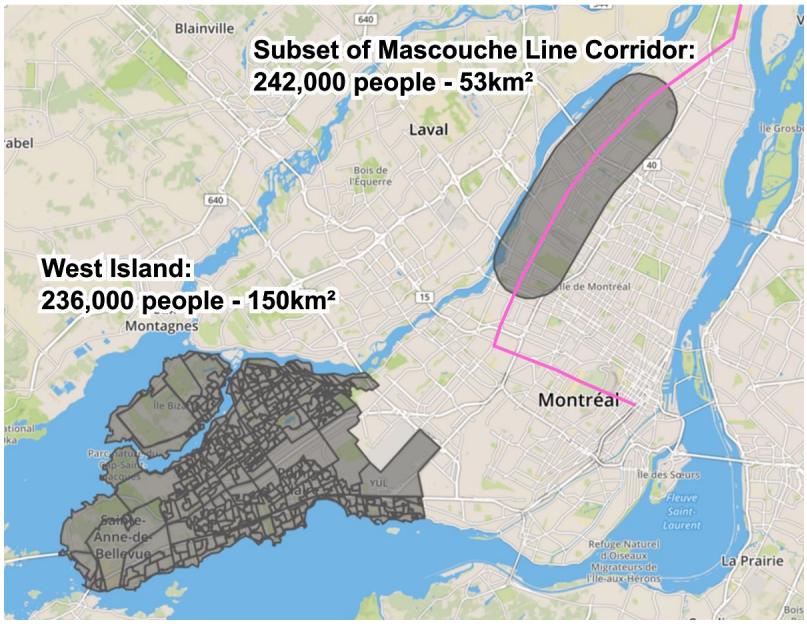



*Density map showing existing AMT lines*

Compare this to the West Island Branches of the REM, which are proposed to be built along very low density areas.




Another way of visualizing this, is the following map, which shows two equal-population areas:




It shows that the Mascouche line has more population within a 2km stretch of the rail line in Montreal North, than the whole West Island, at 3x the density (this map was generated from 2011 census data).

This indicates that the Mascouche line has an incredible potential to add ridership from the area near Montreal North. Several of the Montreal's busiest bus lines are along the corridor:

| Bus Line | 2011 Ridership | % of line near Mascouche line corridor | weighted 2011 ridership |
|---|---|---|---|
| 121 | 32969 | 40% | 13188 |
| 139 | 32325 | 30% | 9698 |
| 69 | 26156 | 60% | 15694 |
| 67 | 21445 | 30% | 6434 |
| 45 | 17197 | 25% | 4299 |
| 33 | 15501 | 30% | 4650 |
| 32 | 13030 | 30% | 3909 |
| 49 | 11516 | 100% | 11516 |
| 48 | 9869 | 100% | 9869 |
| 44 | 9032 | 100% | 9032 |
| 140 | 4973 | 100% | 4973 |
| 43 | 3010 | 100% | 3010 |
| **Sum** | 197023 | | 96271 |

*This table represents ridership of bus lines near the Mascouche line, also weighted by how much of the bus line travels near the Mascouche line. Assuming even distribution of bus riders it allows a glimpse into potential ridership if passengers switched from bus to trains. Source: opus card data, 2011*

If more stations were added on the Mascouche line (along all the important bus corridors), and service was provided more frequently using fares integrated with the STM, the line could attract a lot of ridership.

The REM project will make these improvements, and thus the ridership growth, difficult if not impossible. Firstly, the transfer creates a strong disincentive to travel. A two- or three-leg trip would become a three- or four- leg trip. Also, the CDPQInfra underrepresented the transfer time and effort of the A-40 station. The transfer will reduce ridership potential (and thus the potential to move people from buses and cars to the train).

Second, the REM will simply not have enough capacity to absorb all the Mascouche line riders. At 100k trips per day, this may require up to 10,000-15,000 PPHD -- something the REM can not absorb.

**The St-Jerome Line**

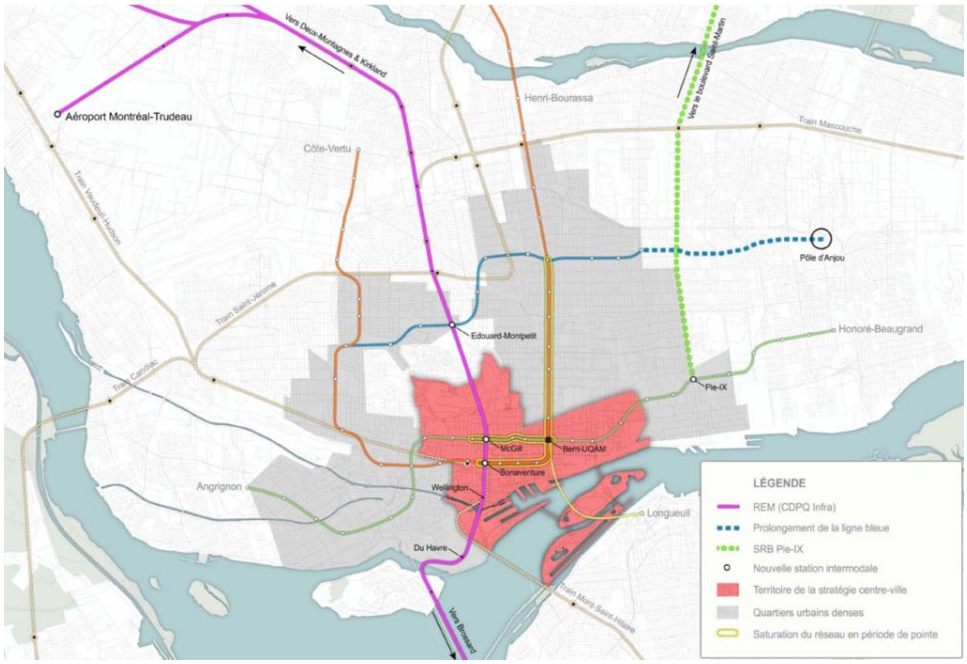
The REM will prevent re-routing of the Saint-Jerome line into the Mont-Royal tunnel, as planned by the AMT for a long time:

> ***Des interventions indispensables pour accroître la capacité d'accueil***
> *(…) Le projet de connexion de la ligne Montréal/Blainville-Saint-Jérôme dans le tunnel Mont-Royal permettra de réduire le temps de parcours vers le centre-ville d'au moins 15 minutes. Ceci créera une augmentation majeure de la demande. D'ailleurs, il est prévu d'affecter à cette ligne une portion de la commande des 160 voitures neuves à deux étages afin d'en augmenter la capacité de 75 % en pointe du matin et du soir.*
> (AMT PTI 2010-2011-2012, page 65)

The REM will prevent this connection. Further, the St-Jerome line may not even receive the connection at Canora as initially proposed by the CDPQInfra, presumably due to capacity issues.

**Relieving the Orange Line**

Note how both the St-Jerome line and the Mascouche line can provide major relief for the Orange line, since they serve some areas that are near each other. Without direct access downtown, those lines are not competitive with the Orange line and can thus not relieve it




*Presentation ville de Montreal (5.2.1), page 20. Note how the St-Jerome line and Mascouche line could relieve the overcrowded Orange line*

**VIA Montreal-Quebec City Train Proposal**

Around the same time that the REM was proposed, VIA proposed its high-frequency rail project to build dedicated passenger tracks in the Quebec-Windsor corridor. This represents an opportunity for transit in Montreal, because VIA has said they would share tracks with the AMT.

The fastest connection between Montreal and Quebec City is via the Mont-Royal tunnel and Trois-Rivieres, which saves 45 minutes of travel time. Without tunnel access, the slower route may be chosen which will convert fewer drivers to rail.

CDPQInfra proposed providing a transfer station for VIA at the A-40 station. This does not seem realistic - high speed trains need to access downtown in order to be viable. It may also mean two extra transfers for travellers going from Quebec City to Toronto.

### 5.4.1. A Second Tunnel?

Some have suggested we should simply build a second tunnel for the AMT and VIA. This doesn't make economic sense.

Consider the logic of this scenario:

We will sell the Caisse our heavy rail tunnel supposedly at "market value". But whatever that "market value" is, it will be way below replacement cost. Then we will invest ten times the money we received to build a second tunnel to replace the one we sold.

It it makes sense to build a second tunnel, then why doesn't the Caisse built it itself?

But also, we don't actually need this second tunnel.

Consider that a rail tunnel can support 40,000 to 60,000 passengers per hour per direction (PPHD). REM will be built for up to 24,000 PPHD.

The St-Jerome & Mascouche line as well as VIA will at most require another 15,000 to 20,000 PPHD together.

So overall, we need a capacity of around 40,000 PPHD. This is within the capabilities of a single tunnel.

Therefore It makes much more economic sense, and it is much more realistic, if the various lines shared the same tunnel which exists today. What we need is a shared system.

### 5.4.2. A Solution: Shared System of REM, AMT, VIA

The Caisse has given various excuses why a shared system is impossible. I want to show that it actually *is* possible. And it is possible without changing the REM project in an unacceptable way - we can have a shared system and the Caisse can still use the tunnel, they can use the same infrastructure for the rest of their system and utilize an automated, high frequency line.

The two biggest issues are:

- The frequency and
- The sharing of light and heavy rail

**The Frequency Issue**

The Caisse is building a system that uses short trains at extremely high frequency. They claim providing frequency is cheaper than building longer stations to accommodate longer trains.

They are planning to have frequencies as high as every 90 seconds. They claim that that a heavy rail system can not run at such frequencies.

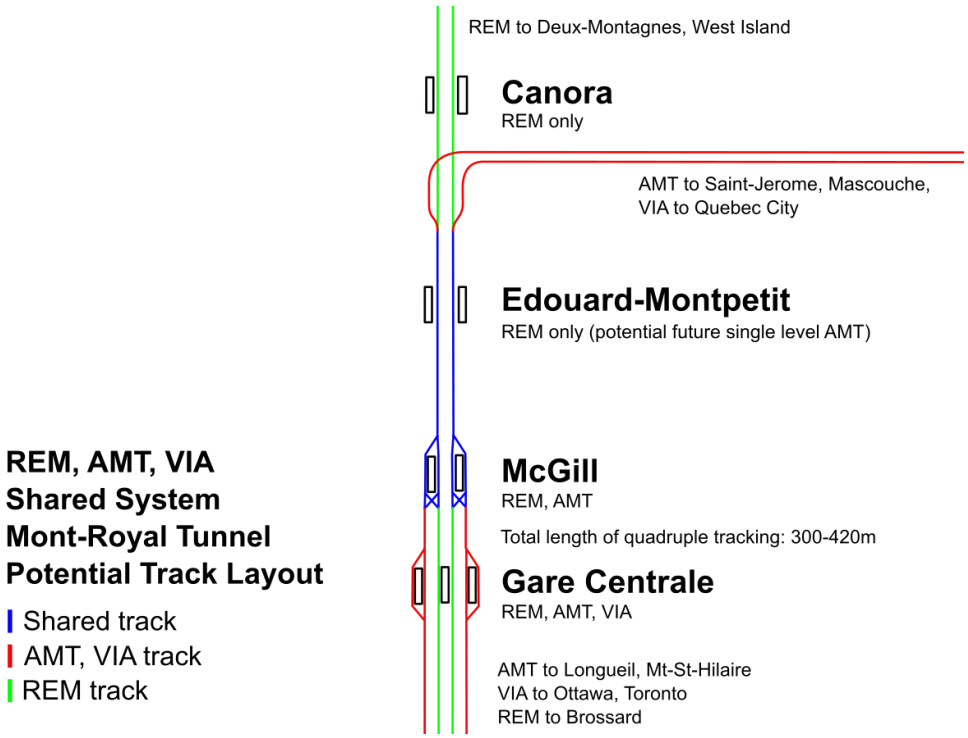
In order to achieve these very high frequencies, the REM will use a very advanced signalling system and automation.

This high frequency would not be possible for AMT trains, because their trains accelerate and decelerate more slowly, and, more importantly, they dwell longer at every stop.

A REM train may stop for as little as 30 seconds. An AMT train may need 90 to 120 seconds at a busy stop.

One possible solution for a shared system, is that AMT trains should not stop at any station that only has two tracks.

This can be accomplished if no AMT trains with double decker cars ever stop at Edouard-Montpetit, and at Mcgill we can only stop if the station is built with four tracks in total.




*A potential track layout for the shared system*

This means there are two tracks in every direction. So while one train is still stopped, another train can already enter on the other track. Since two trains can be stopped at the same time in the same direction, the frequency can be very high, even if the trains have to stop for a longer time.

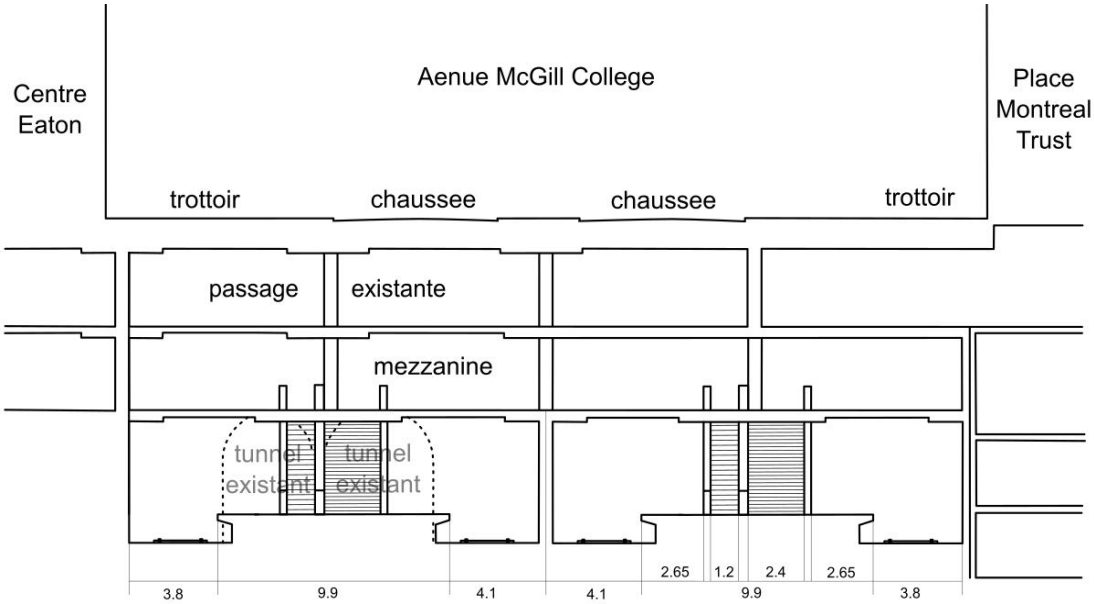
It may be possible to have one train every two minutes using an advanced signalling system. Each train can still be stopped for two minutes at McGill and Gare Centrale.

The REM can still maintain a high frequency even if 40% of the available schedule slots are used by AMT trains.

The frequency on the REM will be somewhat reduced under the Shared System proposal, but the desired capacity can be reached if the REM uses 6-car trains instead of 4-car trains.

This proposal assumes that only the Mont-Royal tunnel is shared, including the McGill station.

Refer to Appendix A for a much more detailed explanation of the Shared System idea, including the issue of sharing of light and heavy rail, some notes on signalling system and rolling stock, as well as a discussion of capacities and platform-screen doors.

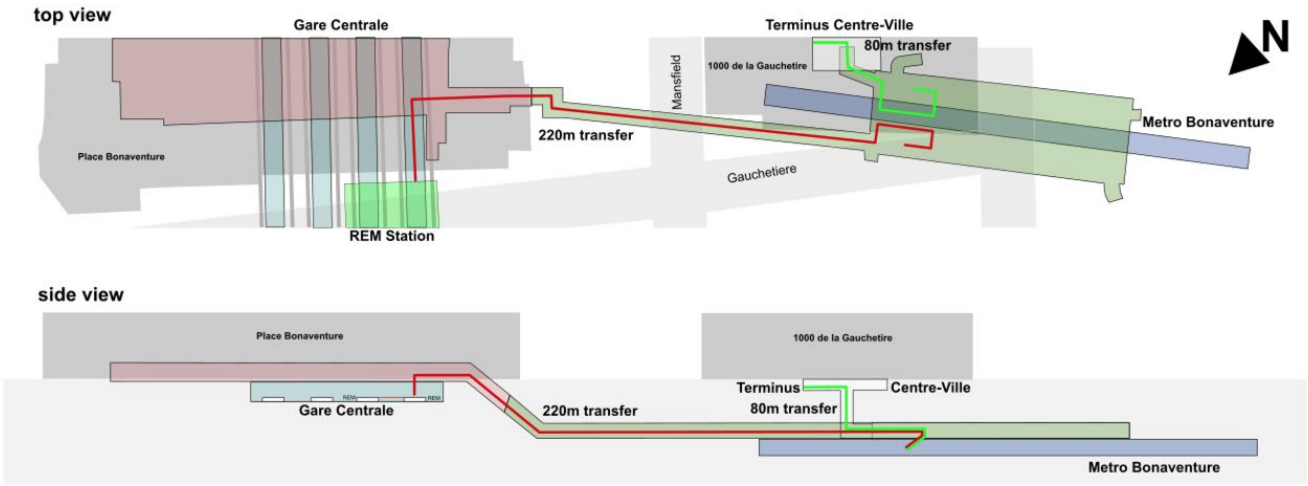



*Profile of a potential layout for a 4-track McGill station, viewing from the the North towards the South.*

## 5.5. Bad Transfers At Gare Centrale

### 5.5.1. REM ↔ Orange Line

A major concern of the REM project as proposed are the long transfers at Gare Centrale. This in particular pertains to to the transfer between the Orange line and the the REM. Today, the buses from the South Shore stop at the bus terminus, the Terminus Centre-Ville, which provides a relatively quick transfer to the metro (~80m transfer platform-to-platform), with two flight of stairs.




*Showing the transfer between Metro and the bus at Terminus Centre-Ville (Green) and transfer between Metro and REM at Gare Centrale*

With the REM proposal, the transfer to the Orange line will be ~220m long - three times as long ast today. It will include three sets of stairs. Depending on the model chosen to calculate the transfer time, it may take 4-6 minutes just for the walk, compared to 2 minutes between the bus and the metro today.

The transit literature usually consider the perceived cost of a transfer to be much larger than staying in a vehicle. People would rather spend more time in a vehicle compared to making a transfer.

1) The MTA (Metropolitan transit agency of New York) uses a model where transfer-time counts as 1.75 times the in-vehicle time [1]. So if the REM makes the transfer 2-4 minutes slower compared to today, this will count as 3:30-7:00 minutes slower.

2) The MBTA uses a 11-minute penalty per transfer (no matter the time), and a factor of 2.25 per transfer time [1]. So if the REM makes the transfer 3-4 minutes slower compared to today, this will count as a 4:30-9:00 minutes slower.

This is a large effect, which will undo the performance gain due to the REM being faster. From Panama station in the South Shore, passengers who transfer at Gare Centrale today may perceive a slower overall time.

Note that bus travellers today have a single-seat seat ride during rush hour, as the buses go directly downtown. In the future, there will be an extra bus-rail transfer at Panama station, which adds to the transfer penalties.

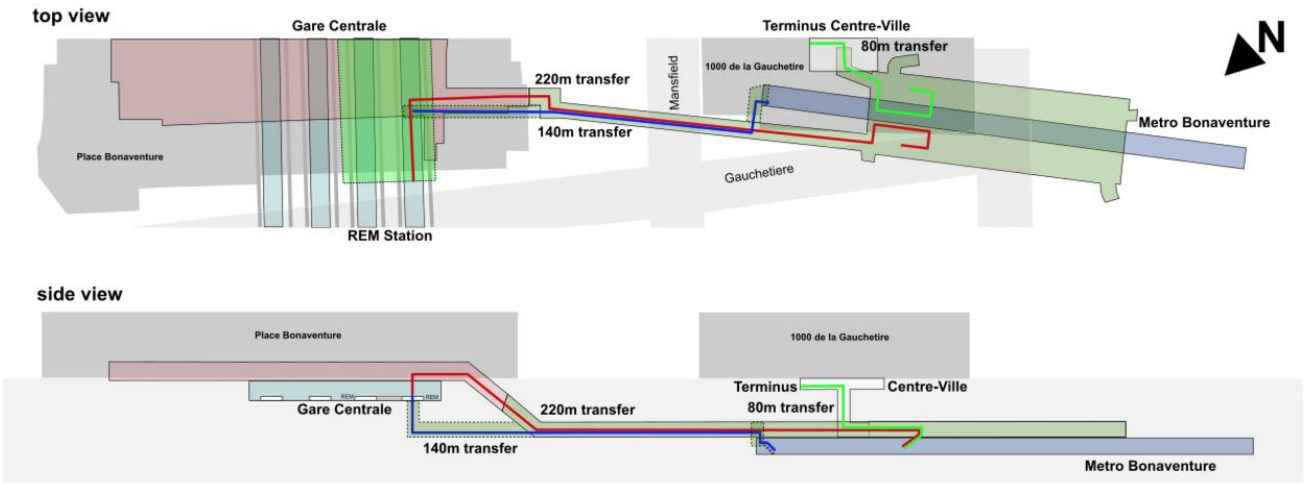
This transfer should be minimized, considering that tens of thousands of transfers will be made per weekday. Amortized over 50 years, and using a cost of time of 15$/hour, and assuming 20,000 riders wasting 5 minutes per day, this implies a cost to society of 326M$. Thus it is reasonable to spend tens of millions to minimize this transfer.

Without minimizing the transfer, some people may perceive longer travel times compared to today, and may switch to using cars. Also, minimizing the transfer time may encourage more drivers to switch to public transit.

### 5.5.2. Improving the transfer REM ↔ Orange Line

The first thing to note is that the REM station is not placed centered on the access tunnel to the Orange line. Secondly, the going up the stairs and then down the stairs to go towards the Orange line appears tedious. Thirdly, note that the connection between the Metro and the connecting tunnel is in the center of the station, connecting at the end could reduce the walking distance.

By adding short pedestrian tunnels and connections through the basements of existing buildings, the transfer distance could be reduced from 220m to 140m, where three stairs (including one long one) are reduced to sets of stairs.




**Gare Centrale**
**Metro - Terminus Centre-Ville - REM**

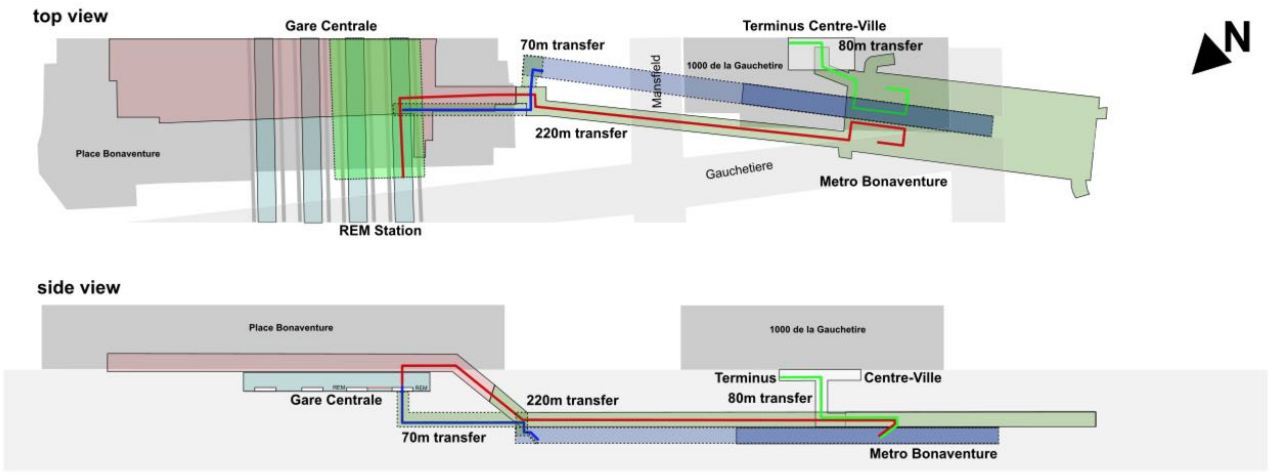
*Improved transfer distance between REM and Gare Centrale (blue).*
*Note the added tunnels / extensions through building-basements,*
*and the moved REM station*

### 5.5.3. Further Improving the transfer - Moving a Metro Station

It may be possible to further reduce the transfer distance by using Berlin for inspiration. There, the extension of the U5 line, currently under construction, crosses the U6 line - and there is no station at that point. The closest station is about 180m South of the intersection. In order to minimize the walking time, the planners decided to construct a second station 180m North, and to shut down the old station:


*Berlin station "Französische Str." is being moved 180m North to meet the U5 line which is currently under construction.*

A similar thing could be done for station Bonaventure. There, the distance is not as great. So instead of replacing the complete station, it may be possible to extend it up to 70 meters East. The existing exits could still be used, and a new exit added at the Eastern end that provides a shortened transfer to the REM.




*Extending Station Bonaventure to minimize the transfer between Metro and REM*

This could provide a transfer that is 70m distance from platform to platform, which is competitive with the transfer to the bus terminal today. It is less than a third of the length of the transfer under the current REM proposal.

Note that this extension is mostly under Mansfield street, which may simplify construction by allowing cut-and-cover techniques, and by reduced interference with other construction.

The cost-benefit of this may not be positive, and it may be technically infeasible. But this solution should nevertheless be studied, because in the long term, it may result in a positive cost-benefit ratio to society.

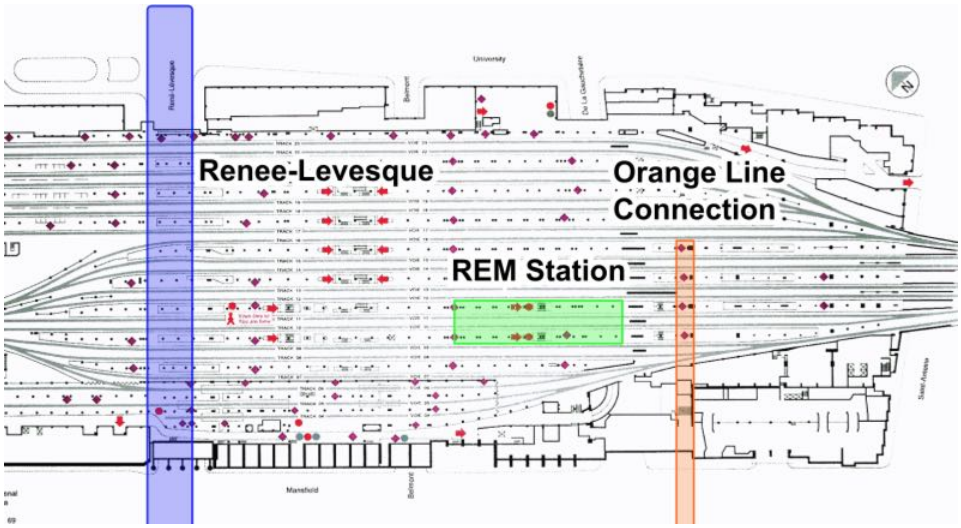
### 5.5.4. REM ↔ Reneve-Levesque

Boulevard Rene-Levesque is a major surface transit corridor through Montreal's downtown. It has numerous frequent bus lines, including express bus lines, the current 747 airport express bus. The street has been identified as the downtown section of a potential tram network in multiple proposals.

Transfer between the REM and this corridor should be minimized. It would allow passengers to travel from the REM to jobs that are not immediately adjacent to the

REM. From a capacity point of view it is desirable to direct passengers onto this corridor, since they will most likely travel away from Gare Centrale in the morning - that is, in the opposite direction of the main commuter flow. These contra-flow passengers will thus not use up peak capacity, but use the capacity that has to be provided anyway.

The current layout for Gare Centrale and the REM looks like this:




*Gare Centrale and the REM as proposed by CDPQInfra*

Note how large Gare Centrale is, compared to the REM station. Note the distance between the REM station and the tunnel connection to the orange line (25-30m), as well as the distance to Rene-Levesque (~150m). The actual distance will most likely be longer, since the various tunnels may impose a detour.

In the previous points, I suggested to move the station closer towards the Orange line (to the right, which is South), to reduce the transfer distance. There is a trade-off here: If the station is moved further South to improve connection with the Orange line, the connection with Renee-Levesque becomes longer.

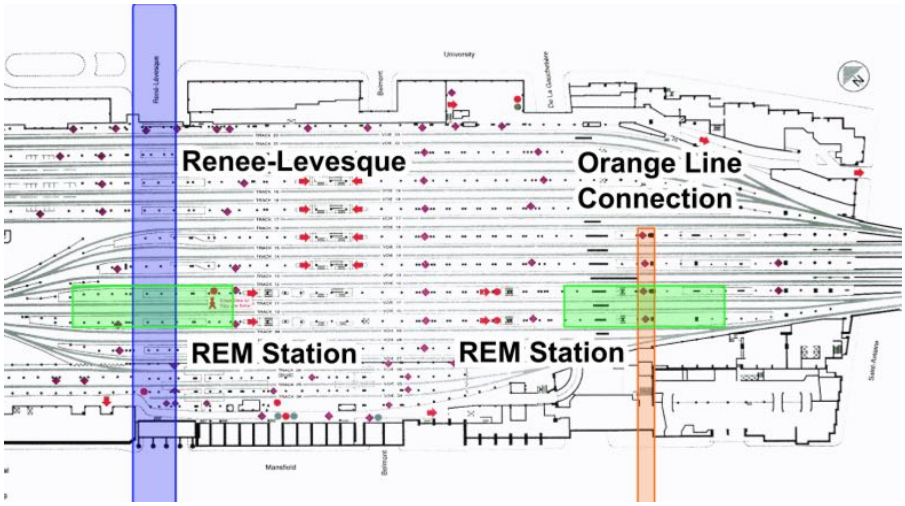
One possible solution is to use two stops within Gare Centrale. Gare Centrale is long enough to accommodate two stops. The interstation distance would be small, similar to the Montreal Metro in downtown.

One major improvement is that this reduces the number of people who will use the single Gare Centrale station. Note that in order to achieve 90 second frequencies proposed as the maximum for the REM, a train may only be allowed to stop for 30 seconds.

If a lot of people get in and out, this will simply not be possible.

Adding a second station closeby will reduce the number of people at the one station. Having two stations closeby may be necessary to achieve the desired 90 second frequencies.

The cost of this scheme is small, because most of the infrastructure already exists.




*Alternative: Gare Centrale with two stops*

The feasibility to use two stations in Gare Centrale to minimize the transfer to the major transit corridors should be studied.

## 5.7. REM: bypassing Griffintown, the Old Port, Pt-St-Charles

## 5.8. Summary

One concern of the REM project is the quality of the connections South of Gare Centrale. Today, transit in the Griffintown Pointe-Sainte-Charles and Southern Old Port is generally of poor quality. Yet these areas are revitalizing and densifying gradually, as industry moved out of the area.

Previous studies and proposals have shown the utility of serving the area better with transit. I collected several such proposals in Appendix B.

The concern is that REM provides weak connections to the area, but since it does provide some connections, it is very unlikely other transit investment will occur in the area, leaving connections poor. This may result in increased car-usage compared to if the REM was serving the area better. It may also reduce the possibility to have more residents live in the area.

The REM plan will also include the closure of Ottawa street, which previous plans identified as a good location for rapid transit. This closure is a big mistake from an urban planning point of view; just as this area is supposed to become more pedestrian friendly and human-scale via the destruction of the Bonaventure Highway.

The previously proposed stations should be restored to the REM project, and Ottawa street should remain open.

## 5.9. Ridership

The ridership study of the REM (DA-17) included a station around Ottawa Street and at Bridge-Wellington. This allows us to evaluate the utility of those stations:


*Ridership study for the REM. Note stations at Gare Centrale, Ottawa (Griffintown), Bridge/Wellington (St-Patrick) Source: CDPQInfra (DA-17)*

The ridership study of the REM (DA-17) found that the “St-Patrick” station (Bridge/Wellington) has the same ridership potential as Ile-de-Soeurs, and

“Griffintown” (Ottawa/Nazereth) had about a quarter to a third of the ridership potential of Gare Centrale. Given the ridership pressure on Gare Centrale and the potential crowding issue with very high frequency trains, moving ridership to another station would be incredibly helpful.

It also implies a reduction in walking distance to access work places for a lot of people, which encourages transit ridership and strengthens these areas as employment centers.

Note that the study assumed that Gare Centrale would be the terminus. This discourages ridership from both the “St-Patrick” and “Griffintown” stations towards downtown, because it is a very short trip -- it may make more sense to walk further to another transit line that goes to more potential destinations, even if the walk is very long (due to the high perceived cost of transfers).

Since the REM project is now integrated with the Mont-Royal tunnel, the number of potential stations that may be reachable in the North without transfer is greatly increased (in particular, McGill and Edouard-Montpetit). Since in turn increases the usefulness of the stations South of downtown.

## 5.10. An Alternative: CN Rail Viaduct

The problem when asking for an extra station at Ottawa, is the alignment chosen by CDPQInfra South of Gare Centrale. One the one hand, the A10/Champlain bridge corridor was connected with the Deux-Montagnes line replacement project, meaning the station has to reach Gare Centrale, which is overground. On the other hand, CDPQInfra chose a tunnel to pass through the harbour area.

In order to go from aboveground to belowground, several hundred metres of ramp are necessary. This ramp is placed around Ottawa - explaining the closure of the street. Since stations cannot be built on inclined sections, the station was moved South into the Peel Bassin.

One solution is to simply continue the rail line at the elevated level. Just keep the line on the rail viaduct, and only leave it in Pointe-St-Charles.


*Alternative (red) to the REM (blue) to have stations better connected to populations. Note the multiple possibilities to connect Bridge/Wellington with Nun's Island in the South. Source: CDPQInfra (DA-61), modified by Anton Dubrau*

The Viaduct has at least 4 tracks, except for the bridge across the Lachine canal. There is a historic swing bridge which makes crossing the canal more difficult -- but given that it is a moveable bridge, it could be rotated, or moved a couple of meters. Alternatively, bridge spans can be built East of the existing bridge.

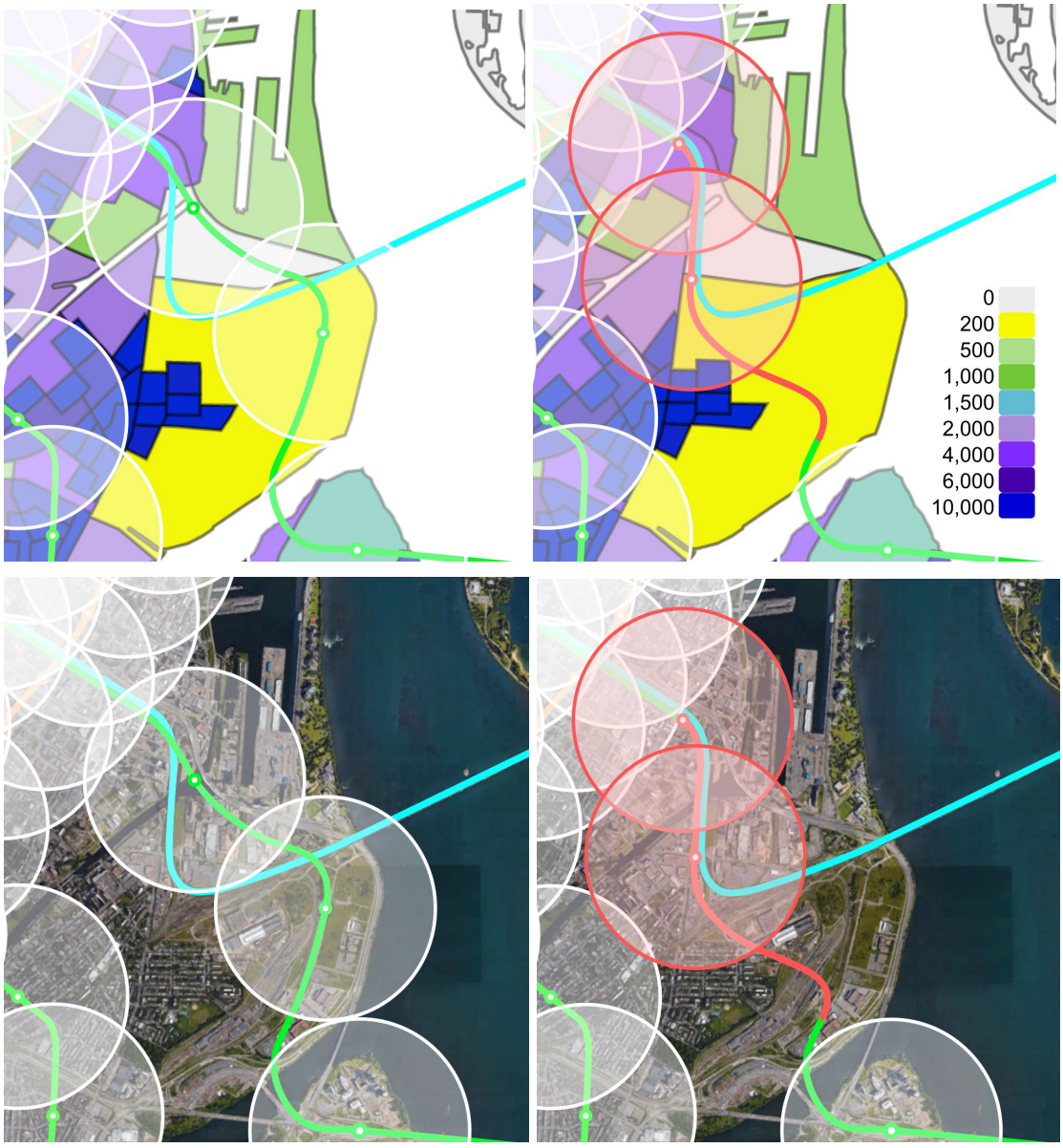
Around Ottawa, the bridge is about 8 tracks wide -- enough for 3 heavy rail tracks, 2 REM tracks, and a REM station.


*CN rail viaduct South of Gare Centrale. Note the large amount of available space. Ottawa street is the one just before the bend (left). Note the historic rotating bridge, which blocks reconstruction of the railroad bridge (right). The historic bridge could be rotated/moved, or the new two-track bridge could be built on the East side (on the right of the existing rail bridge). Source: Google Earth*

One issue is sharing of the rail viaduct with the AMT, VIA and Amtrak. While the track would be built with four tracks, so track sharing is not necessary, this scheme would involve a separation of heavy rail and light rail that is less than 10 metres -- it would require a derogation from Transports Canada to allow this.

The following shows the much better connection to populations of the CN rail viaduct alternative, compared to the REM proposal, which does not connect to populations well.

**REM Proposal** **Alternative via CN rail viaduct**




*Left: density map (top) and aerial photo (bottom) overlaid with REM, metro & AMT lines*
*Right: density map (top) and aerial photo (bottom) overlaid with alternative proposal (red)*

*Both stations are shown with 800m circles, which corresponds to a 10-minute walk. Note that this is an optimistic estimate: due to the street grid and barriers (especially railways and rivers), the actual area that can be reached within 10 minutes is smaller.*

*Source: 2011 census, Google Maps, modified by Anton Dubrau*

The du-Havre station connects mostly to the Technoparc Pointe-St-Charles, a landfill area so toxic that just containment is an issue; the chance for decontamination is remote (see [1]). Otherwise the area is bound by a rail-yard and the St-Laurent river.

The “Bridge/Wellington” station, which is actually under the Peel Bassin, would connect to some population and jobs. But the walking distances are relatively long. A lot of Pointe-St-Charles is not served at all.

The proposed alternative services the population much closer, serves work places in the Old-Port much closer, and leaves much fewer “gaps” in the area served by rapid transit stations.

## 5.11. A Note on Cost

The usage of the CN rail viaduct would represent an efficient utilization of an existing piece of infrastructure. On a stretch of 1.1km the right of way exists almost completely, only a bridge is missing. The scheme would also obviate the need for a complicated and very steep ramp south of Gare Centrale, a bored tunnel under the Peel Basin, and a station under the Peel Basin.

The scheme involves two stations overground, rather than two stations underground.

The connection between Bridge/Wellington and Nun’s Island may involve cut-and-cover tunneling, or some stretches of aerial structures, depending on the exact alignment chosen. Overall, the tunneling should be shorter and less complex than the Peel Basin tunnel.

All this means, overall, that the CN rail viaduct alternative provides plenty of opportunities of cost savings compared to the current REM proposal.

# 6. Summary

Overall the City of Montreal presents some interesting ideas. But these should be consolidated into a bigger vision, one of the creation of a poly-central city.

In order to build this, the city of Montreal should consider the creation of a regional transit system involving the use of very high-capacity tunnels through downtown, which connect to many branches on both sides.

In particular this involves first the creation of a transit system using a North-South trunk line in the axis of the Gare Centrale and the Mount Royal Tunnel. In a later step, a second trunk line in the East-West direction could act as an extension of the various commuter rail lines that now terminate at Lucien L'Allier, while also allowing rail extensions towards the East.

The city has to realize that the current proposal of the REM is inadequate both to fulfill this regional vision and even just the transit requirements of today. This is due to the low peak capacity, lack of sharing the Mount-Royal tunnel. It will also encourage wrong development patterns because of an overall highway-centric planning approach which does not sufficiently encourage density through the region. The city should force improvements to the proposed system which will greatly affect this city, in order to enable it to become part of a truly regional transit system.

This would enable the downtown of Montreal to be the core of a poly-central city.  A city where all the various activity poles have mixed uses and form the center town-like structures. Downtown would also become mixed use, allowing more residents, while also providing the strongest employment center.

A truly regional system will also reduce the reliance on driving; reducing pollution and noise downtown which allows the increase of the quality of life of residents.

If the downtown of Montreal thus becomes more mixed use, having good transit connections to the whole region, and providing a decent quality of life, the city will be better position to encourage more residents to settle in downtown.

# 7. APPENDICES

## 7.1. APPENDIX A: Description of a Shared System between AMT, VIA & REM

The best solution to the problem of the monopolization of the Mont-Royal Tunnel proposed by the REM is to create a system where REM, VIA and AMT trains will share the tunnel.

In the following, I will outline how the REM system may be altered to accommodate track sharing between REM, AMT & VIA, while maintaining many parameters as proposed by the CDPQInfra:

- The same stations and lines for the REM part of the system
- A similar capacity and operating model on the REM part of the system
- A similar overall project cost to CDPQInfra, extra costs for the shared section should be paid by the AMT & VIA
- A high frequency rail system, using automated trains that are light enough to go on the Champlain bridge

In the following analysis, I will include the ‘potential’ stations of Mcgill and Edouard Montpetit because they are integral to the overall proposed system.

I will describe different issues/technical parameters, and how they would be solved by the shared system.

### 7.1.1. Frequency, Dwell times & Schedule

#### 7.1.1.1. The Frequency Problem

The system proposed by the REM specifies service up to every 90 seconds. Based on similar systems, the 90 seconds may break down as follows (my question on that topic wasn’t answered):

- 30 seconds dwell time
- 50 seconds minimum safe distance between trains
- 10 seconds schedule padding

Note that the initial operating of the REM system only assumes 3 minute headways (see “Niveau de Service 1 PM”, page 9 in document DA-90).

The REM trains will have many doors, similar to a metro, and allow quick turn-around resulting in the low dwell time.

This is different from AMT trains, which have only two, less wide doors for an overall longer rail-car, while having a larger passenger capacity. It takes more time for everybody to get in and out of the railcar, so dwell time is much longer. A locomotive-hauled train with passenger cars also accelerates slower. Even if a locomotive-hauled train was equipped with automated driving, the minimum distance between trains may break down to something like this:

- 90 seconds dwell time (assuming 50% of passengers disembarking)
- 70 seconds minimum safe distance between trains
- 20 seconds schedule padding,

Giving a maximum frequency of 180 seconds (3 minutes).

If we assume a schedule that mixes trains like this:

*REM - AMT - REM - AMT - REM - AMT ...*

Then the maximum frequency between two consecutive REM trains would be 4.5minutes (90 seconds + 180 seconds). This is too low. The major problem is dwell time.

### 7.1.1.2. The Solution to the Frequency Problem

REM and AMT trains should not stop at the same platform. For the the two proposed tunnel stations, this results in the following

- Edouard-Montpetit:
  No locomotive-hauled trains stop at Edouard-Montpetit
- McGill:
  McGill station should have four tracks, two in every direction. This allows one train to dwell at one track, while another can enter the station on the other track.

This would allow the following maximum theoretical headways:

- 90 seconds between two stopping REM trains
- 90 seconds between a non-stopping AMT train and a stopping REM train
- 180 seconds between two stopping AMT trains

Due to the more complex system, let's assume a maximum of 30-32 trains per hour (one train every 112.5-120 seconds).

### 7.1.1.3. Service Scenario A

Service Scenario A assumes a maximum frequency of 30 trains per hour. REM service is divided into 10-minute services on each branch (6tph), which overlap to provide service every 3.3 minutes on average on the South Shore branch.

The AMT/VIA trains receive one schedule slot every 5 minutes, which could be divided into 10, 15, 20 or 60 minute services.
Every ten-minute block could have a schedule approximately as follows, in each direction:

- min 0: REM Deux-Montagnes
- min 2: AMT/VIA
- min 4: REM West-Island
- min 6: REM Airport/Roxboro
- min 8: AMT/VIA

In total, this will allow the following service frequencies:

- 18 REM trains per per hour per direction (average frequency: every 3.3 min)
- 12 AMT/VIA trains (average frequency: every 5 min)

#### 7.1.1.4. Service Scenario B

Service Scenario B assumes 32tph (trains per hour). It uses 15 minutes (4tph) as the base frequency for all services. REM services would be provided on twice that frequency on the Deux-Montagnes and West Island Branch, i.e. every 7.5 minutes (8tph). Services could be provided as follows:

- 8 tph: REM Deux-Montagnes
- 8 tph: REM West Island/Airport
- 4 tph: Laval/St-Jerome
- 8 tph: Montreal-North/St-Jerome
- 2 tph: VIA
- 2 tph: extra services / schedule padding

In total, this would allow the following freuencies:

- 16 REM trains per hour (average frequency: every 3.75 min)
- 14 AMT/VIA trains per hour (frequencies: 3.75min - 7.5min)
- 2 unallocated schedule slots

In the future, the AMT should replace their locomotive-hauled trains using double-decker cars with single-decker electric multiple unit trains (EMU) that have many doors. These trains could then stop at Edouard-Montpetit.

In order to provide a similar overall capacity, the length of the REM trains would have to be extended from 4 cars long to 6 cars long. This will be further discussed in the section “Capacity” below.

### 7.1.1.5. A Note on the Airport Train

Note that the service to the airport is not very well defined in the above schedule scenarios.
The underlying problem is that providing service to the airport is wasteful - if the maximum capacity of the tunnel is 30tph or 32tph, and service to the airport is provided every 10 minutes (6tph), then 19-20% of the tunnel capacity is used up by the airport train, even though its projected ridership is extremely low (2,700 trips per day).

**One possible solution** to this problem is the use of the Vaudreuil-Hudson line to serve the airport, which is discussed in detail in section 10. This also works better with an improved, more urban West-Island alignment discussed in section 9.

The alternative alignment is about 30% shorter, and for a similar capital cost as the REM airport branch, it could also serve tens of thousands of passengers mostly in Notre-Dame-de-Grace (i.e. ten times the number of airport train passengers).

**A second possibility** is the the merging and splitting of trains. This is something used on the Hamburg “S-Bahn” rapid transit system on the “S1” airport line. Each train is composed of two 3-car units. One stop before the airport, the train splits into two. One 3-car unit continues to Hamburg Airport, the other to a suburban terminus (“Poppenbüttel”). On the way back, the trains re-merge.


*The S1 In Hamburg branches without dividing frequency by splitting trains (source: wikipedia, user NordNordWest).*

The connecting/disconnecting is done automatically (the train itself is driven manually). The whole process from the first train entering the station until both trains leave takes about two minutes. The service frequency of the line is every 10 minutes. The scheme has been in service since December 2008.

*Hamburg S-Bahn docking of S1 train from Poppenbüttel onto a train from the Airport*

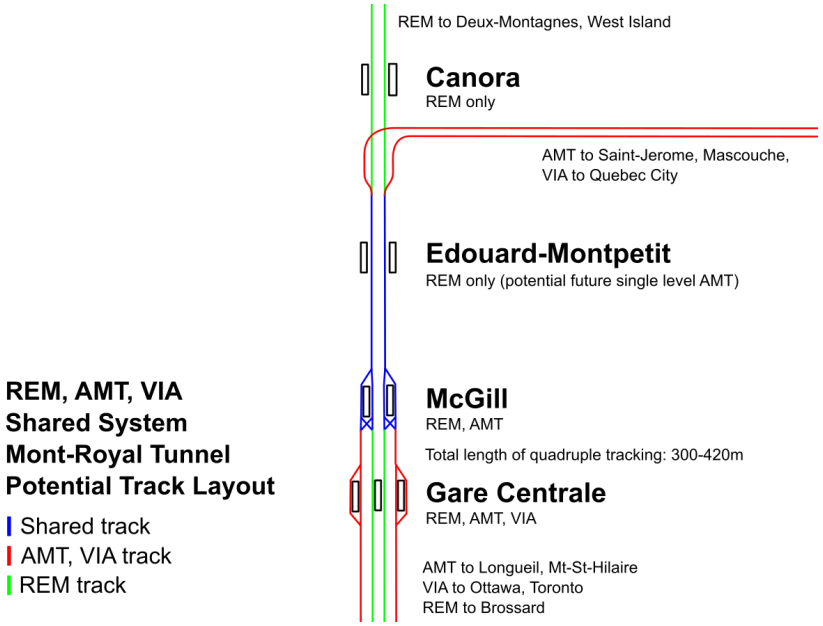
This allows servicing two terminals that require less capacity, without using up valuable schedule slots on the downtown trunk line.

Similar schemes are used on the Munich S-Bahn Rapid Transit system.

A similar scheme could be used on the REM to provide more capacity and frequency to the West-Island or Deux-Montagnes branch while still providing frequent service to the airport, without using up extra schedule slots in the Mont-Royal tunnel.

## 7.1.2. Track Layout and Station

This is one possible configuration of the Shared System:




*Possible Shared System track configuration:*
*Red is AMT/VIA, green is REM, blue is shared track*

Note the four-track section between McGill and Gare Centrale, which is 400m long. Note also the four-track station at McGill station. If AMT trains do not stop there, it would be sufficient to have two tracks -- this may result in a loss of ridership, as the 2007 study by the AMT assumed half the passengers would exit at McGill.

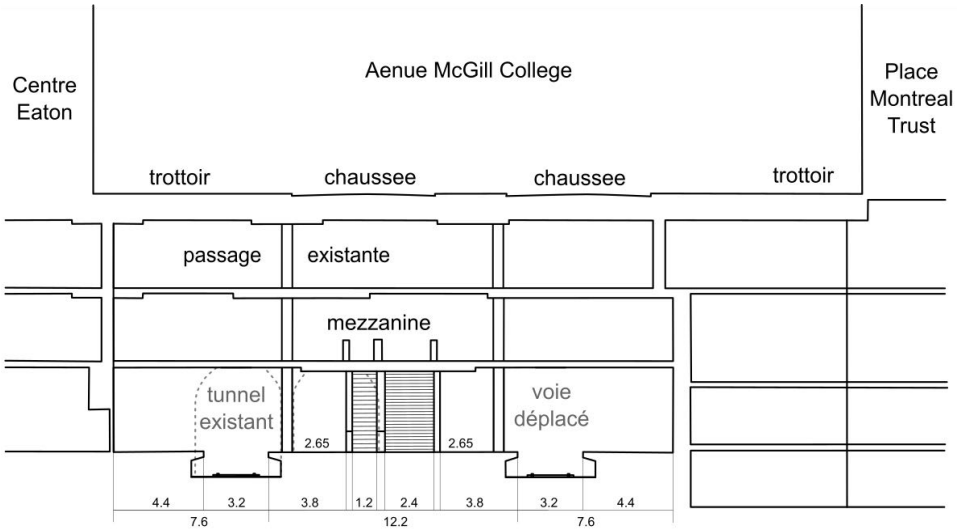
The section that would be quad-tracked is only 400m long, and almost completely contained under Avenue McGill College. This street does not continue on either side, and is not essential for the road network. This means it could be shut down for a long term to construct the additional rail infrastructure using more affordable cut-and-cover methods.

## 7.1.3. The McGill Station

In 2007, the AMT commissioned a study to see whether it is possible to build stations at McGill and Edouard-Montpetit in the tunnel.

The chosen design for the McGill station included three tracks. Using the design as a template, it's easy to see that a four-track station fits within the envelope of the street of McGill College. Refer to the following profile drawings:

Another possibility, if the 4-track station turns out to be infeasible, is the adoption of a station design generally referred to as the “Spanish Solution”. It involves building a 2-track station, with platforms on both sides of each train. This doubles the door-capacity, since doors on both sides of the train can be used, and thus decreases dwell time.




*2-track station design with platforms on both sides (“Spanish Solution”)*

This is for example used in Barcelona. It’s also used in Munich to maintain very high frequencies on their suburban rail system - one train every 120 seconds.

Both the 4-track design and the 2-track “Spanish Solution” design allow phasing of construction that allows maintaining the existing service through the tunnel. The basic idea is to construct the new tracks while the old tracks (or single track) continues to allow operation. Once the new tracks are laid, service can switch over to those new tracks, allowing the reconstruction of the old tracks.

### 7.1.4. Signalling system / automation

When it comes to railway operation, we may differentiate between different levels of automation

- DTO - driver operated trains
- ATO - trains are automatically operated, but drivers are still present
- UTO - trains are automatically operated, and unattended

CDPQInfra insists on using UTO for the REM. While this may be misguided, it is outside of the scope of this discussion, which attempts to propose a Shared System without major changes to the REM system proposal. In order to

facilitate automated driving and high frequency, the REM proposes to use a computer-based-train-control system, or CBTC.

AMT trains are currently manually operated using a signalling system called CTC.

If AMT and REM trains share the central tunnel segment, they need to have some compatible signalling. Since automation and signalling system are related (but not the same), sharing may involve the following options:

1. **REM uses UTO, AMT uses DTO**
   It is possible to mix unattended and attended trains. This has been shown to exist both during the introduction of UTO on Paris' metro line 1, and the Nuremberg subway lines. While it would be an unusual configuration, safety can be ensured. One way to implement this is using a signalling system that allows high frequency, and equip all trains to use this signalling system.
   Additionally, the REM trains should be equipped with an automated driving system that will operate the trains.
   Safety is ensured because the signalling system ensures movement authority for all trains, no matter if manually or automatically operated.
   An example of a system that uses an off-the-shelf signalling system and implements automatic driving on top is the Thameslink project in London. There, a high-capacity tunnel is equipped with the off-the-shelf signalling system "ETCS level 2", which is a standards compliant system that has 8 vendors and can provide high capacity, up to 30tph in the case of Thameslink. On top of that, automated driving is being implemented which simply obeys the signalling system.

2. **REM uses UTO, AMT uses ATO**
   If REM uses a CBTC signalling system that includes automated driving, then the AMT and VIA trains may simply be equipped with the same system. The trains would use conventional signalling everywhere else, but once they enter the shared system of the Mont-Royal tunnel, the drivers would switch to automatic mode and the train would be automated to drive through it, while the driver is observing.
   A scheme like that is implemented in London, for a project called Crossrail. It uses CBTC including automated driving on a central tunnel segment, allowing as little as 60s separation between long heavy rail trains (similar to the REM). Outside of the Central segment, several different conventional signalling systems are used.

3. **REM uses ATO on shared segment, AMT uses ATO/DTO**
   If sharing of unattended is prevented by regulation, then drivers could be used on the REM to observe while the trains are passing through the central tunnel segment. The drivers would only have to be present in this central section, which represents less than 10% of the overall system.

### 7.1.5. Capacity

In order to achieve the same capacity, REM trains would have to be longer: Instead of 4-car trains holding 600 passengers, there would be 6-car trains holding 1000 passengers

Trains would be composed of 3-car units instead of 2-car units.

Note: this implies 167 passengers per car, instead of the REM proposal's 150 passengers per car. This is achievable by making the trains as wide as heavy rail trains (3.2m instead of 3.0m), and by having a middle car which has more capacity in the extra gangway.

Note: during off-peak, single 3-car units can be use used to continue to provide high frequency at reduced relative operating cost.

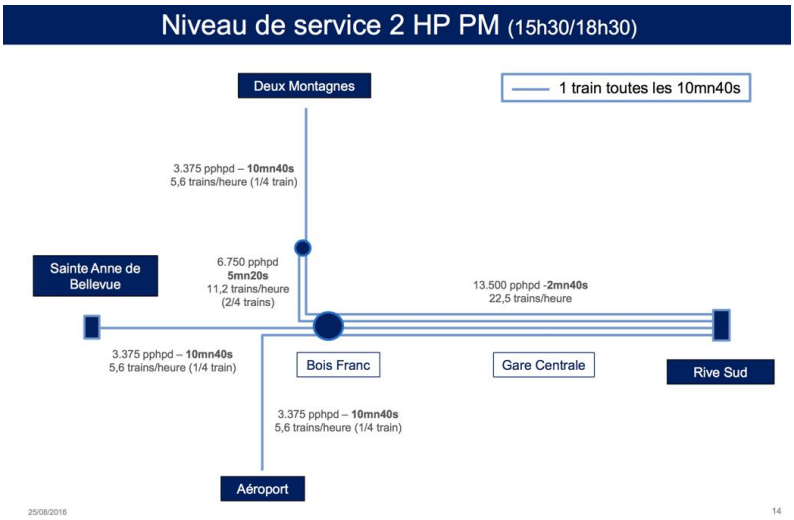
Having a 3-car units makes it easier to use the shared electrification of 25KV, which the Deux-Montagnes line and the Mont-Royal tunnel is equipped with today. The REM project includes conversion of the line to 1.5KV, due to weight concerns. By making the vehicle longer, the weight of the more heavy transformer equipment can be shared across its length, which allows keeping the existing electrification system, while still observing the weight limits on the Champlain bridge.

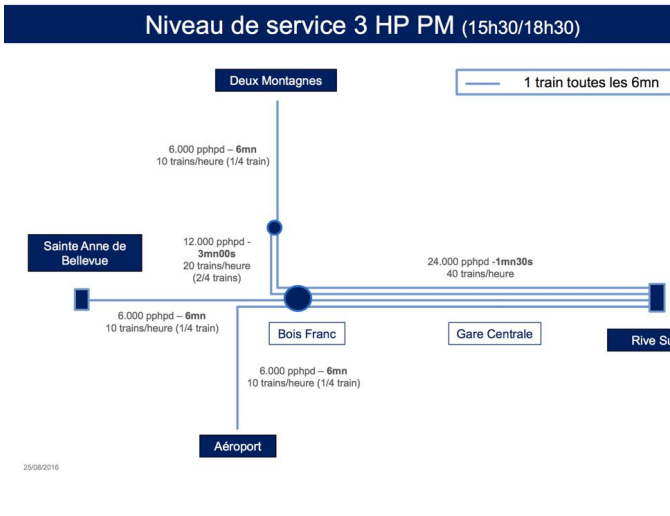
The existing REM is built to accommodate later extension from 4-car trains to 8-car trains, by extending platforms from 80m to 160m. Under the Shared System, the REM platforms would already be 6 cars long, so they should be built to accommodate later expansion to 9-car trains, that is, extension from 120m to 180m.

### 7.1.5.3. Service Levels Vs Capacity Comparison with the REM Proposal

The REM service levels and capacity are defined in DA-91. There are three service levels. Level 1 is insufficient to replace the existing Deux-Montagnes line (see analys in capacity section).

The service Level of the REM that provides the most capacity is “Niveau de Service 3 HP PM”. For this discussion, we will only compare with Service level 2 and 3, during the afternoon peak. If capacity of the Shared System is similar at the highest level, then service can also be provided during a time when less capacity is required.




*Excerpt from DA-91, showing the highest service levels and resulting capacities for the REM project*

### 7.1.5.4. Comparison including Airport Train

The following shows the frequency and capacity of the proposed REM with the Shared System proposal, at different point of the network. The Structure of the network is assumed to te the same under the shared system proposal, except that at Canora, AMT and VIA trains join the line.

| Comparison of REM Propsal Capacity vs Shared System Capacity | | | | |
|---|---|---|---|---|
| All service assumed PM peak, Scenario including airport train | | | | |
| **Trains Per Hour** | REM Level 2 | REM Level 3 | Shared System A | Shared System B |
| Deux-Montagnes | 5.6 | 10 | 6 | 8 |
| Roxboro | 11.2 | 20 | 6 + 6* | 8 |
| Sainte-Anne | 5.6 | 10 | 6 | 8* |
| Airport | 5.6 | 10 | 6* | 8* |
| Bois-Franc | 22.5 | 40 | 18 | 16 |
| Gare Centrale | 22.5 | 40 | 18 + 12 | 16 + 16 |
| | | | | |
| | | | | |
| **Capacity (PPHD)** | REM Level 2 | REM Level 3 | Shared System A | Shared System B |
| Deux-Montagnes | 3360 | 6000 | 6000 | 8000 |
| Roxboro | 6720 | 12000 | 9000 | 8000 |
| Sainte-Anne | 3360 | 6000 | 6000 | 4000 |
| Airport | 3360 | 6000 | 3000 | 4000 |
| Bois-Franc | 13500 | 24000 | 18000 | 16000 |
| Gare Centrale | 13500 | 24000 | 37200 | 41600 |
| | | | | |
| * airport train is a split train, the asterisk denotes trains that merge | | | | |

As you can see, the Shared System provides a similar capacity as the REM.

Note that the Shared System has a reduced capacity after Bois-Franc, which is less necessary because the REM does not have to absorb as many transferees from AMT trains (e.g. at correspondence A-40, or the proposed connection with the St-Jerome line at Canora).

Note that the capacity of services arriving at Gare Centrale is much increased, because it includes AMT lines converging from St-Jerome/Laval and Mascouche/Montreal-North.

Note also how the airport train uses up capacity on the Deux-Montagnes branch (Shared System A) or a the Saine-Anne Branch (shared System B), even though it itself only has a demand of 3,000-4,000 passengers *per day* in both directions.

### 7.1.5.5. Comparison Excluding Airport Train

Assuming the airport train will be served by another line (e.g. the Vaudreuil-Hudson line), rather than the REM, the capacities of the Shared System are even more similar to the REM:

| Comparison of REM Propsal Capacity vs Shared System Capacity | | | | |
|---|---|---|---|---|
| All service assumed PM peak, Scenario excluding airport train | | | | |
| **Trains Per Hour** | REM Level 2 | REM Level 3 | Shared System A | Shared System B |
| Deux-Montagnes | 5.6 | 10 | 6 | 8 |
| Roxboro | 11.2 | 20 | 12 | 8 |
| Sainte-Anne | 5.6 | 10 | 6 | 8 |
| Airport | 5.6 | 10 | - | - |
| Bois-Franc | 22.5 | 40 | 18 | 16 |
| Gare Centrale | 22.5 | 40 | 18 + 12 | 16 + 16 |
| | | | | |
| | | | | |
| **Capacity (PPHD)** | REM Level 2 | REM Level 3 | Shared System A | Shared System B |
| Deux-Montagnes | 3360 | 6000 | 6000 | 8000 |
| Roxboro | 6720 | 12000 | 12000 | 8000 |
| Sainte-Anne | 3360 | 6000 | 6000 | 8000 |
| Airport | 3360 | 6000 | - | - |
| Bois-Franc | 13500 | 24000 | 18000 | 16000 |
| Gare Centrale | 13500 | 24000 | 37200 | 41600 |

### 7.1.6. Regulation of Mixing Heavy & Light Rail

Regarding the mixing of “Light Rail” (the REM) and “Heavy Rail” (AMT, VIA), CDPQInfra has pointed out several times that the fall under different regulatory regimes, and sharing track is not allowed. Further, there is a rule that a light rail and heavy rail corridor have to have several meters of physical separation. The CDPQInfra has explained that this is for ‘safety reasons’.

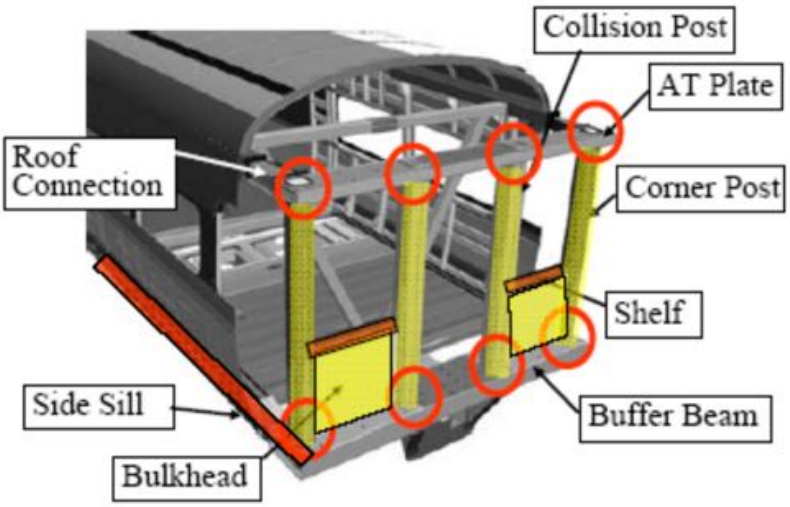
In order to understand this regulation, we have to consider some context. "Heavy rail" in North America is optimized for heavy Diesel Train whose safety is ensured passively. That is, rather than preventing collisions for example using signalling systems, trains are built 'like tanks' to make sure that if a crash happens, the trains will survive the crash -- at least at low speed.

The reason for this is most likely the long distances that trains travel in North America, and the fact that the railroad infrastructure is owned privately. The networks are redundant, meaning overall the network is extremely large. It is not economically feasible to provide advanced signalling systems everywhere that prevents collisions.

At the same time, especially freight trains trains are larger and heavier than in Europe; and there are many more level crossings.

All of these factors result in a passive approach to safety.

The requirements for safety are implemented using techniques  that statically provide a lot of strength. Trains are designed and built so they can withstand a lot of force without deformation (“buff strength”), and they have safety mechanisms that increase safety in collisions with heavy road vehicles (corner posts) and to prevent  telescoping (anti-climbing device).




*North American design approach to rail safety . Source: “Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor”, Page 19, by Caltrain*

In contrast, in the rest of the world, safety is generally provided mainly by *preventing collisions.* Modern signalling systems can provide almost total safety between trains, by enforcing speed restrictions and “movement authority”, i.e. they will not allow a train to enter a section of track unless authorized.

Fewer level crossings means that the risk of collisions with heavy road vehicles is reduced.

In order to provide safety in the event of a collision, rather than relying on static strength, European trains rely on deformable areas on the train to absorb energy - like crumple zones on a car, but much larger. They allow absorbing a lot of energy without being very heavy. This technique is called “Crash-Energy-Management” (CEM).

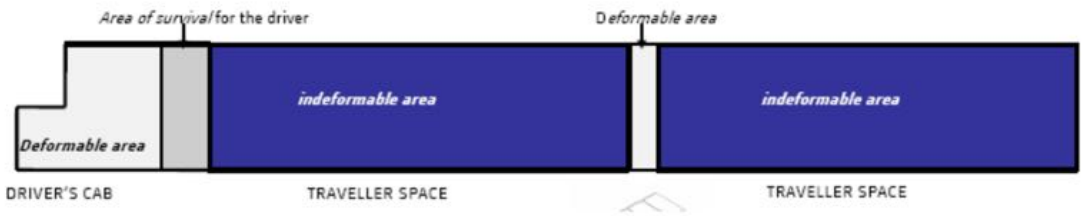



Figure 21 - Typical Crush Zones for European EMU Trainset (Courtesy Alstom)

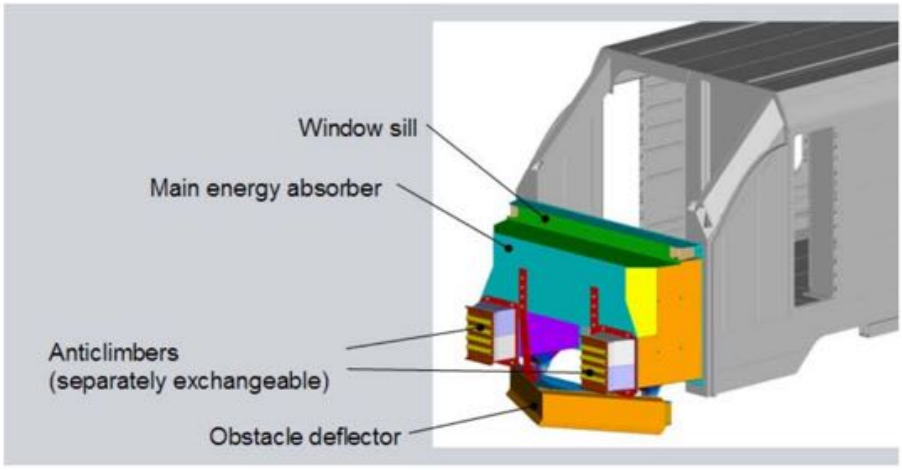



Figure 24 - Typical Cab Energy Absorber Arrangement (Courtesy Siemens)

*European design approach for safety . Source: "Evaluation of European EMU Structure for Shared Use in the Caltrain Corridor", Page 19, by Caltrain*

Evaluations have shown that the 'buff strength' approach used by North American rail only provides more safety in for low speeds (<=40km/), at higher speeds the approaches have similar safety.

The Federal Railroad Administration is currently engaged in a very slow regulatory process to allow a more European approach to safety. These "alternative compliance" are currently being evaluated.

In the meantime, several transit agencies have proven to the regulators both in the States and in Canada that they can provide safety via alternate means, allowing them to run European vehicles shared with freight rail:

- O-Train in Canada in 2001 received a derogation from Transports Canada to run light-weight European trains on the same track as freight, which runs at night. The line also includes level crossings between the light-weight O-train line and a heavy rail line. This level crossing is secured via a safety technology called "Indusi" (A technology used in Germany since the 1930s) that will prevent the O-train from entering the

crossing if it is occupied. The O-train was, at the time a 20M$ project. This example is not necessarily to demonstrate simultaneous mixing of heavy and light rail, but rather the openness of Transport Canada to allow exceptions to the regulation if safety can be ensured by other means.
- The light rail system in Waterloo also received a waiver to mix with heavy rail system (with time separation like the O-train).
- In 2010, Caltrain, a commuter rail system in California, applied for and received a waiver to run light-weight European trains alongside their own heavy diesel passenger trains without time separation. There is also a short stretch that allows running light-weight European style trains and diesel freight trains to share track without time separation.

This shows there is precedent for the REM to receive a similar waiver to share track with the AMT and VIA rail. Note that he shared section if track is less than 10km.

The main reason such a waiver is feasible, and the precedents (in particular Caltrain) are relevant, are the following:

- there would be no freight trains anywhere on the section of track that should be shared between REM, AMT & VIA
- the REM will use a highly advanced signalling system (to facilitate automation), which will make the chance of a collision remote at best
- the section of track that would be shared between the REM, AMT & VIA, the Mont Royal tunnel, is mostly a tunnel. There are no grade crossings, and there would be fences disallowing any track intrusion -- one does not have to worry about collisions for example with road vehicles
- modern light rail trains can provide passive safety using crash energy management

Note that existing examples of heavy/light rail mixing do not include automated driving. This is because these systems are manually operated. Automation will generally increase safety, so should not be an obstacle in obtaining a waiver.

The Federal Railroad Administration in the United States is currently in the process of changing regulation allowing the possibility to provide safety using an alternative safety scheme involving crash-energy-management, in lieu of buff strength and corner posts. This will allow construction of lighter trains without the need for special waivers.

My question to the CDPQInfra whether they had any discussions with Transports Canada regarding receiving a waiver to mix heavy and light rail was not answered.

#### 7.1.6.1. Alternative: Design Light Heavy-Rail vehicles

One reason the REM can not use existing heavy rail vehicles, for example vehicles similar to the MR-90 vehicles used on the Deux-Montagnes line, which could be equipped with an automated driving system, is the weight requirements on the Champlain bridge. The maximum allowed axle load is 14.9T, the REM is designing their system for 14T, and the MR-90 vehicles' motor cars weight 18.25T per axle, including passengers.

Note that the MR-90 vehicles consist of a trailer and a motor vehicle which weigh 44T and 57T. If the weight was evenly distributed between the trains, the axle would only be 16.25T (8%-16% too heavy, based on what safety threshold is used).

So I do believe it is possible to design a FRA-compliant ('heavy rail') vehicle with a 14T axle load. The idea is to take the existing MR-90 vehicles used on the Deux-Montagnes train, which consist of married pairs of 57T and 45T, which is 52m long. Let's assume one adds a half-length-car (45T/2 + 8T for an extra bogie) at the end, which would bring the total length to 65m, and the total weight to 132.5T.

Now reconfigure the resulting train so that all three cars have the same length (about 21m each), and replace the bogies, traction system and transfomers with modern light-weight ones, which saves maybe 12.5T.

The total would be about 120T for a train consisting of three permanently-coupled cars which are 60m long. If the weight is evenly distributed, this gives 10T per axle on average. With 500 passengers, the result is a 13.3T axle load on average.

### 7.1.7. Rolling Stock possibilities

The Mont-Royal tunnel would be continued as a Heavy Rail tunnel with 25kv electrification, requiring heavier transformers on the train then REMs proposed 1.5kv electrification. At the same time, the Champlain bridge demands a very low 14T axle load. One concern is that not enough rail vehicles exist today that may obey these constraints. This concern is unfounded, plenty of vendors can provide appropriate rolling stocks.

Railcars would consist of 3-car units that are made of cars that are 19.45m long (in order to ensure door-alignment compatibility for platform screen doors, see section below), 3.2m wide and high platform.

If a waiver to share light and heavy rail is obtained, the following vehicles can fulfil the requirements:

- Bombardier: Aventra, Electrostar, DB-430
- Siemens: Desiro City
- Alstom: Alstom X'Trapolis

If no waiver is obtained, meaning there will be the requirement to design FRA-complaint vehicles that nevertheless obey the 14T freight limits, then the following vendors could build it, based on having build both metro-cars and FRA-compliant equipment:

- Bombardier (built the MR-90, and cars like Aventra, Electrostar)
- Kawasaki (built the M-8 for Metro North, and various Metro cars)
- Hyundai-Rotem (built the Silverliner 5 for SEPTA and RTD, and various metro cars including thecars for the Canada Line)
- Alstom (is building high-speed trains for Amtrak, built many light mainline trains like the Alstom X’Trapolis)

### 7.1.8. Platform Screen Doors

The CDPQInfra proposes to use platform screen doors for their REM system, in order to ensure total separation of the rail system from passengers, which simplifies automation. The CDPQInfra decided that this is a better solution than the track-intrusion-detection systems on the otherwise technologically similar Canada Line in Vancouver, which are often unreliable and don’t enforce that passengers don’t enter the tracks. On the Canada line, most shut downs are due to intrusion alarms - whether there is a person on the tracks or not.

Platform screen doors help prevent intrusion, and obviate the need for unreliable track intrusion systems. They also allow the installation of air conditioning.

Generally, platform screen doors are used in metro systems to ensure passenger safety in the presence of severe crowding. Medium capacity systems like the REM generally don’t warrant the inclusion of such expensive technology.

They are very expensive relative to utility, especially given the low ridership on the branches of the REM. The CPDQInfra people have stated that they are looking at a very long amortization period (‘100 years’) in order to justify their expense -- although in a matter of only few years, track intrusion systems may become so reliable that platform screen doors may not be needed except on the very busy central sections.

And given the high frequency of the system and the fact that most stations are overground, ACs on the stations are really not that important -- most time will be spent on the trains, no the stations.

Nevertheless, we will continue the discussion of the Shared System assuming that the platform screen doors are a required part of the system.

Under the proposed Shared System, if REM and AMT trains need to share platforms, this should only happen at the following stations:

- Station Édouard-Montpetit: every REM train and potential future AMT electric multiple unit trains with many doors
- Station McGill: every REM train and every AMT train
- Correspondence A-40, if the Mascouche line is not re-routed

Since the REM and AMT have different door-configurations, this presents a problem when platform-screen doors are used: the platform screen doors need to lign up with doors on the train.

There are two options to deal with the platform screen door alignment issue:

#### 7.1.8.1. Option 1: REM and AMT never share a station platform

This is the simpler way of dealing this this problem, but it would mean that the four-tracked station of McGill, the two tracks would be permanently allocated to either AMT or REM trains.

This is operationally undesirable, because during operations it may be preferable to be able to have two REM or two AMT trains occupy the two platforms going in the same direction at the same time, in order to deal with deviations in the schedule.

It would also never allow any AMT trains to share the Edouard-Montpetit station, even with upgraded EMU rolling stock.

### 7.1.8.2. Option 2: Use compatible door configurations

The REM is proposed to have 20m railcars with 3 doors.

Existing AMT rolling stock is 85ft (26m) long; the bilevels have four doors. Two of these doors are high-floor, and two are low-floor. NJTransit owns the same 'Bombardier multilevel' railcar as the AMT, but with a modification allowing all four doors to be high-level. This configuration allows more boarding capacity, so it would be desirable to modify the AMT railcars to also have four doors.

*Left: AMT Bombardier multilevel car with high & low floor doors*
*right: NJTransit Bombardier multilevel car with high & high/loor floor doors*
*(source: Bombardier)*

The following railcars could use a shared platform:

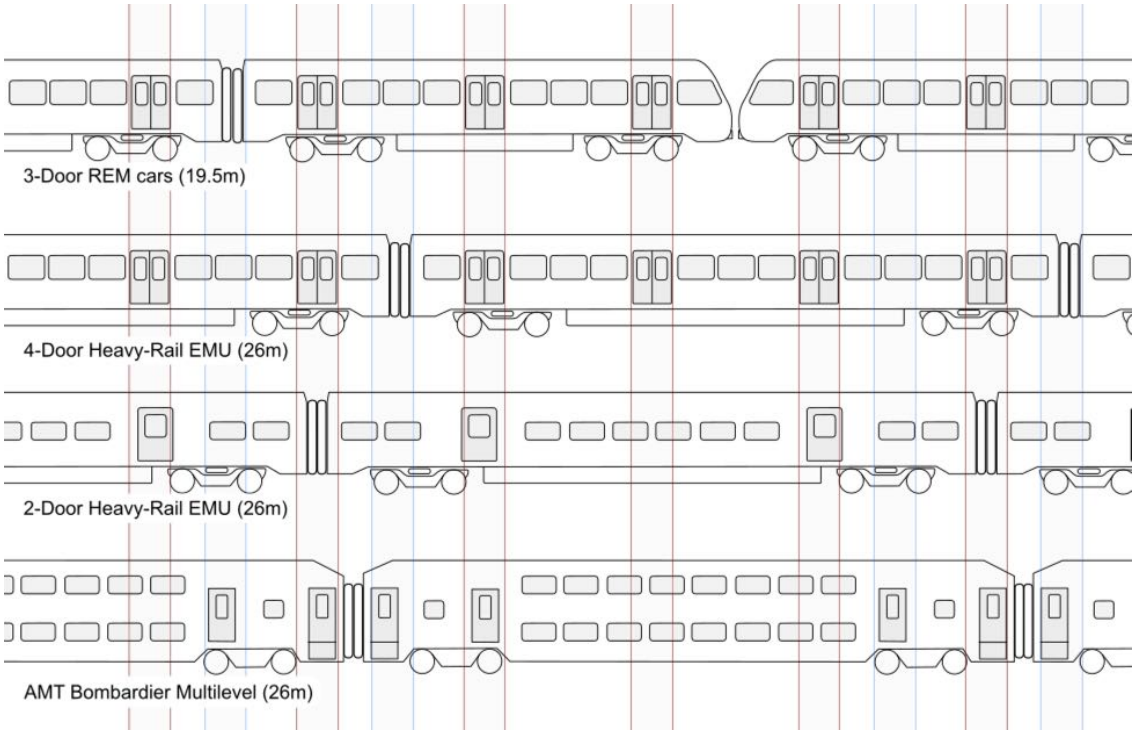
- Existing "Bombardier Multilevel" bilevel cars used currently by the AMT
- Future REM railcars
- Potential 4-door single level railcars, to be used by the AMT
- Potential 2-door single level railcars, to be used by the AMT

Note: it would not be possible to use the MR-90 vehicle used currently by the AMT on the Deux-Montagnes line without modification, because they are slightly longer than the AMT bilevels (25.91m vs 26.01m). If the cars were modified to have the same length, they would be compatible, since they only have a single door per car.

The door configurations of the heavy rail vehicles and the REM vehicles can be made compatible by forcing the REM rail cars to be 19.4m long, i.e. exactly 3/4 times the 85ft 4in (25.91m) heavy railcars. Then the doors will line up if the spacing is even and the REM has 3 doors and a normal 85ft rail car has 4 doors.

Since the bilevels have the doors at the ‘wrong’ places, it is necessary to add extra doors to make everything line up. We shall call the doors at even 6.5m spacing the ‘primary doors’, and the extra doors added to accommodate the bilevels the ‘secondary doors’.

The following shows possible door/railcar configurations:




*Primary platform screen doors (red) use 6.5m spacing, secondary doors (blue) are placed to allow four-door boarding from bilevels.*

This configuration consists of primary doors at an even 6.5m spacing, which could be used by any single-deck vehicle.

Secondary doors allow bilevels to share track with single-deck vehicles. If secondary doors are included, it requires 50% more doors. These would only be required at stations where tracks would be shared with bilevels (i.e. McGill station under a shared track configuration).

Without the secondary doors it is still possible to ensure compatibility between a REM car and a potential single-level 4-door or 2-door AMT car as shown in the drawing (i.e. at station Edouard-Montpetit).

If a door/vehicle configuration is chosen where not all vehicles use all doors, then every door needs a passenger information system at every door. It would show which doors will open, and which services will be available next. This may be required anyway due to the branched nature of the REM system, which also involves changing train lengths.

Note also that the stations would have to support selective door opening, to ensure that platform screen doors only open where there is a matching door on the train. The REM system as proposed by the Caisse requires this anyway, because the train lengths will vary during the day.

### 7.1.9. Ownership & Control of the Shared Segment

Given the shared nature of the central segment, ownership should not be transferred to the CDPQInfra. For example, one possible way to arrange ownership would be to create a new entity which owns the shared segment (including Mont-Royal tunnel and Gare Centrale). This entity could in turn by owned by the AMT (ARTM), CDPQInfra and VIA.

This could actually be advantageous for CDPQInfra, because it allows sharing the construction cost to build the central segment - which is generally the most expensive part.

### 7.1.10. Cost-Mitigation

The Shared System Proposal will result in extra costs to the REM proposal, mainly due to the following:

- Use of 6-car trains instead of 4-car trains, necessitating the construction of longer station platforms (120m instead of 80m). Note that few stations are underground. The loading gauge would also be slightly larger, with a width of 3.2m instead of 3.0m.
- The REM trains should be built to allow future extension to 180m (9-car trains) in the shared system plan. The CPDQInfra has claimed the REM system as proposed would be designed to allow platform extensions to 160m (8-car trains).
- The McGill station would have to be quadruple-tracked, and be longer (210m instead of 80m, to accommodate 8-car heavy rail trains).
- Ideally, Edouard-Montpetit station would have to be built to be longer, in order to support 8-car single level AMT trains in the future.
- More platforms at Gare Centrale would be used by passengers.

- A signalling & automation system and electrification that can be equipped on AMT, VIA and REM may be somewhat more expensive.
- Dealing with regulatory issues, in particular obtaining waivers to mix heavy and light rail.

There are several possible cost-mitigations, which should bring the project cost in line with current cost estimates:

- **Sharing Costs:** The tunnel section, including Gare Centrale, should have shared ownership by AMT, VIA and the CDPQInfra. This means CDPQInfra does not have to purchase all the infrastructure outright. Also, the cost of the more expensive upgrades on that segment can be shared by VIA, the AMT and CDPQInfra.
- **Unnecessary Re-Electrification:** The change of electrification from 1.5KV to 25KV becomes unnecessary, which will save cost. It is also unnecessary to maintain two electrification systems at the same time, as CDPQInfra proposes during the construction phase of the REM. Maintaining more compatibility will make it easier to maintain service during construction, which will reduce the cost of providing replacement service with buses.
- **Single-Tracking:** Since the maximum service frequency on the outlying branches of the Deux-Montagnes line and West-Island line would be reduced from a maximum of every 6 minutes to a maximum of every 10 minutes under the shared system, it is feasible to leave some sections single tracked.
  In general, 10 minute service is possible if one or two sections at the end of the line with a length of up to 3km are single tracked.

  Since the system will be automated, it will be easier to maintain the necessary schedule discipline compared to a manually operated system.
  The following sections may stay single tracked:
    - The bridges between Montreal, Ile-Bigras, Laval and the North Shore may stay single tracked. This implies a large cost reduction as well as less impact on the environment in these sensitive areas.
    - The stations Grand-Moulin and Ile-Bigras may stay single-tracked.
    - The last 2km-3km of the West-Island branch may stay single tracked, including the terminal station.
- **Fewer Vehicles Required:** Generally, the Shared system would require the REM to have the same number of vehicles for the REM to provide

the same capacity -- the trains have more cars, but they run less frequent by approximately the same amount.
However, under the Shared system the, REM would not have to accommodate transfers from the St-Jerome line, the Mascouche line and VIA rail as well as fewer transfers from the STM's Blue Line (due to the AMT transfer at Parc Avenue).
This means the REM will have to provide less overall capacity, which reduces the number of required vehicles.

- **Use of Existing CN Rail Viaduct South of Gare Centrale:** The REM proposal includes a tunnel under the Peel Bassin, including a potential underground station (under the bassin). This issue is separately discussed further below.
  By keeping the technology of the REM compatible with heavy rail, it is possible to use the existing CN rail viaduct south of Gare Centrale, and reach Pointe-St-Charles on that existing rail right of way.
  This means no expensive deep-bore tunnel under water is required, and the station (or stations) in the Griffintown/Pointe-St-Charles area can be built along the rail viaduct overground, which saves cost. There may still be some tunneling or bridges required to cross two CN yards, but those should be cheaper than the Peel Bassin tunnel, and will require no station underground.

### 7.1.11. REM / Shared System Summary / Comparison Table

The following shows comparison of several system-parameters of the Mont-Royal tunnel, comparing the existing system with the 2007 AMT study, the REM proposal and the Shared System proposal.

| | **Today** | **2007 AMT study** | **REM** | **Shared System** |
|---|---|---|---|---|
| Lines in Tunnel | AMT Deux-Montagnes<br>AMT Mascouche | AMT Deux-Montgnes<br>AMT Mascouche<br>AMT St-Jerome | REM Deux-Montagnes<br>REM West-Island<br>REM Airport | REM Deux-Montagnes<br>REM West-Island<br>REM Airport<br>AMT Mascouche<br>AMT St-Jerome<br>VIA Quebec-Montreal |
| Tunnel Capacity | ~17000 PPHD | 27000 PPHD | 12000 PPHD initially<br>24000 PPHD max | ~40000 PPHD |
| Train lengths | 260m (10 cars) | 260m (10 cars) | 80m (4-cars) | REM: 120m (6 cars)<br>AMT: 210m (8 cars) |
| Train widths | 3.2m | 3.2m | 3m | 3.2m |
| Train capacities | 2000 | 2000 | 600 | REM: 1000<br>AMT: 1600 |
| Tunnel electrification | 25kv, 60HZ | 25kv, 60HZ | 1.5kv, DC | 25kv, 60HZ |
| Tunnel signalling | CTC | CTC | CBTC | CBTC or ETCS |
| Edouard Montpetit station | - | 2-track | 2-track | 2-track |
| McGill station | - | 3-track | 2-track | 4-track |

## 7.2. APPENDIX B: Stations in Griffintown, the Old Port & Pt-St-Charles of Previous Proposals for Champlain Bridge Corridor Transit

**Champlain SLR Studies**

Both the 2007 study by the AMT to build a light rail system on the Champlain bridge, and the early studies of the REM system (as evidenced by earlier ridership studies), included a station Around Ottawa/Nazareth (“Station Multimedia”/”Griffintown”). The REM study also included a station at Bridge/Wellingon (“Saint Patrack”), whereas the AMT study included potential stations in the Victoria Bridge Area.



*Left: page 27, DA-17. Right: page 33, “Etudes d’avant-project d’un systeme Leger sur Rail (SLR) L’Axe de l’autoroute 10 / Centre-Ville de Montreal - Rapport Synthese” by AMT, Feb 2007*

**Dalhausie BRT**

The Dalhousie BRT project proposed around 2010 to improve the access of the South shore Bus Rapid transit to the Terminus Centrle Ville. The urban improvement plan called for a revitalization of the area, the repurposing of the CN rail viaduct, and the establishment of a transit station between Ottawa and William.


giving them a distinctive landmark at the city gate.

3. Renewed use of the Canadian National rail viaduct

In order to reinsert the rail viaduct into the urban fabric of the faubourgs, it is proposed to reopen its fenestration, reclaim the ground-level floor space for commercial use, and make more safe and comfortable the many east-west passageways. That part of the rail viaduct between Ottawa and William streets, facing the public place, could house, most usefully, the necessary facilities for the users of public transportation.

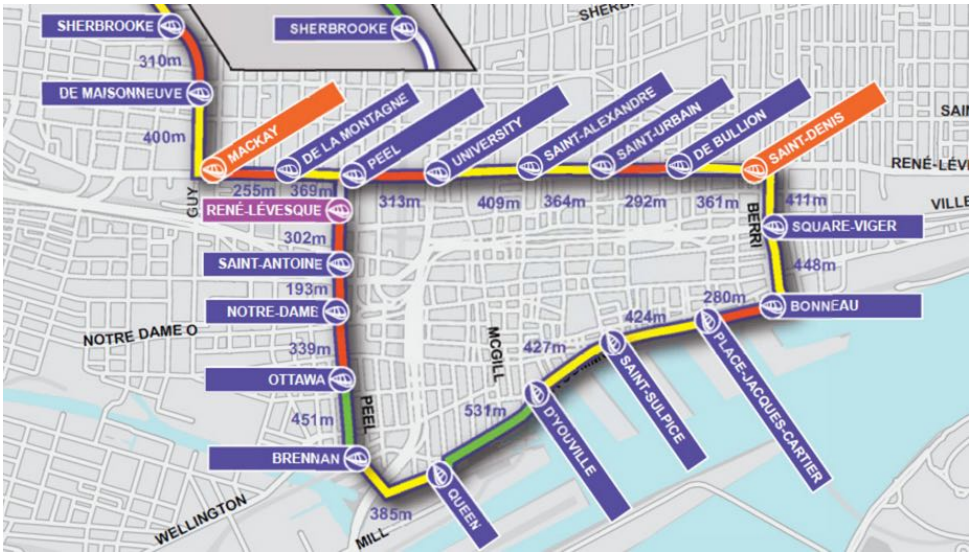
4. Establishment of a dedicated public transportation corridor:

*Several excerpts from the document "Transformation of the Bonaventure Expressway at the Downtown Gateway", showing the urbanization plan and usefulness of a transit station at Ottawa.*

The CDPQInfra has released a study showing the impact of closing Ottawa street DA53, which rated the pedestrian impact "minor". The study only consider the single length detour (to go from Ottawa to the adjacent street), and does not consider the impact on the urban environment.

With the Bonaventure Express demolition project, Ville de Montreal has invested a significantly into urban reconstruction, and removal of urban barriers in the South of downtown. The CN rail viaduct is a major urban barrier whose impact on the urban fabric should be reduced (for example by developing it as shown in the above image). Closing Ottawa street is contrary to that idea.

**Montreal Tram Project**




*Excerpt of Montreal tram study, Ville de Montreal, 2013*

In 2012/2013 the Ville de Montreal studied the possibility of building a tram line on Chemin de la Cotes-des-Neiges, and a loop around the Old-Port of Montreal. The associated ridership study shows great potential on Cotes-des-Neiges, and very poor ridership through the loop -- except the section along the Peel corridor.

**Figure 16.1 Profil de charge du tramway - Heure de pointe du matin (HPAM)**


Source: STM – Août 2010

*Excerpt of Montreal tram study, Ville de Montreal, 2013*

The study shows that while the loop not viable, there is utility in providing better transit between Ottawa and Gare Centrale, even though it is only three stations long. Using the REM project to service this demand is an effective solution to integrate multiple transit issues into one project.

## 7.3. APPENDIX C: The Concern of Privatization of Transit

In 2015, the Government of Quebec passed a Bill (bill-38) to allow the creation of CDPQ Infra, a subsidiary of the Caisse de dépôt et placement du Québec (CDPQ) that engages in transit-related projects. An agreement (DA-62) between Quebec and the Caisse laid out the groundwork of the collaboration between the two entities.

CDPQInfra describes the REM project as a “public-public-partnership”. In reality, this project is “private-only”. The Caisse will own all the necessary infrastructure outright and permanently. The Quebec government can provide funding, but will get no control over any of the assets once the line is built.

This is specified in the ‘entente’ between the government and the Caisse de Depot (DA-62, page 1, emphasis added):

> *This agreement also aims to minimize the impact on the Government’s debt and deficit in compliance with Canadian accounting rules. Thus, in order for the main objectives of this agreement to be reached, the portion of assets or of investments financed by Caisse in connection with any project must comply with the following criteria and, as such,* ***the Government:***
>
> - ***must not exercise control over the assets of the project;***
> - ***must not assume any risks and derive any benefit inherent to the ownership of such assets;***
> - ***must not automatically become the owner of the project or benefit from an option to purchase at a preferential price;***
> - ***must not pay for the majority of the assets through its contributions;***
> - ***must never have the authority to direct the financial and administrative policies of Caisse.***

The is especially problematic because the CPDQInfra will include the privatization of existing transit lines, names the Deux-Montagnes line including the Mont-Royal tunnel. The Mont-Royal tunnel is a very strategic asset, the only direct access to downtown from the North and East.

This is despite the fact that the finance minister, Mr. Leitao, repeatedly assured during the debates of bill-38 that no existing lines would be privatized:

> *"(…) c'est un partenariat avec une entité publique qui va devenir… qui va non seulement construire mais devenir propriétaire et va exploiter cette nouvelle ligne de transport, ça ne s'applique pas aux existants."*
> (Tuesday, May 12, 2015 - Vol. 44 N° 52
> Special consultations and public hearings on Bill 38, An Act to allow the Caisse de dépôt et placement du Québec to carry out infrastructure projects)
>
> *"Donc, c'est très précis, c'est dans le transport collectif, une nouvelle… Et donc c'est doublement clair, parce que c'est une nouvelle infrastructure, donc ce n'est pas une infrastructure existante, on ne va pas prendre une ligne de métro existante, c'est une nouvelle infrastructure de transport collectif."*
> (Wednesday, May 27, 2015 - Vol. 44 N° 57,
> Clause-by-clause consideration of Bill 38, An Act to allow the Caisse de dépôt et placement du Québec to carry out infrastructure projects)

The financing scheme defines that the Quebec government may become an equity partner in the REM project by paying less than 50% of the cost. But this equity stake will allow them no control in the project. Further, this special equity will not automatically entitle them to dividends of the project if it generates profits. This is defined in the same entente between the Government of Quebec and the Caisse:

> *3.6.4 If a participation of the Government is necessary for a project, it shall take the form of an equity interest without voting rights and shall be determined prior to the construction phase. This participation, made entirely at the end of the project construction period, shall be less than that of Caisse and its partners so that the Government at no time has the power to direct the financial and administrative policies of Caisse.*
>
> *In this respect, where the pre-established returns threshold is exceeded, a formula for sharing the returns shall be defined in each of the definitive project agreements. These returns thresholds allowing for such sharing will be adjusted depending on whether or not the Government participates in the equity and, if applicable, the extent of such Government participation.*

**Isn't the line & tunnel essentially transferred from one crown corporation to another?**

Right now the Deux-Montagnes line and Mont-Royal tunnel belong to the AMT, a regional government agency whose mandate is to plan, operate and promote public transit.

The Caisse, on the other hand, is a crown corporation with the mandate to make profit (see “C-2 - Act respecting the Caisse de dépôt et placement du Québec”, section 4.1):

> *“The mission of the Fund is to receive moneys on deposit as provided by law and manage them with a view to achieving optimal return on capital within the framework of depositors’ investment policies while at the same time contributing to Québec’s economic development..”*

The Caisse is a private-equity firm, a holding company managing assets for depositors to generate returns. It has no duty towards the public, no interest in promoting mobility via transit. Any decision it makes will be motivated by money, and money alone.

**But doesn't the government control the Caisse?**

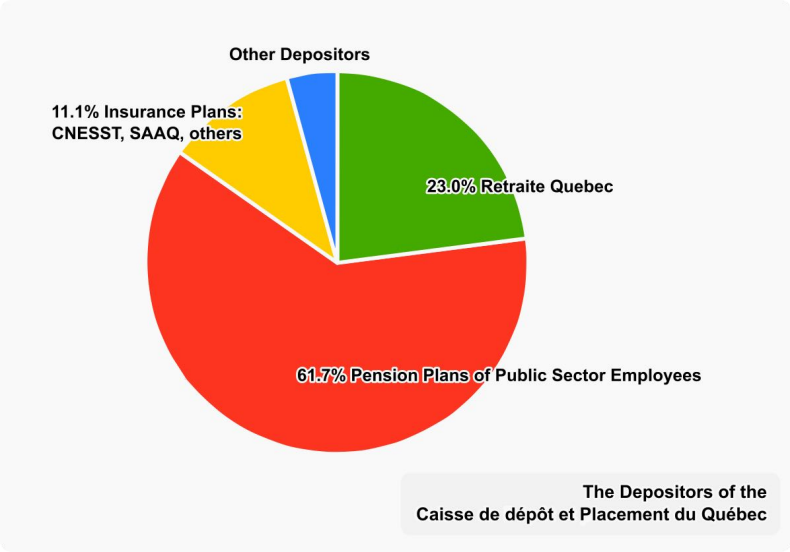
The agreement between the government and the Caisse specifies that the government “must never have the authority to direct the financial and administrative policies of Caisse (sic)".

The government has the power to appoint the PDG and the board of directors. But this will not change the fact that the Caisse still only has legal duties towards its depositors who, ultimately, are the owners of the Caisse’s assets.

**But isn't the public the depositor via the Quebec pension fund?**

Only 23% of the assets managed by the caisse is the public pension fund. This pension fund that is paid by taxes, and from which everybody receives pensions.

The largest part of the Caisse (62%) is actually employee pensions of public sector employees. These are private individuals who happen to work for public institutions.




Besides, the interests of the public pensions and transit users do not align. Pensions need profits to grow, and good transit is not always good for profit. And the Caisse has essentially a legal obligation to sacrifice good transit for good profit.

**But privatization in transit is nothing new, it works okay, for example in Britain!**

In Great Britain, the privatization only concerns operations. The infrastructure and planning remain public. There is then a competitive bidding process to decide which private operator will run the services for a limited time period. The private market is used to reduce operating costs.

The REM proposal, on the other hand, is outright privatization of both infrastructure and planning, with explicit permanent loss of public ownership and control. And that, without any competition. There’s no market, and no way to measure the market value of the assets we are "selling" to the Caisse.

By giving away the Tunnel and the Deux-Montagnes line, we are giving the Caisse a monopoly and allowing it to leverage formerly public infrastructure against the public.

This is problematic, as they alone will have the power to dictate which trains can reach downtown, what extensions can be built to the network, and the capacity of any connecting line, and how much the ARTM has to pay per transported passenger.

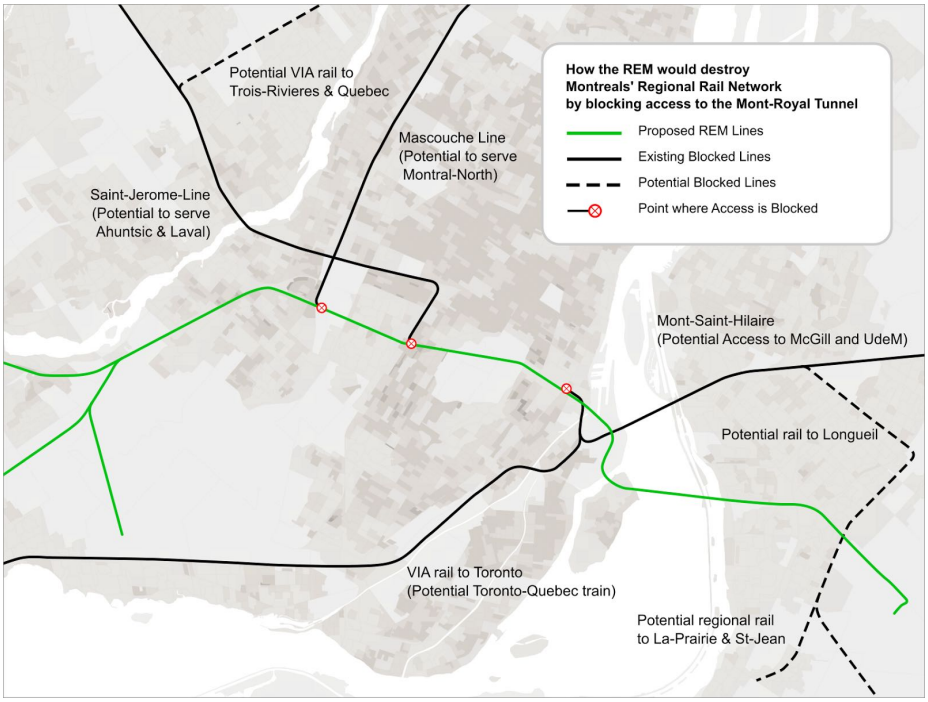
**How will the Caisse use the Tunnel against the public?**

CDPQInfra explained what they will do: kick out all AMT lines and prevent VIA from ever using the tunnel as the best connection for their proposed Quebec-Toronto train.

How are they doing this? By insisting on using a light metro technology incompatible with AMT and VIA lines, which is more expensive to construct (the government pays half of that) but will minimize operating costs (all savings then go to the Caisse).

They will force AMT riders to transfer to the REM to go downtown, and in the process, they are destroying two decades of investment towards an integrated regional rail network.

While many cities in the world, like London (Crossrail, Thameslink), Paris (RER), Berlin, Munich and others, spent billions building expensive tunnels to consolidate rail lines and bring them downtown, Montreal is about to take an existing tunnel and disconnect the lines going through it.




Instead of building a high capacity trunk line serving the whole region, which the public needs, they are building a light metro with a much lower capacity that will only benefit the West Island and Brossard, while negatively impacting Montreal-North and -East, Laval, Longueuil, and VIA-rail passengers.

**The Financing Model will Ultimately cost the Public**

At the same time, the Caisse my require a 10% return from their 2.5B$ investment, which may translate into 270$M per year. This money will ultimately be extracted from the public, one way or the other. Note that right now, it is possible for the public to get loans (bonds) at very low rates, much lower than the 10% required by the Caisse. Additionally, the loans will be repaid after some time. The requirement for the Caisse the much larger returns will be indefinite.

Note that right now, the Deux-Montagnes is subsidized by approximately 18M$ per year (see AMT annual report 2015). The large return requirements of the Caisse will dwarf this subsidy.

Right now the Deux-Montagnes line generates 22M$ in revenue per year, but has 20% of the REM's projected ridership (30K vs 150K trips per day). Most of the ridership coming from further zones - the REM will have a lot of its ridership from zones closer to the city, so revenue per user will be less, given similar fares.

If the REM has five times the ridership, it may generate five times the fare revenue, which would be about 100M$ - that's much less than the required return, and does not consider the cost to actually operate the line (note that automation reduces the requirements on in-vehicle staffing, but the fixed costs, infrastructure & vehicle maintenance and management is not significantly reduced).

The project was touted as a way to build a large transit infrastructure project without incurring significant debt. But it is possible we are creating a liability to the public that will be much larger than simply borrowing money. But, this liability will not show up on the provincial budget. This accounting-trick to build transit while presenting balanced budgets may cost the public much more money down the line.

Furthermore, the project will involve ceding a large amount of infrastructure to the Caisse below cost. This represents a large loss.

The project will also shift the responsibility of paying for transit capital projects to municipalities. This is via the tax-increment financing scheme that will explicitly take municipal tax revenues (the amount percentages, and the time frames of the agreements have not been disclosed). And this is via the possible requirement of indirect subsidies via the ARTM, which is paying the cost to the CPDQInfra per user, which will in turn be used to finance the capital costs.

**Bibliography**

[1] Tehchopark: “Factual Record Montreal Technoparc Submission (SEM-03-005)” http://www3.cec.org/islandora/en/item/11617-montreal-technoparc-factual-record-north-american-environmental-law-and-policy-en.pdf

[2] Alon Levy. “Transfer Penalties and the Community Process”. Pedestrian Observations, 19 decembre 2015 https://pedestrianobservations.wordpress.com/2015/12/19/transfer-penalties-and-the-community-process/

[3] RTL Website. “Equipment Vehicles” http://www.rtl-longueuil.qc.ca/en-CA/rtl/equipment/vehicles/

[DA-17] STEER DAVIES GLEAVE. Transport Collectif sur l’axe A10/centre-ville de Montréal, pour CDPQ Infra Inc., décembre 2015, 45 pages. http://www.bape.gouv.qc.ca/sections/mandats/Reseau_electrique_m%C3%A9tropolitain/documents/DA17.pdf

[DA-61] OPEN STREET MAP. Carte interactive. http://www.bape.gouv.qc.ca/sections/mandats/Reseau_electrique_m%C3%A9tropolitain/documents/DA61-carte%20interactive/DA61.html

[DA-91] HATCH et CIMA+. Exploration du REM – Projet de référence : Hypothèses d’exploitation, 25 août 2016, 25 pages. http://www.bape.gouv.qc.ca/sections/mandats/Reseau_electrique_m%C3%A9tropolitain/documents/DA91.pdf