Montreal, Sept 23, 2016

Memoir for the BAPE hearings on the "Réseau électrique métropolitain" (REM) Proposed by the Caisse de Dépôt et Placements du Québec: Issues & Potential Solutions

by

Anton Dubrau

Final Version

This document outlines issues of the REM project. The REM project was proposed by the CDPQInfra, a subsidiary of the Caisse de Dépôt et Placement du Québec. This is memoir is being submitted as part of the BAPE process for the project. For every section, impacts and problems are identified. For some sections, potential solutions are proposed within the section. A synthesis of requests and solutions is provided in the end.

The section on the Privatization and Monopolization of the Mont Royal tunnel are considered the most significant impact of the REM by the author of this memoir. A potential solution, the "Shared System", is described in considerable detail.

The second most important issue is the alignment of the West-Island Branch of the proposed REM system. Again a potential solution is discussed in detail.

These two issues will be addressed by the author in his verbal BAPE presentation.

Many more issues are discussed in this document.

The reason to discuss alternatives/solutions in such detail is that CDPQInfra has displayed an attitude that presented problems are impossible to solve, and their solution is the only one that is possible. For example, if track sharing is possible in the Mont-Royal tunnel, it makes the impact of not using that solution much more poignant.

It is assumed that the reader is generally familiar with the proposed REM project, basic project parameters will not be repeated. References to other documents submitted to the same BAPE process will simply be referred to by their code, e.g. DA-34 or DB-25.

Another underlying assumption is that effective transit is strongly correlated with environmental, social and economic benefits. The budget for transit is very limited; if it is not spent effectively on generating as many users as possible, than this is effectively an environmental impact relative to engaging in projects that will generate more users.

About the Author

My name is Anton Dubrau. I am resident of the Plateau-Montreal. I've been an advocate of Transit for some time, have ridden and thought about transit and urbanism all my live. I have written a lot of analyses and created data-visualizations on the subject. I generally publish these on www.cat-bus.com.

I'm a computer scientist and mathematician by education. I currently work at "Transit App", a company that develops a mobile application that displays transit information, schedules and maps to users.

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1. Governance / Process / Privatization

1.1. 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?

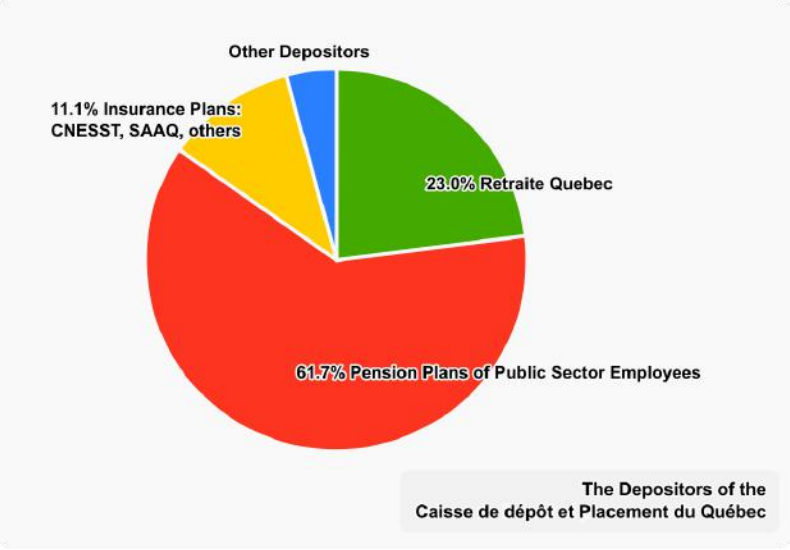
The agreement between the government and the Caisse specifies that the government “must never have the authority to direct the financial and administrative policies of Caisse (sic)".

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.

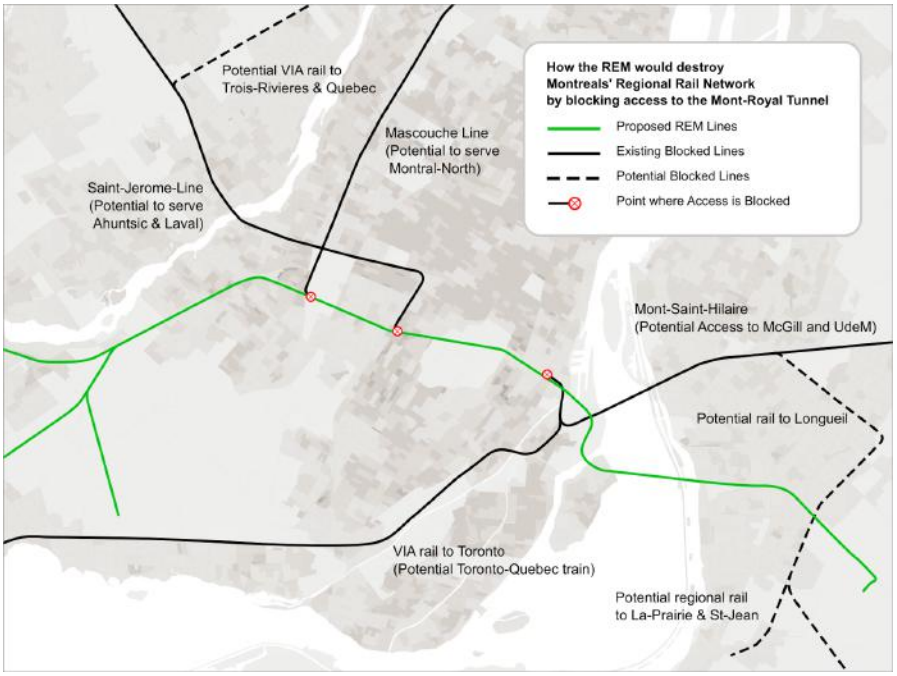
How will the Caisse use the Tunnel against the public?

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.

1.2. Governance

1.2.1. The ARTM and Fares

Bill 76 changed the way transit is organized in Quebec. It will create the ARTM, a new organization that will integrate planning and fares of all the Montreal transit agencies. The REM project, the most important transit project for the region in 40 years, will be exempt from that. This does not make any sense.

The CDPQInfra has explained, when being asked about fares, that it is not responsible for that, that the ARTM will set the fares. This may be true, but the CDPQInfra will still demand a certain amount of cost per user. This will not be an at-arms-length negotiation, since the CDPQInfra will own the complete REM project and the government will have no control. The public will be captive, because it will depend on the continued operation of the transit line, and there will be no competition, the CDPQInfra will be able to demand any price they want per user.

On order to pay for the users of the REM, the ARTM will have two choices:

1) Ask the users for a higher fare. Since the fares will be regionally integrated, this may affect all users, even the ones in less affluent areas of Montreal who will not benefit from the REM (and may actually be negatively impacted in terms of transi)

2) Ask the public to provide more subsidies. This makes the claim that the CDPQInfra will be profitable and not create any risk for the public ironic: in order for the REM to be profitable, the public may have to provide subsidies that will be the profit.

CDPQInfra has assured that the cost structure will be set before the agreement is finalized and agreed to by the government, but has provided very little relevant information at the BAPE process.

1.2.2. Privatization Negotiations are not At-Arms-Length

As previously mentioned, the REM project will include the privatization of the Deux-Montagnes line, the Mont-Royal tunnel and Pointe-St-Charles maintenance center. There is very little information how much CDPQInfra will pay. The total cost for all land and corridor acquisition, infrastructure relocation and soil-treatment is planned at 585M$ dollars (DA-79).

This means the assets of the AMT have be acquired for noticeable less than that. The cost to the public of these assets were much more than that. For example,

- The Deux-Montagnes line received 300M$ in upgrades in the nineties,
- the “Reno-tunnel” project currently being carried out by the AMT cost close to 100M$,
- the “jonction-de-l’Est” grade separation project cost 60M$,
- the Pointe-Saint-Charles maintenance center is budgeted at 320M$,
- the AMT purchased the Deux-Montagnes line for about 100M$ from CN in 2014.

Just these projects carry a price tag of 880M$, is way above what the CDPQInfra may pay. And this is not an exhaustive list of investments that the CDPQ will benefit from, and that the AMT will lose.

The above is only an accounting of cost. The book value may be different. The **replacement value** of the infrastructure that will be sold will be much higher. This is extremely pertinent, because the AMT still needs this infrastructure. In effect, we may create a situation where the AMT is forced to sell assets below cost, and subsequently the public has to pay for the AMT to build replacement assets for a large multiple of the money received.

The ultimate beneficiary will be the depositors of the Caisse (e.g. mostly pensions of private individuals).

The CDPQInfra have claimed they will pay “market value” for the assets. But of course there is no market for transit infrastructure. The CDPQInfra will be the only bidder, which allows them to dictate the price.

Part of the problem is the current governance around this project. The Quebec government apparently wants to push this project through at all cost, so does the government of the city of Montreal. The AMT is in the process of being replaced by the ARTM. Currently it can offer very little resistance and ensure a fair negotiation process. Employees of the AMT also have to worry about receiving new jobs at the new ARTM organization, so may be forced to agree to unfair deals due to political pressure.

1.2.3. The Process

The CDPQInfra is moving incredibly quickly with this project. It was announced in April, the BAPE started in August. The plan was developed in near-secrecy beforehand. The plan clashes with most previous transit planning, it ignores plans set out by the PMAD. Consultations are done with municipalities and stakeholders, but the Caisse has only been willing to make minor modifications to their project - it is large presented as a fait-accomplis.

A project as large and impactful should be planned by the public, not a private entity.

Information on the project is extremely controlled. The Caisse is asking municipal representatives to sign non-disclosure agreements when discussing with the CDPQInfra.

Over the Summer, the Caisse refused to provide their ridership study and a lot of other important information to evaluate the project. The exact text of the mandate given to the CDPQInfra is still not public. With the beginning of the BAPE, the Caisse provided a lot of documentation, but much is still missing. At the same time, given the large amount of documentation provided, and the short time period of all the processes, it is difficult to evaluate the project within such a short time frame. Citizens who are concerned about the project are getting ‘buried in paper’.

The BAPE process is very difficult. The project is extremely large, and we are evaluating high-level privatization issues at the same time as very local impacts do to individual grade crossings. This project is several times the size of usual projects evalated by the BAPE, and should have a longer process.

A list of 29 questions that were submitted by the author to the BAPE process were not answered.

2. A Constantly Changing, Unfinished Project

The REM project by the Caisse is not presented in any completed form. Many paramaters are unknown, many aspects are not finished. The following is information that the CDPQ has not prepared, or has simply not made public:

- The project does not include many important train stations downtown that the CDPQInfra is apparently studying or at least “seriously considering”: McGill, Edouard-Montpetit, the Griffintown station.
- Many impacts are not studied:
    - Impacts on existing transit lines, the Vaudreuil-Hudson line, the Candiac line, the St-Jerome line, the Mascouche line
- Ridership studies that look at the REM project as a whole have not been provided
- The impact on the Blue line, and whether the REM has enough capacity to absorb riders from the Blue Line.
- The cost-benefit has not been proven, broken down by different components of the project
- The revenue model, per-ride charges to the future ARTM are not known
- The exact paramters of the TIF (tax increment financing) scheme are not known, the development surchages are not known
- How much the CPDQ will pay for the privatization of all the public infrastructure assets, in particular the Mont-Royal tunnel, the Deux-Montagnes line and the Centre Entretien Pointe-St-Charles.

The project keeps changing, during the earlier phases of the BAPE process, new documents would often override previous ones. This project is still apparently evolving, while the consultation process is ongoing.

3. Real Estate Conflict of Interest

A lot of the issues and impacts with of the REM related to the alignment of the line (see section on airport train routing, and West Island branch). Why does the Caisse insist on building an airport train to Gare Centrale? Why does it insist in building transit to the Fairview mall, which results in building transit along a highway?

The original main argument for Gare Centrale was that it would result in more airport ridership, up to 10,000 people. Aeroports de Montreal has claimed that ridership would be 22% higher than if the line was routed along a the existing Vaudreuil-Hudson line, terminating at Lucien L'Allier.

The 10,000 ridership number is also what the Caisse kept using in their media presentation files. In their actual own ridership study, airport ridership is shown to be 2700 in 2022, going up to 4200 using their optimistic scenario (see last page of ridership study summary).

So why are they so adamant about going to Gare Centrale if ridership is so low anyway?

One potential connection is real estate.

The Caisse owns two hotels within walking distance of Gare Centrale, the Royal Elizabeth, and the Hotel W. They just invested 140M$ in the Royal Elizabeth. Both assets will undoubtedly benefit tremendously from an airport train within 200m/500m (Gare Centrale), but will benefit less if the airport train is 800m/1000m away (Lucien L'Allier).

The caisse also owns several other assets in the direct vicinity of Gare Centrale and McGill station: the Eaton Centre, Montreal Trust, Place-Ville-Marie, via it's Ivanhoe Branch.

I would consider this a conflict of interest. In my mind, instead of maximizing the cost vs public benefit of transit, they are attempting to maximize the profit of their real estate branch.

This is inappropriate, because they will receive billions of direct funding, and more via public infrastructure assets that will be sold below cost and below replacement value.

4. Capacity

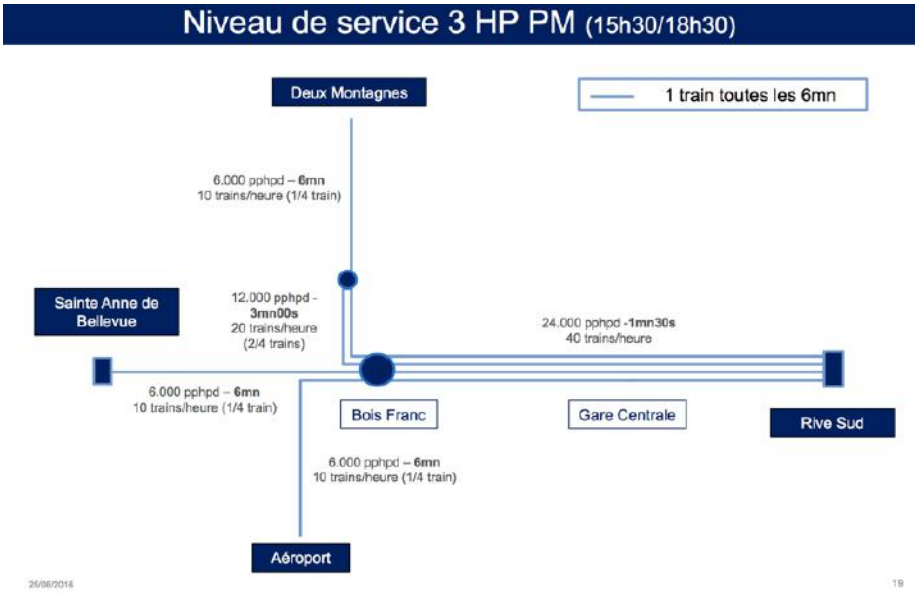
There is concern that the REM will not provide enough capacity, especially on the Deux-Montagnes line compared to today.

It may also not provide enough capacity for the forced transfers due to not sharing the Mont-Royal tunnel, which is discussed further below

COMPARING CAPCITY OF EXISTING DEUX-MONTAGNES LINE AND REM PROPOSAL

The following shows a comparison of the current capacities to the proposed REM capcities on the Deux-Montagnes branch, depending on different service levels. The REM service levels are defined in document DA-91.

Capacity is generally counted in PPHD - people per hour per direction.



An example of a proposed REM service: level 3, afternoon peak. It shows 6,000 PPHD between Ile-Bigras and Deux-Montagnes, and 12,000 PPHD between (DA-01, page 19)

Note that the total capacity includes seating and standing capacity. Seated capacity of REM is 20% of the total capacity of 150 (see session transcript DT2, page 15) vs 44-25% for the existing Deux-Montagnes line's MR-90 cars (88-90 seats per car, 200 total capacity).

In order to allow a comparison free of seat configuration (which can be changed, including on existing trains) and crowding assumptions, the total approximate transported area was included.

The total area of a REM car will be 3m*20m = 60m^2 (see DT-2, page 13), the area of an existing MR-90 car is approximately 3.2m * 26m = 83.2m^2.

REM has three proposed service levels. The initial system, which includes 200 rail-cars, won't have enough rail-cars to implement service level 3. Level 3 requires ~270 railcars, based on the proposed runtimes, frequencies, and a spare ratio of 10%.

Note that about 80% of the current ridership is from/to stations West of Bois-Franc, assuming that there are no trips in-between the stations West of Bois-Franc. This is because 40% of the embarkments/disembarkments are on the stations West of Bois-Franc, according to the AMT annual report (AMT annual report 2015, page 10).

The question is, will the REM improve service for those passengers, especially during the peak time.

*Node: today's headway is given as the average headway during the hour with the most service (i.e. the peak hour), in the peak direction. Service demands for suburban systems are very peaky, about half the demand of the peak period is within one hour.

	Service Off-Peak 1 5:30-6:30, 20:00-1:00				**service Off-Peak 2 9:30-15:30, 18:30-20:00**				**Service Peak AM 6:30-9:30**				**Service Peak PM 15:30-18:30**			
	Headway	total Capacity	Seated Capacity	total train area	Headway	total Capacity	Seated Capacity	total train area	Headway	total Capacity	Seated Capacity	total train area	Headway	total Capacity	Seated Capacity	total train area
Station Deux-Montagnes...Ile-Bigras:																
Today*	**60min**	**2,000**	**890**	**832m²**	**60min**	**2,000**	**890**	**832m²**	**22min**	**5,530**	**2,461**	**2300m²**	**20min**	**6,000**	**2,670**	**2496m²**
REM 1	15min	2,400	480	960m²	15min	2,400	480	960m²	12min	3,000	600	1200m²	12min	3,000	600	1200m²
REM 2	15min	2,400	480	960m²	12min	3,000	600	1200m²	11min	3,375	675	1350m²	11min	3,375	675	1350m²
REM 3	15min	2,400	480	960m²	12min	3,000	600	1200m²	6min	6,000	1,200	2400m²	6min	6,000	1,200	2400m²
Station Roxboro...Sunnybrooke:																
Today*	**60min**	**2,000**	**890**	**832m²**	**60min**	**2,000**	**890**	**832m²**	**16min**	**7,500**	**3,338**	**3120m²**	**20min**	**6,000**	**2,670**	**2496m²**
REM 1	15min	2,400	480	960m²	15min	2,400	480	960m²	12min	3,000	600	1200m²	6min	6,000	1,200	2400m²
REM 2	15min	2,400	480	960m²	12min	3,000	600	1200m²	11min	3,375	675	1350m²	5min	6,750	1,350	2700m²
REM 3	15min	2,400	480	960m²	6min	6,000	1,200	2400m²	6min	6,000	1,200	2400m²	3min	12,000	2,400	4800m²

That table shows that only the highest proposed service level (level 3) increases peak hour capacity compared to today - but this level cannot be implement because CDPQInfra won't have enough rail cars.

None of the proposed new service levels will provide more seats on the Deux-Montagnes branch.

None of the proposed service levels will significantly improve peak hour capacity (seated or area) between the stations of Deux-Montagnes and Ile-Bigras.

It appears that the REM project does not improve the peak capacity significantly, despite grandiose claims by CDPQInfra.

It appears that the main issue with the Deux-Montagnes line today is an operational issue - in particular, the line currently fails to provide the high peak capacity for much more than an hour. Off-peak service is way to infrequent.

The issue isn't line capacity, it's the amount of provided service.

How to achieve similar service levels at much reduced capital costs

In transit planning (especially in Switzerland) there is a mantra:

"operations before electronics before concrete".

According to this idea, desired improvements in service should first be attempted by changing how a line is operated. If that doesn't work, then try to upgrade the signalling system or electrify - which is much more expensive. Only if that still does not sufficiently help should large capital expenditures be planned.

The Deux-Montagnes line appears to be in a situation where operations and small amounts of 'concrete' can provide similar service levels as the REM proposes.

Note the AMT has 58 MR-90 vehicles. Given a spare ratio of 10%, this means 52 vehicles are available at all times. Using 10-car trains (2000 passengers), this means the AMT can concurrently operate five 10-car trains. Using 8-car trains (1600 passengers), the AMT can operate six trains at the same time.

The Deux-Montagnes line takes 35-40 minutes to complete. This means it is possible to make a round-trip in 90 minutes. So if 15-minute service was provided, the AMT would require six trains. This is possible using 8-car trains.

If the AMT switched to 8-car trains on a continuous fixed 15 minute schedule, it could provide service all day long, every 15 minutes. During the off-peak, trains could be split into smaller 6-car or 4-car trains to save money on operating costs.

This is actually not possible on the line right now, because there are single-track sections that are too long. In particular, the section between Bois-Franc and Roxboro

station. Also, there is a siding around gare Sainte-Dorothee which is too short to allow reliable 15-minute service.

In order to provide continuous 15-minute service, the stretch between Roxboro and Sainte-Dorothee would have to be double-tracked. This has been a planned and studied AMT project for a long time. For example in the capital budget of the AMT for 2014-2015-2016, this project had a total cost of 53.3M$ (see AMT PTI-2015-2015-2016, page 12).

A second requirement is the lengthening of the siding near Gare Sainte-Dorothee, including adding a second track at Gare Sainte-Dorothee. The length of this section is much smaller, so the capital cost should be much smaller.

With continuous 15-minute service, using 8-car trains, we have the following hourly capacities:

- total capacity is 6,400 PPHD.
- seated capacity is 2,848 PPHD
- total transported area is 2662m².

This would provide a better service compared to all REM service levels except REM service level 3 (which is not achievable without ordering more trains than the REM project proposes), and only during the afternoon Peak.

The capital cost to convert the existing line to 15-minute service is less than 100M$, compared to more than a billion for the REM project, which includes upgrades to the Mont-Royal tunnel, removing 14 level crossings, rebuilding every station, purchasing tens of new railcars, changing the electrification & installing an advanced signalling and automated driving system.

A note on operating costs

The REM will significantly reduce operating costs for the Deux-Monatgnes line compared to today, due to significantly reduced staffing levels. Right now the annual subsidy on the Deux-Montagnes line is on the order of 20M$, The REM construction cost for the REM Deux-Montagnes branch is more than a billion dollars, i.e. more than 50 times the annual subsidy.

Another way to significantly reduce operating costs is to improve productivity. Moving to a 15-minute schedule will improve productivity compared to a peak-only service due to reduced gap-time and the possibility of shift-work. So the marginal cost of the extra service may be lower than the extra revenue generated by having more service.

Operating costs can be tremendously reduced if a line is operated using single-person-operation. Right now, for many commuter rail systems, the cost of conductors dwarfs the cost for drivers.

Right now the AMT uses a proof-of-purchase system (“honor-system”), which means conductors are not necessary to check tickets. They largely help with the boarding process.

Single-person-operation most likely requires level boarding, which in turn means high platforms would have to be installed at 11 stations. The capital cost for such a project would also be in the range of 70-200M$, still a small fraction of the REM project. It also requires installing mirrors or cctv systems that allow the driver (engineer) to observe the boarding process and control the closing of doors - like is done on the Montreal Metro today.

High-level platforms also reduce dwell time, and thus increase average speed, while improving schedule stability and accessibility.

Again, there is the possibility to significantly reduce operating costs, on top of providing much improved service, given a capital expenditures that are a fraction of what the REM proposes.

Improving Capacity Beyond 15-minutes

To improve service beyond what the 15-minute scheme could provide, the next main bottleneck is the number of available vehicles. If more service was to be provided, more vehicles would be required. Which is again cheaper than overhauling the whole line.

Electric Heavy rail vehicles can be purchased as cheap as 3-4M$/vehicle (See silverline V purchase of SEPTA in 2010, M8 purchase of Metro North). So another 100M$ could increase the size of the available fleet by 50%.

These incremental updates targeting successive bottlenecks provide much more efficient way to improve service on the Deux-Montagnes line, at a fraction of the cost of the REM, and without the impact the construction of the REM will have on the service for several years.

Previous AMT Plans

The AMT capital plan for 2010-2011-2012 includes a similar plan that would allow increasing ridership by 36%. It focussed less on changing operations to continuous service, opting to purchase more vehicles first. However, it did include the doubling of the tracks between Roxboro and Bois-Franc. This plan would have allowed increasing ridership by 36%, which is similar to the REM, at a fraction of the cost.

LIGNE MONTRÉAL/DEUX-MONTAGNES

En service sans interruption depuis 1918, la ligne Montréal/Deux-Montagnes, qui est électrifiée depuis son ouverture, a fait l'objet d'une reconstruction complète par le MTQ de 1992 à 1995, au coût de 300,0 M$. Elle est exploitée par l'AMT depuis 1996.

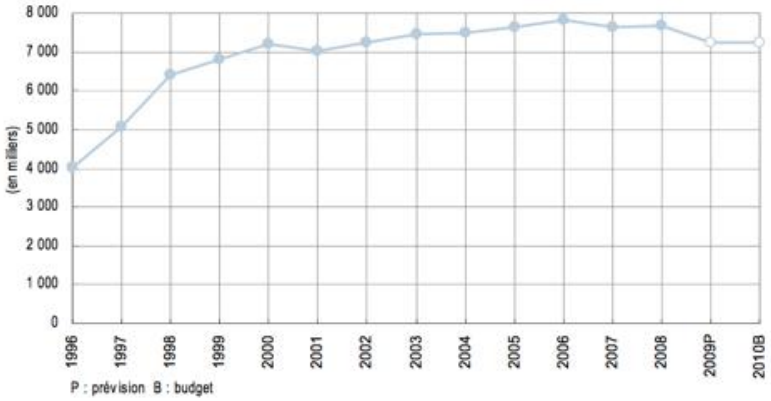
Des interventions indispensables pour accroître la capacité d'accueil

Avec près de 7,7 millions de passagers par année, la ligne Montréal/Deux-Montagnes représente 49 % de l'achalandage total du réseau. Pour répondre à la demande potentielle évaluée à plus de 45 000 passagers par jour, les interventions suivantes sont requises :

- acquérir des voitures passagers neuves à deux étages (incluses dans la commande de 160 voitures) ;
- acquérir des locomotives neuves (incluses dans la commande de 20 locomotives) ;
- doubler la voie entre les gares Roxboro-Pierrefonds et Bois-Franc ;
- étager la jonction ferroviaire de l'Est dans l'arrondissement Saint-Laurent ;
- ajouter une gare au niveau de l'A-13 et prolonger le service vers Saint-Eustache.

Ces interventions permettront d'augmenter la capacité de la ligne de 36 % en pointe du matin et du soir.

Achalandage de la ligne Deux-Montagnes entre 1996 et 2009



EN BREF

- 12 gares, dont 1 commune avec la ligne Montréal/Mont-Saint-Hilaire
- 8 stationnements incitatifs offrant 5 912 places autos et 373 places vélos
- 29,9 km de voie
- 26 départs en direction de Montréal
- 23 départs en direction de Deux-Montagnes

ACHALANDAGE RÉEL 2008

Pointe du matin	13 860
Pointe du soir	12 680
Jour moyen	30 940
Mensuel	670 800
Annuel	7 687 200
Annuel (prévision 2009)	7 230 900

Plan by the AMT from 2012 to increase ridership by 36%, AMT PTI 2010-2011-2012

A Note on the Seat-Capacity vs Standing Capcity Trade-off

Right now, the theoretical capacity of the Deux-Montagnes line is hard to reach, because the seats take up a lot of space. Clearly the system was designed assuming most people would sit. Removing seats would provide more standing capacity at the expense of seating capacity.

This seating/standing comfort trade-off can also be made without removing seating, by making the seating more compact: It decreases the comfort of seating, while not reducing the amount of seating, while also increasing the comfort of standing (by providing more space). More standing space also means more efficient passenger flow.

Left: compact seating in Alstom X'Trapolis 100 (source: wkpedia, wongm).
Right: Mr-90 vehicles on Deux-Montagnes line (source: Alex T). Note the more spacious seating configuration which takes away space from standees. Also note the lack of overhead handle bars.

5. Questionable Cost / Benefit

A study of cost/benefit in terms of ridership on the REM project was not provided. In particular the airport branch appears like a poor investment, costing half a billion dollars, compared to 2700-4200 riders per day. This means that part of the project would cost 100K$-150K$ per daily user, which is ten times the cost of the Orange line extension to Laval.

Given the large amount of direct and indirect funding the public provides, it should be possible to decide which of the different branches will be built, based on their cost/benefit to society in terms of ridership.

6. Monopolization of Tunnel Mont-Royal (Shared System Issue)

6.1. Summary

Many have complained about the inequity of the proposed REM project, which concentrates transit investment in the West Island and Brossard. While this is a valid point, it may be ultimately self-defeating -- if any project is attacked for serving a particular area and not another, if regions are pitted against each other every time a project is proposed, no project may ever get built.

It would be preferable if the public had a regional, integrated, publicly organized transit plan, but the CDPQInfra is not really responsible for this lack of planning. So in some sense it is okay if investments are done in the West and in the South - this is after all the mandate that the CPDQ was given.

The problem is that the now proposed project *actively impacts other lines and regions negatively.*

One major impact of the REM to the rail transportation system of the whole region of Montreal is the Monopolization of the Tunnel Mont-Royal. It's the only direct heavy rail access downtown from the North. It is currently used by two AMT lines, the Deux-Montagnes line and the Mascouche line. Both AMT and VIA have plans to add more lines to the tunnel, which would cover the whole region.

Under the REM proposal, the tunnel would be privatized by the CDPQInfra, which would only allow the REM rail system to access the tunnel. The REM will replace the Deux-Montagnes line, so it still allows that line. But it will 'kick out' the Mascouche line, and will disallow any new lines to access the tunnel.

In the following, I'd like to point out the impacts on existing and planned lines,and a potential solution: a shared system of REM, VIA & AMT trains all using the existing tunnel.

6.2. Impacts/problems

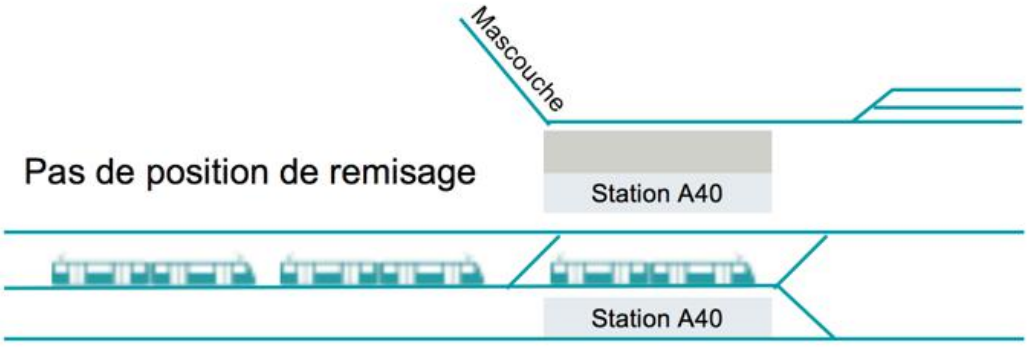
The following section discusses how the Monopolization of the Mont-Royal tunnel, and conversion of this heavy rail tunnel to an exclusive light rail tunnel, will impact several existing and planned heavy rail lines.

6.2.1. Impact on Existing Mascouche Line

With the REM project, the Mascouche line will loose it's direct access downtown, due to the conversion of the Mont Royal tunnel to an incompatible technology. The line will be cut, at the station "A-40", and passengers will be asked to transfer to the REM to access downtown. Right now, about 95% of the users of the line have downtown as their destination.

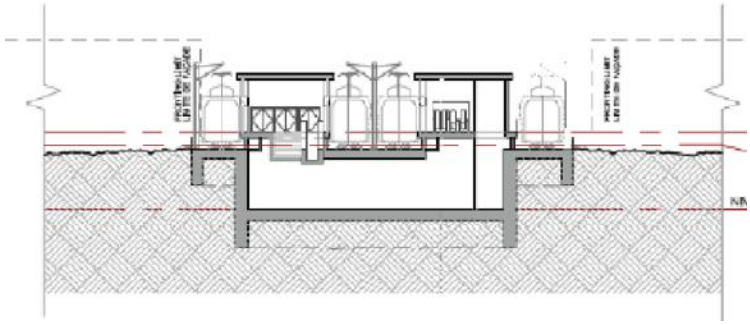
The forced transfer at A-40 station is not ideal because it is from a high capacity train (up to 2,000 passengers) to low capacity trains (up to 600 passengers), which may also not be empty. If there is a capacity of 100 passengers available in every train arriving at A-40 station, then a completely full Mascouche train would require 20 REM departures before everybody can transfer. At 90 second intervals, this would take half an hour.

In order to address this issue, CDPQInfra proposed an 'optimized' station layout that would allow insertion of empty trains at the station, in order to reduce the impact of the transfer.



Optimized layout of A-40 station. Page 10, DA-63

With this new layout, passengers would exit the Mascouche commuter train, then walk to the other platform (using an underground connection), where empty REM trains would be waiting.



Profile of A-40 station. Page 2, DA-39

The issue with this station layout is two-fold,

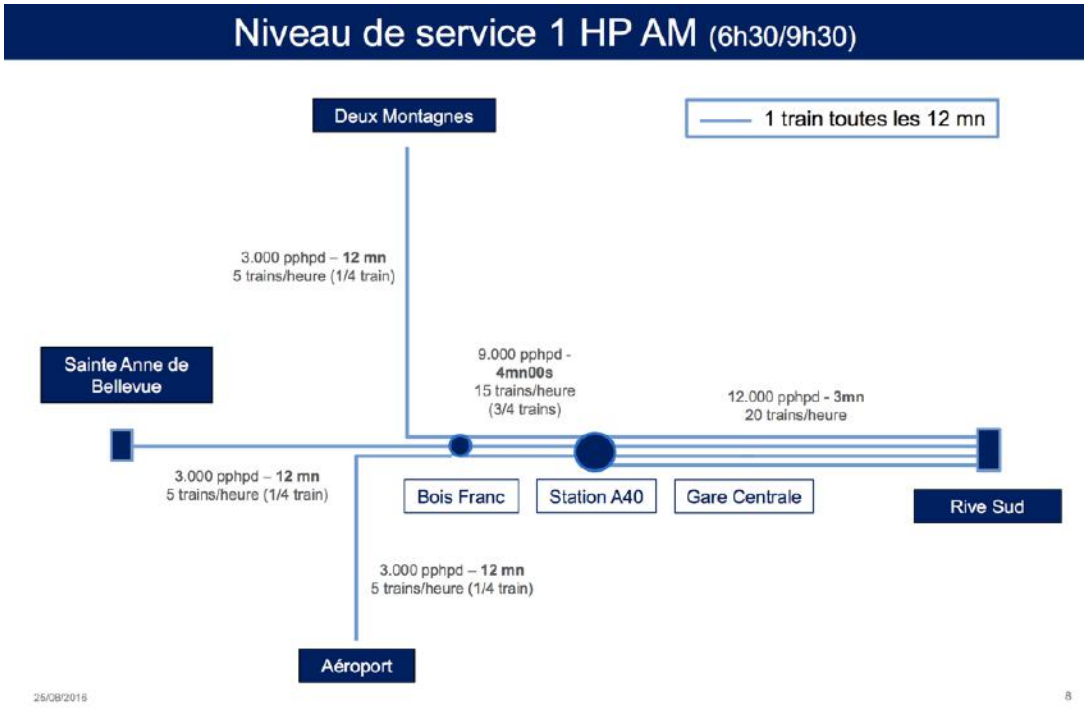
1. Ability To Insert Extra Trains into REM schedule
2. Transfer walk-lengths and Pasenger flow issues

6.2.1.1. Ability To Insert Extra Trains into REM schedule

The REM will use a very high frequency of trains arriving at A-40 station. Thus it will not be possible to for the three REM trains to leave immediately as passengers are received from the Mascouche line.

In DA-91, the CDPQInfra proposed several service levels, showing among others the proposed schedules during the peak. Depending on the service level, the possibility to add new trains, and the resulting wait times, are as follows.

6.2.1.1.1. Service level 1 (AM-peak)



DA-91, page 8

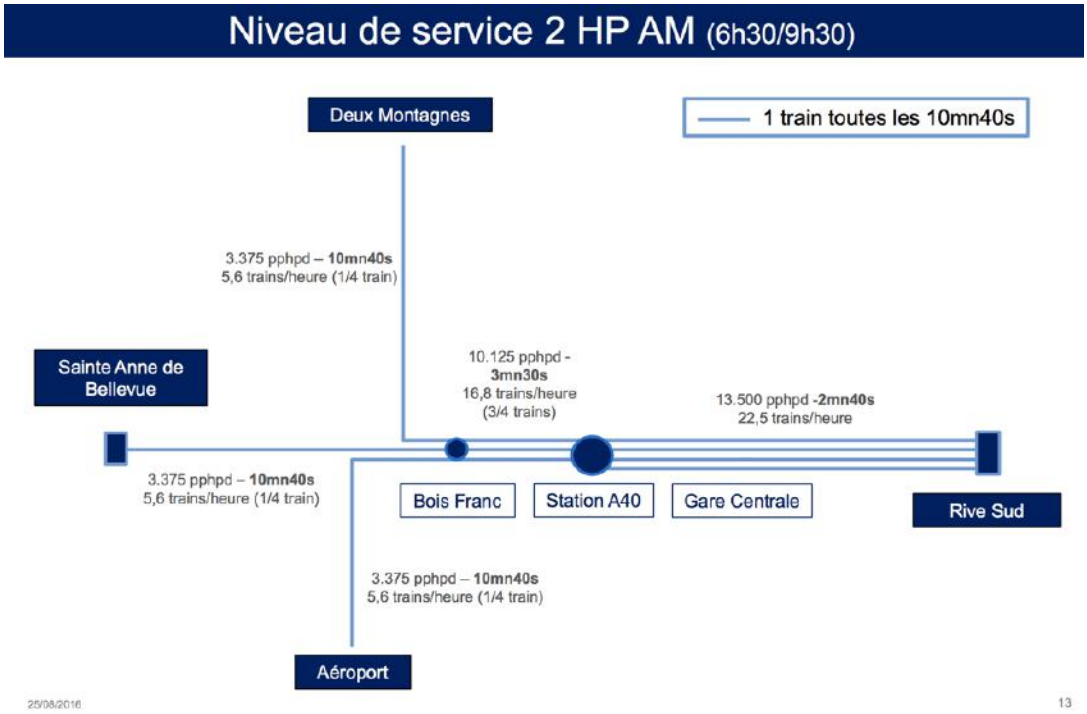
Service level 1 (AM-peak) allows inserting trains at A-40 station.

If the service is provided at even 4 minute intervals from Bois-Franc, extra trains may be inserted at even 4-minute intervals as well. then it will take 8 minutes for three trains to depart from A-40, plus up to 2 minutes wait for the first train (if the first potential slot is missed, requiring wait for the next slot).
Maximum wait: up to 10 minutes.
Average wait: 5 minutes.

If the service from Bois-Franc is spaced to have larger gaps, it may be possible to have the three trains depart more quickly from A-40 station. An uneven spacing is undesirable because it means potential long waits between Bois Franc and A-40. Also, if the Mascouche train is delayed, then it will miss the ‘slots’, causing longer delays.

This service level does not provide sufficient peak capacity compared to today (see section on capacity), and is thus unrealistic.

6.2.1.1.2. Service Level 2 (AM-peak)

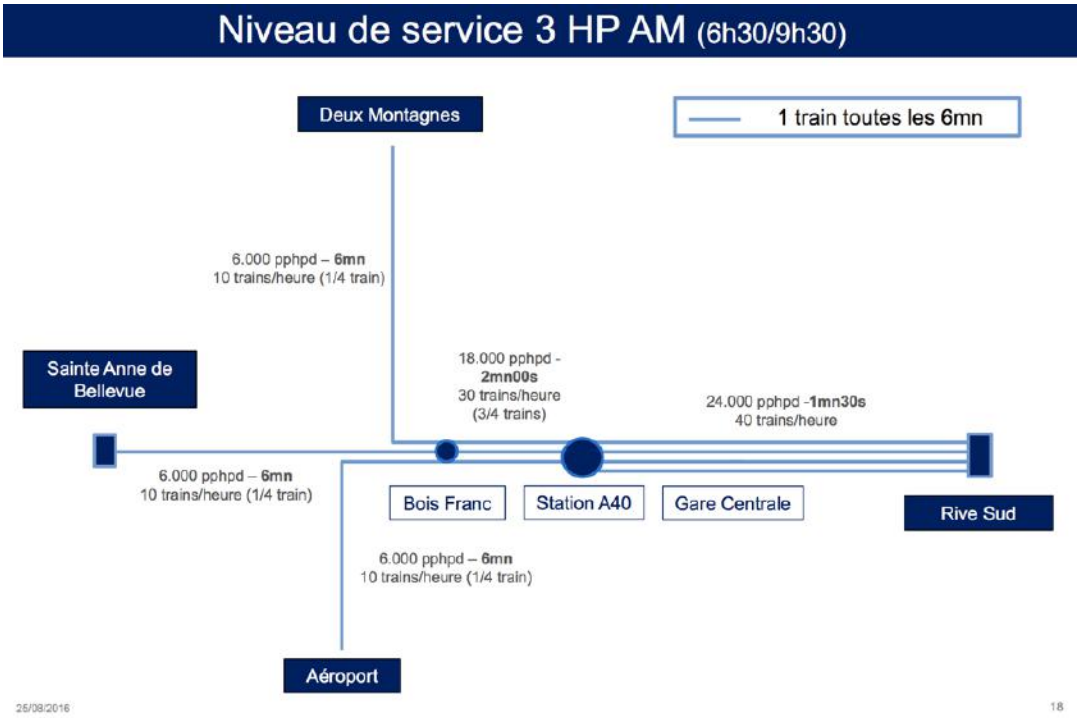


DA-90, page 13

Service Level 2 (AM-peak) also allows inserting trains at A-40 station.

If service is provided at even 3:30 minute intervals from Bois-Franc, then extra trains can be inserted every 3:30min as well. It will take 7 minutes for the three trains to depart from A-40 station, plus up to 2 minutes wait for the first train.
Maximum wait: ~9 minutes
Average wait: ~4.5 minutes

6.2.1.1.3. Service Level 3 (AM-peak)



DA-91, page 18

Service Level 3 (AM-peak) reduces the potential to insert extra trains into the schedule. At A-40 station, 3 of 4 possible schedule slots are used up due to the high overall service level.

This means that an extra train can only be inserted into the schedule every 6 minutes. This means, it would take 12 minutes for three trains to leave, plus up to 4 minutes if the first train missed its available slot (if the Mascouche train is delayed).
Maximum wait: ~12-16 minutes.
Average wait: ~8 minutes.

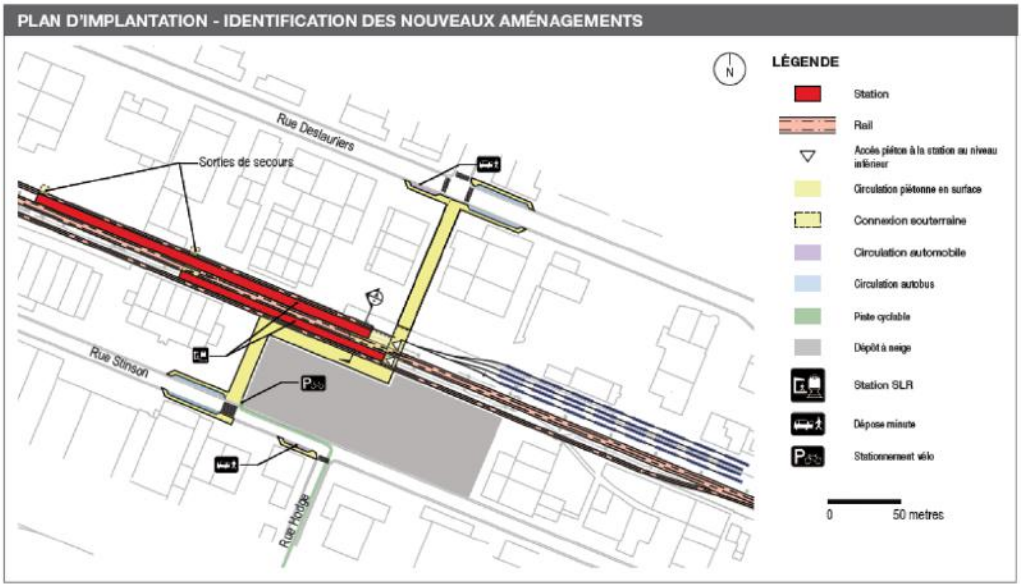
At this service level, insertion of extra trains does not significantly help transferees from the Mascouche line, meaning passengers have to squeeze into potentially full trains coming from further West.

Since at this level, the frequency of trains is one train every 90 seconds, there is an extreme requirement to keep the dwell time low - to about 30 seconds. This means it will be difficult for many people to ‘squeeze’ into each already full train, due to passenger flow issues inside the vehicles.

So as ridership grows, the experience for Mascouche line riders may become worse, and the ‘optimized’ design of the A-40 station becomes moot.

6.2.1.2. Transfer walk-lengths and Passenger flow issues

Besides potentially long wait times to be able to enter waiting REM trains, the transfer is not as good as the CDPQInfra claim. In the morning the transfer is not cross-platform, it is via a tunnel at the South-Est end of the station. Depending on where passengers disembark, they may have to walk the entire length of the train (up to 260m for a 10-car train).



A-40 Station. DA-39, page 2

The passengers will, upon arriving at the REM Southbound platform, have to decide whether to walk to the other end of the train (80m), or wait. Since many passengers may not wish to walk further, there may be uneven crowding along the station, creating passenger flow issues on the one hand, and uneven capacity utilization of the inserted trains on the other.

The average walk may be as follows:

- 105m - half the length of a Mascouche train (8 cars)
- 40m - half the length of a REM train (4 cars)
- 22m - length of the Mascouche train locomotive
- ~30m - estimated transfer walk
- Stairs down, stairs up

This results in a total average walk of ~200m, and two flights of stairs. Just the transfer walk will be 4-5 minutes on average (50m-80m/minute, 30s-60s per stairs), depending on crowding level.

Depending on the exact scenario, the average total transfer time will be in the 7-10 minute range. Given that users perceive transfer walks and transfer times as 2x in-vehicle time, the perceived time will be in the range of 14-20 minutes (See section on “Station Placement and Transfer Issues” for a further discussion on transfer penalties).

This means people may prefer other routes even if they are 14-20 minutes slower compared to today, including, possibly, driving. Overall this will result in reduced ridership on the Mascouche line and reduced ridership growth potential

Note: CPDQInfra have claimed that they have an analysis showing that there will be no time loss relative to today. They did not provide the details of this analysis, but in discussions they have indicated that they assume that Mascouche trains take 5 minutes to empty at Gare Centrale today, which is supposedly the same as the transfer time at A-40 station. This kind of analysis has several problems:

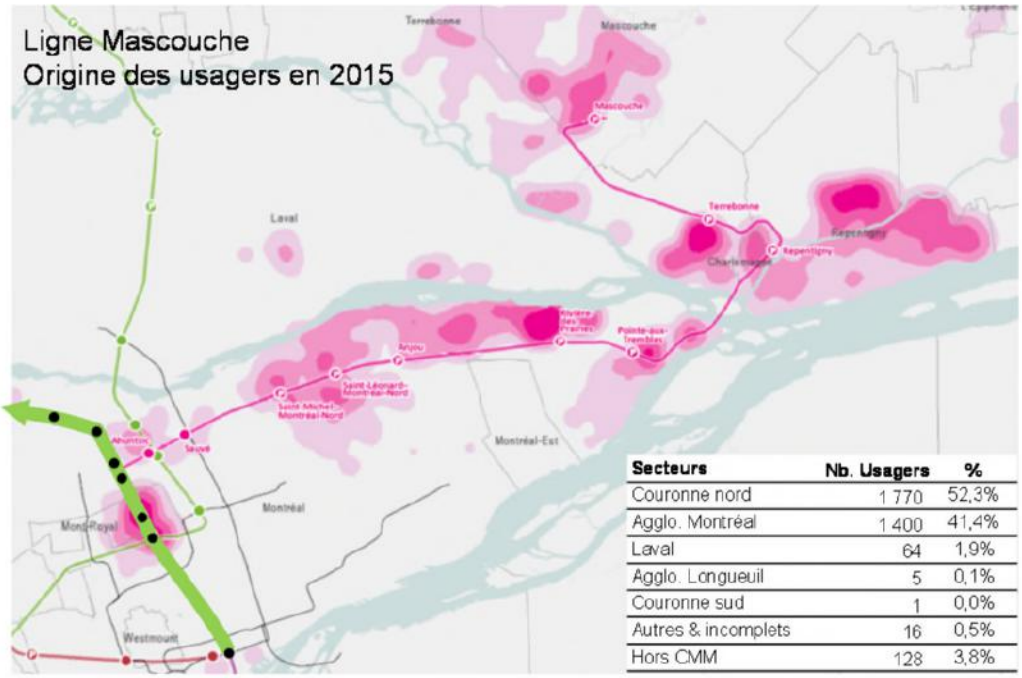
- 5 minutes to empty a train at Gare Centrale is a very high assumption. If this is a case, there are passenger flow issues that should be fixed by other means. The time to empty a train of bi-levels is about 120 seconds (up to 200 passengers exiting via 2 doors, assuming 1.2 seconds per person).
- The transfer at A-40 is assumed to take 5 minutes, which may be a low estimate.
- The analysis may compare the maximum time one the one hand (current disembarking time at Gare Centrale) with an average time on the other (transfer at A-40).
- The transfer time of 3 minutes presented in their PR video
- The perceived impact on passengers is not considered. Transfers have penalties on users that go beyond just the total time they take - generally the transfer time is perceived as 2x in-vehicle time.

6.2.2. 6.2.2.Impact on Potential Mascouche Line Improvements

Right now, ridership along the Mascouche passengers who use the line are not actually coming from the most dense areas along the line.

The densest area along the Mascouche line is Montreal North, which means there is a large potential to improve ridership. The Mascouche line can reduce travel times from Montreal North by 10-20 minutes compared to today, which would imply a large economic benefit for this less affluent area of Montreal

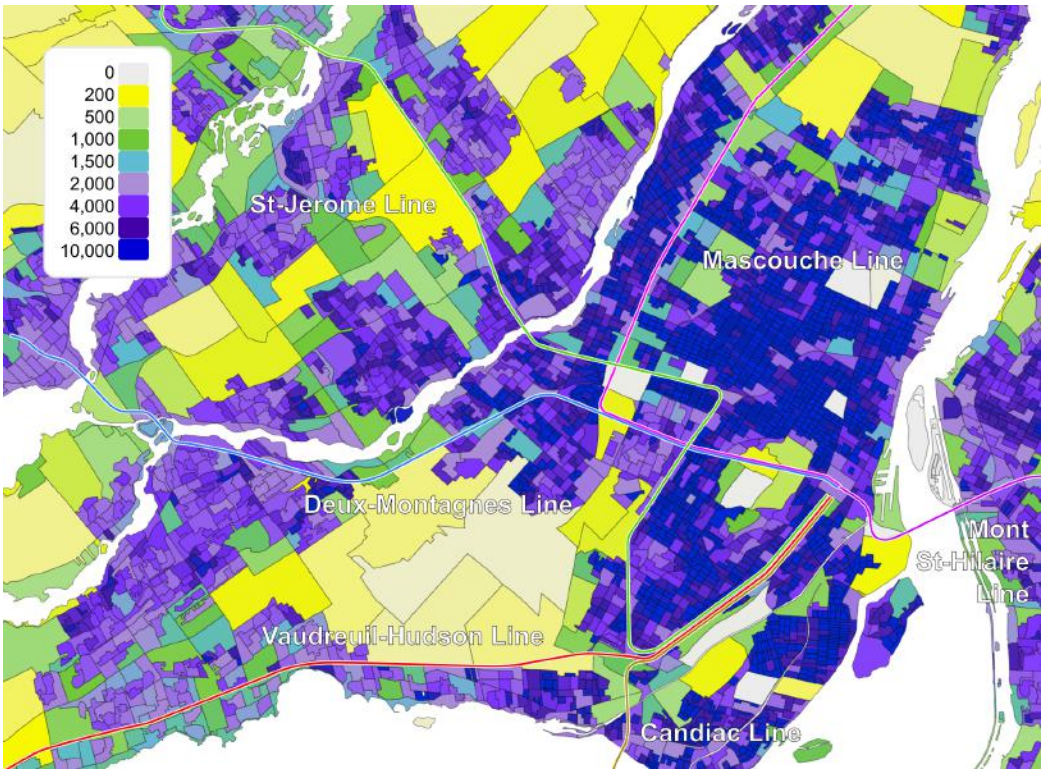
Carte 12 : Origine des usagers de la ligne Mascouche, 2015



Secteurs	Nb. Usagers	%
Couronne nord	1 770	52,3%
Agglo. Montréal	1 400	41,4%
Laval	64	1,9%
Agglo. Longueuil	5	0,1%
Couronne sud	1	0,0%
Autres & incomplets	16	0,5%
Hors CMM	128	3,8%

Source : AMT. Traitement CMM, 2015

Sources of Mascouche line pasengers. Source: CMM, page 18, DB-25



The Various AMT lines and population density: Some of the densest areas near the AMT network are the Mascouche line along Montreal North. But it is not where most ridership comes from

This indicates that the Mascouche line has an incredible potential to add ridership from the area near Montreal North. The corridor along the Mascouche line in Montreal North has 200K people living alongside it, as many as the whole West Island.

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.

Note that the North-shore of Montreal is about 1.5-2.5km away from the Mascouche line, which means many people would take short bus trips to reach the line.

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.

6.2.3. Impacts on Saint-Jerome Line

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

> ***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.

6.2.4. Impacts on the STM Metro Network

The proposed "Improved transfer at Sauve" will result in dump Mascouche line riders on the Orange line. This is the most saturated area of the Montreal Metro system. Any transit project in that area should aim to reduce pressure on the Orange line, not increase it.

> *(...) As a result of its success, the metro network is approaching capacity, particularly on the* ***orange line between the Jean-Talon and Berri-UQAM stations,*** *and on the* ***green line between Berri-UQAM and McGill.*** *This success calls for rail-based projects to be implemented in other major corridors in the region.*
> (https://www.amt.qc.ca/Media/Default/pdf/section8/strategic-plan-2020.pdf, page 39)

Additionally, note that an improved Saint-Jerome line and improved Mascouche line could both reduce ridership on the Orange line if people switch over. If the the Saint-Jerome and Mascouche line can not access the tunnel, resulting in transfer onto the REM and extreme crowding, then the chance to help the saturated Orange line reduced

6.2.5. Impact on VIA Rail "High-Frequency-Rail" Project

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.

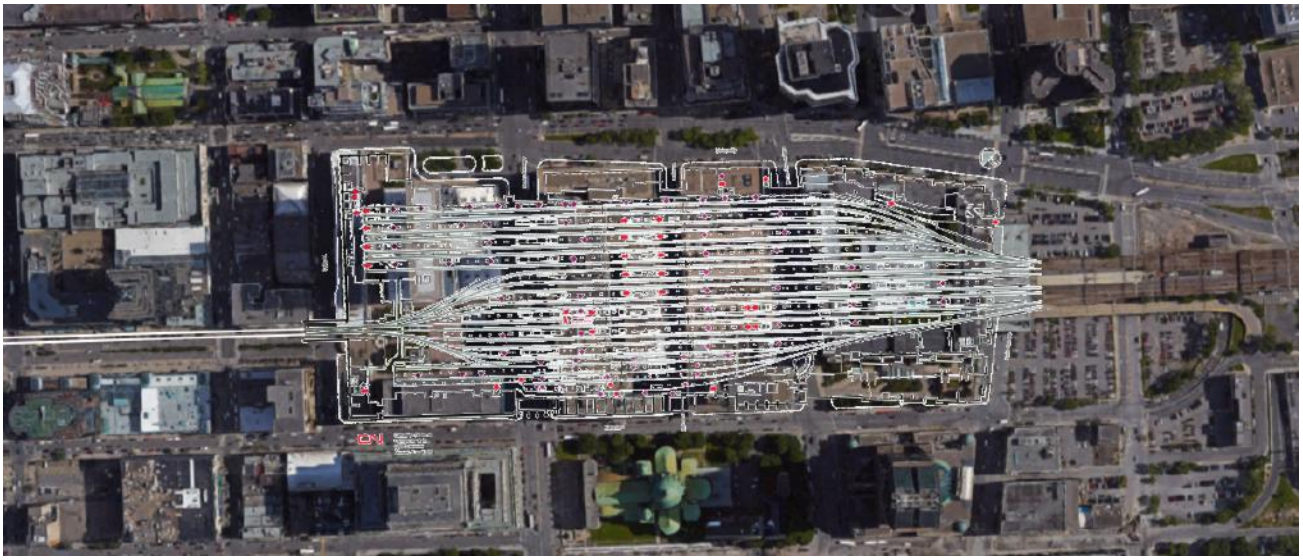
6.3. “Just build a second tunnel”

Some have proposed that if VIA and the AMT need to have a tunnel to access downtown, then they should simply build another one.

This is a strange proposal: the public already owns a heavy rail tunnel to access gare centrale directly, but it will privatize it by selling it to the REM, way below the cost it would take to build the tunnel. The REM would then convert the technology to light rail. Then the public would invest a large amount of money, much more than it received for the selling of the tunnel, to build a second tunnel, again to heavy rail standards.

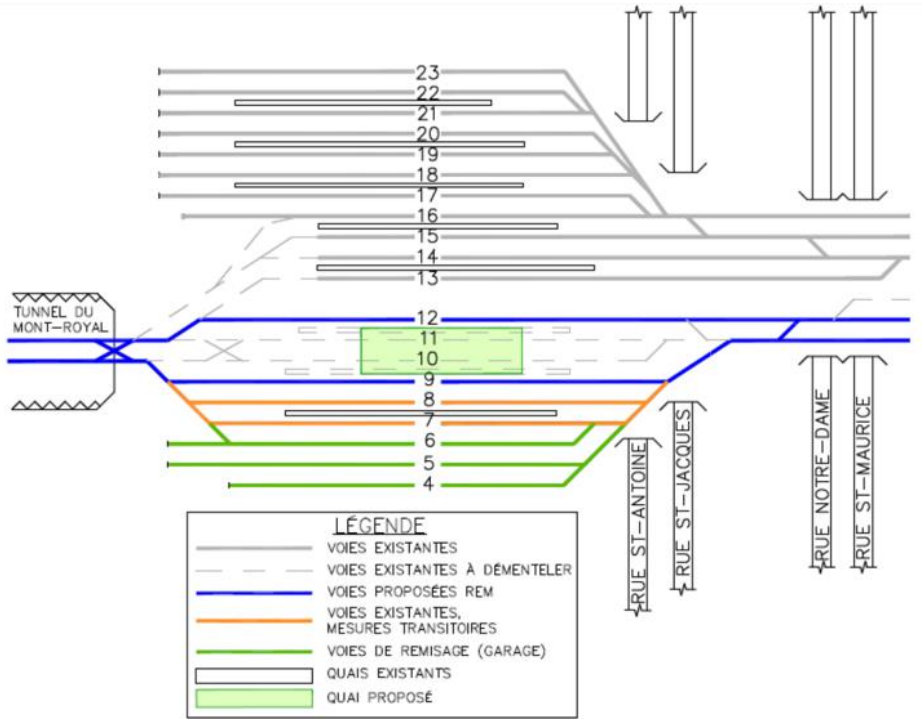
It would seem that under this scenario, it would make more sense if the CPDQ would itself just build a second tunnel.

In any case, the construction of a second tunnel is unrealistic. It may cost 1-2billion$. The cost would be high not only because of the long length of the tunnel and the depth under Mount Royal, but also the complicated insertion into downtown. Right now the Mont Royal tunnel feeds into Gare Centrale. On the North side of Gare Centrale, all the access is blocked by buildings, except for McGill avenue -- where the current Mont-Royal tunnel is.



Gare Centrale, left is North. The REM will take over the part of the station that connects the Mont-Royal tunnel (image: Google Maps, modified by author).

The REM will take over all the parts of Gare Centrale that connect to McGill college, which means any access from the North to Gare Centrale, from McGill Avenue, will be blocked. Thus, Inserting another tunnel into the station will be extremely difficult and thus very expensive.



The REM will take over the Western half of Gare Centrale Source: PR5.2.1, CDPQInfra

Do We need Two Tunnels?

A two-track tunnel can provide a capacity of 40,000-60,000 PPHD (people per hour per direction). The Metro de Montreal can provide 36,000-40,000 PPHD. The RER in Paris provides close to 60,000 PPHD.

The REM is built to provide a capacity of 24,000 PPHD. This includes transfers from the Mascouche line, and possibly some spare capacity, but not transfers from the St-Jerome line. Without transfer from the AMT lines, the REM may only need 20,000 PPHD.

The AMT, via it's St-Jerome and Mascouche line, may only ever require 15,000 PPHD or 20,000 PPHD. A 2007 AMT study to place stations in the Mont-Royal tunnel, at McGill and Edouard-Montpetit, assumed 15 minute service each on the Deux-Montagnes, St-Jerome and Mascouche line, with up to 2300 passengers each. This means each line would provide a capacity of up to 9,2000 PPHD. So the St-Jerome and Mascouche line, if connected to the tunnel and upgraded, may require another 18,000 PPHD.

VIA will require 800 PPHD, based on procuring trains with 400 seats running up to twice an hour.

So the total required capacity is less than 40,000 PPHD - which the tunnel could provide.

Therefore it does not make sense to convert the tunnel to a completely new technology that will keep the capacity at half of what is possible, due to the short trains; while building a second tunnel that will also only need half its theoretical capacity.

It makes more sense to convert the one tunnel we have today to 40,000 PPHD, rather than build a second one and have two tunnels each providing 20,000 PPHD.

In conclusion, it is much more reasonable and cost-effective to share the tunnel.

6.4. Solution & Alternative: Description of a Shared System

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

In the following, I will outline how the REM system may be altered to accomodate 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 shall include the 'potential' stations of Mcgill and Edouard Montpetit because they are integral to the overall proposed system.

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

6.4.1. Frequency, Dwell times & Schedule

6.4.1.1. 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.

6.4.1.2. 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).

6.4.1.3. 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)

6.4.1.4. 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.

6.4.1.5. 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 (own work)

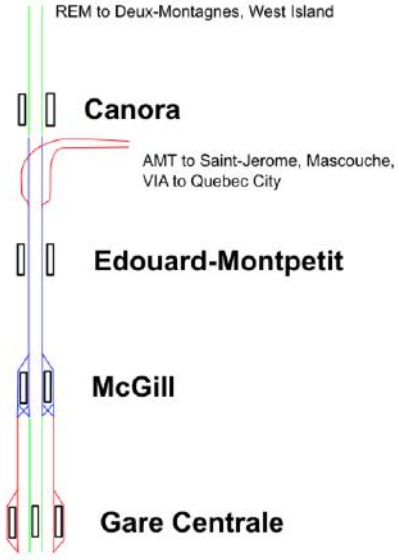
This allows servicing two terminals that require less capacity, without using up valuable schedule slots on the downtown trunk line.

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.

6.4.2. 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.

6.4.3. 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.

6.4.4. 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.

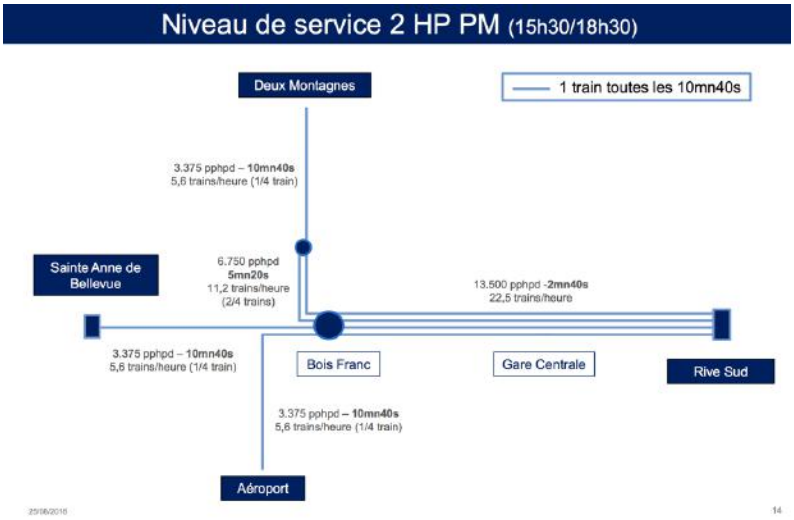
Having a 3-car units makes it easier to use the shared electrification of 25KV, which the Deux-Montagnes line and the Mont-Royal tunnel is equipped with today. The REM project includes conversion of the line to 1.5KV, due to weight concerns. By making the vehicle longer, the weight of the more heavy 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.

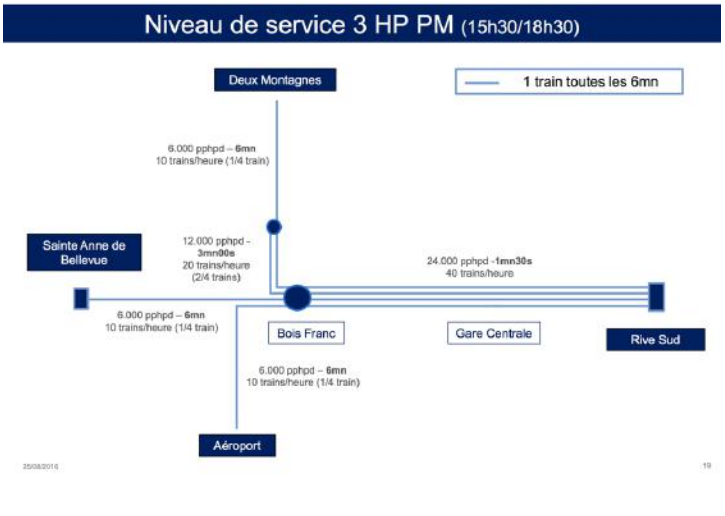
The existing REM is built to accommodate later extension from 4-car trains to 8-car trains, by extending platforms from 80m to 160m. Under the Shared System, the REM platforms would already be 6 cars long, so they should be built to accommodate later expansion to 9-car trains, that is, extension from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

6.4.4.1. 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

6.4.4.2. 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.

6.4.4.3. 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

6.4.5. 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’.

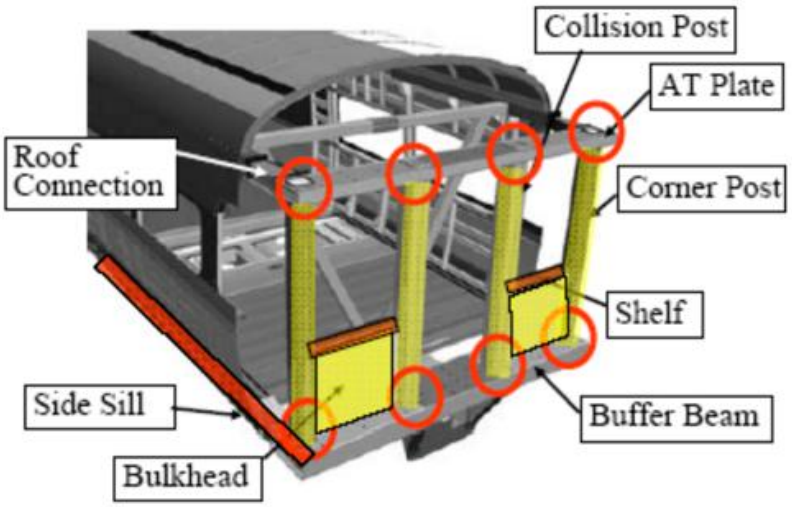
In order to understand this regulation, we have to consider some context. "Heavy rail" in North America is optimized for heavy Diesel Train whose safety is ensured passively. That is, rather than preventing collisions for example using signalling systems, trains are built 'like tanks' to make sure that 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).

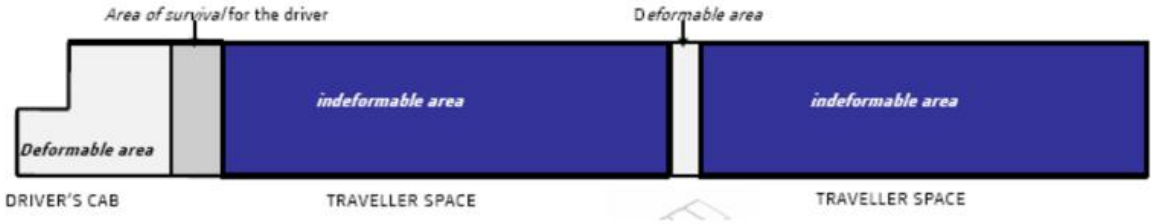


Figure 21 - Typical Crush Zones for European EMU Trainset (Courtesy Alstom)

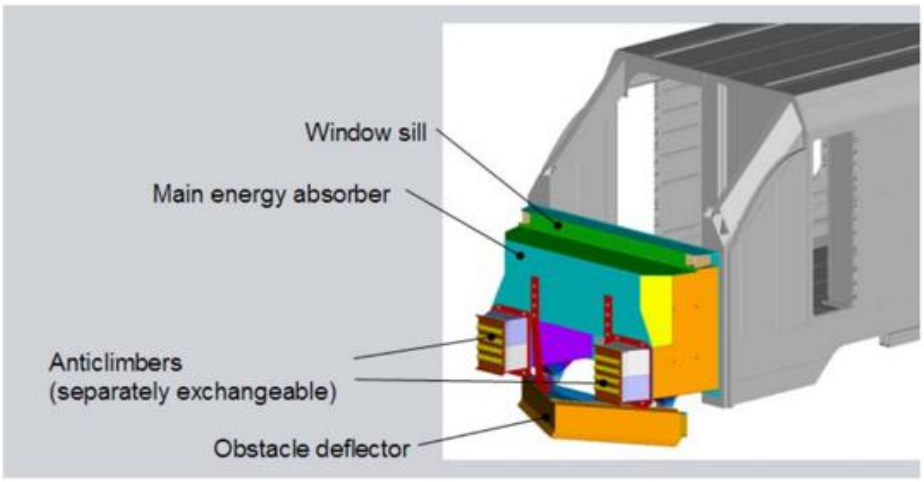


Figure 24 - Typical Cab Energy Absorber Arrangement (Courtesy Siemens)

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.
- 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.

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.

6.4.5.1. 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.

6.4.6. 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)

6.4.7. 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:

6.4.7.1. 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.

6.4.7.2. 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:

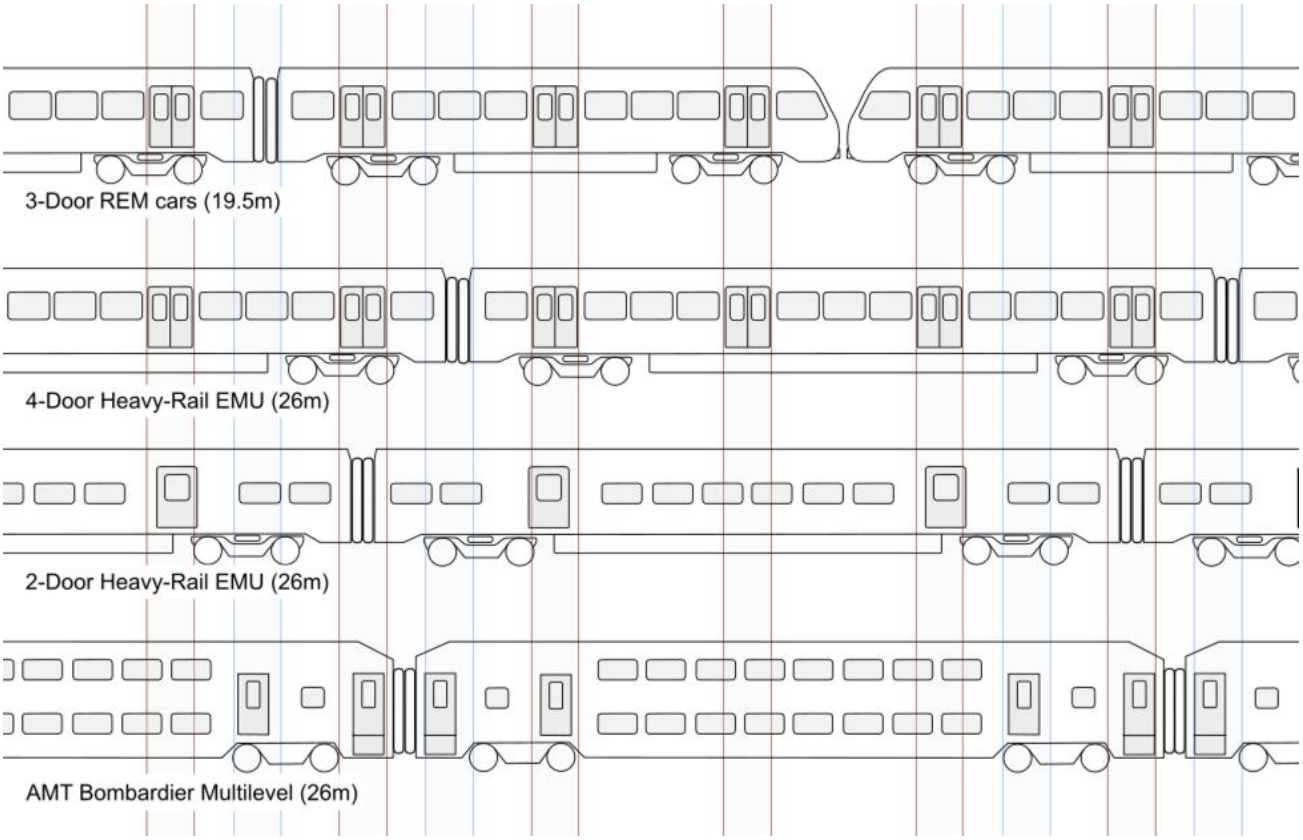
- Existing “Bombardier Multilevel” bilevel cars used currently by the AMT
- Future REM railcars
- Potential 4-door single level railcars, to be used by the AMT
- Potential 2-door single level railcars, to be used by the AMT

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.

6.4.8. 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.

6.4.9. 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.

6.4.10. 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 AMT Mascouche	AMT Deux-Montgnes AMT Mascouche AMT St-Jerome	REM Deux-Montagnes REM West-Island REM Airport	REM Deux-Montagnes REM West-Island REM Airport AMT Mascouche AMT St-Jerome VIA Quebec-Montreal
Tunnel Capacity	~17000 PPHD	27000 PPHD	12000 PPHD initially 24000 PPHD max	~40000 PPHD
Train lengths	260m	260m	80m	REM: 120m AMT: 210m
Train widths	3.2m	3.2m	3m	3.2m
Train capacities	2000	2000	600	REM: 1000 AMT: 1600
Tunnel electrification	25kv, 60HZ	1.5kv, DC	25kv, 60HZ	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

6.5. Additional Benefits / Reductions of Impacts of the Shared System

Having a shared system with less frequency on the out-lying branches will mitigate most of the impacts on the regional rail system, will provide a much higher capacity system that can handle much more ridership and thus have a much more positive environmental and economic impact overall, while at the same time allowing the CPDQInfra to advance with their project with mostly only technical changes to their project.

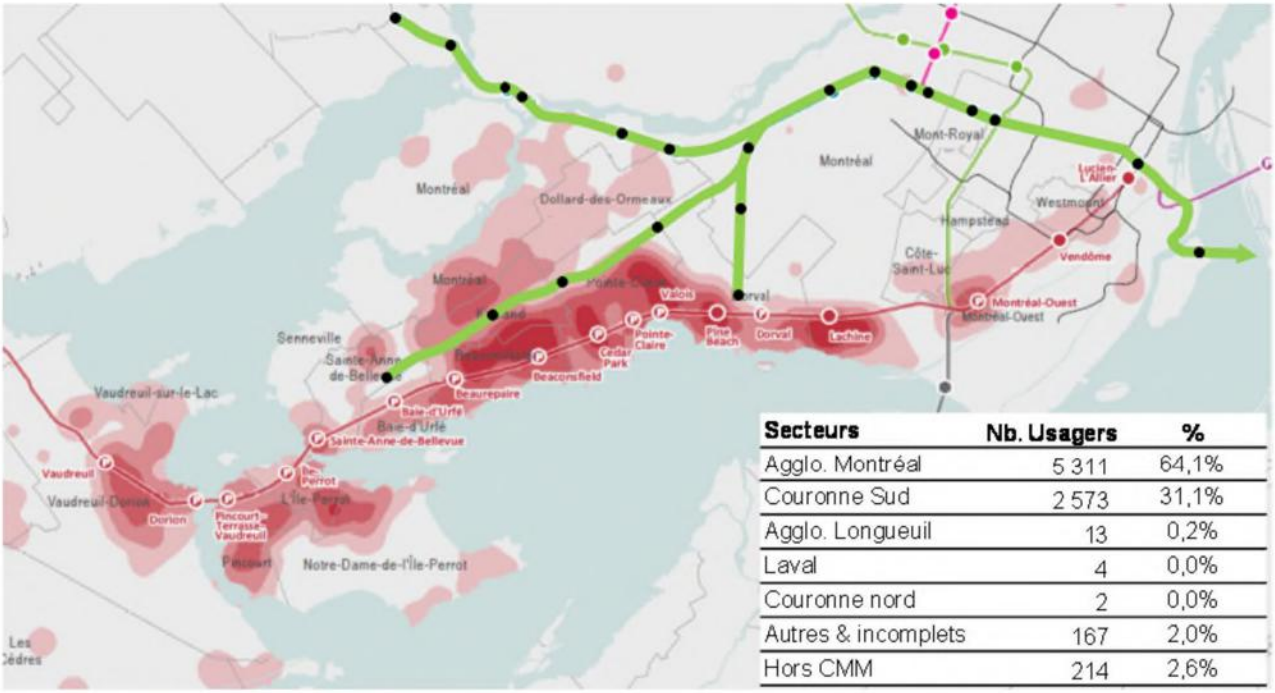
Besides removing the impacts on the regional rail system and increasing the environmental benefits associated with extra potential ridership, the shared system will have the following advantages:

- Keeping the single tracked bridges between Montreal, Ile-Bigras, Laval and the North Shore single tracked will reduce the environmental impact of double-tracking those bridges.
- By maintaining more compatibility with heavy rail (e.g. loading gauge, axle loads), it will be easier to maintain the freight service on the Doney spur.

7. Vaudreuil-Hudson line impact

The REM will be in major competition with the existing Vaudreuil-Hudson line.

Carte 11 : Origine des usagers de la ligne Vaudreuil-Hudson, 2015



Secteurs	Nb. Usagers	%
Agglo. Montréal	5 311	64,1%
Couronne Sud	2 573	31,1%
Agglo. Longueuil	13	0,2%
Laval	4	0,0%
Couronne nord	2	0,0%
Autres & incomplets	167	2,0%
Hors CMM	214	2,6%

Source : AMT. Traitement CMM, 2015

Source: DB-25 "Évaluation des impacts du réseau électrique métropolitain enmatière d'aménagement et de développement du territoire du Grand Montréal", page 19

- There are 3237 parking spots on VH line, 2853 West of Dorval, where the VH line and REM-West-Island-Branch compete with each other.
- The West-Island-Branch would have 5300 parking spaces, meaning up to 10600 trips are generated from drivers. This compares to a total ridership of 16800 per day, meaning up to 63% of the ridership of the West-Island-Branch of the REM will be due to drivers
- People who drive are more mobile, they can drive further to reach a station. It's possible that many drivers will abandon the VH line and use the REM line instead.
- The REM will provide much better frequency and all-day service. As VH-riders abandon the line, service may get reduced, especially off-peak (we only have the promise that there will be "no significant reductions in service during peak time"). This will create a feed-back loop where more riders abandon the VH-line.

How many people would transfer?

- Right now, based on parking utilization, we know about 5438 trips on the VH-line are generated from drivers (3237 parking * 84% utilization * 2 trips per day). This compares to a total weekday ridership of 15800 (all numbers in in 2015). This means that 10362, or about 66% of the riders reach the line without using a car. In turn, 34% of the ridership of the VH line comes from drivers.
  https://www.amt.qc.ca/Media/Default/pdf/section8/amt-rapport-annuel-2015.pdf
- If service is reduced on the VH line, these riders will be negatively impacted, they may drop using transit. That is, ridership on the VH line may decrease by more than than the number of riders that are converted from the VH line to the REM.
- Analysis:
  - The ridership on the West-Island-Branch is predicted to be 16800 trips per day
  - Three scenarios:
    - a) 2800 parking spots of the REM are used by VH-riders
    - b) 2000 parking spots of the REM are used by VH-riders
    - c) 1500 parking spots of the REM are used by VH-riders
  - Every used parking spot corresponds to two trips.
  - Utilization of the parking spots is 84% -> every parking spot generates 1.68 trips per day

scenario	Ridership moved From VH to REM	Direct Reduction of ridership of VH line (%)	Actual new ridership on REM West Island Branch
a	4704	30%	12096 (23% less)
b	3360	21%	13440 (15% less)
c	2520	16%	14280 (10% less)

- The REM studies show no indication that this impact was taken into account when calculating ridership effects and thus greenhouse gas effects
- Conclusion:
  - It is possible that 10-23% of the ridership on the West-Island-Branch may simply be existing ridership of the VH line converted to the REM; and that the overall positive effect of that line is exaggerated
  - It is possible that the VH may lose 15-30% of its ridership directly to the REM
  - Service reductions on the VH line may result in more ridership loss among non-drivers, potentially encouraging them to become drivers.
  - It is possible that converted VH riders that drive to the station will drive longer to reach the REM line, resulting in higher carbon emissions compared to today for those drivers.
- Potential Alternative - see next point

- Strengthen the Vaudreuil-Hudson line that is better at attracting non-driving ridership (This is realistic in particular with improvements that are possible in tandem with VIA rails ‘shared track’ plan)
- Choose an alignment for the West-Island-Branch that will result in
    - Less competition with the Vaudreuil-Hudson line (i.e. it is further away)
    - Attract more ridership from buses and walking to the stations
    - Rely less on people driving to the stations

8. The REM West Island Branch - Highway-Centric Transit

8.1. The West-Island Branch Proposed by the REM

The mandate the CDPQ was given included providing transit to the West Island of Montreal (the exact specification of the mandate were not provided).

Overall, the density of the West-Island is not very high, it is relatively suburban. This makes it difficult to provide a successful rapid transit system. The danger is that the system will rely too much on parking, and will induce more sprawl.

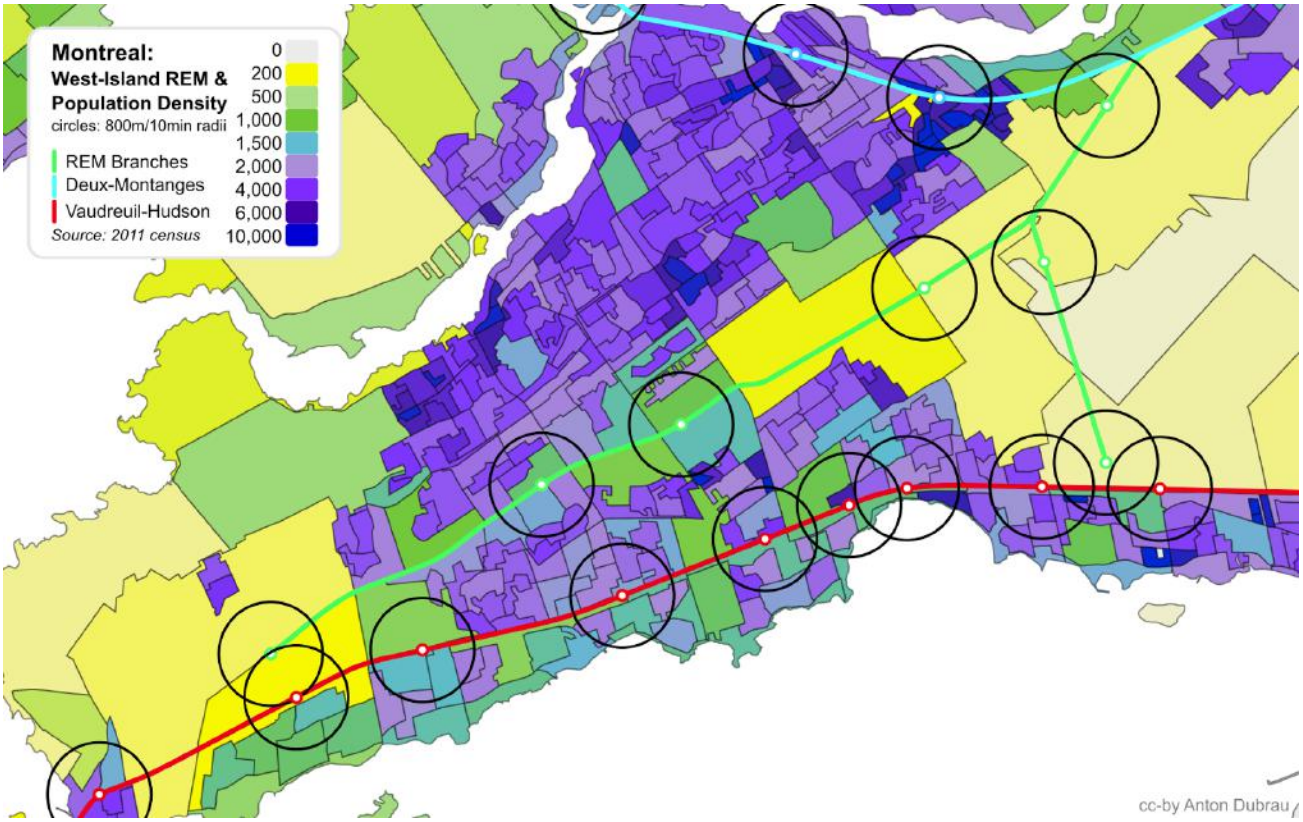
In order to build successful rail transit that will also help urbanize the area, several guidelines should be followed. In particular, the alignment should be carefully chosen to…

1. maximizes the number of **residents** within walking distance.
2. maximize the usefulness of **bus feeders**, making them as fast and convenient as possible and minimizing the impact of bus-rail transfers.
3. maximize the potential for **urbanification & densification** of areas surrounding the stations.
4. minimize competition with **other transit lines,** because there are not enough potential riders to support multiple competing lines.
5. minimize the **reliance on parking**, which should only be used as a last resort.

The West-Island branch of the REM does not follow these ideas at all, and focuses on parking as a first resort instead - resulting in an cost-ineffective project with low projected ridership, negative environmental impacts and few chances for urbanification and densification:

8.1.1. Residents within Walking distance

The alignment in the West Island appears to bypass populations -- very efficiently:



There is very little population within walking distance. This is very bad, because having people within walking distance is the most effective way to ensure that people will use the service. It's also the environmentally most beneficial way to access the station.

Furthermore, if users can walk to the station, they do not have to perform an additional driving or transit trip to reach the station. This trip can be perceived as more burdensome even if the absolute time to reach the station was less.

8.1.2. Connections to Buses

The Fairview station is about 1.0-1.2km West of Boulevard Saint-Jean, the major North-South bus corridor that is adjacent to the Mall. (CDPQInfra did not provide detailled plans for the station like they did for many others, so the exact connection is unknown).

The Kirkland station also appears to be about 1.0 km West of Boulevard Sainte-Charles.

This means buses which run along the North-South corridors have to travel East & West to reach the REM stations, causing delays of 4-8 minutes (due to the circuitous nature of these trips, that involve many intersections including left turns, the average speed may only be

10-14km/h, rather than the usual 18km/h when travelling along a straight suburban corridor, without turns).

The bus feeder systems for the REM will be based on a hub-and spoke system, rather than a rectangular grid. Near the convergence of the lines, bus service will be duplicated and travel parallel to the REM line. This service is inefficient, and more buses have to be run to provide same capacity compared to running a rectangular grid.

Any passenger travelling along the North-South corridors from one side of the REM to the other, will be forced to detour to the REM (it is unlikely that there will be extra bus services along the North South corridors that do not stop at the REM stations). The total delay for these detours may be in the range of 10 minutes.

8.1.3. Potential for Urbanification & Densification

Rapid transit should be built to allow densification around them. In a way, transit stops should become the centers of little transit towns, which should be dense and walkable.

The REM project will only allow for TOD projects that are right on the highway. Since the whole area is anti-urban and anti-pedestrian, the possibilities for urbanization are remote. It may allow large condo-developments, which are essentially condo-towers next to the highway, and do not form the kernel of continuously developed areas.

A lot of the area that is within walking distance of the REM stations on the West Island line is used up by the very wide A-40 corridor. It is also an urban barrier that is not permeable for pedestrians and cyclists

Besides by-passing actually populated areas, the line will have its boundaries outside of the developed area of the city of Montreal. This will have the opposite effect of densification - it will encourage sprawl.

8.1.4. Competition with Other Transit Lines

See section 7, on the Vaudreuil-Hudson line.

8.1.5. Reliance on Parking

The CDPQInfra, in the consultations, have repeatedly claimed that that the REM is primarily designed for reaching the station via active transportation. We've already discussed how the REM actually fails to provide service within walking distance of existing populations, and how it fails to provide convenient bus accesses.

On top of that, in particular the West Island Branch seems to be designed primarily for drivers.

Tableau 2 : Stationnements incitatifs

Ouest-de-l'Île			A10		
Gares	Capacité actuelle des stationnements	Capacité projetée des stationnements	Gares	Capacité actuelle des stationnements	Capacité projetée des stationnements
Gare Centrale	-	-	Gare Centrale	-	-
Canora	-	-	Ile-des-Soeurs	-	-
Mont-Royal	-	-	Panama	962	700
A40	-	-	Du Quartier	2 313 (Chevrier)	-
Montpellier	-	-	Terminale	-	3 000
Du Ruisseau	1 063	1 063			
Bois-Franc	742	742			
Sunnybrooke	515	515			
Roxboro–Pierrefonds	918	918			
Île-Bigras	65	65			
Sainte-Dorothée	1 101	1 600			
Grand-Moulin	304	304			
Deux-Montagnes	1 256	2 000			
Autoroute 13	-	800			
Technoparc	-	-			
Aéroport	-	-			
Des Sources	-	500			
Pointe-Claire	-	1 500			
Kirkland	-	500			
Sainte-Anne-de-Bellevue	-	2 000			
TOTAL	**5 964**	**11 710**		**3 275**	**3 700**

Assumed parking lots, page 8, CDPQInfra REM ridership study, August

The five stations of the West Island branch (Sainte-Anne-de-Bellevue … Autoroute 13) will have a combined capacity of 5,300 parking spaces. Since every parking space can generate two transit trips, this means 10,600 trips per day may come from car drivers, assuming full parking utilization and one single occupant per car. The ridership projection is 16,800, which implies up to ⅔ of the ridership may be due to drivers.

According to the same ridership study, there is a one-to-one relationship between available parking spaces and ridership at the two Westernmost stations, Kirkland and Sainte-Anne-de-Bellevue. This means up to 100% of the ridership may be drivers.

Note that the announcement that changes around the distribution of parking on the West Island Branch doesn't change the fact that most passengers will be drivers -- the stations were not improved to encourage active transportation access.

One thing to note is that the amount of driving to downtown is currently limited by the available parking downtown. Thus it is one of the main factors determining whether people will drive. Since a lot of the parking spaces are charged a market rate, the pricing will ensure demand matches availability.

The REM will provide a lot of additional parking that allows easy access downtown, but there won't be a corresponding reduction of parking spaces downtown. In effect, the total available parking spaces that allow reaching downtown will increase by the amount of parking the REM provides.

Any driver who switches to the REM instead of driving downtown will free up a parking spot downtown. If it is not taken up by another driver immediately, it will lower the cost of parking downtown, and then it will be taken by another driver. Thus, the REM may result in an overall increase of driving -- because the REM fails to encourage people to leave their car home altogether, i.e. to walk or take the bus to the station.

8.1.6. Additional Impacts

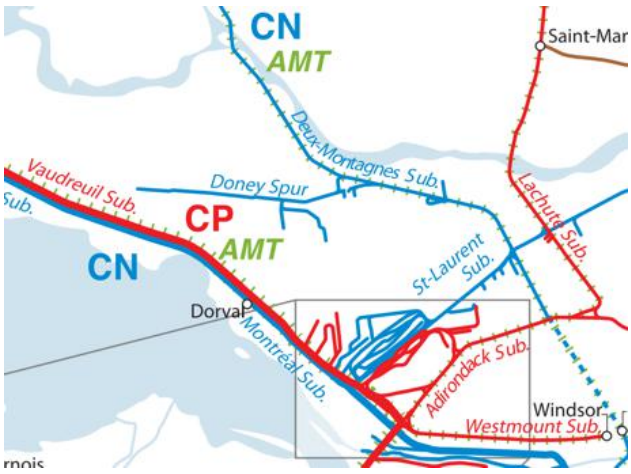
There additional impacts that do not fall under the previously mentioned guidelines for transit planning in the suburbs. They are specific to this project.

8.1.6.1. Putting Development Pressure on Sensitive Natural Areas

The station In the Far West will place development pressure on natural areas, in particular the natural areas of l'Anse-à-l'Orme.

8.1.6.2. Loss of Freight Service on the Doney Spur

In order to build the West-Island Branch of the REM the CDPQInfra proposes to use the "Doney Spur" currently used by freight rail. The conversion to light rail, will make it very unlikely that service will continue, due to incompatible loading gauge, weight restrictions, and grade (steepness of track) of the light rail system.



The doney spur (Source: Railway Association of Canada)
The loss of freight service will shift the traffic from rail to road, which will result in increased greenhouse gas emissions and particulate emissions.

8.1.6.3. Negative Health Effects of Living along Highways

The West-Island Branch of the REM will encourage development along the A-40 highway corridor, as people want to live close to transit. Besides being anti-urban and anti-pedestrian the A-40 highway is also anti-health. The negative health effects are numerous. They are largely due to noise and particle pollution. They will be described in detail in an appendix.

8.2. How to Improve the Alignment

Many urbanists would argue that transit should not be built at all in the West Island, because the above mentioned problems can not be overcome. They would simply argue to build transit elsewhere.

The CDPQInfra people appear to believe that themselves. In personal conversations at their information sessions, I questioned their choice of their plan placing all new tracks and stations along highways. They claimed there is no better alignment, and inquired why I think it's a problem. When I said that it means everybody has to drive to the station, they told me "Welcome to America!"

The anecdote underlines a problem with the thinking the CDPQInfra has with their REM project. Providing transit along highways, just for the sake for having a train, and because it can be built cheaply, does not address the needs of the Montreal Region.

Within the context of of this project, the alignment should be moved to reduce the impacts and improve the outcomes. The goal should be to:

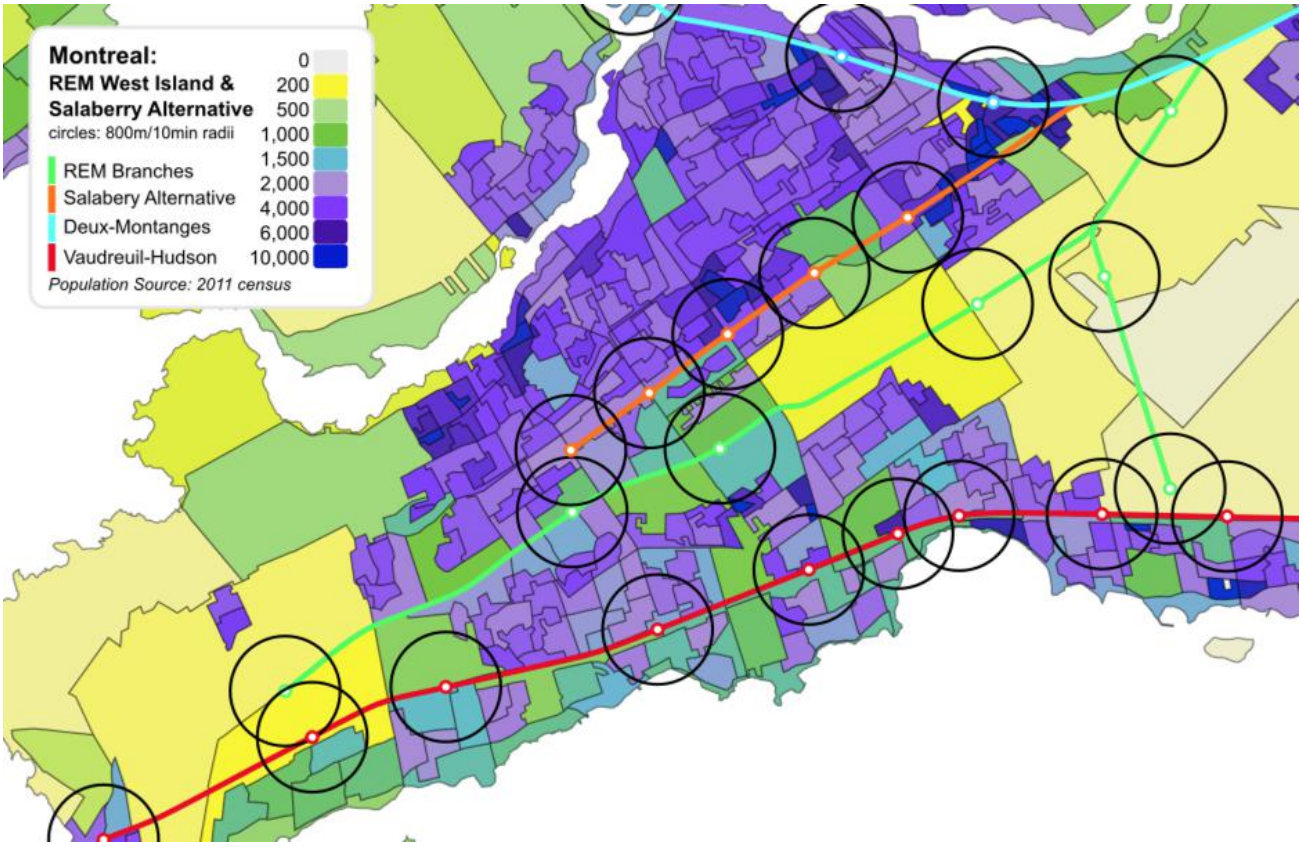
- move the line North to get it closer to population centers in the North (especially within walking distance)
- move the line North to reduce competition with the Vaudreuil Hudson line
- move the stations away from the highway and instead into areas that can actually be urbanified
- move stations directly onto the North-South-boulevards, so that buses will require no detours, and so that the transfers will be as quick as possible -- providing a straight grid of frequent buses exactly perpendicular to the train line
- reduce the length of the line so that it is completely contained in developed areas, to reduce development pressure on natural areas
- reduce the reliance on parking

8.3. A Possible Solution: The Salaberry Corridor

One plausible alternative corridor that can fulfill all the above requirements is the Hydro-Quebec right of way 1.1km-1.3km North of the A-40.

The Slaberry Corridor. Source: Hydro-Quebec

The idea of Salaberry was that it is largely owned by Hydro-Quebec, so relatively public, it's 40-60m wide and should have sufficient space underneath. It's also much closer to the Northern population centers. Also, the access further North means the Deux-Montagnes line is much further West, so you save 2km of tracks, relative to an access from the Doney Spur.



The Salaberry corridor: more people within walking distance, shorter bus trips for others

Together with saving 2km at the East of the line, shortening the line by 5km in the West, and having a straighter line, the Salaberry alignment would be 8.9km instead of the REMs 16.3km. By halving the line length, it is possible to build a **covered trench instead of an aerial line** for a similar cost.

There is currently a BAPE process because Hydro-Quebec wants to put another high-voltage line in the corridor, “Projet de construction du poste Saint-Jean à 315-25 kV et d'une ligne d'alimentation à 315 kV à Dollard-Des Ormeaux”. Local residents want the hydro line to be buried. There's an obvious opportunity to bury both electric and train lines, and build a reduced-footprint substation, which would allow creating a large linear park that would be interrupted by dense developments at each North-South boulevard.

Since the alignment is not along the highway, it is possible to place the stations directly under the North-South corridors. This will allow transfer distances of 30m, instead of ~200m - a reduction of walking time of 2 minutes. By having the stations directly on the corridor, buses will not have to engage in circuitous deviations for 0.9-1.3km, which at 10km/h may save 5-8minutes.

Overall, population North of the corridor can save 9-12 minutes compared to the REM proposal (4min North/South time savings, 4-6min East/West time savings, 1-2min connection savings). This will significantly encourage people to take the bus to reach the REM. This will have a large effect,

since there is more population North of the A-40 rather than South (especially when considering that the South is served by the existing Vaudreuil-Hudson line).

Population south of the A-40, who would have to travel further north, may still be able to save 2-3min, because the necessity to travel 1.0-1.3km further North along a straight corridor is offset by not having to travel a circuitous route 1.0-1.3km West or East along the the A-40, and by having a shorter connection.

By having a more efficient rectangular bus grid, rather than an inefficent hub-and-spoke system, it is possible to run buses more frequently (i.e. shorter bus trips means buses can run more often). This means the buses can run at the same frequency as the the rapid transit lines (6-12minutes), allowing **timed transfers**.

The overall point is that the West-Island branch can be improved a lot. Salaberry is only one possibility that allows implementing these improvements. The New-Brunswick corridor is another. CDPQInfra should study and consider these alternatives that are much more in the interest of the public, and that are much more likely to reach the stated goals of ‘bus first’ and discouraging driving to the stations.

9. 9.The REM Airport Branch: Expensive, Ineffective, Circuitous

9.1. REM Airport Branch Issues & Impacts

There are numerous issues and potential impacts with the airport branch of the proposed REM:

- The routing via the airport is a big detour, which passes through Wetlands, and will encourage development in the Technopark area (a suburban office park in a natural area)

- This big detour means that during the peak, the train is slow (since it has to make all stops), during the off-peak, it maybe be possible to run it as an express, which may be faster - but then it will only stop at Gare Centrale and Bois-Franc, meaning any passenger who has to connect via another station will require another transfer. So depending on the time of day the train is either slow, or requires an extra connection. As service increases on the REM, all-day high frequency will make the airport express impossible.

- The airport branch is expensive - 320M for just the infrastructure, plus maybe another 150M$ for 'material roulant et systeme' (based on the airport branch being 10% of the system, see DA-79 for a cost breakdown). This means the total cost of the airport branch will be around half a billion dollars.

- This compares to a daily ridership of only 2700 in 2022, and up to 4200 in 2041 under the optimistic scenario (based on August ridership study by CDPQInfra).

- This 110K$ - 170K$ cost per weekday trip would make the airport branch one of the most expensive transit projects in Canada (compare to the Orange line extension in Laval at 14K$ per weekday trip).

- The business case for using the Gare Centrale as the terminus (as favored by the Aeroport de Montreal) rather than using the existing AMT line which terminates in Lucien L'Allier (in the past favored by the AMT), was based on higher expected ridership. The Gare Centrale routing was supposed to bring in 10,000 riders per day (22% more than the Lucien L'Allier alignment), which is also what the CDPQInfra used in their Media documents.
  Their ridership study nevertheless only shows a ridership of 2700, which weakens the case Gare Centrale.

- The Caisse owns two of the four closest hotels to Gare Centrale, within walking distance: the Royal Elizabeth, and the Hotel W. The Caisse recently invested 140M$ in the Royal Elizabeth. Both assets will undoubtedly benefit tremendously from an airport train within 200m/500m (Gare Centrale), but will benefit less if the airport train is 800m/1000m away (Lucien L'Allier).

The Caisse also owns the Eaton Centre, Montreal Trust, and has invested significantly in Place Ville-Marie.

All these assets will benefit from an airport train going to Gare Centrale, which represents a conflict of interest:

The Caisse is planning to build a transit line, using large amounts of public funding and infrastructure assets, while not maximizing public utility but apparently maximizing the benefits to their own assets instead.

- The REM project overall will starve the VH (Vaudreuil-Hudson) line (see separate discussion). This may affect NDG and Lachine badly - the VH line could serve NDG and Lachine better if more station and service was added

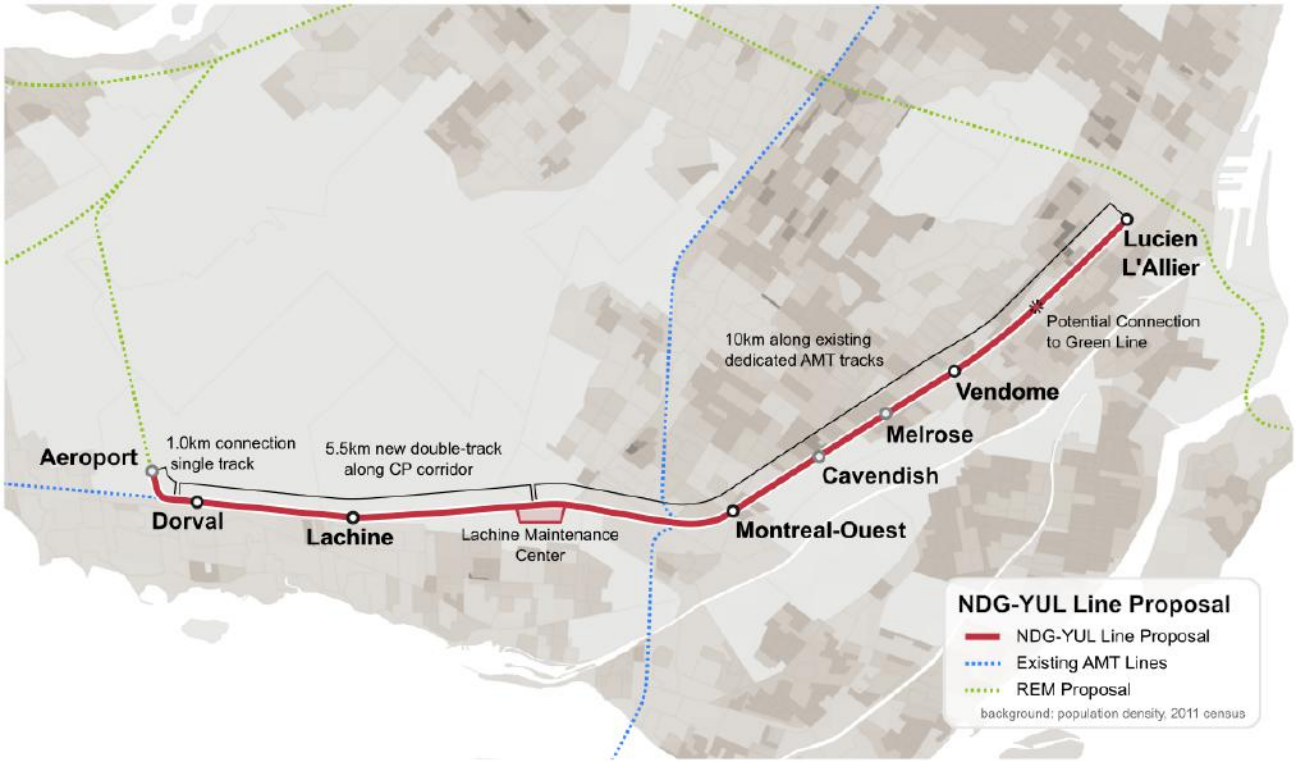
- Despite it's very low utility in terms of rdership, the REM airport branch will use up valuable schedule slots inside the Mont-Royal tunnel. For example, If service is provided every 10 minutes, and the maximum possible frequency through the tunnel is 30-40tph, then 15%-20% of the tunnel capacity will be used by the REM airport train. The Mont-Royal tunnel is a valuable asset whose utility should be maximized.

9.2. Proposed Alternative: Use the Vaudreuil-Hudson line to connect to the Airport & add stations in NDG

Using the existing Vaudreuil-Hudson AMT line to connect to the airport would solve a lot of these issues. For a similar cost, it would be possible to serve much more ridership and strengthen the Vaudreuil-Hudson line rather than weaken it.

At the same time, it would avoid the Technoparc area altogether.

I call this line the "NDG-YUL" line, because it serves Notre-Dame-de-Grace and The Trudeau Airport, which has the code YUL.



NDG-YUL Line Proposal Overview (image by Anton Dubrau)

The following will outline this alternative project in detail:

9.2.1. Rolling Stock & Schedule

The REM will make the MR-90 vehicles used on the Deux-Montagnes line obsolete. But they still should have 20 years of life in them (they are ~20 years old, rail vehicles generally are amortized over 40-45 years). These vehicles are electrified, they accelerate relatively quickly. They are fairly similar to metro vehicles, just heavier.

The MR-90 vehicles used on the Deux-Montagnes line. Source: wikipedia, Mtlfiredude

The AMT owns 58 such vehicles, which could be transferred from service on the Deux-Montagnes line to service on the NDG-YUL line as the REM starts operation.

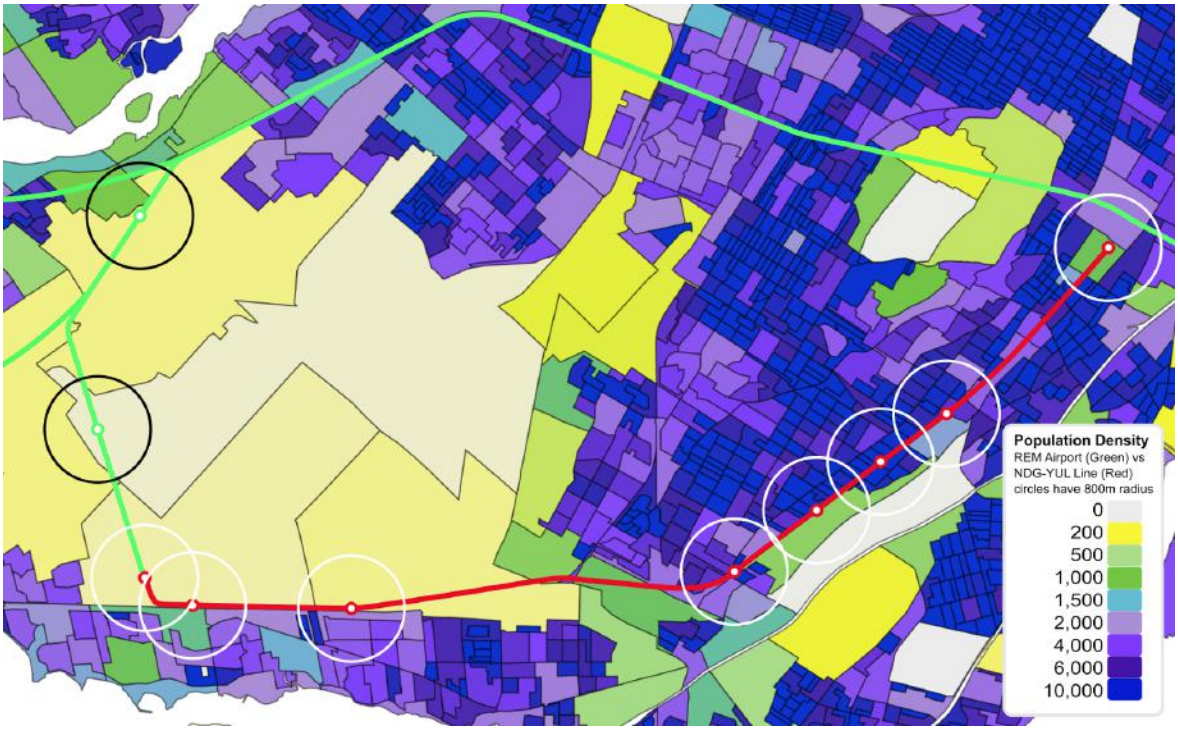
Service on the NDG-YUL line can be provided on a fixed-interval schedule exactly every 15 minutes, all day long. This requires 4 trains (one round-trip is 60 minutes). With 6-car trains, 24 vehicles + spares are required to operate the line. With 4-car trains, only 16 cars + spares are required.

With 6-car trains every 15 minutes provide a total capacity of 4800 people per hour per direction (PPHD). This may be increased up to 5500 PPHD by making seating more compact (or removing it), and changing the end-doors to be high-floor.

This means just on-peak capacity is about 25,000-30,000 trips per day (assuming ⅓ ridership going in the revere-peak direction), about twice the on- and off-peak ridership of the parallel 105 bus.

9.2.2. Nearby Population, Potential Ridership

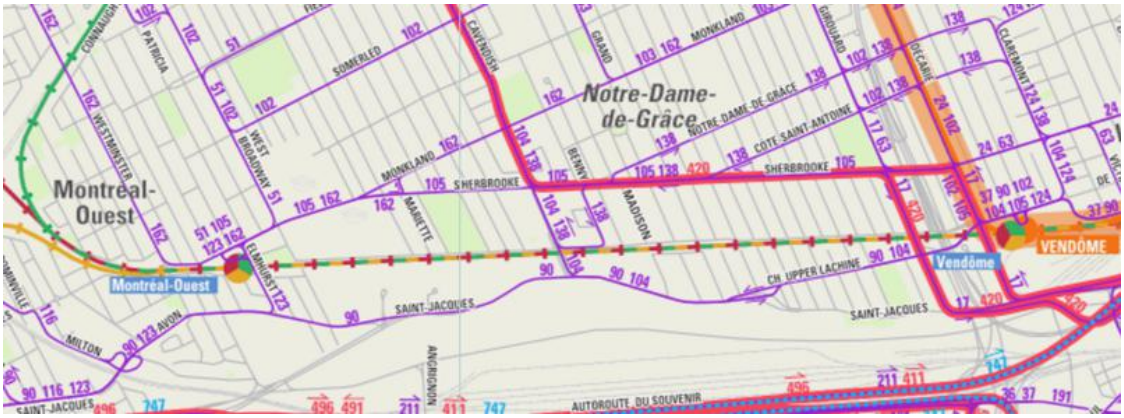
There is much more population nearby the proposed NDG-YUL line than the REM airport branch. Note that the REM airport branch by itself, for the cost of half a billion dollars, only adds the Technoparc and Airport stations. The A-13 stations that is shared with the West-Island branch of the REM may be counted as part of the airport branch as well.



Population density of REM airport branch vs proposed NDG-YUL line. It is easy to see that the potential stations would serve a lot of population within walking distance, with more population only short bus trips away. Source: 2011 census.

There is no detailed ridership study available, but based off just the ridership of the buses in the area (90, 104, 105, 420, 109, 162, 747), 20,000 trips or more per day should be relatively easily attainable.

This would mean more than 5x the ridership of the airport branch of the REM, for a similar cost.



Bus lines parallel to NDG-YUL line corridor, (STM map, 2012)

Bus Line	2011 Ridership
90	10,842
104	2,293
105	14,723
420	1,269
109	2,395
162	3,196
747	2,693
sum	**37,411**

Ridership of parallel bus lines (extracted from Opus card data), 2011

9.2.3. Required Construction

9.2.3.1. Track & Electrification

The project would require the following track construction:

- 10km of dedicated passenger rail track already exists between the Lachine Maintenance centre and Lucien l'Allier (owned by CP). It is mostly triple tracked, adding a fourth track may improve operations.
- 5.5km of new double-track from Lachine Maintenance center to Dorval, along existing CP/CN freight railway. Since the MR-90 are 'heavy rail', the tracks can be built along the existing corridor without sharing issues.
- 1km of single track to reach the existing airport station shell..

The total line length is 16.5km. In order to use the MR-90 vehicles, the line has to be completely electrified.

Electrification and dedicated tracks between Dorval and Lucien l'Allier will benefit the VH line, which will be faster on that segment (using the AMT's dual mode trains) and there won't be freight contention. In the future, dedicated tracks can be expanded further West, especially together with VIAs plan to build dedicated passenger tracks, shared with commuter rail, from Montreal to Toronto.

9.2.3.1.1. Schedule Conflicts

There would be a conflict between AMT trains and the proposed NDG-line train at Lucien L'Allier, because every 15 minutes it has to cross the AMT's tracks going in the other direction. This may block the tracks for 2 minutes or so, which should not be an issue (Union Pearson in Express operates similarly).

There is a conflict at Montreal-Ouest station with 10 downtown-bound trains per day of the St-Jerome line, which have to cross all tracks to reach the downtown-bound tracks.

There is also a conflict at Montreal-Ouest station with 9 outbound trains per day of the Candiac line, which have to cross all tracks to reach the outbound tracks.

On the other end of the proposed NDG-YUL line at Dorval, the connection should be built using a fly-over, so trains going different directions don't have to cross each other.

The signalling system on the line may have to be updated to support this operation.

9.2.3.2. Stations

There would be the following stations:

- Airport Trudeau (YUL) - use the existing station shell
- Dorval
- Lachine
- Montreal-Ouest
- Cavendish - new station along existing road underpass
- Melrose (Saint-Raymond) - new station on existing pedestrian tunnel
- Vendome
- Lucien L'Allier

High platforms at All stations will allow quicker turn-around time, and will reduce operating costs by allowing single-person operation. That is, no conductor is required if the boarding is level. The driver (engineer) can open and close the door while observing the platform via mirrors/monitors, like is done for the Montreal Metro.

9.2.3.3. Level Crossings

There are two level crossings at Montreal-Ouest. For 15 minute service, they don't *have* to be removed, but it should definitely be done if service becomes more frequent.

9.2.3.4. Downtown Connection

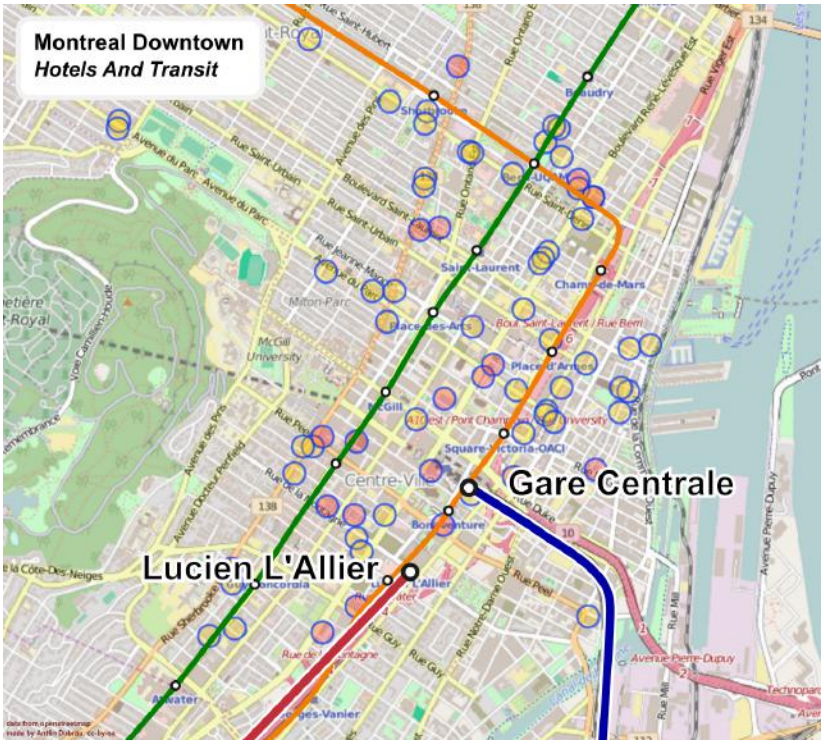
Note the use of Lucien L’Allier instead of Gare Centrale as a downtown terminus. Aeroports de Montreal has insisted on using Gare Centrale, explaining that an airport express would receive 10,000 riders per day if Gare Centrale was used, wheres Lucien L’Allier would receive 22% less ridership.

The ridership study by CDPQInfra only shows 2,700 trips per day. This appears to weaken the case for the necessity of Gare Centrale - the ridership is so low that the terminus should be chosen based on maximizing overall ridership of the line. Since the NDG-YUL line can capture many more riders, for the cost of just the airport branch of the REM proposal, Lucien L'Allier overall provides better cost benefit.

The main importance for the downtown terminus is a good metro connection, and a taxi stand.

Most population travelling to/from the airport will most likely not travel from downtown, necessitating the connection to the metro. The connection at Vendome will facilitate better connections than the REM to the Western and South-Western portion of Montreal.

Most international/business travellers will want to travel to hotels. These are spread relatively evenly throughout downtown, which means these travellers will also either connect to the metro, or use a taxi to make the final connection.



Hotels (yellow and red circles), relative to Gare Centrale & Lucien L'Allier. Source: openstreetmap

A taxi stand would be more convenient at Lucien L'Allier, due to shorter distance to reach the street.

The connection at Gare Lucien-L'Allier could be done by rebuilding the Northern-most track of the station (track 1). The platform should be high-level and on the North side, along the

current connection to the Metro -- this means the distance of the metro-transfer can be reduced.

Photo of track 1 (right) and track 2 (left) of Gare Lucien L'Allier. Note the passage on the right that connects to the Metro Station, which could be used to build the new platform.

There could be a single track for the NDG-YUL line at the Lucien L'Allier, which is a layout very similar to the Union Pearson Express in Toronto. There chould be a taxi stand directly connected to the station, to make it possible to reach nearby hotels.

Schema of proposed Station. Note the more direct connection to the Metro (image: Google Earth, modified by Anton Dubrau)

Union Pearson Express downtown station (source: wikipedia, photo by TheTrolleyPole)

9.2.3.5. Cost Summary

I can not provide valid cost-estimates. But I can give general ideas based on the costs of similar projects.

Capital cost general guidelines of the YUL-NDG-line, see cost references below:

- 800m single-track connection to airport: 70M$ [1]
- 6km of two dedicated tracks along CP/CN line: 90M$ [2]
- 16.5km of electrification (~5M$/km), signalling upgrades: 100M$ [3]
- 12M for 7 stations each to build high platforms: 85M$ [4]
- Modification of 20-30 MR-90 rail-cars (~0.5$M): 15M$
- optional: A fourth track from Montreal West to Downtown 7.9km: 60M$ [2]
- optional: removing 2 level crossings at Montreal-West: 80M$ [5]
- **total: 360M$ - 500M$**

Cost references:

1. Compare to Union Pearson bridge connection, 128.6$ Million for 3.3km of elevated double track spur. source
2. AMT Westmount third track project (4.8km of track for 35.6M$ -- 7.5M$ per kilometre of track along existing ROW) source
3. The Toronto Electrification Study indicates a cost of ~5M/km for electrification
4. based on Fairmount line, 12.2-17.7M USD per 800ft station/platform added to existing line source
5. based on the AMT Jonction de l'Est grade separation project (60M$ AMT PTI 2014-2015-2016, page 74)

Depending on the detailed design of the line, it may have similar cost as the REM airport branch. Since the ridership potential is 5 to 10 times more (15K-30K vs 2.7K), the cost per rider is lower by the same factor.

Note that this project is a subset of the "train de l'Ouest" proposal by the AMT, in 2010. It envisioned creation of dedicated tracks from Lucien L'Allier to St-Anne-de-Bellevue along the Vaudreuil-Hudson line, and creating a connection to the airport. This project included almost triple the amount of new track, and new rolling stock, but no electrification. Projected cost was 768M$.

9.2.4. Operating Costs & Profitability

Unlike the REM proposal, the NDG-YUL line would not be automated. It would be a conventional heavy rail line, except using single-person operation (like the O-train in Ottawa).

The potential for profitability is high for the following reasons:

- It is a relatively short surface line (16.5km)
- There is a lot of ridership potential along the line (especially relative to its length)
- The airport passengers pay a relatively high fare - they may only represent 10% of the ridership, but pay 10x the fare, so may double the revenue given the same capacity. So if the line would have a fare-recovery ratio of 60% without the airport passengers, then it may be over 100% with them.
- There is the chance to use a lot of existing infrastructure and rolling stock which allows keeping capital and operating costs low
- A lot of the infrastructure is shared with other lines which will reduce maintenance costs for each individual line
- The line would be electrified, lowering operating costs
- The line would have even, continuous service, instead of peaky service like traditional commuter rail, which increases productivity and reduces labour cost due the possibility to have normal shifts without gap-times and high utilization, and no dead-heading

- During the off-peak and weekend, trains can be shortened from 6- or 4-car trains to 4-car or 2-car trains.

A note on operator salaries:
With four trains, the salary for engineers (drivers) is about

5 driver/train * 4 trains * 100K$/driver = 2M$/year

This implies a cost of 7700$/weekday. At only 1$ per trip per day (2$ per round trip), only 7,700 extra trips are needed per week day (and 0 on the weekend), relative to the automated REM airport branch proposal, which is easily achievable.

Since the capital cost per rider is much lower, every trip has to pay back less of the capital cost. Thus, less operational efficiency (due to having drivers) can still result in an overall higher return.

9.2.5. TOD Development Potential Along the Line

There is some opportunity for TOD (Transit Oriented Development) along the NDG-YUL line.

Unlike the REM proposal, the stations are in more urban areas that are closer to the city, and farther away from highways. They can be added to the existing city, and add to the urban fabric.

The station at Cavendish represents the largest potential. North of the potential station there are many dense high-rises already, but South of it there are low-density commercial/industrial areas that could be densified.

Proposed Cavendish station with potential TOD development area. The area represents about 170,00 m^2, 41.93 acres, 0.170km^2 (source: Google, modified by Anton Dubrau)

Station Montreal-Ouest may also have some development potential, although the amount of useable space is much smaller. The area can be increased if there is a grade separation project removing the level crossings before and after the station that would place the tracks in a covered trench. Then the area on top of the station could be developed.

9.2.6. Funding Model

The PPP funding-model that the Quebec government and the Caisse de Depot have agreed to, which includes outright privatization of the infrastructure, is inappropriate for the proposed NDG-YUL line, since it requires sharing of infrastructure with the AMT. Most of the required infrastructure is currently owned by CP (Canadian Pacific).

A more traditional PPP model may be more appropriate, in which the capital costs are shared between the public and the private partner, and the private partner would receive a long-term concession to operate the line and receive profits.

Since NDG-YUL line would not be automated, it may require some subsidies.

It would be appropriate to find the private partner in a competitive bidding process, rather than offering this project to the Caisse de Depot by default.

9.2.7. Relevant similar Transit Line Projects in Canada

O-train Ottawa:
The O-train showcases the idea of operating two trains shuttling back and forth, providing a 15 minute service on a short 8km line, while being a very capital efficient project. Note the NDG-YUL-line would be almost exactly twice the length of the O-train, which explains the need for 4 trains to provide 15 minute service. The O-train does not use conductors, which is one reason for its relatively low operating cost of only 4-5M$ during the initial project phase in 2001/2002 (Fact-sheet: http://bit.do/otrain).

Despite not directly connecting downtown, and not serving many population centers, the line generated 9,000+ riders per day in its first couple of years, and about 14,000 about ten years after the beginning of operation. This shows that users are willing to accept transit that is provided on a simple-to-remember, fixed 15-minute schedule.

Union Pearson Express:
A rail line in Toronto going to the airport, using an existing commuter rail line. Service is provided every 15 minutes, 7 days a week.

Note the project cost of 460M$, 75M$ of which were to purchase vehicles - this won't be necessary for the NDG-YUL line, because of the re-use of existing rolling stock. The connection to the airport at Toronto Pearson Airport is a 3km double-tracked bridge. The Montreal airport only requires 1km of single-tracked line.

The downtown station and airport stations of the Pearson express are relatively elaborate, the NDG-YUL-line could be a bit simpler. Also note that the airport station shell in Montreal already exists.

The Union Pearson was built as an airport-express only, without helping adjacent communities. Fare integration is poor. Transfer walks are long. This explains its relatively low ridership (8,200 as of July 2016) and makes the whole project somewhat capital-inefficient.

The Union Pearson Express uses no fly-overs when mixing into and out of existing commuter rail lines, but provides 15 minute service -- which shows that possibility.

The Union Pearson express uses Diesel trains and it uses conductors, so operating costs are relatively high.

10. Poorly serving Griffintown, Old Port, Pt-St-Charles & Expensive Peel Bassin Tunnel

10.1. 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.

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.

The REM plan will also include the closure of Ottawa street, which previous plans identified as a good location for rapid transit.

The stations should be restored to the proposal, and Ottawa street should remain open.

10.2. Previous Proposals

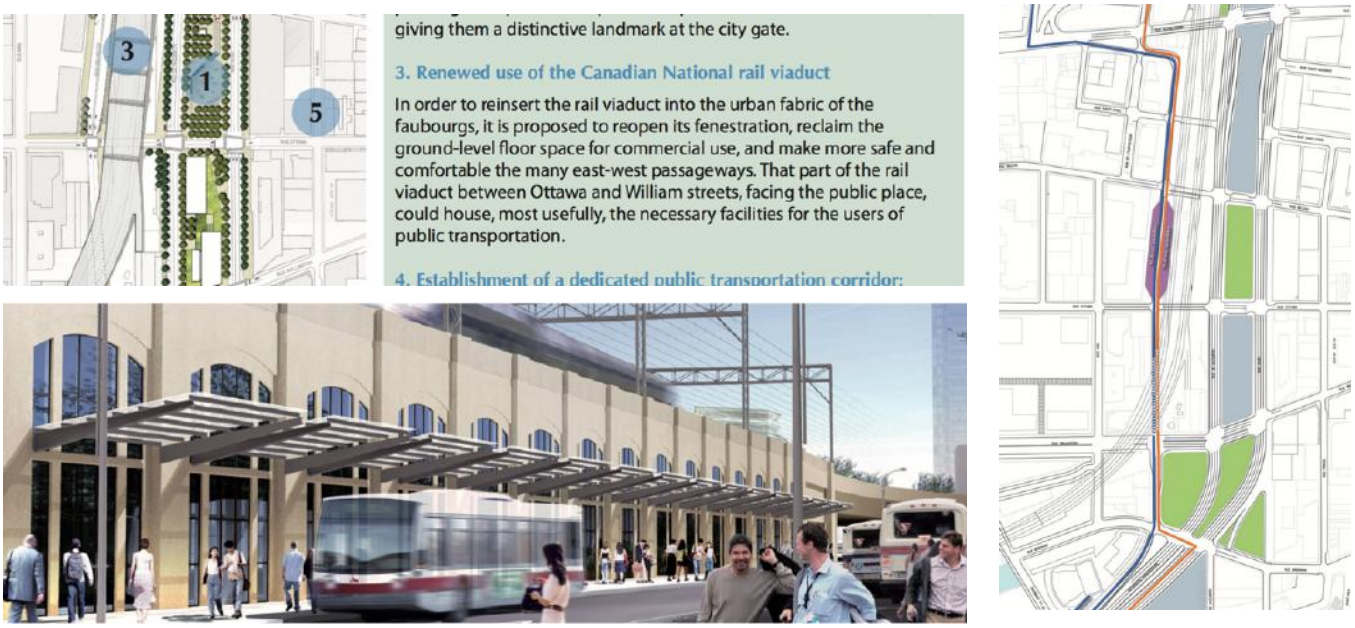
Champlain SLR Studies

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.

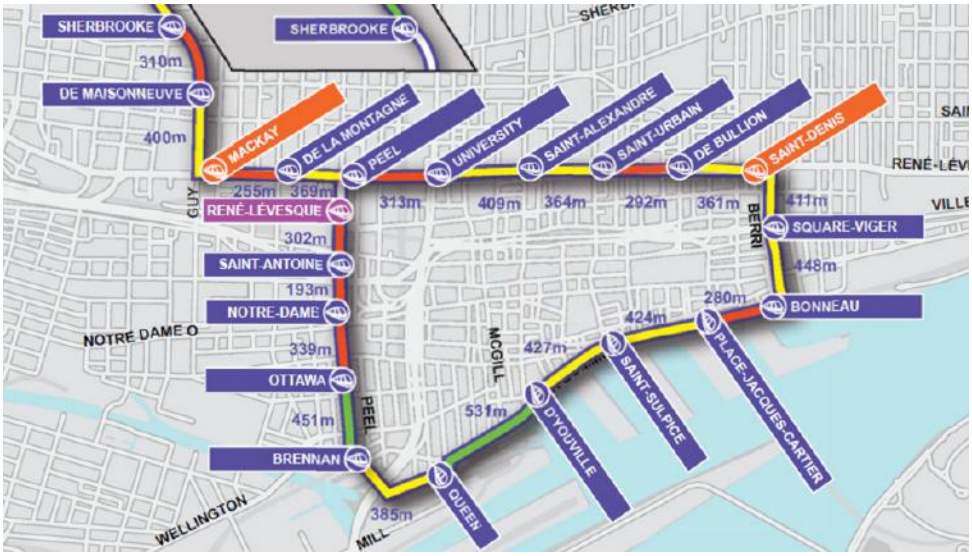


Several excerpts from the document "Transformation of the Bonaventure Expressway at the Downtown Gateway", showing the urbanization plan and usefulness of a transit station at Ottawa.

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 studies 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 -- exact 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.

10.3. Ridership

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.

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.

10.4. A Potential Solution

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 above ground to below ground, 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.

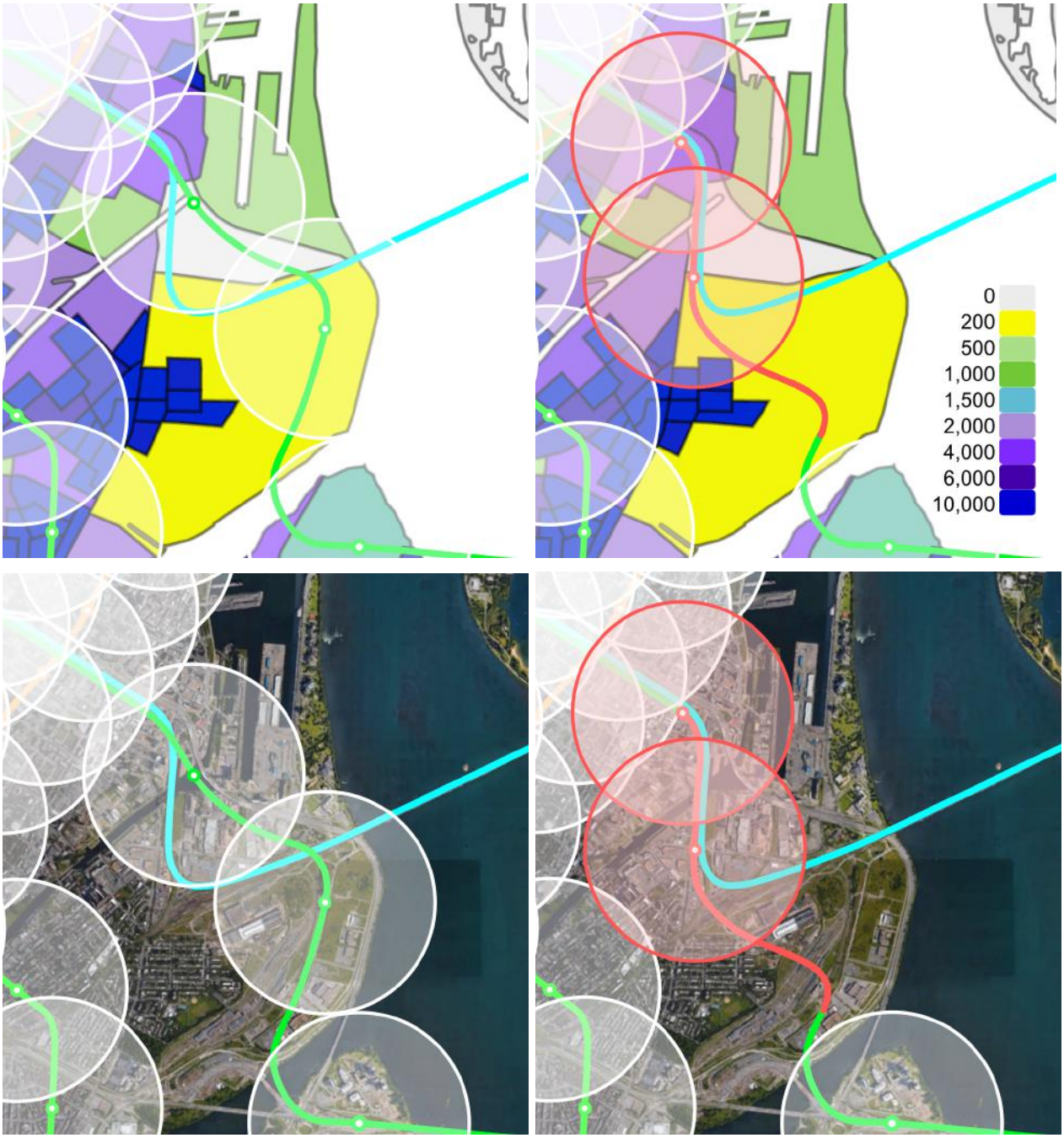
Around Ottawa, the bridge is about 8 tracks wide -- enough for 3 heavy rail tracks, 2 REM tracks, and a REM station.

CN rail viaduct South of Gare Centrale. Note the large amount of available space. Ottawa street is the one just before the bend on the left. Note the historic rotating bridge, which blocks reconstruction of the bridge. 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, adjacent metros & 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*. 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.

10.5. Cost

The usage of the CN rail viaduct would represent the 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 Bassin, and a station under the Peel Bassin.

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 Bassin tunnel.

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

*see source: “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

11. Station Placement and Transfer Issues

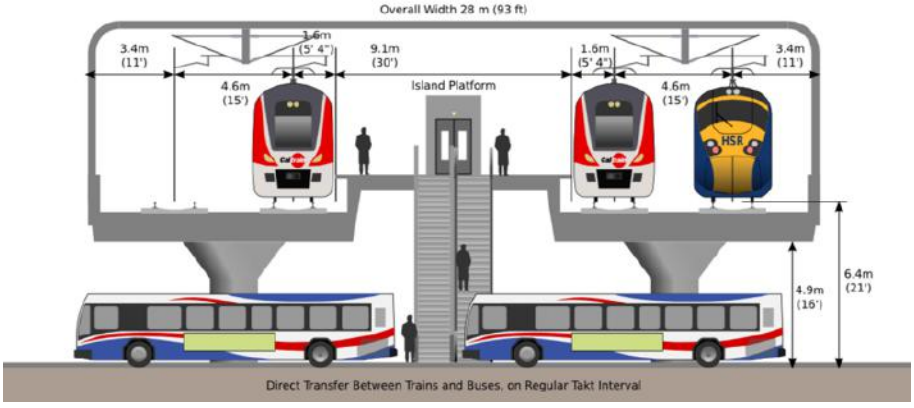
The issues related to station placement of the West Island Branch was already discussed

Panama
One issue is the transfer at Panama. Right now there is no transfer, buses are directly going downtown. Adding the transfer discourages ridership, people will perceive transfer time as 2x in-vehicle time. So even if the total time is not dissimilar, the effort of transferring (especially including long walks) will dissuade ridership.

One issue is the design of the Panama station. Its build with transfers that are 150m-300m long, which means 3-5min to transfer. The fastest transfer is only for exits, and and the quay is aligned only for buses coming from West - at Panam, most buses arrive from the East (i.e. Taschereau). In order to reach the quay, the buses will have to engage in detours.

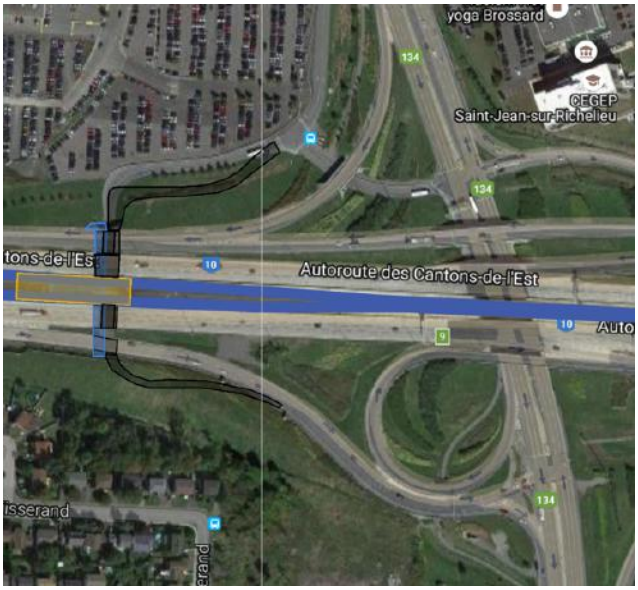
This design is especially bad for the future BRT on the Taschereau corridor, which may also be implemented as a tram. With the large detours, it will make any trip that goes from one side of Panama to the other very slow, which will completely weaken the usefulness of the BRT corridor and the chance for urbanification and densification of the corridor -- if you use transit, areas that are 400m apart will appear like 4km apart, due the long time to travel those 400m.

The station should be re-designed to allow a more direct connection. In particular the buses should stop right under the rail platform.



Optimized bus/rail transfer

This could be possible with a configuration that is something like this:



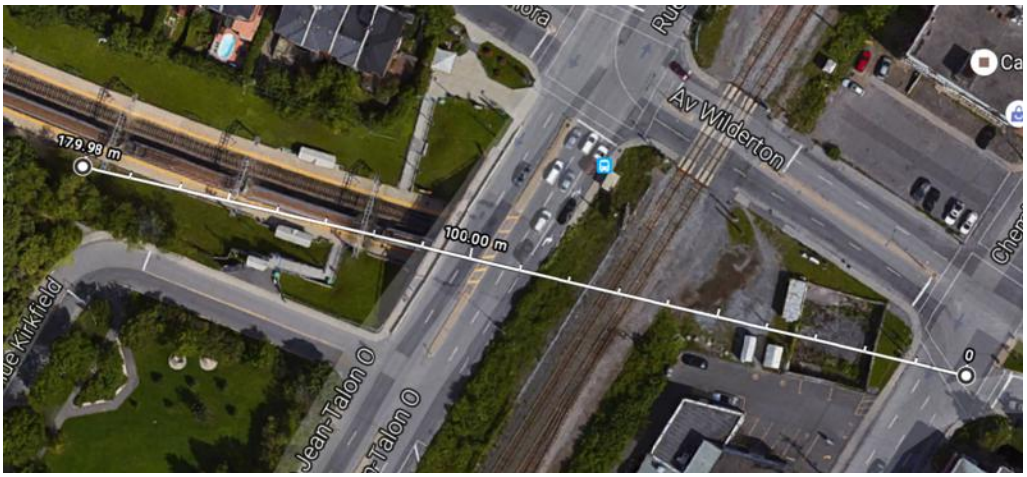
Proposal: Bus platform right under Panama station

One issue is the many bus lines that stop at Panama -- the reason for that is the lack of stations in the South Shore. If more stations were added, then the bus lines would be spread across multiple stops. This also means shorter time to reach the station for bus users. And it would also mean more people within walking distance.

One possible station location is at Boulevard Milan.

Canora

There is a slight curve at Canora station. CDPQInfra have said they will have to place the station North of the curve. This is unfortunate, because it will create a longer connection with a possible St-Jerome line station and it will move the station away from Cotes-des-Neiges.



Canora. Deux-Montagnes line is left/right, entering the tunnel in the Center. The railroad tracks going North/South are the CP tracks used by the St-Jerome line

As you can see in the map, there is a slight curve on the left. Since the area on the East, in Cotes-des-Neiges is more populous, the ridership potential is increased. There is also no further station for quite some distance, whereas on the West, TMR station is only about a kilometre away.

It would be possible to place the station in the mouth of the tunnel (see highlighted white line, which is 180m long). From the intersection of Wilderton/Bates, the tunnel widens sufficiently to accomodate a station, only the rail track-bridge is narrower.

This would improve the connection to population, it would improve the connection to the St-Jerome line, by making the walking distance smaller and obviating the need to cross the wide Jean-Talon street and the CP railraod tracks.

The Eastern portion also has more development potential, which could offset any increased station building cost due to the tax-increment-financing scheme and selling of development rights.

12. Construction Impact on the Deux-Montagnes line

The REM project proposes major changes to the Deux-Montagnes line. Many grade crossings would be removed, some sections would have to be elevated, completely new stations would be built, the signalling system and electrification system have to be rebuilt.

CDPQInfra have claimed that they attempt to minimize construction impact. An idea that that has been reported is to convert the Deux-Montagnes line to single track operation, while rebuilding the track to the proposed light rail technology. Once track is finished, service would switch over to light rail, while the first track would get rebuilt.

The conversion of the Deux-Montagnes line to single track operation would result in severe impacts to service. CDPQInfra have said that service would only be provided during rush hour, and only in the peak-direction. Basically, all available rolling stock would make a single trip to downtown; and in the afternoon all the trains would run back.

This implies the following impacts:

- Complete loss of off-peak service.
- Complete loss of service in non-peak direction during peak.
- Major loss of peak service in the peak direction:
    - There are only 58 MR-90 vehicles. They are currently used in 10-car trains.
    - Using 8-10 car trains, this means at most 6 train-sets.
    - Between 5:50 and 10:10, there are currently 11 trains in the peak direction
    - Between 13:00 and 19:30, there are currently 11 trains in the peak direction
    - This means peak service will be cut in half.
- Overall, 50 trains per day will be reduced to 12 trains per day

Additionally, the Mascouche line will also be cut off from the tunnel, presumably it will terminate at Sauve. This means all the ridership of the Mascouche line will add to the Orange line, which as at capacity on that segment.

The loss of rail service may mean bus-substitution will have to be provided. It may add 20 minutes or more to travel time. This means users may end up switching to using cars, or buying cars.

This situation will persist over multiple years.

12.1. Possible Alternatives

If the line was continued as a heavy rail line, it may be easier to keep short double-track sections that would allow more service. The Mont-Royal tunnel only takes about 7 minutes to traverse, so even if that tunnel was reduced to a single track during construction, service could largely be kept as today if the remaining line stayed a heavy rail line.

If the tunnel has to be shut down completely for upgrade work outside of rush hour, it's possible to divert the Deux-Montagnes line to the Metro Network without using the tunnel.

It is possible to connect the Deux-Montagnes line to Du College Station via jonction de l'Est and CN's St-Laurent Subdivision.

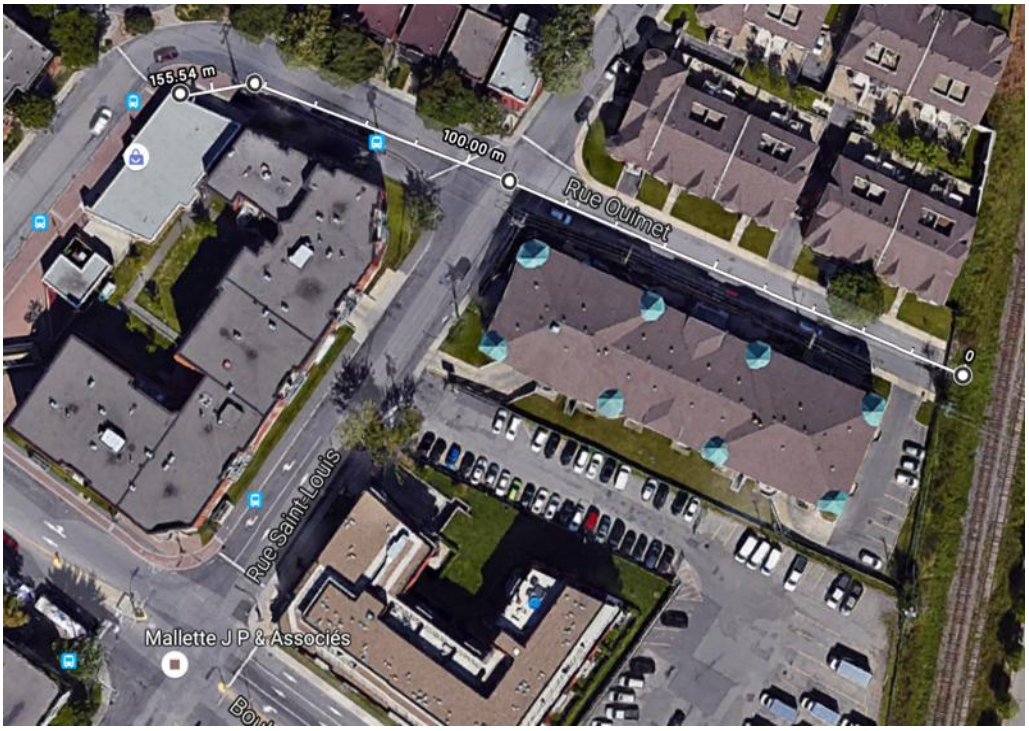
The 2.0km connection between existing Deux-Montagnes line and Metro Station Du College along the CN freight line (map: Apple, modified by author)

The line is a 2.2km detour. At 40km/h, it takes about 200 seconds travel time from Montpellier station.

Currently the travel time between Deux-Montagnes and Montpellier is 24-28 minutes. Together with the travel time to Due College station, a ~60 minute round-trip time may be possible between Du College and Deux-Montagnes.

Passengers would transfer to the Orange line at Du College to be able to travel downtown and elsewhere. The Western branch of the Orange line has sufficient capacity to absorb the Deux-Montagnes riders.

The transfer at Du College would be about 160m from the rail platform to the nearest metro entrance.



Connection between freight rail corridor and Due College Metro Entrance (map: Google, modified by author)

12.1.1. Possible service Scenarios

- With a single track for the whole line, a single train can provide service approximately every 60 minutes.
- With a single passing siding (around Sunnybrooke station), two trains can provide service approximately every 30 minutes.
- With two passing sidings (near Roxboro and Bois-Franc stations), three trains can provide service approximately every 20 minute. In practice, maybe only 25 minute service is possible. The 20-25minute service would be similar to today.

12.1.2. Benefit

The scheme would allow more complete service during construction.

There would be significant travel time benefits compared to bustition, or even driving.

Travel time comparison:

- Currently, the travel time between Montpellier and Gare Centrale is 12 minute during rush hour using the Deux-Montagnes line, without any transfer.
- With the deviation via Metro du Du College, the travel time between Montpellier and Gare Centrale would be as follows:
    - 3.5 minute rail travel time from Montpellier to Du College by train
    - 4 minute transfer at Du College from train to metro

- 1.5 minute (average) waiting time for the Metro
- 15 minute travel time on metro from Du College to station Bonaventure

The total travel time would be 24 minutes.
The delay compared to today is 12 minutes.

Note: those travellers who use the Deux-Montagnes line and transfer onto the Orange or Green line in downtown may only experience a delay of 6-8 minutes or less, compared to today, since they would already be on the Orange line. This means no further transfer is necessary at Gare-Centrale/Bonaventure (4-6 minutes).

The resulting travel time is still competitive with driving during rush hour

Bustitution is generally complicated due to the geography of the Deux-Montagnes line crossing rivers, with no parallel roads. Therefore, it is fairly slow. It will result in the following approximate delays during rush hour, from different stations (source: Google Maps):

Starting Station	Travel time today	Travel time du College	Travel time Bus	Delay via du College	Delay via Bus
Roxboro	27min	39min	59min	12min	32min
St-Dorothee	34min	46min	61min	12min	27min
Deux-Montagnes	40min	52min	65min	12min	25min

12.1.3. Capital Cost

The connection between the Deux-Montagnes line and station Du College requires about 400m construction of track to have the entire section double tracked (to remove interference with freight on the CN main line), plus ~400m of upgrading track (based off Google Earth), and construction of a temporary low level platform at Du College metro station.

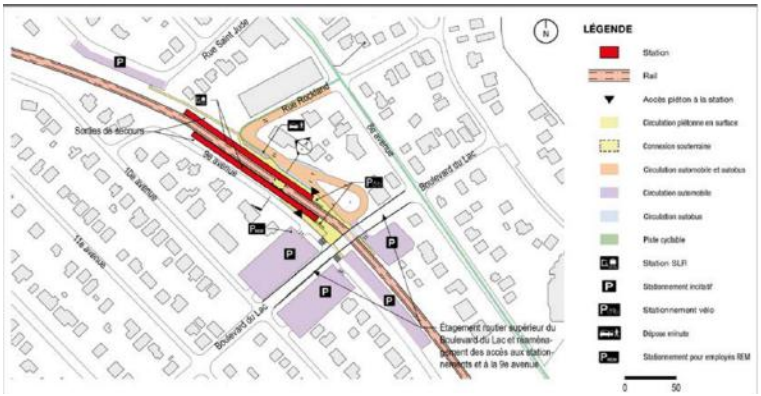
Operating Cost Advantage
The Du-College detour will reduce (or completely obviate) the need for bustitution. Weekend-service can be completely done using the diverted line. This allows shutting down the Mont-Royal tunnel completely during the weekend.

During summers, it may be feasible to use this diversion for several months, greatly simplifying the construction inside the tunnel Mont-Royal.

13. Various Issues

13.1. Problem: Preventing future elongation of stations

CDPQInfra have said that they Are designing their system to allow future expansion to 160m. They also said stations should be completely straight.
But some stations are in curves, which may not get sufficiently straightened to allow later expansion.



13.2. Sprawl in the South Shore

The REM project will provide very fast travel times from the South Shore terminus, and very convenient parking. This means it will be faster to go from St-Jean Sur Richelieu to downtown using a car and the REM, compared to many areas within Montreal by bus and Metro -- about half an hour.

This in turn may cause sprawl.

One related issue is that there are very few stations along the South-Shore line in Brossard, where most of the population being served by the line resides. Adding more stations would improve the quality of service for people living within the developed area of Brossard, encouraging them to take the train. At the same time, a lightly slower time for travelers from the far-terminus outside of the developed area may reduce development pressure outside of the developed area.

13.3. Misrepresentation of Data

- CDPQInfra overrepresented existing travel times, on the Deux-Montagnes line by up to 5 minutes
- Transfer legend at Panama is wrong, it shows 75m but it is actually 220m
- During the first town hall, CDPQInfra claimed during the rebuilding of the line that there would be ‘no service shutdowns, maybe a weekend or two’.
- The Canora station was

14. Demands

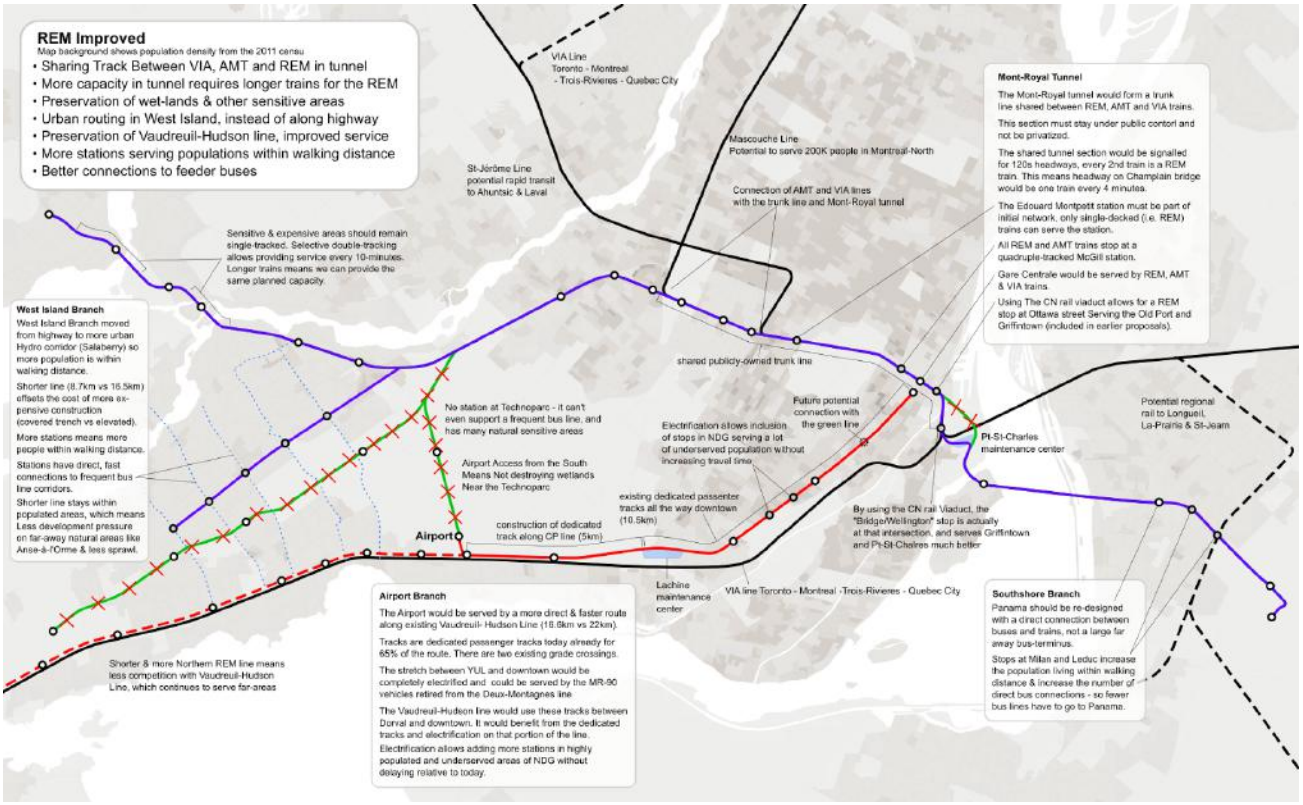
- The BAPE process should be halted and started again once the project is sufficiently defined to make a proper evaluation. This should include the proposed stations under McGill and Edouard-Montpetit. It should include a proper evaluation of the REM on the existing transit network, a better definition of the business case, a more complete ridership study that is actually based on the complete, proposed project. Additionally, the public should be provided all the requested documentation:
    - Complete ridership study
    - Complete business case
    - Required funding in terms of fares which the future ARTM will have to provide
    - More detailed knowledge of the real estate connections in order to better understand conflict of interest
    - The complete set of parameters given to the Caisse de Depot when the mandate was defined, according to 3.1.2. And 3.2.1 of the enquete between the government of Quebec and the Caisse de Depot
    - Evaluation of studied trajectories
    - Evaluation of studied technology choices
    - Exact location for all the stations
- The BAPE process should be given more time.
- Strategic public assets should not be privatized, especially below replacement cost, in particular, the Mont-Royal tunnel and the Pointe-St-Charles maintenance center.
- Any Public-Private-Partnership involving a large transfer of assets should have a competitive bidding process, it is inappropriate that the Caisse is ‘given’ this project by default.
- Service in the Mont-Royal tunnel should be shared between REM, AMT & VIA.
- The REM project should be integrated with AMT and VIA projects.
- The REM project should allow the connection of the St-Jerome line with the Mont-Royal tunnel.
- The impact on other AMT lines should be reduced/removed.
- The REM should not add additional ridership on the saturated Eastern branch of the Orange Line, it should remove ridership from it.
- The airport branch should not be build through the sensitive Technoparc area.
- Instead, the airport should be reached by using the existing Vaudreuil-Hudson line corridor.
- The West-Island-Branch should be rethought and
    - Moved further North to better reach population
    - Moved further North to reduce competition with the Vaudreuil-Hudson line
    - Moved away from the highway and instead into areas that can be urbanified
    - The stations should be moved to connect directly to the North-South-Boulevards in the West Island, so that buses will require no detour
    - Reduced in length to reduce development pressure on natural areas out in the west
    - Made less reliant on parking.

- The project overall should be made less reliant on parking.
- The seating capacity of the REM line should not be reduced compared to today.
- Canora should be moved further South to better connect to population centers and the transit corridor on the St-Jerome line
- The Connection at Gare Centrale should be made shorter
- The crowing at Gare Centrale should be better studied. In order to reduce crowding and transfer walks both to the transit corridor on Rene-Levesque and the Orange line, the CDPQInfra should study the possibility of using two stations within the envelope of the existing Gare Centrale area.
- The bus-rail transfer walk at Panama should be made shorter.
- The stations on the South Shore branch on Chevrier should be included in the Original project
- A station on Milan Avenue should be included in the project to reduce the number of buses that have to go to Panama station, and to decrease travel time for people who live near that area or take buses that would benefit from a Milan station.
- The footprint of all development south of the A-30 should be reduced or removed.
- During construction, all-day service on the Deux-Montagnes line should be maintained in both directions.

15. Alternative Proposal Synthesis

The following map shows a synthesis of an alternative proposal that would reduce most of the negative impacts. It includes

- The Shared Tunnel proposal.
- The use of the Vaudreuil-Hudson line to reach the airport via the the “NDG-YUL-Line” proposal.
- An improved West Island alignment that has more population nearby, connects better to a grid of frequent bus lines, reduces development pressure on natural lands and reduces competition on the Vaudreuil-Hudson line. In the map, Salaberry was chosen, but other alignments may be available as well.
- More stations in the South-Shore
- The CN rail viaduct alternative providing a better connection South of Gare Centrale to Griffintown, the Old Port and Pointe-Sainte-Charles



16. Inspirations

- Munich S-Bahn
- Wien S-Bahn
- RER Paris
- Caltrain
- Thameslink
- Crossrail
- Union Pearson Express
- Ottawa O-train
- Leipzig
- Philadelphia City Connection