5.3

Traffic Light Management (Service des infrastructures, de la voirie et des transports)

Summary of the Audit

Purpose

Ensure that the traffic light upgrade projects and the implementation of dynamic management are advancing in step with the priorities approved by the authorities.

Results

The Service des infrastructures, de la voirie et des transports has not succeeded, as the one responsible for the governance, in setting up a consistent, articulated traffic light upgrades program to ensure it is executed within the deadlines set by the authorities. In our opinion, the management of this program needs several improvements taking into account the main findings hereunder.

In the light of their significance, we believe it is imperative that the management of the program be closely monitored by the Direction générale in order to respect the deadlines, projected costs and target objectives.

- The current inventory is incomplete and does not reflect the level of compliance of the various components of the traffic light systems.
- The costs incurred for the traffic light upgrades significantly exceed the initial estimate set out in the *Transportation Plan*, despite the fact that the intersections have not all been completed.
- There is no overall plan backed by a timeline for all the interventions required to comply with both the standards demanded by the laws and the internal standards stemming from the guidelines in the *Transportation Plan* and the priorities of the municipal administration.
- The cost monitoring mechanisms for the traffic light upgrades are not uniform within the Service des infrastructures, de la voirie et des transports.
- The upgrade program has not been evaluated in terms of the target objectives.
- The current accountability mechanisms do not give the municipal administration all the relevant information about the progress of the upgrades in terms of the timeline, costs and objectives.

In addition to these results, we have formulated various recommendations for the business units.

The details of these recommendations and our conclusion are outlined in our audit report, presented in the following pages.

Note that the business units have had the opportunity to formulate their comments, which appear after the audit report recommendations.

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List of Acronyms

DEESM	Division de l'entretien, de l'éclairage, de la signalisation et du marquage
DERA	Division de l'exploitation du réseau artériel
DI	Direction des infrastructures
DM	dynamic management
POU 1	First phase of upgrades
POU 2	Second phase of upgrades
POU 3	Third phase of upgrades
SITE	Service des infrastructures, du transport et de l'environnement

5.3. Traffic Light Management (Service des infrastructures, de la voirie et des transports)

1. Background

The road network of the Ville de Montréal (the city) is comprised of nearly 2,300 intersections equipped with traffic lights (poles, arms, heads, controllers, cabling, pedestrian signals, audio signal devices, etc.).

The city's responsibility for these assets arises, in part, from the *Municipal Powers Act*[1] which states that the municipality has jurisdiction over public roads[2] that are not under the authority of the Government of Québec or the Government of Canada or one of their Ministries or bodies.

As concerns the traffic light network, the city is therefore responsible for installing new traffic light systems, making changes where required and removing, replacing and maintaining the equipment to ensure it works effectively.

Under the current legal framework, traffic routes are divided into two categories (arterial network and local network). The urban agglomeration council determines which traffic routes make up the arterial network across the agglomeration, through by-laws approved by the Ministre des Affaires municipales et de l'Occupation du territoire. It also has jurisdiction over the arterial network, in terms of standardization, planning and works on certain designated roads.[3] The management of the arterial network is under the jurisdiction of each related municipality, including the city.

The *Charter of Ville de Montréal* states that the arterial network is the responsibility of the city council and that the local network is the responsibility of the borough councils. The Charter also allows the city council to declare its jurisdiction over all the boroughs for a period it determines. In November 2014, the city council made use of this power concerning the traffic lights on the local road network. This decision, which came into effect on January 1, 2015, for an initial duration of two years, was extended to December 31, 2018. Note that since 2002, maintenance of the arterial road network has been delegated to the boroughs under a city council by-law.

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1 Chapter C-47.1, a. 66.

2 The expression "public roads" includes any highway, road, street, lane, square, bridge, footpath or bicycle path, sidewalk or other road that is not in the private domain.

3 Boulevard Notre-Dame, Bonaventure Expressway (phase 1), Rue Sherbrooke (east of 36e Avenue), Boulevard Cavendish (Cavendish/Royalmount), Boulevard Jacques-Bizard (to Highway 40), Boulevard Pierrefonds, Highway 440 service road.

As the city is responsible for managing and maintaining the public roads, it must meet the standards set out in the *Highway Safety Code*.[4] With regard to traffic lights, these are road signage manufacturing and installation standards established by the Ministère des Transports, de la Mobilité durable et de l'Électrification des transports (the Ministry) and recorded in *Tome V – Signalisation routière.* The application of some of these standards is mandatory (e.g., the order of lights in the signal head).

In the 2000s, the Service de l'environnement, de la voirie et des réseaux[5] reported that the controllers[6] in the traffic light systems had exceeded their useful life, causing frequent breakdowns. Since some replacement parts were no longer available, the people in charge at the time said that the solution was to replace the controllers with more reliable, high-performance controllers, to upgrade the traffic lights to the needs of pedestrians and drivers.

In 2004, the city began the first phase of the traffic light upgrading process, to replace the controllers and meet requirements on part of the inventory. The first phase was carried out during the development of a transportation plan for the Island of Montréal.

That plan, which was adopted by the urban agglomeration council in June 2008, announced guidelines[7] in several areas, such as public transit, walking, cycling, the road network, parking, movement and quality of life. More than a hundred projects were planned in connection with the intervention targets. Some of the intervention targets required the traffic lights to be upgraded, including:

- Prioritize pedestrians by improving walking conditions:
  - Requires improved safety for trips by foot, in part by installing pedestrian countdown timers;
- Make public transit the cornerstone of the city's development:
  - Introduces preferential measures for the city buses on 240 kilometres of roads within ten years[8], which requires the installation of transit priority signals in many intersections;
- Develop cycling infrastructure and set up new measures to foster the increased use of bicycles all across the city:
  - Aims to double the network in five to seven years, which would require adapting traffic lights for cyclists;

4 Chapter C-24.2.

5 This department was renamed several times in the following years. In 2004, it became the Service de l'environnement, de la voirie et des réseaux, and in 2005, it was renamed the Service des infrastructures, du transport et de l'environnement (SITE). Then, in 2015, it became the Service des infrastructures, de la voirie et des transports, as we know it today.

6 Specialized traffic light management device.

7 Most of the projects were planned for the first ten years, but some had a 20-year horizon.

8 This objective was increased in 2015 to 375 kilometres of arteries by 2017.

- Show leadership in travel safety across the territory and adopt a “zero accident” vision:
  - Aims to reduce accidents by 40% within ten years. Upgrading the traffic lights is one way to achieve this.

When the *Transportation Plan* was adopted, it mentioned that after the first phase ended in 2008, a second phase would begin, extending to 2010. The projected cost announced in the *Transportation Plan* was in the order of $32 million. Dynamic traffic light management[9] was also planned on four strategic arteries[10], requiring the traffic lights to be upgraded in advance. The projected cost was $10 million. The costs already incurred for Phase 1 (before the adoption of the *Transportation Plan)* were $22 million.

In 2013, the authorities reiterated their commitment to accelerating the installation of pedestrian countdown signals and the number of audio signals. The municipal administration also stepped up its commitment to installing preferential measures for the city buses, extending it from 240 kilometres to 375 kilometres of roads by 2017. A third phase was also launched, in 2015, for intersections in the local network.

Since the traffic light upgrades were meant to comply with legal obligations and help meet several objectives, and since they required major investments, we believe that it is timely, eight years after the *Transportation Plan* was adopted, to evaluate the extent to which the upgrades have been completed across the network.

Moreover, since the upgrade program[11] has been on the Direction générale’s Bureau des projets et programmes d’immobilisations (BPPI) priority program table since 2015 and is slated to be reviewed by the governance committees in spring 2017 and then submitted to the Comité de coordination des projets d’envergure (CCPE)[12], we believe that the observations and recommendations from this audit report will be useful for their work.

2. Purpose and Scope of the Audit

The purpose of the audit was to ensure that the traffic light upgrade projects and the implementation of dynamic management are advancing in step with the priorities approved by the authorities. To this end, we examined the target upgrade standards, the state of the traffic light system inventory, the tracking of completion timelines and

9 Adaptive management of traffic lights based on traffic density, involving the development of numerous traffic light coordination plans.
10 Boulevards Pie-IX, Henri-Bourassa and Crémazie and Rue Sherbrooke.
11 The program is called “Feux de circulation et équipement de gestion de la circulation”.
12 The committee is made up of members of the executive committee, appointed by the mayor, and senior management representatives.

projected costs, the data demonstrating the achievement of the objectives and the accountability data.

Our audit focused on the years from 2008 to 2016. For some aspects, data prior to 2008 were also considered. Our work was carried out mainly from September 6 to December 23, 2016, but we also took into consideration information given to us until March 2017.

Our work was conducted in the Service des infrastructures, de la voirie et des transports, specifically in the Division de l'exploitation du réseau artériel (DERA) (Direction des transports) and the Division de la réalisation des travaux (Direction des infrastructures [DI]). We also met with representatives from the four following boroughs during our preliminary study, to hear their point of view on particular aspects of traffic light management:

- Anjou borough (Direction des travaux publics);
- Montréal-Nord borough (Direction des travaux publics);
- Outremont borough (Direction des travaux publics);
- Rosemont–La Petite-Patrie borough (Division de l'entretien, de l'éclairage, de la signalisation et du marquage [Direction des travaux publics]).

Our audit work consisted of interviewing the staff, examining various documents and conducting surveys that we deemed appropriate to obtain convincing information. This audit is based on an examination of the evaluation criteria presented in Appendix 6.1.

3. Main Findings

The audit work revealed that improvements are required because:

- The current inventory is incomplete and does not reflect the level of compliance of the various components of the traffic light systems;
- The costs incurred for the traffic light upgrades significantly exceed the initial estimate set out in the *Transportation Plan*, despite the fact that the intersections have not all been completed;
- There is no overall plan backed by a timeline for all the interventions required to comply with both the standards demanded by the laws and the internal standards stemming from the guidelines in the *Transportation Plan* and the priorities of the municipal administration;
- The cost monitoring mechanisms for the traffic light upgrades are not uniform within the Service des infrastructures, de la voirie et des transports;
- The upgrade program has not been evaluated in terms of the target objectives;
- The current accountability mechanisms do not give the municipal administration all the relevant information about the progress of the upgrades in terms of the timeline, costs and objectives.

4. Audit Results

The Direction des transports was created in 2007, as part of the Service des infrastructures, transport et environnement (which became the Service des infrastructures, de la voirie et des transports in 2015). Its mission is to manage all activities related to the transportation infrastructure and networks, particularly public transit and the arterial network. It is also responsible for maintaining travel conditions that meet the mobility needs of people and goods. Its mandate includes implementing the *Transportation Plan* adopted by the urban agglomeration council in June 2008.

Within that directorate, the DERA, also created in 2007, has the mission to manage the movement of people and goods through the operation and development of integrated transportation systems, using information and communications technology, with a view to sustainable development[13] and based on the community's needs. To fulfil this mission, since its creation, the DERA has operated the arterial road network and the local network downtown. Its responsibilities include the modernization, upgrading, programming, specific coordination and dynamic management (DM) of the traffic lights, as well as the application of priority measures for public transit, including the introduction of reserved bus lanes. Since January 1, 2015, its management responsibilities have also extended to the local road network of the entire city, since the city council declared its jurisdiction over it.

Although our audit focuses on the period from 2008 to 2016, the period following the urban agglomeration council's adoption of the *Transportation Plan*, the first phase of upgrades (POU 1) began in 2004, and the achievements of the entire upgrading program must be considered for the purposes of this report. To facilitate understanding, Appendix 6.3 presents the business units that were or are responsible for managing the traffic lights on the arterial and local networks from the beginning of the first upgrades. In light of the changes in the legislative framework and the municipal reorganizations that occurred during that period, we also show the area that was under the city's responsibility.

In the next sections, we will begin by examining what the traffic light upgrade process consists of. Then we will look at the information available for managing the traffic light inventory and the level of compliance with the standards. We will also discuss the changes in the upgrade process since the adoption of the *Transportation Plan*, as well as accountability.

[13] Intranet Site – Direction des transports.

4.1. Traffic Light Upgrades

4.1.A. Background and Findings

The standards governing a field of expertise are established by a recognized dedicated organization. The application of some standards is mandatory or even legally mandatory, while others are left to the discretion of the people in charge. These same people may also establish internal standards to achieve a specific objective.

In the case of the traffic light systems, installation and maintenance are governed by standards developed by the Ministry with respect to light signalling, some of which are mandatory. The standards are outlined in a volume titled *Tome V – Signalisation routière* and they provide a road signalling reference tool for people in the Ministry as well as the municipalities and organizations responsible for public roads and bicycle paths.

Between 2008 and 2016, eight updates to *Tome V* were distributed to the managers at the Service des infrastructures, de la voirie et des transports. When an update entails significant amendments to the light signalling devices already installed on the road network (e.g., pedestrian signals), these must be modified or replaced by compliant equipment by a given deadline. To this end, *Tome V – Signalisation routière* provides a full list of deadlines to be met. Furthermore, if the municipalities have to install new light signalling devices, they must comply with the most recent edition of *Tome V – Signalisation routière*.

In addition to *Tome V – Signalisation routière*, traffic light installation and maintenance are also governed by the *Canadian Electrical Code,* which is recognized by the Québec Construction Code, Chapter V, Electricity. The people we met during our auditing work had mixed opinions about whether the city is subject to this code, however. We are of the opinion that an interpretation should be requested from the Régie du bâtiment du Québec to officially clarify the situation.

If a municipality failed to comply with traffic light standards that are actually legal obligations, it would be breaking the law. It might be in a vulnerable position if an accident were to occur.

In the case of the city, the primary purpose of the upgrades is compliance with the legal provisions, but a further purpose is to make changes to the traffic light systems or even install new devices to achieve other objectives.

As we explained in the introduction, the city road network is comprised of nearly 2,300 intersections equipped with traffic light systems. The first phase of upgrades (POU 1 and DM) began in 2004, targeting 800 intersections. Then the second phase of upgrades (POU 2) began in 2008, on another 1,200 intersections. A further 300

intersections will be targeted in the third phase of upgrades (POU 3). For the first two phases, the tendering documents to grant the professional services contracts specified that the traffic light upgrades entailed replacing some obsolete components and adding new components to comply with the recognized standards. Since this is a program that began several years ago, we want to point out that the standards have continued to evolve over time. First, some intersections updated during POU 1 or POU 2 are no longer compliant due to new standards for certain devices. Second, during POU 2, the authorities added new specifications to the tendering documents to reflect the priorities of the municipal administration.

Table 1 on the next page presents the main standards that were considered by the DERA when the professional service contracts were attributed for POU 1 and POU 2.

Table 1 – Main Standards Taken into Consideration for Traffic Light Upgrades (2004 to 2016)

Standards	POU 1 (2004 to 2008)[a]		POU 2 (2008 to 2016)[a]	
	Minimum requirement of the Ministry	City requirement	Minimum requirement of the Ministry or the *Canadian Electrical Code*	City requirement
Traffic light characteristics · Shape and size of the lenses · Backboard · Disposition of optical units · Height and space between lights, etc.	X X X X		X X X X	
Traffic light programming · Limit value of parameters (maximum and minimum duration)	X		X	
Pedestrian signals · Characteristics (e.g., shapes, sizes and disposition of lenses, visibility, display of intervals, call buttons, numeric countdown) · Justification	X	X[b]	X	X[b] X
Audio signals · Characteristics, call buttons · Justification	X		X	 X
Replacement of mechanical controllers by electronic controllers		X		X
Bicycle traffic lights · Characteristics · Traffic light adaptation	X		X	 X
Transit priority lights · Characteristics of transit priority lights · Justification	X		X	X[b] X
Replacement of incandescent lights by light-emitting diodes (LEDs)		X	X	
Replacement of urban furniture with standard urban furniture of the city				X[c]
Certification of signal poles, arms and controllers			X[d]	

[a] Period during which the contracts to do the upgrades were mainly carried out.
[b] Ministry's standards applied differently.
[c] For example, lights with vertical heads, poles in black steel.
[d] Standard taken into account since 2015.

As we mentioned above, the standards required by the Ministry or the *Canadian Electrical Code* are applicable to the city. Failure to comply with them is against the law. When new standards require major changes, the Ministry grants a grace period

to allow municipalities to plan the work required to comply with them. Failure to meet these deadlines is a failure to uphold the law. During the period under examination (2008 to 2016), grace periods were granted for three aspects of signal lights: audio signals, light signals and pedestrian signals. Table 2 shows the deadlines that were established by the Ministry during this period.

Table 2 – Deadlines to Upgrade Light Signalling Devices to the Standards Required by the Ministère des Transports, de la Mobilité durable et de l'Électrification des transports

Light signalling device	Publication date of modification	Initial deadline	Date of revision in *Tome V – Signalisation routière*	Last modified deadline
Audio signals Melody type, call buttons, location of speakers, etc.	02-2003	31-12-2010	12-2007 12-2008	31-12-2013
Audio signals Melody type based on direction of the crossing	12-2016	31-12-2018	12-2010 12-2012	31-12-2018
Light signals Order of lanterns, display of clearance time for right turns, etc.	06-1999	31-12-2010	01-2014 12-2014	31-12-2010
Pedestrian signals Addition of a numeric countdown and the flashing hand activated during the clearance interval	12-2007	31-12-2010	12-2015 12-2016	31-12-2017

As noted, two of the four deadlines were postponed during this period. At the time this audit report was produced, the municipalities had benefited from two postponements. The replacement of regular pedestrian signals with countdown signals should have been completed by December 31, 2017. The addition of a melody type based on the crossing should also have been completed by December 31, 2018.

The DERA chooses to apply some Ministry requirements differently and considers them to be internal standards. To make these choices official, the DERA must submit a review request to the Ministry for approval. In November 2016, the DERA submitted a few review requests to the Association québécoise des transports (AQTr) but did not submit others. We believe that any failure to uphold the Ministry's requirements should be officially communicated for approval.

Other internal standards were integrated into the upgrade phases:

- The addition of pedestrian countdown signals where required. As mentioned above, the Ministry's mandatory standards require regular pedestrian signals to be

replaced with countdown signals. Although the urban agglomeration council made the announcement in the *Transportation Plan*, at the end of 2013 the executive committee mandated the Service des infrastructures, du transport et de l'environnement (SITE) to step up the installation of pedestrian signals in all intersections with traffic lights along streets with heavy vehicular and pedestrian traffic. This is, therefore, an internal standard to extend the installation of pedestrian countdown signals to more intersections than required by the Ministry. It should be noted that the Ministry's deadline, December 31, 2017, applies only to existing pedestrian signals;

- The addition of audio signals first announced by the urban agglomeration council in the *Transportation Plan.* As it did for the pedestrian signals, the executive committee mandated the SITE, at the end of 2013, to step up the installation of these signals where required;
- The replacement of mechanical or obsolete electronic controllers with the new generation of electronic controllers. In addition to remedying the obsolescence of some controllers, their replacement will allow for greater programming capacity and flexibility (e.g., daily programs and light cycle duration, compatibility with pedestrian countdown signals and transit priority measures);
- The adaptation of traffic lights for cyclists, stemming from one of the guidelines in the *Transportation Plan*, which aims to double to bicycle path network within seven years;
- The installation of transit priority signals as part of the preferential measures for buses. Initially, the urban agglomeration council announced the development of 240 kilometres of reserved lanes in the *Transportation Plan*. In 2015, the municipal administration increased this figure to 375 kilometres by the end of 2017;
- The replacement of urban furniture (e.g., signal poles, light heads) for standardization among the boroughs.

Internal standards justify the installation of pedestrian signals, audio signals, bicycle traffic lights and transit priority lights. In this regard, the DERA produced the following guides to complement the Ministry standards:

- *Feux pour piétons à décompte numérique (DT-2001)*, which states the criteria justifying the addition of pedestrian countdown signals where there are existing traffic lights and where there are no traffic lights;
- *Signaux sonores DT-2002*, which provides more detailed information for the standardized installation of audio signals at intersections equipped with traffic lights;
- *Guide de conception des feux en présence d'aménagements cyclables (DT-2005)*, which standardizes practices for traffic light design where there are cycling facilities;
- *Mesures préférentielles pour autobus (MPB) (DT-2003)*, which governs the installation projects for transit priority measures, to ensure they are appropriately integrated into the city's traffic light networks and comply with the *Transportation Plan.*

Although the justification for installing these devices stems from the priorities of the municipal administration, it is important to note that the characteristics of the equipment is nevertheless subject to the mandatory standards set out in *Tome V – Signalisation routière*. Unlike the legal requirements, not all internal standards taken into account by the DERA have an official deadline for application. These internal standards are important, however, since they stem from guidelines outlined in the *Transportation Plan* or from the priorities of the municipal administration, and we believe that deadlines should be established to ensure they are met.

RECOMMENDATIONS	
4.1.B.	We recommend that the Service des infrastructures, de la voirie et des transports obtain an official interpretation from the Régie du bâtiment du Québec on whether the traffic light systems are subject to the requirements of the *Canadian Electrical Code*, to support informed decision-making.
4.1.C.	We recommend that the Service des infrastructures, de la voirie et des transports submit all requests for exemptions from legal requirements to the Ministère des Transports, de la Mobilité durable et de l'Électrification des transports for official approval.
4.1.D.	We recommend that the Service des infrastructures, de la voirie et des transports set deadlines for the application of the internal standards arising from the guidelines outlined in the *Transportation Plan* or from the priorities of the municipal administration, to ensure realistic plans can be made for the completion of the upgrades.
BUSINESS UNIT'S RESPONSE	
4.1.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.
4.1.C.	
4.1.D.	

4.2. Traffic Light Inventory

4.2.A. Background and Findings

Traffic light management must rely on sound knowledge of the inventory of all components for all intersections (e.g., controllers, signal poles, light heads, pedestrian signals, audio signals, detection devices). The upgrade process must be based on the components' compliance with the standards in effect (legal and internal). In this audit,

we wanted to evaluate the extent of the DERA's inventory, in terms of intersections equipped with traffic lights and data qualifying the level of compliance with the standards.

Number of Intersections Equipped with Traffic Lights

As we mentioned at the beginning of this report, the responsibility for the traffic light inventory changed between the beginning of POU 1 (2004) and the end of 2016. At the beginning of POU 1, the SITE was responsible for traffic lights located on the city's arterial network, and the boroughs were responsible for those on the local network. In 2006, with the creation of the agglomeration powers, the SITE became responsible for the arterial network of the entire Island of Montréal. This responsibility continued until the end of 2008. Beginning January 1, 2009, the SITE once again became responsible for only the city's arterial network. Then in November 2014, the city council gave itself jurisdiction over the traffic lights on the local road network also, under section 85.5 of the *Charter of Ville de Montréal*. According to the city council's resolution, this jurisdiction extends from January 1, 2015, to December 31, 2018. Furthermore, in December 2014, the city council adopted the By-law to Amend By-law 02-003[14] to identify the city's administrative arterial network. Even though the arterial network expanded from 24% to 52% of the municipal road network, the DERA has been responsible for the traffic lights on the entire road network since January 1, 2015.

At our request, the DERA produced an inventory file from an Access database known as "Feux 2013." This file, produced on February 15, 2016, shows the distribution of intersections equipped with traffic lights, presented in Table 3.

Table 3 – Distribution of Intersections Equipped with Traffic Lights, According to the DERA on February 15, 2016

Network	Number of intersections equipped with traffic lights
Arterial network	1,722
Local network[a]	575
Total	**2,297**

[a] Distributed among the 19 boroughs.

For the purposes of our work, we checked whether these data were complete. According to the information obtained, this file does not include the most recent

14 *By-law Concerning the Arterial and Local Road Systems* adopted by the city council on December 20, 2001.

amendments made to By-law 02-003 to identify the administrative arterial road network, in December 2014. Although the DERA has had jurisdiction since January 1, 2015, on both the arterial and local networks, the data at its disposition are not current. Since the city council's jurisdiction over the local network may not be permanent, we believe that the DERA's inventory data should take into consideration the amendments made to By-law 02-003.

Also, for three boroughs selected for this audit[15], we compared the intersections equipped with traffic lights in the DERA's inventory list with the information given to us by the boroughs (map showing traffic lights). This comparison revealed gaps related to the addition or removal of traffic lights. The DERA's data appear to be from reports filed by a consultant in 2008, during POU 2. After that exercise, the DERA appears to have taken into account the traffic light additions and removals on the arterial network, because these decisions were made by the city council. Until January 1, 2015, however, for additions or removals on the local network, the DERA was not informed because these were under the responsibility of the borough councils. This situation should have changed in January 2015, when the city council announced the decision to give itself jurisdiction over the local network. Immediately after that decision, the chair of the executive committee informed the boroughs in a memo that requests for changes to existing traffic lights and the installation of new traffic lights would have to be addressed to the director of the SITE. It was not until more than a year later, however (August 2016), that the city council delegated the power to the executive committee to add, remove or change traffic lights and that the executive committee delegated those same powers to the appropriate Level B official at the Direction des transports (September 2016). Although right now these responsibilities are clearly established, we have observed that the data on the number of intersections in the local network are not up to date, because they do not account for additions and removals on that network between the consultant's inventory (2008) and January 1, 2015. The situation should have been remedied in January 2015, after the memo from the executive committee chair, but we have no evidence of this. As we do not know the extent of this situation for all the boroughs, we believe that the DERA should validate the information it has with the boroughs' information, to ensure its inventory information is complete and accurate.

Report Data

The Access database at the DERA's disposal provides data about every intersection, such as:

- the intersection number;
- the names of the streets or arteries that form the intersection;
- the street or artery category (collector street, local street, principal artery, secondary artery);
- the name of the borough where the intersection is located;

[15] Anjou, Montréal-Nord and Outremont boroughs.

- the network the intersection belongs to (arterial or local);
- the electronic programming plan number;
- the intersection's initial commissioning date;
- the most recent commissioning date (the date on which an intersection equipped with traffic lights came into operation in compliance with the programming plan established under the specifications);
- information about the controller (type, make, model, serial number, relay number);
- network number (old, new and future).

Although the database does provide these data, it was not designed to provide information on all the components of the traffic lights and the repair/upgrade history. As such, it cannot be used to determine the level of compliance of each component (e.g., pedestrian signals, light heads). This means that the DERA and other users cannot determine how many intersections meet the Ministry's standards or the internal standards arising from the guidelines in the *Transportation Plan* or the municipal administration's priorities. In short, the current database does not provide an overview of traffic light compliance. This makes it difficult to evaluate the cost required for the mandatory upgrades or the upgrades arising from the guidelines in the *Transportation Plan* or the municipal administration's priorities.

It should be noted that the creation and implementation of a database that could be used to manage the traffic light inventory were, in fact, specified in the POU 1 professional services tender documents (2004). At the time, the information needs cited by the service included data for each intersection about the components of the traffic lights, a vehicle count and a repair/upgrade history. According to the information we obtained, this database was developed but never implemented because it did not meet the needs of the people in charge of safety and counting.

At the time of our audit work, we were informed that in 2014, the DERA hired a consulting firm to examine consolidation solutions for the traffic light data. In 2016, another contract was given to the same firm to develop a database. According to the information obtained, the new database was supposed to be able to generate a compliance sheet for every intersection equipped with traffic lights. The information about the components would come from the various plans produced to carry out the work on the traffic lights (electronic programming plans, base and conduit plans, lighting signal urban furniture plans). According to the information obtained, the DERA's intention seems to be to produce compliance plans only for future work. Although it is an excellent idea to create such files, we believe that measures should be taken to ensure that data are available for all intersections equipped with traffic lights, in order to establish the level of compliance with the standards.

RECOMMENDATIONS	
4.2.B.	We recommend that the Service des infrastructures, de la voirie et des transports take the necessary steps to ensure that the traffic light inventory shows whether each intersection belongs to the arterial or local network, in compliance with the amendments made to By-law 02-003 in December 2014, so the users have relevant information for decision-making.
4.2.C.	We recommend that the Service des infrastructures, de la voirie et des transports validate the list of intersections equipped with traffic lights with the boroughs, in order to establish a complete inventory.
4.2.D.	We recommend that the Service des infrastructures, de la voirie et des transports put mechanisms in place to keep the data on component compliance up to date for all intersections equipped with traffic lights, in order to establish the level of compliance with the legal standards and with the standards stemming from the guidelines in the *Transportation Plan* and the city's priorities.
BUSINESS UNIT'S RESPONSE	
4.2.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.
4.2.C.	
4.2.D.	

4.3. Progress on Traffic Light Upgrade Work Since the Adoption of the *Transportation Plan*

Although the systems in place do not give the DERA access to an up-to-date portrait of compliance with the legal and internal standards, upgrades have been carried out since 2004. Annual investments of $75.7 million have been authorized in the Three-Year Capital Works Program from 2008 to 2016, and real expenditures of $74.1 million were incurred for the period from January 1, 2008, to November 7, 2016.

In our audit, we examined the progress of the traffic light upgrade work since the adoption of the *Transportation Plan*, in terms of deliverables, timeline monitoring and projected costs, but before we begin the next sections, we will briefly describe the traffic light upgrade process.

The upgrade of an intersection's traffic lights is either initiated by the DERA, part of a project managed by another business unit (e.g., development of the bicycle path network) or part of work undertaken to meet a specific need for a borough (e.g., a request for a protected left turn in a particular intersection due to a high number of accidents).

First, when an intersection equipped with traffic lights is identified for an upgrade (legal requirements or internal standards), the DERA prepares the required plans. When these plans are definitive, they are signed and sealed[16] by the engineer in charge. The plans are as follows:

- Electronic programming (PE): Programming plan for traffic light controllers containing all information, parameters, data and special operating instructions (e.g., different times of the day, presence of different devices, such as pedestrian signals, transit priority lights, audio signals);
- Bases and conduits (BC): Shows the location of the traffic light bases and the route of the electrical conduits;
- Pavement marking (MA): Shows the uses of the traffic lanes and the traffic movements;
- Light signalling (SL): Shows the cabling, signal posts, arms, etc., of the target intersection.

When this preparatory work (e.g., plans) is commenced for the intersections, it is entered in an "order book." This is an Excel file maintained for monitoring and follow-up purposes, until the work is completed. Several times a year, interventions are targeted for calls for tender, to grant contracts to entrepreneurs. The plans and specifications are prepared by the DERA. Calls for tender were prepared by the Direction des travaux publics[17] until 2012 and, beginning in 2013, by the Direction des transports.

After the work contracts are granted to entrepreneurs, the contracts are managed in-house or externally. Since 2013, contract management has been under the responsibility of the Direction des transports, but prior to the switch, the Direction des travaux publics was in charge.

Depending on the content of the plan, the upgrades may require, for example, the installation of a new controller or a programming change in the existing controller. The controllers are programmed by either the Division de l'entretien, de l'éclairage, de la signalisation et du marquage (DEESM)[18] or by a contractor, depending on the intersection. When the work is finished, the traffic lights at that intersection are ready to be put into operation in compliance with the electronic programming plans. This

16 Engineer's obligation to sign and seal the plans and specifications under their responsibility.
17 Became the Direction des infrastructures in 2013.
18 It is under the responsibility of the Rosemont–La Petite-Patrie borough's Direction des travaux publics and is primarily involved in the boroughs of the former Ville de Montréal.

operation is called the “commissioning”. It is a very important step, involving a lot of stakeholders (e.g., the contractor, the project manager, the DEESM, Hydro-Québec, the Commission des services électriques de Montréal and the Service de police de la Ville de Montréal [SPVM]), and it determines whether the upgrade functions as intended in the electronic programming plans.

Since the DERA receives services from the DEESM for traffic light interventions, there is a service agreement between the two administrative units. A copy of the first agreement, which lasted a year from February 1, 2014, to February 1, 2015, was given to us. It was renewable annually unless otherwise decided. We were not able to find a copy signed by both parties. A second agreement was produced and signed between the parties, however, in October 2016 (for the period from August 1, 2016, to July 31, 2017).

As mentioned above, when the intersections are upgraded as part of an integrated plan (e.g., sewers and gutters, roadworks or geometric reconfiguration) under the responsibility of another business unit, the traffic light plans are drawn up by the DERA, but the DI manages the contract.

4.3.1. Portrait of Upgraded Intersections

4.3.1.A. Background and Findings

Although the DERA does not have information regarding the level of compliance for the traffic lights, we wanted to establish a portrait of the number of intersections that have been upgraded.

In response to our request, the DERA gave us an Excel file that lists each intersection by the phase during which the upgrade work was planned, that is, POU 1, DM, POU 2 and POU 3. The data for POU 1 and DM are from a tracking file kept by a consultant between 2004 and 2011. For POU 2 and POU 3, there is an upgrade tracking file that was kept by the DERA.

Although the managers say they do not know the proportion of intersections that have been upgraded to the standards, an analysis of these files reveals that 72% of intersections have undergone upgrades. This nuance is due to the fact that partial upgrades may have been carried out at some intersections and that new standards have been added since the initial upgrade work, requiring further upgrades for full compliance. Table 4 presents the situation for each phase.

Table 4 – Intersections Equipped with Traffic Lights that were Upgraded Between 2004 and 2016

No. of intersections	POU 1 (2004-2008)[a]	DM (2004-2015)[a]	POU 2 (2008-2016)[a]	Total
Planned, according to tender documents	631 (territory of former Ville de Montréal)	170 (territory of former Ville de Montréal)	1,200 (entire Island of Montréal)	**2,001**
Plans and specifications entrusted to a consultant	651	173	1,078 (Ville de Montréal territory)	**1,902**
Upgrades (based on information available in tracking file)	649	61	658	**1,368**
Proportion upgraded	99%	35%	61%	**72%**

[a] Period during which the contracts for the upgrades were mainly carried out.

First Phase of Upgrades (POU 1)

According to the information we obtained, the upgrades were carried out based on the standards in effect at the time, and 99% of the intersections were upgraded. It should be noted, however, that some components are not compliant with current standards, and further upgrades will be required. For example, pedestrian countdown signals were not a mandatory standard when the POU 1 work was carried out. It was only in 2007 that the municipalities were given a first deadline concerning pedestrian signals (December 31, 2010). This deadline was subsequently postponed to 2017. According to the information we obtained, the interventions required to upgrade the target intersections will be carried out after POU 2.

Dynamic Management (DM)

The intersections targeted for DM must first be upgraded to standard. Computerized equipment must then be installed to allow for adaptive management of the traffic lights, based on vehicular demand. DM was launched in 2004, with a goal of 217 intersections. On the basis of budget availability at the time, a professional services contract was issued for 170 intersections on four thoroughfares, Pie-IX, Henri-Bourassa, Crémazie and Sherbrooke, along with a contract for the work. The work was meant to be complete by March 2007.

The *Transportation Plan* adopted in 2008 reiterated the intention to install DM on these four thoroughfares. Based on the tracking file received from the DERA, 61 intersections have been updated so far. These intersections include 27 on Pie-IX upgraded to allow for full DM in 2008, and 34 intersections on Henri-Bourassa

upgraded to allow for partial DM in 2012, since only the section in the Ahuntsic-Cartierville borough was completed. Although the five-year report on the implementation of the *Transportation Plan* (2008-2012) states that DM was completed on these two thoroughfares, we have been informed that it is no longer functional in either case.

As for the other thoroughfares (Henri-Bourassa [section in the Rivière-des-Prairies–Pointe-aux-Trembles borough], Crémazie and Sherbrooke), the five-year report on the implementation of the *Transportation Plan* (2008-2012) states that the implementation will continue in 2013 and 2014. According to the tracking file from the DERA, however, DM has yet to be completed. Although the file refers to 85 interventions on intersections along these thoroughfares, according to the information we obtained, further interventions are still required to complete the upgrades. Moreover, there are still 27 intersections to be upgraded on which no interventions have taken place.

Second Phase of Upgrades (POU 2)

The tracking file showed the progress with regard to the signature of electronic programming plans and commissioning, as well as a work completion date. According to the information available, the level of progress is as follows:

- For 658 intersections (61%): Upgrades have been carried out. They are classified as [TRANSLATION] “fully commissioned” and have apparently been put into operation in compliance with the plans;
- For 217 other intersections (20%): Electronic programming plans have been signed and sealed by an engineer. These plans have apparently been entered in the order book, awaiting the other plans (BC, MA, SL) so the contract can be planned and issued;
- For 203 other intersections (19%): Electronic programming plans have not yet been developed or are in the process of being signed and sealed.

For our work, we wanted to ascertain the reliability of the data. On the basis of surveys conducted, we observed that although most of the intersections classified as [TRANSLATION] “fully commissioned” were supported by evidence, other intersections require further upgrades. These are intersections equipped with traffic lights in the boroughs of the former suburban cities. Before January 1, 2015, some boroughs upgraded the traffic lights in their local networks to comply with the Ministry’s mandatory standards, but further work will be required to comply with the internal standards.

Third Phase of Upgrades (POU 3)

The tracking file says that the intersections for this phase are mainly in the local networks. No professional services contract had been issued at the time of our audit

work. Upgrades have apparently been carried out internally, however, through ad hoc interventions.

4.3.2. Timeline Monitoring

The planning of traffic light interventions should include upgrade activities related to the legal requirements (*Tome V – Signalisation routière, Canadian Electrical Code*) and the internal standards stemming from the guidelines outlined in the *Transportation Plan* (e.g., audio signals, transit priority signals) or the priorities of the municipal administration.

The planning is disrupted by the integration of the upgrades with integrated projects from other business units or ad hoc requests from the boroughs.

Furthermore, the traffic light plan must take into account the capacity and availability of several internal stakeholders (the DEESM, the DI, the Commission des services électriques de Montréal, the Société de transport de Montréal [STM], the Service de police de la Ville de Montréal [SPVM]) and external stakeholders (professionals and contractors, Hydro-Québec) that are involved in the work.

The number and diversity of interventions and the stakeholders' restrictions contribute to the difficulty of establishing specific, detailed timelines that can be followed to meet final deadlines. Establishing such timelines is becoming increasingly important if the city is to comply with the legal requirements and meet the expectations set out in the 2008 *Transportation Plan* and the priorities of the municipal administration, however.

Our audit work determined that timelines had been established and that they were being tracked to ensure that the upgrades were carried out as planned.

4.3.2.1. Overall Timeline

4.3.2.1.A. Background and Findings

First, the overall timeline was announced in the *Transportation Plan* adopted in 2008. The upgrades were programmed in two phases. The first phase, which involved 800 intersections including the replacement of traffic light controllers, was already under way and expected to be finished by the end of 2008 at the latest. The second phase, which involved upgrades at 1,400 intersections, was planned for 2008 to 2010.

The *Transportation Plan* also planned for DM on four strategic thoroughfares – Pie-IX, Henri-Bourassa, Crémazie and Sherbrooke – a project that began at the same time as POU 1. Over a five-year horizon, a total investment of $42.4 million was planned,

as shown in Table 5, suggesting that by the end of 2013, the upgrades and DM would be complete.

Table 5 – Investments Announced in the *2008 Transportation Plan*

Target objectives	2008-2013
Adapt traffic lights to pedestrians' needs	$0.6M
Introduce countdown signals at intersections	$1.8M
Upgrade traffic lights	$30.0M
Implement DM for traffic lights	$10.0M
Total	**$42.4M**

For the plan and specification preparations and the oversight of the upgrade work, three professional services contracts were signed with three engineering consortia. The professional services were not for 1,400 intersections but 1,200. According to the information in the decision-making summaries at the time these contracts were granted, the initial work schedule began in November 2008 and ended in December 2012, for a period of four years. When the list of intersections was communicated to the firms, a total of 1,078 intersections were divided among them. The upgrade project consisted essentially of making the traffic lights compliant with *Tome V – Signalisation routière*.

According to the information in the decision-making summaries, during this period, the firms encountered a number of difficulties completing the expected deliverables. A new activity for pedestrian countdown signals was therefore added to the professional contracts. The *Transportation Plan* specified that the standard pedestrian signals would be replaced by pedestrian countdown signals and that countdown signals would be added where required, but since the Ministry's requirements did not mention the justification criteria for adding these signals, the DERA had to develop an internal standard. It was communicated to the consultants in spring 2010 to be taken into consideration in the development of the plans and specifications, which increased the workload.

In spring 2012, an extension was requested for the professional services contracts. The city council authorized additional expenses to the same consortia[19] to complete the plans and specifications and, in some cases, to redo them. The decision-making summaries referred to an initial completion schedule, setting the beginning of the work in December 2012 and the end in December 2014, or two additional years. It should

[19] Some of the engineering firms in the consortia also changed.

be noted that work oversight was removed from the existing contracts, since new decision-making files were to be presented as the needs arose.

In these same decision-making summaries, the DERA announced that the deadline set by the legislator was now December 31, 2017, and that all the requirements enacted by it would be met when the upgrades were completed. It was beginning in this period that the upgrades no longer related exclusively to the legal obligations but also to the application of the internal standards to meet the objectives stemming from the *Transportation Plan.*

As for the plans and specifications, we have found no evidence that a timeline has been established to enforce the completion dates approved by the authorities. According to the information we obtained from the people we met with, the plans and specifications were completed gradually, based on emerging needs. Also, when the plans were received, they were constantly being reviewed, because amendments and additions were made based on new internal standards stemming from the priorities. As mentioned in the previous section, the DERA did not receive the plans for all the intersections initially targeted in POU 2.

Concerning the traffic light upgrades and DM project announced in the *Transportation Plan*, which were to be carried out over a period of five years, with a completion date around 2013 (based on adoption in 2008), we found no evidence of a plan providing the number of intersections to be completed each year (year, location on network) in order to meet the initial timeline or even the deferred 2017 completion date for the pedestrian countdown signal upgrades.

Our audit work reveals that the work contracts granted on the basis of the plans and specifications produced between 2008 and 2016 were actually for around 750 intersections of the 1,200 mentioned in the professional services tender documents. Based on the information in the decision-making summaries for the original timelines, for all contracts granted, we established that the theoretical overall timeline ran from 2011 to 2018. There were no contracts for the other 450 intersections at the time of our audit. We found no evidence that a timeline had been prepared to meet the expected completion dates, but it can be foreseen that the completion date of December 31, 2017, will not be met.

Furthermore, as concerns the DM project announced in the *Transportation Plan*, upgrades on some intersections have yet to be carried out, first to comply with the legal and internal standards, but also to ultimately allow for DM on the four originally planned thoroughfares.

Moreover, although this section deals with POU 2, there are intersections from POU 1 that do not meet the legal requirements concerning the replacement of regular pedestrian signals with pedestrian countdown signals. According to the Ministry’s

requirements, the deadline for complying with this standard is December 31, 2017. The people in charge do not currently know the number of non-compliant intersections.

Finally, the announcement of the upgrade program in the 2008 *Transportation Plan* was for intersections equipped with traffic lights in the arterial network. As we have already mentioned, the boroughs were responsible for upgrades on the local roadwork network until the city council took responsibility for this network on January 1, 2015. As the organization in charge, the DERA had, at that point, to verify the compliance with the legal requirements and internal standards of the 300 intersections in question. According to the information we obtained, this exercise was not planned in the first two upgrade phases, but will be part of a third phase beginning in 2017, POU 3.

Our work revealed the following:

- Since the beginning of the program, we found no evidence demonstrating a real intention to meet the various deadlines imposed by the Ministry (December 2010, December 2012, December 2013, December 2017);
- The deadline set by the legislator (December 31, 2017) will be here in a few months, and the completion schedule for some of the contracts granted continues until 2018;
- The deadline (December 31, 2017) applies specifically to the replacement of the regular pedestrian signals with pedestrian countdown signals and not to all intersections;
- Work contracts have yet to be issued for a significant portion of the intersections;
- Other internal standards have to be applied to achieve the objectives and guidelines arising, in part, from the *Transportation Plan* (some with deadlines and others without).

Consequently, we believe that the DERA should establish a status report concerning the nature of the upgrade work to be completed for all intersections, in order to comply with the legal requirements and meet the guidelines of the *Transportation Plan* or the priorities of the municipal administration. Solid knowledge of what remains to be done should make it possible to establish a realistic timeline for compliance, with either the Ministry's requirements or the internal standards. We also believe that the Direction des transports should have the new deadlines approved by the municipal administration, since major investments are likely to be associated with these additional delays.

Furthermore, the Direction des transports should officially inform the Ministry that it is unlikely that the city will be able to meet the deadline of December 31, 2017, and submit to it a timeline, approved by the Direction générale, for compliance with the standards for pedestrian signals.

RECOMMENDATIONS	
4.3.2.1.B.	We recommend that the Service des infrastructures, de la voirie et des transports prepare a status report about the traffic light upgrade work required to meet the legal requirements and internal standards and to implement dynamic management, in order to determine the investments required to comply with the law, the guidelines set out in the *Transportation Plan* and the priorities of the municipal administration.
4.3.2.1.C.	We recommend, in light of the requirements of the *Transportation Plan* and the guidelines retained by the municipal administration, that the Direction générale establish an overall timeline that takes into account all the interventions required to comply with the legal requirements and internal standards for traffic lights and to implement dynamic management in order to improve the travel and safety of the residents.
4.3.2.1.D.	We recommend that the Service des infrastructures, de la voirie et des transports official inform the Ministère des Transports, de la Mobilité durable et de l'Électrification des transports that it is unlikely that the city will be able to meet the deadline of December 31, 2017, for the installation of pedestrian countdown signals and submit to it a realistic timeline for complying with the *Highway Safety Code*.
BUSINESS UNITS' RESPONSES	
4.3.2.1.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.
4.3.2.1.C.	***Direction générale*** *[TRANSLATION] The overall timeline for interventions is intrinsically linked to the resources available and the work they can perform.* · *The Direction générale will first ask the Service des infrastructures, de la voirie et des transports for a timeline of the actions that can be taken in the short term with the current resources.* ***(Planned completion: June 2017)*** · *In 2018, the Service de la performance organisationnelle will analyze how the work teams involved in traffic light management operate. It will then produce a report.* ***(Planned completion: December 2018)***

4.3.2.1.D.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.

4.3.2.2. Annual Upgrade Program

4.3.2.2.A. Background and Findings

Despite the lack of an overall plan and a detailed, documented timeline to complete the POU 2 work and other interventions, in 2012 the DERA implemented an annual intervention plan for intersections. This program is for upgrades to the *Tome V – Signalisation routière* standards and the internal standards (e.g., audio signals and transit priority signals).

When work is required, the coordinator, who is responsible for the general tracking of traffic light work, receives the various plans required. The target intersections are then entered in the annual order book. For each intersection entered, it shows whether the work is to upgrade to mandatory standards, transit priority measures, audio signals or other. This order book lists the intersections targeted for traffic light work and those for which contracts have been issued. It also serves as a completion tracking tool. It shows the intersection numbers, the streets, the dates the plans were submitted, the type of intervention (e.g., MAN, new light, change of controller, pedestrian signal, audio signal, transit priority light or pre-emption systems), the contract numbers and the planned commissioning dates, which mark the projected end of the intervention and the effective operation of the traffic light.

In 2013, the DERA set the objective of bringing 165 intersections up to the mandatory standards each year. With this objective, it was estimated that all the intersections in POU 2 would be completed in 2017. It was on this basis that the annual program was established. The POU 2 upgrade objective was not met for three years, however (see Table 6), which generates a risk of not meeting the December 31, 2017 deadline. As we can see, priority was placed on other interventions to meet internal standards stemming from the municipal administration's priorities (such as audio signals and transit priority signals).

In 2015 and 2016, an overall traffic light commissioning objective was agreed with the DEESM (300 intersections per year), based on its execution capacity. This overall objective targeted the intersections to be upgraded (POU 2) and other targets that the DERA deemed to be a priority. We have determined that every week, the DERA tracked the number of traffic light commissionings. The overall objective was only attained in 2015, however.

Table 6 – Intersection Commissioning Objectives Tracked by the DERA (2013 to 2016)

Type of intervention	2013		2014		2015		2016	
	Objective	Achieve-ment	Objective	Achieve-ment	Objective	Achieve-ment	Objective	Achieve-ment
Upgrade (POU 2)	165	153	165	116	165	172	130	111
Audio signals	n/a	5	50	25	50	69	50	19
Transit priority signals	n/a	–	50	23	n/a	11	120	136
Integrated projects	n/a	27	n/a	80	84	52	N/A	N/A
Other	–	–	–	–	–	98	–	53
Total interventions[a]		**185**		**244**		**402**		**319**
Total intersections	**165**	**185**	**265**	**244**	**299**	**327**	**300**	**279**

[a] More than one intervention may be carried out on the same intersection.

Note: n/a = not available.
N/A = not applicable.

Furthermore, beginning in 2015, intersections were prioritized in the annual program on the basis of the following criteria:

- Project under way;
- Project combining several targets or interventions (audio signal and transit priority upgrades);
- Audio signal project;
- Upgrade project including transit priority lights under analysis;
- Project including transit priority lights under analysis.

The mandatory upgrade objective for 2017 was reduced to 130 intersections, instead of 165.

In a further effort to explain the difficulty achieving the commissioning objectives, we used surveys to assess whether they were completed in accordance with the timelines shown in the decision-making summaries. We conducted this analysis from the perspective that an overall timeline should have been kept up to date since the beginning of POU 2. To do this, we selected 11 contracts granted between 2011 and 2015. We compared the initial completion period, shown in the decision-making summaries recommending the attribution of the contract, and the intersection commissioning dates, shown in the file used to establish the program. Table 7 presents the results concerning the processing times of the selected contracts. These contracts were for from 4 to 30 intersections to be upgraded, for a total of 136 intersections. For the purposes of our analysis, the processing time for an intersection was estimated

from the last month projected at the time of the initial plan in the decision-making summary and the commissioning date entered in the tracking file.

Table 7 – Processing Time for Commissioning in Comparison with Calendar in Decision-Making Summaries (Selected Contracts Between 2011 and 2015)

Year	No. of contracts	No. of intersections	Processing time				
			Deadline met	1 year	2 years	3 years	Not done
2011	1	5	–	–	5	–	–
2012	4	38	–	21	12	5	–
Subtotal	**5**	**43**	**–**	**21**	**17**	**5**	**–**
2013	4	53	16	31	4	–	2
2014	1	10	8	2	–	–	–
2015	1	30	10	13	–	–	7
Subtotal	**6**	**93**	**34**	**46**	**4**	**–**	**9**
Total	**11**	**136**	**34**	**67**	**21**	**5**	**9**
			Percentage completion (%)				
2011			–	–	100%	–	–
2012			–	55%	32%	13%	–
Subtotal			**–**	**49%**	**39%**	**12%**	**–**
2013			30%	58%	8%	–	4%
2014			80%	20%	–	–	–
2015			33%	44%	–	–	23%
Subtotal			**37%**	**49%**	**4%**	**–**	**10%**
Total			**25%**	**49%**	**15%**	**4%**	**7%**

Our work reveals that beginning in 2013, the DERA upgraded 37% of the intersections within the time expected in the decision-making summaries, 49% the next year and 4% the second year. For 10% of the intersections, we found no evidence that the upgrade was carried out. Overall, this is an improvement in comparison to 2011 and 2012, where no intersections were completed within the time expected in the decision-making summaries. In our opinion, these delays increase the risk of not meeting the deadlines imposed by the government or those related to the internal standards. Several causes may explain these delays. For example, contracts that begin later than the timeline shown in the decision-making summaries, failure to meet upgrade deadlines and unavailability of workers for commissioning.

Prior to 2013, the DERA was responsible for preparing the plans and specifications, while the responsibility for carrying out the work belonged to the DI. Beginning in 2013, the DERA was responsible for the entire process related to traffic light interventions,

from design (plans and specifications) to contract execution, as well as overseeing the work, except for projects integrated with infrastructure work under the responsibility of the DI.

Although all the contracts granted in 2013, 2014 and 2015 covered an 18-month execution calendar and involved a large number of intersections (ranging from 30 to 50), which gave the DERA some flexibility in its annual program, we found that the DERA significantly increased the number of intersections upgraded within the initial completion time shown in the decision-making summaries for contract attribution. Based on our surveys, however, 63% of the intersections were not completed on time.

We believe that the DERA should evaluate the type of delays that occur between the initial execution period, shown in the decision-making summaries for contract attribution, and the actual intersection commissioning dates, to determine the reasons for the delays and make the appropriate changes.

RECOMMENDATIONS	
4.3.2.2.B.	We recommend that the Service des infrastructures, de la voirie et des transports take the means required to upgrade a sufficient number of intersections in order to meet the established annual commissioning objective and meet the deadlines imposed by the law or stipulated by the municipal administration.
4.3.2.2.C.	We recommend that the Service des infrastructures, de la voirie et des transports evaluate the type of delays between the initial execution calendar shown in the decision-making summaries for contract attribution and the actual traffic light commissioning date and take the measures required to reduce these delays in order to meet the overall timeline of the upgrade program.
BUSINESS UNIT'S RESPONSE	
4.3.2.2.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.
4.3.2.2.C.	

4.3.3. Cost of Traffic Lights Upgrades

When planning a program that takes place over several years, such as an upgrade program, the people in charge should determine, from the outset, the scope of the work and the timelines, in addition to estimating the costs. It is on the basis of these

estimates that the authorities should give their approval for the program. Whether the upgrades are imposed by the law or based on internal standards to achieve an objective of the municipal administration, the estimated costs must be taken into consideration to determine whether the city has the budgetary capacity to complete the project within the proposed timeline. In both cases, these cost estimates should support the decisions, from the outset, and be closely tracked throughout the project.

An exercise should also compare the costs incurred at a given date, corresponding to the units completed, not only with the cost estimates but also with the contract (real costs) to identify any overspending at the right time and make the appropriate changes.

Our audit work sought to ensure that cost estimates were provided and tracked throughout the upgrade program. We first examined the overall cost estimate for the upgrade program, then the estimates for the cost of contract execution and finally the cost tracking.

4.3.3.1. Overall Cost Estimate – Upgrade Program

4.3.3.1.A. Background and Findings

To determine the accuracy of the overall cost estimate for the upgrade program, we compared the initial estimate with the costs incurred to date.

At the time that the *2008 Transportation Plan* was adopted by the urban agglomeration council, the Direction des transports announced the upgrade of 1,400 intersections equipped with traffic lights, at a cost of $42.4 million over five years, distributed as follows:

· POU 2 traffic light upgrade:	$30.0M
· Adaptation of traffic lights to pedestrian needs:	$0.6M
· Introduction of countdown signals at intersections:	$1.8M
· Implementation of DM:	$10.0M
	$42.4M

During our audit work, we asked for documentation of the cost estimates supporting the announcements in the *Transportation Plan.* According to the information we obtained, this documentation was not available. We believe that the documentation of cost estimates should be kept to justify the decisions made by the authorities and for verification purposes.

For comparison purposes, we reconciled this estimate with the value of the contracts granted since the *Transportation Plan.* Our work reveals that a total amount of $65.1 million was spent on POU 2 and the DM for professional services and work contracts, from 2008 to 2016 (see Table 8).

Table 8 – Contracts Granted Under the Upgrade Program (2008 to 2016)

Type of expenses authorized at the time of contract attribution	Amount
Professional services: preparation of plans and specifications and work oversight	$15.2M
Execution of upgrade work (traffic lights and civil engineering works – including provision of equipment and components)	$44.7M
Execution of upgrade work integrated in infrastructure network repair work	$5.2M
Total	**$65.1M**

Note: According to the information in the decision-making summaries supporting the contracts, a sum of $19.8 million is for upgrade work and the acquisition of traffic light equipment that will take place in 2017 and 2018.

Specifically concerning the execution of the work, there are 63 contracts for a total of 748 intersections. If we compare this number with the intersections that were initially supposed to be upgraded at the time the *Transportation Plan* was adopted (1,400 intersections), we can see that, to date, there are no contracts for just under half of the intersections.

We also compared the value of the contracts with the real POU 2 expenditures recorded in the books on November 7, 2016, since the adoption of the *Transportation Plan* in 2008. They are equal to $74.1 million, as shown in Table 9.

Table 9 – Upgrade Program (Project 59002)
Real Expenditures (January 1, 2008, to November 7, 2016)

Expense categories	Amount
Plans and specifications, work oversight and other	$15.3M
Work execution (traffic lights and civil engineering works)	$17.7M
Acquisition of equipment and components (internal and external purchases of equipment and specialized services)	$21.3M
Work executed by third parties (refundable)	$3.8M
	$42.8M
Subtotal	**$58.1M**
Work executed internally (capitalizable)	$16.0M
Total	**$74.1M**

Source: Data extracted from SIMON accounting system.

As we can see, the preparation of plans and specifications and the work oversight cost $15.3 million, while the real expenditures related to the execution of the work, the acquisition of the equipment and components and the expenditures by third parties come to $42.8 million, for a total of $58.1 million. For accounting purposes, the cost of the capitalizable salaries of the work force assigned to the upgrade program ($16.0 million) is added to this figure.

In conclusion, the comparison of the original estimate ($42.4 million) with the real costs incurred ($74.1 million) on November 7, 2016, reveals that the work cost more than projected in the *Transportation Plan,* especially because not all the intersections were upgraded as planned. It can be expected that yet other costs will be added to the upgrade program.

Part of the difference can clearly be explained by the fact that internal standards were added between 2008 and 2016 (e.g., the addition of audio signals and pedestrian countdown signals, the changed traffic light furniture and equipment). Indeed, an examination of the decision-making summaries for the attribution of contracts to entrepreneurs reveals that the nature of the work had changed. Adding these standards resulted in additional costs. We saw no evidence that cost estimates were produced when the internal standards were added by the Direction des transports. We believe that the municipal administration should have been informed of the financial impact of these decisions, for all the planned works. To this end, Recommendation 4.3.2.1.B. advocates preparing a status report on the upgrade work to comply with both the legal requirements and the internal standards, in order to assess the investments required.

4.3.3.2. Cost Estimate – Work Execution

Detailed cost estimates serve as a reference for analyzing bids received and recommending contract attribution to the lowest compliant bidder.

Since 2013, when the DERA took responsibility for the entire process related to traffic light interventions, it has prepared the tenders and cost estimates. Previously, and for the POU 2 projects, including traffic light work integrated with infrastructure works, the tenders and cost estimates for the intersections involved were under the responsibility of the DI.

To analyze the preparation of cost estimates, compare the estimates with the proposal retained and track the costs, we selected seven contracts attributed between 2012 and 2016, which are presented in Table 10.

Table 10 – Sample of Seven Contracts Granted Between 2012 and 2016 that Include Traffic Light Upgrade Work

Year	Reference no.	Managed by	No. of intersections	Amount of contract granted		
				Price	Contingencies	Total
2012	219201	DI	11	$172,972	$25,946	$198,918
2013	219501	DI	7	$449,895	$67,484	$517,379
2014	SP2014-2	DERA	10	$1,103,751	$110,375	$1,214,126
2015	282001[a] (integrated project)	DI	2	$217,138	$29,451	$246,589
2015	282901[b] (integrated project)	DI	3	$221,923	$25,473	$247,396
2016	SP2016-02	DERA	40	$6,504,141	$1,300,828	$7,804,969
2016	SP2016-03	DERA	50	$1,538,033	$307,607	$1,845,640

[a] Part of a roadworks, lighting and traffic light contract (price: $2,746,572; contingencies: $292,033; total: $3,038,605).
[b] Part of a roadworks, lighting and traffic light contract (price: $11,937,963; contingencies: $1,229,409; total: $13,167,372).

4.3.3.2.1 Preparation of Detailed Cost Estimates

4.3.3.2.1.A. Background and Findings

The reliability of the detailed cost estimates depends on a combination of two basic parameters: the quantities established and the unit prices associated with them. Reliable estimates are especially necessary when the quantities and work to be completed will be included in tender documents.

Based on the “order book”, the DERA groups several intersections in a lot to issue a tender for the work. From 2008 to 2012, the lots ranged between 4 and 16 intersections. Since 2013, the number of intersections has increased to 30, 40 or 50 intersections. Regardless of the number intersections subject to the tender, the DERA proceeds in every case with an estimate on the basis of the needs of each of these intersections. An overall, detailed estimate is therefore prepared and used to document the quantities and work to be done before issuing the tender. For intersections where the upgrades are part of integrated projects, it is the DI that prepares the cost estimates for the entire project. As mentioned earlier, for the traffic light portion of these projects, the DI relies on the plans produced by the DERA.

Our audit work first sought to determine whether these cost estimates exist. It also sought to ensure that the quantities were established based on the plans and that the determination of the unit prices was documented.

An examination of the decision-making summaries supporting all the contracts issued allowed us to verify the existence of internally prepared reference cost estimates (quantities, unit prices and total cost).

For the period covered by our audit, we observed that the cost estimates became more explicit over time. From simple spreadsheets (2012 and 2013) where the work to be done is briefly described, with quantities and unit prices for each component, beginning in 2014 the estimates became increasingly explicit in terms of the information communicated, clearly identifying the needs in terms of the following categories:

- Cables (detailed by type, size, etc.);
- Furniture (boxes, extensions, poles and arms);
- Equipment (electrical service boxes);
- Work coordination:
  - Identification of the worker mobilization period;
  - Quantification of materials provided by the city to be transported or returned to the city;
- Electrical work:
  - Quantities and description of electrical work to be done, based on components;
- Civil engineering work:
  - Quantities and description of civil engineering work to be done based on the structures (concrete bases and pedestals, access shafts, conduits and surfaces).

These estimates generally contain information about the specific quantities of the traffic light components to be replaced or installed, and the quantities related to the civil engineering work, such as concrete bases for each intersection. Our surveys revealed that (for the contracts in 2012, 2013 and 2015) the quantities established generally relied on the plans[20] for each intersection. For the three contracts issued in 2014 and 2016, however (10, 40 and 50 intersections), the quantities were established on the basis of hypotheses, because the plans were not ready for all the targeted intersections. We understand that this method was used to speed up the completion of the work. We believe, though, that this situation entails a risk that some quantities will be overestimated and others underestimated. This requires rigorous monitoring of the work and the contracts. We will deal with this topic in section 4.3.3.2.3.

To determine the reliability of the unit prices in the establishment of the estimates, we compared those used by the DERA and the DI for certain items at the time the estimates were prepared, for the seven projects in our sample. The unit prices are shown in Table 11.

[20] Base and conduit plan: Shows the location of the traffic light bases and the route of the electrical conduits; geometric plan of the intersection, pavement marking plan, electronic programming plan and light signalling plan.

**Table 11 – Unit Prices Used in Cost Estimates
(Selection of 7 Contracts Between 2012 and 2016)**

Unit that prepared the estimate	DI	DI	DI	DI	DERA	DERA	DERA
Year contract issued	2012	2013	2015	2015	2014	2016	2016
Description of work	Estimated unit price						
Concrete base	$1,200.00	$1,200.00	$1,590.17	$1,676.19	$1,200.00	$1,200.00	N/A
Removal of an arm (4 to 5 m)	$250.00	$250.00	$132.00	$95.41	$125.00	$125.00	$125.00
Installation of controller	$1,500.00	$1,500.00	$1,348.97	$1,348.97	$800.00	$800.00	$800.00
Installation of traffic light head on an arm	$300.00	$300.00	$210.61	$67.51	$125.00	$200.00	$200.00
Transport of materials from the city	$300.00	$300.00	$473.79	$449.21	$450.00	$450.00	$450.00

A careful examination of the changes in unit prices used for the selected items reveals differences based on whether they were established by the DERA or the DI. The unit prices used by the DERA (2014 and 2016) are standard prices that were not adjusted or indexed by year, while those used by the DI (2012, 2013 and 2015) seem to be adjusted prices. To evaluate the size of the gap in the unit prices used by the two business units, we compared the average unit prices established by the DERA (2014 and 2016) with the average unit prices established by the DI (integrated projects, 2015). On the basis of the five items selected, we saw significant differences, as shown in Table 12.

**Table 12 – Differences Between the Average Unit Price Estimates
Established by the DERA and the DI**

Description of work	Average unit price		Difference	
	DERA 2014 and 2016	DI 2015	$	%
Concrete base	$1,200.00	$1,633.18	$(433.18)	–36%
Removal of an arm (4 to 5 m)	$125.00	$113.71	$11.29	9%
Installation of controller	$800.00	$1,348.97	$(548.97)	–69%
Installation of traffic light head on an arm	$175.00	$139.06	$35.94	21%
Transport of materials from the city	$450.00	$461.50	$(11.50)	–3%

This means that the cost estimates used as a reference to evaluate the bids received for the traffic light upgrade work are not standard within the same service (SITE). We believe that a single methodology for determining the unit prices should be established in order to standardize methods between the two business units (DERA and DI).

RECOMMENDATIONS	
4.3.3.2.1.B.	We recommend that the Division de l'exploitation du réseau artériel update the unit prices used to produce the estimates, if appropriate, in order to reflect market prices and prepare relevant analysis reports when evaluating bids received.
4.3.3.2.1.C.	We recommend that the Service des infrastructures, de la voirie et des transports ensure that a single method is used to determine unit prices when preparing cost estimates for traffic light upgrades, to improve the reliability of the data.
BUSINESS UNIT'S RESPONSE	
4.3.3.2.1.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.
4.3.3.2.1.C.	

4.3.3.2.2 Comparison of Cost Estimates with Retained Proposal

4.3.3.2.2.A. Background and Findings

The detailed estimates should be a reliable reference for assessing whether the bids received are reasonable. Reliable cost estimates should therefore represent the market. Otherwise, mechanisms should be in place to identify differences and provide convincing explanations to reassure the authorities when a contract is granted.

During our audit work, we tried to determine whether, when the tenders were issued, the service transmitted the necessary documents to give the bidders a good understanding of the needs and required quantities. We also assessed the reliability of the detailed estimates used to judge whether the bids received were reasonable. To do this, we compared the amount of the detailed estimates with the lowest bid received and we ensured that major differences were explained in the preparation of the decision-making documents before the contract was granted.

It should be noted that the threshold at which the differences between the detailed estimates and the lowest bids have to be analyzed was specified in a guide prepared by the Service du greffe concerning the content and presentation of decision-making files (October 2015). This guide stipulates that business units must present and *[TRANSLATION] "thoroughly explain any difference of more than 10% between the bid of the successful bidder and the last estimate carried out"*.

Concerning the tender documents, we noted that the service had provided and distributed the required documents for contracts granted from 2012 to 2015 to give the bidders a good understanding of the needs and quantities. This documentation included intersection maps, standardized traffic light specifications and bills of quantities. For the contracts granted in 2016, however, on a larger number of intersections (40 and 50), the service distributed the standardized traffic light specifications and the bills of quantities. The quantities in the detailed estimate were established based on hypotheses because the plans were not ready. The lack of plans in the tender documents prevented the bidders from gaining an accurate understanding of the needs in order to submit a bid. It should be noted that the plans are given in lots to the contractor based on the progress of the contracts. It is only at this time that the contractor knows the exact quantities for the targeted intersections. This method requires thorough tracking of the work carried out. We will deal with this topic in the next section.

The detailed estimates and the lowest retained bids are compared in Table 13. The estimates for the contracts granted from 2014 to 2016 were prepared by the DERA. Those for the contracts granted in 2012, 2013 and 2015 were prepared by the DI's Division de la gestion de projets et de l'économie de la construction.

Table 13 – Comparison of Detailed Estimate and Lowest Retained Bid (7 Selected Contracts)

Year contract issued	Contract number and unit in charge	No. of intersections	Amounts			Over- or under-evaluation of cost estimate (%)
			Cost estimate		Retained bid	
2012	219201 DI	11	Contract: Contingencies: Incidental charges:	$185,187 $27,778 $212,965 $178,000 $390,965	$172,972 $25,946 $198,918	6.6%
2013	219501 DI	7	Contract: Contingencies: Incidental charges:	$489,494 $73,424 $562,918 $251,000 $813,918	$449,895 $67,484 $517,379	8.1%
2014	SP2014-2 DERA	10	Contract: Contingencies: Incidental charges:	$999,897 $99,990 $1,099,887 $506,594 $1,606,481	$1,103,751 $110,375 $1,214,126	(10.4%)
2015	282001[a] (integrated project) DI	2	Contract:[b] Contingencies: Incidental charges:	$189,784 $21,597 $211,381 $100,000 $311,381	$217,138 $29,451 $246,589	(16.7%)
2015	282901[a] (integrated project) DI	3	Contract:[c] Contingencies: Incidental charges:	$245,655 $33,565 $279,220 $283,515 $562,735	$221,923 $25,473 $247,396	11.4%
2016	SP2016-02 DERA	40	Contract: Contingencies: Incidental charges:	$5,199,152 $1,039,830 $6,238,982 $3,902,485 $10,141,467	$6,504,141 $1,300,828 $7,804,969	(25.1%)
2016	SP2016-03 DERA	50	Contract: Contingencies: Incidental charges:	$1,409,421 $281,884 $1,691,305 $461,409 $2,152,714	$1,538,033 $307,607 $1,845,640	(9.1%)

[a] Estimates specific to the traffic light upgrades, including civil engineering work at intersections.
[b] Part of a roadworks, lighting and traffic light contract (price: $2,746,572; contingencies: $292,033; total: $3,038,605). Internal estimate (price: $3,360,086.98; contingencies $355,428.06; total: $3,715,515.04).
[c] Part of a roadworks, lighting and traffic light contract (price: $11,937,963; contingencies: $1,229,409; total: $13,167,372). Internal estimate (price: $12,062,858.00; contingencies $1,254,028.51; total: $13,316,886.51).

Our work revealed that the estimates produced by the DERA (2014 and 2016) were lower than the retained bids. We also observed that the DERA provided explanations of the differences in just one decision-making summary for contract attribution, project SP2016-02 (25.1%). According to the guidelines stated in the guide for the preparation of decision-making files, the DERA should have also explained the difference in contract SP2014-2, as it was 10% higher. The estimates produced by the DI in 2012 and 2013 were higher than the retained bids. In these two cases, the Division de la gestion de projets et de l'économie de la construction made a favourable comment in the decision-making summaries.

For the two integrated projects (2015), the DI granted the contracts for the lowest compliant bid for infrastructure work that included traffic lights. The guidelines stated in the guide for the preparation of decision-making files ask the business units to do a comparative analysis between the detailed estimates and the bid retained before attributing the contracts. In both these cases, however, the analyses revealed an over-evaluation of the estimate, by 18.1% for contract 282001 and by 1.1% for contract 282901. We noticed that the Division de la gestion de projets et de l'économie de la construction documented the difference when it was more than 10%, but the explanation provided was not related to the traffic lights, as they represented a small proportion of the work to be carried out (7%).

RECOMMENDATION	
4.3.3.2.2.B.	We recommend that the Service des infrastructures, de la voirie et des transports thoroughly explain, when preparing decision-making summaries for contract attribution, any difference higher than the established acceptable threshold (10%) between the winning bid and the last estimate carried out, in compliance with the guidelines issued by the Service du greffe, to improve the authorities' decision-making.
BUSINESS UNIT'S RESPONSE	
4.3.3.2.2.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.

4.3.3.2.3 Tracking of Work Completion Costs in Second Upgrade Phase (POU 2)

4.3.3.2.3.A. Background and Findings

Tracking is required to ensure that the costs invoiced are for the intersections described in the contract and that they correspond to the services provided. It must also ensure that the costs are in line with the amount initially authorized, so as to detect any overspending in a timely fashion.

Engineers serving as project managers are entrusted with the task of tracking the upgrades of intersections equipped with traffic lights.

For contracts managed by the DERA, this tracking consists of ensuring proper functioning in terms of services rendered, costs and timeline. The project managers rely on work site oversight conducted by either internal resources or external engineering firms. For each intersection, the work must be carried out in compliance with the plans produced by the professionals and accepted by the DERA and the costs submitted by the contractor retained, for both the electrical work and the civil engineering work.

When the upgrade work is part of a contract managed by the DI, all the work, including the work on the traffic lights, is managed by a project manager who reports to the DI. The work oversight for the traffic lights is also the responsibility of the DI. Since 2013, a DERA engineer designated as a respondent with the DI monitors the compliance of the upgrade work with the plans produced.

Every DERA project manager builds a file for each intersection, containing the various plans, pre-work surveys in the form of photographs, materials and equipment forms, the cost estimate, the bid of the retained contractor, all intervention requests communicated to the contractor and any other documents transmitted.

First, as concerns the tracking of the work carried out, for each intersection targeted by a contract, the project manager gives the contractor the order to begin the upgrade work. The DERA provides ongoing oversight of the work (in-house or externally). When the civil engineering and electrical work has been completed, all the stakeholders involved[21] are called together, at the request of the project manager, to officially commission the traffic lights. The commissioning confirms that the traffic lights work in accordance with the programming set out in the electronic programming plan (e.g., length of pedestrian signal, length of traffic light for each lane).

[21] A representative of the contractor, the engineer assigned by the DERA (manager of the contractor's contract), the site overseer (external firm or the city), the DEESM representative who programmed the controller and representatives of the Service de police de la Ville de Montréal to manage the traffic when the traffic lights are interrupted for the commissioning.

Throughout the contract, the project manager is also responsible for monitoring the costs, using progressive payments that show the contract expenditures, at a given date, including contingencies. The monitoring “process” consists of reconciling the quantities invoiced with those shown in the bid form. It relies on the attestation of quantities by the site overseers. The project manager also exercises control over change requests that generate contingencies. At the end of this step, the project manager recommends the approval of the progressive payments to the DERA or DI, as the case may be.

The project manager is also responsible for monitoring the incidental charges that were authorized by the authorities at the time the contract was granted. For each contract, this involves an estimate that combines a variety of expenses that can be foreseen for the payment of technical work (laboratory, marking and signalling) and for the acquisition of the traffic light furniture from the Centre de distribution Louvain and the controllers from the DEESM. During the execution of the work, it is, in part, from internal purchase requests that the project manager exercises control over these incidental charges.

During our audit, we tried to determine whether the number of intersections planned in the contracts had been completed and whether the budget was met. To do this, we looked for evidence in the oversight reports that the planned intersections were commissioned as expected. We also examined the documentation concerning the progressive payments (invoices, authorizations, charts of costs invoiced compared to costs planned in the contractor’s bid) for the contracts in our sample. Finally, we looked for evidence of cost monitoring of the incidental charges, particularly related to the acquisition of traffic light furniture and controllers.

The expenses authorized by the city council and the results of the amounts used are presented in Table 14, for each of the contracts examined.

Table 14 – Authorized Expenses and Amounts Used as of October 31, 2016 (7 Selected Contracts)

Year	Unit in charge	Contract no. No. of intersections Status	Amount authorized Amount used Difference	Cost of contract	Cost of contingencies	Incidental charges – traffic light furniture
2012	DI	Contract: 219201	Amount authorized:	$172,972	$25,946	$165,000
		No. of intersections: 11	Amount used:	$124,816	$7,094	$69,008
		Status: work completed	Difference:	$48,156	$18,852	$95,992
2013	DI	Contract: 219501	Amount authorized:	$449,895	$67,484	$245,000
		No. of intersections: 7	Amount used:	$348,745	$–	$104,783
		Status: work completed	Difference:	$101,150	$67,484	$140,217
2014	DERA	Contract: SP2014-2	Amount authorized:	$1,103,751	$110,375	$359,685
		No. of intersections: 10	Amount used:	$1,034,816	$66,525	$125,043
		Status: work completed	Difference:	$68,935	$43,850	$234,642
2015	DI	Contract: 282001 (integrated project)	Amount authorized:	$217,138	$29,451	$88,777
		No. of intersections: 2	Amount used:	$158,687	$21	$–
		Status: under way	Difference:	$58,451	$29,430	$88,777
2015	DI	Contract: 282901 (integrated project)	Amount authorized:	$221,923	$25,473	$106,756
		No. of intersections: 3	Amount used:	$218,809	$–	$–
		Status: under way	Difference:	$3,114	$25,473	$106,756
2016	DERA	Contract: SP2016-02	Amount authorized:	$6,504,141	$1,300,828	$3,121,988
		No. of intersections: 40	Amount used:	$–	$–	$–
		Status: beginning in 2017	Difference:	$6,504,141	$1,300,828	$3,121,988
2016	DERA	Contract: SP2016-03	Amount authorized:	$1,538,033	$307,607	$369,128
		No. of intersections: 50	Amount used:	$145,312	$1,008	$116,320
		Status: under way	Difference:	$1,392,721	$306,599	$252,808

First, the level of advancement on the seven contracts examined is as follows: one was completed (219501); two (219201 and SP2014-2) had the work finished, but there was no evidence of provisional or final acceptance; three were under way (282001, 282901 and SP2016-03) and one will begin in 2017 (SP2016-02).

In general, for contracts in which invoices were issued, with progressive payments produced and supporting documents, we observed that they were verified by the project manager and had the required approvals recommending payment. On the other hand, in some cases, we noted that the documentation supporting the progressive payments was incomplete with regard to contingencies. We also noted that contingencies were recorded with the contract costs and not in the appropriate budget envelope. In our opinion, this practice does not allow the services rendered to be properly controlled.

As for the contract that was completed (219501), our examination revealed that all the work planned for the seven intersections was completed, and we found the evidence that the commissioning was carried out. Concerning cost tracking, our work shows that $101,150 of the amount provided in the contract (22%) was not spent, that the amount provided for contingencies was not used and that the amount for incidental charges (acquisition of traffic light furniture and controllers) had a positive balance of $140,217 (that is, 57% of the budget). With regard to the cost of the contract, this suggests that the initially estimated quantities had been over-evaluated. Concerning incidental charges, from the information we obtained, although expenses for the acquisition of the traffic light furniture and the controllers were necessary to complete the contract, they were recorded in a general account, not in the account specifically linked to the contract. The effect of this is that it is impossible to know the real, accurate incidental charges of the contract and there is no way to reconcile them with the amounts authorized by the authorities.

For the two contracts that were finished but had not received provisional or final acceptance (219201 and SP2014-2), we determined from the progressive payment documents that for the first contract, only 5 of the 11 intersections had been completed. The commissioning dates recorded in the site reports did not match those in the annual programming calendar, however. In the second case (SP2014-2), we were assured that six of the ten intersections had been completed, based on documentation to support the progressive payments, which was incomplete (no provisional or final acceptances). Based on the commissioning dates in the annual programming, however, and through an examination of the work site reports, all ten intersections had been completed. Since the information in the progressive payments and the annual program did not match, we believe that a reconciliation is required with the number of commissionings carried out (work site reports) and the number given in the tracking file (annual programming).

For the cost tracking on the same two contracts (219201 and SP2014-2), our work shows a positive balance on the amounts planned for contingencies and incidental charges related to traffic light furniture and controllers. In the first case, although the work was not carried out on over half of the initially planned intersections, the remaining balance of the contract is only 28% ($48,156). This leads us to question the reliability of the initial estimate. For the second contract, it is the surplus on the incidental charges that raises questions, due to the use of the equivalent of 35% of the planned amount ($125,043).

Finally, for the three contracts under way, the two managed by the DI (282001 and 282901) will be carried out in 2017. For contract SP2016-03, we have evidence that 10 of the 50 intersections were commissioned in 2016. As for the cost tracking in this contract, we noted that the remaining balance for incidental charges, for the acquisition of traffic light furniture and controllers, is 68% ($252,808) of the authorized amount, after the upgrades were made to 10 intersections (20% of the total planned), which

raises the possibility of cost overruns to complete the remaining 40 intersections in the contract.

Our work also revealed a significant difference in the tools used by the DERA project managers to track the per-intersection costs. The tools they use are entirely up to their discretion. For one, all expenses, in all expense categories (contract, contingencies and incidental charges), are shown for each intersection, which quickly and easily provides total expenses for the interventions carried out, as well as the status of the intersection at any given date. For another, this method was not used. We believe that it would benefit the DERA to institute a standard-tracking system that is used by everyone and that interfaces with the annual programming.

In conclusion, all the contracts examined in our sample showed surpluses in the contract amounts and the authorized incidental charges, but we learned that the work was not always carried out on the original number of intersections planned. As we mentioned in section 4.3.3.2.1, “Preparation of Detailed Cost Estimates”, establishing standard quantities requires careful monitoring. We were not convinced, however, that all the contracts were monitored with the same level of care. Due to these findings, we believe that every contract should be subject to accountability concerning the number of intersections upgraded and the use of the amounts authorized.

RECOMMENDATIONS	
4.3.3.2.3.B.	We recommend that the Service des infrastructures, de la voirie et des transports ensure that the documentation supporting the progressive payments and traffic light upgrade contract invoices is complete, in order to allow for a thorough control of costs and services rendered for the intersections in question.
4.3.3.2.3.C.	We recommend that the Service des infrastructures, de la voirie et des transports ensure that the contingencies invoiced by the contractors are recorded in the contingencies budget envelope provided, in order to accurately track the costs related to the contracts.
4.3.3.2.3.D.	We recommend that the Service des infrastructures, de la voirie et des transports ensure that incidental charges for the traffic light upgrade contracts are charged to the specific SIMON accounts created for this purpose by the authorities, in order to have accurate figures for the costs related to the target intersections.

4.3.3.2.3.E.	We recommend that the Service des infrastructures, de la voirie et des transports put standard tools in place to track the costs of the traffic light upgrade contracts, in order to periodically account for the real costs of the intersections targeted by these contracts in comparison with the expenses authorized by the authorities.
BUSINESS UNIT'S RESPONSE	
4.3.3.2.3.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.
4.3.3.2.3.C.	
4.3.3.2.3.D.	
4.3.3.2.3.E.	

4.3.4. Evaluation of the Upgrade Program in Light of the Objectives

4.3.4.A. Background and Findings

As we mentioned above, the traffic light upgrade program contributes to the achievement of many objectives set out either in the *Transportation Plan* or in commitments made by the municipal administration. These objectives are as follows:

- Compliance with legal requirements;
- 40% reduction in the number of accidents, over ten years, from the beginning of the *Transportation Plan,* with the ultimate goal of the "zero accident" vision;
- Reduction of electricity bill generated by the traffic lights;
- Improved traffic flow;
- Prioritization of public transit and improved efficiency and punctuality of the service.

Since significant sums were invested in the upgrade program, we verified whether analyses had been carried out to assess the achievement of the objectives.

Compliance with Legal Requirements

Although significant sums were invested to comply with the standards beginning with POU 1, at the time of our work, the DERA was not able to demonstrate the level of compliance with the legal requirements for traffic lights. This is true for the legal requirements of *Tome V – Signalisation routière* and, in terms of electrical compliance, the *Canadian Electrical Code*. Consequently, the DERA was unable to demonstrate the achievement of this objective.

Reduction in the Number of Accidents

In the *2008 Transportation Plan*, the municipal administration undertook a process to improve travel safety within the territory. One of the commitments was to reduce the number of accidents by 40% over the ten years following the adoption of the plan (2008 to 2017), with the city's ultimate goal being the "zero accident" vision. This objective was to be evaluated through tracking and in the five-year review of the plan.

The *Transportation Plan* referred to the fact that safety measures were already in place and would be maintained. These measures include upgrades to the traffic lights, the installation of pedestrian countdown signals, the safety program around schools and parks, the intersection safety program, prohibiting right turns on red lights, the lighting improvement program and a significant increase in police presence related to travel safety. Although it is difficult to make a direct connection between the reduction in the number of accidents and the upgrades, it is nevertheless logical to believe that the extensive work done on intersections with traffic lights could have reduced the number of accidents.

To be able to achieve such a goal, accident data must first be measured and evaluated and then improvements have to be made to problematic intersections. This need had already been defined in the tender documents for the professional services contracts for POU 1 and POU 2. In both these cases, a compilation and analysis exercise was planned.

For POU 1 (in 2003), the Direction des transports planned for the creation of an accident database. In its technical specifications, it also required the engineering firms to undertake a safety study for each of the 50 intersections on the list of most accident-prone intersections, submitted by the city. According to the information we obtained, the safety study was produced and recommendations were implemented to correct the situations revealed.

In the case of POU 2, based on the information given to us, we determined that accident data were compiled for 2,439 intersections on the Island of Montréal (2,214 intersections in the city and 225 in the related municipalities). The goal was to target the most dangerous intersections. Each intersection was placed in one of four categories. For most of them, there was a simplified diagnostic, and the exercise identified 70 unsafe intersections for a more detailed diagnostic. During the mandate, however, the analysis of these detailed diagnostics was not deemed useful, as it was not based on recent data (2005-2007). The compilation carried out in the professional services contract was therefore not used to choose intersections to target for accident reduction.

At the time of our audit work, the accident reports drawn up by the police and recorded in a Société de l'assurance automobile du Québec (SAAQ) database were transferred

by the Direction des transports' Division sécurité et aménagement du réseau artériel to a database of the city, but the accident analysis was not systematic. Accidents are only analyzed for geometric redevelopment projects or at the request of a borough, the DERA or another business unit. We believe that while this method may meet specific or occasional needs, it does not provide a safety portrait for all the intersections.

Initially, however, the *2008 Transportation Plan* called for the creation of a travel safety office, which would be the municipal authority that dealt with all issues related to travel safety in the agglomeration territory. It was meant to be a permanent discussion table to develop, implement and monitor strategies to reduce the number of deaths and injuries on the roads, in conjunction with its partners. According to the *Transportation Plan*, the responsibilities of the office would include developing and managing accident data management tools, producing diagnostics, proposing programs and projects, designing analysis and assessment tools, preparing a three-year action plan and assessing the effectiveness of the measures. In 2013, the executive committee gave its agreement in principle to create this office. It was created in 2014, under the responsibility of the Division sécurité et aménagement du réseau artériel, with a budget from the agglomeration, but it was not able to fully carry out the intended mandate.

Although most of the intersections deemed unsafe were apparently upgraded, which should have reduced the number of accidents at these intersections, the DERA is unable to demonstrate this, since the accident data were not analyzed to this end after POU 2. In a recent statement from the city council, however (September 2016), the municipal administration referred to a 26% reduction in accidents involving injuries in eight years (2008 to 2015) and a 53% reduction in fatal accidents over this same period, for the entire territory.

The DERA is unable to demonstrate how the upgrades may have contributed to achieving this objective.

Reduction in Electricity Bill

The decision-making summaries to attribute the first professional services contracts under POU 2 mentioned that electricity savings would be achieved at intersections where the incandescent bulbs were replaced by light-emitting diodes (LED). At the 2011 rates, the savings totalled $580 per year for each intersection. As the DERA is unable, with reasonable effort, to determine how many intersections underwent this intervention, it is hard to assess whether these savings were achieved. Consequently, the DERA is unable to demonstrate the impact of the traffic light upgrades on the achievement of this objective.

Improved Traffic Flow

During our audit, we did not obtain any reports demonstrating improved traffic flow thanks to the upgrades. Consequently, the DERA is unable to demonstrate the degree to which the traffic light upgrades contributed to the achievement of this objective.

Prioritization of Public Transit and Improved Efficiency and Punctuality of the Service

In our audit, we took note of statements from the Société de transport de Montréal (STM) and from the city about changes in transit priority measures. We did not, however, receive any reports that establish a connection between the upgrades and the achievement of this objective.

We conclude that no analysis was conducted to determine how the upgrade program contributed to the achievement of these objectives. In some cases, as the objectives were not given in a measurable form, it was harder to assess whether and to what extent they were achieved.

We believe that the achievement of the objectives should be demonstrated, to justify the money invested in the upgrade program, in its broadest sense, and also to evaluate whether the decisions to endorse the internal standards were appropriate.

RECOMMENDATION	
4.3.4.B.	We recommend that the Service des infrastructures, de la voirie et des transports develop tools that can assess the achievement of the objectives targeted by the traffic light upgrade program to demonstrate the appropriateness of the investments made, justify pursuing the deployment of the internal standards and make any required changes.
BUSINESS UNIT'S RESPONSE	
4.3.4.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.

4.4. Accountability Reporting

4.4.A. Background and Findings

When a department implements guidelines approved by the authorities, it must monitor their progress, evaluate them periodically and report the results. Doing this requires tools that can be used for the periodic production of management reports containing the relevant information, which must then be analyzed to justify any differences from the established objectives. Accountability mechanisms must be in place within the structure to keep managers at different levels and the authorities informed, so that well-founded decisions can be made at the right time. These decisions are likely to affect planning and the allocation of the resources required to achieve the objectives.

In our audit, we looked into the mechanisms in place to report on the developments in the upgrade program and on the level of traffic light compliance with the standards.

First, we obtained reports on the various aspects of the process:

- Statement of the number of plans received from professionals during the year, for the various upgrade phases (POU 1, POU 2, POU 3). This report also shows the number of plans not produced in each upgrade phase. Based on the information we obtained, it is given to the manager in charge twice a year, on request;
- Change in the number of intersections commissioned in relation to the objective agreed with the DEESM (300 intersections per year). This report differentiates the number of intersections to upgrade (POU 2) from those that are the subject of other priority targets of the DERA. It is produced on a weekly basis and submitted monthly to the manager in charge;
- Changes in the Three-Year Capital Works Program project budget, including the upgrade budget envelope. Based on the information obtained, this report is produced monthly for the manager in charge.

In the case of the plan report, the data are not reconciled with the annual objective set for the purpose of tracking deadlines and the number of plans. Furthermore, for the first two reports, the data provided are not reconciled with the corresponding costs. So although the head of the division receives budget change reports for the Three-Year Capital Works Program projects under his responsibility, he does not receive reports that specify the costs related to the mandatory upgrades and the other measures put forward. Likewise, there is no report demonstrating the level of upgrades on the entire traffic light inventory at a given date.

In turn, at the time of performance evaluation, the manager in charge reports to the director about the achievement of the established annual objectives:

- Number of updates;
- Number of electronic programming plans completed;

- Number of traffic lights with final programming implemented;
- Number of pedestrian countdown signals;
- Number of audio signals;
- Number of intersections equipped with transit priority measures;
- Number of kilometres equipped with transit priority measures;
- Number of intersections studied.

Although the objective of this evaluation is related to compensation, the results are reconciled with the measurable objectives established at the beginning of the year, although they are not reconciled with a plan demonstrating that the deadlines and costs have been respected.

We expected that the DERA would periodically inform the department's management team about the progress on the upgrade program, in relation to the projections, deliverable, deadlines and costs incurred. When there were differences, we also expected that explanations would be offered and that corrective measures would be put in place. But we did not find any periodic reports dealing with these issues.

After examining the budget documents presented to the Committee on Finance and Administration, we found that the accountability dealt with almost the same aspects of the upgrades (for the current year and the next year):

- Number of traffic lights upgraded;
- Number of new pedestrian countdown signals installed;
- Number of audio traffic lights installed;
- Number of intersections with transit priority measures.

Until 2016, the activities carried out were not reconciled with the objectives set. Moreover, the schedule and real costs for the upgrades are not provided for either the year or the entire program. Although the upgrade program is only one of many others under the responsibility of the Direction des transports, the elected officials are unable to find information that allows them to determine what the upgrades cost the city.

Finally, although the city took on the responsibility for the traffic lights on the local network on January 1, 2015, originally for a two-year period but now extended to December 31, 2018, we have not found any report dealing with the consequences of this decision on the upgrade interventions (impact on cost and schedule). The timeline imposed by the government is the same for the traffic lights on the local network. Approximately 300 intersections are affected by this situation. Although some boroughs did upgrade work when they were responsible for the lights, so far compliance statements have not been drawn up by the DERA to assess whether these traffic lights comply with the standards required by the Ministry or with the internal standards. These intersections are the subject of POU 3. As such, for these traffic lights, the city is not in compliance with the deadline set by the Ministry. To date, the

Direction générale and the authorities have not been officially informed about this matter.

In conclusion, the accountability mechanisms in place do not provide sufficient information to give the various managers and authorities an overview of the results achieved by the upgrade program in comparison with the plan, in terms of the number of intersections upgraded, costs, deadlines met and difficulties encountered, with regard to any of the standards. We believe it is appropriate to inform the Direction générale and the authorities about the impact on this situation on the safety of the citizens. We also believe that it is important to inform the municipal administration about the progress of the DM project, which is far behind schedule.

RECOMMENDATION	
4.4.B.	We recommend that the Service des infrastructures, de la voirie et des transports periodically report to the Direction générale and the authorities about the status of the traffic light upgrade program, to allow for informed decision-making concerning the expected results. This accountability reporting should cover: · the number of intersections upgraded, differentiating the legal requirements from the internal standards arising from the *Transportation Plan* and the priorities of the municipal administration; · the costs incurred to meet the legal requirements and the internal standards arising from the *Transportation Plan* and the priorities of the municipal administration; · whether the deadlines for each standard category were met; · the consequences arising from the failure to meet certain standards or deadlines; · corrective measures proposed to rectify the situation; · achievement of objectives targeted by the *Transportation Plan* and the city's priorities.
BUSINESS UNIT'S RESPONSE	
4.4.B.	***Service des infrastructures, de la voirie et des transports*** On May 15, 2017, the Direction générale submitted its action plan for the recommendation it was targeted by and informed us that the Service des infrastructures, de la voirie et des transports action plan was under development and would be submitted as soon as possible.

5. Conclusion

The urban agglomeration council's adoption of a multisectoral transportation plan in 2008 clearly demonstrated its intention to deal with issues such as the safety of foot travel, traffic light upgrades, the dynamic management (DM) of traffic lights on targeted thoroughfares, the introduction of transit priority measures and the increased use of bicycles on a cycling network extended to the entire Island of Montréal.

With regard to the traffic light upgrades, the Service des infrastructures, de la voirie et des transports, which is responsible for governing this program, has not succeeded in setting up a consistent, articulated program to ensure it is executed within the deadlines set by the authorities.

Despite the fact that, since 2008, contracts of a considerable value have been issued to engineering firms and contractors, many plans and specifications have been prepared and revised, a host of interventions has been conducted on the traffic light systems and major purchases of traffic light components have been made, the Service des infrastructures, de la voirie et des transports is unable to confirm, for all intersections equipped with traffic lights in the city's territory, the level of compliance with the standards required by the law[22] and by internal standards. This is the ultimate finding of this audit, which is confirmed, in particular, by:

- An intersection inventory that is incomplete in terms of numbers, territorial distribution, the specific components of the traffic light system and their compliance with the standards. Despite three different professional services contracts issued for its development, there is still no up-to-date, consolidated database, which means the proportion of intersections that meet the various standards is uncertain;
- A lack of general and detailed planning concerning both the number of intersections to be upgraded and the type of interventions required to ultimately meet the established deadlines. So far, the intersection upgrades had been punctuated by a stream of partial upgrades;
- Non-standard cost monitoring in the department in charge, while creditable tools exist that it could adapt, make more effective and extend to all project managers. Under the current work method, determining the cost of work by intervention and by intersection is a mission that would be hard to achieve;
- Annual programming that reveals major delays in the completion of the work in comparison with the information provided in the decision-making summaries;
- The lack of periodic evaluations of the upgrades in terms of the objectives targeted in the *Transportation Plan* with regard to accident reduction and compliance with standards, despite the fact that the form of the *Transportation Plan* lends itself well to a program made up of subprograms for each major aspect, with short-, medium- and long-term objectives. This would have allowed for the periodic evaluation of

[22] The *Highway Safety Code* and the *Canadian Electrical Code*.

the results to measure the achievement of the *Transportation Plan* objectives throughout its implementation period;

- Partial accountability concerning the number of interventions on the intersections, but failure to account for other important aspects of sound management, such as costs, timelines, level of compliance with standards and degree of completion of objectives expected by the authorities since the adoption of the *Transportation Plan*.

Consequently, the initial deadlines and budgets in the *Transportation Plan* were not upheld. In 2008, the preliminary estimates in the *Transportation Plan* projected $42.4 million to upgrade 1,400 intersections equipped with traffic lights. In fact, however, the value of the contracts issued to engineering firms and contractors, as of December 23, 2016, was $65.1 million, and relates to interventions on not quite 750 intersections. Considering the cost of internal labour, $16.0 million must be added, for a total of $81.1 million for the second phase of upgrades (POU 2). Given that the initially planned upgrades have not been completed at all intersections equipped with traffic lights, that DM has not been implemented and that significant expenses are still required to comply with either the legal requirements or the internal standards stemming from the orientations of the *Transportation Plan* or the priorities of the municipal administration, the city will definitely not be able to meet the deadline imposed by the law (December 31, 2017). It should be mentioned, however, that over the years, new legal requirements were added and that the city added new internal standards to reflect the priorities of the municipal administration. It is practically impossible, at present, to differentiate between the costs incurred by these internal standards and those related to the mandatory standards of the Ministère des Transports, de la Mobilité durable et de l'Électrification des transports.

We believe it is imperative for the management of the traffic light upgrade program to be closely monitored by the Direction générale in order to respect the deadlines, projected costs and target objectives.

6. Appendices

6.1. Objectives and Evaluation Criteria

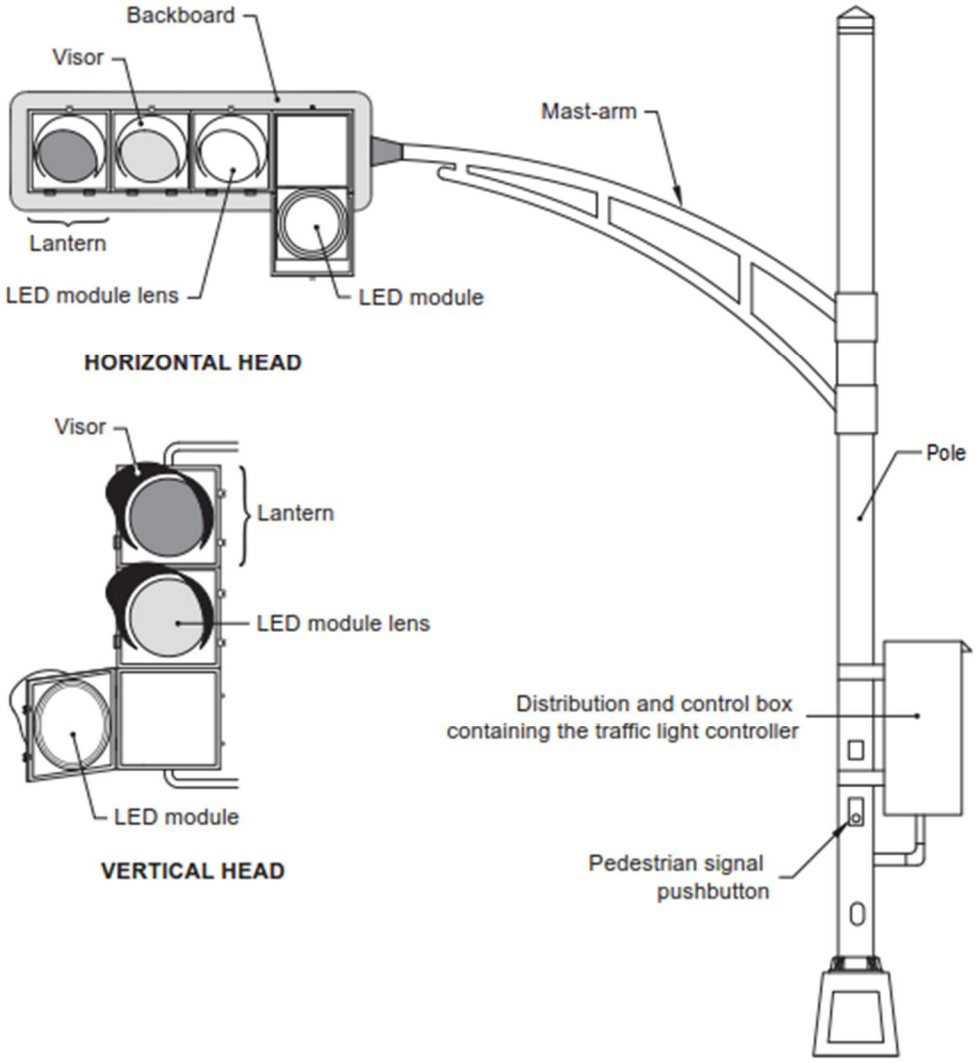
Objective

Ensure that the traffic light upgrade project and the DM implementation project advance in keeping with the priorities approved by the authorities.

Evaluation Criteria

- Traffic light management is supported by keeping a complete, up-to-date inventory.
- The roles and responsibilities of the business units involved in traffic light management are clearly defined with regard to the traffic light upgrade project and the introduction of DM.
- Timelines have been developed and are being monitored.
- Cost estimates have been produced and are being used to track the project costs.
- Periodic accountability mechanisms keep the managers in charge informed (management team of the Service des infrastructures, de la voirie et des transports, Direction générale, city council and urban agglomeration council).
- Analyses are carried out to demonstrate the reduction of negative consequences on traffic and citizen safety.

6.2. Traffic Light Type



Source: Ministère des Transports, de la Mobilité durable et de l'Électrification des transports, *Tome V – Signalisation routière*, chapter 8, page 4.

6.3. Responsibility for Traffic Light Management (Arterial Network and Local Network) – (2002 to 2016)

Responsibility	2002 to 2004	2005	2006	2007 to 2008	2009 to 2014	2015 and 2016
Arterial network	Service de l'environnement, de la voirie et des réseaux → Division de la circulation	Service des infrastructures, transport et environnement → Direction de l'ingénierie de la voirie → Division de l'ingénierie de la voirie	Service des infrastructures, transport et environnement → Direction de l'ingénierie de la voirie → Division de la circulation	Service des infrastructures, transport et environnement → Direction des transports → Division de l'exploitation du réseau artériel	Service des infrastructures, des transports et de l'environnement → Direction des transports → Division de l'exploitation du réseau artériel	Service des infrastructures, de la voirie et des transports → Direction des transports → Division de l'exploitation du réseau artériel
Local network	Boroughs	Boroughs	Boroughs	Boroughs	Boroughs	Service des infrastructures, de la voirie et des transports → Direction des transports → Division de l'exploitation du réseau artériel[a]
Traffic lights managed by the Ville de Montréal	Ville de Montréal	Ville de Montréal	Island of Montréal	Island of Montréal	Ville de Montréal	Ville de Montréal[b]
Maintenance · **Arterial network** · **Local network**	 Boroughs[c] Boroughs	 Boroughs[c] Boroughs	 Boroughs[d] Boroughs	 Boroughs[d] Boroughs	 Boroughs[e] Boroughs	 Boroughs[e] Boroughs[e]

[a] City council decision to declare itself responsible for the local network (until December 31, 2018).
[b] Review of arterial network, beginning January 1, 2015. The proportion rose from 26% to 52%.
[c] Delegated by By-law 02-002, approved by the city council on December 18, 2001.
[d] Delegated by city council subdelegation By-law 05-091.
[e] Delegated by By-law 08-055, approved by the city council on December 15, 2008.