Subject: Ambulance Chassis Review

Report to: Public Health & Social Services Committee

Report date: Tuesday, November 5, 2019

Recommendations

1. That Regional Council **RECEIVE FOR INFORMATION** the following report pertaining to PHD 04-2018 Sole Source EMS Fleet Purchase revised.

Key Facts

- PHD 04-2018 authorized staff to proceed with the sole source purchase of the 2018 annual ambulance replacement built upon the existing chassis used by Niagara EMS for the previous six years
- A staff recommendation was also endorsed to complete a review of the current ambulance chassis and to assess alternative certified platforms. This review would inform staff and Council on a recommended strategy for a preferred ambulance chassis for the next several years
- In November 2018, ApexPro Consulting was awarded the contract for the chassis review. The review included comparison of Niagara EMS with 18 EMS peers.
- The review concluded that the Sprinter (Diesel) platform used by Niagara EMS has the lowest lifecycle cost of available certified ambulance platforms: 28% lower then the Ford E350, 41% lower then the GM3500, and 106% lower then the Ford E450.
- The complete ApexPro report is available as an attachment to this report.
- Niagara EMS staff are working with Procurement staff to purchase the 2019 annual ambulance replacement through a competitive bid process, but informed by the ApexPro review.

Financial Considerations

Since the introduction of the Sprinter chassis in 2012, Niagara EMS has realized considerable savings as detailed in Table 1. In 2012 and through each subsequent year to 2016, previous Ford E350 diesel chassis ambulances were replaced with the Sprinter diesel chassis ambulances through attrition.

Averaging a replacement cycle of eight ambulances per year, the entire fleet was transitioned to the Sprinter chassis by the end of 2016.

Table 1 shows that even with a 40% *increase* in the amount of kilometers traveled by the growing fleet year over year, total fuel consumption has nonetheless steadily *decreased*. Despite fluctuating fuel prices, the cost per kilometer has also declined.

In addition, the non-fuel fleet cost have not increased at the same rate as the growth of the fleet size due to lower maintenance and non-fuel operating costs realized by the Sprinter platform.

Year	Vehicles	Type	Km Travelled	Litres	L/100km	Total Cost/km	Fleet Cost/km (excluding fuel)
2011	36 ambulances	36 Ford	1,792,407	423,799	21.0	$0.49	$0.23
2012	37 ambulances	9 Sprinters 28 Ford	2,017,603	428,387	21.2	$0.46	$0.21
2013	37 ambulances	17 Sprinters 20 Ford	2,276,152	435,053	19.1	$0.44	$0.20
2014	40 ambulances	25 Sprinters 15 Ford	2,339,606	417,814	17.9	$0.45	$0.20
2015	41 ambulances	37 Sprinters 4 Ford	2,377,149	417,164	17.5	$0.44	$0.25
2016	41 ambulances*	41 Sprinters	2,503,792	418,985	16.7	$0.37	$0.21

Table 1 – total km travelled in relation to fuel consumed and associated fleet costs
*additional two Ford E450 specialty transport unit ambulances

Analysis

To assess if the diesel chassis should remain the preferred and recommended option, cost comparison for gas chassis was completed. Table 2 illustrates the cost for each manufacturer chassis only. The addition of an air ride suspension improves patient safety, reduces patient pain and discomfort, improves safety of care provided by paramedics, includes an anti-roll safety system, and also provides the ability for the ambulance to lower the rear portion of the ambulance to assist with the height of people and equipment entering and exiting the ambulance.

Manufacturer	Base Cost	Air Ride Suspension	Total Cost
Sprinter Chassis V6 diesel	$44,137	Included	$44,137
Ford E350 V10 gas	$29,868	$9-12,000 for either fluid or air suspension	$39 868
GM 3500 V8 gas	$39 539	$9-12,000 for either fluid or air suspension	$49,539

Table 2 – cost comparison of chassis with air ride suspension

Industry best practise across North America is that ambulances should be decommissioned after a 54-month of life due to patient safety concerns, risk of breakdowns, and increasing maintenance and operating cost. The Region has incorporated a best practice of selling ambulances that are decommissioned after this lifespan through Government Surplus Auctions (govdeals.com). This best practice is supported by the Apexpro review. In 2017, this was the first year in which several of the first generation Sprinter ambulances were made available for auction. The typical yield for the previous Ford diesel ambulances was $5-$10,000. The yield for the Sprinter diesel ambulances was $18-$22,000 making the Sprinter a more favourable asset at end of usable life.

Over the past five years, Niagara EMS has developed an ambulance platform on the Sprinter MX152A Type 3 chassis that in comparison to previous Ford E350 chassis has provided the Service with increased safety for both the providers and patients, improved environmental impact through decreased emissions utilizing Diesel Exhaust Fluid (DEF), decreased fuel consumption, decreased cost through the lower fuel consumption, decreased maintenance costs, and increased resale value.

The first generation of Sprinter ambulances (2012) were supplied by Crestline Ambulance through an approved tender process. The next six generations of Sprinter ambulances (2013-2018) were supplied by Demers Ambulance, also through an approved tender process. Currently, only one of the two ambulance manufacturers who are certified by the province of Ontario to build ambulances make this chassis available for purchase and delivery. This is Demers Ambulance as confirmed in Appendix 2. The original certification of the Sprinter ambulance manufactured by Crestline has since expired and they do not offer an Ontario certified ambulance on a diesel platform. Crestline has also been acquired by Demers Ambulance.

Each year the service replaces approximately 20% of its fleet based on the attrition rate of ambulances at end of life. In the absence of a purchasing agreement since 2017 and an updated review of available chassis on the market that continued during the first part of this year, the ambulances typically ordered in 2019 have been delayed, meaning, the service is behind in our annual replacement cycle and using aged vehicles that exceed the industry best practice benchmark. The risk associated with an aging fleet is related to patient safety, increased maintenance and operating cost, and reduced reliability.

The lifespan of an ambulance is assessed primarily through continuous monitoring of an increased frequency of unscheduled maintenance.

As the ambulance reaches these thresholds, risk increases with associated increased chance of breakdown and therefore increased patient risk and financial risk. Given the urgent and life-saving nature of the services provided by Niagara EMS, reliability of ambulance performance is imperative for its potential to impact on patient outcomes.

Today, Niagara EMS chassis of choice is diesel due to dependability and fuel efficiency. Further benefits of the current diesel platform include:

- Diesel engines withstand the hard driving conditions endured by ambulances
- Based on industry experience, over a five-year period it is anticipated that there would be more mechanical repairs with a gas chassis
- Almost zero emissions with DEF
- OEM parts comparison (high volume) shows the Mercedes chassis parts to be slightly less expensive than a Ford chassis and less expensive than a GM chassis.

Additional benefits specific to the Sprinter chassis include:

- Tighter steering radius
- Much quieter engine
- No black smoke
- Air ride suspension
- Anti-roll stability control feature
- Added cab space
- Fuel economy
- Longer service intervals

Alternatives Reviewed

Recognizing that the automotive industry is continuously evolving, Niagara EMS is continuously searching for ways to improve overall service delivery including the choice of ambulances. This was the basis of the updated review of platforms recently completed. The review recommended continuing with Demers Ambulances' Sprinter platform.

It is important to commit to a specific platform for a period of time to ensure standardization with the fleet for optimal efficiencies in maintenance, logistics, and both provider and patient safety in creating a consistent working environment for paramedics. Should an alternative platform be determined to be desirable in the future, extensive planning for the transition would be necessary, and a multi-year timeline would be needed to execute the transition.

Relationship to Council Strategic Priorities

The operation of a standardized fleet of ambulances that provide the best economic return on investment throughout the life cycle supports the Council Strategic Priority of Sustainable and Engaging Government through continuous improvement of ambulance design that promotes innovation and optimal cost-efficiencies. This program also adds value to the area of Responsible Growth and Infrastructure Planning as we expect to travel additional distances as the service changes and grows in the years ahead requiring our fleet be evaluated against environmental protection through areas such as reducing our carbon footprint.

Other Pertinent Reports

PHD 04-2018 Sole Source EMS Fleet Purchase revised

Prepared by:
Kevin Smith
Chief, Niagara Emergency Medical Services & Director, Emergency Services

Recommended by:
M. Mustafa Hirji, MD, MPH, FRCPC
Medical Officer of Health & Commissioner (Acting)
Public Health & Emergency Services

Submitted by:
Ron Tripp, P.Eng.
Acting Chief Administrative Officer

This report was prepared by Kevin Smith, Chief, Niagara Emergency Medical Services & Director, Emergency Services and reviewed by Michael Leckey, Program Financial Specialist.

Niagara Region

FINAL REPORT

ASSESSMENT OF ALTERNATIVE AMBULANCE CHASSIS PLATFORMS

APEXPRO CONSULTING INC.

MARCH 6, 2019

RFP # 2018-RFP-47

APEXPRO CONSULTING INC.
EXCELLENCE COMMITMENT PARTNERSHIP – EVERY CLIENT! EVERY TIME!
30 KARL CRT., THORNHILL ON L4J 8H7 CANADA

March 6, 2019

Randy McDougall
Commander Logistics & Planning
Niagara EMS
2 Westwood Court, Unit 300
Niagara-on-the-Lake, ON L0S 1J0

Dear Mr. McDougall:

ASSESSMENT OF ALTERNATIVE AMBULANCE CHASSIS PLATFORMS

It is with great pleasure that we submit this report containing the results of our review and assessment of Niagara Region's diesel-powered Mercedes Sprinter 3500 chassis platform relative to alternative chassis certified for use as ambulances in Ontario, and to newly emerging ambulance chassis technology.

Our review affirms that relative to other alternatives, the diesel-powered Mercedes Sprinter 3500 is the preferred ambulance chassis platform. Our reasons, discussed in the body of the report, include service needs and safety, environment, mechanical reliability, cost and cost efficiency.

Our review also finds that the north-American ambulance industry is in a state of significant flux (also discussed in the report) and it will take time to sort itself out.

For all the above reasons, we recommend that Niagara should maintain the diesel-powered Mercedes Sprinter 3500 as its ambulance chassis platform of choice for at least the next 2 to 3 years, at which point options may once again be re-examined.

Thank you for giving us the opportunity to work on this most interesting assignment.

APEXPRO CONSULTING INC.

Marvin Rubinstein
President

Enc.

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Executive Summary

Introduction

This review, by APEXPRO Consulting Inc., assesses Niagara Region's diesel-powered Mercedes Sprinter 3500 chassis platform relative to alternative chassis certified for use as ambulances in Ontario; also, relative to newly emerging ambulance chassis technology.

We conducted this review, working collaboratively with members of the Niagara EMS leadership team. We acknowledge and thank the following leadership team members for their assistance and support.

- Roger Mayo, Deputy Chief
- Randy McDougall, Commander Logistics & Planning
- Ralph Paolini, Commander EMS Fleet & Support Services

We also wish to acknowledge Gayle Tries of Niagara EMS Fleet and Logistics, for time spent organizing historical vehicle operating data (VOD) records essential to our assessment.

In the course of the review we consulted with 26 of Niagara's EMS peers. A few peers also use the diesel-powered Mercedes Sprinter 3500 chassis platform. Most use chassis manufactured by GM and Ford, which also are certified for ambulance use in Ontario.

Findings and Recommendation

Our review affirms that relative to other alternatives, the diesel-powered Mercedes Sprinter 3500 is the preferred ambulance chassis platform. Our reasons, discussed below and in the body of this report, include service needs and safety, environment, mechanical reliability, cost and cost efficiency.

Our review also finds that the north-American ambulance industry is in a state of significant flux (also as discussed below) which will take time to sort itself out.

For all the above reasons, we recommend that Niagara should maintain the diesel-powered Mercedes Sprinter 3500 as its ambulance chassis platform of choice for at least the next 2 to 3 years, at which point options may once again be re-examined.

Current State of Flux

In September 2018 Demers Ambulances of Beloeil, Quebec announced the acquisition of Canada's only other major ambulance manufacturer (Crestline Coach Ltd. of Saskatoon Saskatchewan).

Also, in September 2018, Demers Ambulances (now Canada's only major manufacturer of ambulances for the international market) informally announced their intent to investigate the development of a fully-electric ambulance. Demers has not committed to a specific timeline however, we may safely assume that a technological change of this significance could take 2 years or more.

XL Fleet of Boston MA has developed a self-contained electric drive train and battery system which, when installed as an after-market product onto a standard OEM vehicle chassis, works seamlessly in the background to increase the vehicle's torque and make the vehicle more fuel efficient and cleaner, reportedly with zero adverse impact on the OEM systems. Several Ontario and BC-based EMS services, including Toronto EMS, York Region Paramedic Services, and Oxford County Paramedic Services are presently trialling this technology.

Ambulance Chassis Certified for Use in Ontario

The diesel-powered Mercedes Sprinter 3500 is one of four chassis certified for use as an ambulance in Ontario under the *"Ontario Provincial Land Ambulance & Emergency Response Vehicle Standard"*.

The others are the gas-powered versions of the Chev (GM) 3500, Ford E350 and Ford E450 chassis. GM and Ford used to manufacture both a diesel and gas version of their chassis for Ontario ambulance use. This is no longer the case. Only their gas-powered versions are currently certified for use in Ontario.

Most Popular Ambulances in Ontario

Niagara EMS' ambulance fleet consists entirely of Demers MX152A (Type 3) ambulances, which are manufactured with the diesel-powered Mercedes Sprinter 3500 chassis.

The Demers MX164A and Crestline Fleetmax are the most popular ambulances used by Ontario peers. Both ambulances are of a Type 3 model and depending on client preference, they are manufactured with the gas-powered versions of the Chev (GM) 3500, Ford E350 and Ford E450 chassis.

The gross vehicle weight (GVW) of a Ford E450 ambulance is about 6,500 kgs, which is significantly heavier than the GVW of a Mercedes Sprinter, Ford E350 or GM 3500 ambulance, which range between 5,000 and 5,600 kgs.

Relatively few EMS services operate fleets consisting mainly of heavier Ford E450's. However, multiple services including Niagara EMS maintain a few such vehicles at hand, to serve bariatric needs, i.e., to transport patients whose weight would severely challenge the capabilities of lighter vehicles.

Service Needs and Safety

The diesel-powered Mercedes Sprinter 3500 chassis supports the service needs of Niagara EMS for a Type 3 ambulance model.

The minimum requirements for land ambulance certification in Ontario are based mainly on safety considerations. The diesel-powered Mercedes Sprinter 3500 fulfills all provincial safety requirements.

The Sprinter's front cab design is spacious, comfortable and will accommodate aftermarket add-ons, e.g., computer mounts and modems. The front cab design also includes dual stage front and side airbags for crash safety.

The Sprinter 3500 chassis is equipped with a VB Air-suspension system that lowers the rear portion of the ambulance making it easier to load both patients and equipment. In addition, the VB Air-suspension system substantially reduces road shock and vibration, and improves load levelling capability, making for a quieter, smoother and more constant patient ride, better overall handling, and rollover resistance.

Vehicle safety is further assured by the chassis' computer, which manages the vehicle's systems, including air-ride suspension, on an integrated basis.

Environment

Fuel Efficiency

Niagara's Mercedes Sprinter is outfitted with a fuel-efficient 3.0 litre diesel engine, and an aerodynamic front cab design and riser, which collectively make Niagara's diesel-powered Sprinter the most fuel-efficient Type 3 ambulance in Ontario, consuming an average of 17.7 litres of fuel per 100 kilometres.

In comparison, the gas-powered Ford E350 and GM 3500 ambulances consume fuel at rates that are 69% higher, averaging about 29 litres per 100 Kms; and the Ford E450 ambulance consumes fuel at a rate of almost 38 litres per 100 Kms, which is over twice that of the Mercedes Sprinter.

CO2 emissions

The primary products of gasoline or diesel fuel combustion are nitrogen (N_2), carbon dioxide (CO_2), water (H_2O) and Oxygen (O_2). CO_2 emissions are proportional to the quantity of fuel consumed. Since the Sprinter's fuel consumption rate is the lowest among peers, its rate of CO_2 emissions is also the lowest.

Nitrogen Oxide and Particulate Matter

Partial combustion of petroleum fuel generates the following unwanted and potentially harmful emissions: nitrogen oxide (NOx), carbon monoxide (CO) and particulate matter in the form of black smoke (soot). Diesel engines, while they are highly efficient in terms of power and performance, also are inherently dirty, capable of generating relatively large amounts of these unwanted emissions.

The Mercedes Sprinter's highly-efficient diesel-emissions technology reduces harmful exhaust levels of nitrogen oxide and eliminates almost all diesel particulate matter, to ultra-low levels that are well within Canada's stringent emission standards, thus creating a cleaner, greener ambulance vehicle.

Idle Reduction System

Fifty-five percent (55%) of the 27 EMS services surveyed by this review have either not equipped their ambulances with idle reduction systems, or they have had the systems disconnected, due to conflicts between the idle reduction system and other essential on-board systems. This includes Niagara EMS. This notwithstanding, Niagara's diesel-powered Mercedes Sprinter is the most fuel-efficient Type 3 ambulance in Ontario.

Mechanical Reliability

Diesel-powered ambulances have proven repeatedly, to be better at withstanding the hard driving conditions endured by ambulances. In this, the diesel-powered Mercedes Sprinter 3500 ambulance is no exception. Annually, Niagara EMS' Sprinter ambulances average 54,700 kilometres a year.

In comparison, according to our survey, EMS peers who use Ford E450's average 14% fewer kilometres a year; those that use Ford E350's average 15% fewer kilometres; and those that use GM 3500's average 27% fewer kilometres.

Also, Mercedes Sprinter ambulances require less frequent servicing. Type 3 ambulances that use Ford and GM chassis are serviced at intervals of about 6,000 kms; whereas, Niagara's Sprinter ambulances are serviced at intervals of 9,000 kms, as recommended by Mercedes.

Cost and Cost Efficiency

Up-Front Chassis Cost

The Mercedes Sprinter 3500 used by Niagara is equipped with VB Air-suspension. Almost 75% of the EMS peers surveyed operate ambulances equipped with a standard leaf spring suspension. Adjusting for the value of VB Air-suspension, we conclude that the Mercedes Sprinter, Ford and GM chassis are of comparable cost, each one averaging about $44,000.

End-of-Life Resale Value

According to Niagara EMS' records, resale values for a Mercedes Sprinter diesel ambulance range between $18,000 and $22,000; which, based on our survey of EMS peers, is higher than the resale values for gas-powered Ford and GM ambulances. Resale values for Ford E350 ambulances range between $3,000 and $8,000. GM 3500's range between $5,000 and $12,000; and Ford E450's range between $13,000 and $14,000.

Sprinter Lifecycle Costs

Our review included a lifecycle cost comparison of the diesel-powered Mercedes Sprinter and Niagara's former diesel-powered Ford E350 ambulance. The cost comparison was based on historical costs managed by Niagara EMS.

Our findings indicate that on a per kilometre basis, Sprinter capital costs are on average 26% lower than that of the former diesel-powered Ford E350's – this due mainly to the Sprinter's higher end-of-life resale value. We also conclude that Sprinter operating costs are on average 5% lower; and total lifecycle costs (sum of capital and operating) are about 10% lower.

Vehicle idling for extensive periods is an example of a hard driving condition that ambulances are frequently required to endure. Ambulances may be left to idle during standby, during hospital offload, and during periods of hospital offload delay. In this, Niagara EMS' ambulances are no exception. Our investigation reveals that Sprinter lifecycle repair costs are highly susceptible to extensive vehicle idling.

We repeated the lifecycle cost analysis, discounting the cost of repairs to illustrate how much money would be saved, if one could mitigate excessive idling. We conclude that Sprinter lifecycle repair costs would be about 16% lower than the reported historical costs; operating costs (inclusive of fuel, servicing and repairs) would be about 8% lower; and total lifecycle costs would be about 7% lower.

Fuel Costs

On a per kilometre basis, fuel costs for the Sprinter average $0.22 per kilometre. In comparison, fuel costs for Ford E350 and GM 3500 ambulances are 65% higher, averaging about $0.37 per Km; and fuel costs for the Ford E450 ambulance are 89% higher, averaging $0.42 per kilometre.

Servicing & Repair Costs

On a per kilometre basis, servicing and repair costs for the Sprinter average $0.25 per kilometre. In comparison, servicing and repair costs for Ford E350 and GM 3500 ambulances are up to 19% higher, ranging between $0.25 and $0.30

per Km; and servicing and repair costs for the Ford E450 ambulance are over twice as high, averaging $0.56 per kilometre.

Total operating Costs

On a per kilometre basis, total operating costs for the Sprinter average $0.47 per kilometre. In comparison, total operating costs for Ford E350 and GM 3500 ambulances are up to 41% higher, ranging between $0.61 and $0.67 per Km; and total operating costs for the Ford E450 ambulance are over twice as high, averaging $0.98 per Km.

Cost of Sprinters vs. Hybrid Technology

Based on information that is currently available, we conclude that outfitting a standard gasoline-powered ambulance with hybrid technology will increase the overall lifecycle cost of that ambulance by a net of $5,000 to $9,000. Many would argue that this is a reasonable expenditure by which to attain a cleaner, greener vehicle. We do not disagree.

This conclusion notwithstanding, Niagara Region which uses a diesel-powered Mercedes Sprinter equipped with an ultra-low diesel-emissions system, achieves the same objectives – a highly fuel-efficient, cleaner, greener vehicle. Moreover, Niagara accomplishes these objectives at a lower cost (as shown above).

1 Introduction

1.1 Project Objective

On February 8, 2018 Niagara Regional Council approved the following recommendation arising from the Public Health and Social Services Committee meeting of January 30, 2018.

… that staff be authorized to proceed with the purchase of MX152A Type III ambulance 2017 Sprinter (Diesel) from Demers Ambulance as a sole source until such time that staff complete a review of the current ambulance OEM chassis to assess future alternative platforms as certified by the MOHLTC to meet specific criteria including safety, environment and cost ...

The MX152A Type III is a diesel-powered ambulance manufactured on a Mercedes Sprinter 3500 chassis platform. By way of this approval, staff would proceed to purchase 18 such ambulances of the model year 2017.

Funding for the 18 ambulances had previously been approved in the 2017 and 2018 capital budgets, in CSD 48-2016 Revised and CSD 65-2017, respectively.

Council's recommendation to review alternative ambulance chassis platforms recognizes that the automotive industry, hence the choice of ambulances, is continuously evolving. The recommendation also is in keeping with the Corporation's strategic policy for fostering organizational excellence.

On September 5, 2018 Niagara Region issued a Request-for-Proposals (RFP) inviting proponents to submit proposals for the provision of consulting services for an ambulance chassis comparison.

APEXPRO Consulting Inc.'s involvement in this project is the direct result of this RFP process. We received notice of award on November 12, 2018 and commenced the project immediately thereafter, in accordance with the following project objective.

The objective of this review is to assess Niagara Region's diesel-powered Mercedes Sprinter 3500 chassis platform relative to alternative chassis certified for use as ambulances in Ontario; also, relative to newly emerging ambulance chassis technology.

The review will either re-affirm the diesel-powered Mercedes Sprinter 3500 as the ambulance chassis platform of choice for Niagara Region, or it will recommend an alternate ambulance chassis platform, as well as a strategy for incrementally implementing the alternative over the next 3 to 5 years.

1.2 Background

Prior to 2012, Niagara EMS' ambulance chassis platform of choice was the diesel-powered E350 manufactured by the Ford Motor Company. In 2012, Ford stopped producing this diesel-powered chassis for Ontario ambulances in favour of models using only gasoline. GM, another principal manufacturer of Ontario ambulance chassis, made a similar decision.

Niagara EMS prefers diesel-powered ambulances, which have proven repeatedly to perform better than gas-powered ambulances in terms of fuel economy, mechanical reliability and cost. This opinion is shared by numerous other EMS services.

With Regional Council's authorization, Niagara EMS commenced to transition its fleet to the only remaining diesel-powered chassis certified for use as an ambulance in Ontario, namely the Mercedes Benz Sprinter 3500. Nine (9) Mercedes Sprinter ambulances were commissioned in 2012; 7 in late 2013 / early 2014; and others between 2014 and 2018, as shown by Exhibit 1.1.

Currently, Niagara's ambulance fleet consists of 43 Mercedes Sprinters. All are 3rd to 6th generation models, commissioned between 2014 and 2018.

Exhibit 1.1: Mercedes Sprinter Chronology, 2012-2018

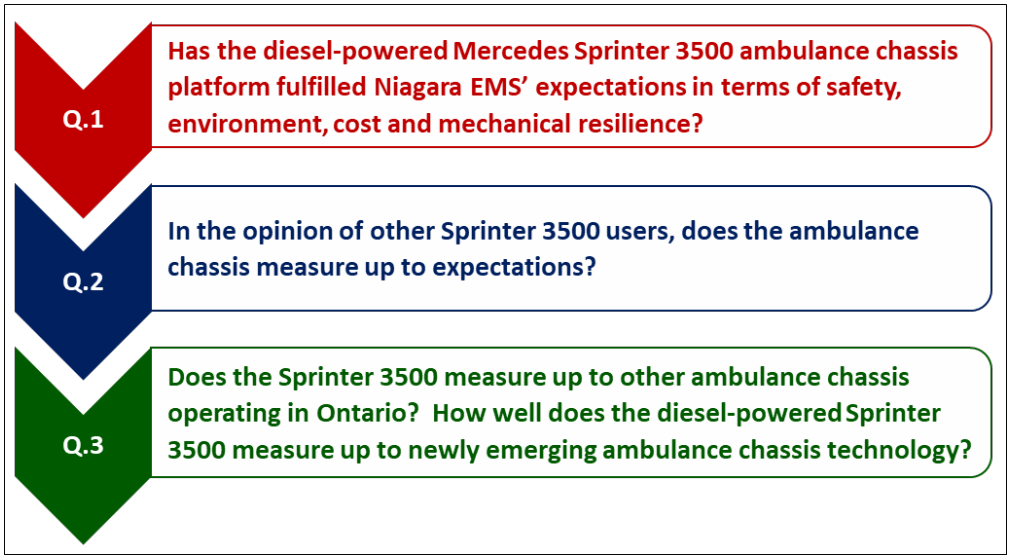
Model Year	# Purchased	Commissioned	Current in Service
2012 - 1st Gen.	9	2012	--
2013 - 2nd Gen.	7	2013 (5) / 2014 (2)	--
2014 - 3rd Gen.	11	2014 (11)	5
2015 - 4th Gen.	11	2015 (4) / 2016 (7)	11
2016 - 5th Gen.	9	2016 (2) / 2017 (7)	9
2017 - 6th Gen.	18	2018	18
Total	**65**	**--**	**43**

1.3 Scope and Approach

Per Regional Council's direction, the focus of this review is mainly on safety, environment, and cost; albeit, we also investigated mechanical reliability as an additional consideration.

We aligned our assessment to the questions listed below. Our findings relevant to Question 1, are reported in Sections 3, 4 and 5 of this report. Question 2 is addressed in Section 6; and Question 3 is addressed in Sections 7 and 8.

Exhibit 1.2: Project Scope



Our assessment is based on vehicle operating data (VOD) and insights provided by Niagara EMS and by operators of other land ambulance services, including those that are piloting emerging technologies.

We also obtained information from: Demers Ambulances, the manufacturer of Niagara's Mercedes Sprinter ambulances; Brock Ford, the Niagara-based dealership that services Niagara EMS' ambulances; and XL Fleet of Boston Massachusetts, the manufacturer of a relatively new electric drive train technology being piloted by several Ontario ambulance services.

A comprehensive listing of contributors of information to this review is included in Appendix A.

1.4 Project Oversight & Support

Project oversight was provided by Niagara EMS. We worked closely with members of the Niagara EMS leadership team, scheduling meetings at key milestones; also, interacting frequently by telephone and e-mail.

We acknowledge and thank the following leadership team members for their assistance and support: Roger Mayo, Deputy Chief; Randy McDougall, Commander Logistics & Planning (who also served as client Project Manager); and Ralph Paolini, Commander EMS Fleet & Support Services.

1.5 Reliability of the Data

The data provided by Niagara EMS and by operators of other land ambulance services was reviewed prior to use, for both reliability and accuracy.

In some instances, we identified data omissions and/or inaccurate information. Where feasible, we corrected these errors, occasionally drawing surrogate data from the broad base of information with which we were presented.

Overall, in our opinion the information provided is sufficiently comprehensive and reliable for this review and assessment of alternative ambulance chassis.

1.6 Costs Presented in this Report

This report investigates historical operating costs for Niagara EMS ambulances, in some instances going back as far as 2009. To appropriately compare costs over time, 2009-2018, we needed to adjust actual in-year costs to a common basis - our purpose being, to adjust for the purchasing power of money which is affected by inflationary changes in prices. For convenience, we chose the current year 2018 as the common basis.

Consumer Price Index (CPI) inflation rates for Ontario were adopted as the means for making the adjustments. CPI, which is tracked by Statistics Canada, is an indicator of changes in consumer prices. It is obtained by comparing, over time, the cost of a fixed basket of goods and services. These include food, shelter, furniture, clothing, transportation, and recreation.

The Statistics Canada CPI inflation rates used in this analysis are listed below. [1]

Conversion Period	Inflation Rate	Conversion Period	Inflation Rate	Conversion Period	Inflation Rate
2009 to 2018	18.03%	2010 to 2018	15.19%	2011 to 2018	11.74%
2012 to 2018	10.18%	2013 to 2018	9.11%	2014 to 2018	6.59%
2015 to 2018	5.34%	2016 to 2018	4.84%	2017 to 2018	2.60%

[1] Source: Inflation calculator at http://inflationcalculator.ca/ontario/.

2 Context

2.1 Definitions

"Ambulance": The *Ontario Ambulance Act* defines an ambulance to mean a conveyance used or intended to be used for the transportation of persons who:

a) Have suffered a trauma or an acute onset of illness either of which could endanger their life, limb or function, or

b) Have been judged by a physician or a health care provider designated by a physician to be in an unstable medical condition and to require, while being transported, the care of a physician, nurse, other health care provider, emergency medical attendant or paramedic, and the use of a stretcher.

"Ambulance Chassis": The term "ambulance chassis" is intended to mean the frame or underpart of the ambulance, on which the patient compartment or box as it is generally referred, is mounted.

By definition, the underpart of the ambulance also includes a platform for the driver's seat and the vehicle's running gear, i.e.: engine, transmission, drive shaft, differential and suspension.

"Conversion": Ambulances are typically manufactured in two stages. Stage 1 is the manufacturing of the ambulance chassis, typically by a manufacturer of light or medium-sized trucks, e.g., Ford, GM or Mercedes-Benz. Stage 2 is the manufacturing of the patient compartment or box by an ambulance manufacturer who specializes in this type of product, e.g., Demers Ambulances and Crestline Coach Limited. [2]

Stage 2, often referred to as the "conversion" process, can be performed by one of two methods, either by coachbuilding where modifications are started from scratch, or by taking a modular approach, placing a pre-built box onto an empty chassis and then finishing off the product.

"OEM": Original Equipment Manufacturer (OEM) means the manufacturer of the vehicle chassis used in the ambulance conversion.

[2] Prior to September 14, 2018 the major manufacturers of ambulances in Canada were Demers Ambulances of Beloeil, Quebec and Crestline Coach Ltd. of Saskatoon Saskatchewan. On September 14, 2018 Demers Ambulances announced the acquisition of Crestline Coach Ltd. We are given to understand that Crestline will continue to manufacture its line of ambulances as a division of Demers.

2.2 Land Ambulance Vehicle Standard

The Ontario Provincial Land Ambulance & Emergency Response Vehicle Standard, Version 5.0, Emergency Health Services Branch, MOHLTC, September 2012, defines the minimum requirements for land ambulances operating in Ontario.

Requirements set out under the *Standard* are based mainly on safety considerations for patients, paramedics and overall land ambulance operations. For illustration purposes, several requirements of relevance to this review are presented below.

Under the *Standard* ambulances are grouped by "type", as follows:

- "Type 1" - conventional truck cab and chassis with a remountable modular body that contains the patient compartment;
- "Type 2" - standard van with integral cab and body, the patient compartment contained within the body and a raised roof over the patient compartment;
- "Type 3 " - cutaway van cab and chassis with a remountable modular body that contains the patient compartment;
- "Special Purpose" - any type of ambulance when built, equipped and certified for a specific non-standard application.

Ambulances operating in Ontario must comply with the requirements under the *Standard*; Canadian Motor Vehicle Safety Standards (CMVSS); and criteria established by the OEM for the conversion of chassis to ambulances.

Ambulances operating in Ontario must be capable of a minimum payload of 770 kg (1700 lbs) over and above the converted curb weight. The total weight of the occupants and cargo shall not exceed the payload.

Only chassis approved by the OEM can be used for an ambulance. All modifications or additions to the OEM chassis must be completed using approved OEM practices, and all modified equipment must meet or exceed OEM performance characteristics.

Every model of ambulance intended for use in Ontario must be certified by MOHLTC, before it can be placed in service. Compliance requirements for certification include performance testing as specified by the *Standard*. The process is normally the responsibility of the ambulance conversion vendor. [3]

[3] Niagara EMS is stringent in this regard, requiring the conversion vendor to ensure certification of ambulances prior to delivery; thus, protecting the Corporation from potentially lengthy delays.

Certification is initially valid for up to three years for all like ambulances produced by the same contractor provided: that the design, material and equipment are the same; that the ambulance is manufactured in the same manner; and that the chassis is of same model, engine and specifications. Certification may be extended by making application to MOHLTC.

2.3 Ontario Certified Ambulance Models

The following chart lists the conversion vendors and their ambulance models, which are currently certified for use in Ontario.

Conversion Vendor	Cert. #	Make / Model
Crestline Coach Ltd.	15-516(R2)	Chev cutaway 3500, 6.0L gas, Type 3 remounted 'New Era' (single cot configurations)
Crestline Coach Ltd.	16-520	Chev cutaway 3500, 6.0L gas, Type 3 'Fleetmax' and 'Commander' (single or dual cot configurations)
Crestline Coach Ltd.	16-521(R)	Ford E350 Cut, 6.8L Gas, Type 3 'FleetMax' and 'Commander' (single or dual cot configurations)
Crestline Coach Ltd.	16-522	Chev cutaway 3500, 139" WB, 6.0L Gas, Type 3 'New Era' (single cot configuration)
Demers Ambulances	17-523	Mercedes Sprinter 3500, 3.0L Diesel chassis, Type 3 'MX152A' (single main cot configuration)
Demers Ambulances	17-524(R)	Ford E350/E450 Cut, 6.8L Gas, Type 3 "MX164A" (single main cot configuration)
Demers Ambulances	17-525(R)	GM 3500 Cut, 6.0L Gas, Type 3 "MX164A" (single and dual main cot configuration)
Crestline Coach Ltd.	18-526	Ford E350 Cut- 6.8L gas, Chev 3500 Cut-6L gas, Type 3 remounted 'Fleetmax' and 'Commander' (single or dual cot configurations)

3 Diesel-Powered Mercedes Sprinter 3500

3.1 Niagara EMS' Chassis Platform of Choice

The diesel-powered Mercedes Sprinter 3500 is Niagara's current ambulance chassis platform of choice, mainly for the reasons listed below. These reasons are addressed throughout this report.

Service Needs and Safety

The diesel-powered Mercedes Sprinter 3500 chassis supports the service needs of Niagara EMS for a Type 3 ambulance model.

The minimum requirements for land ambulance certification in Ontario are based mainly on safety considerations. The diesel-powered Mercedes Sprinter 3500 fulfills all provincial safety requirements.

The Sprinter's front cab design is spacious, comfortable and will accommodate aftermarket add-ons, e.g., computer mounts and modems. The front cab design also includes dual stage front and side airbags for crash safety.

The Sprinter 3500 chassis is equipped with a VB Air-suspension system that lowers the rear portion of the ambulance making it easier to load both patients and equipment. In addition, the VB Air-suspension system substantially reduces road shock and vibration, and improves load levelling capability, making for a quieter, smoother and more constant patient ride, better overall handling, and rollover resistance.

Vehicle safety is further assured by the chassis' computer, which manages the vehicle's systems, including air-ride suspension, on an integrated basis.

Environment

Niagara's Mercedes Sprinter is outfitted with a fuel-efficient 3.0 litre diesel engine, and an aerodynamic front cab design and riser, which collectively make Niagara's diesel-powered Sprinter the most fuel-efficient Type 3 ambulance in Ontario, as will be demonstrated by way of this report.

CO_2 emissions are proportional to the quantity of fuel consumed. Since the Sprinter's fuel consumption rate is the lowest among peers, its rate of CO_2 emissions is also the lowest.

The Mercedes Sprinter chassis is outfitted with a highly-efficient diesel-emissions technology which reduces harmful exhaust levels of nitrogen oxide and eliminates almost all diesel particulate matter, to ultra-low levels that are well within Canada's stringent emission standards, thus creating a cleaner, greener ambulance vehicle. The system is discussed in Section 3.2 of this report.

The Sprinter can be equipped with an idle reduction system, which is intended to improve fuel economy and reduce greenhouse gas emissions. The idle reduction system, which Demers installs with Mercedes Benz's authorization, is discussed in Section 3.3 of this report.

Mechanical Reliability

Diesel-powered ambulances have proven repeatedly, to be better at withstanding the hard driving conditions endured by ambulances. In this, the diesel-powered Mercedes Sprinter 3500 ambulance is no exception.

The Mercedes Sprinter requires less frequent servicing. Type 3 ambulances operating with Ford and GM chassis are serviced at intervals of about 6,000 kms; whereas, Niagara's Mercedes Sprinter ambulances are serviced at intervals of 9,000 kms, as recommended by Mercedes. [4]

Cost and Cost-Efficiency

The up-front capital cost of a Type 3 Mercedes Sprinter ambulance is comparable to the cost of other similarly-sized ambulances operating in Ontario; moreover, the residual value at retirement is higher. Both reasons are affirmed by this report.

Because the diesel-powered Type 3 Mercedes Sprinter ambulance is significantly more fuel efficient than other Type 3 ambulances operating in Ontario, its fuel consumption costs are lower.

With less frequent servicing, the maintenance costs are lower. Also, the Sprinter's high-volume OEM replacement parts for servicing (e.g., brakes and rotors) are less expensive than those of other manufacturers.

Finally, as this report will show, the Mercedes Sprinter's overall operating cost (inclusive of fuel and servicing) is lower than that of other Type 3 ambulances operating in Ontario.

3.2 Ultra-Low Diesel Emissions System

The primary products of gasoline or diesel fuel combustion are nitrogen (N_2), carbon dioxide (CO_2), water (H_2O) and Oxygen (O_2).

[4] Note: Mercedes has recently informed its clients that beginning in 2019, the minimum servicing requirement for warranty purposes will be extended to 15,000 kms (up from 9,000).

Partial combustion of petroleum fuel generates the following unwanted and potentially harmful emissions: nitrogen oxide (NOx), carbon monoxide (CO) and particulate matter in the form of black smoke and soot. [5]

CO_2 emission, which is proportional to the quantity of fuel consumed, is discussed in Section 4.1 of this report. This section discusses the automotive industry technology used to manage the cleanliness of combustion, i.e., to reduce / eliminate the unwanted and potentially harmful emissions.

While diesel engines are highly efficient in terms of power, performance and torque output, they also are inherently dirty, capable of generating relatively large amounts of the unwanted emissions. [6]

Short-term exposure to untreated diesel exhaust can irritate the eyes, nose and throat. Long-term exposure to untreated diesel exhaust can contribute to / cause serious respiratory problems. [7]

US and Canadian government regulations have for many years, required low emission technology to be installed on all newly manufactured diesel-powered vehicles; this, in keeping with highly-stringent diesel emissions standards. [8]

The technology introduced by the automotive industry generally centers about two systems that work in an integrated fashion to mitigate unwanted emissions. One system is the Diesel Particulate Filter (DPF) system; the other is the DEF (Diesel Exhaust Fluid) system.

- *DPF system*: The DPF is a ceramic or woven metal filter that mechanically traps diesel particulate matter (soot). To rid the filter of the accumulated diesel particulates, the engine's computer heats the exhaust to an extremely high temperature. The extreme heat acts like a self-cleaning oven and incinerates the DPF captured soot. This self-cleaning process is known as "regeneration". [9]
- *DEF system*: DEF (Diesel Exhaust Fluid) is neither fuel nor a fuel additive. It is a non-toxic, yet abrasive solution consisting of urea and deionized water that is injected into the diesel exhaust stream to convert harmful nitrogen

[5] https://en.wikipedia.org/wiki/Diesel_exhaust

[6] http://clean-carbonenergy.com/particulate-emissions.html

[7] https://www.canada.ca/en/health-canada/services/environmental-workplace-health/fuels-air-pollution.html

[8] https://www.canada.ca/en/health-canada/services/environmental-workplace-health/fuels-air-pollution.html

[9] http://www.stephensservice.com/bluetec-diesel-issuesproblems/

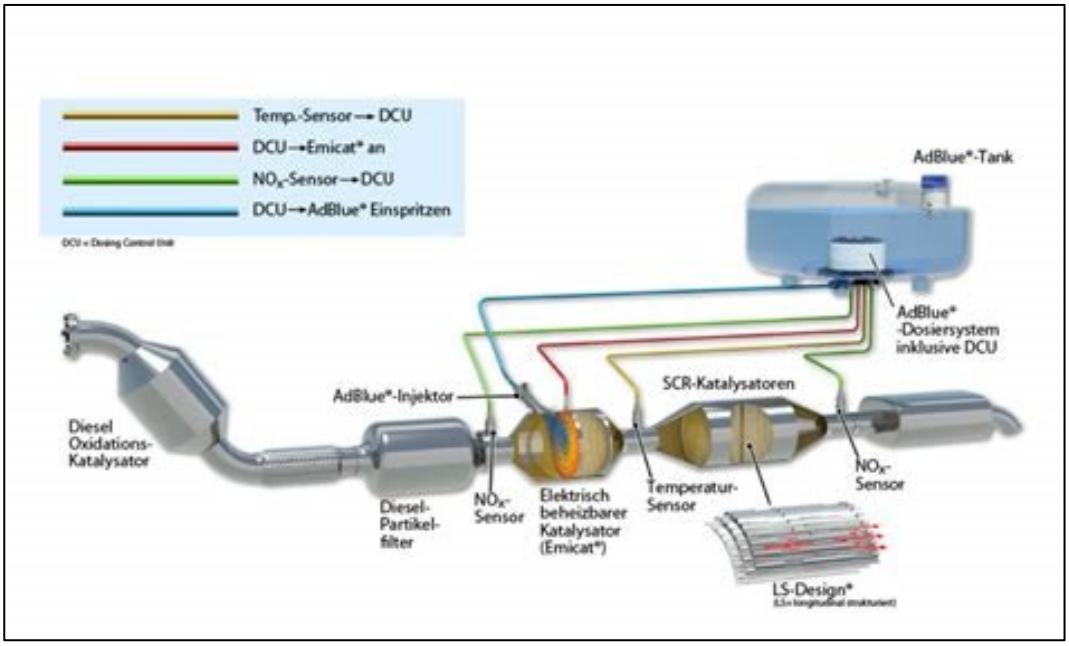
oxide into nitrogen, carbon dioxide and water (i.e., elements commonly found in the air that we breathe). [10] [11]

Mercedes' Sprinter 3500 ambulance chassis is outfitted with an ultra-low diesel-emissions system, which functions essentially as above with both DPF and DEF systems working in an integrated fashion.

The DEF, or Diesel Exhaust Fluid used by Mercedes is trademarked as AdBlue. The fluid is carried in a dedicated onboard tank which is replenished periodically. Normal AdBlue consumption is about 1,200 kms per liter. [12]

The Mercedes diesel-emissions system is shown conceptually in Exhibit 3.1. The diesel emissions control process is described in 4 stages, on the next page.

Exhibit 3.1: Schematic of the Mercedes Diesel-Emissions System



Source: csm_ESCR_Anlage_komplett_deu_498df9e070

[10] https://www.discoverdef.ca/def-overview/

[11] https://www.thoughtco.com/how-mercedes-benz-bluetec-works-533859

[12] https://www.autoevolution.com/news/your-guide-to-adblue-what-is-it-who-needs-it-and-how-to-refill-it-104882.html

Stage 1 - removing carbon monoxide and unburned fuel: Exhaust emissions from the engine enter a diesel oxidation catalyst to reduce carbon monoxide and unburned fuel (hydrocarbons).

Stage 2 - removing particulate matter: The DPF traps diesel particulates. Pressure sensors at the inlet and outlet monitor the filter's status. When the DPF is full (as measured by back pressure) the system triggers an increase in exhaust temperature. The hot exhaust purges the filter of particulate matter, over a period of several minutes.

Stage 3 - AdBlue injection: As the exhaust gas exits the DPF, it mixes with the AdBlue diesel exhaust fluid (i.e., the DEF). As soon as the AdBlue enters the hot exhaust stream, it turns into ammonia.

Stage 4 - removing nitrogen oxide: The exhaust enters a Selective Catalytic Reduction (SCR) converter, where the ammonia reacts with the nitrogen oxide and a catalyst in the SCR, to form harmless nitrogen and water vapour.

In summary, the Mercedes Sprinter's highly-efficient diesel-emissions technology reduces harmful exhaust levels of nitrogen oxide and eliminates almost all diesel particulate matter, to ultra-low levels that are well within Canada's stringent emission standards, thus creating a cleaner, greener ambulance vehicle. [13]

Niagara and others surveyed during this review, report visual inspections showing next to zero diesel particulate in tailpipe emissions. [14]

3.3 Idle Reduction System

Many EMS services, including Niagara EMS, have taken delivery of ambulances equipped with idle reduction systems; this, to improve fuel economy and reduce greenhouse gas emissions.

We are advised by both Niagara EMS and EMS peers surveyed during this review, that idle reduction systems don't always perform per expectations, occasionally conflicting with other essential on-board systems. The problem which they referred to most frequently, is that of not being able to maintain a constant temperature within the patient compartment.

To be clear conflicts between the idle reduction system and other essential on-board systems are not unique to the Mercedes Sprinter ambulance. Issues

[13] https://www.tc.gc.ca/media/documents/programs/adblue_1.pdf

[14] Because most ambulances are retired within 5-7 years, EMS services generally do not perform formal emissions testing. Inspections are primarily visual in nature.

such as the one stated above, have been encountered by multiple EMS peers whose ambulances use Ford and GM chassis.

The Sprinters that Niagara commissioned between 2012 and 2016, were equipped with the Demers "EcoSmart" idle reduction system. The main issue that Niagara EMS associates with this system is the one mentioned above, namely not being able to maintain a constant temperature within the patient compartment; albeit Niagara EMS has also encountered the following difficulties.

The idle reduction system occasionally caused the Sprinter to go into a low-power, self preservation (limp) mode. Also, Niagara has had to replace numerous engine starters, which failed prematurely because of the vehicle's frequent transitioning into and out of the anti-idling mode.

Following unsuccessful attempts to resolve these issues, Niagara EMS had the idle reduction system disconnected, and it is not installed on any of the Sprinters that Niagara commissioned in 2018.

Again, as mentioned above, similar conflicts have also been encountered by EMS peers whose ambulances use Ford and GM chassis.

During this review, we surveyed a total of 27 EMS services. This includes Niagara EMS; 3 peers who also operate Mercedes Sprinter 3500 ambulances; and 23 Ontario EMS peers whose ambulances are built with Ford and GM chassis.

Fifty-five percent (55%) of the services surveyed have either not equipped their ambulances with idle reduction systems, or they have had the systems disconnected, due to issues such as those mentioned above.

The reader is requested to take special note of the following comments. First, as will be shown in Section 7 of this report, despite Niagara EMS having disconnected the EcoSmart idle reduction system, their diesel-powered Mercedes Sprinter is still significantly more fuel efficient than any other Type 3 ambulance operating in Ontario.

Second, idle reduction systems are not installed by chassis manufacturers (i.e., not by Mercedes, nor GM or Ford). They are a 2nd stage installation by the ambulance conversion vendor.

Accordingly, while these findings regarding the idle reduction system are of interest, they are peripheral to this review, which is investigating ambulance chassis – not the patient compartments or any of the aftermarket add-ons.

3.4 Fleet Profile by Chassis Platform

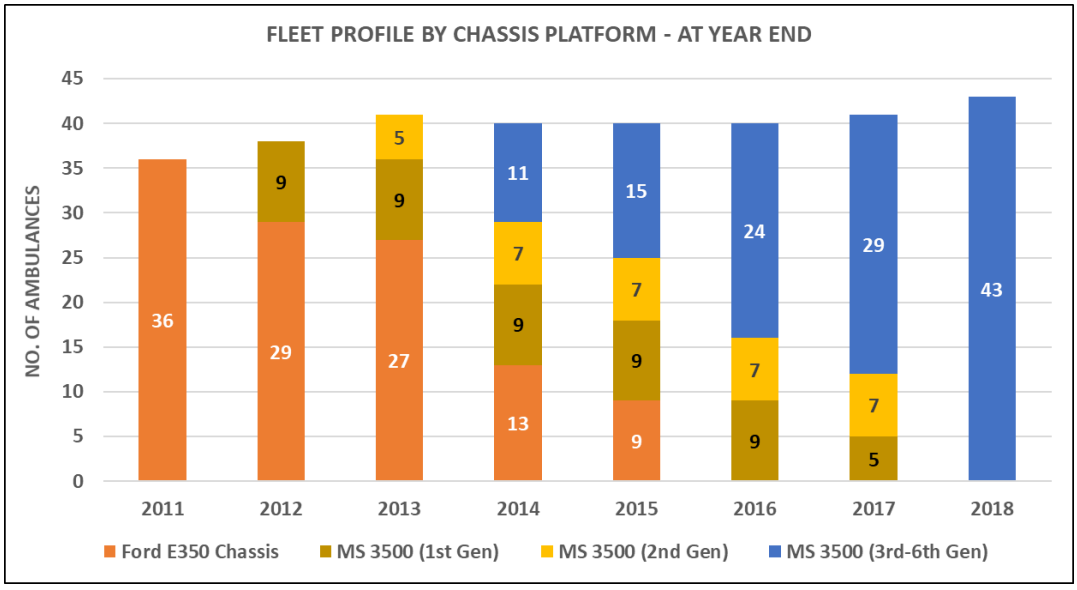
In 2011 Niagara's ambulance fleet consisted of 36 diesel-powered ambulances manufactured on a Ford E350 chassis.

In late 2012, Niagara commissioned its initial 9 Mercedes Sprinters, as replacements for an equal number of Ford E350 ambulances. An additional 7 Mercedes Sprinter ambulances were introduced in late 2013/early 2014, and others were introduced between 2014 and 2018.

All Ford E350 ambulances were retired by year-end 2016. All 1st and 2nd generation Mercedes Sprinter ambulances, and over half the 3rd generation model, were retired by October/November 2018.

Niagara's ambulance fleet currently consists of 43 Mercedes Sprinter ambulances, all of which are 3rd to 6th generation models.

Exhibit 3.2: Fleet Profile by Chassis Platform, 2011-2018



This review excludes Niagara EMS' 2 bariatric ambulances.

3.5 Vehicle Retirement / Replacement Target

Niagara assesses the lifespan of its ambulances by continuously monitoring the frequency and cost of vehicle repairs. To avoid unnecessary costs, and the risk of vehicle failure, Niagara targets ambulance replacements to a 54-month or 250,000 km end-of-life. This means that 20%-25% of the fleet (8 to 10 ambulances) are replaced each year.

Exhibit 3.3: Ambulances with Under 54 Months Service

	2011	2012	2013	2014	2015	2016	2017	2018
No. of Amb's	**26**	**27**	**30**	**34**	**31**	**40**	**36**	**41**
% of Fleet	**72%**	**71%**	**73%**	**85%**	**78%**	**100%**	**88%**	**95%**

3.6 Fleet Profile by Time-in-Service

Exhibit 3.4 (next page) presents the fleet profile, 2011-2018, organized by time-in-service intervals: 36 months or less; 37-60 months; and over 60 months. [15]

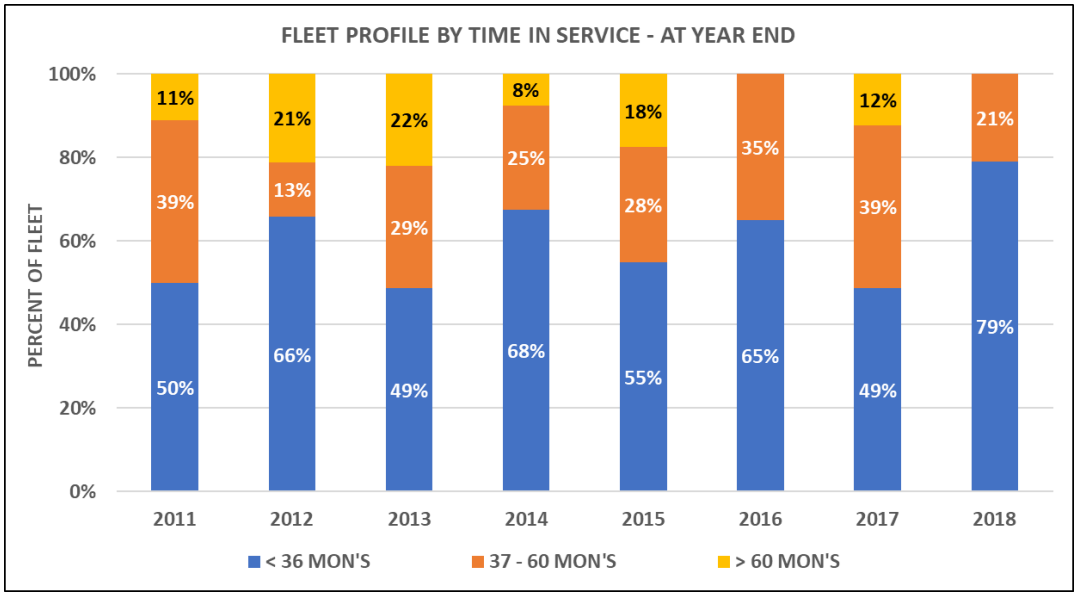
At year-end 2015, eighteen percent of the fleet (i.e., 7 of 40 ambulances) had accumulated in-service times in excess of 60 months. In 2016, the service commissioned 8 new Mercedes Sprinter ambulances, and after replacing older models, the entire fleet's service life was under 60 months.

No additional replacement ambulances were introduced until August-November 2018. Consequently, by year-end 2017, 12% of the fleet (5 of 41 ambulances) accumulated in-service times in excess of 60 months.

Between August and November 2018 Niagara commissioned 18 new Mercedes Sprinters, most as replacement vehicles, and by year-end 2018 every one of the fleet's 43 ambulances was of an in-service time of under 60 months.

[15] Historical VOD files provided by Niagara EMS were not sufficiently precise to assess vehicle lifespans to an exact retirement month (i.e., 54 months). For this reason, we adopted the time-in-service intervals shown above.

Exhibit 3.4: Fleet Profile by Time-in-Service, 2011-2018



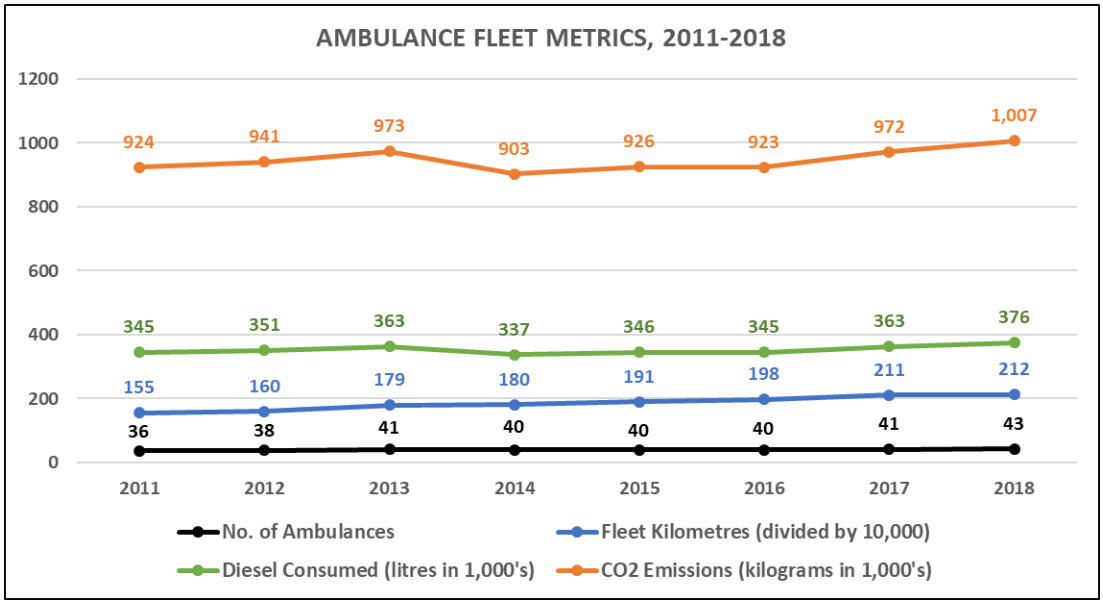
4 Fleet Performance and Costs, 2011-2018

This section reports on the performance and costs for Niagara EMS' ambulance fleet over the period 2011 to 2018. The information presented is based mainly on historical records containing vehicle operating data (VOD) provided by Niagara EMS.

4.1 Ambulance Fleet Performance Metrics

As shown in Exhibit 4.1, the size of Niagara's ambulance fleet increased by 19% between 2011 and 2018. At year-end 2018 the fleet consisted of 43 ambulances (up from 36 in 2011).

Exhibit 4.1: Ambulance Fleet Metrics, 2011-2018



Over the same period, fleet kilometres travelled increased by 37%, to 2,120,000 kms in 2018 (up from 1,550,000 kms in 2011).

In contrast to the above double-digit increases, diesel fuel consumption increased by only 9%, to 376,000 litres of diesel fuel in 2018 (up from 345,000 litres in 2011). CO2 emissions which are directly proportional to fuel consumption also increased by 9%. [16]

[16] Emissions estimates presented in this document are based on published research, indicating that an automobile's consumption of 1 litre of diesel fuel generates 2.68 Kg of CO2, and that 1 litre of gasoline fuel generates 2.37 Kg of CO2.

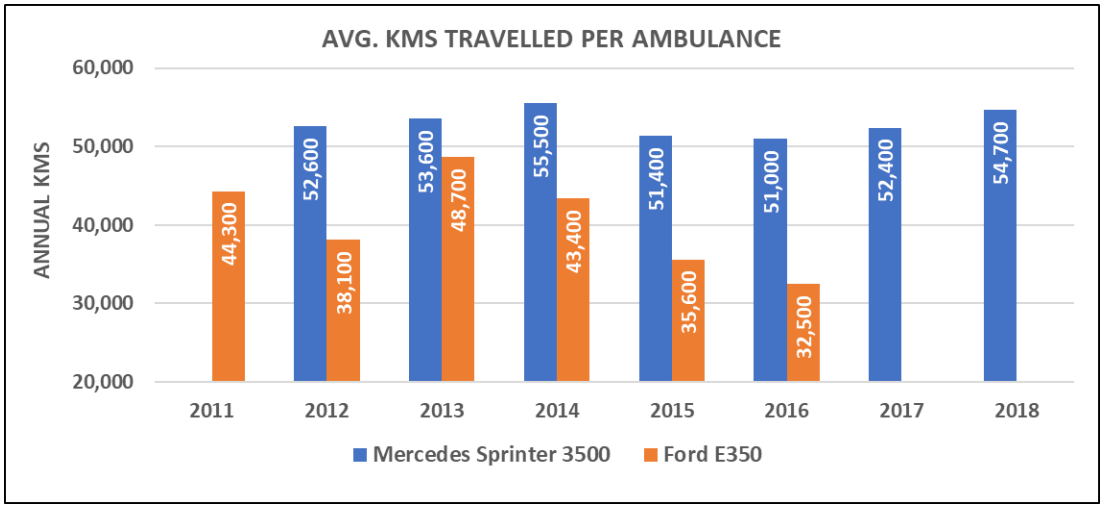
The lower 9% rate of increase in both these metrics, is attributed directly to the replacement of earlier technology Ford E350's with the more fuel-efficient Mercedes Sprinters; said replacement having commenced in 2013-2014.

Exhibit 4.1 clearly shows a decrease in both trend lines during this period.

4.2 Mileage by Chassis Platform

Exhibit 4.2 presents the average number of kilometres that an ambulance travelled annually, between 2011 and 2018. Ford E350 ambulances averaged about 40,000 kms annually per vehicle. Mercedes Sprinters averaged 53,000 kms annually, attaining about 130% more mileage per vehicle.

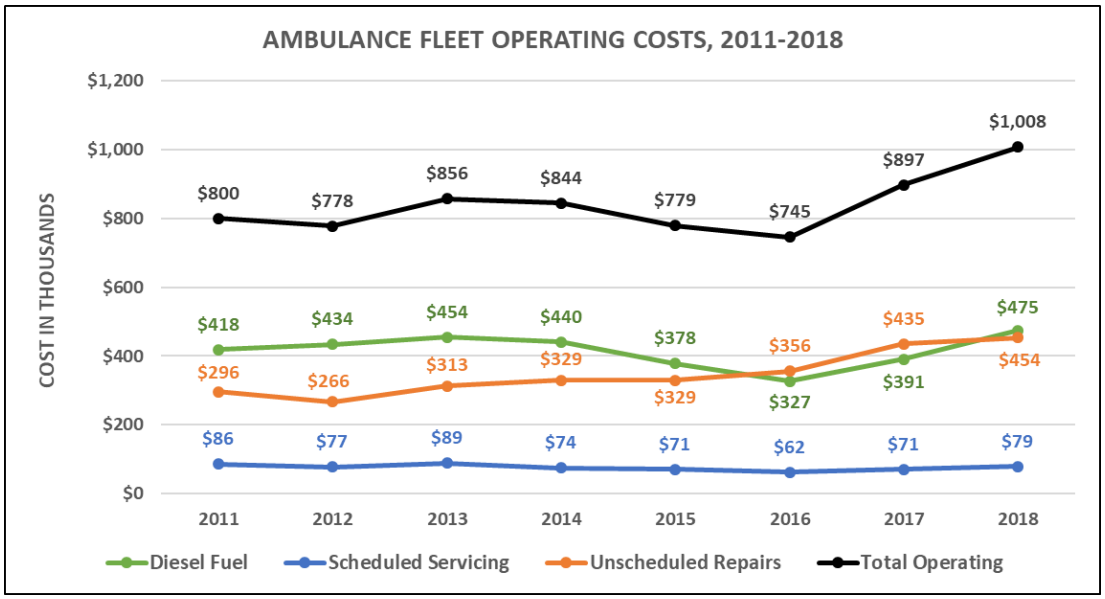
Exhibit 4.2: Avg. Kms Travelled per Ambulance



4.3 Ambulance Fleet Operating Costs

Operating cost trends, 2011-2018, are illustrated in Exhibit 4.3 (next page), organized as follows: cost of diesel fuel consumed, scheduled servicing costs, cost for unscheduled repairs, and total operating.

Exhibit 4.3: Ambulance Fleet Operating Costs, 2011-2018



Costs shown above are actual in-year costs. They have not been adjusted to 2018.

As shown by Exhibit 4.3, with the introduction of the fuel-efficient diesel-powered Mercedes Sprinters in 2012-13, cost of diesel consumption began to decrease, and it continued to do so over subsequent years as more Mercedes Sprinters were commissioned to replace aging Ford E350's.

Type 3 ambulances operating with Ford and GM chassis are generally serviced at intervals of about 6,000 kms; whereas, Niagara's Mercedes Sprinter ambulances are serviced at intervals of 9,000 kms, as recommended by Mercedes. Consequently, as more Mercedes Sprinters were commissioned over time, scheduled servicing costs also decreased.

In 2017, the cost trends for both fuel consumption and scheduled servicing, began to rise, in our opinion reflecting the increase in fleet size (to 41 ambulances in 2017 and to 43 ambulances in 2018), and a corresponding increase in fleet kilometres travelled.

Contrary to the downward trends discussed above, the cost for unscheduled repairs increased over each of the 8 years, 2011 to 2018. This, in our opinion, is due mainly to the following reason – albeit, additional considerations are presented Section 5.

Frequency and cost of unscheduled repairs increase as vehicles age. During the period of interest to this review, 2011-2018, the life spans of numerous ambulances were extended well beyond an optimum 54-months, consequently incurring repeated unplanned servicing and repairs.

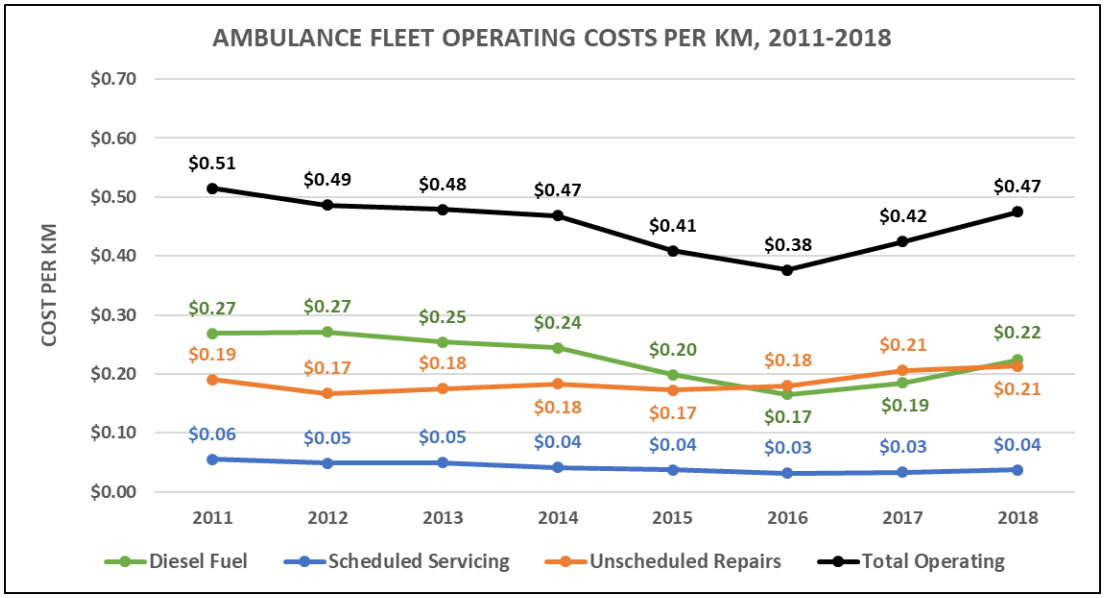
This is particularly true of the Ford E350's, which were purchased prior to 2012, and the 1st generation Mercedes Sprinters, which were purchased in 2012. For some of these vehicles, life spans were extended to roughly 70 months.

4.4 Per Kilometre Operating Costs

Actual (In-Year) Cost Trends

Exhibit 4.4 presents the "per kilometre" cost trends, 2011-2018, expressed in actual (in-year) dollars. The trends mirror those shown previously in Exhibit 4.3. for all major cost components, i.e., diesel fuel consumption, scheduled servicing, unscheduled repairs, and total operating.

Exhibit 4.4: Per Km Costs in Actual (In-Year) Dollars

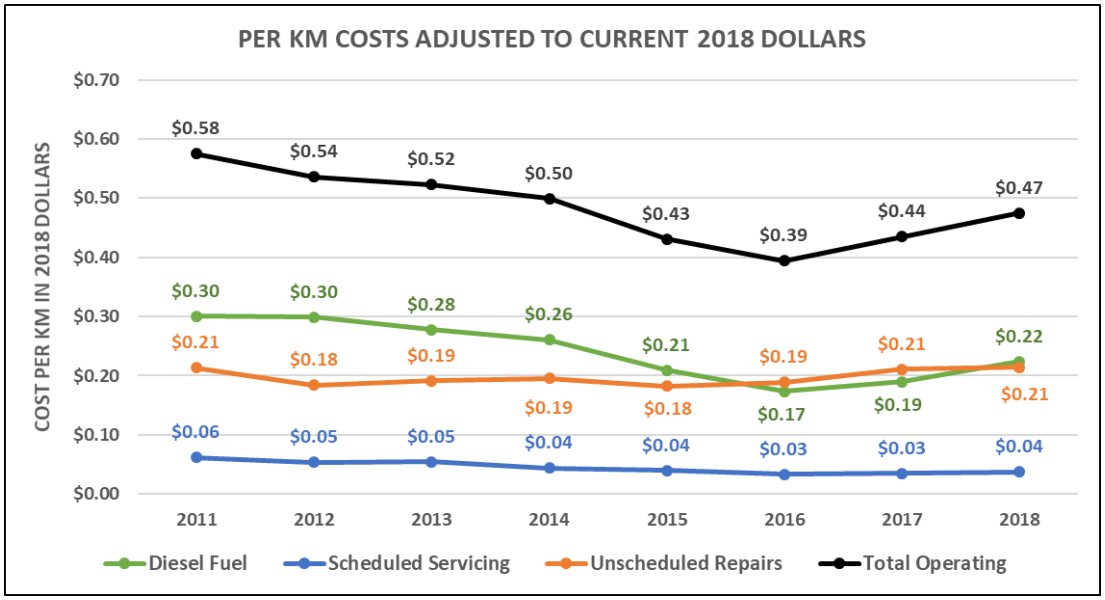


Cost Trends Adjusted to Current 2018 Dollars

To advance our assessment under this engagement, we needed to adjust actual (in-year) costs to a common base. For convenience, we adjusted the values to current 2018 dollars.

Ontario Consumer Price Index (CPI) inflation rates were used as the means for adjustment. Exhibit 4.5 (next page) presents the "per kilometre" cost trends adjusted to current 2018 dollars.

Exhibit 4.5: Per Km Costs Adjusted to Current 2018 Dollars



4.5 Point-in-Time Cost Comparison: Sprinter vs Ford E350 (diesel)

In 2016 Niagara EMS' fleet consisted almost entirely of Mercedes Sprinters with in-service times of under 54 months. In 2011 the fleet consisted entirely of diesel-powered Ford E350 ambulances. Exhibit 4.6 compares the two vehicles using data specific to these timeframes. Costs shown are in 2018 dollars.

Exhibit 4.6: Ford E350 vs. Mercedes Sprinter

	2011 (Ford E350)	2016 (MS 3500)	% Difference
Per Km Cost (in 2018 dollars)			
Diesel Fuel	$0.30	$0.17	-42%
Scheduled Servicing	$0.06	$0.03	-46%
Unscheduled Repairs	$0.21	$0.19	-12%
Total Operating	$0.58	$0.39	-31%
Performance Metrics			
Annual Kms per Amb.	44,300	51,000	15%
Fuel - Litres per 100 Kms	22.2	17.3	-22%
CO2 Kgs / 100 Kms	59.4	46.4	-22%

Note: Per kilometre costs may not total exactly due to rounding of values to 2 decimal places. Also, percentages are rounded to whole numbers for ease of presentation.

The point-in-time cost comparison shown in Exhibit 4.6 affirm the following:

- On a per kilometre basis, the Sprinter's fuel consumption is on average 22% lower than the previous Ford E350 (diesel).
- CO2 emission, which is proportional to the amount of fuel consumed, is also on average 22% lower.
- Mechanical resilience, expressed in terms of kilometres travelled per vehicle, is on average +15% improved.
- Cost of fuel consumption is on average 42% lower. Cost for scheduled servicing is on average 46% lower. Cost for unscheduled repairs is on average 12% lower. Total operating costs are on average 31% lower.

One might ask the following question. If in 2017 and 2018, the fleet consisted entirely of Mercedes Sprinter ambulances, then why are the per kilometre costs

in those years higher than the values shown for 2016 – this, as illustrated by Exhibit 4.5. Below is our response to this question.

Niagara EMS did not introduce any new replacement ambulances between January 2017 and Aug-Sep 2018. Consequently, multiple units accumulated in-service times well in excess of the optimum 54-months, and Niagara incurred previously unanticipated repair costs that are common to an aging fleet.

The per kilometre costs for 2017 and 2018 ($0.44 and $0.47 respectively), while they may be higher than the cost for 2016, are still considerably lower than the per kilometre cost for 2011 ($0.58) when the fleet consisted entirely of diesel-powered Ford E350 ambulances.

Stated another way, the per kilometre costs for 2017 and 2018, are lower than what the costs would otherwise be if Niagara's fleet currently consisted of diesel-powered Ford E350's. [17]

As an additional consideration, with the recent commissioning of 18 new Mercedes Sprinter ambulances in late 2018, Niagara EMS has replaced about 40% of its previously aging fleet. Accordingly, operating costs are expected to decline in 2019 – potentially reaching the relatively low costs last incurred in 2016.

[17] To be clear, this is a hypothetical comparison, since Ford no longer manufactures the diesel-powered E350 chassis for ambulances operating in Ontario.

4.6 Lifecycle Cost Comparison: Sprinter vs Ford E350 (diesel)

We also investigated the "lifecycle" costs of the diesel-powered Mercedes Sprinters and Ford E350's, accounting for both operating and capital. Our findings are summarized in Exhibit 4.7 and discussed on the next page.

Exhibit 4.7: Lifecycle Cost Comparison – Sprinter vs Ford E350 (diesel)

	Ford E350 Diesel	MS3500 - 1st Gen	MS3500 - 2nd Gen
# Amb's in Sampling	**5**	**5**	**5**
Period of Operation	**Aug '09 - Dec '15**	**Nov '12 - Sep '18**	**Apr '14 - Oct '18**
Avg. # Months in Operation	**66**	**70**	**55**
Avg. Kms Travel	**259,000**	**284,000**	**231,000**
Chassis Cost (w/o taxes)	**$44,000**	**$44,000**	**$44,000**
Residual when Retired	**$5,000 - $10,000**	**$18,000 - $22,000**	**$18,000 - $22,000**
Amb. Lifecycle Operating Cost (avg.)			
Diesel Fuel	***$71,570***	***$58,720***	***$46,550***
Scheduled Servicing	***$15,730***	***$10,890***	***$6,780***
Unscheduled Repairs	***$38,670***	***$72,670***	***$53,410***
Total	**$125,970**	**$142,280**	**$106,740**
Amb. Lifecycle Cost per Kilometre			
Capital			
Chassis	***$0.17***	***$0.15***	***$0.19***
Residual	***($0.03)***	***($0.07)***	***($0.09)***
Total Capital	**$0.14**	**$0.08**	**$0.10**
% Difference rel. to E350	--	*-40%*	*-26%*
Operating			
Diesel Fuel	***$0.28***	***$0.21***	***$0.20***
Scheduled Servicing	***$0.06***	***$0.04***	***$0.03***
Unscheduled Repairs	***$0.15***	***$0.26***	***$0.23***
Total Operating	**$0.49**	**$0.50**	**$0.46**
% Difference rel. to E350	--	*3%*	*-5%*
Total Lifecycle	**$0.63**	**$0.59**	**$0.57**
% Difference rel. to E350	--	*-7%*	*-10%*

Costs are in current 2018 dollars. Per kilometre costs may not total exactly due to rounding.

Sample Sizes

Lifecycle costings were carried out using VOD for a sampling of 5 ambulances from each of the following models: Ford E350; 1st generation Mercedes Sprinter; and 2nd generation Mercedes Sprinter.

- *Ford E350 (Diesel)*: One vehicle was commissioned in August 2009; two in Jul-Aug 2010; and two in January 2011. All 5 vehicles were retired in Nov-Dec 2015. The average in-service time was 66 months and the average distance travelled prior to retirement was 259,000 kilometres.
- *Mercedes Sprinter 3500 (1st Gen.)*: All 5 vehicles were commissioned in November 2012 and retired in Aug-Sep 2018. The average lifespan was 70 months and the average distance travelled was 284,000 kilometres.
- *Mercedes Sprinter 3500 (2nd Gen.)*: All 5 vehicles were commissioned in April 2014 and retired in October 2018. The average lifespan was 55 months and the average distance travelled was 231,000 kilometres.

Findings

1st generation Sprinters

- On a per kilometre basis, total lifecycle costs (sum of capital and operating) are about 7% lower than the former diesel-powered Ford E350's, despite the slightly higher in-service times.

2nd generation Sprinters

- On a per kilometre basis, capital costs are on average 26% lower than the former diesel-powered Ford E350's – this due to the Sprinter's higher end-of-life resale value.
- Operating costs are on average 5% lower; and total lifecycle costs (sum of capital and operating) are about 10% lower.

Contrary to expectations, the Sprinter's lifecycle repair costs are higher than those for the former diesel-powered Ford E350. This finding applies to both 1st and 2nd generation Sprinters. This matter is discussed in depth in Section 5.

Chassis Assumptions

Chassis costs were provided by several sources, including Demers Ambulances, Niagara EMS and multiple Ontario EMS peers. [18]

[18] Exhibit 4.7 shows the capital cost for a gas-powered Ford E350 chassis. We are advised that the former diesel-powered Ford E350 chassis would have been slightly higher in price.

The Mercedes Sprinter chassis comes equipped with VB Air-suspension; whereas, Niagara's former Ford E350's diesels operated with a standard leaf spring suspension. Adjusting for the value of VB Air-suspension (which is about $12,000), it was determined that the chassis for the Ford E350 and Mercedes Sprinter 3500, are of comparable cost, at about $44,000.

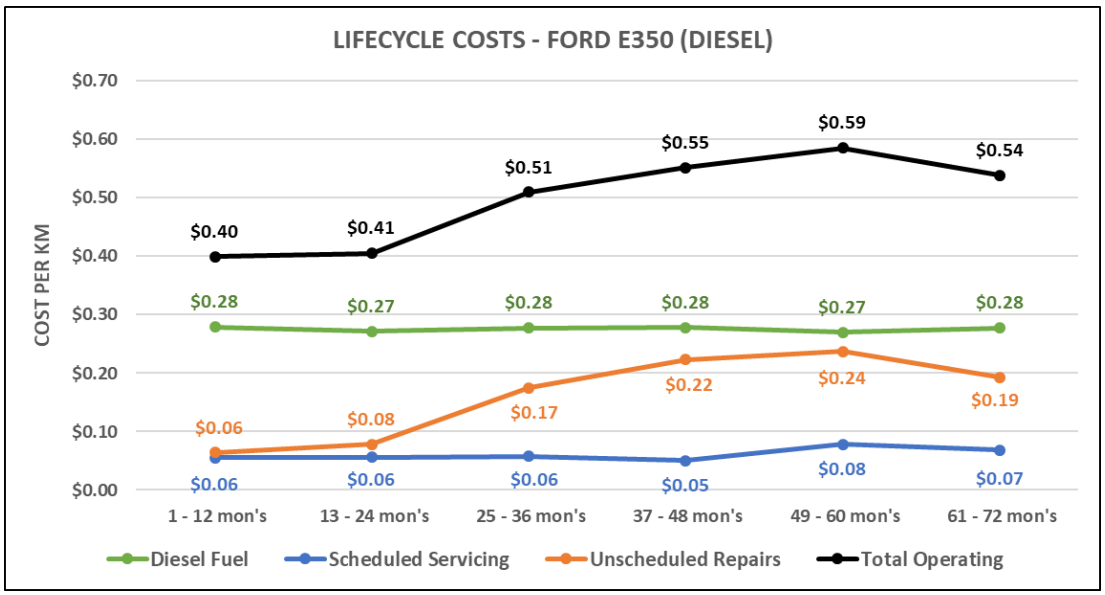
The residual / resale value for the Mercedes Sprinter was provided by Niagara EMS. Resale values for Ford E350's, are derived from our survey of multiple Ontario EMS services, as well as information supplied by Niagara EMS. In the current market environment, the resale value for a Mercedes Sprinter is appreciably higher than that of a Ford E350, as shown in Exhibit 4.7.

Per Kilometre Cost Trends, 2011-2018

For additional detail, trend lines showing the "per kilometre" operating cost by year for the period 2011-2018, are presented in Exhibits 4.8 to 4.10.

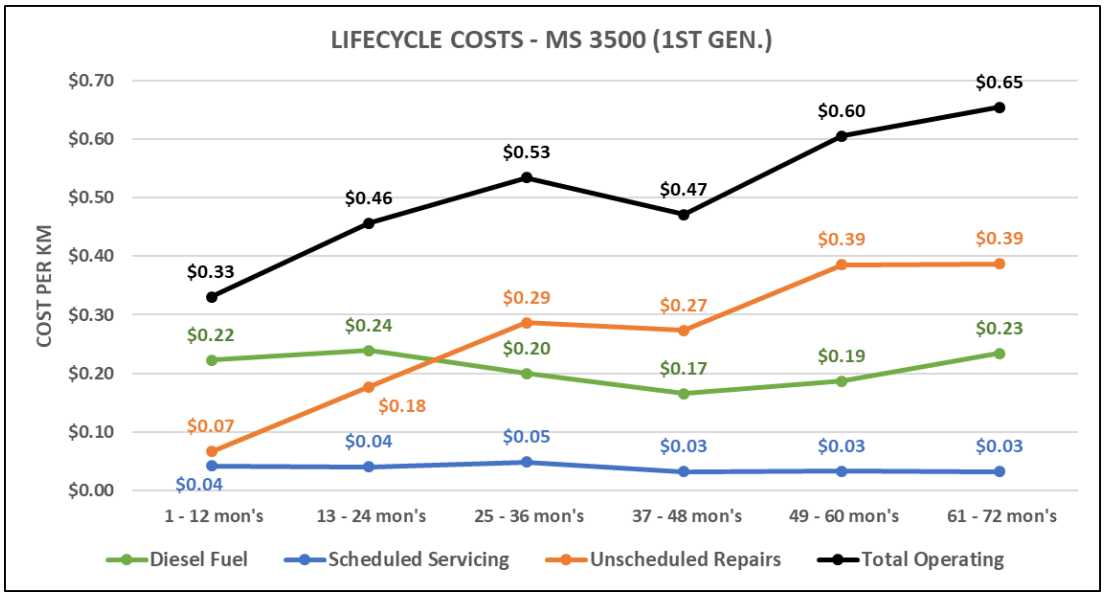
Ford E350 (diesel) trends are shown in Exhibit 4.8 (below). Mercedes Sprinter trends are shown in Exhibits 4.9 and 4.10 (next page).

Exhibit 4.8: Lifecycle Costs - Ford E350 (Diesel)



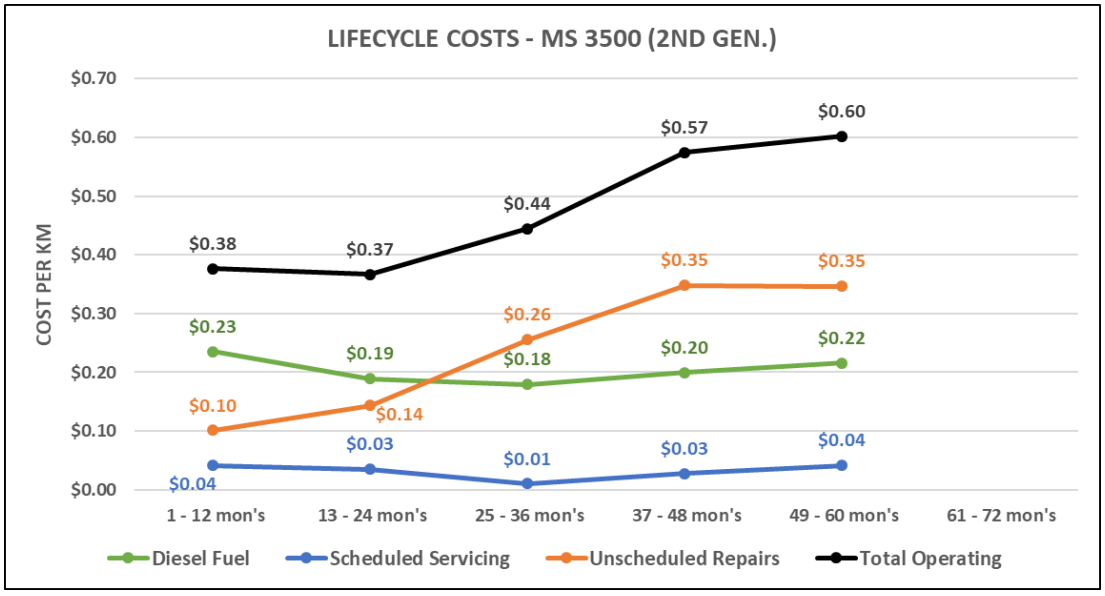
Costs are presented in current 2018 dollars

Exhibit 4.9: Lifecycle Costs - MS 3500 (1st Gen.)



Costs are presented in current 2018 dollars

Exhibit 4.10: Lifecycle Costs - MS 3500 (2nd Gen.)



Costs are presented in current 2018 dollars

4.7 Lifecycle Costs Adjusted to an Optimum Lifespan

The lifecycle cost analysis, presented previously in Section 4.6, was based partially on records for 1st generation Mercedes Sprinters whose average lifespan was 70 months and average distance travelled was 284,000 kilometres, both of which significantly exceed the optimum retirement targets.

We repeated the cost analysis for the 1st generation Sprinters, this time discounting the 6th (final) year of operation; this, to illustrate what the costs would have been, had these vehicles been retired within optimum retirement targets as originally planned.

The findings arising from this adjusted analysis of historical costs are shown in Exhibit 4.11 (next page) and summarized below.

If the 1st generation Sprinters had been retired as originally planned at about 250,000 kms, then:

- The lifecycle operating cost for the 1st generation Sprinter (inclusive of fuel, servicing and repairs), would have been $118,800, or about 17% lower than the figure of $142,280 which we presented previously in Exhibit 4.7.
- We would have concluded that the 1st generation Sprinter at a lifecycle operating cost of $118,800, costs 6% less to operate than the diesel-powered Ford E350 which we reported to cost $125,970.
- Moreover, we also would have concluded that the adjusted operating expense for the 1st generation Sprinter (at $0.48 per kilometre) aligns closely to that of the 2nd generation model, based on a $0.46 per kilometre value for the latter, that we also reported in Exhibit 4.7.

Exhibit 4.11: Lifecycle Costs Adjusted to an Optimum Lifespan

	MS3500 - 1st Gen (per Exh 4.7)	MS3500 - 1st Gen (adj'd to 5 years)	% Difference
# Amb's in Sampling Period of Operation	5 Nov '12 - Sep '18	5 Nov '12 - Sep '18	
Avg. # Months in Operation Avg. Kms Travel	70 284,000	58 248,000	
Chassis Cost (w/o taxes) Residual when Retired	$44,000 $18,000 - $22,000	$44,000 $18,000 - $22,000	
Amb. Lifecycle Operating Cost (avg.)			
Diesel Fuel	*$58,720*	*$50,310*	--
Scheduled Servicing	*$10,890*	*$9,730*	--
Unscheduled Repairs	*$72,670*	*$58,760*	--
Total	$142,280	$118,800	*-17%*
Amb. Lifecycle Cost per Kilometre			
Capital			
Chassis	*$0.15*	*$0.18*	--
Residual	*($0.07)*	*($0.08)*	--
Total Capital	$0.08	$0.10	*15%*
Operating			
Diesel Fuel	*$0.21*	*$0.20*	--
Scheduled Servicing	*$0.04*	*$0.04*	--
Unscheduled Repairs	*$0.26*	*$0.24*	--
Total Operating	$0.50	$0.48	*-4%*
Total Lifecycle	$0.59	$0.58	*-2%*

Costs are in current 2018 dollars. Per kilometre costs may not total exactly due to rounding.

5 Sprinter Repair Costs Adjusted for Extensive Idling

5.1 Extensive Vehicle Idling

The prior section of this report presented a lifecycle cost comparison of the diesel-powered Mercedes Sprinter and the diesel-powered Ford E350 ambulance, which Niagara EMS used prior to the Region's transition to the Sprinter.

That cost comparison, which was based on historical costs, concluded that over the lifespan of the Sprinter, fuel and scheduled servicing costs are lower, whereas repair costs are higher.

Further investigation reveals that the higher than anticipated cost for Sprinter repairs is mainly attributed to extensive vehicle idling.

Vehicle idling for extensive periods is an example of a hard driving condition that ambulances are frequently required to endure. Ambulances may be left to idle during standby, during hospital offload, and during periods of hospital offload delay; this, for a variety of reasons, e.g., to maintain a constant temperature in the patient compartment and driver cab on extremely warm or extremely cold days.

We analyzed the financial impact of extensive idling on the cost for Sprinter repairs, using offload delay hours as the basis for the analysis.

According to Niagara EMS records, the Service incurred about 2,100 hours of hospital offload delay in 2014, increasing to 15,400 hours in 2017, to 18,000 hours in 2018, and it is still increasing.

The current (2018) figure of 18,000 hours of offload delay equates to an average of about 450 idling hours for each Niagara EMS ambulance.

The automotive industry has formulated a conversion factor that equates vehicle idling to equivalent kilometres. The rule of thumb is that 1 hour of vehicle idling is equivalent to driving 50 kilometres. [19] By applying the industry rule of thumb, we arrive at the following – each Niagara ambulance currently accumulates the equivalent of 22,000 additional kilometres a year due to idling.

In 2018, Niagara's Sprinter ambulances averaged an annual 54,700 kilometres travel based on odometer readings. Adding an additional 22,000 kilometres a year due to idling, increases the odometer-based readings by 40%, resulting in

[19] Information provided by Brock Ford and Ottawa Paramedic Services.

an equivalent annual mileage of 76,700 kilometres (the sum of odometer and idling).

In our opinion, the additional 22,000 kilometres a year due to vehicle idling, also adds an additional 40% wear and tear to key operational components of the vehicle, as discussed further in Section 5.2.

The reader is advised that we consider this finding to be somewhat conservative, in that the analysis is based solely on vehicle idling during offload delay. It does not account for other substantial vehicle idling that may be incurred during the initial 30 minutes of hospital offload, nor during community paramedicine or standby calls.

5.2 Impact of Vehicle Idling on DPF & DEF Systems

Working closely with the client, we determined that Sprinter repair costs escalate significantly in the 4th and 5th year of operation, during which time the vehicle's odometer readings range between 150,000 and 250,000 kilometres. We further determined that repairs to the Sprinter's ultra-low diesel emissions control system accounts for the bulk of the repair costs incurred during this period.

As discussed previously in Section 3.2, the Sprinter's ultra-low diesel emissions control system is highly effective in managing and reducing unwanted and potentially harmful diesel emissions.

This notwithstanding, it appears that the system is adversely susceptible to extensive vehicle idling, as described below.

Impact of Vehicle Idling on the DPF System

The DPF system eliminates almost all diesel particulate matter by initially trapping the particulates (soot) in a DPF (Diesel Particulate Filter), and periodically cycling through a high temperature regeneration process, which functions like a self-cleaning oven to incinerate the DPF captured material.

We are advised that the Sprinter's DPF regeneration process will only cycle when the Sprinter is mobile – not when the vehicle is idling. During vehicle idling, the DPF will continue to trap diesel particulates, but the cleansing cycle does not take place. [20]

[20] Information provided by Brock Ford, the Niagara-based dealership that services Niagara EMS' ambulances.

If the Sprinter frequently incurs extended periods of vehicle idling, then the DPF can be irreparably damaged by the build up over time of diesel particulate matter, at which point replacement of the DPF is usually called for.

Impact of Vehicle Idling on the DEF System

The DEF system effectively reduces harmful exhaust levels of nitrogen oxide by periodically injecting AdBlue, the trademarked DEF (Diesel Exhaust Fluid) into the exhaust to convert nitrogen oxide into nitrogen, carbon dioxide and water, which are elements commonly found in the air that we breathe.

We are advised that on-board system sensors continuously monitor the level of nitrogen oxide being emitted from the diesel engine, when the vehicle is operational.

It does not matter whether the vehicle is mobile or idling. If the vehicle is operational, the sensors will continue to function, and the DEF process will continue to cycle, injecting DEF into the exhaust when needed to convert nitrogen oxide into nitrogen, carbon dioxide and water. [21]

Applying the automotive industry rule of thumb that 1 hour of vehicle idling is equivalent to driving 50 kilometres, we may conclude that each hour of idling essentially adds the equivalent of 50 additional kilometres wear and tear to a vehicle's DEF system.

And by extrapolation, we may also conclude that the 450 annual hours of idling incurred by each Niagara ambulance, contributes an additional 22,000 kilometres wear and tear on its DEF system, thus helping to explain the unanticipated repair costs that Niagara EMS has been incurring.

5.3 Repair Costs Adjusted for Extensive Vehicle Idling

We repeated the lifecycle cost analysis presented previously in Section 4; this time discounting the cost of repairs to the Sprinter's emissions control systems in years 4-5, between odometer readings of 150,000 and 250,000 kilometres.

In this, our purpose is to ascertain how much money one might save, if one could mitigate excessive idling and premature ageing of the emissions control systems attributed to idling wear and tear.

We carried out the revised cost analysis for both the 1st and 2nd generation Sprinters, and we found the results to be similar. For ease of presentation, we

[21] Information provided by Brock Ford, the Niagara-based dealership that services Niagara EMS' ambulances.

report only the 2nd generation Sprinter findings. Exhibit 5.1 shows the 2nd generation Sprinter lifecycle costs, with and without adjustments.

Exhibit 5.1: Lifecycle Costs Adjusted for Idling - 2nd Generation Sprinter

	MS3500 - 2nd Gen (per Exh 4.7)	MS3500 - 2nd Gen (adjusted)	% Difference
# Amb's in Sampling Period of Operation	5 Apr '14 - Oct '18	5 Apr '14 - Oct '18	
Avg. # Months in Operation Avg. Kms Travel	55 231,000	55 231,000	
Chassis Cost (w/o taxes) Residual when Retired	$44,000 $18,000 - $22,000	$44,000 $18,000 - $22,000	
Amb. Lifecycle Operating Cost (avg.)			
Diesel Fuel	*$46,550*	*$46,550*	--
Scheduled Servicing	*$6,780*	*$6,780*	--
Unscheduled Repairs	*$53,410*	*$44,650*	*-16%*
Total	$106,740	$97,980	*-8%*
Amb. Lifecycle Cost per Kilometre			
Capital			
Chassis	*$0.19*	*$0.19*	--
Residual	*($0.09)*	*($0.09)*	--
Total Capital	$0.10	$0.10	--
Operating			
Diesel Fuel	*$0.20*	*$0.20*	--
Scheduled Servicing	*$0.03*	*$0.03*	--
Unscheduled Repairs	*$0.23*	*$0.19*	*-16%*
Total Operating	$0.46	$0.42	*-8%*
Total Lifecycle	$0.57	$0.53	*-7%*

Costs are in current 2018 dollars. Per kilometre costs may not total exactly due to rounding.

The reader is reminded that, in contrast to the Section 4 analysis which was based on historical costs, this adjusted cost comparison is a hypothetical analysis inclusive of adjustments to illustrate the potential cost savings if one could mitigate excessive idling and premature ageing of the emissions control systems attributed to idling wear and tear.

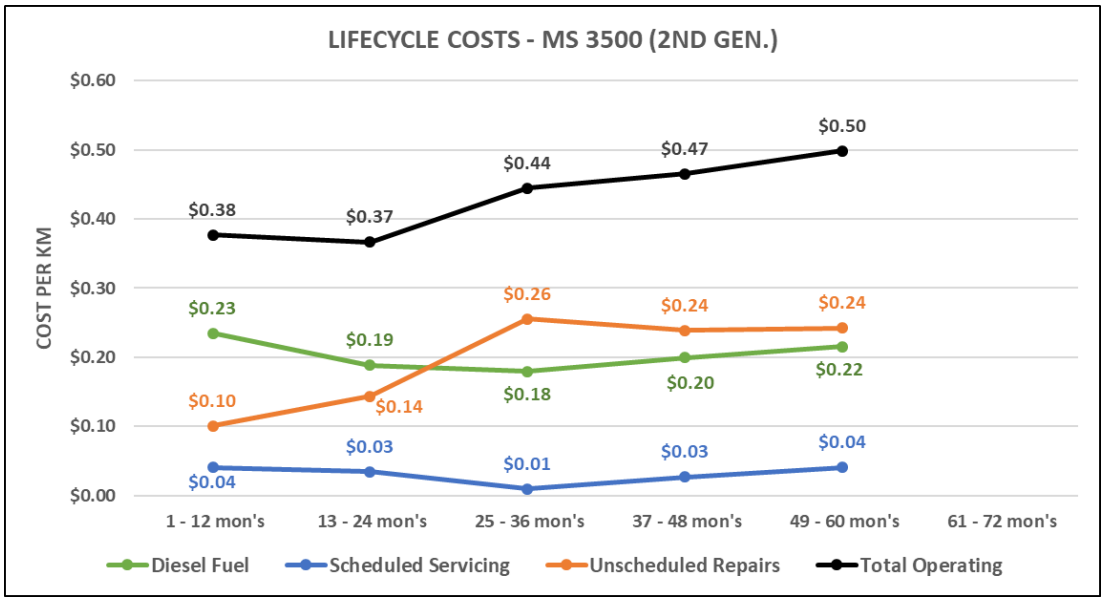
Our findings arising from this adjusted analysis of historical costs are below.

If one could mitigate excessive idling and premature ageing of the emissions control systems attributed to idling wear and tear, then:

- Lifecycle repair costs for the Sprinter would be about 16% lower than the historical cost that we reported previously in Exhibit 4.7; with our analysis coming in at $0.19 per kilometre instead of $0.23 per kilometre.
- Lifecycle operating expenses for the Sprinter (inclusive of fuel, servicing and repairs) would be about 8% lower than the historical cost that we reported previously in Exhibit 4.7; with our analysis coming in at $0.42 per kilometre instead of $0.46 per kilometre.
- Total lifecycle costs for the Sprinter (inclusive of capital and operating) would be about 7% lower than the historical cost that we reported previously in Exhibit 4.7; with our analysis coming in at $0.53 per kilometre instead of $0.57 per kilometre.
- Moreover, we would have concluded that the 2nd generation Sprinter at a lifecycle operating cost of $97,980, costs 22% less to operate than the diesel-powered Ford E350 which we reported to cost $125,970.

Exhibit 5.2 (below) shows the adjusted cost trends 2011-2018, for the 2nd generation Sprinter. Comparable trends showing the unadjusted costs were presented previously in Exhibit 4.10.

Exhibit 5.2: Adjusted Lifecycle Costs - MS 3500 (2nd Gen.)



Costs are presented in current 2018 dollars

5.4 Equivalent Kilometres as a Management Tool

Several Ontario EMS services (including Ottawa) are reporting fleet mileage in terms of both odometer-based kilometre reading and "equivalent" kilometres.

Exhibit 5.3 shows the idling equivalency due to offload delay (OLD) over the optimum 54-month lifecycle of an ambulance, using the Niagara ambulance fleet history over the past 54 months as a basis for the calculations.

Exhibit 5.3: Idling Equivalency Over a Vehicle's Lifecycle

Year	Mon's	Fleet Size (amb's)	Fleet OLD (hours)	OLD Hrs	Equiv. Kms (idle)	Kms (odometer)	Equiv. Kms (odom. + idle)	% Diff.
				Average per Ambulance				
2014	6	40	1,054	26	1,300	27,750	29,050	4.7%
2015	12	40	2,988	75	3,700	51,400	55,100	7.2%
2016	12	40	5,889	147	7,400	51,000	58,400	14.5%
2017	12	41	15,438	377	18,800	52,400	71,200	35.9%
2018	12	41	18,000	439	22,000	54,700	76,700	40.2%
Total	54		43,369	1,064	53,200	237,250	290,450	22.4%

Notes: (1) One idling Hour is equivalent to 50 kms travel; (2) Kms are rounded to nearest 100
(3) The analysis assumes only 6 mon's in 2014.

Offload Delay (OLD) hours are extracted from Niagara EMS records, as are the number of ambulances in the fleet and odometer-based kilometres travelled.

Each Niagara ambulance averaged 237,250 odometer-based kilometres travelled over the past 54 months. However, adjusting for idling using the automotive industry rule of thumb, each ambulance's total kilometers travelled increases by 22% to an equivalent 290,450 kilometres.

The illustration above is based on the past 54 months during which idling levels varied from a low 26 OLD hours a year per vehicle in 2014, to a high of 439 OLD hours a year per vehicle in 2018.

Repeating the analysis, this time focusing on the next 54 months and using current annual OLD hours as the basis for the calculations, one may conclude that in 54 months time, each ambulance's total lifecycle kilometers travelled will be about 40% higher than the odometer-based readings; and each ambulance will incur 40% more wear and tear (attributed to the extensive idling). On this

basis, Niagara Region may wish to consider adjusting the optimum retirement target for ambulances, to account for the idling problem.

5.5 Meeting with Brock Ford

At Niagara EMS' invitation, we attended a meeting with Brock Ford, the Niagara-based dealership that services Niagara EMS' ambulances, to discuss the emissions control systems adversely susceptibility to extensive vehicle idling.

In preparation for the meeting, Niagara EMS compiled a list showing frequent parts replacements and associated costs, derived from VOD historical records.

Presented below is the additional information arising from this meeting.

DPF System

The Sprinter's Powertrain Control Module (PCM) controls DPF system cycling. PCM settings are factory set, they cannot be adjusted to introduce regeneration cycling during vehicle idling.

According to the information assembled by Niagara EMS, there has not been a requirement to frequently replace DPF filters. Hence, the absence of regeneration cycling during vehicle idling, does not appear to be a major issue.

Brock Ford recently trialled an aftermarket solution for cleansing a DPF filter. Cleaning was performed by a Hamilton-based company at a cost of roughly $400 which is substantially less than the cost of DPF replacement. The vehicle was out of service for about 3 days. Brock Ford is impressed with the initial results.

In our opinion, as means for future cost control – and only if warranted by future increases in DPF-related costs – Niagara EMS might wish to consider having DPF filters cleansed at an odometer milestone of 100,000-150,000 kilometres; this, to mitigate the need for DPF replacement at a later date.

DEF System

According to Niagara EMS' VOD records, most emissions system-related repair costs are associated with the DEF system (not the DPF).

In our opinion, and that of others including Brock Ford, there does not appear to be anything wrong with the DEF system. It is operating as designed, to reduce harmful exhaust levels of nitrogen oxide, by converting this unwanted gas into nitrogen, carbon dioxide and water.

The costs incurred by Niagara appear to be due to the extensive vehicle idling, which wears away at the DEF system at a pace that was previously unanticipated.

The level at which the Sprinters are currently idling translates to 40% more wear and tear on the DEF system than the odometer readings would suggest. This explains the unanticipated costs for DEF system repairs.

Brock Ford points out that DEF systems were introduced in 2011. During the initial years, 2011-2013, DEF issues presented at a relatively high rate. In contrast, they currently see relatively few DEF issues of note, suggesting that the resilience of DEF systems has likely improved over the years, due to technological advances.

Brock Ford also points out that DPF issues also presented at a relatively high rate when they were first introduced, and over time major issues have all but disappeared.

The Sprinter lifecycle costings within this report are based on vehicle models for years 2012 and 2013 (i.e., the only model years retired at the time of this review). These 2012 and 2013 vehicles were equipped with initial generation DEF systems.

If the resilience of DEF systems has improved due to technological advances (as Brock Ford suggests), then Niagara is likely to incur fewer DEF system issues of note in future years. In this, there are no guarantees, but it is worthwhile to track.

Niagara EMS may not have to wait very long to find out. The oldest ambulances in the fleet are of model year 2014, which is outfitted with 3rd generation DEF technology, and these ambulances are likely be retired this year or next.

Niagara EMS may also wish to discuss the matter directly with Mercedes.

Additional Comments

It is overly easy to become extensively involved in discussions of one issue or another - in this instance the issue being excessive idling and its adverse impact to the emissions control system. When this happens, it also is overly easy to overlook the following very important fact.

Despite the unanticipated repair costs attributed to vehicle idling, the Sprinter's total operating cost (inclusive of fuel and servicing) is lower than that of any other Type 3 ambulance currently operating in Ontario. This was illustrated in Sections 4.6 and 4.7, and it will be demonstrated again in Section 7.

It also is relatively easy to overlook possible actions by which to manage extensive idling. We are advised that as a result of this review, Niagara EMS will be investigating options that may include changes in operational policy and use of alternate devices to maintain a constant patient compartment temperature (e.g., on-board heater, solar panels, etc.).

6 Does the Sprinter Measure up to Needs of Other Users?

This section of the report addresses the following question of interest to this review. *In the opinion of other Sprinter 3500 users, does the ambulance chassis measure up to expectations?*

To address this question, we reached out to the following 3 additional users of the Mercedes Sprinter 3500 ambulance chassis platform: Cranberry Township EMS, Pennsylvania; CoxHealth EMS, Springfield Missouri; and Renfrew County Paramedic Service, Ontario.

Below is a summary profile of the services derived from interviews with members of their respective leadership teams. The information / insights that they provided is presented on the following pages.

Exhibit 6.1: Summary Profile of Sprinter Users

	Niagara Ontario	Cranberry Township PA	CoxHealth Springfield MO	Renfrew County Ontario
Fleet Size (amb's)	43	4	28	29
Mercedes Sprinter 3500's				
No. Currently in Use	43	3 (w' 1 more in production)	12 (w' 4 more in production)	11
Percent of Fleet	100%	100% Shortly	43% (57% shortly)	38%
When Commissioned?	18 in late 2018 25 in 2014-2016	1 in 2018 2 in 2016	5 in late 2018 7 in 2015-16	6 in 2018 5 in 2017
Deployment Model	Station based	Station based	Dynamic	Dynamic
Annual Kms per Amb. (avg)	54,700	54,000	75,000	75,000
Suspension	VB Air	Spring Leaf	Spring Leaf	VB Air
Equipped w' Anti-Idling?	Disconnected	Disconnected	No	No
Use Power Cot / Lift?	Yes	Yes	Yes	Yes
OEM Replacement Parts or Aftermarket?	OEM	OEM	OEM	Both
Do Ambulances Idle Extensively?	Yes (hospital offload)	No	No	Yes (standby volume)
Fuel Consumption (Litres per 100 Kms)	17.7	--	13 / 20 (Hwy / Urban)	16
Target Retirement (Yrs) Kilometres (Odometer)	4.5 250,000	6 325,000	5 375,000	4 300,000

6.1 Cranberry Township EMS, Pennsylvania

Fleet Profile

Cranberry Township EMS operates with a fleet of four Type 3 ambulances. Three ambulances are Demers MX152A's manufactured using the Mercedes Sprinter 3500 chassis, and one is a relatively old 2009 vehicle manufactured with a Chevy 3500 chassis.

The Township's involvement with the Mercedes Sprinter chassis is relatively recent. They took delivery of 2 Mercedes Sprinters in March 2016 and a third in May 2018. They are awaiting next month's delivery of a fourth Mercedes Sprinter, which they will use to retire the 2009 Chevy ambulance.

Cranberry Township operates a station-based deployment model. Their ambulances travel an average of 54,000 kms a year – roughly, the same distance as Niagara EMS' Mercedes Sprinters.

The Township's ambulances are equipped with a standard spring leaf suspension. Although the service uses power cots, they do not use power lifts. We are advised that their paramedics are not overly concerned with the additional 2+ inch difference in elevation associated with the Mercedes Sprinter chassis.

The initial 2016 Mercedes Sprinters were equipped with an idle reduction system. However, as was the case in Niagara, Cranberry Township found that with the system in operation the patient compartment could not be kept at a constant temperature. Cranberry Township EMS has disconnected the idle reduction system from their 2016 Sprinters. The 2018 Sprinter is not equipped with idle reduction, and neither will the Sprinter currently in production.

Cranberry Township's ambulances are serviced by a Mercedes certified garage. They use only OEM replacement parts. Their ambulances do not idle excessively. The Township targets ambulance replacement (end-of-life) at 6 years or 200,000 kilometres.

Overall Opinion of the Sprinter

Cranberry Township EMS is generally satisfied with the Demers MX152A Mercedes Sprinter 3500 ambulance. Their Sprinters can operate on road for longer periods than their prior Ford F350 and Chevy 3500 ambulances.

Their intent going forward, is to re-mount existing MX152A patient compartments over time onto future Mercedes Sprinter 3500 chassis.

Other Information / Insights

- Absence of a locally-based commercial Mercedes dealership is an issue. The closest Mercedes certified garage is 40 miles away. Vehicle drop off and retrieval is challenging. The dealership operates on a first come / first service basis. When taken to the dealership, an ambulance can be out of service for up to 3 days, depending on the repair issue.
- They have observed a significant difference in AdBlue fluid consumption between ambulances, but they are unable to ascertain why this is the case.
- In their view, they are replacing tires and brakes too frequently. They suspect a wheel alignment issue. [22]

6.2 CoxHealth EMS, Springfield Missouri

Fleet Profile

CoxHealth is a hospital-based ambulance service, which performs both 911 responses as well as inter-facility patient transfers.

CoxHealth EMS used to operate with a fleet of Life Line ambulances; however, safety concerns with respect to the bench and forward-facing seats within the patient compartment, resulted in a corporate decision to transition the fleet over time to the diesel-powered Mercedes Sprinters.

They purchased 10 Type 2 Mercedes Sprinter 2500's between 2012 and 2015. These did not fully meet their service needs. Transitioning to the Type 3 Sprinter 3500 chassis commenced in 2015.

Their fleet currently consists of 28 ambulances. This includes: 12 Type 3 Sprinters commissioned between 2015 and 2018; 10 Type 2 Sprinters commissioned between 2012 and 2015; and 6 relatively old Life Line ambulances (which are being phased out over time). They also have purchased 4 more Type 3 Sprinters, which are in production.

CoxHealth EMS operates a dynamic deployment model using a system status management system to position and re-position their ambulances throughout the day. Sixty percent of the ambulances operate in an urban area; 40% operate from rural posts, where they accumulate considerable highway mileage. Their ambulances travel an average of 75,000 kms a year.

[22] Niagara EMS advised Cranberry Township that Demers sets the vehicle alignment of an empty ambulance. The equipment carried on-board an ambulance can weigh 500-600 pounds. It is Niagara EMS' practice to re-set the alignment of each fully-loaded ambulance prior to commissioning. This practice has significantly reduced tire wear and brake replacement.

CoxHealth's Mercedes Sprinter ambulances are equipped with a standard spring leaf suspension. They are not equipped with an idle reduction system. The service uses both power cots and power lifts.

CoxHealth uses only OEM replacement parts. Their ambulances do not idle extensively. They target ambulance replacement (end-of-life) at 5 years or 375,000 kilometres.

Overall Opinion of the Sprinter

As discussed above, CoxHealth EMS transitioned to the Mercedes Sprinter mainly to enhance patient and paramedic safety during ambulance transport. Safety and integrity of the patient compartment is their utmost consideration.

From this perspective, CoxHealth EMS is very pleased with the Demers MX152A Mercedes Sprinter 3500 ambulance. Their intent going forward, is to re-mount existing MX152A patient compartments over time onto future Mercedes Sprinter 3500 chassis.

They are generally pleased with the fuel-efficiency of the vehicle, which consumes an average 20 litres per 100 km urban travel and 13 litres per 100 km rural. They also are generally pleased with the relatively low CO2 emissions (which are proportional to fuel consumption).

Other Information / Insights

- Absence of a locally-based commercial Mercedes dealership is an issue. It is about a 2-hour drive to get to the closest Mercedes certified garage. Vehicle drop off and retrieval is challenging. When taken to the dealership, an ambulance can be out of service for an extended period.
- CoxHealth ambulances do not incur extensive idling. However, high mileage vehicles have encountered a few exhaust system related repair issues, requiring the replacement of key components, e.g.: fuel injectors. Overall, this has not been a significant issue.
- To manage vehicle servicing, they use a computer software system purchased from Mercedes. The software can log onto the Mercedes intranet network to perform comparative diagnostics.

6.3 Renfrew County Paramedic Service, Ontario

Fleet Profile

Renfrew County Paramedic Service used to operate with a fleet of diesel-powered Demers MX164A Type 3 ambulances manufactured on a Chev (GM) 3500 chassis platform. The Ford company's announcement to terminate production of this chassis for Ontario ambulances, resulted in a corporate

decision to transition the fleet over time to the diesel-powered Mercedes Sprinters.

Renfrew County started off in 2012, by purchasing Mercedes Sprinter Type 2's (i.e., 2500 chassis). These did not fully meet their service needs. Transitioning to the Type 3 Sprinter (i.e., 3500 chassis) commenced in 2017.

Renfrew's fleet currently consists of 29 ambulances. This includes: 11 Type 3 Sprinters commissioned in 2017-2018; 3 Type 2 Sprinters commissioned between 2012 and 2014; and 15 relatively old diesel-powered Demers MX164A Type 3 ambulances manufactured on a Chev (GM) 3500 chassis platform (which are being phased out over time).

The County operates a dynamic deployment model, frequently re-positioning their rural ambulances to provide temporary "standby" coverage for multiple rural/urban areas. Their ambulances travel an average of 75,000 kms a year.

The County's ambulances are equipped with VB Air-suspension. They are not equipped with an idle reduction system. The service uses both power cots and power lifts.

Renfrew County mechanics perform most of the servicing required by their ambulances. The nearest Mercedes certified garage is based in Ottawa, which is roughly a 2-3 hours drive depending on ambulance base of origin.

The County uses mostly OEM parts; albeit, since aftermarket parts are of significantly lower cost, they also use aftermarket products provided they meet Mercedes specifications.

The County's ambulances perform numerous "standby" calls (i.e., temporary repositioning to cover more than one area). While performing "standby" their ambulances also do an extensive amount of idling; this, to maintain a constant temperature in the cab and patient compartment.

Renfrew County targets ambulance replacement (end-of-life) at 4 years or 300,000 kilometres.

Overall Opinion of the Sprinter

Renfrew County Paramedic Service acknowledges that the Mercedes Sprinter 3500 ambulance has some quirks (as described below). However, their overall opinion is that the vehicle, and the Mercedes 3.0 litre diesel engine in particular, are superior to any of the gas-powered ambulances operating in Ontario, from the perspective of engine performance, fuel economy and costs.

They also are pleased with the fuel-efficiency of the vehicle, which consumes an average of 16 litres per 100 km, and the relatively low CO2 emissions (which are proportional to fuel consumption).

Other Information / Insights

- Absence of a locally-based commercial Mercedes dealership is an issue. The closest Mercedes certified garage is based in Ottawa, some 2 to 3 hours drive from Renfrew County ambulance bases. Up to four staff may be needed for vehicle drop off and retrieval. The dealership operates on a first come / first service basis. When taken to the dealership, an ambulance can be out of service for 2 to 3 days.
- For these reasons, the County often performs warranty work on their own, incurring servicing costs out-of-pocket. Parts under warranty can also be an issue, as they need to be shipped in.
- Renfrew County's ambulances incur extensive idling due mainly to the volume of standby calls that they perform. The extensive idling of their ambulances is of concern, as it is contributing to repeated failure and replacement of key exhaust system components (as is the situation in Niagara).
- Renfrew County EMS are of the view that the Sprinter's emissions control system is a solid piece of engineering. Its susceptibility to extensive idling does not mean that it is not sufficiently robust. Gas engines don't run troubled free and are equally susceptible to problems arsing from extensive idling.
- Renfrew County's service area is relatively large and mainly rural. Many ambulance responses involve long-distance travel. Sprinters are equipped with relatively smaller fuel tanks. Paramedics must constantly keep an eye on the fuel level gage.
- Sprinter ambulances are not equipped with an on-board computer warning system to advise when emissions system servicing is needed.[23] Useful warnings would include: "DPF regeneration is in process or complete"; "AdBlue fluid level is low"; and "Check DEF" to advise of a potential system issue.

[23] *Source: https://www.autoevolution.com/news/your-guide-to-adblue-what-is-it-who-needs-it-and-how-to-refill-it-104882.html* In contrast to the above, the on-board computer of many commercial Sprinter vans will notify the driver that the AdBlue fluid level is low and that a refill is required; this by way of an instrument panel warning light. Notification commences several thousand kilometers before the refill is necessary and is repeated for a specified number of times. If the final notification is ignored, the vehicle may either refuse to start or it will default to a self-preservation/limp mode.

7 Comparison of the Sprinter to Other Ambulance Chassis

This section of the report addresses the following question. *Does the Sprinter 3500 measure up to other ambulance chassis operating in Ontario?* The assessment is based on a survey of 23 Ontario EMS peers (identified in Appendix A) whose ambulances are built with GM and Ford chassis. [24]

7.1 Alternative Chassis Used by Ontario Peers

As illustrated by Exhibit 7.1, the GM (Chev) 3500 is the most popular chassis used by Ontario EMS peers. The Ford E350 is also a popular choice. Relatively few services operate fleets consisting mainly of the Ford E450.

Exhibit 7.1: Alternative Chassis Used by Ontario Peers

Chassis	MS 3500 Niagara	Ford E350	GM 3500	Ford E450
EMS Peers that Contributed to this Review	--	6	13	4
Type 3 Amb's that are Common to the Chassis	Demers MX152A	Demers MX164A Crestline Fleetmax	Demers MX164A Crestline Fleetmax	Demers MX164A
Engine Size	3.0L	6.8L	6.0L	6.8L
Fuel	Diesel	Gas f' also Diesel	Gas f' also Diesel	Gas f' also Diesel
Gross Vehicle Weight (kgs)	5,003	5,670	5,579	6,577
Payload (kgs)	864	1,185	1,032	1,894
Max # of Occupants (Kgs)	5 (525)	5 (525)	5 (525)	6 (630)
Cargo Capacity (kgs)	339	660	507	1,264
Overall Length (inches)	264"	271" - 278"		
Overall Width (inches)	86"	95"		
Overall Height (inches)	108"	100" - 106"		
Headroom (inches)	72"	72"		
Wheelbase (inches)	144"	158" - 159"		

[24] Renfrew County Paramedic Service is one of the Ontario EMS services that we surveyed. However, as Renfrew County uses the same ambulance as Niagara (Demers Mercedes Sprinter 3500), its fleet information was discussed previously in Section 6, and Renfrew is excluded from this portion of the analysis, which focuses on alternative GM and Ford chassis.

GM and Ford used to manufacture both a diesel and gas version of their chassis for Ontario ambulance use. This is no longer the case. Only their gas-powered versions are currently certified for use in Ontario.

This notwithstanding, as discussed in Section 7.2, several Ontario EMS services continue to operate fleets that include diesel-powered GM and Ford ambulances; albeit, these vehicles are ageing and are being phased out over time.

The GM 3500 chassis comes with a 6.0 litre gas-powered engine. Ford's E350 and E450 chassis come with a 6.8 litre gas-powered engine.

The Demers MX164A and Crestline Fleetmax are the most popular ambulances used by Ontario peers. Both ambulances are of a Type 3 model and depending on client preference, they can be manufactured with a GM 3500 chassis, or either the Ford E350 or E450 chassis.

The Mercedes Sprinter 3500 ambulance is certified to transport up to 5 occupants. In this respect, the GM 3500 and Ford E350 ambulances are similar.

At a gross vehicle weight of approximately 5,000 kgs, the Mercedes Sprinter 3500 is the lightest among ambulances in its weight class, regardless of chassis. The Sprinter's cargo carrying capacity, at 339 kgs, also is the lowest among ambulances in its weight class.

Ambulances manufactured with the Ford E450 chassis are significantly heavier vehicles, capable of carrying a higher number of occupants and an overall heavier payload.

Relatively few EMS services operate fleets consisting mainly of heavier Ford E450's. However, multiple services including Niagara EMS maintain a few such vehicles at hand, to serve bariatric needs, i.e., to transport patients whose weight would severely challenge the capabilities of lighter vehicles.

For convenience, the following two fleet variations are not shown in Exhibit 7.1.

Thunder Bay's fleet consists of a slightly heavier Fleetmax Commander ambulance manufactured with a gas-powered GM 3500 chassis.

Toronto EMS' fleet includes the gas-powered Crestline New Era as an additional ambulance model. The Crestline New Era is manufactured with a Chev Express 3500 chassis featuring a relatively short 139" wheelbase, which enhances the vehicle's maneuverability in the congested downtown urban area. Its payload capacity is up to 1,577 kgs.

7.2 Major Features

Major features of the alternative ambulance chassis used in Ontario are summarized in Exhibit 7.2, and they are discussed below.

Exhibit 7.2: Summary of Major Features

Chassis	MS 3500 Niagara	Ford E350	GM 3500	Ford E450
EMS Peers that Contributed to this Review	--	6	13	4
Use Power Cot / Lift?	Yes	Yes	Yes	Yes
Chassis Suspension	VB Air	100% standard	70% std / 30% fluid	50% std / 50% fluid
Equipped w' Anti-Idling?	Disconnected	75% no	65% yes / 35% no	50% yes / 50% no
Vehicle Servicing	Outsourced	100% in-house	50% outsourced	100% in-house
OEM Replacement Parts or Aftermarket?	Only OEM	Mainly OEM	50% only OEM / 50% mainly OEM	100% only OEM
Target Retirement (Yrs) Kms at Retirement Residual at Retirement	4.5 250,000 $18,000 - $22,000	5-6 220,000 - 325,000 $3,000 - $8,000	5-7 200,000 - 325,000 $5,000 - $12,000	5 180,000 - 225,000 $13,000 - $14,000
Fuel that the Services Use	Diesel	100% Gas / One is converting to Gas-Hybrid	60% Gas / 40% are transitioning from diesel to Gas. Two are converting to Gas-Hybrid.	100% Gas

Fuel

The Mercedes Sprinter 3500 is the only diesel-powered chassis certified for use as an ambulance in Ontario. This chassis is used by both Niagara Region and Renfrew County.

Eighteen of the 23 peers surveyed by this review, operate gas-powered ambulances. Five (5) peers are in the process of transitioning their fleets from diesel to gas, using gas-powered ambulance replacements when diesel vehicles are retired. The 5 services are: Waterloo, Oxford, Huron, Sault Ste. Marie and Essex-Windsor.

Three services – Oxford, York and Toronto – have successfully trialled gas-hybrid ambulances, and they have commenced to phase them in on a going-forward basis. For more information on gas-hybrids, refer to Section 8 of this report.

Power Cot / Power Lift

The Mercedes Sprinter 3500 used by Niagara and Renfrew is outfitted with both a power cot and a power lift. All 23 EMS peers surveyed by this review use power cots, and most also use power lifts.

Chassis Suspension

The Mercedes Sprinter 3500 used by Niagara and Renfrew is equipped with VB Air-suspension, a system that substantially reduces road shock and vibration, and improves load levelling capability, making for a quieter, smoother and more constant patient ride, better overall handling, and rollover resistance.

VB Air-suspension also enables the rear portion of the ambulance to be lowered, making it easier to load patients and equipment; albeit, this feature is not frequently used since Niagara and Renfrew also equip their ambulances with power cots and power lifts.

Almost 75% of the EMS peers surveyed operate ambulances equipped with a standard leaf spring suspension. About 25% use ambulances outfitted with a liquid suspension having patient ride and vehicle handling characteristics similar to those of an air-ride system – albeit, the rear portion of these ambulances cannot be lowered.

None of the EMS peers surveyed use an air-ride suspension. Several did mention having trialed air-ride suspension but converted to leaf spring after encountering issues with moisture seeping into the compressor lines.

Anti-Idling

The Mercedes Sprinter 3500 used by Niagara and Renfrew is not outfitted with an idle reduction system.

Niagara's Sprinters used to be equipped with the Demers EcoSmart idle reduction system; however, multiple issues were encountered, ostensibly that of not being able to maintain a constant temperature in the patient compartment. Following unsuccessful attempts to resolve the issues, Niagara EMS had the system disconnected.

Among the EMS services surveyed during this review (including peers who also operate Mercedes Sprinter 3500 ambulances), 55% have either not equipped their ambulances with idle reduction systems, or they have had the systems disconnected due to issues such as the one mentioned above.

Vehicle Servicing

Only 10 of the Ontario EMS services surveyed were asked questions regarding vehicle servicing. They consisted mainly of peers serving jurisdictions of comparable population (460,000 residents) or larger.

Niagara EMS outsources its vehicle servicing. Ten percent (10%) of comparably sized EMS services also outsource vehicle servicing. Ninety percent (90%) have their servicing performed in-house by Regional/County fleet / public works centres.

OEM Replacement Parts

As above, only 10 EMS services of comparable size were asked questions about OEM replacement parts.

Niagara EMS uses only OEM replacement parts. Among the services surveyed, 50% use only OEM parts; whereas, the other 50% use a mix of OEM and less expensive aftermarket parts, provided they meet OEM specifications.

Vehicle Retirement and Resale

As above, only 10 EMS services of comparable size were asked questions about ambulance retirement targets and end-of-life vehicle resale values.

Niagara EMS' optimum retirement target is 54 months (4.5 years) or 250,000 kilometres. The Sprinter's residual value at retirement ranges between $18,000 and $22,000.

For the surveyed EMS peers whose ambulances use a GM 3500 chassis, the optimum retirement target ranges between 5 and 7 years (200,000 to 325,000 kms). Vehicle resale values at retirement range between $5,000 and $12,000.

For peers using a Ford E350 chassis, the optimum retirement target ranges between 5 and 6 years (220,000 to 325,000 kms); and vehicle resale values are relatively low, ranging between $3,000 and $8,000.

For peers using a Ford E450 chassis, the optimum retirement target is 5 years (180,000 to 225,000 kms); and vehicle resale values are about $13,000-$14,000.

7.3 Comparison of Performance Metrics

Performance metrics for the alternative ambulance chassis used in Ontario are summarized in Exhibit 7.3, and they are discussed on the following pages.

Exhibit 7.3: Comparison of Performance Metrics

Chassis	MS 3500 Niagara	Ford E350	GM 3500	Ford E450
Fuel	**Diesel**	**Gas**	**Gas**	**Gas**
EMS Peers	--	**6**	**8**	**4**
Avg. Fleet Size (Amb's)	**43**	**30**	**37**	**42**
Annual Kms per Amb. (avg.)	**54,700**	**46,400**	**39,700**	**47,100**
% Diff. Rel. to Sprinter	--	*-15%*	*-27%*	*-14%*
Fuel (Litres per 100 Kms)	**17.7**	**28.9**	**29.9**	**37.5**
% Diff. Rel. to Sprinter	--	*63%*	*69%*	*112%*
CO2 Emis'ns (Kgs/100 Kms)	**47**	**68**	**71**	**89**
% Diff. Rel. to Sprinter	--	*44%*	*50%*	*88%*
Fuel ($/Km)	**$0.22**	**$0.36**	**0.37**	**$0.42**
% Diff. Rel. to Sprinter	--	*60%*	*65%*	*89%*
Servicing & Repairs ($/Km)	**$0.25**	**$0.25**	**0.30**	**$0.56**
% Diff. Rel. to Sprinter	--	*0%*	*19%*	*122%*
Total Operating ($/Km)	**$0.47**	**$0.61**	**$0.67**	**$0.98**
% Diff. Rel. to Sprinter	--	*28%*	*41%*	*106%*

Note: Cost for fuel has been adjusted to a common base; this, to offset variances in jurisdictional purchasing practices and/or the per litre price of fuel.

Assumptions

Our objective is to compare the Sprinter 3500 to other chassis certified for use as ambulances in Ontario.

The Sprinter is the only diesel-powered chassis that is certified for such purposes. All other Ontario-certified chassis are gas-powered; albeit, there are several EMS peers who are still in the process of transitioning their fleets from diesel to gas.

We investigated key performance metrics for both groups of EMS peers, i.e., those that operate gas-powered ambulance fleets, and those that are transitioning their fleets from diesel to gas.

In consideration of the objective stated above, this report only presents the metrics relevant to EMS peers that operate gas-powered ambulance fleets.

The only grouping affected by this decision are EMS peers that operate with GM 3500 chassis. As the reader will recall, within this grouping there are 5 services that are in the process of transitioning their fleets from diesel to gas.

This report does not speak to the metrics associated with the diesels operated by those services, since they are being eliminated.

Our assessment is based on vehicle operating data for 2018, provided by Niagara EMS and the peer services that we surveyed. Costs are expressed in 2018 dollars.

References to kilometres travel are odometer-based. The figures presented do not include a kilometre equivalency for vehicle idling.

A number of the jurisdictions surveyed purchase fuel in bulk for all vehicles that they operate, including EMS, public works, traffic, administration, etc. Our analysis adjusts the cost of fuel to a common basis; this, to offset variances in jurisdictional purchasing practices and/or the per litre price. For this purpose, we adopted the cost per litre that Niagara pays for diesel and gasoline fuels.

Fleet Size

Niagara EMS currently operates with a fleet of 43 Mercedes Sprinter 3500 ambulances.

For the surveyed EMS peers whose ambulances use a Ford E350 chassis, the average fleet size is 30 ambulances. For those using a GM 3500 chassis, the average fleet size is 37 ambulances; and for those using a Ford E450 chassis, the average fleet size is 42 ambulances.

Annual Kilometres per Ambulance

Niagara EMS' diesel-powered Sprinter ambulances travel an average of 54,700 kilometres a year, which in comparison to the gas-powered ambulance chassis that Ontario peers use, is a substantially longer distance.

Ambulances that use a Ford E450 chassis travel an average of 14% fewer kilometres (47,100 kms a year). Ambulances that use a Ford E350 chassis travel an average of 15% fewer kilometres (46,400 kms a year); and those that use a GM 3500 chassis travel an average of 27% fewer (39,700 kms a year).

Fuel Consumption

Niagara EMS' diesel-powered Sprinter ambulances consume an average of 17.7 litres of fuel per 100 kilometres travel, which in comparison to the gas-powered

ambulance chassis that Ontario peers use, is a substantially more economic rate of fuel consumption.

The rate of fuel consumption for ambulances that use a Ford E350 or GM 3500 chassis is up to 69% higher, ranging between 28.9 and 29.9 litres per 100 Kms. For ambulances that use a Ford E450 chassis, the rate of fuel consumption is over twice as high, at 37.5 litres per 100 Kms.

CO2 Emissions

Niagara EMS' diesel-powered Sprinter ambulances emit 47 CO2 Kgs per 100 kilometres travel. CO2 emissions for ambulance fleets that use a Ford E350 or GM 3500 chassis are up to 50% higher, ranging between 68 and 71 CO2 Kgs per 100 Kms. For ambulance fleets that use a Ford E450 chassis, the CO2 emissions rate is 88% higher, at 89 CO2 Kgs per 100 Kms.

Fuel Costs

On a per kilometre basis, fuel costs for the Sprinter average $0.22 per kilometre.

The comparable cost of fuel, for ambulance fleets that use a Ford E350 or GM 3500 chassis is up to 65% higher, ranging between $0.36 and $0.37 per Km. For ambulance fleets that use a Ford E450 chassis, the cost of fuel is 89% higher, at $0.42 per Km.

Servicing & Repair Costs

On a per kilometre basis, servicing and repair costs for the Sprinter average $0.25 per kilometre.

The comparable cost for servicing and repairs, for ambulance fleets that use a Ford E350 or GM 3500 chassis is up to 19% higher, ranging between $0.25 and $0.30 per Km. For ambulance fleets that use a Ford E450 chassis, the cost for servicing and repairs is over twice as high, at $0.56 per Km.

Total operating Costs

On a per kilometre basis, total operating costs for the Sprinter average $0.47 per kilometre.

The comparable total operating cost for ambulance fleets that use a Ford E350 or GM 3500 chassis is up to 41% higher, ranging between $0.61 and $0.67 per Km. For ambulance fleets that use a Ford E450 chassis, the total operating cost is over twice as high, at $0.98 per Km.

8 Comparison of the Sprinter to Emerging Chassis Technology

This section of the report addresses the following question. *How well does the diesel-powered Sprinter 3500 measure up to newly emerging ambulance chassis technology?*

8.1 Fully-Electric Ambulance

Demers Ambulances recently stated its intent to investigate the development of a fully-electric ambulance. [25] We followed up with a Demers representative who recalls the statement but advises that at present there is no additional information to share. To date there has been no formal announcement nor has a commitment been given to a specific timeline.

8.2 XL3 Hybrid Electric Drive Train

The XL3 Hybrid, developed by XL Fleet of Boston MA, is a self-contained electric drive train and battery system which, when installed as an after-market product onto a standard OEM vehicle chassis, works seamlessly in the background to increase the vehicle's torque and make the vehicle more fuel efficient and cleaner, reportedly with zero adverse impact on the OEM systems.

XL Fleet was founded in 2009 with 3 main goals: sustainability, fuel reduction and electrification. XL Fleet is not an OEM vehicle manufacturer. They partner with vehicle manufacturers (e.g., Ford and GM) and, also with ambulance conversion manufacturers (e.g., Demers and Crestline) to attain their goals.

The XL3 Hybrid technology has been implemented and validated by numerous large-fleet operations throughout the USA and Canada, including Canada Post, Coca-Cola, Verizon, FedEx, multiple urban transit systems, multiple public utility systems and most recently by several Ontario and BC-based land ambulance services, including Toronto EMS, York Region Paramedic Services, and Oxford County Paramedic Services. [26]

The XL3 Hybrid is available on a broad range of light and medium-duty trucks (specifically, class 2-6 vehicles with GVW ratings of 6,000 to 26,000 pounds). The technology is installed mainly on gas-powered vehicles; albeit, it also has been installed on several diesels. XL Fleet states that the technology will

[25] Verbal statement made at the Ontario Association of Paramedic Chiefs (OAPC) conference, September 2018.

[26] We are advised that other Ontario EMS services (e.g., Hamilton and Ottawa) may also be looking into the XL3 Hybrid technology.

improve a gas-powered vehicle's performance (as measured in MPG) by an average of 25%; and it will reduce CO2 emissions on average by about 20%.

Technology Overview

Traditional gas-powered, commercial fleet trucks cause more pollution and burn more fuel than any other vehicles on the road. XL Fleet takes a simple approach to making those same vehicles cleaner, greener and more sustainable. [27]

The XL3 Hybrid technology transforms a factory OEM vehicle into a more fuel-efficient hybrid, by adding an electric motor, an advanced lithium-ion battery pack and control software, as shown schematically in Exhibit 8.1.

No other significant modifications to the vehicle are required. No changes are made to the internal combustion engine or transmission. The technology when installed, leaves the OEM factory warranty and powertrain fully intact.

Exhibit 8.1: Illustration of the XL3 Hybrid Installation

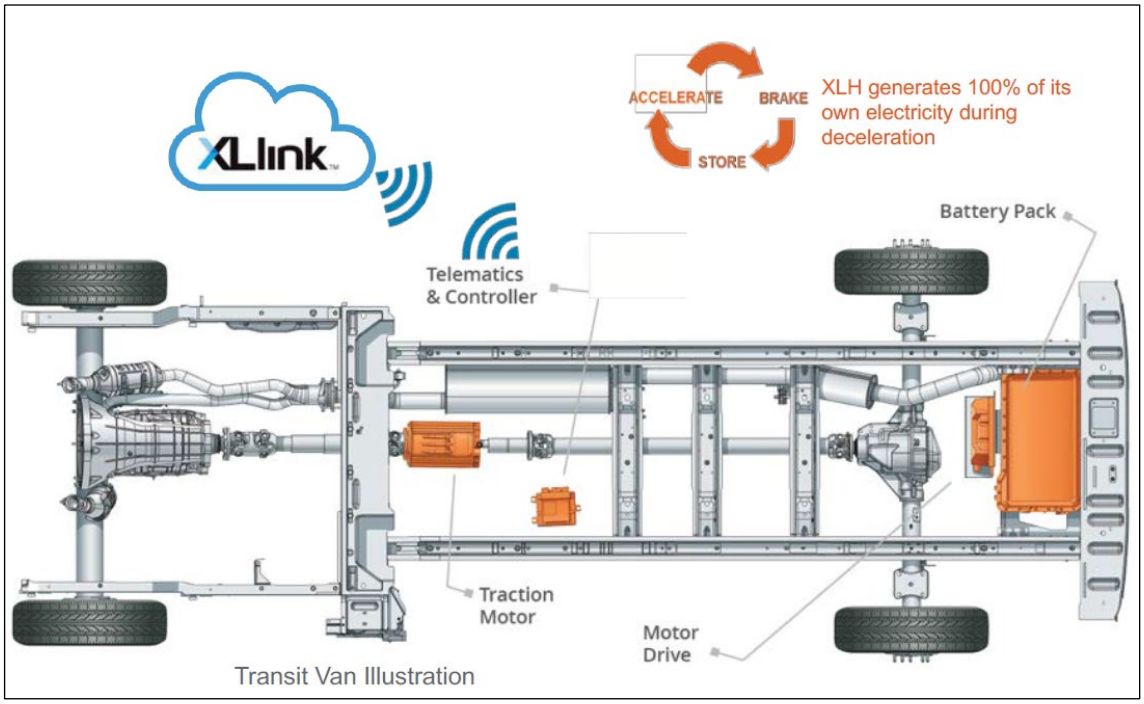


Illustration provided by XL Fleet

[27] https://www.xlfleet.com/content/technology/

Regenerative braking is how the technology functions. Regenerative braking is a process by which an electric traction motor is used to help a vehicle decelerate during braking. A lithium-ion battery stores the regenerative braking energy.

During acceleration, the battery releases stored energy to the electric traction motor, providing an electric assist to help propel the vehicle, and save fuel. A motor drive controls the current flow between the battery and the electric traction motor. A proprietary XL Link technology provides a continuous data link from each hybrid vehicle to measure system performance.

XL-equipped vehicles require no driver training and little to no operational changes from what they're used to. There are no range concerns, drivability challenges or unusual service requirements. [28]

XL Link

The proprietary XL Link technology provides a wireless data link that provides XL Fleet (in Boston) with continuous diagnostics of the XL3 Hybrid system performance on each hybrid vehicle. The XL Link technology will also alert XL Fleet of any potential Hybrid system service requirements.

By way of the data transmitted by this technology, XL Fleet can provide each customer with periodic system performance reporting on each of their hybrid vehicles. Customers are free to help custom-design their reporting templates.

Zero Adverse Impact on OEM Systems

XL Fleet does not have extensive years of experience specific to ambulances. They do however have years of experience with large commercial fleets (e.g., Coca-Cola, FedEx, etc.). Some of these commercial vehicles have attained in-service lives of over 250,000 miles, without encountering any adverse impacts due to the on-board hybrid technology.

To the contrary, positive impacts have been reported, including less wear and tear on brake pads, which do not need to be replaced as often.

Warrantied Servicing

XL Fleet provides customers with 24-hour call centre support. The XL3 Hybrid system is warrantied for 3 years / 75,000 miles. If needed, replacement parts and a service technician can be sent to the customer's site.

[28] https://www.xlfleet.com/content/technology/

XL Plug-In

The XL3 Hybrid system operates with a 1.8-kWh lithium-ion battery. XL Fleet also manufactures an XL Plug-In system technology that is more appropriate to heavier class vehicles. That system operates with a 15-kWh battery, offering both regenerative braking and plug-in charging capacity. XL Fleet states that the XL Plug-In produces a 50% MPG improvement, and 33% CO2 reduction.

Additional Commentary

The XL3 Hybrid system is mounted on the underside of the vehicle. Hence, it does not adversely impact cargo volume carrying capacity. The electric motor and battery pack weighs between 350 and 385 pounds, which will influence a vehicle's cargo weight carrying capacity.

For these reasons, after the XL product is installed onto an ambulance, the ambulance conversion manufacturer will re-weigh the vehicle and issue updated certification.

The XL3 Hybrid technology is not restricted to gas-powered vehicles. It can be implemented on vehicles using alternative fuels, e.g., diesel fuel or natural gas. The real question is whether there is a benefit to doing so.

As stated above, the XL3 Hybrid technology is intended to increase a vehicle's torque, thereby making the vehicle more fuel efficient. Diesel engines, in comparison to gasoline engines, already provide high levels of torque; hence, there potential may not be sufficient benefit to outfit all diesels with the technology.

XL Fleet has considered partnering with Mercedes, in the same manner by which they have already partnered with GM, Ford and others. Aside from the added value benefits and technical issues which would have to be investigated, there also is the matter of economics. Pre-sales estimates would have to offset the cost of the requisite research and development.

8.3 Ontario EMS Experience

Oxford County Paramedic Services

Oxford County was the first municipality in Canada to deploy ambulances outfitted with the XL3 Hybrid technology, taking delivery of 2 such vehicles in October 2017. The technology was installed on gas-powered Crestline Fleetmax Type 3 ambulances manufactured with a GM 3500 chassis.

Oxford County took delivery of 2 more hybrid ambulances in January 2019. The County now operates with 4 such vehicles and plan to convert the rest of the fleet to hybrids, phasing them in over time, as older ambulances are retired.

Oxford County's fuel consumption data affirms that hybrid ambulances are at least 25% more fuel efficient than standard gas-powered ambulances, as attested to by XL Hybrid.

York Region Paramedic Services

York Region commissioned 2 hybrid ambulances in February 2018. Fourteen (14) additional ambulances were retrofitted with XL3 Hybrid systems in December 2018. York Region now operates with 16 such vehicles. The technology is installed on gas-powered Demers MX164A Type 3 ambulances manufactured with a Ford E350 chassis.

York Region's fuel consumption data also affirms that hybrid ambulances are at least 25% more fuel efficient than standard gas-powered ambulances, as attested to by XL Hybrid.

York Region affirms that the XL3 Hybrid system has had no adverse impact on their ambulances' OEM systems. To the contrary, the following benefit has been reported. Their standard (non-hybrid) ambulances typically need brake pad replacement at about 48,000 kilometres travel; whereas, when the initial 2 hybrid ambulances reached this milestone, the rear brake pads still had about 70% life remaining.

Toronto EMS

Toronto EMS commissioned its initial hybrid ambulances in June 2018. Ten (10) additional hybrid ambulances were commissioned in November-December 2018. Toronto EMS now operates with 12 such vehicles. The technology is installed on gas-powered Crestline New Era Type 3 ambulances manufactured with a Chev Express 3500 chassis featuring a 6.0 litre engine and relatively short 139" wheelbase.

Because of their relatively short experience with the hybrid ambulance (i.e., 6 months), Toronto EMS is currently unable to share any hard data on vehicle performance. Albeit, Toronto EMS anticipates savings of about 25% in fuel consumption (per Oxford County and York Region) and zero adverse impact on OEM systems.

8.4 Lifecycle Cost Implications

We are advised that the cost to outfit a Type 3 ambulance with the XL3 Hybrid technology is about $30,000 (Can).

We examined the lifecycle cost implication of outfitting an ambulance with hybrid technology, using for illustrative purposes, the metrics shown previously in Exhibit 7.3 (i.e., the metrics for Ontario EMS peers).

More specifically, for illustrative purposes we used the metrics associated with the gas-powered Ford E350 ambulance.

The Ford E350 ambulance consumes gasoline fuel at an average cost of $0.36 per kilometre. Travelling an average of 46,400 kilometres a year, the cost to fuel one Ford E350 ambulance for a span of a year, is about $16,700.

If hybrid technology reduces gas consumption by 25% as attested to by XL Hybrid (also Oxford County and York Region), then the cost to fuel a Ford E350 ambulance over a span of a year, decreases to $12,500, for an annual savings of $4,200 a year.

Over a 5 to 6-year lifecycle, the fuel-related cost savings due to hybrid technology, would be between $21,000 and $25,000, thereby offsetting the initial $30,000 capital outlay by up to 83%.

If these metrics and assumptions are representative of standard gasoline-powered fleets, then one may conclude following. Outfitting a gasoline-powered ambulance with hybrid technology will increase the overall lifecycle cost of that ambulance by a net of $5,000 to $9,000. Many would argue that this is a reasonable expenditure, by which to attain a cleaner, greener vehicle. We do not disagree.

This conclusion notwithstanding, Niagara Region which uses a diesel-powered Mercedes Sprinter equipped with an ultra-low diesel-emissions system, achieves the same objectives – a highly fuel-efficient, cleaner, greener vehicle. Moreover, Niagara accomplishes these objectives at a lower cost, as demonstrated previously in Section 7.3 of this report.

Appendix A – Contributors of Information to this Review

Appendix A: Contributors of Information to this Review

General

- Demers Ambulances, Beloeil, Quebec *[conversion manufacturer of the diesel-powered MX152A Type 3 ambulance used by Niagara Region]*
- Brock Ford *[Niagara-based dealership that services Niagara's ambulances]*
- XL Fleet, Boston, Massachusetts *[manufacturer of the XL3 Hybrid electric drive train system]*

EMS Peers that Use the Mercedes Sprinter 3500 Ambulance Chassis

- Cranberry Township EMS, Pennsylvania
- CoxHealth EMS, Springfield Missouri
- Renfrew County Paramedic Service, Ontario

EMS Peers that Use Ambulances Built w' Ford & GM Chassis

- Dufferin County Paramedic Service
- Durham Region Paramedic Service
- Essex-Windsor EMS
- Frontenac Paramedic Services
- Guelph Wellington Paramedic Service
- Haldimand Paramedic Service
- Halton Region Paramedic Service
- Hamilton Paramedic Service
- Hastings-Quinte Paramedic Services
- Huron County Paramedic Services
- Middlesex-London EMS
- Muskoka Paramedic Service
- Norfolk County Paramedic Service
- Ottawa Paramedic Service
- Oxford County Paramedic Service
- Parry Sound EMS
- Peel Regional Paramedic Service
- Sault Ste. Marie Land Ambulance Service
- Simcoe County Paramedic Service
- Thunder Bay EMS
- Toronto EMS
- Waterloo Regional Paramedic Service
- York Region Paramedic Service