Snow Vehicles Proof of Value

T4G 's Exploratory Modelling Proposal for City of Saint John

October 22, 2018 / Version 2.0

Contact: Danielle Leighton

Danielle.Leighton@T4G.com / 506.382.0522 x3070

T4G Limited, Saint John

TORONTO   HALIFAX   VANCOUVER   SAINT JOHN   MONCTON

Table of Contents

The Challenge

Maximize productive vehicle time given salt levels, cutting edge state, expected vehicle performance, obstructions and route priorities.

The City of Saint John invested in autonomous vehicle location (AVL) sensor arrays, installed on their fleet of snow plows and salter vehicles. A subset of these vehicles were collecting data during the 2017-2018 winter season, with the remainder ready to collect data over the 2018-2019 winter season. At a high level, optimizing productive vehicle time is a critical consideration for the city, with the dual goals of serving the city's snow clearing commitments as quickly and thoroughly as possible while streamlining costs.

One notable opportunity in the current snow clearing process occurs when plows are unable to continue a route due to either being out of salt or the cutting edge of their blade being too dull. Both require a return trip to a depot for refill or replacement, and depending on route and timing, can mean substantial non-productive time. Another opportunity to optimize the process occurs when vehicles are unexpectedly broken down and require repair or are non-operational entirely.

Work Approach and Deliverables

We propose to address this challenge by engaging our team to explore the AVL and route planning data to address two potential influence points identified in the Discovery Workshop with the City of Saint John and Enterprise Saint John teams in July, 2018. Two of those influence points involve determining if we can predict salt levels or cutting edge state with enough lead time to influence the route in progress. Another involves predicting vehicle breakdown with enough lead time to redirect other plows to optimize route coverage. The output of this engagement will be exploratory models, analysis, and an assessment for two of the influence points chosen: the salt levels predictions or the cutting edge state predictions impact on route in progress or the vehicle breakdown impact on other vehicle's priority routes. The intention is that with this impact assessment in place, the City of Saint John will be able to set criteria for real-world experiments to validate the improvement in productive time, providing proper business case data for an integrated artificial intelligence or machine learning pilot and eventual full deployment.

The Data

In addition to the AVL historical data collected over the 2017-2018 winter season by the subset of vehicles fitted with sensor arrays, we will be analyzing route planning data and any historical management records created during snow events.

The Influence Point Success Criteria

The three main influence points we are able to consider through this engagement are maximizing productive time through: identifying low salt level early enough to adjust the route, identifying cutting edge dulling early enough to adjust the route, or predicting vehicle failure with enough lead time to adapt other vehicle's routes.

The City of Saint John intuits that 10 minutes in advance of no salt or cutting edge replacement will be enough time to adjust the route in progress to maximize productive driving time. We extend that intuition to be true for adjusting other vehicles mid-route to cover unexpected gaps in route coverage. Our first task in this engagement is to verify this intuition, using the city's route prioritization plan and the AVL data to understand typical driving times for the routes.

With this lead time requirement set, success criteria for the low salt prediction can be defined. We anticipate using the brine levels (currently measured in the truck) as a proxy marker for salt levels and verifying this proxy will work within a defined margin of error will be our first goal. With that proxy verified, the prediction of no salt will be made with a strong bias toward predicting running out of salt earlier rather than later. Additionally, a precision on the prediction (the 'plus or minus') will be determined and added to any error given by the proxy.

Success criteria for cutting edge replacement will be determined with a focus on precision. Implementing a solution around cutting edge replacement will require route optimization between two vehicles and will be a critical next step in the following validation pilot.

Multiple vehicles are also impacted in any solution for adjusting routes for a vehicle breakdown, so success criteria will also be focused on precision of the prediction of failure. Implementation solutions will need to access multiple vehicle's routes in progress to able to optimize for appropriate coverage.

Deliverables

Selection	The priority of the project team will be to work with the City of Saint John SME's to determine priority of the influence points, and to select one for investigation in the exploratory modelling phase.
	• **Deliverables:** Analysis to determine feasibility; Project team and City of Saint John SME Workshop to determine priority
Exploratory Modelling	Once an influence point is selected, the priority of the data science team will be to define accuracy measures to create a deeper understanding of the criteria for success. Subsequently, the team has two objectives: to explore and analyze the historical data, and assess their utility in the model prediction service, and to create exploratory models given the determined success criteria.
	• **Deliverables:** Exploratory analysis and initial exploratory model

Project Team and Roles

Name	Role	Responsibility
Jeff Hussey	CSJ Project Sponsor	Executive Sponsor
Danielle Leighton	T4G Sponsor	Executive Sponsor
Jim Lafferty	T4G Project Manager	Project delivery, management of scope, timeline and budget
Bill Neal	CSJ Data Analyst	Subject matter expertise; data steward
TBD	T4G Data Science Team	Responsible for selection workshop, success criteria, exploratory modelling and demonstrations
TBD	ESJ Data Engineer	Ingest of data into ESJ Azure data lake

Proposed Timeline

T4G is positioned to begin this engagement on October 26, 2018.

The following chart indicates the relative milestones of activities and an approximate level of effort required:

Milestone	Approximate Effort Timing from Start
Selection Workshop	1 week from start
Success Criteria Definition	2 weeks from start
Exploratory Modelling	3 weeks from start
Final Demonstration	6 weeks from start

Work Effort and Payment Schedule

Work Effort	Cost
Selection & Success Criteria Definition	$15,000
Exploratory Modelling	$25,000
Test/Demonstrations	$10,000
Total	**$50,000**
Multiple joint-partner funding investment model	
T4G Limited	$15,000
Microsoft	$10,000
ESJ	$25,000
Total	**$50,000**

Pricing Notes

- The City of Saint John will pay invoices to T4G in the amount of $33,350 as the project progresses. The City will then apply to Enterprise Saint John for reimbursement of 75% of this up to $25,000 as part of the project. Once the City of Saint John signs off on the project per the Microsoft funding and it is released, T4G will reimburse the City of Saint John $8,350.
- Does not include any costs related to the purchase of Enterprise licenses, or environment maintenance fees or access costs
- This is a fixed price quotation based on the information we have at this time.
- Any out of scope changes will be estimated as they arise and a Change Request outlining the additional effort will be issued.
- Unless otherwise noted, the prices included in this document are quoted in CAD dollars.
- All fees included in this document are exclusive of and subject to applicable taxes.

Payment Schedule

Milestone	Estimated Date	Payable on Event
Sign off on SOW	October 31, 2018	30%
Completion of Selection & Success Criteria Definition	November 23, 2018	10%

Second Demonstration (Exploratory modelling)	December 7, 2018	20%
Final Demonstration	December 21, 2018	40%
	Total	**100%**

Assumptions and Constraints

- No streaming data pipelines from vehicle location data or weather updates

- Vehicle location data and status (plow and salt/sander status) access will be provided

  - Initial pilot will be street vehicles only, no sidewalk vehicles and no ministry of transport highway vehicles

- Saint John Street Plow Routes data exists in a geo format today

- No production environment is assumed, and exploratory models are not production ready

- The City of Saint John will sign off on Microsoft POE (Proof of Execution) at the end of this project in order to release the $10,000 contribution from Microsoft

Future Phases

Should the exploratory model support the success criteria determined, the next phase is to design a pilot, with appropriate implementation and validation (testing) cycles.

If the influence point selected does not have a modelling option that meets the defined success criteria, the next phase will be an exploratory phase for the next influence point in the backlog.

Sign Off Information

By signing below, the City of Saint John and T4G agree to abide by the Terms and Conditions in Appendix A.

City Of Saint John   **T4G Limited**

Signature: _____   Signature: _____

Printed
Name: _____   Printed
Name: _____

Title: _____   Title: _____

Date: _____   Date: _____

Appendix A - Terms and Conditions

1. Payments

a) After commencing work on the SOW T4G will invoice City of Saint John twice per month for services rendered and reasonable out of pocket expenses. The invoices will cover the periods from the 1st to the 15th of the month, and from the 16th to the end of the month. T4G shall provide monthly progress reports to City of Saint John indicating the progress of the SOW and a description of the work remaining to be completed.

b) For Time and Material projects, each invoice shall indicate the name(s) of the personnel and/or associates involved the number of hours worked by each, and any disbursements reasonably incurred and properly documented. In respect of any disbursements exceeding $250, City of Saint John reserves the right to require that a copy of the invoice substantiating the disbursement be attached to T4G's invoice.

c) All invoiced amounts shall be due upon receipt of invoice. Overdue amounts shall be subject to interest at the rate of 1.5% per month or 18% per annum.

d) Fees stated in the SOW may not include goods and services tax, duties or other similar taxes. If T4G is required to pay any such taxes (other than income taxes) based on services provided in the SOW, such taxes will be billed to City of Saint John and City of Saint John agrees to pay such additional amounts.

2. Warranty

a) T4G warrants that the services performed under this SOW will be performed using reasonable skill and care.

b) THE WARRANTY ABOVE IS EXCLUSIVE AND IS IN LIEU OF ALL OTHER WARRANTIES AND REPRESENTATIONS, EXPRESS, IMPLIED, STATUTORY OR OTHERWISE WITH RESPECT TO THE SERVICES OR PRODUCTS PROVIDED UNDER THIS SOW, THE PERFORMANCE OF MATERIALS OR PROCESSES DEVELOPED OR PROVIDED UNDER THIS SOW OR AS TO THE RESULTS WHICH MAY BE OBTAINED THEREFROM INCLUDING WITHOUT LIMITATION, ALL IMPLIED WARRANTIES AND CONDITIONS OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

3. Limitation of Liability

a) In no event shall T4G's liability to City of Saint John in connection with this SOW or with respect to the services or materials provided pursuant to such SOW exceed the amount actually paid by the City of Saint John to T4G for this specific SOW.

b) IN NO EVENT SHALL T4G BE LIABLE TO City of Saint John FOR ANY INCIDENTAL, SPECIAL, CONSEQUENTIAL, INDIRECT, PUNITIVE OR ECONOMIC DAMAGES (INCLUDING BUT NOT LIMITED TO LOST PROFITS AND ANTICIPATED SAVINGS OR OTHER COMMERCIAL OR ECONOMIC LOSS OF ANY KIND WHATSOEVER), REGARDLESS OF WHETHER SUCH LIABILITY IS BASED ON BREACH OF

CONTRACT, TORT, STRICT LIABILITY, BREACH OF WARRANTIES, FAILURE OF ESSENTIAL PURPOSE OR OTHERWISE AND EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

4. Rights in Programs and Data

a) Any copyright and any other intellectual property (including moral rights) in any computer program, code or any materials owned by T4G or its affiliates independently of this Statement of Work ("SOW") which may be provided to City of Saint John pursuant to this SOW ("T4G Pre-Existing Works"), any enhancement, modification, adaptation or improvement to any T4G Pre-Existing Works provided to City of Saint John pursuant to this SOW ("T4G Pre-Existing Work Enhancements"), and/or any computer program, code or any materials that are developed in the performance of this SOW but which are not part of the Deliverables ("T4G Works") shall remain the sole property of T4G and its affiliates. T4G hereby grants City of Saint John a non-exclusive, perpetual, royalty free right to use, reproduce, modify and distribute any T4G Pre-Existing Works, T4G Pre-Existing Work Enhancements and T4G Works owned by T4G and, unless notified otherwise, owned by its affiliates.

b) Any copyright and any other intellectual property (including moral rights) in any computer program, code or materials other than T4G Pre-Existing Works, T4G Pre-Existing Work Enhancements and T4G Works which are developed by T4G at the specific direction of City of Saint John and provided to City of Saint John in the course of T4G's performance of this SOW ("Specific Works") shall be jointly owned by the City of Saint John and T4G (or T4G's assignee). Each party hereby grants the other party a non-exclusive, perpetual, royalty free right to use, reproduce, modify, resell and distribute any Specific Works.

c) Any and all publications by City of Saint John of any T4G Pre-Existing Works, T4G Pre-Existing Work Enhancements, T4G Works and Specific Works must contain the applicable copyright notice, as specified by T4G or its assignee.

5. Currency

Unless specifically indicated otherwise, all references to monetary amounts in this SOW are in USD.

6. Governing Law

This SOW will be governed by and construed in accordance with the laws of the Province of Ontario and the laws of Canada applicable therein.

7. Confidentiality Obligations of T4G and City of Saint John

a) **Maintaining Confidential Information.** Each of T4G and City of Saint John (which for purposes of this Section shall include their respective officers, directors, employees and agents) understands and agrees that during the course of the SOW, it may obtain confidential

information of the other party and its affiliates including, without limitation, information relating to computer programs, designs, processes, methods, data, developmental or experimental work, whether of a commercial or technical nature, employee work history, products, trade secrets or techniques, customer and supplier lists, pricing, costing, advertising, marketing and any other information relating to the business and affairs of the other party and its affiliates ("Confidential Information"). Each party acknowledges the valuable nature of Confidential Information of the other party and covenants and agrees to hold and maintain in strict confidence, and protect such Confidential Information against the direct or indirect unauthorized disclosure to any other firm, person or corporation and agrees that it shall not use, disclose, reproduce or dispose of Confidential Information of the other party for its own benefit or for the benefit of any other firm, person or corporation. Without limiting a party's rights with respect to any directors, officers, employees or agents of the other party, each party shall be responsible for any breach of this Section 7 by any such person.

b) **Non-confidential Information**. The confidentiality obligations of either party with respect to the Confidential Information set forth in Section 7a) above shall not apply to any Specific Confidential Information received from the other party which:

   (i) is or becomes publicly known or within the public domain other than through a breach by the receiving party;

   (ii) was known to the receiving party prior to its receipt thereof from the disclosing party;

   (iii) was rightfully received or obtained by the receiving party from a third party without an obligation of confidence to the disclosing party;

   (iv) was disclosed without similar restrictions to a third party by the disclosing party;

   (v) was approved for release by written authorization of the disclosing party; or

   (vi) is required to be disclosed pursuant to a governmental agency or law so long as the receiving party provides the disclosing party with reasonable notice of such requirement prior to any such disclosure.

c) **Remedies**. Each party recognizes that if it improperly uses or discloses the Confidential Information of the other party, such party may suffer significant irreparable injury, inadequately compensable in damages and that, accordingly, such party shall be entitled to an injunction restraining any breach of the undertakings described in Section (a) above in addition to any other remedies provided by law.

d) **Survival**. It is expressly agreed by each of T4G and City of Saint John that their respective obligations set out in Section 7 a) shall survive the performance of any SOW, or any termination, discharge or cancellation thereof.

8. Media Releases

Each party agrees that it shall not, without the prior written consent of the other party, announce, market, advertise or promote, discuss or reveal any aspect of this SOW to any person.

As an exception to the above, the City of Saint John acknowledges and agrees that T4G is authorized to:

a) Represent City of Saint John 's name and corporate logo in printed format as part of T4G's customer list.
b) Develop a case study and/or customer success story featuring the activities between City of Saint John and T4G.
c) Promote City of Saint John 's use of T4G's services on the web sites of T4G and its affiliated companies.

9. Non-Solicitation

During the term of this SOW and for a period of one (1) year following the date of early termination or expiration of this SOW, neither T4G nor City of Saint John shall directly solicit for employment any contractor or employee of the other who is directly or indirectly involved in the performance of this SOW. For greater certainty, a general advertisement for a position will not be deemed solicitation.