



Fixed Assets in the Montreal Metro: a Real- Time Process

Présenté par : Pascal Dubois, Engineer CPM-IS
Alejandro Agudelo, Analyst, CPM-IS
Société de transport de Montréal



Agenda

- Introduction to STM
- Metro overview and Command Center
- Project OPALE
- PI System architecture
- Security considerations
- Integration approach for fixed assets
- Escalator monitoring
- Other use cases
- Future projects
- Improvement suggestions
- Conclusion



STM Overview

Société de Transport de Montréal

- Public company – Operator of the public transit system in Montreal: Metro and Bus services. Operates 4 underground train lines, totalizing 68 stations, 220 bus lines and 1771 busses
- 2nd largest urban transit network in Canada, after Toronto Transit Commission
- Montreal Metro is the largest in Canada in terms of passenger traffic, and 3rd in North America in terms of daily passengers, after New York and Mexico
- En 2016, 416,2 millions passenger-trips

STM Overview

Société de transport de Montréal

- In 2016
 - Annual budget: 1.4 B\$
 - Number of employees: 9 298
 - Asset maintenance deficit: 3,9 B\$
 - GHG avoided in Montreal: 3,9 Mt
- Date of inception: 2002 (replaced former STCUM)
- Origins dating as far as 1861 with the Montreal City Passenger Railway company

Metro Critical Assets

- **Railcars** → MR-63, MR-73, MPM-10
- **Rails and tires** → Test Zones, CDV
- **Train control** → Switching monitoring
- **Power supply** → 750Vdc (traction), HQ 12,5KV - 25KKV → DHT, PR, PSD, UPS, etc. → 315M KWh/year
- **Ventilation** → PVM, PVN
- **Fixes assets** → Escalators, Elevators, HVAC, pumps, lighting
- **Safety** → Fire, video, intrusion
- **IT/OT** → SCADA, servers, displays in station
- **Telecom** → Networking, radio, intercom, phone

Railcars Evolution

MR-63, MPM-10, MR-73



Command Center

Until 2012



Today



OPALE Project Description

(Optimisation des Processus et Activités à L'Entretien)

- OPALE project objective was to increase the level of control over fixed asset maintenance
- Software application at the Command Center were not fit for the maintenance team needs
- Project deliverables:
 - New maintenance process and procedures
 - SAP-PM
 - Data infrastructure

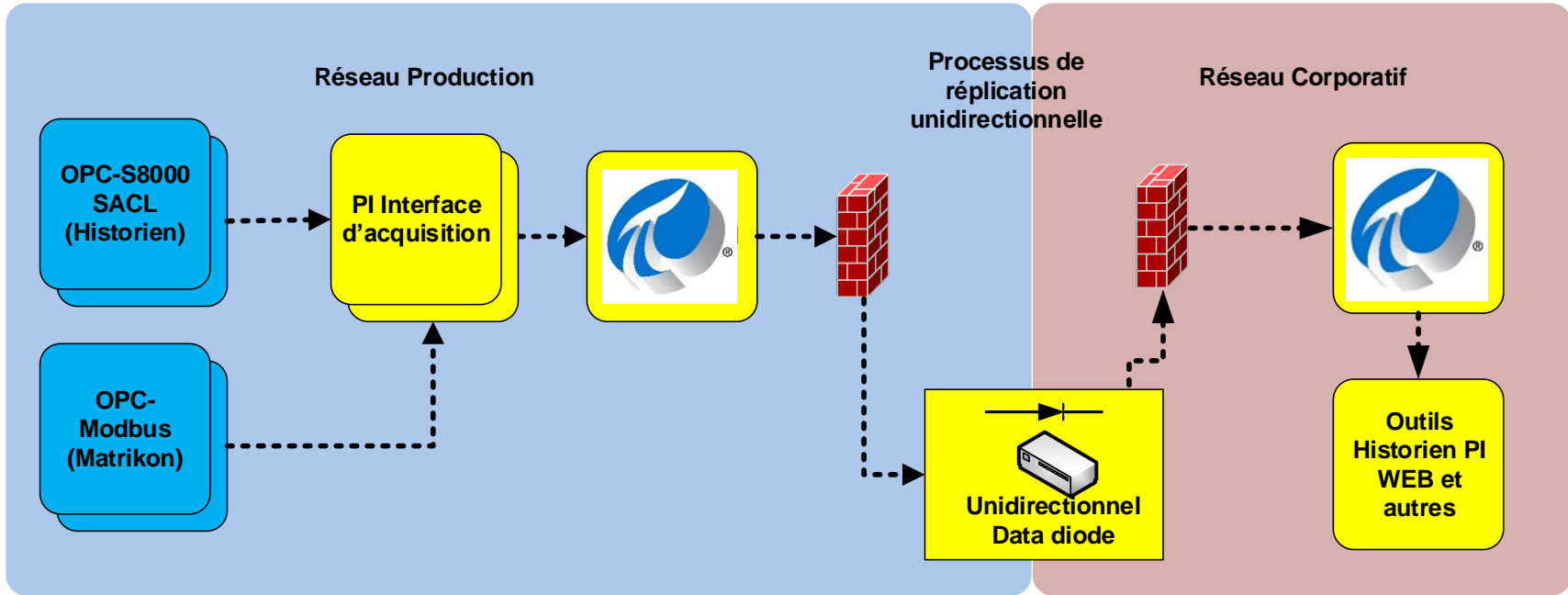
OPALE Project Description

Context



- No data collected by Maintenance on fixed equipment
- Restricted access to fixed assets status and alarm management
- Hard to generate reports and KPIs
- Difficult to diagnose field equipment issues
- No visibility on real-time process, other than through Command Center
- Command Center is not designed for flexibility needed by maintenance

PI System Architecture



Architecture is not fully HA , but is built for robustness and stability.

Level of Security

Data transfer from Production to Corporate network

- Data Diode → utmost security
- Provider: Waterfall → single fiber allows data transfer only From production network To corporate network
- Light **transmitting** diode on (Production) and light **receiving** diode (Corporate) physically isolates networks



Fixed Assets Integration Approach

Key Points:

- Define data access → OPC-S8000 / OPC-Modbus-TCP
 - Look for quick wins and low risk
- Pick an equipment type with high potential for improvement
 - Customer experience → escalators
- Find a sponsor who is motivated to make improvements
- Get experts' help (OSIsoft– Keops)
- Roll-out End to End for this asset before moving to the next
 - PI Tags, Data diode, PI AF, PI Vision, PI ProcessBook, SSRS

Fixed Assets Integration Approach

Challenges:

- Convince internal teams NOT to code a solution
- Display data in real-time, not part of the culture
- IT infrastructure integration – multi disciplinary team
- Corporate network integration
 - Doubts and Concerns
- Data acquisition
 - OPC-S8000 configuration change over time
 - Matrikon → VM performance
- PI ProcessBook, PI ActiveView displays vs PI Vision
 - Initially got some display problems... moved to PI Vision

Maintenance Visibility on Escalators

Asset Health

COMPANY and GOAL

STM's Entretien Équipements Fixes (EÉF) department oversees maintenance of 298 escalators for the Métro. Seeking customer experience improvement, maintenance wanted fleet-wide real-time data access to escalators health.



Good customer experience is related to asset health



CHALLENGE

Data is not accessible.
Time to answer does not meet maintenance needs.
Range and types of assets, various acquisition methods.

SOLUTION

Using Matrikon, and PI Interface for OPC DA gives us a new path to acquire data from the Command Center.

- “EÉF can now see the escalators fleet status in real-time from their desk as they are added to the network.

RESULTS

Quicker time to action in station leads to improved customer experience.

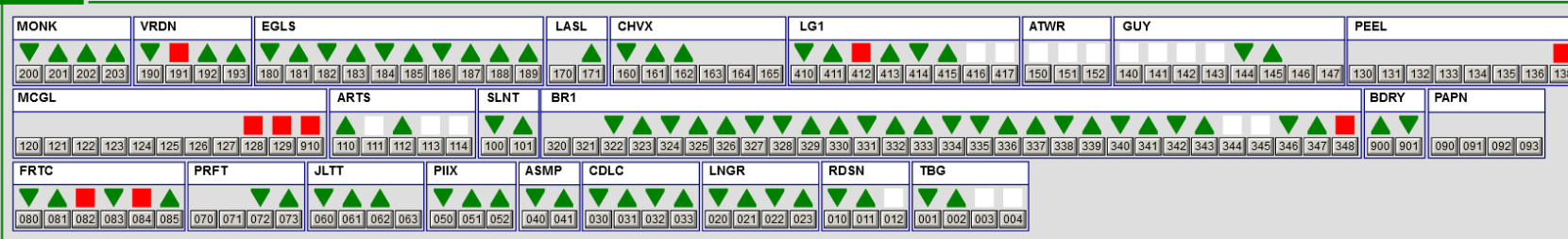
- Ability to remotely detect an anomaly.
- Determine whether a mechanic intervention is required.

Escalators Fleet-Wide Monitoring

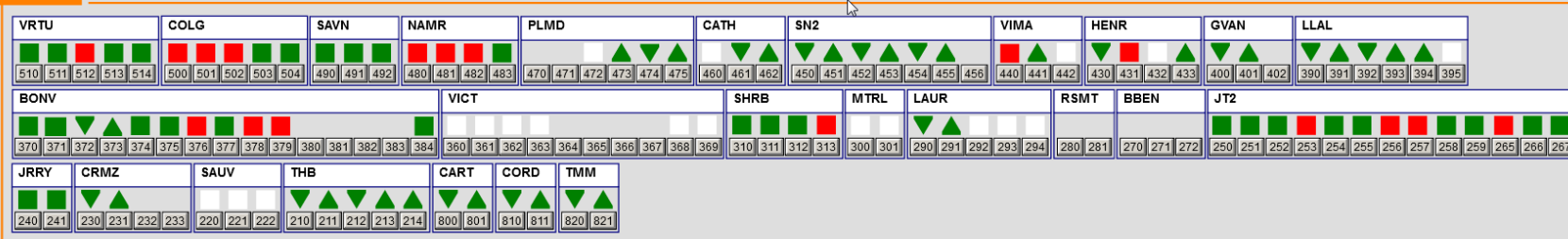
ESCALIERS MECANIQUES

2017-10-11 21:44:34

LIGNE 1



LIGNE 2



LIGNE 5



Légende: Perte terrain; En problème; En fonction;

Escalators Fleet-Wide Monitoring

Details display – Escalators



ESCALIERS MECANIKES

2017-10-12 07:56:58

Ligne: 1
Station: BDRY

Escalier: L1900
Modèle: CNIM2

Statut:



NOMINAL

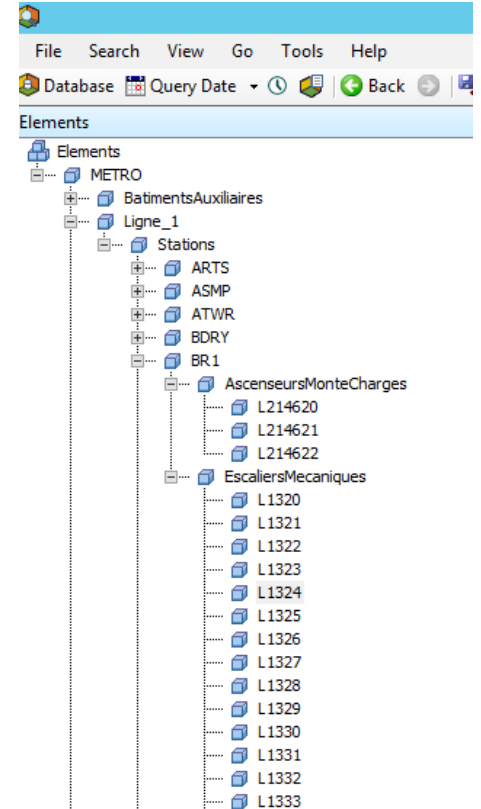
RETOUR

Arrêt et verrouillage 1348-CM0303-EM-GEN-GEN-11900-EMAC		Affaissement de marche 1348-CM0303-EM-GEN-GEN-11900-EMAM		Frein Électronique 1348-CM0303-EM-GEN-GEN-11900-EMFE		Usure garniture frein de service 1348-CM0303-EM-GEN-GEN-11900-EMGS	
Arrêt par la fosse ou la balustrade 1348-CM0303-EM-GEN-GEN-11900-EMAF		Arrêt automatique 1348-CM0303-EM-GEN-GEN-11900-EMAA		Levée frein service 1348-CM0303-EM-GEN-GEN-11900-EMFS		Variateur de fréquence 1348-CM0303-EM-GEN-GEN-11900-EMVF	
Arrêt sans verrouillage 1348-CM0303-EM-GEN-GEN-11900-EMAN		Arrêt baladeuse 1348-CM0303-EM-GEN-GEN-11900-EMAB		Levée frein d'urgence 1348-CM0303-EM-GEN-GEN-11900-EMFU		Vitesse Escalier 1348-CM0303-EM-GEN-GEN-11900-EMVE	
Pompe lubrification basse pression 1348-CM0303-EM-GEN-GEN-11900-EMBP		Arrêt corde, panneau 1348-CM0303-EM-GEN-GEN-11900-EMAP		Levée de marche & Recul de plaque peigne 1348-CM0303-EM-GEN-GEN-11900-EMFP		Vitesse main courante droite 1348-CM0303-EM-GEN-GEN-11900-EMVD	
Vitesse veille non fonctionnelle 1348-CM0303-EM-GEN-GEN-11900-EMVND		A.S.I. Alimentation 1348-CM0303-EM-GEN-GEN-11900-EMAI		Main courante dérapée 1348-CM0303-EM-GEN-GEN-11900-EMMD		Vitesse main courante gauche 1348-CM0303-EM-GEN-GEN-11900-EMVG	
Validation terrain Testé en RS1		Bas niveau d'huile lubrification 1348-CM0303-EM-GEN-GEN-11900-EMNL		Peigne soulevé 1348-CM0303-EM-GEN-GEN-11900-EMPS			
		Bas niveau d'huile réducteur de vitesse 1348-CM0303-EM-GEN-GEN-11900-EMRV		Perte alimentation 1348-CM0303-EM-GEN-GEN-11900-EMPA			
		Cache volant moteur 1348-CM0303-EM-GEN-GEN-11900-EMCV		Plinthe déplacée 1348-CM0303-EM-GEN-GEN-11900-EMPD			
		Chaîne de marche brisée 1348-CM0303-EM-GEN-GEN-11900-EMMB		Plot de blocage chaîne de marche 1348-CM0303-EM-GEN-GEN-11900-EMMB			
		Chaîne principale brisée 1348-CM0303-EM-GEN-GEN-11900-EMMP		Présence de marche 1348-CM0303-EM-GEN-GEN-11900-EMPM			
		Changement de mode de fonctionnement 1348-CM0303-EM-GEN-GEN-11900-EMMF		Relais chaîne de sécurités 1348-CM0303-EM-GEN-GEN-11900-EMCS			
		Clé bloquée 1348-CM0303-EM-GEN-GEN-11900-EMCB		Surcharge moteur 1348-CM0303-EM-GEN-GEN-11900-EMSM			
		Clé bloquée avec bouton d'arrêt 1348-CM0303-EM-GEN-GEN-11900-EMMB		Tension main courante 1348-CM0303-EM-GEN-GEN-11900-EMTM			
		Baladeuse ou A.S.I. communication 1348-CM0303-EM-GEN-GEN-11900-EMAS		Trappe caisson fosse 1348-CM0303-EM-GEN-GEN-11900-EMTF			
		Contacteur principal 1348-CM0303-EM-GEN-GEN-11900-EMCP		Twido M.C. Vitesse Défaut 1348-CM0303-EM-GEN-GEN-11900-EMTV			
		Entrée main courante 1348-CM0303-EM-GEN-GEN-11900-EMEM		Twido Tapis ou communications 1348-CM0303-EM-GEN-GEN-11900-EMTC			

Escalators Fleet-Wide Monitoring

Location-based and Occupation-based AF structures

- Metro
 - Auxiliary buildings
 - Metro line
 - Station
 - Fixed Assets
- Business Unit (references)
 - Escalator Mechanic
 - Fixed Assets



Escalators Fleet-Wide Monitoring

Sample alarms report

SQL Server Reporting Services

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Ligne Station Sévérité

⏪ < of 1 > ⏩ ↺ ↻ ⏴ ⏵ Find | Next

ALARMES ACTIVES

Nombre d'alarmes: 28

Ligne	Station	Escalier	Message	Severite	Start Time	Acked By	
2	VIMA	L1440	Escalier en arrêt et verrouillé	100	2017-10-12 08:12:42		DETAILS
1	BR1	L1337	Etat de l'escalier indéterminé	100	2017-10-12 08:09:40		DETAILS
1	LG1	L1415	Escalier en arrêt et verrouillé	100	2017-10-12 08:04:07		DETAILS
1	BDRY	L1901	Escalier en arrêt et verrouillé	100	2017-10-12 07:55:14		DETAILS
1	CDLC	L1024	Escalier en arrêt et verrouillé	100	2017-10-12 07:43:58		DETAILS

Escalators Fleet-Wide Monitoring

SSRS Report (Proof of Concept)

État des escaliers mécaniques

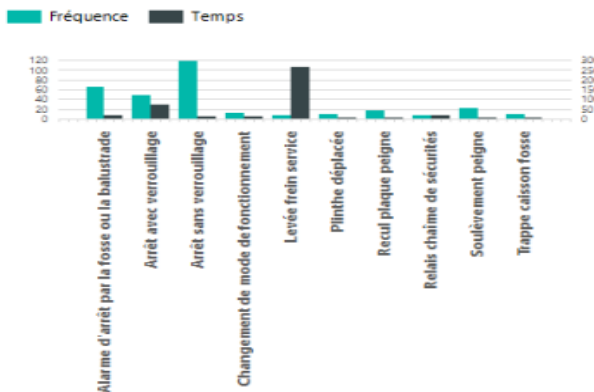
Date de début : 2017-10-11 00:00:00

Modèle: CNIM1

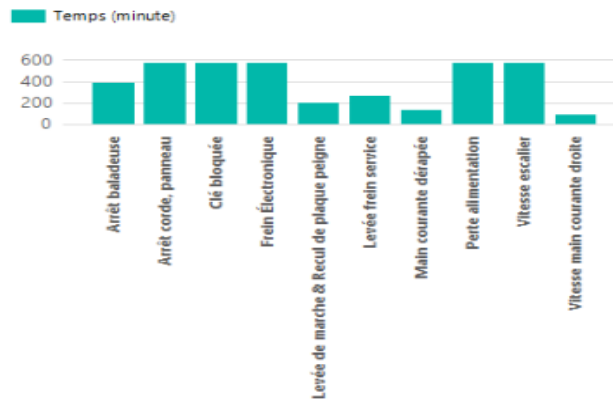
Date de fin : 2017-10-12 00:00:00

	Objectif annuel	Période rapport	année
Taux disponibilité global (%)	90	85	93
Temps moyen des arrêts (min)	7	32	40
Temps moyen entre les arrêts (min)	960	197	562
Nb moyen d'arrêt par escalier	10	4	540
Nb d'escaliers hors service, plus de 30 minutes	7	20	70

Les 10 causes d'arrêt les plus fréquentes & leur durée moyenne (min)



Les 10 causes d'arrêt avec le temps moyen le plus long (min)



Example – UPS Monitoring



While working on the display, anomalies were detected!! Better off without UPS here as the current frequency is widely unstable!

Name ▲	Description	Value	Units	Trend	Minimum	Maximum	StdDev	Range
1S40-LT0122-BT-UPS-GEN-1.ASFS	Fréquence de sortie	Equip fail			000	000	0	0
1S42-LT0219-BT-UPS-GEN-1.ASFS	Fréquence de sortie	800			800	800	0	0
1S44-LT0123-BT-UPS-GEN-1.ASFS	Fréquence de sortie	599			599	599	0	0
1S46-LT0473-BT-UPS-GEN-1.ASFS	Fréquence de sortie	585			531	604	3,3287	73
1S46-LT0473-BT-UPS-GEN-2.ASFS	Fréquence de sortie	598			527	604	3,379	77
1S48-LT0312-BT-UPS-GEN-1.ASFS	Fréquence de sortie	599			599	599	0	0
1S50-LT0207-BT-UPS-GEN-1.ASFS	Fréquence de sortie	800			800	800	0	0
1S52-LT0412-BT-UPS-GEN-1.ASFS	Fréquence de sortie	801			595	802	0,46275	7
1S54-LT0116-BT-UPS-GEN-1.ASFS	Fréquence de sortie	599			599	599	0	0
1S56-LT0210-BT-UPS-GEN-1.ASFS	Fréquence de sortie	599			599	599	0	0
1S58-LT0234-BT-UPS-GEN-1.ASFS	Fréquence de sortie	800			800	800	0	0
1S60-LT0129-BT-UPS-GEN-1.ASFS	Fréquence de sortie	599			599	599	0	0

Other Types of Fixed Assets

Elevators and Freight Elevators

ASCENSEURS ET MONTE-CHARGES

2017-10-18 07:19:52

LIGNE 1

BR1	LG1
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214620 214621 214622	213210 213211 213212

LIGNE 2

PUBLIC

TMM	CORD	CART	HENR	JT2	RSMT	MARS	ARMS	BONV
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/>
228820 228821 228822	228620 228621 228622	228220 228221 228222	228020 228021 228022 228023	227220 227221 227222	226820 226821 226822	225821 225822	256621 256622	225221 225222
SN2	VRTU							
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>							
223620 223621 223622	222220 222221 222222							

BÂTIMENTS AUXILIAIRES

PDK	CCR	PSN
<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
200420	200471	200080

LIGNE 2

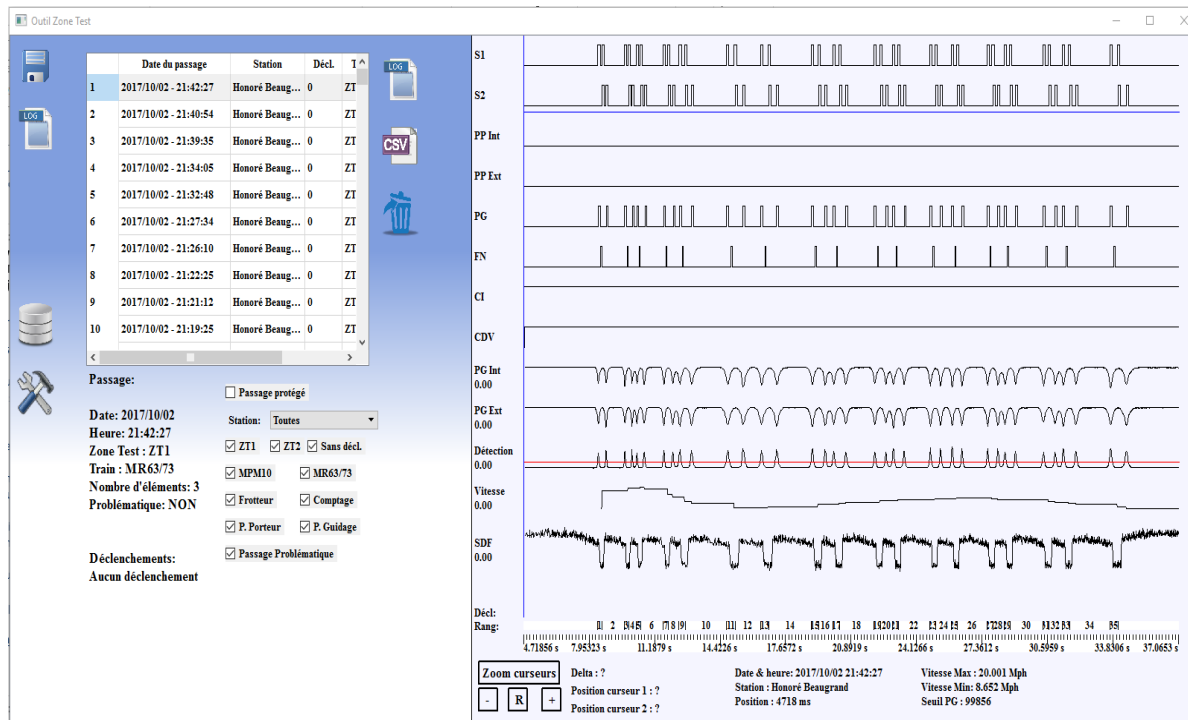
STM

CORD	TMM
<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
200660	200653

Future Projects – Test Zones



Home-grown application to be converted to PI Vision



Test Zones are located at various stations and take measurements on metro tires to ensure physical integrity

Future Projects

- Réno-Systèmes dedicated to fixed assets is a program funded by Ministère des Transports du Québec (MTQ)
- Program objectives:
 - Renew fixed assets → Reliability, maintainability, availability, and security in order to contribute to the overall state of the Métro.
 - Meet owners requirements at lowest costs
 - Optimize and integrate implementations while minimizing impacts on passengers and Métro operator
 - Observe agreed upon parameters with funding partner (MTQ)

Opportunities for leveraging the PI System

Future Initiatives

- Elevators
- Test Zones
- E-Worker
- Ticketing
- KPIs
- MPM10 (new railcars)



Feature Requests



- **PI Vision**
 - PI ProcessBook equivalent functionalities
 - Symbols Collections scalability with large number of similar assets
 - Table symbol customization options in order to highlight exceptions
- **PI Builder**
 - Data compression analysis and optimization tool
- **OSIsoft Cloud Services**
 - Cloud platform offering

Conclusion

- STM will invest large amount of money in the next years to maintain asset health
- STM owns assets which are analogous to industrial plants:
 - Leverage industry best practices
 - Do not reinvent the wheel or create home-grown solution

Orientations:

- Speed-up integration of additional fixed assets
- Limit Command Center to operations needs
- Align STM maintenance teams over leveraging the PI System

STM believes that the PI System can play an important role with:

- Asset maintenance
- Optimisation
- Ease of integration
- Data access

Pascal Dubois

pascal.dubois2@stm.info

Engineer,
STM

Alejandro Agudelo

alejandro.agudelo@stm.info

Analyst, Systems
Development, STM

감사합니다

Danke

谢谢

Thank You

Gracias

Merci

ありがとう

Спасибо

Obrigado