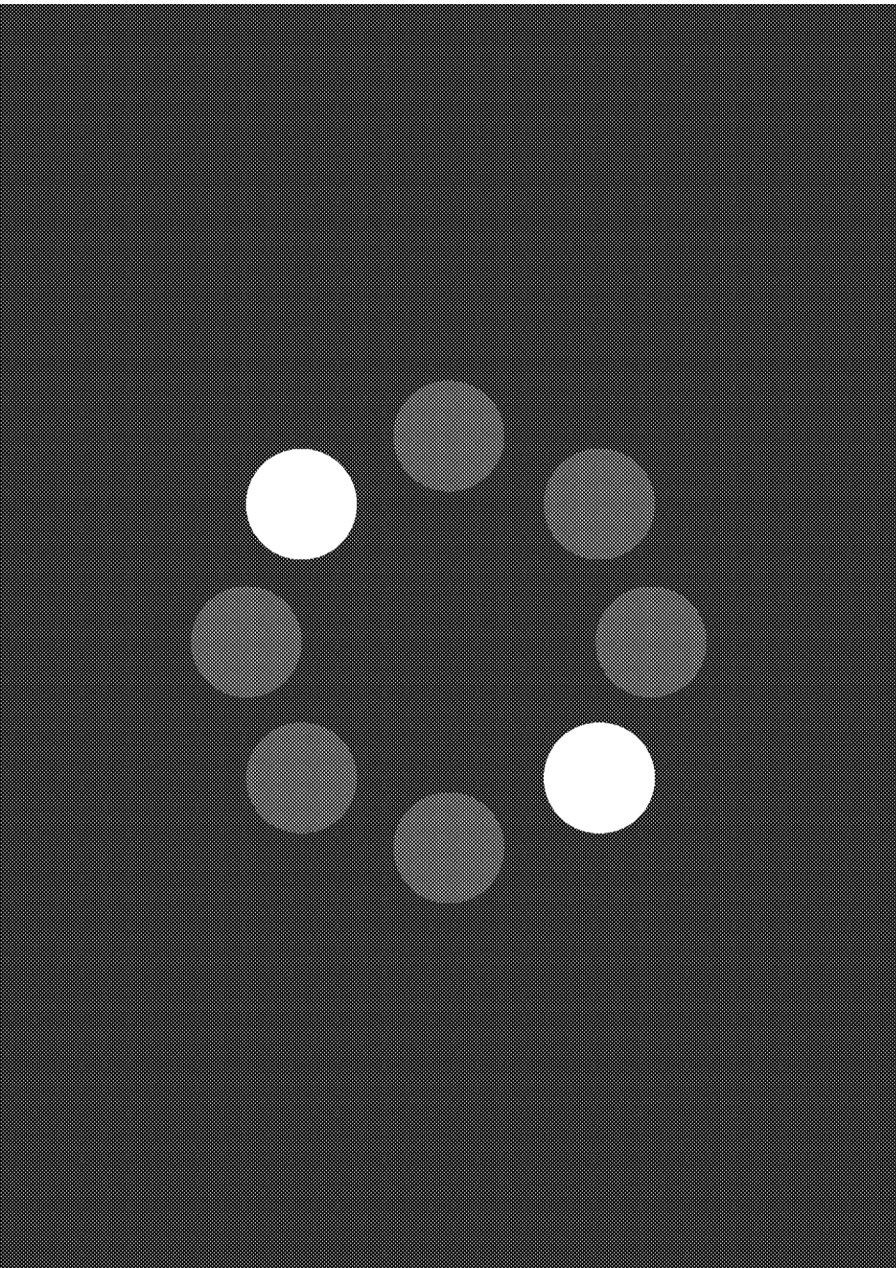


# OTT LRT Axle Spline Connection

6/30/2021

**ALSTOM**  
• mobility by nature •





- 
1. Spline wear problem overview
  2. V5 fleet status
  3. T20 axle solution
  4. Ottawa retrofit planification



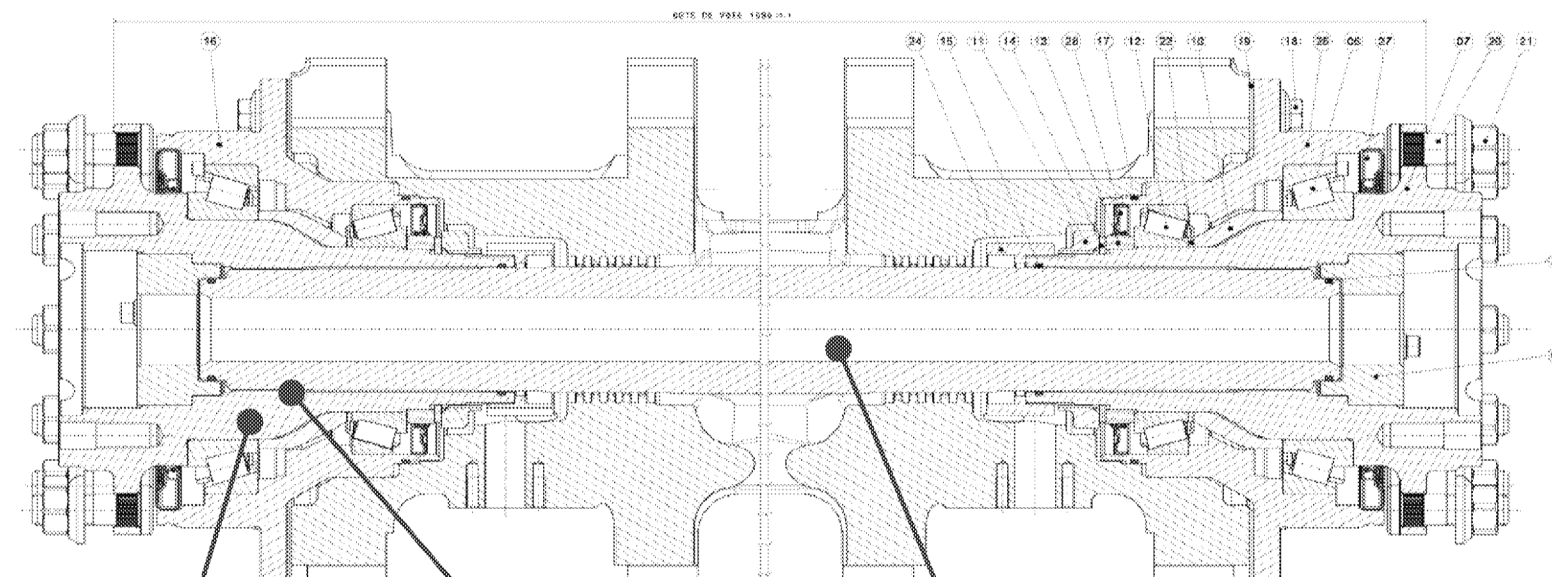
# 01

## Spline Wear Problem Overview

# Spline wear problem overview

**Axle assembly- Supplier TEXELIS**

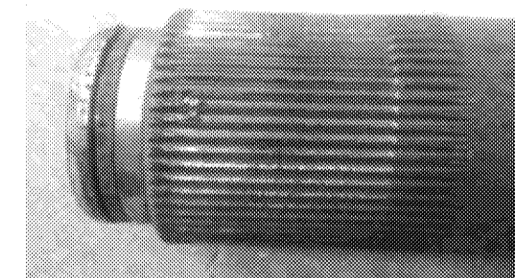
**Ixege / Iponam type bogies**



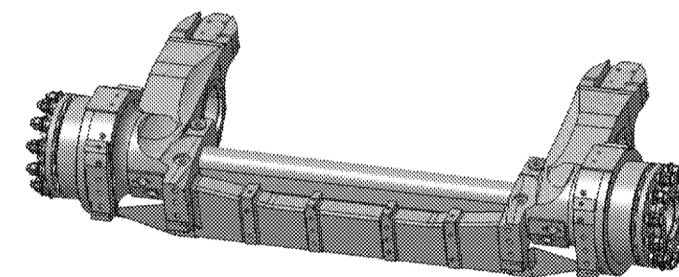
**Hub**

**Splines**

**Torque Shaft**



Wear of the splines leading to excessive play between the hubs and the torque shaft and ultimately failure of the splines and loss of drive between the two wheels.



**2 axle assemblies/ bogie**



# Spline wear problem overview

## *Safety Analysis*

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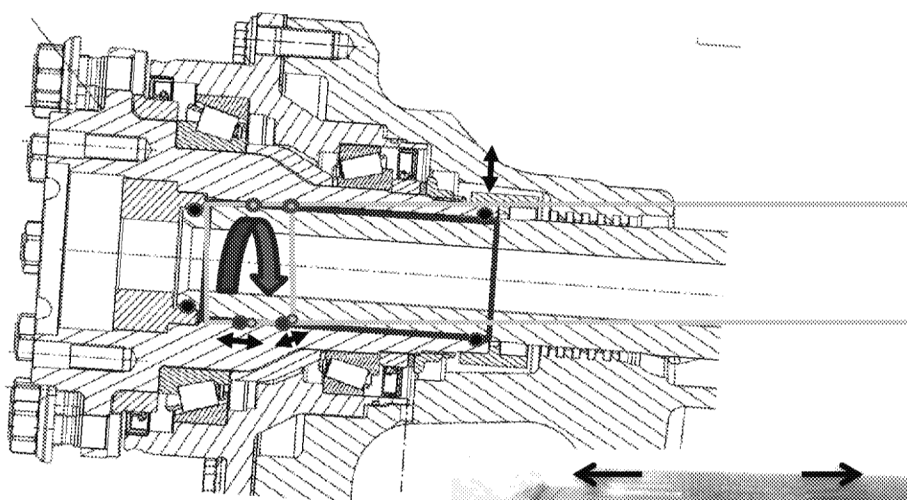
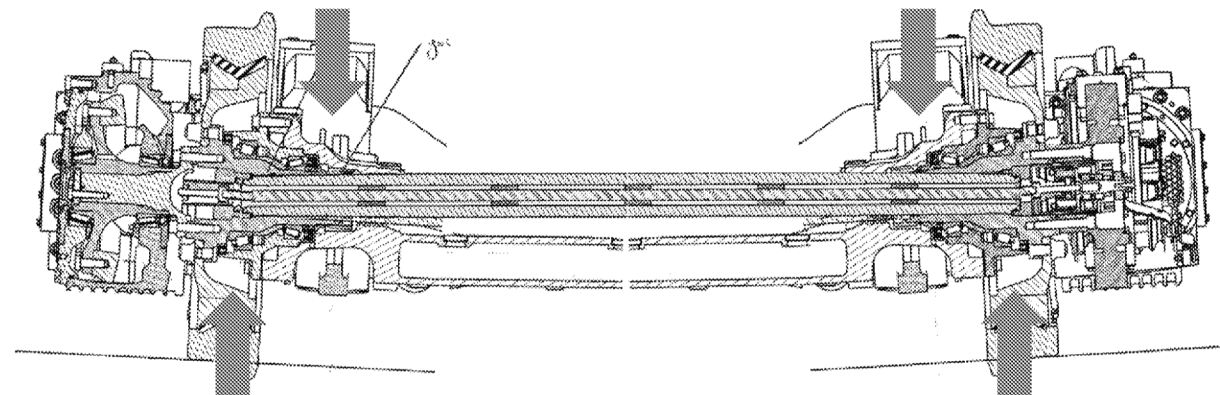
- Braking performances
  - On Motor bogie only, retarding force x 2 on intact side
    - ➔ risk of flats on tyres, not a safety risk
  - Loss of brakes on complete bogie already taken into account through degraded mode (NBE-19-00076591 §5.1.2, §5.2.2, §5.5)
- Stability and track safety
  - Detailed analysis done on Istanbul 301 (NBE-01-00080556)
    - ➔ No safety risk for independent wheels
- Detectability (in between 25kkm check): noise

**No injury / Reduction of system capacities => Risk severity III (Marginal)**

# Spline wear problem overview

## Root cause explanation

Assembly → play in spline connection  
 Vertical load → axle beam bending  
 At 0 torque → Straight shaft +  $\Delta$  angle max



Torsional torque  
 +  
 Shaft rigidity



Partial realignment between shaft and hubs

$\Delta$  angle

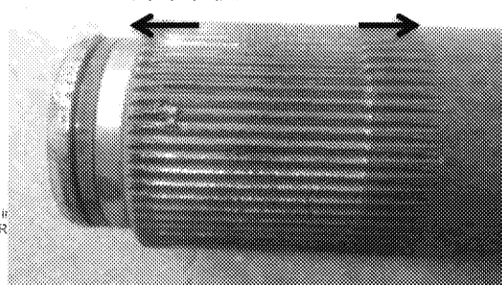


Sliding speed in spline connection  
 +  
 Non-uniform stress distribution in spline

Contact pressure  
 +  
 Sliding



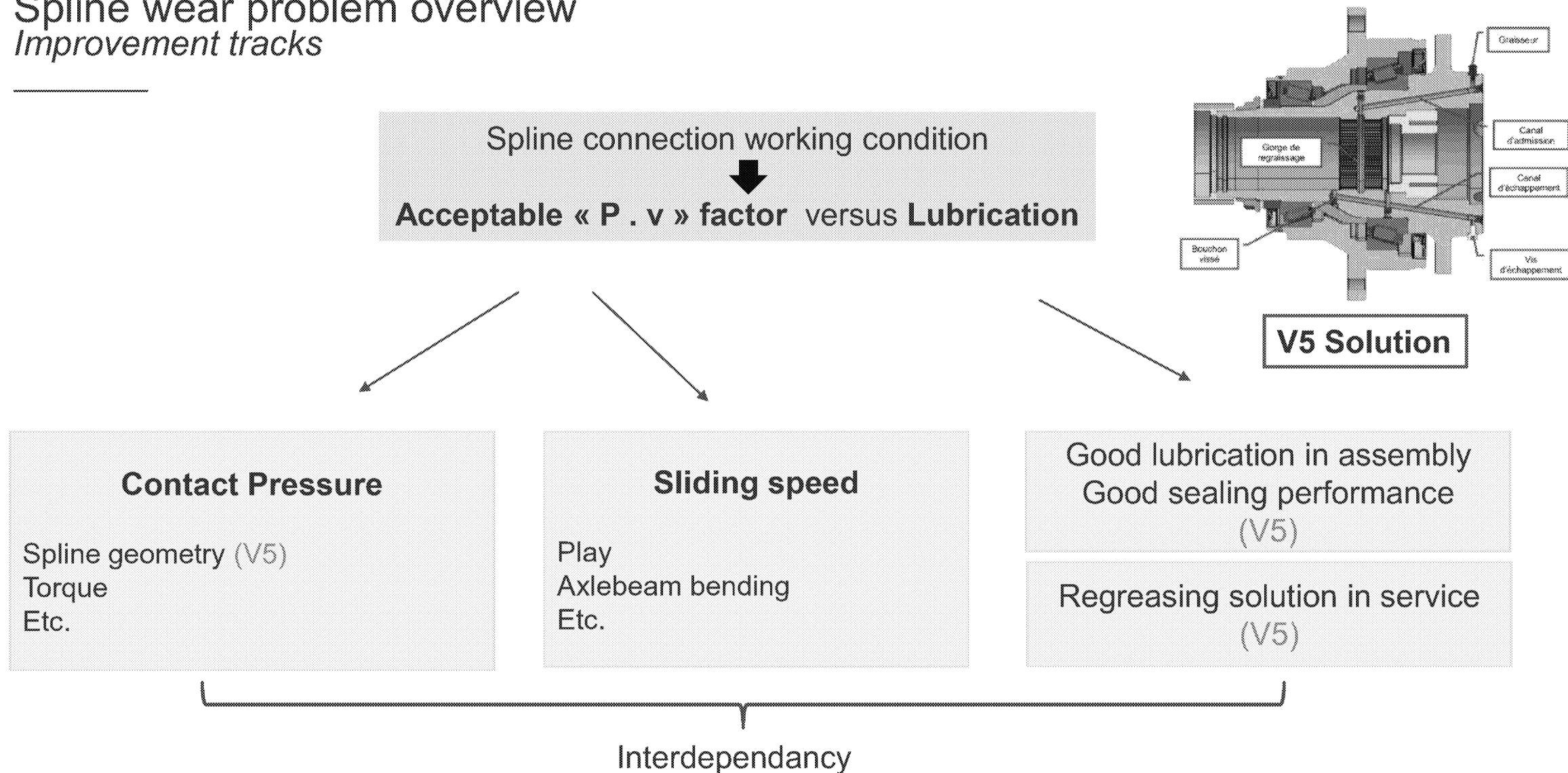
Power dissipation in spline  
 Wear  
 Grease migration to extremities (pumping effect)





# Spline wear problem overview

## Improvement tracks



# 02

## Ottawa V5 Fleet Status





## Ottawa V5 fleet status

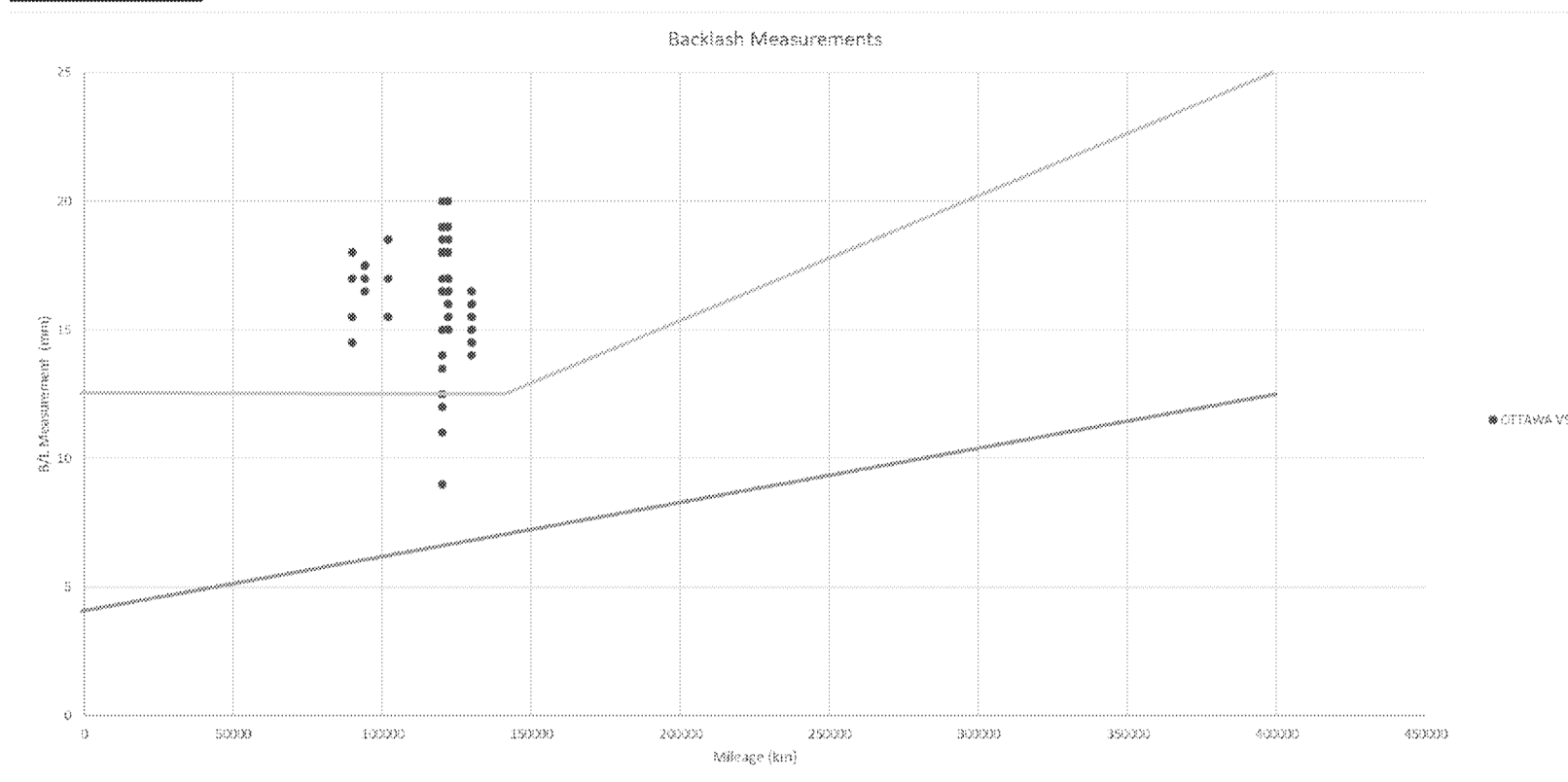
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- V5 retrofit:
  - 100% revenue service fleet completed
  - LRV 41-46 to be completed – not in revenue service
- V5 fleet mileage
  - Highest mileage post retrofit: 126.000 km
  - Lowest mileage post retrofit: 15.000 km



# Ottawa V5 fleet status

## V5 spline wear follow-up



- Data gathered from 7 LRV with high mileage so far
- B/L measurement at reflecting spline wear
- 25mm as replacing criteria (within 40kkm)

**Alerting V5 fleet performance**

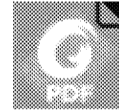


# 03

## T20 axle Solution

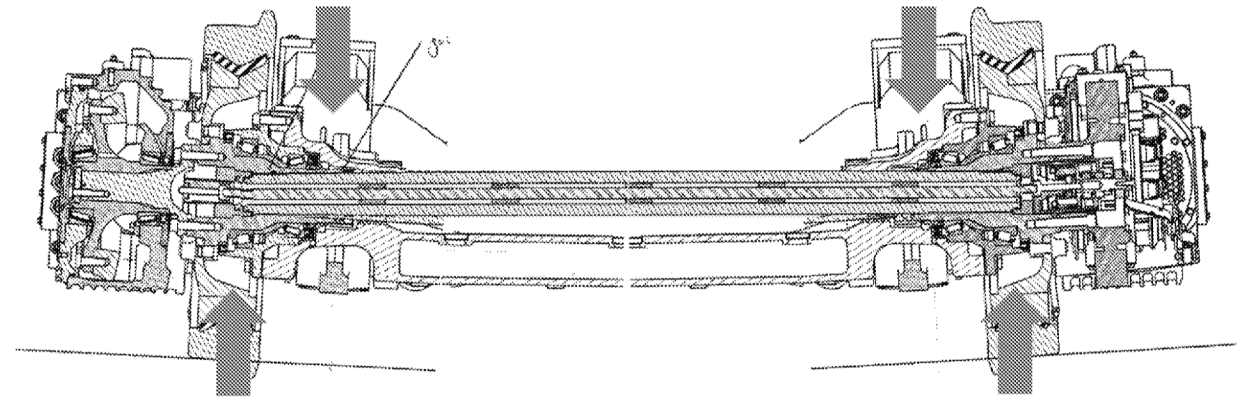
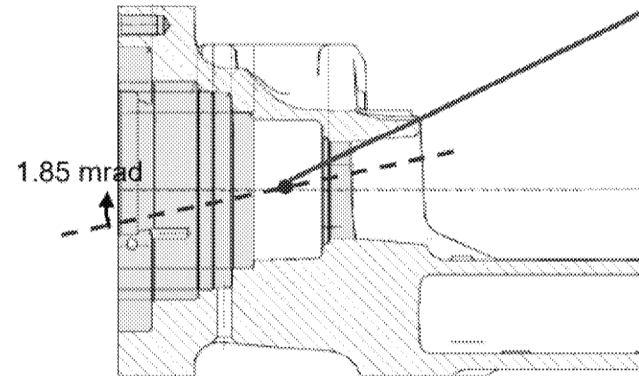


## T20 axle solution



### IPONAM T20 Design Presentation

- Texelis T20 axle implemented on Toronto project
- 1 change in machining process in order to re-align hub / shaft spline connection



- Rotating angle calculation based on weighted average of IPONAM bogie axle loads and considering geometrical constraints for assembly operation. Rotating angle defined as **1.85mrd** (0.106°)
- Identical Back-to-Back measurement by adjusting mounting shims

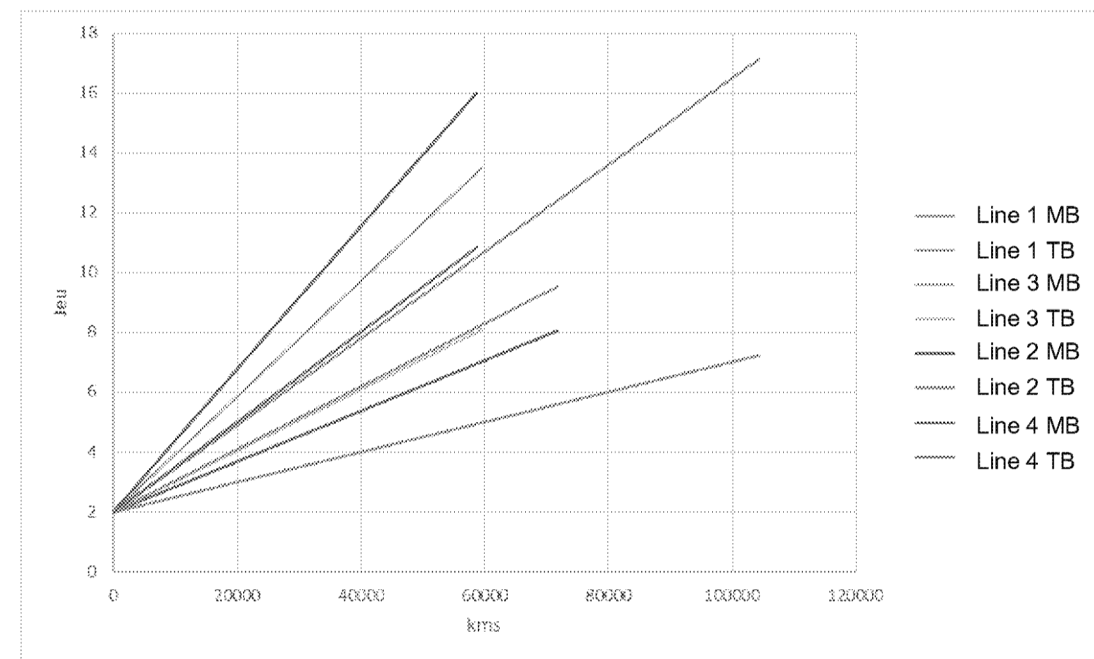
# T20 axle solution

## Simulation Results

- Simpack simulation model
- Good correlation simulation results VS fleet evolution

track	Wear mm/km	P Diss kW*hr/100kkm
Line 1 TB	5.02E-05	9.7
Line 2 MB	8.43E-05	12.8
Line 3 TB	1.02E-04	16.6
Line 2 TB	1.05E-04	11.8
Line 1 MB	1.45E-04	12.7
Line 4 TB	1.50E-04	17.4
Line 3 MB	1.93E-04	20.5
Line 4 MB	2.38E-04	19.7

	kW*hr / 100kms	Gain car.
T20 Mean value	1.9	ref
V5 Mean value AW0	9.6	5.2
V5 Mean value AW3	13.8	7.5



V5 Fleets wear follow-up



# 04

## Ottawa retrofit planification

# Spline wear problem overview

## *Design and retrofit status in different fleets*

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- IPONAM:
  - Ottawa: V5 in revenue service
  - Toronto: T20 in production

=> Target to implment T20 for bogies remaining to be built
- IXEGE:
  - TTNG: V5 in revenue service, T20 for prototype
  - Istanbul: V5 in revenue service, T20 under discussion



## Ottawa retrofit planing

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- Targetting minimal number of LRV to be retrofitted in V5
- T20 retrofit:
  - Tentative start in Q4 2021 (December 21)
  - First LRV at 3-4 weeks turn-around time
  - Next 3 LRV ar 2 weeks turn-around time
  - Estimated 1 LRV / week after learning curve