

# Development and Implementation of a Water-Based Friction Modifier Train-Borne Dispensing System for Transit

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RAIL TRANSIT SEMINAR • JUNE 6

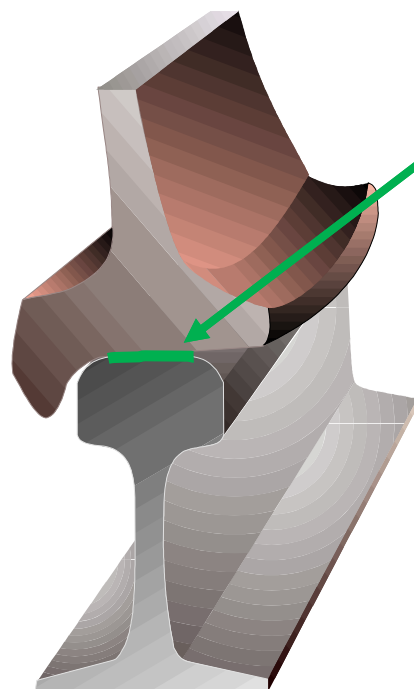
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- Benefits of Top of Rail Friction Management
- KELTRACK™
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  - Consumables
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# Benefits of Top of Rail Friction Management



**Target CoF: ~0.35**

## **Top-of-Rail / Wheel Tread**

### **Benefits:**

- Reduced Rail / Wheel Wear
- Improved Fuel Efficiency
- Reduced Lateral Forces
- Lowers Derailment Potential
- Mitigates RCF Development
- Reduces Vehicle Hunting
- Mitigates Noise
- Mitigates Corrugation Damage

CoF = Coefficient of Friction



**Slide 3**

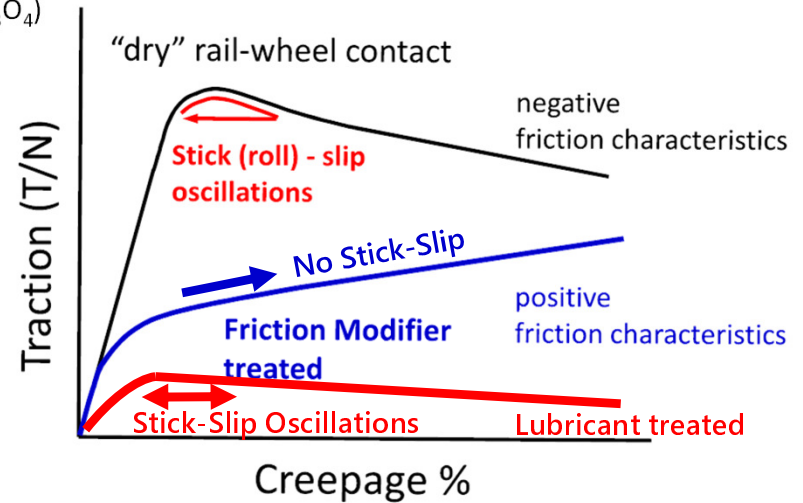
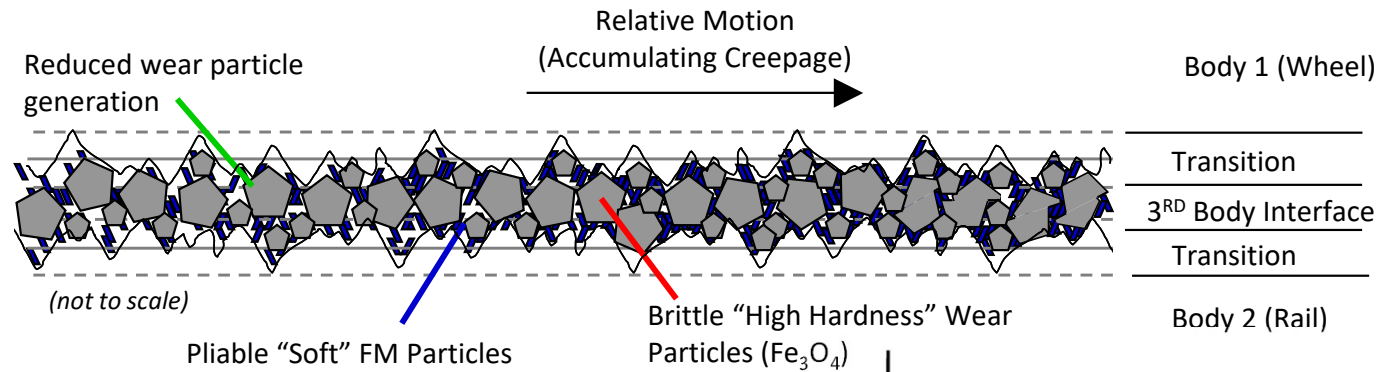
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**JB0**

missing corrugation from TOR benefits

Jackie Butterfield, 2022-06-15T14:49:42.642

# “KELTRACK Treated” Wheel / Rail Interface

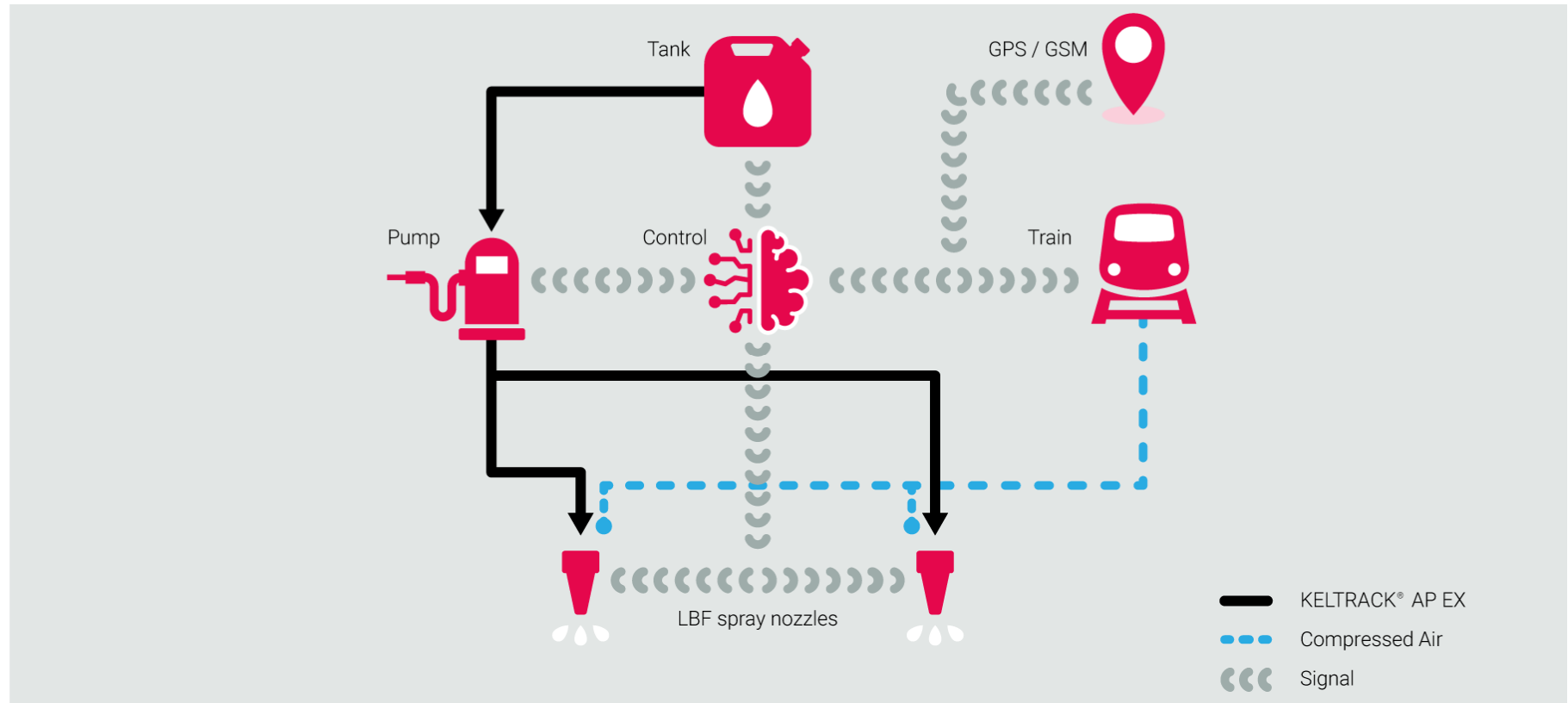


## What is KOB?

- *KELTRACK*<sup>®</sup> *On-Board (KOB)* is a vehicle mounted spray system.
- It dispenses water-based drying Friction Modifier material directly to the top-of-rail.
- The primary benefits include reduction of:
  - *Noise, corrugation, rolling contact fatigue, wheel wear, rail wear, and fuel consumption.*
- The system is specifically designed to work with *KELTRACK*<sup>®</sup> *AP EX* friction modifier.
- *KOB SL* is designed for use on passenger rolling stock.



# System Architecture



# KOB Technology Development - Background

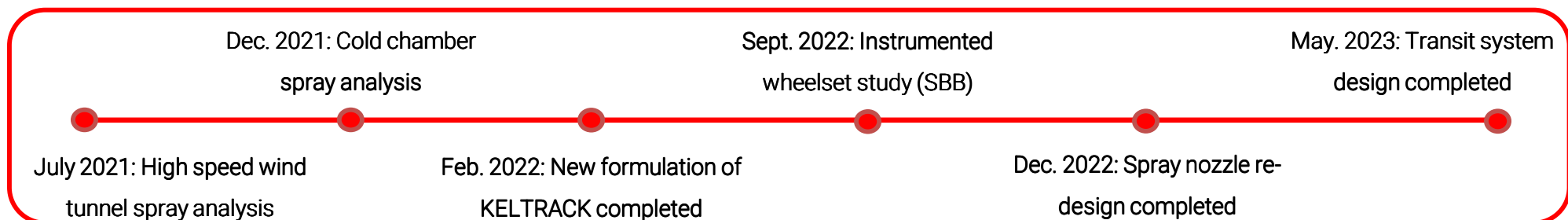
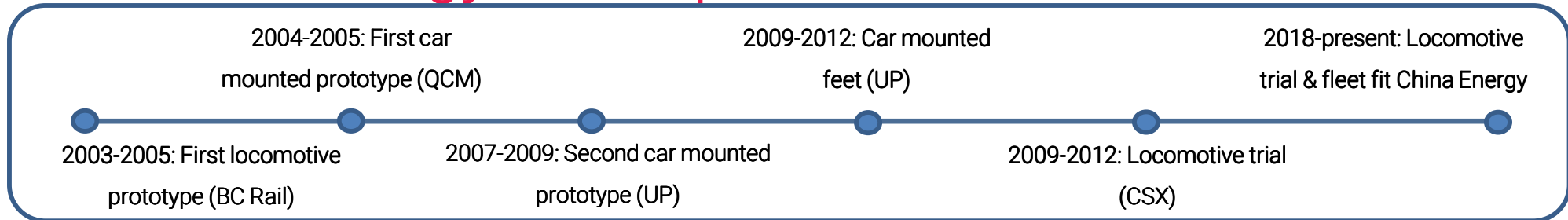
- 2018 - Emerging Opportunity identified in on-board sprayable FM solutions in the Transit sector.
- The current state of the technology was freight focused; several development areas were identified to enable fit into the transit space:
  1. Air compressors on transit vehicles have a lower volumetric capacity and often lower operating pressures – reduce air requirements
  2. Eliminate the need for heated elements to allow KELTRACK to function in environments below 0°C reducing complexity, cost and power requirements.
  3. To fit in to a typical transit vehicle, the space required of the dispensing cabinet and spraying nozzle must be dramatically reduced.

Smaller, cheaper, more reliable. A development program was commenced.





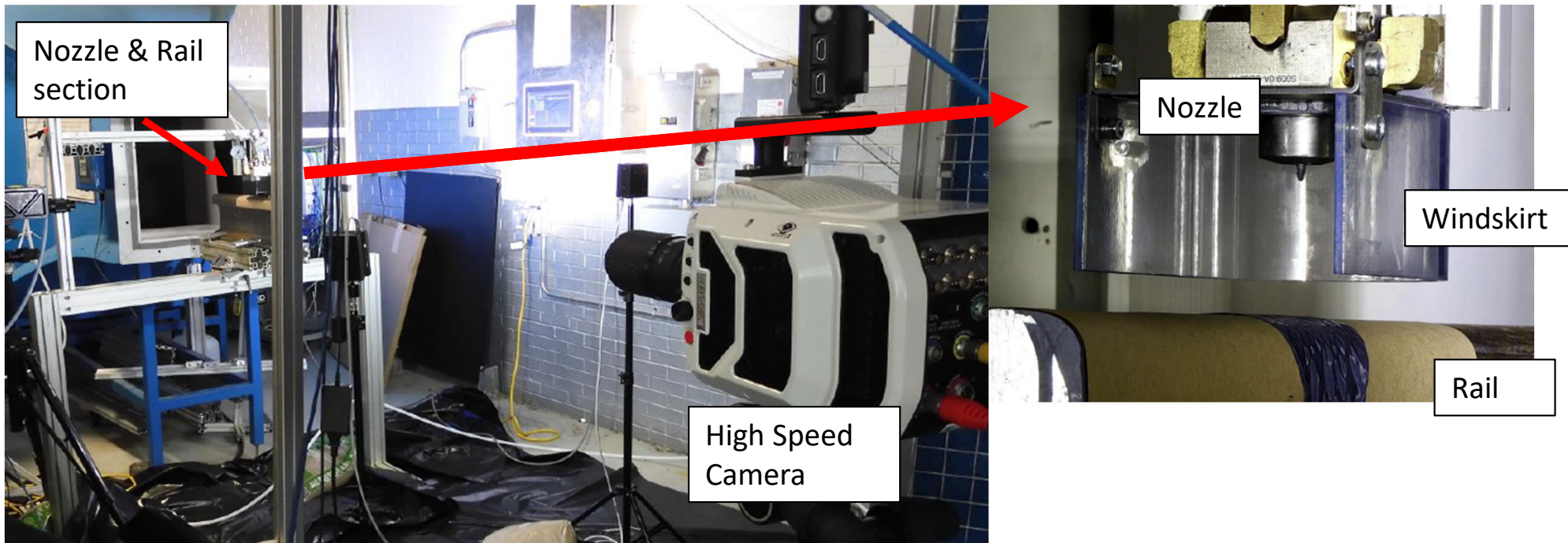
# KOB Technology Development - Timeline

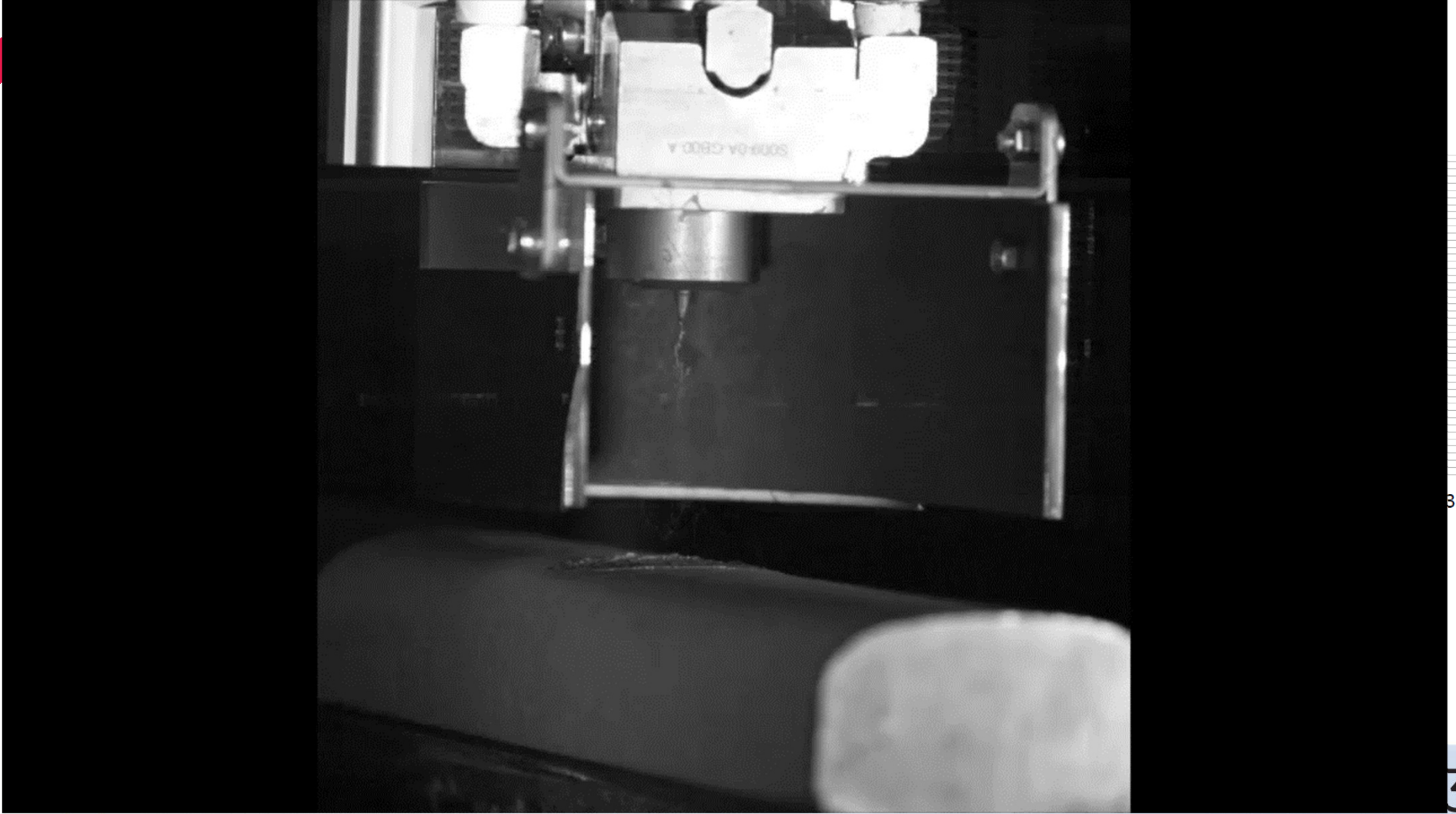


- Early years development focused on Class 1 railroad sector.
- Company R&D spending constrained 2012-2018, KOB development program paused during this period.
- 2018 onwards there has been a focus on evolving the technology for the transit market.
- 2021-present has seen intense development activity to progress the technology to a market-ready state for Transit

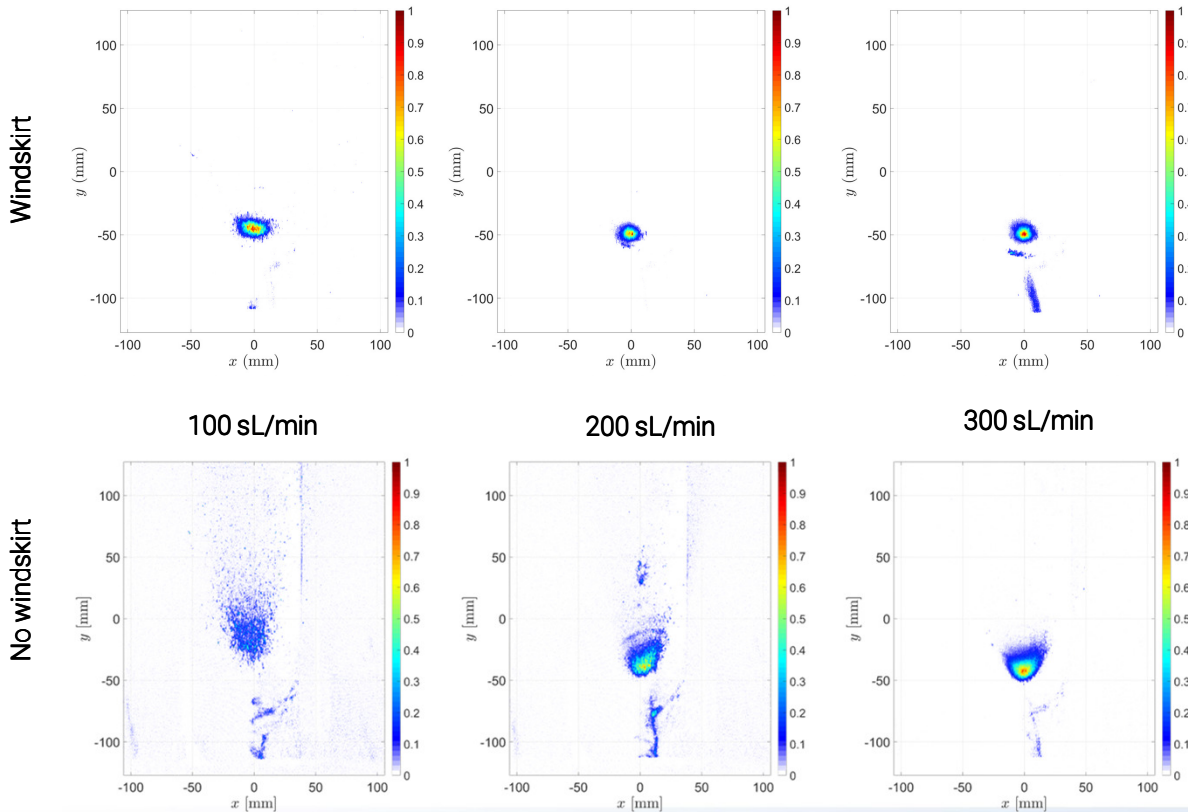


# KOB Technology Development – Spray Analysis





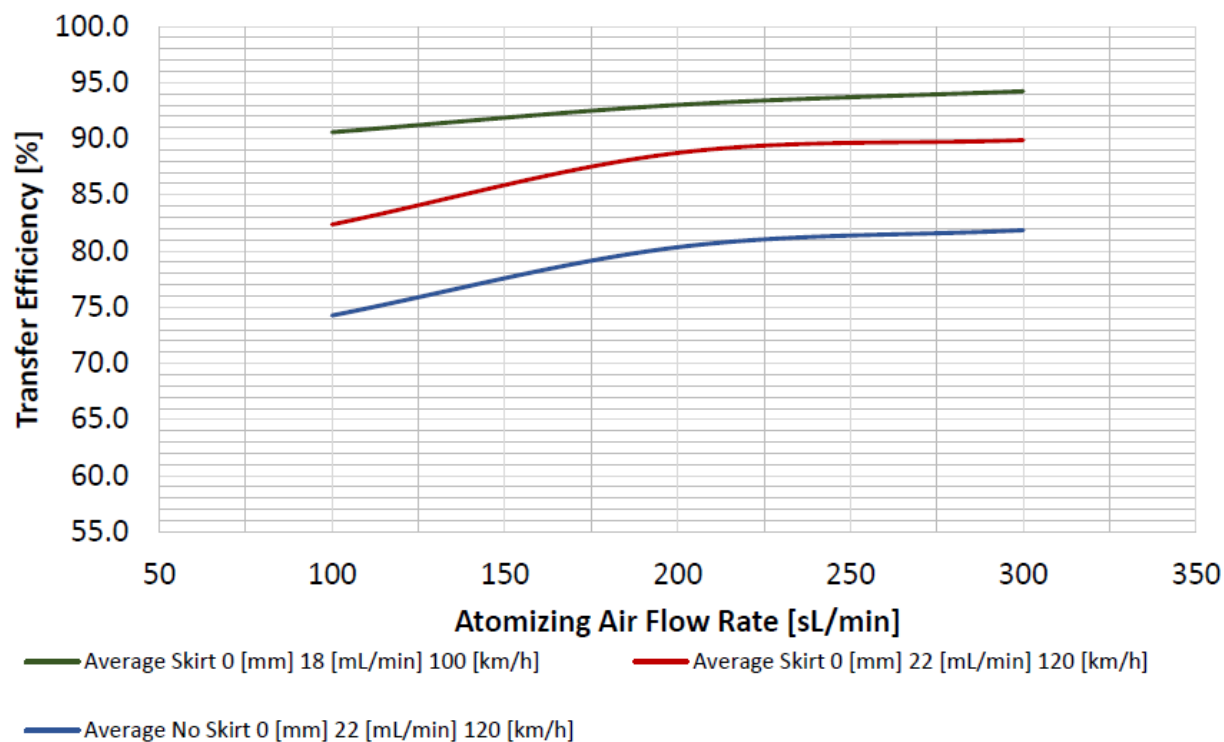
# KOB Technology Development – Spray Analysis



- laser sheet imaging plots to assess overall intensity and spread of product on railhead.
- Atomized air flow varied (100, 200, and 300 standard liters per minute of air) to observe the effects.
- Wind velocities were varied (up to 120km/h)
- Impact of “windskirt” assessed
- spray pattern concentration increased with increasing airflow; results acceptable even at low flow conditions with windskirt.
- Without windskirt results undesirable leading to poor transfer efficiency to railhead



# KOB Technology Development – Spray Analysis



# KOB Technology Development – Consumable Development

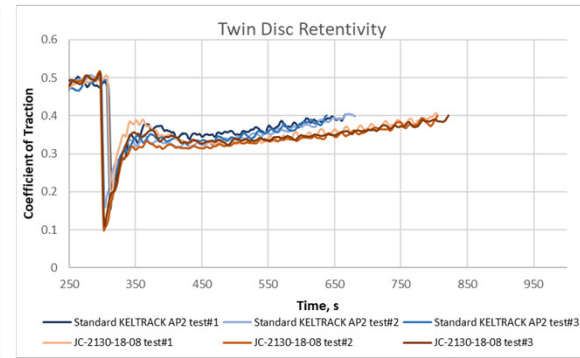
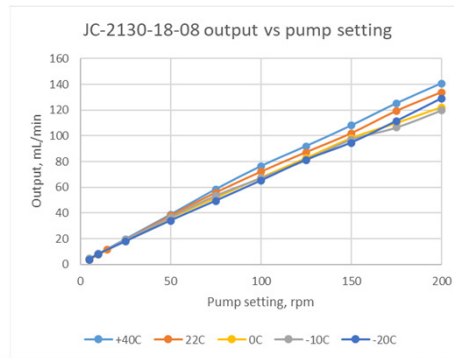
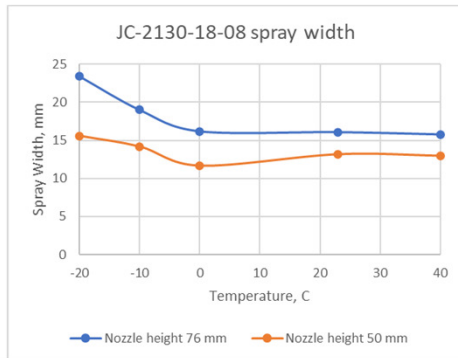
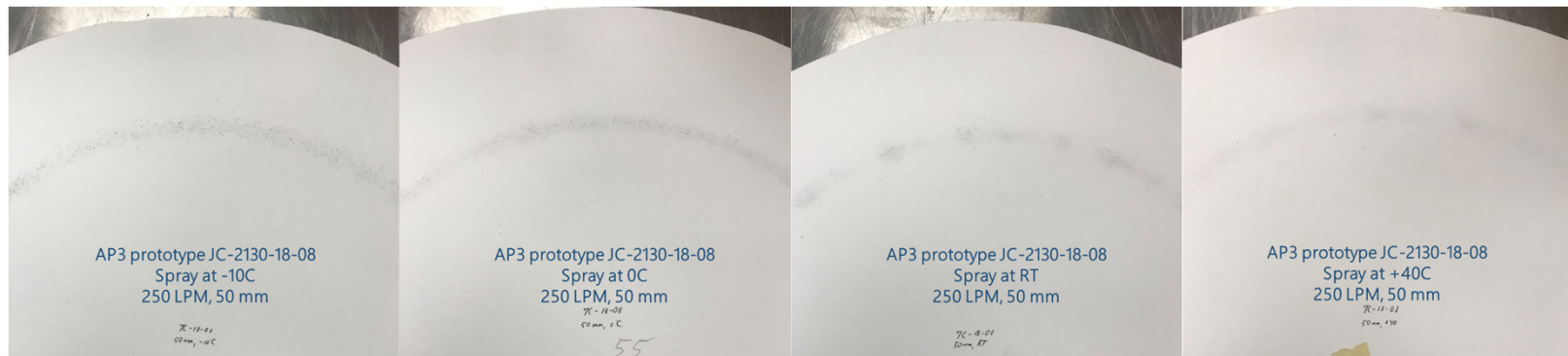
Several prototype formulations of KELTRACK were developed in-house and reviewed against key criteria:

- Must show positive friction and stable intermediate friction levels as a Friction Modifier (via twin disc testing)
- Stability of spray width versus temperature
- Stability of spray density/ ability to atomize versus temperature
- Stability of output volume versus temperature
- Good product stability, must achieve minimum 12-month storage without product degradation
- Must be water-based and classified as non-hazardous

The prototypes had a mandatory operating temperature range -20°C to +40°C.

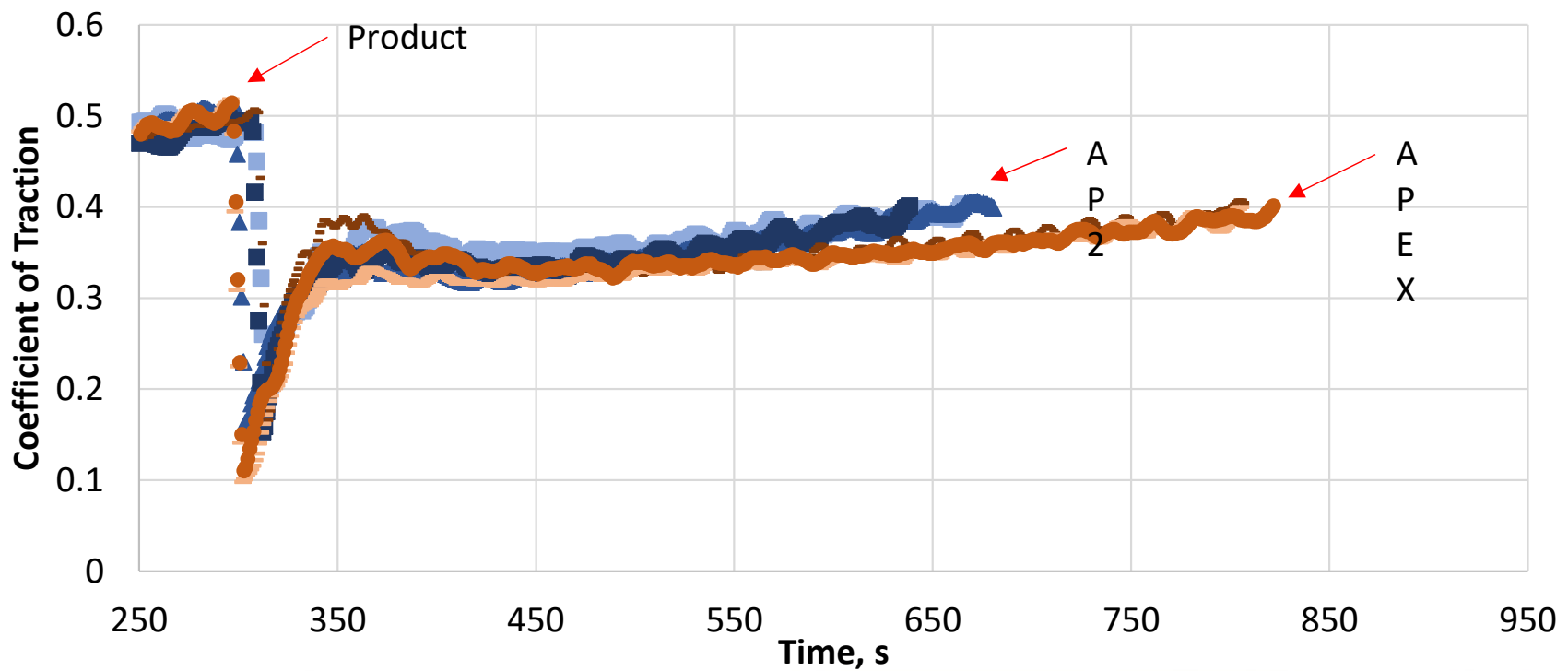


# KOB Technology Development – Consumable Development



# AP EX – Improved retentivity

## Twin Disc Retentivity





## AP EX - Features

- Low freezing point of -25°C.
- Longer lasting “intermediate friction levels” based on twin disc retentivity testing.
- Positive friction characteristics.
- Stable application rates in the temperature range of -20°C to +40°C.
- Good sprayability through KOB hardware in the temperature range of -20°C to +40°C.
- Good product stability based on accelerated settling tests.
- The product does not propagate steel corrosion.
- The product does not contain nonylphenol-ethoxylate (NPEO) additives or other highly hazardous ingredients. It is classified as non-hazardous and environmentally benign.



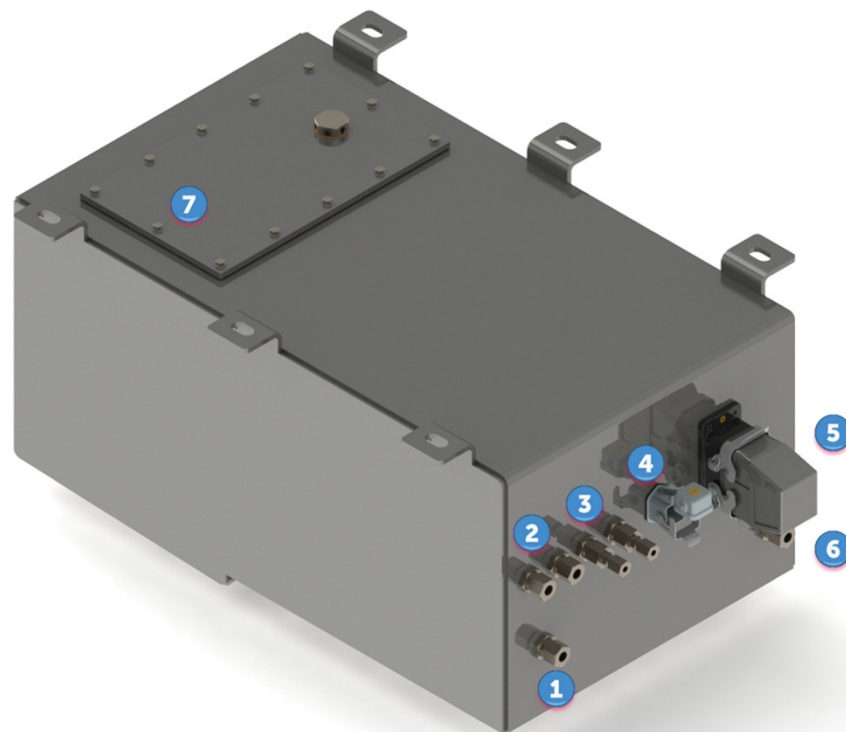
## Features & Benefits

Feature	Benefits
<ul style="list-style-type: none"> <li>Low freezing point of -25°C.</li> </ul>	<ul style="list-style-type: none"> <li>No heating required, simpler design, lower cost.</li> </ul>
<ul style="list-style-type: none"> <li>Longer lasting “intermediate friction levels” based on twin disc retentivity testing.</li> </ul>	<ul style="list-style-type: none"> <li>Fewer vehicles need to be equipped to provide system coverage.</li> </ul>
<ul style="list-style-type: none"> <li>Positive friction characteristics.</li> </ul>	<ul style="list-style-type: none"> <li>Effectively mitigates corrugation &amp; noise.</li> </ul>
<ul style="list-style-type: none"> <li>Stable application rates in the temperature range of -20°C to +40°C.</li> </ul>	<ul style="list-style-type: none"> <li>Consistent all-season performance.</li> </ul>
<ul style="list-style-type: none"> <li>Good sprayability through KOB hardware in the temperature range of -20°C to +40°C.</li> </ul>	<ul style="list-style-type: none"> <li>Consistent all-season performance and longer nozzle maintenance intervals.</li> </ul>
<ul style="list-style-type: none"> <li>Good product stability based on accelerated settling tests.</li> </ul>	<ul style="list-style-type: none"> <li>Longer shelf life.</li> </ul>
<ul style="list-style-type: none"> <li>The product does not propagate steel corrosion.</li> </ul>	<ul style="list-style-type: none"> <li>Safe for use on steel wheels and rail.</li> </ul>
<ul style="list-style-type: none"> <li>The product does not contain nonylphenol-ethoxylate (NPEO) additives or other highly hazardous ingredients. It is classified as non-hazardous and environmentally benign.</li> </ul>	<ul style="list-style-type: none"> <li>Safe for use in urban areas and near waterways.</li> </ul>



# Dispensing & Controls Cabinet

- (1) Air In (from vehicle)
- (2) Atomizing Air Out (to left & right nozzles)
- (3) Control Air Out (to left & right nozzles)
- (4) Human & Electrical Interface Port
- (5) Power In (from vehicle)
- (6) KELTRACK Out (to left and right nozzles)
- (7) 20 L Reservoir with removable top access panel



## Dispensing & Controls Cabinet (cont.)

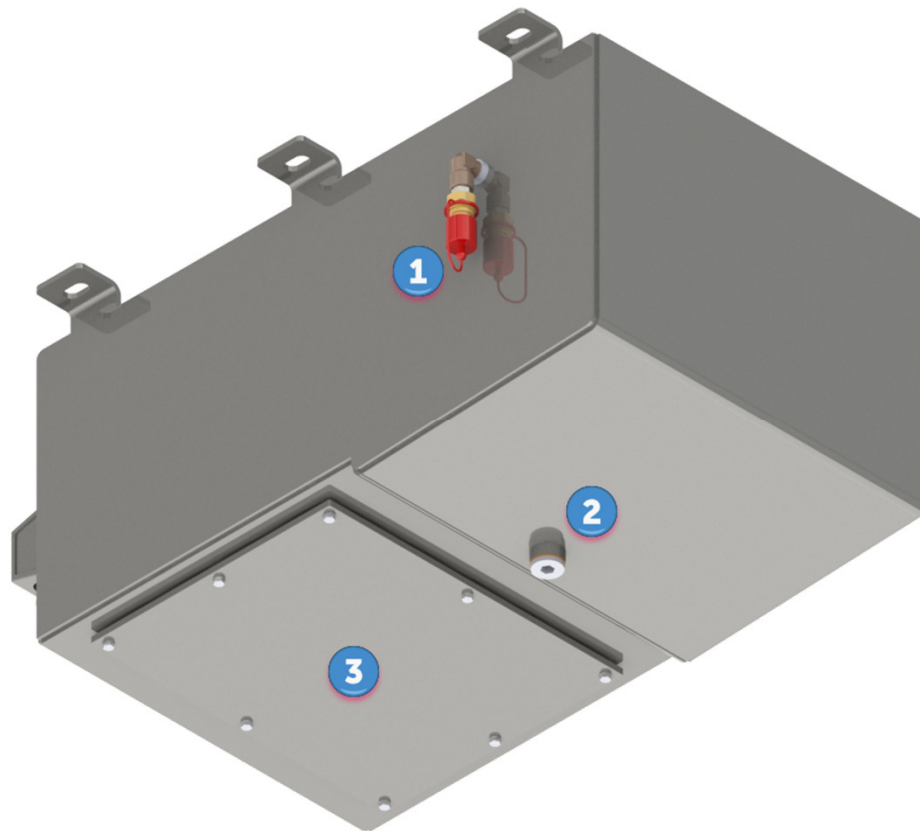
### (1) KELTRACK Bulk Filling Port

- Allows automatic filling and shut-off when used with bulk filling equipment.

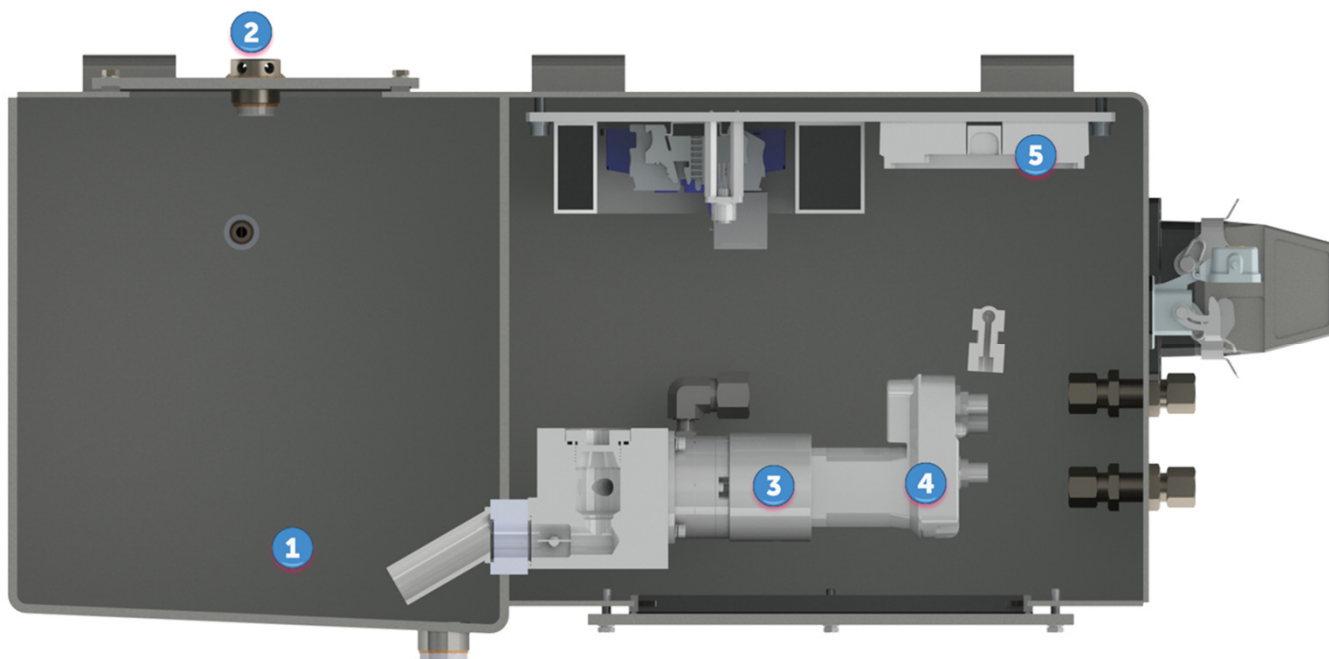
### (2) KELTRACK Drainage Port

### (3) Removable bottom access panel

- Allows access to electrical and pump/motor components.



## Dispensing & Controls Cabinet (cont.)



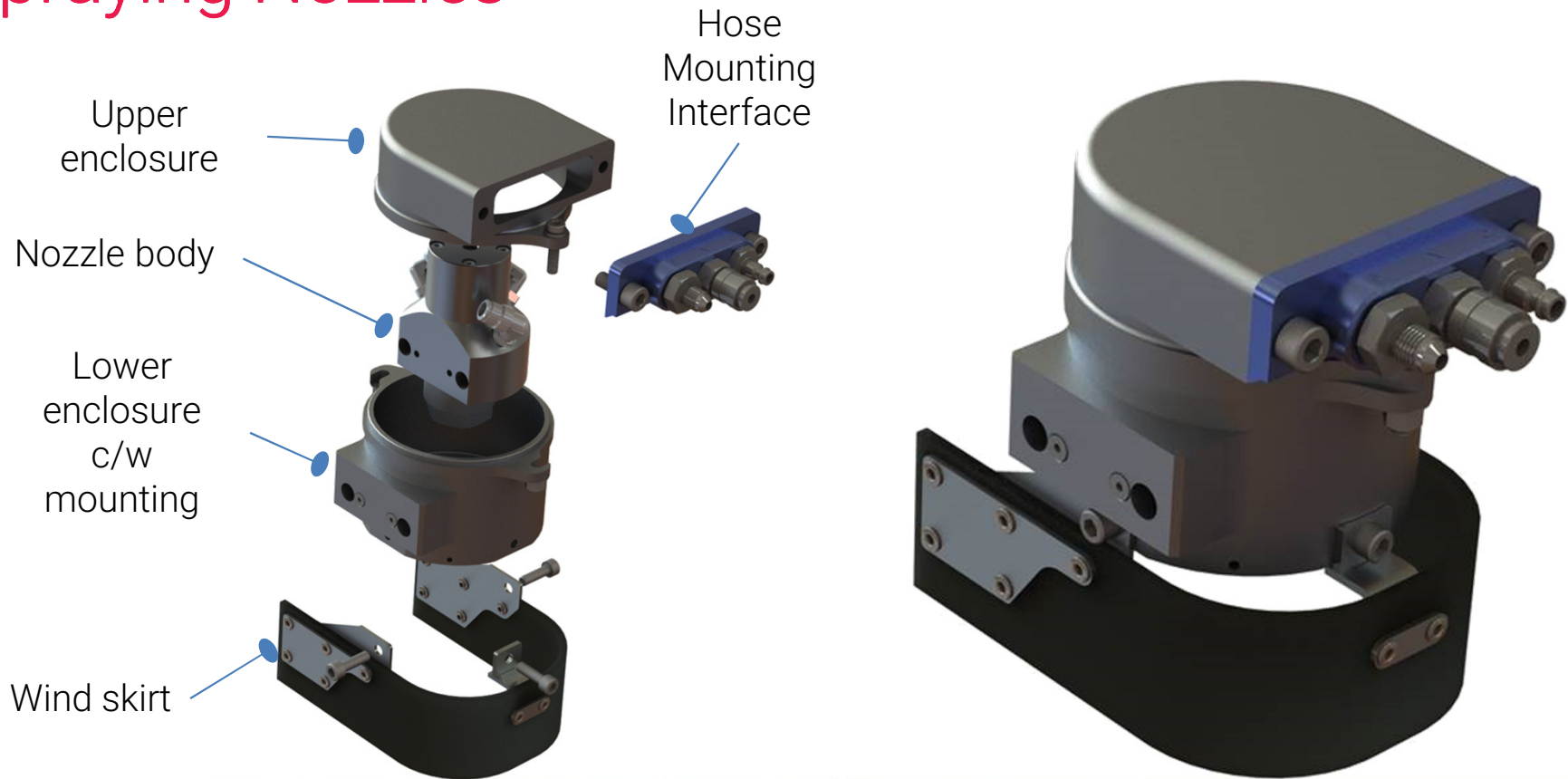
- (1) KELTRACK Product Reservoir  
Standard 20L capacity for KOB SL
- (2) Breather Valve
- (3) Dispensing Pump
- (4) Dispensing Motor
- (5) System Controller



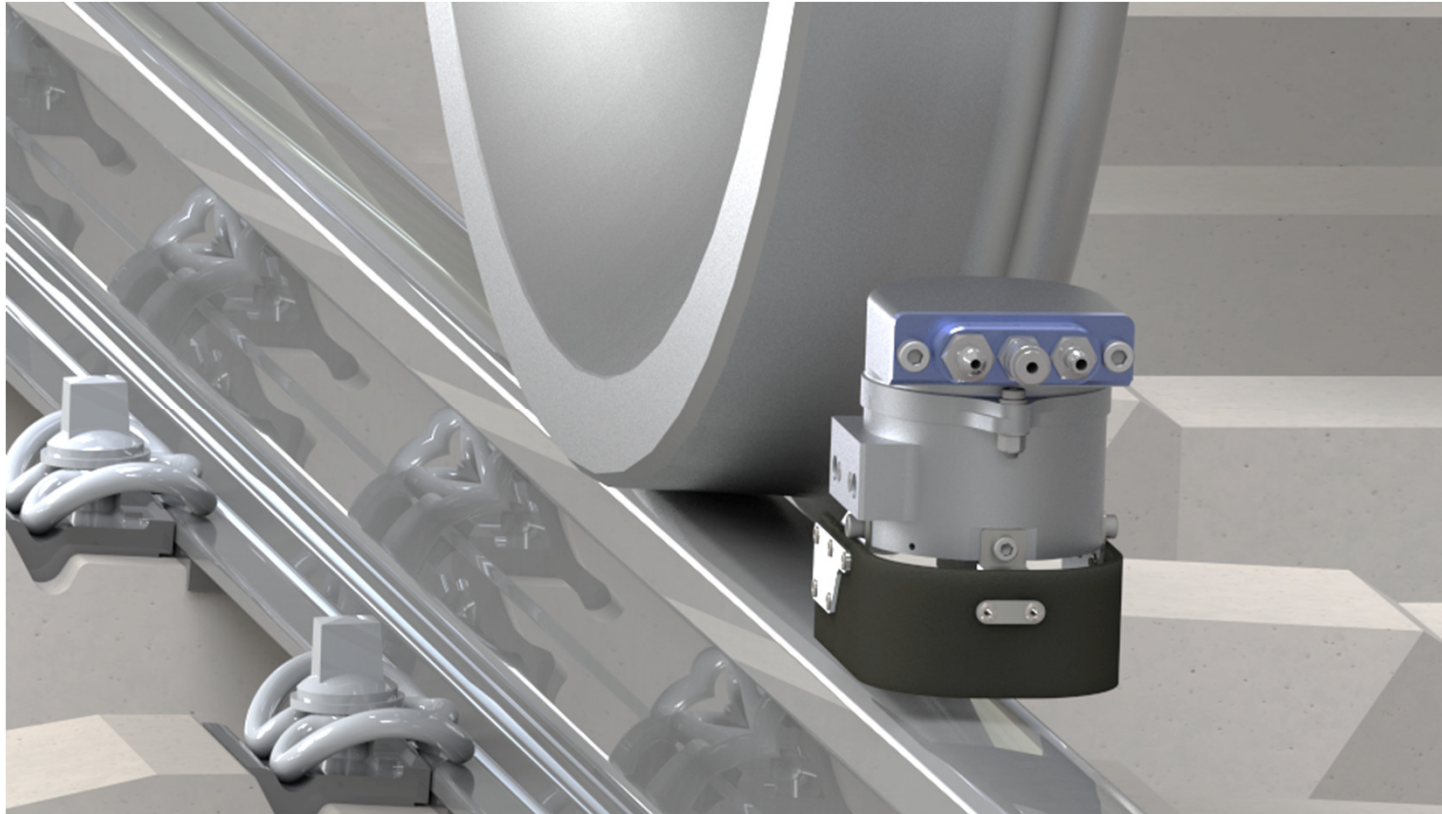
# Dispensing & Controls Cabinet (cont.)



# Spraying Nozzles



# Spraying Nozzles

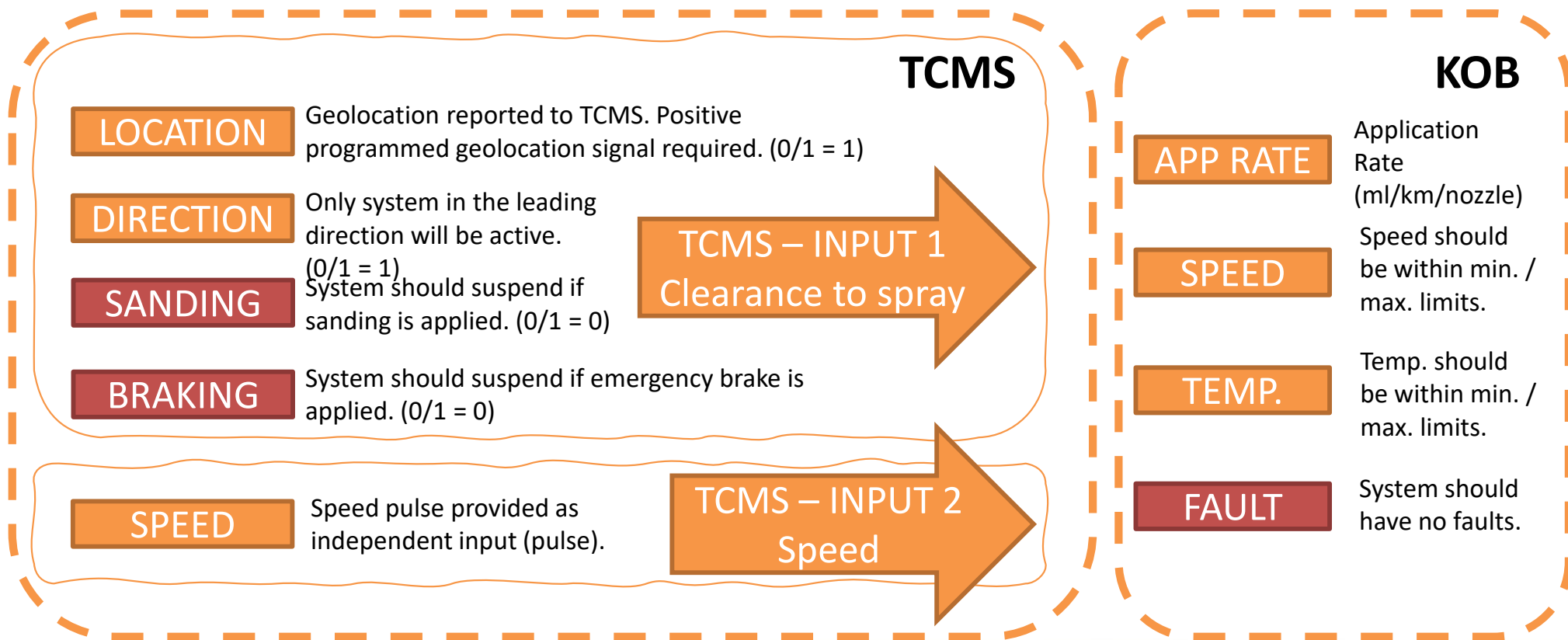


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# Operation Logic



# Technical Specifications

	KELTRACK® On-Board SL	
Air	6-10 bar Nominal: 500L/min; Minimum: 350L/min ISO 8573-1	
Power	24 VDC (125W)	
	Dimensions (mm)	Mass (kg)
Spray Nozzle	171(w)x135(d)x157(h)	1.8
Dispensing & Control	712(w)x326(d)x324(h)	58 (empty) 82 (full)
Electrical & HMI	400(w)x300(d)x205(h)	8.6
Tank Volume	20L	
Signal Interface	Speed Braking* Sanding* Direction* Location*	
Approvals	EN 61373 (Shocks & Vibration) EN13749 (Bogie Frame Loading) EN44545-2 (Fire)	EN50121-3-2 (Gen. Elec) EN60068 EN50125-1 (EMC)



# Field Tests - Braking & Traction Study (SBB)

## Goal:

- Analyse performance of KELTRACK AP versus oil-based and grease-based products with respect to braking.

## Outcomes:

- KELTRACK frictional values were in-line with optimal conditions (0.3-0.35). Good alignment to reference values.
- Adhesion for KELTRACK aligned well with reference values.
- Tractive effort with KELTRACK was unchanged from reference conditions.

		Product 1	Product 2	Product 3 (Keltrack)
Percentage extension of stopping distance (Starting speed 115km/h (E-brake) for example 120km/h)				
Tread brakes	R	Unchanged	Unchanged	Unchanged
Disc brakes	R	+7%	+7%	Unchanged
	R+Mg	+11%	Unchanged	Unchanged
Electric brakes	E	+34%	+39%	+4%
Percentage extension of accelerating distance (Final speed 120km/h)				
Trailer load: 87t (two coaches)		~+24%	~+18%	Unchanged
Trailer load: 111t (three coaches)		~+54%	~+48%	Unchanged

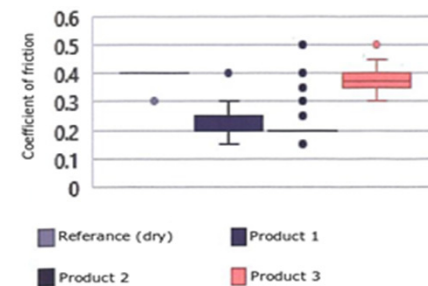


Fig.4 Coefficient of friction

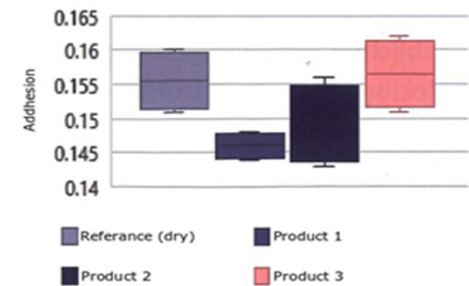
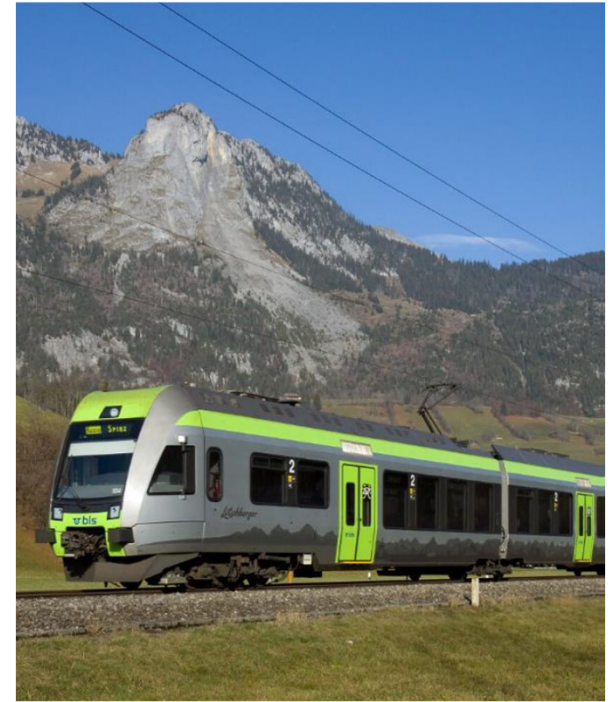


Fig. 5 Effective adhesion wheel-rail during braking



# Prototype Vehicle



# Instrumented Wheelset Study

## Goal:

- Analyse and quantify the performance of KELTRACK AP in reducing wheel / rail forces in narrow curves.

## Method:

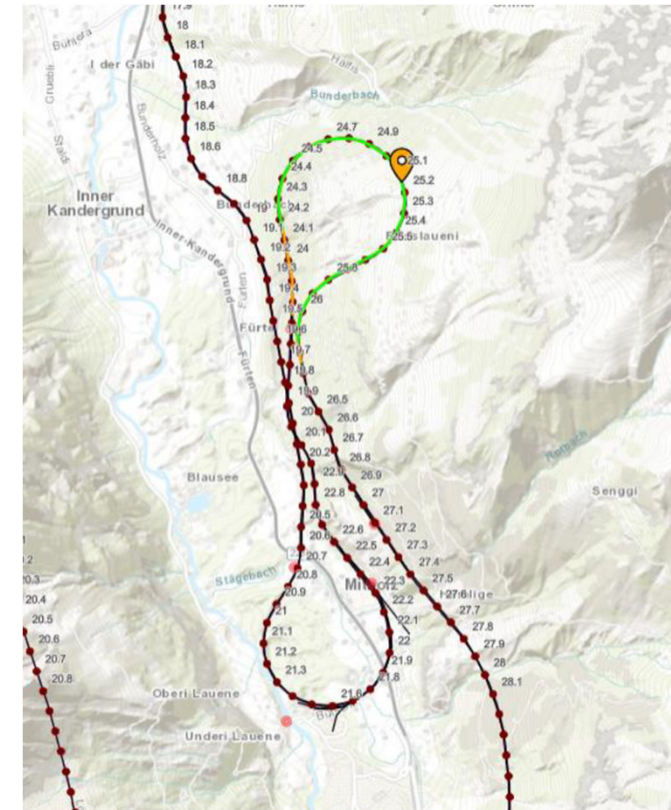
- Running dynamics measurement based on EN 14363
  - Measuring wheel / rail forces with measuring wheelsets in all three dimensions: vertical force (Q), lateral force (Y), and longitudinal force (T).
  - Y/Q of leading wheelset is used as indication of friction coefficient.
- Curves measured were 250-400m radii., Cant deficiency up to 130mm.
- Speed consistent at 80km/h.



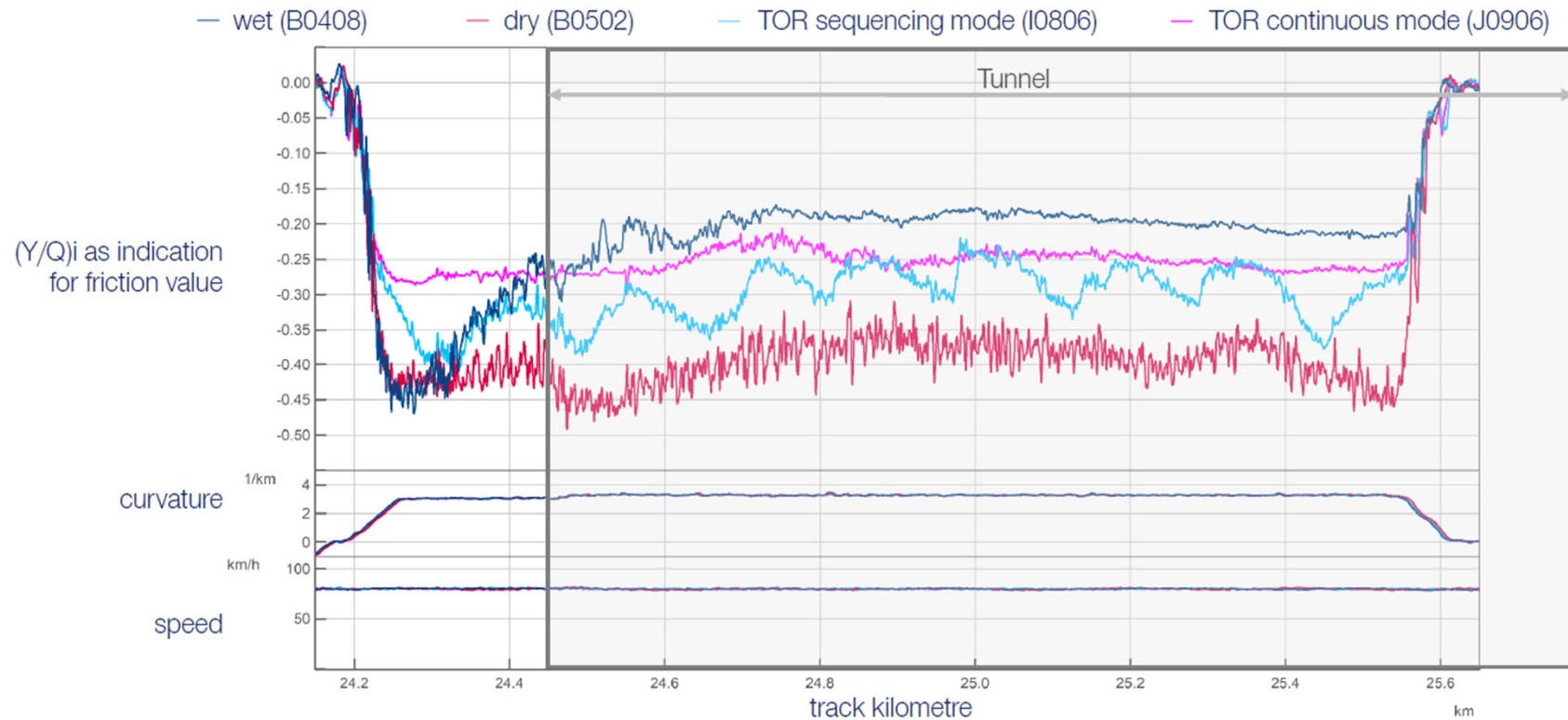
# Application Strategies

Active System	Application Mode	Application Amount
Leading System	Sequencing Mode: Sequentially left and right nozzle active	20g / min
Leading System	Continuous Mode: Continuously applying from left and right nozzle	12g/ min

curve radius  $\approx 300$  m  
 curve length  $\approx 1300$  m  
 tunnel section shortly after the start of the full curve  
 running speed  $\approx 80$  km/h



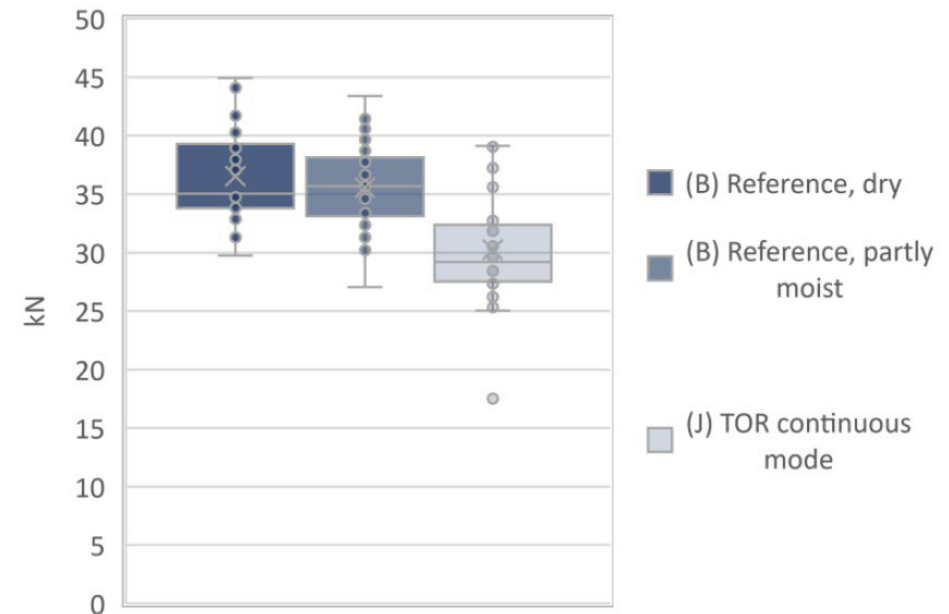
# Calculated Friction Measurements



# Lateral Forces

## Outcomes:

- Reductions in lateral force in excess of 16-20%.
- Independent measurements using push tribometer friction values in the range 0.3-0.35.
- Future work seeks to characterise performance with a range of application volumes.





## KOB SL – Next Steps

1. Commercial offers(s) into operators in 2023
2. Further field trial work in Switzerland (RCF based analysis)
3. Further trial work in NA to assess application strategy
4. Scaled field trial unit for efficient data and testing capability (push trolley)
5. Continuing links with academia for next generation of technology (hydrophobic nozzle materials etc.)
6. Qualification of nozzle vs. ERTMS with major axle counter supplier



# Conclusions

- Benefits of application of Water Based Friction Modifiers well established
- On-board application has clear benefits in terms of safety, maintenance and efficiency
- Refined design for freight systems for transit vehicles
- Development of all aspects of equipment and consumables
- Field tests using push tribometer and instrumented wheelset
  - Reduction in friction and lateral forces validated
- Future development work planned



# Thank you



# Human & Electrical Interface

## (1) Human Machine Interface (HMI)

- Allows the operator to review the system status, perform tests, and modify system parameters etc.
- Mounted in the vehicle cab.

## (2) Optocouplers

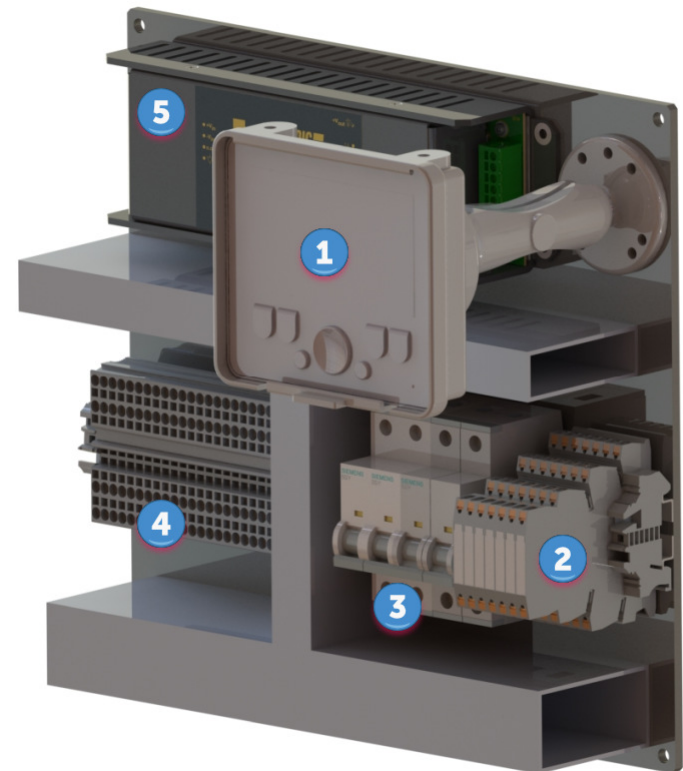
- Voltage free couplers used to transfer signals (fault, warning, speed, spray etc.) between the vehicle and KOB SL.

## (3) Circuit Breakers

## (4) Wiring Terminals

## (5) DC/DC Converter

- Used to transform vehicle DC supply down to 24VDC.



# Human & Electrical Interface (cont.)

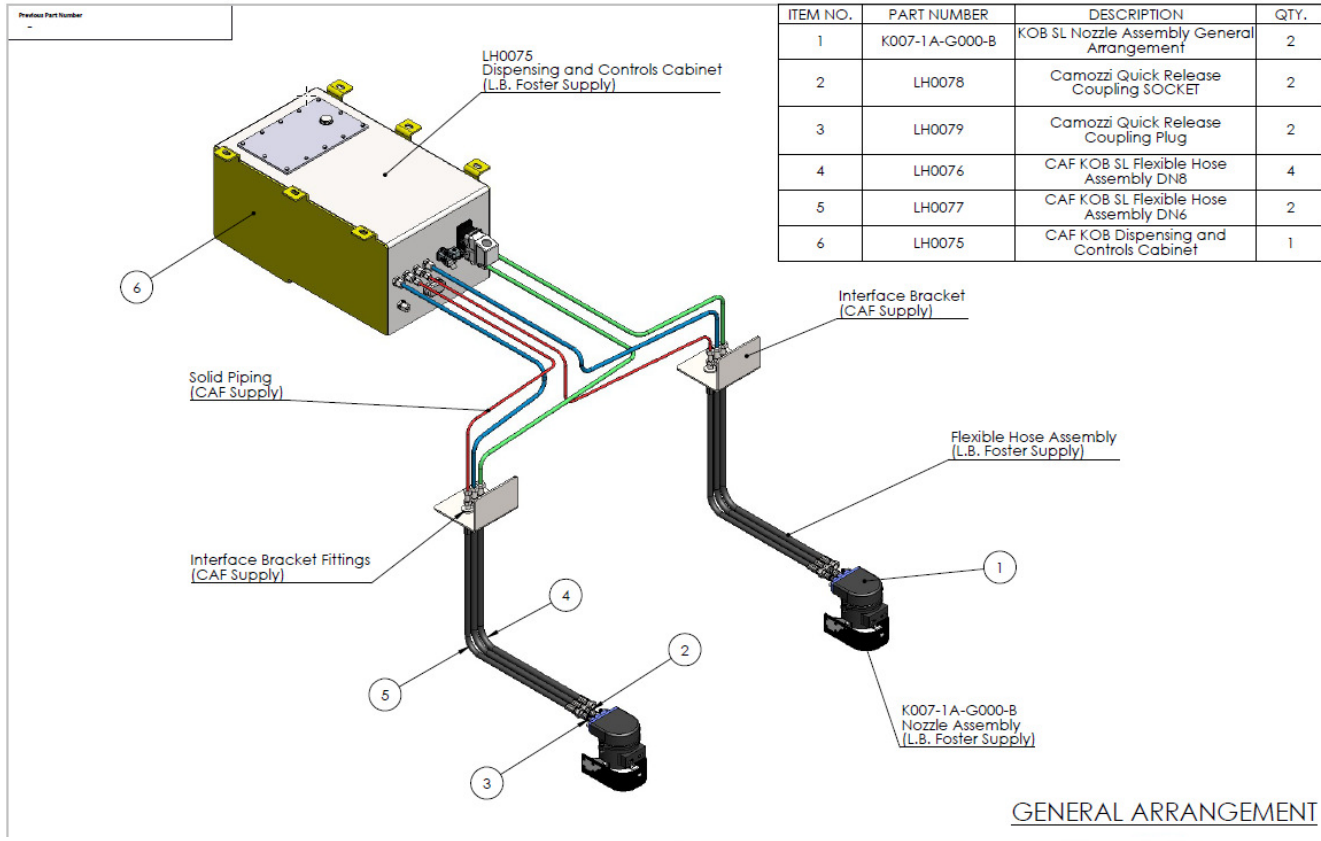
Vehicle signals			Ready for operation	
V	90 km/h	Clearance to spray L	Fault	
Air	3750 mbar	Clearance to spray R	Level low	
Rate:	Pump	12 °C	Tank	
30 ml/km/rail	44.9 ml/min		72 %	
SPRAY ON L	2500 mbar		SPRAY ON R	
ON	OFF	OK	ACK	

PARAMETER ENABLE SPRAYING	220
Minimum speed V<value -> Spraying off [km/h]	5
Maximum speed	100
Minimum temperature T<value -> Spraying off [°C]	-10
Vehicle tube pressure p<value -> Spraying off [mbar]	3500
▲ OK ▼	

FAULTS AIR/PUMP	430
Tank level below MIN	1
Air pressure low	0
Medium pressure high, nozzle blocked L -> ACK	0
Medium pressure high, nozzle blocked R -> ACK	0
Stepper motor/drive fault -> ACK	0
	0
	0
	0
RESET COUNTER	ACK



# KOB SL –



## KELTRACK® AP EX - Technical Specifications

	Method	Unit	KELTRACK AutoPilot EX
Label			AP3
Appearance	-	-	Gray Thixotropic Gel
Base	-	-	Water
Viscosity at 77 °F (25 °C)	Brookfield RV5 at 80 rpm	cP	1,300-1,600
Density at 77 °F (25 °C)	ASTM D1475	g/cm <sup>3</sup>	1.06 - 1.08
Freezing Point	ASTM D2386-97	°C	-25
pH	ASTM E70	-	9.4 – 9.8
Operating Temperature Range	-	°C	-20 to +40
Friction Coefficient	L.B. Foster Twin Disc Methodology	-	Intermediate friction coefficient (0.3 - 0.4)
Retentivity		-	Excellent
Friction Characteristics		-	Positive friction characteristics
Corrosion Mitigation	L.B. Foster Method		Excellent
Aquatic Toxicity	OECD 203	-	(Non-toxic to freshwater fish, LC50 > 100 mg/L (ppm))
Flammability	-	-	Non-Flammable
Environment	-	-	Not classified as hazardous to aquatic life

# Nozzle Connections

PART NUMBER

## NOZZLE CONNECTIONS

