Introduction to the Dynatest RAPTOR Rolling Wheel Deflectometer

Martyn Stonecliffe-Jones
Dynatest Director of Consulting

Copenhagen 2017

M J Lacroix (France 1956)

PDDLE (UK 1970)

French Curviameter (France 1973)

Airfield Rolling Weight Deflectometer by Quest Inc (US 1990's)

Applied Research Associates RWD (US 2000)

Traffic Speed Deflectometer by Greenwood (Denmark 2001)

RAPTOR by Dynatest (Denmark 2018)

ERPUG

Dynatest®

2011	Dynatest initiates a project together with DTU (Technical University of Denmark) for developing a RWD, partially funded by the Innovation Fund Denmark
2013	Dynatest acquires a patent on the new principle of the RWD, utilizing image correlation for deriving deflection data
2015	The project ends with a functional prototype
2016	Dynatest and DTU initiates a new project called AWAPAVE, for developing a mature product based on the RWD technology. DTU leads the modelling effort towards back calculation.
2018	Dynatest starts offering high speed deflection measurements

Basic Principle

GOCATOR 2300 SERIES MODELS	2320	2330	2340	2350	2370	2380
Data Points / Profile	1280	1280	1280	1280	1280	1280
Linearity Z (+/- % of MR)	0.01	0.01	0.01	0.01	0.04	0.04
Resolution Z (mm)	0.0018 - 0.0030	0.006 - 0.014	0.013 - 0.037	0.019 - 0.060	0.055 - 0.200	0.092- 0.488
Resolution X (mm) (Profile Data Interval)	0.014 - 0.021	0.044 - 0.075	0.095 - 0.170	0.150 - 0.300	0.275 - 0.550	0.375 - 1.100
Repeatability Z (µm)	0.4	0.8	1.2	2	8	12
Clearance Distance (CD) (mm)	40	90	190	300	400	350
Measurement Range (MR) (mm)	25	80	210	400	500	800
Field of View (FOV) (mm)	18 - 26	47 - 85	96 - 194	158 - 365	308 - 687	390 - 1260
Recommended Laser Class	2M	2M	3R	3R	3B	3B
Other Laser Classes	3R	3R, 3B	3B	3B		
Dimensions (mm)	Side Mount 35x120x149.5	Top Mount 49x75x142	Top Mount 49x75x197	Top Mount 49x75x272	Top Mount 49x75x272	Top Mount 49x75x272
Weight (kg)	0.8	0.74	0.94	1.3	1.3	1.3

Laser-based surface profilers

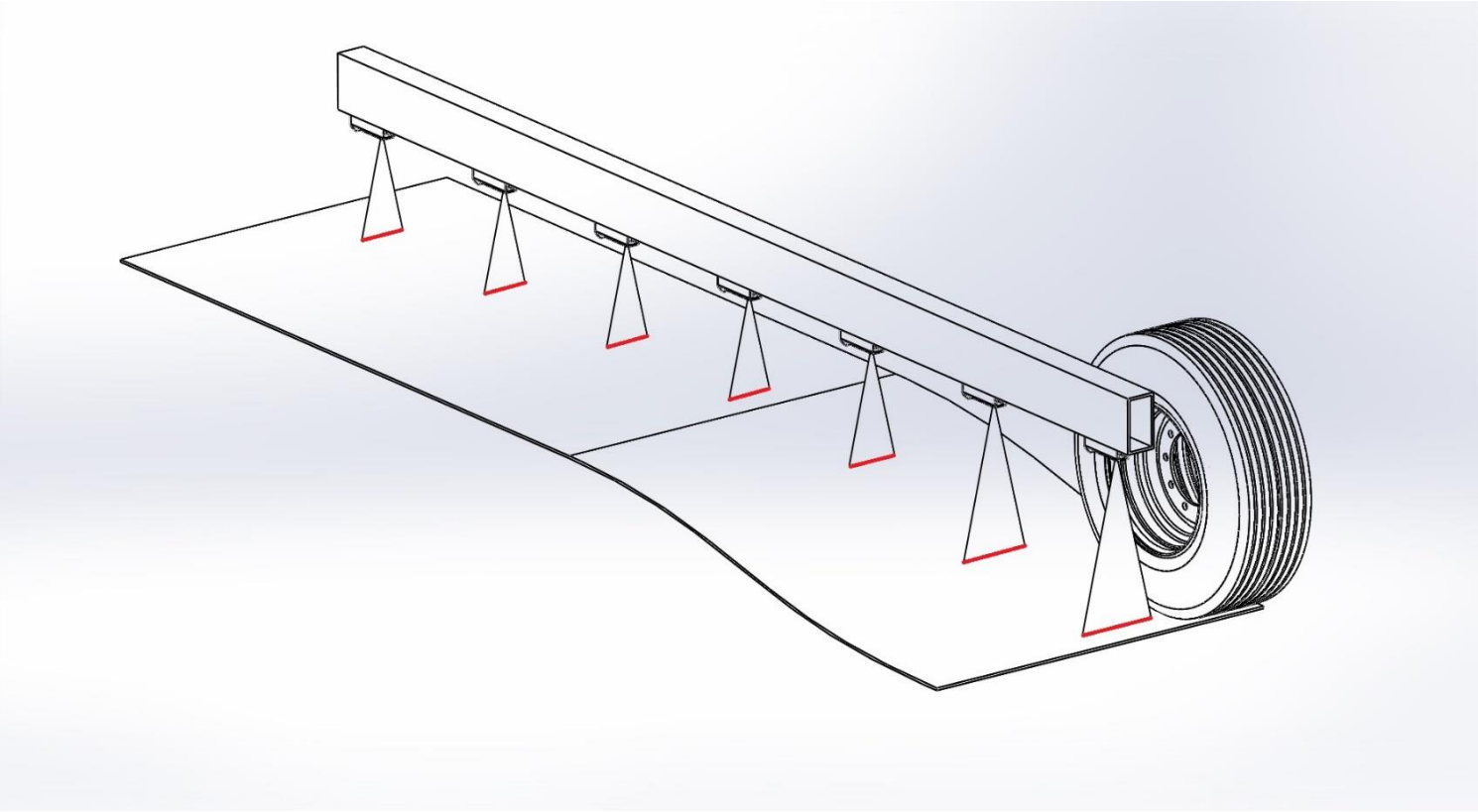
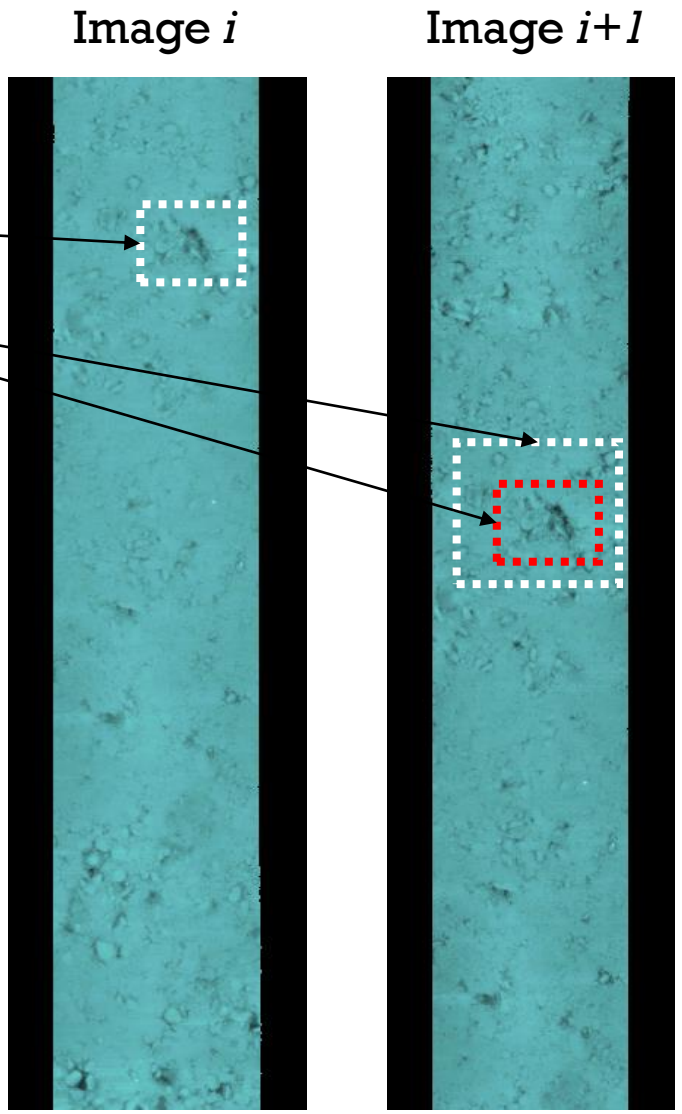


Image scan from several laser profilers for image recognition

- Define template in image from Gocator *i*
- Define search area in Gocator *i+1*
- Nomalized cross-correlation finds best match
- Calculate deflection - Harr algorithm or other



Deflections

d_0

d_1

d_2

d_3

Slopes

$S_1 = d_0 - d_1$

$S_2 = d_1 - d_2$

$S_3 = d_2 - d_3$

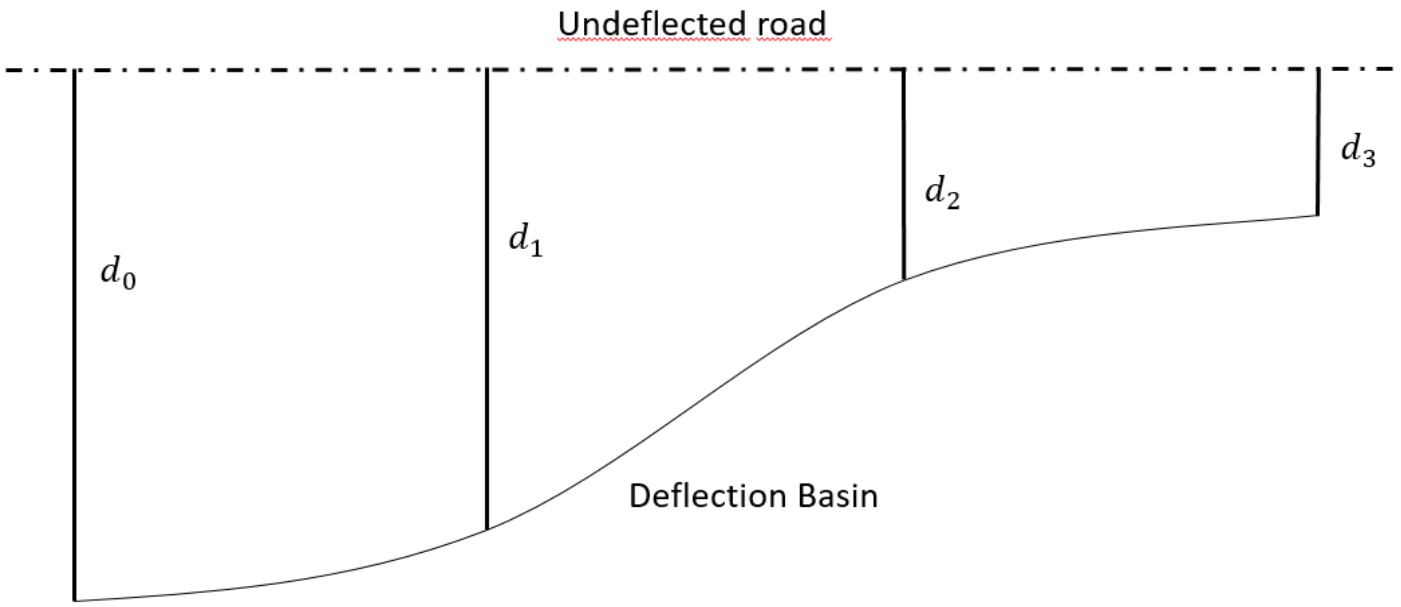
Curvatures

$C_1 = S_1 - S_2 = d_0 - 2d_1 + d_2$

$C_2 = S_2 - S_3 = d_1 - 2d_2 + d_3$

Curvature difference

$CVD = C_1 - C_2 = d_0 - 3d_1 + 3d_2 + d_3$



Design Features

Axle-free trailer

No rear axle will allow lasers to be positioned inline the centre of the wheel load.

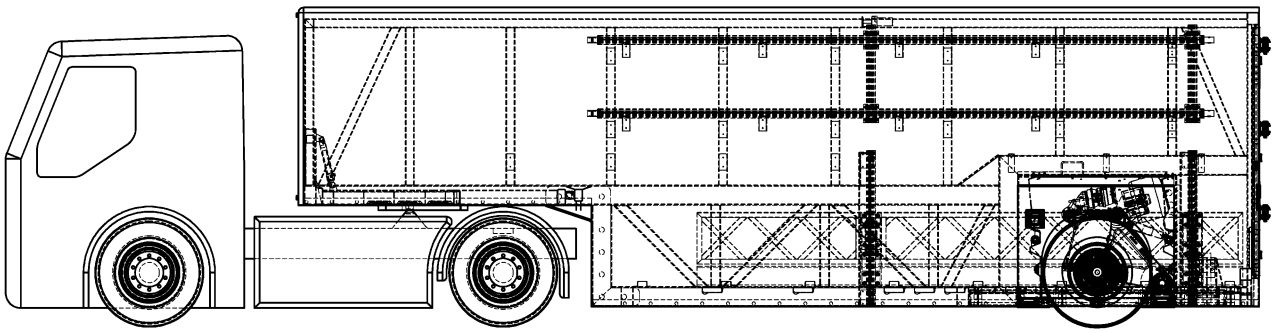
Also allows the ballast to be slid into the trailer system.

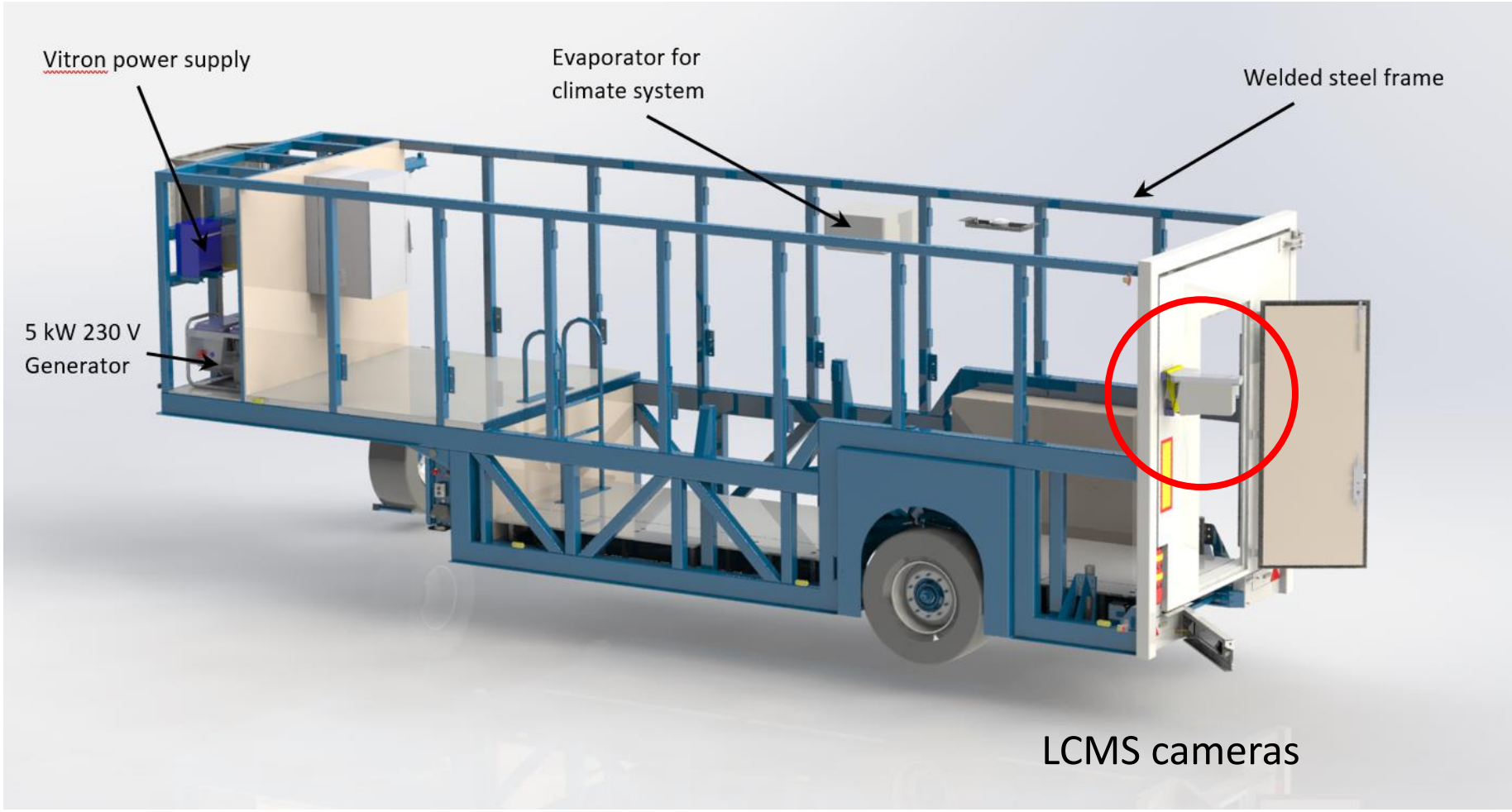
Air Suspension

The air suspension allows higher payloads, easy loading of ballast, low center of gravity and low crosswind sensitivity.

Self Calibrating System

Allow calibration of laser sensors before starting a test.




Vitron power supply
Evaporator for climate system
Welded steel frame
5 kW 230 V Generator
LCMS cameras

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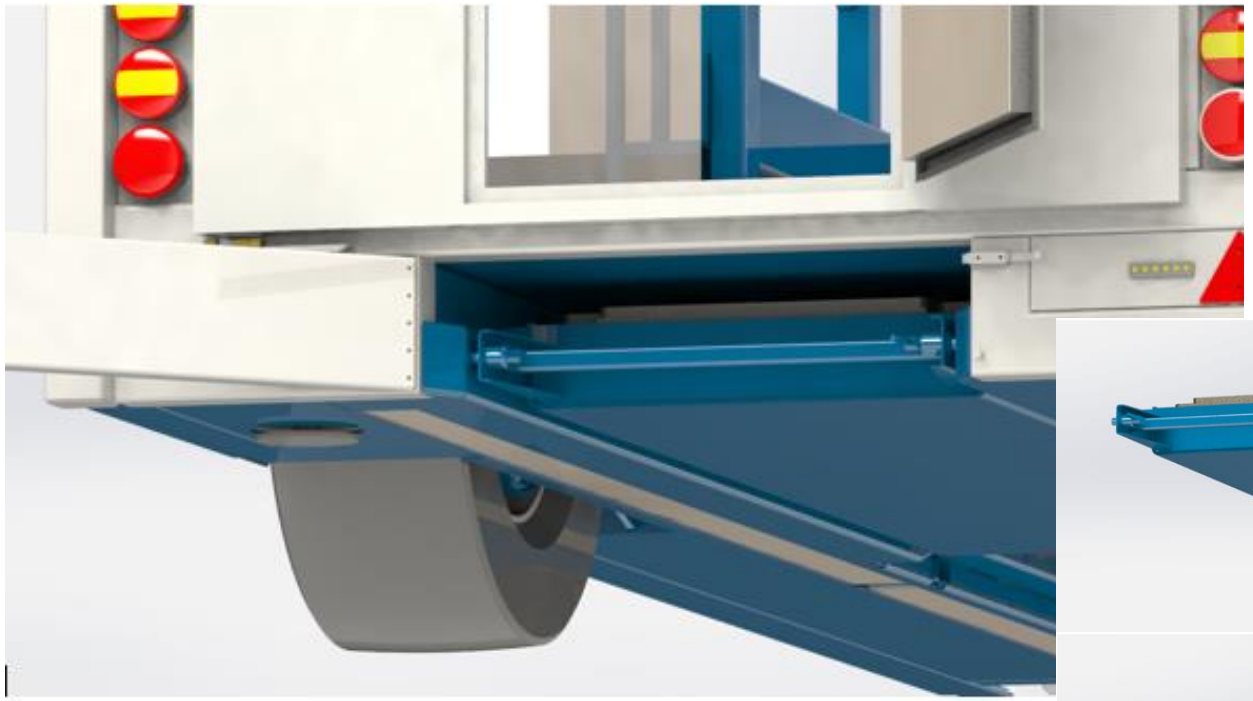
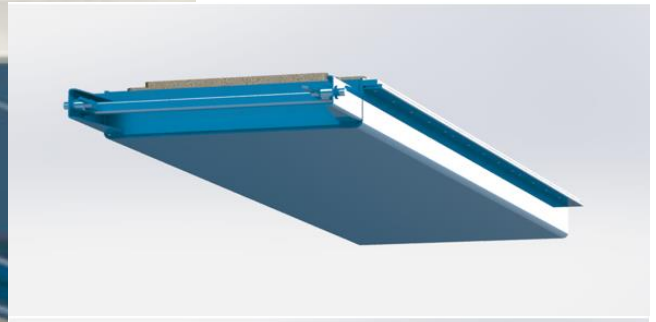
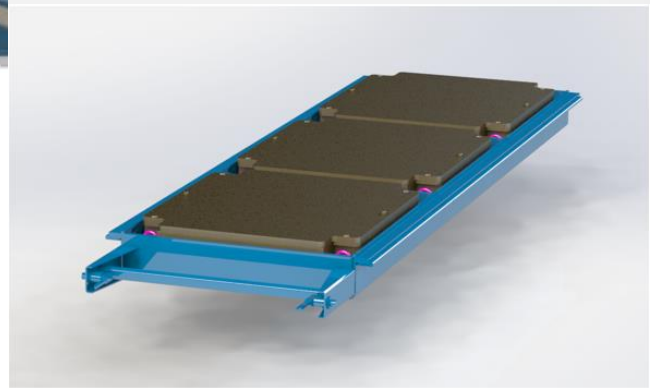
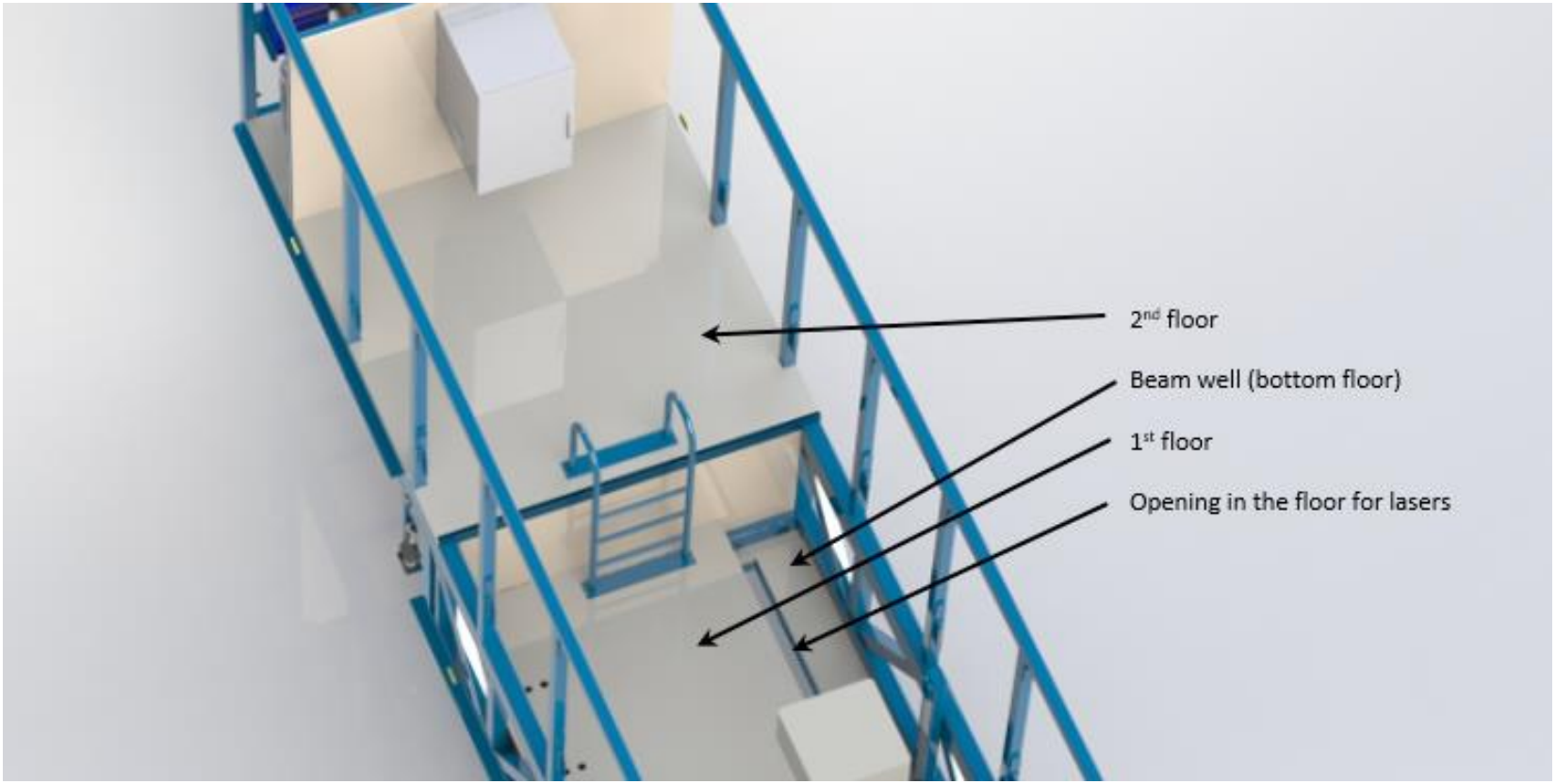







2nd floor
Beam well (bottom floor)
1st floor
Opening in the floor for lasers


ABUS

	RAPTOR	Bus
Trailer Length (m)	9.5m	-
Total Length (m)	13.0	13.0
Width (m)	2.50	2.55
Height (m)	3.15 to 3.55	3.75

Can survey local roads where highest rates of deterioration are most likely.

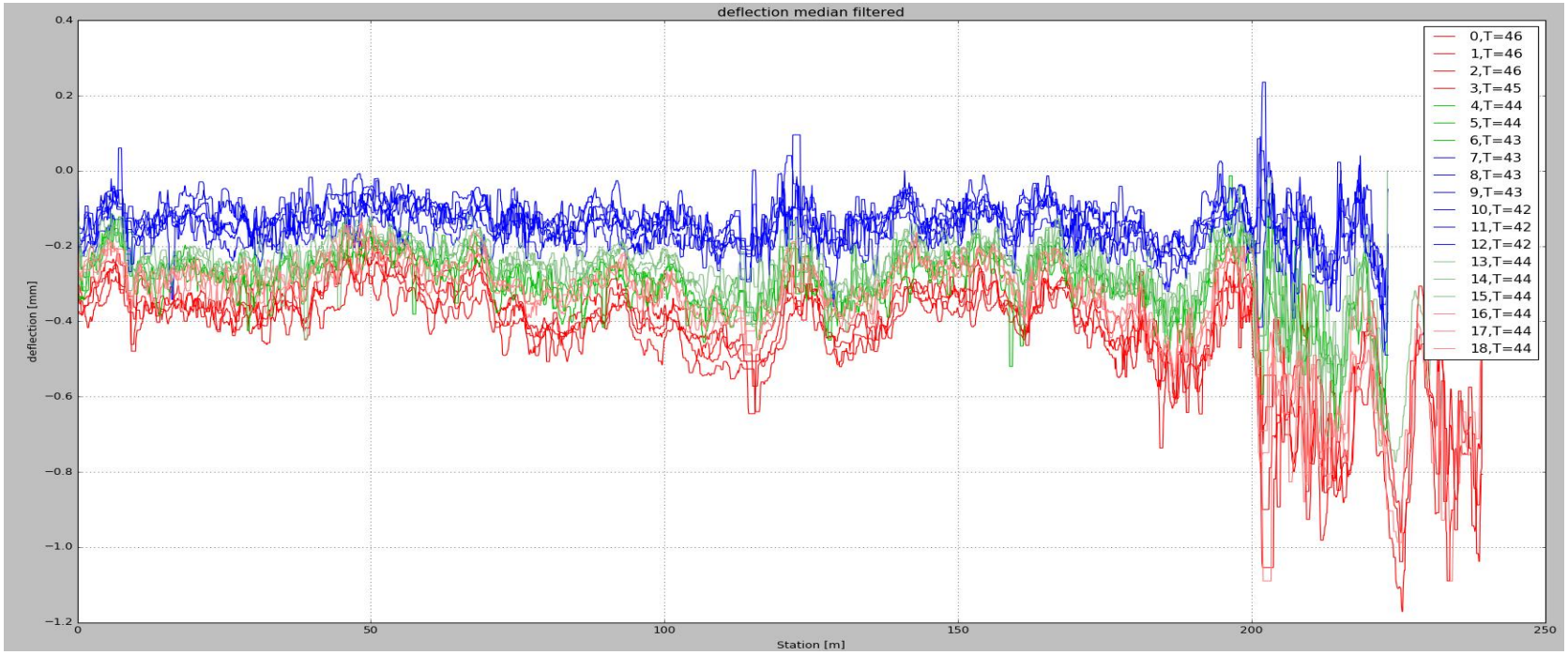
Main Features:

- Road friendly air suspension – higher loads allowed
- Easy loading of test systems and ballast
- Low center of gravity
- Low crosswind sensitivity
- Shift beam to either side
- Integrated calibration system

Test Data

Repeatibility - Loading

- Central deflection
- 19 repetitions
- 3 different loads
- 250m test length
- 2.5 meter average



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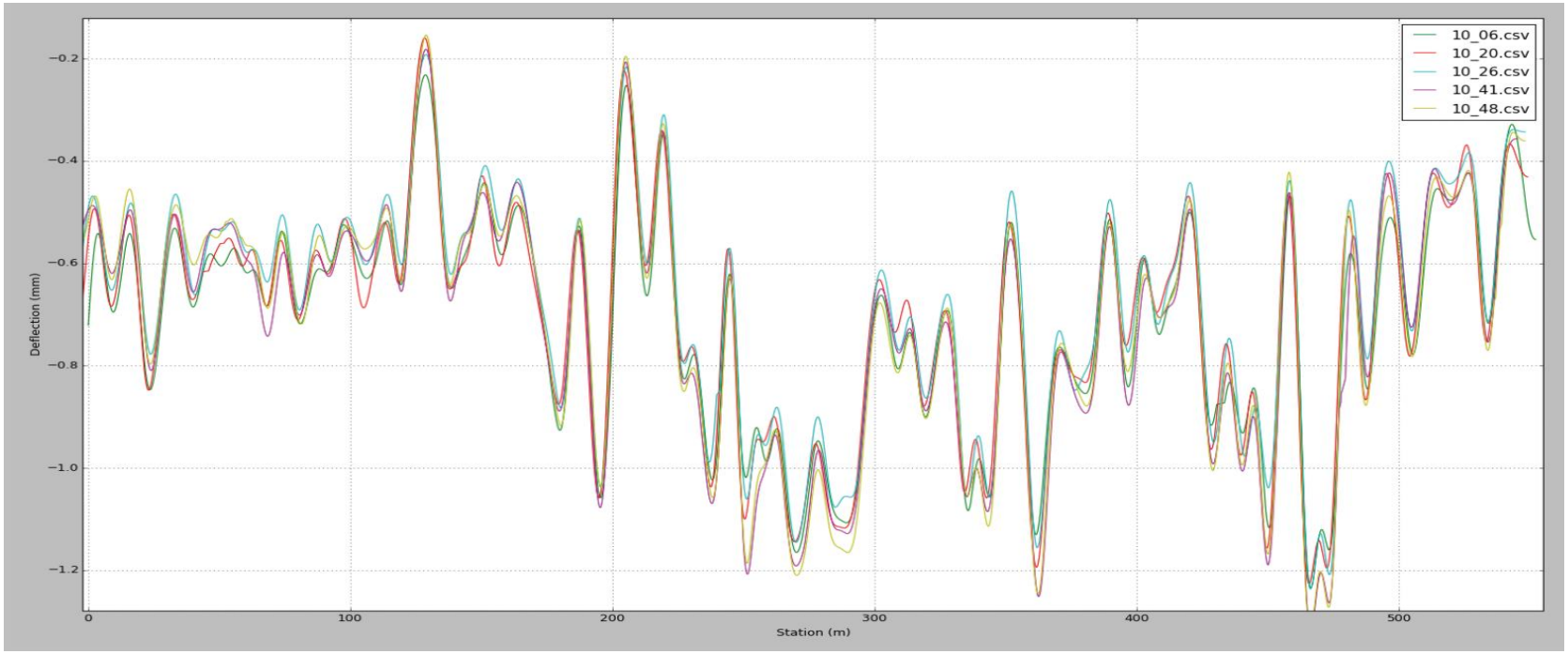
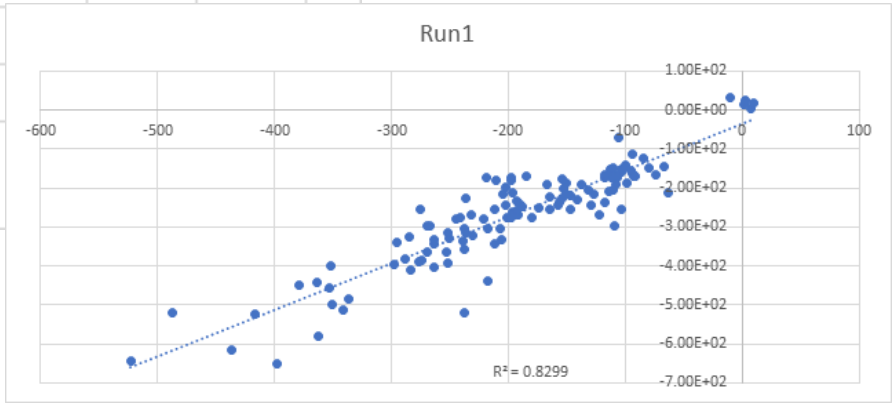
Repeatibility - Speed

- Central deflection
- 5 repetitions
- 2 Speeds (25kph and 40kph)
- 550m test length
- 10 meter average



Validation – RAPTOR vs FWD

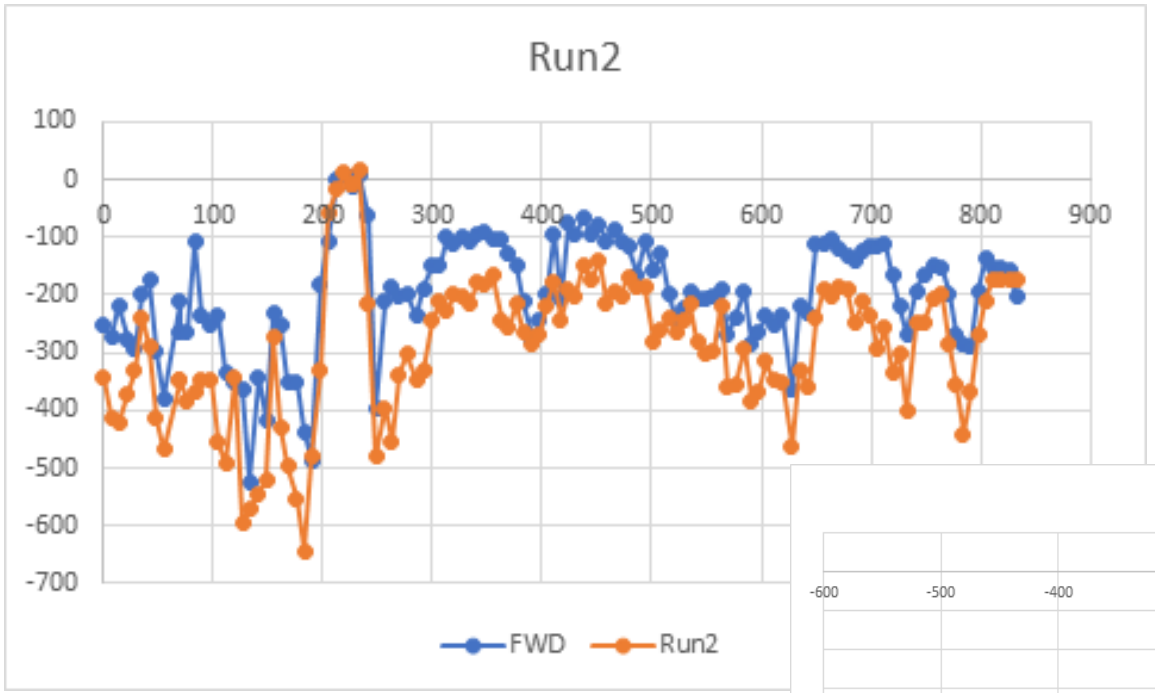
- 850m Comparison site will be tested throughout the year
- Test locations every 10m

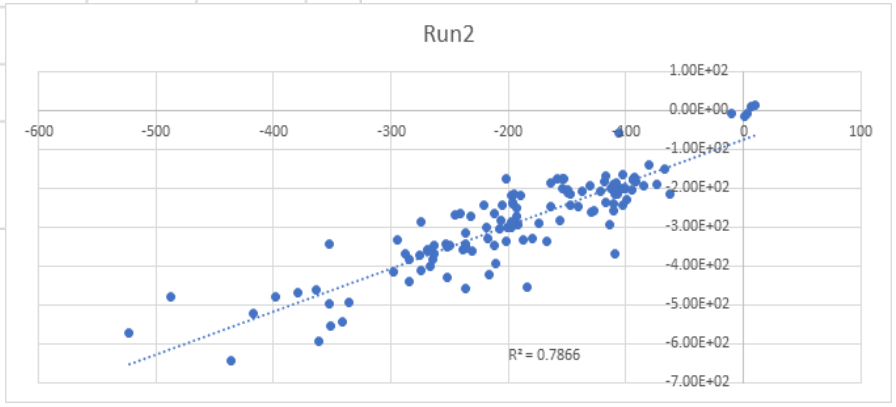


R2 = 0.8299

Validation – RAPTOR vs FWD

- 850m Comparison site will be tested throughout the year
- Test locations every 10m

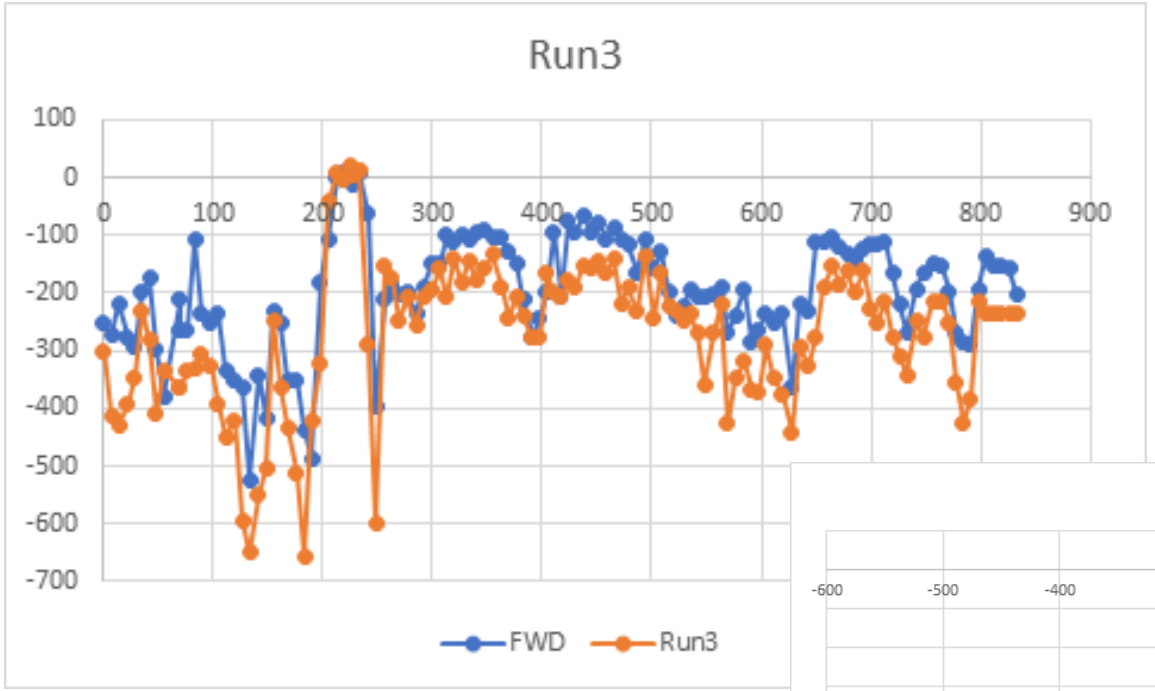


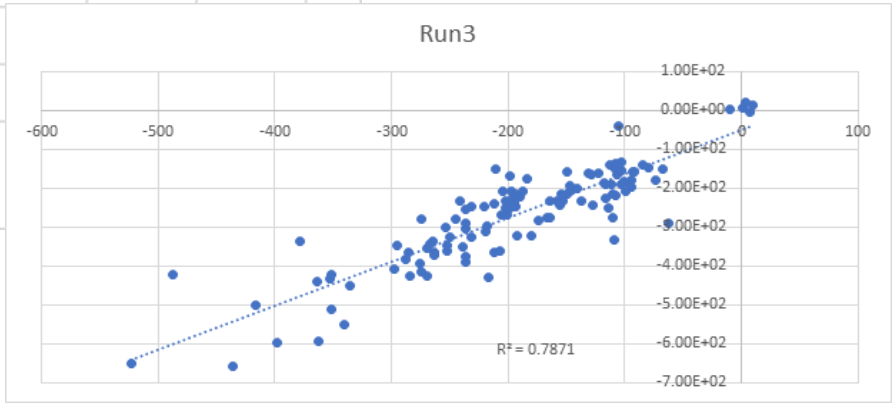


R2 = 0.7866

Validation – RAPTOR vs FWD

- 850m Comparison site will be tested throughout the year
- Test locations every 10m





R2 = 0.7871

Validation – RAPTOR vs FWD

- 200m Site
- Test locations every 5m

Next Steps

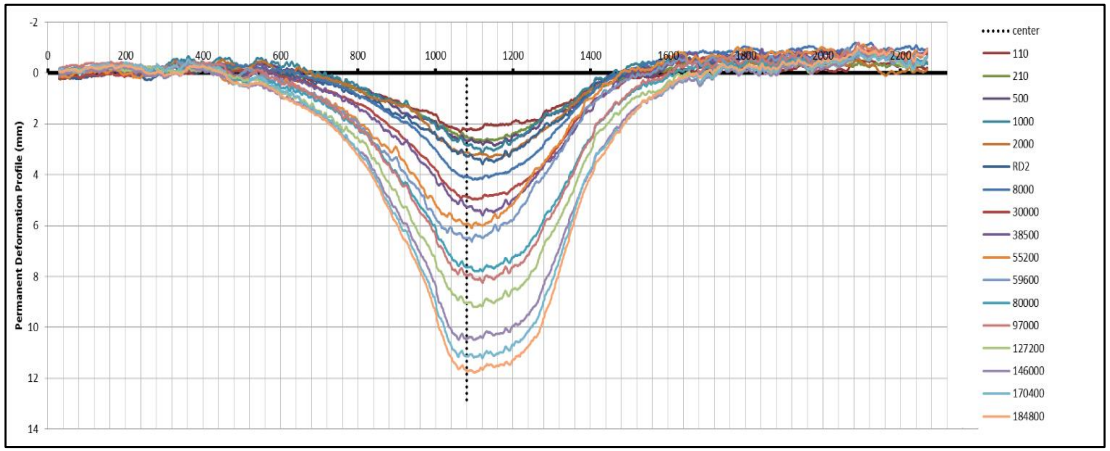
- Continue with FWD vs RAPTOR correlation
- Possibly expand the analysis to include layer stiffness levels
- Add LCMS cameras
- Maybe add GPR but improvements within the analysis of this data will be needed
- Maybe add LiDAR
- First commercial survey April 2018

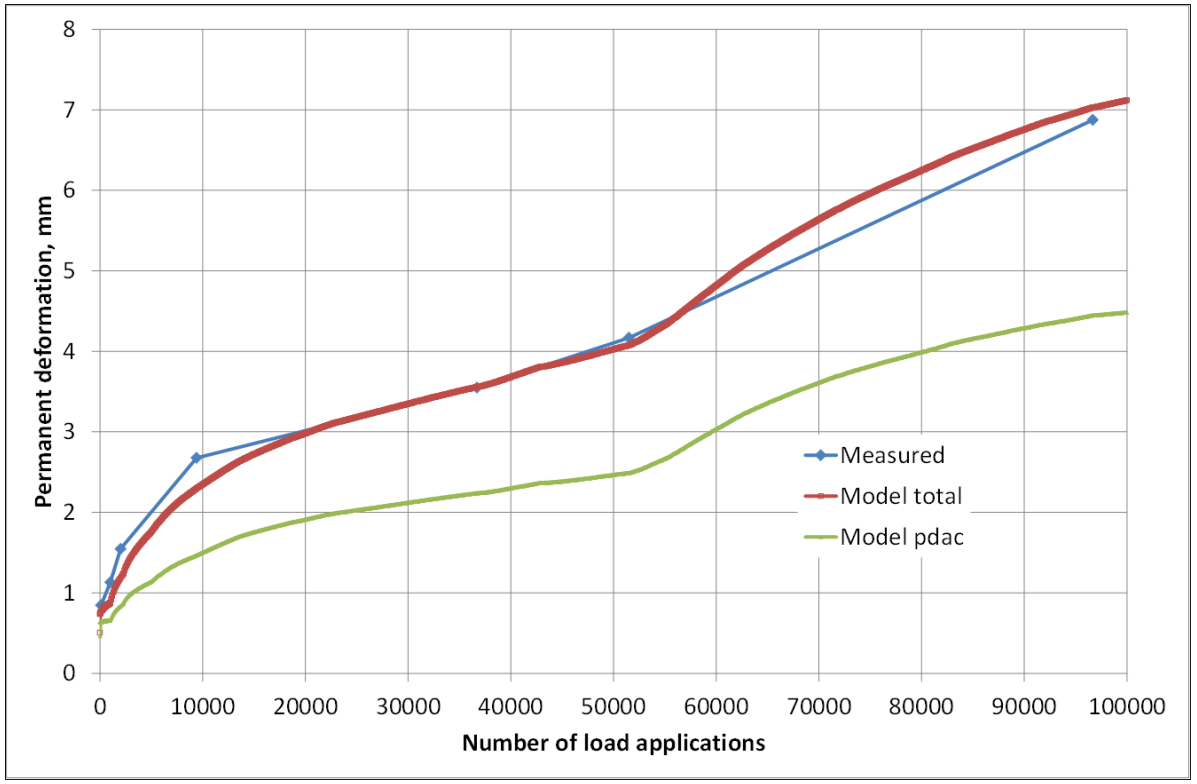
Incorporate other Dynatest equipment

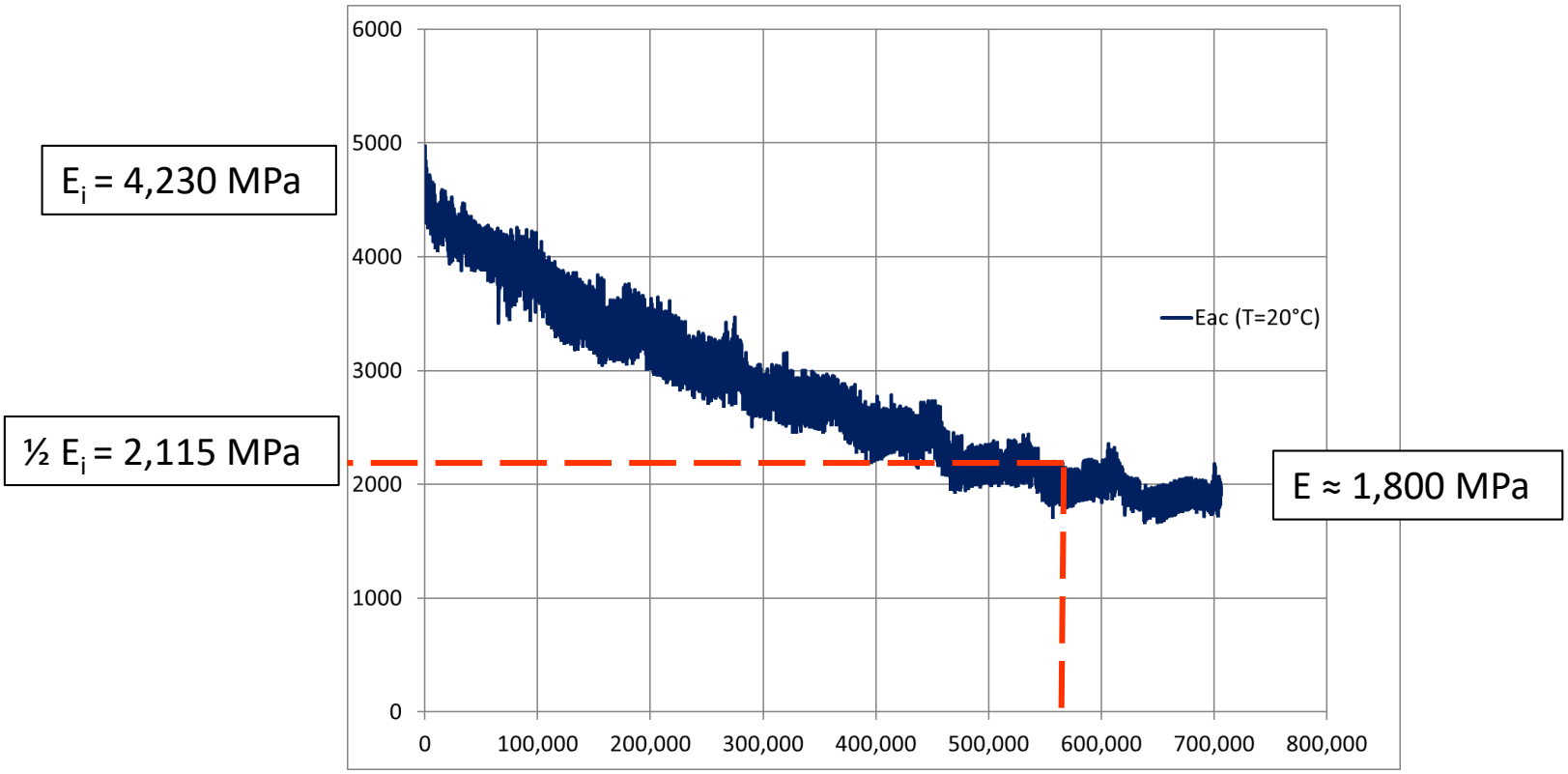
RAPTOR (including LCMS)

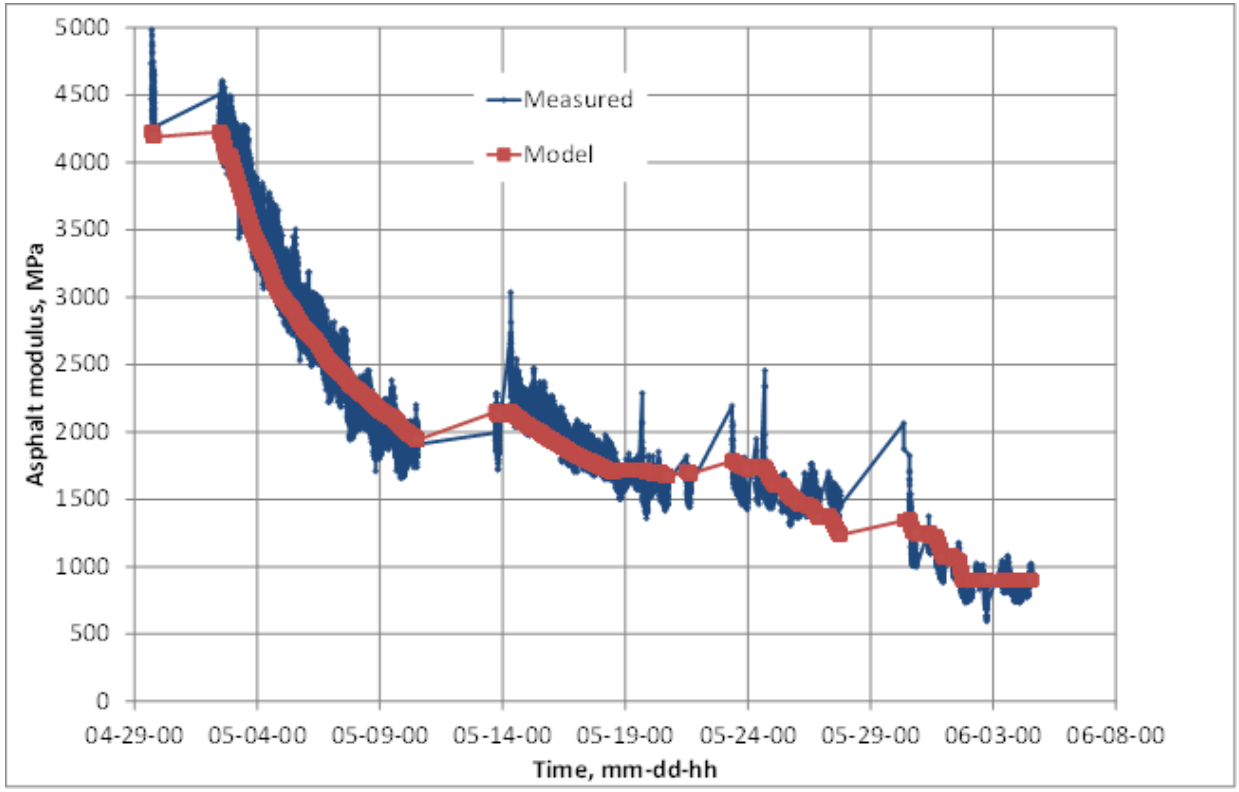
Fast Falling Weight Deflectomter (FFWD)

FFWD Accelerated Pavement Tester (FFWD-APT)

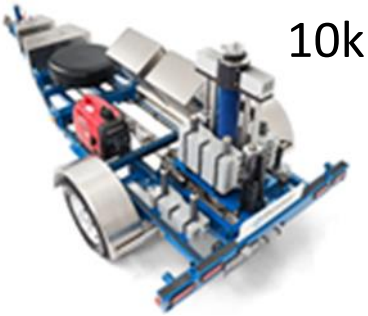

Permanent Deformation Profile (mm)
-2
0
2
4
6
8
10
12
14
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
center
110
210
500
1000
2000
RD2
8000
30000
38500
55200
59600
80000
97000
127200
146000
170400
184800


Permanent deformation, mm
0
1
2
3
4
5
6
7
8
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
Number of load applications
Measured
Model total
Model pdac


E_i = 4,230 MPa
½ E_i = 2,115 MPa
E ≈ 1,800 MPa
Eac (T=20°C)
6000
5000
4000
3000
2000
1000
0
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
800,000


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Asphalt modulus, MPa
Measured
Model
04-29-00
05-04-00
05-09-00
05-14-00
05-19-00
05-24-00
05-29-00
06-03-00
06-08-00
Time, mm-dd-hh

100km to 350km per day



10km per day

1 location per day

Speed of Survey

Level of Information

Thank you