Auger Roll Over

February 2018 – ver 1.0

Author - DA Brand

CONCUSION

5 Why Analysis

What happened?

Tanker 15033 over turned onto Truck D915

1. Tanker fell onto the truck because the fifth wheel/ king pin coupling broke.
2. The laden tanker was at an acute angle to the truck and in a rapid body roll.
3. The combination was making a sharp U-turn on a sloped area.
4. The driver had to modify his approach to the turning area due to an obstruction in the road.
5. It is unknown why the obstruction was dumped in the approach path.

Conclusion

It is concluded that the driver modified the standard approach to the safe area due to an obstruction. It is unknown if the driver acted intentionally, but the fact that he brought the vehicle to a complete stop when he lined up with the obstacle could be telling. The sharp turn induced the fully laden tanker into a rapid body roll (+/- 22.5° per second). The resultant force acting on the coupling was orders of magnitude larger than the safe working limit. This resulted in sudden and complete failure of the coupling.

ORIENTATION

ORIENTATION

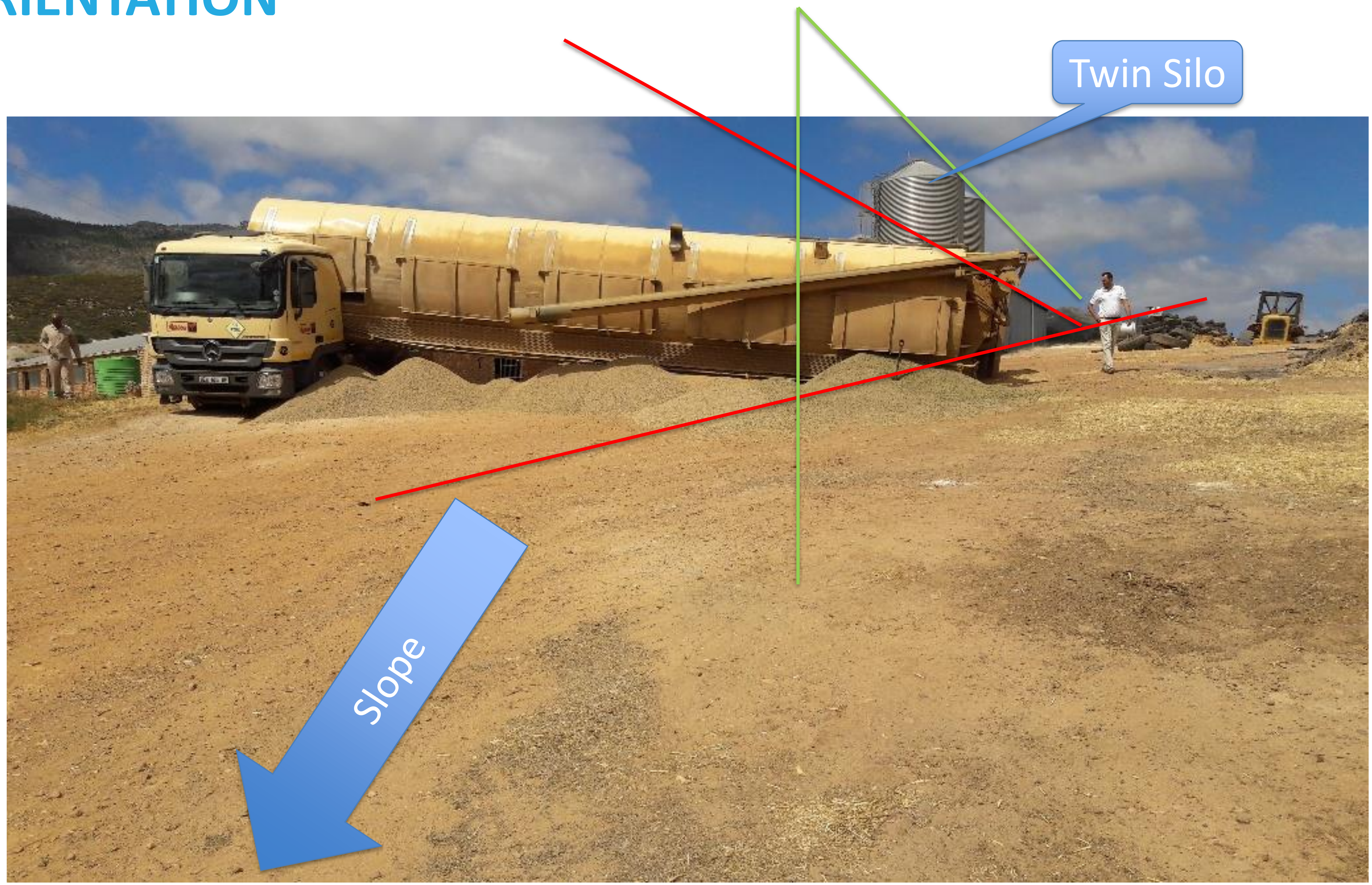
Reference Points

1. Twin Silos
2. Single Silo
3. Tree 1 – Truck Faced
4. Tree 2 – Tanker Faced

Telematics Replay

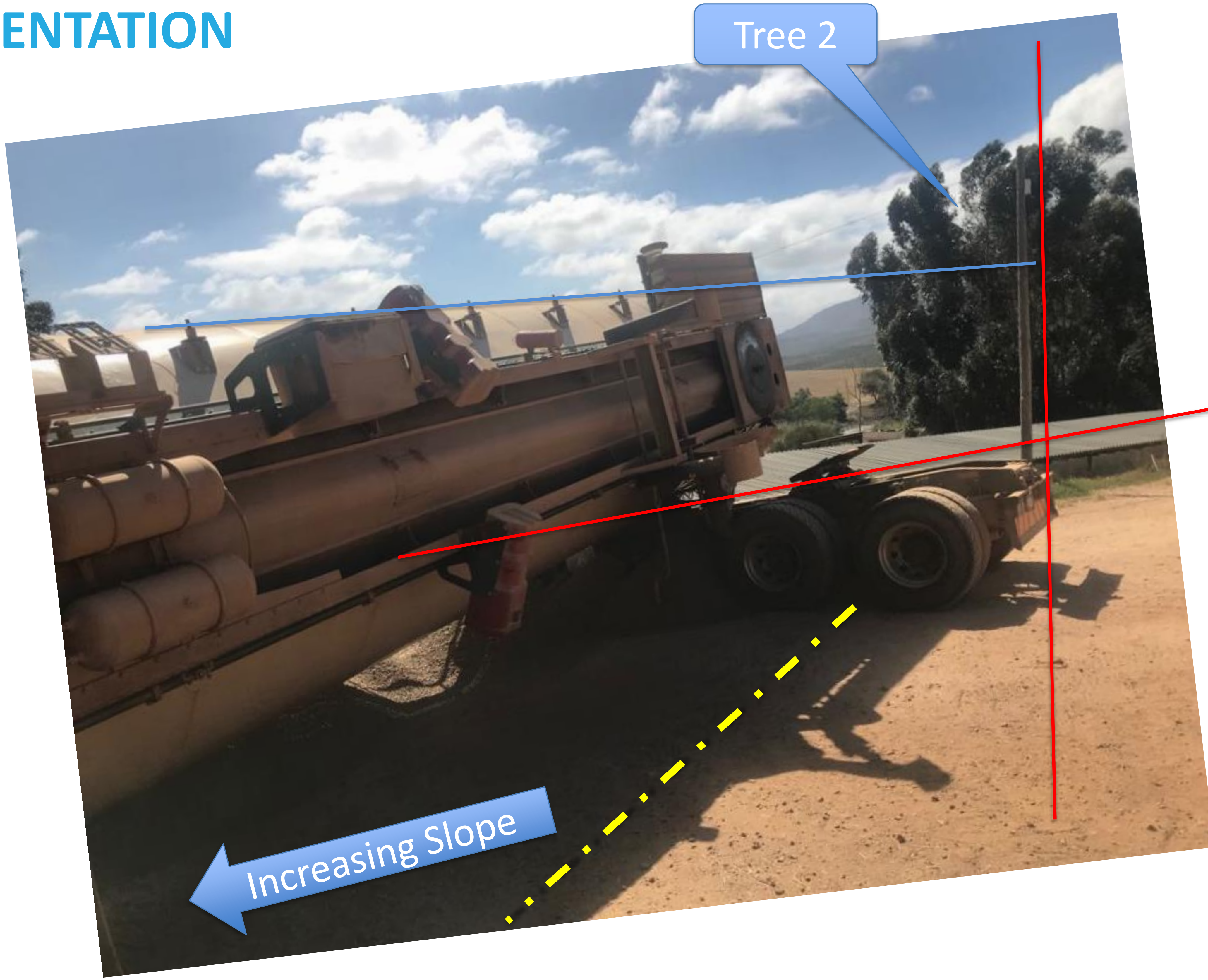
MiX | TELEMATICS

ORIENTATION



ORIENTATION

ORIENTATION



ORIENTATION

ORIENTATION

ORIENTATION

Tree 2

Single Silo

Increased Slope

ORIENTATION

Tree 2

ORIENTATION

Tree 1

Drivecam footage

lytx DriveCam™

ORIENTATION

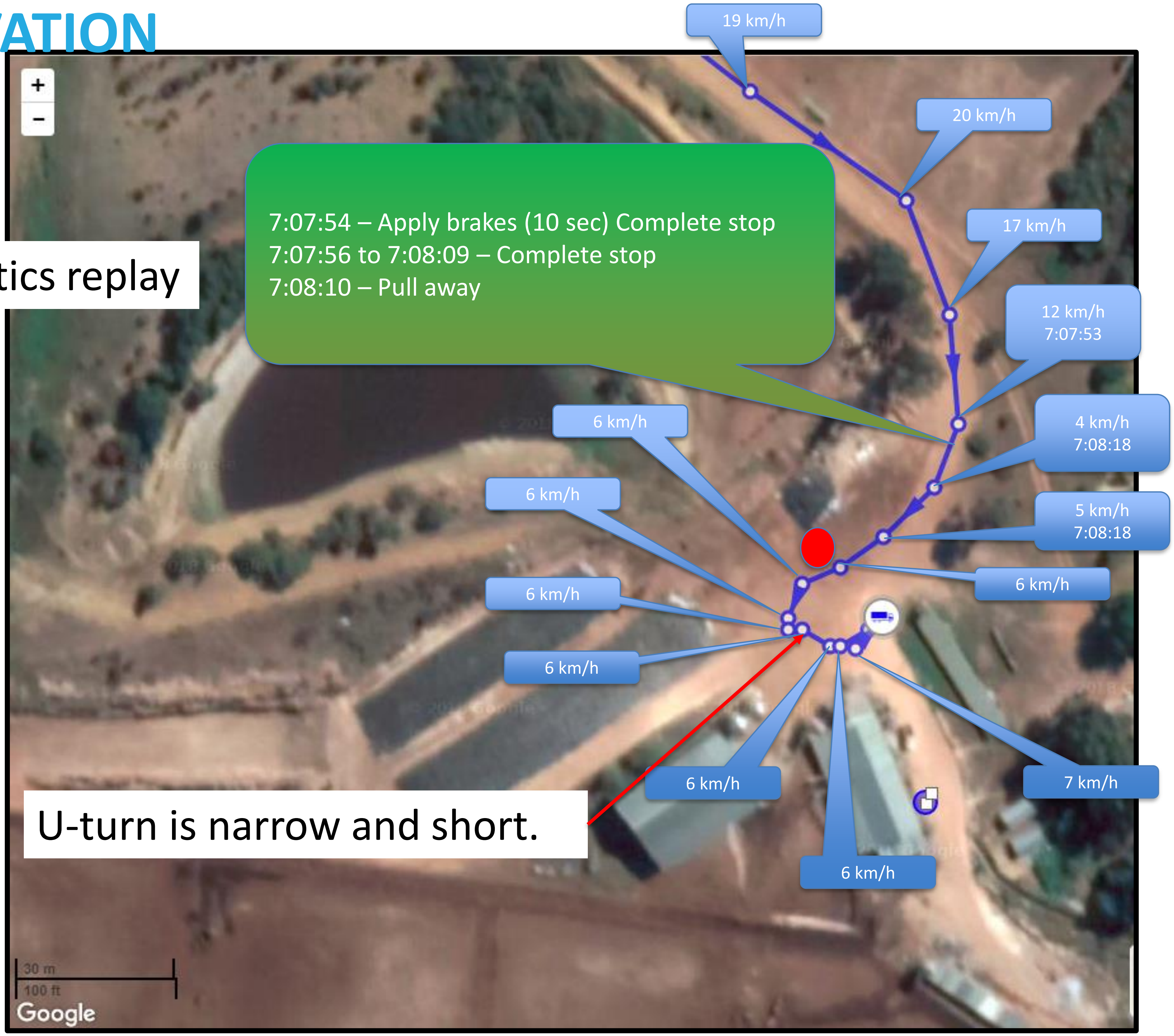
OBSERVATION

AREA OBSERVATIONS

OBSERVATION

Telematics replay

7:07:54 – Apply brakes (10 sec) Complete stop
7:07:56 to 7:08:09 – Complete stop
7:08:10 – Pull away



U-turn is narrow and short.

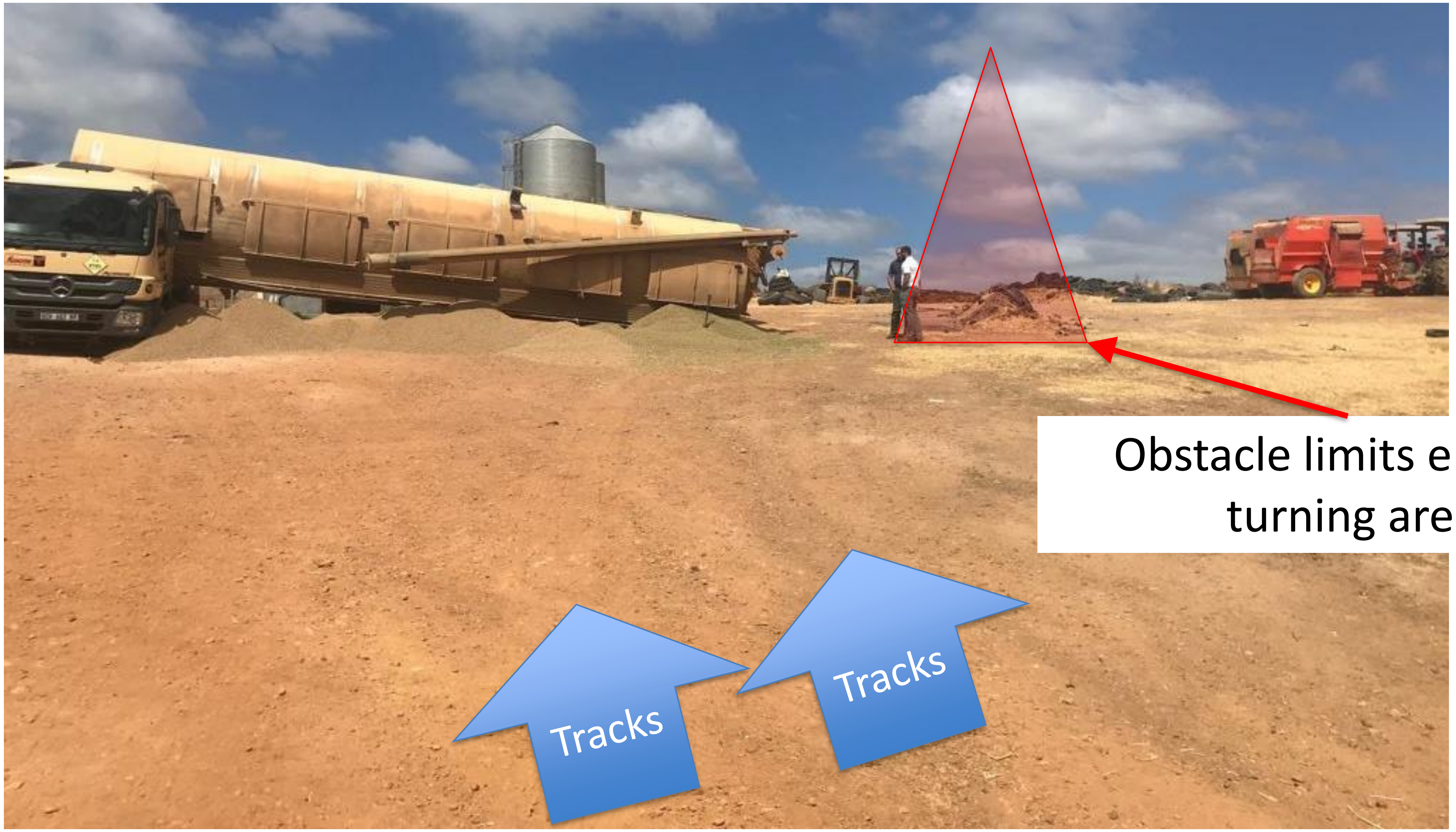
Date (UTC+02:00) Harare, Pretoria	F1 = J1708/CAN - Speed (km/h)	I1 = Foot Brake Used
7:07:53 AM	13	0
7:07:54 AM	8	1
7:07:55 AM	4	1
7:07:56 AM	0	1
7:07:57 AM	0	1
7:07:58 AM	0	1
7:07:59 AM	0	1
7:08:00 AM	0	1
7:08:01 AM	0	1
7:08:02 AM	0	1
7:08:03 AM	0	1
7:08:04 AM	0	0
7:08:05 AM	0	0
7:08:06 AM	0	0
7:08:07 AM	0	0
7:08:08 AM	0	0
7:08:09 AM	0	0
7:08:10 AM	1	0
7:08:11 AM	2	0
7:08:12 AM	3	0
7:08:13 AM	5	0
7:08:14 AM	8	0
7:08:15 AM	8	0
7:08:16 AM	6	0
7:08:17 AM	4	0
7:08:18 AM	4	0

MiX | TELEMATICS

OBSERVATION

Normal "Safe" turning area was not utilised

OBSERVATION



OBSERVATION

Obstacle limits entry to safe turning area

OBSERVATION

Conclusion

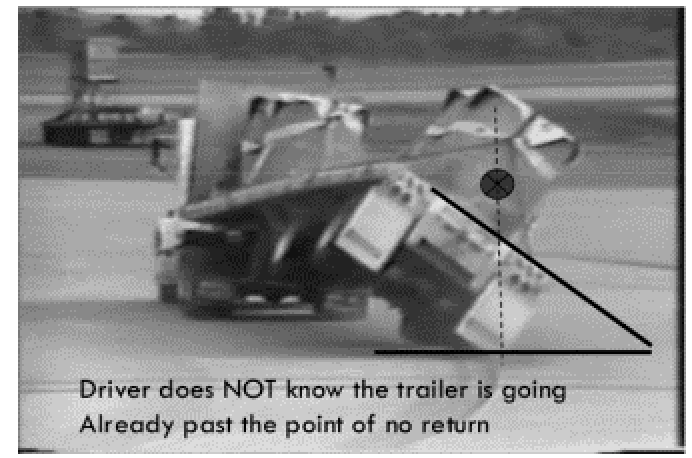
- An obstacle obscured the entry to the safe turning area
- The driver brought the truck to a full stop for 9 seconds before proceeding toward the obstacle.
- The combination performed a very narrow U-turn. In executing the manoeuvre, the combination crossed a ridge of increased slope of 4° to 7°
- The inner wheels dug into the ground.
- The tanker started to tilt while executing the turn. The rate of body roll is estimated a 22.5° per second (Drivecam footage)

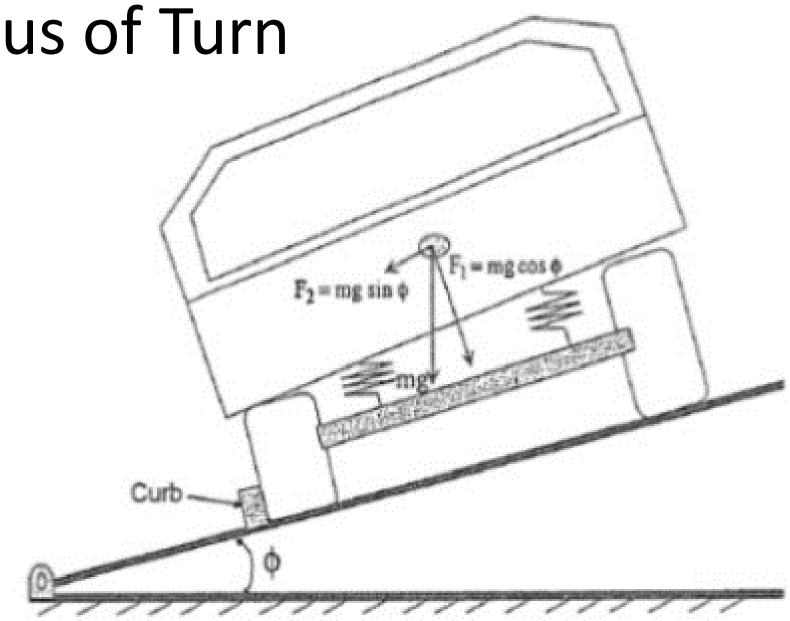
ROLL MECHANISMS

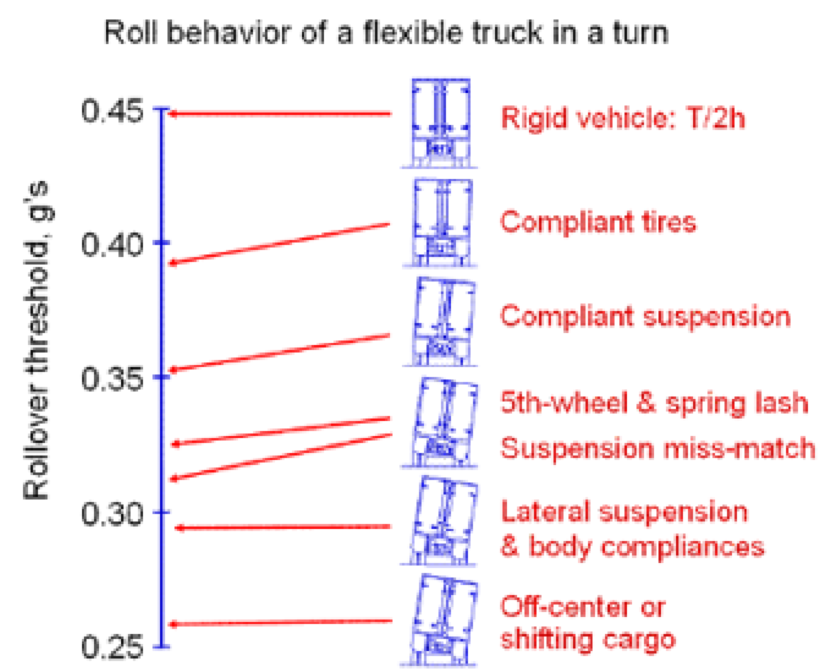
ROLL MECHANISMS

Variable Factors that influence body roll and weight transfer

- Tyre/Road contact area
- Surface angle
- Tyre deflection
- Spring deflection
- Chassis stiffness
- Centre of Gravity Height
- Load Centre – Shift (tank cross-section)
- Velocity of vehicle
- Radius of Turn







Source: Winkler, C.B., et al. *Rollover of heavy commercial vehicles*. Society of Automotive Engineers, Warrendale, 2000, pp. 74. SAE RR-004. ISBN 0-7680-0626-0. Library of Congress: 00-104395

ROLL MECHANISMS

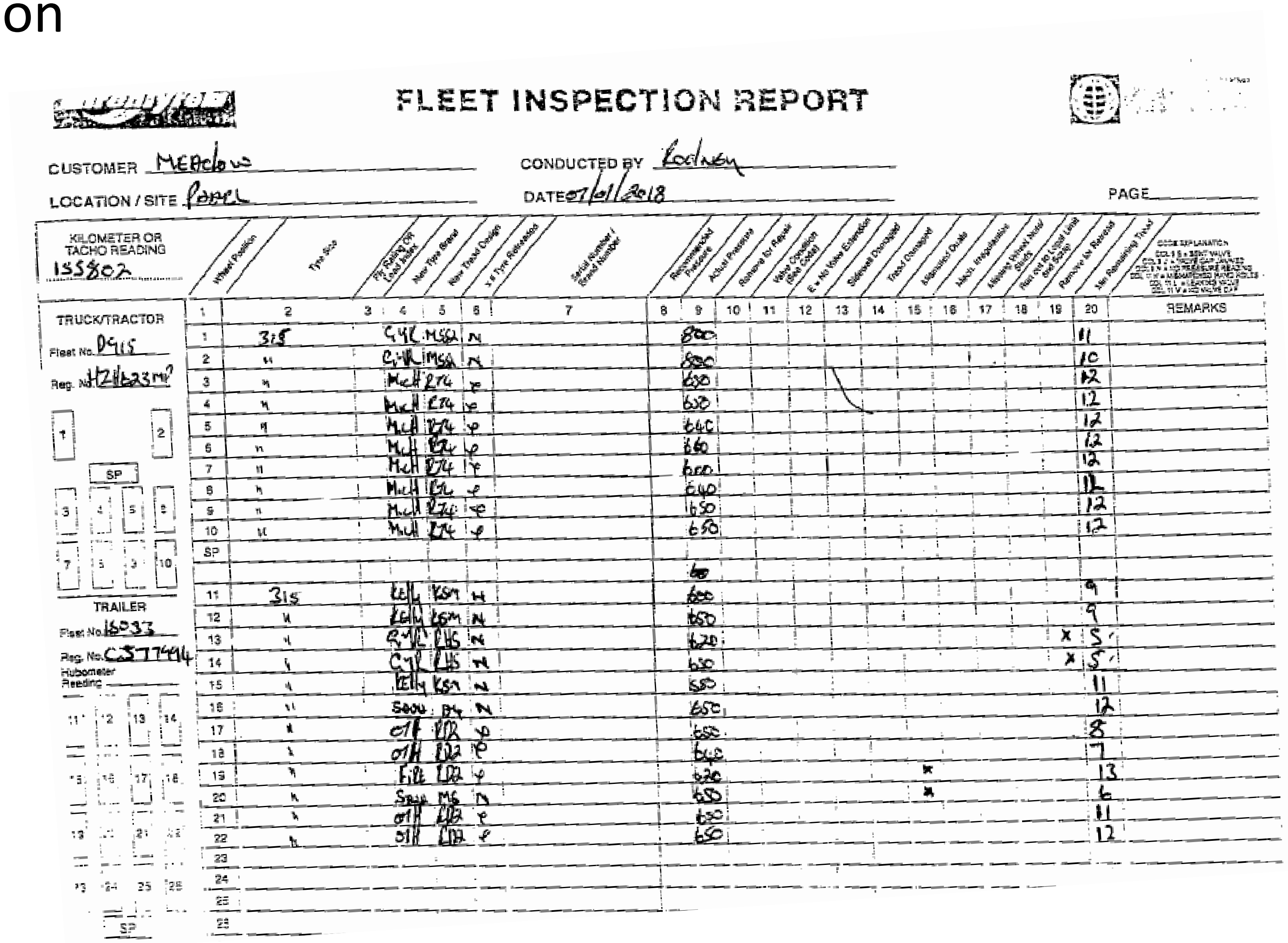
VARIABLE	INFLUENCERS
Tyre/Road Contact Area	• Tyre pressure • Hardness of ground surface • Moisture content
Surface Angle	• Approach relative to slope
Tyre Deflection	• Tyre pressure • Vertical load
Spring Deflection	• Spring Tension (Age) • Vertical load
Chassis stiffness	• Fatigue (Age)
Centre of Gravity	• Product level
Load Shift	• Product – Ease of flow
Velocity of vehicle	• Forward speed
Radius of Turn	• Sharpness of turn

MECHANISM – ROAD SURFACE

- Dry hard ground
- Scuff marks indicates “digging in” of tyres

MECHANISM – TYRE DEFLECTION

- Tyre Survey – 7 January 2018
- All Pressures within recommended pressure
- Inspection of tyres after incident indicates that tyres are within specification



FLEET INSPECTION REPORT

CUSTOMER MEAdows CONDUCTED BY Rodney

LOCATION / SITE Parel DATE 07/01/2018 PAGE

KILOMETER OR TACHO READING 155802

TRUCK/TRACTOR Fleet No. D915 Reg. No. HZH623MP

TRAILER Fleet No. 16033 Reg. No. CS77494 Hubometer Reading

1 Wheel Position	2 Tyre Size	4 New Tyre Brand	5 New Tread Design	6 X if Tyre Retreaded	9 Actual Pressure	15	19 Remove for Retread	20 Min Remaining Tread
1	315	GYR	MSA	N	800			11
2	"	GYR	MSA	N	800			10
3	"	McH	E74	Y	650			12
4	"	McH	E74	Y	650			12
5	"	McH	E74	Y	640			12
6	"	McH	E74	Y	660			12
7	"	McH	E74	Y	600			12
8	"	McH	E74	Y	640			12
9	"	McH	E74	Y	650			12
10	"	McH	E74	Y	650			12
SP								
					600			
11	315	Kelly	KSM	N	600			9
12	"	Kelly	KSM	N	650			9
13	"	GYR	LHS	N	620		x	5
14	"	GYR	LHS	N	650		x	5
15	"	Kelly	KSM	N	650			11
16	"	Sesu	B4	N	650			12
17	"	OTH	LD2	Y	650			8
18	"	OTH	LD2	Y	640			7
19	"	Fil	LD2	Y	620	x		13
20	"	Sava	MS	N	650	x		6
21	"	OTH	LD2	Y	650			11
22	"	OTH	LD2	Y	650			12
23								
24								
25								
26								

REMARKS

MECHANISM – PRODUCT

Ease of flow of product

Load shift was likely during the roll retardation just prior to the coupling failure

MECHANISM

VARIABLE	INFLUENCERS	FINDINGS
Tyre/Road Contact Area	Tyre Pressure	With in Specification
	Surface Hardness	Extremely Hard Ground
Surface Angle	+/- at right angle to slope	Estimate 4° to 7° ground angle Tanker were pulled over by truck up to point of failure
Tyre Deflection	Vertical load	Full tanker mass on outer wheels only. Full deflection
Spring Deflection	Vertical load	Full tanker mass on outer wheels only. Full deflection
Chassis stiffness	Fatigue (age)	2011 year model – 7 years
Centre of Gravity	Product level	Fully loaded – 30,000 kg
Load Shift	Product Ease of flow	Relatively easy to flow. Product shift was probable
Velocity of vehicle	Forward velocity	6 km/h
Radius of Turn	Sharpness of turn	Full lock turn – Drivecam clip

MECHANISM

Conclusion

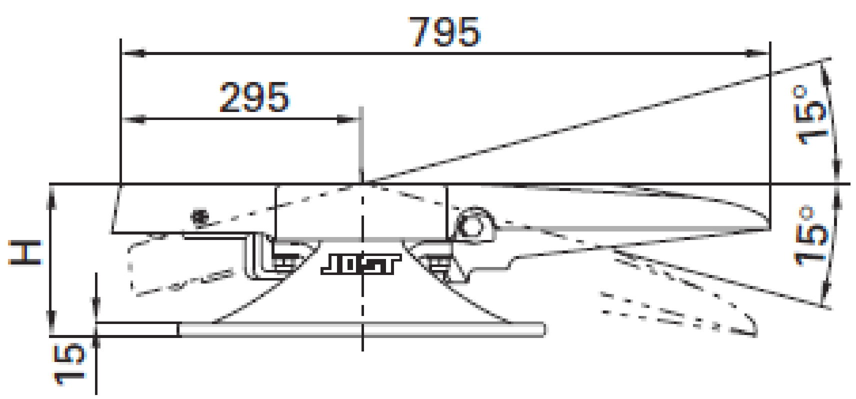
- All mechanical items were within specification
- The tanker were at an acutely sloped angle while simultaneously in a rapid body roll
- Load shift was likely. This would have accelerated the body roll.

COUPLING

COUPLING

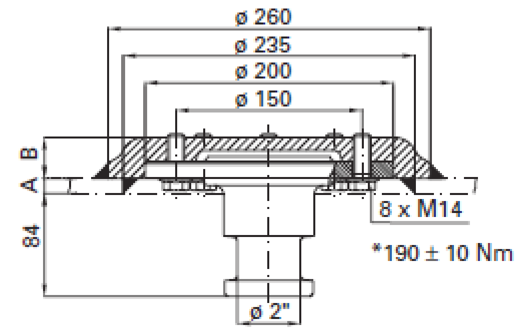
The material shows no “beach marks” of previous cracks.
The failure was instantaneous and catastrophic

COUPLING



Order No.	H (mm)	D value (kN)	Imposed load U (t)	Weight (kg)	Approval EC	Mainte-nance	Handle length
JSK 37 C150						M	K
JSK 37 C150 Z						Z	K
JSK 37 C150 W	150	152	20	149	e1 00-0116	W	K
JSK 37 C150 J						M	J
JSK 37 C150 ZJ						Z	J
JSK 37 C150 WJ						W	J
JSK 37 C170						M	K
JSK 37 C170 Z						Z	K
JSK 37 C170 W	170	152	20	151	e1 00-0116	W	K
JSK 37 C170 J						M	J
JSK 37 C170 ZJ						Z	J
JSK 37 C170 WJ						W	J
JSK 37 C185						M	K
JSK 37 C185 Z						Z	K
JSK 37 C185 W	185	152	20	152	e1 00-0116	W	K
JSK 37 C185 J						M	J
JSK 37 C185 ZJ						Z	J
JSK 37 C185 WJ						W	J

KZ 1012



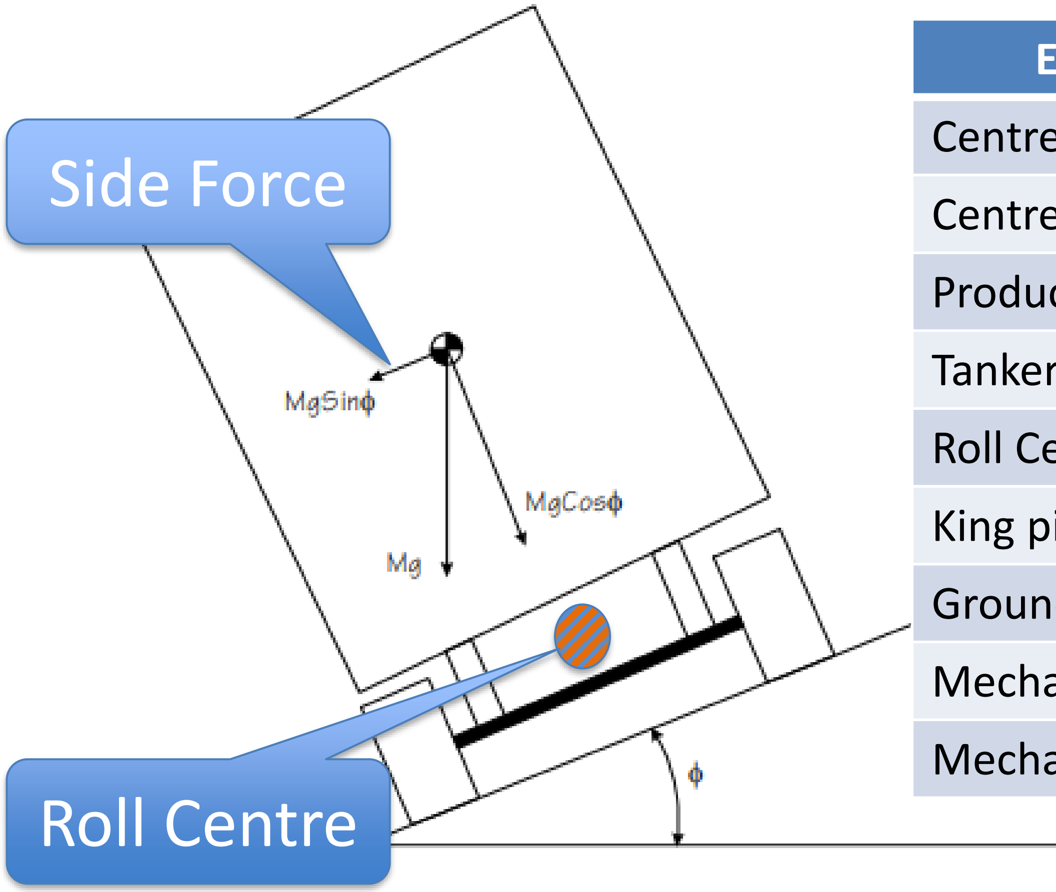
Selection table / Versions available

Order No. King pin, complete	D value (kN)	Dimensions (mm) A	B	Approval EC
KZ 1008	162	8	37	e1 00-0145
KZ 1010		10	34	
KZ 1012		12	33	
KZ 1410	162	10	34	e1 00-0147
KZ 1412		12	33	

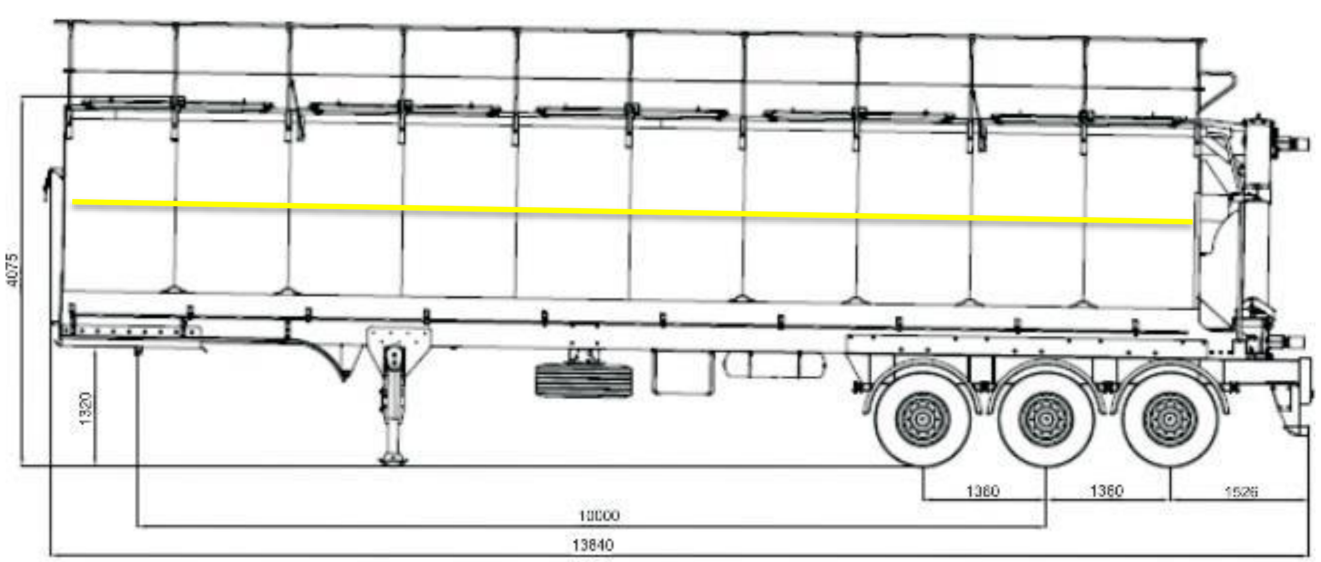
Maximum tilt allowed by Jost is 15°
The fifth wheel was execively over extended prior to failure

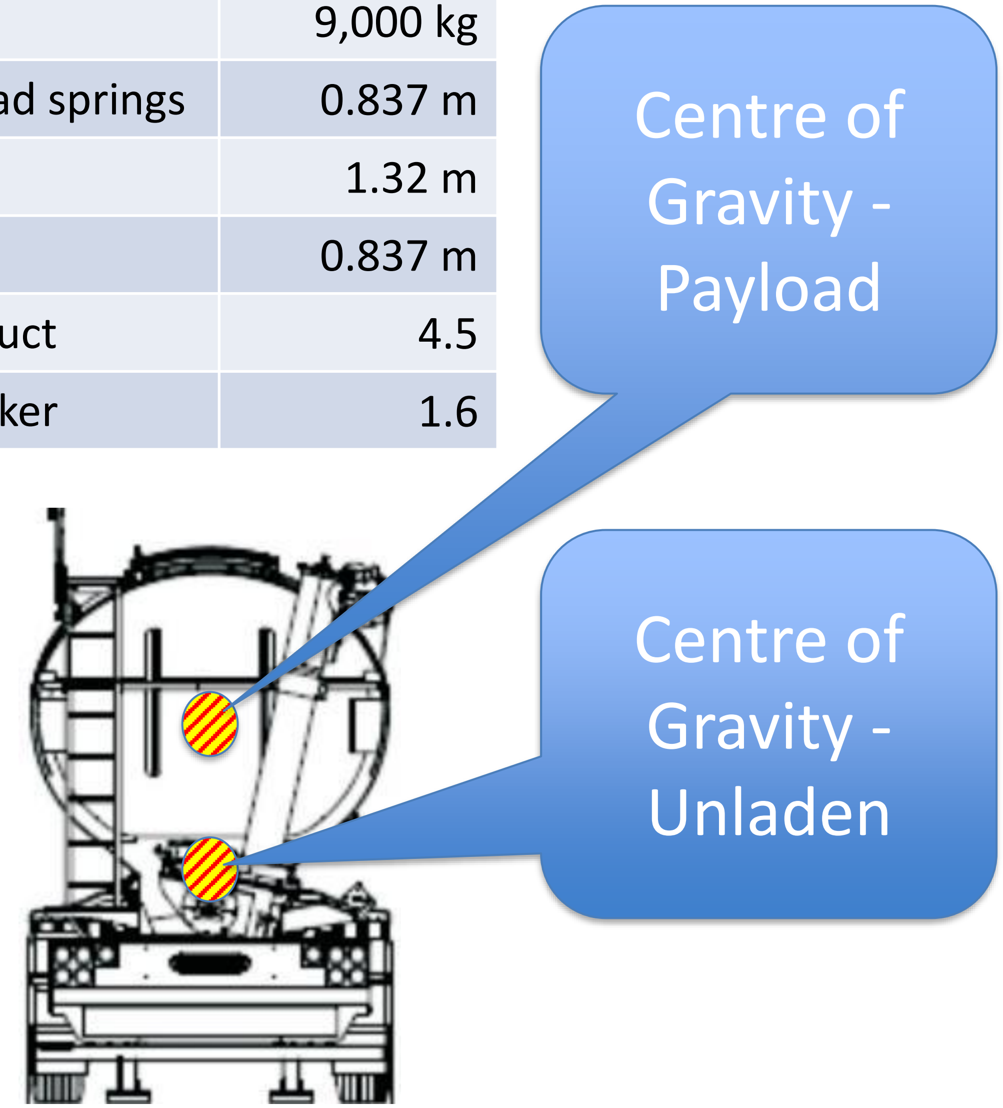
Fifth wheel and king pin were within specification and complies to regulations

COUPLING



ESTIMATED VALUES AS USED IN CALCULATIONS	
Centre of Gravity – Unladen Tanker	1.6 m
Centre of Gravity – Product	3 m
Product mass	30,000 kg
Tanker Tare mass	9,000 kg
Roll Centre – Centred between road springs	0.837 m
King pin height	1.32 m
Ground to Roll Centre	0.837 m
Mechanical Leverage Ratio – Product	4.5
Mechanical Leverage Ration – Tanker	1.6





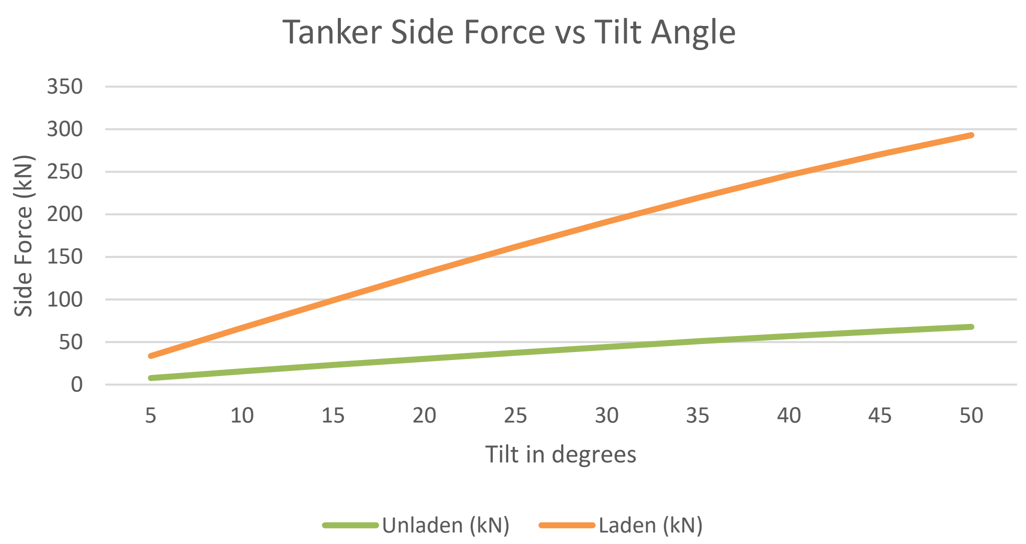
COUPLING

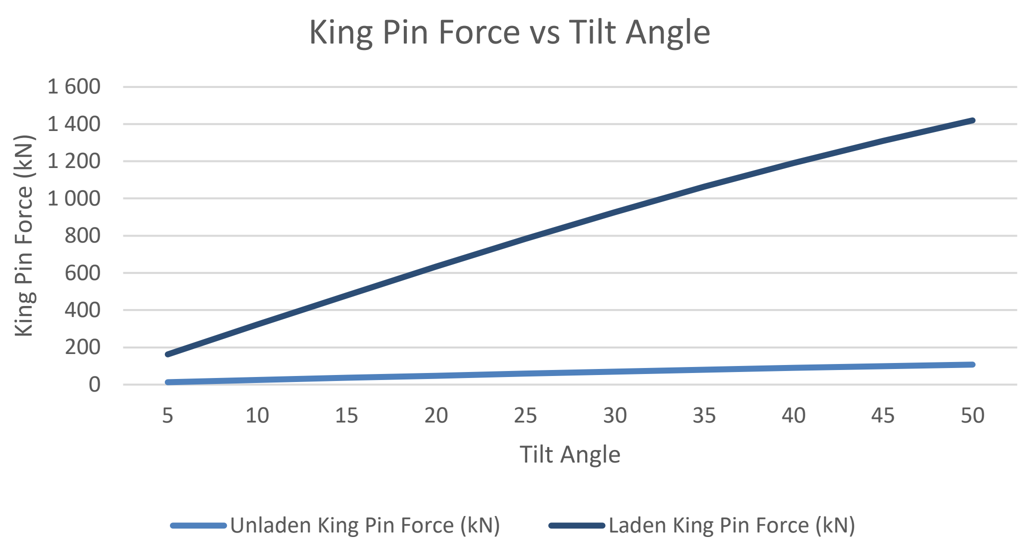
Tilted Unladen Tanker (Stationary – no rate of body roll)

No coupling failure experienced

Estimate angle 30° to 40°

COUPLING





A static, fully laden tanker at tilt of 30° to 40° generates +/- 1,000 kN at the king pin.
The effect of the dynamic roll motion was not taken into consideration, but would add significantly to the resultant force.

The Fifth Wheel and King Pin failed due to an upward force
No destructive testing is done nor legally required in this direction of action

Only two specifications are published for fifth wheels

	Jost 37C – 2" king pin	Jost 38C – 2" king pin	Jost 38C – 3.5" king pin As used on Abnormal vehicles
D-Value (Drawing)	152 kN	170 kN	260 kN
Imposed Load	20 t	28 t	36 t

COUPLING

Conclusion

1. Fifth wheel was over extended by double the allowable deflections
2. Considering only the stationary forces, Fifth wheel / king pin was over loaded by > 10X the drawing specification. The dynamic forces induced by the body roll would have resulted in significantly higher forces.

PREVIOUS INCIDENTS

PREVIOUS INCIDENTS

It was noted that with the previous incidents of tanker roll overs, the tankers were of the same design and age.

- Paarl 6 Oct 2016 – Truck D920 – Tanker 15034
- PMB 22 June 2017 – Truck D896 – Tanker 15021
- Paarl 7 February 2018 – Truck D915 – Tanker 15033