Simulation of freight trains with up to three traction units in radio communication

Cantone L.

University of Rome Tor Vergata, Dept. of Enterprise Engineering “Mario Lucertini”, Via del Politecnico 1, 00133, Rome, Italy

Introduction

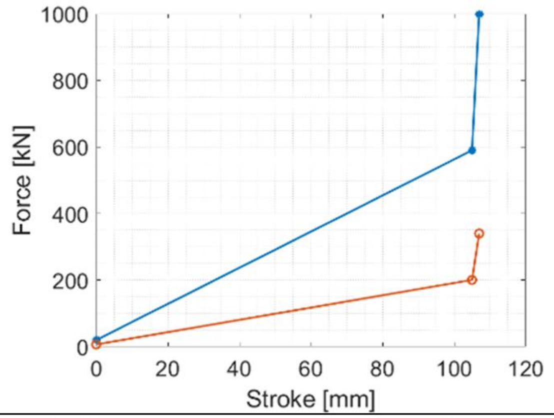
- SERA: increasing efficiency for freight trains in Europe.
- OC Marathon2Operation (M2O, H2020 N. 826087) and CFM FR8RAIL II together to demonstrate the feasibility of Distributed Power System (DPS)
  - Simulations, safety and assessment
- Radio wireless communication, based on GSM-R and LTE (as bridge to future FRMCS standard)
- *TrainDy* software, initially developed by the University of Rome Tor Vergata and Faiveley Transport of Italy, from 2007 owned and developed by UIC.
- Application of Leaflet UIC 421 methodology to demonstrate the safety in terms of in-train forces (stopping distance analysed as well).
  - Comparison of standard and DPS trains performances on level and up/down hill tracks, under different operating conditions.

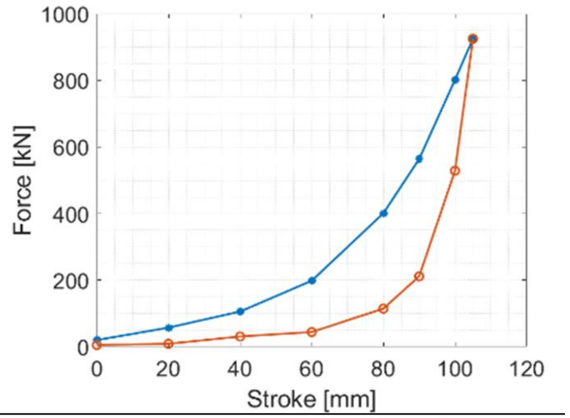
Simulation data

	Facns-124	Res-676	Facns-133	Eanos_x-59
Tare [t]	25	24.5	22	23.56
Length [m]	19.04	19.9	16	15.74
Payload [t]	0	0	0	63

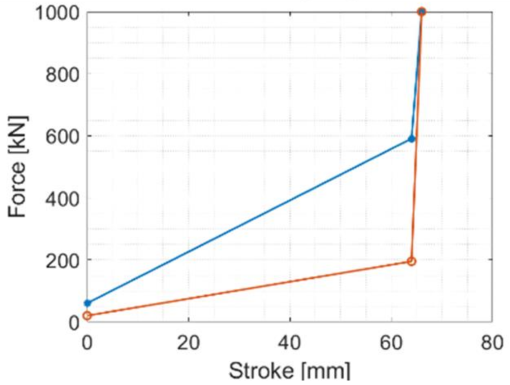
BR188, Measuring Coach, Wagons, BR187, Wagons, BR187

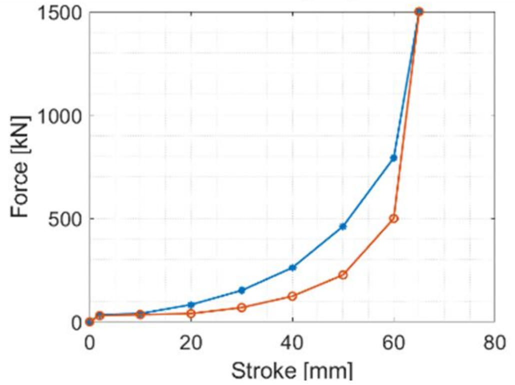
Buffing gears





Draw gears

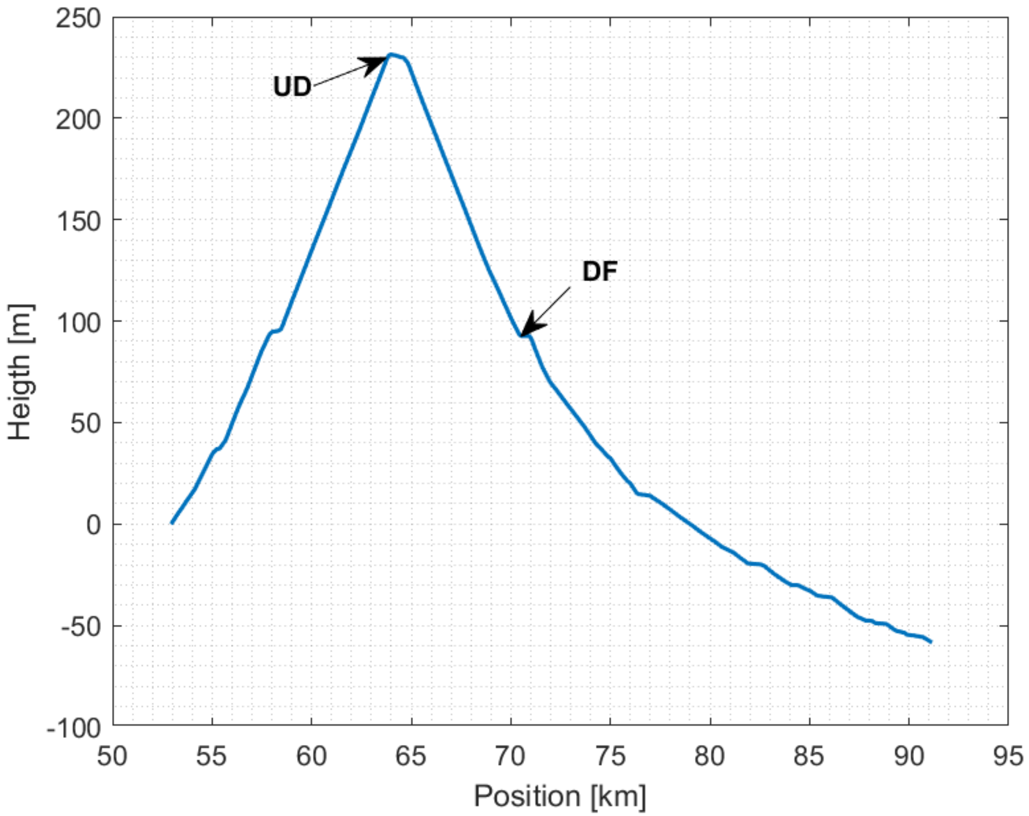


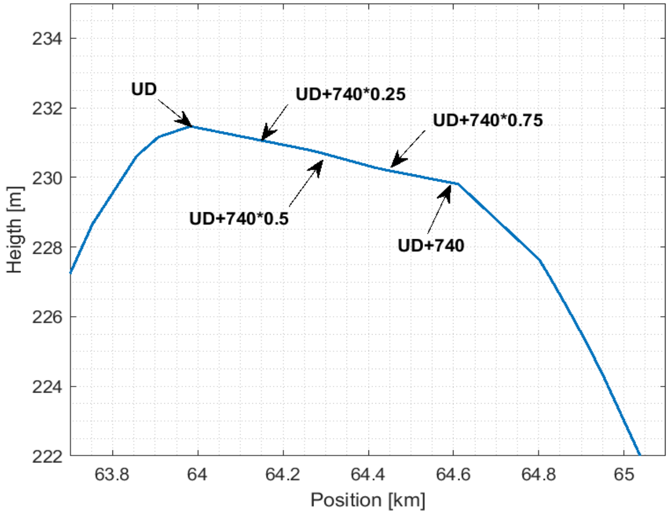


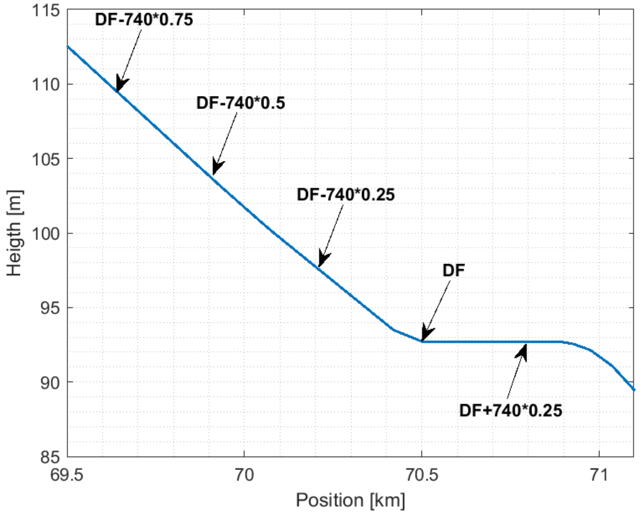
Simulation data

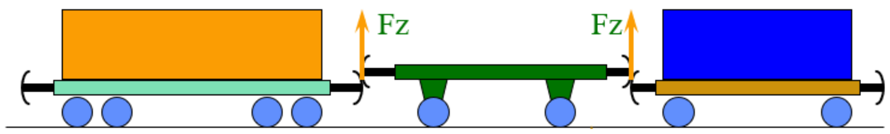
	Facns-124	Res-676	Facns-133	Eanos_x-59
Tare [t]	25	24.5	22	23.56
Length [m]	19.04	19.9	16	15.74
Payload [t]	0	0	0	63

BR188, Measuring Coach, Wagons, BR187, Wagons, BR187

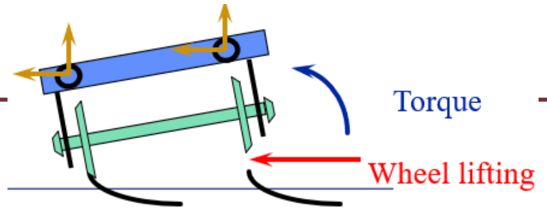








(a)



(b)

Simulation scenarios

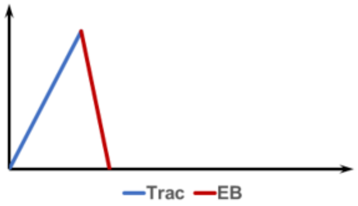
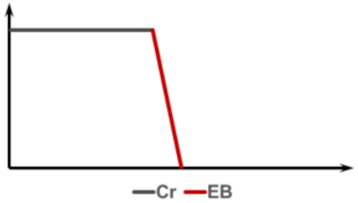
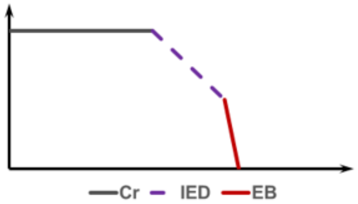
- **LWL**
  - ✓ **REF** 
  - ✓ **DPS** 

- **LWLW** 

- **LWLWL** 

Comparison REF vs DPS

Symbol	Meaning
	System is in **nominal mode**
	A **communication loss occurs simultaneously** to a traction / braking command of an operational maneuver
	System has **declared a communication loss**; traction has been ramped down and main switch has been opened **before** there is a new traction / braking command
	**Total DPS failure** - A communication loss occurs simultaneously to a traction / braking command of an operational maneuver. Additionally, the DBCU does not work

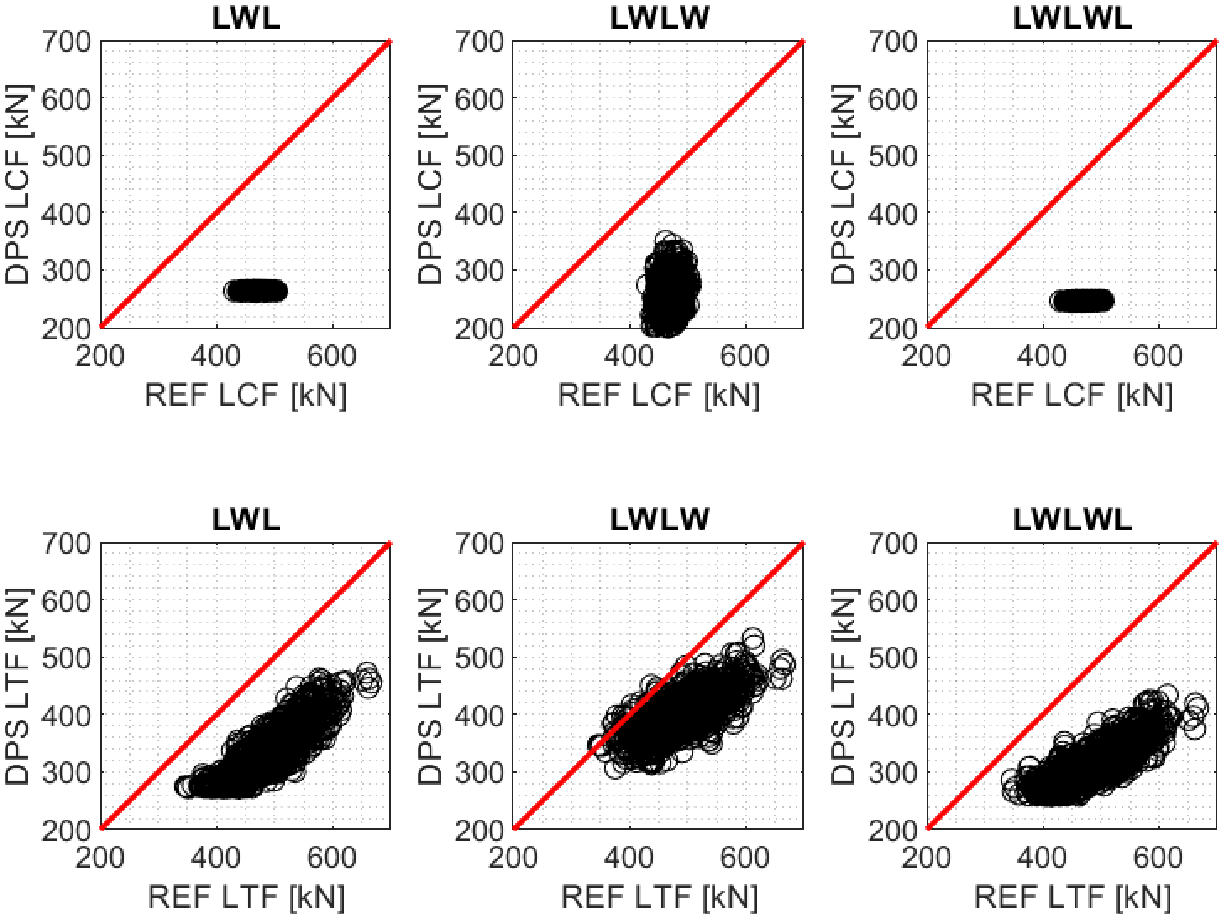
Symbol	Meaning
	**Trac → EB** (Traction to Emergency Braking)
	**Cr → EB** (Cruising to Emergency Braking)
	**Cr → IED → EB** (Cruising to Independent Electro-Dynamic Braking to Emergency Braking)

The trainsets are four (one REF and three DPS), the train operations used are two: assuming the radio link between the TUs is active or it is lost. The braking regimes are two (G and LL) and the working directions are two: forward and backward. Since the measuring coach does not brake (as said above), the braking regime LL is possible only in BW direction, according to the operational German rules.

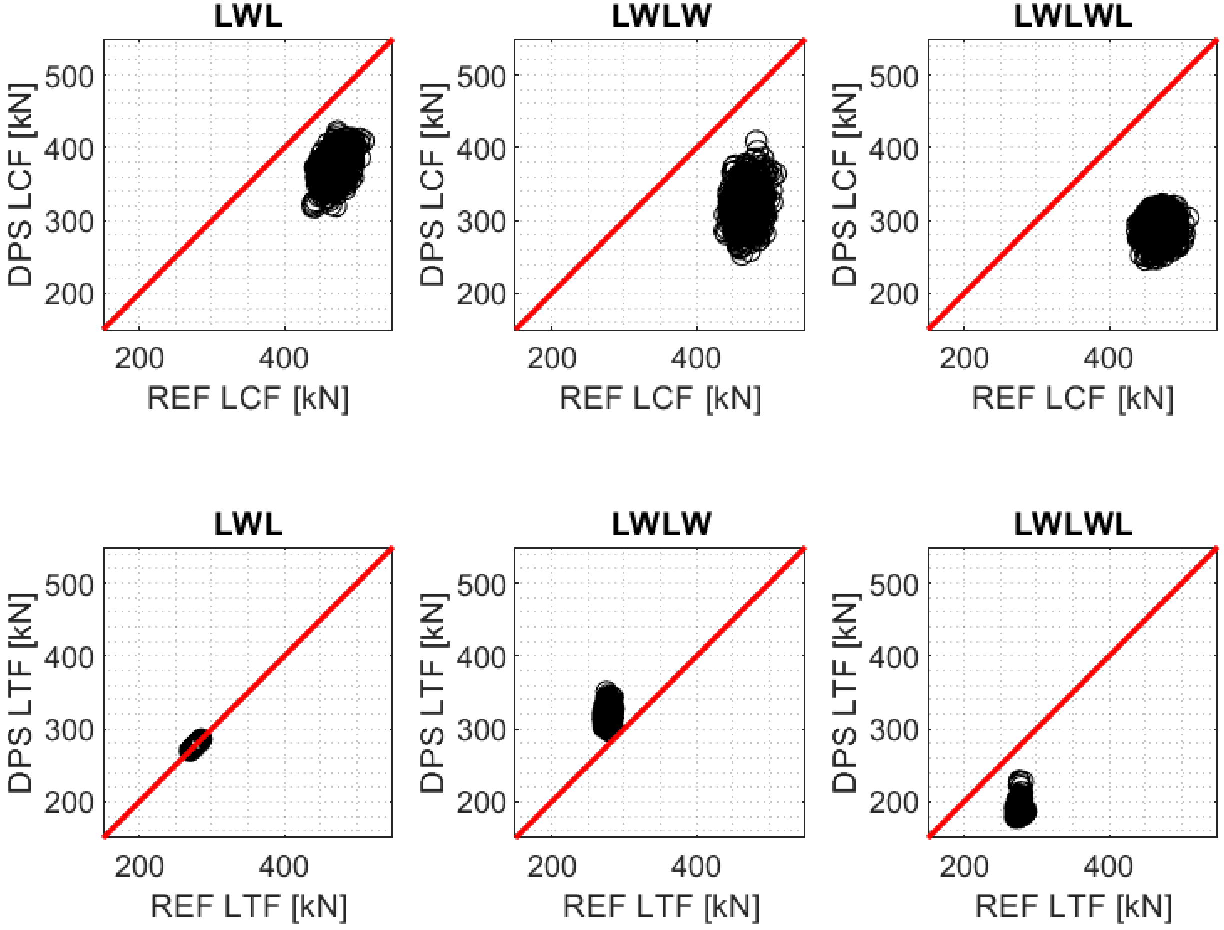
Simulation scenarios

- 1xxx Train acceleration and then coasting (cruising)
- 2xxx Full-service braking from coasting (cruising)
- 3xxx Emergency braking from coasting (cruising)
- 4xxx Train acceleration followed by an emergency braking.
- 5xxx Train is accelerating, the radio link is down (DPS on guided TU reacts after “time of radio communication loss”), then the leading TU issues a braking.
- 6xxx train is braking (ED is activated alone or together with a first application step of pneumatic braking), the radio link is down (DPS on guided TU reacts after “time of radio communication loss”), then the leading TU issues a “stronger” braking to stop the train (emergency braking or a full service braking). This scenario is meaningful on a downhill, mainly.
- 7xxx and 8xxx train is braking (ED is activated alone or together with a first application step of pneumatic braking), then the leading TU issues a “stronger” braking (full-service braking for 7xxx and emergency braking for 8xxx) to stop the train and the radio link is down: DPS on guided TU reacts when it detects a pressure drop of 0.2 bar in brake pipe.
- 9xxx train is accelerating, then the leading TU issues an emergency to stop the train and the radio link is down: DPS on guided TU reacts when it detects a pressure drop of 0.2 bar in brake pipe.
- 10xxx train is running at a certain speed and an emergency braking is commanded by the guided TU Elecrodynamic Brake

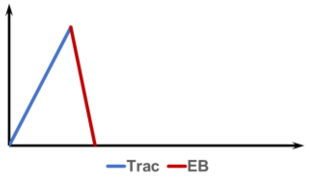
Trainset definition

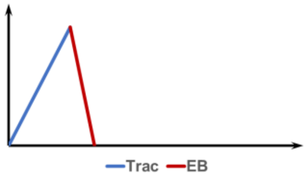


Regime LL, radio link on, backward direction

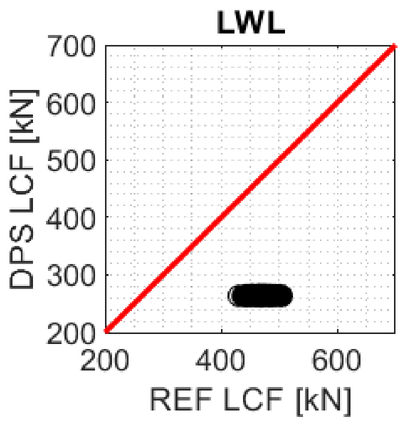


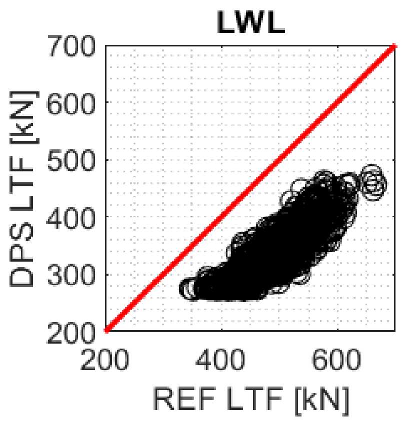
Regime G, radio link off, backward direction



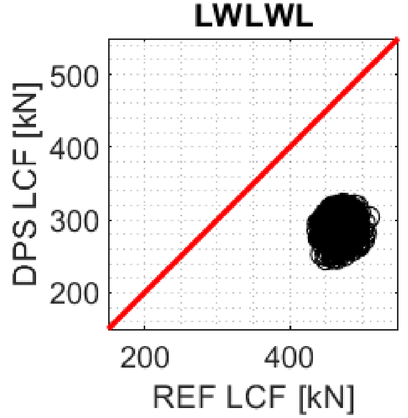


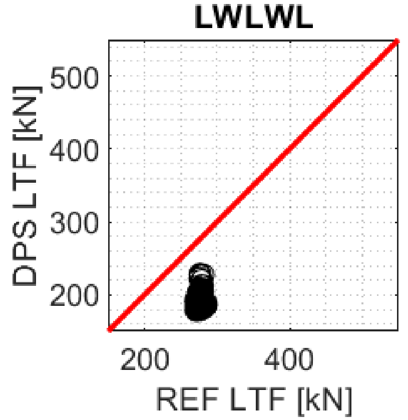
Trainset definition





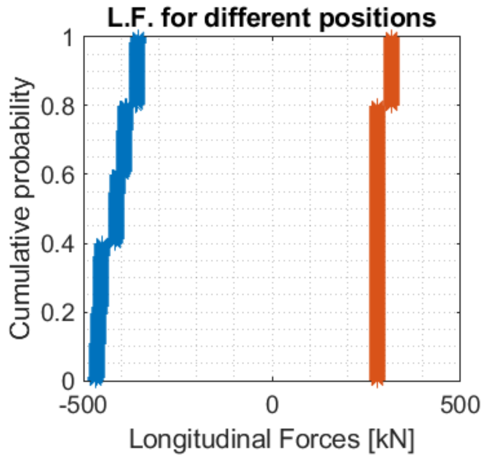
Position	Type	Manoeuvre	Wagon Length [m]	Train Length [m]	Brake Pipe Length [m]	GP coupl. status	Load [t]	Tare [t]
1	BR188	Man01L	18.9	18.9	37.8		0	86
2	Measuring		26.4	45.3	29.04		0	63
3	Facns-133		16	61.3	16		0	22
4	Res-676		19.9	81.2	19.9		0	24.5
5	Facns-124		19.04	100.24	19.04		0	25
6	Facns-133		16	116.24	16		0	22
7	Res-676		19.9	136.14	19.9		0	24.5
8	Facns-124		19.04	155.18	19.04		0	25
9	Eanos_x-59		15.74	170.92	15.74		60	23.56
10	Facns-124		19.04	189.96	19.04		0	25
11	Facns-124		19.04	209	19.04		0	25
12	Eanos_x-59		15.74	224.74	15.74		60	23.56
13	Facns-133		16	240.74	16		0	22
14	Eanos_x-59		15.74	256.48	15.74		60	23.56
15	Eanos_x-59		15.74	272.22	15.74		60	23.56
16	Eanos_x-59		15.74	287.96	15.74		60	23.56
17	Res-676		19.9	307.86	19.9		0	24.5
18	Facns-133		16	323.86	16		0	22
19	BR187	Man01G	18.9	342.76	37.8		0	84
20	Eanos_x-59		15.74	358.5	15.74		60	23.56
21	Eanos_x-59		15.74	374.24	15.74		60	23.56
22	Eanos_x-59		15.74	389.98	15.74		60	23.56
23	Eanos_x-59		15.74	405.72	15.74		60	23.56
24	Facns-133		16	421.72	16		0	22
25	Facns-133		16	437.72	16		0	22
26	Res-676		19.9	457.62	19.9		0	24.5
27	Eanos_x-59		15.74	473.36	15.74		60	23.56
28	Eanos_x-59		15.74	489.1	15.74		60	23.56
29	Facns-124		19.04	508.14	19.04		0	25
30	Facns-133		16	524.14	16		0	22
31	Res-676		19.9	544.04	19.9		0	24.5
32	Res-676		19.9	563.94	19.9		0	24.5
33	Res-676		19.9	583.84	19.9		0	24.5
34	Res-676		19.9	603.74	19.9		0	24.5
35	Facns-124		19.04	622.78	19.04		0	25
36	BR187	Man01G	18.9	641.68	37.8		0	84

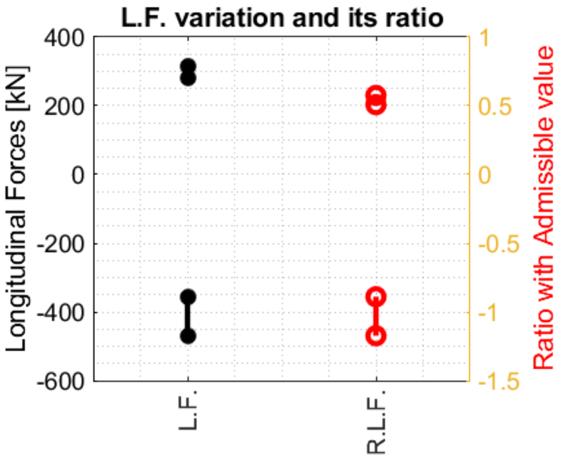


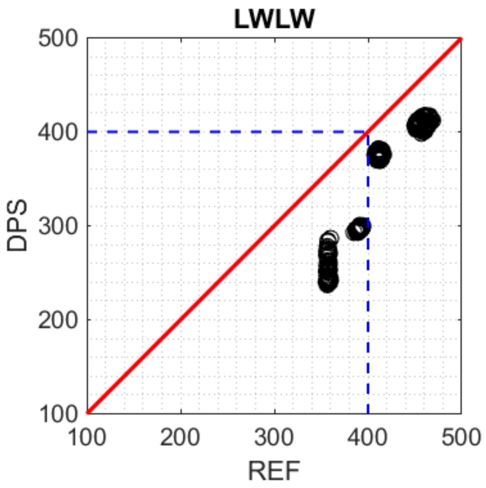


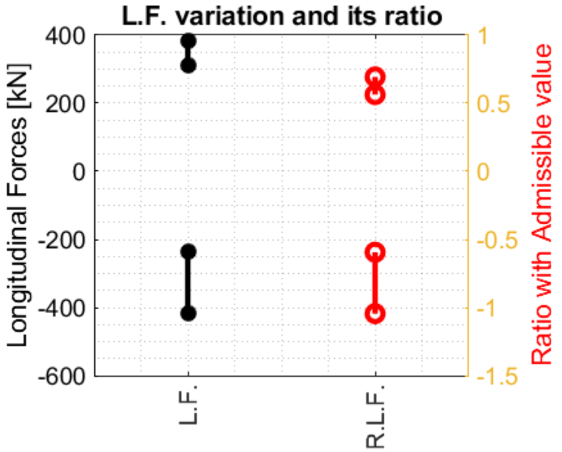
Regime L, r ... rd direction

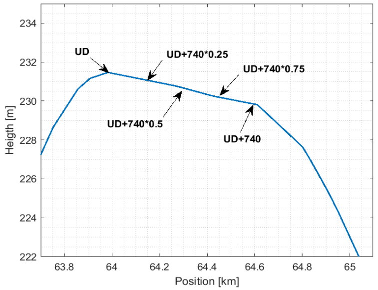
Simulation results, in-train forces

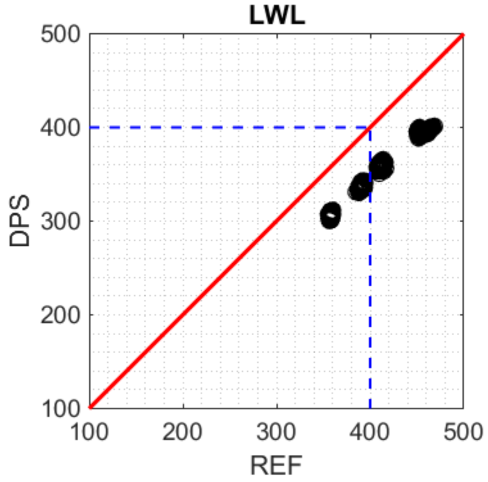


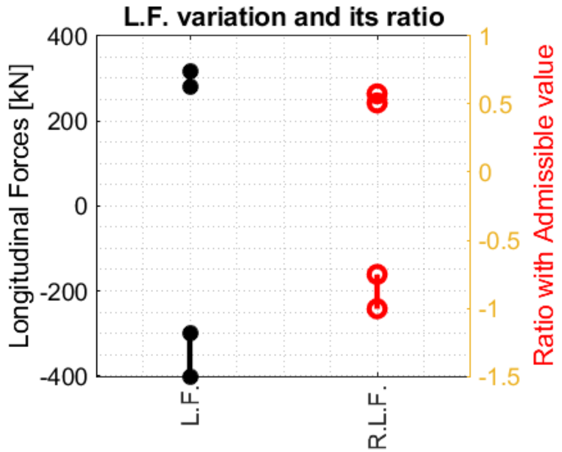


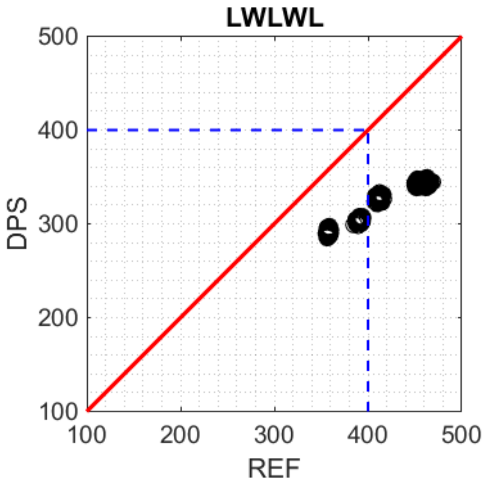


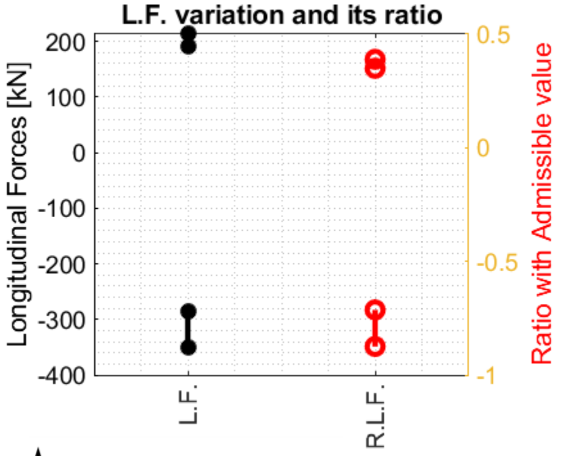


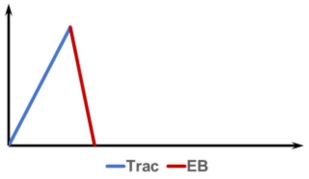






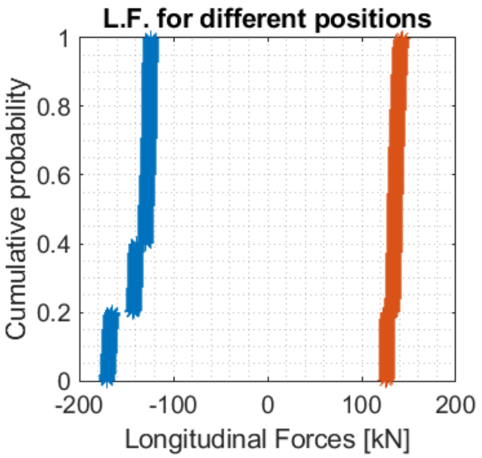


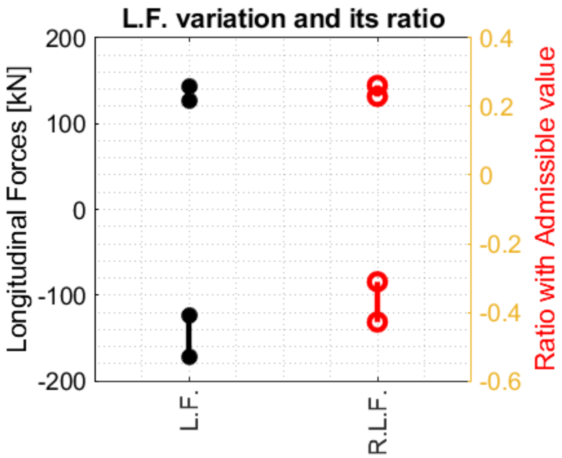


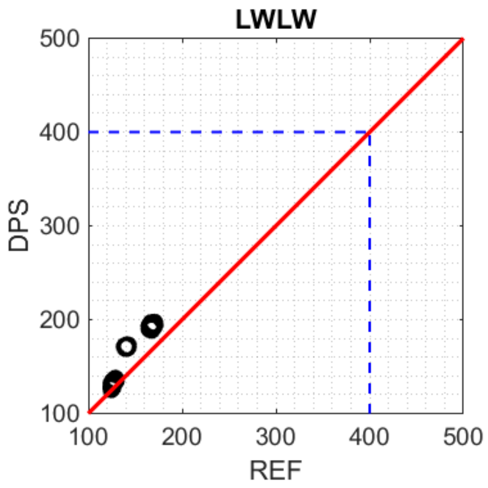


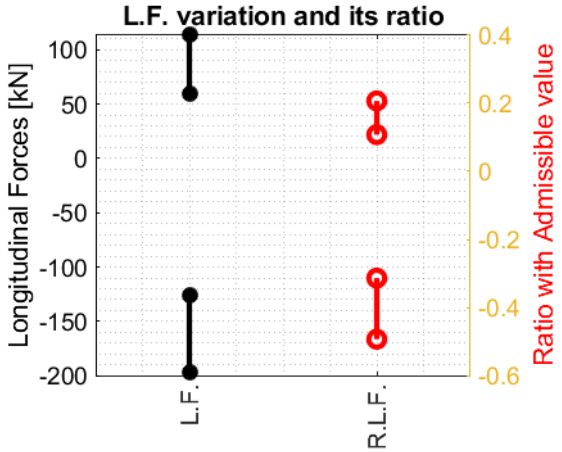
Regime LL, technical parameters variation

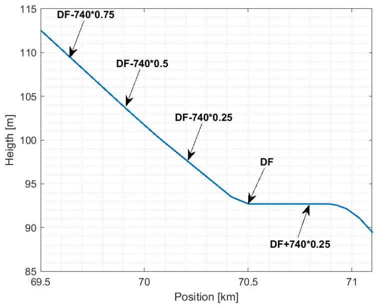
Simulation results, in-train forces

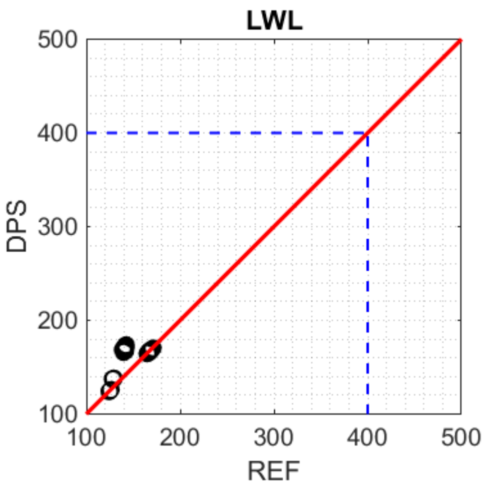


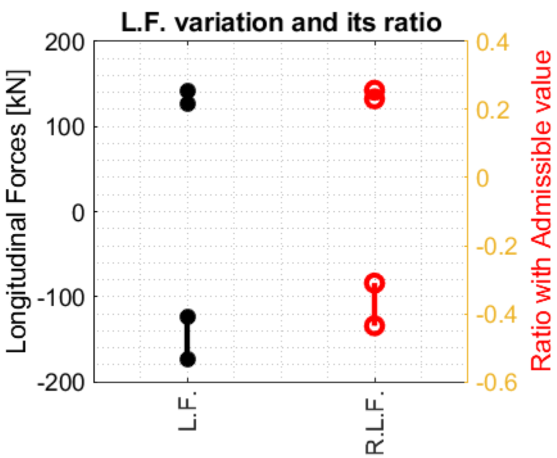


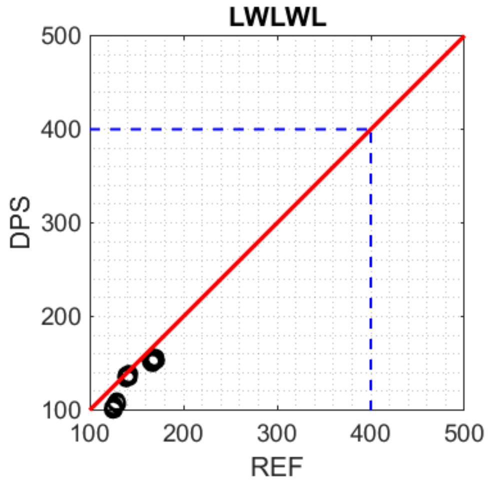


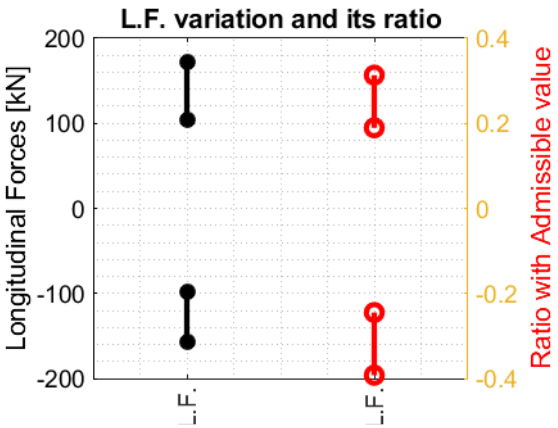


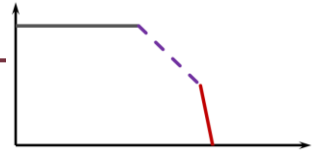






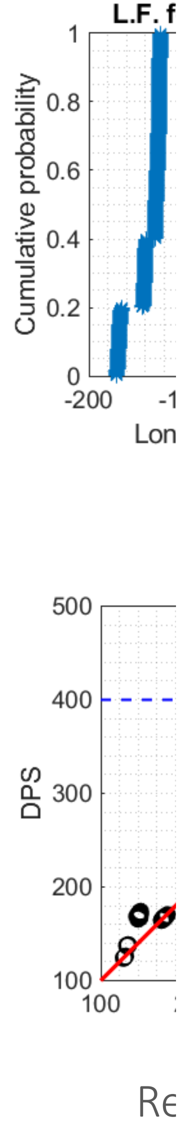


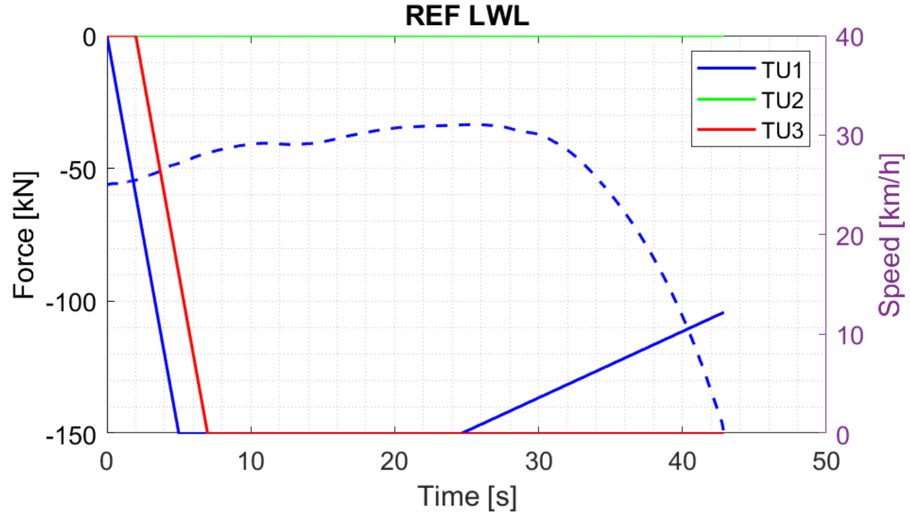


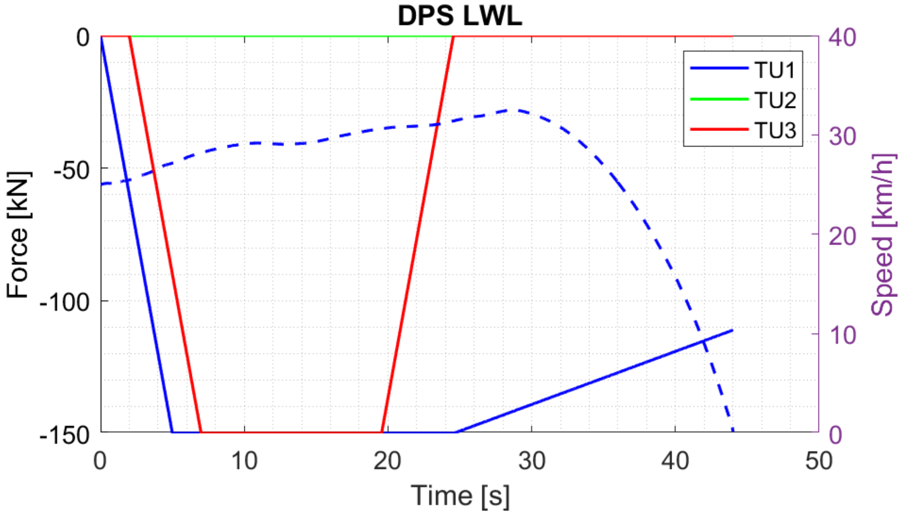


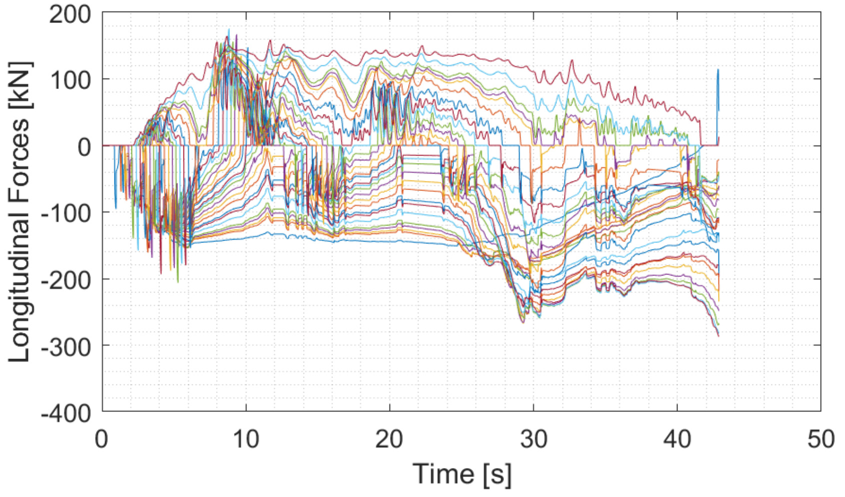
Regime G, technical parameters variation

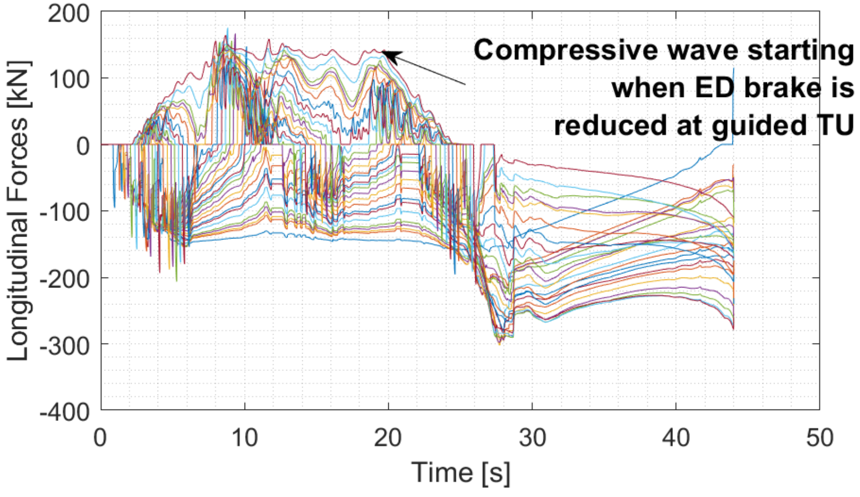
Simulation results, in-train forces

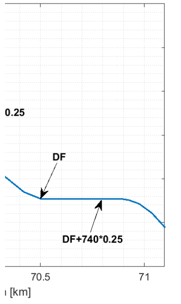




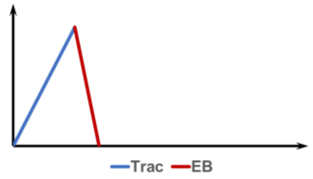


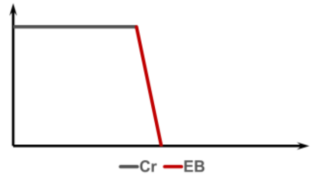






Simulation results, stopping distance





Emergency braking at 100 km/h from full traction				
		Nominal	Degraded	
REF	LWL	863	864	
		On	Off	Fail
DPS	LWL	812	847	864
	LWLW	811	841	855
	LWLWL	833 (806)	875 (844)	898 (860)
Emergency braking at 100 km/h from coasting				
		Nominal	Degraded	
REF	LWL	793	794	
		On	Off	Fail
DPS	LWL	768	789	794
	LWLW	766	792	794
	LWLWL	762	790	794

Regime G (longer distances expected) level track

- On 
- Off 
- Fail 

Conclusions

- Distributed Power System (DPS) always improves the safety of freight trains, when radio communication is available, with respect to Longitudinal Compression Forces (LCF).
- When there is a radio communication loss, the DPS train is usually better than the reference (REF) train with respect to LCF
  - Scenarios in which this conclusion is not valid refer to an initial application of electro dynamic brake, which can be optimized.
- Above conclusions do not depend on the track gradient, i.e., the DPS train is better than the REF train with respect to LCF, even if the LCF values depend on the track gradient.
- DPS technology is able to reduce the stopping distance and this statement is true for all the working conditions of DPS analysed.
- In general, an optimized mass arrangement is beneficial also with DPS technology and it can increase the hauled mass, safely.
- Further studies are needed to optimize the behaviour of DPS brake to better consider the trainset in which this technology is implemented: i.e., different and more optimized behaviours are possible according to different trainset layouts (LWL, LWLW or LWLWL).

Thanks for your kind attention