

**BOMBARDIER  
TRANSPORT  
FRANCE  
CRESPIN**

**Engineering Tests France**

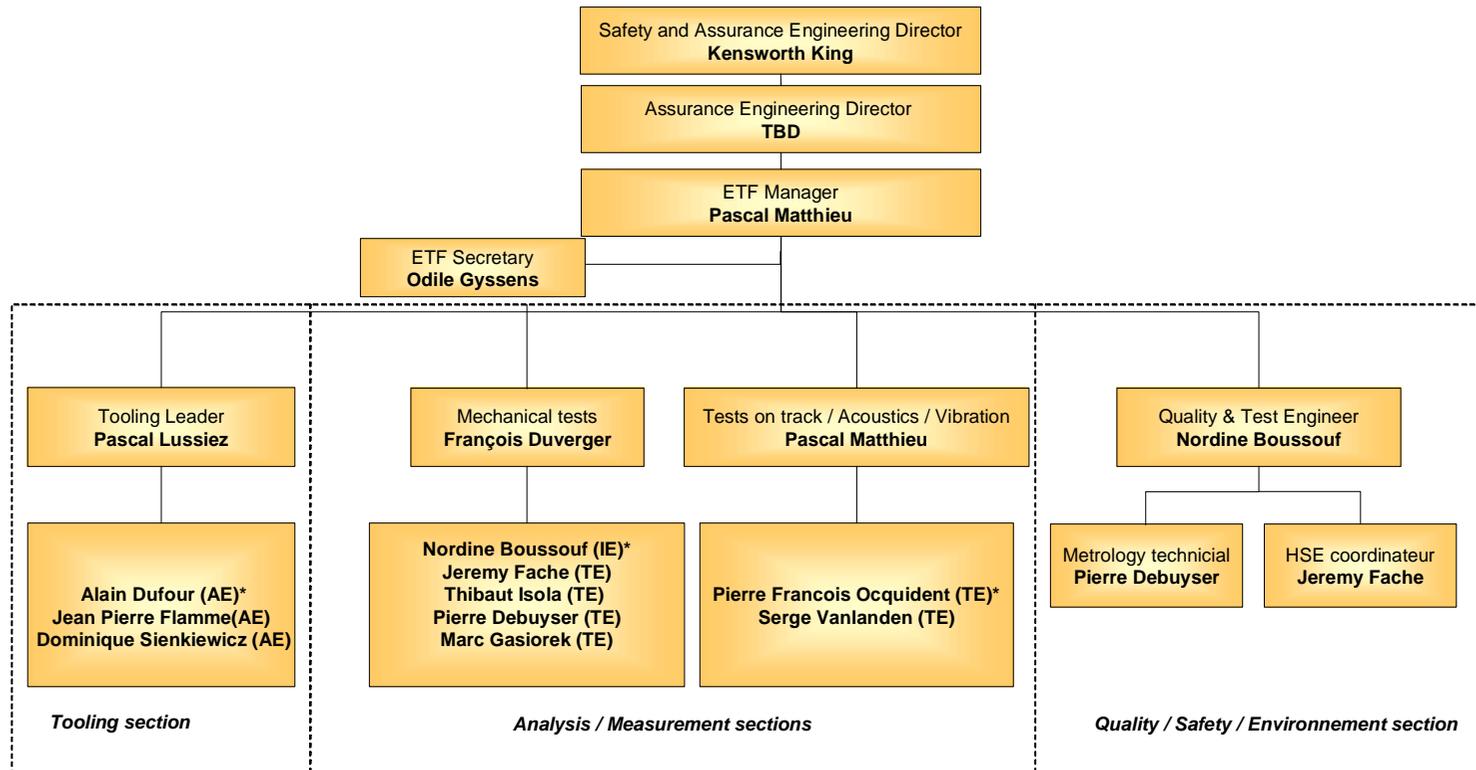
**TEST FACILITIES**

Validé le : 2006-03-13

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Visa :

**Organization ETF department – Status: 08/02/2006**



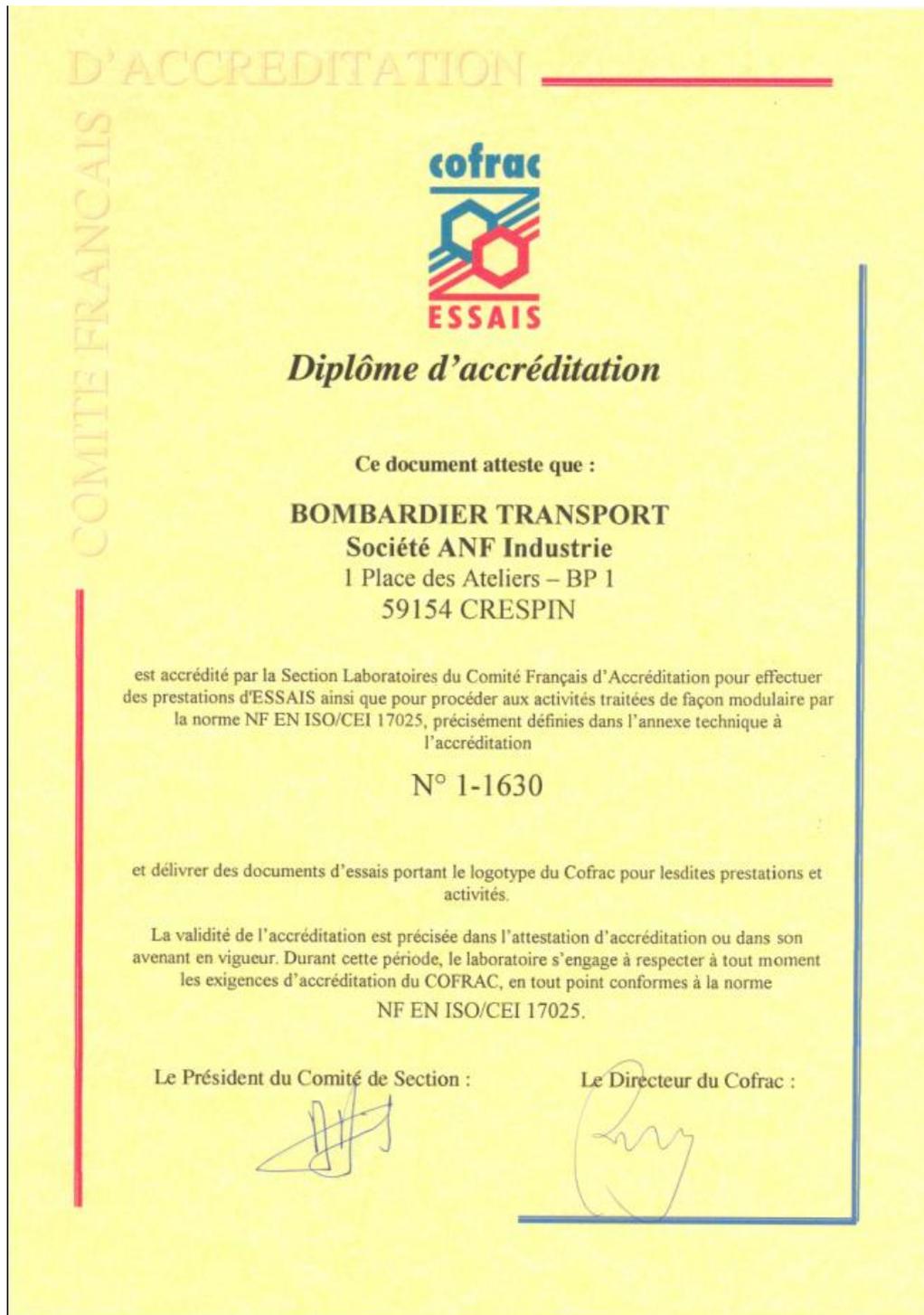
**BOMBARDIER TRANSPORT FRANCE CRESPIN**  
Engineering Tests France  
Test facilities

**BOMBARDIER**

**Iso 9001 : 2000 certified**



## Accreditation ISO/CEI 17025 for Crash test



<http://www.cofrac.fr/fr/recherche/ftechnique.mpi?enti=1303017>

## Main Tests Performed by ETF

CRASH TEST		
Date	Project	ELEMENT TESTED
July 2005	Nat	Several crash test of absorber : 1 MJ
December 2004	Tram train Flexity Link Saarbrücken	Crush tube dynamic test using the drop hammer
December 2004	LISA	Crash test of the second LISA demonstrator (600 kJoules in two stages)
September 2003 to October 2004	ICE3 (High speed train, Germany)	Several crash test of absorber : 1 MJ, coupler : 1 MJ, obstacle deflector : 240 kJ, frame : 1.7 MJ
October and July 2004	MML (Train, England)	Crash test of 2 absorbers : 400 kJ and 1 MJ
November 2003	MS HUCK (R&D, England)	Crash test of a riveted mock-up : 300 kJ
November 2001 to September 2003	AGC (Train, France)	Several crash test of absorber : 300 kJ, coupler : 400 kJ and crash of the all cab : 3 MJ
November 1998 to august 1999	VIRGIN (Train, France)	Several crash test of absorber and crash of the all cab : 2 MJ And quasi static crash of cab
June 1997	SAARBRÜCKEN (Tramway, Germany)	Crash test of the cab : 2 MJ
May 1997	R 142 (Tube, USA)	Several crash test of absorber and crash of the cab : 1 MJ
September 1994	M12N (Suburban train, France)	Crash test of intermediate absorber : 2 MJ

<b>STATIC TEST</b>		
<b>Date</b>	<b>Project</b>	<b>ELEMENT TESTED</b>
November 2005	MF2000	Test of the carbody and cab : 70 strain gages
October 2005	Loco T27	Test of the carbody and cab : 90 strain gages
October 2003	MF2000 (Tube, France)	Test of the carbody and cab : 176 strain gages
January 2003	MML (Train, England)	Test of the carbody : 160 strain gages
September 2002	M6 (Train, Belgium)	Static test of a rod of the bogie
February 2002	CHINA Sleepers 2 (Train, China)	Static test of the bogie
August 2001	CHINA sleeper 2 (Train, China)	Test of the carbody : 170 strain gages
September 1999	VIRGIN (Train, England)	Test of the carbody : 160 strain gages
April 1999	CARACAS (Tube, Venezuela)	Static test of the bogie
January 1999	MF 88 (Tube, France)	Static test of the bogie and the engine brackets
January 1997	TER2N (Train, France)	Test of the carbody : 200 strain gages
April 1996	SAARBRUCKEN (Tramway, Germany)	Test of the carbody : 150 strain gages
June 1995	COLOGNE (Tramway, Germany)	Test of the carbody : 200 strain gages
March 1995	MI2N (Suburban train, France)	Test of the carbody : 180 strain gages

<b>FATIGUE TEST</b>		
<b>Date</b>	<b>Project</b>	<b>ELEMENT TESTED</b>
October 2005 to January 2006	TAIPEI Bogie	Fatigue test of the TAIPEI Bogie
August 2005	AM96 (Train, Belgium)	Fatigue test of the bearing for the bogie
July 2005	TER2NNG (Train, France)	Fatigue test of the anti roll bar
March 2005	TPGN (Tramway, France)	Tests of wear of the new roller of the guiding system of the TPGN
February 2005	TPGN (Tramway, France)	Fatigue test of the new roller of the guiding system of the TPGN
December 2004	TPGN (Tramway, France)	Fatigue test of the new secondary suspension
November 2004	TPGN (Tramway, France)	Fatigue test of the guiding system of the TPGN
July 2004	AGC (Train, France)	Fatigue test of the shock absorber of the AGC
April 2004	LRV Tramway	Fatigue test of the bearing for LRV
March 2004	TPGN (Tramway, France)	Fatigue test of the secondary suspension
February 2004	M6 (Train, Belgium)	Fatigue test of the bearing for the bogie
February 2004	AGC (Train, France)	Fatigue test of the shock absorber of the AGC
December 2003	AGC (Train, France)	Fatigue test of the power pack frame of the AGC
June 2003	M6 (Train, Belgium)	Fatigue test of the traction bare of the M6 bogie
March 2003	MINEAPOLIS (Tramway, Florida)	Static and fatigue test of the bolster
October 2002	MF 2000 (Tube, France)	Static and fatigue test of the bolster
May 2002	VIRGIN (Train, England)	Fatigue test of the tilting bolster
May 2000	TML	Fatigue test of the floor of TML
February 2000	VIRGIN (Train, England)	Fatigue test of the floor beam
January 1999	MF88 (Tube, France)	Fatigue test of the motor bracket
January 1998	AM96 (Train, Belgium)	Fatigue test of the anti roll bar of the bogie AM96
Mai 1997	CARACAS (Tube, Venezuela)	Static and fatigue test of the bogie side frame

<b>AIR GUN CRASH TEST</b>		
<b>Date</b>	<b>Project</b>	<b>ELEMENT TESTED</b>
January 2006	Glaverbel	Shoot on windscreen : 4000 g at 160 km/h
July 2005	VLU	Missile Protection of composite door structure
April to May 2005	LISA	Crash test of 150 specimens using Air gun test bench
January 2005	VLU (Train, England)	Shoot on metal sheet : 900 g at 160 km/h
June 2004	OTU (Train, England)	Shoot on lifeguard of bogie OTU 22,2 kg at 127 km/h
February 2004	LISA (Train, England)	Shoot on alu foam 116 kg at 30 km/h
January 2003 and october 2003	MML (Train, England)	Several shoot on the shield on low part of the carbody : 50 g at 160 km/h
April 2001	VIRGIN (Train, England)	Shoot on lifeguard of bogie: 25 kg at 50 km/h
January 2001	TER2N (Train, France)	Shoot on the screen of the piping : 50g at 120 km/h
September 1999	VIRGIN (Train, England)	Several shoot on bogie shield : 900g at 400 km/h

<b>CLIMATIC BENCH</b>		
<b>Date</b>	<b>Project</b>	<b>ELEMENT TESTED</b>
December 2005	TGV	climatic test of all train : vehicles R2, R3 and R7
February 2005	AGC (Train, France)	Outdoor climatic test of all train : 40 temperature measurement
April 2004	MML (Train, England)	Climatic test : 120 temperature & humidity measurement
October 2004	AGC (Train, France)	Climatic test of the trailer car & the motor car with cab : 120 temperature & humidity measurement
October 2003	TER2NNG (Train, France)	Climatic test : 120 temperature & humidity measurement
July 2003	MF 2000 (Tube, France)	Climatic test of the cab : 120 temperature & humidity measurement
January 2002	GLT (Tramway, France)	Climatic test : 70 temperature measurement with solar gain
June 2001	VIRGIN (Train, England)	Climatic test : 70 temperature & humidity measurement
March 2000	MI2N (Suburban train, France)	Climatic test : 4 temperature & humidity measurement
November 1997	TER2N (Train, France)	Climatic test : 50 temperature & humidity measurement
September 1996	TGV DUPLEX (High speed train, France)	Climatic test : 53 temperature & humidity measurement
November 1992	EUROTUNNEL (Train, England & France)	Climatic test : 49 temperature & humidity measurement

<b>NOISE &amp; VIBRATION TEST</b>		
<b>Date</b>	<b>Project</b>	<b>ELEMENT TESTED</b>
September 2005	AGC	Noise measurement of the brake caliper of the AGC
July 2005	AGC	Noise measurement of the AGC klaxon
April 2005	AGC	Vibration measurement on 2 brake caliper of the AGC in Caen
March 2005	AGC	Vibration measurement on the Charge air line
February 2005	AGC	Qualification noise measurement of the Z train of the AGC
2003 & 2004	AGC (Train, France)	Internal and external noise measurement. Vibration and comfort measurement
February 2004	AGC (Train, France)	Modal analysis of the carbody
June 2003	MF 2000 (Tube, France)	Modal analysis of the carbody with and without cab
March 2003	AGC (Train, France)	Modal analysis of the carbody
December 2002	K4000 (Tramway, Germany)	Vibration measurement on the engine
October 2002	M6 (Train, Belgium)	Internal noise measurement
July 2002	M6 (Train, Belgium)	Vibration and noise measurement
July 2001	CHINA Sleepers 2 (Train, China)	Modal analysis of the carbody
June 2001	GRAZ CITY RUNNER (Tramway, Austria)	Vibration measurement of th carbody, bogie, floor
March 2001	VIRGIN (Train, England)	Vibration measurement of the engine, carbody, floor. external noise
June & July 2000	VIRGIN (Train, England)	Internal noise measurement
March 2000	VIRGIN (Train, England)	Modal analysis of the carbody
June 1995	MF88 (Tube, France)	Modal analysis of the bogie frame

<b>TEST ON TRACK</b>		
<b>Date</b>	<b>Project</b>	<b>ELEMENT TESTED</b>
September to October 2005	T3000	Dynamic tests on the T3000 in Brussels, 160 channels
August 2005	AGC	Test on track of the AGC motor bogie : train 105 (4 carbodies Z27529), 60 channels
June to July 2005	IC3 Israel	Track test in Israel on the bogie frame and torque reaction bar : 3 trains and 80 channels per train
July 2005	Norvege	Measurement of stresses, displacements and accelerations on titling bogies
April to June	Metro of Madrid, serie 2000	Distance measurement between the station of lines 1 and 6 in Madrid, Complete track.
April 2005	Istanbul	Measurement of track quality, track twist, forces in the anti roll bars and carbody accelerations
March 2005	TPC	Test on track on the vehicle TPC, force in the anti roll bar
February 2005	TPGN	Stability test of the guiding Wheel of the TPGN
December 2004	AGC (Train, France)	20 analog measurements channels & all train parameters by CAN-BUS
November 2004	T2000 (Tramway, Belgium)	17 pressures & displacements on the 2 <sup>nd</sup> suspension bogie
October 2004	CROYDON (Tramway, England)	21 strain and acceleration measurements on the standing bracket
2003 & 2004	GLT (Tramway, France)	30 strains, vibrations, pressures & displacements measurements
May 2004	TPC (Train, Switzerland)	20 acceleration and strain measurement
March 2004	AGC (Train, France)	200 strains, vibrations & displacements measurements
June 2003	BUCHAR (Tube, Romania)	80 strain measurements : life time of bogie
May 2003	NORWAY (High speed train, Norway)	150 strain measurements on the bogie
January 2003	AM96 (Train, Belgium)	15 strain measurements on the life guard
June 2002	M6 (Train, Belgium)	Strain measurement on a rod
December 2002	K4000 (Tramway, Germany)	12 strain & vibration measurements on the engine
August 2002	K4000 (Tramway, Germany)	38 strain measurement on the bogie
May 2002	VIRGIN (Train, England)	64 strain & displacement measurement on the bogie during tilting phase

<b>TEST ON TRACK</b>		
May & July 2001	<b>AM96</b> (Train, Belgium)	21 train & vibration measurement on the life guard
January 2002	<b>VIRGIN</b> (Train, England)	12 strain measurement on the bogie
June 2001	<b>VIRGIN</b> (Train, England)	17 strain measurement on the bracket engine
May 2001	<b>VIRGIN</b> (Train, England)	Strain measurement on rod
September 2000	<b>CARACAS</b> (Tube, Venezuela)	80 measurement channels : life time of bogie
May 1999	<b>T 2000</b> (Tramway, Belgium)	Strain measurement on the bracket engine
March 1998	<b>MF88</b> (Tube, France)	23 strain measurements on the up date carbody
December 1996	<b>MF88</b> (Tube, France)	38 strain measurements on the bogie

## Static test bench for carbody :



Maximum vehicle length	: 26 m
Maximum compressive force	: 2000 kN
Maximum tensile force	: 2000 kN
Maximum compressive forces on the cantrail	: 300 kN
Data recorder system	: 248 channels

## Static test bench for bogie :



Maximum longitudinal force	: 50 kN
Maximum lateral force	: 200 kN
Maximum vertical force	: 600 kN
Data recorder system	: 248 channels

## Quasi static test bench for crash test :



Size of the rigid wall	: 3000 x 3500 mm
Maximum compressive force	: 9000 kN
Maximum jack stroke	: 1200 mm
Velocity of the jack	: 0.8 mm/s
Data recorder system	: 248 channels

## Component quasi static crash test bench :



Size of the sample	: 300 x 600 x 800 mm
Maximum compressive force	: 3000 kN
Maximum jack stroke	: 250 mm
Velocity of the jack	: 5 mm/s

## Component dynamic crash test bench :



Size of the sample	: 1000 x 1900 mm
Maximum drop mass	: 12 t
Distance between mass and ground	: 4.55 m
Maximum impact velocity	: 9.4 m/s
Maximum energy	: 530 kJ
Data recorder system	: 80 channels
<b>Example: Specimen 0.8 m long -&gt; <math>V = 8.3</math> m/s, <math>E_c = 413</math> kJ</b>	

## Climatic bench :



### Size:

Length	: 32 m
Width	: 5.4 m
Height	: 6.1 m
Entrance width	: 4.3 m
Entrance height	: 5.65 m

### Climatic performance:

- Cooling power : 140 kW
- Heating power : 48 kW
- Air flow : 80 000 m<sup>3</sup>/h
- Temperature range : 0° to 40°  
+/- 1° not predictable with solar gain
- Air velocity along vehicle : 1 to 2m/s
- Humidity : > 40% RH  
Can be measured but not adjustable
- Solar gain enable

## Dynamic buff test ramp bench :



Size of the rigid wall  
Maximum impact mass  
Maximum impact velocity  
Maximum energy  
Data recorder system

: 4000 x 5000 mm  
: 120 t  
: 8.8 m/s, 32 km/h  
: 4650 kJ  
: 80 channels

## High speed air gun bench :



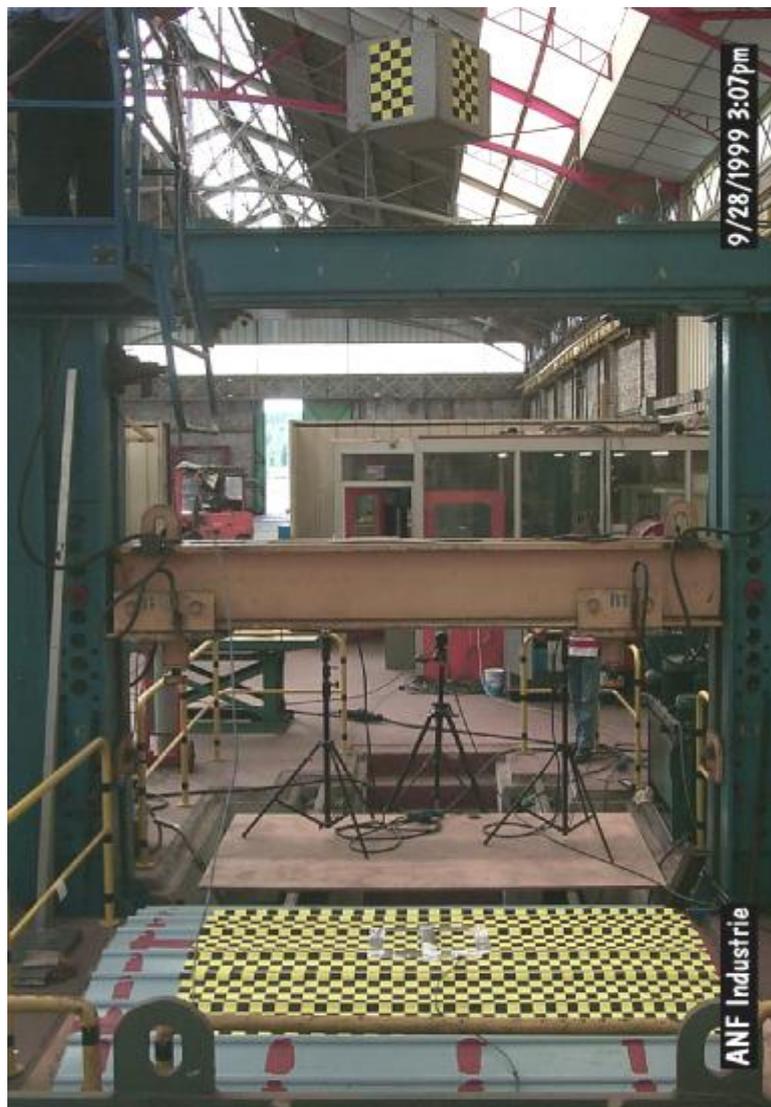
Inside view of shelter cab



Outside view of shelter cab

Air gun launch length		: 4300 mm
Max size of the sample		: 2600 x 2600 mm
Maximum impact mass	(today)	: 200 kg
Maximum diameter of the missile		: 150 mm
Maximum impact velocity	(today)	: 130 m/s
Maximum energy		: 35 k Joules
Example of energy	(50 kg at 20 m/s)	: 10 k Joules

## Drop weight bench :



Size of the sample	: 3000 x 3000 mm
Maximum impact mass	: 200 kg
Maximum impact speed	: 10 m/s

## Fatigue test bench :



Number of electronic controlled hydraulic jacks	: 16
Example of force	: 10 kN to 200 kN
Frequency	: up to 10 Hz
Size of the first bench	: 5.4 x 4 m
Size of the second bench	: 8 x 6 m
Command system tower	: 3
Hydraulic generation	: 250 bars and 376 l/mn
Data recorder system for static tests	: 248 channels

## GLT fatigue test bench :



### 6 axes controlled in proportional

Rail speed: 70km/h  
Lateral force:  $\pm 40$  kN  
Lateral displacement:  $\pm 60$  mm  
Vertical displacement:  $\pm 60$  mm  
Cant:  $\pm 5^\circ$   
Curve:  $\pm 5^\circ$

### 2 axes controlled in all or nothing

Dropping  
Air spring inflated

## Track gradient test



Hydraulic jack under bogie



AGC train, inclination: 160mm



Control and data recording system

Number of hydraulic jack

: 8 simultaneously driven in level  
Position or independent by  
Remote control

Length of train

: 60 meters

Number of electronic clinometer

: 12

## 2 Fast video camera



1 x Fast Camera (White and black)  
1 x Fast Camera (Colour):

: 250 pictures per second  
: 80 pictures per second

### Synchronised acquisition of :

- 16 channels (force, pressure speed temperature, strain, acceleration...)
- 2 video recording
- Global position

## Measurement equipment :

Number of static and dynamic data recorder channels	: 248 Channels IMC
9 dynamic data recorder systems (crash and test on track)	: 144 channels Multidata
	: 144 channels Multidata
	: 50 channels Edaq
	: 32 channels DEWETRON
	: 16 channels DEWETRON
	: 16 channels DEWETRON
	: 16 channels DEWETRON
	: 8 channels DEWETRON
	: 16 channels MULLER BBM
	: 16 channels OROS OR38
Accelerometers from 1 g to 500 g	: 118
Displacement sensors from 38 to 1200 mm	: 38
Electronic displacement transducer 10 & 50 mm	: 20
Laser displacement sensors 100 mm	: 14
Laser telemeter (0,2 to 200m)	: 1
Pressure transducer from 66 m bar to 350 bar	: 69
Force transducer (200 N to 2000 kN)	: 109
Dynamic strain gauge signal conditioners	: 112
Microphones (class 1)	: 19
Sonometer (class 1)	: 2
Integrating sound pressure level meters	: 3
FFT analyser	: 2
Noise source	: 1
Temperature transducer PT100 and thermocouple	: more than 200
Frequency signal conditioner	: 16
Pyranometer	: 1
Linear camera	: 7
Doppler radar, up to 300 km/h	: 4
Shaker	: 1
Impulse Hammers (0 to 5000 lbs)	: 3
Measurement of wheel profile	: 1
Electronic Clinometers	: 12
Luxmeter	: 1

Air debimeter Accubalance	: 1
Wind speed sensor (0 to 20 m/s)	: 2
Humidity transmitter	: 6
Weight (~ 26 kg)	: 2500
Voltage sensor from mV to 1500 V	: 11
Current sensors from 10 A to 1000 A	: 16
Synchronised Camera with data recorder	: 2
GPS, Multidata and Dewetron	: 3

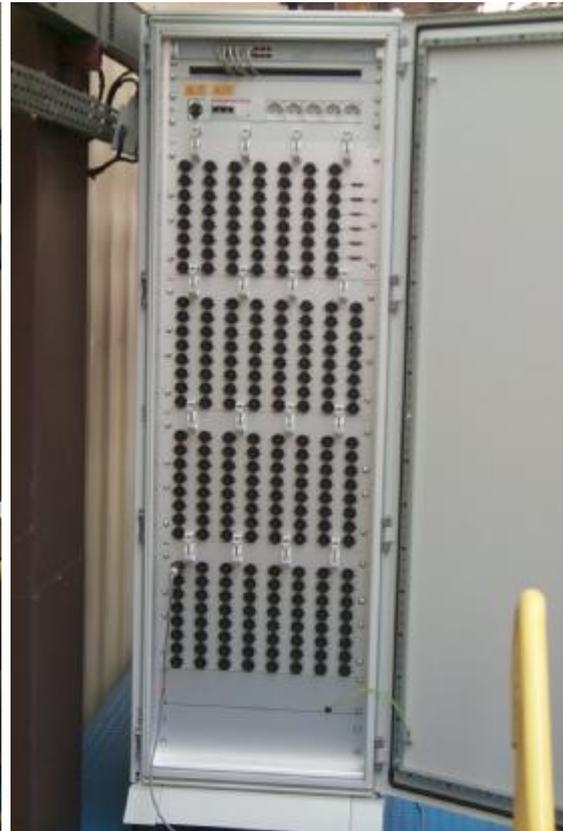
**Software :**

Data treatment	: EASE
Fatigue treatment	: EASE
Frequency analysis	: VSI ROTATE
Modal analysis, running modes	: ME'SCOPE VES <sup>TM</sup>
Noise treatment	: MULLER BBM
Vibration, Noise and Comfort	: OROS
Passenger riding comfort	: DASYLAB
Passenger riding comfort	: OROS
Real time treatment	: DASYLAB
Real time treatment	: FAMOS one line
Data treatment	: FAMOS

## Static and dynamic data recorder system: IMC



Front side



Rear side

Type of test

: Static test and test on track

Total number of channel

: 248 Channels

Maximum throughput rate

Voltage or Strain gauges

: 800 kHz for 64 channels

Sample rate per channel for 248 channels

: 12.5 kHz

## Two Data recorder systems: Multidata



Type of test	: Crash test and test on track
Total number of channel	: 144 + CAN BUS data recorder
One with those channels:	
Number of voltage channel	: 104
Number of counter channel	: 24
Number of thermocouple channel	: 16
Pulse width modulation with the counter channels, maximum 12 channels	
The other with those channels:	
Number of voltage channel	: 32
Number of strain gage channel	: 112
Maximum throughput rate	: 800 kHz
Sample rate per channel for 144 channels	: 5 kHz
Fully synchronised channels	

## Data recorder system: Edaq



Stand alone Data logger

Type of test : test on track,

Total number of channel : 50 channels

Number of voltage channel : 16

Number of strain gauge channel : 16

Number of counter channel : 8

Number of digital channel : 10

Maximum sample rate : 10 kHz

Pulse width modulation with the counter channels

Calculated channels

Real time rain flow

## Data recorder system: DEWETRON



Type of test	: Test on track
Number of channel	: 32 channels
Modular signal conditioners: voltage, strain gauge, frequency, ICP, ...	
Maximum sample rate	: 500 kHz
Fully synchronised channels	
Real time calculation	
Passanger riding comfort	: ISO 2631, SPERLING, ...

## Data recorder system: MULLER BBM



Type of test	: Noise measurement
Type of hardware	: HP VXI
Number of channels	: 16 channels
Maximum sample rate per channel	: 65 kHz
Band width	: 25 kHz
Fully synchronised channels	
FFT, Spectrum, Octave analysis, Signal generation, Impact hammer test, ...	

## Hydraulic jack



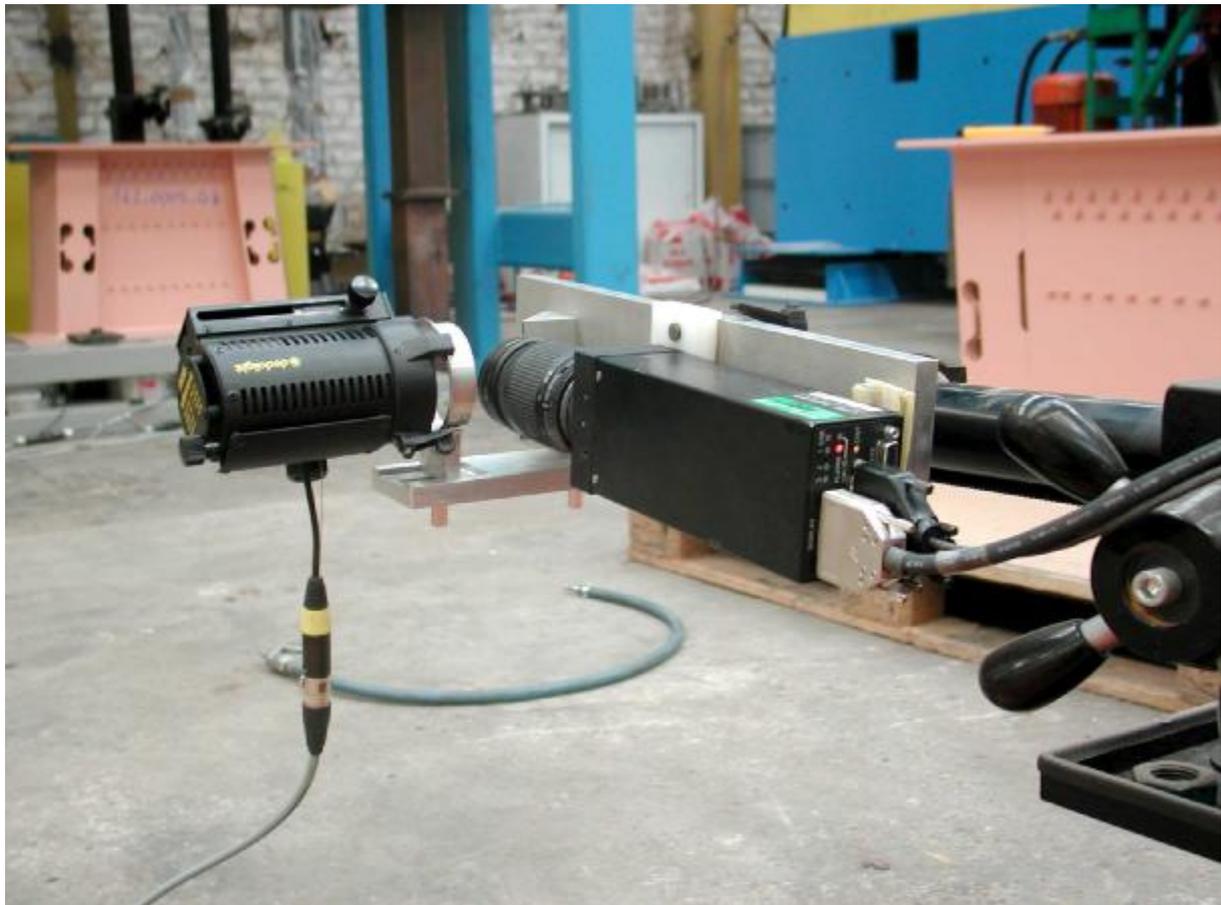
Type of test	: Fatigue test
Maximum load	: 18 kN to 340 kN
Travel	: 100 mm
Position sensor	: magnetostrictive

## Sound source



Power : 122 dB, minimum 100 dB for each 1/3 octave  
Frequency range : 100-5000 Hz ventral frequency of 1/3 octave

## Linear camera



Type of test	: Crash test
Measurement of displacement without contact	
Number of pixels	: 2048
Number of images per second	: 1400

## Laser displacement sensor



Type of test	: Dynamic test
Measurement of displacement without contact	
Displacement range	: 10 to 200 mm
Band width	: 1200 Hz

## Doppler radar



Type of test  
Maximum speed  
Pulse every

: Test on track  
: 300 km/h  
: 4 mm

## Shaker



Type of test	: Modal analysis
Brand	: VTS 100
Maximum force	: 500 N
Maximum stroke	: 19 mm
Frequency	: 0 to 6500 Hz

## Accubalance : Air debimeter



Type of test

: Air debit measurement

Brand

: TSI

Minimum debit

: 15 l/s

Maximum debit

: 1000 l/s

## Weight of 26 kg



Quantity

: 2500