



MODBRAKE

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WP 1 - Management

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TABLE OF CONTENT

1 – PROJECT EXECUTION _____ **5**

1.1 – Origin and objectives of the project _____ **5**

1.2 – Consortium _____ **5**

1.3 – Project outcomes _____ **5**

2 – DISSEMINATION AND USE _____ **16**

Glossary

BBE	Bogie Brake Equipment
DMU	Diesel Multiple Units
EMU	Electric Multiple Units
ETCS	European Train Control System
FIS	Functional Interfaces Specifications
FBS	Functional Breakdown Structure
FRS	Functional Requirements Specifications
LCC	Life Cycle Cost
ORS	Operational Requirements Specifications, currently containing of ORS locomotives (ORS loco), ORS high-speed-trains (ORS HST) and ORS Driver-Machine-Interfaces (ORS DMI)
PBS	Product Breakdown System
RAMS	Reliability, availability, maintainability, safety
SyRS	System Requirements Specifications
TCMS	Train Control Monitoring System
TSI	Technical Specifications for Interoperability

1 – PROJECT EXECUTION

1.1 – ORIGIN AND OBJECTIVES OF THE PROJECT

MODBRAKE stands for *Innovative Modular Brake Concepts for the Integrated European High-Speed Railway System*. This research project, co-financed by the European Commission under the 6th Framework Programme for Research and Technological Development, with a total budget of 4.9 million Euros, contributes to one of the main objectives of the EU policy in railway transportation: the realisation of interoperability and standardisation for the brake system.

MODBRAKE (2006-2009) has been set in addition to the proceeding Integrated project MODTRAIN to consider brake systems for high speed trains. Within nearly four years of joint work in an international team, MODBRAKE has developed specifications for reliable, affordable and interoperable brake systems of brake modules which will serve as input for the European standardisation bodies CEN and CENELEC.

The braking system is one of the most important and complex subsystems of rail vehicles, in particular when it comes to safety. Today, the brake supply sector is characterised by a broad variety of different designs, and testing, validation and maintenance procedures vary considerably. To reduce this complexity - and therefore costs - MODBRAKE divided the brake system into individual modules, elaborating specifications for each of them. This serves the demand for a shorter design phase and better life cycle costs (LCC).

The specifications developed by MODBRAKE will be used as a basis for further standardisation. The standardised modules will be interchangeable in their functionality, interfaces and test procedures. Inside they retain the specifications of each manufacturer to guarantee technological progress in the future.

1.2 – CONSORTIUM

MODBRAKE consortium is composed of 15 partners from 5 EU countries (Germany, France, Italy, Belgium, and Poland), and groups together:

- The four main European system manufacturers: ALSTOM, ANSALDOBREDA, BOMBARDIER and SIEMENS
- The two worldwide leading brake system suppliers: KNORR-BREMSE and FAIVELEY
- 3 railways operators: SNCF, DB and TRENITALIA
- 3 research centres with competencies in the field of railways: POLITECNICO DI TORINO, TECHNICAL UNIVERSITY OF BERLIN and TABOR
- 2 professional associations: at European level UNIFE (Coordinator) and UIC
- A project management specialist: Alma Consulting Group which works together with UNIFE (Coordinator) on project management tasks.

The project's general objectives are fully in line with Unife's mission to promote greater standardisation and the harmonisation of interfaces.

1.3 – PROJECT OUTCOMES

In order to avoid jeopardising competition, MODBRAKE afforded the standardisation of interchangeable brake modules, at least in terms of functions while the modules may be still specific to each manufacturer so as to enable technological progress.

MODBRAKE Contract: FP6-PLT-031498 / TST5-CT-2006-031498
Deliverable Report – WP1 – D1.7

Therefore, common geometry, physical interfaces (TCMS, pneumatic, electrical and mechanical) and functions for the brake modules were needed.

The following picture shows the methodology adopted.

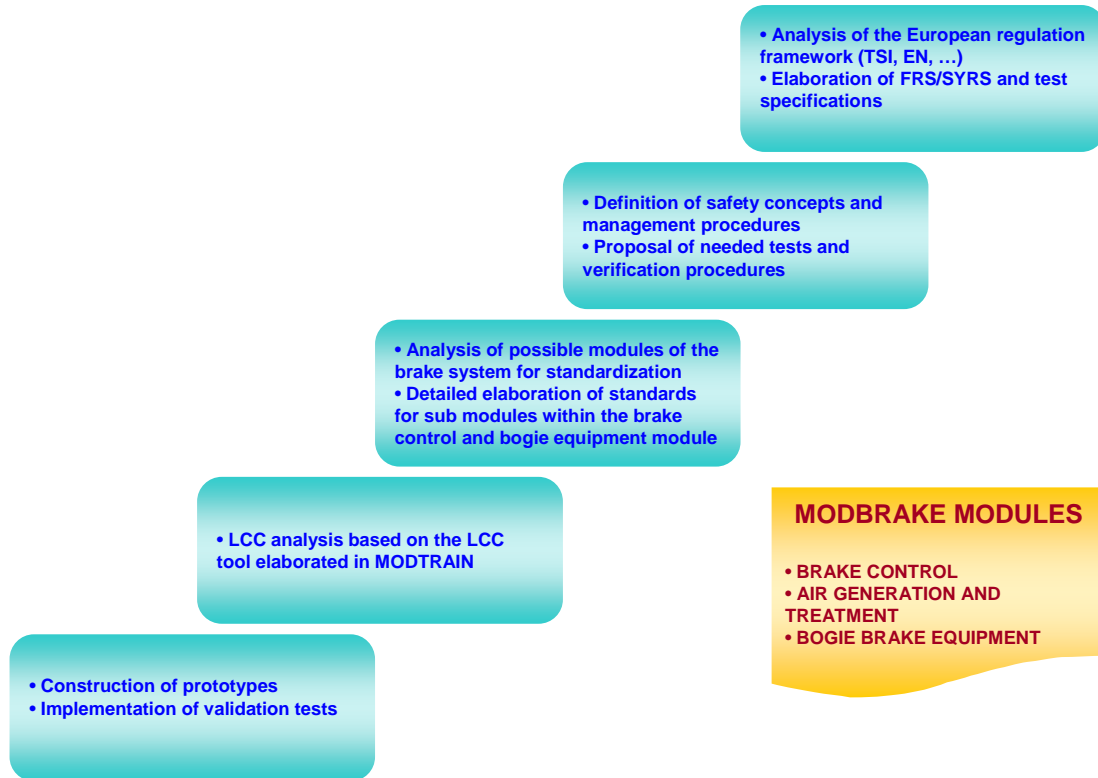


Figure 1 - MODBRAKE Methodology

The work has been organized in work packages, as shown in Figure 2.

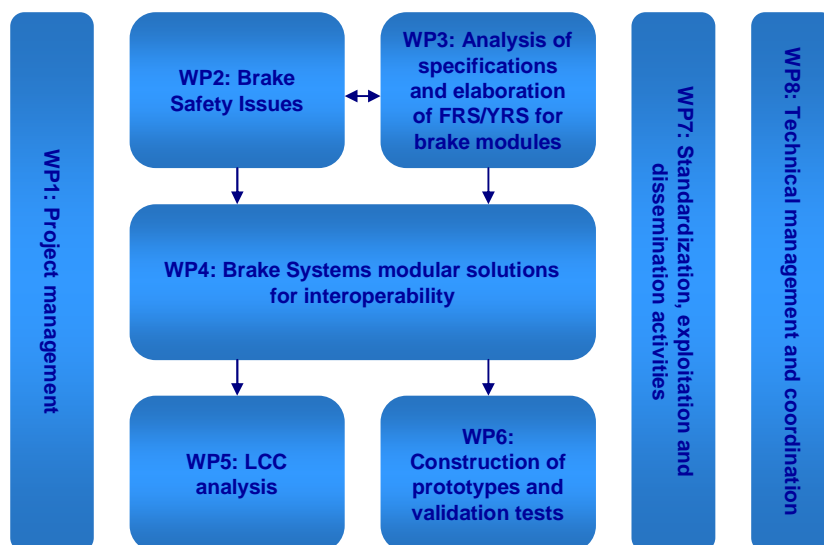


Figure 2 - MODBRAKE Structure

1.3.1 – WP2 – Brake safety issues

In relation to brake safety issues, MODBRAKE aimed at supplying a draft for future European Norms with the objective of making the verification of the safety level of brake systems destined to MOD-TRAIN vehicles clear and homogeneous.

A synthesis of national rules from United Kingdom, France, Germany, Italy, and Poland was carried out, together with an analysis of TSIs requirements relating to brake safety and brake safety responsibilities. As a result of this work, recommendations to the standardisation bodies have been issued by MODBRAKE.

Additionally, the analysis of the safety relevant brake requirements coming from the TSIs and the identification of the currently implemented testing procedures brought the project partners to suggest recommendations for the improvement of the testing procedures, and suggestions for additions/clarifications to TSIs.

1.3.2 – WP3 – Elaboration of FRS/SYRS for brake modules

Within this workpackage, MODBRAKE focused its work on standardisation issues in order to harmonise the reference functional and system requirements for the main brake modules to be supplied and fitted to the next generation of high speed trains.

These summarized requirements FRS/SyRS define the basis for the intended standardisation and harmonization effort for the main braking modules. Harmonization of system designs and standardisation of component interfaces will improve competitiveness of railway systems, especially due to LCC-savings and availability improvements.

The work obtained has performed the functional requirements for the train functions “Provide deceleration and keep the train at standstill” (FBS 6.2) and the system requirements for the Brake Control Modules for European High Speed Trains with speed of 190 km/h at least and the following train configurations:

- ❖ A: IC Train (fixed number of cars) with locomotive
- ❖ B: Universal locomotive
- ❖ C₀: High Speed Train with distributed power
- ❖ C₁: High Speed Train with concentrated power
- ❖ D: Electric Multiple Unit

As preliminary work, MODBRAKE analysed the FRS and SyRS issued from MODTRAIN together with its FBS/PBS breakdown structure, as well as the ORS HS documents. This led to the identification of the requirements relevant to the brake system.

MODBRAKE consequently elaborated the FRS and SyRS specifications for the main brake modules (Brake Control, Air Generation, Bogie Brake Equipment) of the brake modular system.

The activity was focused on the analysis of the European standards concerning the braking issues; “the core” of the specifications is in particular the standard prEN 15734 (Railway applications - Braking systems of high speed trains - Part 1: Requirements and definitions; Part 2: Test methods) with the analysis of about 500 requirements of the prEN 15734-1. Each requirement was analysed and classified according to its relevance for MODBRAKE project.

In relation to the Use Cases item, the following ones identified for requirements classification have been considered:

- ❖ UC1: Passenger Alarm and Passenger Alarm override function

- ❖ UC2: Penalty braking
- ❖ UC3: Brake Tests
- ❖ UC4: Equalizing and Filling Stroke


Furthermore, the requirements took in to account the following aspects:

- ❖ (Direct) Electro-pneumatic (EP), see figure 3, brake for high speed trains and major points of discussion about it:
 - the role of an automatic (indirect) brake equipment with a brake pipe in a high speed train equipped with direct EP-brake (backup for regular service, fully redundant emergency brake function or just input interface to detect BP-pressure of hauling locomotive/train);
 - the simplified distributor valve: further specification is necessary; a pneumatic scheme is required
- ❖ Electrodynamic-Braking (ED);
- ❖ Brake Management;
- ❖ Air supply;
- ❖ Brake control and major points of discussion about it:
 - Auxiliary control devices/features of the brake: manual release handles etc., location of these devices (inside or outside the vehicle);
 - Assimilation function: operational aspects, differences in current vehicle design, automatic assimilation, developing of MODBRAKE alternatives, precise clarification of what is specified in ORS 612;
- ❖ Short trains;
- ❖ Parking brake;
- ❖ Configuration;
- ❖ Brake Test.

The MODBRAKE related requirements have been referenced according to the DIN/MODTRAIN FBS structure (prEN 15380-4) and MODTRAIN PBS structure. During this analysis, the necessity to merge FBS and PBS to a single structure covering both aspects has emerged.

In conclusion, the MODBRAKE team intends to communicate this position to the international standardization body (CEN) and one possible future input of this activity is to start a working group in the CEN body to perform this item (the CEN enquiry related to the prEN 15380-4 has been started).

During the elaboration of these specifications the WP3 group considered and analysed the following additional European standards too:

 **TSI CR (Technical Specification for Interoperability - Conventional Rail)**

It has been established not to consider the TSI CR since it is yet in an elaboration phase so that revisions are continuously evolving and, at today, no stable basis has been reached in the elaboration. However the TSI's for freight wagon were considered only as far as the interface aspects with the loco are concerned.

 **TSI HS (Technical Specification for Interoperability - High Speed)**

The requirements, divided into functional and system ones, relevant to brake system have been extracted and inserted for the elaboration of FRS/SyRS. For the allocation of functional requirements to **FBS (Function Breakdown Structure)** and the allocation of system requirements to the vehicle **PBS (Product Breakdown Structure)** the activity took into account the latest FBS/PBS versions elaborated in the MODTRAIN project.

 **ORS (Operator Requirement Specification)**

MODBRAKE Contract: FP6-PLT-031498 / TST5-CT-2006-031498
Deliverable Report – WP1 – D1.7

The requirements of the ORS's 612-0-1-2 specifications were analysed and some of these, especially the ones relevant to the air supply module (612-2), were considered and belong to the WP3 final documentation; some of these modified the ones extracted from prEN 15734-1.

The MODBRAKE related requirements do not consider the following parts:

- ❖ FIS (Function Interface Specification)
- ❖ RAMS
- ❖ Documentation
- ❖ Quality management process
- ❖ Documentation of the assessment test procedures for the brake system modules

The final documents relevant to the above mentioned WP3 activities have constituted an input for the design of the Brake Modules in WP4 workpackage of MODBRAKE project.

MODBRAKE Contract: FP6-PLT-031498 / TST5-CT-2006-031498
Deliverable Report – WP1 – D1.7

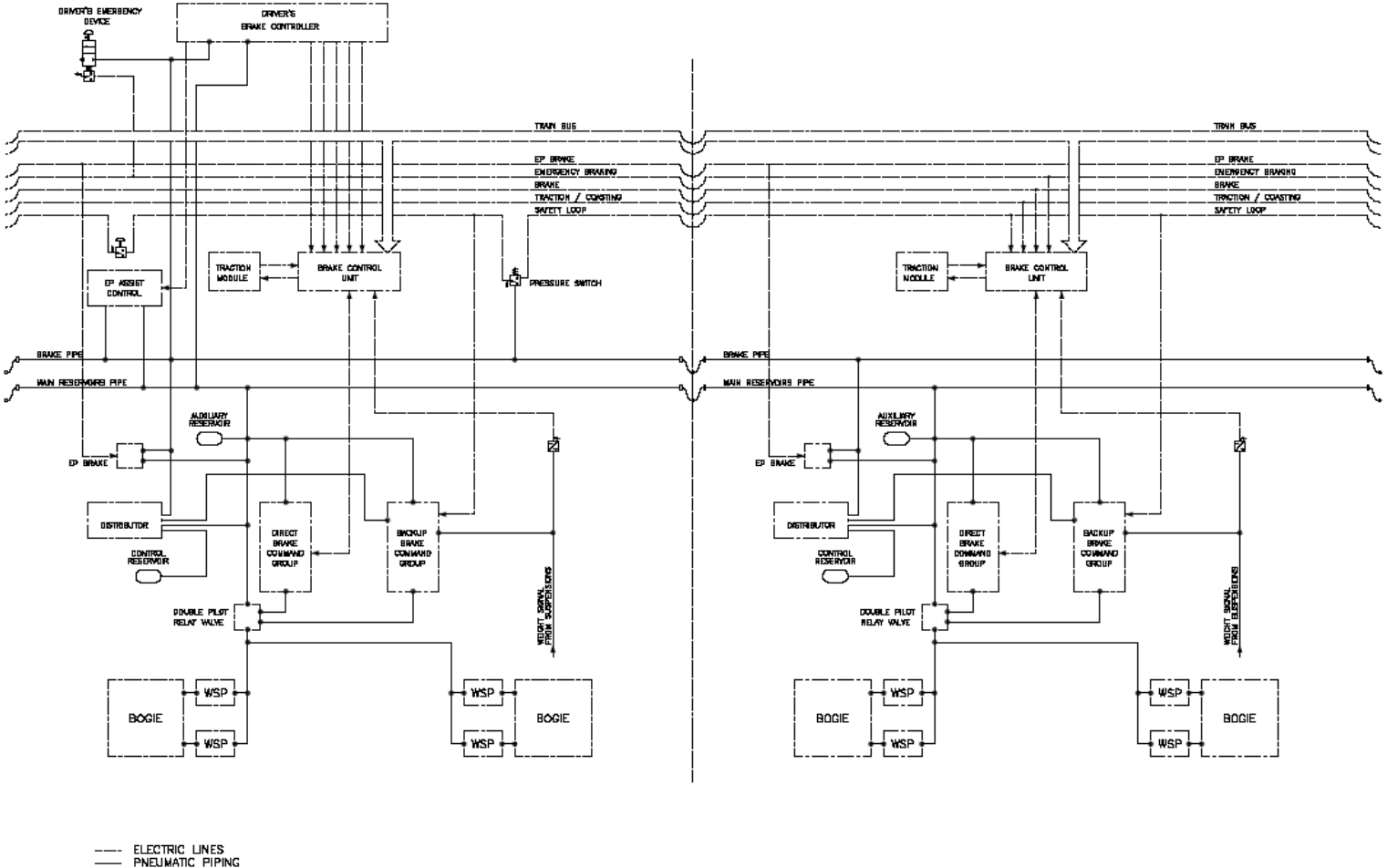


Figure 3 - Example of architecture for direct EP-brake with full pneumatic redundancy

1.3.3 – WP4 - Brake systems modular solutions for interoperability

Objectives

WP4 focused on the one hand on a broad analysis of possible modules of the brake system which can be candidates for standardisation and on the other hand on a detailed elaboration of pre-standards for sub modules within the brake control module as well as in the bogie equipment module. The standardization efforts focus mainly on the interfaces and functions of brake control modules to the system. The analysis of the requirements on the interfaces and functions leads to specifications, which can be directed as proposals to standardization bodies to contribute to existing or to define new standards.

In order to allow further development and innovation, the module has not to be standardized completely. The standardization activities have been divided into the three main modules of the brake system: air generation and treatment, brake control and bogie equipment.

Results

The scope for the standardization items has been narrowed down considering the analysis results of WP 3. The identified components foreseen for standardization are summarized in the deliverable D4.1. The list of pre-standards has been communicated to CEN TC256 and DIN-FSF in April 2009.

The next step used an iterative process to define functional, interface as well as design and installation requirements for the identified components supported by on the industrial and operational expertise of all project partners. In particular, the Operational Requirements Specifications (ORS) 612-0 played an important role within the MODBRAKE specification development process. The standardisation process for the different components was organised in small working groups involving the relevant specialists. One main input for the specification work has been obtained from work package 3, where national and European norms and regulation were analysed with regard to requirements for the brake system.

The standardisation activities on the area of **Air Supply** resulted in the description of the main technical parameters of a standard Air Generation and Treatment Unit for High Speed Trains and locomotives with regard to functional requirements, mechanical, electrical and pneumatic interfaces the air supply units class 2400 and 1600. In addition, a reference procedure for the calculation of air consumption on a train, a specification for the air quality on board of rolling stock and validation procedures of Air Generation and Treatment Units have been produced.

Within the area **Brake Control**, three architectures for Multiple Units have been defined with the aim to standardise the interfaces among the identified sub-modules. The following main architectures (all compliant to the TSI High Speed requirements) have been taken into account by the MODBRAKE partners:

- Indirect brake system based on UIC requirements.
- Direct/indirect brake system UIC compatible.
- Direct/indirect brake system.

Components of the brake control unit:

In addition, the brake control standardisation activities focused on the standardisation of the two following driver's desk devices with regard to the functional requirements as well as mechanical, electrical and pneumatic interfaces:

- Drivers Brake handle/controller (position and time dependent)
- Emergency Brake push button.

Special attention has been given to the ORS612-0.

The standardisation work in the area **Bogie Equipment** specified the requirements and interfaces as well as the operational environment of modern compact actuators/callipers that act on axle or wheels installed brake discs. MODBRAKE also addressed interoperability issues for Eddy Current Brakes (ECB) by describing technical features and giving explanations of the impact of the (vehicle borne) ECB on the infrastructure.

1.3.4 – WP5 – Life Cycle Costs analysis (LCC)

Within MODBRAKE, the LCC toolbox LifeCyCal previously developed in the MODTRAIN Integrated project has been converted into a specific LCC toolbox which can be used to analyze the LCC of brake systems for high speed passenger trains in the European Union. This means that the cost components and their influencing parameters can be found and put together into a consistent model of high speed brake system Life Cycle Costs. The resulting model can facilitate comparisons of different brake system modularisation solutions and provide data for decision making.

By a computer simulation carried out by Technical University of Berlin, the cost share from the total net value of the LCC showed the striking predominance of the maintenance costs. This was due to the relatively high work that is necessary for the regular maintenance operations. The brake system as one of the most relevant parts for the security of the train operation is strongly influenced by the process of abrasion and needs a regular and extensive maintenance. On the other hand, the acquisition of the brake system components, in the form of relatively simple components, does not have such a great influence on the total costs.

The main conclusion from the calculation should therefore be that modifications and modularisations of the brake system components should have the aim to reduce the maintenance needs of the brake system. This could lead to great cost reductions in the entire lifecycle. Even a slight or medium increase in the acquisition costs could be highly compensated by the cost reductions in the maintenance costs.

1.3.5 – WP6 – Prototypes and validation tests

In this workpackage, MODBRAKE produced, tested and evaluated brake modules in order to demonstrate how they work together and show the level of compatibility of the interfaces.

Brake Control – Brake modules

WP4 produced the specifications for various Brake Control architectures for High Speed Trains. Two of them are of particular interest and very good performances can be achieved thanks to the fact that electronic braking control is distributed along the train. Such performances, like the brake application time, are better than in traditional architectures.

It has therefore been decided to manufacture a prototype of a brake control module belonging to these architectures. In particular, a Local Brake Control Module has been manufactured. The Local Brake Control Module is present at least once in each coach of the train and receives the train-wide brake commands and actuates them locally by sending air pressure to the brake equipment on the bogie.

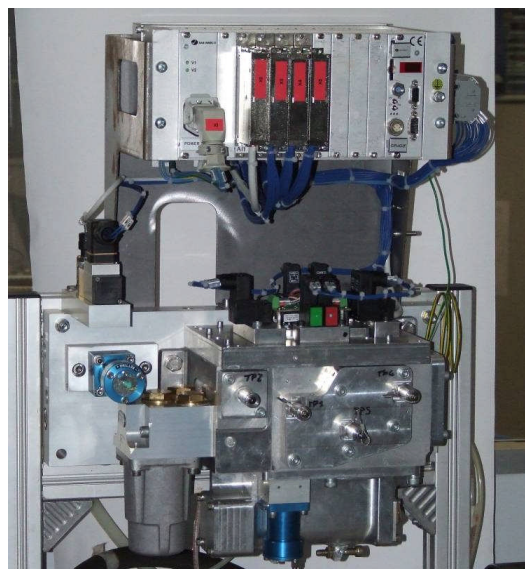


Figure 4 - Prototype of Local Brake Control module

The amount of functions ensured by the Local Brake Control Module is large and for each of these performances need to be checked. An automatic bench capable of performing autonomously all tests would facilitate the tasks by, for instance, comparing the performances of two different modules. Such an automatic test bench for brake control modules was designed and manufactured by the Politecnico di Torino University.

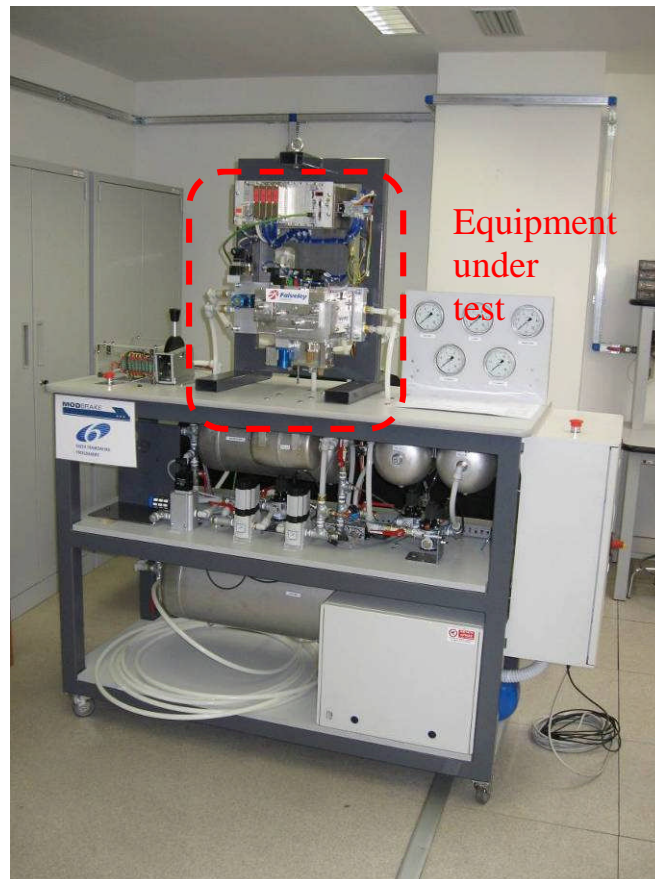


Figure 5 - Automatic test bench for validation of Brake Control modules

Brake Control - Components

The quality of the specifications produced in WP4 has been evaluated.

A prototype of brake controller (the handle through which the driver controls the brake effort) was manufactured by the two industries Faiveley Transport and Knorr-Bremse.



Figure 6 - The Knorr Bremse Brake Controller



Figure 7 - The Faiveley Transport Brake Controller

Both brake controllers have been verified with the support of Tabor, a polish test institute against interoperability criteria, defined in the standardization proposal.

Bogie Brake Equipment – Disk Brake Unit

The validation of the brake equipment installed on the bogie involved a demonstration of mechanical interoperability and the deep testing of units.

In particular, Disk Brake Units have been considered. MODBRAKE called Disk Brake Units compact actuators/caliper incorporated in one part.

Through the mock-up showed in Figure 8 it has been possible to analyze the interoperability of the Disk Units provided by the two industries.



Figure 8 - Mock-up for the mechanical interoperability

In addition, deep testing activities have been carried out by the Tabor test institute, on two Disk Units.



Figure 9 - Testing a Disc Brake Unit at -40°C

2 – DISSEMINATION AND USE

The following table summarises the MODBRAKE deliverables defined as public by the Consortium. They will be made available for download on the project website: <http://www.modbrake.com/>

Item N°	Detailed Name
D2.1	Proposal for improvements or additions within TSI
D2.2	Standards summary and standardisation recommendations to the standardisation bodies
D2.3	Safety and reliability analysis and targets through life cycle
D2.4	Proposition of safety relevant test procedures
D3.1	Requirements for MODBRAKE inherited and completed from MODTRAIN
D3.2, D3.4	FBS, PBS, ORS, and FRS for brake modular system and brake interoperability constituents MODBRAKE modules and SyRS for each brake module
D4.1	Weightened priority list of modules to be standardised
D4.2 – part B	Systems requirements/specifications with standardised interfaces for interchangeability for the air supply module (Air consumption calculation and questionnaire)