Could you outline how you came to work on the Eddy CuRrent brake Compatibility (ECUC) project?

Our department at the Centro de Investigaciones Técnicas de Gipuzkoa (CEIT), a non-profit research institute in Spain, has a wealth of experience in the railway sector and provides technology to train manufacturers such as the Constructions and Auxiliary of Railways (CAF) and has coordinated high-profile European Union projects. Together with major manufacturers such as Knorr-Bremse and Deutsche Bahn, we have encountered the need to exploit the full potential of eddy current brakes (ECBs) for high-speed trains throughout Europe. This need led to the launch of the ECUC project.

ECBs have been successfully used on German railways in recent years. What lessons have been learned from the German experience?

It is the German success that makes the technology so promising. After several years on specific German railway tracks, future expansion to other countries is being considered. However, a thorough interoperability study is very important. That was the rationale of ECUC: to provide starting recommendations for this.

How do ECBs differ from traditional railway brakes?

Basically, an ECB is a large magnet which, when it comes into close proximity with the rail, slows down the train. What makes ECBs so special are their ‘green’ features. As there is no mechanical contact between the brake and track, there is no wear, fine dust, smell or noise from its usage. It can be used as both a service and an emergency brake. Catenary power supply is not essential in all ECBs.

How has the project used electromagnetic and thermal modelling to anticipate the behaviour of railway systems?

Two computer models have been developed in ECUC: one thermal, to anticipate the temperature of the track, and another electromagnetic, to calculate the interference produced by the brake. Both have been contrasted with measurements taken in the laboratory and in test runs on a track with an intercity 3 (ICE3) train fitted with ECBs. The models provide estimated outputs according to particular inputs.

In the case of temperature, the inputs are train braking force, numbers of ECBs per train, speed, number of trains per hour, wind speed and ambient temperature. The output is the temperature increase in the track due to ECB operation. In the case of interference, the input basically refers to the brake current. The output is radiated emissions or interference with axle counters – namely, devices on a railway that detect the passing of a train between two points on a track.

What regulation of ECBs would you like to see to enable further development?

Each country has its own tabulated threshold track temperatures over which there is a certain risk of infrastructure damage. This temperature limit can now be observed from the point of view of ECB performance superimposed on the current agents that increase rail temperature. In the case of electromagnetic emissions, the standard that probably lies closest to our case study is the CLC TS 50238-3, which defines compatibility between rolling stock and train detection systems, particularly in regard to axle counters. However, this standard ignores the usage of ECBs. ECUC does not intend to directly impact on any standard, but can initiate a review by providing insights and recommendations.

Have there been any surprising results from the project?

From a thermal point of view, intuition says that maximum speed (300 kilometres per hour) and brake performance will lead to a maximum track temperature increase. Yet in reality that is not always the case. Our modelling and measurements show that there are speeds that are more critical for rail heating in combination with maximum ECB performance, such as 120 kilometres per hour.

From an electromagnetic point of view, the interferences of ECBs at the frequency of operation of axle counters will probably not be the most important factor to watch. The interaction of ECBs and axle counters are realised through the rail, to which both are very close. It is the change in the properties of the rail, caused by the action of ECBs, that could hypothetically make an axle counter fail in its reading.
As the **Eddy C Urrent brake Compatibility Project** nears completion, its firm recommendations for greener, quieter and more economic braking technology could contribute to increasing the capacity and performance of Europe’s high-speed railway systems.

**IN 1851, THE** French physicist Léon Foucault discovered that a metal conductor moving in a strong magnetic field generated circular magnetic fields, or eddy currents, within the conductor. He found that this dissipated the kinetic energy produced as heat. The phenomenon came to be used in eddy current brakes (ECBs) some decades after Foucault died.

ECBs are currently used in amusement parks on rollercoasters and other rides that need to change speed abruptly. They are also used on high-speed trains, such as Japanese bullet trains, and trains on the LGV Est line in France and some of the Deutsche Bahn lines in Germany.

**BENEFITS OF ECBS IN TRAINS**
ECBs on trains consist of electromagnets in a linear arrangement, with alternating north- and south-pole alignment. A magnetic field operating across the air gap between the rail head and magnets mounted on the truck induces a braking force due to eddy current losses. The magnetic field is created using electromagnets fed by an external power supply, thus the braking force can be finely controlled by adjusting this field. The faster the train travels, the greater the braking force.

Since ECBs exploit magnetic force directly, the braking force is independent of the coefficient of friction. This means that they are efficient regardless of environmental conditions, such as whether or not there are wet leaves on the line, for instance. In contrast to regular contact brake systems, dust pollution, noise and odour are not problems – and as there is no mechanical wear of the brakes, they require very little maintenance and are therefore economically friendly. Indeed, compared to contact brakes, ECBs are estimated to be 50 per cent more cost effective over the course of their lifecycle.

Gilles Ruaux, Head of Subsystems for Brakes and Air Production at the National Society of French Railways (SNCF), considers that:

The **ECUC team** designed a physical setup for testing different eddy current brake systems under real-world conditions with an ICE3 train, at speeds of up to 300 kilometres per hour.
THE EDDY-CURRENT BRAKE COMPATIBILITY PROJECT

OBJECTIVE
To prove that Eddy Current Brake (ECB) is a highly effective and applicable solution for increasing the braking capacity of new high-speed trains.

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ECBs can deliver additional economic benefit by increasing the capacity of the European railway infrastructure, allowing the more frequent usage of railway lines. This is because shorter stopping distances make the increase of the train flow possible. Additionally, because ECBs function independently of adhesion between the wheel and track, and can be powered independently of the catenary electricity supply, they bring an additional brake force not reachable by conventional contact brakes.

ECB ISSUES
Gilles Ruaux is currently collaborating on a research project focused on the suitability of wider ECB deployment in Europe. Entitled Eddy Current brake Compatibility (ECUC), the three-year project is part of the European Commission 7th Framework Programme, and will be completed at the end of August 2015. ECUC researchers were tasked with investigating whether ECBs would increase the braking capacity of next-generation European high-speed trains, and to put forward recommendations for interoperability in complex railway systems.

One issue with ECBs is that the intercity express 3 (ICE3) transets used on some European lines have raised questions about their electromagnetic compatibility with Europe’s railway infrastructures. Potential problems include track composition, negative effects on trackside signalling and, additionally, compromised train control systems from ECB-generated electromagnetic interference.

One fundamental issue is that since ECBs generate heat that is passed into the rail head, longitudinal forces increase, introducing extra-vertical force which can lead to the buckling of the rail. At the very least, this causes potential scheduling limitations – a major concern if the line is frequently used. Moreover, questions surround the additional weight ECBs bring to a truck. For example, the ICE3 ECB assembly weighs more than 800 kilograms – and this is before accounting for its controller module and electrical cables. “Such concerns must be overcome before the full implementation of EBs across Europe,” states Dr Daniel Valderas, ECUC project leader. “For example, significant track temperature increases should be controlled, particularly for a repetitive operation over the same section, to avoid potential lateral buckling of rails.”

ECB EVALUATION AND TESTING
Due to the extensive knowledge and experience of the ECUC team, the project has successfully expanded understanding of the interactions between ECBs, the track and trackside signalling equipment. The researchers have also identified critical thermomechanical and electromagnetic design parameters for ECBs and train and trackside compatibility limits, and have developed new design, engineering and operational guidelines for ECBs and trackside signalling equipment.

A key feature of the project was the design and implementation of state-of-the-art testing facilities. Using the test bench of Knorr-Bremse, the foremost ECB manufacturer, the ECUC team designed a physical setup for testing different ECB systems under real-world conditions with an ICE3 train, at speeds of up to 300 kilometres per hour.

Electromagnetic tests were also conducted in the laboratory, using 3D computer modelling systems to explore ECB interaction with wheel sensors and other parts of the infrastructure, as well as increases in track temperature resulting from their use. The tests covered cases where the ECBs were disconnected, and at both high and low electromagnetic frequencies. As a result of these modelling systems, the ECUC team determined that ECB performance was satisfactory. They also produced a range of worst-case scenarios covering operational conditions, signalling systems, rail head and rolling stock.

INTO THE FUTURE
As a result of testing, ECUC has produced a new set of requirements for ECBs, as well as design and installation guidelines and operational recommendations for signalling systems, tracks and other infrastructure components.

Andrea Demadonna, Technical Affairs Manager at UNIFE and leader of ECUC’s communication activities informs that: “the open ECUC conference in Vienna on 27 August 2015 will present the results from testing, focusing on elements such as ECB emissions by the trackside, interactions with signalling systems, and observed and projected temperature increases in rails due to ECB brake forces”. Recommendations for air gap controls, future ECB design and development and for specific truck design parameters will also be presented. Ultimately, the hope is that these activities will lay the groundwork for faster, cleaner, quieter and safer high-speed train systems in Europe.