Kooperation zwischen dem Ministerium für
Ausrüstung, Transport und Tourismus der
Französischen Republik
und dem
Bundesministerium für Bildung und Forschung
der Bundesrepublik Deutschland

Coopération entre le Ministère de l'Equipement,
des Transports et du Tourisme de la République Française
et le
Ministère fédéral de l'Education et de la Recherche
de la République Fédérale Allemande

Kooperationsprojekt
Schlussbericht

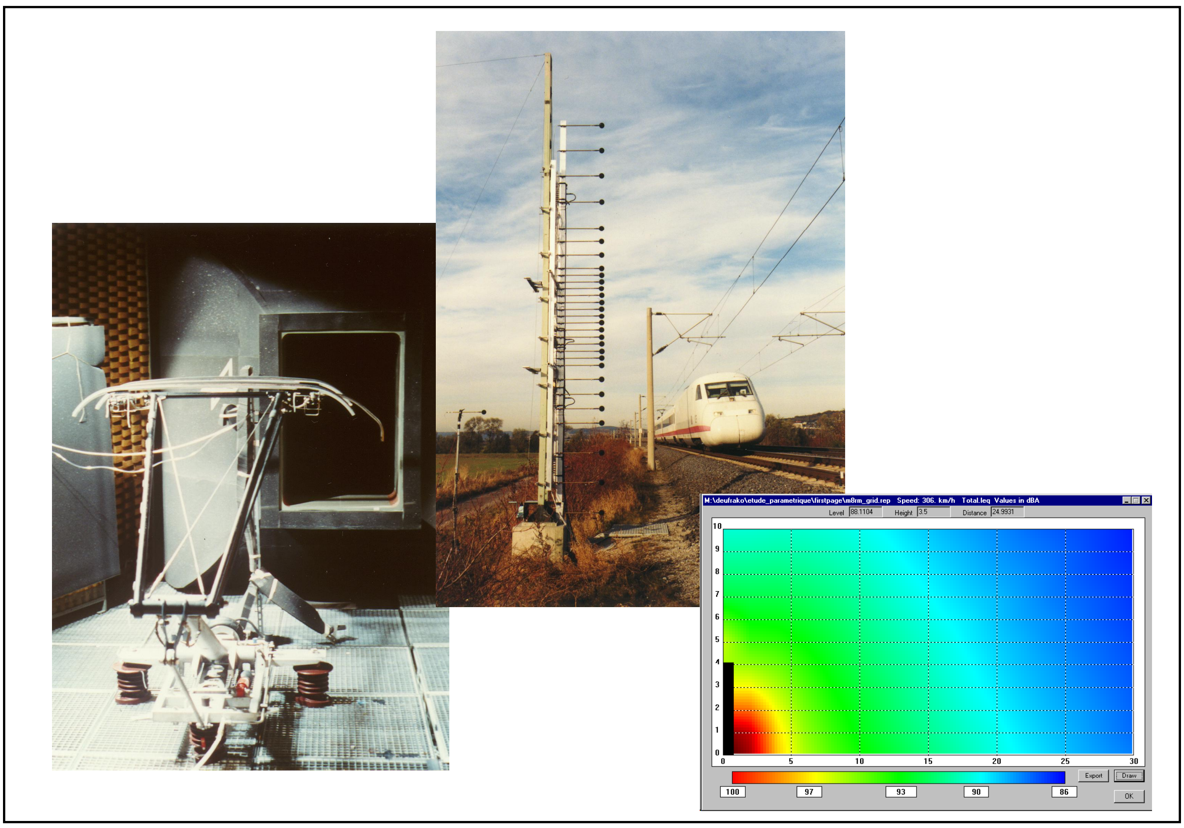
K2

Projet de coopération
Rapport final

DB INRETS SNCF

Geräuschquellen des spurgebundenen Hochgeschwindigkeitsverkehrs

Sources de bruit des transports guidés à grande vitesse



DEZEMBER 1999 / DECEMBRE 1999

Deutsch-Französische Kooperation, Anhang K2

Coopération franco-allemande, Annexe K2

German French Co-operation, Appendix K2

Final Report

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FOREWORD

An agreement of Co-operation has been existing for several years between the Ministry for city planning, Housing and Transport of the Republic of France and the Ministry for Research and Technology of the Federal Republic of Germany in order to help the development of high-speed guided systems. Appendices to this agreement have been defined each time a new project research was undertaken in this field of transport for the common interest of both parties.

The problem of the sound emission of high speed guided systems was identified as a subject of co-operation since the end of the years 80. A first research programme was carried out mainly in order to measure and document the sound emission from the high speed guided vehicles existing in both countries. This programme entitled appendix K allowed to identify the main sources of noise of high speed vehicles.
Nevertheless, even if the objectives of this research programme were reached, the experts at that time advised going more into the knowledge and in particular getting more information about the individual sources of noise in order to propose sound reduction measures.
Thus, an extension of the co-operation for the problem of sound emission was agreed by both Ministries and a new research programme, appendix K2, was defined in 1994. Comparatively to appendix K, it's worth noticing that the subject of the new appendix mainly concerns railway companies and people involved in the development of the TRANSRAPID preferred not to be fully associated to this research.

The work programme K2 was clearly a follow up of the appendix K and was dedicated to the global assessment of the reduction of noise that could be reached on high speed vehicles with actions undertaken on each acoustic source previously identified.

Thus, **a global modelling of a high speed train emission** based on the sum of the different sources radiation was the first objective of the project ; the corresponding software allows now the assessment of this global reduction of noise, of the weight of each source contribution and the **identification of the main parameters influencing the global emission of noise**.

To build this global modelling it was necessary before to carry out researches on the characteristics of each acoustic source and on the possible reduction of noise that can be expected for each of them.
The noise of high speed trains on operation is composed of rolling noise and aerodynamic noise. As many researches were already engaged in the field of rolling noise (ERRI), the work programme K2 concentrated on **aeroacoustic sources**. Nevertheless, it was agreed that two mechanical phenomena would be studied, **the parametric excitation and the stick-slip**, in order to compare them to the roughness mechanism assumed to be so far at the origin of rolling noise.

Even if the final objective for the railway companies had to be the reduction of noise, it was agreed that researches should not go up to the step of designing industrial solutions ; the product of this research in common had to apply both to German and French high speed technologies.

For this reason the work programme was dedicated to the study of the phenomena involved in the generation of noise in order to be able to define general concepts for the reduction of noise, the measurement and treatment methods being developed within the project if necessary. As regards the global modelling, an other objective was also to provide a sufficiently accurate description of these sources to model them.

The results of this ambitious project are reported here without too much detail in order to keep this document readable. These results satisfy the objectives of the project and, in the different research fields treated, they might stand for a reference.

Finally, it's worth mentioning that the project has mobilised many companies and people. Representatives of DB AG, INRETS and SNCF technically contributed to the research and also managed the project. The partner companies or institutes, retained within the project to carry out some tasks as subcontractors, have provided a work of great quality, their last contribution to the project being to help writing this report providing a synthesis of their results.
The name of the involved companies, institutes and participants are the following :

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PART 1

THE AEROACOUSTIC PART

Introduction

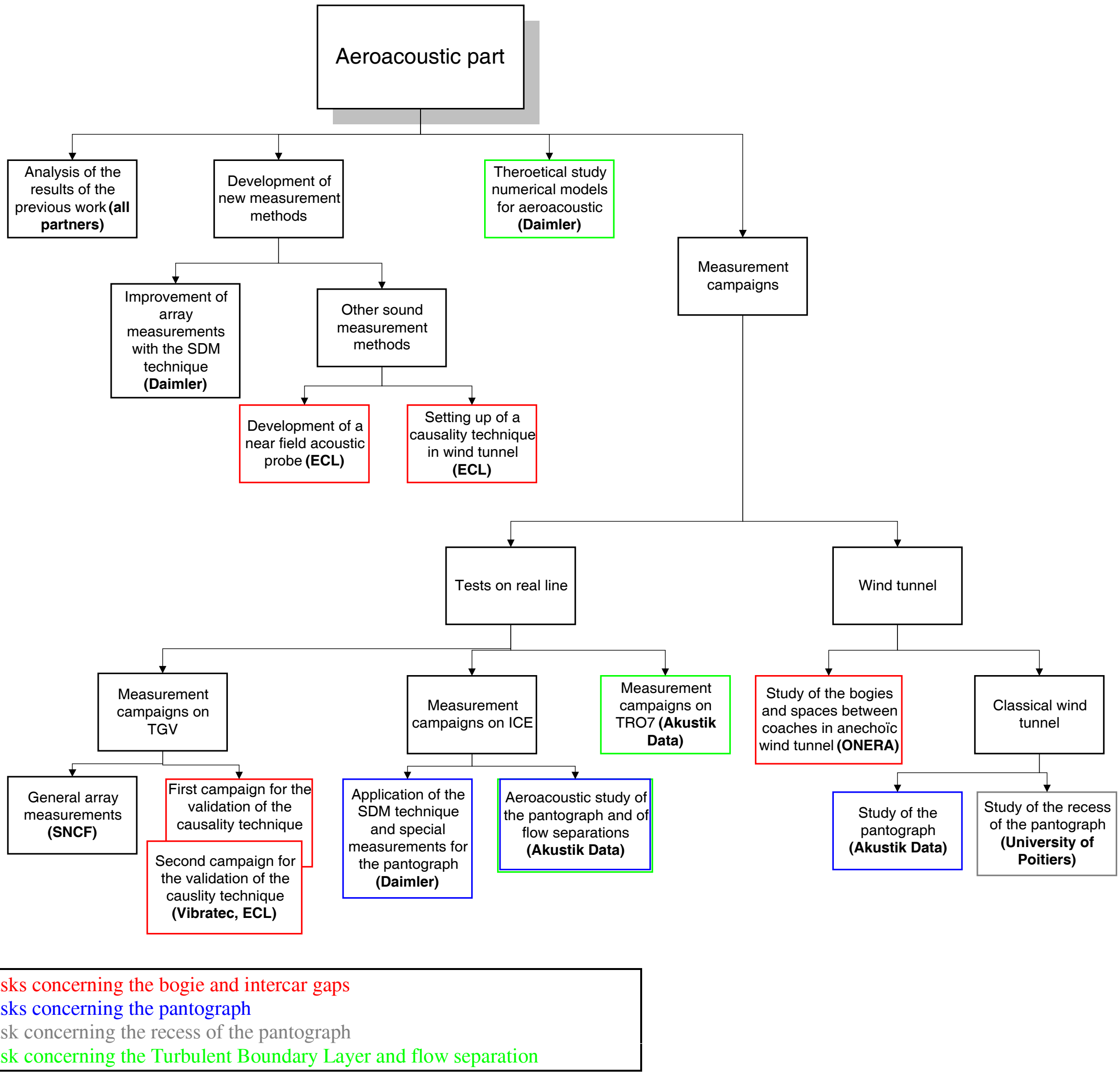
The global objectives defined at the beginning for the aeroacoustic part were the following :

to characterise more accurately the sources of aerodynamic noise and to better understand the mechanisms generating noise,
to be able to define noise prediction models from the knowledge acquired,
to define general concepts applying to each source for the reduction of noise.

To achieve these objectives, each region of high speed trains identified as an aeroacoustic source in the appendix K had to be the subject of an individual study. These elements are the following :
the pantograph,
the recess of the pantograph (and the equipement),
the intercar gap,
the bogie,
the nose of the power car (flow separation were suspected),
the surfaces (it concerns the boundary layer).

The consulted companies at the call for tender had the possibility to propose works, for a given source or several ones, in the following packages :
a state of the art concerning the element or phenomenon at study,
the development or improvement of measurement and treatment methods (to get more accuracy in the source studies),
the realisation of measurement campaigns dedicated to one source,
theoretical study and modelling.

The results of the call for tender allowed to build a research programme for the aeroacoustic part that covered all the points mentioned before. In order to lower the cost of the project, only one study was carried out for each element, either for the ICE or for the TGV, assuming that general results could be extended to both technologies. The following work breakdown structure presents all the tasks planned within the aeroacoustic part.



Work break down structure of the aeroacoustic part

Almost all the tasks were carried out completely except the theoretical task of modelling which has not provided the expected results. Moreover the task entitled « measurement campaign on the TR07 » does not correspond to the realisation of measurements but to the processing of data previously acquired with array measurements.

In the following chapters, the results of the aeroacoustic part are reported for each source studied making the synthesis of all the tasks carried out for it.

1- The pantograph

1-1 Introduction

The pantograph was one of the element identified as an aeroacoustic source in the appendix K for which it could be expected that some well known flow phenomena, induced by the cylindrical elements of the structure itself, were at the origin of noise. This a priori knowledge on the phenomena greatly helps building a complete study for the pantograph, to confirm these phenomena occurrence and to check they are predominant as well as to define concepts for this noise abatement. Thus, three studies were undertaken. The first study in an anechoïc wind tunnel allowed to investigate the noise of cylinders, or parts of a pantograph, placed in a flow. The results of this study concerning noise abatement concepts for a pantograph were verified with a second measurement campaign led at real scale on an ICE, with acoustic array measurements. Finally an attempt to better understand the behaviour of the pantograph on operation and to identify the main noise radiating parts was carried out with special measurements on an ICE.

1-2 Acoustical investigations of free-ended cylinders and a full-scale DSA 350 SEK pantograph in an anechoic open-jet wind tunnel (Akustik Data)

Within this first study, the investigation of the pantograph noise component was the subject of two series of measurements [1, 2]. The main goal was to better understand the generating mechanism as well as to develop practical techniques for controlling and abating this noise. Since a pantograph comprises a number of cylindrical elements, it seemed to be useful to study the sound generated by flow interactions with slender bodies at first. Therefore, the investigations included the following two steps:

wind-tunnel experiments with a variety of basic slender bodies, i.e., cylinders [1] and,

wind-tunnel experiments with a full-scale DSA 350 SEK pantograph [2].

The first Report [1] is introduced by a detailed theoretical study of aerodynamic noise produced by slender bodies. A slender solid body immersed in an ambient stream of moving fluid can generate tonal sound. Many publications about this phenomenon do already exist, so that [1] contains a detailed summary of this existing knowledge. In addition, [1] deals with some new aspects which have barely been investigated before.

1-2-1 Wind-tunnel experiments with cylinders

1-2-1-1 Wind tunnel and measuring equipment

The investigations were carried out in the acoustic wind tunnel (AWB) located on the grounds of the DLR Research Centre in Braunschweig. An anechoic chamber surrounds the test section of the open jet. The exit nozzle has a rectangular cross-section of height 1.2 m and width of 0.8 m. With this nozzle, the wind tunnel has a maximum operating wind speed of 69 m/s. All cylinders were located along the centreline of the jet. Sound was measured with two single microphones which where positioned at a distance of 1.4 m laterally to the