PROJECT PROPOSALS FOR THE 2ND CALL OF FP7

(DEC 2007 – JAN 2008)

Template for the project synopsis

1. Proposal for project name

Holistic Approach to Rail Corrugation and Induced Noise (HARCIN)

(subproject of Large Scale Project in FP7 on the mitigation of vibrations and vibration induced noise from railways or Small-Medium size standalone Collaborative Project)

2. Problem that the project will address (why is the project being initiated?)

Rail corrugation is a main factor of noise and vibration along railway lines and nearby structures. It affects ride quality and have a big impact on the safety of railway transportation.

3. Scope of the project

The present project aims at understanding from an holistic approach the causes of corrugation, particularly short-pitched corrugation (20-80mm) and identify possible remedies to vibrations and noise for their elimination at source.

Main (measurable) objectives

1. Clarify the differences from the main models in the literature (Frederick 1986, and its evolutions Tassilly and Vincent 1991), and others (Hempelmann & Knothe, 1996, etc).

2. Understand the main causes for short pitch corrugation mainly to distinguish between lateral and longitudinal wear mechanisms, to distinguish parametric resonance effects due to discrete sleepers support, etc.

3. Identify which active or passive damping techniques can work also with the "resonance-free" mechanism.

Proposed solutions and deliverables

Identify which features of the vertical model give rise to resonance-based mechanism (Grassie-like) and which to resonance-free mechanisms (non-Grassie-like). Rail corrugation and induced noise will be simulated with software tools taking into account both the classical models and the new resonance-free model and the simulation results will be checked against corrugation and ride quality measurement acquired with MER MEC monitoring systems. Active or passive damping systems will be suggested, robust in eliminating the resonance-based mechanisms for corrugation, but also the "resonance-free" mechanisms, or at least not giving worsening of the corrugation due to this mechanism.

4. Which section of the 2nd call draft is being addressed?

SST.2008.1.1.3 Holistic noise and vibration abatement (level 1)(CP-FP/CSA) p. 71, and in particular:

- holistic noise and vibration abatement solutions which consider the entire vehicle/vessel and infrastructure system and addresses annoyance aspects;
- new technologies and system approaches for improved noise and vibration control at source;
- comparative cost benefit analysis of noise reduction systems and unified noise assessment methodologies considering the standing practice of implementation and legislation on noise.

5. State of the art: previous or on-going research or standardisation initiatives in this area

Short-pitch corrugation is one of the main causes for noise in rolling contact, but despite its importance and the many efforts in research to understand the main features, present approaches and classifications of rail corrugation have been based on the concept that corrugation is induced by dynamic resonances of the system (Grassie and Kalousek 1993, Grassie 2005), despite this is not fully in agreement with experiments. In metro system, the second torsional resonance of the wheel at about 300Hz has been considered as the main factor (Elkins Grassie and Handal, 1998). Now, while this has given rise to important research into active and passive damping systems which were suggested probably the first time by Elkins Grassie and Handal in the TCRP Rail Corrugation Mitigation in Transit in 1998, and have been explored also in the EU project Corrugation (see Colette 2007, Colette et al 2006), this classification does not take into account that short-pitch corrugation has never been convincingly firmly attributed to single resonance by all authors.

Although recently Grassie et al (2007) claim that the “enigma is largely solved” pointing exclusively to the pinned-pinned resonance regime (bending of the rail between two sleepers at a frequency which is around 460Hz in metro systems, and around 1kHz in railways), this is in contrast with earlier findings at least for North American metro systems by Grassie himself in the TCRP Rail Corrugation Mitigation in Transit (1998), suggesting the 300Hz torsional resonance regime, and more importantly this is in contrast to the large collection of data from BR (British Rail) collected over more than a century. So it seems prudent to take the earlier view by Grassie (1990) admitted the corrugation is still an “enigma”

The main railways corrugation seems to be there similar to the Vancouver SkyTrain (which has no pinned-pinned resonance since there is continuous support) and where most data fall continuously in the range from 300Hz to 800Hz which shows no resonance of the system. Ciavarella & Barber (2008) recently suggested a “resonance-free” mechanism which is possibly also at play together with the resonance-based mechanisms, and indeed seems to explain the main features of the recorded short-pitch corrugation.

6. Estimated budget (total and EC Contribution)
(Please note that under FP7 R&D activities as well as demonstration will be 50% funded)

To be defined

7. Project duration *(indicative range: between 24 and 48 months)*

To be defined

8. The leader of the proposal preparation

MER MEC and Politecnico

9. Main potential partners (names of companies supporting the proposal as opposed to potentially interested stakeholders)

- MER MEC S.p.A. (Italy)
- TECNOGAMMA S.p.A. (Italy)
- INNOTECH SARL (France)
- Politecnico di Bari (Proff. Ciavarella and Demelio) (Italy)
- PoliMechanica (spin-off of Politecnico di Bari led by Prof. Demelio) (Italy)

10. Contributions to standards – can the results of this projects be transferred into future EN standards? *(Maximum 5 lines)*

Classification of corrugation should be revised. Grassie and Kalousek (1993) have introduced the system of classifying corrugation by “fixing mechanism” and “damage mechanism” which sometimes is ambiguous, since it assumes that “fixing mechanism” is a resonant frequency. The idea of “fixing-mechanism” is possibly confusing since it does not recognize the “resonance-free” regime, and associates two corrugation regimes to the two vertical resonances in the range 50-300Hz (Type 1 corrugation of P2 resonance type, and Type 4 for resonance of traverse) whereas it is the complex interplay of the two resonances and the antiresonance, and the "contact filter” which gives the corrugation regime. Also, the same frequency can give rise to both long-pitch corrugation for large speeds, or short-pitch for low speeds.

A possible alternative is to distinguish between the following cases.

a) The corrugation regimes below 300Hz: the two main vertical resonances of the rail-wheel system in this range are one where the rail and sleeper move in phase on the flexibility of the ballast, whereas at the higher one, they move in antiphase on the flexibility of the pad. The pad stiffness is seen to be extremely important, as while there is always a peak of normal force at 100Hz, a second peak can exist in the range from 300 to about 1000Hz for the highest stiffness, where we have the highest force anyway, corresponding to the oscillation of the contact stiffness alone. A quite distinct case is the wooden sleepers case: the second resonance is not seen so it is like the beam has a simple damped support and generally much higher flexibility than the other cases.

b) The corrugation regimes between 300Hz and ~1kHz (pinned-pinned resonance). This is the regime explained in Ciavarella and Barber (2008) and is due to the phase shift from the dynamic normal load due to the “contact filter” and depends mostly on the mass and the stiffness of the rail beam considered as attached at infinity (hence not dependent on the sleepers support) and the contact filter itself, which in turn is sensible to geometrical features of the 3D contact.

c) The corrugation regimes around ~1kHz (pinned-pinned resonance). More studies are needed here, especially to include the parametric resonance effects, which are probably strong above 20m/s and hence with high-speed trains, and whose effect is neglected in most present studies.

11. Implications of the project for current individual company products and practices – is the proposal supported internally within each major partner at the strategic level? *(Maximum 5 lines)*

MER MEC S.p.A. provides the diagnostic vehicles and the measurement systems for the measurement of rail corrugation (non contact, opto-electronic on-board systems) and ride quality (inertial on-board systems). On the other hand, the holistic model for rail corrugation

and induced noise will contribute to the design of active and passive damping systems that will be installed on-board so as to optimize the ride quality and the measurement systems' performances.

The proposal is strategical for the proposers and strongly supported by the top management.

12. Risk factors that could jeopardize the implementation of results. How to ensure market up-take and who will have the responsibility over the implementation? *(Maximum 5 lines)*

The involved companies will be in charge of project results exploitation.

Please send it back to: giorgio.travaini@unife.org