MARKET IMPACT EVALUATION

ERRAC was set up in 2001 and is the single European body with the competence and capability to help revitalise the European rail sector:

• To make it more competitive
• To foster increased innovation
• To guide research efforts at the European level

ERRAC Project Evaluation Working Group (EWG)

Objectives:
• Determine the market impact of previous rail research to improve use of research funding
• Ensure a strategic approach to the prioritisation of rail research

Project Evaluation
• Individual projects are evaluated after they have been completed to ensure successful dissemination of project results
• To ensure that the results of previous rail research can be taken into account for future projects
• To avoid weak market uptake of results by learning the lessons of previous research
• The EWG will provide intelligence based on the project evaluations for input into future European Framework Programmes
ERRAC Project Evaluation Group

ALJOIN
<table>
<thead>
<tr>
<th>Project acronym:</th>
<th>ALJOIN</th>
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</thead>
<tbody>
<tr>
<td>FP:</td>
<td>5</td>
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<tr>
<td>Project Reference:</td>
<td>G3RD-CT-2002-00829</td>
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<td>Call identifier:.</td>
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<tr>
<td>Total Cost:</td>
<td>2,177,806 EURO</td>
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<tr>
<td>EU Contribution:</td>
<td>1,200,036 EURO</td>
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<tr>
<td>Timescale:</td>
<td>01.08.2002 - 31.07.2005</td>
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<tr>
<td>Project Coordinator:</td>
<td>Dr Donato Zangani</td>
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- Presented by: M.Robinson
- Date evaluation: 8.07.2009
- Market uptake: S
- Follow up projects:
  - ALJOIN Plus
- Other related Projects:
Crashworthiness of joints in aluminium rail vehicles

Premise:
Ensuring the competitiveness of European industry in the future requires substantial investment in research and innovation today… It is equally important for industry and public authorities to foster the transition to a sustainable world. Working practices must be transformed, regulations improved and the use of resources optimised, from the extraction of raw materials right through to effective waste management.

European science and technology is second to none - its exploitation by industry, however, is not. Financial investment in innovative, technology-oriented firms is lower in Europe than in some other parts of the world, while Europe’s industries remain separated by regulatory, cultural and legal barriers despite the single market. These problems are particularly relevant to the take-up of more environmentally friendly technologies and the development of a more efficient, integrated transport system.

(from: European Competition, Global Concerns, Programme Brochures, Vth Framework Programme, Research DG’s Communications Unit, EC, 2000)
Crashworthiness of joints in aluminium rail vehicles

Rationale:

The project has been developed under the aegis of Competitive and Sustainable Growth, one of the four thematic programmes of the Fifth RTD Framework Programme (1998-2002), conceived to tackle the key challenges facing European industry – sustainable transport, efficient and quality-based production, materials for the 21st century, measurement for quality control and more. In particular, ALJOIN focuses on the development of joining technologies for the manufacture of rail vehicles in order to improve their performance in the event of a collision and thus enhance the safety of rail passengers and staff.
Crashworthiness of joints in aluminium rail vehicles:

Background

Main Objective:

- The main objective of the project was to provide sufficient knowledge to design cost effective aluminium rail vehicle bodies that will not fail by catastrophic joint failure under extreme loading. This will be achieved through the following intermediate objectives:
  
  ✓ To determine the performance specifications required by critical aluminium joints in rail vehicle cars to ensure the structural integrity;
  ✓ To provide physical evidence of the energy absorption capability of aluminium alloy welds by testing;
  ✓ To investigate performance and failure criteria for aluminium welded and bolted joints;
  ✓ To explain test results assessing the adequacy or inadequacy of current design and construction practices of aluminium alloy welds in the context of crashworthiness;
  ✓ Implementation and validation of material failure models for welds of aluminium alloys;
  ✓ Definition of the main material and structural parameters which can influence the mechanical behaviour of the joints;
  ✓ Development of the material constitutive modelling for the parent material and the material in the welded volume;
  ✓ Numerical modelling of simple joints subjected to axial and transversal forces;
  ✓ Numerical analysis of components and structures subjected to quasi-static and impact (dynamic) loading conditions in order to evaluate the structural response in terms of mean axial crushing force, total energy absorption, load efficiency and uniformity, deformation mechanism.
  ✓ To investigate alternative welding techniques and/or joint designs for improved joints of aluminium alloys.
ALJOIN: Background

Details
- FP5
- Project Reference: G3RD-CT-2002-00829
- Total Cost: 2,177,806 EURO
- EU Contribution: 1,200,036 EURO
- Timescale: 01.08.’02- 31.07.’05
- Project Coordinator: Dr. Donato Zangani

Partners
- D’APPOLONIA S.P.A.
- NEWRAIL – The University of Newcastle
- ALCAN TECHNOLOGY & MANAGEMENT AG
- BOMBARDIER TRANSPORTATION LTD
- DANSTIR APS
- THE WELDING INSTITUTE (TWI) LTD
## ALJOIN : Background

### Partners interviewed:

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Name of interviewee</th>
<th>Country</th>
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<tbody>
<tr>
<td>D’Appolonia SPA</td>
<td>D. Zangani</td>
<td>I</td>
</tr>
<tr>
<td>NewRail – Newcastle University</td>
<td>G. Kotsikos</td>
<td>UK</td>
</tr>
<tr>
<td>Bomabardier Transportation</td>
<td>M. Roe</td>
<td>F</td>
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<tr>
<td>Danstir</td>
<td>T. Lorentzen</td>
<td>DK</td>
</tr>
<tr>
<td>The Welding Institute (TWI)</td>
<td>J. Davenport</td>
<td>UK</td>
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<tr>
<td>Alcan</td>
<td>D. Hofmann</td>
<td>CH</td>
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ALJOIN : Background

Project description:

1. The research during this project has examined the merits of various fusion welding techniques such as Metal Inert Gas (MIG), Friction Stir Welding (FSW) and Laser Beam Welding (LBW) in terms of their performance under dynamic loading. None of the weld techniques was able to completely suppress the development of dynamic tear (weld unzipping) observed in real rail vehicle collisions.

2. The choice of an Al-Mg filler wire in automated MIG welding of extruded sections improved the tearing resistance of the joints and has been recommended for use in new rail vehicle manufacture.

3. Of greater importance to suppressing weld unzipping of welds has been the design of the joint itself. A thickening of the cross-section at the joint region of 1.4 times the extrusion sheet thickness is sufficient to alter the failure mechanism from weld unzipping to ductile tearing of the parent plate.

4. A methodology for modelling the outcome of a rail vehicle collision has been developed based on the material characterisation work in this project. The collision FEA simulation has been able to reproduce the failures observed in real life collisions and has demonstrated the improvements in crashworthiness through the implementation of the joint designs developed in this project.
ALJOIN: Background

Achievements:

1) Material testing techniques
A novel testing technique utilising real extruded sections to produce large Double cantilever beam specimens and based on the energy dissipation rate approach has been developed to assess the tearing resistance and energy absorbed during growth of a crack along the weld. The results from this testing approach have also been used to optimise the finite element analysis (FEA) model used for the subsequent simulation of a rail vehicle collision.

2) Impact Testing
A special rig has been designed and built to assess the performance of full size welded extrusions under highly dynamic loads. The rig is fully instrumented to record the maximum impact load and strain on the extruded sections thus providing a full picture of the energy absorbed by the joint.

3) Modelling techniques
A FEA model has been developed to simulate the effects of a collision on a rail vehicle. The model allows for the introduction of various joint geometries in order to assess the performance of the structure under impact. The model has been validated through results from a real life collision of a class 165 DMU.
ALJOIN : Background

**Achievements:** Material testing
Novel specimen in testing machine for assessing tearing failure in welded region
ALJOIN: Background

Achievements: Impact testing
Testing facility to assess joint behaviour under highly dynamic loads
ALJOIN : Background

Achievements: Modelling
Finite Element Analysis model. Computer simulation of the collision of a rail vehicle. Model has been validated through data from real life collisions.
ALJOIN : Evaluation

1. Were the results implemented in the design of the new products and services? Were these new products/services put into commercial operation

– Yes, the main ALJOIN project outcomes have been the implementation of a joint design for extruded aluminium sections and an input to European Norms for aluminium welded joints.

2. Is new legislation and standardization based on findings from this research project

– Yes, the output from ALJOIN has contributed to additions in prEN 15085 "Railway applications - Welding of railway vehicles and components" and prEN 15227, the draft standard for Crashworthiness of Rail Vehicle Bodies

3. Are the results of the project implemented across Europe or only in a small number of Member States

– The results will be implemented across Europe.
4. Are the results of the project implemented outside Europe before being accepted in Europe — *It is not known at the moment but interest has been shown by Japan on the results of this project.*

5. Did the projects increase competitiveness of the European railway sector abroad with regard to products, services, standards and system design
   — *Yes, implementation of the recommendations from this project have enhanced the crashworthiness of new rail vehicles produced in the EU and consequently improved the safety of passengers using rail transport.*

6. Did the project increase competitiveness of the railway transportation compared to other transport modes
   — *Yes, the railways are one of the safest modes of surface transport and this project has contributed towards enhancing safety.*

7. Are the results of the project taken into consideration when preparing public tenders
   — *Yes*
ALJOIN : Evaluation

8. Does the implementation of the project results help facilitate cross-border operations by problem-solving in the domain of interoperability
   – No

9. Does the implementation of the project results help facilitate inter-modal operations by problem-solving in the domain of inter-modality
   – No

10. Can benefits be assessed in financial terms
    – we don’t have information about

11. Applicability of results to future scenarios
    – Yes,

12. Usefulness of research procedures for future projects (incl. modeling)
    - Yes the modelling approach in this project provides all necessary information to further improve the design of future rail vehicles
ALJOIN : Reasons for outcome

✓ ALJOIN has addressed a specific technical problem that has concerned the rail manufacturing industry for many years by bringing together, industry, academia and research institutions in a joint effort to provide a solution.

✓ The project analysed in detail joining techniques by addressing both the metallurgical parameters of the fusion welding process as well as the geometry of the joint itself.

✓ The technical solutions developed through ALJOIN have been exploited by the European Rail manufacturing industry and already implemented in the manufacture of rail vehicles.

✓ The results have been made available for the review of the future revisions of the relevant standards in the field of aluminium joint crashworthiness and for the construction of the future aluminium railway cabodies.

✓ Aljoin provided a significant contribution in relation to the report to the Cullen Enquiry, related to the Ladbroke Grove rail crash (1999)