FINAL TECHNICAL REPORT
PUBLISHABLE

SYNTH.

CONTRACT N.: **BRE2-CT92-0246** (SED)

PROJECT N.: **BE5549**

TITLE: **ADVANCED TECHNOLOGIES FOR AUTOMOTIVE SEAT EVALUATION AND DESIGN**

PROJECT COORDINATOR: **C.** R.FIAT (Centro Ricerche Fiat)

PARTNERS :

LEAR Italia	(Lear Seating Italia)
COURTAP	(Courtaulds **Textiles** Automotive Products)
LEAR GmbH	(Lear Seating GmbH & Co.KG)
TUB.IFT	(Technische Universität Berlin - Institut fur Farzeügtechnik)
ULOUGH.DHS	(University of Loughborough - Department of Human Sciences)
USOU.ISVR.HF	(University of Southampton - Institute of Sound and Vibration Research - Human Factors)

REFERENCE PERIOD FROM 01/11/92 **to** 31/10/95

STARTING DATE 01/11/92 DURATION: 36 MONTHS

PROJECT FUNDED BY THE EUROPEAN UNION UNDER THE BRITE/EURAM PROGRAMME

DATE: 15/ 12/95

TABLE OF CONTENTS

1) SUMMARY

The objective of the Project has been to achieve a breakthrough in automotive seating product development.

The objective has been reached by means of a set of integrated methodologies enabling a new way to design, evaluate and test the seats of an automobile.

These methodologies have" the goal to cover the following aspects of the seat development process, in which the main weaknesses of current engineering capabilities are located:

- passive safety:
  side impact evaluation of the system "seat & occupant"
  numerical simulation of all crash conditions

- thermal comfort:
  objective evaluation of the level of thermal comfort
  analysis of properties influencing thermal comfort
  design criteria addressed to thermal comfort

ergonomics and postural comfort:
  influences of car seating on musculoskeletals deseases
  assessment of factors influencing postural comfort
  numerical simulation of man-seat interaction

vibrational comfort:
  need of an anthropodynamic dummy to limit vibrational tests on human subjects
  assessment of the vibrational mission of the seat
  assessment of the design factors influencing the vibrational comfort
  criteria for vibrational design of foam paddings

recycling:
  assessment of recycling strategies for the seat, with the main focus on foam recycling
  trade-off between vibrational comfort and recycling in foam design.

Then, all the above mentioned methodologies have been integrated by means of a layer of Information Technologies, achieving the so called "Engineering Platform" for automotive seat evaluation and design.

Fig. 1, shows the Project structure as well as the sharing of the tasks among the partners of the consortium.

At the present, the Engineering Platform has been fully completed; its operating capabilities have been demonstrated through the following steps:

- pilot application to a seat with magnesium structure

- pilot application to a seat with integrated belts.

Therefore, as main result of the Project, the industrial partners of the consortium are ready to develop new seats according the Concurrent Engineering Process presented in Fig. 2.

AH the development subprocesses are run in parallel, choosing between the virtual approach or the physical approach according the complexity of the engineering factors to evaluate: as an example, it is now possible to evaluate passive safety mainly in virtual reality, instead it is necessary the experimental approach to evaluate thermal comfort or vibrational comfort as a consequence of the complexity of the physical phenomena involved.

When the experimental approach is choosed, within the Engineering Platform is available a data base of reference tests from which to extrapolate the behavior of the new seat, without to wait for the specific prototype.

This complementary numerical - experimental approach allows to adopt numerical simulation only where the virtual approach is quicker and cheaper of the experimental one, for all the other cases the evaluation arises from already existing experimental data, without interrupt the Concurrent Engineering Process.

It is to mention that this Concurrent Engineering Process starts with the Target Setting Phase for the development of a new seat and lasts till the completion of the Product Release for start of production.
The level of complexity of the engineering evaluation is coherent with the above mentioned phases: very synthetic at the beginning of the process, very accurate in development & tuning phase.

The Concurrent Engineering Process has the core team in the development centers of both the seat maker and his 1st tier suppliers (e.g. fabric supplier}, but also research centers and universities will play a remarkable role as engineering suppliers for all cases in which unexpected technical difficulties will arise in developing innovative concepts of seat.

Finally, the Concurrent Engineering Process of the seat deeply involves also the car maker (Fig. 3): each development phase addressed to a new car is simultaneously performed by the network operating on seat development; this network interacts through the seat maker, that represents the 1st tear supplier of the car maker for the overall seating system.

This Concurrent Engineering Process, performed through the Engineering Platform developed in this Project, enables the seat maker as well as his suppliers to effectively face the strong competition characterizing the automotive market as the result of both the global outsourcing policy adopted by the car makers and the consequent globalization policy currently undertaken by their suppliers.

2) INTRODUCTION

The seat is the car subsystem most important in determining the quality of the life spent travailing in a car.
The seat has to guarantee to the human body proper conditions in terms of comfort and passive safety, meeting medical criteria, legislation, customer and social view-points; and additional requirement to be considered is the recycling at the end of the service life.

The proper design of seat characteristics may significantly contribute in reducing fatalities and injuries due to car accidents. Due to improved comfort, acting on psychophysical factors, the active safety level of the system car/driver will also be increased.

Besides the introduction of new technologies for seat design focused on numerical simulation, with consequent reduction of prototyping activities, will also induce better working conditions creating new opportunities in education and employment within industries.

The industrial impact of the project results will be remarkable, since the market size of car seat kits in Europe is 8000-10000 MECU. Besides the trend of this market is showing a further rise for the higher complexity of the seat system as an element strongly influencing the customer satisfaction.

The enhanced codesign capabilities achieved through this project will strengthen the integration among car makers and SMEs, facilitating in the future dissemination of R&D among them.

Besides the better capability to understand the behaviour and the performances of the seat with regard to safety and comfort have also allowed, within this project, to address normative proposals representing for the E.U. an opportunity for establishing norms and standards to achieve social benefits in working & life conditions, also reducing the social costs due to injuries and diseases.

3) TECHNICAL DESCRIPTION

The key-objective of the project is the development of an Engineering Platform to support seat development so that, in parallel to the accomplishment of usual targets on style/quality/cost, demanding specifications regarding safety/comfort/recycling and time to market can also be accommodated.
In this Project the term "Platform" is used for a layer of information technology integrating:

. Databases: mission profiles, design criteria, standards, recycled materials characteristics;

. Tools: specific CAE software for numerical evaluations, experimental tools for road tests and laboratory test-rigs;

. Methodologies: design and evaluation procedures for the different phases of the product development cycle.

The main advantages associated with the use of the Engineering Platform are:

to allow concurrent engineering covering all seat objectives

to analyse in the early design phase the interaction between car seat and human body, reducing prototyping and focusing experimental activities

to reduce time to market by using the most advanced CAE numerical and experimental tools, fully compatible with industrial standards.

It is aLso an objective of this project the full validation of the above mentioned Engineering Platform by applying it to a pilot case such as the development of a new seat concept.

To reach all the capabilities of the Engineering Platform, the following specific achievements have been defined and reached:

On Passive Safety:

An experimental sled test procedure for seat evacuation in sick impact conditions based on the dummy biomechanical response
FEM numeric procedures in compliance with the experimental ones for seat evaluation in front, side, rear impact conditions based on the dummy biomechanical response.

On Thermal Comfort:

Methods of correlating the subjective assessment of the car occupants to objective test procedures so that the comfort sensations can be Iinked to measurable parameters of the trim material

. Procedures for trim materials characterization.

Design criteria

On Ergonomics and Posture:

. An integrated battery of tests to improve the predictive performance of the individual objective/subjective measures

A 3D solid model of seat and driver that permits the representation of their deflection characteristics.

On Ride Comfort:

The development of vehicle test procedures and data reduction methods specific to seat comfort evaluation

The definition of standard seat vibrational missions

The writing of specifications for a vibrational test bench to be used in seat comfort evaluation

The analysis of the frequency response functions of various seat/person combinations, and correlation with certain seat design parameters

The development of criteria to specify the vibrational properties of the foam used for paddings and cushions

Definition of mass and frequency properties necessary for an anthropodynamic dummy

An evaluation of the role of the seat in reducing vibrational disturbances felt by the occupants of an automobile.

On recycling:

Recommendations regarding "How to pick the most suitable foam for a car environment"; that means to select the best compromises between recycling on one side and comfort & safety on the other one

Assessment of seat dismantling techniques, re-use constraints, and re-use opportunities.

On the Engineering Platform:

Development of Sw procedures to manage the Concurrent Engineering Process

Design of a data base for seat design & analysis and integration of experimental and numerical procedures

Proposal for up-dating of national and international standards & recommendations on safety and comfort.

4) ACHIEVED RESULTS AND CONCLUSIONS

The following key achievements have been reached and demonstrated:

a new product development process for seat engineering is operating within the development centers of the industrial partners joining the consortium

a network for R & D in seat engineering is operating as a result of the know-how achieved by universities and research center belonging the consortium

- the achieved results on criteria for comfort and safety represent the starting point to address the evolution of related European Normative and Standards.

The value as well as the expected return of the above mentioned achievements is remarkable, this is the consequence of the continuous rise of the expectations as well as of the functions related to the seat systems, determining a key role of the Engineering Platform for developing new products for automotive seating.

5) PUBLICATIONS

The following publications have been emanated in the Project period:

"Evolution of the car seat as a system"
G. Bellina, (SEPI) - 4th International Conference - ATA - Florence, 1994

"The seat as integrated component within vehicle safety systems"
P. Maritano , (SEPI) - XVII Automotor International Show - Turin, 1994

"Musculoskeletal Troubles and Driving in Police Officers" Diane Gyi and J. Mark Porter, (Loughborough University), The 4th Annual Conference on Safety and Well-being at Work - Loughborough University, 1994

"Some Investigations into the Relationships between Car Seat Cover Materials and Thermal Comfort using Human Subjects"
W. Fung (Courtaulds) -The Vehicle Comfort and Ergonomics Conference - ATA - Bologna, 1995

"An experimental approach for a vibration optimization of automotive seats"
J. Giacomin, R. Bracco - C. R.FIAT - The Vehicle Comfort and Ergonomics Conference - ATA - Bologna, 1995

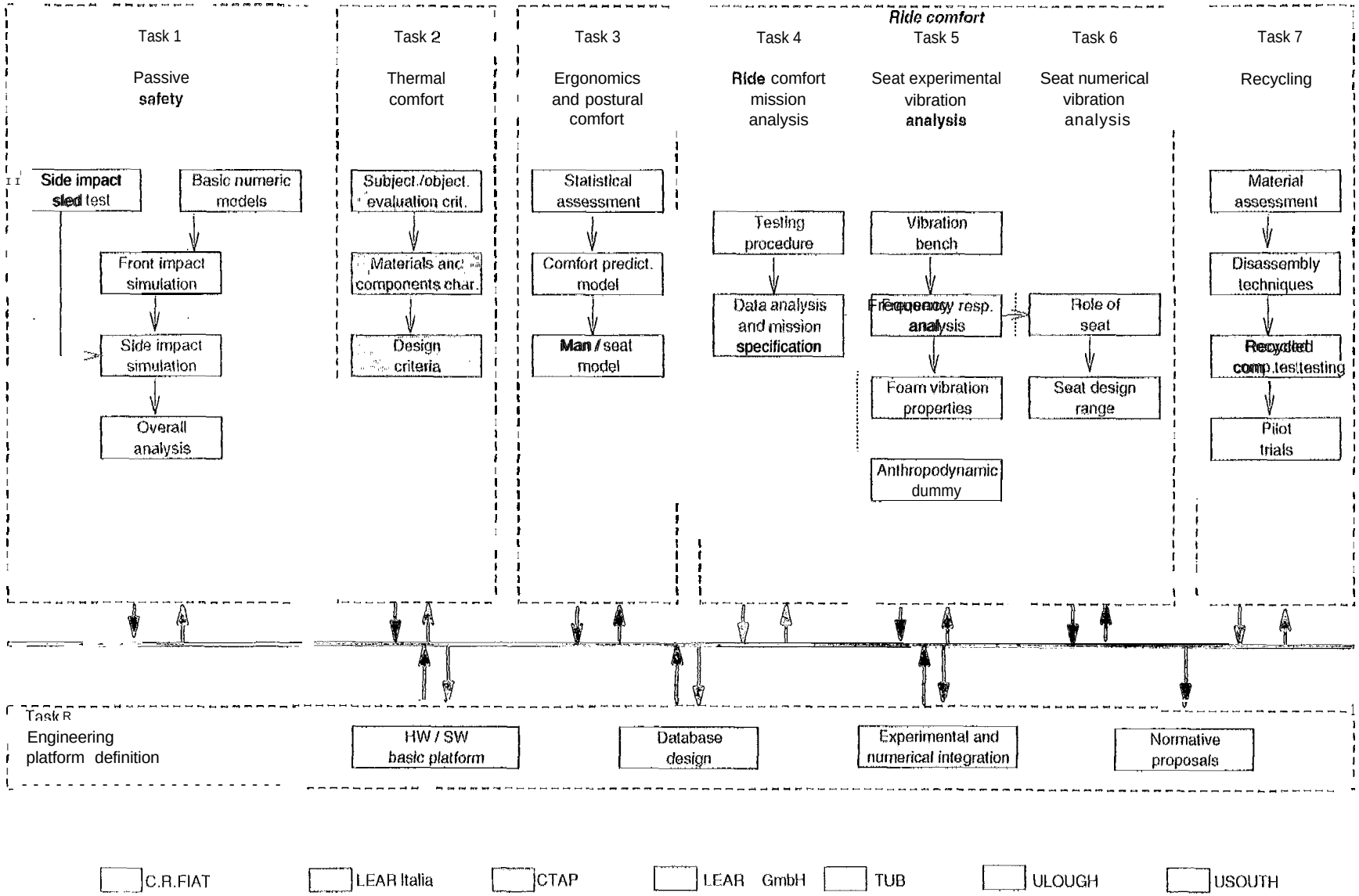
"A Road Test Procedure for the Definition of the Vibrational Mission of the Automotive Seats"

F. Giuliano, A. Buco, C. R.FIAT - The Vehicle Comfort and Ergonomics Conference - ATA - Bologna, 1995

"Musculoskeletal Troubles and Driving: A Survey of The British Public"
Diane Gyi and Mark Porter (University of Technology, Loughborough), The Ergonomics Society -1995 Annual Conference - University of Kent

"Low Back Trouble and Driving" - PREMUS '95 Montreal, September 1995.

Fig. 1 - PROJECT STRUCTURE



Fig, 2 - DEVELOPMENT PROCESS FOR THE SEATING SYSTEM

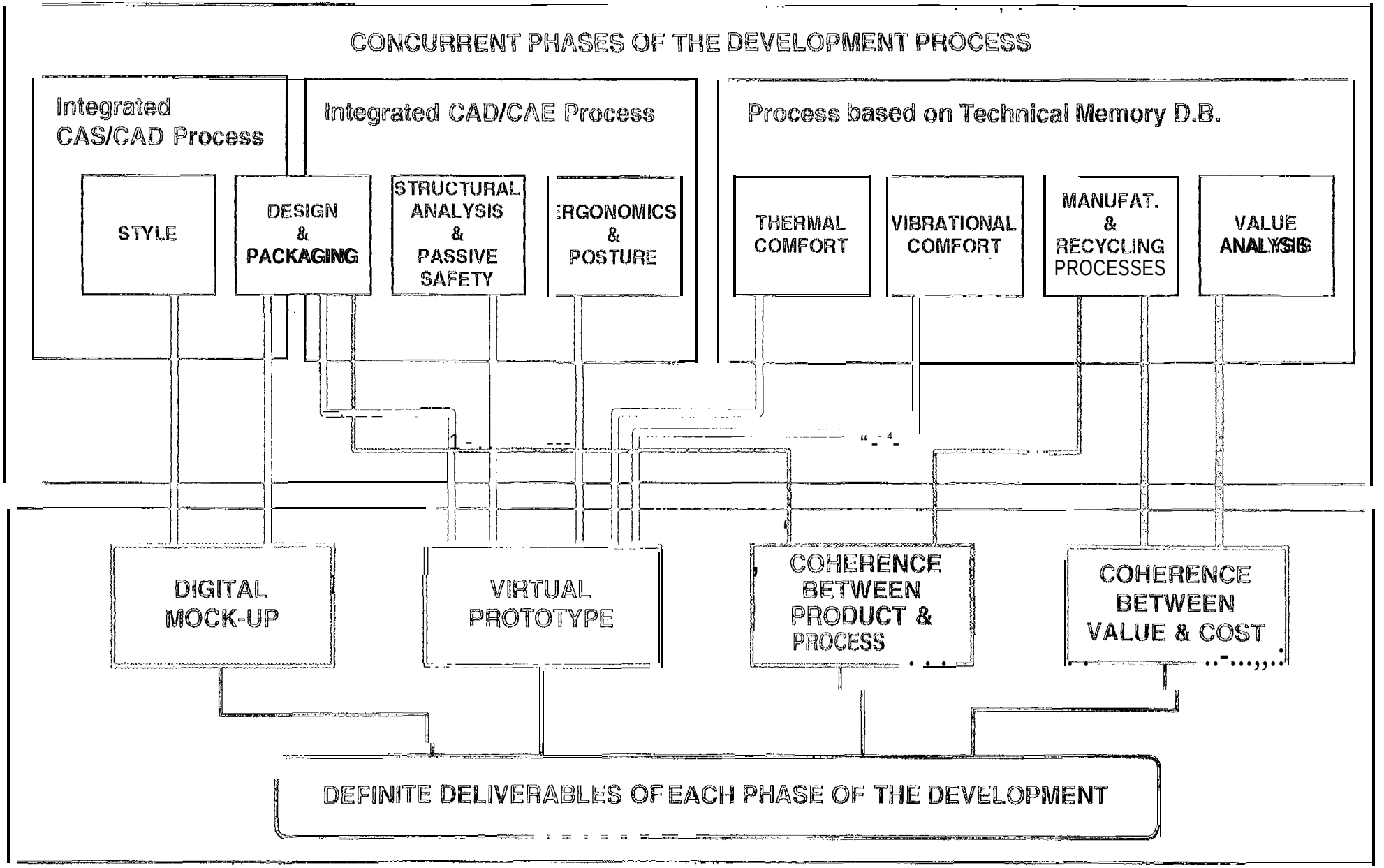


Fig. 3 - MAIN OPERATING ACTIVITIES AND LINKS FOR CONCURRENT ENGINEERING IN THE DEVELOPMENT PROCESS OF SEATING SYSTEM