

SEVENTH FRAMEWORK PROGRAMME
SUSTAINABLE SURFACE TRANSPORT (SST)-2008-RTD-1



ADSEAT

Adaptive seat to reduce neck injuries for female and male occupants

Project no. 233904

Summary from 1st Periodic Report

9 June 2011

Start date of project: 1 October 2009

Duration: 42 months


Name and organisation of lead contractor for this Deliverable

Author/organisation: Astrid Linder/VTI



Publishable Summary from 1st Periodic Report

The following table summarises the project data

Project acronym and full name		ADSEAT Adaptive seat to reduce neck injuries for female and male occupants	
Contract Number		233904	
Date of start	01 October 2009	Duration	42 months
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Consortium	Participant Organisation Name	Participant Short Name	Country
	Statens väg- och transportforskningsinstitut	VTI	Sweden
	Chalmers University	CHALMERS	Sweden
	Ludwig-Maximilians-Universität Muenchen	LMU	Germany
	Folksam Ömsesidig Sakförsäkring	FOLKSAM	Sweden
	Technische Universität Graz	GUT	Austria
	Université de Strasbourg	UdS	France
	Stiftung Arbeitsgruppe für Unfallmechanik	AGU	Switzerland
	Loughborough University	LU	United Kingdom
	Humanetics Europe GmbH (name changed from FTSS as per 1 Jan 2011)	Humanetics	Germany
	Fundacion Cidaut	CIDAUT	Spain
	Volvo Personvagnar AB	Volvo	Sweden
	Faurecia Sièges d'Automobile	FAURECIA	France
Web site: www.adseat.eu			





Summary description of project context and objectives

The ADSEAT (Adaptive Seat to Reduce Neck Injuries for Female and Male Occupants) project is an EU funded project within the 7th Framework which started 1 October 2009 and will end 31 March 2013. The overall objective of ADSEAT is to provide guidance on how to evaluate the protective performance of vehicle seat designs aiming to reduce the incidence of Whiplash Associated Disorders (WAD), also known as whiplash injuries. The work concentrates on evaluating the protective performance of seats beneficial to female as well as male motor vehicle occupants. For this purpose a finite element model of an average female dummy will be developed. This new research tool will be used in conjunction with the currently available rear impact dummy of an average male, the Biofidelic Rear Impact Dummy (BioRID) II, when evaluating enhanced whiplash injury protection.

Context

Whiplash injuries sustained in vehicle crashes is a worldwide problem. It is estimated that 300 000 citizens annually suffer whiplash injuries in the European Union, of which 15 000 result in long term suffering with an associated socio-economic impact of approximately 4 billion Euros per annum (insurance estimates). In Sweden, such injuries account for ~70% of the costs for the insurance companies of injuries due to vehicle crashes. The majority of those experiencing initial neck symptoms recover within a week of the car crash, however, 5-10% of individuals experience different levels of permanent disabilities. Whiplash injuries occur at relatively low velocity changes (typically <25 km/h), and in impacts from all directions. Rear impacts, however, occur most frequently in crash statistics. It is well established that the whiplash injury risk is higher for females than for males, even in similar crash conditions. Injury statistics from the mid 1960's until today all show that females have a higher risk of sustaining these injuries than males, ranging from 1.5 to 3 times higher. Females and males have different anthropometry and mass distribution, which may influence the interaction of the upper body with the seat back rest and head restraint and thus the injury risk.

Crash test dummies are used when developing and evaluating the occupant protection performance of a vehicle. The 50th percentile male crash test dummy correspond to a ~90th - 95th percentile female with regards to stature and mass, resulting in females not being well represented by the existing low velocities rear impact male dummies: the BioRID and the RID3D. Consequently, the current seats and whiplash protection systems are primarily adapted to the 50th percentile male dummy available today, without considering female properties, despite a higher whiplash injury risk in females.

The detailed objectives of ADSEAT

The overall objective of ADSEAT is to improve seat design to reduce whiplash injury. The project will focus on innovative adaptive seat design that can be adjusted to provide benefit for both male and female occupants. By focusing project resources on the latter group, the





influence of gender and additional factors on whiplash injury risk will be established. The project aims at establishing the properties for a model of an average female and to implement those in a finite element model in order to provide an improved tool for the development and evaluation of adaptive systems, with special focus on protection against whiplash injuries.

The ADSEAT project is divided into seven work packages (WP), including management (WP 6) and dissemination (WP 7). The aims of the five technical work packages are:

- To analyse real world data and perform literature review(WP 1)
- To establish biological data of females (WP 2)
- To develop a finite element dummy model of an average female (WP 3)
- To establish injury criteria and thresholds for females (WP 4)
- To develop a seat demonstrator illustrating how whiplash protection can be achieved for a wider population, using adaptive seat design. In addition, seat evaluation guidelines will be specified.(WP 5)

Description of work performed since beginning of the project and achievements within the ADSEAT project as of March 2011.

Real world data, WP1

An extensive literature review and analysis of databases, available within the consortium, was carried out. The results showed that weight and height close to the 50th percentile female is appropriate for a dummy model representing females. Analysis of insurance data indicates that the average weight and height for females reporting whiplash injuries correspond quite well with the average sized female among the European countries. The review on injury criteria shows that there are no gender specific injury criteria. No methods are validated to adequately scale proposed threshold values of postulated injury criteria.

Real world data analysis carried out shows that existing whiplash protection concepts are more effective for males than females, with a 45% risk reduction in permanent medical impairment for females and 60% for males. This analysis was published by Kullgren and Krafft, IRCOBI 2010.

Biological data, WP2

- The anthropometry of the 50th percentile female for a rear impact crash dummy model was established based on data found in the scientific published literature and the model was called EvaRID (Eva - female/RID - Rear Impact Dummy). The detail of this specification is part of the publication of Chang et al. 2010.
- Test data from volunteer tests using male and female volunteers in identical test conditions were collected and analyzed. Corridors for dynamic female crash dummy response



was established and forwarded to WP3 for initial evaluation of the EvaRID dummy model. The results were published in Carlsson et al. (2010) and presented at the IRCOBI conference.

- New volunteer tests involving eight male and eight female volunteers were performed in November 2010. The tests were carried out in a new laboratory seat that allows replication in computational modelling environments. The test matrix replicates cases with varying injury risk. The analysis of the test results will be carried out during spring 2011 and will be used in the development of the finite element model of EvaRID. The results will add new, improved evaluation data for future dummies and occupant models.
- Two test rigs for whiplash exposure have been manufactured and tested. The stationary rig will allow us to carry out an extensive parameter study to determine the influence of different load and motion parameters on the pressure-time histories in the spinal canal and on the injury risk to spinal ganglia, facet joints and cervical muscles. In addition, methods for pressure instrumentation insertion have been established in pilot studies. Methods to rapidly remove tissue samples with good quality have also been developed.
- A new acceleration sled test set-up with a high speed X-ray movie recording unit has been installed for PMHS testing in rear impact conditions. The set up will provide detailed information about the motion of individual cervical vertebrae.

Computational modelling, WP3

A first version of a finite element dummy model of an average female, called EvaRID, has been developed. EvaRID is based on the same design concept as the 50th percentile male rear impact dummy, the BioRID II, Figure 1.1. A first version, EvaRID V1.0, was developed in LS-Dyna.

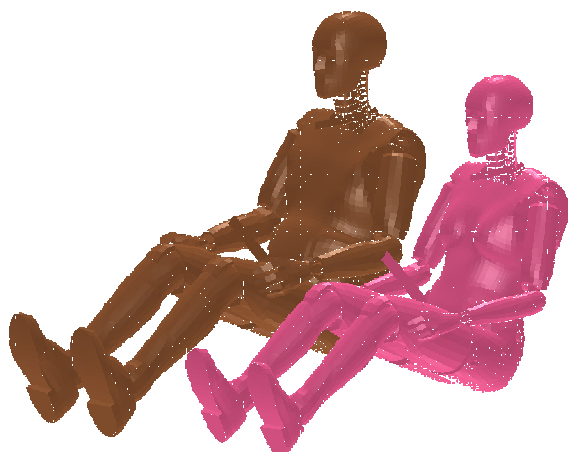


Figure 1.1. EvaRID V1.0 and BioRID II model.

The dynamic response of EvaRID V1.0 was compared to data from rear impact tests with female volunteers, Figure 1.2. It was found that it is necessary to further adjust the stiffness of

the spinal joints in order to fully mimic the motion of the volunteers. In future, the EvaRID dummy model has the potential to be a valuable tool when evaluating and developing seats and whiplash protection systems.



Figure 1.2. EvaRID V1.0 model run in a test set-up to compare its dynamic response to those recorded in volunteer tests run in the same test configuration.

During the reporting period the specifications of the numerical dummy model was completed. In close cooperation with WP1 and WP2 a full set of requirements was defined and reported. This includes:

Model anthropometry: Based on a survey of accident and insurance data in WP1 it was decided that the model developed in the ADSEAT project should be a model of an average female. In close cooperation with WP2, a full set of anthropometric requirements was derived from existing databases. The requirements were defined such as to allow for scaling down from the BioRID II dummy model which represents a 50th percentile male.

Biomechanical requirements: An initial set of biomechanical requirements was collected from literature and from project partners (Chalmers and LMU) whom had previously conducted volunteer tests with female subjects. Project partner Chalmers generated response corridors on the basis of volunteer tests with eight subjects. Humanetics generated a detailed sled model of the set-up to reconstruct the tests for model validation.

Based on the dummy model specifications the modelling was started by scaling down the existing BioRID II dummy model. Local re-meshing was required to compensate for time step and element distortion effects resulting from the scaling. The model was evaluated under calibration loading conditions, which showed good correlation. Furthermore, overload conditions were applied to check on the model robustness.

Once the first version of the EvaRID was available, detailed evaluation against biomechanical requirements was made. The first evaluation showed that the model response correlates reasonably well with the test data. However, for final use in the project, further model refinement is needed. As reported in a paper at the Whiplash 2010 conference (Chang et al. 2010), the stiffness of various components needs to be fine-tuned.



Injury Criterion, WP4

The literature review in the frame of WP1 summarizes the possibilities to consider neck injury risk. It first describes suggestions of how the female neck injury risk could be assessed. Based on this, theoretical suggestions were developed to consider the female injury risk. Focus was set on the modification of existing injury criteria, particularly the Neck Injury Criterion (NIC) and Nkm.

The theoretical approaches will be complemented by sled testing and computer simulations to investigate their practical applicability. The corresponding sled tests have been performed 21-24 March 2011. The performance of computer simulations is currently being prepared. Two different sets of simulations will be conducted. Firstly a model of the BioRID II will be compared to the newly established EvaRID model. Secondly, human body models representing a male as well as a female will be used. Both series of simulations will utilize the same seat model in order to allow better comparison of the results. The crash pulses used in the simulations are based on real-world crash data collected by Folksam.

Seat Evaluation, WP5

The work in the final technical work package, seat evaluation, is being planned and will start during 2011 as specified in Annex 1.

Management, WP6

The work constructed in the ADSEAT project has been performed on time and to a high standard. All beneficiaries have contributed with top quality involvement. The management of the project has arranged meetings (1 kick-off and 2 project assemblies) and has followed up on reports/activities/deliverables/deadlines as well as beneficiaries' commitment and work progress (through e-mails and telephone calls). Due to ambiguous wording found in the Consortium Agreement, Addendum 1 was formulated, distributed, beneficiaries signatures were collected and submitted to the project officer. A web based platform is used to administer the project. In addition, preparation of the financial details of all partners has been carried out and contact with the EC office has been held. Saab Automobile was considered as an additional member of the consortium. After detailed investigation into the requirement for adding a partner it was decided that Saab should become a member in the Advisory Group.

Dissemination, WP7

The results of the ADSEAT project have been published in and presented at:

Linder A (2010) Biomechanical Data for a Computational Model of an Average Female, 6th *World Congress on Biomechanics*, Singapore.





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- Carlsson A, Siegmund G P, Linder A, Svensson M (2010) Motion of the Head and Neck of Females and Male Volunteers in Rear Impact Car-to-car Tests at 4 and 8 km/h *Int. IRCOBI Conf. on the Biomechanics of Injury*, Hannover, Germany.
- Kullgren, A, Krafft, M (2010) Gender Analysis on Whiplash Seat Effectiveness: Results from Real-world Crashes, *Int. IRCOBI Conf. on the Biomechanics of Injury*, Hannover, Germany.
- Schick S, Kullgren A, Tomasch E, Jakobsson L, Linder A, Gales N, Hell W, Schmitt K-U (2010) Basics for Developing a Female Occupant Model for Investigating Cervical Spine Distortion injury (CSD), *ESAR conference*, Hannover, Germany.
- Chang F, Carlsson A, Lemmen P, Svensson M, Davidsson J, Schmitt K-U, Zhu F, Linder A (2010) EvaRID, A dummy model representing females in rear end impacts, *Whiplash 2010 Neck Pain in Car Crashes, 3rd International Conference*, Munich, Germany.
- Tomasch E, (2010) Gleichberechtigung“ bei den Dummy modellen, *Virtual Vehicle Magazin*, Issue Number. 8, 2010-4.
- Schick S, Thorsteinsdottir K, Horion S, Hell W (2010) Risikofaktoren für die Inzidenz des WAD (Whiplash Associated Disorder) - Unterschiede zwischen Mann und Frau? *Jahrestagung der Deutschen Gesellschaft für Rechtsmedizin*, Berlin, Germany.
- Linder A (2011) Tool for evaluation of adaptive seat to reduce neck injuries for female and male occupants, *IQPC 6th International Conference Innovative Seating*, Frankfurt, Germany.

In addition, the project ADSEAT was described in:

SafetyNews, Today's topic October 2010, www.carhs.de/newsletter_archive/safetynews_2010-10-04-en.html

EU at the steering wheel of Road Safety, EU-funded research to make Europe's roads safer (2010) Directorate-General for Research, Cooperation/Transport (including Aeronautics), ISBN: 978-92-79-16338-8.

A project logo has been designed, a website set-up and a leaflet made. Furthermore, a project advisory group has been established consisting of representatives from: Toyota Europe, Saab Automobile, Insurers Institute for Highway Safety (USA), JARI (Japan), BAST, pdb (Germany) NHTSA (USA) and MAPFRE Insurers. An advisory group meeting was held to receive feedback on the current work and take further steps to improve in accordance with experts' opinions and needs.

The expected final results and their potential impact and use (including the socio-economic impact and the wider societal implications of the project so far)

The final expected result of ADSEAT is to provide guidance on how to evaluate the protective performances of seats in order to reduce the risk of whiplash injuries and thereby reduce the socio-economic cost to the European Union for these injuries. It will, for the first time ever, be possible to make such evaluations due to the ADSEAT project.

The address of the project public website

www.adseat.eu

