EUROPEAN COMMISSION
DG RTD

SEVENTH FRAMEWORK PROGRAMME
THEME 7
TRANSPORT - SST
SST.2007.4.1.2: Human physical and behavioural components
GA No. 218740

COVER BIOMECHANICS COORDINATION

COVER

Coordination of Vehicle and Road Safety Initiatives, With a focus on Biomechanical coordination

Deliverable No.	COVER Final Report	
Deliverable Title	Final Report	
Dissemination level	Public	
Written By	Paul Lemmen (Humanetics) Jolyon Carroll (TRL) Xavier Troisseille (Gie Re Pr)	30 March 2013
Checked by	Cor van der Zweep (UNI)	16 April 2013
Approved by	Paul Lemmen (Humanetics)	16 April 2013
Issue date	16 April 2013	

Executive summary

The problems arising from the growth in road traffic are looming ever larger in our daily lives and are impairing the quality of life of everyone[1]. The citizens of Europe may legitimately demand clean, safe, intelligent, high-performance cars. Meeting this demand at competitive prices represents an enormous technological challenge for the European side of the automotive industry, and is also an essential prerequisite for maintaining, or even bolstering, its competitiveness in the future. At the same time traffic-related accidents are still a major threat to life in the European Union, especially when the low average age of the victims is taken into account. In 2005 alone, around 41,600 people were killed and more than 1.7 million injured in European road accidents[2]. Although the number of road fatalities declined down to 34,817 in 2009[3], further efforts will have to be made to make European roads safer. This may be particularly challenging taking into account the growing transportation needs of the elderly and the recent expansion of the EU with countries that historically lacked effective safety standards.

Previous research in the field of vehicle passive safety contributed to significant improvements in vehicle and road safety. However, the focus has been on average protective measures optimised for “average occupants” whereas in the real world substantial differences appear under factors like gender, age and size. Brought forward by stakeholders this topic was recognised by the EU Commission and put high on the research agenda under the 7th framework. As a consequence, four projects were executed in this field dealing with two topics of high importance:

- Child safety addressing improved numerical and experimental test procedures for younger children as well as adolescents.
- Thoracic injuries addressing a body part which on the one hand side is highly at risk during collisions as found in previous EU research projects like VC COMPAT, PRISM and FID and on the other hand subject to large biometric variations over age, gender and size due to geometry and material changes in bones.

The projects dealing with child safety are EPOCh (Enabling Protection of Older Children, GA No. 218744) and CASPER (Child Advanced Safety Project for European Roads, GA No. 218564). The projects dealing with thoracic injuries are THOMO (Development of a finite element model of the human thorax and upper extremities, GA No. 218643) and THORAX (Thoracic injury assessment for improved vehicle safety, GA No. 218516).

The general objective of the COVER Coordination and Support Action was to develop a harmonised and consistent direction of research between these projects and to accelerate the implementation of research findings of four complementary research projects in the field of crash biomechanics. This was realised by aligning project plans in terms of dissemination activities and coordinating some joined activities like accident surveys and Post Mortem Human Subject tests.

[1] CARS 21: A Competitive Automotive Regulatory System for the 21st century, Final Report, 2006

[2] Mid-term review of the European Commission’s 2001 transport white paper, Keep Europe moving, Sustainable mobility for our continent

[3] Data taken from European Road Safety Observatory

Contents

1 Project context and main Objectives

1.1 Project Context

COVER is a Coordination and Support Action under the Seventh Framework, theme 7 Transport. The project is coordinated by Humanetics (former FTSS). Partners are Bundesanstalt für Straßenwesen (BASt), Centre Européen d'Etudes de Sécurité et d'Analyse des Risques (CEESAR), Groupement d'Intérêt Economique de Recherches et Etudes PSA-RENAULT (Gie Re Pr), RWTH Aachen University (IKA), Transport Research Laboratory (TRL) and Uniresearch B.V. (UNI).

Previous research in the field of vehicle passive safety contributed to significant improvements in vehicle and road safety. However, this research was focused on average protective measures optimized for "average occupants" whereas in the real world substantial differences appear under factors like gender, age and size. Brought forward by stakeholders, this topic was recognized by the EU Commission and put high on the research agenda. In the 1st call of the FP7 transport programme four projects were accepted dealing with child safety and thoracic injuries respectively. Projects related to child safety are CASPER and EPOCh. Both are addressing improved numerical and experimental test procedures for younger children as well as adolescents. Projects related to thoracic injuries are THOMO and THORAX. The aim of the COVER Coordination and Support Action is to consolidate research and development activities of the four involved projects related to biomechanics. This paper provides an overview of the COVER CSA and the underlying projects.

1.2 Main Objectives

Main aim of the Coordination and Support Action is to accelerate improvements in biomechanical tools for the design and evaluation of vehicle crash safety systems with the goal to further reduce the number of annual road victims for the European Union. The joint technical and scientific objective of COVER is to consolidate research and development activities related to biomechanics, providing tools and know-how to industry and governments for future enhancement of vehicle safety.

Specific objectives are:

- Implementation and coordination of joined research activities dealing with human physical (biomechanics) aspects. In particular these relate to:
  - Collection and analysis of accident data
  - Development of consistent sets of human data related to thoracic injuries as well as data analysis resulting in injury mechanisms and injury risk curves for various ages, sizes, genders and restraint loadings.
  - Development of a consistent set of test procedures for child safety
- Joint dissemination towards relevant high-level stakeholders in order to provide clear messages and obtain the necessary visibility needed for the acceptance of new test and evaluation methods
- Organisation of workshops and joint meetings between the projects to exchange research findings

1.3 Objectives per work package

1.3.1 WP1 – Research coordination

The main objective of this Work Package was to coordinate relevant research efforts and developments among the involved initiatives. As such the following sub-objectives can be defined:

- Harmonise plans of the involved projects
- Define the relationship between thorax injuries and (1) Impact type (2) restraint type and (3) occupant characteristics (age, size and sex) based on real world (in-depth) accident data.
- Coordinate PHMS testing and related simulations to provide sound and consistent human data sets.

1.3.2 WP 2 – Joint dissemination for harmonisation (including exchange of best practise)

- Maximise the dissemination of results of the individual initiatives by developing joined dissemination actions, especially towards relevant stakeholders at governments, industry and suppliers.
- Develop a joined agenda of workshops, events and seminars that enable the exchange of gained know-how and practical experience among the initiatives

1.3.3 WP 3 – Management

- Managing of the CSA activities
- Keep track of costs and progress of planned activities, and monitoring of budget situation.
- Keep each member, including the Commission, fully informed about the CSA status, the work planning (adjustments) and all other issues which are important and relevant to the partners in order to obtain maximum transparency for all involved and achieve synergy of the integration.
- Provide the basic infrastructure needed to operate the CSA.

2 Main Science & Technological results and Foreground

The COVER CSA started April 1st 2009 and ended March 31st 2013. COVER includes four research programmes dealing with human physical aspects. Fig. 1 depicts the participating projects in a diagram with respect to age (being a key factor in user diversities) and intended outcome of the project. Under the implementation of the exchange of information and best practices was enabled and a structure of joint research activities was installed to optimise the outcome. Main focus though was the joined dissemination to increase awareness of the individual projects. Examples of activities facilitated by COVER include (see Fig. 1):

- Collection and analysis of in-depth real world data on thoracic injuries
- Generation of consistent sets of human data for thoracic injuries as well as studies into injury mechanisms and injury risk curves
- Joint dissemination to increase awareness of the individual projects and their outcome

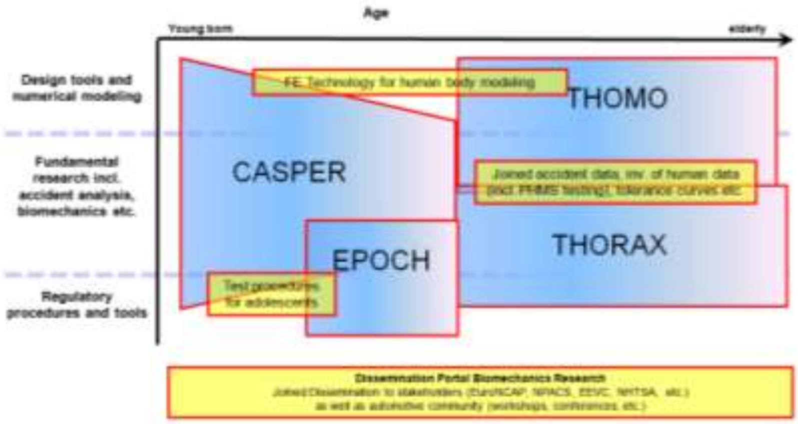


Fig. 1. Projects in COVER and examples of areas for coordination of research activities

2.1 WP1 – Research coordination

2.1.1 Harmonisation of project plans

The first task in COVER was to harmonize the activities of the four underlying projects. For this purpose the planning of the four involved projects was aligned in terms of technical and dissemination activities. The technical line-up of the projects was addressed in the negotiation phase of the COVER project with the Project Officer and included in an updated version of the Description of Work resulting from that phase. Results were described as well in Deliverable report D1. Some key elements for the alignment included newsletters and flyers (press releases from the underlying projects were merged into a general press release and it was decided to have four annual newsletters with contributions from all projects). A structure of four workshops was defined: a mid-term and final workshop dealing with Child Safety (CASPER, EPOCh results) and a mid-term and final workshop dealing with Thoracic injuries (THORAX, THOMO results). Finally PMHS testing needed for THORAX and THOMO was aligned and it was decided to have a joined test matrix composed under the COVER project in Task 1.3.

2.1.2 Overview of Real World Thoracic Injuries

In 2009 accident data were studied within the COVER project to identify the two most relevant thoracic injury types for car occupants and to provide detailed information on the type and severity of thoracic injuries in relation to impact type, restraint type, and occupant characteristics. The data were controlled for impact partner, impact severity, overlap and intrusion, and type of restraint system used. Results have been presented in Carroll *et al.* (2009a)[4], Carroll *et al.* (2010a)[5], Adolph *et al.* (2009)[6] and Chauvel *et al.* (2009)[7] all available from the COVER project website http://www.biomechanics-coordination.eu/. Results were meant for usage by THORAX and THOMO. As this task related to technical work in support of underlying projects a more extensive description of results is provided below.

Body region: From the THORAX study, see for instance CCIS (Cooperative Crash Injury Study) analysis in Fig. 2, it became clear that the thorax has superseded other body regions in terms of the number of occupants receiving an injury, particularly at the severe MAIS (Maximum Abbreviated Injury Scale) ≥ 3 level.

[4] Carroll, J., Cuerden, R., Richards, D., Smith, S., Cookson, R., Hynd, D. (2009a). Matrix of serious thorax injuries by occupant characteristics, impact conditions and restraint type and identification of the important injury mechanisms to be considered in THORAX and THOMO. *COVER project GA No. 218740, Deliverable D5-Annex I.*

[5] Carroll, J., Adolph, T., Chauvel, C., Labrousse, M., Trosseille, X, Pastor, C., Eggers, A., Smith, S., Hynd, D. (2010a). Overview of serious thorax injuries in European frontal car crash accidents and implications for crash test dummy development. *IRCOBI 2010 proceedings*.

[6] Adolph, T., Eggers, A., Pastor, C. (2009). Matrix of serious thorax injuries by occupant characteristics, impact conditions and restraint type and identification of the important injury mechanisms to be considered in THORAX and THOMO. *COVER project GA No. 218740, Deliverable D5-Annex II.*

[7] Chauvel, C., Labrousse, M. (2009). Matrix of serious thorax injuries by occupant characteristics, impact conditions and restraint type and identification of the important injury mechanisms to be considered in THORAX and THOMO. *COVER project GA No. 218740, Deliverable D5-Annex III.*

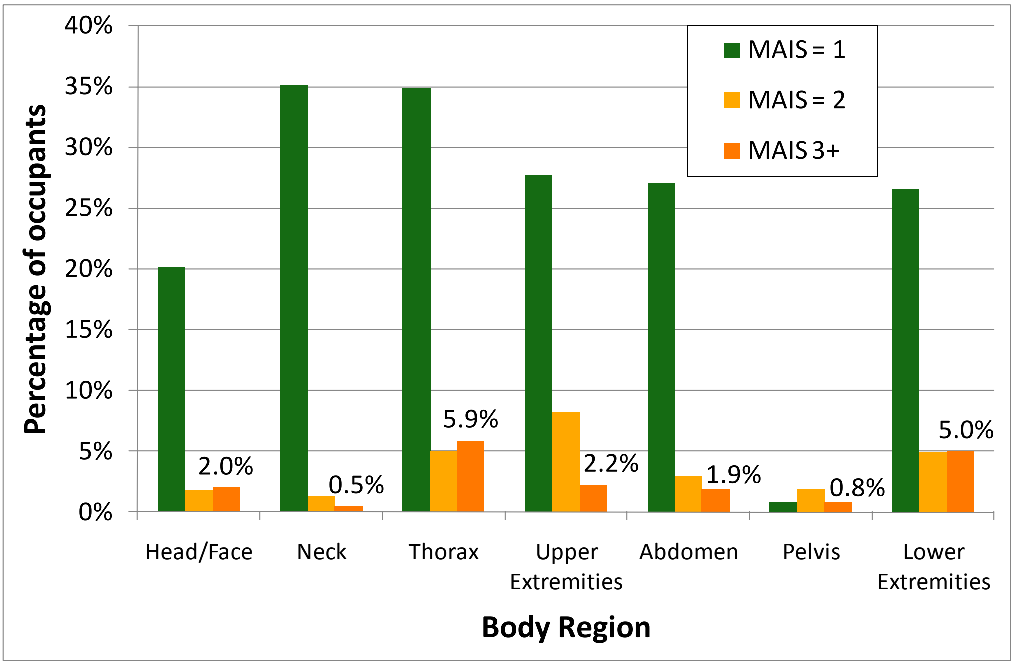


Fig. 2. Body regions injured and MAIS level for all occupants from the CCIS frontal impact sample (n = 2148 occ.)

Occupant position: From the combinations of injury groupings in the CCIS sample, it was evident that drivers had a particular risk of sustaining a thorax or a lower extremity injury. However, front seat passengers were at an even higher risk of sustaining a thorax injury and at a higher risk of sustaining an injury to an upper extremity.

Crash types and speed: The GIDAS (German In-Depth Accident Study) analysis indicated that AIS ≥ 3 torso injuries were more likely to occur in impacts with narrow objects (diameter less than 40 cm) than in collisions with other types of object. A trend from the GIE RE PR (Groupement d'Intérêt Economique de Recherches et Etudes PSA-Renault) torso injury data is that frontal impact accidents involving over two thirds of the vehicle front tended to produce proportionally more of the moderate to severe thorax injuries (AIS ≥ 2) than the other overlap categories. Despite differences in the data collection strategies this appears to be consistent with the findings from the UK CCIS sample. Regarding collision speed, an analysis of the distribution of front seat occupants in the GIE RE PR sample by Equivalent Energy Speed (EES) showed that most of the frontal impact accidents in this database occurred with an EES between 26 to 65 km/h.

Occupant characteristics: The GIDAS dataset was used to show that relatively more females had AIS 1 torso injuries and that males were overly represented in the group of uninjured. Both effects are significant. In addition the GIE RE PR data showed that the risk of receiving a torso injury was greater for older than for younger occupants. The older occupants (over 52 years of age) were 3.7 times more likely to receive an AIS ≥ 2 torso injury, and 2.8 times more likely to receive an AIS ≥ 3 torso injury than the younger occupants (12 to 52 years).

The GIDAS sample was able to show that occupants who were 150 to 180 cm tall were statistically more likely to have an AIS 1 torso injury than taller (180 to 220 cm) occupants. The analysis also showed that occupants weighing 40 to 60 kg were statistically more likely to have an AIS 1 torso injury. However, neither of these trends was significant at the more severe AIS 2 or ≥ 3 injury score levels. Additionally, the GIDAS sample showed that front seat passengers were statistically more likely to receive an AIS 1 torso injury than occupants in other seating positions. This finding was supported by CCIS sample analysis.

From the distribution of torso injuries of male and female occupants (including those occupants with no torso injury), it became clear that relatively more females had AIS1 torso injuries and that males were overly represented in the group of uninjured. Both of these effects were significant in the GIDAS sample.

Injury type: Data analysis showed that at the AIS ≥ 2 severity level, thoracic fractures occur most frequently of the various injury types recorded in the accident databases. These fractures occur to the ribs and sternum, and are observed often, particularly when AIS 1 rib fractures are counted. Lung injuries also occur frequently in frontal impact accidents (even though they are AIS ≥ 3) and are the most frequently observed injuries to an organ.

Restraint system dependency: The majority of front seat occupants in the sample of cars and car-derivatives, from 2000 onwards, had combined seat-belt and airbag restraint. Within the CCIS sample selected for this work, 1899 occupants had a front airbag fitted, which accounted for 97 percent of the drivers and 78 percent of front seat passengers. When considering seat-belt pre-tensioners, it was found that 1758 occupants (82 %) of the CCIS sample had a pre-tensioning device fitted at their seating position. However, based on the distribution of torso injuries amongst these occupants, it seems as though the presence of a pre-tensioner did not have a large influence on the risk of sustaining a torso injury. Most occupants (57 %) who received an AIS ≥ 3 torso injury were in a restraint system consisting of seat-belt, airbag, pretensioner(s), and a load limiting device.

The GIE RE PR database contains information about the force-limit used in different load limiting devices. Risks of AIS ≥ 2 and AIS ≥ 3 thoracic injuries as a function of the shoulder belt load limit for cars designed since 1990 and for all EESs (the number of cases with AIS ≥ 2 or AIS ≥ 3 divided by the total number of cases) are shown in Fig. 3. Efficiencies of the 6 kN and 4 kN or 5 kN load limitations for EES > 45 km/h (with regard to a baseline of 100 passengers without a load limiter) were calculated and appear to be 21% and 49% respectively for 6 kN and 4 kN or 5 kN. A further analysis showed that the use of 4 or 5 kN limiters and the increase of car mass decreased the risk of thoracic injuries.

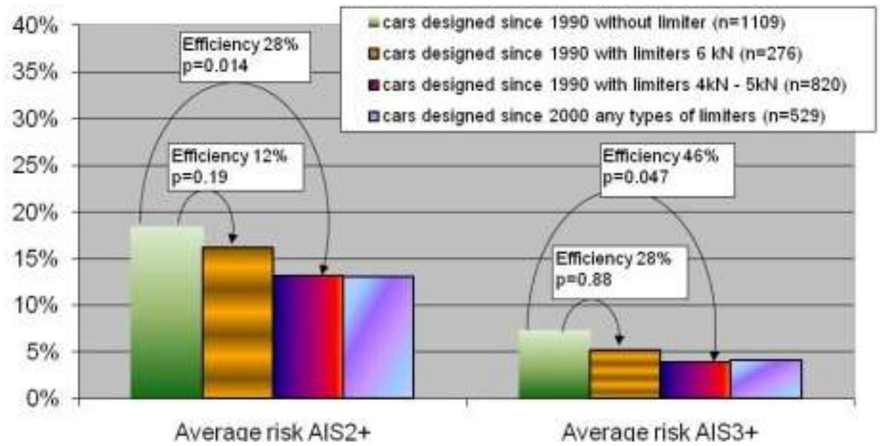


Fig. 3. Evolution of the average thoracic injury risk for seat-belted front occupants in frontal impacts at all EES

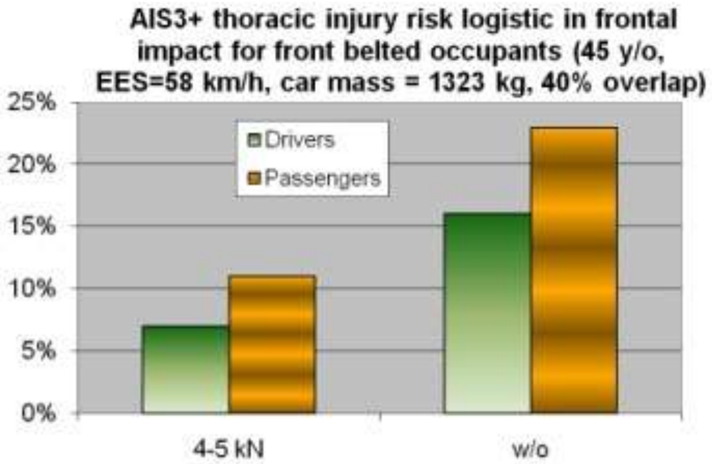


Fig. 4. Thoracic injury risks from accident studies

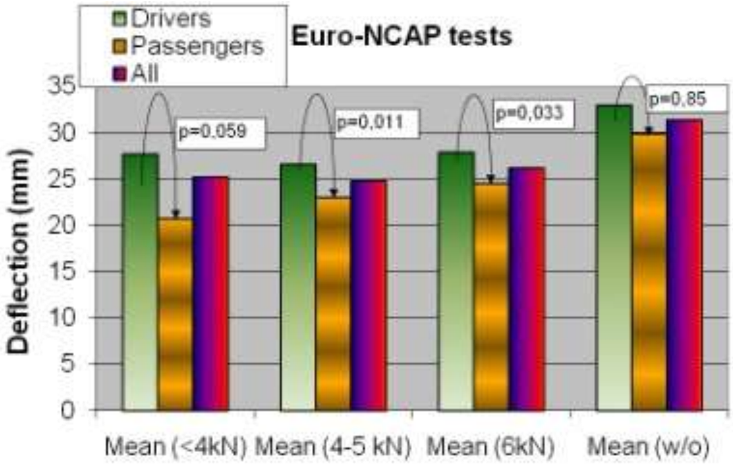


Fig. 5. Mean deflections NCAP tests for different load limitations

Also the availability of force-limit data allowed a global comparison between crash investigation outcomes and Euro NCAP tests in terms of shoulder belt force limitation efficiency. Fig. 4 shows estimated thorax injury risks for '4 to 5 kN load limiters' and 'without load limiters' as obtained from cases with impact conditions close to those from Euro NCAP frontal impacts. Fig. 5 provides mean chest deflections from Euro NCAP tests. In the tests the chest deflection for the drivers remains almost constant for any levels of load limiter (except for the case without a load limiter) while for the passenger chest deflections increase with load limit levels. Also passenger chest deflections are lower compared to the driver. Effects of other available parameters like mass of the car were checked and found not to be significant. When comparing risks calculated from the Euro NCAP tests and values from the crash investigations (45 year old occupant, 58 km/h, 40 % of overlap, car mass of 1323 kg) results appear to be coherent for the drivers but markedly different for the passengers. While the passengers had a higher risk of torso injury than the drivers in accidents, chest deflections are lower in the Euro NCAP tests. This indicates that the risk of thoracic injuries is underestimated for the passengers in Euro NCAP tests.

2.1.3 Human data and injury risk curves

Both THORAX and THOMO conducted substantial efforts to collect human data and analyze this data to obtain injury risk curves. In COVER a specific task was incorporated to coordinate the activities in both projects resulting in consistent datasets. For this purpose a joined test matrix between THORAX and THOMO was defined and reported in COVER deliverable D7 (see also Fig. 6). Common test conditions (fixtures, pulse, etc.) were defined for the evaluation of numerical models and a test matrix was defined up for joint THORAX / THOMO tests which is complementary and does not contain overlaps (see for instance distribution of test set-ups in Fig. 7). In total 18 tests with Post Mortem Human Subjects (PMHS) were defined to complete existing datasets for usage by THORAX and THOMO. The tests itself were performed in THORAX and THOMO and not reported here.

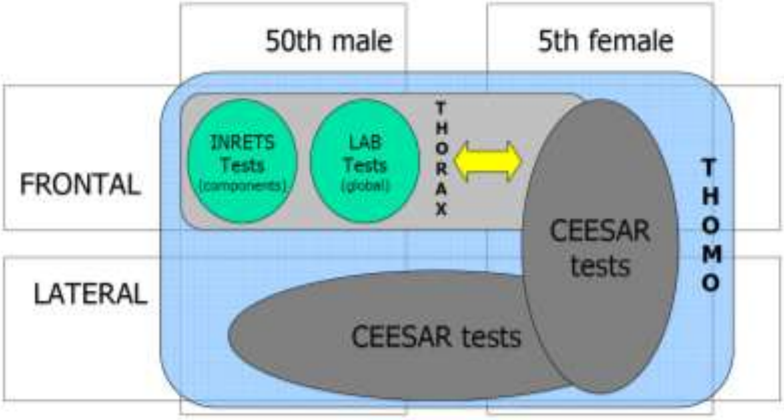


Fig. 6. Synergies between THORAX and THOMO PMHS tests

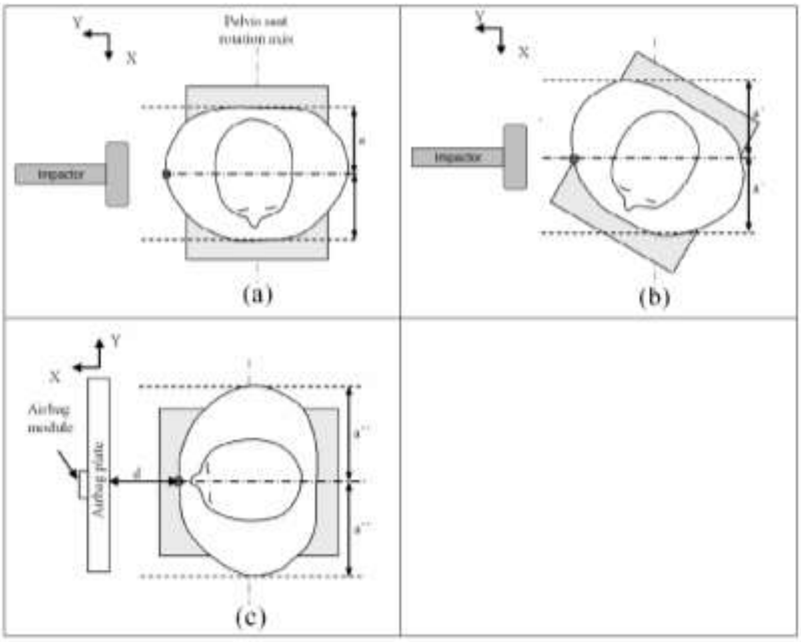
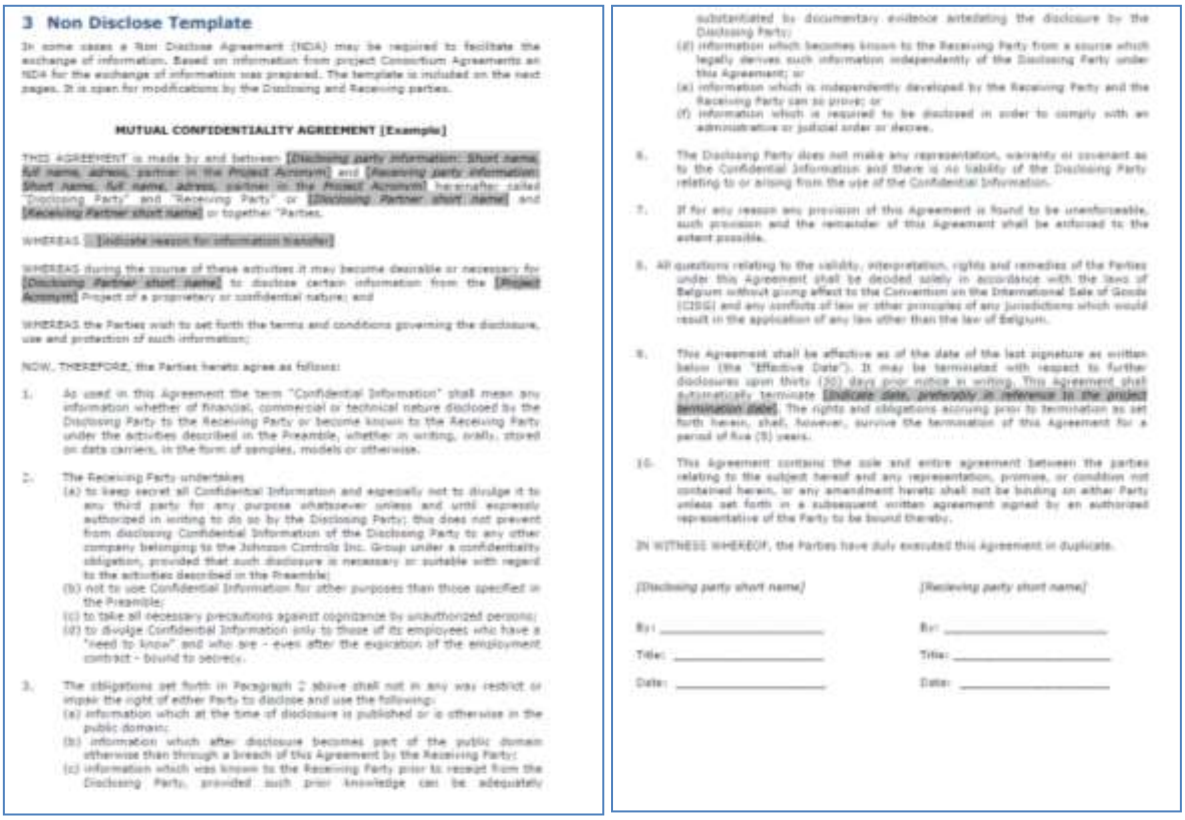


Fig. 7. Example of contents in test matrix: Specimen position in the X-Y plane for the 90° impactor tests (THOMO), 60° impactor tests (THOMO but of interest for THORAX) and 0° airbag tests (THORAX but of interest for THOMO).

Once the tests were executed a workshop was organised for THORAX and THOMO project partners to exchange information of the PMHS tests. In total 24 people attended this workshop including biomechanical experts but also end users of the data like for instance persons responsible for the HBM development in THOMO or the dummy developments in THORAX.

2.1.4 Intellectual Property Rights

Whilst the projects involved in COVER were envisioned to be of a pre competitive nature exploitation of the project results remained a main issue for the research of all the partners. Although it is the responsibility of the individual projects to take measures to avoid the duplication of existing design solutions and to take actions to safeguard outputs not covered by existing IPRs, appropriate actions needed to be defined in COVER to ensure the safeguarding of IPR’s and especially ownership of know-how when exchanging information, tools and best practises. For this purpose potential IPR issues were identified in meetings with project coordinators. Although in general IPR was not an blocking exchange of information, some issues in the field of dummies and sensors were identified. As a resolution a standard NDA formulation was defined facilitating partners to exchange know-how and tools without affecting any IPR (see Fig. 8).



3 Non Disclose Template

In some cases a Non Disclose Agreement (NDA) may be required to facilitate the exchange of information. Based on information from project Consortium Agreements an NDA for the exchange of information was prepared. The template is included on the next pages. It is open for modifications by the Disclosing and Receiving parties.

MUTUAL CONFIDENTIALITY AGREEMENT [Example]

THIS AGREEMENT is made by and between [Disclosing party information: Short name, full name, adress, partner in the Project Acronym] and [Receiving party information: Short name, full name, adress, partner in the Project Acronym] hereinafter called "Disclosing Party" and "Receiving Party" or [Disclosing Partner short name] and [Receiving Partner short name] or together "Parties.

WHEREAS ... [indicate reason for information transfer]

WHEREAS during the course of these activities it may become desirable or necessary for [Disclosing Partner short name] to disclose certain information from the [Project Acronym] Project of a proprietary or confidential nature; and

WHEREAS the Parties wish to set forth the terms and conditions governing the disclosure, use and protection of such information;

NOW, THEREFORE, the Parties hereto agree as follows:

1. As used in this Agreement the term "Confidential Information" shall mean any information whether of financial, commercial or technical nature disclosed by the Disclosing Party to the Receiving Party or become known to the Receiving Party under the activities described in the Preamble, whether in writing, orally, stored on data carriers, in the form of samples, models or otherwise.

2. The Receiving Party undertakes
   (a) to keep secret all Confidential Information and especially not to divulge it to any third party for any purpose whatsoever unless and until expressly authorized in writing to do so by the Disclosing Party; this does not prevent from disclosing Confidential Information of the Disclosing Party to any other company belonging to the Johnson Controls Inc. Group under a confidentiality obligation, provided that such disclosure is necessary or suitable with regard to the activities described in the Preamble;
   (b) not to use Confidential Information for other purposes than those specified in the Preamble;
   (c) to take all necessary precautions against cognizance by unauthorized persons;
   (d) to divulge Confidential Information only to those of its employees who have a "need to know" and who are - even after the expiration of the employment contract - bound to secrecy.

3. The obligations set forth in Paragraph 2 above shall not in any way restrict or impair the right of either Party to disclose and use the following:
   (a) information which at the time of disclosure is published or is otherwise in the public domain;
   (b) information which after disclosure becomes part of the public domain otherwise than through a breach of this Agreement by the Receiving Party;
   (c) information which was known to the Receiving Party prior to receipt from the Disclosing Party, provided such prior knowledge can be adequately substantiated by documentary evidence antedating the disclosure by the Disclosing Party;
   (d) information which becomes known to the Receiving Party from a source which legally derives such information independently of the Disclosing Party under this Agreement; or
   (e) information which is independently developed by the Receiving Party and the Receiving Party can so prove; or
   (f) information which is required to be disclosed in order to comply with an administrative or judicial order or decree.

6. The Disclosing Party does not make any representation, warranty or covenant as to the Confidential Information and there is no liability of the Disclosing Party relating to or arising from the use of the Confidential Information.

7. If for any reason any provision of this Agreement is found to be unenforceable, such provision and the remainder of this Agreement shall be enforced to the extent possible.

8. All questions relating to the validity, interpretation, rights and remedies of the Parties under this Agreement shall be decided solely in accordance with the laws of Belgium without giving effect to the Convention on the International Sale of Goods (CISG) and any conflicts of law or other principles of any jurisdictions which would result in the application of any law other than the law of Belgium.

9. This Agreement shall be effective as of the date of the last signature as written below (the "Effective Date"). It may be terminated with respect to further disclosures upon thirty (30) days prior notice in writing. This Agreement shall automatically terminate [indicate date, preferably in reference to the project termination date]. The rights and obligations accruing prior to termination as set forth herein, shall, however, survive the termination of this Agreement for a period of five (5) years.

10. This Agreement contains the sole and entire agreement between the parties relating to the subject hereof and any representation, promise, or condition not contained herein, or any amendment hereto shall not be binding on either Party unless set forth in a subsequent written agreement signed by an authorized representative of the Party to be bound thereby.

IN WITNESS WHEREOF, the Parties have duly executed this Agreement in duplicate.

[Disclosing party short name]	*[Recieving party short name]*
By: ____________	By: ____________
Title: ____________	Title: ____________
Date: ____________	Date: ____________

Fig. 8. Template for Non Disclosure Agreement as defined in COVER to facilitate exchange of confidential information between projects.

2.2 WP 2 – Joined Dissemination

2.2.1 Introduction

A key task of COVER dealt with external and internal (between projects) dissemination. For the future implementation of research findings in industry design processes as well as regulatory and rating procedures, it was regarded essential to seek for agreement on and acceptance of the findings and conclusions at relevant stakeholders such as GRSP, EEVC and Euro NCAP. For this purpose high exposure to such groups was supported crucial. Some of the involved projects already included this in their own dissemination activities but via COVER efforts were organised.

2.2.2 General dissemination activities: dissemination database and joined newsletters

To facilitate the dissemination of the underlying projects a database of contacts was constructed with inputs from all individual projects. The database contains over 500 contacts from OEM's, Suppliers, Governments and research Groups. To allow for targeted mailings subgroups have been defined. The database is available for other projects as well and access can be requested via COVER partner Uniresearch.

Through the runtime of the project various newsletters and flyers with technical results and announcements from the projects were prepared and distributed via COVER. The newsletters are available from the COVER website. An impression of the newsletter is provided in the figure below.

Fig. 9. Impression of the COVER third newsletter

Fig. 10 Screenshots showing the four pages of the fourth and final newsletter

2.2.3 Public Workshops

To bring the results to the automotive community four public workshops were organised by COVER:

1) Mid-term workshop on Child Safety presenting results from CASPER and EPOCh
2) Mid-term workshop on thoracic injuries presenting results from THORAX, THOMO and other projects on this topics ongoing world-wide
3) Final workshop on Child Safety presenting results from CASPER and EPOCh
4) Final workshop on thoracic injuries presenting results from THORAX, THOMO and other projects on this topic ongoing world-wide

Workshops on Child Safety

The mid-term workshop on child safety was organised in December 2010 followed by a final workshop in March 2012 at CASPER partners TU Berlin. The final workshop was joined by almost 90 representatives from governments, restraint suppliers, child restraint suppliers, car manufacturers, test houses, research groups / academia and the Commission. Stakeholder groups like GRSP Informal Group on Child Restraint Systems, Euro NCAP and ETC were represented. Discussions during the various sessions focussed on transfer of research results and tools developed to the stakeholder groups for implementation in future regulations and test protocols. Some info like accident data is directly usable as input to decision making on items like frontal test pulse. Tools developed in the two projects, like Q10 dummy and abdominal sensors are either on the roadmaps of the stakeholder groups or identified as high potential (see also information on stakeholder visits included below). Further testing and evaluation of these tools is planned / ongoing outside the projects to facilitate implementation over the next years.

FE models of children and dummies were presented and discussed. The dummy FE models are being used in design by OEM's but need further development to reach adequate response to loads in a vehicle environment. Child human models have a potential for future design and biomechanics studies. Again here further validation is needed. In relation to these models virtual testing was discussed. Stakeholder groups indicated though that the child / child restraint / vehicle configuration is too complex to allow for approval by simulations. Hence use of these tools mainly in the design phase of the systems, not in the evaluation.

An impression of this well visited and successful workshop is provided in the pictures of Fig. 12.

All presentation material from both the mid-term and final workshop on child safety is available from the COVER website as well as from the CASPER and EPOCh websites.

Fig. 11. Flyer / invitation for final workshop on child safety and Agenda

Workshops on thoracic injuries

The mid-term and final workshop on thoracic injuries were organised in conjunction with the annual IRCOBI conference. The mid-term workshop was held the day before the 2010 conference while the final workshop from THORAX / THOMO was organised as a special session of the 2012 IRCOBI conference. That session was held at the Friday 14th of September and chaired by Mr Stephen Ridella, Director - Office of Vehicle Crashworthiness Research from NHTSA. In his position Mr. Ridella is responsible for the Biomechnaics research activities by NHTSA. The workshop was joined by about 80 participants from industry, governments and research groups world-wide. Results of THORAX and THOMO were presented in the form of reviewed papers in the IRCOBI proceedings as well as presentations during the workshop. In addition to the input from both the EU FP7 projects information from projects in the US was provided by speakers from that region.

The overview of speakers for the THORAX / THOMO final workshop session is provided in the Fig. 13.

All presentations are results of reviewed papers for the IRCOBI conference. The papers are available via the IRCOBI conference and presentations can be downloaded from the COVER, THORAX and THOMO websites.

Fig. 12. Photo's of the Final Workshop on Child Safety March 2012

THORAX / THOMO Workshop session at IRCOBI conference
Introductory remarks (S. Ridella)
Biomechanics research overview NHTSA (S. Ridella)
Development of an advanced frontal dummy demonstrator (Lemmen)
Design implications for improving an anthropometric test device based on human body simulation (Brolin)
Updated biofidelity targets for the thorax in frontal impact (Lebarbé)
Application of the human thorax FE model in safety restraint assessment (Gierczycka)
Application of detailed thorax model to behind armour blunt trauma (Cronin)
closure of session

Fig. 13. Photo's of the Final Workshop on Child Safety March 2012

Fig. 14. Photo's of the Final Workshop on Child Safety March 2012

2.2.4 Stakeholder visits

During the runtime of the COVER project continuous visits to stakeholders were arranged. An overview of the most important stakeholder groups and examples of interactions is listed below:

- GRSP Informal Group on Frontal Impacts: Accident surveys from THORAX / THOMO and COVER were presented in April 2010 to this group. The relevance of user diversity was forwarded to the group indicating the risk of females compared to males. As a consequence of this study the Informal Group is now considering the introduction of a female dummy in front seats of future test procedures. During the subsequent April 2012 and January 2013 meetings of this group status and forecast reports on THOR dummy developments were presented. The presentations were done by partners TRL and Autoliv presenting information on the dummy developments and it's performance in biomechanical and restraint evaluation testing. Presentation material is available from the UNECE website.

- Euro NCAP Frontal Protection Group: Meetings of the Frontal Impact groupo were joined by various partners of the underlying projects. Accident surveys indicating the need for considering user diversities were forwarded in 2009 and 2010 resulting in the decision of Euro NCAP to include dummies representing small females and children in the 2015 updates of the test protocols. In addition special attendance was arranged to Euro NCAp biomechanical workshops held March 2011 and July 2012. Various activities and research findings from the THORAX, THOMO and EPOCh were forwarded to Euro NCAP. Following the June 2012 workshop a specific working group was established by Euro NCAP on more advanced assessment criteria for the thorax. Representatives from THORAX project (including BASt, Gie Re Pr, Autoliv) join this group that also reports to the GRSP IG on Frontal Impacts.
- GRSP Informal Group on Child Safety: many of the CASPER and EPOCh partners are directly involved in this Informal Group and information of both projects is directly forwarded. Various meetings were joined throughout the runtime of the projects and COVER. Based on the information forwarded the informal group is considering the use of the abdominal sensor developed in CASPER, various dummy improvements proposed by CASPER and the Q10 dummy are on the list of implementation in future updates of R44 on Child Restraint testing. Also information from accident surveys and other studies from CASPER / EPOCh are used by this GRSP group to decide on items like sled pulse to be applied. In view of the relevance of research input from CASPER and EPOCh to the discussions in this Informal Group it was decided that CASPER and EPOCh representatives can join the meetings even now projects have ended to forward results and findings.
- Euro NCAP Child Dummy Working Group: Information from CASPER and EPOCh are forwarded to the Child Dummy working group via COVER. This includes a reporting on the performance of the dummy developments as included under COVER task 2.2. Based on the information provided the informal group is considering the use of the Q10 for future protocol updates.

2.2.5 Links to other research projects

Because of it's relevance Biomechanical research for occupant safety is being conducted world-wide. In COVER a specific task was included to monitor ongoing projects and developments in other regions as well as in Europe. In case needed links and cooperations were established. Some examples are listed below:

- On the child safety side activities world-wide are still being monitored and included on the website. An example includes the activities by Transport Canada on the safety for rear-seat occupants. Activities were facilitated by providing a Q10 dummy (EPOCh) with abdominal sensor (CASPER) for running and reporting tests.
- In Europe and Japan testing programs with the Q10 dummy and the abdominal sensor were supported to allow for further evaluation and acceptance of the sensor. This included tests done for the European Commission DG Enterprise to support the development of future regulations on child safety. Analysis and, in particular, reporting of the test results was supported by COVER Task 2.2 and forwarded to EEVC WG12 for evaluation of the Q10 dummy.
- THOR dummy developments and evaluations ongoing in the US. Cooperation and exchange of information is arranged via the THORAX Technical Advisory Group meetings. However, during the first workshop on thoracic injuries it was indicated that it would be beneficial to have a more extensive dissemination of the THORAX and THOMO project results in the US to inform the local community on the developments. Various activities were started in the second reporting period s included in the period II report. This was continued during the last year of COVER. It included the organisation of a THOR Dummy seating procedure workshop in October 2012 at

the premises of BMW. This workshop was meant to give the reference for positioning the dummy in the THORAX WP4 testing. The workshop was joined via WebEx by members form JAMA / JARI (both Japan) and VRTC/ NHTSA / UVa (all US) providing input and experience on the seating of the THOR dummy previously gained in projects / activities in Japan and the US. The exercise resulted in a seating procedure as included in THORAX D4.2. The procedure will be forwarded to the SAE group in the US for adoption. In addition telecalls were organised between THORAX and NHTSA / UVA / VRTC on injury risk curve developments for the THOR dummy. In the December 2012 – March 2013 timeframe various telecalls were held to exchange information on the risk curve development for the THOR dummy. It was decided to extend this exchange beyond the runtime of THORAX and COVER as basis for future cooperation on this subject.

2.2.6 Technical reporting for the Automotive Community and Stakeholders

A part of the dissemination activities general overview reports integrating the results of projects involved in COVER were prepared. This includes reports on:

- Thoracic injuries: contents largely based on input from THOMO and THORAX.
- Report on child safety: using input from CASPER and EPOCh.

The COVER Deliverable report D25 reports on Child Safety presents research findings related to child safety as obtained from the CASPER and EPOCh projects. It gives a full status overview of biomechanical know-how, tools and methods as developed in the projects. Information on the following topics is provided:

- Accidentology (e.g. type of injury versus age group and CRS use)
- Hardware dummy information (e.g. requirements, technical description of dummies / parts, instrumentation, biofidelity evaluation, injury Risk curves and IARV (Injury Assessment Reference Values))
- Virtual and experimental test procedures child safety (e.g. scenario and conditions, test / simulation tools used, technical description of the set-up, evaluation of the proposed procedures, indication on the benefit and expected reduction in fatalities and serious injuries when introducing proposed procedures)

The information is largely coming from (reviewed) papers presented at key conferences like IRCOBI, Protection of Children in Cars and ISAR. Items not covered at such conferences are covered by including info from public project reports. The report became available February 2013.

In the same manner an overview report on research findings and results related to thoracic injuries was prepared (COVER D24). Again information from public reports and papers was used to bundle findings from accident surveys, biomechanical studies, hardware developments, numerical modelling (including Human Body Modelling) and evaluations.

3 Impact

3.1 Potential Impact

With more than 30,000 deaths and around 1.5 million injured in 2011[8], road remains the least safe mode of transport. Although the number of road fatalities is declining rapidly (see for example Fig. 15), continued efforts are needed, in particular when taking into account the growing transportation needs of the elderly and the expansion of the EU with countries that historically lacked effective safety standards.

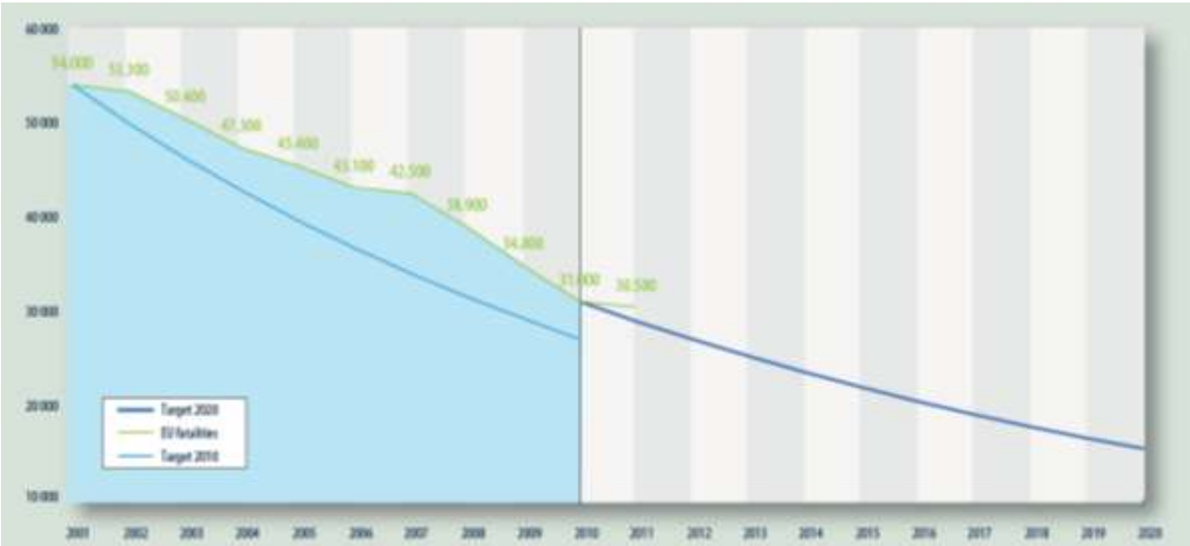


Fig. 15. Road fatalities in EU since 2001 (source European Road Safety Observatory, www.erso.eu)

As a Coordination and Support Action, COVER did not produce its own research results other than the in-depth accident data generated as input for involved projects. However, COVER has shown to be vital for an efficient conduction of several European research projects in the field of biomechanics for crash protection by coordinating some joint activities and dissemination. An example of the former includes the successful coordination of the PMHS testing between THORAX and THOMO providing good synergy and maximum output for both projects within the available budgets. The External dissemination as arranged via COVER, is a key factor to create necessary visibility and acceptance at stakeholders. During the first reporting period this was shown by various examples like for instance forwarding the need for inclusion of dummies representing females in future protocols and regulations to Euro NCAP and the GRSP Informal Group on Frontal Impacts. On this basis Euro NCAP already decided to include these dummies into consumer rating tests starting from 2015. Also GRSP is considering the inclusion of a 5th female HIII dummy in future frontal test procedures. As such the project did directly contribute to the societal need for safe cars the future reduction of the numbers of fatalities and injuries on roads.

On the child safety side information from CASPER and EPOCh was forwarded to Euro NCAP as well as the GRSP Informal Group on Child Restraint Systems. Also for this topic both groups are using directly the research findings from the EU FP7 projects. Based on reporting's during the final workshop on child safety and dedicated presentations made to the GRSP Informal Group it was decided to investigate the use of the abdominal sensors developed in CASPER for future regulations on child restraint systems. As this involves the Q10 dummy developed in EPOCh exchange of dummy information and availability of that dummy for use by CASPER was arranged between the projects.

[8] Data from the European Road Safety Observatory (www.erso.eu).

COVER BIOMECHANICS COORDINATION

Apart from dissemination of test tools various other outcomes of the projects like accident survey data were forwarded to the indicated stakeholder groups contributing to decisions on items like sled pulse to be applied in Child Restraint Testing.

3.2 Main dissemination activities after the project's runtime (2013-2016)

As a Coordination and Support Activity the focus of COVER was on dissemination. An overview of results was provided in Chapter 2. After the completion of the COVER project continued dissemination is foreseen. On the one hand side the COVER website will be maintained for several years after the project as a guide into the underlying projects. Moreover participation to stakeholder meetings will be continued to monitor and support the implementation of research findings into regulations. An approximate timeline is as follows:

General

- 2008 - 2013 Realisation of numerical and experimental tools for usage in the design and evaluation of protection systems by the underlying projects
- 2013 – 2016 Continued presentation of results from underlying projects at international conferences, e.g. ESV 2013 and through the project's website:
  For the 2013 ESV papers were submitted and accepted on topics like Q10 dummy developments and abdominal sensor integration, THOR SD3 shoulder evaluations. This work was largely conducted during the last year of the underlying projects and in some cases concerns follow-up activities (e.g. Q10 developments).
- 2013 – 2016 Availability of the project website, to keep results and findings directly accessible to the public
- To provide access to the results and findings the COVER website will remain available for the next four to four years, providing links to the underlying projects and their deliverables.

Child Safety

- 2012 – 2014 Phase II GRSP Informal Group on Child Restraint Systems developing procedures for Isofix seats that use adult belts to restraint the child. Involves Q6 and Q10 as well as abdominal sensor CASPER
- 2014 – 2015 Phase III GRSP Informal Group on Child Restraint Systems developing procedures for booster cushions. Involves Q6 and Q10 as well as abdominal sensor CASPER
- 2013 – 2017 Euro NCAP Child Safety protocols for frontal and side impact. Starting off with the introduction of the Q1,5 and Q3 dummy in an early stage and followed with the replacement by Q6 and Q10 dummies representing larger children.
- 2013 – 2014 In support of the above EEVC WG12 has started an activity to evaluate research results like abdominal sensors and Q dummy updates and give recommendations to Euro NCAP and GRSP. The COVER report on Child Safety will serve as basis for the evaluation by the biomechanical experts in EEVC WG12.

Thoracic injuries

- 2010 - 2014 Completion of harmonised frontal impact dummies based on latest biomechanical insight, through close cooperation with NHTSA.
- 2014 - 2020 Implementation of harmonised frontal impact dummy in EU and US frontal impact directives. For the EU the activities will run via the GRSP Informal Group on Frontal Impacts, for the US it will largely go directly via NHTSA.
- 2010 - 2016 Implement know-how in harmonised human body models, considering relevant biometrics (age, gender and size)

3.3 Exploitation of results

Apart from in-depth accident data required for some of the involved projects COVER will not produce its own research results and has therefore not defined any exploitation related activities of its own. But, as a Coordination Action, COVER has shown to be effective in forwarding results of underlying projects to key stakeholders and the general public. Examples of this have been listed in section 3.1

4 Website and contact details

4.1 Website

The project public website has been set up for the general public and can be found at the web address: www.biomechanics-coordination.eu The website provides general information on the project objectives, the work to be performed, details of the project partners, overview of events in the field of Biomechanics including COVER workshop announcements. At the home page clear links to the underlying projects THORAX, THOMO, CASPER and EPOCh are provided as well as direct links to the deliverable reports of all these projects.

4.2 Contact persons

Coordinator:
Humanetics Europe GmbH
Linnewever 12
2292 JH Wateringen
The Netherlands
Mr Paul Lemmen
e-mail: plemmen@humanetics.eu
Tel: +31 6 227 56 277

5 List of project participants

Partner No.	Partner organisation name	Short name	Country
1 Co.	Humanetics Europe GmbH	HUMAN	Germany
2	Bundesanstalt für Strassenwesen	BAST	Germany
3	Centre Européen d'Etudes de Sécurité et d'Analyse des Risques	CEESAR	France
4	Groupement d'Intérêt Economique de Recherches et Etudes PSA-RENAULT	Gie Re Pr	France
5	RWTH Aachen University	IKA	Germany
6	TRL Limited	TRL	United Kingdom
7	UNIRESEARCH BV	UNI	The Netherlands