Minutes

GTR No. 7 / BioRID TEG

Group of Experts Whiplash Injury Criteria Meeting

Date & Timing:	Monday September 8th 2014, 13:00-17:30 (CET) and Tuesday September 9th 2014, 9:00-13:00 (CET)
Location:	TU Berlin, Automotive Engineering, Building TIB 13.5, 4th Floor, Gustav-Meyer-Allee 25, 13355 Berlin, Germany.
Minutes drafted by:	Bernd Lorenz (BASt/EEVC), David Hynd (TRL)
Participants:	Klaus Bortenschlager (PDB); Johan Davidsson (Chalmers); Thomas Frank (Lear); David Hynd (TRL); Annette Irwin (SAE/ISO/GM); Yun-Seok Kang (Ohio State Uni); Agnes Kim (Ford); Bernd Lorenz (BASt,/EEVC); Kevin Moorhouse (NHTSA/VRTC); Koshiro Ono (JARI); Philippe Petit (LAB); Norbert Praxl; Fusako Sato (JARI); Lex van Rooij (TNO) (see doc <WCWID-1-08e>).
Documents:	documents of the meeting are uploaded to the UNECE website under the BioRID TEG (<WCWID-1-xy>)

Day 1 (8th September 2014)

1. Welcome (Chair) / Roll Call / Introduction

Bernd Lorenz (BL) welcomed the participants. He explained that it is the task of the group to decide recommendations for WP.29/GRSP/IWG GTR No. 7 regarding injury criteria for whiplash based on the "Gothenburg List" (<WCWID-1-02e>). It is not the intention to provide limits for those criteria at this stage and it is also not the intention to discuss BioRID related issues.

BL explained that the recommendations of the group shall be put forward to the IWG GTR No. 7 meeting in November and that the chair of the IWG wants to provide a final draft GTR text to the GRSP meeting in December this year.

Norbert Praxl (NP) asked whether the discussion is about Whiplash Associated Disorders WAD (the usual terminology in Europe) or ligamentous injuries (as reported in the work NHTSA)?

Kevin Moorhouse (KM) replied that although a couple of major ligamentous injuries were observed in the experimental seat (due to the head wrapping around the head restraint), the majority of the injuries observed in the NHTSA study (including all the injuries observed in the production seats) were subluxations deemed to be not so different to the WAD 2 and 3 injuries reported elsewhere. It is the hope that any injury criteria chosen will cover subluxations consistent with WAD 2 and 3 injuries, as well as naturally also prevent more major ligamentous injuries.

2. Approval of the Agenda

The draft agenda was approved without changes.

3. Election of Secretary

David Hynd (DH) volunteered to provide his notes.

4. Information / Discussion on Whiplash Injury Criteria

4.a. Evaluation of Seat Performance Criteria for Rear-end Impact Testing: BioRID II and Insurance Data

Johan Davidsson (JD) presented a common study of Chalmers and Folksam on the evaluation of seat performance criteria based on insurance data (<WCWID-1-03e>). The presentation was an update of <GTR7-14-02>. The study was performed within the EEVC work programme by EEVC WG12 (see report <WCWID-1-09e>):

Approach for the study is to compare claim rates for different seats in the Folksam insurance data with BioRID II metrics from tests for the same seats.

The focus is on neck injury and very few thoracic or lumbar spine injuries/claims are contained in the Folksam database

Two risk levels:

1. Symptoms for more than one month in case of initial symptoms
2. Permanent medical impairment in case of initial symptoms (with no financial incentive to claim this level of symptom)

The Chalmers/Folksam/EEVC study uses 150 cases per seat (IIHS used a minimum group size of 30 cases, which may explain the weak correlations that they reported).

In Sweden, the risk for a given vehicle has reduced over 10 years, indicating that the assessment of injury by the medical profession has become stricter. This has been compensated for in the study by normalising to the 2005 risk level.

The risk for different seats cf. the NIC was shown as an example. Philippe Petit (PP) asked if the differences were tested for significance, because the range is quite small. This was not the case. Norbert Praxl (NP) asked if confounding factors were controlled like e.g. delta-v? JD replied that there was no information on delta-v, but ensured that the groups were not very light or very heavy vehicles. The Volvo and Saab had a step-change in seat design on a vehicle platform of very similar mass and structure.

Koshiro Ono (KO) asked whether the patients' medical records were re-reviewed by the study in order to confirm the diagnosis and the severity of WAD. This was not the case, but for the permanent injury rating there is a considerable effort that the patient has to go to in order to be classified, with little reward.

Overall, NIC showed the best correlation with risk, both at the symptoms > 1 month and the permanent medical impairment levels. OC-T1 x-axis relative displacement and L1 x-axis acceleration correlated with long-term injury risk. Neck extension and T1 x-axis acceleration may be candidates, but appear to be sensitive to inclusion or not of outliers.

Limitations of the study include:

- Changes to the dummy over time
- Changes since the seats in the study were tested
- Correlation coefficients were maximum 0.72.

PP noted that there is a very strong assumption that the pulse is the same over time, even for an identical vehicle. In France, it was observed that the average speed of fatal collisions was increasing until automatic ticketing was introduced, when it dropped 5%. JD: 2009 pulses likely to be more severe than 1999, due to changes in the vehicle structures.

Agnes Kim (AK) noted that the study is based on Folksam data and that means Swedish drivers, who are more likely to sit in a 'standard' position than US drivers, who tend to have a very poor, non-standard posture. BL: This is the data we need – the regulator can only assume that a driver is sitting in a good position with a correctly adjusted seat, and ensure that they are provided with a minimum level of safety in this case if they take this care. The seat-belt doesn't protect you if you don't wear it, but it is still required to be fitted. AK pointed out that in regulations to date we take due care to ensure that if an occupant is somewhat out of position they will still be protected, but the rear impact is somewhat different.

Annette Irwin (AI) asked whether the BioRID predicts that the risk is, as would be expected, lower in the heavier vehicles. JD replied that he can't answer this question based on this data, but other studies have done this.

4.b. Status of JARI Research: Reviews on Injury Parameters and Injury Criteria for Minor Neck Injuries during Rear-end Impacts

JARI/Koshiro Ono (KO) presented a review on injury parameters and injury criteria for minor neck injuries during rear-end impacts (<WCWID-1-05e>).

Objectives of this study: review the published papers and current knowledge for reducing minor neck injuries; review of injury evaluation parameters from human volunteer tests and accident reconstruction simulations.

A chain of evidence from different sources (PMHS tests, volunteer tests, animal tests etc.) was presented:

- Excessive deflection leads to soft tissue injury
- Facet joint is most common injury site
- Strain rate affects rupture strength of soft
- Stretch of facet capsule is related with pain

Symptoms from six volunteer tests were presented. It was noted that each subject received multiple tests, from 4 to 9.4 km/h delta-*v*. The strains in the facet joints were estimated from the high-speed x-ray data and safe and failure zones defined. The correlations of the strains and strain rates (principal and shear) with candidate injury criteria were presented. The injury criteria were calculated for each volunteer (not for the BioRID II). Head and neck loads were calculated using inverse dynamics and external forces from strain gauges on the head restraint supports.

Accident reconstructions (20 occupants in 15 cars) were then presented. The THUMS FE model was scaled based on the height and weight of the occupant (with the mass scaled by adjusting the density). The head restraint backset was not known, so a standard backset of 50 mm was used.

Injury classified as WAD 2+, so WAD 1 (pain only with no identifiable physical change) was classified as non-injury.

The correlation between the candidate criteria and the strain / strain rate in the simulations was presented. KM noted that the correlations are for a lower level of injury than we are targeting with the regulation.

A comparison between the Japan and US approaches and suggested criteria was presented, followed by a comparison of facet joint strains for tensed and relaxed muscle conditions. Upper facet joint strain was higher in the relaxed state; lower facet joint strains were higher in the tensed stated.

It seems not to be possible to evaluate neck injury risk from OC-T1 kinematics alone; NIC, and neck forces/moments are also required. This is because the head-neck motion is not achieved by a simple rotation of a straight line neck, but includes an s-shaped neck.

Concluding, various injury risk curves (IRC) were presented for human subjects, with 95% confidence intervals. Good correlations with WAD2+ were found for NIC, upper neck Fx & My, lower neck Fx & My.

For IV-NIC of 1.1, an 82.9% risk of WAD2+ was derived. As such, when the neck is flexed or extended 10% above the physiological range, an 82.9% risk of WAD2+ exists.

4.c. Status of NHTSA Research: Preliminary PMHS Injury Risk Curves and Potential Injury Criteria in Rear Impact

Yun-Seok Kang (YSK) presented the status of NHTSA research (<WCWID-1-06e>).

The study is divided in two phases. In Phase 1 tests are performed using a laboratory seat and in Phase 2 one using a production car seats.

Aims of Phase 1 (laboratory seat) were:

- Evaluate the biofidelity of candidate dummies
- Investigate the mechanism of injury
- Relate injury to measured PMHS variables

The seat included load cells in the base, back and head restraint. Springs controlled the initial response, with dampers to control rebound. Tests were performed at 17 km/h, 8.5 g and 24 km/h, 10.5 g – two tests with each of seven PMHS (plus four low-speed tests with one additional PMHS).

A new technique for mounting instrumentation to each cervical body without disrupting the main musculature of the neck was developed. This gave the rotation and displacement of each vertebral body. It was found that intervertebral flexion dominated the response.

Disc ruptures, subluxations (representing WAD) and ligament lacerations were identified upon necropsy.

Correlated intervertebral kinematics (linear/angular acceleration, velocity and displacement) and injury; used this to suggest criteria and correlate with global kinematics in order to identify potential injury criteria on the dummy. Rotation about the y-axis had the best correlation, with angular velocity and facet joint slide reasonable. However, each intervertebral level may have a different threshold, so the data was normalised using the physiological range of motion.

JD commented that the data is being treated as though the measurements at each intervertebral level are independent, but they may not be – if you damage at one level it may release other levels. The rupture and laceration only occurred in the lab seat tests, due to over-riding the head restraint resulting in hyper-extension. In the car seat tests (to be presented later), hyper-extension did not occur and there were none of these more serious injuries – only subluxations.

IV-NIC rotation was the best injury predictor, and rotation measures were better correlated than displacements or strains

Potential 'global' PMHS injury criteria were NDCrot and NDCx (and NIC).

However, this test condition was designed for evaluating biofidelity, repeatability etc. – not to represent a real seat; rigid head restraint affects loads; upper and lower neck loads not accurate after head restraint contact due to ramping-up motion; and seat back rotation was more uniform that real seats. The lab seat induces flexion, which will left-censor the risk functions considerably – therefore the values from this study should not be used directly. This, with other limitations, meant that tests were performed with production car seats.

There was some discussion regarding the lack of muscle tone in PMHS subjects. The muscle tone in vivo (once the head is upright) to maintain position is 1-5% of maximal exertion, and reaction to loading occurs after the period of interest, so no significant limitation to using PMHS.

Phase 2: Production car seats

- Paired BioRID II and PMHS tests
- Verify measures from experimental seats highly correlated to injury

Toyota Camry and Chevy Cruze chosen – one with good IIHS and Euro NCAP ratings, one with poor. Three pulses: FMVSS 202a, JNCAP, 24 km/h. Seven PMHS, with the combination of seat and pulse altering the dose. Aimed for 50 mm backset, which was achieved for five PMHS.

Global motion was rearward (extension), but at each cervical vertebral level, *flexion* again dominated. BioRID also showed flexion (lower magnitude at the higher, 24 km/h severity).

Again, injuries at each vertebral level were compared with intervertebral kinematic measurements. Rotation about the y-axis had the best correlation.

NDCrot had the best correlation for these seats.

In conclusion:

- IV-NICrot was the best PMHS injury risk predictor.
- The most promising BioRID injury criteria were IV rotation and NDCrot.

KM noted that the IIHS and Euro NCAP assessments seem to be doing the right sort of thing, so could just add the metric(s) recommended from the GTR-7 work. JD noted that the

metrics used in the consumer information tests are focussed on preventing hyper-extension, so an additional metric to prevent injurious flexion would be welcome.

KM noted that the subluxations cannot be observed on a live patient, and we are currently working with a neurosurgeon to determine whether the subluxations would be associated with WAD, rather than the more severe, conventionally AIS-coded injuries.

Presentation from KM on the alignment of the US and Japan studies:

Best injury predictor for a dummy:

- US – iV-NICrot
- Japan – iV-NICrot (well correlated with strain and strain rate)

Potential 'global' injury criteria

- IV-NICrot -> NDCrot, NDC, NIC
- IV-NICrot -> NIC, UNFx, UN My, LN Fx, LN My

Common ground

- NIC
- US: Investigated forces and moments in PMHS. May need to consider direct correlation with the forces and moments in the BioRID
- Japan: Investigated NDCrot and NDCx (well correlated to WAD2+)

Sensitivity analysis showed that the PMHS neck forces and moments were very sensitive to the position of the centre of the contact, which was not well characterised. Also, the BioRID skull cap force did not match the head restraint forces in 5 out of 7 tests.

Future work:

- Ensure the dummies represent the final regulatory tool
- Re-run 5 injury criteria sled tests using (both BioRIDs) with Camry and Cruze seats
- Conduct paired BioRID/Hybrid III sled tests
    - To get extension metrics to supplement the flexion metric
    - 5 seats (Cruze, Camry, Toyota Matrix, Ford F150, Honda Odyssey), all three pulses
    - Check BioRID metrics deliver at least the protection level of 202a with Hybrid III head angle metric – which is the minimum requirement for the US to be able to adopt BioRID, because the current safety level cannot be degraded

4.d. Other Whiplash Injury Criteria work

Lex van Rooij (LvR) indicated that TNO performed a large study with validated numerical models of car seats, BioRID II and Active Human Models that could be beneficial to this group once compared against real-world injury data. Since the last step is currently being performed, no scientific findings from this project could be presented. As such, this ongoing work was not presented.

LvR did however show results from an analysis on Euro NCAP test results from 2010 and 2011. A total of 38 anonymous test results on NIC and upper neck Fx shear force and the

correlation between the two was shown. The analysis showed no correlation between NIC and Fx, indicating that Fx is a criterion that is not captured with just using NIC. The presentation was shared with the group (<WCWID-1-07e>).

5. Recommendations to the GTR-7 Informal Group

Day 2 (9th September 2014)

Introduction

Bernd Lorenz gave an overview of the process at Geneva for a GTR. Unlike an UN Regulation, which requires a two-thirds majority, a GTR requires a unanimous decision from the Contracting Parties. For example, the EC is the voting CP for European countries under the 1998 agreement (GTRs).

It is also important to understand that "GTR testing" is to be performed by any technical service in the world as opposed to consumer testing which is performed by state-of-the-art labs. As such criteria shall be based on measurements as far as possible.

Objectives of the day are to:

- Recommend one or more criteria
- Identify any candidate criteria for the future
- If possible, exclude any candidate criteria from the Gothenburg meeting that are no longer considered applicable

5.a. Candidate Whiplash Injury Criteria

The sub-Group reviewed the Gothenburg candidate criteria list (<WCWID-1-02e>).

KM noted that IVrot and NDCx were deleted in Gothenburg, due to the difficulty of instrumenting the dummy. The sub-Group noted that the NDCx has to be done from film analysis. Most labs can do this, but the problems are calibrating the camera system so that assessments at all labs are comparable. AI noted that SAE have tried to address this with many experts and have been unable to ensure reproducibility.

JD noted that the NDCrot value (12°) is well within the physiological range of most people, so not injurious. There must be a time component that says that this range happened too quickly.

BL reiterated that the goal has been for a long time to give the public protection from long-term impairments, loss of work, costs etc – i.e. the consequences of an injury or disorder.

The sub-Group discussed whether IV-NIC = 1.1, which gives a WAD2+ risk of 82.9% and and AIS risk of 50%, should be used as a basis for deciding a threshold. It was noted that NHTSA are still looking at the appropriate statistical method, so the number could change.

KM noted that using both NDCrot and NIC captures components similar to V*C. It was noted that it is important to have criteria that address extension injury and flexion injury.

It was agreed that NDCx should be eliminated, due to the difficulty of making the measurement at all laboratories.

It was agreed that NIC should be used.

BL asked if NDCrot can be measured directly with angular rate sensors (ARS) with sufficient reliability. KM noted that new ARS are much more reliable than older designs and are

suitable. NHTSA have done a lot of work on these for BrIC and there is a test procedure in the NPRM for the Q3S that uses ARS and the NPRM includes a specification for the ARS. There are at least two manufacturers.

It was agreed that NDCrot should be used, using appropriately specified angular rate sensors.

JD presented some updates and clarifications from yesterday's presentation:

Permanent Medical Impairment (PMI) classification requires multiple medical assessments over a period of 1-3 years. People with PMI classification typically do not return to their previous work.

Action JD to provide more details on the PMI classification.

KM noted that the data is from older tests, where the flexion bumpers were not as well controlled as they are today. Need to do some fleet assessment tests with the current dummy. JD noted that the EEVC results should be considered preliminary, due to the reliance on data from previous versions of the dummy. However, based on the data the NDCrot indicates that no seats will fail, other than WIL. KM noted that JNCAP have found a much wider range, with 50% failing the proposed threshold.

JD showed EEVC data for NIC, showing that the majority of the seats evaluated would not pass. However, the results may be somewhat different for the current version of the dummy and some of the seats that would fail have already been removed from the market. JD noted that at Gothenburg, EEVC recommendation on a NIC threshold was pragmatic – based on eliminating older seat designs with poor real-world performance.

KM asked what criteria would be recommended by the EEVC work. JD noted the following:

- NIC
- OC-T1 x-axis displacement
- (L1-x acceleration – in brackets because it may just be a measure of the severity of the test)

TF noted that for the last 50 'good' rated seats in Euro NCAP the NIC was 6.7 to 19, with an average 12.

Lex van Rooij (LvR) presented all the 2010-2011 NIC results from Euro NCAP, for all three pulses. Visually, about 80% of the seats were below NIC 15 and 95% below NIC 20.

Action LvR to provide the Euro NCAP NIC graphs for 2010-2011.

KO presented the 2009-2011 NDCrot and NIC JNCAP data. It was noted that NDCrot relates well to the JNCAP rating. BL cautioned that there still needs to be a link between the rating and the real-world performance.

BL noted that NIC in Euro NCAP is only assessed up to head restraint contact. YSK noted that NIC peaked before head restraint contact in the VRTC tests. KB and NP agreed with the use of NIC. AK noted that the correlation was not high in the VRTC tests. Can it be judged that the NIC can discriminate between good and bad real-world performance? It seems okay at the extremes (good and poor), but maybe not in the intermediate range. BL: This is a problem for the consumer testing, but not for regulation. We need to be sure that we have a positive effect in the field – i.e. provide people with protection to a minimum level decided at

the political level, and don't guide seat design in the wrong direction. The latter is very important for regulation, because it can take a long time to remove something from legislation. PP noted that it is important not to take excessive budget from other safety features that relate to more serious injuries, which can be achieved by making the requirements reasonable for low-cost cars.

BL noted that the GTR-7 still has the dynamic test as an option – if a seat passes the static geometry requirements then a dynamic test is not necessary. This is still the case in FMVSS 202a. Something different is conceivable for adoption in a UN Regulation.

JD noted that there is only one, no longer produced seat that has good real-world performance and a high NIC. KM identified that it would be important to review the seat and the test data and see what is the reason for this and whether it would still apply if it was tested today.

Action JD to check this seat, and also the high NDCrot with one modern anti-whiplash seat design. Data may be available from other laboratories for these seats which may help clarify the results.

It was agreed that upper and lower neck Fz should be deleted.

Upper and lower neck My(flexion/extension) were discussed. BL asked whether the NDCrot and upper neck My(flexion/extension) were well correlated, such that it would not be necessary to have both. NDCrot well correlated (R^2=0.80) with upper neck My(flexion), for pre-contact and contact phases. Poor correlation for upper neck My(extension) (R^2=0.42). For the lower neck, there was no correlation (R^2=0.01) for My(flexion) and poor correlation for My extension (R^2=0.2). However, the NDCrot value was for flexion only, and it does not make sense for the NDCrot(flexion) to correlate with My(flexion).

BL: Do we need both upper and lower neck loads? TF: At the upper neck, the correlation is good with NDCrot, so duplicate parameter, and injuries tend to be identified in the lower neck.

There was no information on the correlation between NDCrot(extension) and upper or lower neck My(extension), and probably won't get this from JNCAP data because most seats don't allow large extension any more. KM noted that this data will be available from the VRTC fleet analysis, so it is possible that this could be updated soon.

There was no information to indicate that upper neck Fx would be duplicated by NDCrot or any other criteria already selected. KM noted that there isn't an obvious reason why they would be correlated.

AK asked if the neck shears were related to injury. KO presented correlations between upper and lower neck Fx and symptoms, and KM noted that the Fx was well correlated (approx. R^2 0.75) with injury, where Fx was estimated from inverse dynamics only up until head restraint contact.

AK asked if the neck shears were correlated with NIC, such that Fx would be a duplicate requirement. LvR presented 2010-2011 Euro NCAP data and there was no correlation. BL noted that the Euro NCAP lower performance limit is 30 N for upper neck Fx, which is less than the force on the due to gravity when you get out of bed –with such low forces it is maybe no surprise that there is no correlation. Additionally, the limits were derived pragmatically from tests with 30 seats at one laboratory, and the head restraints then were not as high as they are now, so some of the heads would wrap over the head restraint – giving low Fx and high Fz compared to many modern seats.

KO presented JNCAP data showing no correlation between NDCr(flexion or extension) and upper neck Fx(flexion or extension. and no correlation between NDCrot(extension) and upper neck My(extension). In most tests, NDCrot(extension) was zero. There was no correlation between NDCrot(extension) and lower neck My(extension), so no reason to delete lower neck My(extension).

KM noted that the recommendation for My and Fx comes from Japan. KO noted that it comes from the volunteer and accident reconstruction simulation studies, because it correlates with the strains that are directly related to the injury. NDCrot doesn't capture injuries that are due to high strains during the s-shaped phase. Upper neck and lower neck My more related to global motion, so duplicated by NDCrot, but the shear forces are necessary. KM noted that if IVrot were used, Fx may not be required, but we have excluded IVrot so we need Fx to control loading during the s-shape. KO: Yes.

BL asked if legislation would misdirect head restraint design if upper neck My was deleted? It was agreed that it would not. **It was agreed that upper neck My should be deleted provided that NDCrot has requirements for both flexion and extension.**

BL asked the same question for lower neck moment. It could be possible to review the data with new knowledge in some years' time. **It was agreed that lower neck My should be deleted provided that NDCrot has requirements for both flexion and extension.**

BL asked the same question for upper and lower neck Fx. KM noted that both are probably required. KO considered that these are required in order to fully assess loading during the s-shaped phase. DH noted that he would be uncomfortable with a proposal that did not adequately assess loading during the s-shaped phase, because in some cases the strains have been shown to be high in this phase, even with modest head rotation relative to T1. Deleting the neck forces and moments entirely could leave a gap in the assessment and therefore the safety. NP noted that it is not clear that the shear forces can be deleted safely. KM noted that if the intervertebral kinematics were used, the shear would not be required, but given that NDCrot is a global assessment the Fx is still required. BL reminded that the Fx were important in the Japan volunteer and accident reconstruction simulations. PP asked whether both the upper and lower neck Fx were required. KM noted that the lower neck Fx would be expected to be more important in the pre-contact phase, and the upper neck Fx more important in the head restraint contact phase. PP noted that he understood the discomfort with removing the Fx, but it could be very sensitive to the initial positioning of the dummy. There should be some information on this from the upcoming VRTC fleet study.

It was reiterated that this is consideration of the measurement as an injury criterion, not a consideration of whether the dummy measures this reliably.

AK asked whether there was a correlation between upper neck Fx and lower neck Fx in the JARI modelling.

Action KO to check whether the upper and lower neck shear forces are correlated in the JARI accident reconstruction simulations.

It was agreed that upper and lower neck Fx should be used.

5.b. Further Recommendations

None.

6. AoB

Limits will have to be discussed in a subsequent meeting. BL noted that it will be necessary to understand the target risk level that will be acceptable to the Contracting Parties.

Action BL to ask CPs what their target risk level is.

7. Summary of the Meeting

Decisions

It was **agreed to delete** the following criteria from the candidate list:

- NDCx due to the difficulty of making the measurement.
- Fz upper and lower neck.
- My upper and lower neck provided that NDCrot has requirements for both flexion and extension.

It was agreed that the following criteria should be recommended for the purpose of regulation:

- **NIC**
- **NDCrot for both flexion and extension,** using appropriately specified angular rate sensors.
- **Fx upper and lower neck.**

Actions

- **Johan Davidsson** to provide more details on the PMI classification.
- **Lex van Rooij** to provide the Euro NCAP NIC graphs for 2010-2011 (done).
- **Johan Davidsson** to check this seat, and also the high NDCrot with one modern anti-whiplash seat design. Data may be available from other laboratories for these seats which may help clarify the results.
- **Koshiro Ono** to check whether the upper and lower neck shear forces are correlated in the JARI accident reconstruction simulations.
- **Bernd Lorenz** to ask CPs what their target risk level is.