Preliminary ACEA comments on the papers presented during the 3rd Flex-TEG Meeting at BASt on 24 April 2006

(In blue letters: Answers from the Flex-TEG chairperson on 6 June 2006)

Papers:

1. Information on the Flexible Pedestrian Legform Impactor GT Alpha (Flex-GTa)
2. Evaluation Activities on Injury Assessment Ability of the Flexible Pedestrian Legform Impactor GT Alpha (Flex-GTa)

ACEA welcomes the improvements of the Flex-PLI since the Flex-GTa appears to be usable at a test speed of 40km/h (see part 1 of paper 2). Nevertheless there are still some remaining comments and questions collected so far. The subject of the evaluation of the injury assessment ability is a very difficult issue. The studies done so far in paper 2 can be seen as a valuable first step to address this highly complicated aspect.

In June 2006 the ACEA experts will meet for a detailed discussion on the state of the Flex-PLI assessment. ACEA vehicle tests are scheduled for autumn 2006 and will give additional information and more experience to evaluate the Flex-GTa more precisely particularly with regard to industrial use and to car design process.

Due to the delay of the vehicle tests ACEA believes that the final assessment of the Flex-GTR until end of 2006 is very optimistic.

Reference charts in "*italics*"

Ans. Thank you for your precious comments. I would like to address your questions carefully in order to promote the Flex-TEG activity.

Paper 1:

Generally:
The comparison of the injury assessment ability should be done between the Flex-GTa and the TRL-LFI.

Ans. Thank you for your comments. We are planning to conduct a comparative analysis of injury assessment ability between the Flex-GT and the TRL-LFI in our further study (computer simulation or testing, by end of Aug. 2006).

"*Length, C.G. Location, and Mass*"
The table indicates that some of the dimensions and properties of the Flex-GTa are less biofidelic when compared to the 50% human leg and the Flex-G. However, the final conclusion of better injury assessment ability of the Flex-GTa needs to be drawn to the TRL legform and not necessarily to Flex-G which only is a development step.

Ans. When we complete the comparative analysis of the Flex-GT and the TRL-LFI, we will introduce sentences which will incorporate your above request.

"*Long Bones, Materials*"
There are many changes in the various materials. More explanation of the reasons is needed.

Which problem is linked to the lighter bones, i.e. to the use of different materials?

Ans. Basically, we changed the materials in order to reduce the mass of the exterior housings of long bones. As a result of these changes, the Flex-GT-alpha became comparable with the human FE model in kinematics. The primary reason for introducing the changes is the fact that the attachment of human flesh to the long bones is not rigid; in other words, human flesh is a movable mass. This means that we need to consider the effective mass of flesh because if all the mass of flesh is rigidly attached to the impactor's long bones, the impactor will differ from the human body in kinematic characteristics.

"*Long Bones, Sectional dimensions of bone core*"
An explanation is needed for the smaller bending stiffness and the link to the conclusion.

Ans. The smaller bending stiffness leads to less severe impact phenomena generated by the impactor. We reduced the impactor's bending stiffness slightly to better simulate the human body behavior.

"*Long Bone, Bone core binding method*"
The wording "just tight enough" needs to be more precise.

Ans. We will try to describe the optimum tightness numerically in terms of N/m (binding torque).

Also the use of screws for shear force reaction should be reconsidered.

Ans. I cannot grasp the exact meaning of the above comment. Could you explain in greater detail?

In addition, looking at the drawings and photographs of the bone design a detailed assessment seems necessary for the ability of the Flex-PLI to also bend sideward in case of an impact closer to the edges of the impact area. (The bending obviously is only possible in vehicle longitudinal direction!)

Ans. True, the Flex-GT long bone bends only in one direction. This is because the one-direction bending gives a good repeatability of test results. It is understandable to investigate the impactor phenomenon at an impact point close to the bumper corner; however, as a regulatory tool, I believe a one-direction bending impactor is much more suitable.

"*Long Bones Bending characteristics (Leg)*"
It shows no significant difference of the bending behaviour of the Flex-G and the Flex-GTa. Why is the leg core changed so drastically then?

Ans. The leg core was changed to reduce the bending stiffness of the Flex-GT-alpha leg as compared to the Flex-G (see Paper 1, P14) in order to obtain lower extremity kinematics comparable to those of the human body (see Paper 2, P8).

"*Knee, size and design*" and "*Knee, knee ligaments*"
The slides show the sophisticated design of the Flex-GTa knee joint. For a detailed assessment ACEA requests JARI to provide a comparison of the Flex-GTa and the TRL-LFI

regarding the following items:

Number of parts of both tools
Ans. Knee ligament ?
Flex: 10 pieces (reusable), TRL: 1 piece (breakable, not reusable)
Consequences on costs related to purchase and maintenance
Ans. Knee ligament (maintenance cost) ?
Flex: 0 euro (because reusable), TRL: 110 euros per test
Failure probability of both tools
Ans. Knee ligament ?
Flex: Normally no failure, TRL: Failure in each test
Frequency of checks and (re)certification compared to number of vehicle tests
Ans. Knee ligament (checks) ?
Flex: In each test, TRL: In each test
Ans. Knee ligament (change) ?
Flex: No need (reusable), TRL: In each test
Ans. Knee ligament (recertification) ?
Flex: Check by assembly test (preferably in each test)
TRL: 20 times per test or when the threshold is reached (?)
Difficulties of periodic tests for both tools
Ans. Flex: No difficulties, TRL: No difficulties (?)
List of spare parts for the two tools
Ans. Flex: Knee ligament wire and springs (Normally not needed)
TRL: Knee ligament (for each test)

(As we are basically not familiar with the TRL-LFI, could you update our information on the TRL-LFI.)

"*Flesh*" and "*Measurements*"
For these part ACEA requests for a comparison of the Flex-GTa and the TRL-LFI regarding
Number of parts, costs and frequency of replacements
Ans. Number of parts ?
Flex: 10 pieces (reusable)
TRL: 2 pieces (Confor Foam™ not reusable)
Ans. Cost ?
Flex: Decided by distributors
TRL: Skin (110 euros), Confor Foam™ (120 euros)
Ans. Frequency of replacements ?
Flex: No need to replace (reusable)
TRL: Confor Foam replaced for each test

Reliability of measurements (e.g.: the more cables the higher the possibility of failure measurement)
Ans. Flex: Good reliability, TRL: ?
Consequences of the above comparisons on industrial testing
(and car design process) for the two tools
Ans. ?
The possible influence of "wrapping mistakes" for the different "flesh" layers
Ans. Flex: Low possibility of mistakes (Rubber sheets are glued by each other in order to treat the sheets as one sheet. As for the neoprene sheets, these

names are printed on their surfaces in order to avoid misuse.)
TRL: ?

(As we are basically not familiar with the TRL-LFI, could you update our information on the TRL-LFI.)

"*Thigh (3-point bending)*", "*Leg (3-point bending)*", "*Knee (3-point bending)*"
ACEA requests for a comparison of the Flex-GTa and the TRL-LFI regarding
Frequency of calibration for both tools
Ans. Flex: Normally calibrated during the initial assembling
TRL: ?
Difficulties / easiness of the calibration
Ans. Flex: Not so difficult
TRL: ?
Difficulties / easiness to find causes for a possible non compliance
Ans. Flex: Not so difficult
TRL: ?
Consequences of the above comparisons on industrial testing
(and car design process) for the two tools
Ans. ?

(As we are basically not familiar with the TRL-LFI, could update our information on the TRL-LFI.)

"*Results Leg-1 (maximum value)*" to "*Results Leg-4 (maximum value)*"
There are 6 outliers (Flex-GTa-T06a, -T06b, -T09a, -T09b, -T12a and T12b). An explanation is needed for TEG.

Ans. I believe it is a normal dispersion of test results; however, we intend to observe dispersion trends continuously in our further studies.

Paper 2:

Part 1:
"*Test Conditions*"
What was the reason for choosing this vehicle (Sedan 1, 2004 year model)?

Ans. The only reason was simply that we had been using the car in our study since 2004.

"Simulation Conditions"
Why was the simulation performed using a 2001 model instead of the 2004 model? The facts that the front shapes are slightly different (independent of how big or small the differences are) and that the centre of the knee is at a different height could completely change the overall behaviour of the leg.

Ans. The only reason was simply that a 2004 FE model was not available (does not exist). Therefore, we will change the test car and use the same model year FE model in our further studies.

In addition, an indication is necessary which simulation model has been used to assess

possible limitations of the respective FE model (e.g. as a kind of FMEA) and to allow double-checking of the results.

Ans. It is possible to indicate the validation results of the FE models that we are going to use in our further study.

"*Comparison*"
The values of the knee bending angles should be given under the pictures for the tests and the simulation.
Nevertheless, final conclusions should not be drawn without further investigations.

Ans. Our further study is now underway, and detailed discussions on values will be included in this additional study.

"Test Results"
Are there results from the simulation with the human FE leg model which are comparable to the test results?

Ans. Our further study is now underway, and detailed discussions on values will be included in this additional study.

Part 2:
"*PMHS Test Data*"
For the discussion in the informal group the details (make, model, model year etc.) need to be made available.

Ans. We cannot give you the details of car information because there are no details in reference literature.

"*Tentative Thresholds*"
An indication is necessary why those data were specifically chosen.

Ans. We chose the data tentatively from among data available to us. If you have better ones, we will welcome the new data.

"*Reconstruction Test Results (Car: C1)*"
It is only stated that the measured tibia bending moment is above the fracture level. Tibia fractures are observed in real world PMHS tests. But in addition the Flex-GTa also measures MCL elongations at the respective knee injury level and very high thigh bending moments and thus a high risk of knee and thigh injuries were indicated by the impactor which was not observed in the PMHS tests. A conclusion of good injury assessment ability should be drawn very carefully.

Ans. The PMHS indicated that after a long bone fracture no severe load generates in other parts of the lower extremities. This is because a bone fracture cuts off the load transmission paths to other parts. On the other hand since Flex has no fracture mechanism, the load continues to be applied to other parts even after reaching the tibia fracture threshold. It means, when we use the Flex impactor (TRL-LFI also) for the reconstruction test on PMHS test or Car-Pedestrian accidents, we shall focused on the initial injury because of the lack of long bone fracture and/or ligament rupture

mechanism in the impactor. In order to determine the realworld post-fracture load on the lower extremities, we will need to develop a fracturable/rupturable impactor but such an impactor will not be usable as a regulatory tool.

"*Reconstruction Test Results (Car: C3)*"
Although the Flex-GTa indicates a high risk of thigh, tibia and knee injuries the real PMHS leg suffers only tibia/fibula fractures (see also comment above).

Ans. The answer is the same as the above. It is meaningless to compare the post-fracture behaviors of impactors and PMHS.

Part 3:
Generally
The Flex-GTa is designed to represent a 50th percentile human leg. The masses of the real injured pedestrians in part 3 of paper 2 are 45kg and 48kg. Those masses indicate more or less a 5th percentile human being. Which vehicles are C2 and C3?

Ans. Because it is extremely difficult to obtain an exact 50th percentile accident data, we are proposing the use of a validated 50th percentile human FE model.

"*Reconstruction Test Results (Car: Car3)*"
The Flex-GTa indicates high risks of thigh, tibia and knee injuries although only tibia fractures are observed in the real world accident (see also comments above).

Ans. Same as the aforesaid answer to "Reconstruction Test Results (Car: Car3)".

30. May 2006
ACEA, Task Force Pedestrian

Message from chairperson:
To discuss above items among us is very important. I am very appreciating to continue this kind of activities among us with full use of the knowledge and experience of all the people involved.

6 June 2006
A. Konosu, Chairperson of Flex-TEG