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The following is based upon a review of 4 reports and corresponding Scan-Crash input and output files prepared by henrik Nesmark of REKON DA. The reports and files reviewed are as follows:

1. Rekon DA Reference **SC 977**, Traffic Accident 07.07.03, collision between a LS 49241 with driver (A) and LS 52951 with driver (B), Sparebank 1 Skadeforsikring Reference ERKJE 1721040,1,executive officer Erlend Kjevik

2. Rekon DA Reference **SC 1259**, Traffic Accident 05.04.00, collision between a LH 71906 with driver (A) and LH 87949 with driver (B), If Skadeforsikring – Legal Section Reference IP 05659, executive officer Elisabeth Broen Falstad

3. Rekon DA Reference **SC 1238**, Traffic Accident 07.01.04, collision between a DK 41688 with driver (A) and KF 82383 with driver (B), Vesta Skade AS Reference 1161611-3-OJB, executive officer Ole Jacob Borgen

4. Rekon DA Reference **SC 1052**, Traffic Accident 15.09.03, collision between a DK 67631 with driver (A) and CE 75505 with driver (B), Vesta Forsikring AS Reference TR 02833784, executive officer Tonje Ringstad

EXECUTIVE SUMMARY

Reconstruction of highway collisions are based on analysis of pre-impact and post-impact motions and/or analysis of damage. The physical laws are applied to measured or rigorously estimated (e.g., photogrammetric) evidence. In the evaluated case reports, there is no analysis of motions of the vehicles. Rather the reports only deal with vague and unscientific descriptions of cosmetic disfigurements as opposed to actual examination and measurements of damage.

The reports by Nesmark are not scientific. They include too many speculative assumptions about the nature and extent of damage to each of the vehicles. Since there are no photographs or scientific measurements of any damage to any of the vehicles Nesmark chose to speculate approximations of the damage based mainly upon unscientific witness statements and repair descriptions. The nature and extent of damage to the vehicles in the subject accidents are not documented and he provides no background material on any of the vehicle models. Many vehicles in vehicle to vehicle collisions do not have any visible external residual deformation for impact speed changes of 6 kph or higher.

Nesmark then used these unscientific damage approximation values to speculatively approximate the EES. The values for EES were then used as inputs to the Scan-Crash computer program. The Scan-Crash program made a simple calculation of the speed and DeltaV which would be required for each vehicle to produce the speculative input for EES based mainly on the vehicle weights.

The reports by Nesmark are not scientific and not in keeping with sound scientific practices and principles.

DETAILED REVIEW

The **Methodology** in each report Nesmark states that "Scan-CRASH data programme has been chosen". Nesmark further states that Scan-Crash "simulates vehicle movements and collisions following the input of certain sequences" and can be used to determine "how a particular crash occurred/progressed and the movements in time and distance of the individual vehicles before and after the crash"

Nesmark then indicates that "In order to calculate the collision's progression, two parameters for the crash have to be established with the greatest possible accuracy: Firstly, the amount of energy expended in deforming each of the vehicles. This energy is expressed as EES (Energy Equivalent Speed) value in km/h. The EES values determines the speed at which a vehicle must be driven against a solid wall in order to inflict the damage in question. To arrive at the EES value, the actual damage is compared to pictures and descriptions from controlled crash tests"

Nesmark further adds that "EES values have to be determined with a certain safety margin. The size depends on how well the damage is documented and the amount of background material that is available for the model of car in question". Nesmark states that he must determine "with the greatest possible accuracy" the "actual" damage to each vehicle in each subject accident.

Nesmark Determination of Damage

Nesmark determined the nature and extent of damage for each vehicle based upon the drivers' unscientific "simple description in the claim form" or on an unscientific basic repair description or on an unscientific NAF (1) inspection. For many of the vehicles in the accidents there was no description and therefore no information on the nature and extent of damage to the vehicle.

The following are direct quotes from Nesmark from the reports documenting the unscientific sources for his speculative EES estimate:

- **SC 1259** The Opel "was inspected by NAF (1) after the crash" and a basic narrative created, There was "no documentation of damage to the Toyota apart from a simple description in the claim form"
- **SC1238** The Saab "The driver of the Skoda has written in the claim form that no damage could be seen on either vehicle at the time", "no damage to the actual bodywork was recorded" The Skoda "The driver of the Skoda has also given details of the damage to one vehicle in the claim form" 'it is described as "a small bend on the number plate"
- **SC 1052** Mercedes: "The Mercedes suffered damage at the rear necessitating replacement of the bumper valance. No damage of the actual bodywork was recorded." Polo: "Damage to the Polo is not documented. In cases such as this I have to estimate a range in which the Polo's EES value ought to lie" "we do not know to what degree the vehicles are equally rigid, but there is every reason to suppose that they are in the same rigidity class"
- **SC 977** Ford "the ford suffered damage to the rear end so that the bumper had to be repaired" Opel: "Damage to the Opel is not documented. In cases such as this I have to estimate a range in which the Opel's EES value ought to lie", "we do not know to what degree the vehicles are equally rigid, but there is every reason to suppose that they are in the same rigidity class"

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1 Norwegian Automobile Federation (NAF) (http://www.naf.no) is the largest automobile organization in Scandinavia. Vehicle Inspections NAF Vehicle inspections are widely known and ensure that your car is in good running condition, safe to drive, economical and environmentally friendly.

In order to perform a scientific reconstruction of an accident it is essential to inspect, measure and photograph the vehicles involved. This is particularly true in the event of lower speed collisions. In lower speed collisions the restitution, or spring back, of the structure is the greatest. Therefore an inspection must include looking at the underlying structure and components of the vehicle to determine the maximum extent of damage and amount of restitution or spring back of the vehicle structure. Simple descriptions of the damage without benefit of photographs and/or measurements do not provide any scientific basis for estimating the vehicle damage.

Many vehicles in vehicle to vehicle collisions do not have any visible external residual deformation for impact speed changes of 6 kph or higher (**2**,**3**). The type of collision, the collision partner (what type of vehicle struck the vehicle), the presence of tow bars, whether there was braking, all can affect the 'threshold' where damage might visually begin to appear. The design of modern bumpers often prevents the direct observation of bumper damage without physical removal of the bumper. This is true of US and European bumper systems.

The extent of damage is required to allow for a determination of the approximate energy dissipated in the collision. The following is a brief list of what can be measured and documented in a vehicle inspection:

- The location and amount of crush to each vehicle
- Determination of whether there was any 'hidden' collision damage (bumper components, structural components) all of which represent additional energy dissipation
- Measurement of the extent of bumper engagement on each of the vehicles and whether they were fully or partially engaged.
- Determination of any bumper override or underride (**4**)
- Documentation of any additional hardware on each vehicle, such as towbars, etc., which might affect the vehicle response to impact (**5**)
- Determination of the angularity or offset of the vehicles at impact.
- The nature and extent of any possible pre-impact steering or braking (**6**) which might have precipitated the event. Pre-impact steering and/or braking can produce angularity or offset of the impact between the vehicles by changing the relative position, heading angle and pitch angle of either of the vehicles at impact.

Nesmark has no idea whether there was any angularity of the subject collisions.

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2 **Automobile Bumper Behavior in Low-Speed Impacts**, King, Siegmund, Baily, MacInnis Engineering, SAE paper 930211

3 **Characteristics of Specific Automobile Bumpers in Low-Velocity Impacts**, Siegmund, Baily, King, MacInnis Engineering, SAE paper 940916

4 **Vehicle and Occupant Response in Low Speed Car to Barrier Override Impacts**, Vern Goodwin, Dennis Martin, Roger Sackett, Gerry Schaefer and David Olson, MDE Engineers, Inc., Allan Tencer, University of Washington, SAE 1999-01-0442,

5 **When Do AIS 1 Neck Injuries in Long-Term Consequences?** KRAFFT, Folksam Research. Stockholm. Sweden Traffic Injury Prevention. 3:89-91. 2002

6 **Whiplash in Low Speed Vehicle Collisions**, Richard I. Emori and Junji Horiguchi, Faculty of Engineering, Seikei Univ. Musashino, Tokyo, SAE 900542,

For lower speed collisions which may include possible Whiplash Associated Disorders (WAD)(7) or other neck and spine injuries, additional items which should be measured and documented and which may affect the outcome of a collision are:

- Seat type and positioning, headrest type and positioning (**8**)
- Injured parties size and positioning pre-impact
- Bumper type,
- Amount of bumper engagement
- Compatibility of bumpers between colliding vehicles – was their underride?, override?, vehicle pitch angle changes due to braking?
- Engine placement- both in distance from contacting surface to the engine block and whether the engine was longitudinally or laterally placed in the vehicle (**9**)

Safety Margin

Nesmark further adds that "EES values have to be determined with a certain safety margin. The size depends on how well the damage is documented and the amount of background material that is available for the model of car in question"

There is no documentation or quantification of any of the damage to any of the vehicles in the subject accidents and there is no indication by Nesmark of his having reviewed any background material on any of the vehicle models in the subject accidents. So any indication by Nesmark of "safety margins" to bracket the errors in his EES estimates are baseless and without any scientific merit. His initial estimate of the EES is a speculative guess, and therefore the margin of safety for the speculative guess must be 100% or more. He has no idea of EES for any of the vehicles in the subject accidents.

For 'background material' Nesmark might have tried using available EES Catalogs [**10**]. However he could not use an EES catalog because in order to compare the EES of a calculated impact with a comparison of the damage in a subject accident there needs to be quantifiable information on the damage. There was no information on the damage in any of the subject accidents and no information on the actual impact configuration (width and angle of interaction), nor any information on the damage to the collision partners.

Therefore there is no scientific basis for the use of any safety margin for his speculatively guessed EES values.

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7 **Influence of Crash Pulse Characteristics on Whiplash Associated Disorders in Rear Impacts-Crash Recording in Life Crashes**, KRAFFT, KULLGREN, and YDENIUS, Folksam Research, Stockholm, Sweden, TINGVALL Swedish National Road Administration, BorHinge, Sweden, Traffic Injury Prevention, 3:141-149, 2002,

8 **Relationships Between Occupant Motion and Seat Characteristics in Low-Speed Rear Impacts**, Watanabe, Ichikawa and Kayama, Nissan Motor Co., Ltd., Ono, Japan Automobile Research Institute, Kaneoka ,Tokyo Kosei-Nenkin Hospital, Inami, University of Tsukuba, SAE 1999-01-0635,

9 **Current Front Stiffness of European Vehicles with Regard to Compatibility**, Huibers,de Beer,TNO Automotive Crash Safety Centre,The Netherlands, Paper No. ID#239, ESV 17th conference

10 AZT Catalog, Melegh 1999, Melegh 2002, PC CRASH Operating Manual, Dr Steffan Datentechnik, Linz, Austria,

Other Reconstruction Techniques

Another way to supplement a scientific reconstruction in some accidents is to obtain information on the movement of the vehicles subsequent to the collision. The energy required for the vehicles to move from impact to positions of rest can be used to form the basis for an approximation of the speeds of the vehicles at impact. This was not done in any of the above referenced cases.

Nesmark has no idea of the extent and nature of any movement of any of the vehicles subsequent to the any of the collisions.

In summary, in all the cases there were no vehicle inspections, no measurements or any photographs and therefore there was no scientific basis from which Nesmark could approximate the EES in any of the accidents.

Therefore the EES he used as input to the 'Scan-CRASH data programme' was based entirely on speculation and is not based on any sound scientific practices or principles.

Overview of Scan-CRASH/PC-CRASH

The 'Scan-CRASH' program is a version of the PC-CRASH program [**11, 12**] made for Norway. The Scan-Crash and PC-Crash are the same program, produce the same results and are subject to the same limitations.

PC-CRASH is a relatively recent (1996) addition to the software programs available for accident reconstruction. The PC-CRASH program is mainly used as a momentum based program. The PC-CRASH program includes the assumption that momentum is instantaneously exchanged at a user specified instant during the collision contact. In the real world the exchange of momentum during an automobile collision takes between 50 and 150 milliseconds. In automobile collisions the duration and wave form of the collision force during the momentum exchange can significantly affect the simulated behavior (**13**).

The fact that a computer program is based on or includes the laws of physics is insufficient in itself to validate a program for general use or for use in any particular individual application. The general type of accident must be demonstrated and tested by comparison of predicted and experimental results to be an appropriate application of the program. The limited validations of PC-CRASH are based on comparisons of the results of PC-CRASH with known results of full-scale tests which allowed the arbitrary and subjective variation of the inputs to provide the best match of the physical evidence. There have been no independent verifications of the validity of results of the PC-CRASH program in general applications wherein the results are not known prior to the application of PC-CRASH.

The primary PC-CRASH program validations were presented in a 1996 paper [11]. The validation procedure consisted of the program vendors (**14**) using the PC-CRASH program to reconstruct 25 full-scale crash tests. The desired results were known beforehand and the authors of the validation paper subjectively changed and refined the inputs to improve the

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11 **The Collision and Trajectory Models of PC-CRASH**, Steffan, H, Moser, A., SAE 96-0886
12 **Validation of PC-Crash—A momentum-based accident reconstruction program**, Cliff, Montgomery, MacInnis Engineering Associates, SAE Paper 960885
13 **CRASH-97 - Refinement of the trajectory solution procedure**, McHenry, McHenry, SAE paper 97-0949
14 **MacInnis Engineering Associates, Ltd** are the primary distributors of the PC-CRASH program in North America and they are also the authors of the validation studies

correlation of the PC-CRASH program with the full-scale crash tests. A required input to the PC-CRASH program is the impact speed, which for the cited validation tests, was known. The impact speed in the subject accidents was not known by Nesmark.

The results of the validation tests of the PC-CRASH program included errors in the predicted impact speeds of 51.5%, 42.4%, 39.6%, 39.3% , 21.1% [15]. The validation paper [11] concluded that the "PC-CRASH simulation predicted speeds were found to be in good agreement with real world results" Errors of 20% to 50% in the PC-CRASH validation tests cannot be considered to be 'in good agreement' and, therefore, the validation of PC-CRASH is unacceptable from a scientific standpoint in his Scan-CRASH simulations.

Nesmark use of Scan-CRASH

Nesmark used as input to the Scan-CRASH program the EES values he determined through the speculative guessing described in the sections above. In his Scan-CRASH analyses, he assumed no braking or control inputs for either of the vehicles. He gave the impression that he was performing a simulation by the statement "The positioning of the point of collision is fine-tuned until the relationships between the EES values agree with those that have been established". However in his Scan-CRASH analysis he used identical positions for impact and rest. There was no vehicle movement.

His Scan-CRASH analysis consisted mainly of his use of the program to calculate the impact speed required to produce the EES values he determined through speculation.

Nesmark states "Provided the collision time can be determined, the results of Scan-Crash simulation can be used to calculate the average acceleration/retardation to which the vehicles centers of gravity have been subjected"

He provided no basis for his determination of the collision time, he did not simulate the collision, and therefore he has no scientific basis for determining the collision time.

Any calculations he made of the approximate range of accelerations in the subject accident are based on his speculated EES, his crude approximation of the collision time and therefore have no basis in science.

Nesmark assumes in each of the four reports a 'collision time of 0.12 seconds' and he used that value to calculate the acceleration of the struck vehicle in each case file.

First that calculation is for an average value for the acceleration based upon his speculated EES value and his baseless collision time of 0.12 seconds. Secondly, research on low speed impacts(**16**) demonstrates a wide range of collision times (.08 to .185 seconds) and a wide range of accelerations (1 to 7 g's) in low speed rear impact collisions.

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15 see Tables 4 of Reference 11

16 **Relationships Between Impact Pulse Duration and Occupant Kinematics in Low Speed Rear Impacts,** Szabo, Voss and Welcher, SAE 2002-01-0029

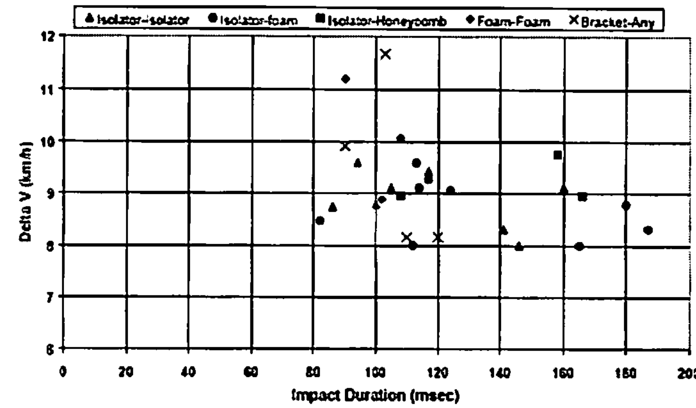

Figure 1: Relationship Between Delta V and Pulse Duration for Low Speed Rear Impacts with Contemporary Production Bumpers

Figure 1: From Reference (**16**)

A study (17) has demonstrated that a similar delta-V can be generated by a variety of mean accelerations. Since mean acceleration have been found to be the main factor influencing the risk of AIS1 neck injuries, both delta-V and the duration of the crash pulse for a specific delta-V (i.e. mean acceleration) should be taken into consideration when defining impact severities.

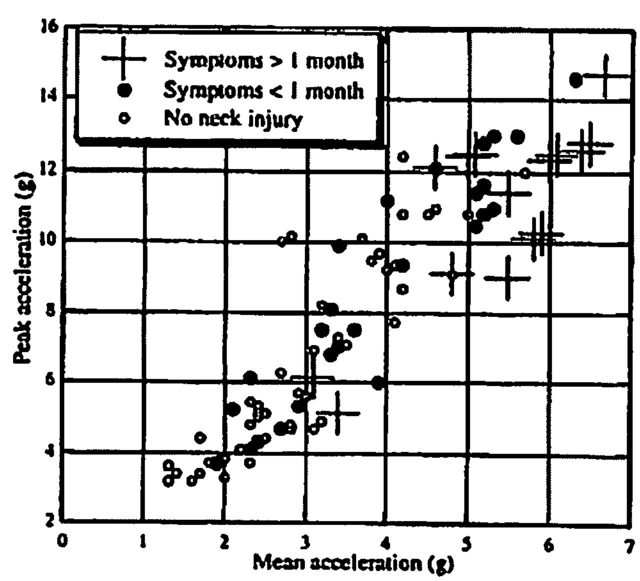

Figure 4 Mean acceleration versus peak acceleration for uninjured occupants and those with symptoms for less than or more than one month.

Figure 2 From Reference (7)

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17 Change of Velocity and Pulse Characteristics in Rear Impacts: Real World and Vehicle Test Data, Linder, Avery, The Motor Insurance Repair Research Centre, Thatcham, United Kingdom, Krafft, Kullgren, Folksam Research, widen Paper No. 285 18th ESV

CONCLUSIONS

The cited findings serve as the basis for the following conclusions based on a reasonable degree of scientific certainty:

1. The reports by Nesmark have too many speculative assumptions about the nature and extent of damage to each of the vehicles.
2. There is no scientific foundation to any of the applications of Scan-CRASH by Nesmark due to the speculative nature of his inputs for EES.
3. The reports by Nesmark are not scientific and not in keeping with sound scientific practices and principles.

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