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ASPECTS REGARDING INFLUENCE OF VEHICLE SPEED IN THE REAR-END IMPACT

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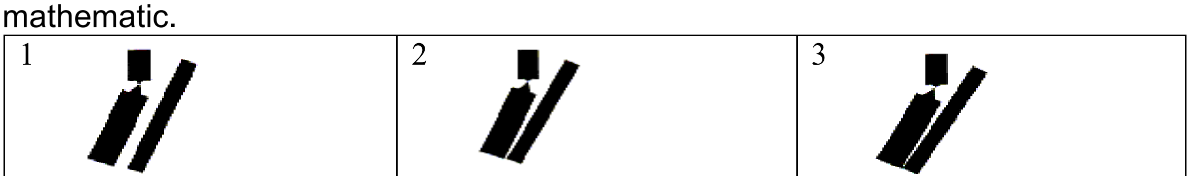
Keywords: simulation, safety, accident, analysis.

Abstract: The human insurance of human safety in a condition of driver, passenger or pedestrian is one of the most important conditions for the life quality in the preoccupation of the scientific researchers for the cars builder industry. The knowledge of the cinematic movement in the time of collision impact a of human in a condition of the driver (in these case) is the first step of the investigation of researchers for determining which value of determining parameters is most dangerous for the human safety. In the real traffic is very importing to establish the threshold limits speed of any tip of car for which the risk of injurious is very high. For this problem's analysis he was used the PC-Crash program, a program which allows increasingly complex calculations to be performed on a personal computer, capable to simulate many different accident situations.

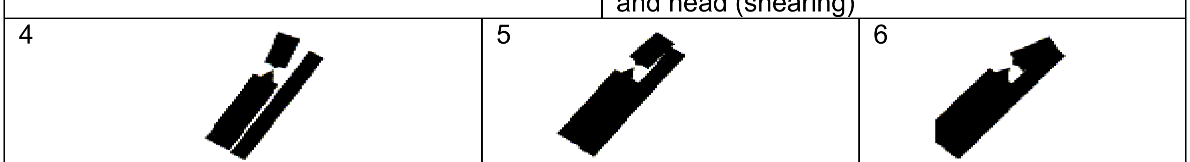
1. THE HUMAN BODY MOVEMENT IN THE REAR END IMPACT

Investigation of cars crashes begin with accidence data type setter upon base of the skid marks, values of body cars deformations, length of random-position shattering a glass fragment, etc. The most important is to know to correctly collect these data because any little mistake will spoil the results of the investigation. The movement of driver/passenger was analyses in the experimental tests with volunteer people, cadavers and dummies.

This paper treats the movement of driver on base of simulations model, upon point of view mathematic.



1-2 t = 0,00 s	2-3 t = 0,04 s
Passenger space translators Seat movement Seat-back turn	Trunk turn Inflection Translation relative movement between torso and head (shearing)



3-4 t = 0,08 s	4-5 t = 0,11s	5-6 t = 0,14 s
Head turn Limits of flexion angle	Begin extension Contact head/head restraint	Maxim seat-back angle Maxim dynamics deformation of head restrain Maxim extension angle

Figure 1. Movements phases in the rear-end impact

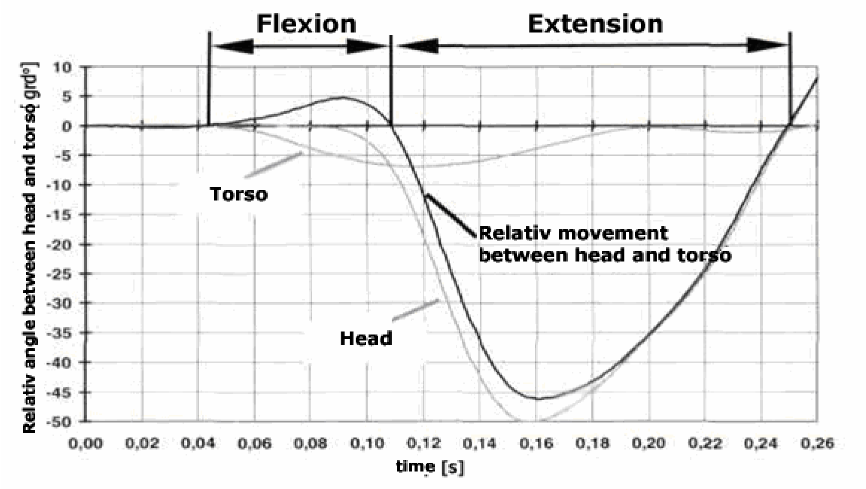


Figure 2. Relative movement between head and torso

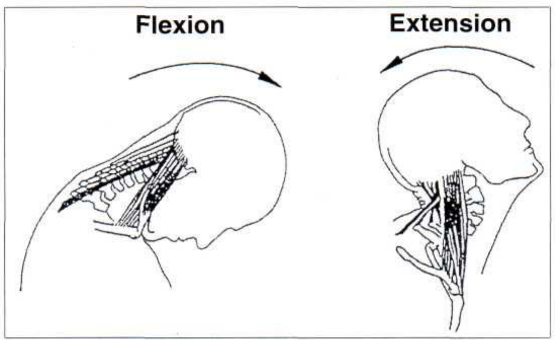


Figure 3. Description of the relative motion between head and torso

In case of collisions, neck injuries can occur as a result of its bending because of head inertia, at sudden accelerations/decelerations. Neck bending can occur towards any direction; using medical literature, neck back bending is called extension, forward bending is called flexion, while lateral bending – lateral flexion. In the moment of the impact, the body is pushed in to back seat; the torso movement is faster than the movement oh the head. Because of that appears a relative movement between the head and the torso, movement which can be dangerouse for the human health.

Knowing the head and thorax impact acceleration, the NIC (Neck Injury Criterion) can be determined. The neck injury criterion (NIC) is calculated as follows:

$$NIC(t) = a_{rel}(t) \cdot 0.2 + (v_{rel}(t))^2, \text{ where}$$
$$a_{rel}(t) = a_x^{T1}(t) - a_x^{Head}(t), \qquad v_{rel}(t) = \int a_{rel}(t)dt, \quad \text{and} \qquad (1)$$

$a_x^{T1}(t)$ = acceleration versus time measured in the antero - posterior (x) direction at the height of the first thoracic vertebra (lower neck accelerometer)

$a_x^{Head}(t)$ = the acceleration versus time measured in the antero - posterior (x) direction at the height of the c.o.g. of the head (head accelerometer), i.e. near the first cervical vertebra

2. INJURY MECHANISMS

If the cervical region suffers from affections produced by different etio-pathogenic factors, or by clinical demonstrations of the cervicarthrose, in case of the rear-end impact, then the injury appearance danger is increasing. The known spinal deviations are: Scoliosis, Cyphosis, Lordsis.

The neck part of the spine is formed by seven vertebrae, linked by the intervertebrae disks. With the lower part of its the first two segments (ATLAS if AXIS) of particular morphology and not very prone to the arthrosic degeneration, the cervical rachis comprises 3 articular systems likely to be the seat of osteoarthritis.

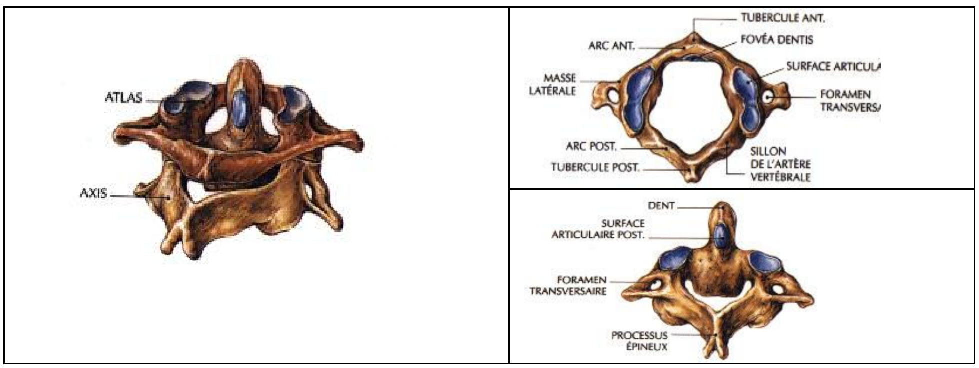


Figure 4. Description of anatomic configuration of the vertebrae Atlas-Axis

Cervical area movements of the spinal cord and of the skull are accomplished by muscle pairs. Dorsal muscles are bigger than the anterior; as following, the flexion resistance will be higher than the extension resistance. This is the reason for which most such neck injuries take place in rear-end collisions, their severity increasing if, during impact, the head is twisted laterally.

During impact, some of the head applied force will be transferred to the thorax by the neck link. The amount of the neck related force will depend on the place/direction of the application of the force upon the head, head inertia and spinal cord configuration for the cervical area, at the impact time. As a result, spinal cord loading will be reduced for a strait neck, when only axial forces apply and increased for a flexed neck, when complex loading would occur.

All axial force-start time combinations found above the delimitation line will lead to major neck trauma with permanent cut-off for some body functions. This can occur even for points found under this line, when a complex neck loading took place during impact.

Injury in hyperextension

The rear-end collision explain most part of diagnosis injuries a neck level, which appear on vehicle occupants. Neck lesion results are in general classifying like hyperextension trauma and includes symptoms such: localize neck pain, pain which radiate on the shoulder, vague pains, discomfort and vortex (sore tendril) because a affected ligaments and joints, multiple fracturing of the cervical vertebras.

Injury in hyperflexion

In this case the all stress is transferred by vertebras, vertebras disks and proximal areas ligaments. When the neck is increase in flexion, the outside disks vertebras are compressed and if the compression is very high then anterior parts of vertebras bones may be fractured. The posterior ligaments of joints areas may be lacerated in time of hyperflexion. In particular case the ligaments that joint epineux process supports the highest elongation and may cod to break the process epineux or the part of proximal areas vertebras out spinal way.

Injury in lateral flexion

This tip of injury appears less frequent and in case of severe lateral flexion the damaged region is C5 and C1.

Most victims which suffer minor injury through an slow speed in rear end impact, them came back to healthy quickly, the other suffer permanent or more time. This kind of injuries' is more frequent in case of the vehicle rear end collision, than in lateral or frontal collision.

Symptoms include neck pain, stiffness, headaches, dizziness, blurred vision and numbness and may be associated with damage to cervical muscles, ligaments, facet joints, nerve roots, vertebral arteries, or brain stem. [13]

A analyses of the collision have shows as the most neck injuries appears in case of rear end collision between two vehicles at difference of speed $\Delta V=(10 \ldots 15)$Km/h

Table 1.: The classification of WADs[1] compared with AIS classification [14]

WAD Grade	AIS	Clinical Presentation
0	0	No complaint about the neck
1	I	Neck complaint of pain, stiffnes, or tenderness only, no physical sign(s)
2	I	Neck complaint and musculoskeletal sign(s)*
3	I	Neck complaint and neurological sign(s)**
4	II	Neck complaint and fracture or dislocation

*Musculoskeletal signs include decreased range of motion and point tenderness

**Neurological signs include decreased or absent deep tendon reflexes, weakness and sensory deficits.

Symptoms and disorders that can be manifest in all grades include deafness, dizziness, tinnitus, headache, memory loss, dysphagia, and temporomandibular joint pain.[14]

4. SIMULATION IN PC-CRASH

PC-Crash is a powerful program for simulation of motor vehicle accidents, covering many different accident situations. It takes advantage of the latest hardware and software developments, which allows increasingly complex calculations to be performed on a personal computer. The program contains several different calculation models, including an impulse-momentum crash model for realistic trajectory simulations, and a simple kinematics model for time-distance studies. For maximum versatility, PC-Crash simulation results can be viewed and outputted in scale plan and elevation view, and numerous diagrams and tables. [15]

[1] Whiplash-Associated Disorders

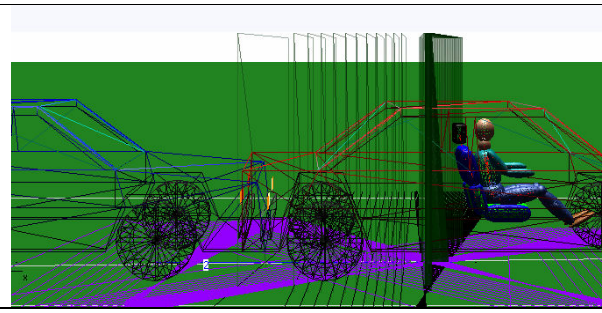
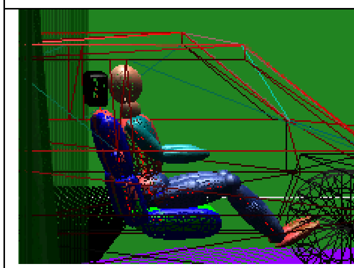
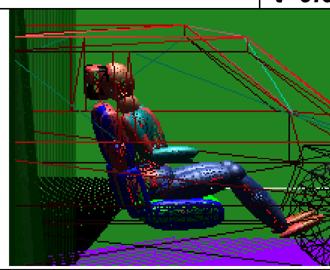
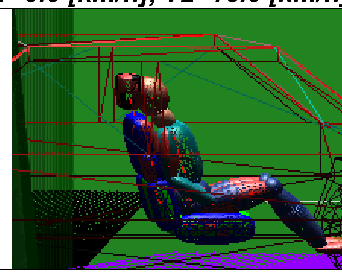
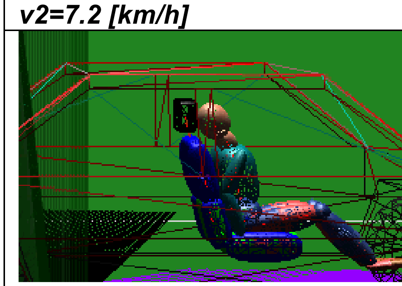
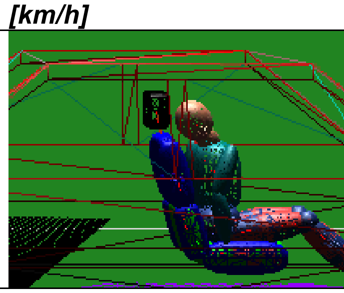
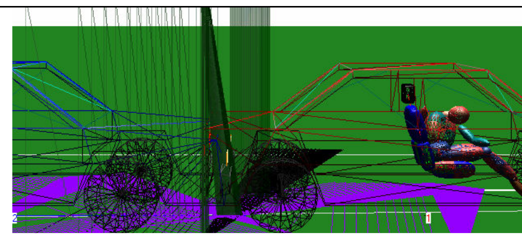
<table>
<tr><td colspan="2">Impacts between two vehicle.</td><td rowspan="2"></td></tr>
<tr><td>Vehicles data1:
Weight: 1000kg
Lenght: 4.21 m
Width: 1.698 m
Height: 1.393 m
Speed: 0.0 km/h</td><td>Vehicles data1:
Weight: 1000kg
Lenght: 4.482 m
Width: 1.695 m
Height: 1.408 m
Speed: 16.0 km/h</td></tr>
<tr><td colspan="2"></td><td>t=0.00 s; v1=0.0 [km/h]; v2=16.0 [km/h]</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>t=0.04 s; v1=8.4 [km/h]; v2=7.2 [km/h]</td><td>t=0.08 s; v1=7.9 [km/h]; v2=7.2 [km/h]</td><td>t=0.16 s; v1=7.1 [km/h]; v2=7.2 [km/h]</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>t=0.30 s; v1=6.2 [km/h]; v2=6.6 [km/h]</td><td>t=0.46 s; v1=5.4 [km/h]; v2=5.6 [km/h]</td><td>t=1.24 s; v1=0.0 [km/h]; v2=0.3 [km/h]</td></tr>
</table>

Figure 5. Movements phases in the simulation rear-end impact

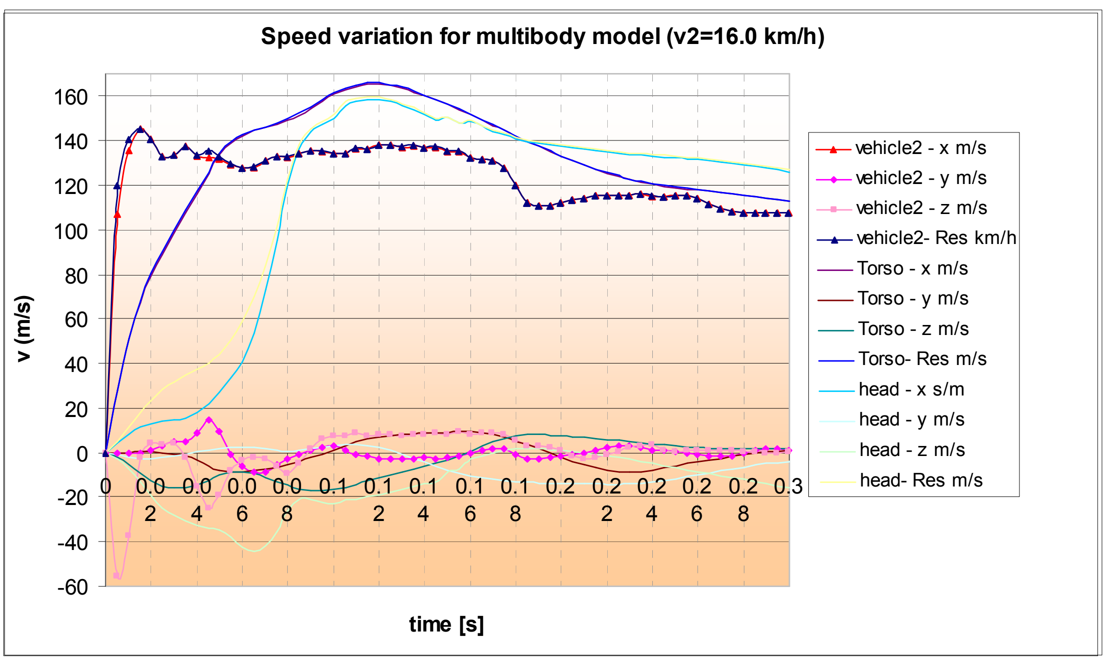


Figure 6. Variation speeds for vehicle two when v2=16 km/h.

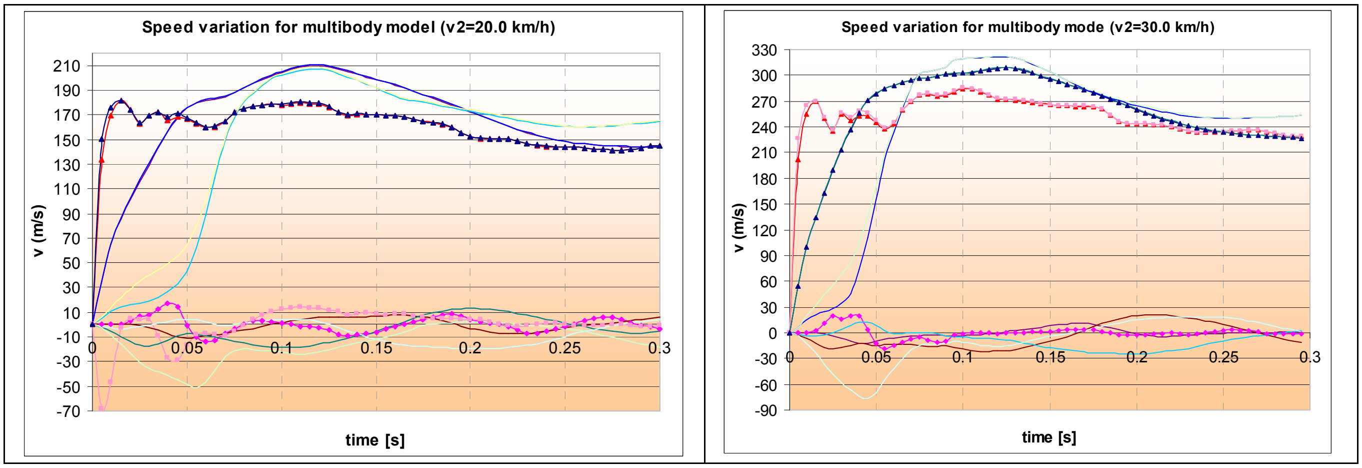


Figure 7. Variation speeds for vehicle two when v2=20 km/h, v2=30 km/h.

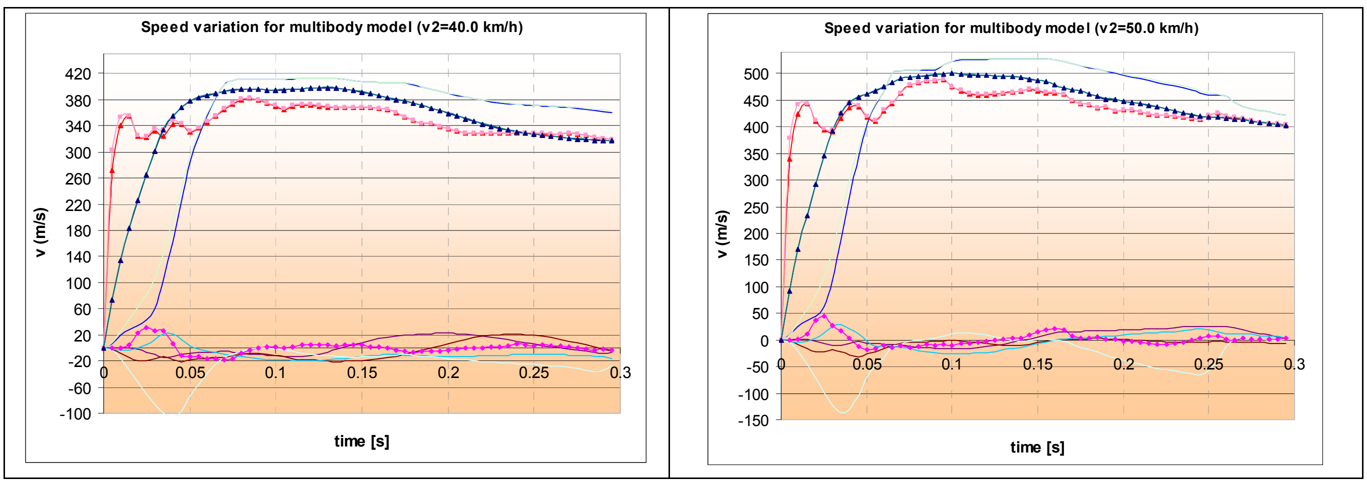


Figure 8. Variation speeds for vehicle two when v2=40 km/h, v2=50 km/h.

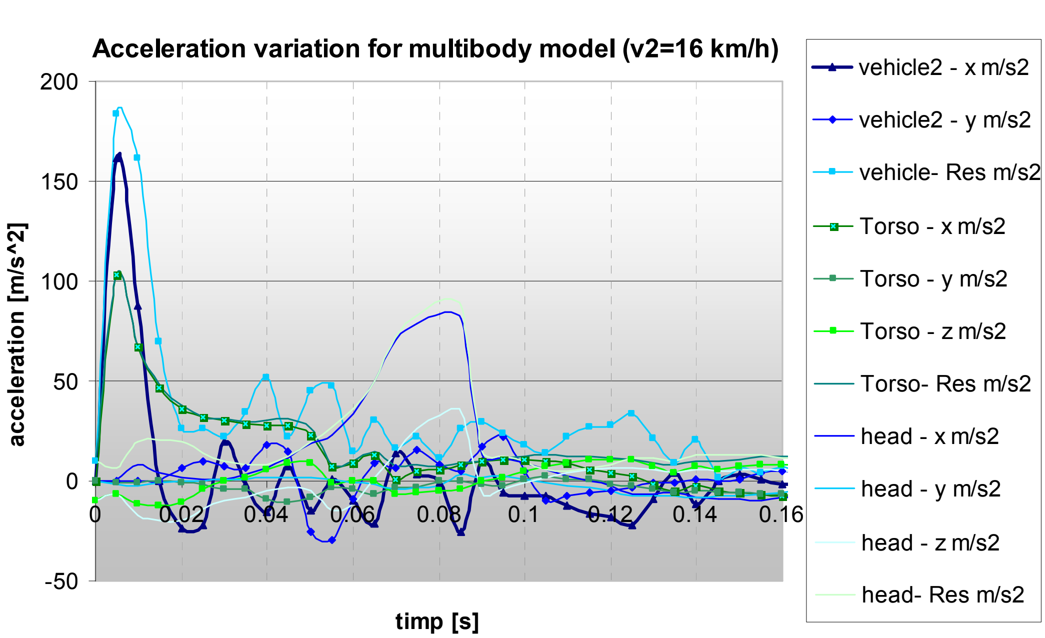


Figure 9. Variation accelerations for vehicle two when v2=16 km/h,

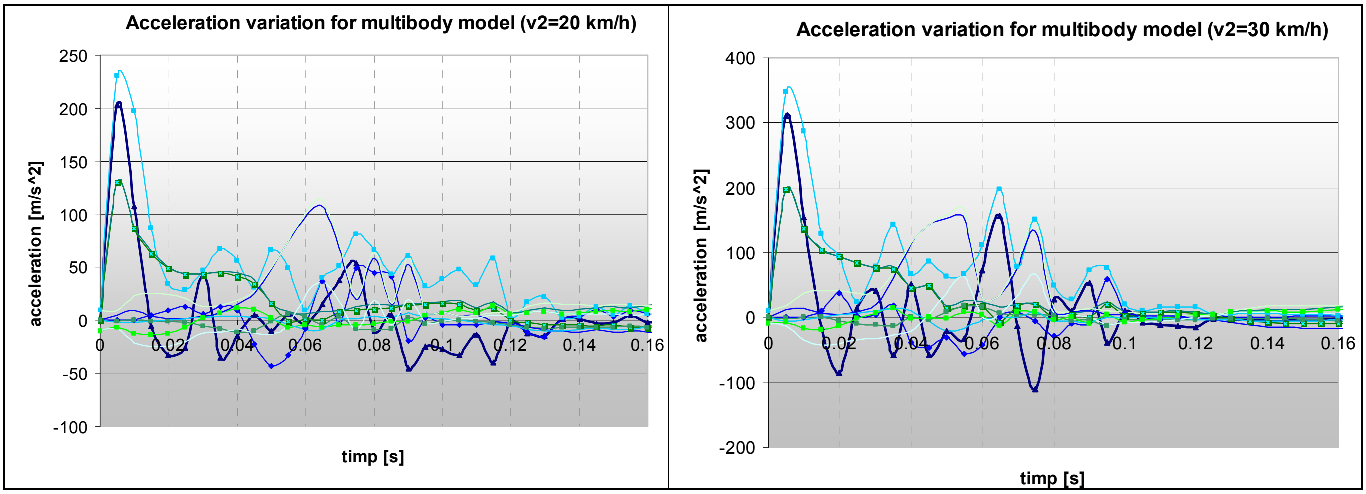


Figure 10. Variation accelerations for vehicle two when v2=20 km/h,v2=30km/h.

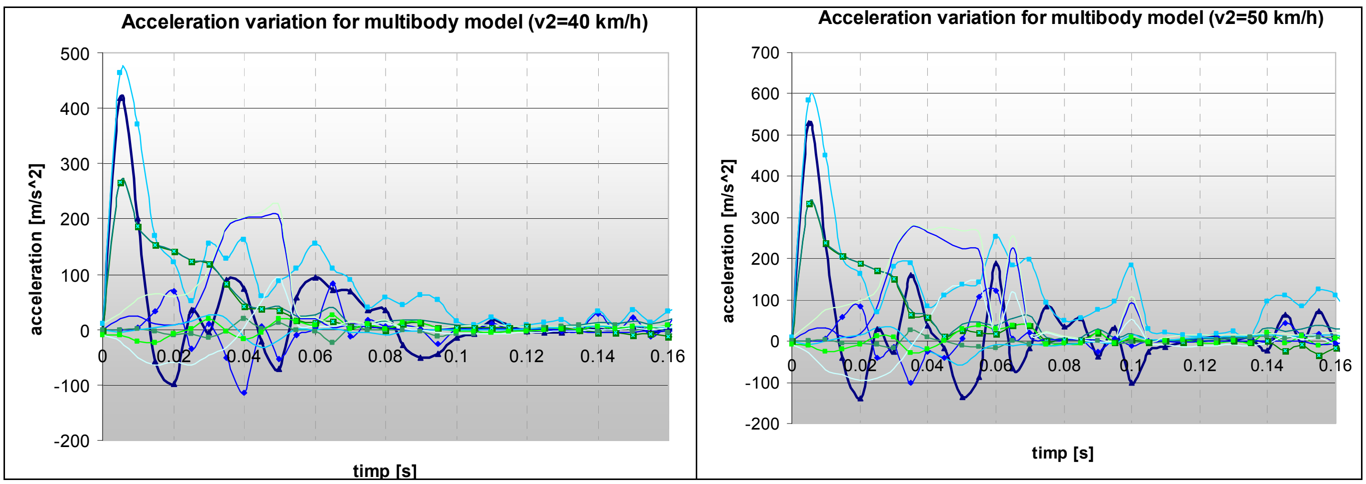


Figure 11. Variation accelerations for vehicle two when v2=40 km/h, v2=50 km/h

v 16	time	torso acc x	torso speed x	head acc x	head speed x	**NIC value [m^2/s^2]**
	0.005	103.272346	27.91606667	0.768783	4.317333333	**577.4009275**
	0.08	5.461283	149.1563667	83.943518	120.00785	**833.9395769**
v20	time					
	0.005	129.973603	35.39123333	4.600187	4.73735	**964.7352466**
	0.065	0.491797	182.7429333	106.996368	118.8840167	**4056.660324**
v30	time					
	0.005	198.017774	54.08935	12.143645	5.8282	**2366.313425**
	0.055	18.518785	283.8267333	152.317752	200.1363	**6977.328838**
v40	time					
	0.005	266.795937	72.8099	18.981541	7.049166667	**4374.036928**
	0.05	36.031605	377.94705	203.080309	284.0583667	**8781.675117**
v50	time					
	0.005	335.220999	91.65595	27.870675	8.377433333	**6996.781403**
	0.045	12.012357	455.7962	244.334615	342.4427833	**12802.53262**

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