

## **UNUSUAL STATISTICS ABOUT ROLLOVER ACCIDENT OF BUSES – V.** (Transmitted by the expert from Hungary)

1. This is the 5<sup>th</sup> statistics in the line:
  - I. 78<sup>th</sup> GRSG, April 2000, informal doc. No.6
  - II. 80<sup>th</sup> GRSG, April 2001, informal doc. No.5
  - III. 83<sup>rd</sup> GRSG, October 2002, informal doc. No.7
  - IV. 84<sup>th</sup> GRSG, May 2003, informal doc. No.4
  
2. It is very difficult *to get technically informative accident* statistics about bus rollovers. This type of accident is a rather rare one. There is no organization, institution which is interested in, which has the capability to collect and record these data. In the best case, the statistical yearbooks contains one column – among the road vehicles – for buses, giving the total number of all kind of bus accidents, the total number of fatalities and injuries. But these information is almost nothing to understand deeply the types of a certain accident (like rollover), their severity, to establish a good standard accident for the approval test, etc. There are two possibilities to get more, deeper information, statistics:
  - a) A certain expert group in an institution (e.g. Cranfield CIC in U.K., AUTÓKUT in Hungary, HUK Verband in Germany etc.) builds up good personal and institutional connections to big bus operators, local polices and the experts are immediately informed about every bus accident they are interested in, so they can study the crashed bus on the scene and collect all the important data, they can take photos, etc.
  - b) Experts keep watch on the media (Radio, TV, newspapers, journals, etc.) which reports about the so cold “interesting”, severe accidents. While a bus rollover is an interesting and severe accident, there are many reports in the media.
  
3. This new, unusual way is used in Hungary in the last 10 years, but really intensively in the last 3years. In the Annex of this paper *40 new rollover bus accidents have been collected* from the last 8 months. These media information are not officially checked, neither technical nor medical examinations, investigations were made. The structural deformations were estimated about the pictures presented in the newspapers, or about the films shown on the TV. As it can be seen in the Annex, the reports say only a few words about the accident, sometimes nothing about the bus type, or specific information about casualties. In spite of these insufficiencies, some interesting things, tendencies may be read out from the 157 rollover accidents. Table 1. gives a summary of the five statistics containing altogether 157 rollover accident. Table 1. needs some explanations which follows below (the referring numbers are used in Table 1. as well):
  - (1) countries may be involved as manufacturer, approval authority, operator or the scene of the accident.
  - (2) not too severe accident, but more than turning on side (1/4 rotation): roll down into a ditch, down on a slope (not more than 2 rotation) turned down from an overbridge of a highway (the level difference between the start and end position less than 8 m)
  - (3) more than two rotation, more than 8 m level difference in the rollover or falling dawn
  - (4) the combined accident means e.g. rollover after a serious frontal collision, rollover with fire, falling into water after rollover, etc.
  - (5) serious deformation means the damage of the survival space, (the collapse of the super-structure obviously belongs to this category).
  - (6) slight deformation means that the survival space very likely is not damaged in the rollover accident.

Table 1.

Summary of rollover statistics	Statistics I. 1990- 1999	Statistics II 01.01.2000 01.03.2001	Statistics III 01.03.2001 31.07.2002	Statistics IV 01.08.2002 31.12.2002	Statistics V 01.01.2003 31.08.2003	$\Sigma$ (I-V)
Number of accidents	23	23	51	20	40	157
Number of countries in- volved <sup>(1)</sup>	min.15	min.15	min.26	min.14	min.22	min.48
Total number of						
- fatalities	238	254	519	170	534	1726
- serious injuries	103	107	94	56	112	492
- light injuries	122	123	170	47	59	525
- injuries without classification	197	122	189	160	360	1028
- reported "many injuries"	2 times	1 time	6 times	1 time	5 times	15 times
Type of rollover (severity)						
- turned on side	4	2	5	5	4	19
- rollover from the road <sup>(2)</sup>	13	12	18	7	16	67
- serious rollover <sup>(3)</sup>	3	6	9	3	12	33
- combined accident <sup>(4)</sup>	3	3	19	5	8	38
Category of the bus rolled over						
- C I. (city, suburban)	2	2	2	-	1	7
- C II (intercity, local)	-	2	2	-	4	10
- C III (tourist, long-distance)	18	10	20	9	14	71
- Small bus (Reg.52)	-	2	9	8	11	30
- Double decker (Reg.107)	2	2	1	-	3	8
- School bus	-	1	2	-	2	5
- Other (worker, pilgrim, etc.)	-	1	4	-	-	5
- unknown	1	3	9	3	5	21
Deformation of superstructure						
- serious deformation <sup>(5)</sup>	4	5	6	9	7	31
- slight deformation <sup>(6)</sup>	5	5	11	7	6	34
- no information	14	13	34	4	27	92

4. It is very difficult to get a valid picture about the *worldwide situation of the bus rollover accidents*. This new method collects worldwide statistics but this statistics is projected by the Hungarian media (It means that from the far countries only the very serious accidents are reported) Table 2. gives the yearly distribution of the accidents. It is interesting to mention that the real collection of the data started in 1999 but this was not a complete year. The intensity of the collection was increased during the years. The small buses, mini buses were out of interest before 2001.

So the yearly increasing number of bus rollovers does not cover a real tendency in this kind of accidents, but it shows the result of a more precise and intensive observation of the media (More newspapers, TV channels are involved) The number of the registered buses in Hungary is around 19 thousand. This fleet produces 10 rollover accidents per year as an average. (Independently from the casualties) The complete European bus fleet could be in the range of 500-550 thousand units. Using the Hungarian proportion the expected number of bus rollover accidents in Europe could be in the range of 260-290/year. It is interesting to mention that in Spain 33 rollover accidents were reported [1] between 1984-88 and 20 in the years 1991-92 [2] This figures involves only the tourist coach accidents in which passengers died. (At least one)

Table 2.

	1990-1998	1999	2000	2001	2002	2003*	Total
Hungary	4	2	4	13	12	9	44
Europe (excl. H.)	13	8	7	6	8	12	52
Other than Europe	4	7	7	12	19	14	61
Total	21	17	18	31	39	35	157

\* only the first 8 months from the total year

The world wide statistics means that at least 48 countries are involved anyhow (see Table 1. and belonging remarks) The scene of the accident is known in every case (100%) but the manufacturer, operator and the approval authority (if any) in less cases, as Table 3. shows.

Table 3.

Known from the statistics	Number	%
Scene	157	100
Operator	102	65
Manufacturer	45	29
Approval authority	14*	9

\* only Hungarian buses

It is interesting to have a glance on Table 4., in which those countries are listed which are mostly involved in the rollover statistics.

Table 4.

Country	As the scene of the rollover	As bus operator	As bus manufacturer	Total
Hungary	44	33	15	92
Germany	4	8	22	34
China	11	8	-	20
Austria	13	2	-	15
Spain	5	3	-	8
Poland	3	4	-	7
Greece	3	4	-	7

Brief comments to the figures:

- Hungary – the statistics is based on the Hungarian media
- Germany – strong bus industry
- China – huge country, many serious rollover
- Austria – hilly roads

**5. The severity of the accident** is an essential issue when determining the standard approval test, this expresses the demand of the public opinion: in which kind of accident situations should be the passengers protected, the survival possibility assured. The number of the different kind of rollover accidents – based on their virtual severity – in the whole statistics is shown in Table 1. It seems to be acceptable to say that the first two accident type, the “turn on side” and, “rollover from the road” accident categories should be covered by the standard rollover test. That means, in these kind of accidents the occupants should be protected, the survival space should be intact (protected accidents) In this statistics 86 accidents (55% of the total) belong to these two categories. It must not be forgot that the rate of the severity in this statistics depends on the locality of the accident, e.g. a “turn on side” of a minibus without fatalities is reported if it happened in Hungary, but it is not a news for the Hungarian media if it happened in Brasilia or China. This is proved by Table 5. The conclusion of this effect is that the more severe rollover accidents are over-represented in this accident statistics considering the whole world, or in other words the “protected accident types” cover at least 70-75% of the total bus rollover accidents around the world as it is shown in Table 6. Table 7. shows that the majority of the injuries are “produced” by these two accident types and their fatality rate is also exceeding the 30%.

Table 5.

	Turned on side	Rollover from the road	Combined rollover	Serious rollover	Total
Hungary	12 (27%)	27 (61%)	5 (12%)	-	44 (100%)
Europe (excl. H.)	7 (14%)	22 (45%)	11 (22%)	9 (19%)	49 (100%)
Other than Europe	1 (2%)	17 (26%)	22 (34%)	24 (38%)	64 (100%)
Total	20	66	38	33	157

Table 6.

	All rollover accidents	Protected accidents	
		number	%
Hungary	44	39	87%
Europe (exl.H.)	49	29	60%
Other than Europe	64	18	28%
Total	157	86	55%

Table 7.

Injury levels in the protected accidents (totally 86 accidents)	Number of persons	% of the total, given in Table 1.	Number per accident
Fatalities	496	29 %	5,8
Serious injuries	277	85 %	3,2
Light injuries	377	72%	4,4
Injuries without classification	497	48%	5,8
Statement "more fatalities and injuries"	6 times	40%	-

6. It is difficult *to control the standard approval test used* in ECE Regulation 66, whether it is adequate to separate the strong superstructure from the weak one, to meet the demand of the public, to assure the required safety for the passengers at least in the protected rollover accidents. A slow feedback can be found from the accident statistics, from the analysis of rollover accidents.

This new rollover statistics does not give direct information about the approval of the buses regarding ECE-Reg.66. But indirectly Table 8. gives an interesting comparison. As it was defined above, "protected rollover accident" covers those accidents in which the passengers should be protected, the survival space shall be maintained. Among the 157 rollover accidents there are 62 in which we have information about the behaviour of the superstructure: 32 accidents did not cause damage in the survival space and in 30 accidents the survival space was harmed, including the total collapse, too. The casualties belonging to these two groups are significantly different. The fatality rate is 13 times, the serious injury rate 4 times higher when the survival space was damaged. From this recognition it comes the clear goal of the international regulation: in the protected accidents the survival space shall be maintained. It is interesting to mention on the basis of Table 9. that the number of the light injuries are not closely related to the type or category of the accident. It may be assumed that this type of injuries are caused mainly by the inside collision of the passengers when they are leaving their seats, seating position during the rollover process. The main tool to reduce this kind of injuries could be the use of seat belts. (It has to be emphasized that the seat belt can reduce the number of fatalities and serious injuries, too.)

Table 8.

Considered accidents	Number of events	Casualty per accident			
		fatality	Serious injury	Light injury	Injury without classification
All rollover accidents	157	11,0	3,1	3,7	6,5
Protected rollover accidents	86	5,8	3,2	4,4	5,8
Survival space unharmed	32	1,0	1,6	4,2	5,2
Survival space damaged	30	12,8	6,1	4,9	9,2

7. The attention was called in the very beginning of the studies to the fact that the *ejection* could be very dangerous situation for the passengers in a rollover accident. This new type of accident statistics showed and analysed here is not detailed enough to get reliable information about this problem. But it has to be mentioned that there were 7 reports in which the ejection of the passengers were mentioned. It proves that this is an existing problem. There are different possibilities, tools to reduce the risk of

the ejection, e.g. safety belt, laminated safety glazing of side windows, horizontal rail (hand strap) at the side windows (at the shoulder of the seating passengers) etc.

8. *The high decker (HD) coaches* became very popular in category 3 (long distance and tourist coaches) in the last decade, their ratio in this category is increasing, mainly in the developed countries. Table 1. shows that 45% of buses having rollover accident belongs to category 3. (71 accidents) Considering the double decker coaches (DD) too (8 rollover accidents) this rate is 50%. The HD and DD coaches are really tourist and long distance coaches independently from the fact that they are covered by two different general safety regulations (Reg.36. and Reg.107) Table 9. shows that 28 coaches were HD and DD among the rollover accidents (35% of the coaches) In 23 cases there was no information about the construction of the coach, so 3 or 4 of them might be as well HD or DD. It means that 40% or more is an acceptable estimation for the representation of the high coaches (HD and DD) in the rollover accident of the long distance and tourist coaches. In other words: they are over-represented in the rollover statistics compared to their rate in the total population of long distance and tourist coaches around the world. Two important technical problem is connected to the HD coaches:

- a) the dynamic lateral stability of these high vehicles is not sufficient, it should be increased and regulated
- b) because of the geometrically limited structural deformation, caused by the given geometry of the rollover test (800 mm depth of the ditch) the existing standard approval test is not appropriate for HD coaches to separate the weak superstructure from the strong one [3] and for the DD coaches there is no regulation for the strength of the superstructure.

Table 9.

Conclusion of coaches having rollover accidents	Number	%
Traditional (total height 3-3,2 m)	21	27
Probably traditional	7	9
HD (total height more than 3,4 m)	20	25
DD (double decker coaches)	8	41
Non information about construction	23	29
Total	79	100

9. *The rollover problem of the small buses* has been neglected in the past. For the question “Why?” there are some possible explanations, e.g.:

- small bus, smaller passenger capacity, lower casualty figures in a rollover accident, lower public interest,
- no statistical data about the rollover accidents of small buses,
- the small buses (ECE-Reg.52) are not covered by ECE-Reg.66 requiring the strength of bus superstructure in case of rollover.

In the unusual bus rollover statistics we started to collect the information about the small buses, too. Unfortunately not at the beginning of the work, for ten years they were out of interest. These accidents are collected only in the last 3 years. The first problem was – and still it is – that in the everyday language (in the news) different words are used: minibus, microbus, small bus, club bus, etc. without any technical background. ECE-Reg.52 has a clear specification: in the small bus the passenger capacity should not exceed 22. But in the everyday practice that covers rather different vehicles As Table 1. shows: altogether 30 rollover accidents have been recorded. Table 10. gives the casualties in these accidents. It has to be mentioned that in two reports there was nothing about casualties, the accidents were mentioned in the radio as the reason of heavy traffic jam.

Table 10.

Casualties in rollover of small buses (30 accidents)	Number	Casualty per accident
Fatality	96	3,2
Serious injury	54	1,8
Light injury	55	1,8
Injury without specification	32	1,1
Report "some injuries"	once	

Considering that the passenger capacity of the small buses is roughly one fourth compared to the big coaches (40-70 passengers) as an average, comparing the figures of casualty per accident given in Table 8. and Table 10. it may be stated that casualty risk for the small bus passengers is not negligible. This is the first announcement in this subject, further investigations are needed (the population of small buses, the characteristic types and categories of small buses, their structural deformations in rollover accidents, the rollover process of this category, etc.)

## REFERENCES

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Bus rollover accidents collected between  
01.01.2003-31.08.2003

	<b>Date</b> <b>City (district)</b> <b>Country</b>	<b>Bus type</b> <b>Category</b> <b>Operator</b>	<b>Circumstances of rollover</b>	<b>Fatalities and in-</b> <b>juries</b>	<b>Damage of the super-</b> <b>structure</b>
1	15.10.2002 Izabella Philippines	school-bus local operator	The bus left the road hit a tree and rolled into a water worn. Police said: the bus was overloaded	12 fatalities many injuries	
2	17.9.2002 Catamarca Argentina	long-distance coach (C3) local operator	The bus drifted from the road and rolled down into 30 m deep precipice. 62 pilgrims on board.	49 fatalities 14 injuries	
3	7.9.2002 Kirganga India	long-distance coach local operator	The bus left the road, rolled over into a river, pilgrims on board	30 fatalities 16 injuries	
4	25.11.2002 San Vincente Philippines	long-distance coach (C3) local operator	The driver fell asleep, the bus left the road and rolled down into a 30 m deep gorge	33 fatalities 6 serious injuries	
5	24.11.2002 Madhya Pradesh India		The bus rolled over and burned out. Reserve fuel cans were located behind the driver seat.	30 fatalities 27 injuries	
6	02.01.2003 Petronell-Bad Austria		Icy road, the bus slipped and turned on its side	only light injuries	The superstructure did not damaged
7	07.01.2003 Taltenango Mexico	intercity bus (C3) Mexican operator	Hilly road, the breaks refused to act, the accelerated bus changed the lane and in a sharp curve left the road and rolled down into a deep precipice	18 fatalities 22 serious injuries	
8	10.01.2003 Morone Santiago, Equator	long-distance coach (C3) local operator	Hilly road, the bus passed another vehicle, but slipped on the shoulder of the road and rolled down into a 200 m deep precipices	12 fatalities 27 injuries	

9	12.01.2003 Yuunan China	School-bus local operator	Hilly road, the bus drifted in a curve, crossed a guard, rolled down into a river	17 fatalities 1 serious injuries 9 untraceable persons	
10	04.02.2003 Murau (Steier) Austria	minibus Hungarian	The minibus slipped on the icy road and rolled over. Three person were on board, two of them has been ejected and killed. The third person remained in the bus and uninjured.	2 fatalities	
11	December 2002 Poland	Mercedes 0305 Tourist coach HD	Straight road, the driver was distracted, the bus hit the rear of a truck, left the road and rolled over into a field.	1 fatality (driver) few minor injuries	the superstructure was not dramatically deformed (except the front wall)
12	19.01.2003 Plovdiv-Szófia Bulgária	Mercedes 0305 Tourist coach HD Turkish operator	The bus broke throw the guard rail of highway bridge and rolled down into a 40 m deep valley.	5 fatalities many injuries	The rear half of the bus was completely collapsed and deformed, the front third was intact.
13	24.01.2003-08-26 Fagersta Sweden		The bus slipped, left the road and rolled over	6 fatalities 4 serious injuries 23 light injuries	
14	26.01.2003 Katmandu Nepal	long-distance coach (C3) local operator	The bus left the road and rolled down into a valley.	13 fatalities 30 injuries	
15	28.01.2003 close to Vietnam border China	small bus local operator	34 people on board (the nominal capacity of the bus was 12 passengers) The driver left the control, the bus rolled into 40 m deep gorge	18 fatalities 16 injuries	
16	31.01.2003 Goré Hungary	Intercity bus (C2)	Icy road, the bus slipped and rolled down from the road into a ditch. Stopped on its side	3 serious injuries 4 light injuries	No major structural damage, the survival space remained intact
17	19.02.2003 Himalaja Nepal		Wedding family and guests on board. The bus rolled down into a precipice.	23 fatalities 31 injuries 20 persons un-	



				traceable	
18	23.02.2003 Saloniki, Klidi Greece	long-distance coach (HD) local operator	The bus rolled down from a bridge into a river (10 m) 23 passengers on the board. Regular intercity line to Athens	13 fatalities 6 injuries 4 persons untraceable	The roof completely collapsed, the seats were pressed down by the roof.
19	08.03.2003 Kaplice Czech Republic	Neoplan N112/3 tourist coach, DD, 3 axle Czech operator	20+50 ski tourist on board. First the bus hit the right side guard rail, turned left, cut through the left side rail and rolled down on a slope (7 m) One full rotation	19 fatalities 27 serious injuries 10 light injuries	The upper body part was completely demolished, the seats were pressed down by the roof.
20	11.03.2003. Miskolc Hungary	Mercedes microbus (ambu- lance) local operator)	The microbus was transporting patients, slipped and rolled over.	2 serious injuries 5 light injuries	
21	1.02.2003 Nyírózsony Hungary	microbus (ambu- lance) local operator	Slippery road, snow, the bus rolled over.	2 injuries	
22	15.03.2003 Quito, Alog Equador		The bus left hilly road and rolled down into a 150 m deep precipice.	26 fatalities 17 injuries	
23	26.03.2003 Nagybátony Hungary	IKARUS 256 Intercity 11 m (C2) Nográd Volán	The driver became unconscious, but before, tried to stop on the pavement. The bus rolled into the ditch, stopped on its side.	2 serious injuries 6 light injuries	No serious damage of the superstructure, no deformation
24	30.03.2003 Mezőkövesd Hungary	VW Transit minibus Ukrainian operator	On a highway the bus hit the belt guard, rolled over it and rolled down into a ditch (3 m) 4 persons on board. The driver fell asleep.	1 fatalities 2 injuries	
25	06.04.2003 Budapest Hungary	minibus (ambulance) Hungarian operator	The minibus was hit by a car, turned on its side	2 injuries	No significant deformation of the superstructure
26	13.04.2003 Győr	small bus	On the highway M1 the driver lost the control (probably fell asleep) sudden changed the line,		

	Hungary		rolled over		
27	14.04.2003 Tembi valley Greece	MAN Tourist coach 12 m Greek operator	Hilly part of a highway, between Saloniki and Athena. Billets fell down from a timber truck, the bus tried to avoid them, but hit one and other vehicles, too, finally rolled over	24 fatalities 30 injuries	The superstructure seriously damaged, the seats were pressed by the roof
28	18.04.2003 close to Lima Columbia	Tourist coach (C3)	The bus hit a car, the driver lost the control, the bus rolled over and stopped on its roof.	10 fatalities 13 injuries	The survival space probably was not harmed
29	17.05.2003 Lyon France	Tourist coach, DD German operator	Wet road, the bus slipped, hit the safe guard of the highway, felled a pylon and finally rolled into the ditch of the highway. Stopped on the roof.	28 fatalities 47 injuries	
30	02.06.2003 France	Tourist coach Moroccan operator	The bus rolled over and fell into the ditch next to the road	7 fatalities 26 injuries	
31	06.06.2003 Hatvan Hungary	minibus	On the highway M3 the microbus rolled over and landed in the ditch next to the highway	1 serious injury 1 light injury	
32	08.06.2003 Secuan China	minibus local operator	The bus rolled over and landed in a river. 11 persons on board	10 fatalities	
33	08.06.2003 Kauntang China	intercity bus (C2) local operator	The driver lost the control in a curve, rolled over and fell into a river. 40 persons on board.	26 fatalities	
34	30.06.2003 Columbia	Tourist coach, 12 m	The driver lost the control, broke through the safety rail, rolled over and down from the road (10-12 m)	12 fatalities 52 injuries, most of them serious	The superstructure collapsed, no survival space remained
35	04.07.2003 Mosonmagyaróvár Hungary	small bus	On the highway M1 the bus rolled over		
36	10.07.2003		The small bus went to the airport on the high-	7 fatalities	

	Manchester United Kingdom	small bus local operator	way M56, hit the safety rail and rolled over. Four cars run into the damaged small bus.	2 serious injuries 10 light injuries	
37	10.07.2003 Honkong China	city bus, DD, 3 axles local operator	The bus collided a truck, after that broke the safety rail of the highway bridge and fell down from the bridge (12-15 m) hit the ground by the front wall, and turned on its roof.	34 fatalities 20 injuries	The survival space was harmed, the front part completely demolished.
38	14.07.2003 Cairo Egypt	intercity bus (C2) local operator	The driver fell asleep, the bus collided a truck and after that rolled over and got fire.	15 fatalities 2 injuries	
39	21.07.2003 Kujcsón China	local operator	The bus took a curve with too high speed, drifted from the road and rolled down into 40 m deep precipice	23 fatalities 22 injuries	
40	03.08.2003 Péterfalva Slovakia	Scania 124 tourist coach C3 Slovak operator	Narrow, hilly road, 47 persons on board. The driver could not take a sharp right curve, he reserved but the engine stopped. The driver could not start it again, therefore he went out to the engine compartment. Because of the insufficient breaking the bus started to roll back, it turned on its side and rolled down on a slope, after 1,5 rotation stopped on its roof.	11 fatalities 20 serious injuries 4 light injuries	The superstructure completely collapsed