Airbag Progress Report 10

In our first progress report (1), we assumed that ignition was initiated at the moment of collision. The data shows an approximately three millisecond ignition delay. There is a dearth of published data on sodium azide ignition delay, but ignition delay is known to be temperature and pressure dependent, and can vary over a wide range, according to published data for other explosives (2,3). It turns out, however, that ignition is not initiated at the moment of collision in air bag systems. There is an additional delay, which we may refer to as system delay. In order to understand this, we need to look at how air bag systems function.

Figure 1 shows an early model air bag design:

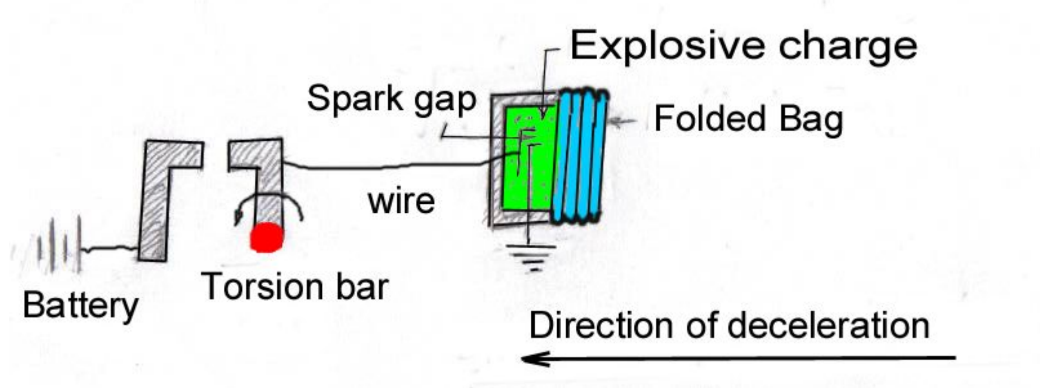

Figure 1

The system consists of an accelerometer, an igniter, an explosive charge, and a folded bag. Over the years, various types of accelerometers have been used (4). Figure 1 shows a torsion bar type accelerometer. Notice how the air bag videos always assume that the vehicle will experience a deceleration in the axial direction of the vehicle. As we have shown in previous reports (1,5,6,7, etc.), not only is the air bag theory fatally flawed, but it is based on an accident scenario which seldom happens in practice. It is important to show, however, that even in the type of accident scenario postulated by the air bag theory, the air bag increases, not decreases, the chance of severe injury to the vehicle occupant.

As numerous authors have pointed out (4,8,9), there is a delay between the moment of impact and the deployment of the air bag. Reference (8) puts the delay at between 10 and 25 milliseconds. Reference (4) puts the delay as between 20 and 30 milliseconds. Reference (9) puts the delay at 30 milliseconds, with the bag not “fully inflated” until 60 milliseconds. Term “fully inflated” is something of a misnomer, as air bags never “fully inflate” but experience a highly unsteady three dimensional deployment in which shock waves and rarefaction waves inside the bag bounce back and forth in a complex manner, causing the shape of the bag to fluctuate at a high rate of speed, while holes in the bag cause some of the generated gas to escape almost from the moment of ignition.

In the type of system shown in Figure 1, the accelerometer was typically located at the front of the vehicle where it would be smashed by the postulated collision, though whether before or after it has closed the contacts and ignited the charge would depend on the circumstances – speed, type of vehicle, rate of deceleration, degree of crush, etc.. As we have already pointed out in a previous report (10), it is not certain if the charge would be set off by the accelerometer or by the shock of the collision. In any case, it would take a finite time for the contacts to close and the circuit to send an electric charge to the spark gap. This time would vary depending on numerous factors, such as the temperature, (since the modulus of torsional rigidity varies with the temperature), as well as contact resistance, corrosion, metal fatigue and other chemical and physical effects of aging, since the air bag would not likely be called upon to deploy just after leaving the factory but months, or even years after being bounced around in the car, going through numerous shocks and temperature cycles. Even if the air bag were called upon to deploy just after leaving the factory, the system delay would still vary, since even the best mass production quality control cannot make the system delay identical to the millisecond in each unit.

A more recent type of system is shown in Figure 2.

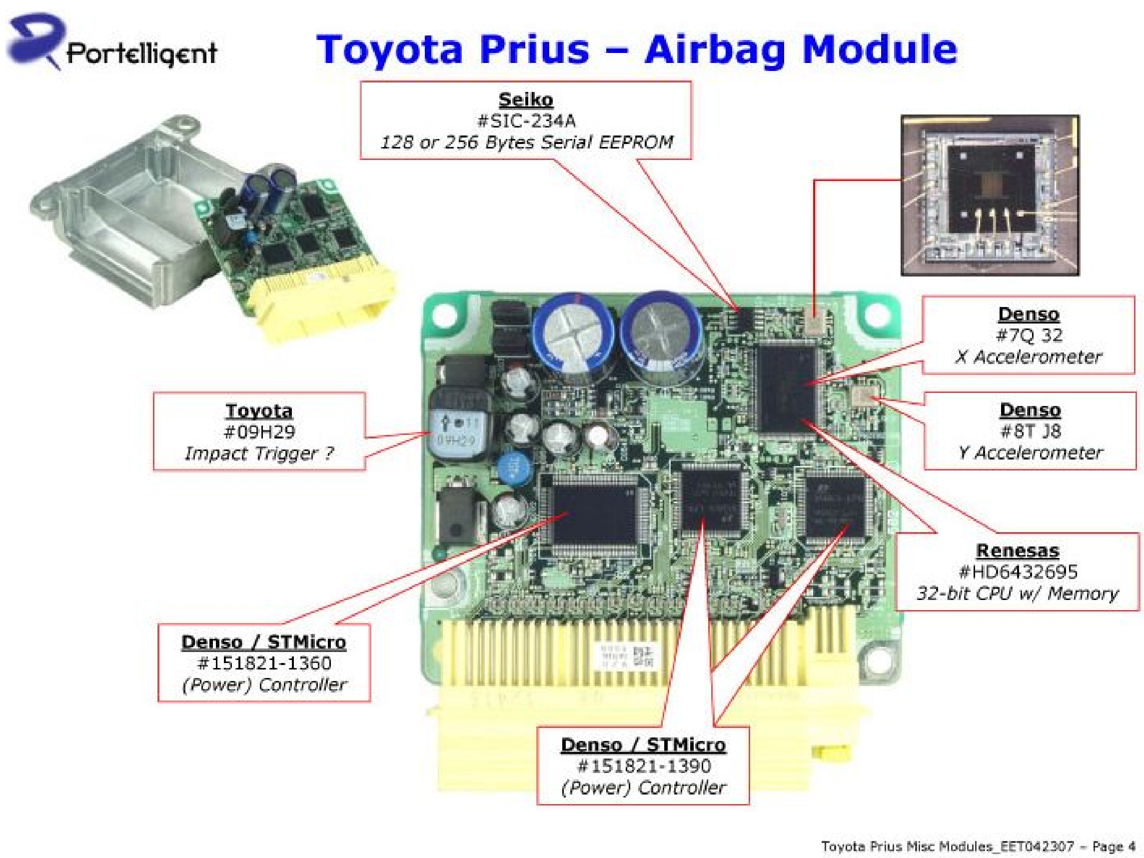

Figure 2

(Notice the labeling error for the CPU and the x accelerometer). Here the accelerometers rely on a piezoelectric effect and there are two of them, one in the x direction (the longitudinal axis of the vehicle) and one in the y direction (the transverse axis of the vehicle). The system involves a printed circuit, a microprocessor, a computer program, and numerous inputs such as speed of the vehicle, rate and direction of deceleration (or acceleration), weight of the driver or passenger, seat position, and so on. The computer program is supposed to process all this information and decide whether or not to deploy the air bag and, in the case of two stage combustion chambers, the time interval between the first and second detonation. At best, the end result of all this rigamarole will be to vary the time interval. An increase in the time interval is supposed to decrease the peak pressure and velocity of the air bag in order to decrease the severity of the injury which the bag causes the vehicle occupant. But, as Wu et al. (11) have already shown, the effect of an increase in the time interval between the first and second detonation is to increase the time of deployment and thus to increase the chance of the occupant being struck by the bag while it is still deploying, while the reduction in peak pressure and velocity is too small to make much difference. In fact, the second charge would almost certainly be set off by the first (10), if, indeed, the first charge itself is not set off by the shock of the collision, thus making the whole system irrelevant. Even if this were not the case, piezoelectric systems are strongly temperature dependent (12,13) so that a system designed to set off the bag at 5g might set it off at 3g or 7g, depending on the temperature.

Generally speaking, the more complicated or “sophisticated” a system is, the more likely it is that something will go wrong, simply because there is more to go wrong. This is particularly true after the system has been in the car for some time, going through numerous temperature cycles, shocks and the effects of aging. Computer programs can give wrong readings, microprocessors can mal function, and printed circuits boards are likely to crack. The system may set off the bag accidentally causing a serious or even fatal accident. This is likely to be a greater danger than the possibility of the vehicle being involved in the type of accident envisaged by the air bag theory, in addition to the danger which the air bag itself presents in such an accident.

Reference (8) states that “air bags typically extend 10 to 25 milliseconds after collision. The impact thresh hold for the process is based on a transient impact of 5g to 7g at a crash speed of 5 to 15 miles per hour.” The glib reference to collision implies a front end collision in the direction of the longitudinal axis of the vehicle at a speed of 5 to 15 mph, something which rarely happens and, if it did happen, the vehicle occupants would not be seriously hurt without seatbelts or air bags. Airbag papers and videos usually imply that all auto accidents are of this nature when, in fact, few of them are. Circumstantial evidence indicates that auto companies have progressively been lowering the deployment thresh hold since air bags were first introduced, because they kept getting sued by motorists whose air bags did not deploy in a lower speed accident. The plaintiffs were basically suing the car companies for doing something which probably saved their lives.

5 mph is the lowest asserted thresh hold we've seen, although other authors (4) do mention 14 mph. Motorists are not usually injured in a 5 mph hour axial, front end collision, or seriously injured in a 15 mph one, while being struck by an air bag in such a collision can cause serious injury or death. Moreover, if the trigger is so sensitive as to deploy the air bag in a 5 mph collision, the air bag may deploy as a result of the car hitting a severe bump, or just accidentally, causing severe injury or death to the motorist.

In order to see if the motorist would be struck by the air bag in these cases and, if so, at what speed, we have extended our computer program to include system delay and run it for the following conditions: axial, front end collisions at 5mph and 5g, 15 mph and 7g and 30 mph and 30g, with system delays of 10, 25 and 30 milliseconds, in accordance with the conditions cited in the references. In It should be pointed out, however, that based on the government's own data (14) the average fatal head on collision takes place at 56 mph, and we know from photographs and accident reports that at these speeds the victim is crushed to death as the vehicle is stove in. Nevertheless, it is important to show that even in the unlikely and unrealistic cases postulated by the air bag theory, the air bag is more likely to increase, rather than decrease the severity of the injuries suffered by the motorist.

The extended computer program is presented in Appendix 1, and the results of the calculations are presented in Appendix 2. The air bag data is once again taken from the biodynamics video, since such published data is very rare. The results show that in all of these cases the motorist is struck by the air bag while it is still deploying. We may summarize the results in the following tables:

Case	Speed (mph)	System delay (ms)	Deceleration (g)
5-1	5	10	5
5-2	5	25	5
5-3	5	30	5
15-1	15	10	7
15-2	15	25	7
15-3	15	30	7
30-1	30	10	30
30-2	30	25	30
30-3	30	30	30

Let ts = time driver collides with the air bag (ms)
rsab(ts) = speed relative to car of air bag at time ts (fps)
rsd(ts) = speed relative to car of driver at time ts (fps)
absd(ts) = speed of driver relative to air bag at time ts (fps)
dd(ts) = distance of driver from steering wheel at time ts (inches)

Case	ts	rsab(ts)	rsd(ts)	absd(ts)	dd(ts)
5-1	24.2	151	3.65	154.65	17.4
5-2	35.5	130	5.48	135.48	16.84
5-3	42.4	116	6.50	122.5	16.4
15-1	24.0	145	5.1	150.1	17.3
15-2	35.25	117	7.6	124.6	16.4
15-3	41.7	104	9.0	113	15.8
30-1	22.5	100	20.5	120.5	15.4
30-2	31.4	180	29.0	209	12.73
30-3	36.9	223	33.8	256.8	10.8

Motorists are seldom seriously hurt in 5 mph or even 15 mph collisions. Thus it is clear that in these cases the air bag presents the greatest danger to the motorist. While the results show that in these cases the air bag could be prevented from hitting the motorist in its initial expansion by making the air bag slightly smaller and preventing it from overshooting, they also show that the term "fully deployed" is something of a misnomer. Looking at the graphs we see that the airbag continues to fluctuate back and forth at a high rate of speed after reaching its maximum extent. This is due to the compression and rarefaction waves inside the bag reflecting and interacting back and forth in complex, unsteady, three dimensional ways, and it takes some time for the waves to attenuate. These waves would continue to hit the driver after he is contact with the bag. At the same time, the gas generated by the explosion is also venting through the small holes in the back of the bag. Thus, the bag never really reaches a steady state. A better criterion might be the time it takes for the waves inside the bag to attenuate to the point where they no longer present a danger to the driver.

For the 30 mph cases we see that the air bag would strike the driver even if it does not overshoot and the bag would have to be made much smaller to keep the driver from hitting it before the internal shock waves have attenuated. Again we have to bear in mind that the speeds cited here, which are taken from published air bag propaganda papers and vidoes, are well below the speeds at which most fatal accidents take place. According to the government's own data (14), the average fatal head on collision takes place at 56 mph, at which speed the victim is crushed to death as the vehicle is stove in, something which cannot be prevented by the air bag. It is clear, therefore, that at the speeds cited here, it is the air bag itself which presents the greatest danger to the motorist.

References:

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2. Lewis, B. and von Elbe, G. "Combustion, Flames and Explosions of Gases" Academic Press, New York, 1952
3. Smith, M.L. and Stinson, K.W. "Fuels and Combustion" McGraw Hill Book Company, New York, 1952
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5. www.safetychoice.org/Documents/abpr2.htm
6. www.safetychoice.org/Documents/abpr3.htm
7. www.safetychoice.org/Documents/abpr8.htm
8. www.ehow.com/about_5549727_speed-airbag-deploy.html
9.http://engineering.suite101.com/article.cfm/automobile_airbags#ixzz0qIrgm6Qm
10. www.safetychoice.org/Documents/abpr5.htm
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12. Argrist, S. "Direct Energy Conversion" Allyn and Bacon, Inc., Boston, Mass. 1976
13. Miller, B. "Findings of Accelerometer Investigation for Airbag Deployment Systems" http://prizewriting.ucdavis.edu/past/2001-2002
14. ftp://ftp.nhtsa.dot.gov/FARS/

APPENDIX 1

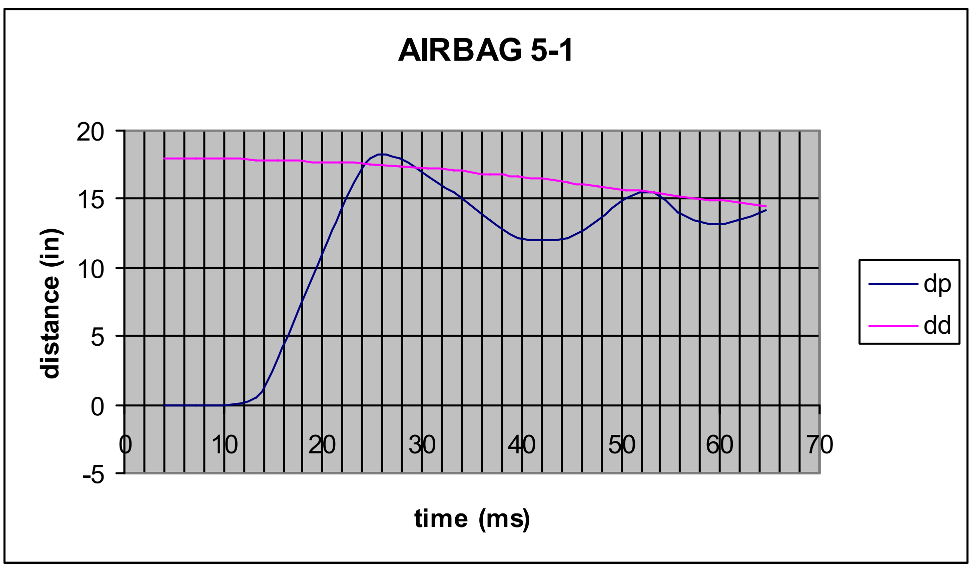
```
 program airbag1
      integer n,m
      real rsab(21), sc(21), rsd(21), asc(21), rdd(21), arsd(21),
     +t(21), d(21), rddt(21), dd(21), rddto, rddo, dc, sd, sco,
     +idd,dp(21)
C    rsab = speed of airbag realtive to car at time t(n)
C    sc = speed of car at time t(n)
C    rsd = speed of driver relative to car at time t(n)
C    asc = average speed of car during the interval t(n)-t(n-1)
C    rdd = distance moved by driver relative to car at time t(n)
C    t = time from initial signal to detonate airbag, in ms
C    d = distance airbag has moved relative to car at time t(n),
C    in inches, with no system delay
C    arsd =  average relative speed of driver during the time
C    interval t(n)-t(n-1), in ft/sec
C    rdd = distance driver has moved relative to car during the
C    time interval t(n)-t(n-1),in inches
C    rddt = total distance driver has moved relative to car at
C    time t(n), in inches
C    sco = initial speed of car, in ft/sec
C    dc =  rate of deceleration of car in ft/sec/ms
C    sd = absolute speed of driver = absolute inititial speed of
C    car
C    idd = initial distance of driver from steering wheel of car,
C    in inches
C    dp = distance airbag has moved relative to car at time t(n),
C    in inches, with system delay
C    m = system delay
      m=7
      idd=18.0
      dc=0.968
      sd=44.0
      sco=sd
      OPEN(50,file='data3.txt')
      READ(50,*)(t(n),n=1,21)
      READ(50,*)(d(n),n=1,21)
      DO 6 n=m+1,21
      dp(n)=d(n-m)
    6 CONTINUE
      DO 7 n=1,m
      dp(n)=0
    7 CONTINUE
      DO 10 n=1,m
      rsab(n)=0
   10 CONTINUE
      n=m+1
      rsab(n)=d(1)*1000/t(1)
      DO 11 n=m+2,21
      rsab(n)=(dp(n)-dp(n-1))*1000/(t(n-m)-t(n-1-m))
   11 CONTINUE
      sc(1)=sco-dc*t(1)
      DO 12 n=2,21
      sc(n)=sco-dc*t(n)
      IF (sc(n).LE.0) THEN
```

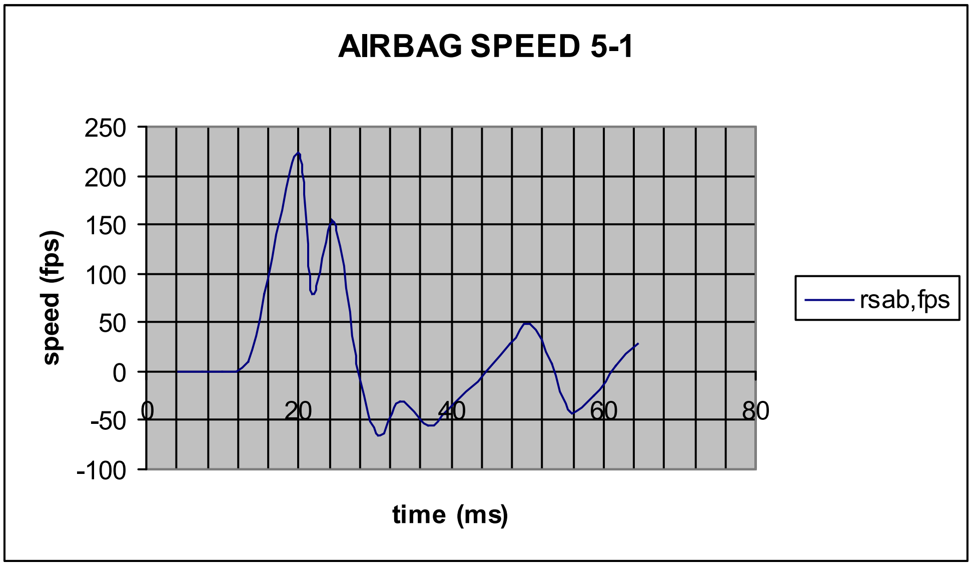
```
      sc(n)=0
      END IF
   12 CONTINUE
      asc(1)=(sc(1)+sco)/2.0
      DO 13 n=2,21
      asc(n)=(sc(n)+sc(n-1))/2.0
      IF (asc(n).LE.0) THEN
      asc(n)=0
      END IF
   13 CONTINUE
      rsd(1)=sd-asc(1)
      DO 14 n=2,21
      rsd(n)=sd-asc(n)
   14 CONTINUE
      arsd(1)=rsd(1)/2.0
      DO 15 n=2,21
      arsd(n)=(rsd(n)+rsd(n-1))/2.0
   15 CONTINUE
      rdd(1)=arsd(1)*t(1)*0.012
      DO 16 n=2,21
      rdd(n)=arsd(n)*(t(n)-t(n-1))*0.012
   16 CONTINUE
      rddt(1)=rdd(1)
      DO 17 n=2,21
      rddt(n)=rddt(n-1)+rdd(n)
      IF (rddt(n).GE.idd) THEN
      rddt(n)=idd
      END IF
   17 CONTINUE
      dd(1)=18.0
      DO 18 n=2,21
      dd(n)=idd-rddt(n)
   18 CONTINUE
      PRINT 20
  20  FORMAT(//,T5,'t',T13,'dp',T20,'rsab',T30,'rddt',T39,
     +       'rsd',T48,'rdd',T56,'dd',T65,'sc')
      DO 26 n=1,21
      PRINT 25, t(n),dp(n),rsab(n),rddt(n),rsd(n),rdd(n),
     +dd(n),sc(n)
  25  FORMAT(F7.3,2X,F5.1,2X,F8.3,2X,F7.3,2X,F7.3,2X,F7.3,
     +2X,F6.3,2X,F7.3)
  26  CONTINUE
      END
```

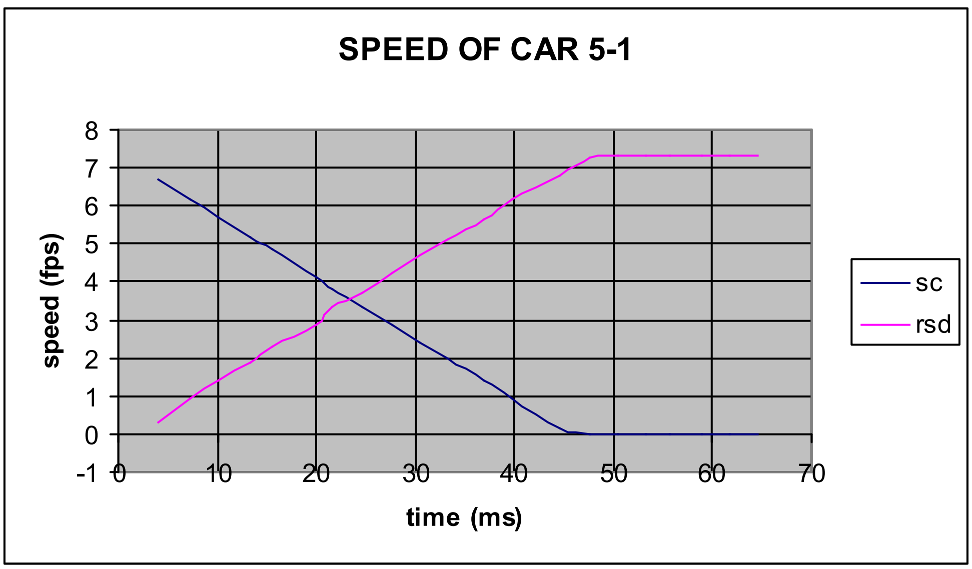
APPENDIX 2

Case 5-1

t	dp	rsab,in/sec	rddt	rsd	rdd	dd	sc	rsab,fps
4.077	0	0	0.008	0.328	0.008	18	6.674	0
7.277	0	0	0.032	0.914	0.024	17.968	6.158	0
10.077	0	0	0.071	1.397	0.039	17.929	5.708	0
13.277	0.5	122.639	0.134	1.88	0.063	17.866	5.192	10.21991
15.477	3.5	937.5	0.189	2.315	0.055	17.811	4.838	78.125
19.877	11	2678.572	0.325	2.846	0.136	17.675	4.13	223.2143
21.677	14	937.5	0.392	3.345	0.067	17.608	3.84	78.125
24.677	18	1818.182	0.519	3.731	0.127	17.481	3.357	151.5151
27.677	18	0	0.663	4.214	0.143	17.337	2.874	0
30.477	16.6	-777.778	0.812	4.681	0.149	17.188	2.423	-64.8143
33.277	15.5	-366.667	0.977	5.132	0.165	17.023	1.972	-30.5558
36.877	13.5	-666.667	1.21	5.647	0.233	16.79	1.393	-55.5558
39.677	12.2	-464.286	1.408	6.163	0.198	16.592	0.942	-38.6905
44.677	12.2	0	1.797	6.79	0.389	16.203	0.137	0
47.677	13.4	333.333	2.05	7.261	0.253	15.95	0	27.77775
50.477	15	571.429	2.295	7.33	0.245	15.705	0	47.61908
53.277	15.5	100	2.541	7.33	0.246	15.459	0	8.333333
55.677	14	-500	2.752	7.33	0.211	15.248	0	-41.6666
58.877	13.2	-285.714	3.034	7.33	0.281	14.966	0	-23.8095
61.677	13.4	71.429	3.28	7.33	0.246	14.72	0	5.952416
64.477	14.2	333.334	3.526	7.33	0.246	14.474	0	27.77783

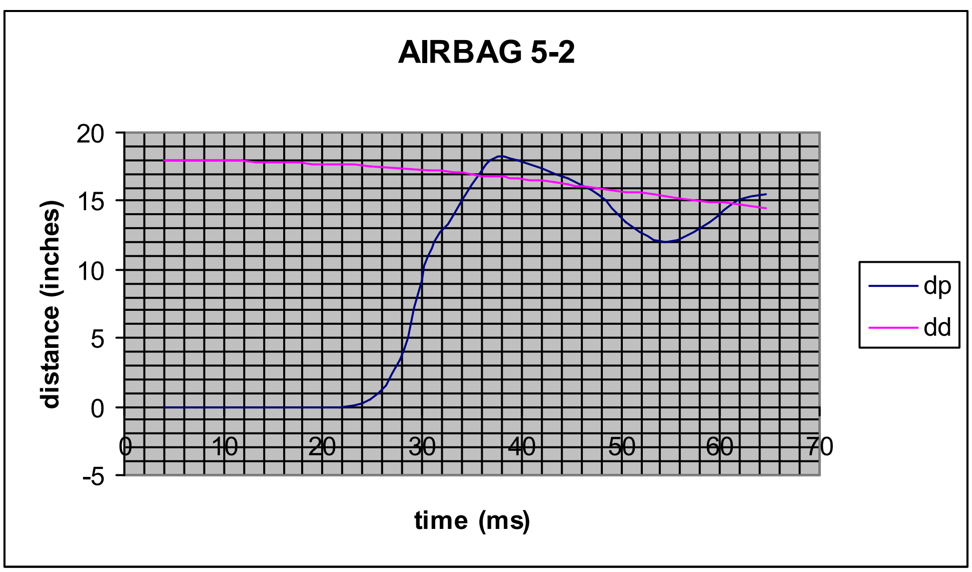


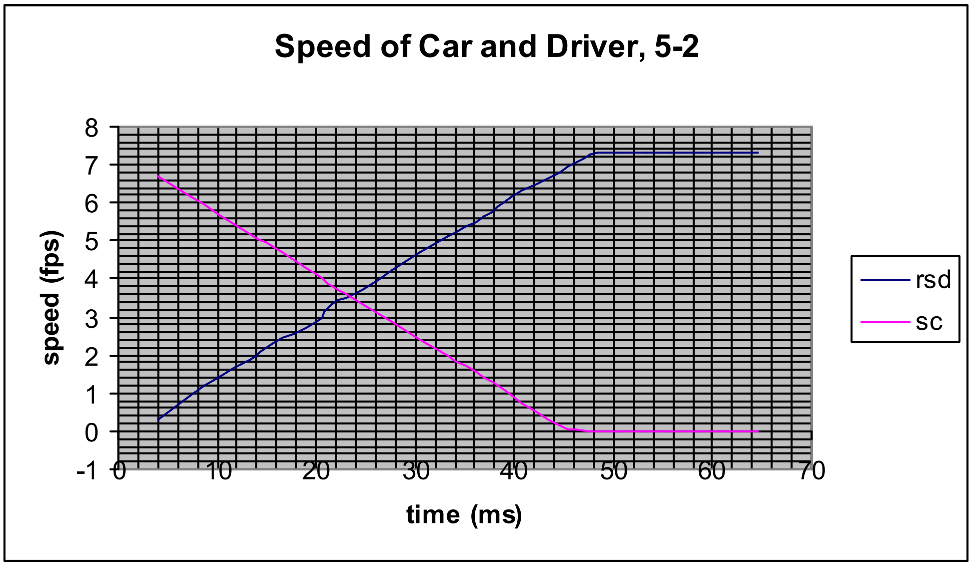

AIRBAG SPEED 5-1
250
200
150
100
50
0
-50
-100
0
20
40
60
80
speed (fps)
time (ms)
rsab,fps

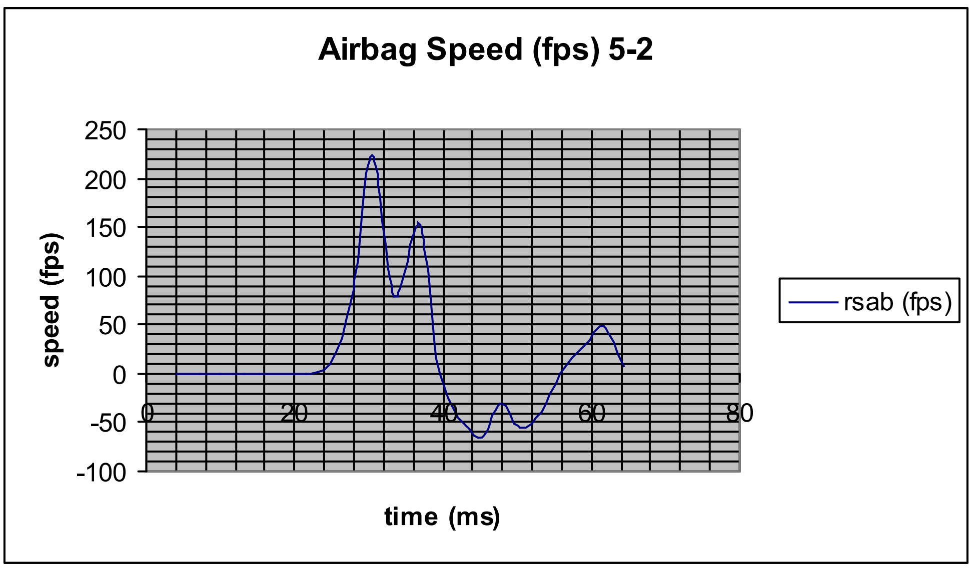

SPEED OF CAR 5-1
8
7
6
5
4
3
2
1
0
-1
0
10
20
30
40
50
60
70
speed (fps)
time (ms)
sc
rsd

Case 5-2:

t	dp	rasb (ips)	rddt	rsd	rdd	dd	sc	rsab (fps)
4.077	0	0	0.008	0.328	0.008	18	6.674	0
7.277	0	0	0.032	0.914	0.024	17.968	6.158	0
10.077	0	0	0.071	1.397	0.039	17.929	5.708	0
13.277	0	0	0.134	1.88	0.063	17.866	5.192	0
15.477	0	0	0.189	2.315	0.055	17.811	4.838	0
19.877	0	0	0.325	2.846	0.136	17.675	4.13	0
21.677	0	0	0.392	3.345	0.067	17.608	3.84	0
24.677	0.5	122.639	0.519	3.731	0.127	17.481	3.357	10.21991
27.677	3.5	937.5	0.663	4.214	0.143	17.337	2.874	78.125
30.477	11	2678.572	0.812	4.681	0.149	17.188	2.423	223.2143
33.277	14	937.5	0.977	5.132	0.165	17.023	1.972	78.125
36.877	18	1818.182	1.21	5.647	0.233	16.79	1.393	151.5151
39.677	18	0	1.408	6.163	0.198	16.592	0.942	0
44.677	16.6	-777.778	1.797	6.79	0.389	16.203	0.137	-64.8143
47.677	15.5	-366.667	2.05	7.261	0.253	15.95	0	-30.5558
50.477	13.5	-666.667	2.295	7.33	0.245	15.705	0	-55.5558
53.277	12.2	-464.286	2.541	7.33	0.246	15.459	0	-38.6905
55.677	12.2	0	2.752	7.33	0.211	15.248	0	0
58.877	13.4	333.333	3.034	7.33	0.281	14.966	0	27.77775
61.677	15	571.429	3.28	7.33	0.246	14.72	0	47.61908
64.477	15.5	100	3.526	7.33	0.246	14.474	0	8.333333

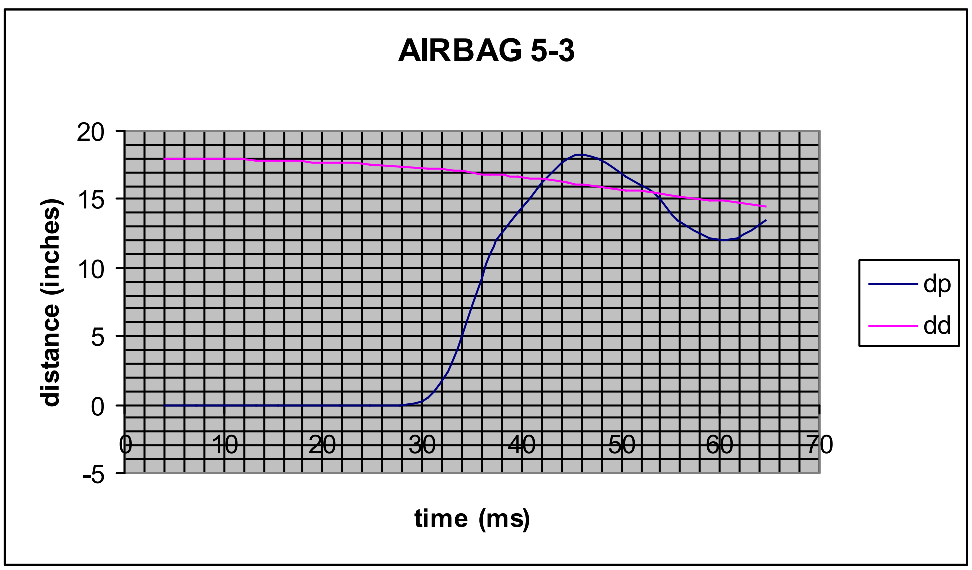


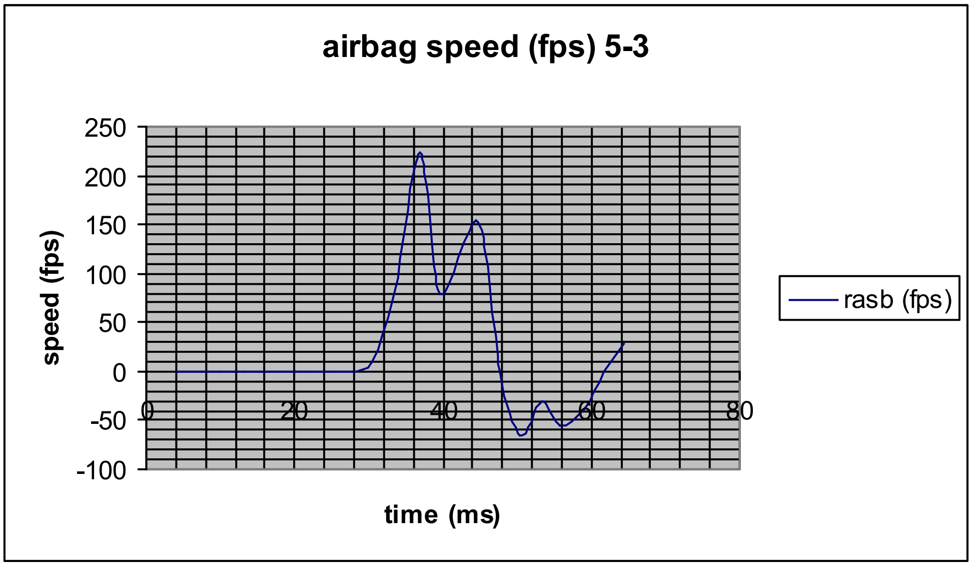

Speed of Car and Driver, 5-2
speed (fps)
8
7
6
5
4
3
2
1
0
-1
0
10
20
30
40
50
60
70
time (ms)
rsd
sc

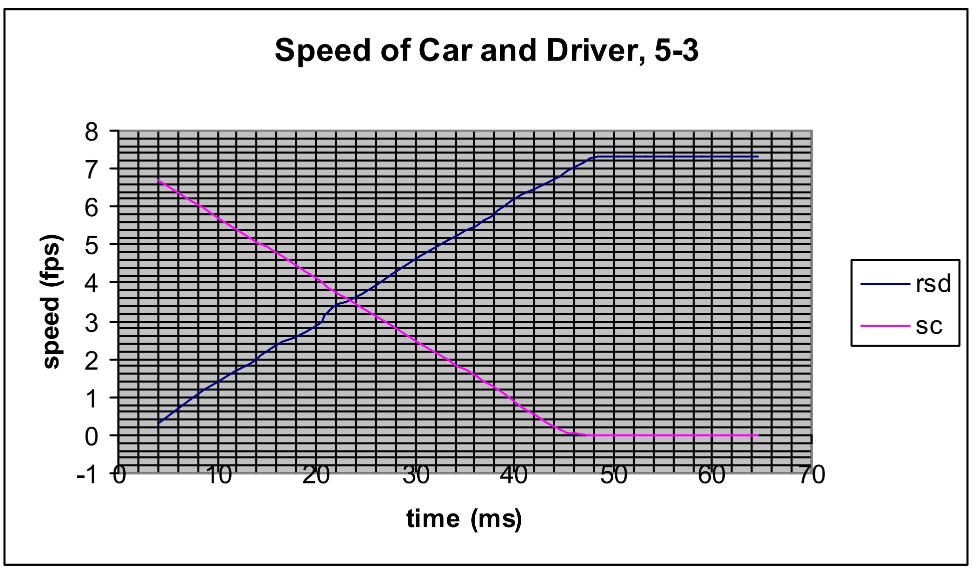

Airbag Speed (fps) 5-2
speed (fps)
250
200
150
100
50
0
-50
-100
0
20
40
60
80
time (ms)
rsab (fps)

Case 5-3:

t	dp	rasb (ips)	rddt	rsd	rdd	dd	sc	rasb (fps)
4.077	0	0	0.008	0.328	0.008	18	6.674	0
7.277	0	0	0.032	0.914	0.024	17.968	6.158	0
10.077	0	0	0.071	1.397	0.039	17.929	5.708	0
13.277	0	0	0.134	1.88	0.063	17.866	5.192	0
15.477	0	0	0.189	2.315	0.055	17.811	4.838	0
19.877	0	0	0.325	2.846	0.136	17.675	4.13	0
21.677	0	0	0.392	3.345	0.067	17.608	3.84	0
24.677	0	0	0.519	3.731	0.127	17.481	3.357	0
27.677	0	0	0.663	4.214	0.143	17.337	2.874	0
30.477	0.5	122.639	0.812	4.681	0.149	17.188	2.423	10.21991
33.277	3.5	937.5	0.977	5.132	0.165	17.023	1.972	78.125
36.877	11	2678.572	1.21	5.647	0.233	16.79	1.393	223.2143
39.677	14	937.5	1.408	6.163	0.198	16.592	0.942	78.125
44.677	18	1818.182	1.797	6.79	0.389	16.203	0.137	151.5151
47.677	18	0	2.05	7.261	0.253	15.95	0	0
50.477	16.6	-777.778	2.295	7.33	0.245	15.705	0	-64.8143
53.277	15.5	-366.667	2.541	7.33	0.246	15.459	0	-30.5558
55.677	13.5	-666.667	2.752	7.33	0.211	15.248	0	-55.5558
58.877	12.2	-464.286	3.034	7.33	0.281	14.966	0	-38.6905
61.677	12.2	0	3.28	7.33	0.246	14.72	0	0
64.477	13.4	333.333	3.526	7.33	0.246	14.474	0	27.77775

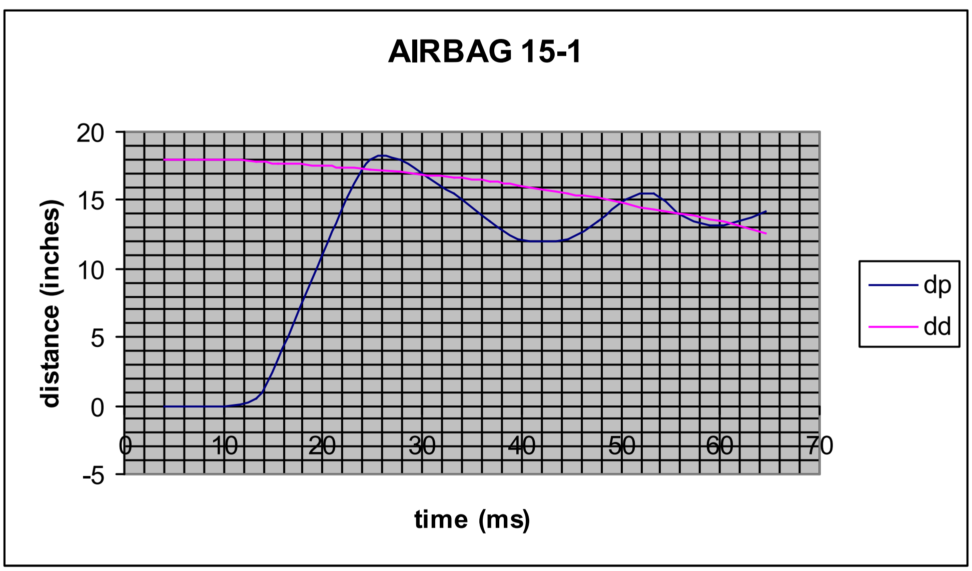


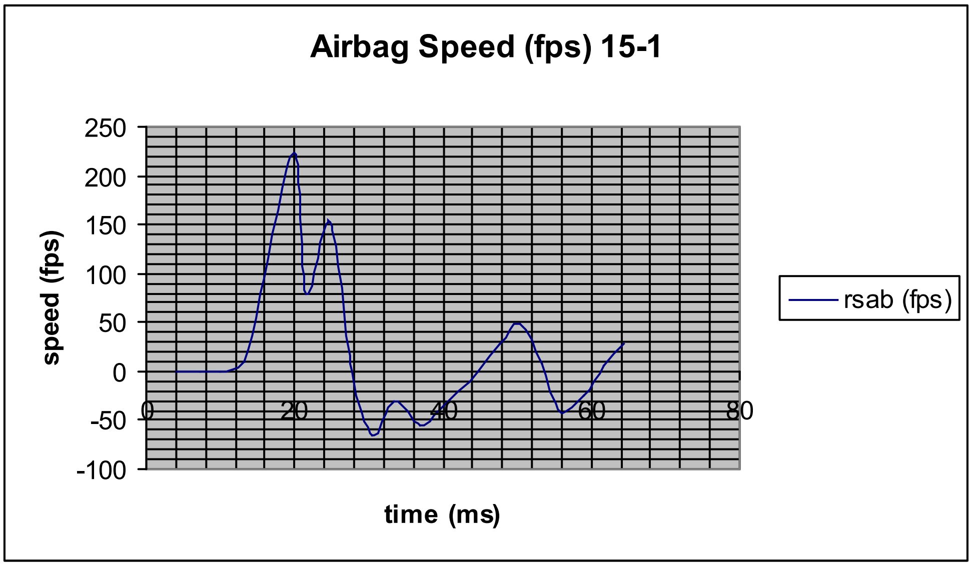

airbag speed (fps) 5-3
250
200
150
100
50
0
-50
-100
0
20
40
60
80
speed (fps)
time (ms)
rasb (fps)

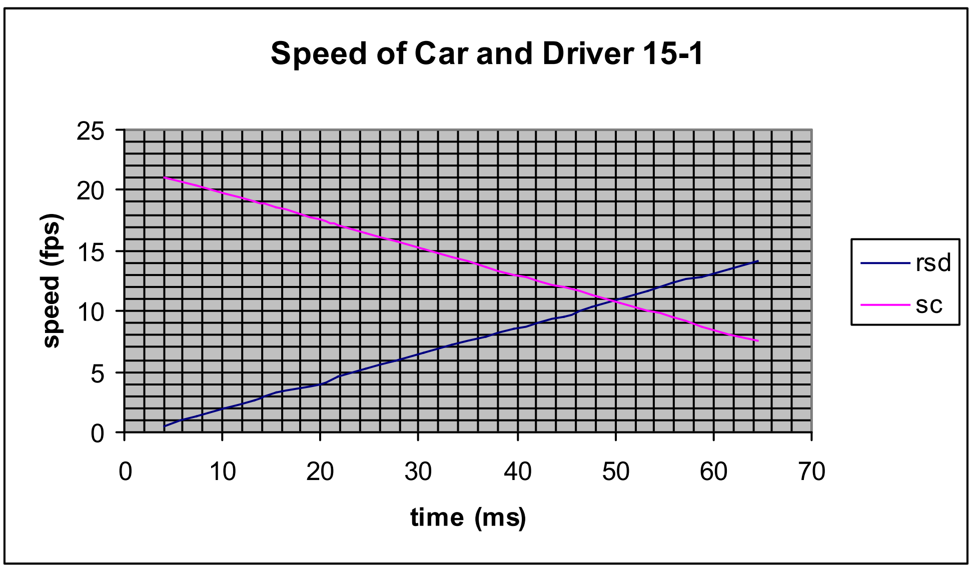

Speed of Car and Driver, 5-3
8
7
6
5
4
3
2
1
0
-1
0
10
20
30
40
50
60
70
speed (fps)
time (ms)
rsd
sc

Case 15-1:

t	dp	rsab (ips)	rddt	rsd	rdd	dd	sc	rsab (fps)
4.077	0	0	0.011	0.459	0.011	18	21.083	0
7.277	0	0	0.045	1.277	0.033	17.955	20.363	0
10.077	0	0	0.099	1.952	0.054	17.901	19.733	0
13.277	0.5	122.639	0.187	2.627	0.088	17.813	19.013	10.21992
15.477	3.5	937.5	0.264	3.235	0.077	17.736	18.518	78.125
19.877	11	2678.572	0.455	3.977	0.19	17.545	17.528	223.2143
21.677	14	937.5	0.548	4.675	0.093	17.452	17.123	78.125
24.677	18	1818.182	0.726	5.215	0.178	17.274	16.448	151.5152
27.677	18	0	0.926	5.89	0.2	17.074	15.773	0
30.477	16.6	-777.778	1.135	6.542	0.209	16.865	15.143	-64.8148
33.277	15.5	-366.667	1.365	7.172	0.23	16.635	14.513	-30.5556
36.877	13.5	-666.667	1.691	7.892	0.325	16.309	13.703	-55.5556
39.677	12.2	-464.286	1.968	8.612	0.277	16.032	13.073	-38.6905
44.677	12.2	0	2.511	9.49	0.543	15.489	11.948	0
47.677	13.4	333.333	2.869	10.39	0.358	15.131	11.273	27.77775
50.477	15	571.429	3.229	11.042	0.36	14.771	10.643	47.61908
53.277	15.5	100	3.61	11.672	0.382	14.39	10.013	8.333333
55.677	14	-500	3.955	12.257	0.345	14.045	9.473	-41.6667
58.877	13.2	-285.714	4.438	12.887	0.483	13.562	8.753	-23.8095
61.677	13.4	71.429	4.882	13.562	0.444	13.118	8.123	5.952417
64.477	14.2	333.334	5.348	14.192	0.466	12.652	7.493	27.77783

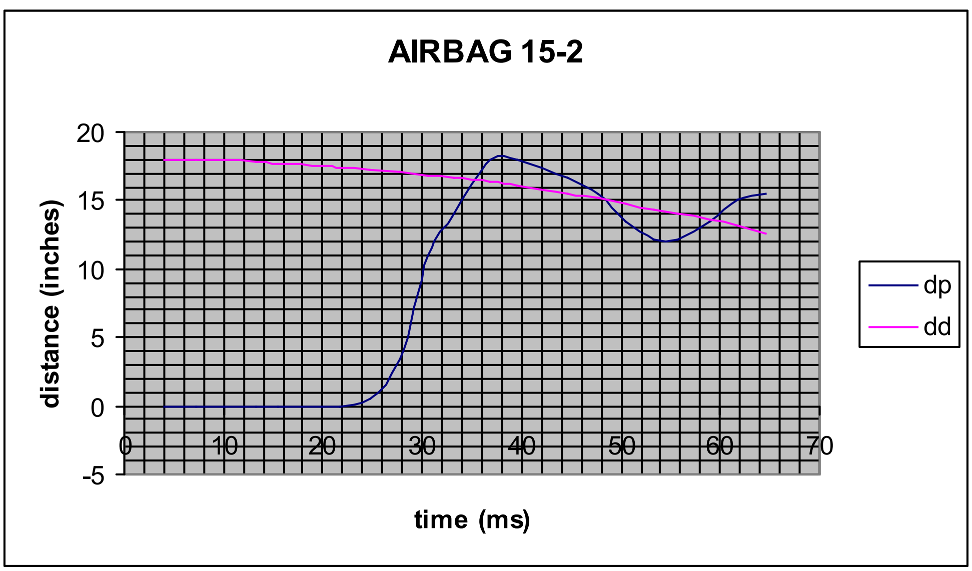


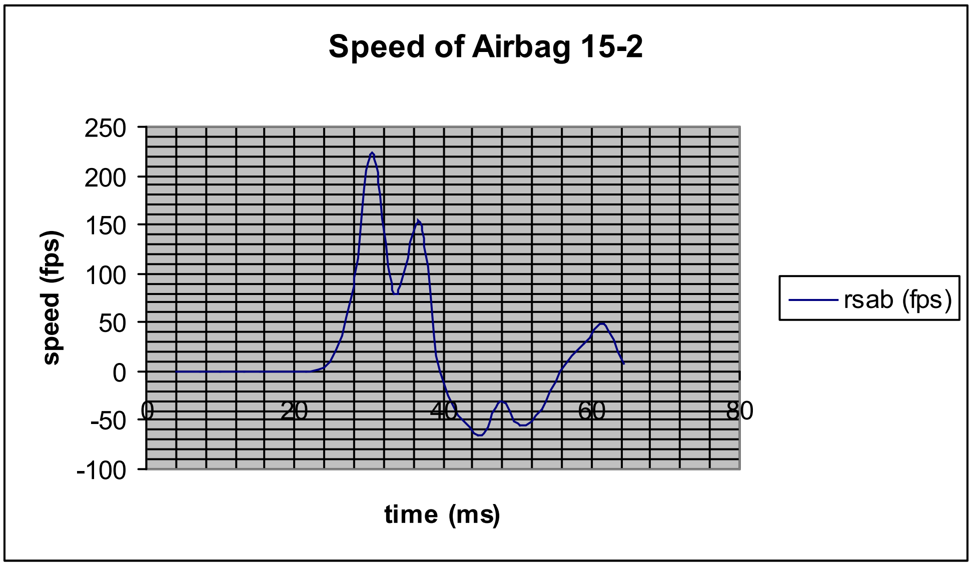

Airbag Speed (fps) 15-1
250
200
150
100
50
0
-50
-100
0
20
40
60
80
speed (fps)
time (ms)
rsab (fps)

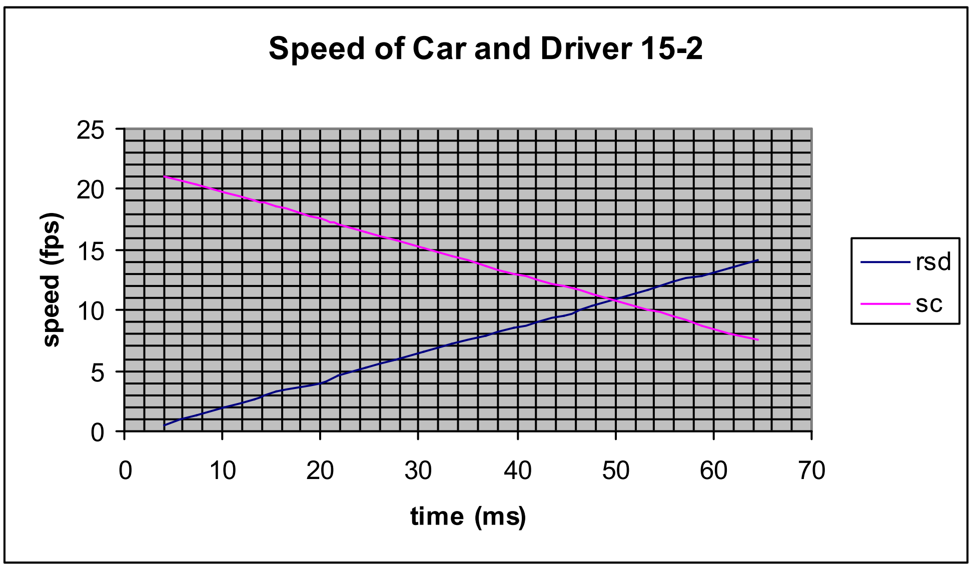

Speed of Car and Driver 15-1
25
20
15
10
5
0
0
10
20
30
40
50
60
70
speed (fps)
time (ms)
rsd
sc

Case 15-2:

t	dp	rsab (ips)	rddt	rsd	rdd	dd	sc	rsab (fps)
4.077	0	0	0.011	0.459	0.011	18	21.083	0
7.277	0	0	0.045	1.277	0.033	17.955	20.363	0
10.077	0	0	0.099	1.952	0.054	17.901	19.733	0
13.277	0	0	0.187	2.627	0.088	17.813	19.013	0
15.477	0	0	0.264	3.235	0.077	17.736	18.518	0
19.877	0	0	0.455	3.977	0.19	17.545	17.528	0
21.677	0	0	0.548	4.675	0.093	17.452	17.123	0
24.677	0.5	122.639	0.726	5.215	0.178	17.274	16.448	10.21992
27.677	3.5	937.5	0.926	5.89	0.2	17.074	15.773	78.125
30.477	11	2678.572	1.135	6.542	0.209	16.865	15.143	223.2143
33.277	14	937.5	1.365	7.172	0.23	16.635	14.513	78.125
36.877	18	1818.182	1.691	7.892	0.325	16.309	13.703	151.5152
39.677	18	0	1.968	8.612	0.277	16.032	13.073	0
44.677	16.6	-777.778	2.511	9.49	0.543	15.489	11.948	-64.8148
47.677	15.5	-366.667	2.869	10.39	0.358	15.131	11.273	-30.5556
50.477	13.5	-666.667	3.229	11.042	0.36	14.771	10.643	-55.5556
53.277	12.2	-464.286	3.61	11.672	0.382	14.39	10.013	-38.6905
55.677	12.2	0	3.955	12.257	0.345	14.045	9.473	0
58.877	13.4	333.333	4.438	12.887	0.483	13.562	8.753	27.77775
61.677	15	571.429	4.882	13.562	0.444	13.118	8.123	47.61908
64.477	15.5	100	5.348	14.192	0.466	12.652	7.493	8.333333

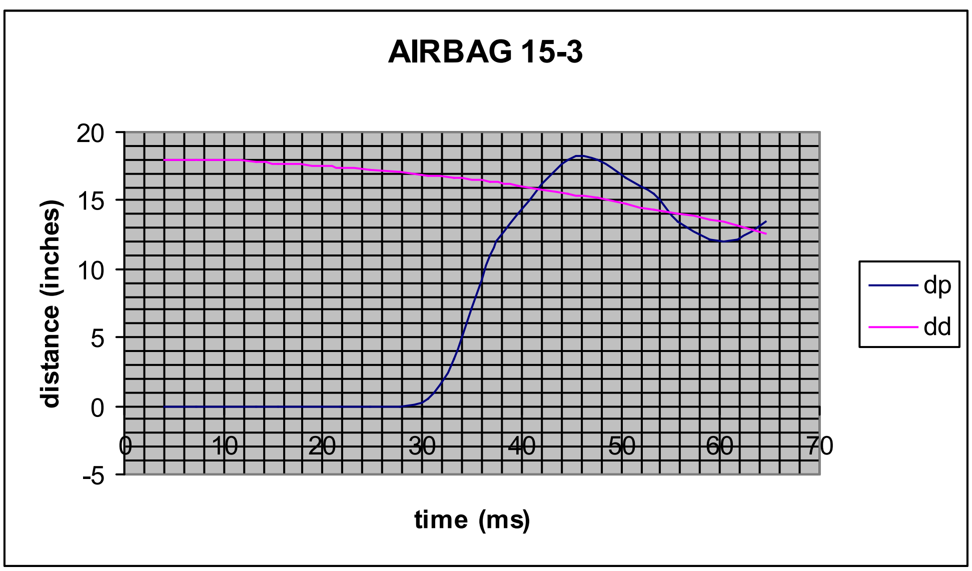


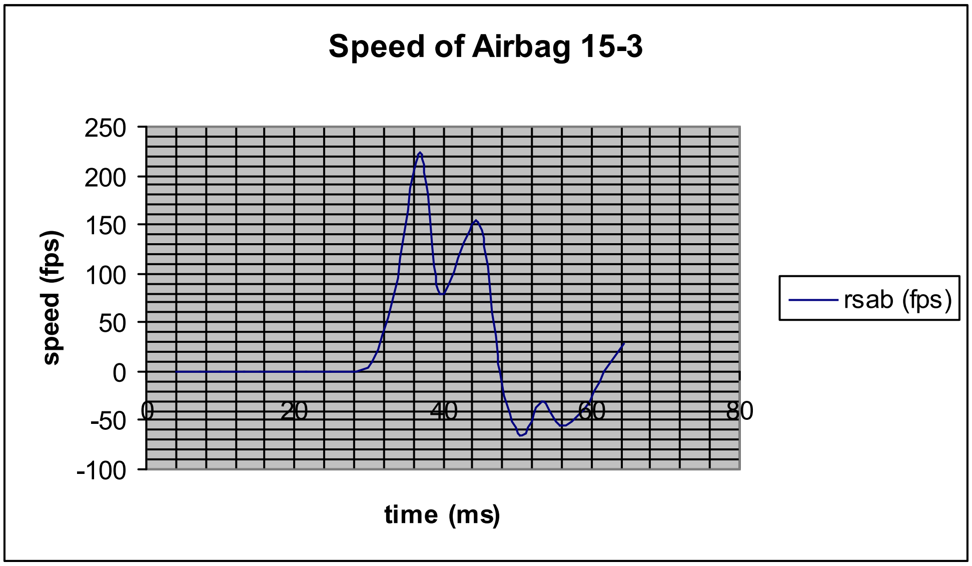

Speed of Airbag 15-2
speed (fps)
250
200
150
100
50
0
-50
-100
0
20
40
60
80
time (ms)
rsab (fps)

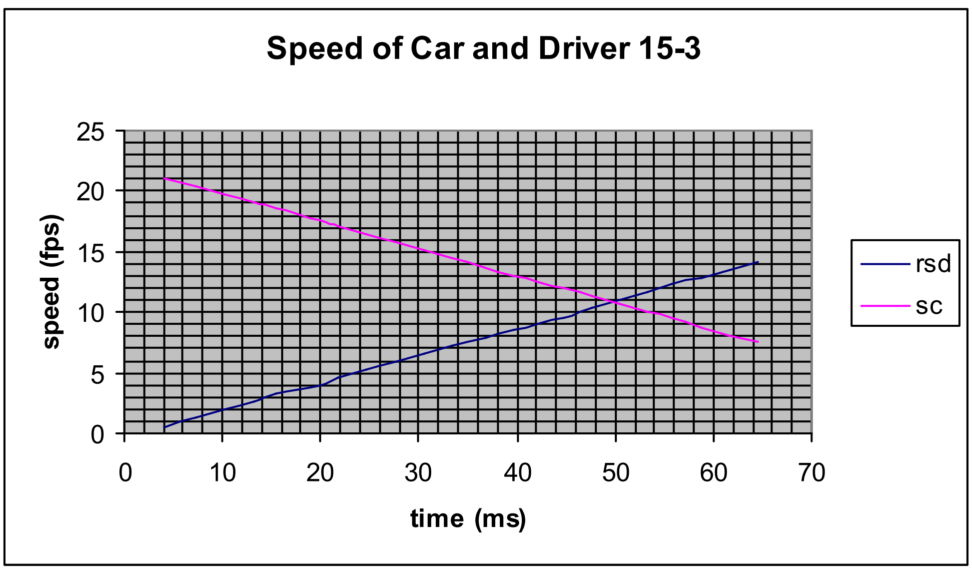

Speed of Car and Driver 15-2
speed (fps)
25
20
15
10
5
0
0
10
20
30
40
50
60
70
time (ms)
rsd
sc

Case 15-3:

t	dp	rsab (ips)	rddt	rsd	rdd	dd	sc	rsab (fps)
4.077	0	0	0.011	0.459	0.011	18	21.083	0
7.277	0	0	0.045	1.277	0.033	17.955	20.363	0
10.077	0	0	0.099	1.952	0.054	17.901	19.733	0
13.277	0	0	0.187	2.627	0.088	17.813	19.013	0
15.477	0	0	0.264	3.235	0.077	17.736	18.518	0
19.877	0	0	0.455	3.977	0.19	17.545	17.528	0
21.677	0	0	0.548	4.675	0.093	17.452	17.123	0
24.677	0	0	0.726	5.215	0.178	17.274	16.448	0
27.677	0	0	0.926	5.89	0.2	17.074	15.773	0
30.477	0.5	122.639	1.135	6.542	0.209	16.865	15.143	10.21992
33.277	3.5	937.5	1.365	7.172	0.23	16.635	14.513	78.125
36.877	11	2678.572	1.691	7.892	0.325	16.309	13.703	223.2143
39.677	14	937.5	1.968	8.612	0.277	16.032	13.073	78.125
44.677	18	1818.182	2.511	9.49	0.543	15.489	11.948	151.5152
47.677	18	0	2.869	10.39	0.358	15.131	11.273	0
50.477	16.6	-777.778	3.229	11.042	0.36	14.771	10.643	-64.8148
53.277	15.5	-366.667	3.61	11.672	0.382	14.39	10.013	-30.5556
55.677	13.5	-666.667	3.955	12.257	0.345	14.045	9.473	-55.5556
58.877	12.2	-464.286	4.438	12.887	0.483	13.562	8.753	-38.6905
61.677	12.2	0	4.882	13.562	0.444	13.118	8.123	0
64.477	13.4	333.333	5.348	14.192	0.466	12.652	7.493	27.77775

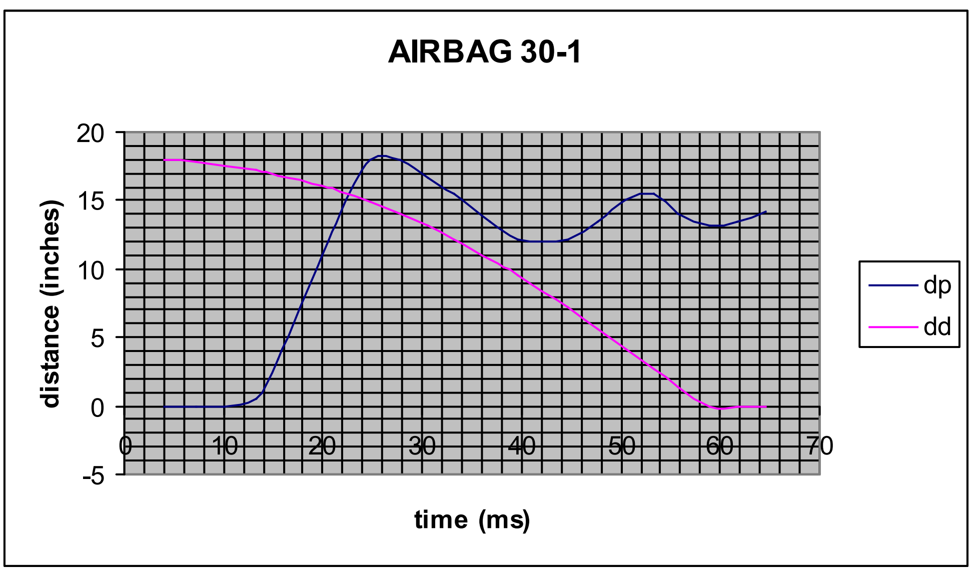


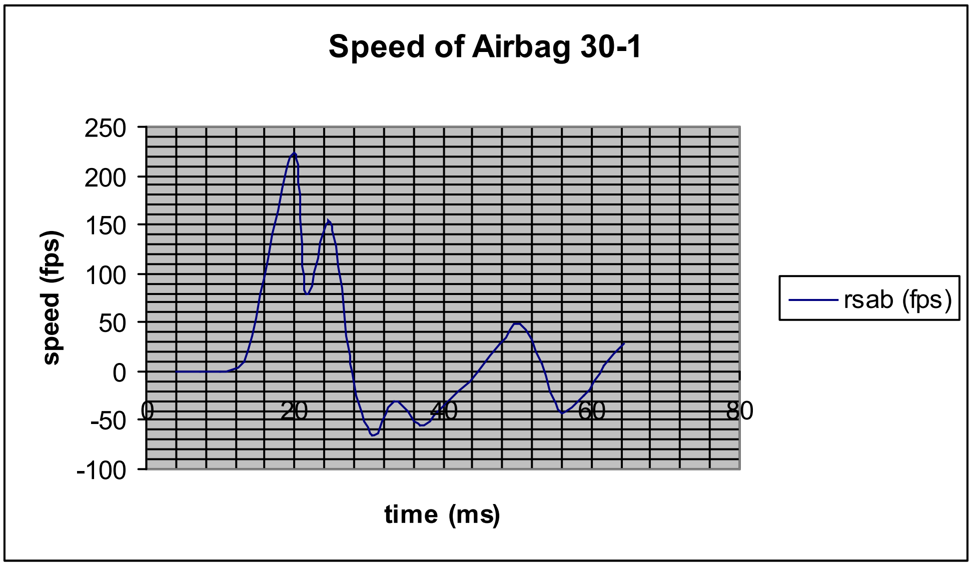

Speed of Airbag 15-3
250
200
150
100
50
0
-50
-100
speed (fps)
0
20
40
60
80
time (ms)
rsab (fps)

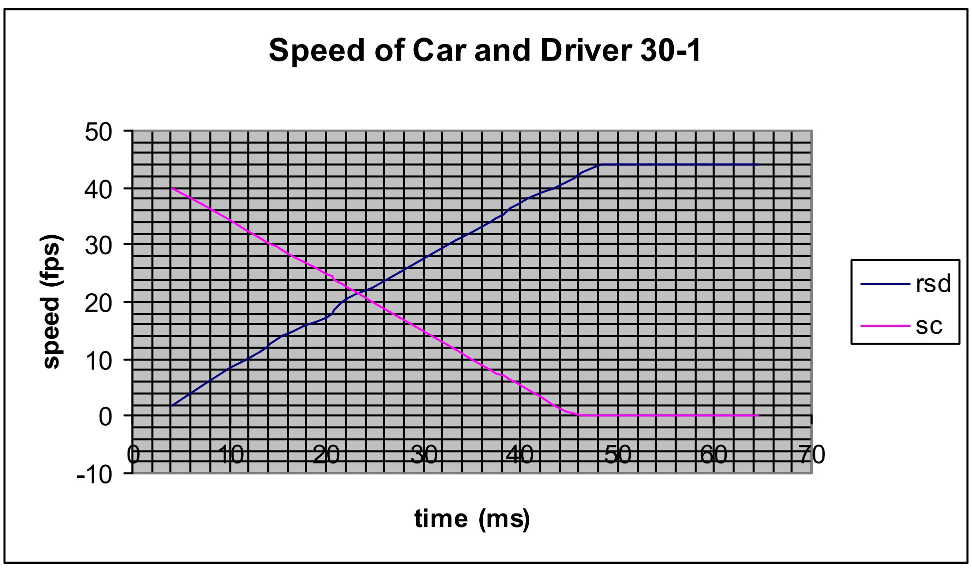

Speed of Car and Driver 15-3
25
20
15
10
5
0
speed (fps)
0
10
20
30
40
50
60
70
time (ms)
rsd
sc

Case 30-1:

t	dp	rsab (ips)	rddt	rsd	rdd	dd	sc	rsab (fps)
4.077	0	0	0.048	1.973	0.048	18	40.053	0
7.277	0	0	0.192	5.495	0.143	17.808	36.956	0
10.077	0	0	0.425	8.399	0.233	17.575	34.245	0
13.277	0.5	122.639	0.803	11.303	0.378	17.197	31.148	10.21992
15.477	3.5	937.5	1.136	13.917	0.333	16.864	29.018	78.125
19.877	11	2678.572	1.955	17.111	0.819	16.045	24.759	223.2143
21.677	14	937.5	2.357	20.112	0.402	15.643	23.017	78.125
24.677	18	1818.182	3.123	22.435	0.766	14.877	20.113	151.5152
27.677	18	0	3.983	25.339	0.86	14.017	17.209	0
30.477	16.6	-777.778	4.882	28.147	0.899	13.118	14.498	-64.8148
33.277	15.5	-366.667	5.873	30.857	0.991	12.127	11.788	-30.5556
36.877	13.5	-666.667	7.273	33.955	1.4	10.727	8.303	-55.5556
39.677	12.2	-464.286	8.466	37.052	1.193	9.534	5.593	-38.6905
44.677	12.2	0	10.802	40.827	2.336	7.198	0.753	0
47.677	13.4	333.333	12.322	43.624	1.52	5.678	0	27.77775
50.477	15	571.429	13.794	44	1.472	4.206	0	47.61908
53.277	15.5	100	15.273	44	1.478	2.727	0	8.333333
55.677	14	-500	16.54	44	1.267	1.46	0	-41.6667
58.877	13.2	-285.714	18	44	1.69	0	0	-23.8095
61.677	13.4	71.429	18	44	1.478	0	0	5.952417
64.477	14.2	333.334	18	44	1.478	0	0	27.77783

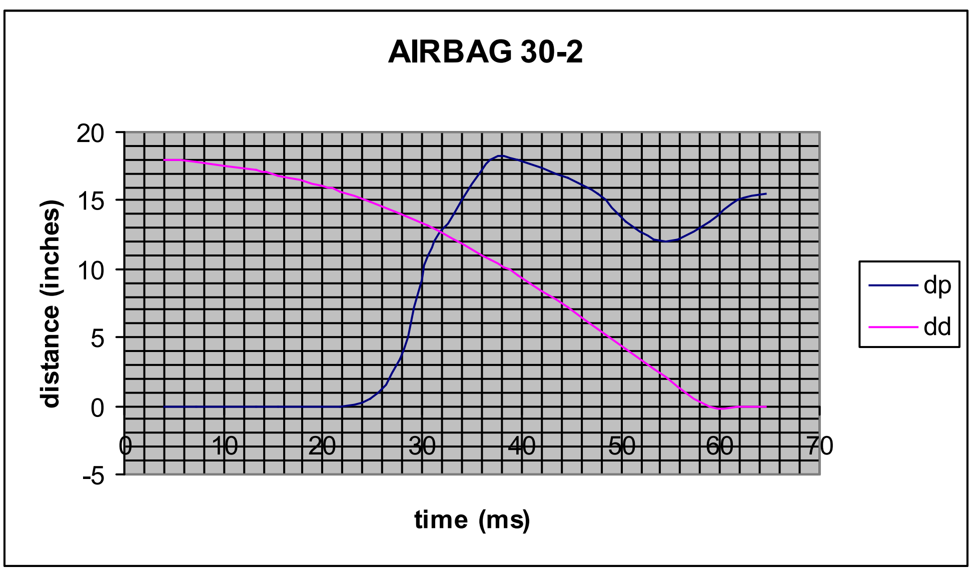


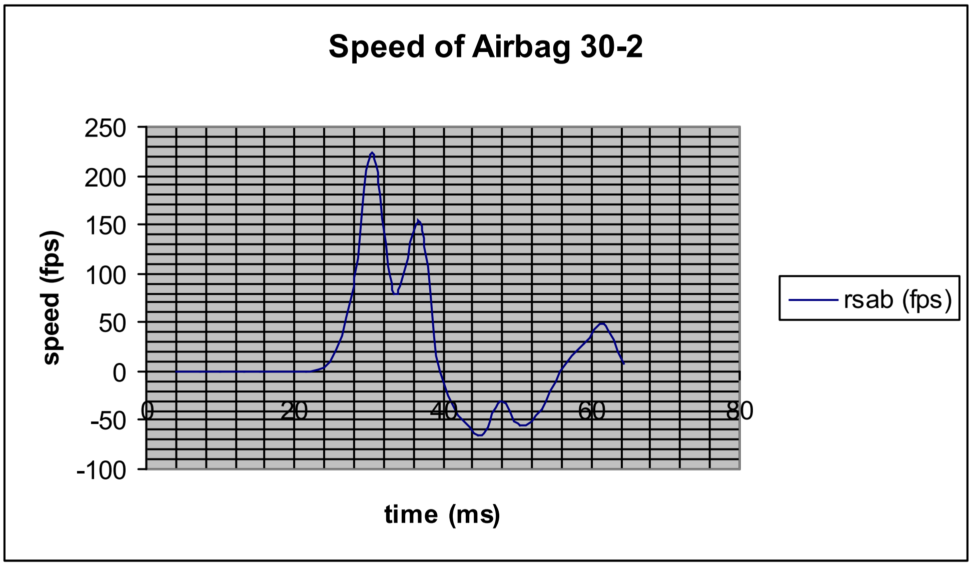

Speed of Airbag 30-1
250
200
150
100
50
0
-50
-100
0
20
40
60
80
speed (fps)
time (ms)
rsab (fps)

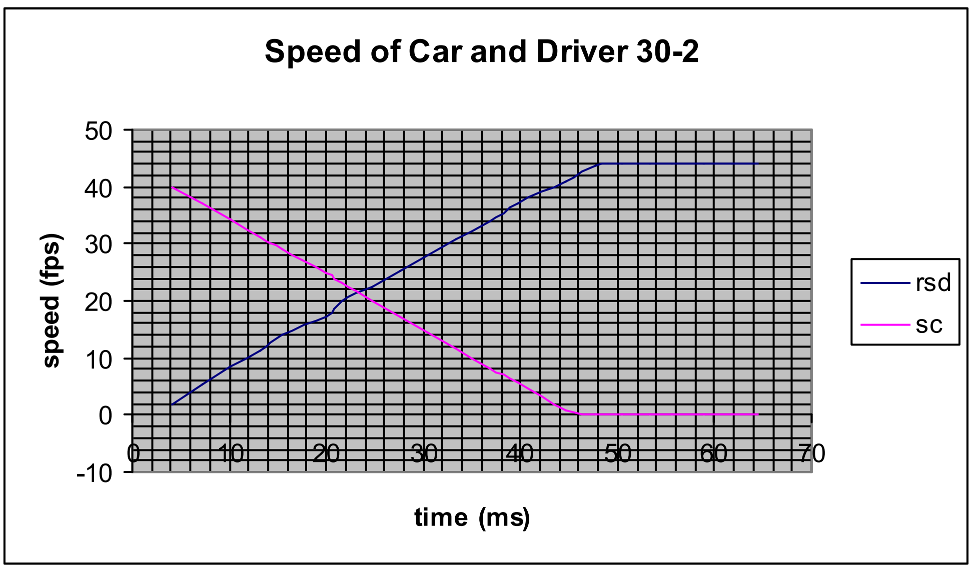

Speed of Car and Driver 30-1
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
speed (fps)
time (ms)
rsd
sc

Case 30-2:

t	dp	rsab (ips)	rddt	rsd	rdd	dd	sc	rsab (fps)
4.077	0	0	0.048	1.973	0.048	18	40.053	0
7.277	0	0	0.192	5.495	0.143	17.808	36.956	0
10.077	0	0	0.425	8.399	0.233	17.575	34.245	0
13.277	0	0	0.803	11.303	0.378	17.197	31.148	0
15.477	0	0	1.136	13.917	0.333	16.864	29.018	0
19.877	0	0	1.955	17.111	0.819	16.045	24.759	0
21.677	0	0	2.357	20.112	0.402	15.643	23.017	0
24.677	0.5	122.639	3.123	22.435	0.766	14.877	20.113	10.21992
27.677	3.5	937.5	3.983	25.339	0.86	14.017	17.209	78.125
30.477	11	2678.572	4.882	28.147	0.899	13.118	14.498	223.2143
33.277	14	937.5	5.873	30.857	0.991	12.127	11.788	78.125
36.877	18	1818.182	7.273	33.955	1.4	10.727	8.303	151.5152
39.677	18	0	8.466	37.052	1.193	9.534	5.593	0
44.677	16.6	-777.778	10.802	40.827	2.336	7.198	0.753	-64.8148
47.677	15.5	-366.667	12.322	43.624	1.52	5.678	0	-30.5556
50.477	13.5	-666.667	13.794	44	1.472	4.206	0	-55.5556
53.277	12.2	-464.286	15.273	44	1.478	2.727	0	-38.6905
55.677	12.2	0	16.54	44	1.267	1.46	0	0
58.877	13.4	333.333	18	44	1.69	0	0	27.77775
61.677	15	571.429	18	44	1.478	0	0	47.61908
64.477	15.5	100	18	44	1.478	0	0	8.333333

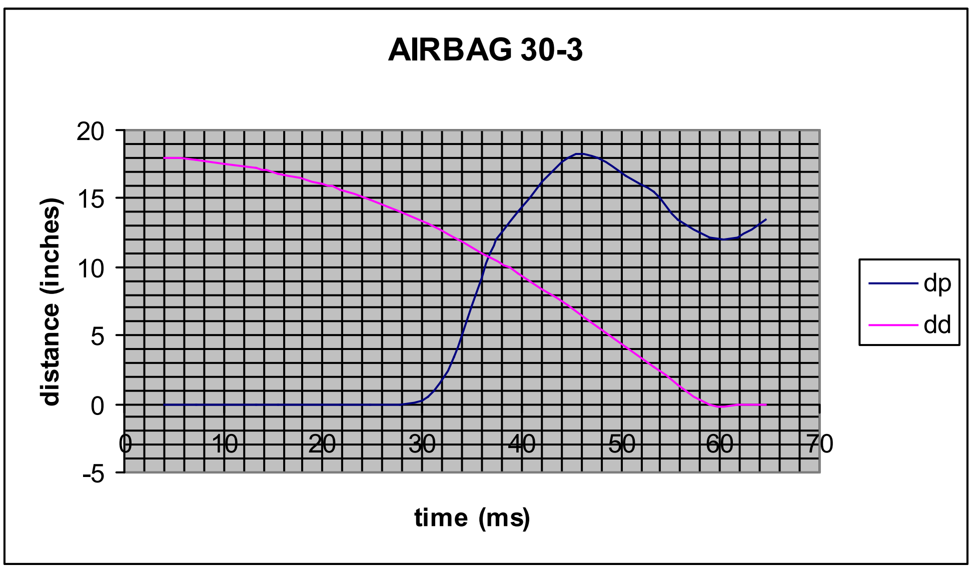


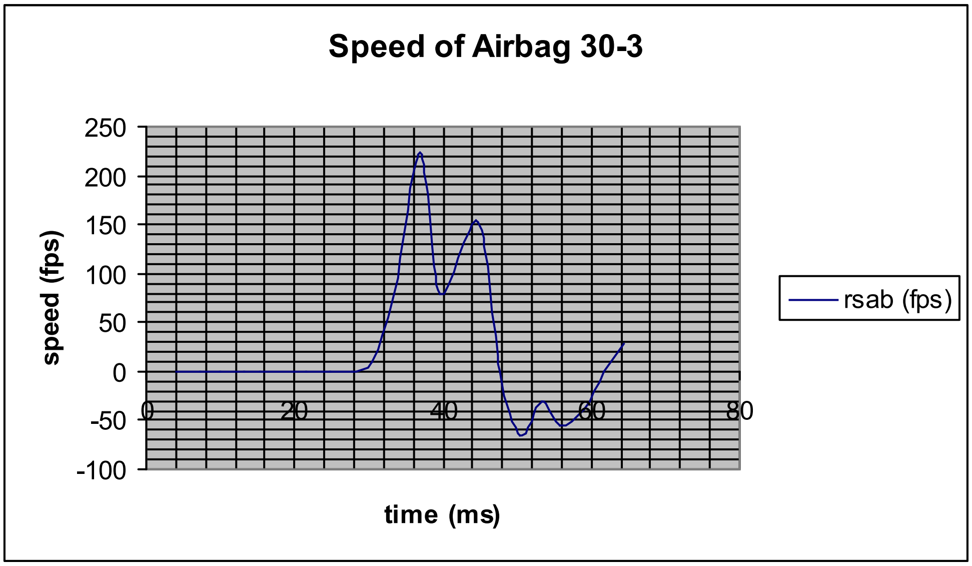

Speed of Airbag 30-2
250
200
150
100
50
0
-50
-100
0
20
40
60
80
speed (fps)
time (ms)
rsab (fps)

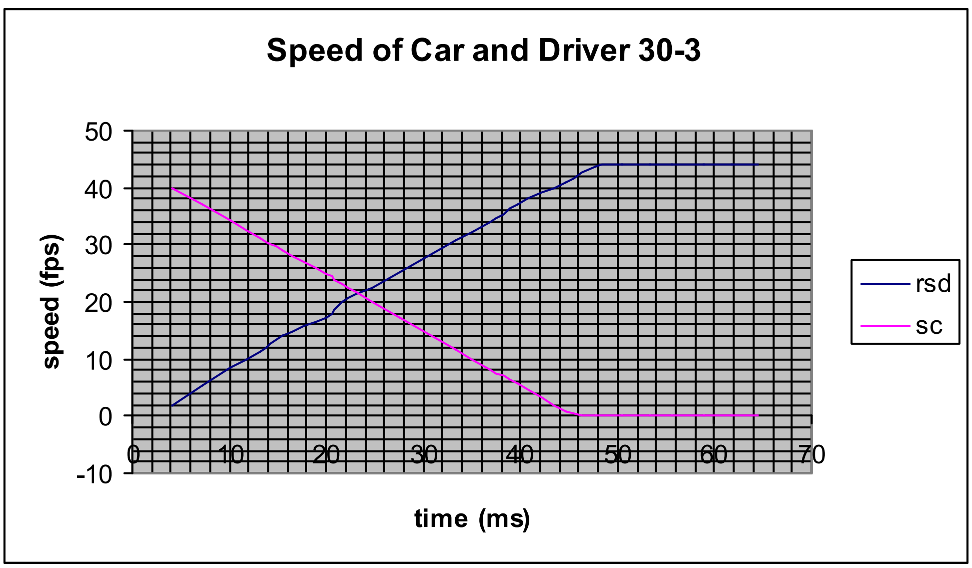

Speed of Car and Driver 30-2
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
speed (fps)
time (ms)
rsd
sc

Case 30-3:

t	dp	rsab(fps)	rddt	rsd	rdd	dd	sc	rsab(fps)
4.077	0	0	0.048	1.973	0.048	18	40.053	0
7.277	0	0	0.192	5.495	0.143	17.808	36.956	0
10.077	0	0	0.425	8.399	0.233	17.575	34.245	0
13.277	0	0	0.803	11.303	0.378	17.197	31.148	0
15.477	0	0	1.136	13.917	0.333	16.864	29.018	0
19.877	0	0	1.955	17.111	0.819	16.045	24.759	0
21.677	0	0	2.357	20.112	0.402	15.643	23.017	0
24.677	0	0	3.123	22.435	0.766	14.877	20.113	0
27.677	0	0	3.983	25.339	0.86	14.017	17.209	0
30.477	0.5	122.639	4.882	28.147	0.899	13.118	14.498	10.21992
33.277	3.5	937.5	5.873	30.857	0.991	12.127	11.788	78.125
36.877	11	2678.572	7.273	33.955	1.4	10.727	8.303	223.2143
39.677	14	937.5	8.466	37.052	1.193	9.534	5.593	78.125
44.677	18	1818.182	10.802	40.827	2.336	7.198	0.753	151.5152
47.677	18	0	12.322	43.624	1.52	5.678	0	0
50.477	16.6	-777.778	13.794	44	1.472	4.206	0	-64.8148
53.277	15.5	-366.667	15.273	44	1.478	2.727	0	-30.5556
55.677	13.5	-666.667	16.54	44	1.267	1.46	0	-55.5556
58.877	12.2	-464.286	18	44	1.69	0	0	-38.6905
61.677	12.2	0	18	44	1.478	0	0	0
64.477	13.4	333.333	18	44	1.478	0	0	27.77775




Speed of Airbag 30-3
250
200
150
100
50
0
-50
-100
0
20
40
60
80
speed (fps)
time (ms)
rsab (fps)


Speed of Car and Driver 30-3
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
speed (fps)
time (ms)
rsd
sc