Airbag technote 1

This isn't meant to be a scientific paper or anything. We just thought we'd take a look to see what would happen to a driver in the NHTSA dummy test video if the car was equipped with airbags instead of seatbelts. As you may recall, that was the original justification put forward for airbags - they were supposed to save drivers (or passengers) in an accident if they weren't wearing seatbelts. Just to refresh your memory, in the video a test vehicle, supposed to represent a car, is driven perpendicularly into a concrete wall, with about a foot of crush resulting in the front of the vehicle. We inquired several times how fast the test vehicle was going when it hit and were variously told 30 or 35 mph. Just to be on the conservative side, we assume 30 mph. Since such accidents almost never happen (in seven years of studying accident reports we've never actually come across such an accident) this is mainly of academic interest; but it does show that if the driver or passenger is thrown directly forward in a collision, he may be hit by the airbag while it is still expanding.

In order to get some idea of what happens, we wrote a quick and dirty computer program and ran it through a fortran compiler. The program, the input data and the output are shown on the following pages.

We were fortunate to find experimental data from an actual airbag deployment (1). Referring to the first graph on page 4, the blue line represents the position of the front of the airbag as a function of time, given as the distance from the steering wheel, in inches. The time is in milliseconds. The red line shows the position of the driver, also in inches from the steering wheel (from which the airbag deploys). As you can see from the graph, the driver gets slammed by the airbag before he's moved even two inches. The rest of the red line is, therefore, irrelevant. It merely shows the how the driver would have moved if there had been no airbag. The initial position of the driver is assumed to be 18 inches from the steering wheel. This is based on actual measurements from a number of popular car models. The driver is assumed to continue moving forward at 44 fps after the collision, in accordance with Newton's first law of motion.

The second graph shows the speed of the front of the airbag as a function of time. This was obtained by breaking up a slow motion video of an airbag deployment into a series of still pictures, roughly one every three milliseconds, and measuring the position of the airbag as a function of time and space. As we can see from the second graph, the front of the airbag is travelling forward at roughly 125 fps when it strikes the driver.

1. Airbag data courtesy of Biodynamics, Inc.

```
      program airbag1
      integer n
      real rsab(21), sc(21), rsd(21), asc(21), rdd(21), arsd(21),
     +t(21), d(21), rddt(21), rddto, rddo, dc, sd, sco
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
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 initital speed of
C   car

      dc=0.986
      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 10 n=1,21
      PRINT 6,t(n),d(n)
    6 FORMAT(1X,'t=',F7.3,3X,'d=',F6.1)
   10 CONTINUE
      rsab(1)=d(1)*1000/t(1)
      DO 15 n=2,21
      rsab(n)=(d(n)-d(n-1))*1000/(t(n)-t(n-1))
      sc(1)=sco-0.968*t(1)
      sc(n)=sco-0.968*t(n)
      asc(1)=(sc(1)+sco)/2.0
      asc(n)=(sc(n)+sc(n-1))/2.0
      rsd(1)=sd-sc(1)
      rsd(n)=sd-sc(n)
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```
   arsd(1)=rsd(1)/2.0
   arsd(n)=(rsd(n)+rsd(n-1))/2.0
   rdd(1)=arsd(1)*t(1)*0.012
   rdd(n)=arsd(n)*(t(n)-t(n-1))*0.012
   rddt(1)=rdd(1)
   rddt(n)=rddt(n-1)+rdd(n)
15  CONTINUE
   PRINT 20
20  FORMAT('',T6,'t',T16,'d',T24,'rsab',T36,'rddt',T46,'rsd',
  +       T56,'rdd')
   DO 30 n=1,21
   PRINT 25, t(n),d(n),rsab(n),rddt(n),rsd(n),rdd(n)
25  FORMAT(2X,F7.3,3X,F5.1,4X,F8.3,3X,F7.3,3X,F7.3,3X,F7.3)
30  CONTINUE
   END
```

t	d	rsab	rddt	rsd	rdd	18-rddt
4.077	0.5	122.639	0.097	3.947	0.097	17.903
7.277	3.5	937.5	0.308	7.044	0.211	17.692
10.077	11	2678.572	0.59	9.755	0.282	17.41
13.277	14	937.5	1.024	12.852	0.434	16.976
15.477	18	1818.182	1.391	14.982	0.367	16.609
19.877	18	0	2.295	19.241	0.903	15.705
21.677	16.6	-777.778	2.729	20.983	0.434	15.271
24.677	15.5	-366.667	3.537	23.887	0.808	14.463
27.677	13.5	-666.667	4.449	26.791	0.912	13.551
30.477	12.2	-464.286	5.395	29.502	0.946	12.605
33.277	12.2	0	6.432	32.212	1.037	11.568
36.877	13.4	333.333	7.898	35.697	1.467	10.102
39.677	15	571.429	9.143	38.407	1.245	8.857
44.677	15.5	100	11.593	43.247	2.45	6.407
47.677	14	-500	13.202	46.151	1.609	4.798
50.477	13.2	-285.714	14.798	48.862	1.596	3.202
53.277	13.4	71.429	16.486	51.572	1.687	1.514
55.677	14.2	333.334	18.004	53.895	1.519	-0.004
58.877	14.9	218.75	20.133	56.993	2.129	-2.133
61.677	15	35.714	22.094	59.703	1.96	-4.094
64.477	14.2	-285.714	24.146	62.414	2.052	-6.146