PREPARED FOR

DOT/NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

ENGINEERING SYSTEMS STAFF

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WASHINGTON, D.C. 20590

ATTN.: BRUCE C. SPINNEY

- REPORT -

COMPARISON

MULTI- STAGE AIRBAG INFLATOR

VS.

SINGLE STAGE AIRBAG INFLATOR

PREPARED BY

LUDTKE & ASSOCIATES

6200 29 MILE ROAD

WASHINGTON, MI. 48094-1311

INTRODUCTION

A special request was made by NHTSA personnel at the Initial Meeting of the Task Order - 001 Project. This request consisted of a comparison between the variable manufacturing costs of a "new" airbag multi-stage inflator and a current state-of-art pyro airbag single stage inflator It was agreed that this comparison would be completed by December 1, 1997

The multi-stage inflator analysis was to be based on the TRW Automotive dual stage augmentation inflator. This inflator is currently in the prototype stage of development.

In order to meet the December 1. 1997, deadline, it was decided to base the pyro single stage inflator data from a NHTSA Mercedes-Benz Airbag Cost Analysis Project, previously conducted by Pioneer Engineering. The current BMW 528i airbag system is being analyzed under the current Task Order; however, because of delays in acquiring the inflator hardware it was decided that the cost data on these units would not be available by the deadline date. Mr. Ludtke was Manager of the Pioneer's Cost Analysis Department while the -Mercedes-Benz project was being conducted, therefore there is familiarity with the data.

The following paragraphs present the results of this effort in the Summary and pertinent assumptions and rationale are in the Discussion Section. A breakdown of these costs are included in the Discussion Section.

SUMMARY

The following results compare the variable manufacturing costs (in "97" doilars) and tooling costs of a single stage pyro inflator Vs a muiti-stage augmented inflator and its associated components required for functionality

	DRIVER		PASSENGER		TOTAL	
	Var. Mfg.	Tooling	Var. Mfg.	Tooling	Var. Mfg.	Tooling
• Mercedes-Ben& *) (Single Stage)	25.57	652.000	51 13	1,304,000	76 70	1,956,000
• TRW (Multi - Stage)	14.64	663,000	18.78	5 10,000	33.42	1,349,300
**Harness-Igniter	1 00	5,300				
**Support Br't Xssy	0.67	170,000				
**Incremental Cost (2 Add'l. Strands)	0.25					
Watch Spring Assy						
Total Driver	16 56	839,300				
• Difference Inflator Only (Merc-Benz - TRW)	9.01	-186,300	32.35	794,000	41.36	607,700
• Seat Switch*** (Merc-Benz)	9.48	134,913	9 48	134,912	18.36	269,524
• Difference Single Stage Inflator Vs Multi-Stage & Seat Switch	-0.47	-321.212	22.83	669,088	22.40	347,876

* The Mercedes-Benz system utilizes two driver airbag modules for the passenger side. This is the reason the passenger side is double the driver side,

** The single stage inflator does not have these components which are required for the Multi-stage Inflator

*** If the Multi-Stage Inflator is to operated from a seat switch then a seat switch would have to added to each seat, driver and passenger. This data is obtained from the Mercedes-Benz Seat Switch cost study conducted in 1996 for NHTSA by Ludtke & -Associates

The TRW system is a pre-pressurized container that includes two different solid propellant charges that can be fired in different sequences to provide the multi-level airbag pressures.

DISCUSSION

TRW Automotive provided actual prototype dual augmentation inflator units for this study. The prototypes consisted of one driver side dual stage augmented inflator, one passenger side dual stage augmented inflator and one single stage augmented inflator. Costs for these units were developed via the standard asset center costing methodology, starting with a Teardown analysis. The costs are based on 1997 Detroit. MI., automotive economics

The Mercedes-Benz costs were developed from a 1983 airbag cost analysis study conducted by Pioneer Engineering, Detroit, MI., for NHTSA. This study also utilized the standard asset center costing methodology. The summary cost charts on the inflator from that study were reviewed for correctness and consistency of data. The corrected charts were then changed to reflect 1997 Detroit area labor and material rates. In some cases, consideration was given to reflect productivity improvements. These data were then summarized to arrive at the above total costs.

It should be noted that, independently, Bruce Spinney, NHTSA, evaluated data from the "Statistical Abstract of the U.S., 1996 Edition" (NHTSA library) to arrive at a multiplier factor to upgrade costs (from the Mercedes-Benz study) from 1982 to 1997 The multiplier factor was 1 391. The resulting, comparative factor resulting from revising labor and material costs on the Mercedes-Benz summary charts, discussed above, is 1.3 58. These two factors are within 2.4%, which provides credence for the above Mercedes-Benz costs.

The -Mercedes-Benz tooling cost were revised upward by a factor of 1.5 1.

Enclosed are Summary Charts for both the TRW and the Mercedes-Benz inflators.

SUMMARY

SINGLE & MULTI-STAGE AUGMENTED AIRBAG INFLATOR & ASSOCIATED HARDWARE

VARIABLE MANUFACTURING, TOOLING and CAPITAL EQUIPMENT COSTS

INFLATORS	MATERIAL COST ($)	LABOR COST ($)	VENDOR BURDEN COST ($)	ESTIMATED VARIABLE COST ($)	ESTIMATED TOOLING COST ($)	EST. CAP EQ'PM'NT COST ($)
P/N 4100 PASSENGER, SINGLE STAGE INFLATOR	4.82	3.69	9.28	17.69	534000	3289000
P/N 4400 PASSENGER, DUAL STAGE INFLATOR	5.04	4.31	9.43	18.78	510000	4517500
P/N 5200 DRIVER, DUAL STAGE INFLATOR	3.05	3.84	7.79	14.64	664000	3315500
P/N 20204921 HARNESS-IGNITER	0.43	0.34	0.23	1	5300	35000
P/N 7002 SUPPORT BRK'T ASM.	0.37	0.7	0.2	0.67	170000	
INCREMENTAL COST (2 ADD'L. STRANDS WATCH SPRING ASSM.	0.15	0.06	0.04	0.25		

This Chart is from the 1996 Mercedes-Benz Seat Switch Cost Analysis Report.

Passenger Side Air Bag Detection Switch and System Support
Variable Manufacturing Costs

	Material Cost	Labor Cost	Variable Burden Cost	Estimated Variable Cost
Increase in Seat Cost	$1.05	$0.36	$1.09	$2.50
Increase in Air Bag Control Module Cost (Pro-rated)	$3.33	$0.09	$0.21	$3.63
Increase in Air Bag Wire Harness Cost	$0.48	$0.01	$0.03	$0.52
Increase in Final Assembly Cost		$0.47	$2.36	$2.83
Total Variable Increase	$4.86	$0.93	$3.69	$9.48

Estimated Tooling Cost	$134,912
Estimated Capital Equipment cost	$1,514,256

Note: Variable manufacturing cost estimate is based on Mercedes-Benz type hardware.

Table 1

PROJECT: MERCEDES AIRBAG **COST DATA REVISED TO "97" TIME PERIOD** **DATE: NOVEMBER 22, 1997**

PRODUCT: GAS GENERATOR

CONTRACTOR: THIOKOL

ANNUAL VOLUME = 300,000

ITEM NO	DESCRIPTION	PROCESS DESCRIPTION	MAT'L TYPE	QTY PER ASSY	MATERIAL FIN WT (LB)	MATERIAL COST PER LB.	MATERIAL COST	DIRECT LABOR MAN MIN	DIRECT LABOR WAGE RATE	DIRECT LABOR COST	BURDEN	MFG COST	OTHER COSTS	SALES PRICE	SPECIAL TOOLS
1 02	Gas Generator			1	2641		11 239	4985		1648	3736	16623	8943	25566	652
1 0201	Assy - Gas Generator Complete	Assy		1			0 25		1985	0331	0 715	1296			55
1 0202	Assy - Housing G. G Outer	Summary		1	101		2334					2334			115
1 0203	Assy - Outer Filter	Summary		1	0 1326		1116					1116			62
1 0204	Assy - Filter Sealer			A R			0 035					0 035			
10205	G G Air	Stamping	C.R.S.D.C	1	017	075	0128					0128			45
10206	- initiator Assy to Hsg	Purchase	Rubber	1	001	1 15	0012					0012			
1 0207	Assy - Gas Generator Body			1				235	1985	0777	1678	2455			66
1 0208	Assy - Gas Generator & Igniter	Stamping	Aluminum	1	0 094	1 56	0 1 4 7	0 055	1985	0018	0074	0239			37
1 0209	Assy - Igniter	Assy		1	029		3005					3 005			109
10210	Housing - Booster		Steel Tub	1	083	046	0382					0382			25
10211	Foil - Aluminum	Purchase	Alum - Ac	1	0 0028	161	0005					0005			
1 0212	Charge - Booster		Boron - P Nitrate	1	0 008	42	0336					0336			
1 0213	Cap - Booster Housing	Stamping	Aluminum	1	0019	156	0 03	0.15	1985	0049	0106	0 185			
1 0214	Assy - Filter Inner	Summary		1	01		1334					1334			22
1 0215	Cap - Int Filter Top Edge Prot	Stamping	C R S.	1	0 296	031	0092	0 42	1985	0139	03	0531			15
1 0216	Pellets - Gas Generater		Sodium Azide		0 22	66	1452	0458	1985	0152	0328	1932			12
1 0217	Filter - Serfiber Wafer	Die Cut	20 4sq ft		0 0011	0 0026 per sq ft	0 054	0152	1985	0 05	0 1 0 8	0 2 1 2			IO
1 0218	Assy - Pellet Retainer	Summary		1	0033		0188					0188			14
1 0219	Cover - Gas Generater Body	Stamping	Aluminum	1	0015	156	0023	0 15	1985	0049	0106	0178			20
1 0220	Cover - G G. Inner	Stamping	H S L A.	1	059	031	0 183	0 25	1985	0 083	0321	0587			50
1 0221	palent - Qtr Hsg. Air Outlet		Plastic, Qty as Req		001		0 093					0093			
1 0222	Label - Adhesive	Purchase	Paper	1			004					0 04			

Note: Original estimates were based on 1982 economics. This Char-t reflects **1997, Detroit, MI., automotive labor** and **material** rates.

C - This Chart reflects the data in Chart B revised to incorporate 1997 labor and material rates.

PROJECT: MERCEDES AIRBAG COST DATA REVISED TO "97" TIME PERIOD DATE: NOVEMBER 22, 1997
PRODUCT: GAS GENERATOR - OUTER HOUSING
CONTRACTOR: VENDOR TO THIOKOL

ANNUAL VOLUME = 300,000

ITEM NO	DESCRIPTION	PROCESS DESCRIPTION	MAT'L TYPE	QTY PER ASSY	MATERIAL FIN WT (LB)	MATERIAL COST PER LB.	MATERIAL COST	DIRECT LABOR MAN MIN	DIRECT LABOR WAGE RATE	BURDEN COST	MFG COST	OTHER COSTS	SALES PRICE	SPECIAL TOOLS
1.020201	Assy - Housing G.G. Outer	Sumary		1	2.181		0.797	1.525		0.4976	1.796	3.091	0.297	3.388	115
1.020202	Assy - G. G. Housing Outer	Assy - Arc Weld		1				0.485	19.85	0.158	0.451	0.609	0.061	0.67	20
1.020203	Housing - G. G. Outer	Stamping	H. S. L. A.	1	1.321	0.31	0.409	0.79	19.85	0.258	1.032	1.699	0.17	1.869	60
1.020204	flange - G. G. Hsg. Outer	Stamping	H. S. L. A.	1	0.86	0.31	0.267	0.25	19.85	0.0815	0.313	0.6615	0.066	0.728	35
	Paint						0.058					0.058		0.058	
	Weld Rod						0.063					0.063		0.063	

Note: Original estimate was based on 1982 economics. This estimate is based on 1997, Detroit, MI., automotive labor and material rates.

PROJECT: MERCEDES AIRBAG **COST DATA REVISED TO "97" TIME PERIOD** **DAT**

PRODUCT: GAS GENERATOR INNER FILTER

CONTRACTOR: VENDOR TO THIOKOL **ANN**

ITEM NO	DESCRIPTION	PROCESS DESCRIPTION	MAT'L TYPE	QTY PER ASSY	MATERIAL FIN WT (LB)	MATERIAL COST PER LB.	MATERIAL COST	DIRECT LABOR MAN MIN	DIRECT LABOR WAGE RATE	DIRECT LABOR COST	BURDEN	MF CO
1 021401	Assy - G. G Filter Inner	Summary		1	01		0885	0672		0219	04731	157
1 021402	Assy - G G Filter Inner	Assy		1				042	1985	0137	02959	043
1 021403	Screen - In'r Filter Inner		Stainless Steel 40 Mesh	054 sq ft	006	1.4835 per sq ft	07078	008	1985	0026	00562	07
1 021404	Serifiber - Filter Cloth		Woven Serifiber	23 sq ft	001	00026 per sq in	00608	007	1985	0023	00497	013
1 021405	Screen - In'r Filter Outer		Stainless Steel 18 Mesh	0156 sq ft	0 03	07475 per sq ft	0.1166	0 102	1985	0033	00713	022

Note: Original estimate was based on 1982 economics. This estimate is based on 1997, Detroit, MI., automotive labor and

PROJECT: MERCEDES AIRBAG **COST DATA REVISED TO "97" TIME PERIOD** **DATE:NOVEMBER 22, 1997**
PRODUCT: GAS GENERATOR PELLET RETAINER ASSY
CONTRACTOR: VENDOR TO THIOKOL **ANNUAL VOLUME = 300,000**

ITEM NO	DESCRIPTION	PROCESS DESCRIPTION	MAT'L TYPE	QTY PER ASSY	MATERIAL FIN WT (LB)	MATERIAL COST PER LB.	MATERIAL COST	DIRECT LABOR MAN MIN	DIRECT LABOR WAGE RATE	DIRECT LABOR COST	BURDEN COST	MFG OTHER COSTS	SALES PRICE	SPECIAL TOOLS
1 021801	Assy - Pellet Retainer	Summary		1	0221		008	014		0046	0101	0227	0023	0 25	14
1021802	Assy - Pellet Retainer	Assy		1			0001	0085	1985	0028	0063	0092	0009	1 01	3
1 021803	Retainer	Stamping	Aluminum	1	0021	156	0033	0055	1956	0018	0038	0089	0009	0098	11
1021804	Spacer (Foam)	Purchase, Die Cut	Silicone Rubbe	1	0 2		0046					0046	0005	0051	

Note: Original estimate was based on 1982 economics. This estimate is based on 1997, Detroit, MI,. automotive labor' and material rates.

PROJECT: MERCEDES AIRBAG **COST DATA REVISED TO "97" TIME PERIOD** **DATE: NOVEMBER 22, 1997**

PRODUCT: GAS GENERATOR IGNITER

CONTRACTOR: VENDOR TO THIOKOL

ANNUAL VOLUME = 300,000

ITEM NO	DESCRIPTION	PROCESS DESCRIPTION	MAT'L TYPE	QTY PER ASSY	FIN WT (LB)	MATERIAL COST PER LB.	COST	DIRECT LABOR MAN MIN	WAGE RATE	COST	BURDEN	MFG COST	OTHER COSTS	SALES PRICE	SPECIAL TOOLS
1020901	Assy - Igniter Complete	Summary		1	1738		1756	3617	1 179	2547	5482	0548	6 03		109
1020902	Assy - Igniter Comp.			1				0 8	1985 0261	0 563	0 42				24
1020903	Housing - Ignder	Machined	C. R S. Bar S	1	0.18	0 41	0 074	011	1985 00359	0 078	011				
1 020904	Insulating Sleeve	Purchase, Molded	P henolic	1 00446		075 0033					0029				
1 020905	Conlact - Protector	Stamping	Copper	1	0051	12	0.61	0 375	1985 01223	0 264	0518				18
1020906	Connector Housing	Injection Mold	Nylon	1	0 05	12	006				0045				
1020907	Potting Compound		Resin Hdnr.	A R 0044		086 0038					0033				
1 020908	Epoxy			A R 00038		15 00057					0 005				
1 020909	Assy - Initiator	Assy		1				0 655	1985 0214	0462	032				18
1 020910	Cage - Initiator	Machined	Aluminum	1 00356		156 0056		0017	1985 00055	0012	0044				
1 020911	Ferrite Bead	Purchase, Sintered	Powdered	1 00825		1 0083					0066				
1020912	Sealent			A R 0005		12 0006					0 005				
1020913	Potting Compound			A R 0017		086 0015					0013				
1 020914	Assy - Initiator Cap	Assy		1				1 505	1985 04906	1059	0731				38
1 020915	Header - Initiator	Machined	C R S. Bar Stc	1 00105		0 4 1	0 004	0125	1985 00408	0 088	0065				
1020916	Glass Bead	Purchase		1	0 0169	075 0013					0011				
1 020917	Ceramic Disk	Purchase		1	0033	115 0038					0033				
1020918	Terminal Wire	4 Slide	C R S. Wire	2	0955	0 4 2	0 395	003	1975 0 0098	0021	036				11
1 020920	Bridge Wire		Nicrome	1 00044		8625 0038					0033				
1020921	Charge Holder			1	00311	1035 0029					0 028				
1020922	Ignition Charge	Purchase	Lead Slyphnate		0 0055	23 00127					0011				
1020923	Output Charge		Zirconium Potassium Percholrate	1	0 00026		0 038				0 033				
1 020924	Cup	Stamping	Stainless Stee	1	0 092	065	006				006				
1 020925	Silicon Space	Die Cut	Silicon Rubber		0 036	092 0033					0 029				

Note: Original estimate **based on 1982 Western US labor rates. This** estimate **is based on 1997 Detroit MI.** automotive **labor** and material **rates**

PROJECT: MERCEDES **AIRBAG** COST DATA REVISED **TO** "97" TIME PERIOD DATE: NOVEMBER **22, 1997**

PRODUCT: GAS GENERATOR

CONTRACTOR: THIOKOL

ANNUAL VOLUME = 300,000

ITEM NO	DESCRIPTION	PROCESS DESCRIPTION	MAT'L TYPE	QTY PER ASSY	MATERIAL FIN WT (LB)	MATERIAL COST PER LB.	MATERIAL COST	DIRECT LABOR MAN MIN	DIRECT LABOR WAGE RATE	DIRECT LABOR COST	BURDEN COST	MFG COST	OTHER COSTS	SALES PRICE	SPECIAL TOOLS
1 02	Gas Generator			1	2.641		10 874	4985		047	09	12244	6587	18831	652
1 0201	Assy - Gas Generator Complete	Assy		1			025		55	009	0135	0 475			56
1 0202	Assy - Housing G G Outer	Summary		1	101		2334					2334			115
1 0203	Assy - Outer Filter	Summary		1	0 1326		1116					1116			62
1 0204	Assy - Filter Sealer			A R			0035					0035			
1 0205	G G. Air	Stamping	C.R.S D (	1	017	065	0111					0 111			45
10206	- initiator Assy to Hsg	Purchase	Rubber	1	001	1	0 011					0011			
1 0207	Assy - Gas Generator Body			1				235	55	0216	0 311	0527			66
1 0208	Assy - Gas Generator & Igniter	Stamping	Aluminum	1	0 094	125	0117	0055	12	0011	0045	0 173			37
1 0209	Assy - Igniter	Assy		1	0 29		3 005					3005			109
1 0210	Housing - Booster		Steel Tub	1	083	04	0332					0332			25
10211	Foil - Aluminum	Purchase	Alum - Ac	1	0 0028	14	0004					0004			
1 0212	Charge - Booster		Boron - P Nitrate	1	0 008	40	0 32					032			
1 0213	Cap - Booster Housing	Stamping	Aluminum	1	0019	1 25	0 0 2 4	0 15	12	0014	0 024	0062			
1 0214	Assy - Filter tnner	Summary		1	01		1334					1334			22
1 0215	Cap - Int Filter Top Edge Prot	Stamping	C.R S	1	0.296	028	0083	0 42	12	0046	0188	0317			15
1 0216	Pellets - Gas Generater		Sodiurn Azide		0 22	5 7 4	1.263	0.458	55	0042	006	1365			12
1 0217	Filter - Serfiber Wafer	Die Cut	20 4sq ft		00011	00023 per sq ft	0047	0152	12	0014	0 024	0 085			10
1 0218	Assy - Pellet Retainer	Summary		1	0033		0188					0 188			14
1 0219	Cover - Gas Generater Body	Stamping	Aluminum	1	0015	125	0019	015	12	0014	0 024	0 057			20
1 0220	Cover - G G Inner	Stamping	H S L A	1	059	0 28	0165	0 25	12	0 023	0089	0 277			50
1 0221	patent - Qtr Hsg. Air Outlet		Plastic, Qty as Req		001		0 081					0081			
1 0222	Label - Adhesive	Purchase	Paper	1			0 035					0 035			

Note: Original **estimates were based on 1982 economics. This** chart **reflects a revision of the one submitted with the** original report. **There where several errors in the** original **chart and in the revised** corrections that **were hand written** on **the** charts. **These have been corrected** to **provide the best possible base for the revision to "97" economics.**

B - This Chart reflects review of the data in Chart A and revised for correctness and consistency of labor hours and material costs. These costs are "82"

PROJECT: **MERCEDES AIRBAG**
PRODUCT: GAS GENERATOR
CONTRACTOR: **THIOKOL**

DATE: NOVEMBER 22, 1997
ANNUAL VOLUME = 300,000

ITEM NO	DESCRIPTION	PROCESS DESCRIPTION	MAT'L TYPE	QTY PER ASSY	MATERIAL FIN WT (LB)	MATERIAL COST PER LB.	MATERIAL COST	DIRECT LABOR MAN MIN	DIRECT LABOR WAGE RATE	DIRECT LABOR COST	BURDEN COST	MFG COST	OTHER COSTS	SALES PRICE	SPECIAL TOOLS
1 02	Gas Generator			1	2641		14 109	596		0.547	0786 15442	8314	23756	652	
1 0201	Assy - Gas Generator Complete	Assy		1			025	1	55	009	0135 0475				55
1 0202	Assy - Housing G G Outer	Sumrnary		1	101		2 324	3 15		0289	0434 3057				115
1 0203	Assy - Outer Filter	Summary		1	01		1 116	1 12		0103	0154 1373				62
1 0204	Assy - Filter Sealer			1			0035				0035				
10205	- G G. Air	Stamping	C R S	1	017		0749				0749				45
10206	- initiator Assy to Hsg	Purchase	Rubber	1	001		0011				0011				
1 0207	Assy - Gas Generator Body			1				235	55	0216	0311 0527				66
1 0208	Assy - Gas Generator 8 Igniter	Stamping	Aluminum	1	0 024	125	0117				0117				37
1 0209	Assy - Igniter	Assy		1	029		4 628			4 628		4 628			109
10210	Housing - Booster		Steel Tub	1	083	04	0333				0333				25
10211	Foil - Aluminum	Purchase	Alum - Ac	1	0.0001		0004				0004				
1 0212	Charge - Booster		Boron - P Nitrate	1	0.008	40	033				033				
1 0213	Cap - Booster Housing	Stamping	Aluminum	1	0019	1.25	0024				0 024				
1 0214	Assy - Filter Inner	Summary		1	01		1334				1334				22
1 0215	Cap - Int. Filter Top Edge Prot.	Stamping	C R S	1	0296	027	008				008				15
1 0216	Pellets - Gas Generater		Sodium Azide		0 22	5 74	1263	0.008	55	0042	006 1 355				12
1 0217	Filter - Serfrber Wafer	Die Cut		1	00011		0047				0047				10
1 0218	Assy - Pellet Retainer	Summary		1	0033		0.067				0188				14
1 0219	Cover - Gas Generater Body	Stamping	Aluminum	1	0015	125	0019				0.081				20
1 0220	Cover - G G inner	Stamping	H S L A	1	0.59	028	0165				1 071				50
1 0221	palent - Qtr. Hsg. Air Outlet		Plastic, Qty as Req		001		0081				0081				
1 0222	Label - Adhesive	Purchase	Paper	1			0035				0035				

A - This Chart reflects the marked up copy received from Spinney which was copied from the Mercedes-Benz 1982 Airbag Study conducted by Pioneer Engineering for NHTSA. These costs are "82" economics