CAR WARS

Factors Underlying the Success or Failure of New Automobiles

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INTRODUCTION

In an effort to understand the factors driving product success and failure in the automotive market, much can be learned from looking to past history. To gain an historical insight into the factors driving the success and failure of automobiles, we performed case studies on ten significant product successes and ten significant product failures in the United States automotive market over the past fifty years. This paper presents the findings of the twenty case studies, provides inferences regarding the factors driving the product to success or failure in the marketplace, and sets the stage for continued research into the impact of disruptive technologies on the automobile industry.

SUCCESSES AND FAILURES

We first define the criteria for success and failure. Then we present the sets of ten successes and ten failures on which are analyses are focused.

Criteria

To identify the factors underlying the success and failure of new automobiles, we first had to develop a list of vehicles to perform case studies on. We chose to study twenty new vehicles programs in the United States market over the last fifty years. To limit the risk of sampling on the dependent variable we looked to the extremes in the market. Ten new product successes, representing the best of the best, and ten new product failures, representing the worst of the worst, were selected for the case studies. The automobiles studied had to be a completely new market entry for the manufacturer to be considered for the study. For example the 1986 Ford Taurus was considered for the study, while the 1992 Ford Taurus and 1996 Ford Taurus did not qualify.

Each vehicle considered for the study was judged on both its ability to meet the corporate goals set for it by the manufacturer and its impact on the marketplace. The products, as selected by the authors, were judged by their innovation, perception in the market, and degree to which the expectations of the manufacturer were met. The ten best and worst vehicles represent extremes in the automotive market. Considering single factors such as vehicle volume or profitability alone would have given an entirely different set of vehicles to evaluate. For example, looking at vehicle volume alone would have given us a dataset of pickup trucks to study. Reviewing the history of the auto industry over the last fifty years enabled us to create an initial list of vehicles. Through careful consultation with experts in General Motors' Research and Planning organizations, the initial list was finalized to twenty vehicles to perform case studies on. While the absolute ten best and ten worst vehicles in the United States automotive market over the last fifty years are often subject to heated debate, the products in the study are a very worthy representation of successes and failures.

Products

The ten product successes studied are listed in Table 1. The list includes vehicles as old as the 1955 Chevrolet and as recent as the 2003 Cadillac CTS. This listing contains a fair distribution of vehicles over the last fifty years with each decade from the 1950s to the 2000s represented by at least one product. All the American "Big Three" manufacturers are represented in list as well as Toyota and Volkswagen.

Table 1 - Ten Product Successes
1955 Chevrolet
1964 Pontiac GTO
1964 Ford Mustang
1974 Volkswagen Rabbit
1984 Chrysler Minivan
1986 Ford Taurus
1998 Lincoln Navigator
1998 Toyota Prius
2001 Chrysler PT Cruiser
2003 Cadillac CTS

The ten product failures studied are listed in Table 2. This listing also contains a fair distribution of vehicles over the last fifty years with each decade from the 1950s to the 2000s represented by at least one product. The listing contains multiple vehicles produced by General Motors and Ford, with now defunct American Motors and DeLorean Motor Company each having one entry. The GM10 program represents General Motors midsize car replacement program in the 1980s and contained the following nameplates: Oldsmobile Cutlass Supreme, Pontiac Grand Prix, Buick Regal, and Chevy Lumina.

Table 2 - Ten Product Failures
1958 Edsel
1960 Chevrolet Corvair
1971 Chevrolet Vega
1971 Ford Pinto
1975 AMC Pacer
1981 DeLorean DMC-12
1982 Cadillac Cimarron
1988 GM10 Program
1990 Saturn
2001 Pontiac Aztec

METHODOLOGY

The methodology followed for the project comprised five main steps:

1. Candidate generation and selection
2. Case study preparation and analysis
3. Factor generation and review
4. Content analysis
5. Statistical analysis

Candidate Selection

To develop and analyze the list of factors underlying the success and failure of new automobiles, we selected a case study approach to the problem. To perform the case studies a pool of candidates had to be collected and documented. We imposed constraints on the list, to narrow the field of candidates, by limiting the study to vehicles launched over the last fifty year and concentrating on the United States automobile market. As noted above, the automobiles studied had to be a completely new market entry for the manufacturer to be considered for the study. The twenty vehicles selected are listed in Table 1 and Table 2, above. While recent successes such as the Mazda Miata and Ford Explorer are very worthy candidates, the twenty vehicles selected present a strong representation of the extremes of success and failure. By looking into the extremes underlying factors contributing to success and failure can be inferred.

Case Studies

A case study was performed for each vehicle in the list. The data for each case study was compiled through referencing newspaper accounts, historical sales data, academic journals, magazine articles, and business books. For example, articles from the mid 1980s appearing in the Detroit Free Press and Ward's Automotive news detailed General Motors' ambitious plans and objectives for the GM10 program, while "The Machine that Changed the World", by Womack, Jones and Roos, recounted the disastrous results of the program. From these and many other sources we can write the story of each vehicle in the study.

For each vehicle we derived a list of program objectives, inferred the degree of which the program met the objectives, and derived the factors which contributed to attaining or missing the objectives. For example the objectives derived for the 1955 Chevrolet are listed in Table 3.

Table 3 – 1955 Chevrolet Objectives
1. Regain styling and performance leadership
2. Move to youthful, performance image
3. Develop V8 engine to package in vehicle
4. Perceived luxury at affordable price

Keeping the four objectives in mind, we then evaluated how well the objectives for the 1955 Chevy were met. By the early 1950s, Ford Motor Company had taken the industry styling and performance lead away from General Motors. General Motors countered Ford with the 1955 Chevrolet. The ’55 Chevy was developed in just 22 months and offered beautiful styling and a market leading 162 HP V8 engine. The new V8 engine could be readily packaged into any GM vehicle. The 1955 Chevy utilized a clean sheet design to meet its target market dead on with very short lead time. The V8 option became the engine of choice for “hot rodders”. By meeting the program objectives dead on with very short lead time GM engineered one of the most successful vehicles of all time.

The case study for the 1975 AMC Pacer is an example of a product failure. Again, through reviewing literature on the Pacer the objectives for the program were derived. The objectives are listed in Table 4 below.

Table 4 – 1975 AMC Pacer Objectives
1. Design and engineer a futuristic breakthrough vehicle
2. Manufacture vehicle on existing factory lines
3. Launch a new vehicle capable of a long model run
4. Utilize small, lightweight engine
5. Design and engineer a small vehicle with the same interior room as a midsize

The AMC Pacer was an all or nothing “bet the company” vehicle for AMC. While AMC achieved a futuristic design with the Pacer, the need to conserve capital by manufacturing the vehicle on existing lines drove a quirky design which was branded as ugly by the buying public. Additionally, the Pacer was designed to package GM’s Wankel Rotary engine. When GM suddenly cancelled the engine, AMC’s design could not accommodate another engine to meet the performance and reliability needs of the small car market. The Pacer failed to meet the objectives set forth by AMC and failed miserably in the marketplace. Each case study performed is included in the Appendix A of this document.

Factors

Through the creation and careful review of the twenty case studies performed, the factors underlying the success and failure of the vehicles were derived. The factors contributing to the achieving or missing program objectives were tabulated for each program. We combined and condensed all the factors into a master listing of 14 key factors. The factors are grouped into five main

categories: Product, Performance, Market, Organization, and External and are listed in Table 5.

Table 5 – Factors
Product: Styling
Product: Flexibility
Product: Lead Time
Product: Technology
Performance: Horsepower
Performance: Fuel Economy
Performance: Quality
Market: Target Segment
Market: Price
Market: Safety
Market: Utility
Organization: Corporate Goals
Organization: Development Process
External: Economy

Each factor was given a clear definition. For example flexibility is a factor in the product category. The flexibility of a vehicle design and architecture enables a program team to quickly configure new models to meet the needs of the market at a low development price. The Lincoln Navigator, Pontiac GTO, and Ford Mustang hit the market quickly and cheaply primarily due to product flexibility. The Navigator was engineered from the newly launched Ford Expedition into a luxury edition by trimming the interior with leather, wood, and fine carpeting in just 13 short weeks. Leveraging the body on frame architecture of trucks, Ford engineers had to change a few body panels and add a chrome grill to create the Navigator. John DeLorean took the Pontiac Tempest, stripped it to bare essentials, added 389 cubic inch V8 and beefed up the brakes and suspension to create the GTO. Ford engineered the Mustang by sharing components and parts with the newly released Ford Falcon. Ford's cost to develop the Mustang was only $75 million at a time when most programs cost $300 - $400 million.

Too much flexibility can also hurt a product program. General Motors attempted to use flexibility and save development costs for the Pontiac Aztek by sharing mechanical underpinnings with the Pontiac Montana minivan. The distinctive exterior design of the Aztek, which contributed to the failure of the vehicle, is directly attributed to the need to stretch its sheet metal over Montana's substructure. Product flexibility can be dangerous when the new model does not meet customer expectations. The Cadillac Cimarron hit dealership offering little more than a dressed up Chevrolet Cavalier at nearly double the sticker price. General Motors attempting to leverage product flexibility to cheaply produce the Cavalier and Cimarron did little more than add leather seats and a roof rack to the Cadillac and as a result the product languished in the marketplace. The definition for all thirteen factors can be found in the Appendix B of this document.

Content Analysis

Combining the key factors and the products studied we created a factor matrix. The factor matrix is shown in Table 6. The vehicles in each row are matrixed with the columns of thirteen factors.

TABLE 6

	Styling	Flexibility	Lead Time	Technology	Horsepower	Fuel Economy	Target Segment	Price	Quality	Utility	Safety	Corporate Goals	Development Process	Economy
1955 Chevy														
1958 Edsel														
1960 Chevrolet Corvair														
1963 Pontiac GTO														
1964 Ford Mustang														
1971 Ford Pinto														
1971 Chevrolet Vega														
1974 Volkswagen Rabbit														
1975 AMC Pacer														
1981 DeLorean														
1982 Cadillac Cimarron														
1984 Chrysler Minivan														
1986 Ford Taurus														
1988 GM10														
1990 Saturn														
1998 Toyota Prius														
1998 Lincoln Navigator														
2001 Chrysler PT Cruiser														
2001 Pontiac Aztek														
2003 Cadillac CTS														

TABLE 7

	Styling	Flexibility	Lead Time	Technology	Horsepower	Fuel Economy	Target Segment	Price	Quality	Utility	Safety	Corporate Goals	Development Process	Economy
1955 Chevy	↑			↑	↑		↑	↑	↑			↑	↑	
1958 Edsel	↓					↓		↓	↓			↓		↓
1960 Chevrolet Corvair	↑		↓		↑		↓	↓			↓	↑		
1963 Pontiac GTO		↑	↑		↑		↑	↑						↑
1964 Ford Mustang	↑	↑	↑	↑	↑		↑	↑				↑	↑	↑
1971 Ford Pinto	↓		↓						↓		↓			
1971 Chevrolet Vega			↓	↓			↓	↓	↓					
1974 Volkswagen Rabbit	↑	↑		↑		↑	↑	↑				↑	↑	↑
1975 AMC Pacer	↓			↓	↓				↓	↑				
1981 DeLorean	↑				↓	↓						↑		↓
1982 Cadillac Cimarron	↓	↓	↓				↓		↓			↑	↓	
1984 Chrysler Minivan				↑			↑	↑		↑		↑		
1986 Ford Taurus				↑			↑	↑				↑	↑	
1988 GM10							↓		↓			↓		
1990 Saturn	↑					↑			↓					
1998 Toyota Prius				↑		↑	↑					↑	↑	
1998 Lincoln Navigator	↑	↑					↑			↑		↑		↑
2001 Chrysler PT Cruiser		↑					↑	↑				↑	↓	
2001 Pontiac Aztek	↓						↓	↓						
2003 Cadillac CTS	↑			↑			↑		↑			↑		

Evaluators filled in the matrix, via a pull-down list in each cell, by placing an arrow up (↑) for a contributing factor to the success of a program and an arrow down (↓) for a factor detrimental to the success of a program. If the factor had no effect on the program the square was left blank. A completed matrix is shown in Table 7. The factor matrix was independently filled in by three evaluators after each had carefully reviewed each case study.

Statistical Analyses

Our first analysis involved assessing the degree to which the three evaluators agreed using Krippendorff's alpha[1]. The first step in this assessment is construction of a reliability matrix.

Units u:	***1***	***2***	.	.	.	***u***	.	.	.	.	.	***r***
Observers: 1	c_{11}	c_{12}	.	.	.	c_{1u}	.	.	.	.	.	c_{1r}
i	c_{i1}	c_{i2}	.	.	.	c_{iu}	.	.	.	.	.	c_{ir}
j	c_{j1}	c_{j2}	.	.	.	c_{ju}	.	.	.	.	.	c_{jr}
.	.	.				.						.
m	c_{m1}	c_{m2}	.	.	.	c_{mu}	.	.	.	.		c_{mr}
Number of values in u:	m_1	m_2	.	.	.	m_u	.	.	.	.	.	m_r

When data are missing, the numbers m_u of values in columns or units u are variable.

The second step is to tabulate the coincidence within the units.

Values:	**1**	.	**k**	.	.	
1	o_{11}	.	o_{1k}	.	.	n_1
.	.		.			.
.	.		.			.
c	o_{c1}	.	o_{ck}	.	.	$n_c = \Sigma_k\, o_{ck}$
.	.		.			.
	n_1	.	n_k	.	.	$n = \Sigma_c \Sigma_k\, n_{ck}$

$$o_{ck} = \sum_u \frac{\text{Number of c - k pairs in unit u}}{m_u - 1}$$

Finally, the alpha is calculated.

$$\text{nominal } \alpha = 1 - \frac{D_o}{D_e} = \frac{(n-1)\sum_c o_{cc} - \sum_c n_c(n_c - 1)}{n(n-1) - \sum_c n_c(n_c - 1)}$$

Krippendorff's alpha is a measure of the level of agreement between raters. When raters agree perfectly, observed disagreement is zero and alpha is equal to one. When raters agree on the basis of chance the results indicate an absence

of reliability and the alpha measures a score of zero. Thus, for a measure of reliability, the alpha range is between 0 and 1.

The preliminary results indicate a strong level of agreement among the three evaluators who participated in this initial assessment. Calculating the Krippendorff's alpha using contributing factors (↑) and detrimental factors (↓), and treating the no effect as blank, yields an alpha of 0.93. This result indicates that it is reasonable to pool the data from all three evaluators.

Using this pooled data, we then performed three analyses: single factor linear regression, step-wise regression, and discriminant analysis. Table 8 shows the single factor linear regressions where the dependent variable was class membership, i.e., success or failure. Target Segment explains the largest percentage of the variance (85.9%), followed by Development Process (76.8%).

Table 8 – Adjusted R2 for Each Factor

Factor	R^2(%)
Product: Styling	27.2
Product: Flexibility	25.4
Product: Lead Time	39.1
Product: Technology	38.9
Performance: Horsepower	22.3
Performance: Fuel Economy	6.1
Performance: Quality	53.9
Market: Target Segment	85.9
Market: Price	53.7
Market: Safety	4.4
Market: Utility	0.0
Organization: Corporate Goals	32.4
Organization: Development Process	76.8
External: Economy	28.8

The step-wise regression resulted in a simple two-factor model that included only Target Segment and Economy. This model explains 89.6% of the variance. The reason that so many of the high R^2 variables in Table 8 were not retained in the model is their high correlation with Target Segment. Thus, including all 14 factors in the model only increases the R^2 to 94.5%.

We also performed a two-class linear discriminant analysis, which is more appropriate when the dependent variable is class membership. The resulting linear models were 100% accurate in predicting class membership based on each automobile's characteristics in terms of the 14 factors. Target Segment was again the main difference between the linear models for each class. The resulting linear models can be used to estimate the probability of class membership for an automobile concept characterized in terms of the 14 factors identified in this study. In light of the dominance of Target Segment, we

anticipate the need to define more specific attributes of this overall factor in order for these linear models to relate to finer-grained distinctions among concepts.

DISCUSSION

Our results indicate that success requires getting two things right: Target Segment and Economy. As elaborated in Appendix B, these two factors are defined as follows:

- **Target Segment** is the measure of how well the vehicle meets the needs of the market segment targeted. . The Chrysler Minivan, Pontiac GTO, and Toyota Prius launched with tremendous success by meeting the needs of emerging segments in the market dead on. The GM10 rolled out to the public with two door sedans when the mid size car market was demanding four doors. The Chevrolet Corvair was designed to be an economy car with performance but was not competitive with basic economy vehicles. The Pontiac Aztek targeted young buyers who did not buy new vehicles.

- **Economy** as a factor concerns the economic conditions at the time the vehicle hits the marker. The Edsel was clobbered by the recession of the late 1950s. The Cadillac Cimarron was rushed into production to fill the luxury small car market when fuel prices spiked in the early late 1970s. The Volkswagen Rabbit, with high fuel economy and low price, benefited from high gas prices in the 1970s. The Mustang and GTO hit the market in the early 1960s to a booming economy. The Lincoln Navigator greatly benefited from the high flying economy of the United States in the late 1990s.

Getting Target Segment right requires deep understanding of the target market. In contrast, getting Economy right involves many forces and actors beyond the automobile manufacturers. A useful strategy for manufacturers is to design and develop cars quickly so that the economic conditions are less likely to differ from the conditions assumed for the program. Thus, the bottom line is: deep market understanding acted upon quickly.

CONCLUSIONS

Through the creation and analysis of twenty case studies of product successes and failures in the United States automobile market we have generated an initial listing of fourteen factors driving success or failure. Several statistical analyses have provided interesting insights, although these insights are only based on three evaluators. A larger sample of evaluators and further analyses are needed. It would also be good to independently verify the nature, definition, and measurement of each of the factors employed. We plan to conduct this broader assessment with an online survey of industry experts.

Appendix A

PRODUCT SUCCESSES AND FAILURES

TEN PRODUCT SUCCESSES

1955 Chevrolet

GM Corporate approval was given in June of 1952 to the Chevrolet Division to plan a new vehicle for the 1955. GM would respond to Ford's threat for sales leadership with a clean sheet design which included a V8 engine. Table A1 shows the program objectives.

Table A1 – 1955 Chevrolet Objectives
1. Regain styling and performance leadership
2. Move to youthful, performance image
3. Develop V8 engine to package in vehicle
4. Perceived Luxury at affordable price

GM's legendary Harley Earl created the vehicle design featuring clean modern lines, hooded headlamps a Ferrari like egg crate grille and a wraparound windscreen, with much improved interior room.[2] The styling of the vehicle was clearly meant to give buyers the impression they were getting a car that was very similar to one of the much more expensive vehicles in the General Motors lineup. With eyebrows over the headlamps, and the vertical pillar wraparound windshield, it strongly resembled its top-of-the-line corporate sibling, Cadillac. The $300 million allocated to the program was at the time the biggest expenditure for a new model in automotive history.

The program was headed by future GM president Ed Cole and took just 22 months to get into production. Once the car's engineering specifications were locked in there were almost no deviations. And when it arrived in showrooms, it proved to have very few glitches. The key to the vehicle was the development of a brand new optional 162 horsepower small block V8 engine. The small block design could be packaged in cars and still had the strength to power large trucks. Ed Cole started with a clean sheet of paper and brought together all the key elements that would eventually create Chevy's new small block V8.[3] He capitalized on the latest metallurgy, casting and manufacturing techniques to produce a compact, lightweight but strong package.

The 1955 Chevrolet is, arguably, the best car General Motors has ever produced. Although not the fanciest, most expensive, fastest or best-handling car the 1955 offered a high value package to consumer. The stunning styling, two-tone paint and optional V8 engine, launched sales of 1.6 million cars for Chevrolet that year versus the 1.2 millions sold the previous year.[4] By meeting needs of the market, the sales numbers of the '55 Chevy gave the vehicle nearly a quarter of the total

1955 United States vehicle output of approximately 7.1 million cars - and a stunning 44 percent of the low-price market against rivals such as Ford and Plymouth.[5] Chevrolet innovated in the market with a new V8 engine to meet the growing need for performance. A clean sheet design resulted in the development of the small block V8. Cole and his team were not constrained by existing engine designs within GM. A new version of the original V8 design engine is still in used today by General Motors.

1964 Pontiac GTO

In 1963, General Motors placed a corporate ban on factory participation in stock car racing. Pontiac's entire advertising and marketing approach was based on performance with racing being a vital component in the strategy. Pontiac wanted something to keep its performance image alive. The Pontiac team used the following objectives listed in Table A2.

Table A2 – 1964 Pontiac GTO Objectives
1. Continue performance based marketing approach without racing support
2. Quickly hit market for high performance vehicles
3. Develop cheap bare bones performance vehicle
4. Leverage existing assets to minimize cost
5. Minimize budget to avoid Engineering Policy Group

General Manager Pete Estes and Chief Engineer John DeLorean started experimenting with the intermediate Tempest model. The Pontiac Tempest had entered the market in 1961 and had not enjoyed much sales success. The team fitted a 389 cubic inch V8 from the full sized Pontiac Catalina and Bonneville into the Tempest to beef up its performance. By promoting the big engine Tempest as a special high performance model, they could appeal to the speed minded youth market. The team took the Tempest stripped it to bare essentials, added heavy duty brakes and suspension system, threw in three two barrel carburetors and a four speed manual transmission. The vehicle would be named the Pontiac GTO.

The development activity for the GTO had been hidden from senior GM management. DeLorean did not inform the Engineering Policy Group because previous program ideas for Pontiac had quickly been rejected. By the time management became aware of the vehicle it was too late to abort the GTO option. Pontiac launched the GTO in fall of 1963, narrowly beating competitors to market with models that were built for young motorists with a hunger for big burly engines and four-speed transmissions. The car, with an affordable European sports cars feel, reached the market at a low price of $4,000 in 1964.[6] The GTO was an instant sales success and within weeks Pontiac was revamping its production mix to increase the number of GTOs available. By the end of the year GM produced 32,540 GTOs. Pontiac had created a whole new class of

vehicle: the muscle car. GTO sales continued to rise, reaching 75,352 in 1965, and peaking with 96,946 in 1966.[7]

DeLorean and Estes circumventing the Engineering Policy Group allowed the Pontiac GTO to be developed without excessive oversight. The vehicle was developed quickly to meet the needs of an emerging segment in the market. As a result of the GTO, the Engineering Policy Group became even more deeply involved in the day-to-day engineering decisions of the automotive divisions, a move which eventually hurt the GM's ability to respond quickly to emerging markets.[8]

1964 Ford Mustang

In the late 1950s, Ford market research began to recognize a large and growing segment of car buyers. Affluent Americans were now shopping for a second car that captured the 1960s mood of youth and individualism. After extensive research to understand customer desires and needs Ford launched the Falcon. Despite strong sales of the Falcon, something was still missing. Ford researchers analyzed the buying patterns of Falcon customers and found many customers opting for sportier options, including more powerful engines. As a result the Mustang program was formed with the objectives listed in Table A3.

Table A3 – 1964 Ford Mustang Objectives
1. Share mechanical parts with Ford Falcon
2. Enter market quickly
3. Adopt customer centric basis for development
4. Address market for second car, singles, and women
5. Engineer high volume sports car

The Mustang program team was given 18 months to develop the vehicle. Ford used this extensive customer research, combined with customer visits, to develop a set of features that exceed the basic requirements of the customer. In an effort to compete against higher volume vehicles, Ford Division manager Lee Iacocca pushed developers away from a two seat concept. The vehicle would be sports car with mass appeal.

Ford sold 418,812 vehicles in 1964 the first year of production, about four times as many as the company had originally anticipated.[9] During its first two years the Mustang generated net profits of $1.1 billion in 1965 dollars. By shifting to a customer centric focus Ford nailed the needs of its customers with the Mustang and proved the company had learned from the Edsel experience. The Mustang was smaller, lighter, and cheaper than the competition. The Mustang could accommodate a small family and with its low cost the appeal reached two thirds of all U.S. car buyers. At the time of the Mustang's introduction, the development of an all new model cost between $300 and $400 million. By sharing components with the Falcon, Ford's cost to develop the Mustang was only $75 million

Many factors contributed to the success of the Mustang, including customer centric focus and product flexibility. Ford market researchers aimed the Mustang squarely at a new class of customers in a new segment of the market. Ford produced a sporty second car that incorporated the needs of woman and single customers. By leveraging the mechanical components of the Falcon, Ford produced a completely new market entry in just eighteen months and at a fraction of the cost to develop a new vehicle. Ford's product flexibility allowed them to be first to market and enjoy little competition from GM for almost three years.

1974 Volkswagen Rabbit/Golf

Successfully replacing the smash hit Beetle was vital to Volkswagen's continued survival. In 1971 a revaluation of the Deutsche Mark lifted the Beetle's price to around $3,500, from about $2,000, and the car's unchanging look had grown stale in the market. The novelty of the Beetle had run out and sales were in decline. Competitors' front-engine, rear drive small cars like the Toyota Corolla were drawing customers away from VW's noisy underpowered engines and dated styling. By the early 1970s VW had fallen deeply into financial problems. In 1974 VW lost a staggering $313 million.

During its time in the U.S., the Volkswagen Beetle became a part of American culture and an icon to people of all ages. But the Beetle's time was quickly ending. Volkswagen sales in the United States fell from 570,000 in 1970 (35% of all VW sales) to 334,000 in 1974 and 203,234 in 1976 (16% of total sales).[10]

To develop the Rabbit/Golf, VW successfully took up market technologies from mid size Audi's and moved them into their high volume product. Leadership decided the Beetle replacement would enter the market as a mid sized vehicle versus the popular choice of small car. Volkswagen's planners felt the small car segment would remain small and hypercompetitive and feared a vehicle too small would not sell in the United States. Table A4, below, shows VW's objectives for developing the Rabbit/Golf vehicle.

Table A4 – 1974 Volkswagen Rabbit/Golf Objectives
1. Design larger Beetle replacement vehicle to meet US market demands
2. Engineer front engine, front wheel drive vehicle
3. Innovative replacement for the Beetle
4. Engineer high fuel economy compact car
5. Configurable in many body styles

The flexible design of the vehicle allowed it to be produced in many body configurations. In the United States, the Volkswagen Rabbit was hailed as a revolutionary hatchback compact car. The small front wheel drive water-cooled 4

cylinder, with a transversely mounted engine was available for around the same price as a Japanese economy car. [11]

The Rabbit/Golf contained many design and engineering innovations and represented a new paradigm in car design for a decade or more. The program took advantage of computer stressing techniques, which enabled designers to exploit the full weight saving potential of front wheel drive. The engine was modern and fuel efficient. In the late 1970s, inflation has raised the prices of most American cars above those of competing foreign models, and no U.S. automaker could match the gas mileage of the 38 mpg Volkswagen Rabbit The diesel version of the Rabbit, with 42 mpg city driving and 56 mpg on highway became the most fuel efficient available in the U.S.

The design of the Rabbit sparked another generation of VW-alike American compacts, such as the Omni, Escort and Cavalier in the 1980s, just as the Beetle has inspired the Ford Falcon and Chevrolet Corvair in 1960s. The Rabbit was the first Volkswagen assembled in the United States. The vehicle, launched in the United States in 1975, sold well for a premium small car with average sales of 130,000 units per year. The ~$3000 sticker price of the Rabbit even drew the ire of the United Automobile Workers on suspicion of dumping

1984 Chrysler Minivan

The Dodge Caravan and Plymouth Voyager debuted in the US auto market in 1983. Public demand for the “garageable” van made the Plymouth Voyager and Dodge Caravan an automotive phenomenon. The minivan was the first truly original vehicle produced since the Model T. The minivan created an entire new market category for Chrysler and the automobile industry as a whole and kept Chrysler out of bankruptcy for 10 years. The Chrysler-produced minivans appealed to families, small businessmen, and to baby boomers.

The idea of a garage size personal van had been floating around in the auto industry since the early 1950s. For decades, car companies debated and evaluated the personal van concept with near misses, design deficiencies mandated by budget constraints, and marketing myopia. In the early 1970s, designer Don DeLaRossa at Ford identified front wheel drive as the essential ingredient to maximize interior space.[12] Hal Sperlich at Ford constructed a prototype in secret. The little prototype van was powered by a Honda Civic engine and transaxle simply because no components were available inside Ford. The pet project was given little support from Ford’s senior management. In fact, Lee Iaccoca wrote that Henry Ford II rejected the idea by grousing that the company did not indulge in “experiments”.[13] The primary objection to the project was the cost of developing new engines and combination transmission-differentials called “transaxles” for the FWD vehicle.

By the middle 1970s, a small group of Truck Division designers at Chrysler became convinced of the potential for a new compact van that could be housed in a normal garage but could not get management approval to go forward with the project.[14] When Hal Sperlich moved to Chrysler in the late 1970s, the minivan idea was given new life. Chrysler now produced a front wheel drive platform in the Omni/Horizon vehicles which allowed significant improvements in the overall height and interior dimensions. [15] At the time Chrysler was the dominant player in the full-sized van market mainly due to offering car like conveniences. Chrysler was not selling many station wagons. The vision for the minivan vehicle became clear: to produce a downsized van for families, one which would not cannibalize full sized vans sales, but instead would steal sales from station wagons.

The project was given the code T-115 and entered Chrysler's portfolio plans. Table A5, below, shows the objectives Chrysler followed to produce the minivan.

Table A5 – 1984 Chrysler Minivan Objectives
1. Develop FWD garage size personal van
2. Appeal to families, small businessmen, and baby boomers
3. Design from inside out
4. Maximize interior space
5. Easy to enter and exit

Defying traditional Detroit approach to designing the exterior first, T-115 engineers gave highest priority to the interior layout and appearance of the van, adapting components from the K-Car program to save money. The boxlike exterior was then wrapped around the interior design. The low floor of the simple front wheel drive vehicle, due to the absence of an intruding driveshaft, meant easy entry and exit and the ability to fit in a garage.

Now head of Chrysler, Lee Iacocca argued Chrysler could not afford such a vehicle. All available resources in the cash strapped company were being devoted to the K-Car sedans and an eleventh hour attempt was launched to look into a rear-drive version but found the intrusion of the bulky powertrain into the passenger compartment defeated the basic purpose of the expansive interior. Chrysler marketing pressured the company to spend money on a compact pickup, not a radical, front-drive, midget sized van appealing to an uncertain market. Both Ford and GM were moving into the small pickup market, and conventional wisdom demanded Chrysler follow suit.

Lee Iacocca approved the program with the more expensive FWD product at a time when the corporation was having trouble paying its bills and maintaining product competitiveness in existing market segments. The vehicle launched to a rousing success. Every major rival of Chrysler missed the mark in their attempts to enter the newly created market segment. Ford and GM launched compact vans which were essentially scaled–down version of rear drive vans aimed

primarily at traditional van buyers. General Motors had a big stake to protect in station wagons, in 1985 GM sold 366,500 wagons or 40% of the market, and saw little to gain from cannibalizing station wagon sales with front-drive minivans.[16]

Chryslers' competition completely missed the market for minivans. In 1984 Chrysler has record profits of $2.38 billion. From the 1983 introduction of the Voyager/Caravan, minivan sales in the US exploded from 31,000 units annually to 725,000 units per year in 1988. As of 1988, more than 40 percent of Chrysler's pretax profit came from mini-vans. Chrysler has controlled closed to 70% share of the minivan market since the vehicle debuted in 1983.[17]

The development and launch of the front wheel drive, "garageable", minivan is one of the most significant innovations in the history of the auto industry. The success of the minivan can largely be attributed to Chrysler's vision of the new market and understanding of the needs of its customers. Chrysler engineers held on to the true vision of the vehicle and insisted on developing a front wheel drive vehicle. The development of the vehicle broke with traditional vehicle development methodology by designing the vehicle from the inside out. The company took a calculated risk and spent additional capital to develop a vehicle 100% right for the market. The developers of the minivan were able to see past the traditional uses of vans and design a product which appealed to a broad range of customers. Chrysler dominated the new market it had created as the competition struggled for years to understand it.

1986 Ford Taurus

In the late summer of 1979, Ford Executives conducted an all day meeting to plan for their new midsize car program. According to projections, the new program would ultimately cost $3 billion, or about one-third of the company's 1979 net worth, and would hit the market until 1985. The essentials of the car, the chassis, engine and transmission would be the basis for most of Ford's larger models and most of its profits until close to the year 2000. [18] The new program, code named Taurus, would be an attempt to reach into the upper level of the mid size car segment consisting of well equipped vehicles just shy of luxury models and controlled by General Motors. The company had tried and failed to enter this market in the 1950s with the Edsel and management was very nervous about the program. When the program was approved, Ford was losing hundreds of millions of dollars. Ford would be counting on the Taurus for one quarter or more of its U.S. car sales, or about 500,000 units annually.[19] Ford would plunge deeply into debt to develop the Taurus and it would quickly become a "bet the company" vehicle. [20]

Industry research indicted General Motors would move to front wheel drive entries in their new mid size car entries. Ford leadership did not want to go against GM's dominant position in the segment and pushed for Ford to enter with market with front wheel drive (FWD) vehicles. The question to develop a front or

rear wheel drive (RWD) vehicle was extensively studied by Ford. Engineering and Marketing pushed for FWD while finance waffled over extra $1 billion price tag to produce a FWD vehicle. Internal technical studies rated a FWD plan and RWD plan a draw. Ford leadership received candid input by all functions in the company and decides to follow GM and produce a FWD vehicle.

The decision to produce the vehicle with FWD meant the car would be a clean sheet design. Ford did not have a FWD architecture for a mid size vehicle. Ford designers were now free to break away from the boxy designs of their old models in favor of softly rounded, aerodynamic styling that resembled the Audi cars of West Germany.[21, 22] Ford moved aggressively to put the Taurus into the front of the worldwide trend toward sleeker, more aerodynamic styling. Taking a cue from Audi, Ford enveloped the Taurus with a smooth, jellybean-like body. The Ford Taurus and Mercury Sable represented the culmination of a design trend called the aero look (by Ford) and the jellybean look (by competitors), championed by Ford Design Chief John J. Telnack. Ford eased the aerodynamic look into public acceptance with the release of specialty cars such as the Thunderbird and Cougar in 1983. The Ford program team followed the objectives listed in Table A6 below.

Table A6 – 1986 Ford Taurus Objectives
1. Engineer FWD upper level mid size sedan
2. Utilize cross functional team work to develop
3. Seize styling lead in the US market
4. Achieve "best in class" quality
5. Incorporate voice of customer

The Taurus program was one of the early projects in the U.S., to fully utilize the concept of cross-functional teams and concurrent engineering practices. The program team established close ties with vendors and subcontractors, and was characterized by a spirit of cooperation and strong synergy among teams. The new product philosophy was designed to make each of its products "best-in-class," by carefully selecting a composite of product attributes that will best meet the customer's wants and needs at an affordable price. “Team Taurus” included people from manufacturing, advertising and sales, areas that hadn’t been closely involved in new-car development before.[23] For Ford, the Taurus also represented something even more important: the first test of a new, efficient teamwork method for designing, producing and selling a car called "simultaneous engineering."

With the implementation of the team concept, the company removed the old top down management structure. The design and marketing of the Ford Taurus included wholesale involvement from all stakeholders in the company's future. For the first time, the car and the process used to make it were designed and engineered at the same time, ensuring higher quality and more efficient production.[24] The result was a remarkable market and business success. Its

revolutionary design and outstanding quality, created a new trend in the U.S. automobile industry, and customers simply loved the car.
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Ford aimed squarely at one of the fastest-growing parts of the U.S. car market: young professionals with children. Before the final vehicle plans were drawn, more consumer tests were done than any vehicle Ford has ever produced. Potential customers were allowed to drive handmade prototypes, instead of just being able to look at them, and many suggestions were incorporated into the vehicle design. The exterior and throttle linkages are tweaked based on consumer feedback. The vehicle met the latest design trends with a stiffer suspension and more interior room. The program included firmer seats, better ergonomics, and more trunk space.

The first generation of Ford Taurus became the best selling car in America in the late 1980s. The vehicle set the standard for new practices in project management and product development. The Taurus saved Ford from bankruptcy and, for a project which began as an extreme risk, would sell over 1 million units by 1989. Ford's share of the domestic auto market rose from 14 percent in 1985 to 38 percent in 1991.

1998 Lincoln Navigator

In the late 1990s, with the American SUV craze in full gear, Ford leadership realize they were losing sales at a price point above $35,000. Ford was the marker leader with the Ford Explorer and Mercury Mountaineer at price points under $35,000. But when potential customers had $40,000 to spend they were buying Land Rover, Infiniti, or Lexus. Additionally, Ford research indicated a surprising number of luxury seekers wanted a four-wheel-drive sport utility vehicle. The Lincoln Navigator was developed to address this niche in the full-size utility segment.

The launch of Lincoln Navigator introduced the concept of the American luxury SUV. The only true competition to the Navigator was the Land Rover Range Rover, which sold less than 7,000 units a year. The Navigator was designed in just 13 short weeks. Ford developed the Navigator to meet the objectives in Table A7.

Table A7 – 1998 Lincoln Navigator Objectives
1. Create luxury full size SUV market
2. Leverage Ford Expedition to minimize development costs
3. Fill SUV line up above $35,000

Ford quickly engineered its all new Expedition into a luxury edition by trimming the interior with leather, wood, and fine carpeting. By basing the Navigator off of the Expedition, Ford saved development costs and the same manufacturing line could be used to produce both vehicles. Taking advantage of the body on frame

architecture of trucks, Ford engineers just had to change a few of the Expeditions body panels and add a chrome grill to create the Navigator. The Navigator was engineered for performance. The Navigator's strengths included a 5.4-liter, single overhead cam V8 engine that produces 230 horsepower and 325 foot-pounds of torque.[25] The Navigator was launched with available rear-wheel drive or four-wheel drive mated with a four-speed automatic transmission as standard equipment.

No luxury vehicle at the time could match the Lincoln Navigator sport-utility for sheer audacity. From its massive, grinning, chrome grille and jewel-like projector headlights, to the plastic cladding on the sides, to the hearse-like rear window, the Navigator announces wealth coming, passing and going.[26] The Navigator easily found a spot with celebrities and the customized truck scene. Despite the luxury appointments, the pickup truck roots of the Navigator could easily be spotted. This didn't slow sales and upon introduction of the 1998 Lincoln Navigator, waiting lines for the Navigator formed.

The launch of the Navigator sent the competition scrambling. Lincoln had changed its image from old-fashioned to modern. Cadillac would take two years to get a competitor on the road. As the first American luxury sport-utility vehicle, it became an overnight success. Fully 60 percent of Navigator customers were new to the Lincoln brand. LLincoln planned to sell about 18,000 Navigators in 1997 and 25,000 in 1998. Ford Motor would make ~$15,000 profit on the $45,000 vehicle.[27,28] In 1998 Ford sold 43,000 Navigators and over 35,000 units per year until 2001.

1998 Toyota Prius

In the early 1990s Toyota Chairman Eiji Toyoda became alarmed at the prospect of complacency in product development at Toyota. The company had not changed its product development system for decades. At one board meeting Toyoda asked, “Should we continue building cars as we have been doing? Can we survive in the 21st century with the type of R&D that we are doing?”[29] In response to the Chairman’s questions Toyota’s Executive VP of Research and Development, Yoshiro Kimbara, was appointed to lead a task force code named G21.

G21 received only the guidance of being a small and fuel efficient vehicle with a large spacious cabin. The team was given two project goals: 1.) Develop a new method for manufacturing cars for the 21st century, 2.) Develop a new method of developing cars for the 21st century. Working part time on the project, the team presented a high level concept to executives after three months. The five main objectives for the vehicle are listed in Table A8 below.[30]

Table A8 – 1998 Toyota Prius Objectives
1. Roomy cabin space
2. High seating position
3. Aerodynamic Styling
4. Fuel economy of 47.5 mpg (50% greater than current Corolla)
5. FWD configuration with Continuously Variable Transmission

Recognizing the program to be the most innovative in decades, Toyota selected a Chief Engineer for the vehicle with extensive background in research. Leadership felt the program needed a deep level of research support to ensure success. The project team camped out in a top-secret room to work on the project.

The project team was given a clean sheet of paper and almost unlimited resources to produce the Prius. Management pushed the team to think of all possibilities to achieve the program targets. The team narrowed down the concept and settled on building a car that would be friendly to the environment and natural resources while still keeping the features of a modern car. To meet the fuel economy target the team reviewed several alternatives:[31]

- A direct injection inline 4 cylinder engine, electric vehicle, fuel cell, or hybrid. The direct injection gas engine would improve fuel economy by more than 30% over conventional engines
- An electric vehicle, while fuel efficient with zero emissions, was not practical from an infrastructure standpoint.
- The team viewed fuel cells as emerging too far off in the future.
- A hybrid engine would give a nice blend of fuel economy and technology, which could be implemented.

The G21 team began to wonder if they could achieve the performance target by using existing parts or would new parts have to be developed from scratch. Toyota leadership again stepped in an offered a hybrid propulsion system as a viable option for the program. Prius team members reviewed about 80 varieties of hybrid systems that had been introduced to the world

The Prius team settled on a two-type hybrid propulsion system. During acceleration or driving downhill the vehicle runs on the motor alone. During normal driving condition, the car uses both the engine and motor, storing extra electricity in the battery. When cruising at high speeds the car runs almost entirely on the engine. When extra power is needed to accelerate while cruising, electricity is drawn from the battery to give more power to the motor. The braking energy is recovered and stored in the battery. When the engine is idle, the engine is turned off except for times when the air conditioner is used or when the battery is extremely low and needs to be charged. Nine computers inside the vehicle control the complex modes of driving.

Although customers are drawn to the Prius for added fuel economy without sacrificing performance, Prius' marketing focuses on the car rather than the environment, positioning the vehicle as a desirable four-door family car. Consumers are made aware of the added benefits of an environmentally-friendly power source for the long term, such as fuel economy and taxation. The Prius is rated in the United States at 66 miles per gallon and regularly performs in the 40-44 miles per gallon range in city driving, the market leader for sedans.

Prius is the world's first and most successful hybrid power vehicle and the world's cleanest family car. Toyota leadership purposely selected a project leader with extensive research background for the program. Toyota leadership recognized the program to be the most innovative undertaking in decades and needed a deep level of research support to ensure success. More than 300,000 Prius cars have been sold worldwide since the first generation Prius was launched in Japan in 1997.[32] The Prius program raised the bar in terms of its fuel- efficient engine and low levels of harmful emissions. The vehicle emits only half the carbon dioxide of a regular gas engine and cuts other tailpipe emissions by about 90 per cent.[33] Sold at $17,700 US, Toyota will lose heavily on the hybrid, which costs as much as $41,000 a car to produce. [34] Although Toyota loses money on every Prius it sells, the company fully expects hybrids to be profitable in the future.[35]

2001 Chrysler PT Cruiser

The PT Cruiser project started for Chrysler in 1994 when the company began looking for an image vehicle with good fuel economy. The vehicle would help the company sell more full size trucks. Chrysler sells many large trucks and needed to produce a small truck-like vehicle to satisfy government regulations on fuel economy. To be classified as a truck the vehicle had to have a flat floor pan among other things. The objectives for the PT Cruiser are shown in Table A9.

Table A9 – 2001 Chrysler PT Cruiser Objectives
1. Develop image vehicle for Chrysler
2. Capture "Spirit of America"
3. Develop small truck to improve CAFÉ
4. Utilize Dodge Neon a basis for design

In the mid ‘90s the Chrysler Corporation had launched the Neon, a small economy car that was designed to appeal to both International and US markets. Chrysler management felt they could base their image vehicle off of the Neon. Chrysler engineers discovered that, to get a flat floor plan, basic changes to the suspension were needed. As a result the PT Cruiser had a hybrid of two suspension types and turned out to be four times as stiff as the Neon’s. The extra stiffness allowed for more vertical shock absorbers which created nine inches more interior space. The end result is that the PT Cruiser has an immense interior for given its size. The PT Cruiser is larger than the Cirrus inside and shorter than the Neon.

The Plymouth Pronto concept car was shown to the public in 1997. The vehicle was tall with many practical features, a roomy interior and flexible seating. European journalists liked the car, but those in the US were less enthusiastic. Chrysler management felt the basic vehicle concept was good but more was needed in the design. Lengthy research and management debate led to the idea of a car that could somehow capture the 'Spirit of America'.[36] Designer Bryan Nesbitt took inspiration from the bold styling of 1930s era vehicles and designed the Pronto Cruizer concept. Chrysler showed the vehicle at the 1998 Geneva Car show to test public reaction. In 1999, the PT made a surprise launch at the North American International Auto Show.

The final design and engineering was done with networked computers, allowing suppliers to play a large role in design. Virtual reality and simulation tools were used from the beginning, allowing early optimizing of the interior and ergonomic design. The biggest design hurdle of the program was getting the interior of the small truck to meet expectations promised by the exterior. Chrysler had to abandon plans to share such Neon components as the steering wheel and manual gear shift selector — for the latter they settled on a white, cue ball-like knob mounted on an aluminum shaft.[37]

Chrysler designed the PT Cruiser to anticipate the needs of owners by understanding emerging trends in the ways people use their vehicles.[38] Focus groups told Chrysler that the PT was a slam-dunk success, but Chrysler viewed it as a niche car and moved very cautiously on volume estimates for the vehicle[39] The PT Cruiser (PT for personal transportation) went on sale to the public in April 2000. Built at the Toluca plant in Mexico, the use of innovative computer technology greatly reduced pre-production time and costs. This unique car could not have been produced without some very bold management decisions at DaimlerChrysler. The development team perfectly executed translation of the Plymouth Pronto concept vehicle to production. The PT was destined to be a classic right from its launch in April 2000, when waiting lists of nearly a year led to some PT's changing hands at twice their original selling price. Sales hit 121,389 units in 2000 and peaked with 191,544 in 2001.

2003 Cadillac CTS

For years General Motors experimented with small, sporty Cadillac vehicles in an effort to compete with BMW, with little or no success at all. Notable failures such as the Cimarron and Catera were unable to win over the buying public. General Motors' management desperately needed to create a small Cadillac BMW fighter to restore Cadillac's battered image. GM believed the storied vehicles of Cadillac's past were a direct result of the fusion of design and technology. The company wanted to develop and a futuristic design with advanced technologies. General Motors called this design theme "art and science"; the CTS became the lead vehicle for the new direction.

In the late 1990s, General Motors' management became concerned over the health of its' Cadillac nameplate. The Cadillac brand was more profitable per-vehicle than any division that GM had at the time.[40] The Cadillac customer base was quickly aging and potential customers come along had expressed no interest at all in Cadillac. Two important decisions were made to shape the future of Cadillac: 1) create a unique exterior shape and 2) move to rear-wheel-drive on a purpose-built platform.[41] A clean sheet design vehicle would be engineered for Cadillac. GM would no longer "badge engineer" a Cadillac small car. The objectives for the CTS program are listed in Table A10 below.

Table A10 – 2003 Cadillac CTS Objectives
1. Launch competitive vehicle in Entry Level Luxury segment
2. Design a vehicle which stirs the emotions of customers
3. Test the vehicle against the world's benchmark (Nurburgring)
4. Create a consistent design theme for Cadillac vehicles
5. Engineer RWD architecture for Cadillac

The vehicle would be built of a brand new RWD architecture code named Sigma. The new vehicle was produced as rear-wheel drive for true ride and handling performance. CTS was tested extensively and refined on the most challenging race circuit in the world, Germany's famed Nurburgring, to ensure that it would handle the way the great German sports sedans do.[42] The experience influenced pedal positions, brake operation, and even seat design in the CTS. The CTS represented the Cadillac for the 21st century and a perfectly executed design concept. The CTS has a more responsive chassis and better body control than in any Cadillac in history. Steering is crisp and spot-on, the engine pumps out ample power and finally Cadillac has an application for perhaps the best five-speed automatic available, a Hydra-Matic transmission previously only available on the BMW 5 Series and X5.[43]

CTS would be priced at a mere $29,990, nicely competitive with its top competitors. GM's luxury Cadillac brand is perhaps the best example of how edgy, love it or hate it designs can energize sales. CTS vehicle sales continue to grow today – 2002 sales 38,000 units, 2005 sales 61,000 units- 60% growth. CTS.[44] 2003 CTS, which will go down in history as the car that started Cadillac on its march back to quality[45]

TEN PRODUCT FAILURES

1958 Edsel

The Edsel was a new brand of automobile launched by the Ford Motor Company in the 1958 model year and produced through the 1960 model year. The car brand is best known as one of the most spectacular failures in the history of the United States automobile industry. In 1956 Ford management pushed to fill a

void in their mid size car line up. The management team compared the line up of Ford models to General Motors' and believed they were losing customers to GM and others when Ford drivers wanted to move to a more luxurious automobile. Ford planned to move Lincoln more upscale to compete with Cadillac and introduce a new brand to fill the void. Ford's objectives for the Edsel are listed in Table A11, below.

Table A11 – 1958 Edsel Objectives
1. Launch a brand in the upper midsize segment
2. Fill niche between young and sporty and middle age segments
3. Utilize existing Ford manufacturing assets

The Edsel was introduced to America on September 4, 1957. A massive promotional campaign, which included multi-page "teaser" ads in major national magazines, prompted some 2.5 million Americans to pour into Edsel dealerships on "E-Day".[46] Ford promoted the vehicle with a highly rated television special, "The Edsel Show". Despite the high dealer traffic, Ford soon realized few Edsels were actually being sold. Although, Edsels had many features that were innovative for the time, e.g., self adjusting brakes and electric hood release, the public expectation was much higher than the car could deliver.

Ford's marketing strategy for Edsel went terribly wrong. The pre-vehicle launch publicity of the vehicle was shrouded in mystery. The buying public was not even permitted a clear view of the cars before their release date.[47] In the months leading up to the launch ads began running containing only the pictured hood ornament and exclaiming "The Edsel is Coming". Ford shipped the vehicles to dealerships under wraps and kept them wrapped on the dealer lots. The advertising campaign gave the public expectations that could not possibly be lived up to.

When the Edsel was in its planning stages in the early and mid 1950s, the American economy was robust and growing. The Edsel became the wrong car for the wrong market at the wrong time. The failure of the vehicle highlighted the limitations of market research. Ford marketing had developed plans for a new medium-priced car to compete with Chrysler's Dodge and DeSoto, General Motors' Pontiac, Oldsmobile and Buick. The vehicle would strike a happy medium between young and sporty and the middle aged segment. Marketing studies showed that by 1965 half of all U.S. families would be buying cars in the medium priced market and Ford could sell up to 400,000 Edsels a year. The flaw in all the research was that by 1957, when Edsel appeared, the bloom was gone from the medium-priced field, and a new boom was starting in the compact field, an area the Edsel research had overlooked completely.[48]

When the Edsel hit the showroom floor, the United States economy had moved into a recession. American consumers not only shifted their idea of what an ideal

car should be; they were growing interested in smaller economy cars. The public's interest in huge, big fin cars with glitzy chrome was ending.[49] The buying public had lost interest in bizarre grills and lots of chrome. Despite the economic conditions, Ford pushed the Edsel's powerful engine that required premium fuel and delivered poor fuel economy when the buying public was moving into more fuel efficient cars.[50] Ford loaded up the first models to hit the show room with lots of options leaving many with sticker shock. The Edsel was more expensive than other comparable cars, and the price of the loaded, top-of-the-line models that were first on the showroom floor scared many buyers. The Edsel turned into a victim of misbegotten styling and an inconvenient economic recession[51]

The Edsel models ran down the same assembly line as Ford and Mercury models. The assembly workers had trouble shifting to produce Edsels and sometimes forgot to install parts. Many Ford/Mercury employees resented having to build another division's vehicles and did not put their best effort into the vehicles. Edsel quality suffered. Supplier issues forced Ford to ship many vehicles with parts missing and the dealerships were ill equipped to replace the parts or add on accessories.

In the 1958 model year Ford delivered 63,110 Edsels, 63% short of the sales goal. The American public never bought into the Edsel's styling, in particular the grill. Ford's turn around expert Robert McNamara moved to cut costs by eliminating the dual wheelbases and separate body used for the Edsel in 1958. The 1959 Edsel would share a Ford platform and inner body structure. The advertising budget was steadily reduced in 1959 and 1960 and the final blow came when management decided the Edsel was doomed and ended the program after just three years of production. Only 110,000 Edsels were ever sold.

There is no single reason why the Edsel failed. Vehicle styling, poor quality, and weak internal support for the program added to a complete lack of market understanding by Ford management. Another strong contributing factor is bad timing. The Edsel launched just as America went into a recession. Several cars were also hurt by the poor economic times at the end of the 1950s including the end of De Soto, Packard, Nash and Hudson.

1960 Chevrolet Corvair

In late 1959 General Motors released the 1960 Chevrolet Corvair to the United States auto market. The influence of the Volkswagen Beetle had driven a rise in popularity of economy vehicles among Americans. The objectives for the Corvair program are summarized in Table A12, below. General Motors, led by Chevrolet General Manager Ed Cole, created a revolutionary new economy car for the American market.

Table A12 – 1960 Chevrolet Corvair
1. Develop revolutionary compact car
2. Counter small lightweight imports
3. Engineer first modern rear engine sports car
4. Market as economy car with sports car image

Powered by an air-cooled six-cylinder engine—a first for Chevrolet—it was referred to as a "flat six," since the cylinders were horizontally opposed rather than in the typical "V" configuration.[52] The engine was mounted in the rear of the car, driving the rear wheels through a compact automatic transaxle. Suspension was independent at all four wheels. The Corvair had no conventional frame and was the first unibody construction built by GM's body group.[53] The design was championed by Ed Cole as an answer to the growing popularity of small, lightweight imports. Chevrolet deliberately designed the Corvair as a radical departure from the conventional Chevrolet. The styling of the vehicle was unconventional for the time. The lines of the vehicle were subtle and elegant. Missing were the tailfins and chrome of the day.

The Corvair adorned the cover of Time magazine and was named Motor Trend Magazine Car of the Year for 1960. Despite its critical acclaim, the Corvair did not dominate the marketplace. The vehicle was expensive to manufacture due to the unusual design and lagged the competition in the economy class of vehicles. Chevy's General Manager was so enthralled with the idea of building the first modern rear engine sports car that the vehicle was approved even though serious concerns were raised about its engineering.

An engine placed in the rear of the vehicle powered the Corvair. The vehicle was supported by an independent, swing axle suspension. Rear engine vehicles using a swing axle suspension at high speeds tend to become directionally unstable and very difficult to control. In high performance, the Corvair conveyed a false sense of control to the driver. Mercedes had found a similar design too unsafe to build. Problems with Corvair were well documented inside GM's engineering staffs long before the vehicle went on sale. Charlie Chayne, vice president of engineering took a very strong stance against the Corvair as an unsafe car long before it went on sale in 1959.[54] There was a mountain of documented evidence that the car should not be built. Fitting the vehicle with a safer conventional rear suspension would cost GM more money to build. The vehicle went forward into production.
GM marketed the Corvair to the buying public as an economy car with a sports car image. Young Corvair owners were trying to bend their car around curves at high speeds and killing themselves in alarming numbers. In 1961, Bunkie Knudson the new head of Chevy insisted on installing a stabilizing bar in the rear to counteract the natural tendencies of the car to flip. The $15 cost was refused for being too expensive[55]. By 1965 GM had corrected the safety issues by placing a safer independent suspension in the vehicle. By then the damage was

done. The unfavorable publicity and Ralph Nader's book, "Unsafe at any Speed", severely damaged sales. GM had planned 1966 as the last model year for the Corvair but with the safety publicity had opened up a National Highway and Traffic Safety (NHTSA) investigation. GM management would not stop producing the vehicle and appear to admit any safety issues. The Corvair ran through 1969 and the NHTSA report concluded the Corvair was no more prone to accidents and rollovers than any other comparable car of the period.

The Corvair pioneered such technological advances as turbo-charging, true four-wheel independent suspension and unibody construction. 1,710,018 Corvairs were built between 1960 and 1969. Experts argue that the rear-engine car was the last innovative GM car.
It was not a muscle car, like the Corvette or Mustang, but it did have an air-cooled six-cylinder engine where its trunk should have been, making it easy to handle, its fans say, and fun to drive.[56] GM, after looking at Ford's hot new Mustang, decided in 1965 it had to come up with a competitor that had a conventional front-engine, rear-drive design. The competitor turned out to be the 1967 Camaro. GM's decision left no more development money for the Corvair rear-engine vehicles. General Motors spent millions on legal expenses and out of court settlements due to the Corvair.

1971 Chevrolet Vega

On October 3, 1968 General Motors Chairman James M. Roche announced that in two years GM would introduce a new sub compact car designed for American tastes and developed to counterattack the growing trend toward foreign cars. The announcement broke with GM's tradition of not speaking about future products for fear of hurting sales of current products. The announcement of a GM small car created a stir among the nation's millions of car enthusiasts and sent a signal to import manufacturers that the giant domestic auto industry was now serious about competing in small cars. The small car market, comprised of American compact and subcompact cars and the little imports, was expected to total 3 million units in 1971.[57]

Roche predicted the car, code named XP-887 and later named Vega, would weigh less than 2,000 pounds, be priced less than $1800 and feature the most automated assembly process known to American automotive technology[58]. The Vega would contain an all new aluminum engine, fail safe sophisticated marketing research, and be produced through highly automated assembly techniques.[59,60] The objectives of the Vega program are summarized in Table A13, below.

Admittedly GM had not understood the demand for smaller cars in the past and responded too much to demand for performance.[61] The Vega was going to be the first car that consumers told GM they wanted to buy and not vice versa.

Table A13 – 1971 Chevrolet Vega Objectives
1. Counter small lightweight imports
2. Address the needs and wants of consumers
3. Engineer all-new aluminum engine
4. Weigh less than 2,000 pounds, be priced less than $1800

GM tradition dictated headquarters would decide a new market should be developed (policy) and then would assign the responsibility for producing the car for that market to one of the five car divisions.[62] The traditional concept of centralized policies and decentralized decisions was not followed in the development of the Vega. Ed Cole, executive vice president of Operating Staffs, and Bill Mitchell, the vice president of design staff would lead the development of the Vega. Cole's corporate position pushed his personal vehicle proposal to be selected over a proposal from Chevrolet. The vehicle would be developed by people at central staffs at least one step removed from the marketplace with total autonomy. No system of checks and balances remained in place.

The engine, pushed by Cole and corporate engineering featured an aluminum cylinder block with a cast iron head. The automotive industry had tried to utilize aluminum engines for decades and each time rejected them due to cost. The critical importance of weight in small cars pushed the team to using aluminum, which is one third as heavy as iron. However the disadvantage of aluminum, as compared with iron, is that it does not wear as well and is distorted more easily during heat of operation. Past practices had been to put iron sleeves into each cylinder with standard aluminum piston to improve the wearing characteristics of aluminum engines. The corporate engineers went for an innovative production process in using aluminum but relied on an older longer stroke engine to control emissions. The final product was a relatively large, noisy, top-heavy combination of aluminum and iron which cost far too much to build and weighed more than the cast iron engine the Chevy divisional engineers had proposed as an alternative.

The Vega was a pilot program for using a product manager for the entire marketing of a car line. Chevy marketing spent more than a half-million dollars on marketing research. The marketing team evaluated how the vehicle was going to be perceived in the market and decided the they should abandon the lower end of the mini-car market and spend more on trim and appointments to price as a premium. Corporate Staff rejected the suggestion but kept the higher pricing.

The Vega program created a hostile relationship between the corporate staffs, which essentially designed and engineered the car, and the Chevrolet Division which was to sell it. When James Roche publicly announced the vehicle, his information came from statistical abstractions. Not one prototype Vega had been built or tested. When Chevy engineers took the first prototype Vega to the GM test track in Milford, Michigan the front of the Vega broke off after only eight miles of driving.[63] Chevrolet's engineering staff was disinterested in building the Vega.

The central staff completely misgauged the weight of and the cost of the car. Simple items such as side door crash protection beams were overlooked even though they were in plans for all GM future cars. The Vega hit the market heavier and costlier than planned ($300 more than the VW Bug). In the 1971 model year sales reached just 245,000 units against an estimated 400,000.[64] Heat distortion problems inherent in aluminum engines surfaced, Vega engines began to burn out when excessive thermal expansion forced water out of the cooling system. Thousands of Vegas had burnt out engines and 132,000 Vegas had to be recalled due to defective carburetors. The Vega ended production in 1977.

The failure of the Vega hits on four key factors: corporate staffs at GM bypassed the traditional vehicle development process, the project did not receive buy-in and support throughout the organization, data driven marketing decisions were ignored, and the development was handled at the highest levels without any checks and balances. The organizational structure of General Motors' in the early 1970s consisted of a corporate entity to set policy and five operating divisions to produce the vehicles. Corporate staffs elected to engineer the Vega on their own and then hand the vehicle over to Chevy to produce the vehicle. They selected a new technology for the engine, which was not supported by Chevrolet engineers. Chevy engineers pushed for a short-stroke design for the innovative engine but corporate staffs went with an old basic design for the bore stroke. Vehicle pricing and positioning recommendations, based on extensive market research, were ignored by the corporation. The position of Ed Cole in the corporation allowed the project to operate in complete autonomy, ignoring the input and recommendations of the vehicle development experts closer to the pulse of the market. The Vega proved to be an utter failure for General Motors.

1971 Ford Pinto

In 1971 Ford launched the Pinto sub compact to compete with new import and domestic subcompacts. The Pinto was a very conventional car with little daring or innovative engineering, although it featured an overhead camshaft and pioneered rack-and-pinion steering in America.[65] The vehicle was essentially a scaled down version of a large car. The conventional design utilized a unibody construction, rear wheel drive, manual or automatic transmission. Seating was very low to the floor, and styling somewhat resembled the larger Ford Maverick in grille and tail light themes.

Lee Iacocca insisted on rushing the Pinto into production to meet the challenge of import vehicles in the sub compact market. At the time vehicles were being developed in 44 months. The Pinto program was given 25 months. To meet the tight timing schedule, the tooling for the vehicle had to be purchased very early on in the development process. The Pinto was not to weigh an ounce over 2,000 pounds and not to cost a cent over $2,000. Although the Pinto would sell more than 350,000 in its first model year, foreign importers would continue to gain market share in the United States.[66] The Pinto did, however, outsell GM's rival

entry the Vega every year until the Vega was discontinued in 1977. The Pinto was still priced higher than the rival Volkswagen.

In 1972 Californian Lily Gray's Pinto was rear-ended by another car. The gasoline tank ruptured, filling the inside of the car with fumes, which ignited into an inferno. Gray died a horrible death, and a young student passenger, Richard Grimshaw, required extensive surgery. The Pinto became a focus of a major safety scandal. The car's design allowed its fuel tank to be easily damaged in the event of a rear-end collision which sometimes resulted in deadly fires and explosions. Critics argued that the cause was the vehicle's lack of a true rear bumper as well as any reinforcing structure between the rear panel and the fuel tank. In certain collisions, the tank would be thrust forward and puncture. This, and the fact that the doors could potentially jam during an accident made the car a potential deathtrap. Ford engineers had discovered in pre-production crash tests that rear end collisions would easily rupture the fuel tanks. The assembly line machinery was already tooled when the defect was discovered and Ford management decided to proceed with putting the vehicle in production[67]. Ford's engineering estimated a $10 per car cost increase to correct those faults.[68]

Pre-production planning considered using the Capri gas tank in the Pinto. The Capri has been so successful in over 50 crash tests that Ford used it as an experimental safety vehicle. Lee Iacocca had issued the following imperatives, summarized in Table A14, for the Pinto program:

Table A14 – 1971 Ford Pinto Objectives
1. Develop compact vehicle in 25 months
2. Cost $2000 or less
3. Weigh 2000 lbs or less
4. Low cost of ownership
5. Clear product superiority

Safety was not listed. Engineers at Ford developed a variety of ways to correct the gas tank problem, including putting the gas tank on top of the axle. This solution would cut luggage space, and therefore was rejected by executives. When confronted about the predicament, Ford argued that all the federal safety requirements were met and that the Pinto was just as safe as any other car of that size and type. There were no standards for withstanding rear-end collisions of a specified number of miles per hour until a few years later in 1977

Ford appealed the subsequent court case all the way to the California Supreme Court, but ended up paying Grimshaw $6.5 million. It was the beginning of more than a hundred lawsuits, which cost Ford many millions of dollars. Ford eventually recalled 1.4 million 1971-76 Pinto's for safety modifications under pressure from the National Highway Traffic Safety Administration.[69] Over 100 lawsuits against Ford forced the auto maker to pay out millions of dollars in damages. At least fifty-nine people burned to death in rear-end collisions. With a

half million cars rolling off the assembly lines each year, Pinto was the biggest-selling subcompact in America and a huge source of Ford's profits.

1975 AMC Pacer

American Motors Corporation (AMC) under the leadership of chief stylist Richard A. Teague began work on a new vehicle in early 1971, anticipating an increased demand for smaller vehicles in the 1970s. The result was a two-door compact car offered in the United States between 1975 and 1980. The car, with its bulbous "Fish Bowl" look and different sized doors, is an easily recognized icon of the 1970s. The car was designed to appear very futuristic. AMC had limited capital to develop truly new models in the early 70s, yet management felt that AMC needed to try something radically different to make its voice heard in the market.[70] AMC management gave approval to produce a vehicle targeting the objectives summarized in Table A15.

Table A15 – 1975 AMC Pacer Objectives
1. Design and engineer a futuristic breakthrough vehicle
2. Manufacture vehicle on existing factory lines
3. Launch a new vehicle capable of a long model run
4. Utilize small, lightweight engine
5. Design and engineer a small vehicle with the same interior room as a midsize

In 1971 AMC management reviewed new model options for release in 1975. The company targeted a high volume vehicle, with good profit potential and an appeal to futuristic living. The program team set up a decision making matrix relating Pacer design goals to different underbody designs that could be used. Leadership started with 36 choices, boiled it down to 12, to 3 and then to 1.[71] AMC research indicated Americans at the time were not comfortable with the front-wheel drive layout, preferring more the traditional and familiar rear-wheel drive. Rear and mid-engine layouts were considered. The Pacer was designed to meet new government mandated safety requirements, and also included a new windshield safety glass that broke into small round beads instead of sharp edges. However, successful lobbying by GM, Ford, and Chrysler pushed the government mandated safety requirements out in time. AMC was able to pull out some of the added safety features but not all of them. AMC did not advertise the safety features well and very few people were willing to buy a Pacer for its safety.

The AMC Pacer was developed to be a breakthrough automobile. The shape of the vehicle was highly rounded with a huge glass area, very unusual for its time. The width of the car matched an American full size car and was very wide for a small car. The AMC designers assumed customers needed to have as much room as in a large vehicle to consider purchasing a small car.

The wide design allowed AMC to use existing manufacturing assembly lines, which were unchanged from the days of full-sized cars. The result was an American attempt at an "economy car", or, in the words of AMCs advertising blurb, "the first wide small car". The dashboard was put as far to the front of the vehicle as possible to maximize passenger cabin space, known today as “cab forward design”. The Pacer contained many technical innovations. The vehicle was among the first production cars in the U.S. to feature electronic ignition and a catalytic converter. The Pacer’s passenger side door was four inches longer than the driver's side, the rationale being to encourage rear-seat passengers to enter the car from the safer side.

AMC’s original design featured a Wankel rotary engine which would be purchased from General Motors. GM was developing a wide-scale introduction of rotary engines in their vehicles. The fuel crisis and upcoming emissions legislation in the United States doomed the GM rotary engine. Unable to meet emission laws, General Motors cancelled development of the Wankel in 1974. The sudden cancellation of the engine left the Pacer without an engine. The Pacer was designed around the rotary engine. AMC hastily reconfigured the vehicle to fit in their existing I6 engine. The rotary engine was more compact and lighter than I6 engine installed in the Pacer. The heavier engine, added safety features, and extra width of the vehicle made the Pacer 350 to 500 pounds heavier than the competition. The heavier weight hurt the fuel economy of the vehicle. The Pacer managed only 16 mpg in the city, although on the highway it could get 26 mpg or better, depending on driving habits and transmission used. Customers did not like the Pacer’s lack of power. Competitor’s vehicles weighed a good deal less, were sporty and were more fuel efficient. Additionally, the heavy engine used by the Pacer put more load on the front suspension than intended, which caused the rack and pinion steering to fail frequently.

The Pacer was launched in the midst of a fuel crisis in the United Sates and increasing sales of imports. The American public was beginning to be educated in the sophisticated ways of the European automobile and learning to love the thrift and reliability of Japanese cars. In its first year of production, the Pacer sold well, with 145,528 units. Unfortunately for AMC, Pacer sales fell rapidly after the first two years and production ceased after a short run of 1980. Improved competition and resistance to the Pacer's unusual styling are often cited as the reasons for this outcome. The AMC Pacer was an automobile that was the product of extensive usability design, but failed to capture the market because it lacked visual appeal.[72] Additional drawbacks included a lack of cargo space when carrying a full load of passengers. In an effort to spur sales a higher output model of the Pacer was launched in 1976. The gain in performance could not offset the much higher fuel consumption.

The failure of the Pacer is rooted in AMCs decision to design the car around an unproven engine design. The Pacer was conceived for a future that did not

come.[73] When GM cancelled development of the Wankel engine, AMC had to shoe horn an out of date and heavy inline six cylinder into the vehicle. The car did not have the right combination of horsepower and fuel economy to compete in the small car segment. The edgy styling of the vehicle never caught on with buying public. Teague's design was criticized for being nonstandard. The Pacer was not a boxy car with a blunt pseudo-classic grille, a long hood, a high belt line, or the typical cramped interior found in small cars.[74] The Pacer was way ahead of its time. The Pacer contained many features, including “cab forward” design and safety glass, considered to be ahead of their time and did not enter mainstream automobiles until the 1990s.

1981 DeLorean DMC-12

John DeLorean left GM in 1973 to build a modern ethical, fuel efficient sports car. Frustrated by GM’s giant myopic bureaucracy, many automotive experts felt DeLorean actually understood what was needed for the survival of the American auto industry but could not deliver on it.[75] In order to carry out his plans, DeLorean built around himself a staff that at the time included some of the automobile industry's top executives. By October 1976 the first DeLorean prototype was completed.

The car was a gull-wing, two-passenger, Giugiaro-designed, rear-engine sports car, engineered by ex-GM standout William Collins.[76] The objectives for the vehicle are listed in Table A16. The platform was molded of a resin impregnated sandwich, with a urethane foam core and fiberglass surfaces from a new and untested manufacturing technology known as Elastic Reservoir Molding (ERM). ERM would contribute to the light-weight characteristics of the car while presumably lowering its production costs. Grumman aircraft helped develop the body-in-white of the vehicle. The Delorean’s brushed stainless steel body and fancy gull-wing doors were intended as a glimpse of the future.[77] The stunning design was to be powered, at the outset, by Citroën's lightweight Comotor Wankel engine. However fuel economy problems pushed the vehicle into a Peugeot-Renault-Volvo fuel injected V6.

Table A16 – 1981 DeLorean DMC-12 Objectives
1. Develop modern ethical, fuel efficient sports car
2. Develop chassis from ERM molding to save weight
3. Utilize unpainted stainless steel body panels
4. Achieve 200 hp

The engine swap was the first of many changes required to bring the vehicle in to mass production. The new ERM technology, for which DeLorean had purchased patent rights, would quickly be found unsuitable for mass production. As pressure to produce the car grew, much of the engineering work on the car was turned over to Lotus, who substituted a variation on the Lotus steel backbone

frame for the original plastic substructure. Of the original prototype, only the stainless steel skin and gull wing doors were retained

DeLorean turned the manufacturing location of his new vehicle into a world wide competition. In the end, the British government dolled out over $198 million in grants and loans in return for DeLorean locating the vehicle factory in jobs-poor Northern Ireland. [78] Ground was broken in October 1978 on the construction of the factory. Production of the vehicle, now named the DMC-12, was scheduled to start in 1979.

The original vision for the vehicle targeted performance of around 200 horsepower, but DeLorean eventually had to settle on 170 horsepower. But in order to meet US emission regulations a catalytic converter had to be added before it could be sold in the US. To meet the requirements the engine output had to be reduced to 130 HP. Coupled with a weight gain of 600 pounds from the switching the ERM backbone to steel and the reduced horsepower had serious effects on the vehicles performance. The original vehicle was estimated to achieve 0–60 mph in 8.8 s. A very competitive time compared to the Corvette (9.2 s), Porsche 944 (8.3 s), and Mazda RX-7(9.7). However, Road and Track clocked the production vehicle at 10.5 s. All this helped to give the car its 'gutless' reputation, right from the start. [79]

The numerous engineering changes pushed the launch of the vehicle out to 1981. By then, the design was teetering on being outdated and those who bought the vehicle found a litany of quality-control problems, from doors that wouldn't always open, windows falling out, electrical failures, knobs falling off and a stainless steel body that was impossible to keep clean.

The quality problems were so bad with the DMC-12 that Quality Assurance Centers (QAC) had to be set up throughout the United States. Among the items fixed were the fit of the stainless steel body panels, the hanging of the gull wing doors and replacement of weak alternators. One published report put the average cost of repairs per car at $2500. The QAC operations cost DeLorean roughly $2 million a month to operate.[80]

DeLorean Motor Corporation struggled internally. The company had very high turnover among the executive staff. DeLorean himself seemed to have trouble adjusting to leading a small company. His leadership skills, honed at General Motors, were not a match for a small company.

The DMC-12 did not meet the targets set out for it. DeLorean paid dearly for betting on unproven technology. To mass produce the vehicle trade offs had to be made which made the vehicle non competitive. The poor performance and lack of quality heavily contributed to the down fall of the DMC-12. Around 8,583 DMC-12s were made before production fizzled.

1982 Cadillac Cimarron

In the early 1980s GM was in the midst of changing virtually all of its cars from rear wheel drive to front wheel drive. The initiative included the launch of GM's import fighter the J-car. The development of the J-car program was handcuffed by financial staff's tight budget. The J-car program would have to share parts with the older and larger X-body platform. The result produced a vehicle only 400 pound lighter than the X-car and sharing the following features: steering system, front suspension control arms, front-wheel drive axle joints, wheel bearings, starter motor, generator, power steering pump, radiator and air-conditioner compressor, and automatic and manual transmissions.[81]

In an attempt to respond to the energy crisis, Cadillac was included in the program. The Cadillac J-car would be the smallest Cadillac produced since 1905 and first to carry a four cylinder engine. GM management put the Cimarron program together to meet the objectives summarized in Table A17 below.

Table A17 – 1982 Cadillac Cimarron Objectives
1. Engineer a high fuel economy Cadillac
2. Engineer peppy and fuel efficient entry level luxury car
3. Match quality and performance of BMW 3 series
4. Engineer a small entry level vehicle to raise corporate CAFÉ rating

GM wanted to compete with BMW for young affluent buyers who were looking to drive small, fuel efficient, luxury cars with some pep. GM named the Cadillac the Cimarron. But Consumers saw the Cimarron not as a Cadillac but as a renamed Chevrolet Cavalier.[82] The product was no more than a gussied up Chevrolet Cavalier subcompact built on the same assembly line, but sold for nearly double the Chevrolet's price.[83] GM commanded a price of $12,131 for the Cimarron.[84] GM had done little more than add leather seats and a roof rack.

GM management made a critical error in the powertrain selection for the program. GM selected a sluggish four-cylinder engine for the J-car program, despite higher revving engines being a major attractor to imports like the Honda Accord. Engineering pushed for a more technical and peppier 1.8L overhead camshaft from Opel. Financial selected the older four-cylinder because money could be saved through part sharing with the X-car V6 engine.

The Cimarron was rushed into production in May 1981 to an unsatisfied buying public and dealer network. The Cimarron was a small, poorly performing vehicle ill equipped to compete with BMW and Mercedes. The vehicle was endlessly ridiculed in the press. The perceptions of the Cimarron helped devalue Cadillac as the ``Standard of the World''. First year sales of the vehicle reached just 25,968 units, a third of GM's expectation. The vehicle suffered from chronically bad quality throughout its lifecycle. The car was discontinued in 1988 with sales of only 6,454 units.

The Cimarron is a prime example of “badge engineering” and the declining individuality of the car divisions at General Motors. GM assembled five J-cars, all virtually identical. The vehicles were known as the Cadillac Cimmaron, Chevrolet Cavalier, Pontiac J-2000, Buick Skylark, and Oldsmobile Firenza. GM management attempted to dress up an economy car as a Cadillac and force it on the market. The Cimarron was not developed to meet the needs of luxury car customers at the time

1988 GM10 Program

In 1981 General Motors began planning for a replacement for its just launched front wheel drive A-Cars and its older rear wheel drive G-cars, the company’s offerings in the intermediate-size segment of the North American market. The new program was to be biggest in automotive history and with a $5 billion dollar budget, the most ambitious new car program in GM’s 79-year history.[85] GM knew Ford was developing a new intermediate size model for introduction in 1985, and Japanese companies were planning a much stronger presence in the segment. GM Senior Executives concluded GM could wait no longer than 1986 for a new model entry in the intermediate size segment.

The cars GM scheduled to replace with the GM10 program represenedt 37% of GM’s total 5.4 million North American car production in 1985[86]. GM would replace two current lines offered by all GM Divisions except Cadillac. The 1978 vintage rear drive G-body specialty coupes and the 1982 vintage front drive A-body family sedans. GM planned to first replace the rear wheel drive G-body sporty coupes: Buick Regal, Oldsmobile Cutlass Supreme, and Pontiac Grand Prix. Then, follow the next year replacing the A-body Celebrity sedan and G-body Monte Carlo. Finally the Buick Century, Oldsmobile Cutlass Cierea, and Pontiac 6000 would be replaced a year later.

GM10 was first large scale new product program undertaken by the General Motor’s CPC (Chevrolet – Pontiac – Canada) organization, implemented two years prior to streamline GM’s bureaucracy and wring out efficiencies[87]. GM attempted to implement cross-functional program management for the development of the GM10 program. Robert Dorn, chief engineer for the Pontiac Division, was selected as the GM10 program manager. A management center was set up for the program with representation from all functions. All the disciplines were located in the same building, product engineering, process engineering, manufacturing, financial, and marketing.

Dorn and his staff worked to get the four car divisions to agree on the target market of consumers for the car and the product features these buyers would find most appealing. The team ordered large amounts of market analysis and research to set the physical dimensions, general appearance, performance, target market, price, cost, fuel economy target, and vehicle styles. The program

would employ new manufacturing and assembly techniques and incorporate new ways of dealing with suppliers. The team worked to fulfill the objectives set out in by GM management and summarized in Table A18. The team signed on suppliers early who could measure up to stringent quality and productivity targets.

Table A18 – 1988 GM10 Objectives
1. Replace all mid size cars with one program
2. Leverage early supplier input
3. Incorporate voice of customer in market
4. Incorporate cross functional management

Early on Robert Dorn became concerned GM10 was slipping past the five year timetable. Dorn and his staff quickly realized their role was little more than serving as coordinators. The functional areas held on to the decision making power. GM10 coordinators had limited authority. The role was seen as a dead end job, where success leads to little reward and failure is highly visible. To make matters more difficult top management frequently overrode the team leader about specifications and feel of the product.

The Ford Taurus introduction in 1985 caused GM to redesign the exterior sheet metal because senior executives thought the vehicles would look too similar.[88] Many running changes were incorporated into the design to in an attempt to increase customer satisfaction. The GM10 program was developed when the competitive landscape in midsize cars was rapidly changing. All the first GM10 entries were coupes, when the market segment had moved overwhelmingly to a four door sedan style.[89,90] GM had scheduled coupes first on the basis of past sales. GM Chief Roger Smith rejected proposals to speed up the sedans.[91] The new midsize family cars from GM would be launched with two doors, useless to the largest group of customers in the segment. Members of the Baby Boomers were well into their child rearing years and needed four doors for their children. In 1985 Dorn resigned from GM and by 1988, when the first vehicles finally launched, the program had its third manager.

From 1985 to 1995 GM's share of new midsize cars, as defined by Ward's Automotive Reports, tumbled from 51% to 35.6%.[92] From mid-1987 to late 1988, GM launched nine recalls – hoods popping open unexpectedly and wheels coming off, cruise control re-engaging after brakes applied. GM dedicated four assembly plants to four models which never sold more than what could have been built by two. By 1990, overcapacity and 100,000 build combinations added up to a loss of $1,800 on every GM10 vehicle sold.

The failure of the GM10 program can be attributed to many factors. General Motors failed to understand the evolving North American mid size car market, a market the company had dominated for decades. Despite a huge budget and the availability of vast resources, GM management did not give the product team the

authority and autonomy to execute the program. The cross-functional program management organization structure was purely for coordination. The functional areas at GM retained their decision making power and reported to their functional silos. When the program team did finally try to make decisions they were often overruled by top management. The limited authority the program manager had on the GM10 program is evidenced by the fact that a $7 billion vehicle program went through three program managers in four years.

The launch of the Ford Taurus and onslaught of Japanese entries redefined the mid size car market and last minute design changes could do nothing to help GM. An unrealistic assessment of their expected market share resulted in huge overcapacity problems. The enormous breadth of replacing two million units of vehicle volume drove huge amounts of complexity into the program which coupled with limited decision making authority and last minute design changes drove the release of the first vehicle two years past the target date 1988.

1990 Saturn

After losing market share to Japanese imports during the '80s, GM Chairman Roger Smith put together a team to carry forward the idea of a new and innovative small car project in June 1982. The program was to incorporate Japanese management principles and copy Japanese car style. “A different kind of company” was created to prove GM could make a competitive small car in the US market. The Saturn Corporation was founded in 1985 as a wholly owned subsidiary of General Motors.

Saturn would employ non-traditional labor techniques in its manufacturing facilities. Workers would have more input and control over their jobs than in traditional UAW shops. GM executives believed Saturn would blossom as a division free from the labor strife, stifling bureaucracy, and all the other dysfunctions of General Motors. The objectives for the Saturn program are summarized in Table A19.

Table A19 – 1990 Saturn Objectives
1. Engineer small car for the 21st century
2. Attract Non-GM customers
3. Establish independent company
4. Incorporate Japanese management principles

Furthermore, Saturn would infect the rest of the company with its enlightened and effective management techniques.[93] This was the little car that would revitalize General Motors. Saturn used a dedicated platform (Z-body), a dedicated engine (1.9 L Saturn I4 engine), and was made at a dedicated plant in Spring Hill, Tennessee. The original models SL, SC, and SW were three different body styles of the same vehicle. All Saturn vehicles featured dent-resistant plastic body panels which were also touted as allowing the company to quickly

change the look of the vehicles. However, in practice, the company kept the vehicles mostly unchanged for years. The vehicles ranged from only 85-124 horsepower but were among the most fuel-efficient vehicles of their day, offering up to 40 miles per gallon.[94]

The first Saturn hit the market in 1990. GM hoped Saturn would sell 150,000 in its first year and 500,000 units annually. In the first nine months of production, Saturn built 24,000 cars and sold 15,000 of them. Six months after opening, Saturn was operating at half-speed, and selling only half of what it produced. The styling of the vehicle was very bland and did not make much of a splash on the market. Saturn has never come close to selling 500,000 units a year.

By the year 2000, Saturn was a several billion dollar loss for GM. GM had spent over $15 billion on Saturn and the division had never earned a dime. Although Saturn set new standards for satisfied buyers and formed remarkably strong customer bonds, the notion of a tiny independent company making low-margin small cars proved totally unworkable. Saturn achieved its goal of attracting buyers who were not typically interested in GM cars, but failed to change their opinion of the company.

The huge capital investments required to build a manufacturing company from scratch far outweighed the benefit of keeping Saturn away from GM's bureaucracy. GM at the time had under utilized manufacturing capacity available, but instead invested in dedicated assembly and powertrain facilities for Saturn. Despite being independent, Saturn's cost structure prohibited the company from competing with low cost Japanese and Korean manufacturers. The cultural change dreamed of by GM leadership, while very hard to measure, does not appear to have migrated throughout the organization much at all. Additionally, Saturn's special treatment by management created animosity between the other GM divisions and Saturn. The other divisions felt Saturn was getting priority for precious capital to fund Roger Smith's pet project.

Saturn's troubles began when Smith's handpicked successor, Robert Stempel, was driven from office in a coup by GM's board of directors in October 1992. New leadership at General Motors left Saturn with no friends at the top of the company. The other GM divisions, particularly Chevy, were jealous of Saturn's special treatment and successfully battled it for scarce capital to fund future programs. The Saturn Corporation was folded into a GM nameplate in 2004.

2001 Pontiac Aztek

The Pontiac Aztek, featuring a boxy design, entered the market as GM's first cross-over vehicle in mid 2000. General Motors Corp. executives touted the Pontiac Aztek as the first fruit of the No. 1 automaker's drive to become more innovative. To become more innovative, GM management set out to creates a vehicle meeting the objectives listed in Table A20 below.

The vehicle was created around satisfying customer needs that were not being met by the market. The vehicle design immediately gave a love/hate reaction and was intended to be controversial.[95] Pontiac produced the Aztek to be an ultimate 4x4 crossover vehicle, which blended a mid-sized sedan, minivan and four-wheel drive to lure Generation X go-getters.[96] GM believed the Aztek had created a new vehicle segment - the sport recreation vehicle (SRV).[97] The Aztek was believed to have hit on the styling formula to attract the Gen X age group.[98] The Aztek offered three custom accessory packages to appeal to the go-getters tastes: the camping package, the hiking package, and the biking package.[99]

Table A20 – 2001 Pontiac Aztek Objectives
1. Develop cross over vehicle
2. Target Young Car buyers
3. Create the ultimate Sport Recreation Vehicle
4. Improve GM perception in market

The concept vehicle version of the Aztek was a hit in the 1999 auto show circuit. But when GM developed the vehicle for production the Aztek shared most of its mechanicals with the Pontiac Montana minivan. The distinctive exterior shape of the Aztek is directly attributed to the need to stretch its sheet metal over Montana's substructure. The engine and transmission were also shared with the Montana. The vehicle was targeted at young buyers and featured gray plastic body cladding in its design. But unfortunately, young buyers have less money and tend to purchase used cars.[100] With a price range starting at $24,995, Aztec was too expensive for the younger buyers it targeted.

No one in GM has taken credit for the design of the Aztek. Due to the cold public reception, GM performed a minor attempt to turn the ugly duckling into a slightly less-ugly duckling. The product team had an eight-month deadline to conduct focus groups, do research, digest the information and conjure up a viable facelift for the Aztek. The results came back with what GM already knew: Crowds at the auto shows loved the monochromatic exterior color scheme and wider wheels on the original concept version. The team worked to add better-looking wheels to vehicle and ripped off the dreadful gray plastic lower-body cladding.[101] The redesigned Aztek had entry-level price lowered to $21,445.

The Aztek product development team and numerous focus groups failed to alert management that the styling was a turn-off to the very audience it targeted.[102] GM might have been able to save the Aztek if they changed a few pieces of sheet metal. But instead Senior Management was not given the right data to make the right decisions.

Despite industry leading functionality and award winning customer satisfaction, the Aztek could not win over enough of the buying public to survive. The controversial styling forced into a minivan platform to save capital created a

love/hate design which was unfortunately hated by most of the public. The Aztec is regularly named the ugliest car in the world in online polls, despite a hasty redesign two years after its launch in 2001.[103] The Aztek program took a highly successful concept vehicle, designed the production version by committee and produced an oddly styled vehicle to meet a target market which could not afford it. GM targeted sales at 50,000 – 70,000 units annually.[104] Deliveries totaled only around 27,000 units in 2001 and 2002. GM cancelled the Aztek in 2005 and began retooling the Ramos Arizpe plant for a new product.

Appendix B

FACTORS AFFECTING SUCCESS AND FAILURE

Factors

From the twenty case studies we derived thirteen primary factors driving the success or failure of automotive vehicles. The factors can be grouped into five main categories: Product, Performance, Market, Organization and External. Each factor is defined and summarized in this appendix.

Product: Styling

Styling is paramount in the success or failure of a new vehicle. Styling gives a unique identity to the vehicle. The styling of a vehicle visually allows the vehicle to stand out in the market place. Styling was critical to the success and failure of the vehicles under study. The 1955 Chevy hit the market with a look that featured clean modern lines and an aura of luxury. The "jelly bean" look of the Ford Taurus redefined the look of sedans in the 1980s. The PT Cruiser captured the "spirit of America" with its design and launched a retro movement in automotive design. The Cadillac CTS with its edgy angular style helped revive the Cadillac brand. While these products benefited from great styling, the AMC Pacer and Pontiac Aztek were quickly labeled ugly ducklings. The Pacer and Aztek while very functional vehicles, suffered endless ridicule in the media and generated discouraging sales results. When the Ford Motor company launched the Edsel division in 1958, the public's interest in huge, big fin cars with glitzy chrome was ending.[105] Edsel hit the market with dated styling which contributed to the brands quick demise.

Styling alone does not guarantee the success or failure of a vehicle. The 1960 Chevrolet Corvair launched with styling that was unconventional for the time. The subtle and elegant lines of the vehicle replaced the tailfins and chrome of the day. The Corvair garnered critical acclaim, including the 1960 Car of the Year award, but was unable to make a big impact in the marketplace. The DeLorean DMC-12 hit the market in 1981 with gull wing doors and a stainless steel body. The DMC-12 could not perform to expectations and the long waiting lists for the vehicle quickly evaporated.

Product: Flexibility

The flexibility of a vehicle design and architecture enables a program team to quickly configure new models to meet the needs of the market at a low development price. The Lincoln Navigator, Pontiac GTO, and Ford Mustang hit the market quickly and cheaply primarily due to product flexibility. The Navigator was engineered from the Expedition into a luxury edition by trimming the interior with leather, wood, and fine carpeting in just 13 short weeks. Leveraging the

body on frame architecture of trucks, Ford engineers had to change a few body panels and add a chrome grill to create the Navigator. John DeLorean took the Pontiac Tempest, stripped it to bare essentials, added 389 cubic inch V8 and beefed up the brakes and suspension to create the GTO. Ford built the Mustang off of its newly released Falcon. By sharing components with the Falcon, Ford's cost to develop the Mustang was only $75 million at a time when most programs cost $300 - $400 million. General Motors attempted to use flexibility and save Aztek development costs by sharing mechanical underpinnings with the Pontiac Montana minivan. The distinctive exterior design of the Aztek, which contributed to the failure of the vehicle, is directly attributed to the need to stretch its sheet metal over Montana's substructure.

Product flexibility can be dangerous when the new model does not stand out in the marketplace. The Cadillac Cimarron hit dealership offering little more than a gussied up Chevrolet Cavalier at a sticker price of nearly double the Chevrolet's price. [106] General Motors did little more than add leather seats and a roof rack.

Product: Lead Time

The time to develop a vehicle program is another factor to consider in the success and failure of vehicle programs. While few programs hit the market at the perfect time, rushing a program into production or hitting the market late can lead to disastrous results. While the quick launch of the Mustang and GTO contributed to their successes, the time crunch put on the Pinto team by Ford management strongly contributed to its safety problems. At the time vehicles were being developed in 44 months. The Pinto program was given 25 months. Ford engineers had discovered in pre-production crash tests that rear end collisions would easily rupture the fuel tanks. The assembly line machinery was already tooled when the defect was discovered and Ford management decided to proceed with putting the vehicle in production[107]. General Motors started the GM10 program in 1981. When the vehicles finally hit the market in the 1988 model year the entire complexion of the mid size car market had changed. GM's program assumptions were no longer valid and the program underperformed in sales and drove huge manufacturing overcapacity. In response to high fuel prices in the early 1980s, GM pushed a Cadillac entry into the J-car program at the last minute. While quickly reaching the market, the Cadillac Cimarron did not live up to the standard expected of a luxury card and failed miserably.

Product: Technology

Technology can define a vehicle. The Toyota Prius is a vehicle powered by hybrid propulsion. Betting on a new technology can make or break a vehicle program. The DeLorean program team envisioned a chassis produced from a new and untested manufacturing technology known as Elastic Reservoir Molding (ERM), which would contribute to the light-weight characteristics of the car while presumably lowering its production costs. When the ERM technology could not

be used for mass production, the vehicle had to use a steel backbone frame. The steel added 600 pounds of weight to the vehicle and severely affected the performance of the vehicle to unacceptable levels. Similarly, the AMC Pacer was designed around a small, fuel efficient Wankel engine. The engine was to be purchased from GM. When GM cancelled the Wankel, AMC had to put in their existing I6 engine into the vehicle. The vehicle became 350 – 500 pounds heavier than the competition and could only manage 16 mpg. The Volkswagen Rabbit program took advantage of computer stressing techniques to exploit the full weight saving potential of front wheel drive.[108]

Performance: Horsepower

Horsepower is important in the vehicle in the sense that the expectations of the customer are met. The original Chrysler Minivan debuted with only a measly 86 horsepower. The power performance of the minivan had little bearing on whether the vehicle sold or not. However, the Cadillac Cimarron hit the entry level luxury market offering only a four cylinder engine with only 88 hp and was easily beaten by BMW and Mercedes. Both BMW and Mercedes offered up to six cylinders in their entry level luxury cars and could generate up to 130 hp. The Cimarron could not live up to the expectations of the luxury market. Pontiac crammed 325 hp into the GTO and created the muscle car segment through raw power.

Performance: Fuel Economy

The extent of which fuel economy meets the expectations of the customer is critical in the success or failure of a vehicle program. The fuel economy of small vehicles such as the Volkswagen Rabbit and the original Saturn drew consumers to the product. Toyota used the fuel economy of the Prius as a market differentiator. Poor fuel economy hindered sales of the AMC Pacer and the DeLorean. While the Chevy Vega and Ford Pinto had good fuel economy, their performance was equal or worse than competitors and could not be used to differentiate the product.

Performance: Quality

The quality of the product as perceived by consumers factors very high into the success or failure of a product. Major quality issues contributed to the failure of the Edsel, Pinto, and Vega. In fact, eight of the ten product failures under study had quality issues. However, the Pontiac Aztec and original Saturn could not leverage high quality into product success. The quality of the Cadillac CTS increased the reputation of Cadillac in the market place and helped to revive Cadillac as a luxury brand.

Market: Target Segment

Target Segment is the measure of how well the vehicle meets the needs of the market segment targeted. . The Chrysler Minivan, Pontiac GTO, and Toyota Prius launched with tremendous success by meeting the needs of emerging segments in the market dead on. The GM10 rolled out the public with two door sedans when the mid size car market was demanding four doors. The Chevrolet Corvair was designed to be an economy car with performance but was not competitive with basic economy vehicles. The Pontiac Aztek targeted young buyers who did not buy new vehicles.

Market: Price

Price is important relative to the competition as well as the customers to whom the vehicle is intended to appeal. The low price of the Mustang made the vehicle affordable enough for customers to have a second car. The Ford Pinto and Chevy Vega could not beat the Volkswagen Bug on price. GM tried to price Cadillac Cimarron at the level of Mercedes and BMW. The Cimarron was clearly inferior to these products and consumers spent their money on other products. The Pontiac Aztek appealed to young buyers who did not have enough money to buy the vehicle.

Market: Safety

The safety of the vehicle is an important factor in the success or failure of a product. While none of the vehicles under study used safety to positively differentiate itself in the market. The safety records of the Ford Pinto and Chevy Corvair marred the vehicle in the market. While short term sales of these vehicles did not suffer greatly, the long term reputation to the manufacturer is immeasurable.

Market: Utility

The utility of the vehicle is very important in segments of the market. The Chrysler minivan offered broad functionality to everyone from business owners to young families. The Lincoln Navigator gave consumers the utility of a full size SUV with unmatched luxury. The Chrysler PT Cruiser utilized a flexible and roomy interior to give consumers very good utility for a vehicle its size.

Organization: Corporate Goals

The extent to which the vehicle meets the goals of the corporation factors into the judgment of whether or not the vehicle is a success or not. The 1955 Chevy was designed to meet and defeat a direct threat from Ford for sales leadership. Ford failed to position the Edsel brand at price points between Ford and Lincoln vehicles. Toyota proved they could market and produce hybrid technology with

the Prius. The success of the high fuel economy PT Cruiser created Café credits for Chrysler. Chrysler turned around and sold more, high margin, full size trucks without paying fines to the government. The GM10 program failed to maintain market leadership in mid size cars for GM. While GM succeeded at creating a new, independent brand with Saturn the tremendous capital cost strained product development throughout the company.

Organization: Development Process

The development process used to create the vehicle factors in its success or failure. The development of the Chevy Vega was done completely out of process, with no oversight. The Chevy division was asked to manufacture a vehicle it did not engineer. The process created friction between GM central staffs and Chevrolet as well as apathy within Chevrolet. Ford used cross functional project management to power the Taurus to success. While GM's project management approach with GM10 failed primarily due to no authority being granted to the project manager.

Organization: External

The economy at the time the vehicle hits the marker is a larger factor. The Edsel was clobbered by the recession of the late 1950s. The Cadillac Cimarron was rushed into production to fill the luxury small car market when fuel prices spiked in the early late 1970s. The Volkswagen Rabbit, with high fuel economy and low price, benefited from high gas prices in the 1970s. The Mustang and GTO hit the market in the early 1960s to a booming economy. The Lincoln Navigator greatly benefited from the high flying economy of the United States in the late 1990s.

Factor Matrix

The factors can be summarized in a matrix form to show the positive or negative effect the factor had on the vehicles understudy. A sample matrix is shown in Table B1 below.

	Styling	Flexibility	Lead Time	Technology	Horsepower	Fuel Economy	Target Segment	Price	Quality	Utility	Safety	Corporate Goals	Development Process	Economy
1955 Chevy	↑			↑	↑		↑	↑				↑	↑	↑
1958 Edsel	↓					↓		↓	↓			↓	↓	↓
1960 Chevrolet Corvair	↑		↓		↑	↓	↓	↓			↓	↑	↓	
1963 Pontiac GTO		↑	↑		↑		↑	↑				↓	↑	↑
1964 Ford Mustang	↑	↑	↑		↑		↑	↑				↑	↑	↑
1971 Ford Pinto			↓						↓		↓		↓	
1971 Chevrolet Vega			↓	↓			↓	↓	↓				↓	
1974 Volkswagen Rabbit		↑		↑		↑	↑	↑				↑	↑	↑
1975 AMC Pacer	↓			↓	↓	↓			↓	↑		↓		
1981 DeLorean	↑			↓	↓	↓		↓	↓			↑		↓
1982 Cadillac Cimarron	↓	↓	↓		↓		↓	↓	↓			↑	↓	
1984 Chrysler Minivan				↑			↑		↑	↑			↑	
1986 Ford Taurus	↑			↑			↑					↑	↑	
1988 GM10			↓				↓		↓			↓	↓	
1990 Saturn	↑					↑			↓			↓		
1998 Toyota Prius			↑	↑		↑	↑					↑	↑	
1998 Lincoln Navigator	↑	↑	↑				↑			↑		↑	↑	↑
2001 Chrysler PT Cruiser	↑	↑					↑			↑		↑	↑	
2001 Pontiac Aztek	↓	↑					↓	↓	↑	↑		↑	↓	
2003 Cadillac CTS	↑						↑		↑			↑	↑	

Table B1. Example Factor Matrix

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