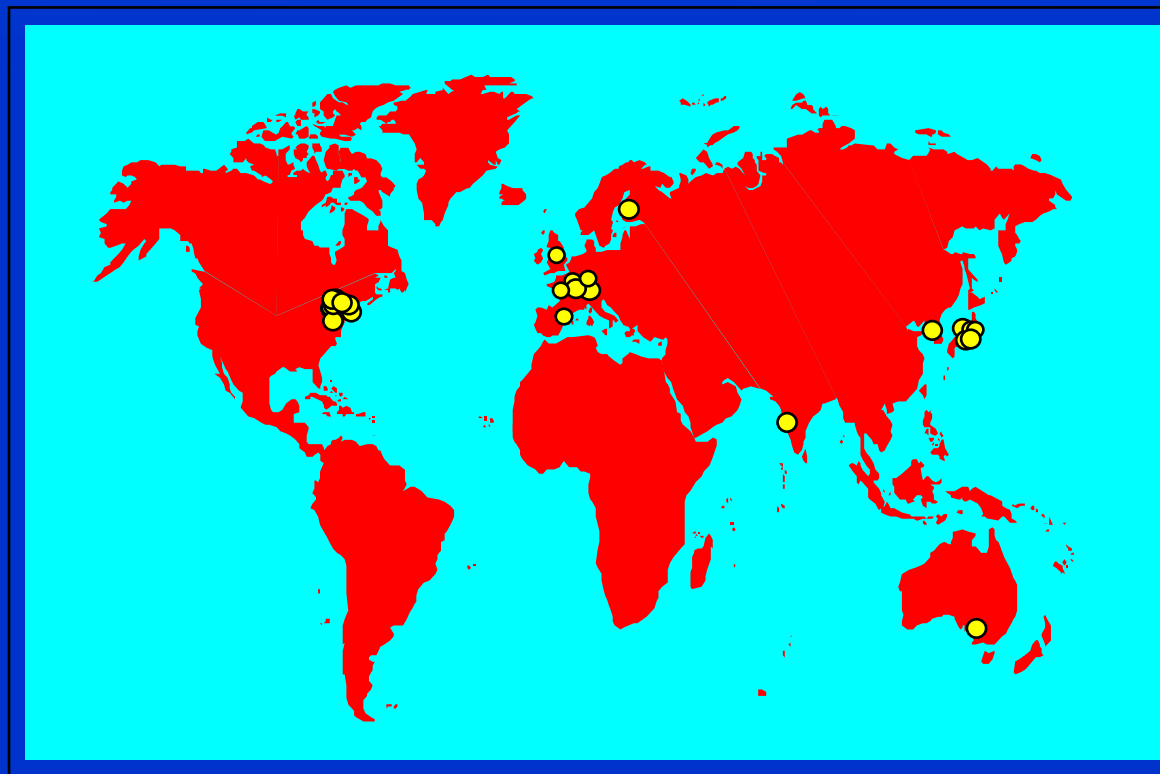




UltraLight Steel Auto Suspension (ULSAS)



THE ULSAS CONSORTIUM



- Consortium of 34 steel producers from 15 countries
- Conducted by Lotus Engineering (UK)





ULSAS Consortium Members

- **Aceralia - Spain**
- **Acme Metals - United States**
- **AK Steel - United States**
- **Bethlehem Steel - United States**
- **BHP Steel - Australia**
- **Böhler Uddeholm AG - Austria**
- **Cockerill Sambre (Usinor) - Belgium**
- **Corus Engineering Steels - United Kingdom**
- **Corus - Netherlands**
- **Dofasco Inc. - Canada**
- **Georgsmarienhütte GmbH - Germany**
- **Ispat Inland - United States**
- **Ispat Stahlwerke Ruhrort GmbH - Germany**
- **Kawasaki Steel - Japan**
- **Kobe Steel- Japan**
- **LTV Steel - United States**
- **National Steel - United States**
- **Nippon Steel - Japan**
- **NKK Corporation - Japan**
- **Pohang Iron & Steel - Korea**
- **Rautaruukki Oy - Finland**
- **Rouge Steel Company - United States**
- **Stelco Inc. - Canada**
- **Sumitomo Metal Industries - Japan**
- **The Tata Iron and Steel Co. - India**
- **Thyssen Krupp Stahl AG - Germany**
- **Usinor - France**
- **US Steel Group - United States**
- **USS/Kobe Steel - United States**
- **Vallourec Group - France**
- **Vöest-Alpine Stahl Linz GmbH - Austria**
- **VSZ Holding A.S. Kosice - Slovakia**
- **WCI Steel Inc. - United States**
- **Weirton Steel Corporation - United States**

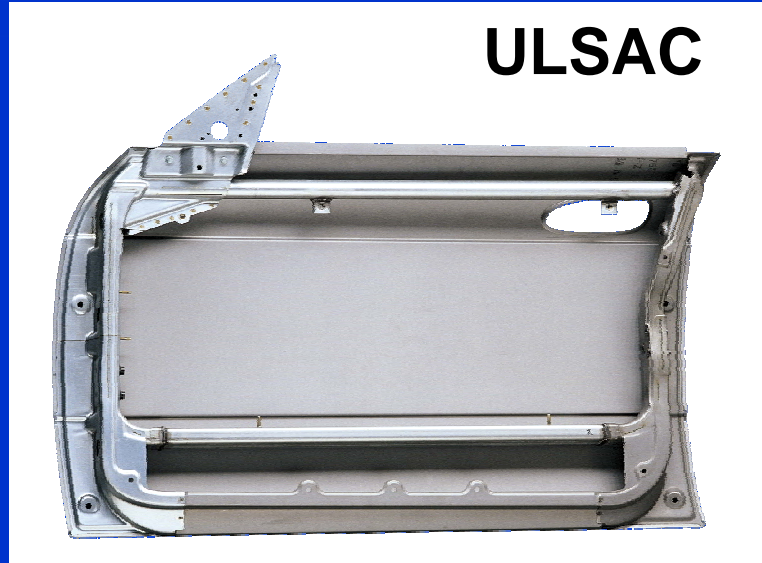


ULSAS PROJECT BACKGROUND

ULSAB



ULSAC



ULSAS





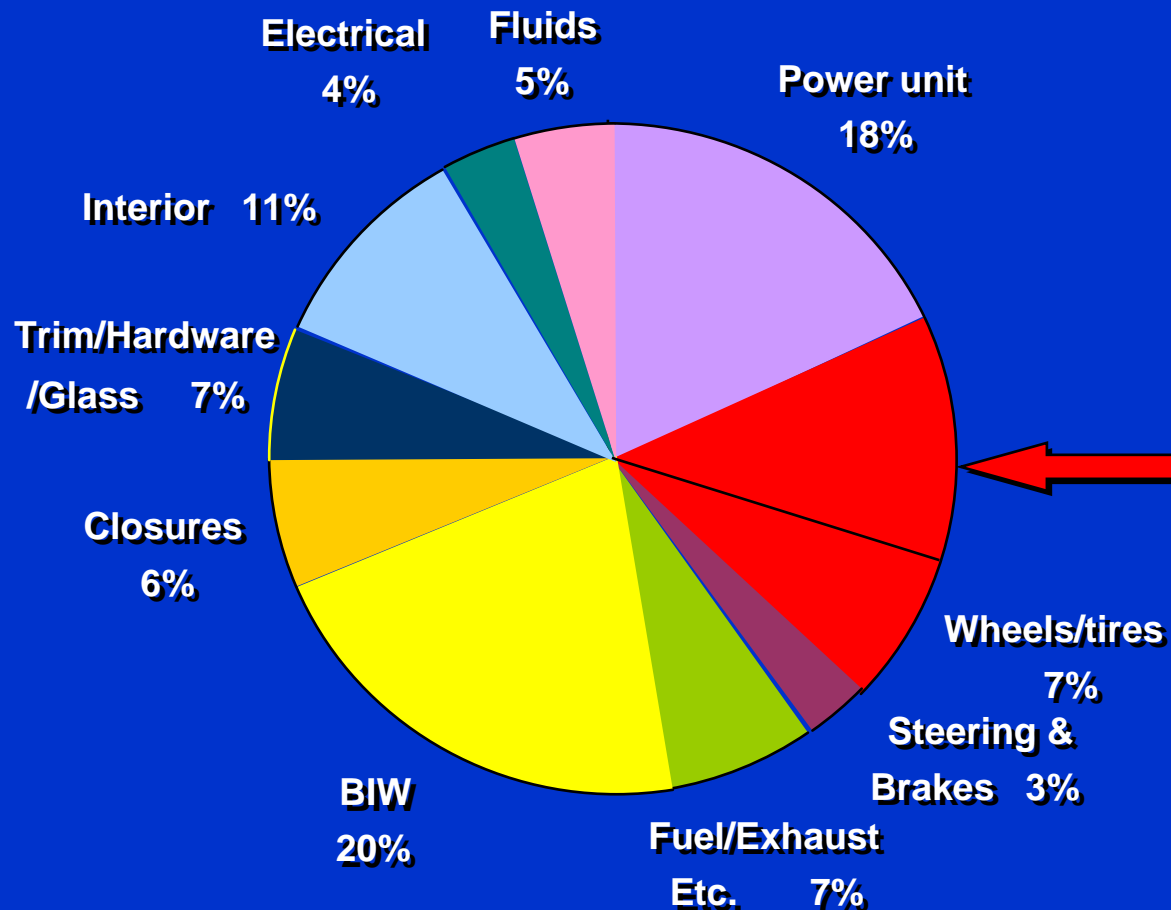
ULSAS OBJECTIVES

- **Demonstrate the potential for optimized, cost-effective, environmentally-friendly and lightweight steel-intensive solutions**
- **Explore and promote the full range of steel product and process technologies**
- **Develop suspension system design concepts with a high level of performance, passive safety and efficiency**
- **Assist automotive manufacturer competitiveness**



PROJECT DRIVERS

TYPICAL PASSENGER CAR MASS BREAKDOWN



- SUSPENSION SYSTEMS ACCOUNT FOR A SIGNIFICANT PROPORTION OF VEHICLE MASS

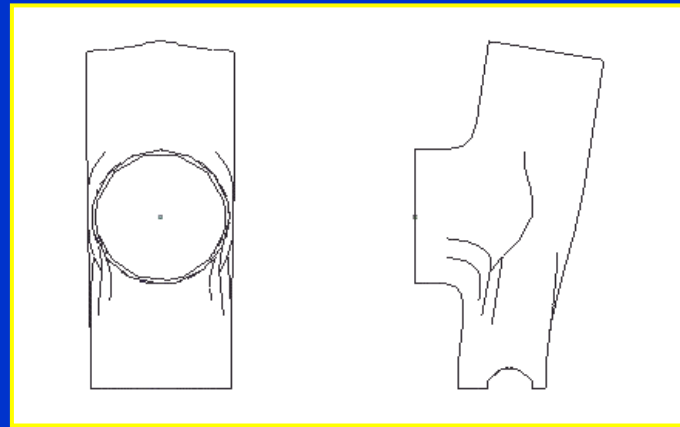
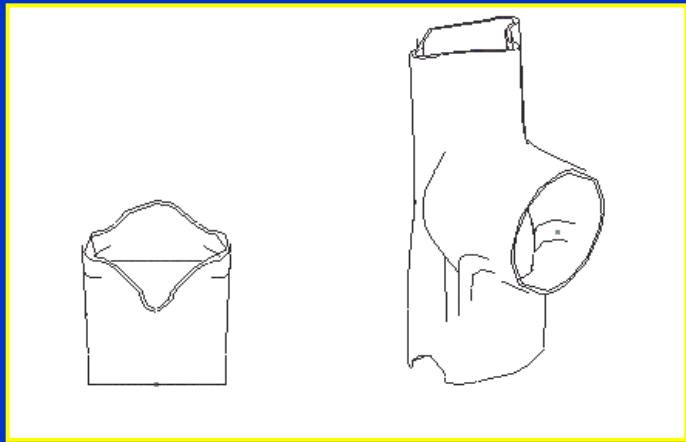
SUSPENSION
12%

- UNSPRUNG MASS DIRECTLY INFLUENCES VEHICLE DYNAMIC PERFORMANCE



PROJECT OVERVIEW

- **ULSAS Program Phases**
 - Phase I - Benchmarking and target-setting
 - Phase II - Design





BENCHMARKING OVERVIEW

- **Nine European**

- Audi A6
- Peugeot 306
- Fiat Brava
- Vauxhall Astra
- Vauxhall Vectra
- BMW Series 5
- Nissan Primera
- VW Golf
- Ford Mondeo

- **Four North American**

- Ford Taurus
- Mercury Cougar
- Dodge Intrepid
- Chevrolet Lumina

- **Three Asia/Pacific**

- Hyundai Elantra
- Honda Accord
- Toyota Camry



BENCHMARKING WORKSCOPE

**Subjective Assessment
& Expert Review**

**K&C*, Geometry, Photos,
Design, Mass**

**Package Comparisons, NVH,
Manufacturing Review, Costing**

Level

1

16 Vehicles

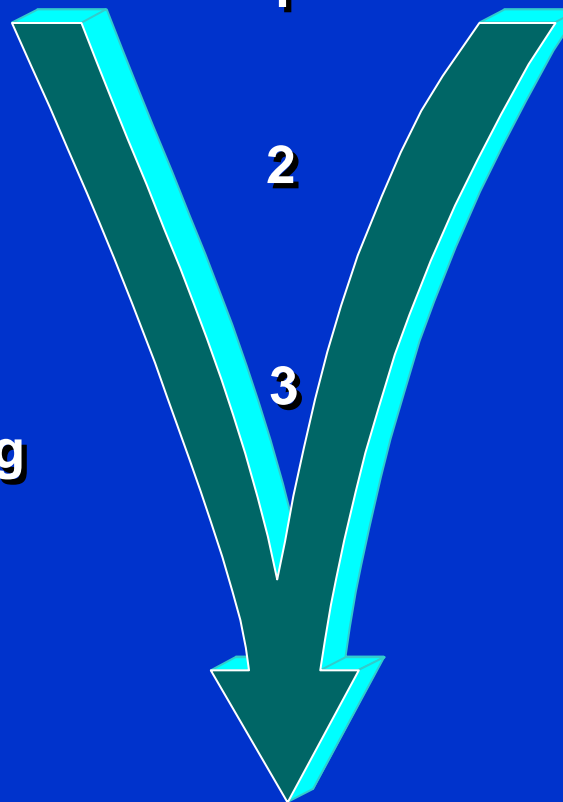
2

**8 Vehicles
(Rear Suspension
Only)**

3

4 Suspensions

*** Kinematics and Compliance**





BENCHMARKING OUTCOME

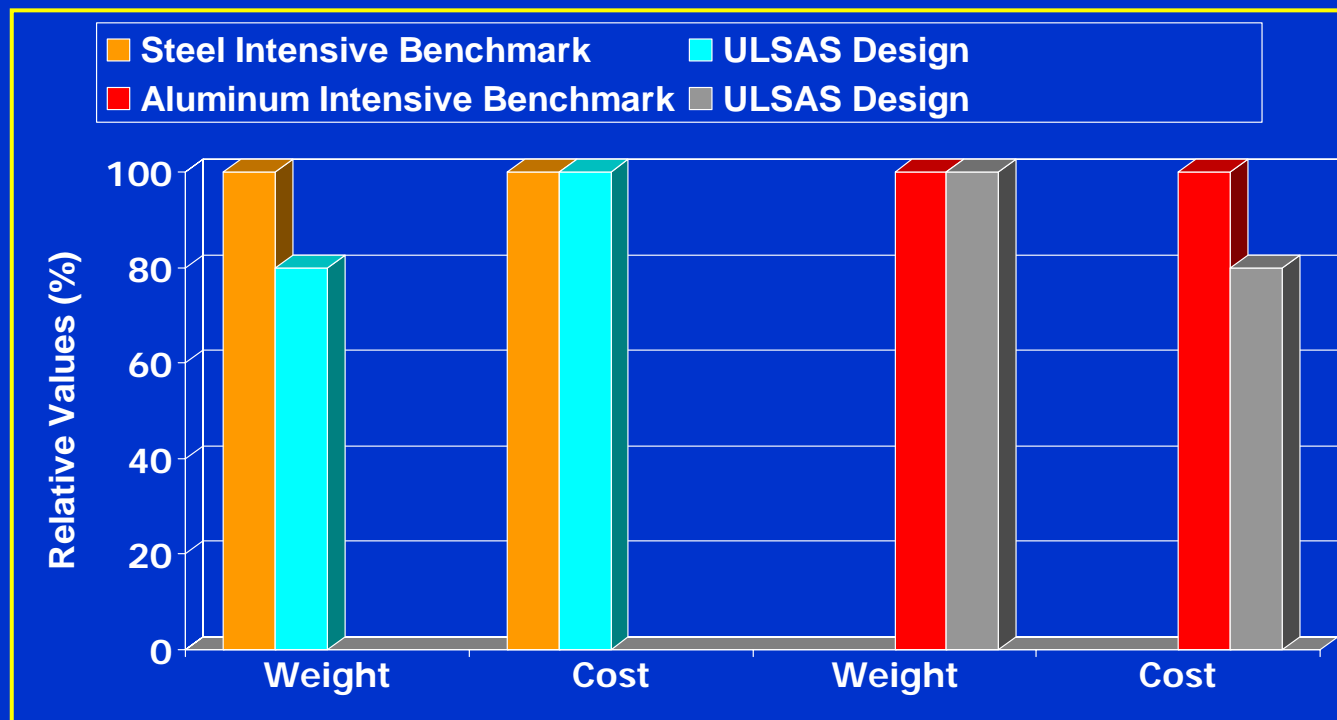
- Four rear suspension systems were selected for the design phase





DESIGN OBJECTIVES

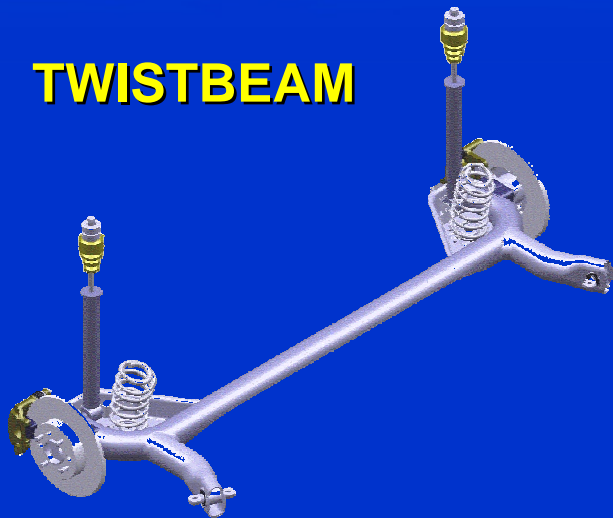
- Reduce mass of steel design by at least 20 percent with no cost penalty
- Match mass of aluminum design by using steel, while demonstrating cost savings of at least 20 percent



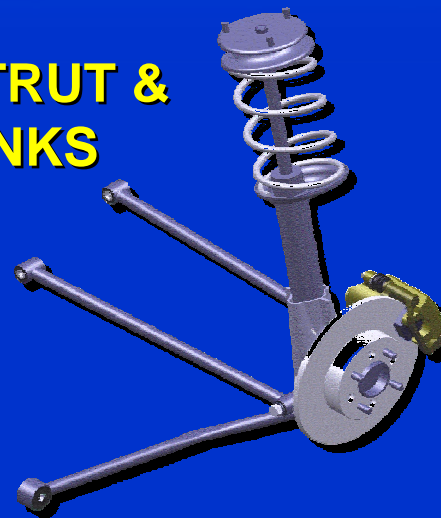


ULSAS DESIGN PHASE

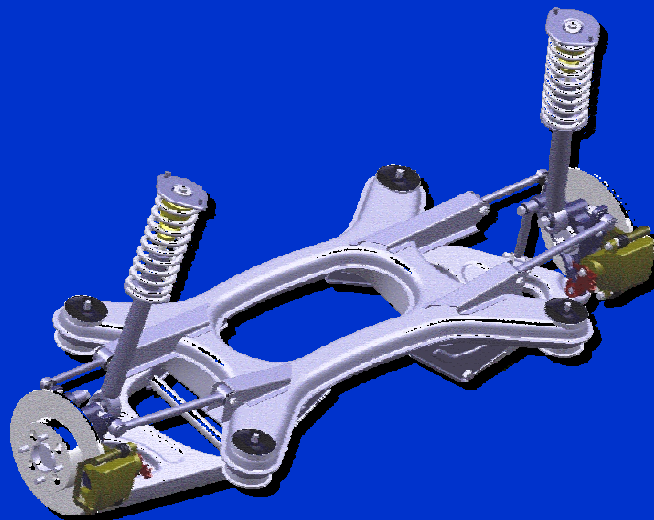
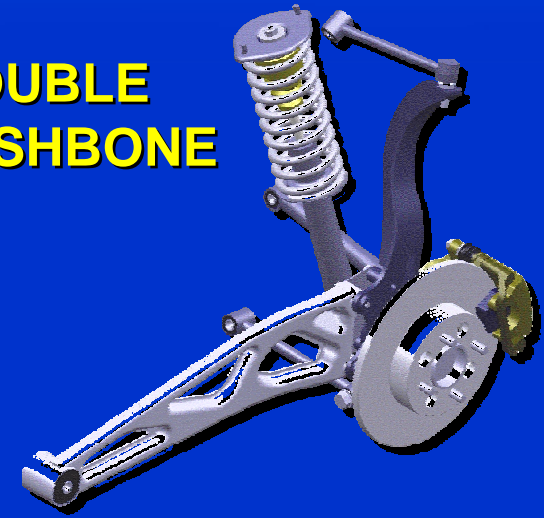
TWISTBEAM



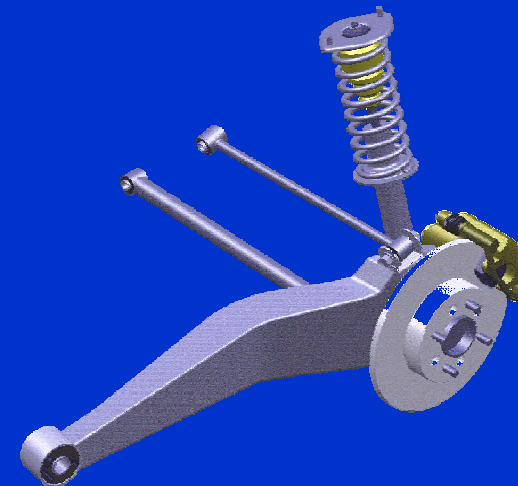
STRUT & LINKS



DOUBLE WISHBONE



MULTI-LINK

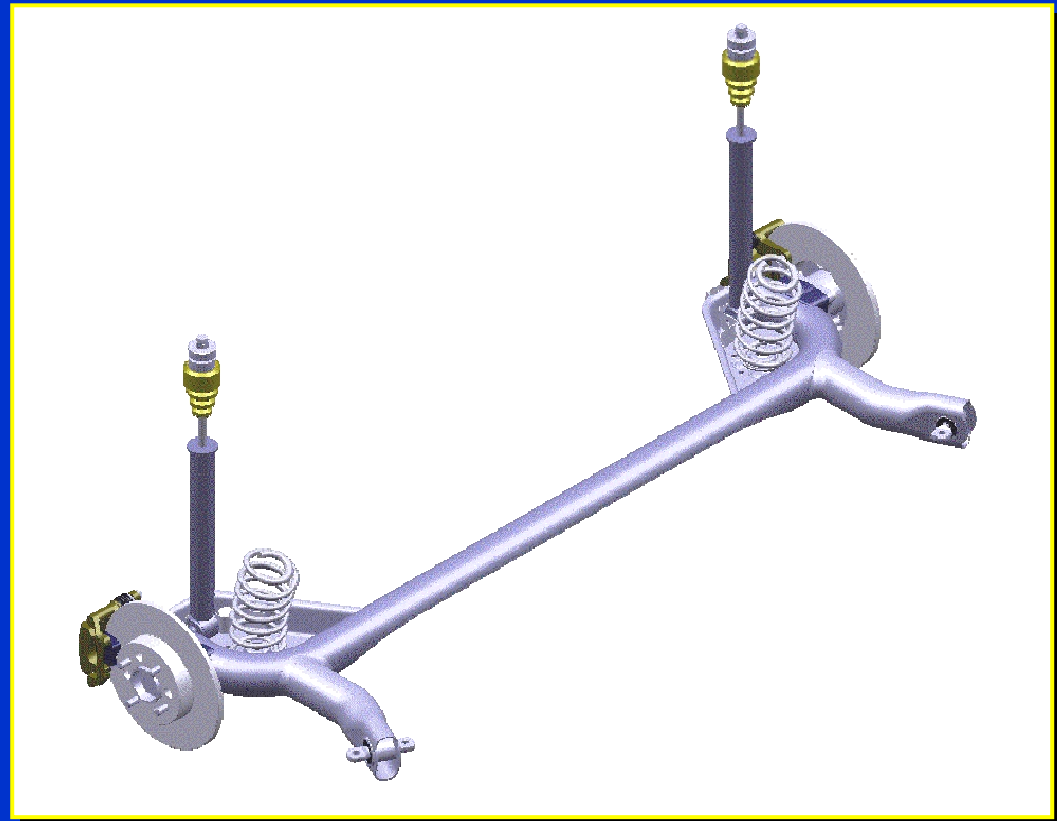


LOTUS UNIQUE



TWISTBEAM-Results Summary

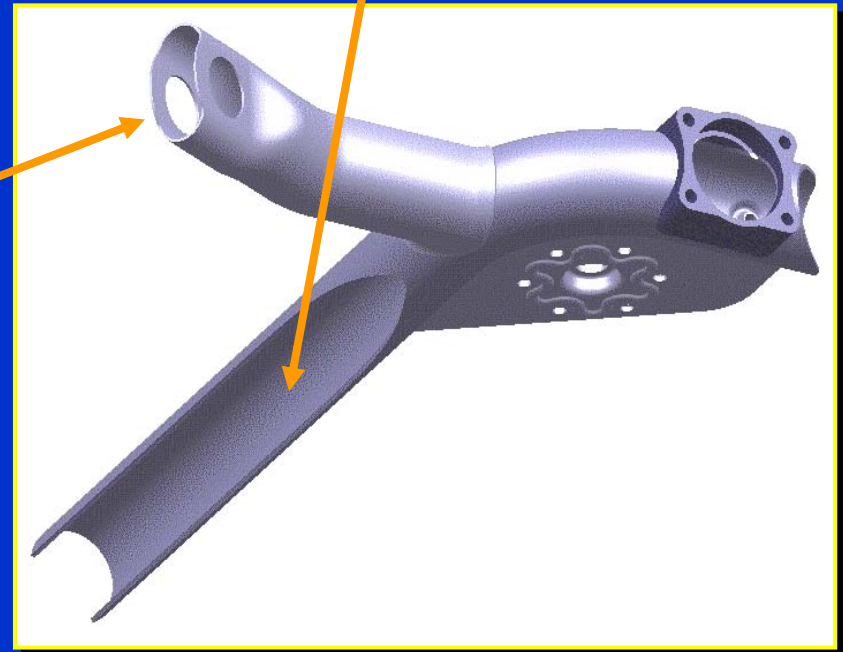
- 32 percent reduced mass
- No cost penalty
- Better performance





TWISTBEAM-Design Highlights

- Features extensive use of advanced steel technologies such as:
 - Thin wall high-strength steel tubular transverse beam
 - Hydroformed high-strength steel forward arm





TWISTBEAM-Cost Comparison

(US\$)	Twistbeam	
	Benchmark E	ULSAS E
COMPONENT COST	\$178.30	\$169.90
TOTAL TOOLING COST (\$.000)	\$5,611	\$2,965
5 YEAR Volume (Assumptions)	2,000,000	2,000,000
TOOLING COST	\$2.80	\$1.50
TOTAL SYSTEM COST	\$181.10	\$171.40
SYSTEM ASSY		
Labor Rate (US\$/min on \$44/Hr)	\$0.73	\$0.73
Assembly Minutes	3.86	2.42
SYSTEM ASSEMBLY COST	\$2.83	\$1.77
VEHICLE FITTING		
Labor Rate (US\$/min on \$44/Hr)	\$0.73	\$0.73
Fitting Minites	1.21	0.93
VEHICLE FITTING COST	\$0.89	\$0.68
Total Cost (\$)	\$184.80	\$173.90
Cost Saving(\$)		\$11.00
Cost Saving %		6%



STRUT & LINKS- Results Summary

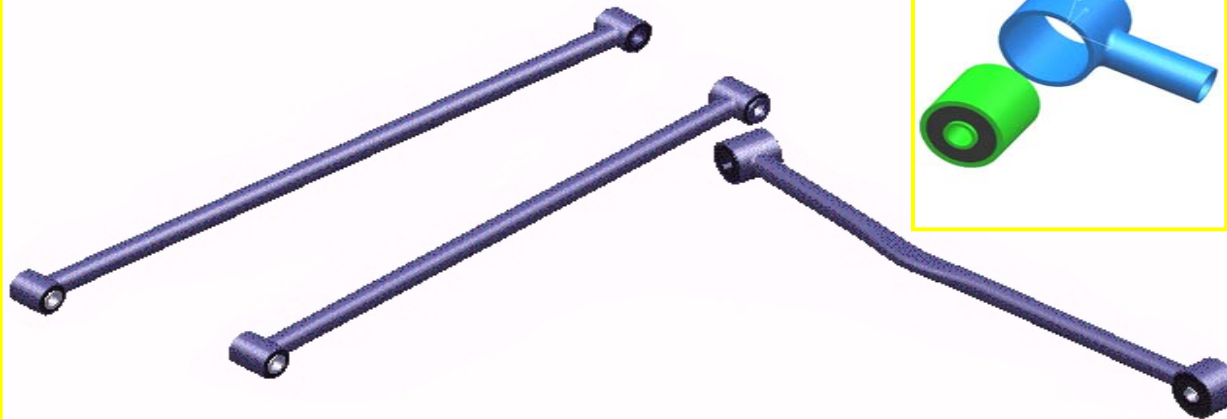
- **25% mass savings**
- **Minor cost savings**
- **Performance exceeds benchmark**
- **Better ride & handling characteristics**



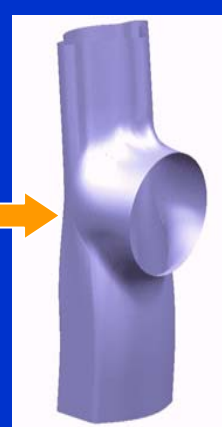
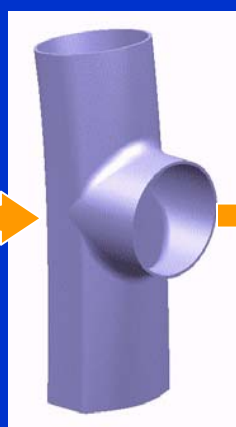
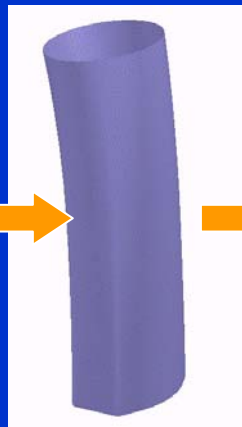


STRUT & LINKS- Design Highlights

Longitudinal and Lateral Links



INITIAL
TUBE FORM



FINAL
FORM

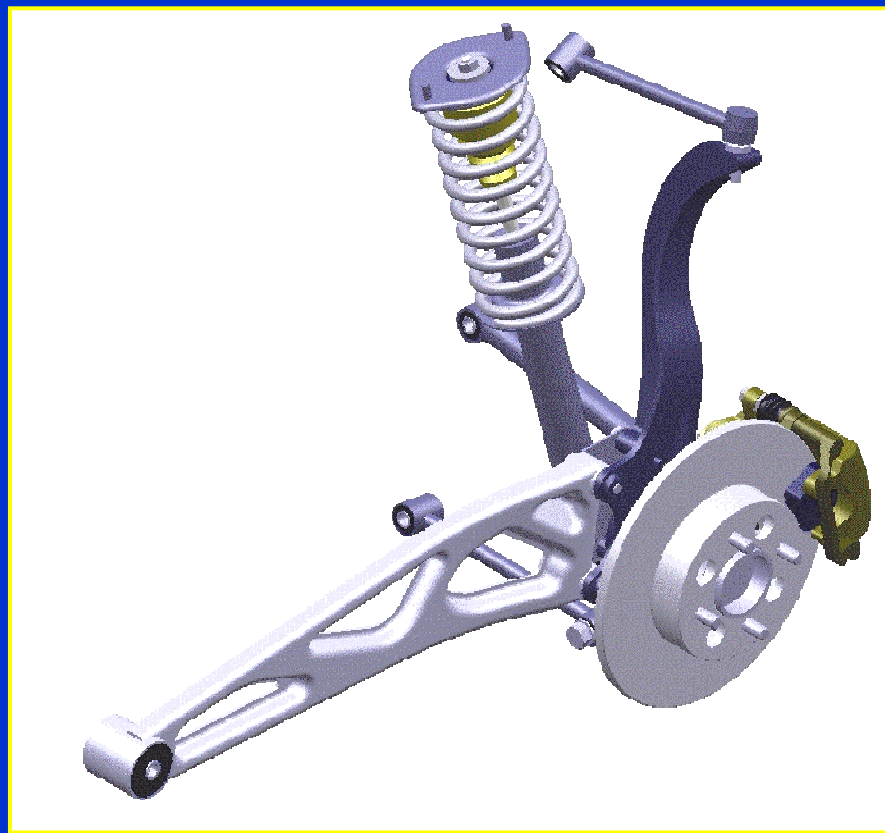


Hydroformed Knuckle



DOUBLE WISHBONE- Results Summary

- 17% mass savings
- No cost penalty
- Performance exceeds benchmark
- In all other areas benchmark results are matched



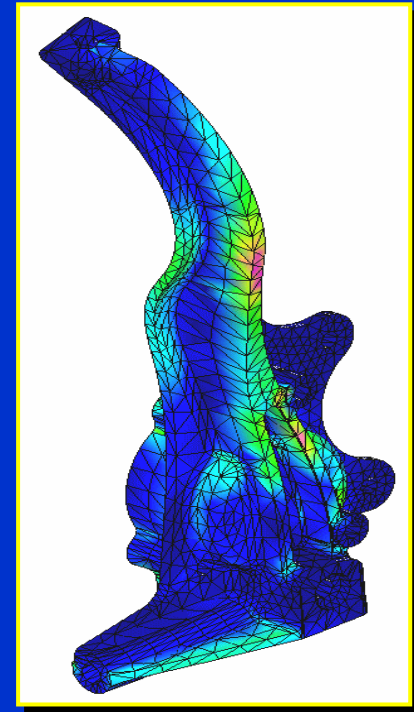


DOUBLE WISHBONE- Design Highlights

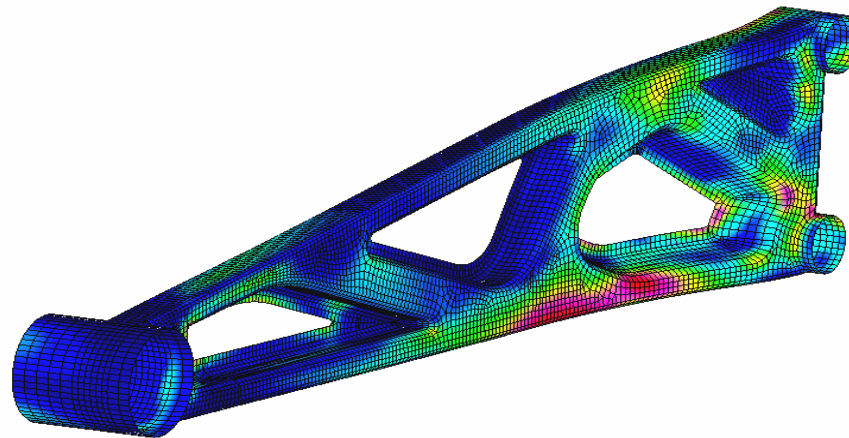
- ULSAS based on extensive use of computer simulations
- Includes using Design Optimization software
- Forming analysis performed by steel companies



**HIGH STRENGTH
STEEL FORGED
KNUCKLE**



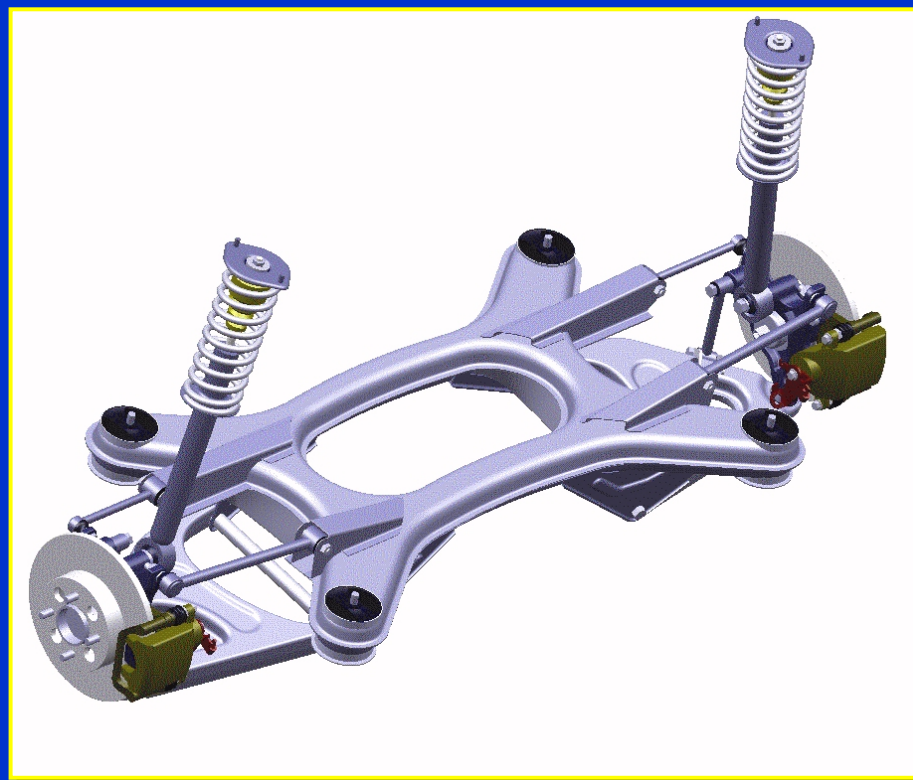
**HIGH STRENGTH
STEEL STAMPED
FORE-AFT ARM**





MULTI-LINK-Results Summary

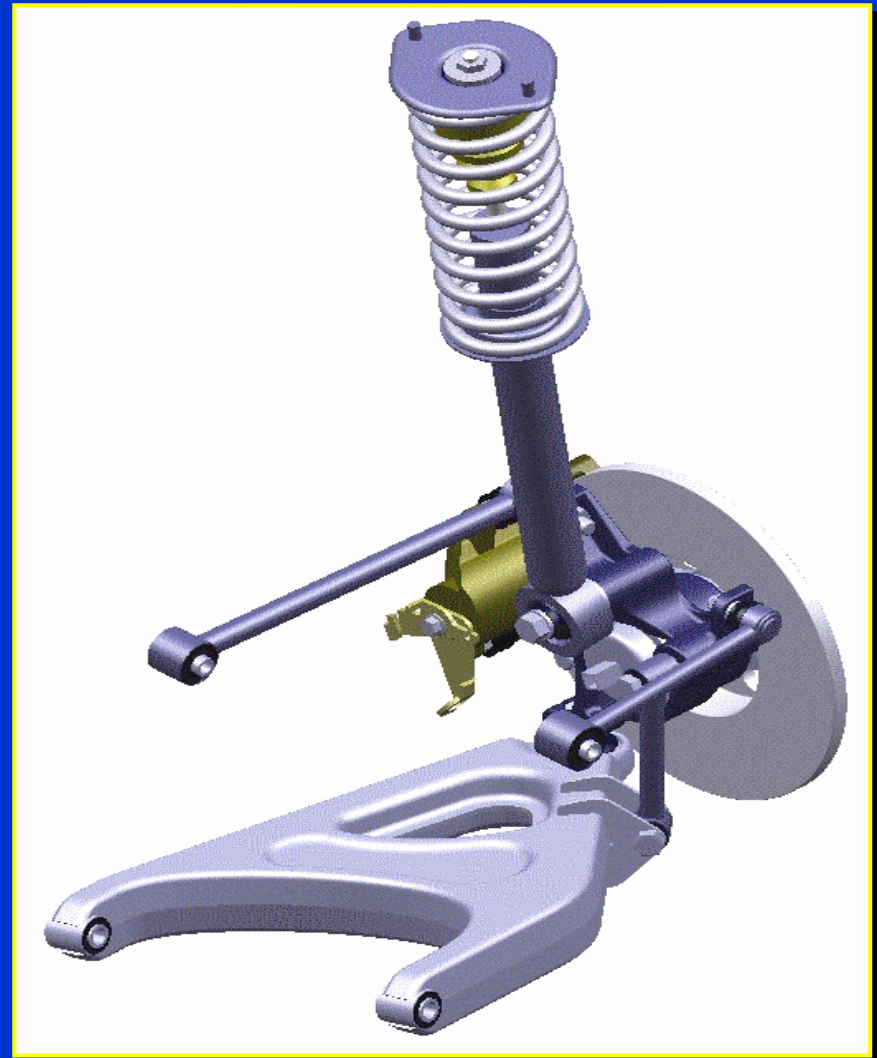
- 30% cost savings
- Minor mass reduction
- Provide superior ride & handling and superior vehicle refinement
- In all other areas benchmark results are matched





MULTI-LINK-Design Highlights

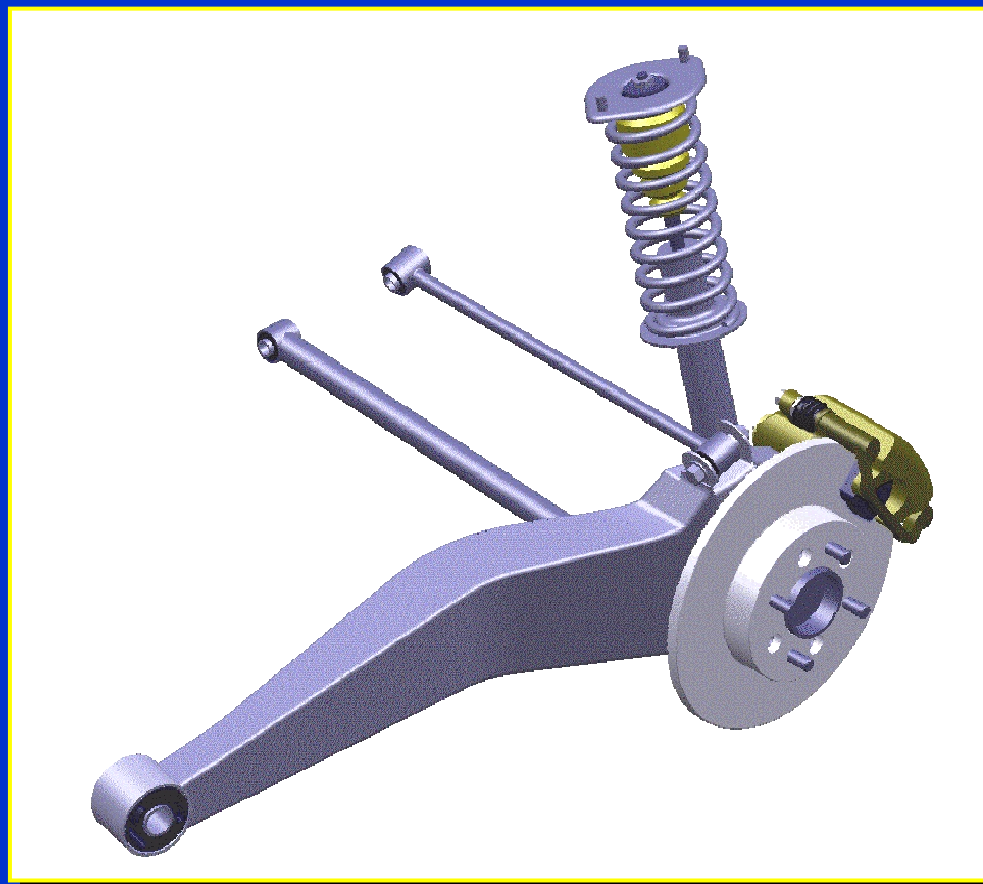
- All major parts are of high- and ultra high-strength steel
- Pressed sub-frame and lower control arm
- Tubular links
- Forged knuckle





LOTUS UNIQUE- Results Summary

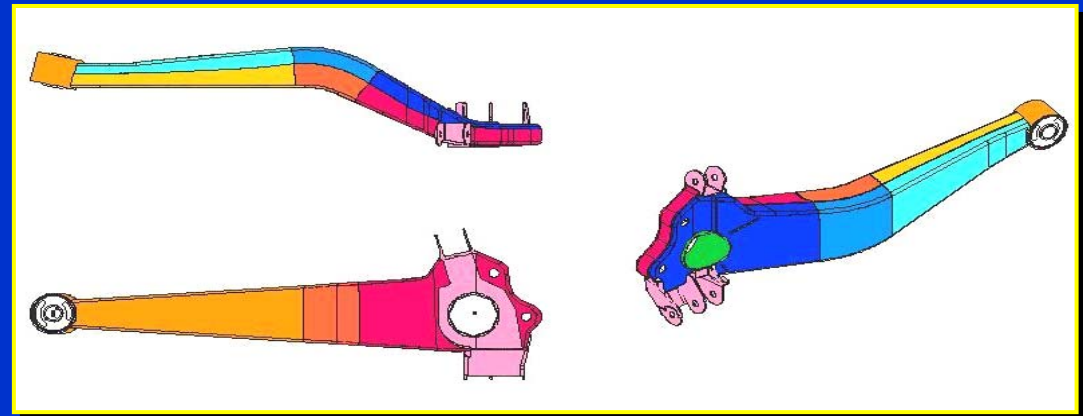
- **34 percent mass savings compared to double wishbone**
- **22 percent cost savings**
- **Good overall performance**





LOTUS UNIQUE- Design Highlights

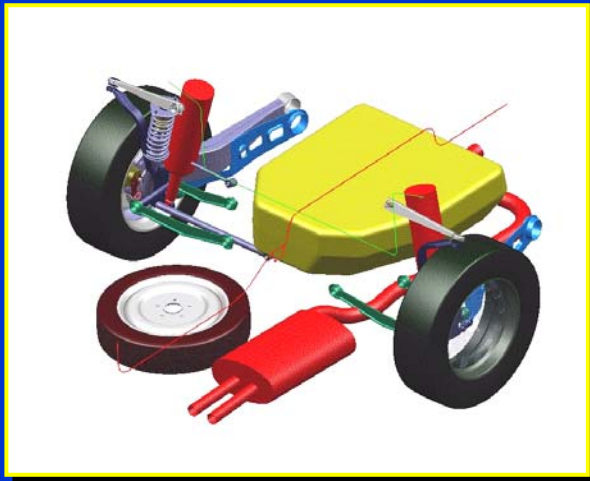
- Extensive use of high- and ultra high-strength steels
- Minimized number of parts
- Component integration through multiple functionality
- Packaging advantages
- Easy to manufacture and assemble



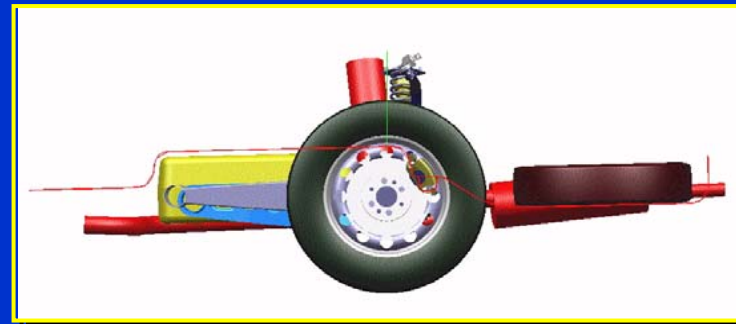
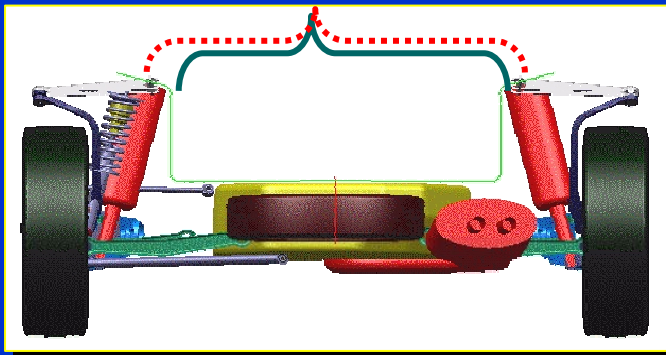
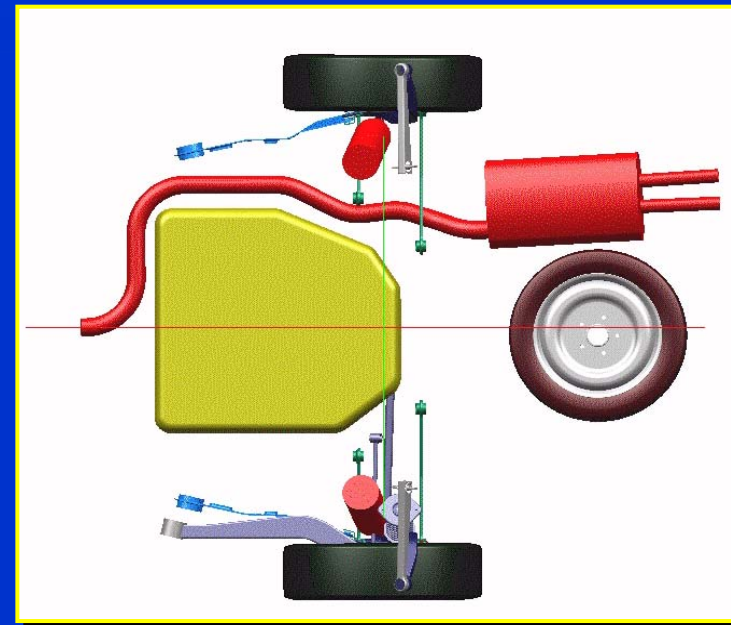
**STAMPED
FORE-AFT ARM
USING TAILOR WELDED
BLANKS**



LOTUS UNIQUE- Design Overview



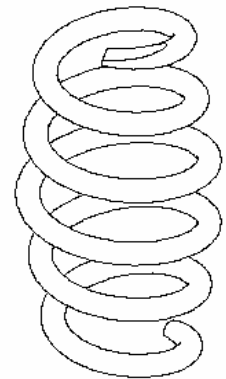
- Benchmark Vehicle (D Class)
- ULSAS Solution (D Class)





MATERIAL UTILIZATION

- **Sheet Steel**
 - Thickness range 1.2 to 5 mm
 - Strength range 150 to 500 MPa
- **Tubes**
 - Thickness range 1 to 3.5 mm
 - Diameter range 13 to 70 mm
 - Strength range 150 to 600 MPa
- **Bar & Rod (springs)**
 - Diameter range 8.5 to 12.5 mm
 - Strength 1300 MPa
- **Forgings**
 - Strength range up to 750 MPa





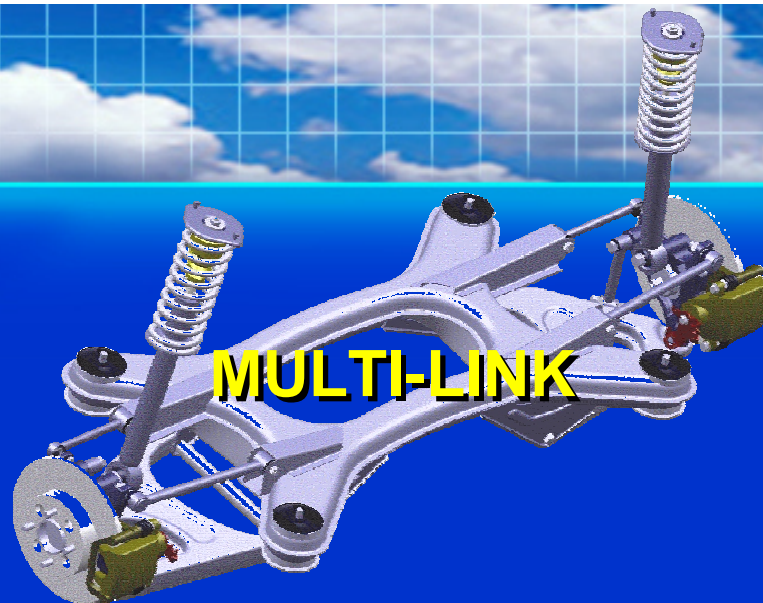
OVERALL RESULTS SUMMARY

SYSTEM TYPE	Cost Saving		Mass Saving	
	Target	Results	Target	Results
Twistbeam	0%	6%	20%	32%
Strut & Links	0%	2%	20%	25%
Double Wishbone	0%	0%	20%	17%
Multi-Link (Vs Aluminum Benchmark)	20%	30%	0%	3%
Lotus Unique (Vs Double Wishbone)	0%	22%	20%	34%



PROJECT HIGHLIGHTS

- **Weight savings of up to 34 percent over current steel designs at no additional cost**
- **Match the mass of an aluminum system, while achieving a 30 percent cost benefit**
- **Performance not compromised**
- **Currently available steel grades and technologies are key enablers to success of ULSAS**



MULTI-LINK



LOTUS UNIQUE

THANK YOU



STRUT & LINKS



TWISTBEAM



DOUBLE WISHBONE