Lincoln/Jaguar marriage bears first fruit

International design teams give birth to high-spirited offspring, each with distinctive traits By Rick DeMeis, Senior Editor -- Design News, July 19, 1999

When Ford took Jaguar in corporate marriage back in December 1989, the union was blessed with skepticism not only by many consignetti but some of those at the British-based company as well. As one long-time owner puts it, "Could Ford continue the heritage of the cars without meddling in the product design, feel, and reputation for exclusivity? It was looked on by many die-hards as tantamount to a sell out." (Although, keep in mind some loyalists thought Jaguar lost some of it's appeal when the cars stopped leaking and periodically breaking down after some terrible quality problems in the early '80s).

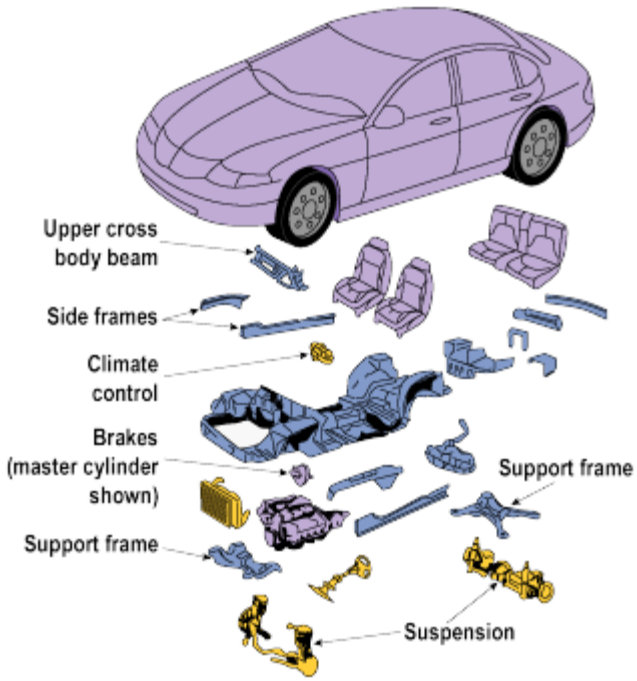
Well rest easy, if not merry, gentlemen (and ladies), nothing to dismay. After nearly a decade, the union has infused Jaguar with quality improvements, from Ford's process technologies, and cost savings, from a wider supplier base and economies of scale enough so that the UK manufacturer was probably rescued from disappearing altogether. This rejuvenation has allowed Jaguar not only to prosper in its traditional luxury market, with its in-house designed XJ sedans (see *Design News* 12/1/97, p. 74) and XK8 sports cars, but broaden it now with the joint Ford- and Jaguar-developed platform supporting the Jaguar S-Type and Lincoln LS sedans (along with a Ford Thunderbird waiting in the wings). The cars are designed to appeal to drivers traditionally looking to BMW for handling, performance, and luxury.

The words "joint platform" may make many aficionados cringe with memories of merely renamed Dodge Aspens and Plymouth Volares dancing in their heads. "A joint platform can be a disaster or a success," says David Szczupak, Jaguar's chief program engineer for the S-Type. "Our challenge (with Lincoln) was to deliver in parallel two unique cars using a common architecture. With two different models, where then could you design together, using quality systems, without compromising the character of the cars?"

Commonality, but with distinction. While designers wanted to keep the cars distinct, Szczupak says they knew significant savings could be realized in many areas "if done right." For example, both cars would need items such as fuel-system and climate-control components, basic transmissions, axles, etc. that could be procured in common for design and volume cost savings. "But the Jaguar would have to ride and handle differently, with a different powertrain, and shift-pattern and air-conditioning software," he emphasizes. The platform's suspension geometry is common in castings, but aligned, tuned, and damped to produce distinct feel and control. Shock absorbers (see sidebar) and power steering valving are different as well.

Because of the joint development, "Both cars are better," notes Szczupak. Not just in common components, but in drawing from expertise in both organizations. In the three-year development, engineers worked together in co-located design teams at each company where needed. Jaguar engineers served on teams in the U.S., while their Ford counterparts similarly went to England.

Szczupak says key co-developments were the suspension geometry and initial crash-worthiness work. For these, the teams did CAD and stress analysis with Ford's now-standard I-DEAS Master Series from SDRC (Milford, OH), and MADYMO by TNO-MADYMO North America (Northville, MI), respectively.



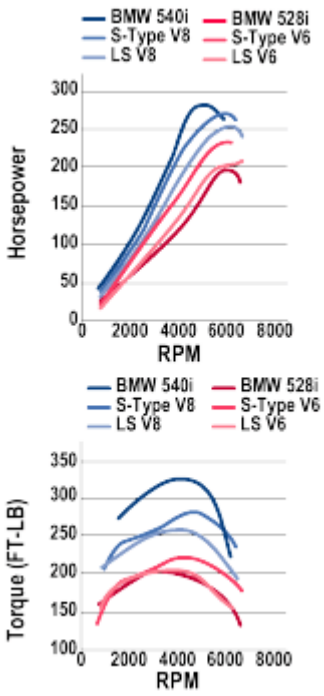
KEY: <u>Purple</u> - different components <u>Blue</u> - common components <u>Yellow</u> - common elements tuned differently and/or having some different parts.

One program aim was to develop common S-Type/LS components to save cost and be 'transparent' to the driver. Unique features give each car its own characteristics.

Quality keys. Szczupak also notes program-management and quality-planning software that Ford developed and brought to the Jaguar enterprise as vital to S-Type development. In particular, he cites dynamic program simulation that ties together engineering, logistics, and management concerns to allocate program resources and determine the implications of decisions. Also noteworthy was Advanced Quality Planning, which also involves suppliers, and uses Failure Modes and Effects Analysis (FMEA) to anticipate, analyze, and remove potential quality problems. The cross-functional design teams used FMEAs to determine the best designs and methods of manufacture.

Ken Kohrs, Ford vice-president for large and luxury cars notes, "The LS used more CAE and reliability testing and analysis than any vehicle we have ever done." Company designers also used Mechanical Dynamics (Ann Arbor, MI) ADAMS software, previously used to simulate race car performance, to virtually evaluate different handling characteristics before development time and money, and prototype hardware, were committed.

At Jaguar, engineers additionally worked with knowledge-based engineering software from Knowledge Technologies International (KTI, Lexington, MA), which combines CAD inputs with rules-based expert systems. Szczupak specifically notes material-thickness optimization using strength-to-weight criteria; location and orientation of the GPS navigation antenna under the rear-window shelf to maximize viewing of the necessary three satellites; and a virtual mannequin for ergonomic and safety studies.



Cross-fertilization. Asked if there were mindsets or corporate cultures to be merged, Jaguar's Szczupak says, "Engineers the world over have a common understanding of goals and what needs to be delivered. In both organizations, they are customer-focused today."

Down in the design trenches, one young Ford dynamics engineer was enthusiastic about how each company's engineers learned from their counterparts, not just on the early co-development teams, but also in trouble shooting problems as each car independently matured. He notes, for example, brainstorming to make the best steering refinements in response to a similar undesirable characteristic. "The Jaguar guys were fantastic, they are very skilled in empirical vehicle evaluation they can jump in a car and tell you what's wrong. We're more analytic, and complemented each other well. They helped us design in ride comfort, which is very subjective, and seems to hinge on audible and other cues, and thus hard to model." He feels with fewer models, Jaguar engineers "have a good feel for what a car should be as a Jaguar. We have so many models and move between programs, getting wider experience, but may not have such a seat-of-the-pants feel."

Szczupak adds the new Jaguar factory producing the car allowed company designers to use processes and quality methods gained from Ford to be applied to Jaguar's smaller volume base. "Jaguar brings richness to the party in our global awareness engineers able to meet needs around the world which helps the Lincoln LS be a world car. We bring knowledge of small-volume, high-quality markets where the key is how you manage with less investment, automation, and fewer people." He notes that the performance sedan customer is demanding, but model sales are limited to perhaps a couple of hundred thousand worldwide thus a quality product must be efficiently manufactured.

Likewise, Charles Repp, chief Lincoln LS program engineer, notes that Ford benefits from Jaguar's experience in targeting the LS for Japan and Europe as well as the U.S. He cites specific Jaguar technology, such as precision variable-ratio, speed-sensitive, rack-and-pinion steering. By designing the LS for European front-offset and side-impact safety mandates, engineers exceeded U.S. requirements with the common platform's crash structure.

Szczupak mentions that the S-Type's needs in a six-cylinder engine were best met using the lower half of Ford's Duratec V6 with a different top end. He concludes, "I'm most pleased about how the teams managed to 'mature' the car to deliver character, ride, and feedback in driving whether handling sprightly or on the limit of adhesion."

For the LS, Ford also folded its racing experience into the mix. Fine tuning the vehicle to take on Autobahn-dominating BMW in handling and performance, the company called on Hau Thai-Tang as development engineer. His experience was concentrated on tweaking LS dynamics. Other steering and suspension team members spent time in Formula 1 Racing.

Thus, the common-platform development program not only tapped joint technology resources and tools, but gave designers the flexibility and components to produce two cars for the world market distinct for each company's customers.

How do they drive? See news in this issue and next.

Common heritage: Other S-Type and LS technologies

- Anti-dive rear suspension geometry to minimize pitching during braking or acceleration
- Double-rail torque boxes run along frame sides for strength
- Aluminum support structure and suspension components save weight

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Cross-continent design team tips

Charles Repp, Lincoln LS chief program engineer, serves a recipe for successful international design:

- Co-located design teams: set up early for technology and expertise cross-pollination
- Face-to-face meetings with counterparts for understanding
- Communication, including teleconferencing and the Internet: phase communications and queries to take advantage of international time differences, allowing the program to function 'round the clock; while you can't get away from personal contact, much can be seen by "throwing a drawing on the wall during a video teleconference"
- Compatible computer systems avoid data-file conversion delays and problems
- Visit markets to find needs: for example, Ford was able to see the value of different spec shock valves on the LS by determining roadway differences in its markets
- Best practices: merge design criteria and modify standards for a world market

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5 keys to S-Type/LS quality

Quality methods used by Ford, and instilled in the Jaguar organization as well, are cited by both as critical in the joint LS/S-Type development:

1. Cross-functional program module teams: interchange of expertise and technology among Ford, Jaguar, and suppliers
2. Supplier initiatives: early involvement to ensure understanding design and quality requirements
3. Dynamic program simulation: simulate the development program, its people and skills, needed to deliver on time
4. Advanced Quality Planning: program checkpoints that must be met to deliver a quality product
5. World-Class Timing development process: schedule, with flexibility, all product development activities, and monitor against targets and milestones

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Timeline for Design

Mid '80s: Jaguar wants to develop

S-Type-class car but financial losses prevent it

December 1989: Ford buys Jaguar

1993: Jaguar's Browns Lane plant modernized

Late 1994: Lincoln looks at joint development but Jaguar occupied with new XJ6 series

Late 1995: S-Type/LS program approval

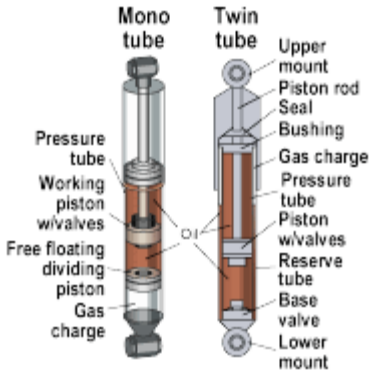
May 1999: built in an all-new plant, S-Type goes on sale

June 1999: LS goes on sale

2001: Small Ford/Jaguar common-platform sedan to debut

Shock truths: different strokes for different cars

While the LS and S-Type share suspension geometry, here's why their design teams selected different shock absorbers to help tune the distinct characteristics desired into each.



Ford engineers picked twin-tube shocks. LS Vehicle Development Manager Hau Thai-Tang notes the Monroe twin-tubes give the car "crisp roll damping, right away." Both a base and piston valve are available for tuning. Also surface quality of the outer tube is not critical if made out of round by rock impacts or being dropped during installation. A disadvantage is a tendency of oil to cavitate, lowering damping, during repeated large, or high-frequency displacements.

Jaguar put Bilstein mono-tubes on the S-Type. Senior Engineering Specialist, Chassis Development, Mike Cross, says, "Within a given tube envelope, the larger piston gives a better rolling feel," softening an initial displacement, for the characteristic Jaguar ride. The greater diameter, thus more effective, piston allows more flexibility in its tuning.

Engineers at both companies also selected their style of shocks factoring in their greater design experience with the same types on previous vehicles.

For more information

Design software from SDRC: **Product Code 4771**

Analysis packages by TNO-MADYMO North America: **Product Code 4772**

Knowledge-based software from KTI: **Product Code 4773**

By the numbers						
Here's how the Jaguar S-Type and Lincoln LS compare to the BMW 5 Series, considered by most driving enthusiasts to be the standard for performance sedans.						
	Jaguar S-Type		**Lincoln LS**		**BMW 5 Series**	
					528i	**540i**
Engine	3.0/ V6	4.0/ V8	3.0/ V6	3.9/ V8	2.8/ inline 6	4.4/ V8
Peak hp/torque (ft-lb)	240/221	281/287	210/205	252/267	193/206	285/324
Transmission	5 spd auto		5 spd auto & manual	5 spd auto only	4 spd auto 5 spd manual	5spd auto 6 spd manual
0-60 mph (sec)	8.0	6.6	8.0 man est 9.3 auto est	7.5 est	7.0 man 7.7 auto	5.8 man 6.2 auto
Top speed (mph), electronically limited	130 (141 w/sport package)		N/A		128	155 man 128 auto
Weight (lb)/ distribution front/rear (%)	3,650 51/49	3,770 52/48	3,593 auto 52/48 3,598 man 51/49	3,692 53/47	3,549 auto 50.9/49.1 3,495 man 50.5/49.5	3,803 auto 52.5/47.5 3,748 man 52.1/47.9
Wheelbase/track (in)	114.5/ 60.5 front, 60.8 rear		114.5/ 60.5 front, 60.2 rear		111.4/ 59.5 front, 60.1 rear	
Wheel dia. (in)/tire width (mm)	16/225 17/235 w/sport pkg		16/215 17/235 w/sport pkg	15/225	16/225 auto 17/235 man	
Turns, lock-to-	2.6/37.7		3.0/37.7		3.0/37.1	3.0/37.4

lock/ turning circle dia (ft)						
C_D	0.32		0.317		0.30	0.31
EPA mileage (mpg) city/hwy	18/26	17/23	18/25 auto 19/25 man	17/23	18/26 auto 20/29 man	18/24 auto 15/23 man
Base price	$42,400	$48,000	$31,450 auto $32,250 man w/sport pkg	$35,225	$40,445 auto $39,470 man	$51,670 auto $54,470 man