Jaguar Land Rover
Company Overview

11 vehicle lines – with ambitious expansion plans to extend product offerings

Jaguar F-TYPE, XF Sportbrake & XE announced as the 9th, 10th & 11th vehicle lines

4 UK assembly plants, with 2 UK product development facilities

New £1.1bn engine investment - plant under construction

Employs 30,000 people globally - increase of 11,000 over last 3 years

Employs 7000 engineers and designers - up 1,000 on the prior year

Global sales reach, worldwide network covering 178 countries
Ground-breaking Days at Jaguar Land Rover
New 2014 Successes
So far …….

USA Superbowl Advertisement
Queen's Award for Enterprise
Jaguar Best Brand in What Car & 2nd J.D. Power US Quality

250 New Jobs at Halewood new home of Discovery Sport
Launch of Special Vehicles
XE Launch – New Medium Segment Jaguar
Jaguar Land Rover
Recent Awards

- **BEST COMPACT SUV**
  - Auto Express UK Award 2013

- **MOST BEAUTIFUL SUV**
  - Auto Motor Und Sport Magazine 2013
Global Retail Sales Growth Up 16%

Jaguar Up 22k 38% growth rate
Land Rover Up 38k 12% growth rate

<table>
<thead>
<tr>
<th>Year</th>
<th>Jaguar Sales</th>
<th>Land Rover Sales</th>
<th>Total Sales</th>
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</thead>
<tbody>
<tr>
<td>2009/10</td>
<td>208,197</td>
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<tr>
<td>2010/11</td>
<td>240,905</td>
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<tr>
<td>2011/12</td>
<td>305,859</td>
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<td>374,636</td>
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<tr>
<td>2012/13</td>
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<td>434,311</td>
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Region-wise Sales:
- CHINA: 23%
- EUROPE: 20%
- UK: 18%
- USA: 17%
- ROW: 17%
- ASIA: 5%
Emerging markets now account for nearly 50% of our total sales creating an improved balance to the geographical sales mix.
Challenging Conditions
Period of Opportunity through Innovation

Mature Industry Experiencing a New Age of Innovation

Increase oil prices, exchange rate volatility & changing tax regimes

European capacity

Engine downsizing, focus on emissions & fuel efficiency

Competitor overseas manufacturing & consumers offers

Regulatory change

Automotive 9 of the 20 Top Innovative Companies

[Boston Consulting Group]
The Challenge for Engineering

“More Great Product Faster”
50 product actions in 5 years

10,000 Requirements
> 100,000 Test Cases

18 Customer attributes:
e.g. Ride & Handling,
Performance & Economy

100s New Leading Edge
Technologies

Massively increased
Systems Complexity

6 Functions:
Body, Chassis, Powertrain,
Electrical, Hybrids, Vehicle

1000s New Parts
55 Major Systems
1,200 features

100 ECUs
> 100 Millions of lines of code

4500 Data Signals
Refreshed 100*/Sec

178 Global Markets

"More Great Product Faster"
50 product actions in 5 years
Delivering the Next Generation of Jaguar and Land Rovers
Requirements & the Customer Experience

**DNA:** This is the excitement character of what makes a vehicle into Jaguar Land Rover vehicle. It defines the aspects that tie our products together, and make them a unique proposition in the market place.

**Standards:** Are used to generate the basic hygiene level of performance for all our products – reused and assessed on all vehicles, they cover aspects of durability, material performance etc…

**PALS:** For each of the Attributes (characteristics of the vehicle which can be perceived directly or indirectly by the customer) a relative positioning of performance against the identified competition.

Customer Quality Data
NCBS / CQI / J.D.Power

DNA

Standards

PALS
Brand DNA

Hearts
- Driveability
- Vehicle Dynamics
- Vehicle NVH & Powertrain Sound
- Seductive Design

Minds
- Safety & Security
- Perceived Quality
- Usability
- Performance & Economy

Inner Strength
- World’s SUV Brand of Choice
- Definitive Capability
- Iconic Design

World’s SUV Brand of Choice
Definitive Capability
Iconic Design
How Does Virtual Engineering Help?

- Develop New Design Concepts
- Integrate New Technology
- Assess Alternative Designs
- Develop and Verify Targets
- Confirm Design Compatibility
- Develop Systems Architectures

- Sign Off Customer Requirements
- Evaluate post test Failure Modes
- Develop and verify countermeasures
- Final Baseline Correlation

- Confirm Performance Targets
- Develop Engineering Solutions
- Assess Potential Failure Modes
- Assess Design Sensitivity
- Develop Countermeasures
- Assess Derivatives and Options
- Optimise Design and Performance
- Test design through range of customer usage
- Manufacturability and tooling
Virtual Engineering
At Jaguar Land Rover

Stability Control Systems

Thermal management

Aerodynamics

Brake Squeal
Virtual Engineering
At Jaguar Land Rover

Body Crash Analysis and Optimisation

Vehicle Dynamics

Climate Control Systems

Wiper Noise Analysis
Delivering the Virtual Car

To date to deliver all variants of Jaguar XE

- 36 Million HPC CPU Hours
- 1.8 Million Simulations
- 1200 TB of data generated
Impact of New Technology and Complexity

Advanced Driver Assistance Technologies

Enhanced Park Assist functions with Perpendicular Park

Blind Spot Monitoring with Close Vehicle Sensing

Lane Departure Warning

Surround Camera System

Enhanced Adaptive Cruise Control & Queue Assist

Adjustable Speed Limiter

Adaptive Xenon headlamps

Torque Vectoring

Emergency Brake Assist
Advanced Driver Assist Technologies
Impact on Systems
Advanced Driver Assist Technologies
Impact on Attributes

A06 – Product Efficiency
A01 – Safety
A02 – Perceived Quality
A03 – Accommodation & Usage
A04 – Vehicle HMI & Audio Visual Performance
A05 – Vehicle Dynamic

A06 – Braking
A07 – Performance & Driveability
A08 – Vehicle NVH & Sound Quality
A09 – Durability & Reliability
A10 – Off Road & On-Road Capability
A11 – Weight

A12 – Environment & Energy Management
A13 – Service & Ownership
A14 – Air Weather, Comfort & Video
A15 – TASE
A16 – So ciągu

Body
Chassis
Powertrain
Electrical
Research

Autonomous Driving
Model Based Design Process

Virtual Integration Framework

Virtual
Semi Virtual
Semi Physical
Physical

Driver in the Loop

Functional Requirements
Model in the loop
Software in the loop
Component Hardware in the loop
Continuous V&V
Vehicle the loop
Full Vehicle HiL in the loop
System Hardware in the loop
Model Based Design Process

- Requirements
- Functional Definition in Doors
- Abstract Detail/Targets/Test Case Definition to Simulink Stateflow

Virtual Integration Framework

Virtual ➔ Semi Virtual ➔ Semi Physical ➔ Physical

Functional Requirements ➔ Continuous V&V ➔ Vehicle the loop

Model in the loop ➔ Software in the loop ➔ Full Vehicle HiL in the loop

System Hardware in the loop ➔ Component Hardware in the loop

Virtual Integration Framework

Virtual ➔ Semi Virtual ➔ Semi Physical ➔ Physical
Model Based Design Process

- Detailed Integration & Simulation Coupling
- High Detail Modelling & Accuracy
- Continuous HPC Scheduling
- Scenario Verification
Model Based Design Process

- Execution on Host Computer
- Verify the Behaviour of Production intent code
- Evaluate Metrics prior Software Release

Virtual Integration Framework

- Virtual
- Semi Virtual
- Semi Physical
- Physical

Functional Requirements

Model in the loop

Vehicle the loop

Full Vehicle HiL in the loop

System Hardware in the loop

Component Hardware in the loop

Software in the loop

Continuous V&V
Model Based Design Process

- Component/Systems/Vehicle Hardware in the Loop
- Integration with Real Time Physical Models
- Automated Test Case’s aligned to Requirements
- Systems Robustness
Model Based Design Process

- Real Vehicle as System Under Test
- Late Failure Mode Find & Fix
- Automated Verification
- Static End of Line Testing
Model Based Design Process

- Driver in the Loop
- Integration of the Real Driver
- Continuous and Rapid Design
- Evaluate Complex Features

Virtual Integration Framework

Virtual
Semi Virtual
Semi Physical
Physical

Functional Requirements
Model in the loop
Software in the loop
Component Hardware in the loop
System Model (Hydro/Mech/Elect...)

Vehicle the loop
Full Vehicle HiL in the loop
System Hardware in the loop
Model Based Design Process
Summary

Drivers
- Handling Complexity
- Handling Real World Variation
- Speed
- Sensitivity and Robustness
- Reducing Late Error States
- Overall Efficiency
- Design Cost / Product Cost

Challenges
- Parametric Data
- Complexity Embedded Systems
- Representing Mechanical Systems
- Legacy Software Versions
- Compatibility of Simulation Codes
- Real World Use Cases

Metrics
- Model Detail
- Accuracy
- Speed
- Latency
- Scenarios
- Reduction in Error States
- Total Cost

Enablers
- Increased Upfront Modelling
- Mathworks Support
- Tier 1 Support
- Automation
- Software and Modelling Standards
- Parallelisation and HPC
- Driver in the Loop Integration
Virtual Realisation

Experiencing the Virtual Car
Thank you