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BLOODHOUND to test fire Britain's biggest hybrid rocket

- **British design produces World beating power and efficiency**
- **Major milestone in the development of 1000 mph LSR car**

It was announced today (03.03.11) that The BLOODHOUND Project will undertake the first full test firing of their 122 kN (27,000lbs) prototype hybrid rocket in the UK. Created especially for the BLOODHOUND SSC Land Speed Record car it will be the largest rocket tested in this country for twenty years.

A number of sites are currently being evaluated for the test which will take place this summer.

The rocket, like the Project itself, is a remarkable story of innovation and achievement against the odds.

It has been designed and manufactured by The Falcon Project Ltd, a specialist rocket company based in Manchester, led by 27 year-old self- trained rocketeer Daniel Jubb.

The term 'hybrid' stems from the fact that BLOODHOUND's rocket combines solid fuel with a liquid oxidiser to create its power. Although technically demanding, this approach is the safest and most controllable, with driver Andy Green able to shut off the flow of oxidiser and extinguish the rocket if required.

At 4m (12 feet) long, 45.7 cm (18 inches) in diameter and weighing 400kg, the Falcon rocket is the largest hybrid ever designed in the UK.

It will burn for 20 seconds per run, during which time it will consume 181kgs of solid fuel and 963g of oxidizer to produce 122kN (27,500 lbs) peak thrust (equivalent to 77,500hp, or the combined power of 645 family saloon cars).

This will be in addition to the 90 kN (20,000lbs) of thrust provided by the car's other main engine – a state of the art EJ 200 jet from a Eurofighter. Together, they make BLOODHOUND SSC the most powerful land vehicle ever built.

There are four main elements to BLOODHOUND's propulsion package: the solid fuel combustion chamber, the liquid oxidiser and its pumping system, and the associated control system.

The rocket itself consists of a solid fuel made from synthetic rubber (HTPB, or Hydroxyl-Terminated Polybutadiene, similar to that used in aircraft tyres) with metal powders and burning rate modifiers added to the mix. This is contained within a composite case mounted beneath the EJ200 jet engine.

Just as the car design team made extensive use of computational fluid dynamics (CFD) to predict airflow over the aluminium and carbon skin of BLOODHOUND, so Daniel's seven-strong team used CFD to model the flow of gasses *inside* the rocket. They then optimised its performance by varying the composition and geometry along the length of the solid fuel grain. The result is a hybrid rocket of world-beating power and efficiency.

High Test Peroxide (HTP) is the liquid oxidiser used to burn the solid fuel. A staple of the UK rocket programme during the 1960's and 70's, HTP is non-toxic and relatively safe to handle. This makes it the ideal choice for use in a land speed record car that will be refuelled in a desert environment during a record attempt.

The need to deliver 963kg of liquid HTP to the rocket in a mere 20 seconds presented a significant technical challenge in its own right.

BLOODHOUND's solution takes the form of a Cosworth CA2010 Formula 1 engine, the most reliable on the grid, mounted to a pump from a 1960s' Blue Steel cruise missile. Upgraded by the original designer, our pump is now 15% more efficient that its airborne predecessors and able to convert the 800bhp produced by the V8 race engine into 1100lb/in^2 (76 Bar) of pressure and a flow rate of 105 lb/sec (47.6 kg/sec) – enough to fill a bath in three seconds.

Prior to commencing a high speed run the Cosworth engine (also known as the Auxiliary Power Unit or APU) will be started and left idling at between 3000 and 4500rpm. The oxidiser tank will also be pressurised to 24psi using inert nitrogen gas.

With the car accelerating under the power of the EJ200 jet engine alone, Andy will engage the APU with the pump via a clutch and gearbox.

20 seconds into the run, with the speed approaching 230mph, he will prime the rocket by filling the fuel lines and pump with oxidiser and injecting a small quantity of HTP into the rocket. This will react with a silver oxide catalyst pack mounted in front of the main propulsion chamber to create superheated steam and oxygen. As the solid rubber fuel

begins to char in the 600°C temperature, heat haze and black smoke will issue from the rocket nozzle. As low-level combustion starts, this will turn into a powerful flame. The rocket is now primed, ready to deliver full power at Andy's command.

At around 350mph, 25 seconds into the run, the driver will depress the right-hand trigger on his steering wheel, summoning the full force of the Cosworth engine. As the maximum flow rate of HTP reaches the catalyst vast quantities of oxygen will be produced, supporting the combustion of the fuel grain, and generating 27,000lbs of thrust, a 3000°C temperature at the nozzle and a 25-foot long plume of flame studded with incandescent shock diamonds.

After a further 20 seconds of acceleration, at up to 2.5G, BLOODHOUND SSC will have reached its maximum design speed of 1050mph. Once through the measured mile, Andy Green will use airbrakes, a parachute and finally wheel brakes to bring the car to a halt, having covered 10 miles in a mere 100 seconds.

Even allowing for his many years experience flying fast jets, priming and firing the rocket, driving the EJ200 and ensuring that BLOODHOUND SSC is both on course and stable will tax Andy Green's concentration to the limit.

To help him and ensure his safety, BLOODHOUND features a complex control system designed by Formula 1 systems specialist Dr John Davis.

Cosworth electronics and custom-written software watch over key vital signs including HTP tank temperatures and pressures, pump pressure, inlet and outlet pressures, valve positions, rocket chamber pressure and the temperature of the outer rocket casing along its length.

In the event of an abnormal reading the control system will automatically shut down the supply of oxidiser, thereby extinguishing the rocket. Andy will also be able to shut the rocket down manually.

The three-year long development of the hybrid rocket has had a major influence on the overall design of the car.

In early configurations it sat on top of the larger, heavier jet, the rationale being to keep the centre of gravity low to aid stability.

As the aerodynamic modelling data from Swansea University's super computer revealed in ever increasing detail the herculean power needed to reach 1000mph, the rocket increased in power and size.

By late 2009 it became clear that the enormous thrust from the now 400kg rocket would pitch BLOODHOUND's nose downwards, thanks to its position high above the centreline of the car. This would increase steering loads, reduce the weight pressing down on the back wheels and disturb the airflow over the rear of the car, potentially causing lift.

The decision was taken to redesign the entire rear section of the car and mount the rocket underneath the jet, which is the position it occupies now in the final build configuration.

BLOODHOUND SSC is the world's ultimate racing car but something more besides: it is the focal point of global education initiative designed to stimulate interest in science, technology, engineering and mathematics. The development of its rocket by a small, visionary and dedicated team of engineers encapsulates the spirit of the Project. When, later this year, the rocket breathes fire at its UK test location, BLOODHOUND SSC will be that much closer to speeding across a dry lake-bed in the Northern Cape, South Africa; the world will be watching.

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For more information, images and animations please contact:

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Images available at: http://www.bloodhoundssc.com/media/car_images.cfm

Animations can be viewed online at: www.youtube.com/1050mph also available in broadcast quality