DEVELOPMENT. In early 2009, Safran resumed development of the Vinci cryogenic rocket engine, intended for the upper stage of an upgraded version of the Ariane 5 launcher, set for its first liftoff in 2016.

VINCI ON TRACK

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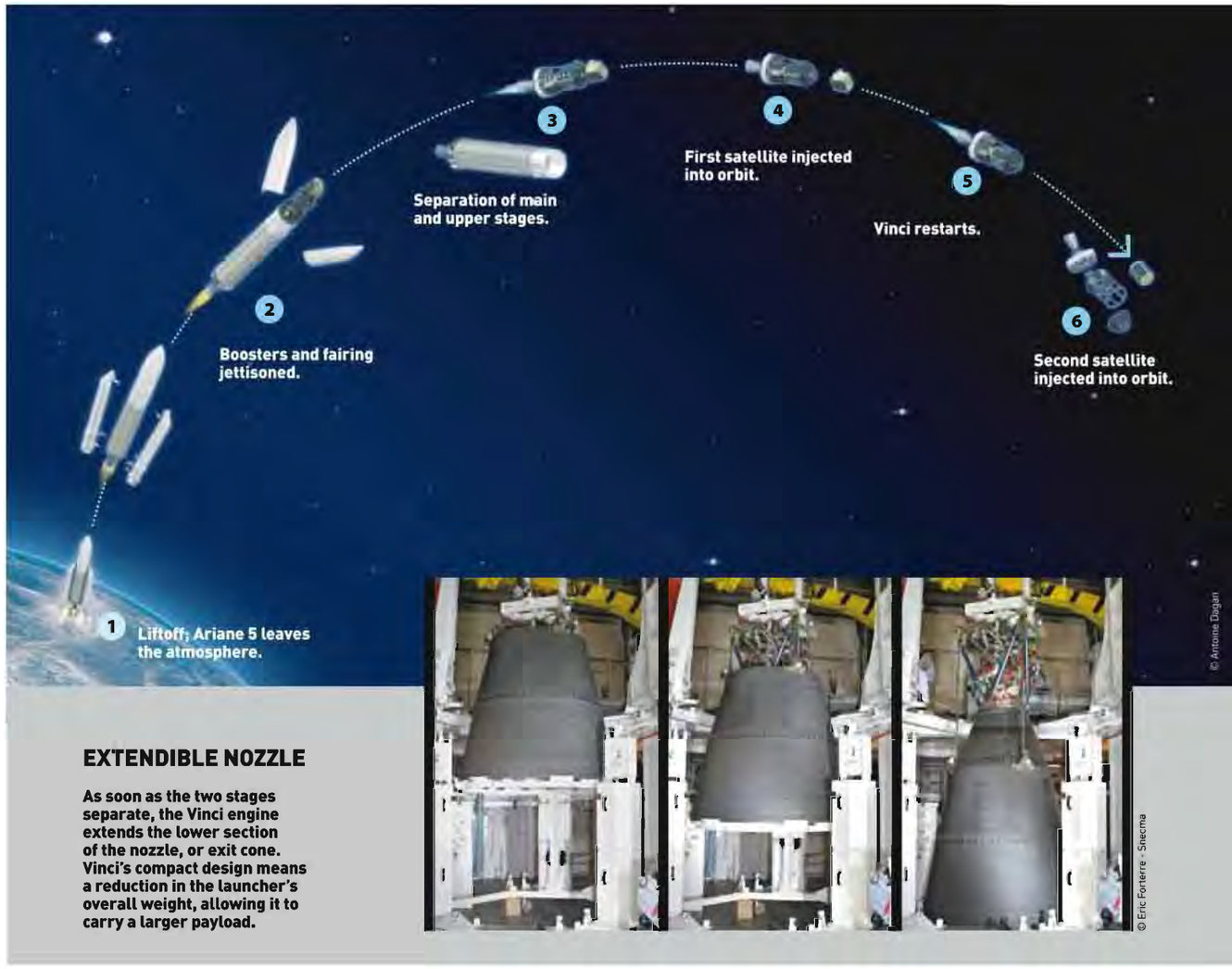

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EXTENDIBLE NOZZLE

As soon as the two stages separate, the Vinci engine extends the lower section of the nozzle, or exit cone. Vinci's compact design means a reduction in the launcher's overall weight, allowing it to carry a larger payload.

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Escaping the Earth's gravity is no laughing matter, but Ariane 5 has largely proven its bona fides. The European launch vehicle needs three separate propulsion systems to carry out its missions, and Safran leads the development and production of all three.

First step: liftoff! This is mostly handled by the two huge solid rocket boosters, which provide some 90% of the total thrust needed for liftoff – as much as several nuclear powerplants! Two minutes and twenty seconds after T-0, they burn out and are jettisoned to lighten the launcher. The main stage Vulcain 2 engine continues to operate for another seven minutes, bringing Ariane 5 above the Earth's atmosphere to an altitude of 150 kilometers. After using up all its propellants, the main stage also shuts down and separates, leaving the upper stage and its HM7B engine to take over for the next 20 minutes. It's up to this stage to inject the satellite or satellites (Ariane 5 often launches two payloads at once) into their assigned orbits. Like the main stage Vulcain 2, the HM7B is a cryogenic engine fueled by liquid oxygen and hydrogen, which create thrust through combustion and then ejection of the hot gases at very high speed.

The future is spelled "Vinci"

Ariane 5 is the leader in today's commercial launch services market, but it has to evolve to cope with the gradual increase in satellite weight and greater international competition. For that reason, Snecma, a Safran group company in charge of HM7B production, has also been working since 1999 on a successor, dubbed "Vinci". Tests of the two demonstration engines from 2003 to 2008 validated the design choices. Based on these results, the European Space Agency's ministerial-level council meeting in November 2008 voted to continue development of the Vinci engine for an upgraded Ariane 5 Mid-life Evolution (A5ME) model, that would be operational towards 2016.

"The main changes to the launcher involve the upper stage, which actually injects the satellites into orbit," notes Emmanuel Edeline, A5ME program manager at Snecma's Space Engines division. "The primary objective for this upgrade is to improve payload capacity into geostationary transfer orbit (GTO) from 9.6 metric tons for the current version, to 11.2 metric tons on A5ME. Furthermore, the Vinci engine is restartable in space, enabling its satellite passengers to use less of their own fuel for the orbital positioning phase, and therefore extend their service life."

More powerful, more flexible

The main improvements in the new Vinci engine address these trends. It will develop nearly 40,000 pounds of thrust, three times that of the HM7B, and offer a significant improvement in thrust-to-fuel consumption ratio. Vinci's higher performance is due to a new combustion cycle that uses all the liquid oxygen and hydrogen in its tanks.

Also new on the Vinci is an extendible nozzle. As Emmanuel Edeline explains, "The hot gases from the combustion chamber expand in this cone-shaped nozzle. In a vacuum, the longer the nozzle the higher the speed of the exhaust gases, which gives us higher performance for the

A FRENCH-LED EUROPEAN PROJECT

Snecma's Vernon plant in Normandy, about an hour west of Paris, oversees the development of the Vinci engine and all propulsion functions on the new upper stage. This management team calls on the plant's specialists in design, testing and production, as well as a vast network of European partners, including Astrium GmbH in Ottobrunn, Germany, a partner for more than 30 years for the thrust chambers on Snecma's cryogenic engines, and Avio in Turin, Italy, in charge of the oxygen turbopump. Volvo Aero Corp. of Sweden makes the turbines, Techspace Aero, a Group company in Belgium, is responsible for the valves, and Snecma Propulsion Solide is in charge of the nozzle (see below).

same propellant consumption. The advantage of an extendible nozzle is that it takes up less space in the launcher, enabling us to save weight. After separation of the main stage the nozzle is deployed by an electro-mechanical system." Last, but certainly not least, the new Vinci is capable of being reignited several times in flight.

"These are the main upgrades from the customer's standpoint," adds Edeline, "but behind them is a series of technological innovations based on twenty years of joint research with the French space agency CNES." For example, the rotor on the hydrogen turbopump, operating at some 100,000 rpm, uses ceramic ball bearings developed by Snecma. And its ability to restart in space calls on new computer simulations validated by "microgravity" testing on the Airbus A300 Zero-G aircraft. The extendible nozzle made of thermostructural composite materials is the fruit of 40 years of experience at Snecma Propulsion Solide (Safran group), which has developed a number of nozzles for solid rocket motors. In fact, it applied this same expertise to the extendible nozzle on the American Delta 4 launcher (right). This technology is exclusive to Safran, and led to Snecma Propulsion Solide being chosen to develop the Vinci nozzle.

Almost ready for ground tests

Snecma is aiming to meet three major objectives by 2011. First, shift the project into higher gear and get all the partners in fighting trim (see box). Secondly, resynchronize the major stages in the development of the Vinci engine and its subsystems with the major stages in the A5ME project. Thirdly, demonstrate the engine's maturity to ESA through new series of tests. The first engine is now being assembled for testing that is slated to start in early 2010, and a second engine will be ready for ground testing in 2011. "These prototypes will be tested with the extendible nozzle, so we can test them under realistic operating conditions and carry out the initial endurance tests," notes Edeline. "At the same time, we're gearing up for production, so the Vinci can be produced at a rate of eight engines per year, dependably and competitively."

From Ariane 5 to Ariane 6

There is a lot at stake in this program, all the more so since the development of Vinci is a real long-term investment. For example, the French prime minister ordered a report on European space policy, which was published last May. The report underscores the necessity of having the Vinci cryogenic engine to power the upper stage of the next Ariane launcher, and also considers the possibility of using this technology on a future upgrade of Europe's new light launcher, Vega. ■