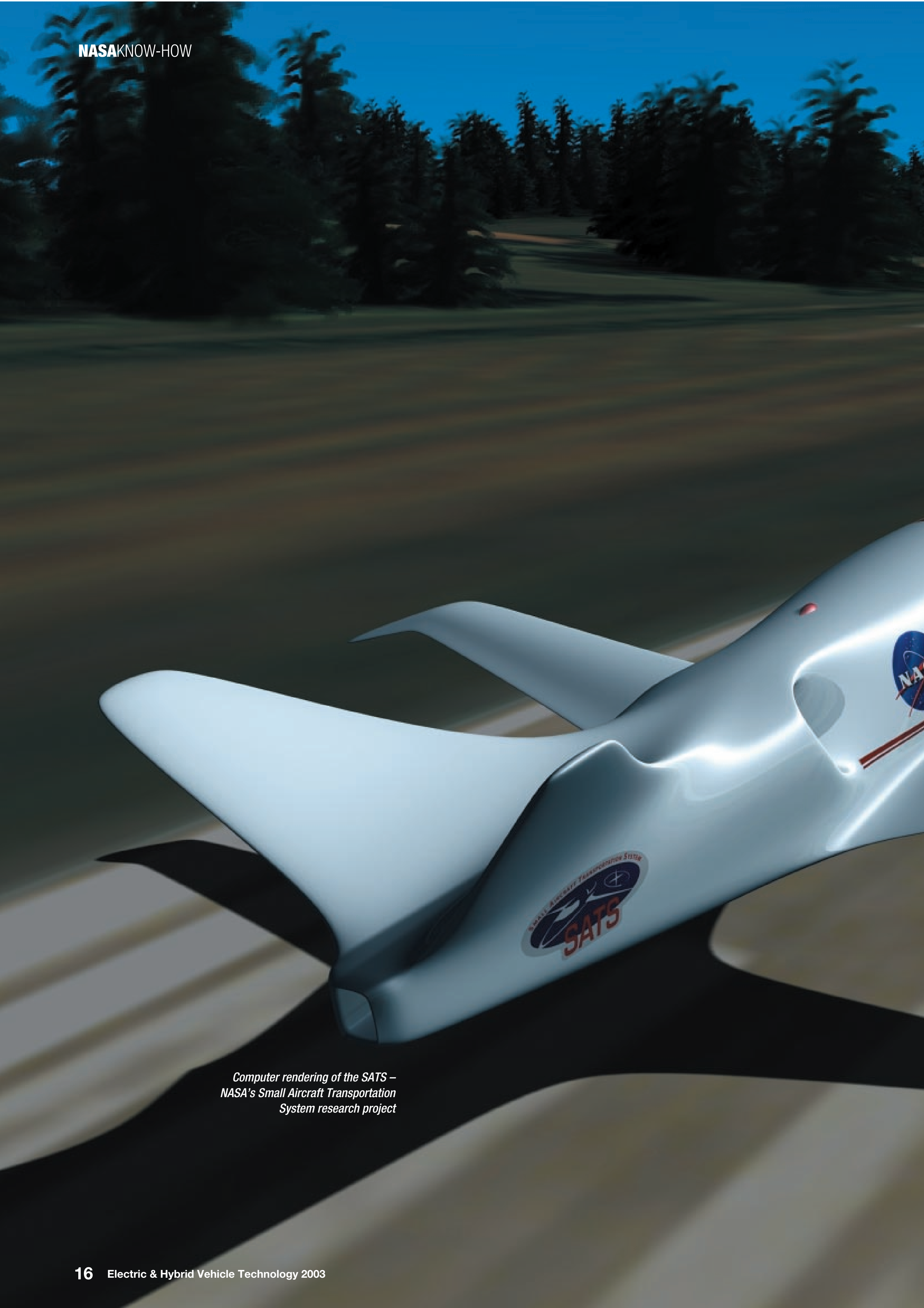


Computer rendering of the SATS – NASA's Small Aircraft Transportation System research project

High flyers

Keith Read talked to NASA about far-out research programs that could soon benefit auto makers “the car of the future? It’s one that flies!” says Sandy Munro, a consultant whose Michigan-based company operates in the automotive and aviation sectors and is deeply involved in SATS – NASA’s Small Aircraft Transportation System research project. It’s a prediction that is made with conviction. And his comments make a lot of sense.

They also fit well as pieces within the jigsaw that is the development of future transportation, frequently mirroring predictions and projections set out by two key NASA men and a leading academic... Bruce J. Holmes, associate director for airspace and vehicle integration systems, and Michael H. Durham, manager, distributed air ground systems and advanced air transportation technologies at NASA’s Langley Research Center, Virginia, got together with aviation academic Dr Scott Tarry, associate professor at the Aviation Institute, University of Nebraska, to present a paper at the AIAA-ICAS International Symposium on Air & Space in July 2003.

Munro cites several reasons why future ‘drivers’ will need to take to the sky: an ever-growing bill for bridge and highway maintenance that means the authorities will never catch up; the lack of a comprehensive rail infrastructure providing inter-city travel of up to 800km (500 miles), and the increasing amount of time that existing scheduled airline travel takes for a similar distance thanks to security measures in a world on constant alert for terrorism.

But it’s not his prediction of cars that fly that is so worrying. Nor is the fact that they will effectively fly themselves, with the biggest responsibility of the everyday men and women ‘driving’ these flying cars being the instruction to their offspring to buckle up! Nor, indeed, is it that this could all start to happen (albeit in a minor way) within a few years and literally take off while Munro and I are still alive (we’re both in our 50s).

What is so frightening, in the Western world at least, is that unless America wakes up, the Japanese will be in the pilot’s seat of this revolution and could go on to take over the US domination of world general aviation. Says Munro: “Toyoda-san – Mr Toyota himself – gave me the following quote: ‘We are in the transportation industry – our destiny is aircraft.’ And Toyota (and Honda) already have planes flying.”

Toyota’s Advanced Aircraft (TAA) project got off the ground a year ago from an airstrip in the Mojave Desert. The prototype, a four-seat Cirrus and Lancair lookalike, cruised at 140 knots (says an online information source) and is believed to have been powered by a Lycoming 360-series engine. However, things may be different in the future. Toyota is understood to be exploring diesel powerplants for aircraft and it funded a research project to examine conversion of its Lexus V8 engine to aircraft use. This became the FV4000, a 360bhp water-cooled engine that, according to some sources, was actually certificated by the FAA to include type and production certificates.

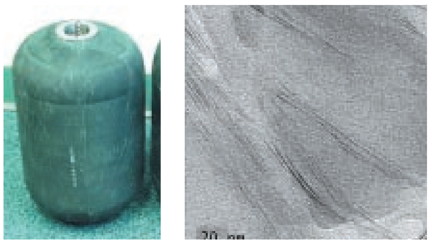
TAA, and any other prototypes that Japanese manufacturers are sponsoring, will almost certainly undercut the existing US-dominated general aviation aircraft production market (reckoned by Munro to be excessively expensive). However, with both his and NASA’s predictions about cars of the future being models that fly, it’s easy to see the value to the big Japanese auto makers of being big players in the general aviation market.

That’s why Munro and his team are linked with NASA’s SATS project, trying to bring cost- and quality-conscious automotive industry standards to the aviation industry so that the car that flies can be built at an affordable price. “Take a propeller,” he says. “Today it costs US$10,000. We’re looking to produce propellers of equivalent quality, efficiency and durability for something like US$900 to US$1,300. That’s what it’s going to take to develop these vehicles of the future. We have the technology to do it.”

Holmes, Durham and Tarry make no direct references to cars that fly in their presentation; in fairness to Munro, he is not exactly advocating vehicles that sprout wings and zoom into the air from the highway at the whim of the driver! But the goal of the SATS project is to enable much greater use of thousands of small airstrips and airports across the US for what amounts to point-to-point travel. Initially, this will be in a piloted aircraft – equivalent in automotive terms to a chauffeured sedan or minivan. Munro believes that many potential users of this form of travel could walk or even cycle to the point of departure.

In the longer term, SATS expects self-piloted flights to be commonplace thanks to upcoming technologies that simplify or automate many of the operational functions in the aircraft and airspace. In 2005, NASA plans to demonstrate the

Initially the flying cars will be piloted in much the same way as a bus or taxi. Later, they may fly themselves



NASA’s filament-wounding hydrogen storage tank

Toyota’s Advanced Aircraft is already in the air

operating capabilities being developed by SATS and explain the implication of those capabilities on the SATS vision. The demonstration's outcome is intended to inspire public understanding and confidence in the ability of new aviation technologies to enable the use of smaller aircraft and smaller airports for public transportation.

Meanwhile, in another of NASA's many centers, work on fuel cells aimed at developing a unit suitable for use in aircraft powered by electricity is close to a breakthrough that could immediately benefit the auto industry as it ramps up efforts to bring zero-emission electric vehicles to the mass market.

Dr Michael Meador is part of NASA's John H. Glenn Research Center team at Lewis Field, Cleveland, Ohio, looking at making proton-exchange membrane fuel cells perform better (giving higher power density output), making them last longer and reducing weight – not only of the fuel cell itself but also of the ancillary items that help make the whole assembly work. While all three elements of the work are critical to the aviation industry, the automotive sector will be more than happy to benefit from the improvements that Meador and his team may achieve.

To increase power density, the team is looking at new membranes that will operate at higher temperatures (120–150°C), reckoned to be the optimum heat and also the temperature at which catalyst poisoning in fuel cells operating at 80°C is eliminated.

Current fluorinated membranes – Nafion is perhaps the best example – are expensive and, at higher operating temperatures (above 80°C), they dry out, rendering the membrane ineffective. By pressurizing the system and running at high relative humidity, it is possible to push Nafion membrane to 100°C with a resultant increase in power density. But the added complexity and physical weight of hydrating the membrane means it's a non-starter for the aviation industry (although auto makers are working with Nafion membranes). "However, what they'd really like is a new membrane," says Meador, "and we've been experimenting with materials that operate between 120 and 150°C.

"We have systems right now that show reasonable proton conductivity at 120°C and 25 per cent relative humidity, which is much easier to achieve. We currently have agreements with a couple of commercial fuel cell users in which they have undertaken to evaluate the material. We're sending them the material and they will construct the fuel cell stacks using that material."

Meador declined to name the companies but confirmed that both were parties interested in alternative fuel cell use in aircraft propulsion and that one of them is an automotive company.

To reduce weight, the NASA team is focusing on the bi-polar end plates on the fuel stack. The relatively complex end plates need good mechanical strength to contain pressure within the fuel cell, good electrical conductivity and good heat transfer properties in order to manage the fuel cell's operating temperature. Metal meets requirements but is too heavy. Graphite is where some developers are currently looking, despite its inherent fragility.

"While the work is critical to the aerospace industry, the automotive sector will benefit"

Meador and his team are working on fiber-reinforced polymers using the experience gained on aircraft engine applications. These materials have a density that is about one third that of metal end-plates but with an equivalent strength. However, the conductivity of these materials is insufficient. To overcome this, NASA is using carbon nano-tubes and dispersing them within the polymer to increase conductivity.

Another of their targets for weight reduction is the hydrogen storage tank(s) necessary for proton-exchange membrane fuel cells. Filament winding a polymer composite into the shape of a tank can help reduce weight but the end product cannot contain hydrogen with its small molecules without the addition of an inner liner that re-introduces weight. NASA has shown that adding very small amounts of specially-treated clay to the polymers reduces the level of permeability to the point where filament-wound tanks could hold hydrogen satisfactorily. The added clay also produces other enhancements, all of which provide benefits for potential users. And this work was initially carried out by Toyota in Japan...

Getting aerospace materials into the automotive industry is a real challenge for Meador and his team because the industry is highly demanding when it comes to cost. But he sees this changing: "One of the women in my team asked the other day how much the clay added to the cost!" he says. ***E&H***

Six of the best

NASA's experts cite six main reasons shaping transportation demand characteristics as we move through the first decade of the 21st century...

1. Maturing of the hub-spoke infrastructure into the saturation phase of its natural growth by 2008-2010.
2. Increasing gridlock on America's mature highway system (and on the rail network, too).
3. Migration of Americans and their jobs from city centers and airports to more rural areas.
4. Growth of the 'Baby Boomer' generation in maturity and retirement may increase travel demand.
5. Transformation of the industry from standardized, customized products and services. (Transport is not yet on a par with PCs, cellular phones, automobiles and so on.)
6. The value of human time (and thus the premium value of doorstep-to-destination speed) related to increased productivity during the information age.

Been there, done that

The first flying car to make it to the drawing board is believed to be the Curtiss Autoplane of 1917. But public interest in a car-plane hybrid didn't take hold until after World War II when airplane manufacturers were shifting away from military aircraft to consumer production lines. Half a decade earlier, in 1940, Henry Ford is quoted as saying: "Mark my word: a combination airplane and motorcar is coming. You may smile. But it will come…"

There have been plenty of attempts to prove him right, although most have either crashed, been written off as impractical, or simply failed to get off the ground. None has achieved the dual-environment success enjoyed by amphibious cars.