Meeting the USA Challenge and More

True3D HUD Wins Global SatNav Competition

A story in which two expatriate students from Poland turn lifetimes of engineering experience into prize-winning technology for GNSS applications.

GLEN GIBBONS

Photo (top) of the Galileo Master award ceremony October 19 in Munich, Germany, from left: Thorsten Rudolph (Managing Director of Application Center for Satellite Navigation Oberpfaffenhofen AZO, the instigator of ESNC), Ulrike Daniels (Business Development at AZO), Martin Zeil (Bavarian State Minister of Economic Affairs), and representing overall winner, Making Virtual Solid–California, Tom Zamojdo and Juliana Clegg.

Photo credit: S. Hörmann/AZO.

A San Francisco Bay Area company — Making Virtual Solid–California (MVSC), which snared a trio of awards in a global GNSS competition for its novel approach to driver assistance, is still in early phases of development.

The origins of the company, however, go back more than 40 years to the Cold War era when its principals, Chris Grabowski and Tom Zamojdo, were studying physics and theoretical mathematics at the University of Warsaw, Poland.

But more about that later — first, the news.

In October, MVSC was declared overall winner of the European Satellite Navigation Competition (ESNC), which despite its name and the victor's title, Galileo Master, is an eight-year-old worldwide contest that drew 100s of entries from nearly 50 countries. MVSC also gained a special topic prize for mobile enterprise solutions, sponsored by NAVTEQ, the well-known digital map company.

Among the rewards for their ESNC accomplishments is a €20,000

(US$27,800) cash prize. The NAVTEQ win brings benefits valued at approximately €75,000 ($101,250), including a 12-month incubation program that includes one year of free access to NAVTEQ map data, content, and services.

To be considered for the Galileo Master and special topic prizes, individuals and teams must first enter their application concepts in regional contests — which numbered 23 this year. These include the USA Challenge, the North American regional partnership organized by *Inside GNSS* magazine and cosponsored by NovAtel, Inc., and the Institute of Navigation.

MVSC captured the USA Challenge title in a close finish among 19 regional competitors with its novel head up display (HUD) for vehicle navigation, the True3D Volumetric HUD. In the first year of the North American contest, MVSC had finished within a few points of eVotz, the 2010 winner, on the strength of its Virtual Cable concept, an integral part of the HUD design. (For further details on the North American regional competition, see the sidebar, "USA Challenge 2011," which begins on page 39.)

True3D Volumetric HUD stood out in the regional and global competitions by falling under a safety-of-life category, which comprised only 13 percent of the ESNC entries. The majority of concepts (56 percent) entered are classified as "mass market" and the remainder, "professional" applications.

The USA Challenge winner also stood out because its inventors have working prototypes that they have been demonstrating over the past year. In contrast, many of the ESNC entries are essentially "bright ideas" that lack the engineering investment to, well, make the virtual into something solid.

Since April 2011, the company has entered an accelerated period of exposure to partners, press, public, and academic experts, says the company's COO Juliana Carnes Clegg. They have the prototype and partners together at conferences and corporate headquarters throughout the United States and Europe. In May the prototype demo created a solid buzz at the Augmented Reality Event 2011 in Santa Clara, California, and the Maker Faire in San Mateo.

So, what *is* this innovation that has garnered so much attention?

True3D Volumetric HUD is an advanced, conformal system built into a vehicle or other platform that places accurately positioned images into a driver or pilot's view of the real, physical world. Typically, the route ahead of the driver is indicated by a Virtual Cable running overhead in the driver's viewscape.

Based on designs with patents pending in the United States, Japan, and the European Union, the company will

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Wikipedia Media

Making Virtual Solid

A Technology Whose Time Had Already Come

Many technologies are created before their best applications are even thought about. This leads to a business phenomenon known as "technology push" in contrast to "consumer pull." The True3D Volumetric HUD technology did not share this path.

Aware of the lifestyle-changing potential of GPS navigation technology and at the same time frustrated with the clunky and distracting designs of screen-based navigation systems, Chris Grabowski and Tom Zamojdo challenged themselves with trying to envision how navigation systems could look in a distant future, without limits of any technologies existing today.

First came the idea of a giant mirror high in the sky, where the driver could see the reflection of roads ahead of the car. The correct route would be marked on the mirror, and the driver could follow it by correlating the mirror image with the real road.

As it turned out, in this case the technology needed to implement this idea already existed in a form of a head up display (HUD) used primarily in military aircraft. In 1998, Grabowski and Zamojdo applied for a U.S. patent on this idea of a reflective approach to an image in a HUD (number US6272431 issued in 2001), but at the same time they did not think this was the breakthrough they were looking for.

That came when the two men realized that the road network map shown in the mirror could be reduced to a single line, but only if such a line was displayed in three dimensions. The 3D depth cues would allow the driver to easily correlate the line with the road and turns ahead.

Unlike the other navigation systems, this method eliminated the need to identify or count cross-streets and other objects along the route in order to know where to go next. Just follow the line you see suspended over the road. Thus, the trademarked idea of the Virtual Cable was born.

But what if following the Virtual Cable would have some undesirable effects on the driver? Would it distract a driver's attention? Could it be annoying? Would it require a lot of attention to follow correctly?

Grabowski and Zamojdo realized that the new interface would require extensive testing. But how does one test an idea without having the technology to implement it? As it turned out there was a way.

"Where Little Cable Cars . . ."

Living in New Jersey at the time, Grabowski remembered seeing pictures of San Francisco with overhead trolley cables hanging above the streets throughout the city. Only, instead of seeing lines bringing in power to the municipal streetcars and electric buses hooked up to them, the two engineers saw directional cues to drivers.

So, Grabowski and Zamojdo built a plan for field trials based on the idea of following the overhead trolley powerlines through the hilly West Coast city, driving — for hours at a time — along various routes using the cables as guides.

And it all worked as they had hoped.

Following the trolley cables *above* the road turned out to be much easier than following cable car tracks on the road, because the cable's shape and direction could be seen considerably farther ahead. As an added benefit, the cable did not obstruct any objects on the road. Seeing the cable with peripheral vision was sufficient (just like seeing road curbs out of the corner of one's eyes) so that a driver could keep eyes on the road and hands on the wheel at all times.

The hundreds of people who, years later, drove test cars with a working Virtual Cable display have confirmed this all over again.

Grabowski and Zamojdo felt that they had successfully answered their initial challenge of creating a non-distracting navigation guide, but this only created another one. Can such interface be realized using any existing technology?

At first, the only solution that came to mind involved technology would cost more than $20,000 per unit, like using acousto-optic (AO) crystals for high speed optical scanning, a non-starter in the automotive space. But a couple of years later, in 2003, a combination of persistence and luck paid off, and their novel True3D Volumetric HUD technology was born.

How Does It Work?

True3D image is a single three-dimensional ("volumetric") optical image, not a stereo pair of 2D (flat) images, as is the case in 3D TV or 3D movies. Because of this, no special eyewear or head-tracking cameras are required for the image to be seen in 3D.

The Making Virtual Solid -California (MVSC) HUD design stems from the same optical principles that allow people to see their own reflection in a mirror as a true-3D image – which appears to be *behind* the mirror. Such 3D images inherently present the viewer with all the depth cues of natural objects, including perspective, stereopsis, eye-focus, motion parallax, optic flow, convergence, and shading.

The true-3D HUD provides generous field of view, more than 20 degrees of angle in the horizontal direction and, depending on the dashboard geometry, that much or nearly that much in the vertical. This is perfectly adequate for car navigation and provides a generous-sized head motion box or *eyebox* — a 3D area where the driver's eyes need to be positioned for the HUD images to be viewed. This enables drivers to move their heads naturally without losing sight of the image.

Data from MEMS gyroscopes allows generation of an image that is stabilized relative to the landscape; so, bounces of

the car do not affect it. The display can place any part of a generated image at the distance where it needs to appear at the moment, from a few yards to a mile.

Drawing on NASA HUD usability and safety studies for reference, the volumetric technology was chosen not just to eliminate any need for eyewear or head tracking cameras. Grabowski and Zamojdo also wanted to provide a much more precise, more convincing 3D effect than stereoscopic technology using a stereo pair of 2D images could accomplish.

The novel feature is a new "swept volume" type of volumetric display that incorporates a small internal vibrating projection screen, vector graphic laser projector, and high-magnification HUD optics.

A key contributor to the ongoing effort in optics design in MVSC is Dave Kessler, who spent 24 years managing the advanced optical design group at Kodak Research Labs. Kessler has filed for a patent on a "pupil-expanded volumetric display," which may become part of the planned MVSC system design.

While volumetric displays are generally hobbled by their huge data and component bandwidth requirements, MVSC's HUD leverages the unique geometric simplicity of the Virtual Cable symbology to accomplish great performance with remarkably low-cost hardware. At its core is a 3D vector graphic display engine that uses a small, DVD-writer–class laser diode and a few very low-tech and low bandwidth electromechanical actuators — magnets, coils, and springs. (See Figure 1.)

But these low-tech components are driven by a high-tech brain. The display engine is able to paint the Virtual Cable image 60 times per second with high-enough quality by employing sophisticated microprocessor control of all these components, including the previously mentioned vibrating screen.

This screen looks like a small acoustic speaker with white a ceramic concave dome, but its vibrations are under precise closed-loop control and constantly being adjusted according to the content of the displayed image.

The 3D engine can produce images that are high-resolution and bright enough to be visible against a sunny sky.

Just How Different Is This HUD?

Unlike screen-based navigation systems, with an HUD system the driver does not need to look away from the road to view a screen. And unlike other HUDs, the True3D system places images with exquisite accuracy (often within less than one meter of the target location) into a driver or pilot's landscape view (above or below the horizon, overlaid to GPS locations or projected independently of "real" objects in the forward field of vision).

Rather than the fixed image distance of two-three meters typical of HUDs, the True3D images are projected as though appearing at any depth, even to infinity. Images can be shown near or far, over a wide field of view using regular windshield glass with no special coating. (See Figure 2.) The system provides depth cues, all of them correct and in complete agreement with each other, just like those of real objects; for example, normal head movements allow the driver to see the imaged object from either side.

These features of the True3D HUD are key and differentiating, according to MVSC. HUD systems developed by others are severely limited by the depth cues they can display, and typically require head-tracking or eye-tracking cameras to create the images aligned with the objects outside.

The system can generate still and motion graphics, re-cast aerial imagery for use by ground-level units, or place a "guide wire" navigational line ahead of drivers. Icons and images displayed by the system are designed to be shown with crisp resolution and (optionally) in full color.

Going forward, Grabowski and Zamojdo plan to simplify the hardware even further by employing MEMS scanners and focusers instead of discrete moving-iron or moving-coil actuators. IG

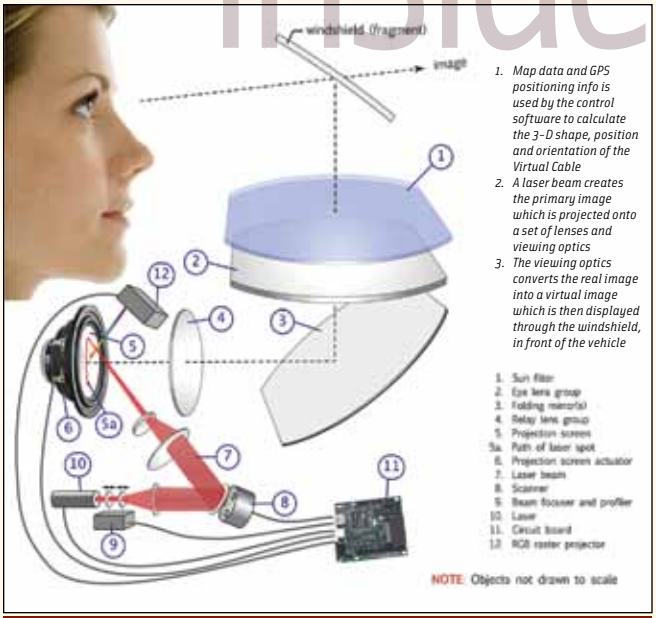

FIGURE 1 True3D Volumetric HUD components and operation

FIGURE 2 Comparison of True3D HUD user view with other types of nav aids

USA Challenge *continued from page 33*

offer a hardware-plus-interface (software) system incorporating inexpensive optics, low-cost lasers and robust mechanical parts, interacting with software that generates graphics to create conformal 3D in a miniature package, mountable in-dash or overhead as an after-market product for trucks.

Unlike other vehicle HUD designs, including a research prototype introduced by General Motors last year, the MVSC system requires no complex eye- or head-tracking elements, special gear for the driver, nor does it need to use abstract symbols such as arrows, numbers, or graphs to indicate distances (to a turn, for example).

(More of the technical details can be found in the sidebar, "A Technology Whose Time Had Already Come," beginning on page 34.)

MVSC is targeting their HUD for use in markets where extreme accuracy in navigation and target identification saves lives: automobiles, trucks, homeland security, defense, and avionics. The company believes that medical device and gaming platforms also show strong potential, but current designs are focused on maximizing situational awareness for private drivers, truckers, security personnel, first responders, and similar groups.

Behind the Inventions

Grabowski is MVSC's CEO, chief science officer, and the principal inventor and designer of the Virtual Cable and True3D Volumetric HUD technology. The concept drew on his broad knowledge of several seemingly disconnected areas of human/machine interface (HMI) design, optics, and the physiology of human vision.

Zamojdo is the chief technology officer and co-inventor of the MVSC core products. Developing the concepts into mature designs required cross-discipline knowledge of advanced optical design, including laser optics, electrical and mechanical engineering, and software engineering.

But neither man's CV seemed to point toward such navigation-oriented, hardware-intensive systems in the automotive, aviation, and defense field.

For 18 years Grabowski was a software engineer at The Clearing House in New York, responsible for a complex real-time multilateral netting and settlement system that transfers more than $1 trillion a day among financial institutions worldwide.

Zamojdo worked for 10 years at Bell Labs and Bell Communications Research and then left to start a software engineering consulting company in North Carolina. That company provided custom software solutions to such clients as Wachovia, Bank of America and Duke Energy.

To find the origins of their MVSC collaboration, one needs to go back to 1979 when Grabowski and Zamojdo shared common courses at Warsaw University. At the time, Poland was a key member of the Soviet bloc, literally the namesake for the Warsaw Pact military alliance.

Had the two men continued in their academic fields — physics, math, and computer science — their professional trajectory might well have taken them into their nation's missile program or similar military-related endeavors. Instead, they defected to the West, eventually settling in the New York area and becoming U.S. citizens.

Mike Rowe, host of the Discovery Channel series Dirty Jobs, gets behind the wheel with MVSC's HUD system at the Makers Faire in San Mateo, California. MVSC CEO Chris Grabowski sits in the passenger seat; CTO Tom Zamojdo is in straw hat.

From there they turned their skills toward software engineering — Grabowski writing software to secure financial institutions from use by criminal and terrorist organizations, Zamojdo designing software solutions for Fortune 500 companies. After eight years in North Carolina, Zamojdo returned to New York in 2001 to work with his compatriot on the Virtual Cable project.

"They grew up together," says Clegg, who joined the company in 2009. "Their friendship is older than some of the wireless companies who want to buy us."

She characterizes Grabowski as "very much the deep-brained scientist. Chris is acerbic, cool, and reserved. Tom is totally the opposite — a big bear of a man, funny, deeply compassionate, and has a work ethic the likes of which I rarely see." The two men work together in their San Francisco lab, and in the apartment above it.

She met Grabowski and Zamojdo when they were testing the waters in Palo Alto — demonstrating their technology to auto companies. "Their consultants at the time didn't know how to deal with Silicon Valley, where much of our future sup-

port would come from," says Clegg. "I offered to house them for a year-plus and set them up with office space if they wanted to test the West Coast waters, . . . and they never went back."

Clegg began her career buying software companies for a Taiwan-American venture capital group, then subsequently co-founded an IT consultancy where she specialized in sales to international software companies and European Internet service providers.

In addition to her self-described roles of "incubator, investor, friend, banker, and marketer," she has raised most of MVSC's capital, developed the company's advisory board, and secured its legal team. "Presenting the founders with partners and funders who are patient enough to foster this safety-of-life technology has been my main goal," Clegg says.

The Business Opportunity

MVSC is a navigational systems development company, focused on developing intellectual property in the target markets (automotive, defense, trucking, avionics, marine) where its 3D HUD platform will have maximum benefit for life safety, situational awareness, and fuel efficiency. Based on its unique patents-pending designs, the company will offer a hardware-plus-interface (software) system.

To the company directors, the most accessible market is automotive, where car manufacturers are under pressure to find solutions in two areas: developing profitable advanced cabin technology and managing driver distraction.

Virtual Cable was developed first as a navigation tool and designed to provide comfortable, non-distracting guidance. It was developed long before the company's principals or even automakers recognized that distraction would become the issue for drivers, legislators, and makers of in-cabin infotainment systems.

Even before car manufacturers got religion about non-distraction, however, they needed to find new technology-based features to improve their margins. Until now, those two mandates have been at odds — "cool tech" conflicting with the new focus on non-distraction.

MVSC's business model calls for licensing and joint development with auto manufacturers, Tier 1 suppliers, defense contractors, and other large-scale players to maximize the value of the company's core designs. Grabowski and Zamojdo expect to work collaboratively with several licensees, building out the firm's in-house capacity to develop new intellectual property. However, the founders do not anticipate creating a large organization.

The company is already selling research product; so, it has both investment and revenue. "Profitability could come as

soon as 2014," says Clegg, "depending on how soon we enter the commercial trucking, fleet management and other sectors. Automotive will be a longer haul to revenue."

In early 2011 MVSC rebuilt the HUD in response to demand from the automotive industry. The new interface demonstrates the icons and symbols that auto company infotainment teams demanded. "We did it the old fashioned way," says Clegg. "We bootstrapped to re-engineer on the fly so our future partners could really get a look at the broader capabilities of the system."

With both interfaces available now, (Virtual Cable for navigational comfort, and Virtual Signs to demonstrate infotainment capabilities), the company is in a position to capitalize on being a global provider of these HUD interfaces for multiple markets — automotive, commercial fleet management, avionics and marine.

"At this point, Tom and Chris are probably more deeply educated about navigational HMI than most car companies," says Clegg. "It would be difficult for anyone to mature these systems for cars or trucks without close collaboration with the inventors. But we're looking forward to that. Our dialog with several car companies is excellent, very intimate at this point."

Forget the Science — Leave the Driving to Us

As interesting as their technology may appear to an engineer, MVSC believes that it should be transparent to the driver, who is nonetheless able to use it with ease and comfort. The ultimate purpose of all this technology is to enable a simple, elegant, minimalist, yet extremely powerful visual route guidance.

But what is the ultimate purpose of this minimalist simplicity in MVSC's human/machine interface? To create comfort, safety, and user-friendliness that leads to frequent usage — navigation as a part of a daily routine.

Over the last few years, many innovative people have produced ingenious solutions for a wide range of location-based services (LBS). Real-time weather infomation, crowd-sourced traffic, location-based advertising, searches, and so on.

In the United States, the vast majority of trips (83 percent) are made not on foot but by a private car, according to the Federal Highway Administration's 2009 National Household Travel Survey. Yet countless efforts to influence a consumer at point A to become a customer at an unfamiliar point B have not been paying off.

Why the disconnect? Grabowski, Zamojdo, and others at their company believe they know the reason: The currently stressful and unsafe nature of navigating unknown neighborhoods keeps large numbers of potential clients away. Solving this problem will allow small retail businesses to attract customers from the outside of their local area, unlocking currently untapped revenues from advertising and other LBS services.

Based on their extensive experience with hundreds of people driving their test car, the company believes that navigating an unfamiliar route using the Virtual Cable is just as convenient to the driver as navigating a familiar route where no navigational aid is needed. IG

USA Challenge 2011

European GNSS Ideas Contest Draws Global Competition

United States and Canadian innovators join 21 other countries and regions to see who has the best commercial ideas for satellite PNT technology

ELIZA SCHMIDKUNZ

The ideas ranged from the family friendly — a smartphone app that reads historical markers and travel tidbits as you drive by — to the seriously scientific — a new secure time reference authentication method (TRANM) for GNSS receivers.

Five innovative GNSS application ideas won the hearts and minds of six GNSS experts in the 2011 USA Challenge, a regional contest of the annual European Satellite Navigation Competition.

One of them, Making Virtual Solid–California's True3D Head Up Display, went on to win the top international prize, €20,000 (US$27,800) and the Galileo Master title, at the ESNC awards ceremony in Munich, Germany in October. (MVSC received NAVTEQ's mobile enterprise app award and placed highest in the USA Challenge, too.)

Another entry in the Final 5, TRANM, was part of a suite of innovations that won two other top prizes at the ESNC, one from DLR, the German Aerospace Center and another from the German Galileo Test and Development Environment (GATE).

The smartphone travel app, Georeader, won the "People's Choice" award at the Institute of Navigation GNSS conference in Portland, Oregon in September.

Conference participants used the technology developed by last year's USA Challenge winner, eVotz, to select their favorite finalist by turning their own mobile devices into secure, authenticated voting machines.

In addition to MVSC's winning entry, here are the applications ideas that caught the eye of the USA Challenge judges:

The Arthurs. *Named after science fiction icon Arthur C. Clarke, the custom-designed statuettes were awarded to the top five finalists in the USA Challenge. In 1956, Clarke foresaw the development of satellite-based positioning and navigation, writing to a friend that within 30 years an "orbital relay system" could take over all existing surface [communication] networks: " . . .three stations in the 24-hour orbit could . . . make possible a position-finding grid whereby anyone on earth could locate himself by means of a couple of dials on an instrument about the size of a watch . . . no one on the planet need ever get lost."*

GEOREADER

Dave Moreau, Deb Dihel, Jeff Dihel and Dan Rogas, of New York–based Social Mobility, developed this free smartphone app that allows any written text to be placed at any GPS location in the world. It starts out as a mobile travel guide, with an installed database of thousands of U.S. historical markers and other worldwide points of interest. The phone's text-to-speech function reads the text aloud as users drive by. It's hands free and doesn't interfere with the phone's GPS navigation or music players. Best of all, users can create their own 200 word messages, "Talking Points," and can make those entries public, private or friends-only. A filter allows users to hear information only on topics of interest to them.

TRANM

Developed by Antonio Puante-Cuadrupani of PanamNav in Spain, this innovation compares signals received from GNSS satellites with a reference provided by the ground control center. From these records, the control center can calculate the corresponding combination of navigation messages at any point at any time. It issues a "Unique Signature in 4 Dimensions—US4D. This is used to authenticate the received information at each location and for a given instant. The method does not impose any requirement to the space or ground segment of the system. It can be implemented as an additional, non-interfering layer of information, similar to SBAS systems. GNSS, SBAS plus TRANM can offer position, integrity and authentication all at once.

HITCH ON

A mobile travel app idea by Shen Ge, Anish Bhattacharya, Tejal Thakore, and Neha Satak, hitch ON will offer the usual travel advice on hotels, restaurants and attractions. It differentiates itself by providing crime information and local prices without scanning barcodes. hitchON will acquire information from third-party web services, NAVTEQ maps and user-uploaded data. Information duplication will be handled through a user-rating system, which allows users to vote on the most reliable source of information. hitchON will use the PhoneGap open source framework, coded in HTML5/CSS/Javascript and will circumvent cross-platform issues between different operating systems and mobile devices.

SMPTE/GNSS

Having GNSS data available is only half the problem, says Thomas Zerucha of Ohio. How to access it or store it in a robust form can be far more difficult. Typically it is serial data and most things don't work well with raw serial. He suggests using an existing technology, SMPTE linear time code (LTC). It has fields for hours, minutes, seconds, and frames, as well as for film, television and video. If GNSS data is merged into the user bytes of the SMPT LTC stream, digital video or audio can then incorporate contemporaneous location and velocity information.

Special Topic Prizes at ESNC

Galileo Master Awards 2011 Prizes include technology that helps cars communicate danger, collision avoidance for teeny drones, proximity-detection software for social networks, anti-spoofing and authentication technology for critical sectors, coupons that know where you go, and a GNSS-enhanced "white cane" for the blind.

In the eighth year of the Galileo Masters contest — officially the European Satellite Navigation Competition — the first permanent Galileo GNSS satellites have just gone into orbit.

But, over nearly a decade, GNSS has entered every sphere — and so has the ESNC, which started out with 14 idea submissions in 2004. This year, they welcomed satellite navigation applications ideas from 401 innovators in 49 countries, all competing for a prize pool of more than €1 million (US$1.39 million).

The ESNC organizers from Anwendungzentrum (Space Applications Center) Oberpfaffenhofen, Germany, say that one-third of the previous winners participated in incubation programs. "The fact that about 80 percent of their ideas are now being implemented proves how successful the ideas competition is in translating ideas into new businesses."

The contest has always included special topic prizes to solve specific needs of industry. This year, eight such sponsored prizes were awarded.

POTHOLE PROTECTION

One of them, the new prototyping prize, Galileo Pro, looked for the best "connected vehicle" app. They found it in DLR's safety application that uses on-board sensors to detect potholes and other road damage and then communicate that information to other cars on the road. The €10,000 prize came from Industrial Technology Group (ITRI) in Taiwan, which wants to incorporate next-generation GNSS into the WAVE (wireless access in vehicles) and dedicated short-range communications technologies used in intelligent vehicle systems.

AIRY AVOIDANCE

CTAE, a Catalonian aerospace research center, developed a traffic collision avoidance system for mini UAVs, weighing less than 4-1/2 pounds and unable to handle the weight of a full suite of avionics equipment. The innovation allows the UAVs to make use of data from piloted aircraft around them. The European GNSS Agency, a business development arm of the European Commission, sponsored this prize for the best use of EGNOS, the new GNSS satellite-based augmentation system.

ALWAYS CONNECT

The European Space Agency attracted nearly a quarter of the special topic submissions for its innovation prize. The winner, twofloats, tracks proximity from large numbers of moving objects. Registered users — or a trusted third party — are notified whenever another user comes close. The developers say, "You'll never miss an opportunity to meet your future spouse."

ANTIJAMMING

Antonio Pujante of PanamNav, the same Spanish company that made it into the USA Challenge Final Five, won two special topic prizes, both for parts of his technology package that integrates positioning, navigation, and signal authentication. The German Aerospace Center (DLR) recognized "SARA" — Signal Authentication through Receiver Autonomous techniques.

INFRASTRUCTURE PROTECTION

IFEN's and NavCert's GATE prize recognized "TIMEWISE," a method that provides protection to telecommunications, energy distribution networks, and other key sectors that rely on GNSS receivers for synchronization. The prize includes three days of system experimentation at the outdoor Galileo test range (GATE) in Bavaria.

WATCHFUL COUPON

A European Union series of projects called GNSS Living Labs awarded their €10,000 prize to Geo-Coupon, an idea from Taiwan's ITRI. It's a limited-duration digital coupon that monitors the actions the user must take in order to realize the worth of the coupon — for example, number of visits to a certain store.

VIRTUAL SIGHT

Two graduate students from Karlsruhe Institute of Technology developed an idea for a device that would give true independence to the vision impaired — a virtual "white cane." They intend to use Galileo's accuracy for an integrated image-processing unit that combines indoor and outdoor navigation. Their idea snared the ESNC University Challenge Prize in location-based services. IG