In the automotive community at Stanford, we are dedicated to the idea of hands-on learning, believing that it is our role to help students take the ideas in their heads and get them onto the road or test track. As you will see in the pages that follow, 2014 was a fantastic year for this, with students across the university able to participate in automotive classes, projects and experiences, both on campus and, literally, around the world.

We are deeply grateful to all of the sponsors who enable us to deliver this experience to our students. From our CARS industry affiliates to Miles Collier and the sponsors of the Revs Program at Stanford to our industry partners that build strong, sustained research programs with individual faculty, we are fortunate to have so many believers in our mission. We take the trust you have placed in us seriously and work each day to build outstanding student experiences on that foundation.

I hope you will enjoy this collection of some highlights from the past year. These touch on the full range of our community activities, from classes and research projects to seminars and the activities of our CARS and Revs Programs. Through this, I hope you see all of the great things going on here on campus and think about how you might like to get more involved.

While 2014 was an amazing year for activities, it was also challenging for many of us since it was our first year without the warm and always stimulating presence of Cliff Nass. I would like to dedicate these highlights to Cliff. I know that as you read through them, you will see his influence in many ways, from the deep focus on the human to the many people and connections he brought to this community. He remains an inspiration to all of us and the deep impression he made on our work continues.

Chris Gerdes
Associate Professor of Mechanical Engineering
The **Revs Program at Stanford** launched in 2011 to forge new scholarship and student experiences around the past, present and future of the automobile. Along with our colleagues at CARS, we play a key role in building great experiences for students using the automobile. Our program has four key pillars: research, education, heritage and connection. In 2014, our students and faculty worked on some amazing projects: from a class centered around historical significance of the automobile to a student-initiated research trip to Bogotá to study an innovation bus system, we really did span the past, present and future of the automobile. Through these pages, I hope you’ll enjoy seeing the work of our students and researchers as much as we did in supporting them.

The **Center for Automotive Research at Stanford** links industry and academia around the future of the automobile and personal mobility. CARS has a forward-looking focus and provides a portal for automotive companies and other industrial partners into auto-mobility research at Stanford. On the academic side, CARS links students, researchers, industry and government to study and innovate solutions for safer, more efficient and enjoyable personal mobility.

During 2014, CARS grew tremendously. The program now has 27 affiliates, our Resume Book expanded by 20% and 3 new research vehicles now call home the Volkswagen Automotive Innovation Lab, the research facility that CARS operates. CARS co-chaired with PATH discussions on the needs and benefits of a testbed in the San Francisco Bay Area that would support the research and development of automated and connected vehicles. We also co-hosted with the Stanford Center on Longevity, “Automated Vehicles and the Aging Population” workshop. This growing network of students, researchers and industry affiliates makes CARS one of the most diverse industry programs on campus.
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A hub for automotive research at Stanford is VAIL (the Volkswagen Automotive Innovation Lab), located on central campus and inaugurated in April 2010. The working garage is home to several labs, countless research vehicles, the Stanford Solar Car Project, a driving simulator and a machine shop. CARS provides the infrastructure and manages the day-to-day operations of VAIL.

A day in the life of VAIL finds students working on their research vehicles, industry affiliates meeting with Stanford researchers, human subjects arriving for tests in the simulator, and the solar car team designing their next vehicle. If you come to campus, you absolutely have to visit VAIL.
Machining parts on the CNC machine for a next generation research vehicle, Mechanical Engineering graduate student Jon Goh is in his element.

Stanford Solar Car Project Systems Engineering Lead Max Praglin at work on circuit boards for the new solar car.
Research Associate Austin Hendrix makes adjustments to the LiDAR on ‘Junior,’ the autonomous VW Passat Wagon.

Top, The Society of Automotive Historians biennial symposium brought researchers and academics to VAIL for a two-day conference on the history of the motor vehicle industry.

Solar Car team winds down after a long day testing Luminos, the solar car which raced in the last World Solar Challenge.
Transformative Student Experiences

Graduate Mechanical Engineering student Jonathan Goh is no stranger to the machine shop, but what he learned during his metal shaping class at McPherson College’s summer institute in McPherson, Kansas brought some new skills to light. His weeklong class focused on sheet metal restoration, learning to form, bend and shape aluminum and steel using more ‘traditional’ tools such as hammers, tucking tools, an oxy torch and the English wheel. Said Goh “This gave me an appreciation for how hard it is to fix a sheet metal problem -- thus, even more incentive not to crash any of our cars!”

One commonly held belief among our community is that transformative student experiences can take place inside and outside of the classroom. This year saw a host of amazing opportunities that truly impacted student lives. The automotive community at Stanford played a key role in supporting these initiatives, ranging from presentations at a historic vehicle conference to a fact-finding field trip in Bogotá, Colombia.
Transformative Student Experiences

When Environmental Resources Engineering senior Usua Amanam told his teacher, Christina Mesa, about his interest in fuel and its distribution systems, she knew he had to meet the Revs Program. Usua’s incredible passion for filling stations was palpable – and his dedication to learning about their history was well documented in Christina’s class and research team. As a result, Usua gave a fantastic presentation about the history of filling stations at the 2014 Society of Automotive Historians Conference, held at Stanford in April.

The Stanford Solar Car Project (SSCP) is America’s top solar car team and competes in the bi-annual World Solar Challenge in Australia. The team’s 11th car, named Luminos, is seen here during its final leg in Adelaide. The team finished 4th overall, their best result yet. A design for a new car is underway at VAIL, the build cycle starts in the spring and will take to the road in 2015.

One quiet afternoon on Stanford’s campus, Stanford Law Student Doug Sharp told us we should sponsor him to visit the world’s best bus rapid transit system; we told him to drive down to San Jose and call us when he arrived. Little did we know that Doug’s research was miles ahead of us – some 4,000 miles ahead, in fact – as the world’s most state of the art BRT is actually in Bogotá, Colombia. Flying there during his Spring-term Urban Studies 167 class taught by Fred Stout, Sharp needed to see up close the innovative designs and engineering ideas found within. His findings were the foundation for a paper about city transit and how San Francisco might evolve using some of Bogotá’s ideas.
Under the clear blue skies of Thunderhill Raceway in Willows, California, Mechanical Engineering graduate students John Kegelman, Joe Funke and Hyungchai Park analyze results from X1, a steer-by-wire test vehicle, following a test run. Our time at Thunderhill results in some of our most rewarding experiences, as the reality of the race track meets the theory of our prototype designs.

The first drivers who brought their cars to horse tracks likely had no idea what they were starting. The activity might have satisfied their needs for speed and competition, but what began on those dusty trails evolved to be much more. Race tracks would become a field for competition among nations, a proving ground for new technology, and a gigantic billboard for everything from pretzels to cigarettes. We can safely assume those brave pioneers never expected they’d be establishing a laboratory for cutting-edge research and a wonderful learning environment for students. But that’s exactly what the race track has become for us at Stanford.

Testing on the track requires a level of preparation far deeper than an exam. It requires an ability to adapt to changing circumstances and the need to stay calm and work the problem with your team in the middle of a noisy, busy environment. The opportunity to work with some of the greatest cars and drivers of all time motivates the team to step up to that same level with instrumentation and analysis.

We believe that these lessons represent a perfect complement to on-campus learning and want to make sure that the next generation of engineers, scientists and researchers are forged not only in the classroom, but on the track.
Mechanical Engineering graduate student Stephen Erlien had a remarkable year, from testing new methods of sharing control between an automated vehicle and its driver to defending his PhD thesis. Seen here, Steve sits in the student-built experimental vehicle, X1, which leverages the precision and vigilance of computers while still retaining the unique cognitive and reasoning abilities of human drivers. Using steer-by-wire technology, computers in X1 augment the driver’s steering command in response to obstacles or vehicle instability. When steering alone is not enough to ensure the safety of the vehicle, automatic brakes provide additional means to modify X1’s trajectory to avoid collisions and spin outs. These next generation driver assistance systems have the potential to dramatically improve vehicle safety and are a key step toward fully automated driving.

For the past three years, graduate and undergraduate students from Stanford have been working alongside experts from CH Motorcars and some of the world’s best drivers to instrument vintage race cars from the Revs Institute. This past August, the Collier collection’s 1965 Ferrari 250LM performed flawlessly, but our 2014-vintage equipment proved to be the most troublesome. A data acquisition system failed, forcing a quick flight to Southern California for repairs, but the team got the system back online for the main race. It is amazing how lessons like this come through clearly - and occasionally harshly - on the race track.
Mechanical Engineering graduate student Joe Funke and Visiting Scholar Tomoko Jinno ‘ride’ along for an experimental run at Thunderhill Raceway. Funke’s work on autonomous vehicle control looks deeply at racing and emergency scenarios; his goal is to design autonomous cars that can use all of their performance capabilities to safely react to emergency situations.

The man with the cap is not a swimmer, but he is as fit as an Olympian — he’s professional race car driver Gunnar Jeanette. On this particular day at the track, he is playing a key role in how Dr. Lene Harbott and Social Science Researcher Andrew Gundran study safety and driving enjoyment, looking at the brain activity of drivers under different driving conditions. Here, Harbott and Gundran set up a near infra-red spectroscopy (NIRS) cap on Jeanette with Visiting Scholar Toshiya Arai looking on, to monitor the changes in the patterns of his brain activity as he drives a set course. Says Harbott: “Together with our ongoing studies of brain wave activity using EEG (electroencephalography), we use NIRS to learn how the very best drivers are able to perform at such a high level, and to design vehicle safety systems that help everyday drivers perform better.”
Automated vehicles hold the promise of unprecedented levels of safety, comfort and mobility for future road users. Delivering on this promise requires not only technological advances in the areas of sensing, decision-making and control but also the consideration of a broad range of societal perspectives, from public policy to ethics to law. At Stanford, our students are pushing the boundaries of vehicle automation by bringing their ideas to the road or track for evaluation. By connecting with lawyers, philosophers and social scientists, the engineers driving these innovations share their perspectives on what is possible and gain the insight of other disciplines on what is valuable. This combination of deep technological solutions placed in a broader societal and human context characterizes our approach to vehicle automation.
Nitin Kapania and Joe Funke evaluate the autonomous driving performance of “Shelley.” Kapania’s work is focused on developing autonomous driving software that mimics the racing performance of top professional drivers. In 2014, “Shelley” began to match lap times with expert drivers, on her way to challenge the professionals.

Working as a data engineer for a racing team, Vincent Laurense used to analyze race car data in order to find ways in which the drivers could push their cars to the limit around the race track. At Stanford, Vincent now investigates the racing performance of a car without a driver, and implements new algorithms aimed at using all the friction available between the road and the tires. Here he is seen installing a camera on “Shelley” before one of its runs.

Professor Gerdes and Nitin Kapania discuss control system performance between test runs.

Work in progress: Changing the way cars will drive in the future. Students Sameep Tandon, Tao Wang and Jeff Kiske from Associate Professor in Computer Science Andrew Ng’s group make adjustments to the sensor platform on their Infiniti Q50.
Mechanical Engineering graduate student Avinash Balachandran has a realistic view of what modern vehicles are doing for -- and to -- us. Since new cars have the ability to aid in the driving task like never before, keeping the driver connected with what the vehicle is doing becomes increasingly important. His work focuses on using the steering wheel as a haptic device to better connect the driver with the vehicle. His experiments incorporate haptic steering communication with an obstacle avoidance controller, trying to improve vehicle safety while maintaining driver trust and acceptance of the system.

Understanding how people and machines work together has never been so important when building vehicles of the future. At Stanford we are fortunate to have a range of disciplines approaching this issue and we make available a variety of tools and experiences to our researchers, among them road testing and simulated road testing in our new driving simulator within VAIL. We also take great advantage of track testing at Thunderhill Raceway in Willows, just a few hours from campus.
One research team making great use of the simulator is led by Dr. Wendy Ju and Professor Larry Leifer from the Center for Design Research. The team’s research seeks to understand how people will interact with increasingly automated vehicles. Key partners to this research include Toyota CSRC, Ford, Renault, Bosch, Volkswagen’s ERL, The Revs Program at Stanford and CARS.

Wendy Ju with her team in the simulator, including (from left) Rob Semmens, Mishel Johns, Brian Mok, Sonia Baltodano, Nik Martelaro and Srinath Sibi. In the past year, they have completed a number of studies focused on how drivers perform under different levels of vehicle automation.

Communication graduate student Dave Miller conducts an initial test of the simulator before the day’s research begins.
The team makes use of experimental protocols that blend experimentation and naturalistic study methods to allow greater exploration of the interactive design space. This ‘Wizard of Oz’ capability allows researchers to monitor participant reactions and performance in real-time, and to improvise communications, interface responses and simulator events in response. Above, Mechanical Engineering graduate students Brian Mok and Srinath Sibi at the controls.

Mechanical Engineering graduate student Holly Russell, seen on the left along with graduate student Jonathan Goh, has an unusual focus for someone in sunny California: she wants to make vehicles feel like they’re on ice. The way that cars handle can change unexpectedly as a result of power steering failures, speed changes, and variable road conditions, among other factors. How do drivers adjust to these unanticipated changes? Leveraging the unique capabilities of the X1 research vehicle, she is currently performing a user study to characterize the way that drivers adapt to sudden changes in vehicle handling properties.
We are grateful for the opportunity we have to interface with great people, and we often find these connections spark new discussions and lines of inquiry. Frequently throughout 2014 we were joined by industry experts, visiting researchers, enthusiasts, collectors and historians. In an effort to share research insights with the world, we facilitate these connections through organized speaker events, museum visits and sometimes just by opening up our front door.

Two years ago, the automotive community at Stanford piloted a new speaker series called Open Garage Talks. The free-to-the-public series matches a notable automotive figure (Nissan Renault CEO Carlos Ghosn, BMW designer Chris Bangle, and filmmaker Jeff Zwart among others) with the Stanford community and friends from the Bay Area. This past spring we featured our first-ever student-led Open Garage Talk when we welcomed the Stanford Solar Car Project to tell us about their 2013 race in Australia. In November of 2014 we welcomed Corvette Chief Engineer Tadge Juechter. Find out about the next "OGT" on revs.stanford.edu.
Since the foundation of CARS in 2009, its signature class ME302 “The Future of the Automobile”, has introduced mobility related topics to a wide range of students from engineering, humanities, business and law.

Students in ME302 develop an understanding of the requirements that go into the design of the automobile and learn about different interdisciplinary aspects that characterize the automobile and personal mobility. In the autumn quarter, a mix of academic and industry lecturers discuss topics in automated, electrified, connected, and shared mobility. In the winter quarter, ME302 looks at “Driver Assistance and Automated Driving” as an industry expert shares his perspective on the path to automated vehicles. The theme in the spring quarter is “Vehicle Communication Systems” where an industry expert discusses applications, challenges and solutions for intelligent vehicles and connected mobility.

For the fourth year in a row, CARS supported the strategic leadership class at the Graduate School of Business, S574 “Strategic Thinking in Action - The Evolving Global Electric Vehicle Industry”. This seminar class, co-taught with Professor Robert Burgelman, focuses on strategy-making to deliver vehicles that reduce dependence on fossil fuels and climate change, taking into consideration the changes in how consumers purchase, use and appreciate their vehicles. Students learned from academic and industry experts and gained insight from real-world examples from ChargePoint, EPRI, Tesla and Toyota. At the end of the term students drafted strategy papers for specific segments of the industry, looking across OEMs, suppliers, and infrastructure providers and across the USA, Europe and Japan.
Introduced in the spring of 2012, the CARS webinar is hosted every two months providing a forum for discussing current and upcoming activities of the program and introducing research topics to the affiliates. The goal of the webinar is to initiate new connections for collaboration between Stanford researchers and industry affiliates. This year webinars covered a variety of topics from automated driving to alternative propulsion to mobility services.

WEBINARS

110 Participants
5 Webinars
5 Topics

Worksheets focus workshops and special lectures on specific topics such as “The Aging Society and Automated Driving,” “Transportation 2025 and Beyond,” and “Shaping Sustainable Mobility for the Future” are held throughout the year. Workshops address specific topics and highlight the work of Stanford researchers or accomplished guest speakers. These events are central to creating a rich community of academics and industry partners with Stanford serving as a nexus for collaborative learning, mutual exchange of ideas and community experiences.
What looks like a campfire barbeque is just that – and so much more. This group is gathered the night before the Pebble Beach Concours d’Elegance as well as the races during the Monterey Motorsports Reunion and our student teams will be participating in a big way in both. Among the student teams in this photo, you might also notice one noted Pulitzer Prize winner (author and friend Paul Ingrassia), one champion racecar driver (John Morton) and one well-worn firepit. This evening at Laguna Seca’s campground represents the intersection of many things we value at our program, from students to faculty to friends and industry supporters.

In a rare moment of repose, our administrative staff gathers in VAIL: Lab Manager Erina DuBois, CARS Executive Director Sven Beiker, CARS/Revs Program Manager Adele Tanaka, CARS/Revs Administrative Associate Jo Yuan, and Revs Executive Director Reilly Brennan.

Revs instructors Mike Serpe, Michael Sturtz and Director Chris Gerdes talk shop at a VAIL ice cream social.
Professor Michael Shanks starts off the car class by…not talking about cars at all! His interactive design workshop of objects forced students to think about historical significance in a new way.

One of the world’s most exhilarating automotive experiences takes place every third Sunday in August on the 18th fairway of Pebble Beach. At this legendary Concours d’Elegance, the careful eyes of the most experienced judges examine and rank some 200 sought-after machines. At the end of that day, one stands alone: the Best of Show, a vehicle on the top of the heap as scored by its historical accuracy, technical merit and style. It is, by many accounts, the single most important award in all of automobile collecting.

No doubt this event is an experiential tour de force. Certainly it is a worthy photo for one’s Facebook feed. But is it a useful learning environment for students?

Undoubtedly so.

We use the event as device to discuss what makes objects historically significant.

In doing so, we believe the methods and thinking will be useful for the students well beyond a single day in August. It is yet another way that we at the Revs Program believe automobiles are a fantastic multidisciplinary tool.
The students in our recent ME200 class, titled ‘Understanding Historical Significance,’ seem like the luckiest bunch on earth. Their task – to develop their own criteria for historical significance, apply those rules to the field of Pebble Beach cars and ultimately choose a winner – might sound like feastwork.

But how do you approach a field of cars with no prior judging experience and no existing knowledge of the entries? It’s no small task.

To get started, we began not with a deep dive into automobiles or transportation history. Rather, the teaching team of David Kelley, Michael Shanks, Jon Feiber and Reilly Brennan invited a group of experts from fields as disparate as fine art, archeology and design thinking to join us. Their views and approaches on ranking, sorting and thinking about objects formed the foundation for the students before their vehicle research began in earnest. That foundation proved to be a brain-scrambling experience for our students; it wasn’t always clear how to connect the dots between speakers. And we loved that.
The Stanford team members from ME200 gathered in August at Pebble Beach to do their final judging. After a long day of interviewing owners and inspecting vehicles, the team presented the Revs Award to the owner a 1957 Ferrari Testa Rossa 0704, owned by Thomas Hartley, Jr.
A photograph from the George Phillips collection on the Revs Digital Archive shows a crowd of spectators and officials watch as a line of Porsches arrive at Le Mans scrutineering in 1955. In the future, Stanford Libraries plans to expand the types of material preserved and include materials from other collections, such as the recently acquired Road & Track Archive.

Down the Road

SIMULATOR LAB MANAGER
We are excited to announce that after an exhaustive search, our new Driving Simulator Lab Manager will join Stanford in early 2015. This person will oversee multiple facets of simulator operations, collaborating with researchers, students, and staff on projects related to driver / vehicle interactions and user experience design.

DATA JOURNALISM CONFERENCE
During the winter, we are proud to support the Stanford Journalism Program as they launch their new data journalism lab. Our collaboration will see early results in the ‘Automotive Data Conference’ held on campus in late Winter. The car and related infrastructure are generating a wealth of data, such as driving / commute patterns, traffic bottlenecks, economic growth patterns and accident statistics just to name a few. To understand how this information can be used by both journalists and developers to make stories about automobility, we’re partnering with the Journalism department to create a repository of sources and explore how to use this data. At our conference we’ll gather automotive and media experts to delve deeper into this topic and expect to see some of this work resulting in new classes and research.

REVS INSTITUTE COLLECTOR SYMPOSIUM
Since 2013, the Revs Program at Stanford has played a key role in the planning and support of the biennial Connoisseurship and the Collectible Automobile symposium in Naples, Florida. In 2015 our faculty and students will once again feature prominently, bringing together automobile collectors and faculty from around the world to discuss critical issues in collecting and preserving important historic automobiles.

TRANSPORTATION, MOBILITY AND POLITICAL CHANGE
The Revs Program at Stanford has joined with Professors Clayton Nall, Zephyr Frank and Jonathan Rodden for a project entitled ‘Interdisciplinary Studies in Transportation, Mobility, and Political Change.’ The collaboration between Revs, Urban Studies, CESTA and the Spatial Social Science Lab brings together faculty and students from across a range of disciplines and research centers to focus on the history and significance of road transportation networks in patterning social and political change.

THANK YOU TO THE CARS AFFILIATES:
Established in 2008, CARS is a unique community which brings together academic researchers, students as well as industry experts and interest groups. Our industry partners provide the program with the resources to advance education and research in the automotive and mobility fields. The success of this community inspires us to further cultivate this model to develop more and deeper exchanges between academia and industry around automobility. We are grateful for our affiliate support and proud of the partnerships as we work towards improving vehicle safety systems and creating new mobility models.

THANK YOU TO REVS INSTITUTE:
Through a close collaboration with the The Revs Institute for Automotive Research, Inc. in Naples, Florida, our students benefit from the people, vehicles and library of the Collier Collection, a collection of over one hundred significant automobiles built between 1896 and 1995. These vehicles are the ones that variously blazed technical pathways, redefined aesthetic standards, made history, and changed the world. We are grateful for the access our students have to these vehicles and the Institute’s fantastic library.
DEDICATED TO CLIFF NASS
1958-2013

“As cars become intelligent, we now have to act intelligent, not just be intelligent.”
Life is way too short for boring cars.