Future Technologies
Introduction

In the world's laboratories and research departments, the technologies of tomorrow and the day after tomorrow are being developed: Cars that can be steered with the voices and glances of their drivers and that warn of slippery streets ahead or maintain a safe distance from other drivers. Refrigerators that keep track of their own contents and create shopping lists when something's about to run out. Shipping containers that are tracked by satellites and can be remotely monitored to maintain their internal temperatures and external security. Cell phones that simultaneously translate what conversation partners are saying. And humanoid robots programmed to talk with people in a lifelike way.

Modern technology will revolutionize communication between people, between people and their machines, and even between machines themselves. Wolfgang Wahlster, director of the German Research Center for Artificial Intelligence and scientific advisor for the OCF session on Communication, is sure of it: "Most of the urgent problems of humankind can be solved using information and communication technology," he says. It's already clear to him that these developments are well under way. Says

Wahlster: "The application of these innovations is already changing our lives."

In their presentations, OCF participants gave a long list of examples that showed how high tech is routine already, or will soon be making our everyday lives easier. Electronic pill bottles can monitor a patient's daily dosages and remind patients to take their medicine. And GPS systems can be harnessed to help the elderly call for help any time they need it. "There are more and more people over 60 who can now use these technologies to ensure their mobility and independent living," says Wahlster.

Participants in the sessions on "Mobility" and "The Factory of the Future" stressed the need for a broader perspective, including social responsibility when developing new technologies. Just as it's impossible to know all the implications of an invention, it is important to think about both the social and economic impacts technological developments may have, ideally through collaboration between academics and politicians across disciplines and geographic locations.

For instance, mobility researchers are collaborating with environmental engineers and urban planners to think about new and better modes of transportation. Some of the

solutions include different fuel systems, smart cars and unorthodox ideas to get people out of their auto-centered lifestyles – from new forms of car sharing to traffic taxes.

Although inventing technologies in the realm of communication, mobility or production takes great creativity, researchers say the most difficult part is not the idea phase – it is implementation. This also applies to new manufacturing technologies, product design, and the organization of global supply chains. To design technology that improves our future while taking resource efficiency and sustainability into account, OCF speakers say we must dismantle old ways of doing things and re-imagine what is possible.

The technology is ready – the only question is whether society will have the foresight and will to adopt seemingly inconvenient solutions to pressing problems. "Everybody is obviously aware that changes are essential," says Fritz Klocke, scientific advisor for OCF and a renowned professor of manufacturing technology and engineering at RWTH Aachen University. But is the public truly prepared to hop on and take a ride into the future?

1,966,500,000

people in the world were connected to the Internet in 2010.

1,000,000

Number of electric cars China plans to have on its roads by 2015, supported by $15 billion in investments.

50%

of air pollution is caused by traffic.

37%

of Internet users were located in Europe and North America in 2010.

5,000,000,000

Estimated number of mobile phones in the world in 2011.

Putting a Friendly Face on the Technology of Tomorrow

"Are virtual humans attractive conversation partners?"

Justine Cassell is the director of Carnegie Mellon University's Human Computer Interaction Institute and a former researcher at the MIT Media Lab. She co-authored the 1998 book *From Barbie to Mortal Kombat: Gender and Computer Games.*

As computers grow ever more prevalent in our daily lives, there is a growing sense of unease about the toll computer-assisted communication is having on our society. In her keynote speech at the OCF conference, Carnegie Mellon University professor Justine Cassell said only by studying how humans communicate with each other, can we design machines that emulate the complexities and subtleties of human interaction. That way, future technology can wear a more human face, setting users at ease and bringing us closer together as a society.

There was a time when communication was about talking face to face, person to person, in close proximity, in real time. There was a time when collaboration was about working together in the same room, assisting each other in concrete tasks. Today, communication is about iChat or Skype or leaving each other messages on the Facebook wall. And collaboration is about using a robot to do surgery in South America while I move a robot arm in Sydney, Australia; it is about a group of people collaborating to create an article on Wikipedia.

While the communication and collaboration technologies of today are exciting and raise our hopes about what will be possible one day, they also raise fears about the future. They raise fears about a day in which we might lose the skills of personal relationships and the ties to community that make us human. In my work I ask how we can preserve and develop those skills that are most representative of our human existence, those values we take to be most important.

I pursue these questions by asking how we can use what we know about the human body, about human social interaction, and about the human mind to develop new technologies – that we don't sacrifice what we hold most dear about human existence. And I rely on the fields of anthropology, developmental psychology, literary theory, and linguistics to inform the development of those newest technologies so that we maintain a link with the past.

My methodology in pursuing these questions through the multidisciplinary lens outlined above is to begin with the study of real humans and then to model virtual humans on those real humans. I begin by trying to understand those things that we take for granted about ourselves and our interactions with others. Simple things, like what we do with our eyebrows when we talk, and more complex things like how our eyes smile when we are truly happy, whereas only the corners of our mouths turn up when we want to look happy. Why do I sometimes look you in the eye and sometimes look away when we are talking? It turns out that eyebrow raises accompany important points in conversation, and that eye gaze is a way of managing turn taking.

Studying these minute behaviors of human communication microscopically serves two purposes: First of all, it allows us to better understand humans themselves – how we function, how we differ from other animals, how we interact with one another. And, secondly, only by studying these minute but utterly human details of communication can we maintain them in our virtual human interlocutors of the future. In turn, only by maintaining these utterly human details of communication in virtual humans can we ensure that virtual humans will draw out the very human patterns of communication in us. By watching real humans interact with the virtual humans, I get a sense of where the gaps lie in our knowledge of real humans. Then I can return to studying real humans, and the iterative process of study begins again.

In looking at conversational behavior over the years, it has become clear that meaning is made up out of language and intonation and hand gestures and posture and facial movements, among other sources. Virtually all people use their faces and their hands and their bodies and their eyes (and so forth) to make meaning in conversation. And in all people in all countries, these embodied resources join in tight con-figurations to convey particular meanings and particular stances. The meanings that we make may differ from person to person and from culture to culture, but the ways that we make meanings are the same. So, for example, it appears to be the case that virtually all people in all cultures use gesture in order to clarify what they are saying in words. And virtually all people use eye gaze to manage the conversation. And virtually all people modulate the tone of their voices to add meaning to the content of the words they are saying.

These kinds of studies of human communicative behavior have been carried out for decades, but only 17 years ago did we first use such studies of human communicative behavior to build a virtual human that behaved in the same way as we do. And only 15 years ago did we first use these studies of human behavior to build a virtual human that could communicate with real humans in some of the same ways as humans communicate with one another.

For example, we watched hundreds of people describing a house. From those observations, we were able to draw generalizations about how people use speech and gesture together to contribute to their communicative goals – communicative goals which have to do with describing a house to the person sitting across from them. Based on this model of communication, we were able to implement a virtual human – a realtor, in fact – who understood the questions of the people talking to her, and who responded to them, based on the model of human – human speech and gesture.

It is important to note that the virtual human's speech and gesture were not scripted, they actually came from her understanding of what the human asked her, her reasoning about the best answer to make in response to him, her knowledge of human language and gesture and facial movements, and her ability to synthesize all of those into conversation.

Now, you will notice that REA (the Real Estate Agent) is not as beautiful as the actresses from the movie *Final Fantasy* – in

fact, she does not even look as realistic. However, while Final Fantasy was filmed by animating the performance of real actors, REA is her own woman (one might say!). REA is based on an artificial intelligence engine and a natural language generation engine that understands the notion of thinking about space and communicating one's own representation of the world.

REA constituted a breakthrough in how humans and computers communicate with one another. But the REA system was just a first step in understanding what makes us human through the use and study of virtual humans, and in maintaining those abilities and values in the digital world. In the years since REA was introduced in 1996, we have pursued the methodology described above to further analyze human behavior, and to implement it into virtual humans. No human conversation only concerns facts and goals; all of our conversations have a social component. So a later version of REA gave her the ability to engage in small talk, or social chitchat.

In order to understand those abilities we followed a genuine real estate agent around and analyzed the ways in which she used social chitchat on the job. We found that the realtor – and other people we observed – used small talk in a very subtle way to establish a relationship, to avoid embarrassment, and to get past conversational impasses. On the basis of those data, we were able to build a model of the places in the conversation in which she was likely to use small talk and the places in which she was likely to stick to the

"Virtual humans are an important aspect of human-computer interaction today."

task. And that model of small talk that we built from hundreds and hundreds of hours, not just looking at this real estate agent but also looking at sales people, allowed us to build a virtual human who used small talk in her interactions with real humans.

By this stage, we were fairly confident in the accuracy of our models of human communication, based on the way in which we collected the data, the hundreds of hours of video we analyzed, and the accuracy of the models we implemented. But at this point we had to ask ourselves whether the virtual humans we were implementing were effective. That is, are virtual humans who act like real humans attractive conversational partners? Do they get the task done? Are their skills judged in the same way as real human skills are judged?

In order to evaluate our real estate agent we therefore asked people to work with REA to look at apartments for rent. Some of the people worked with a version of REA with social skills and some worked with a version of REA who got right down to business. In

"Technologies of today raise fears about the future."

fact, even though none of the experimental participants knew about the differences between the two versions, and none of them knew the purpose of our study, we discovered that there was quite a difference between the two REAs. People preferred the version of REA who was able to use small talk; they thought she was smarter, and that she understood their needs better – just like in the real world! Even more strikingly, however, when we looked at the personality of the people in our study, it turned out that it was extroverts who most preferred the version of REA who used small talk, while introverts didn't care which version they used.

And this, too, is very similar to what happens in the real world, where extroverts engage in small talk and appreciate small talk, while introverts might prefer to be left alone.

For example, an extrovert who used the version of REA that engages in small talk, and who did not know about the purpose of the study, said to us:

"I thought she was pretty good. You know, I can small-talk with somebody for a long time. It's how I get comfortable with someone, and how I get to trust them, and understand how trustworthy they are, so I use that as a tool for myself."
And an introvert said:

"REA exemplifies some things that some people, for example my wife, would have sat down and chatted with her a lot more than I would have. Her conversational style seemed to me to be more applicable to women, frankly, than to me. I come in and I shop and I get the hell out. She seemed to want to start a basis for understanding each other, and I would glean that in terms of our business interaction as compared to chitchat. I will form a sense of her character as we go over our business as compared to our personal life. Whereas my wife would want to know about her life and her dog, whereas I really couldn't give a damn."

We were pleased to have been able to evoke such strong feelings in the people who interacted with our virtual humans, and pleased that our study of human behavior resulted in virtual humans who were so realistic in their behaviors (even if not in their looks!).

As time has gone on, our study of human behavior, and our implementation of models of human behavior into virtual humans, has advanced beyond the building blocks of turn-taking and acknowledgement and introducing new topics, past gesture and eye gaze and posture, to more social phenomena such as social chitchat and, most recently, culture and identity. We have been able to understand more and more about those phenomena that make us most human, and that we most value, and the behaviors that signal those phenomena. And as we understand more about these phenomena in humans, and as we collect more data about the behaviors that make them up, we are better able to build those behaviors into virtual humans.

Most recently, we have begun to think about the thorny but preeminently important questions of identity and culture. How do we show others who we are? How do we

demonstrate our alliance and affiliation to particular groups? As we have begun to study this, and to read the literature from social psychology and anthropology, it has become clear that "national origin" is only one aspect of who we are – in fact, each of us belongs to a number of different "cul-

"We needn't fear that we will lose the face-to-face nature of interaction."

tures." I am American, and I am also female, a professor, from New York City, with years of living in France. Each of these aspects of my identity is more important to me, and to the people around me, at some moments than others. And I highlight the importance of each aspect of identity as I move from context to context throughout the week. Not only do I dress differently, but my accent changes, my gestures adapt, I move with more excitement or with more reserve.

I might speak differently with my elderly parents than with the college students I teach. From this perspective, cultural identity can be seen as the demonstration in a particular context of a set of behaviors and practices that show other members of the group, and members of other groups, one's cultural community membership.

With this in mind, we set about exploring issues of identity and culture that were more subtle than national origin, and that come up frequently in people's perceptions of who they are. Most languages are spoken in different ways in different parts of the country. In Germany, for example, German is spoken quite differently in the north than in the south, and the way one speaks German plays quite an important role in how others see you, and how you identify yourself.

The United States is no exception, and so we studied some American subcultures and dialect use. Of course, while language is spoken differently in different parts of the country, it is often the case that one dialect is felt to be the most appropriate for use in school. In the United States, this dialect is called "mainstream American English," or MAE.

How do children use the different dialects they hear around them? Do they learn to switch between the dialect spoken at home and the dialect spoken at school? We read in the educational literature that children who do learn to switch into MAE at school are more likely to do well on their schoolwork – not because MAE is a better version of English, but because it is more accepted. Following our usual methodology, we asked if we could observe how dialect is used in culture, if we could build a model of its use, and of switching between dialects, and then if we could build that model of dialect and cultural identity into a virtual human.

Our research with this virtual peer showed that children recognize the cultural identity of the virtual peer as being the same as their own cultural identity. And when we built the ability to switch dialects into the virtual peer, we found that children are willing to switch dialects to match the dialect of the virtual peer. We believe that by maintaining the important aspects of cultural identity that we all prize, we may have built an educational tool that could help children learn the mainstream dialect that they need for school.

In order to maintain those aspects of human identity that we prize, virtual humans must have minds, they must have social skills, and they must fit into communities of identity. In the long run, we needn't fear that we will lose the face-to-face nature of interaction and be consigned to only using text to communicate. Virtual humans are an important aspect of human – computer interaction today, and their importance continues to grow. And we needn't fear that we must give up our humanity to live in the future. Studies of real humans can and do play an essential role in the development of future technologies. And studies of those technologies can shed light on our human behavior, as well as helping us develop technologies that maintain those

behaviors and values that we prize. In fact, communication between real and virtual beings can be important for teaching and learning.

In 1772, the Droz brothers, Swiss clockmakers, built a series of automatons that were able to carry out real human tasks, such as writing and drawing, in the way that humans do. Others followed the same path, and automatons became quite popular. Although these automatons were based on gears rather than software, they were not so different from the virtual humans of today – and their presence as entertainment in drawing rooms of the time began to worry people. As the German novelist E. T. A. Hoffmann wrote, "The story of the automaton had struck deep root into their souls and, in fact, a pernicious mistrust of human figures in general had begun to creep in."

Every time a new technology comes on the scene, whether it's an automaton or a

"No human conversation only concerns facts and goals."

virtual human, our tendency is to fear it. But if we make sure that those automatons or virtual humans are based on us and not solely on the capacity of gears or computers, without reference to our minds, hearts and communities, then we will carry our humanness far into the next century and beyond. ◆

A Vision For Sustainable Transportation

"We must begin to create something more efficient."

Daniel Sperling is the founding director of the Institute of Transportation Studies at the University of California, Davis.

A green future is a future without cars – or at least without internal combustion engines. Yet experts agree vehicle ownership in the future will rise. Daniel Sperling, director of the Institute of Transportation Studies at the University of California, Davis, says innovative strategies are needed to transform behavior, vehicles, and fuels. In an OCF conference keynote, Sperling told participants in the session on Postfossil Mobility it will take consumers, local governments and entrepreneurs working together to develop the needed transformations.

Imagining a transportation world of 2050 can give us an inkling of what is required to dramatically reduce oil use and greenhouse gas emissions. What might this future look like? With sustainability as the goal, it most certainly will not continue to embrace the American car-centric model – near universal ownership of big, powerful, gas-guzzling cars in mega-garages and suburban enclaves. We must begin to create something more efficient, affordable, and civilized.

This future world would not depend on internal combustion engine cars and oil and would be populated by a wide range of mobility services. In this world, suburbs have come to resemble villages or urban neighborhoods, with commercial and recreational centers aesthetically integrated so that residents can walk, bike, or take a neighborhood electric vehicle to jobs, schools, doctors, playing fields, and local merchants of food, clothing, home wares, and entertainment. For urban and suburban dwellers alike, a powerful, pocket-sized computer serves as an electronic travel agent arranging for mobility beyond the immediate neighborhood. The list of menu items includes car-sharing, ride-sharing, and jitney service, all of which can be lined up automatically and instantaneously – thanks to advanced technology.

Imagine garages that once housed gas-guzzling SUVs now sheltering zero-emission

electric vehicles, plug-in hybrids, and e-bikes. Imagine being able to recharge these with the neighborhood's intelligent renewable-energy grid, which automatically switches from recharging to feeding electricity from the battery back to the system. Imagine easy access to bus rapid transit (BRT) with your neighborhood electric car or a smart jitney that picks you up within five minutes of your electronic call. A typical traveler might use one form of transportation or mobility service one day and another the next, depending on the nature of the errand, time available, distance, weather and traffic conditions, and personal considerations. And imagine banking credits for all of the carbon you save to use later for a special travel vacation.

In this future world, electric-drive vehicles have supplanted most of those old-fashioned gasoline cars with internal combustion engines. These electric-drive vehicles are powered in part by electricity generated by power plants with near-zero emissions, along with hydrogen made from a mix of renewables and natural gas. The remaining electric-drive vehicles are very efficient hybrids getting well over 100 mpg and powered by biofuels – not the old kind made from corn, but from grasses, wood, algae, and various waste materials. Choices have expanded. Convenience and sustainability have become primary considerations. Transportation with near-zero carbon emissions has replaced the carbon-laden transportation monoculture.

Essential Underpinnings

For this future world to take root, an entirely new set of incentives must be put in place. These incentives will motivate consumers, governments, and business to respond rationally to the carbon and energy constraints that increasingly bind us.

These incentives will work alongside an expanded set of technological gadgetry to

realize a new array of mobility options. Computers that understand the human brain, recognize individual and collective behavior patterns, and enhance intelligence will be part of this tool set. Real-time information and global communications will facilitate the transfer of ideas, enabling policymakers to replicate each others' best practices without waiting. Intelligent technology embedded in cars and other vehicles will promote eco-driving, helping travelers reduce their carbon footprints.

The new incentives will motivate socially rational behavior by giving tomorrow's consumers much clearer signals about the impacts of their choices. Personal carbon budgets will be set up for individuals and families. Carbon accounts will be credited and debited based on travelers' decisions. A portion of the balances that accrue from low-carbon lifestyles can be spent by individuals or sold to others. Taxes and fees will

> "Imagine garages that once housed gas-guzzling SUVs now sheltering zero-emission electric vehicles."

be indexed to carbon, so that those making greener choices will pay less for goods and services. Heavier polluters will help finance the low-carbon purchases of others by paying a surcharge that goes to provide rebates for less-polluting cars and fuels.

Local officials and developers will follow consumers' lead. As demand for low-carbon products and lifestyles increases, sprawl will cease and smarter development will ensue. Cities, businesses, and even developers will also have carbon budgets to adhere to. The decisions will be theirs to make, but with changes in tax laws and federal financing to reward compact development, local governments will be motivated to reduce sprawl and offer creative ways to reduce vehicle travel. In the United States, decades of zoning and permitting rules that had codified sprawl into law will be reversed.

Cities and individuals will be motivated and empowered to find ways to reduce energy use and carbon emissions. Not only will they be rewarded with lower energy bills – and in the case of cities, more funding for low-carbon transportation (spent on a wide selection of new mobility options) – but they'll also be able to sell their excess credits to other governments, businesses, or individuals.

As for state and national governments, not only will they alter transportation funding formulas to favor low-carbon mobility services and low-impact infrastructure, but they'll also alter the tax code and the vast array of rules and standards they administer to reward energy efficiency and low-carbon investments and behavior. Mortgage deductions, sales taxes, and much more will be tied to environmental impact. Comprehensive regulations will replace piecemeal policies to guide the development of low-carbon vehicles and fuels. These regulations will be fuel and technology neutral, taking governments out of the business of picking winners

"New policies are needed that spur energy companies to invest in low-carbon fuels and necessary infrastructure."

and instead setting clear targets so that the most promising technologies will advance.

Investments in clean tech R&D will ramp up to buoy companies in their competition for global markets. Entrepreneurs will become even more engaged in the green energy and vehicle race. Their efforts will be rewarded by global communications that halo them, new collaborations that inspire them, and new markets for novel products that enrich them. With higher oil prices and vibrant carbon markets, paybacks will be high on their low-carbon technology investments. In good times and bad, the most innovative entrepreneurs will advance a diverse portfolio of smart bets and pie-in-the-sky dreams.

Needed Changes

Three sets of changes are needed to realize this vision of the future: Vehicles must become far more energy efficient, the carbon content of fuels must be greatly reduced, and consumers and travelers must behave in a more eco-friendly manner. By mid-century, we envision a massive shift under way in all three realms. Electric-drive vehicles will have largely supplanted internal combustion engine vehicles, low-carbon fuels will have nearly vanquished petroleum, and the transportation monoculture will be fragmenting, even in car-centric America.

The automotive transformation is already beginning. Automakers are shifting toward electric-drive vehicles that use electric motors for propulsion and to control steering, braking, and acceleration. They are moving from a mechanical engineering to an electrical engineering culture. The first generation of electric-drive vehicles, gasoline hybrids, are still fueled by petroleum, with the fuel converted into electricity onboard the vehicle. But several major automakers are about to unveil battery electric and plug-in hybrid vehicles that will operate mostly or totally on electricity – motivated in part by California's zero-emission vehicle program. And automakers continue to invest in hydrogen-powered fuel cell vehicles that could reach mass commercialization in the next decade and beyond. There's little uncertainty about this evolution toward efficient, electric-drive vehicles – it's more a question of how fast it will occur.

With transportation fuels, the path to the future is less certain and probably slower. While biofuels are already well established in two regions, America's farm belt and Brazil, these biofuels of today are not likely to play important future roles. In this vision, biomass will contribute a modest chunk of future transport fuels, some of it from Brazil's sugar cane but none from corn or other food crops. Biofuels of the future will

come mostly from waste materials – crop residues, forestry wastes, and urban trash – plus grasses and trees in areas where food crops don't grow well. The more important fuels will be electricity and hydrogen, used in battery, plug-in hybrid, and fuel cell vehicles. But the transition to these latter fuels will require major transformations of the very large companies that dominate the automotive and oil industries, and thus will proceed slowly.

In this time frame, the two other big energy stories are unconventional oil and coal. A big challenge of policy is to head off oil companies' embrace of oil sands, very heavy oil, and oil shale as conventional oil supplies become less available. The other big challenge, the one that requires more nuanced treatment, is coal. Because it's so abundant and so cheap to extract, coal will be an important energy source for a long time. It will continue to be a principal source of electricity and will be a tempting source of future transportation fuels. Its CO_2 emissions are so inordinately high, though, far more than petroleum, that dramatic changes are needed in how coal is processed and used. Coal conversion must become much more efficient and, most critically, the embedded carbon must be prevented from entering the atmosphere. For transportation fuels, that means converting the coal into carbon-free fuels such as hydrogen and electricity, capturing CO_2 emitted at the production facility, and then sequestering that CO_2 underground – with the understanding that "cleaner" coal is a half-century stopgap measure awaiting low-cost renewable hydrogen and electricity.

The third arena, eco-friendly travel behavior, is the most problematic. Cars are firmly entrenched in our culture and modern way of life. Reducing inefficient car-dependent vehicle travel requires reforming monopolistic transit agencies, anachronistic land use controls, distorted taxing policies, and the mindsets of millions of drivers who've been conditioned to reflexively get into the car every morning. It's much more challenging than transforming a small

number of energy and car companies. But even in California, the birthplace of car-centric living, the realization is starting to settle in that mobility must be more sustain-

"Automakers can ultimately build efficient vehicles."

able. Spurred by escalating gas prices and accelerating evidence of climate change, consumers are already beginning to recognize that the transformation of the car-centric monoculture is long overdue.

The really big changes in travel will come slowly. By mid-century, it's possible that the transportation monoculture will be fragmenting. A myriad of electronic, communications, and mobility innovations – including carsharing, dynamic ridesharing, smart paratransit, bus rapid transit, and advanced telecommunications services, all coupled with small neighborhood cars, revitalized transit providers, enhanced pedestrian and bicycling facilities, and smarter land use – will enable a new transportation system that better serves the diverse needs of all people, including those less fortunate, the aging, and the disabled. This transport system will be less expensive, more efficient, and more sustainable than today's.

This vision of the future might have seemed far-fetched even a few years ago, but much has already changed. If we had to pick one year when the world seemed to turn a corner, when it began to be motivated to make large changes, it would be 2006. It will be a decade or more before history will be able to confirm this observation. But it was in 2006 that the United States, the laggard among rich nations, finally accepted that climate change is a threat to humanity. Oil and car companies, politicians of all stripes, and voters finally accepted mounting scientific evidence that climate change is real. Led by California, the national debate shifted from "if" to "what."

But realization and understanding are just a first step. The world is still in denial about the staggering challenge it faces and the radical transformation it must undertake. Achieving a 50 to 80 percent net reduction in greenhouse gas emissions isn't something that businesses, consumers, and politicians can fully imagine. Life after cheap oil evokes images of crises to come. There's no escaping that there will be winners and losers, but strong leadership and good policy can ease the transition. Because CO_2 resides in the atmosphere for a hundred years and because investments in energy and infrastructure endure for decades, it's important to get started immediately.

To realize this future vision of a lower-carbon, less oil-driven future, we need a strategy for getting there – a pragmatic, action-oriented approach inspired by innovation, fueled by entrepreneurialism, and sensitive to political and economic realities. This approach must be rooted in and responsive to the realities of today, but with an eye to the future.

The recommendations that follow constitute a strategy for achieving this vision of the future. The recommendations are guided by two overarching principles. First, enact policies to align consumer and industry interests with the public good. And second, develop and advance a broad portfolio of efficient, low-carbon technologies to transform transportation.

Transforming Vehicles

The most effective and least costly way to reduce transportation oil use and greenhouse gas emissions is to improve the energy efficiency of vehicles. And yet, it's surprising, even appalling, how little the United States and many other areas have done. For twenty-five years, from the early 1980s to 2008, the fuel economy of new cars and light trucks remained stagnant. Vehicle technology improved dramatically, but the energy-efficiency improvements have been diverted to serving private desires for bigger and more powerful cars – especially in the

United States. The challenge is to capture more of the benefit of technology improvements to serve the public interest, even if that means scaling back vehicle size, weight, and especially power and performance. Sizable fuel economy gains are possible through incremental improvements to today's technology; even more gains are possible with an accelerated transition to electric-drive vehicles.

Transforming Fuels

Dramatic changes are needed in the energy sector. Given the flawed marketplace and absence of guiding policy, today's oil industry is maximizing private gains. But that behavior isn't in the public interest. Oil mar-

"The challenge is to capture more of the benefit of technology improvements to serve the public interest."

kets are unresponsive to prices, largely ignore greenhouse gases, and invite geopolitical conflict. Massive investments are being directed toward high-carbon unconventional petroleum.

New policies are needed that spur energy companies to invest in low-carbon fuels and necessary infrastructure. Large oil companies need to be encouraged to transition into broader energy companies that are less dependent on fossil energy. Many politicians and companies across the United States and other affluent nations are embracing the need for a more coherent approach to energy. But, alas, the public debate is focusing on corn ethanol and policies unlikely to have much effect on transport fuels, including carbon taxes and cap-and-trade programs. And where policies have been adopted – the biofuels directive in Europe and the renewable fuel standard in the United States – they're deeply flawed.

Consumer Behavior

Automakers can ultimately build efficient vehicles, and energy companies can supply

low-carbon fuels. But unless consumers are willing to buy more-efficient vehicles that use low-carbon fuels and to reduce vehicle travel, there's no hope of reducing oil use and greenhouse gases. Thus, the focus here is on consumer behavior, plus one other player, local governments, since they operate and manage – and indirectly influence – much of the transportation system, particularly transit services. They also regulate land use, which has a large effect on vehicle usage. Only with enhanced transport choices and smarter land use can individuals and cities reduce their carbon footprints.

Realizing the Vision

As we head toward a future world of increasing vehicle ownership, innovative strategies are needed to transform behavior, vehicles, and fuels. We can look to innovative policymaking in California for new ideas on how to proceed. We can learn from innovative cities in Europe, such as Freiburg, Paris, London, and Stockholm. We can invoke novel ways to stimulate China and other awakening giants to be part of the solution and not part of the problem. We can align incentives to motivate consumers to act for the greater public good. We can rewrite the rules so local governments make decisions that further low-carbon transportation options. And we can invite entrepreneurs to develop the needed transformations in transportation.

Indeed, the first transformation, that of vehicles and fuels, is already under way, albeit tentatively. It will take many years for this transformation to play out. It will undoubtedly happen in surprising ways, calling for open-ended policy approaches that don't pick winning technologies but instead establish fair but tough, escalating goals. The second stage of the transportation revolution, a complete rethinking of how we move about, will evolve more slowly. Both transformations will require incentives, mandates, research, and demonstrations.

Change will happen. It must happen. The days of conventional cars dominating personal mobility are numbered. There aren't sufficient financial and natural resources, or climatic capacity, to follow the patterns of the past. Consumers, governments, and companies all have essential roles to play in making the needed changes. The sooner we get on with addressing the issues, the better. And a durable framework is a better approach than the haphazard and ad hoc road we've been on. Adopting a strategic, long-range view is the key.

The road to surviving and thriving is paved with low-carbon fuels and electric-drive vehicles, new mobility options, and smarter governance. Enlightened consumers, innovative policymakers, and entrepreneurial businesses worldwide can drive us to a sustainable future. ◄━━━━

**This is a condensed version of a speech given at the session on Mobility.
More can be found at www.ourcommon future.de/sperling**

Greening the Global Supply Chain

"Executives face … pressure to look at sustainability."

David Simchi-Levi is a professor at the Massachusetts Institute of Technology and author, most recently, of *Operations Rules: Delivering Value through Flexible Operations.*

> Whether stretched around the world or around the block, supply chains are tremendously sensitive to movements in the costs of labor and fuel. Using real-world examples, MIT professor David Simchi-Levi explains how supply chains can be levered by savvy policymakers to make manufacturing processes more environmentally friendly – and, ultimately, make the world a greener place.

Global market and supply chain challenges are well-known. At the top of this list of challenges are rising and shifting customer expectations. On the one hand, customer demand is difficult to predict. On the other hand, there is a lot of pressure to increase service levels.

On top of that, in the last few years there has been a significant increase in labor costs in developing countries. To illustrate this, just look at China and Mexico. In the last five years, labor costs in China increased by an average of 20 percent each year. In Mexico they've gone up by an average of five percent. In the United States, the increase is about three percent, year over year. Those numbers mean that if a company made production-sourcing decisions five years ago, they may need to revisit some or all of these decisions in light of changing costs.

Not only have we seen significant increases in labor costs in developing countries, but we have also seen significant increases in logistics costs. One reason is energy prices; a second reason, at least in the United States, is limited rail capacity. That increases rail transportation costs, but also

means that companies start moving shipments from rail to the trucking industry. As a result, transportation costs in general go up.

In addition, we have seen a significant increase in the level of risk assumed by many companies. The reason for that, surprisingly, is precisely successful implementation of strategies like lean production, outsourcing and offshoring. What does lean mean? Lean implies a low level of inventory. A low level of inventory suggests that if there is a disruption, the supply chain will not be able to meet demand. Similarly, outsourcing and offshoring imply that the supply chain is geographically more diverse – and as a result, open to all sorts of potential problems.

The level of volatility, especially in just the last two to three years, has increased

significantly. And when I talk about the level of volatility, I don't focus only on volatility in demand, I also focus on volatility in supply – in particular, the impact of commodity price volatility.

The oil price is an illustration of this. Between January 2009 and November 2010, oil prices almost doubled. In fact, this is true not only for oil prices, but for almost every commodity that you can think of.

Thus, companies face increases in labor costs in developing countries, increases in risks and volatility both on the demand side and the supply side. And at the same time, there is an increased pressure to focus on sustainability. So it's interesting to understand where this pressure is coming from and how it affects supply chain strategies, manufacturing strategies, and logistic and distribution strategies.

Supply Chain Efficiency

The first driver is supply chain efficiency. When you talk to executives who are thinking deeply about their logistics, you realize that many of them correlate supply chain efficiency with sustainability. What they think about is that when the carbon footprint is high, when carbon emissions are high, that is an indication that the transportation system is not efficient. Inefficiency motivates them to try to improve supply chain efficiency, and this also leads to a re-

"Insurance companies ... associate risk with sustainability. Some executives are looking at this as an opportunity."

duction in the overall carbon footprint.

In fact, they are right that the logistics sector is a large and growing emitter of carbon dioxide, and the data suggests that logistics contribute about six percent of total emissions. Out of this, almost 90 percent is associated with transportation-related activities.

Different modes of transportation have different emission efficiencies. Rail, for example, is six times more efficient in terms

of CO_2 emissions than trucks. Ocean transportation is almost 50 times more efficient than air transportation in terms of its carbon footprint. So it's not only about production. It's also about selecting the mode of transportation in your supply chain that will affect the level of emission associated with a specific company.

Public Policy's Power

The second driver that has got executives focused on sustainability comes from public policy and regulations. The Kyoto Protocol has forced companies, especially in Europe, to look at the level of carbon associated with the production and delivery of products. In the United States, there has been a lot of discussion, but no significant change in policy. Still, many executives are concerned that this is soon coming.

Even without regulations in the United States, executives face a lot of pressure to look at sustainability as an important area. This pressure comes from three different directions. Some – not a lot – comes from consumers. There's pressure from supply chain partners. And probably the most important source of pressure is from insurance companies, which associate risk with sustainability.

Some executives are looking at this as a competitive opportunity. What they are worried about is that their competitor will introduce a greener product and this will shift market demand. In fact, a number of surveys indicate that consumers in general prefer greener products to other products. That's not surprising. The problem is that none of these surveys show at what price point consumers prefer to switch to greener products. The second thing surveys suggest is that people in developing countries are the most concerned and ready to act.

In response to all this, retailers are putting pressure on their suppliers. And these come in general in two different ways.

Some retailers introduce environmental scorecards that they use to compare the performance of different suppliers. They already rate the performance of their suppliers based on quality, cost and service, and now they're starting to look at the environmental scorecard.

Other retailers require their suppliers to add a label on the product providing information not only on where the product is made, and what material goes into the product, but also what levels of carbon emission it takes to produce and deliver the product to the retail outlet.

Finding the Right Metric

Introducing the environmental scorecard suggests a question: What is the right metric to use? Some companies are focused on carbon footprint. That's a direct way to measure the impact on the environment. Others are focusing on what is called "dead-end distance." This is the nonproductive movement of trucks, or movements where the truck is empty. And we've seen some who use product-miles, the total distance the products travel to the retail location, especially in the media, as criteria.

But this can be a very misleading indicator. The impact on the environment has nothing to do with distance. Take a simple example: You're in a nice restaurant in New York City and you're about to order a red wine. You're trying to choose between two different types: One from the Napa Valley, and one from the Loire Valley. Surprisingly, from the carbon footprint point of view, the one from Napa Valley generates more carbon, because it is trucked to the East Coast, whereas the French wine is shipped over the ocean – a more efficient means of long-distance transport. This suggests that the supply chain network has a huge impact on carbon footprint and therefore on the environment.

Some companies are focused on finding the right trade-off. An example of a company that made a big difference is Walmart. At the end of 2005, they announced a plan to reduce energy use, cut waste and cut greenhouse gas emissions. Their objective

was a 20 percent cut by 2012, not only on emissions associated with their supply chain but also the emissions associated with their suppliers' supply chain. To do that, Walmart started rating their suppliers based on an environmental scorecard that has eight dimensions, including greenhouse gas emission levels, recycled content and renewable energy.

"If oil prices increase, you will see a move from global manufacturing."

This made a big impact. Their largest third-party logistics company in Canada changed the way they distribute products to Walmart stores, switching from road to rail and changing some of their trucks to electric power, both of which significantly reduced the carbon footprint and reduced the amount of fuel used by the trucks. Surprisingly, the two measures not only reduced the impact on the environment but also reduced costs for the third-party logistics companies and as a result for Walmart customers.

When companies start to look at carbon footprint in their supply chain they need a lot of data. They need data on the carbon footprint associated with different transportation activities and information about the carbon footprint associated with warehouses, plant and production activities. Carbon emissions by fuel type, average fuel efficiency, electricity consumption by building characteristics because building size, geographical region, the number of workers, the age of the facility – all these inputs have an impact on carbon footprint.

In my research and consulting projects, I have tried to identify the right way to balance cost, service, and carbon footprint. One example is a US manufacturer of office furniture with two plants, one in Iowa and one in Delaware. They have two distribution center warehouses at the same locations. There were two objectives: One was focusing

on reducing costs and improving customer service. And the other one was focused on reducing carbon footprint.

Though their plants were in Iowa and Delaware, their customers are all over the country. What should this company do to reduce costs and improve service? You can see that we started with two distribution centers, but if you want to improve costs and service, the best strategy is to add two additional warehouses, one on the West Coast and one in the South. This will reduce supply chain costs and improve customer service by reducing average time to market by almost 50 percent.

The question is: What is the impact of additional distribution centers on the carbon footprint associated with this company? As you add distribution centers, you start to reduce average distance to the market. Reducing average distance to the market implies that you reduce transportation costs from the warehouses to the customers – but at the same time you increase transportation costs from the plants to the warehouses.

In this supply chain, transportation from the warehouses to the customers is done by trucks, whereas transportation from the plant to the warehouses is done by rail, yielding a reduction in the carbon footprint. The problem is that you now have more facilities. More facilities consume more energy.

It turns out that the right balance between, cost, carbon footprint, and response time was achieved by adding four distribution centers. This allowed the firm to reduce costs by two percent, cut average distance to the customers by almost 60 percent and cut carbon footprint by about one-third.

Sustainable Thinking

Now when you talk to executives about carbon footprint and sustainability you realize very quickly that the higher the oil price, the more interest they have in focusing on sustainability. When the oil price is low, on the other hand, there is very little interest. Therefore, it's important to understand what the impact of oil prices are on manufacturing, on logistics and supply chains. As the oil price increases, the transportation cost

goes up, and so transportation becomes more expensive relative to inventory and relative to warehousing cost. Similarly, as the oil price increases transportation cost becomes more expensive relative to manufacturing cost. If transportation becomes more expensive relative to inventory and warehouse costs, that suggests you need more warehouses. And because transportation costs become more expensive than manufacturing cost, you need to move manufacturing closer to market demand.

This tells you something about the discussion around public policy. Many people talk about taxation and the impact of policy on manufacturing and supply chain strategies. That suggests that if there is an additional tax on fuel in the United States, you will see a change in manufacturing and supply chain strategies.

It also suggests that if oil prices increase because of limited resources, you will see a

"Companies are focused on finding the right trade-off."

move from global manufacturing – where manufacturing is done in low-cost countries – all the way to local manufacturing, where manufacturing is closer to market demand.

This is a completely different way of thinking about manufacturing and supply chain strategy. Whether green policies are implemented because of government regulations, pressure from supply chain partners or consumers, or changes in oil price, such policies are making or will make a huge impact on how companies design and manage their supply chain. ◄

Taking Technology Use to the Next Level: Being 3.0

Concerned about the disparity between technology and its responsible use, researchers from the Global Young Faculty came together to find out just how Germans were using the Internet – and what lessons could be learned for the future. Their results, in the form of a survey of over 1,000 Germans, were surprising. Awareness of the dangers lurking on the Internet was high, even if people didn't always act in their own best interests online.

In the beginning, there was man: Naked and alone, with no idea how the environment could be harnessed (with the help of some sharp rocks and a few sticks) to make life easier.

Then came Being 1.0, and with him the first hints of modern humanity: Man, the toolmaker, shaping his surroundings. That wasn't the end of man's development, though. "Being 1.0 is the simple toolmaker, not aware he is influencing his environment. Being 2.0 is a different level, in which a person realizes he is part of his environment and a larger group," says Roberto Avanzi, a professor of mathematics at the Ruhr University-Bochum.

Together with other like-minded members of the OCF conference's Global Young Faculty, Avanzi wondered if the flood of digital technology that has pervaded every aspect of life over the last few decades promised yet another phase to humanity's development.

Talking to friends, co-workers and family, Avanzi and his colleagues noticed that the power of technology often outstripped people's preparedness for the results. One particularly worrying example is data protection. Says Avanzi: "There are lots of people who use the Internet but are not concerned about the consequences of their data."

The group coined the term "Being 3.0" for people who were both adept at using technology and conscious of the risks involved. "Being 3.0 is what we want to achieve – people who are aware of the risks, but also responsible for their actions," Avanzi says.

To see where on this imagined continuum the average German stood, the group put together a survey of 1,004 Germans. To their surprise, the survey indicated that most Germans were remarkably astute and aware Internet users. A whopping 80 percent of the people they surveyed were aware of the risks to personal data posed by the Internet.

"Quite a lot of them are already there, so to speak," says Sandra Sülzenbrueck, a GYF member and researcher at the Leibniz Research Centre for Working Environment and Human Factors in Dortmund. "They seem to be behaving, and seem to know about the risks. Most people, it turns out, are more active than passive."

The telephone survey suggested that the users of the future – "digital natives," or young people who have grown up with information technology permeating every part of their lives – were the least careful with their personal data online. The group's survey showed that young people are willing to post personal information on sites like Twitter and Facebook, or on publicly accessible blogs, that they might later regret. "The interesting thing is why people do this," Sülzenbrueck says. "Maybe it's like being your own pop star – everyone wants to be meaningful and relevant."

Discussions with other group members raised topics for future research. The gradual creep of technology into every corner of our lives is eroding skills previous generations once took for granted, for example. Take what Avanzi calls "digital dementia." "There are plenty of people who rely too much on machines and do not remember data" like telephone numbers, appointments and addresses, "just how to search for it."

The group's members shared little except a common interest in the future of technology. When it came to deciding on a project to pursue, that diversity was an obstacle that the group transformed into an asset. "I never, ever would have expected to work with an art philosopher, a production designer or a bionics researcher," Avanzi says. "Yet we were able to do something, and do something surprising. That's the most rewarding for me personally."

Missing the Bus

Caught between a lack of transportation and sprawling cities, many people living in Europe's impoverished inner cities can't change their situations because they can't get to jobs, supermarkets or universities. The solution lies not in more cars, but in sound investment in buses and other forms of accessible, affordable public transport, said OCF Fellow Bob Jeffery at the OCF conference's workshop on Postfossil Mobility.

Mobility defines our lives in myriad ways. Access to safe and affordable transportation can connect us to higher-paying jobs, cheaper food and better education. But many cities struggle to bring that freedom of movement to their citizens.

Bob Jeffery, a PhD candidate in sociology at the University of Salford in Greater Manchester, UK, was invited to the conference to contribute to the session on Mobility. Among other things, he researches the impact of transportation on quality of life and the way attitudes towards mobility are perpetuated from generation to generation.

"An important part of this discussion is suburbanization – which in the UK is a more extreme phenomenon than in the rest of Europe," says Jeffery.

Suburbanization is the growth of commerce and development on the outskirts of cities – sprawl, in other words. Jeffery says that as services move to cities' edges, those citizens who rely primarily on public transportation like ethnic minorities, the elderly, and the impoverished are affected the most.

"The UK has a fully deregulated, fully privatized transport system which encourages car growth for those who can afford it, but leads to the continuing exclusion of those who cannot," says Jeffery.

Examples of this from the UK government's own research include the fact that every two out of five job seekers report that transport is a barrier to getting a job. Half of all 16 to 18-year-olds experience difficulties

Born in 1983, Bob Jeffery is a sociologist focusing on transportation and social justice at the University of Salford in Greater Manchester, UK.

accessing college, and 1.4 million people per year miss, turn down or choose not to access medical help because of transport problems.

A sad irony is that while many inner cities lack adequate public transportation options, they also have the highest density of roads. So while people have difficulty moving from one community to another using public transport, they still have to deal with traffic noise and pollution in their neighborhoods.

This can cause serious public health concerns. Jeffery says the neighborhood he's researching in Greater Manchester has sig-

nificantly lower life expectancies – eight years lower than the national average. Children of those from the lowest social class are more than five times more likely to be killed on the roads than those from the highest social class. This is not limited to the UK, in Germany children from lower social classes (and especially Turkish children) are also more likely to be victims of road traffic accidents.

That's only one reason why Jeffery supports the Campaign for Free Public Transport in the UK. He describes it as "an embryonic activist group which is campaigning for a radical solution to the UK's transport problems." Jeffery concedes this movement is marginal, but he thinks social science should place priority on addressing people's needs, not moving in lockstep with policymakers' agendas.

Jeffery's interest in the subject is more than academic. For him, there's a personal element as well. He says early experiences with the impact of poverty, drugs, and crime motivated him to study social science. That's also why he wants to stay involved with community groups and local politics.

"I actually live in the deprived community which has been the focus of my research," says Jeffery. "I think one of the problems with the social science that studies deprivation is that people are very much kind of coming in from the outside trying to tell these communities what their problems are. I don't think there is enough listening going on."

Jeffery plans to edit a book in 2011 on debates around free public transport, spreading the word about cities where low or no-cost mobility solutions have been implemented to positive effect.

More can be found at:
http://www.freepublictransport.org.uk
http://salford.academia.edu/BobJeffery

Industrial Design

Products for a Better Future

Too often, companies respond to the market's demands by churning out simple products that yield immediate profits. But that kind of thinking overlooks the potential gains of taking a longer view. Instead, companies should innovate for future needs. Auckland University of Technology lecturer Ayse Idil Gaziulusoy argues profits can be sustainable if companies take a broader view, and look more creatively at what part their business – and their innovations – will play in a complex world.

Industry often takes a short-term approach when it comes to sustainability issues, settling for small tweaks rather than sweeping reinventions. Take the common washing machine: Product developers work to make it better each year, introducing features that lower the unit cost, use less energy or save water. Such steps are progress, to be sure – but not much.

Instead, product developers should come up with new ways to wash. What about a public laundry where neighbors can meet and pool resources, or a fabric that repels dirt, or a wardrobe that cleans clothes automatically? We don't need incremental improvements, we need sweeping change that leads to less wasteful living, says Ayse Idil Gaziulusoy. She joined the conference as an Our Common Future Fellow contributing to the session on the Factory of the Future.

This approach doesn't always come naturally to companies focused on making the biggest profits for the smallest investment. Corporate short-term thinking leads to long-term problems, from the well-known example of climate change resulting from human-induced carbon-dioxide emissions to depleted fisheries, clear-cut forests, and the deluge of electronic waste shipped to developing countries.

"In order to achieve a sustainable society, we have to change everything in society – and industry has a key role to play," Gaziliusoy

A. Idil Gaziulusoy is a lecturer at the Auckland University of Technology in New Zealand. She was born in 1978.

says. "We must ask ourselves how product development can be aligned with the long-term transformation that needs to take place in society."

Gaziulusoy was born in Turkey. She says the enormous disparity she observed there between rich and poor made her want to be an agent of change. She's trying to change the world through changing how businesses

work, and today is a passionate advocate of what she calls "system innovation": Designers must acknowledge that the world is interconnected and complex, and products should support a sustainable society.

To illustrate her point, Gaziulusoy recalls a speech she heard in 2005, at the Sustainable Business Network Conference in Auckland. The New Zealand executive of Toyota talked about the company's hybrid Prius car. After the executive's speech, someone from the audience asked what the company could do to increase the sustainability of transport. "He said we have to build more roads to increase diffusion of hybrid cars," Gaziulusoy recalls.

That was the wrong answer. "Toyota had great foresight in anticipating that reducing carbon emissions and enhancing fuel efficiency would become major selling points and developed the Prius. But arguing that hybrid cars are the ultimate in sustainable mobility was caused by a lack of systemic understanding," Gaziulusoy says. More cars on roads means increased traffic, stress levels and a loss of biodiversity. "The company wasn't thinking about meeting a societal need, it was thinking about a specific product, the Prius. We have to get beyond thinking about specific products."

Gaziulusoy knows that only a few people in the world are trying to link product development to the broader-scale transformation that needs to take place. But she has a few suggestions on how to get there. Companies can collaborate with each other and establish partnerships with NGOs and governments.

Companies like Toyota shouldn't just focus on developing their next car, but also consider larger questions involved in societal mobility. What would a world without cars look like – and how could Toyota play a role in such a world? "Think conceptually. Then, you might start thinking about greater societal innovations and systemic shifts might become possible," Gaziulusoy says.

The Brazilian Model

Luc de Ferran is an industrial consultant and former vice president of Ford Latin America Group.

"It was a unique opportunity to do everything differently."

The auto industry is in constant flux. Companies come and go. Production moves to meet demand. Models morph into ever more futuristic designs. Even the epicenters shift: Latin America, Brazil in particular, is an emerging leader. That's why many in the auto world are keeping a close eye on the Brazilian model of growth and innovation. Former Ford executive Luc de Ferran, who helped lead the automotive giant's efforts in Latin America, was invited to talk about his experiences at the session on Future Technologies. He says successful automotive companies in the future will have to change the way they approach staffing in developing countries.

▶ **Why has Brazil experienced such dynamic growth in the auto sector?**

de Ferran: First, our country is going through violent growth. Even in 2009, when the economy was very bad everywhere, Brazil broke even. And in 2010 our gross national product grew 7.4 percent. That's the projection. Brazil's per capita income takes us out of the poverty range. We are at about $10,000 per person now. Second, the mix of

"In another five years, Brazil will be the fourth largest car market in the world."

cars is completely different. I think what damaged the auto industry in the United States was the size of the cars. You need to think about how much the vehicle will waste in comparison to how much the vehicle will carry. If you look at the Brazilian market, 75 percent is small cars.

Why are more fuel-efficient cars so popular in Brazil, while other countries like the United States still loves its gas guzzlers?

de Ferran: In Brazil, we've mostly made small cars. Why? Because we couldn't afford bigger ones. So we started the other way around. The public income ten years ago was probably less than a thousand dollars per head per year, something like that. Now it's ten times higher. But the Brazilian auto industry actually was born ten years ago. Before that, the industry was flat at around one million cars sold a year. Now we are reaching four million and growing very quickly. In another five years, Brazil will be the fourth largest car market in the world behind China, the United States, and Japan.

How did Brazil become a major player in auto manufacturing?

de Ferran: The Brazilian industry is not fresh. It started in the 1900s. We shipped Ford Model T's from Dearborn, Michigan to São Paulo back in the first decades of the 1900s, but the real industry started production in Brazil in 1957. Most recently, we built revolutionary new plants. Totally new processes – fully integrated with logistics processes that are benchmarks. Everything we do to build these vehicles is very productive.

You played a major role in that reestablishment of Ford in South America – specifically in the way factories are managed. What changes did you make at the Ford plant in Bahia, Brazil for example?

de Ferran: It was a unique opportunity to do everything differently. I had all kinds of models I had studied. With all those models, I said I will do something which is unbeatable from quality, production and profitability viewpoints. And we worked on it. One of the things I found is that the involvement of human resources was incredibly important. We made it so workers were no longer workers, and bosses were no longer bosses. Workers need help, they get together and ask each other. They are all well trained to handle this responsibility. In Bahia, I took 13,500 people out of poverty and gave them 900 hours of training each.

How did this kind of approach affect the bottom line?

"In Brazil, we've mostly made small cars. Why? Because we couldn't afford bigger ones."

de Ferran: The quality improved when the workers understood that what they do contributes to the satisfaction of what their customers will buy. In the end, this is paying their salaries. Also, the level of education inside the plant was much higher. It helped tremendously. You get more dynamic ideas from the staff.

What has the impact been on the local population?

de Ferran: There is better healthcare, dental care and education. I am advocating that you cannot isolate the guy from his job or from his participation in society – you just cannot. One way or another, one ends up affecting the other. So you had better recognize that and make it work.

So you aim to build not just a factory, but a community?

de Ferran: In reality that's what it is. Now sometimes it works. Sometimes it doesn't. But what you have to have in mind is "I'm not hiring a worker, I'm hiring a person." That's a big difference, isn't it? And there is a relationship that needs to be well-done and long-term. That's the difference. That's human. You can do that any place in the world. ◀

Impressions from the conference.
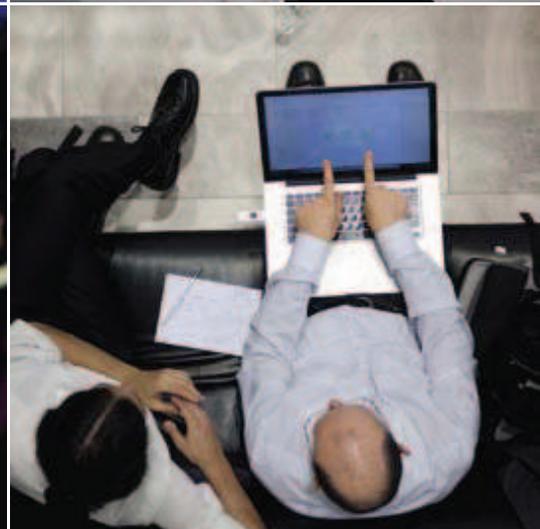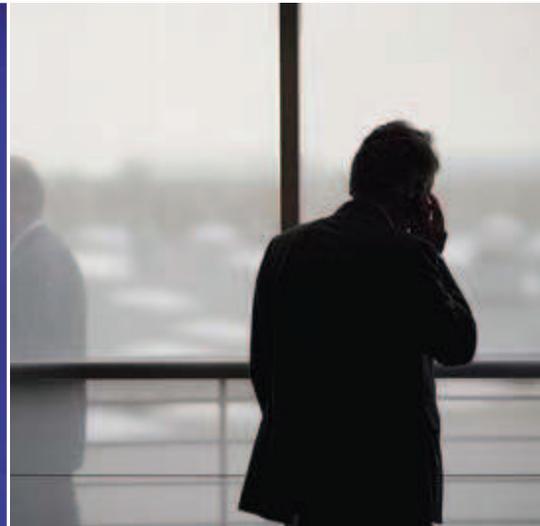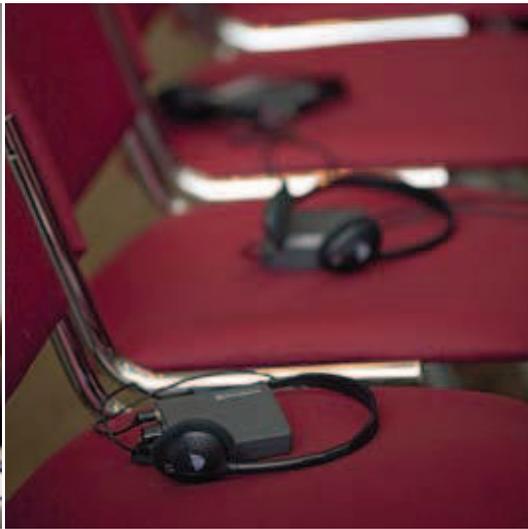
4 Questions, 8 Answers

"What fact makes you the most optimistic about our common future?"

Klocke: People are aware of the big challenges we face. This makes me optimistic that science and industry will find adequate solutions.

Wahlster: Our presentations showed that most of the urgent problems of humankind can be solved with the help of IT innovations, and this makes me optimistic.

"What is the greatest challenge facing us in the next 25 years?"

Klocke: The move towards more effective use of renewable energy sources, along with the development and introduction of new concepts for more resource-efficient production processes and products.

Wahlster: The biggest challenge for society is finding the right balance between open Internet communication and privacy. Technology can give us a better life, but it can also create new problems if we are not careful.

"What piece of advice would you give young researchers in your field today?"

Klocke: Go for interdisciplinary research approaches. Look beyond the borders of your discipline and join multidisciplinary research teams.

Wahlster: Try to solve not only academic toy problems but those problems that have some impact on our daily life. And focus on those topics that have a societal and an economical impact in researchers' respective countries.

"What was the most surprising insight you had at this conference?"

Klocke: I was surprised at how well the conference was attended.

Wahlster: I was really amazed by a young researcher who showed that elderly people can trace a line on paper faster and more accurately than young people. It turns out elderly people are used to handwriting letters, whereas young people use email keyboards and touch screens more often. If young people don't develop the dexterity of their hands, it could be a problem in the future – especially in fields like surgery and dentistry that require refined motor skills.

Wolfgang Wahlster and Fritz Klocke served as scientific advisors for the OCF sessions on Communication and The Factory of the Future under the frame topic Future Technologies. Wahlster is professor of computer science at Saarland University (Saarbrücken, Germany) and director and CEO of the German Research Center for Artificial Intelligence (DFKI). Klocke is head of the Fraunhofer Institute for Production Technology (IPT) in Aachen as well as professor of manufacturing technology and co-director of the WZL Laboratory for Machine Tools and Production Engineering at RWTH Aachen.