TEXAS TECHNOLOGY TASK FORCE

THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Technical Memorandum#0-6902-TM1

To: RTI Project Manager: Sonya Badgley

From: CTR Research Team: Kristie Chin, Andrea Gold, C. Michael Walton

Subject: TxDOT Project 0-6902 – Technical Memorandum for Task 1

Date: 12/15/15

TEXAS DEPARTMENT OF TRANSPORTATION SPONSORED PROJECT

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1 Introduction

The intent of this research project is to form a core knowledge group, known as the Texas Technology Task Force (TTTF), and a network of subject matter experts (SMEs) that will identify emerging technologies with the potential to transform Texas's transportation system. The TTTF and UT-Austin research team will analyze potential impacts of the technologies and use the analysis to inform the development of key strategies to select and promote the most critical of these technologies. The Task Force is committed to advancing the development of a high-performance transportation system to position Texas as the leading nexus of economic activity and technological innovation. Since its inception in February 2013, the Task Force has supported the Texas Department of Transportation (TxDOT) by outlining clear actionable strategies and enhancing the delivery of quality transportation services. The Task Force has progressed through three phases that are described below.

Inception: Authorized by Texas's 83rd Legislature, General Appropriations Bill S.B. No. 1 Item 44 VII-31, TxDOT established the TTTF in early 2013 to develop a vision for the future of Texas's transportation system.

Phase I: (February to August 2013) Began with a core knowledge group that sought experts in various transportation technologies. The initial Emerging Technology Portfolio was presented and a public-private consortium was established to further develop key emerging technologies.

Phase II: (September to December 2013) Focused on the background research pertaining to the Strategic Technology Business Plan (STBP) and outlined steps for completion in the next phases.

Phase III (current): (September 2014 to December 2015) Dedicated to updating the Emerging Technology Portfolio, developing white papers on critical technologies, and drafting initial chapters of the STBP. Already in this phase, the research team has prepared the following three products: 1) *Updated List of Task Force Members* (P1), 2) *Emerging Transportation Technology Portfolio* (P2), 3) *Critical Transportation Technologies (Preliminary Analysis)* (P3).

The remainder of this technical memorandum reports on returning and proposed new Task Force members, updates and expansion to the technology portfolio, Phase III meeting goals, and the selection of critical technologies for focus during Phase III.

2 Task Force Membership, Meeting Dates, and Goals

To form the Task Force, research team members identified thought leaders who would provide significant insight into new and developing technologies from information and communication, manufacturing, transportation industries, and more. In Phase I eleven members came together to form the original Task Force. These eleven remained through Phase II, and in Phase III eight Task Force members returned. The research team sought input from TxDOT leadership and returning Task Force members regarding recommendations for additional experts fitting the project needs. The first Phase III deliverable (*Updated List of Task Force Members*, December 31, 2014) provides a list of returning members and proposed additional members to

participate with the Task Force. During Phase III meetings one, two, and three, the following individuals joined the task force:

- Srimat Chakradhar, *Department Head – NEC Laboratories*
- Thomas Bamonte, *General Counsel – North Texas Tollway Authority*

As the project progresses into the next phase, new membership is under consideration. The research team is seeking input from TxDOT leadership and returning Task Force members regarding recommendations for additional experts fitting the project needs.

Meeting dates based on TxDOT leadership and Task Force availability were established in early 2015 with the following dates.

- Meeting 1: May 11, 2015
- Meeting 2: August 11, 2015
- Meeting 3: December 10, 2015

One-on-one interviews with returning members and TxDOT leadership informed individual meeting goals. Meeting goals are listed below.

- Meeting 1: Discuss steps necessary to build a strong foundation, including fundamental elements necessary to ready Texas for the forthcoming transformations and enhancements.
- Meeting 2: Discuss the Strategic Technology Business Plan and its proposed outline, identify areas of greatest potential, and develop a roadmap for completion.
- Meeting 3: Select the three most promising technology areas for further business case development.

3 Critical Technologies, Meeting Discussion, and Technology Package Selection

The following three critical technologies were identified as areas requiring additional exploration:

- Airport Operations
- Wireless Networks
- Alternative Energy

During Phase III—Meeting 3, the following SMEs were brought in to present on the critical technologies:

Panel 1: **Enabling Aviation Technologies while Safeguarding the Public**

Description: System performance in the aviation industry relies upon a community of stakeholders, including government, businesses, flight operators, airports, and the public. NextGen air traffic control has the potential to enhance capacity and safety while reducing fuel burn emissions. As disruptive and legacy technologies interact with one another, the challenge will be in adapting existing policies to effectively address public safety and security.

SME: Jim Crites, *Executive Vice President Operations – DFW International Airport*

***Panel 2*: Evolving the Mobile Network to Empower New Services**
Description: The mobile network is continually evolving and expanding. As patterns of urbanization continue, a densification of the network will occur to provide new and reliable services for end users. Key applications to consider are the Internet of Things (IoT), Machine to Machine (M2M) solutions, and Smart Highways. 5G technology will be a critical platform for the success of a connected transportation system.
SME: Myron Gregorek, *Business Development Director – Alcatel-Lucent*

***Panel 3:* Introducing Alternative Energies into the Marketplace**
Description: Alternative energies present an opportunity to build consumer demand for a new and relevant technology. Electric vehicles and hydrogen fuel cell vehicles offer practical benefits of lowering the environmental impact of the automobile. For these technologies to be viable, an infrastructure network of fueling stations is required. By exploring partnership opportunities, incentive policies, and educational outreach, Texas can craft a message to support innovation.
SME: Geri Yoza, *National Manager, Business Planning, Product Marketing – Toyota*

Task Force members were polled in order to identify the five technologies that were most critical for further business case development. The following five key technology areas were prioritized for further discussion in Phase III—Meeting 3:

- Connected Vehicles and V2I Capabilities
- Autonomous Vehicles and Freight Platooning
- Electric Vehicles and Alternative Energy
- UAS, Inspection, and Emergency Response
- Big Data, Open Data, Smart Cities, and Internet of Things

Each discussion was led by a facilitator, who presented opening remarks and addressed the following five areas: 1) High-Level Solutions, 2) Benefits and Barriers, 3) Market Opportunities, 4) Stakeholder Identification, and 5) Future Research. After individual discussion on each area, meeting participants emphasized autonomous and connected vehicles, freight applications, and big data. Upon additional follow-up conversation and consideration, these technologies were organized into the following three technology packages for further business case development:

- Urban Solutions
- Freight Solutions
- Rural Solutions

4 Conclusions

This technical memorandum summarized the changes in Task Force participation, 2015 meeting dates, and meeting goals. Critical technologies, meeting discussion, and the three

technology packages selected for further business case development are given. Additional materials may be found in the Appendix.

5 Appendices

Provided as appendices are the presentations made at the December 10, 2015 TTTF meeting, along with the meeting agenda and the meeting minutes.

TRANSFORMATIVE TOPICS
December 10, 2015

Enabling Aviation Technologies while Safeguarding the Public

Moderator**:** Thomas Bamonte, *General Counsel – NTTA*

System performance in the aviation industry relies upon a community of stakeholders, including government, businesses, flight operators, airports, and the public. NextGen air traffic control has the potential to enhance capacity and safety while reducing fuel burn emissions. As disruptive and legacy technologies interact with one another, the challenge will be in adapting existing policies to effectively address public safety and security.

Jim Crites, *Executive Vice President Operations – DFW International Airport*

Evolving the Mobile Network to Empower New Services

Moderator**:** Thomas Bamonte, *General Counsel – NTTA*

The mobile network is continually evolving and expanding. As patterns of urbanization continue, a densification of the network will occur to provide new and reliable services for end users. Key applications to consider are the Internet of Things (IoT), Machine to Machine (M2M) solutions, and Smart Highways. 5G technology will be a critical platform for the success of a connected transportation system.

Myron Gregorek, *Business Development Director – Alcatel-Lucent*

Introducing Alternative Energies into the Marketplace

Moderator**:** Thomas Bamonte, *General Counsel – NTTA*

Alternative energies present an opportunity to build consumer demand for a new and relevant technology. Electric vehicles and hydrogen fuel cell vehicles offer practical benefits of lowering the environmental impact of the automobile. For these technologies to be viable, an infrastructure network of fueling stations is required. By exploring partnership opportunities, incentive policies, and educational outreach, Texas can craft a message to support innovation.

Geri Yoza, *National Manager, Business Planning, Product Marketing – Toyota*

TEXAS DEPARTMENT OF TRANSPORTATION

TEXAS TECHNOLOGY TASK FORCE

AGENDA

GOAL: Select the three most opportunistic technology areas for further business case development

DATE December 10, 2015
TIME 9:00am – 5:00pm
LOCATION TxDOT, Ric Williamson Room

9:00 AM **Welcome** – Darran Anderson, *TxDOT* & Dr. C. Michael Walton, *UT Austin*

9:15 AM **Project Overview** – Andrea Gold & Kristie Chin, *UT Austin*
Introduce the project, present updates, and outline the Task Force's path forward.

9:30 AM **TRANSFORMATIVE TOPICS: Airport Operations, Wireless Networks, and Alternative Energy**
Moderator: Thomas Bamonte, *General Counsel – NTTA*
Jim Crites, *Executive Vice President, Operations – DFW International Airport*
Myron Gregorek, *Business Development Director – Alcatel-Lucent*
Geri Yoza, *National Manager, Business Planning, Product Marketing – Toyota*

11:00 AM **Break**

11:15 PM **LUNCH PRESENTATION: Cybersecurity & Connected Vehicles**
Josh Johnson, *Assistant Director, Intelligent Systems – Southwest Research Institute*

11:45 PM	**Workshop Introduction –** Andrea Gold & Kristie Chin, *UT Austin* Present survey results and set the stage for the afternoon workshop by introducing problem statements. High-Level Solutions | Benefits & Barriers | Market Opportunities | Key Stakeholders | Future Research
12:00 PM	**KEY TECHNOLOGY: Connected Vehicles & V2I Capabilities** Facilitator: Shelley Row, *President & CEO – Shelley Row Associates*
12:45 PM	**KEY TECHNOLOGY: Autonomous Vehicles & Freight Platooning** Facilitator: Harry Voccola, *Executive Advisor – HERE*
1:30 PM	**Break**
1:45 PM	**KEY TECHNOLOGY: Electric Vehicles & Alternative Energy** Facilitator: Mike Heiligenstein, *Executive Director – CTRMA*
2:30 PM	**KEY TECHNOLOGY: UAS, Inspection, & Emergency Response** Facilitator: Jim Crites, *Executive Vice President, Operations – DFW International Airport*
3:15 PM	**KEY TECHNOLOGY: Big Data, Open Data, Smart Cities, & Internet of Things** Facilitator: JD Stanley, *Global Director of Strategy & Integrated Solutions – Cisco*

4:00 PM **Break**

4:10 PM **Opportunity Area Identification** – *Dr. C. Michael Walton, UT Austin*
Participants work together to select and recommend the three most opportunistic technology areas for further business case development in the next phase.

4:50 PM **Closing Remarks –** Darran Anderson, *TxDOT* & Dr. C. Michael Walton, *UT Austin*

5:00 PM **Adjourn**

TEXAS DEPARTMENT OF TRANSPORTATION

TEXAS TECHNOLOGY TASK FORCE

Meeting: **Texas Technology Task Force, Phase III, Meeting II**

Date: Thursday, December 10, 2015 | 9:00am – 5:00pm

Location: TxDOT 125 E 11th Street, Ric Williams Room

In Attendance: Darran Anderson, TxDOT; Stacey Strittmatter, TxDOT; Kent Marquardt, TxDOT; C. Michael Walton, UT-Austin, Andrea Gold, UT-Austin; Kristie Chin, UT-Austin; Jim Crites, DFW International Airport; Myron Gregorek, Alcatel-Lucent; Geri Yoza, Toyota; Josh Johnson, SWRI; Harry Voccola, Nokia/HERE; Mike Heilingenstein, CTRMA; JD Stanley, Cisco; Thomas Bamonte, NTTA; Shelley Row, Shelley Row Associates LLC

Project Overview – *Andrea Gold & Kristie Chin, UT-Austin*

- Previous meetings have focused on technologies within the realm of the possible for Texas.
- Moving forward, TTTF will seize on these opportunities by focusing on three technology areas.
- TTTF provides value to TxDOT and the customer. As a collaborative effort with thought leaders from across public agencies, industry, and research, the TTTF has developed a robust emerging technology portfolio. The activities of the TTTF follow a path of discovery, development, and delivery; the development phase is the current focus.
- Since the August meeting TTTF has presented at AASHTO and the UTC Spotlight. TTTF is working with the TxDOT Communications Division to prepare a plan for outreach on relevant technologies. On December 8th, the TTTF in partnership with the Texas House Innovation & Technology Caucus hosted a TECHtalk to build awareness within the State Legislature around the connections between transportation, technology, and policy.
- The objectives of the December 10 meeting include engaging the panelists in critical discussion, selecting three technology areas for further business case development, and providing guidance for next steps.

TRANSFORMATIVE TOPICS: Airport Operations - *Jim Crites, DFW International Airport*

- Next Gen technologies are high-performance, multi-user technologies fielded and integrated or leveraged tomorrow.
- There is a virtual presence with DFW air traffic controllers. Through this type of technology, some of these idle facilities can get more use. The new system enhances capacity and safety while reducing fuel burn emissions.
- Airport operator engagement is critical for addressing community impacts. The new flight patterns are helpful but it means they are flying over new communities. They are working with the Government, the business community, flight operators, the airport, and the public community to address system performance, flight performance, financial, safety, and environmental impact concerns. Fostering education amongst the officials and the local communities leads to more understanding.
- Unmanned Aerial Systems (UAS) – There will be an estimated 700K recreational drones given out at Christmas this year. Flying these devices near an airport can prove to be very dangerous. The next gen system connects all planes but there are concerns that unintended consequences could cause very bad accidents.
- FAA has created evolving regulations on this issue. They have been providing public service announcements to make sure they are used appropriately.
- A disruptive technology is one that displaces an established technology and shakes up the industry or one that is a ground breaking product that creates a completely new industry. Necessary supportive infrastructure, environments, and policies will be needed for a more multi-modal approach.
- Looking abroad, most airports are privatized and they have a large duty free section. In the US everyone is looking to move very quickly. Every retail experience whether it is food or shopping must be done quickly. DFW is planning on doing shorter leases for retail spaces within the airport. This will allow them to do more market research on the types of businesses that thrive in these settings.
- Enabling technology is empowering more people than ever before. New technologies will continue to be developed. Since the challenges are already there, DFW is encouraging open dialogue to try to keep the public safe.

- DFW Airport has a renewables program. There were a lot of cost efficiency measures put into place and this included energy efficient measures. They now use 40% renewable energy. It is cheaper and better for the environment. They are interested in partnering with Toyota to add FCV to their fleet.
- Airports are a good place to test innovative new technologies.

TRANSFORMATIVE TOPICS: Wireless Networks – *Myron Gregorek, Alcatel-Lucent*

- Network (LTE) is continually evolving and expanding. There have been major advancements in the last two years. Voice over LTE capability is a game changer. There will be HD voice and video calling. LTE multicast allows you to connect or share with lots of people very easily.
- Service providers are adding a special channel to each tower to make it easier for private industry and governments to reach out to consumers. QOS will be useful for traffic management because it will be dedicated to a specific use, minimizing drops in service.
- LTE advanced enables different channels to be bonded together to give the user more bandwidth. Alcatel-Lucent is working on the densification of the network to bring the network to the consumer. This involves adding small cells with a short range to different kinds of infrastructure.
- Verizon is working to put LTE over the Wi-Fi spectrum. It is hard to purchase additional channels for more LTE service but there is Wi-Fi everywhere.
- LTE U for unlimited is being developed for the Internet of Things (IoT). One M2M provides a secure and efficient end to end data control exchange. An entire subindustry has been created to deal with machines. Anticipated growth in the number of devices connected to the internet is expected to grow by one to two billion devices.
- Bell Labs announced their idea for the super highway of the future. The roads will contain sensors that guide the cars. There may be private IP connections to help with privacy concerns with AVs and CVs.
- 5G is coming and it will have massive broadband traffic capacity, reduce costs, provide spectrum efficiency, and access a new spectrum. There will be a flexible barrier design. IoT is not waiting for 5G and is developing on a parallel path. Alcatel-Lucent wants to reset the bar to have the US be a leader in this field.
- Verizon will do this by increasing broadband access in dense areas among other things. There are no official standards for 5G yet. Verizon is working to predict what they need to prepare. 5G will use policy control to adapt the network to the user. In order to take full advantage of 5G benefits, service providers will need to scale their operations and grow exponentially.
- Transportation is chasing towards DSRC in Connected Vehicles but they will end up using a combination of DSRC and 5G.
- The densification of the network is an excellent opportunity for a public-private partnership to add cells to government street lights and infrastructure. Verizon is working with Oklahoma City, Austin, and San Antonio. They are partnering with Cap Metro to provide free Wi-Fi on all Austin buses.
- Alcatel-Lucent is on an 18-month development schedule. Using light sources as a spectrum to transmit data is only used in fiber optics. This is not being used with 5G. Alcatel-Lucent is experimenting with centimeter and millimeter wave frequencies.
- An issue with the dense network of small cells is that the cells are programmed to talk back to the core wireless network but they have no way of talking to the other cells on the road. These are all connected through a fiber optic network. With new roadway projects they generally try to include fiber when possible. Alcatel-Lucent only sells to service providers.
- WiMAX is no longer being used with the exception of remote cases in India.
- To establish an AV network, government agencies should consider forming a partnership with a service provider.
- Service providers are not currently using satellites but are considering projecting LTE into the air. The service providers are willing to pay for the expansion of the network to rural areas as long as those areas sign service agreements.
- Verizon is trying to show municipalities that they can save money by upgrading their systems since they will have less down time and a better connection.

TRANSFORMATIVE TOPICS: Alternative Energy– *Geri Yoza, Toyota*

- The G21 vision is to develop a small vehicle with a lot of room, high fuel economy, and low emissions with no sacrifice in performance. This led Toyota to the Prius and Hydrogen Fuel Cell Vehicles.
- In 2000, gas was cheap so that was not a concern but there were a lot of environmental concerns. Toyota realized the Prius was a good fit.
- Toyota's 2001 Prius goals were to gain dealership participation and support for hybrid sales and marketing. Pre-launch activities included educating the public and government entities. They started the Prius family demo

program. This allowed them to learn a lot about the potential buyers. They provided a strong after sales support package to encourage people to trust this new technology. They had stringent dealer requirements.
- Currently, they have sold 7M hybrid vehicles worldwide. Toyota is currently launching their Hydrogen Fuel Cell Vehicle called the Mirai. The vehicle is a zero emissions vehicle (ZEV) that places no limitations on the owner. They are currently being sold in CA. Toyota is planning on expanding to the Northeast in 2016. The price of hydrogen fuel is variable so they are offering three years of complimentary fuel with the purchase of the car.
- Potential buyers are typically 40-50 years old males who work in the tech or science fields. They usually make $150K or more per year. The entire marketing campaign is digital; there will be no commercials or print ads.
- The major point of concern is having enough convenient fueling stations.
- The policies and initiatives key to Fuel Cell Vehicle deployment involve fuel station development and purchase incentives. The California Governor's Office started an office to specifically help Toyota permit these vehicles.
- The remaining challenges involve fuel station development in other states. Toyota would like the Federal Government to reinitiate the Federal Tax Credit for fuel efficient vehicles.
- The Mirai vehicle has been approved as an emergency power source in Japan. By the end of 2015, 20 refueling stations are scheduled to be opened throughout CA. By the end of 2016, 12 refueling stations are scheduled to be opened throughout the Northeast.
- Hybrids are currently at 6% market penetration. There is a lot of room to expand. The state can play a role in changing consumer behaviors and adding more charging stations. If fuel efficient vehicles become the norm in the marketplace, the fuel tax may become insufficient and the State Legislature may need to revise its transportation funding policies.
- The FCV is emitting pure water in the form of water vapor depending on the temperature. The car has an electric drivetrain and it can go from 0-60 mph in 9 seconds.
- Toyota looked to where the trend was going instead of where it currently stood. They used the hybrid approach to mix in new technologies slowly. For new technologies to be accepted, the right ecosystem has to be in place.
- TxDOT is responsible for managing Texas transportation with a holistic perspective, so it is important to understand how all of these different technologies and modes can progress together.
- Toyota is working with Universities and NREL to explore how the renewable field will expand over the next 10-15 years.

Cybersecurity with Connected Vehicles – *Josh Johnson, SWRI & Jason JonMichael, HNTB*
- Cybersecurity is becoming more sophisticated. This summer there were a series of car hacks.
- Social network data, smartphone app data, online/offline shopping, car navigation data, biometrics, etc. have all been hacked.
- Cybersecurity hacks can happen through the recovery of system secrets, wireless attacks, and software attacks. Cybersecurity is not at one point of entry.
- Connected Vehicles are a system of systems. Since it is not just one connection, there are many vulnerable places. The current car has around 100M lines of software running. LTE or similarly enabled vehicles are becoming commonplace. The auto world is quickly becoming more and more connected. By 2020 every car will be connected in some way. CVs improve safety, mobility, and reduce their environmental impact. For CVs to be successful at a large scale, they must have hundreds of computers and multiple networks in order to communicate with agency networks and with each other.
- As 5G is rolled out it will have new security features to make it harder to hack.
- The benefits of CVs outweigh the risks, but TxDOT should be aware of the risks in order to make recommendations regarding the necessary safeguards and protocols. DSRC standards are designed to make it more difficult to hack than other communication mechanisms in the CV environment.

Workshop Introduction – *Andrea Gold & Kristie Chin, UT-Austin*
- TTTF has been exploring five technologies and is seeking guidance in narrowing the list down to three. While discussing the technologies they would like the following areas to be considered: 1) High Level Solutions, 2) Benefits & Barriers, 3) Market Opportunities, 4) Stakeholder Identification, and 5) Future Research Areas.
- The technology businesses cases will be focused around improving safety, enhancing mobility, and fostering economic development.

KEY TECHNOLOGY: Connected Vehicles & V2I Capabilities – *Shelley Row, Shelley Row Associates*
- The main priority for car companies should be V2V. The Government should be play a regulatory role. V2I is going to have a major impact on mobility. This is an area where Government can have a bigger impact.

- V2I is less developed so there is more room for improvement. The Federal Government has not done enough research on exactly how much more increased capacity we can get on the roadways with CVs. There might be some mixed objectives, so it would be good if TxDOT could add some focus to this kind of study.
- The Federal Government is going to start regulating this field in the next couple of years so TxDOT should be prepared. San Antonio has placed some sensors on I-10.
- Signal phase & timing will improve productivity and reduce emissions. There is a lot of talk about these kinds of ideas but not a lot of action. Texas has 6,000 traffic signals. TxDOT operates 5,000 of these signals. 2,500 of the signals are operated on Traffic Management Systems. Additional expertise would be required in order for TxDOT to implement an integrated signal timing program.
- Using LTE will allow vehicles to communicate with each other across farther distances. The technology is available now, and service providers have could assist TxDOT in deploying systems that could be upgraded or expanded in the future. Verizon recommends starting small with one city or district.
- TxDOT should prioritize where would be the best place for a demonstration pilot. TxDOT can use the data collected from the demo to adapt regulations, increase funding, and provide direction to the State Legislature.
- Upon consideration of the privacy and security concerns, TxDOT may consider partnering with service providers.
- For V2I, TxDOT should consider partnering with OEMs to integrate the infrastructure and vehicle technologies in an environment beyond the test track.
- Any pilot program will have to be broken down by industry because freight concerns are different from passenger vehicles.
- Big data raises concerns regarding collection, storage, and management processes.
- OEMs are seeking standardization in this field so the cars can talk to one another. This may be an area where TxDOT could be a useful facilitator.
- TxDOT is assisting the City of Austin with their application for the Smart Cities grant.
- The Waze app allows for crowdsourced incident reporting, however few users provide reliable information regarding incident clearance. This may be an opportunity for TxDOT to provide accurate and timely information.
- TxDOT and the City of Austin have made a lot of data publicly available so people can use it to develop solutions.

KEY TECHNOLOGY: Autonomous Vehicles & Freight Platooning – *Harry Voccola, Nokia/HERE*

- Freight platooning is an established technology that has been demonstrated in several pilots. There is a public education issue. Insurance companies have not weighed in on truck platooning yet due to the perceived risks associated with the technology. Companies are proposing platooning on the road as early as 2017.
- AVs will help with increased capacity but it is another area where TxDOT should considering partnering with an OEM.
- The weight of commercial vehicles and their impact on the infrastructure is something that should TxDOT should consider if freight platooning technology is used to increase the capacity of the highway network.
- TxDOT is planning a commercial platooning project with Volvo and TTI.
- CVs and AVs are synergistic technologies, sharing the same long term objective of producing a crashless vehicle. Many semi-autonomous options available now.
- Austin may be a good test site for AVs since it boasts a vibrant tech industry, it is the capital of the state, and a premier research university provides local expertise. The downtown area could be used to showcase technology in a semi-controlled environment. TxDOT should reach out to OEMs and other technology companies in order to understand what conditions are required to create an ideal ecosystem for small scale deployments.
- Adding digital signs that communicate with AVs but still display information for standard cars is something to consider.
- Google has not shared the LIDAR information they have collected mapping the city. Mapping roads this way is very expensive and roads change frequently.
- A beneficial partnership may involve TxDOT sharing its plans for new or upgraded roads to assist OEMs in maintaining current mapping data. Sensors can also increase the vehicle's confidence in understanding its surroundings.

KEY TECHNOLOGY: Electric Vehicles & Alternative Energy – *Mike Heiligenstein, CTRMA*

- There is a limited role for TxDOT in the electric vehicle and alternative energy space. TxDOT may consider working with the State Legislature to establish an incentive program for clean energy vehicles.
- In order for FCV to be a viable technology, a network of hydrogen fueling stations will be required.
- There was concern that EVs do not specifically address the three goals of improving safety, reducing congestion, or fostering economic development. Since environmental benefits have not been one of TxDOT's historic

priorities, it was recommended that at this time the Task Force prioritize other technologies that better align with the Department's goals.
- Incentives in CA include permitting single-occupant EVs in the HOV lane as well as reducing tolls for clean energy vehicles. If this were to be applied in Texas, the State Legislature, TxDOT, and tolling authorities would need to revise the current policies.

KEY TECHNOLOGY: UAS, Inspection, & Emergency Response – *Jim Crites, DFW Airport*

- UAVs range from recreational to commercial use. There are a variety of sizes with a variety of purposes. The role for TxDOT and the FAA will be in managing the airspace and regulating pilot certifications. These are largely unconnected vehicles. Most UAVs have seek and avoid technology but the smaller recreational vehicles do not have this kind of technology.
- The recreational user can be irresponsible or ignorant in operating the UAV properly. The public has raised some concerns because they do not want them flying over their homes or being used to spy on people. There has been some discussion on using highways as safe spaces to fly UAVs. There are some concerns that any malfunction may cause them to fall into the highway, causing accidents or damage.
- There is some concern as to which government agency is best positioned to regulate the airspace below 500ft. It will most likely require a combination of federal and local regulations.
- Airports are asking for law enforcement assistance to prevent the malicious use of lasers. TxDOT should consider what infrastructure may be required to allow drones and other vehicles to operate safely. Geofencing is one potential solution that can be used to prevent drones from entering certain air space. Most drones have the capability to safely return to their home base when they lose signal. DFW has had issues with drones being flown around the airport.
- Although the FAA regulates UAVs over 55 pounds, helicopter pilots are concerned because smaller vehicles could cause them major damage.
- Standards and regulations could be developed to ensure that drones have seek and avoid technology or return to base technology. When a consumer purchases a UAV, the user is required to register it with the FAA, however this is not universally followed. One potential solution is requiring a code to be entered upon completing registration with the FAA in order to activate the UAV.
- TxDOT is not currently using drones on a large scale. There is an opportunity to use them for traffic management and/or road planning in the future. They could be used to easily share footage from around the state at all levels within TxDOT.

KEY TECHNOLOGY: Big Data, Open Data, & Internet of Things – *JD Stanley, Cisco*

- TxDOT should maintain good quality data. When data is made widely available it gets copied and errors can be introduced. There is a large human element in the collection of data so there can be errors introduced at many stages. When there is a big system for data, there are a lot of stakeholders. It is important to provide context surrounding the data in order to create value for each of the stakeholders.
- Big data is a service that should be designed to be helpful to consumers. A beneficial partnership may be between TxDOT's Lonestar system and Waze in order to provide the consumer with reliable and timely incident warning information. Currently, TxDOT only shares Lonestar information with those who have signed a MOU. TxDOT makes some of its data available through www.data.gov and www.drivetexas.org. TxDOT has also participated in hackathons with DIR. The most recent one produced a new traffic app.
- Using the data TxDOT has collected over the last couple of decades, TxDOT has created models that predict traffic with reasonable accuracy.
- Kaggle is a company that scrutinizes data to identify what can be learned. The Watson team at IBM also analyzes data sets. TxDOT may consider partnering with OEMs and other data sources in order to determine what value may be created. These partnerships may also be able to identify gaps so TxDOT may strengthen its data collection processes.
- TxDOT is currently working on developing a data collection tool based on a virtual warehouse for data storage and management. When developing a new system, it is important to design a practical tool that users will properly maintain.
- There are concerns about data storage since TxDOT has a rule to never throw anything out. Each CV car generates 1GB of data per day.
- Spoofing sensors is another big data concern since this can affect markets and policies.
- Another use for big data is to study construction and maintenance projects to identify areas to improve efficiency.

Opportunity Area Identification – *Dr. C. Michael Walton, UT Austin*

- When discussing the five technologies, it was unclear that UAS would be revolutionary in the near term for the average population. TxDOT may consider implementing UAS for bridge inspections and emergency response applications. It was decided that at this time, UAS is not a priority for the Task Force as a key technology for further business case development.
- Since EV does not specifically advance TxDOT's goals of improving safety, enhancing mobility, and fostering economic development, it was also decided that at this time EVs and alternative energies are not a priority for the Task Force as a key technology for further business case development.
- The Task Force decided to combine CVs and AVs due to their synergistic nature. It was also determined that Freight should be a separate application since this field has so many specific requirements. This discussion produced the following list of three areas where the Task Force should focus moving forward:
    - CVs & AVs
    - Freight
    - Big Data

Closing Remarks – *Darran Anderson, TxDOT*

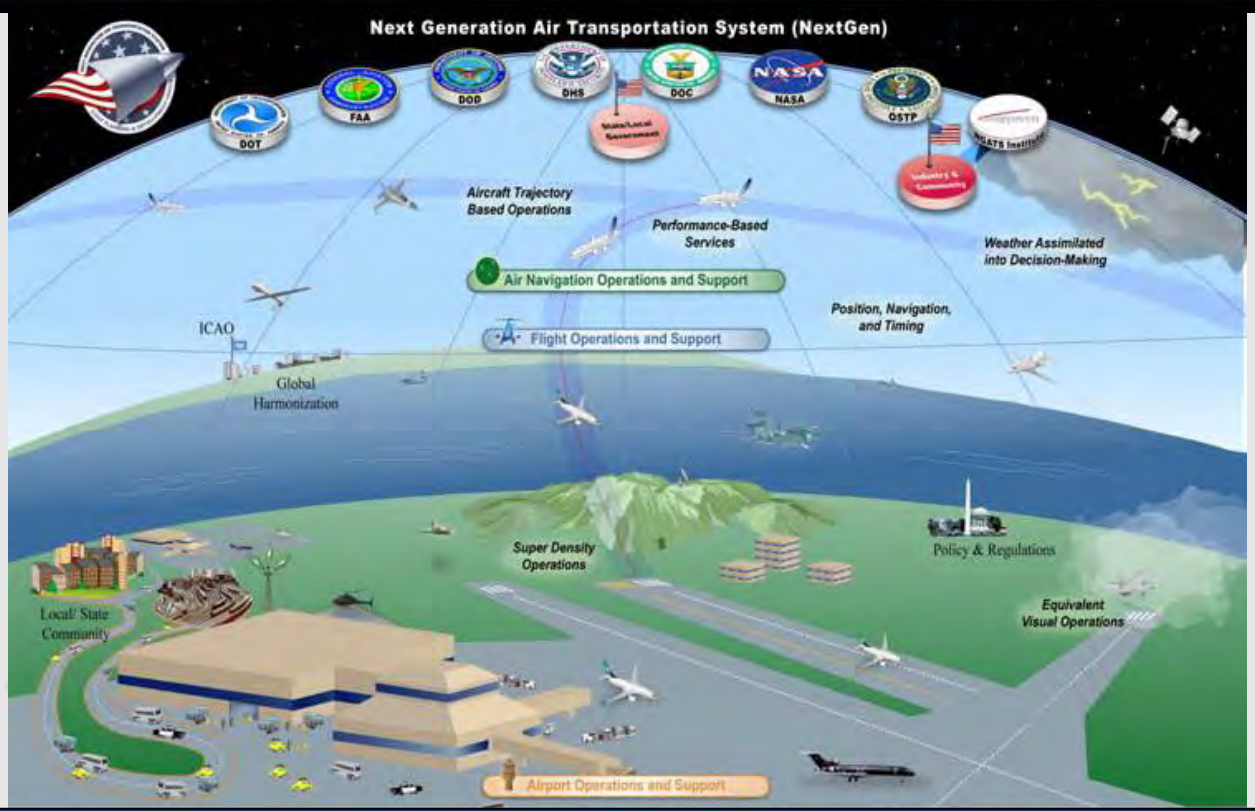
- The TTTF meetings continue to build upon one another and are a valuable resource for information. TxDOT is looking forward to the future and is excited by the role emerging technologies will play in improving safety, enhancing mobility, and fostering economic development. Pilot programs are being planned to lay the foundation for largescale implementation.
- He thanked everyone for participating and encouraged attendance at the next meeting in 3-4 months.






TRANSFORMATIVE TECHNOLOGIES IN AVIATION

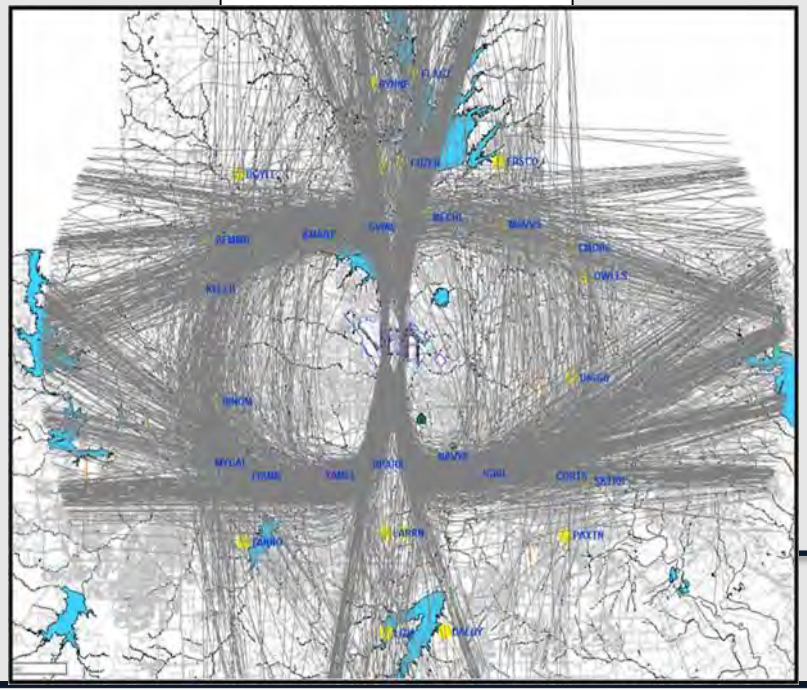
James M. Crites, EVP Operations,
Dallas/Fort Worth International Airport



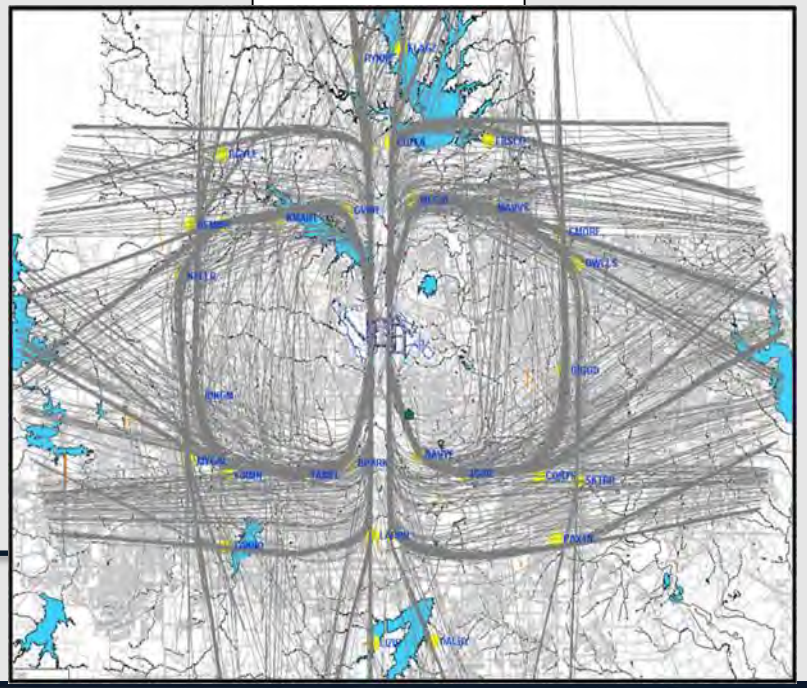
NextGen:

High-performance, Multi-User Technologies Being Fielded Today Integrated/Leveraged Tomorrow

Conventional Departures

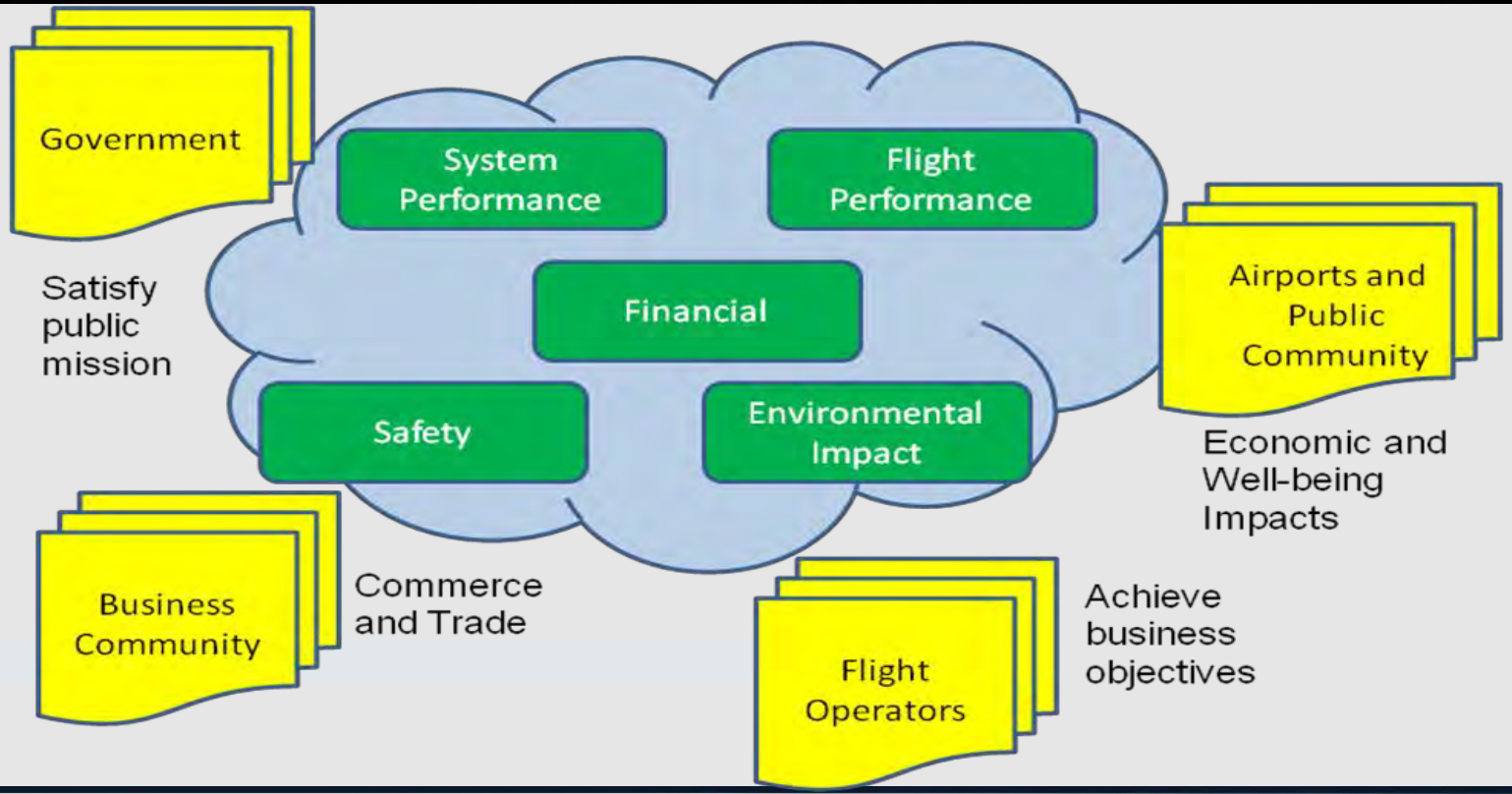


RNAV/PBN Departures



Enhances Capacity and Safety While Reducing Fuel Burn Emissions

Airport Operator Engagement Critical for Addressing Community Impacts



POLICY TRADESPACE – COMMUNITY OUTREACH
(EDUCATION & ENGAGEMENT > > > ADVOCACY)

UNMANNED AERIAL SYSTEMS (UAS)

Advent of recreational UAS/Drones (under 55 lbs) ~ 700k to be sold this Holiday Season

- Uninformed (not “Enthusiasts” with some recognition of risks)
- Accidental impact with aircraft as well as helicopters (tail rotor strike: catastrophic)
- FAA evolving regulation
- FAA providing public service announcements and information “Know Before You Fly”

Commercial UAS Market is substantial

- FAA still developing regulation

Community Outreach

- FAA partnering with airports and local communities and institutions to familiarize potential recreational users of risks and obligations to ensure safe flight
- FAA partnering with local law enforcement to provide consistency in enforcement

Enabling (Disruptive) Technologies: A technology that displaces an established technology and shakes up the industry or a ground-breaking product that creates a completely new industry.

- Challenge: efficiently adapt existing code, rules, regulations to effectively address public safety and security to accommodate both new and “replaced” legacy technologies
  - Computer, Cell Phone, NextGen, UASs, Transportation Network Companies (e.g,. Uber, Lyft), 3D Printing, Renewable Energy, Social Media
- Challenge: pace of research (developing understanding of risk as well as mitigation measures) versus Market expectations for enabling new technology
- Necessary supportive infrastructure, environments, and policies for them

Intermodal planning and interfaces

Emerging Security Threat and Implications on Transportation as well as Trade and Tourism Industries

- 9/11
  - *Aviation* Transportation Security and Compliance (*ATSAC*) Legislation
  - $850B + adverse economic impact on U.S. Travel and Tourism Industry
  - Potential permanent market shift of International Gateways
  - Added cost of travel (time, $, resources) > Price elasticity of demand – mode shift
- Challenge/Opportunity: Emerging Technology as a means to both safeguard the public as well as the marketplace to include the Transportation/Travel/Trade Industries
  - Expedited research to enable rapid development/implementation

Alcatel·Lucent

Mobile Network Evolution Update

Agenda

- Current state of 4GLTE
- IoT (Internet of Things)
- Movement towards 5G

Will this evolution continue?.....What's Next?

Network is continually evolving and expanding

HD Voice And Video calling

LTE Multicast

QoS - traffic management

Densification of the Network

More cove
in more pl

Deliver higher-quality
air interface

Provide 5 bar
voice quality

Metro cells also improve
QoE for users remaining
On the macro network

End users enjoy higher
throughput and faster, more
reliable data connections

IMPROVES QOE

Evolving and Bringing New Capabilities

Using all spectrum types

Extending LTE Advanced to unlicensed spectrum

Making Wi-Fi a virtual extension of LTE

Empowering new services

LTE Direct always-on proximity awareness

Evolving LTE Broadcast, going beyond mobile

Connecting more industries

Optimizing LTE Advanced for machine-type communications

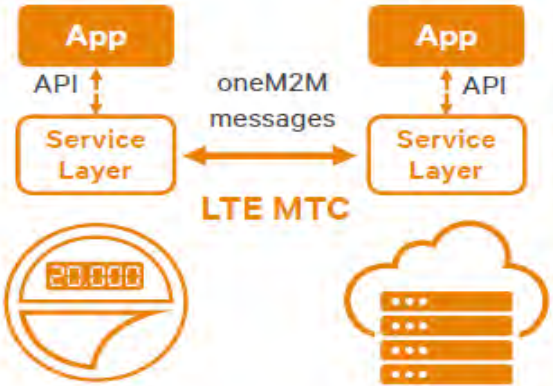
Connecting more verticals like cars

LTE Advanced

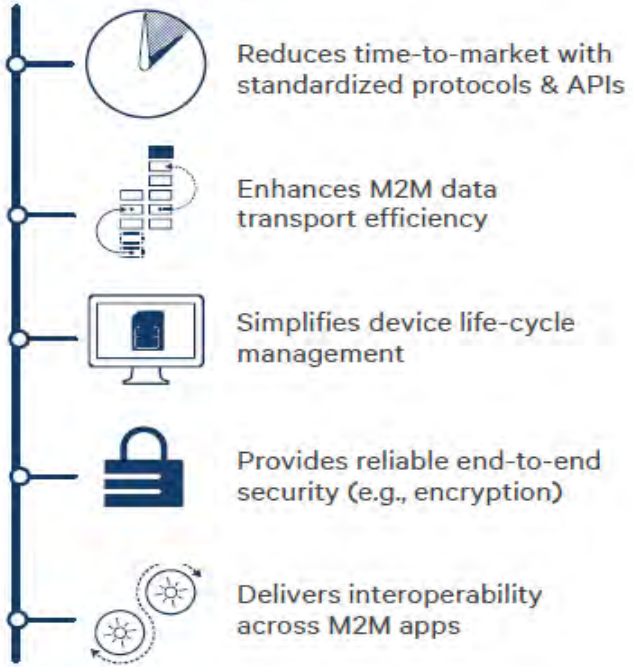
Rel. 12 & beyond

MTC – Industry working standardized Service Layer

oneM2M provides a secure and efficient end-to-end data/control exchange



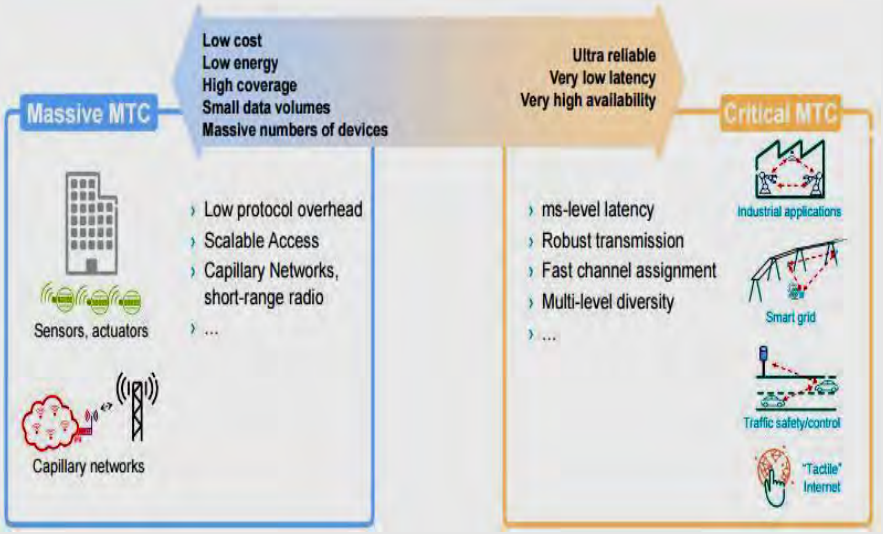
- Middleware between M2M apps & communication HW/SW
- Typically implemented upon IP
- Provides functions common across M2M apps



Challenges/Opportunities with IoT/M2M

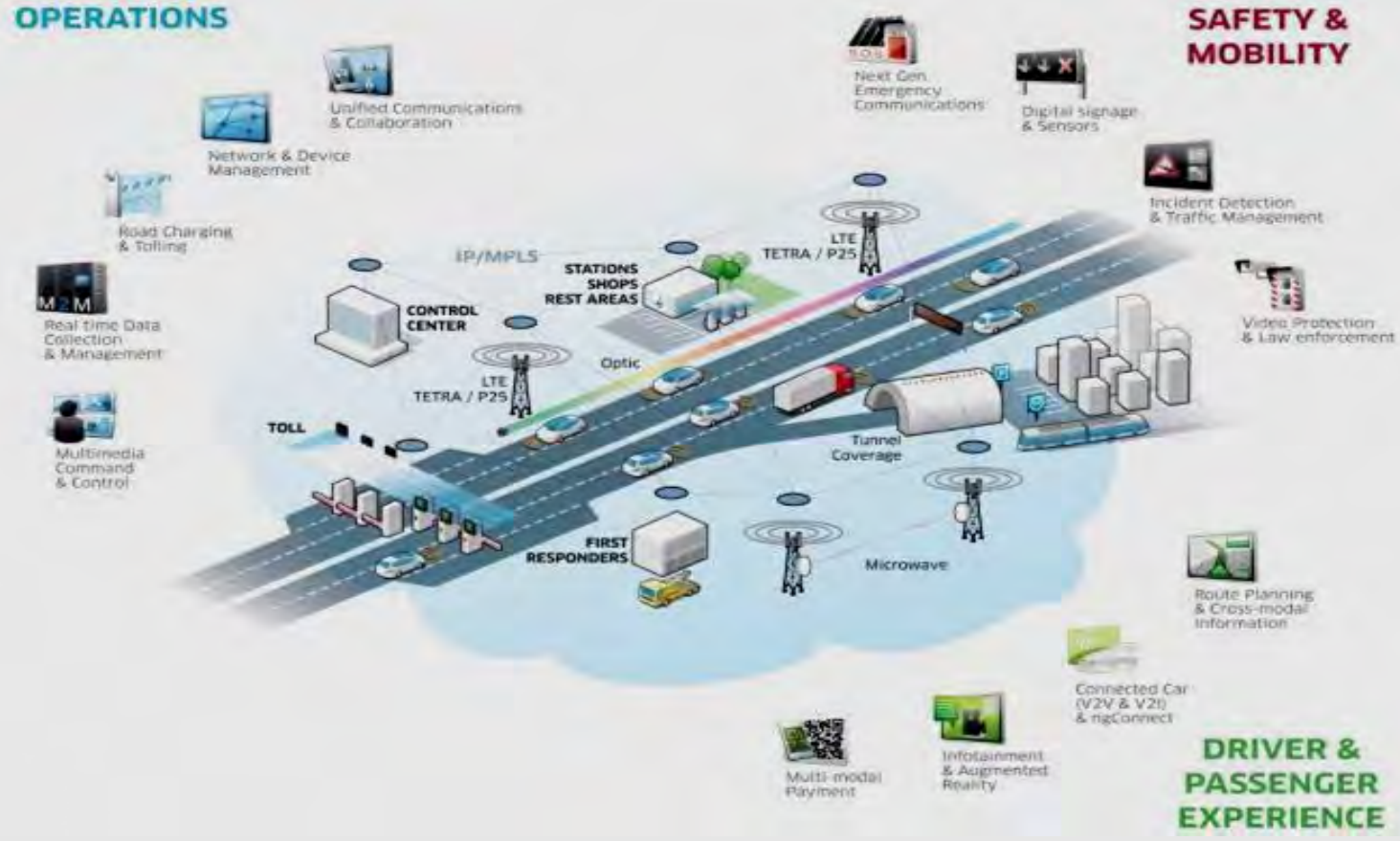
- Anticipated growth in the # of devices: 1 to 2 Billion mobile MTC devices by 2020. Growth rate expected to be 25% to 40% YoY

  (Source: GSMA Intelligent – Sep 2014; Heavy Reading-Aug 2015).
- New/Evolving Standards
- Wide spectrum of verticals and devices to address:
  - Low cost/low power consumption / massive deployments
  - Mission critical MTC
  - Streamlined, robust testing with quick turn aroun to meet time to market

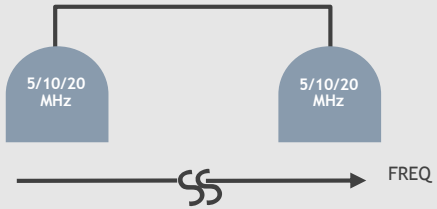


vRAN addresses challenges and unlocks new opportunities

SMART HIGHWAYS

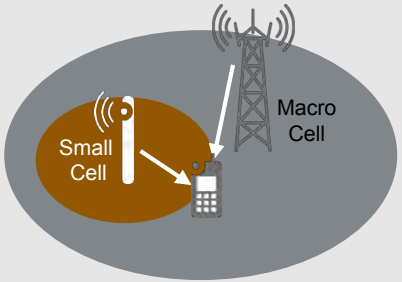


LTE-advanced Offers Key Enablers for 5G

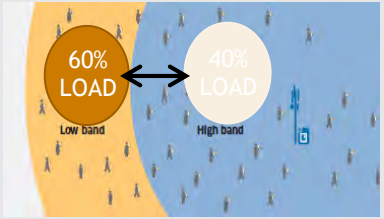


CARRIER AGGREGATION FOR COMBINING MULTIPLE LTE CARRIERS

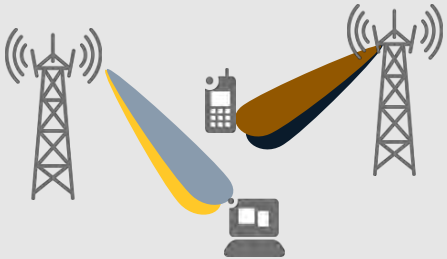
MIMO ENHANCEMENTS FOR CELL EDGE AND CAPACITY



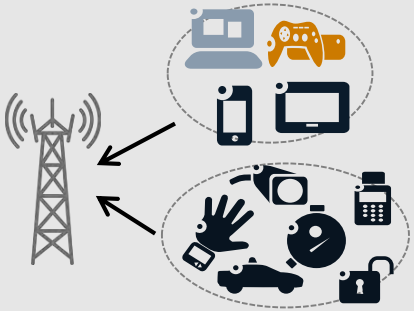
DUAL CONNECTIVITY FOR COMBINING SITES



CARRIER AGGREGATION FOR LOAD BALANCING



CoMP FOR CELL EDGE AND CAPACITY



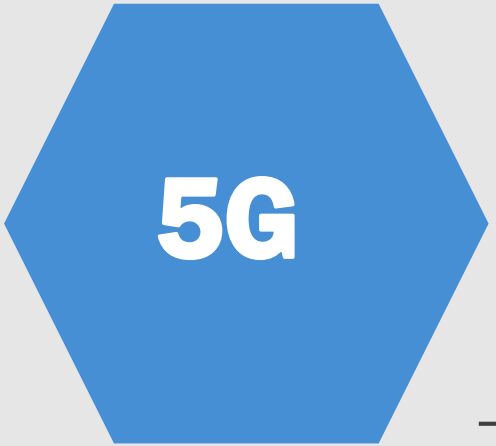
MTC ENHANCEMENTS FOR CAPACITY, COVERAGE AND COST

What's Driving 5G?

BROADBAND
- Massive traffic capacity
- Reduce Cost
- Spectrum efficiency
- Access new spectrum

INNOVATIVE SERVICES
- Flexible bearer design
- 3rd party policy

EXTREME DENSITY
- Massive user density
- User content



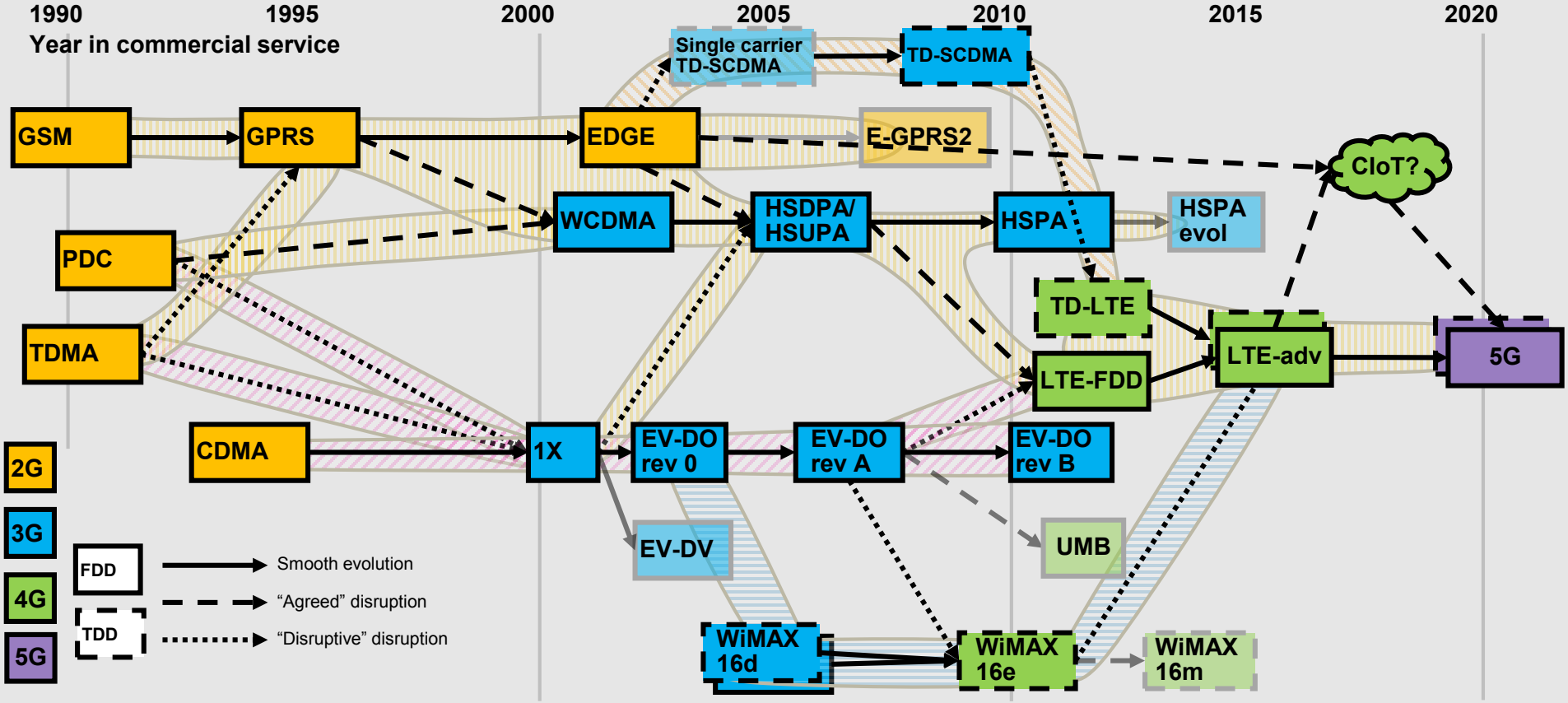
MISSION CRITICAL
- Very low latency
- High reliability
- High availability
- Security

BATTERY LIFE
- Signaling reduction
- Energy optimization

NON TRADITIONAL DEVICES
- Short packet
- Sporadic access
- More devices
- More device types

5G Will FOCUS ON SOLVING THESE ISSUES

30 years of Evolution and disruption



Proposed 5G Use-Case Categories

Broadband access in dense areas PERVASIVE VIDEO 	Broadband access everywhere 50+ MBPS EVERYWHERE 	Higher user mobility HIGH SPEED TRAIN 	Massive Internet of Things SENSOR NETWORKS 
Extreme real-time communications TACTILE INTERNET 	Lifeline communications NATURAL DISASTER 	Ultra-reliable communications E-HEALTH SERVICES 	Broadcast-like services BROADCAST SERVICES 

DEFINING 5G – WHAT'S INVOLVED?

TIMELINE FOR 5G STANDARDS AND ROLLOUT

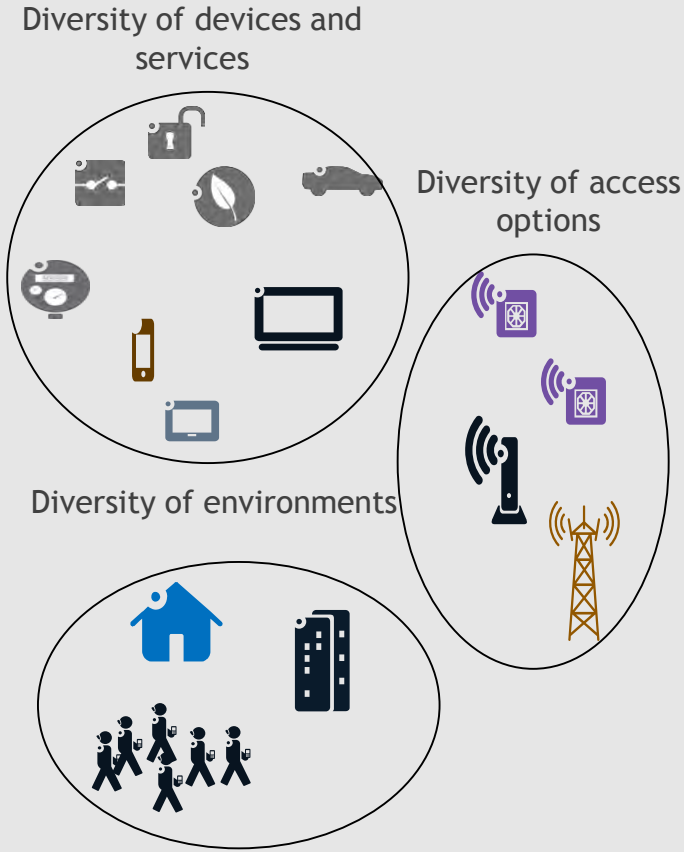
Period	3G	4G	5G	3GPP Releases	ITU-R Recommendations
1995-2000	Principles Initial specs (rel99)			Rel3 (99)	
2000-05	Deployment and ongoing evolution	Research (OFDM, MIMO)		Rel4-7	IMT-2000
2005-10	Mainstream adoption	Principles Initial specs (Rel8)		Rel8-9	IMT-2000 updates
2010-15	Maturity	Deployment and ongoing evolution	Research	Rel10-12	IMT-2000 updates IMT-Advanced
2015-20	Declining usage?	Mainstream adoption	Principles (SI rel14) Initial specs (WI Rel15)	Rel13-16	IMT-Adv. updates IMT-2020
2020-25		Maturity	Deployment and ongoing evolution	Rel17-?	IMT-2020 updates

Generations arrive every 10 years and take about 10 years from early research to deployment
5G will most likely be available from 2020

5G Radio: NEW AIR-INTERFACE needed

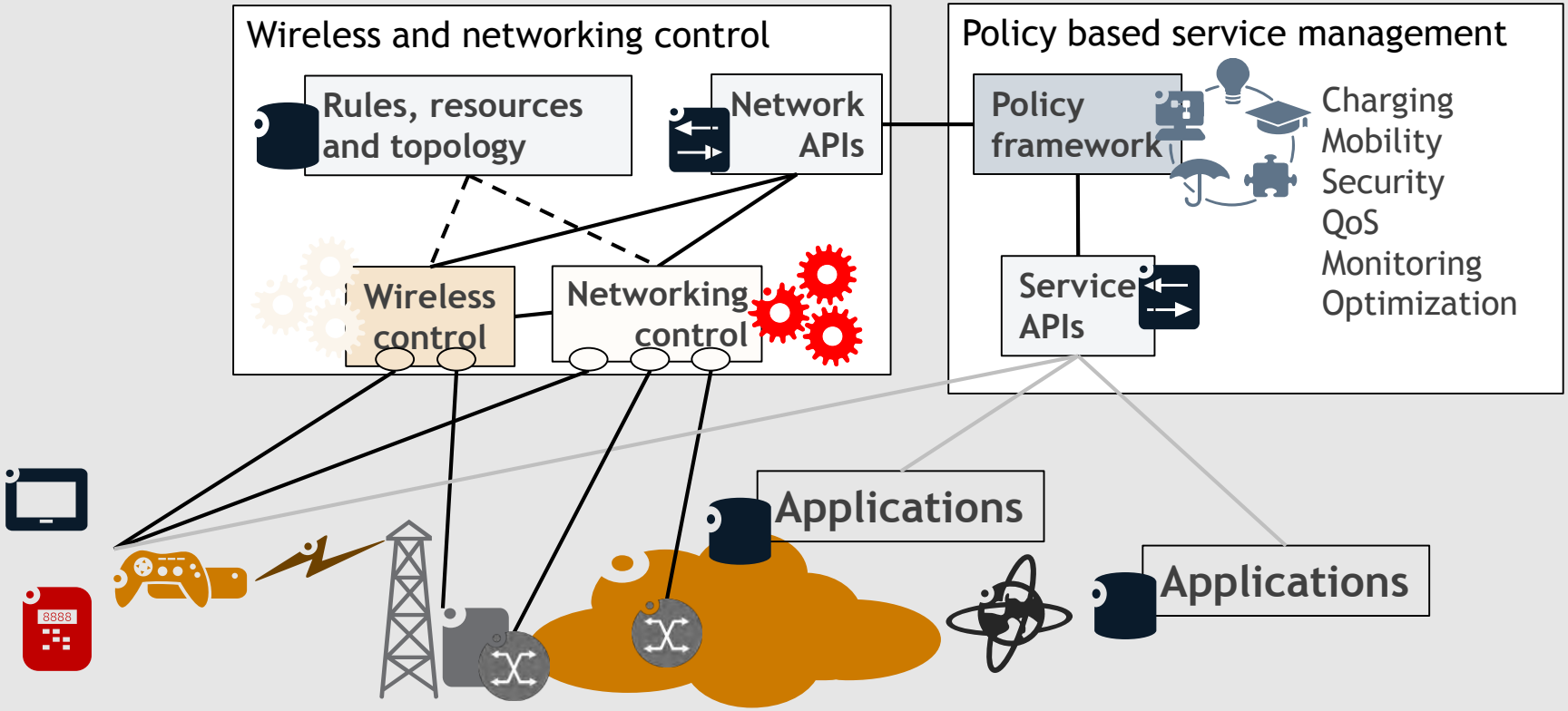
- Unified framework for multiple services with different requirements
  - Spectral efficiency improvement for short bursts
  - High battery life for short packet IoT devices
  - Very low latency for critical applications
  - Acceptable performance out to cell edge

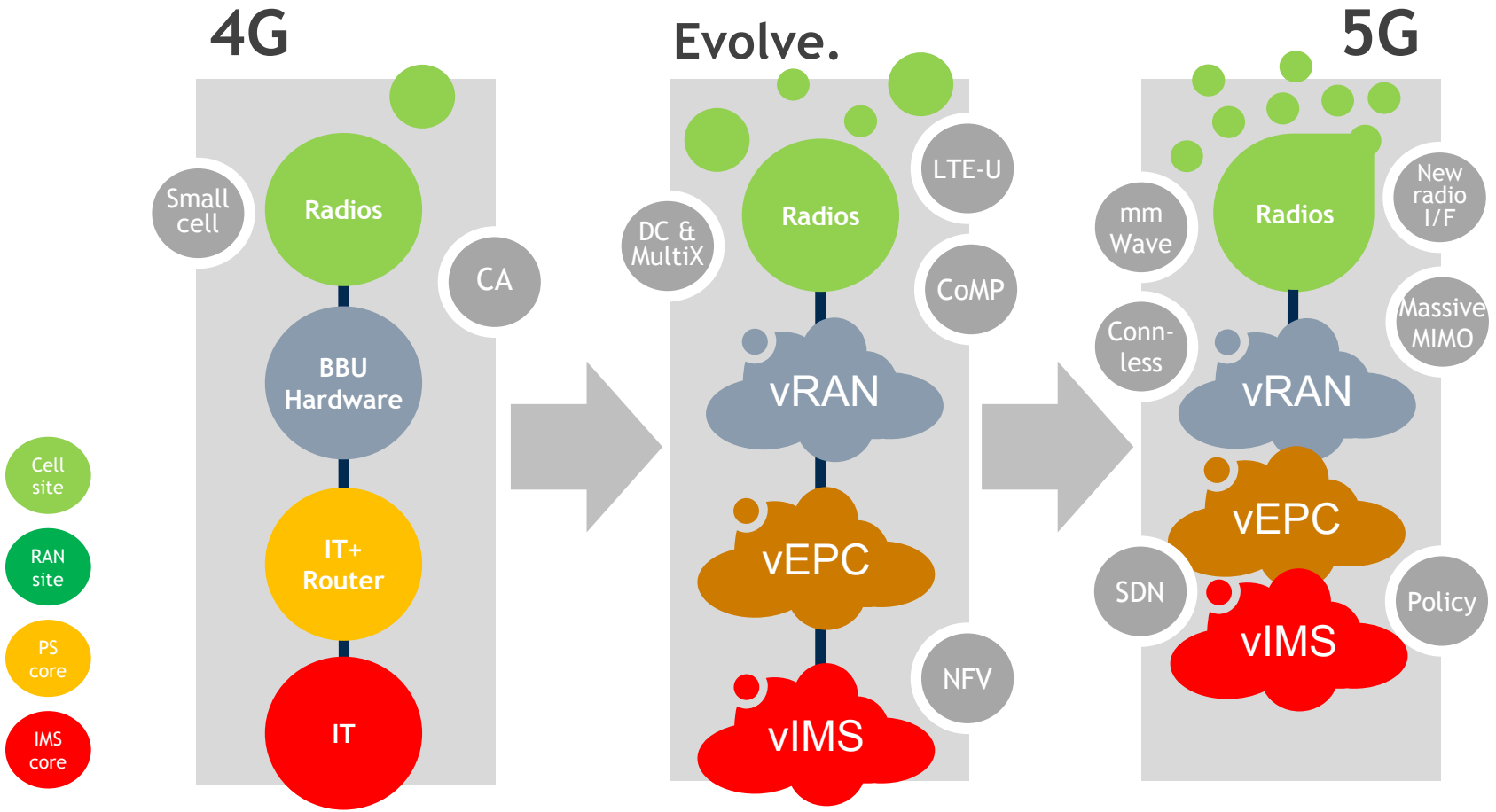
- Flexibility to optimize the parameters for different situations
  - Service needs (latency, activity, performance)
  - Vehicle speeds (static/nomadic to 500 km/hr)
  - Environments & Propagation (indoor/small cell/macro in urban/rural)



WHAT WILL 5G Network LOOK LIKE?

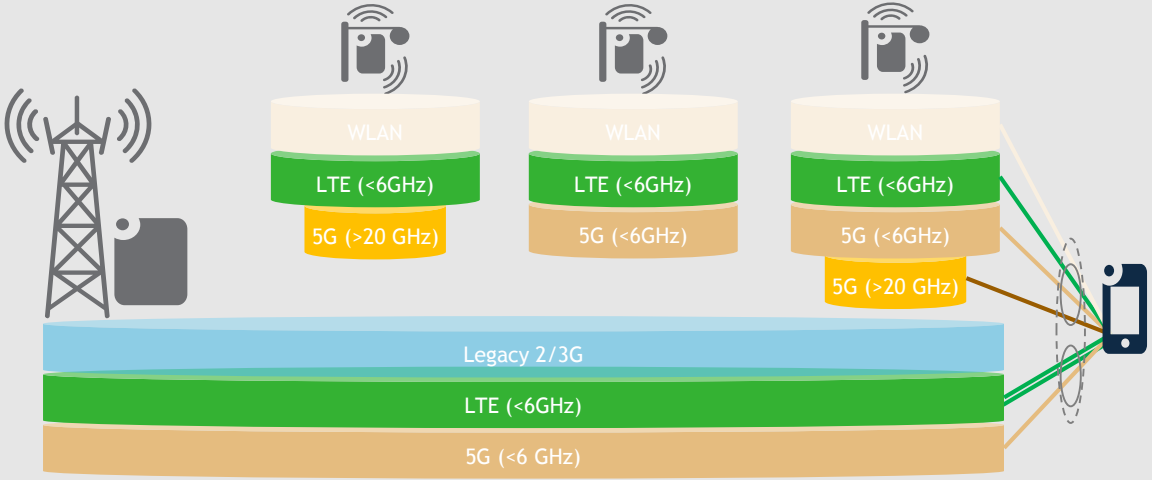
5G WILL use policy control to adapt the network to the user




4G
Evolve.
5G
Small cell
Radios
CA
BBU Hardware
IT+ Router
IT
DC & MultiX
Radios
LTE-U
CoMP
vRAN
vEPC
vIMS
NFV
mm Wave
Radios
New radio I/F
Conn-less
Massive MIMO
vRAN
vEPC
SDN
vIMS
Policy
Cell site
RAN site
PS core
IMS core

WHAT WILL 5G LOOK LIKE?

5G Radio: COMPLEMENTS 4G AND WLAN



MULTIPLE CARRIERS AND SITES

Combined using Carrier Aggregation and Dual Connectivity
Combining 5G, LTE and WLAN interfaces

5G (<6 GHz) on MACRO and SMALL CELL

- Coverage
- Connectionless service
- Low latency bearers
- Capacity

5G (>20 GHz) on SMALL CELL

- Massive Capacity
- Extreme low latency
- But unlikely to match lower band coverage

LTE EVOLUTION on MACRO and SMALL CELL

- Coverage for 4G
- Capacity for 4G and 5G
- Fallback coverage for 5G

WLAN on SMALL CELL

- Capacity for 5G and 4G
- Standalone service for any device

5G Radio: Macro and Small Cell layers, low and high bands plus LTE and WLAN

GERI YOZA

NATIONAL BUSINESS PLANNING MANAGER TOYOTA MOTOR SALES USA

G21 vision

DEVELOP A SMALL VEHICLE WITH A LOT OF ROOM, HIGH FUEL ECONOMY, AND LOW EMISSIONS WITH NO SACRIFICE IN PERFORMANCE

2000 MARKET CONDITIONS

environmental outlook 2000

BROAD PUBLIC CONCERN FOR ENVIRONMENT, especially AIR POLLUTION

2001 prius goals

GAIN DEALER PARTICIPATION & SUPPORT FOR HYBRID SALES & MARKETING- LAUNCH SALES PLAN: 12,000 UNITS

public relations pre-launch activities

PRIUS FAMILY DEMO program

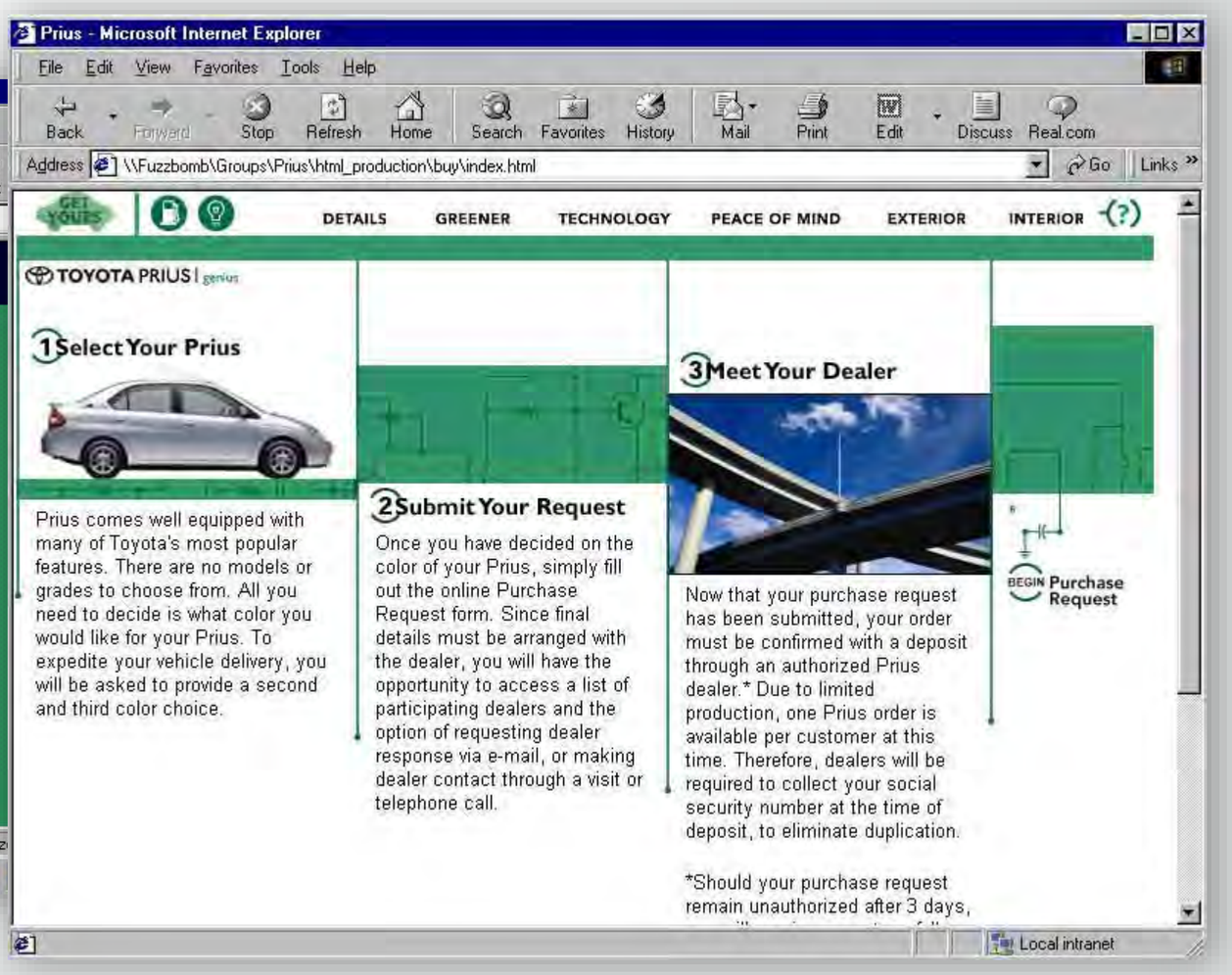
targeted PRIUS BUYERS

advertising

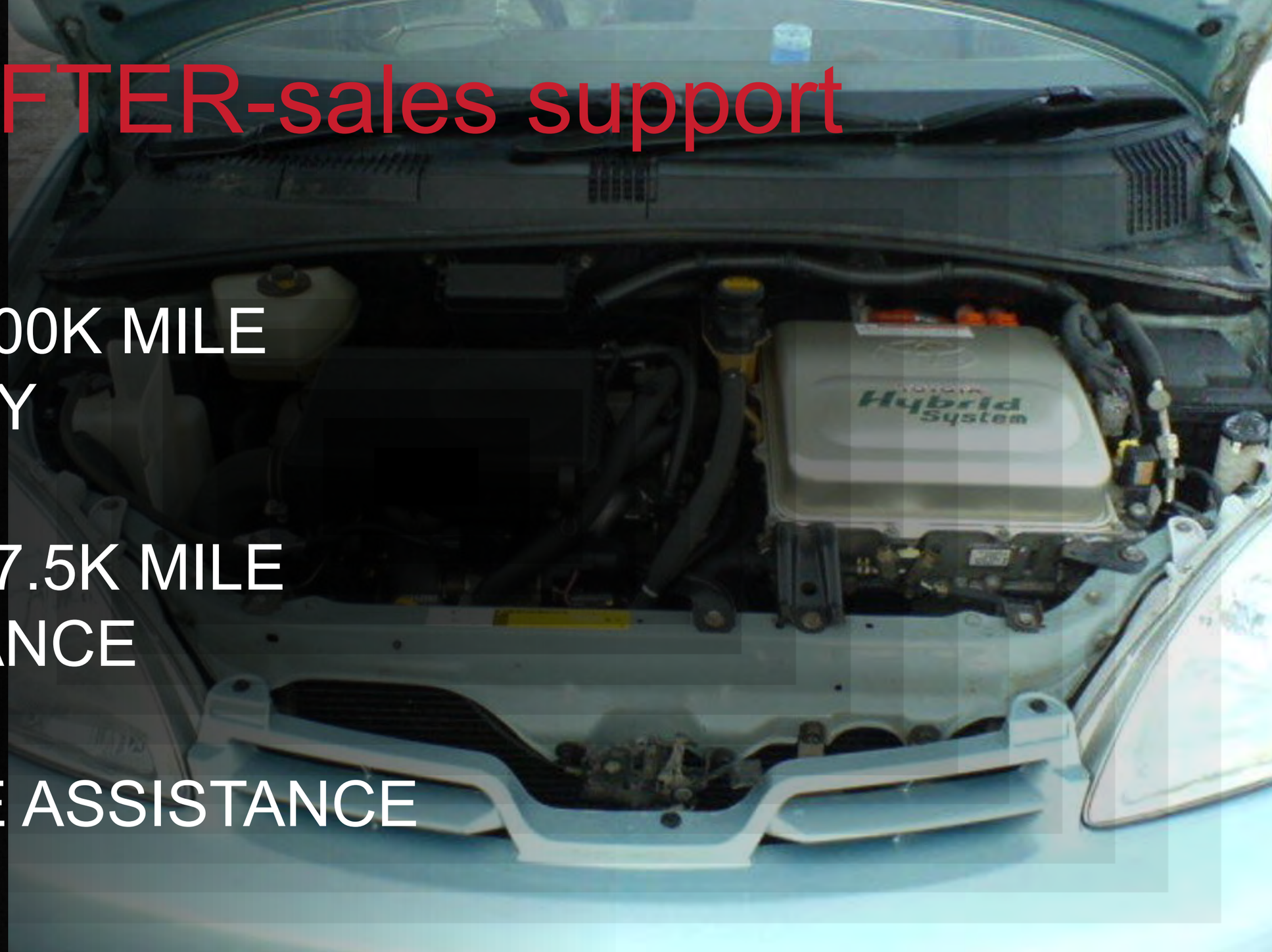
The new car for a used world.

PRIUS | genius

new SALES process



strong AFTER-sales support



- 8 YEAR / 100K MILE WARRANTY
- 3 YEAR / 37.5K MILE MAINTENANCE
- ROADSIDE ASSISTANCE

stringent DEALER requirements

Toyota hybrid and FCV experience

World’s First production hybrid vehicle: Generation I Prius
7 hybrid models available in 2015
7 million+ hybrids sold WW

FCV is the next step in the electrification of the hybrid powertrain
FCV is the product of 20 years of in-house hydrogen FC development
FCV system is scalable and can be used in a variety of body platforms

hydrogen

Most plentiful element in the Universe

Non-toxic

Dissipates quickly (lighter than air)

Produced from natural gas and renewable sources: biogas, wind, water

Transported and stored easily

why sell commercially viable FCV NOW?

- ***Lowers*** fuel cell production costs
- ***Lowers*** hydrogen costs
- ***Increases*** accessibility to hydrogen fueling infrastructure
- ***Increases*** customer (retail & fleet) demand

INTRODUCING

MIRAI

NO compromise

An environmentally-sensitive ZEV that places no limitations on the owner

Same usability, range (EPA-certified 312 mi) and refueling time (about 5 min) as gasoline vehicles

Efficient power package that does not take away from the roomy, comfortable interior

Mirai LAUNCH

LEAVE YOUR MARK
TOYOTA.COM/FUELCELL | TOYOTA Let's Go Places

CA deliveries began Oct 21st with 8 dealers
- Deliveries in NE States (NY, NJ, CT, MA, RI) in 2016
- Anticipate 3K cars on the road by 2017 YE

MSRP: $57,500
- $499/mo lease (3-yr/36K-mi term)

Strong Ownership Experience Program:
- 3 years' worth of complimentary fuel
- 3 years factory maintenance and roadside assistance
- 8-yr/100K-mi warranty on key components
- 24/7 customer call support

potential buyers

MIRAI buyers are trailblazers

One-Way Mars Colony Project Draws 200,000 Volunteers

By Megan Gannon, News Editor | September 11, 2013 03:42pm ET

1269 Share

60 Tweet

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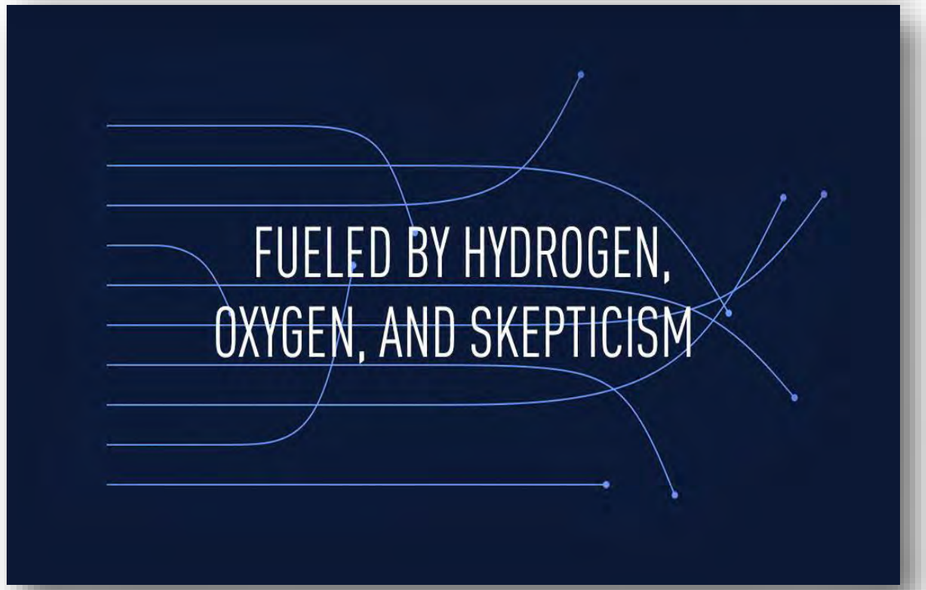
Artist's concept of Mars One astronauts on the Red Planet. Pin it

Credit: Mars One / Bryan Versteeg

View full size image

digital-focused marketing

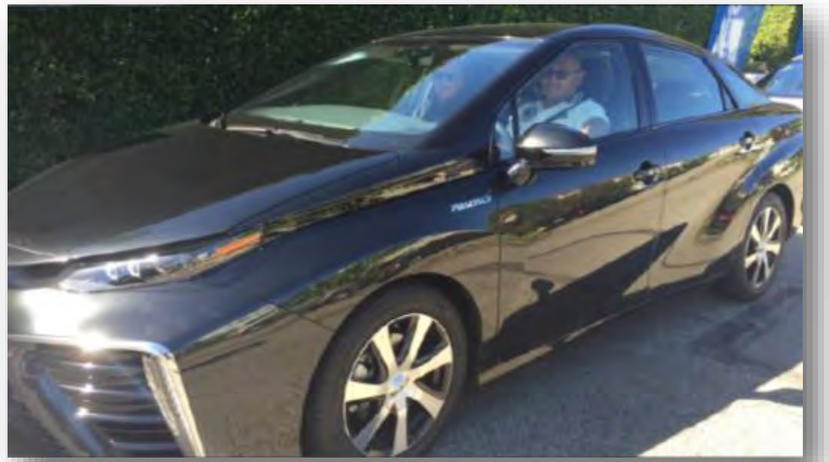
communications messaging



educational video campaign


FUELED BY
THE FUTURE

TURNING POINT summer tour



convenient customer H2 FUELING

Mirai well-received

“This is so exciting…it’s finally starting to come true! It’s no longer out of a sci-fi movie.”

“Mirai is a chance to align my values with my behavior…the future is here and I want to be a part of it with the greatest.”

“Surprising. Impressive! Honestly changed my impression of Toyota.”

lessons learned

Be Authentic

Provide Value & Convenience

Stay the Course

policies & incentives key to FCV market & fuel station development

Vehicles:

- CA Clean Vehicle Rebate Program: $5K rebate towards FCV purchase/lease
- CARB Public Fleet Pilot Project: $15K rebate towards purchase of a ZEV
- DMV White Sticker (for ZEVs) allows single occupancy in HOV lane and discounted tolls
- Various municipalities offer vehicle rebates and preferential/free parking

Stations:

- CEC funding for station construction and operation
- Go-BIZ: CA Governor's office liaison for infrastructure (station) development
- Workshops (Codes and Standards, First Responder Training, Standardized Permit Process, FCV Market Readiness)
- Industry collaboration (CAFCP, CHBC, government agencies, OEMs)

remaining challenges

OEMs:

- Bring out FCVs in volume
- Making FCVs profitable over time
- Continue to develop market for hydrogen

State Government:

- Work with states to identify funds to support FCVs and station development

Federal Government:

- Engage government to re-instate $8K federal tax credit

Oil & Gas:

- Be bold and keep advancing investment in fueling
- Develop an accelerated path towards affordable green hydrogen

www.toyota.com/fuelcell

www.toyota.com/mirai

Southwest Research Institute®
Cybersecurity and Connected Vehicles

Josh Johnson

Assistant Director R&D – Intelligent Systems Department

Presentation Outline

- Cybersecurity
  - How prevalent
  - How it is accomplished
- Connected Vehicle
  - Where is it vulnerable
  - How is it hacked
  - What are the points of exposure in a deployment
- Next steps
  - What should you be concerned about

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Could hackers seize control of your car?

By Barry Neild, CNN
updated 5:43 AM EST, Fri March 2, 2012 | Filed under: Mobile

(CNN) -- When car companies begin exhibiting at mobile
shows, it's a sign that the "connected" vehicle has truly ar
allowing us to take our digital lives with us as we hit the h

But while Ford's unveiling of its latest car at Mobile Worl
-- a major cell phone industry event -- this week may have
new automotive age, it also heightens fears that our techr
crammed cars could be hijacked by hackers.

Just like our PCs and smartphones, the computerized cor
that have infiltrated almost every aspect of modern vehicl
potentially be broken into, experts say. Only, with a car, th
have far more dangerous consequences.

COMPUTERWORLD

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Security

Application Security | Cybercrime and Hacking | Mobile Security | Privacy

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Car-hacking: Remote access and other security issues

It's not time for full-on panic, but researchers have alre
applied brakes remotely, listened into conversations an

By Linda Melone
August 6, 2012 07:00 AM ET | 14 Comments

+Briefcase | More

Computerworld - A disgruntled former employee of Texas A
chose a creative way to get back at the Austin-based deale
into the company's computers and remotely activated the v
immobilization system, which triggered the horn and disabl
system in more than 100 of the vehicles. The dealership ha
system in their cars as a way to deal with customers who fe
payments.

Police arrested the man and charged him with breach of computer security.
His legal status was unclear as of our deadline for this story.

Out-of-control honking horns may be annoying, but other types of hacking,
such as cutting the engine of unsuspecting drivers, could have deadly
consequences. Although most experts agree there isn't an immediate risk,
vehicle hacking is something that bears watching.

A 2011 report (PDF) by researchers at the University of California, San
Diego and others site numerous "attack vectors," including mechanics' tools,
CD players, Bluetooth and cellular radio as among the potential problems in
today's computerized cars.

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Sci-tech | Hackers steer a new route – to your car

Breaking News | French President François Hollande says France will support military operation in Mali but st

SCI-TECH hi-tech

Hackers steer a new route – to your car

25/09/12 13:18 CET

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Exclusive: CEO says hackers tried to extort data, money

Karim Hijazi knew his nightmare was just beginning when he saw that a mysterious e-mail had arrived in his inbox at 3 a.m. on May 26 that included his e-mail password and the subject line "Let us talk."

That would mark the beginning of a weeklong saga of e-mail exchanges and Internet Relay Chat (IRC) discussions in which Hijazi says a group of hackers told him they wouldn't publicly divulge information they had gotten from snooping on his accounts if he revealed sensitive security information acquired by the botnet-tracking firm, Unveillance, that he launched last year. The hackers, who call themselves LulzSec, wanted to know the whereabouts of compromised computers on the Internet that when remotely controlled are used en masse to attack Web sites, he told CNET in an exclusive phone interview late last night.

When he refused, LulzSec went public with his data, Hijazi says, posting his personal contact information, e-mails, and chat logs for download online yesterday as part of a campaign to embarrass the FBI and its InfraGard partner. The group had hacked the Web site of InfraGard Atlanta and grabbed usernames and passwords for about 180 members, including Hijazi. Because Hijazi had used the same password on the InfraGard site that he used on his personal Gmail account and his corporate Google Apps account, the hackers were easily able to spy on his personal and business activities.

Hijazi contacted the FBI right after that first LulzSec e-mail and said he plans to prosecute if he can.

"They had me under the gun for a little over a week with threats and extortion," said Hijazi, chief executive of Unveillance. "The very nature of having to contend with someone who is holding something ransom is not pleasant."

8/13/2015
02:15 PM

The Summer Of Car Hacks Continues

New research shows how SMS messages manipulating vulns in insurance dongles can kill brakes on cars.

Ericka Chickowski
News

The summer of car hacks continues this week as another set of researchers demonstrated how it's possible to affect the control of a car's braking system without even engaging with any electronics embedded in the car itself.

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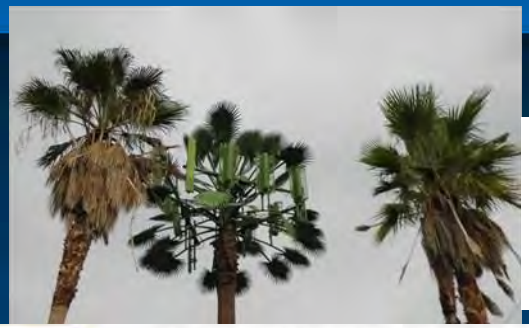
Big Data S

Cellular Security Topics in the News…



TECH 9/03/2014 @ 3:00AM | 13,849 views

Rogue Cell Towers Could Be Intercepting Your Call

A--REQUEST FOR INFORMATION (RFI) / SOURCES SOUGHT (SS) NOTICE INVESTIGATION FOR CELLULAR LONG TERM EVOLUTION (LTE) TECHNOLOGIES

Solicitation Number: W56KGU14RA012
Agency: Department of the Army
Office: Army Contracting Command
Location: ACC-APG - Aberdeen Division A

Markets | Fri Jan 30, 2015 10:15am EST

BMW fixes security flaw in its in-car software

FRANKFURT

Army examines feasibility of integrating 4G LTE with tactical network

September 25, 2012

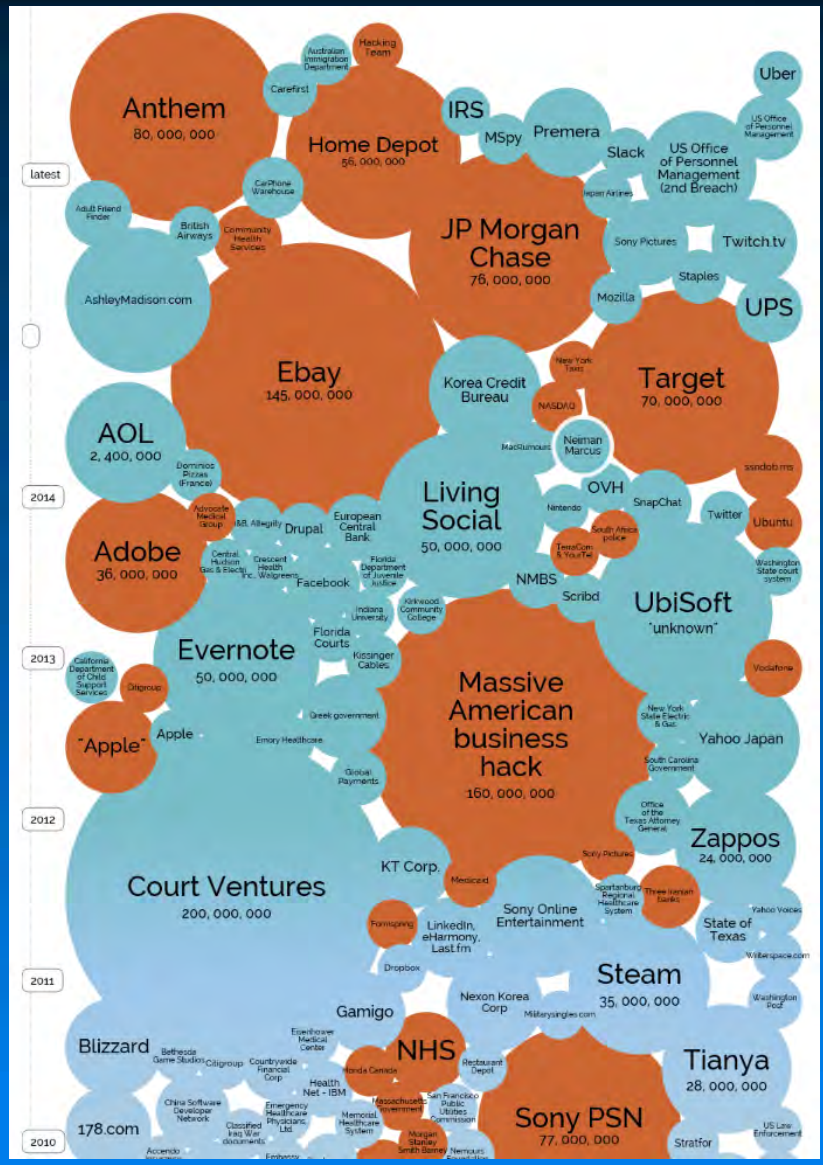
By **Edric Thompson, RDECOM CERDEC Public Affairs**

Stingray Tracking Devices: Who's Got Them?

Data Hacks

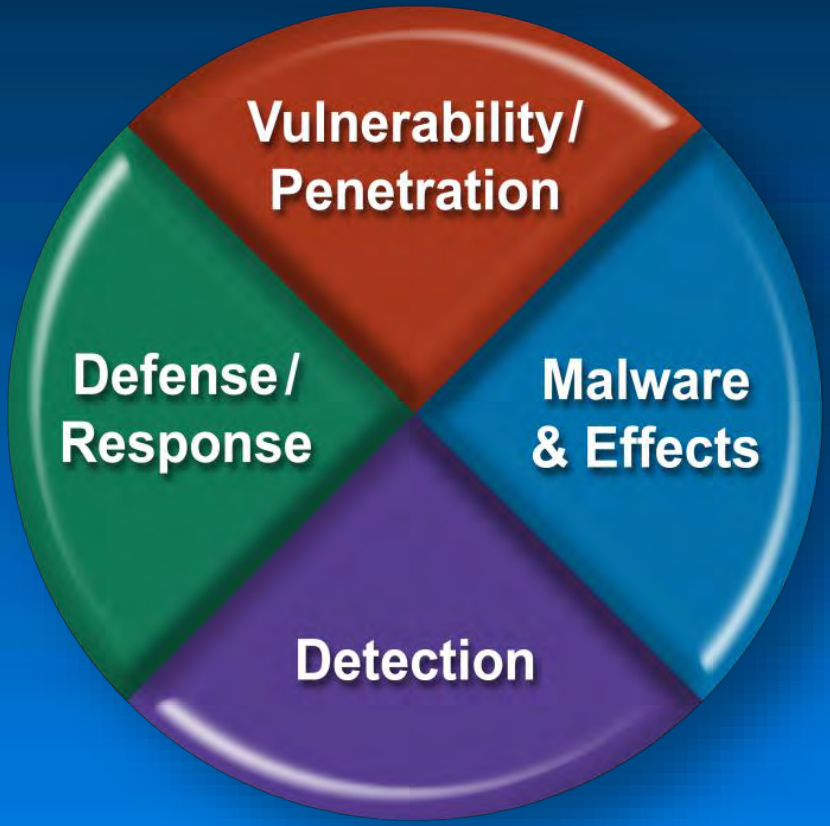
(source: http://www.informationisbeautiful.net)

- What is being hacked:
  - Social network data
  - Smartphone app data
  - Online/Offline shopping
  - Car navigation data
  - Biometrics
  - Healthcare data
  - IoT telemetry
  - Smart grid pricing & usage
  - Intellectual property
  - Industrial diagnostics
  - Demographic data
  - National security data
  - Etc.
- What is your story?



Four Major Aspects of Cybersecurity

- How Can Someone Gain Unauthorized Access?
- What Could They do if They Gained Access?
- How Can We Detect Unauthorized Access?
- What Can be Done in Response to an Attack?



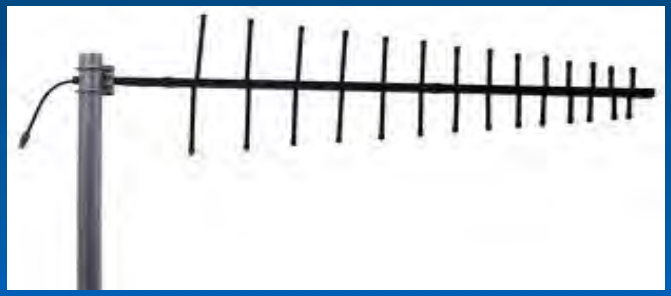
How Do Cyber Attacks Occur:
Physical Attacks

- Assesses what attacks may be performed with physical access to a system.

- Recovery of system secrets
  - Cryptographic Keys
  - Passwords
- Intercept communications
  - Network and IP Traffic
  - Internal Signals
- Modify and inject traffic
  - Serial
  - Cellular
  - CAN

How Do Cyber Attacks Occur:
Wireless Attacks

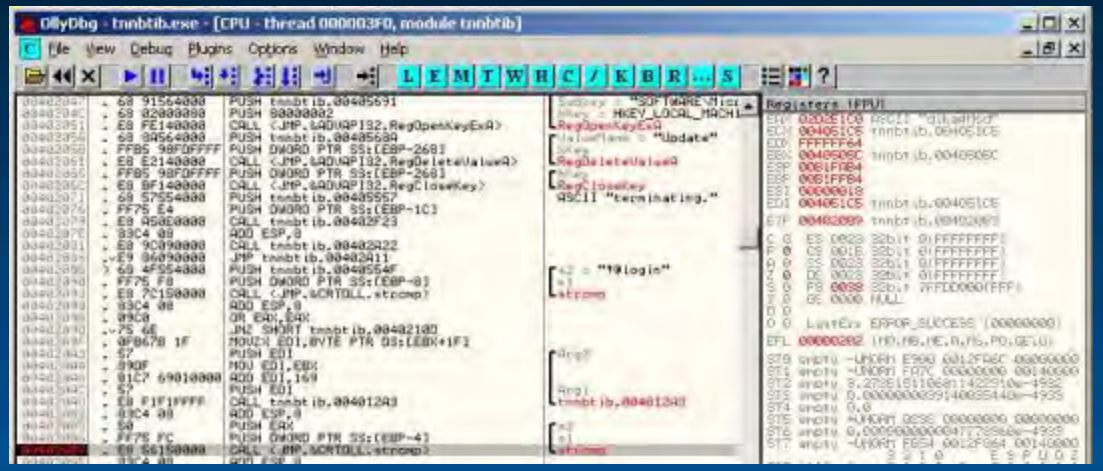
- Types
  - Cellular
  - CB Radio
  - Mesh Network
  - WiFi
  - Bluetooth®
- Approaches
  - Denial of service
  - Device Spoofing
  - Traffic Injection
- Tools
  - Software Defined Radio
  - Custom Hardware and Software



How Do Cyber Attacks Occur:

Software Attacks

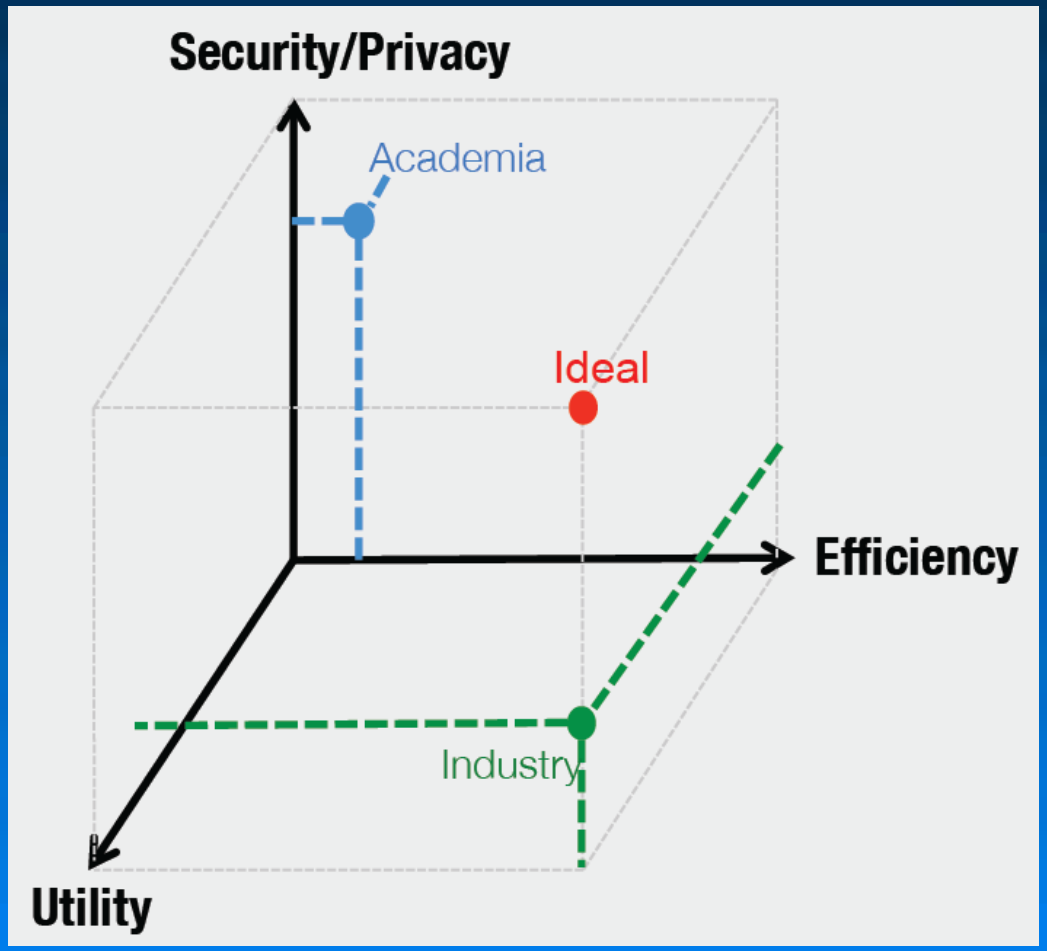
- Types
  - IP / Network
  - Embedded Firmware
  - Business Applications
  - Web Applications
- Approaches
  - Reverse Engineering
  - Fuzzing
  - Configuration Analysis
  - Design Review
- Tools
  - Backtrack / Kali Linux
  - Disassemblers / Debuggers
  - Custom Scripts



Cybersecurity is not “one” Entry Point

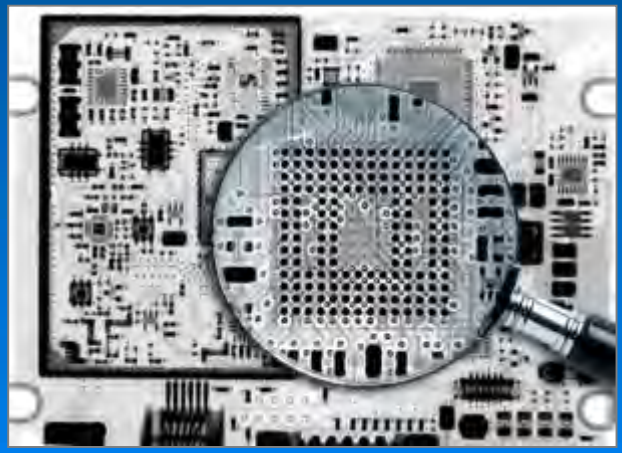
Security is a Balance…

- How much do you want to pay for security?
  - Usually not a lot until you are compromised ☺
- Like all technology solutions, a balance has to be reached based on funding, accessibility and reality
- Every organization has to decide the level of "acceptable risk"



How to Prevent Attacks:
Penetration Testing

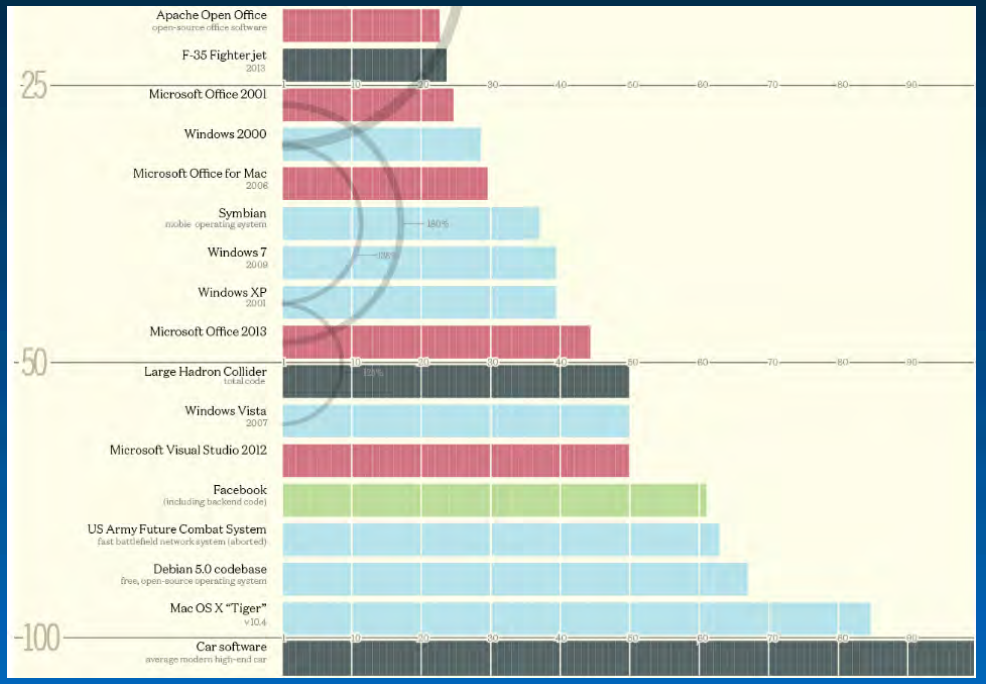
- Assesses the susceptibility of a system to a security intrusion
- Methodical approach ensures that most frequent and most damaging attacks are mitigated
- Helps create and maintain a secure system at an acceptable level of risk



Connected Vehicle (CV) Cybersecurity

- From a DOT / County perspective “connected vehicle” is a system of systems – its NOT just one connection
- Where is the responsibility for cybersecurity:
  - Standards
  - Network
  - Vehicle
  - Etc.
- CV is not just “DSRC”
- There are MANY entry points into a CV infrastructure

Cars are becoming complex…
(and Connected Vehicle is only part of it)



http://www.informationisbeautiful.net

- 1965:
  - No computers
  - No software
- 2015:
  - Up to ~200 computers
    - Consider TPMS are 4 computers and wireless…
  - >100 million lines of code
  - LTE (or similar) enabled vehicles are becoming commonplace

Challenges with Connected Vehicles

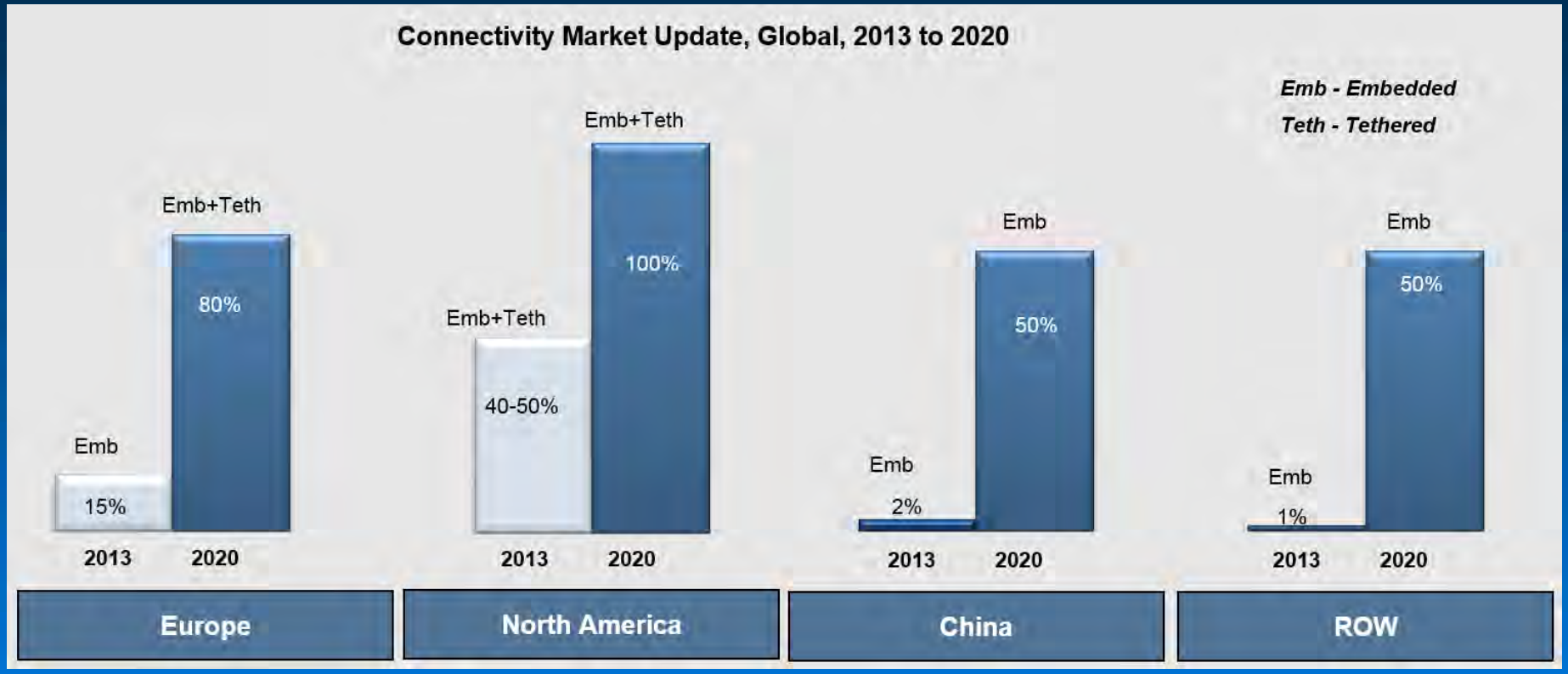
- **Recent attacks on Connected Vehicles:**
  - **Jeep Cherokee: *"Hackers Remotely Kill a Jeep on the Highway—With Me in It"***
  - **GM OnStar: *"This Gadget Hacks GM Cars to Locate, Unlock, and Start Them"***
  - **Tesla Model S: *"Researchers Hacked a Model S, But Tesla's Already Released a Patch"***


Image Source: Wired Magazine


Image Source:
Wired Magazine

- Impact of these attacks:
  - Erodes public trust
  - Raises awareness – improves security practices
  - Not a setback for DSRC

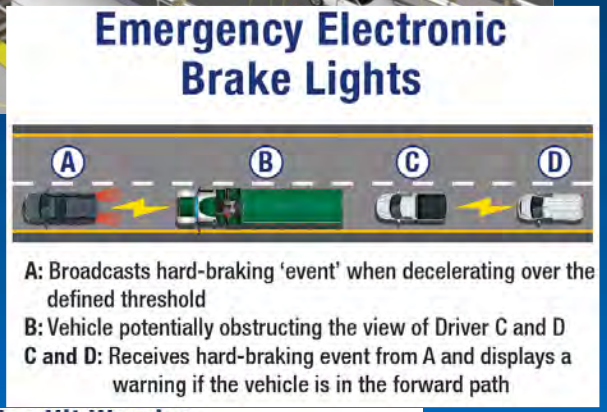
The Auto World is Quickly Becoming Connected – by 2020…

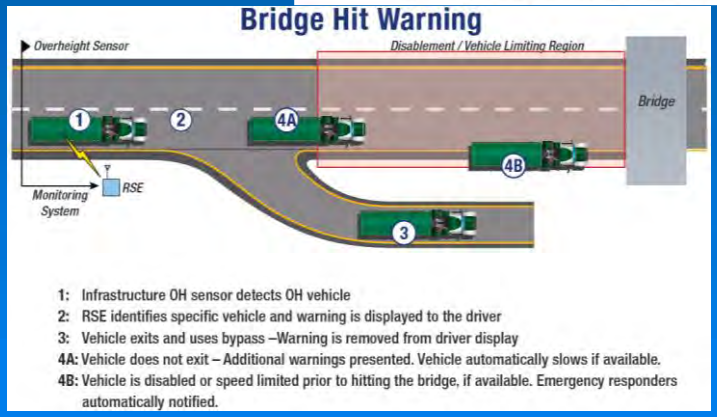


Source: Frost and Sullivan analysis

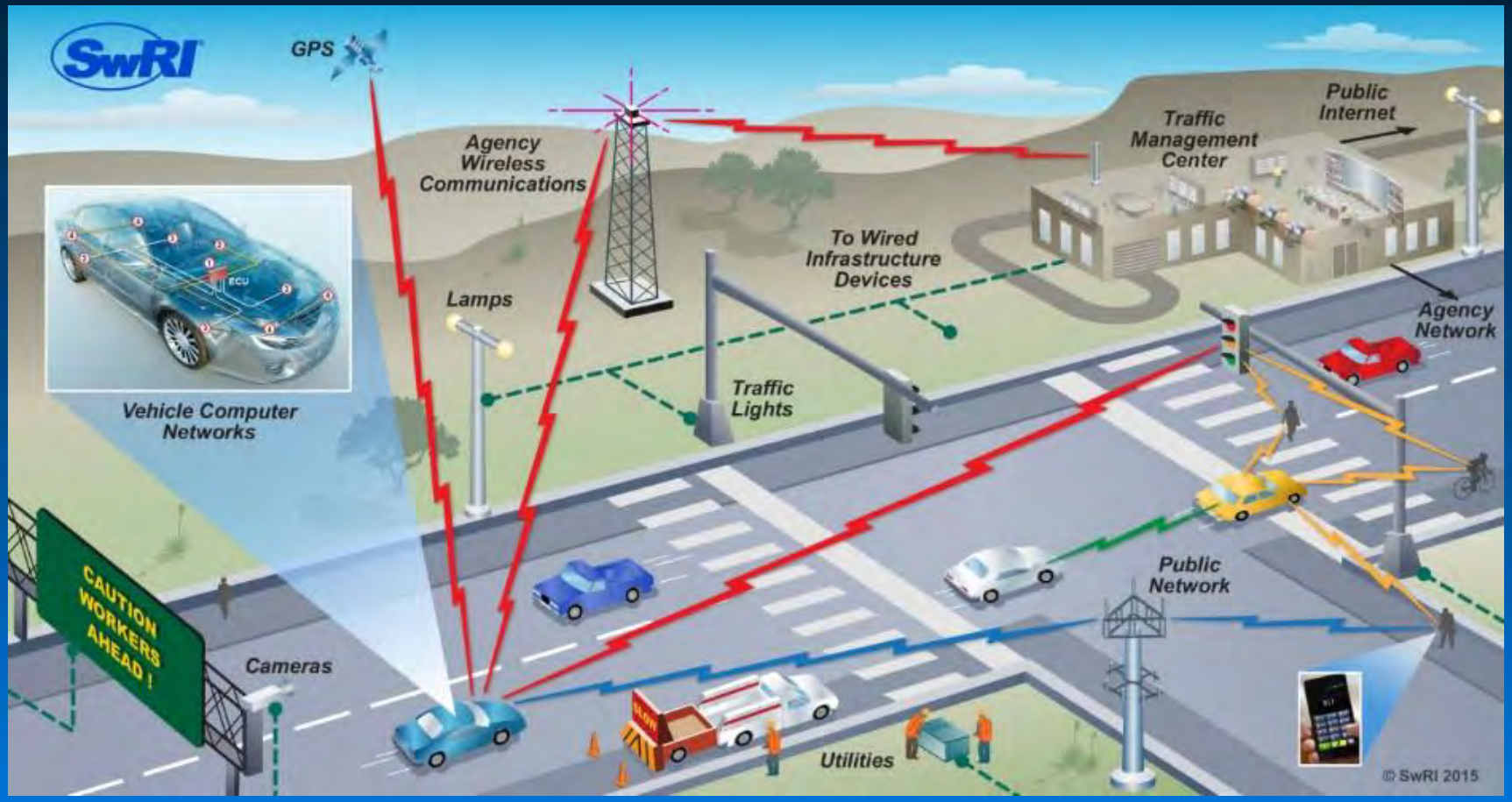
Connected Vehicle Overview

- Cooperative system where vehicles communicate:
  - With each other (V2V)
  - With infrastructure (V2I)
  - With pedestrians, bicycles, etc… (V2X)
- Improves: Safety, Mobility, Environmental Impact
- Example Applications:
  - Emergency Electronic Brake Lights (V2V)
  - Overheight Vehicle Detection and Warning (V2I)
- Major question:
  - Who should you trust?



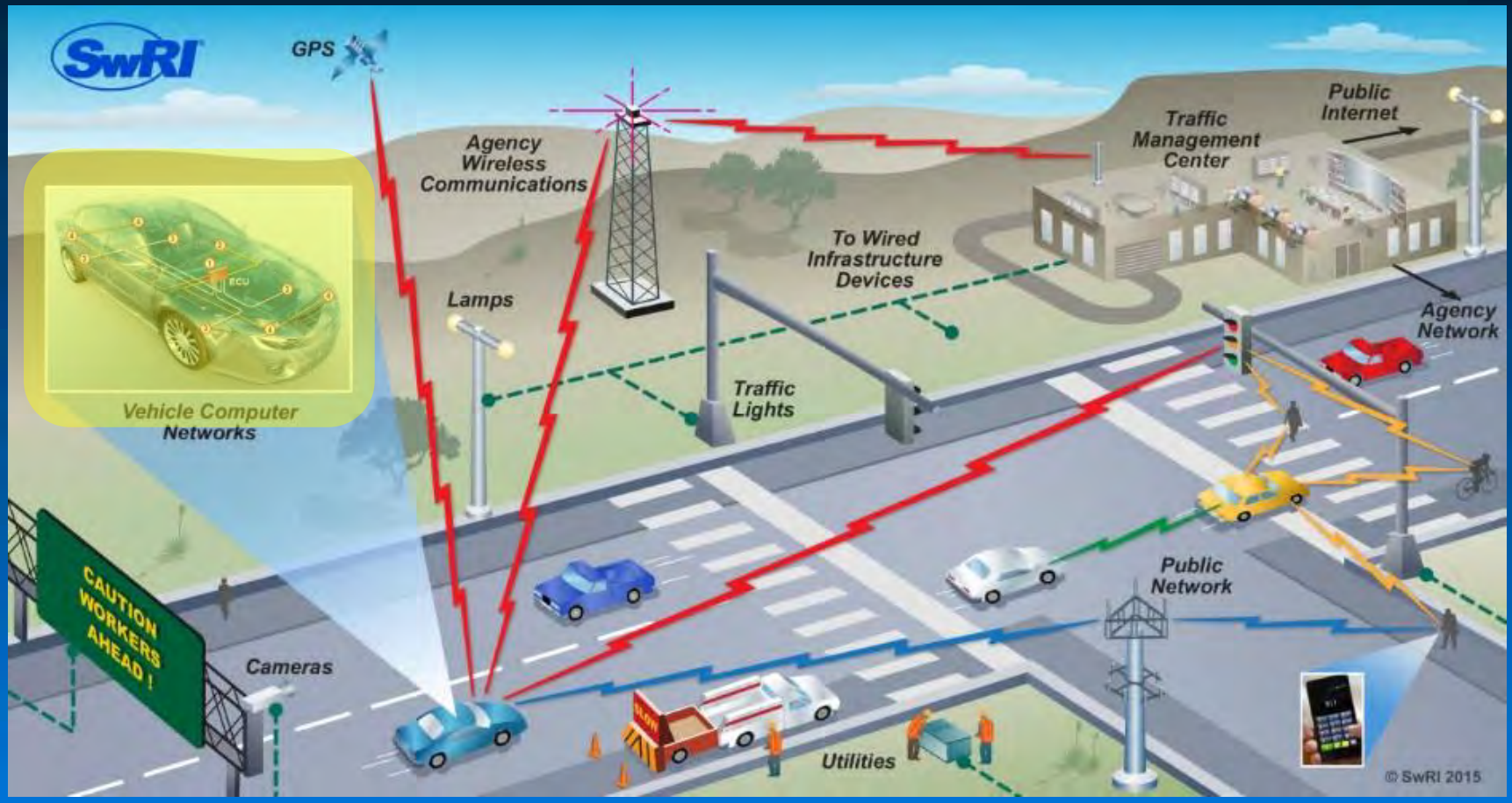


Consider a CV Environment



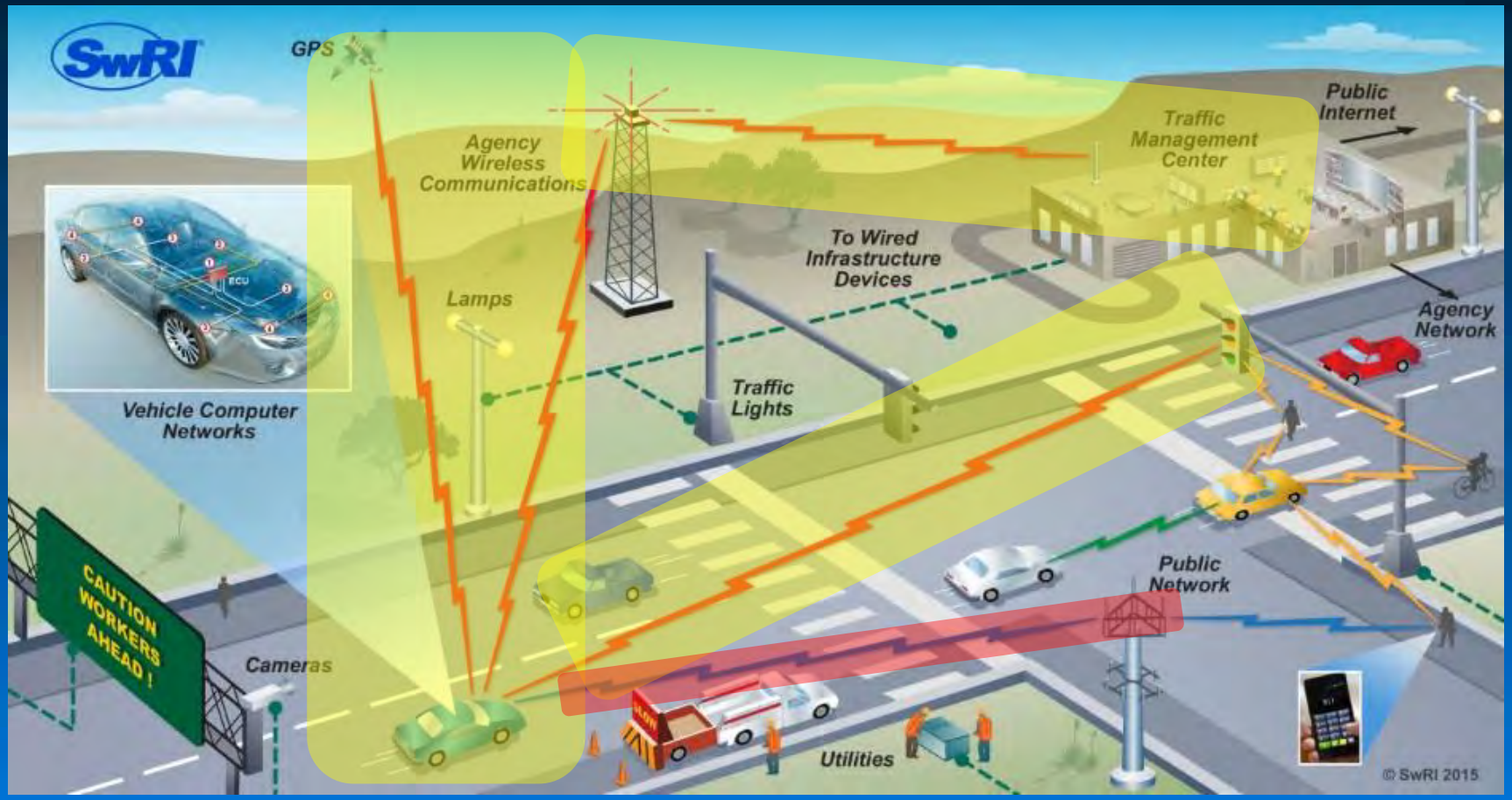
- For Connected Vehicle to be successful it must be integrated into the transportation infrastructure

Consider a CV Environment:
The Vehicle



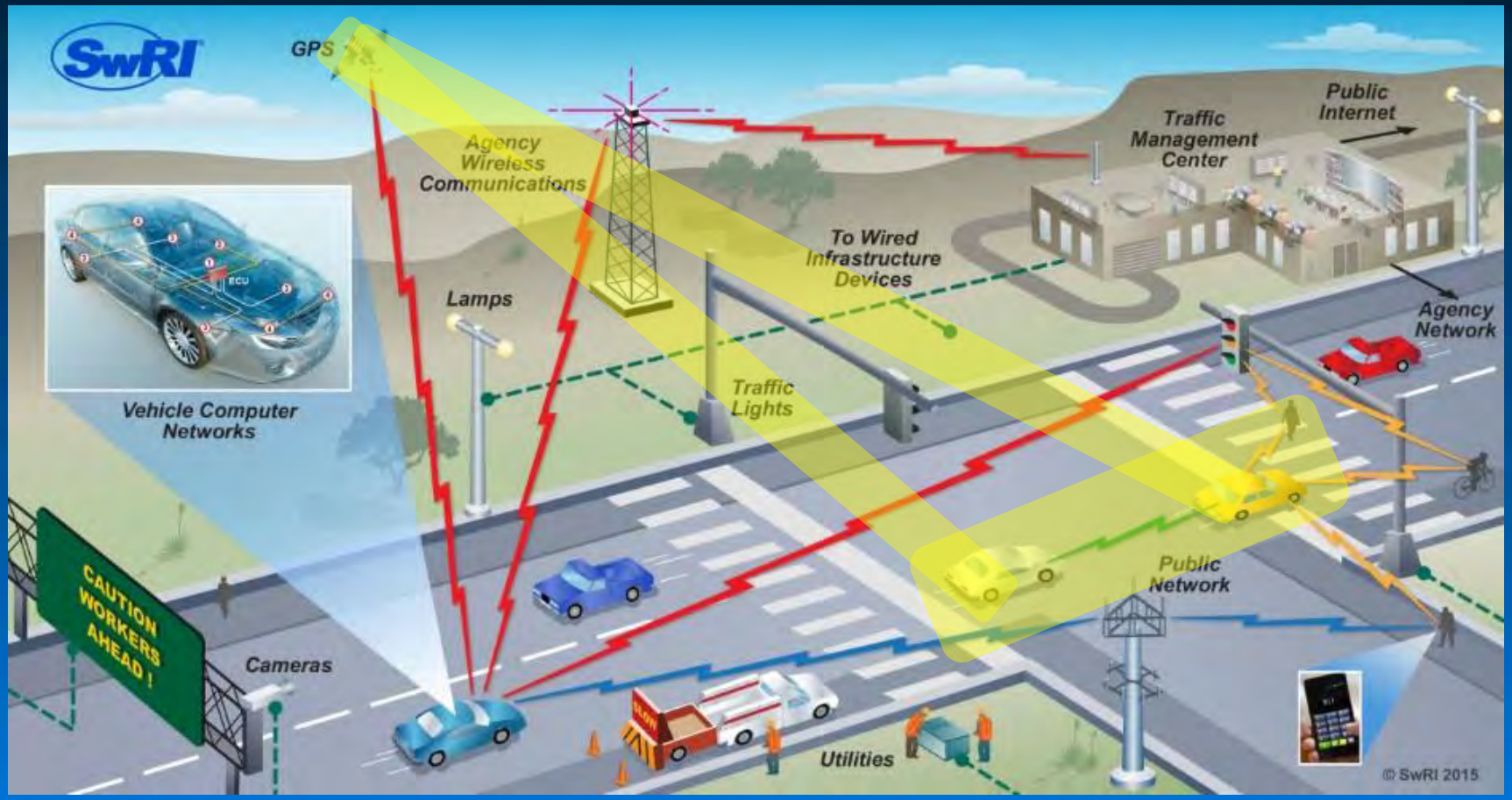
- Vehicle may have several hundred computers
- Multiple networks
- Each an entry point into the “infrastructure”

Consider a CV Environment:
Vehicle to Infrastructure (V2I)



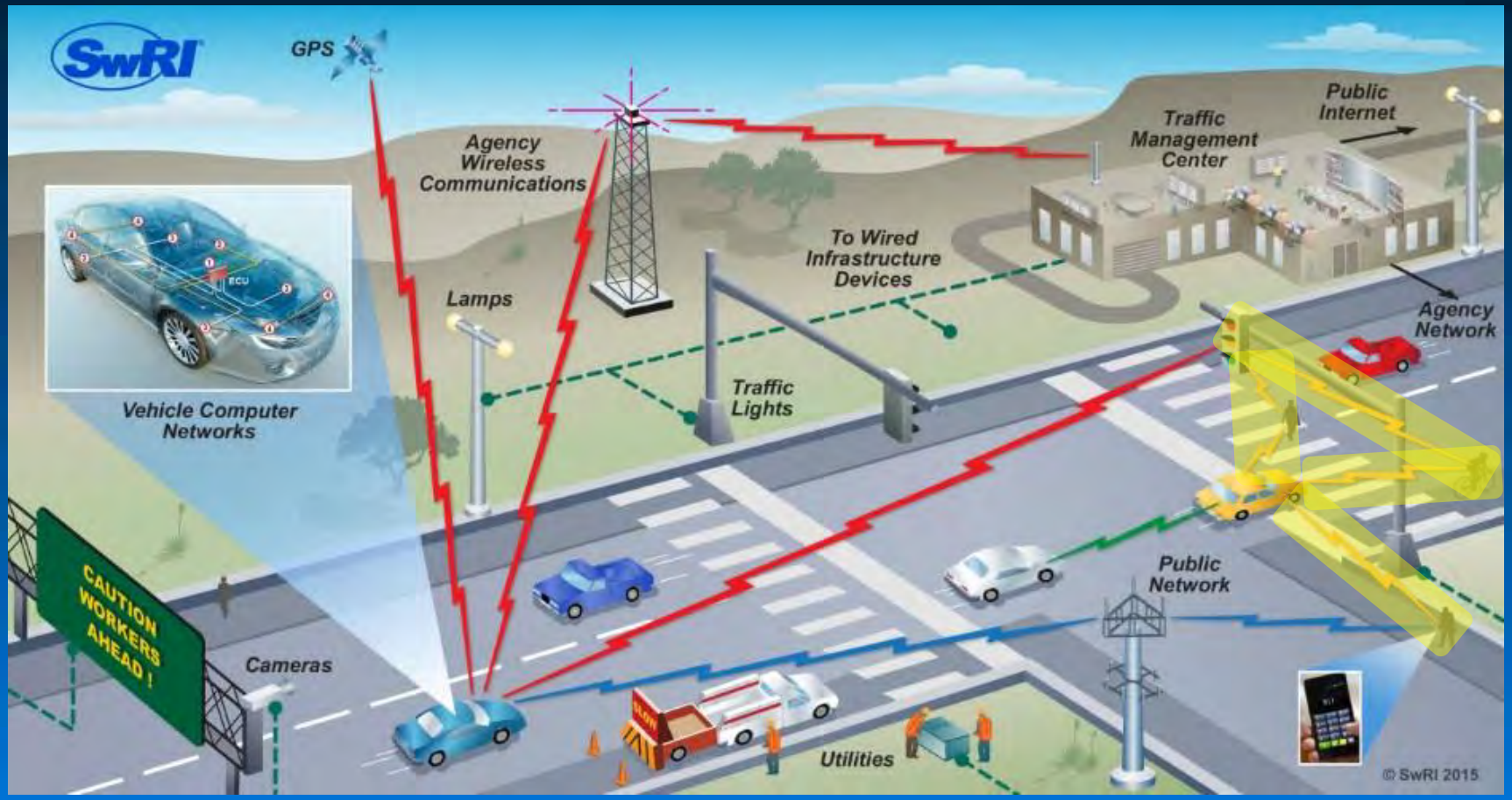
- Vehicle can communicate to agency networks (e.g. DSRC)
- Data may pass both directions
- Vehicle may communicate to NON-agency networks also

Consider a CV Environment:
Vehicle to Vehicle (V2V)



- Vehicles communicate directly with each other (trust issues)
- No public infrastructure required
- Focus of current NHTSA rulemaking

Consider a CV Environment:
Vehicle to Pedestrian (V2P)



- Improving the safety of vulnerable road users
- Communications link may be DSRC, cellular, etc.
- Low latency and highly reliable data very important

Connected Vehicle Security

- Connected Vehicles utilize a number of communication mechanisms and protocols:
  - Cellular
  - Bluetooth
  - Wi-Fi
  - Dedicated Short Range Communications

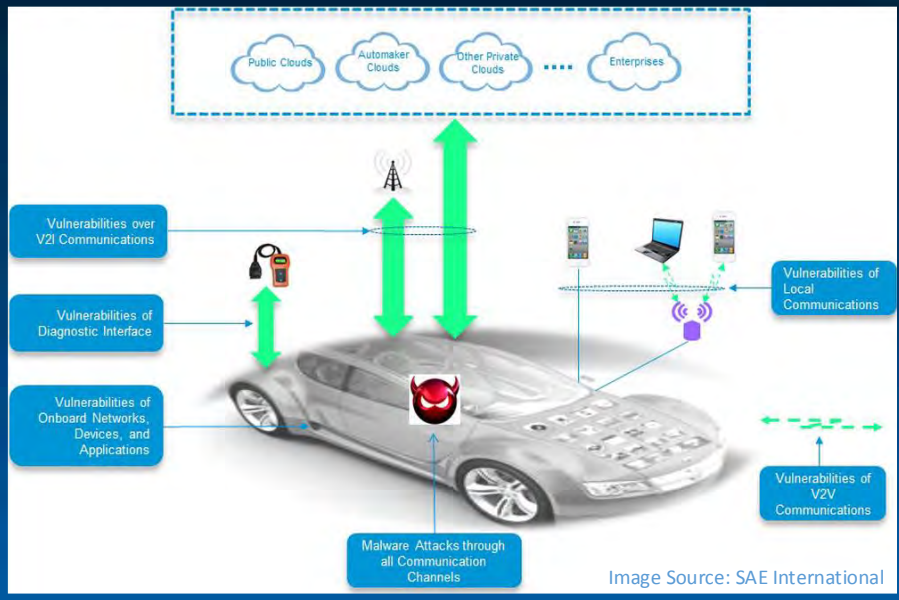


Image Source: SAE International

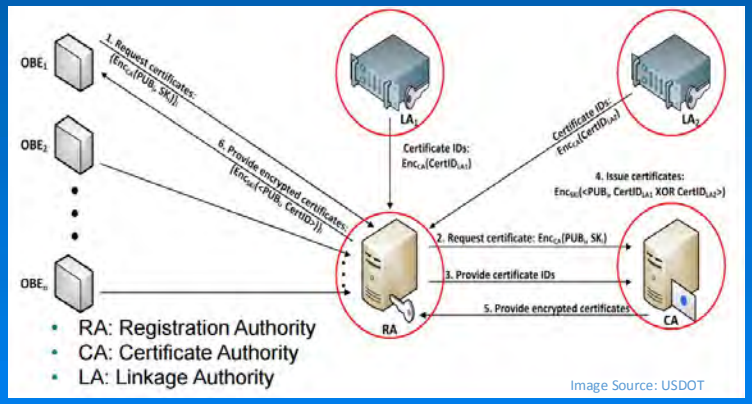
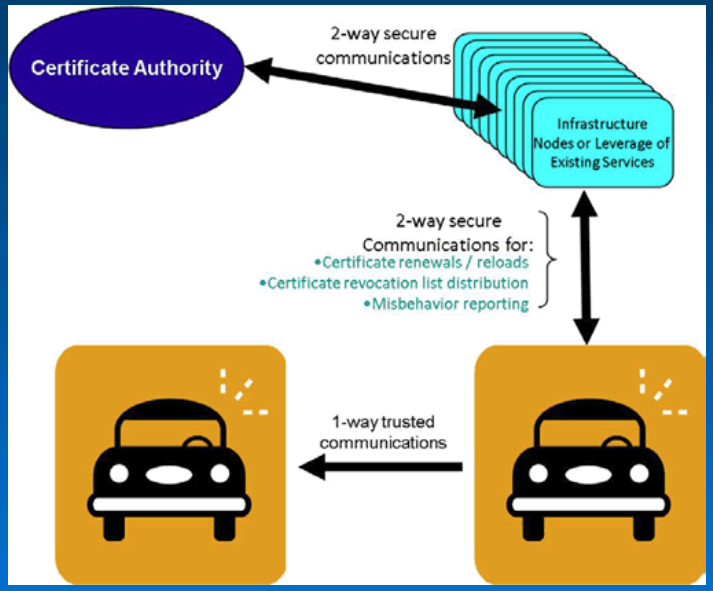


Image Source: USDOT

- DSRC standards have security designed in:
  - IEEE 1609.2 standard
  - Public Key Infrastructure (PKI)
  - Security Credential Management System

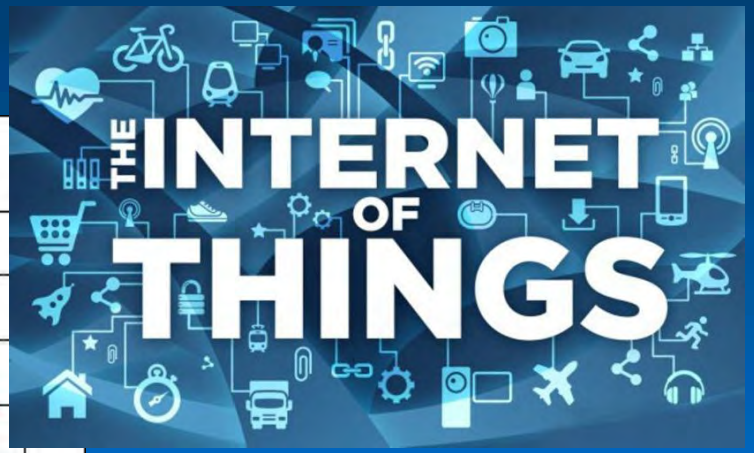
Connected Vehicle Privacy

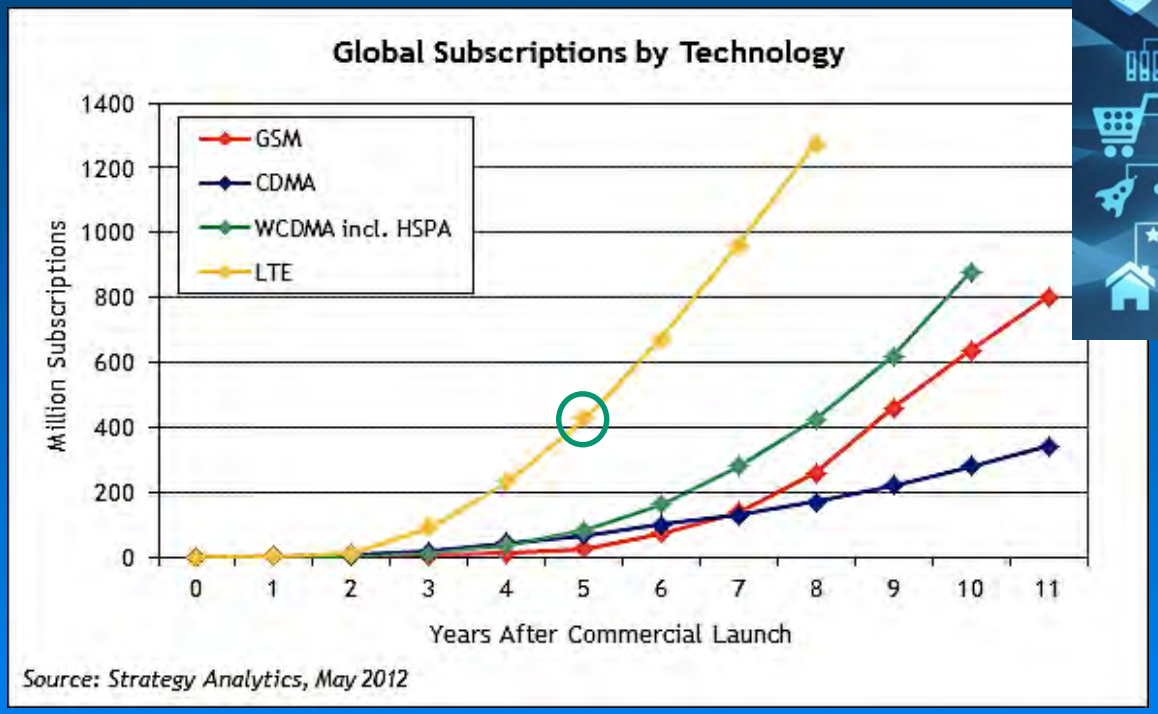
- NHTSA mandate will require that vehicles publish a Basic Safety Message over DSRC at 10 times per second
- This will generate a lot of rich data!
- Standards are designed such that all identifiers "tumble" frequently to make it extremely difficult to track someone
- Information cannot be connected to a particular individual
- Policies will need to be in place to handle this type of data



Projected Growth/Interest in LTE

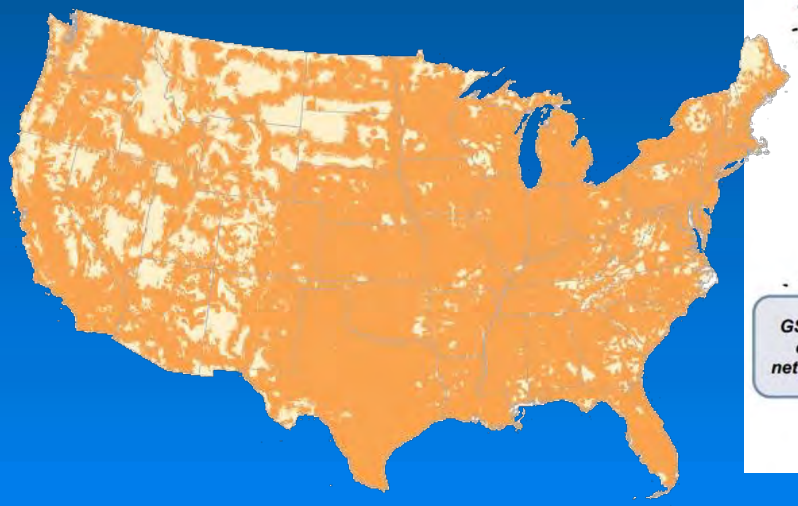
- Cyber Physical Systems & Internet of Things will drive future economy
  - Expected network revenue will exceed Cloud & Big Data
- LTE subscriptions will explode
  - 1 billion in 2016 (7 yrs after launch)

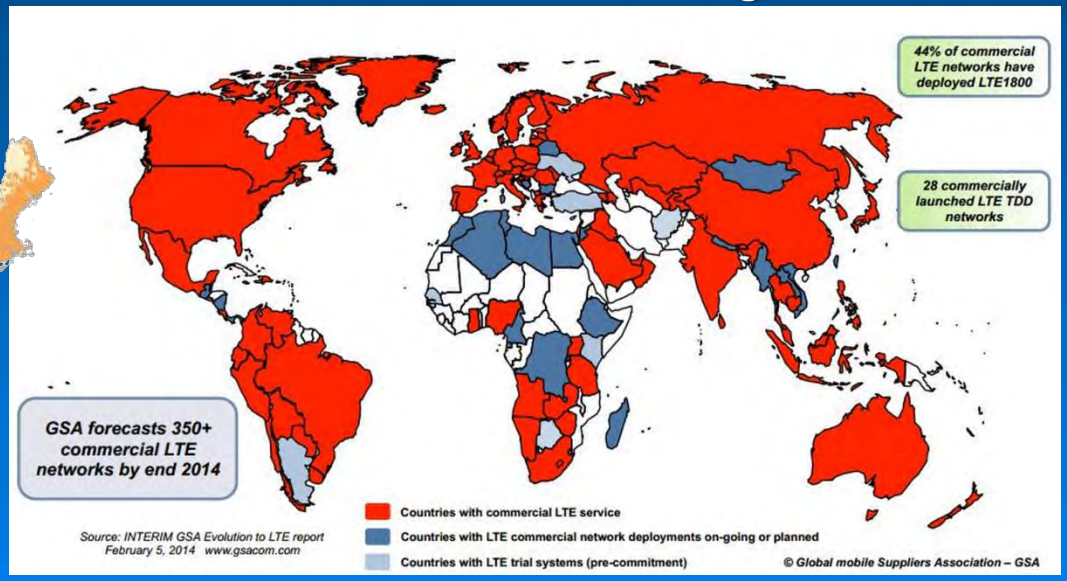




Fixed/Mobile Coverage (Convergence)

- **Mobile Coverage (Wi-Fi vs Cellular)**
  - WIFI coverage is limited, but cellular coverage already spans much of the country and world
- **Fixed/Mobile convergence**
  - Femtocells (10-20 m) extend cell coverage indoors and at edges of macrocell (esp. when spectrum is crowded (e.g. SxSW))
  - Users benefit: better coverage, data, battery life, and lower fees
  - Operators benefit: happy customers & more universal coverage

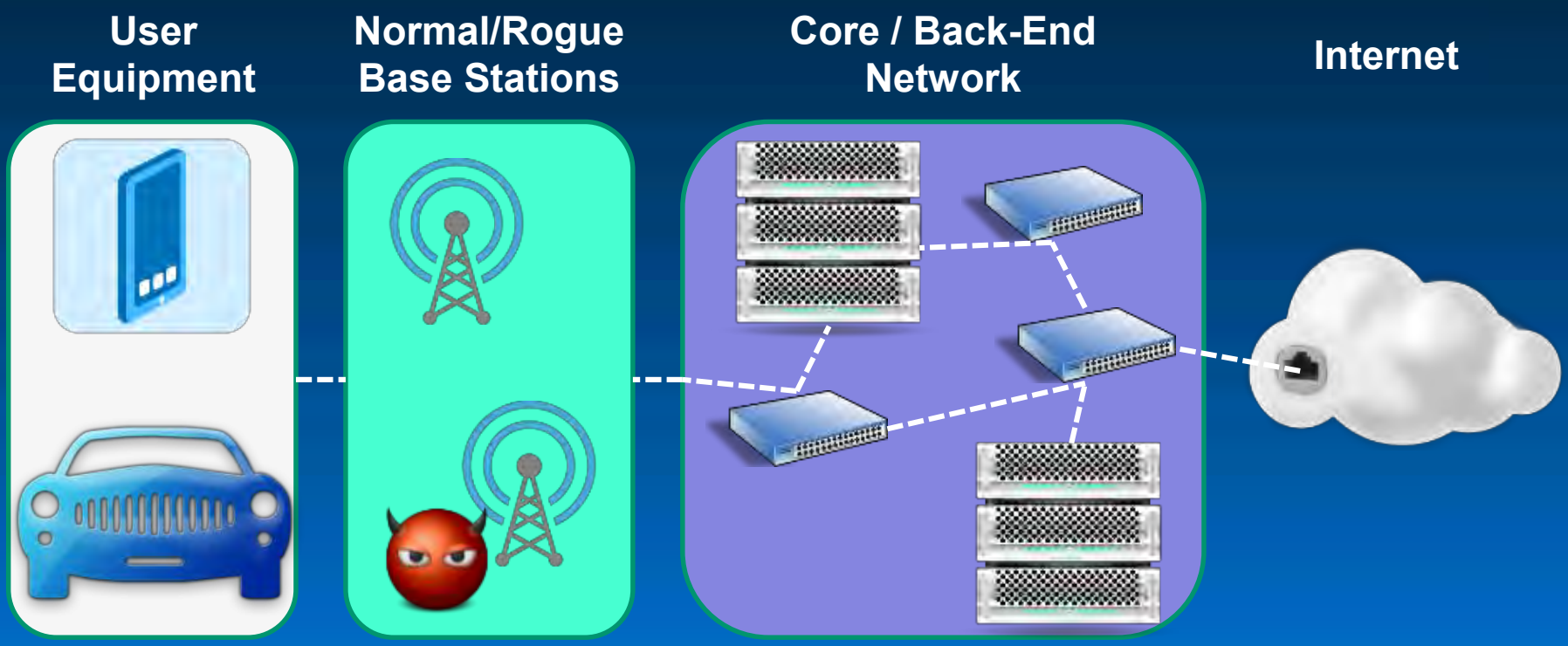




Wireless: What are the problems?

- Connected Car, Home, City
  - Many mobile platforms / sensors will likely connect via cellular (LTE has broad coverage, moderate cost / power)
- However, problems should be expected
  - 3G systems had numerous problems, including rogue femtocell attacks
  - LTE security better, but control segment still unencrypted & many problems probably remain hidden
  - Significant concern over a Man in the Middle attacks
    - Unknown vulnerabilities are always worse than what is known

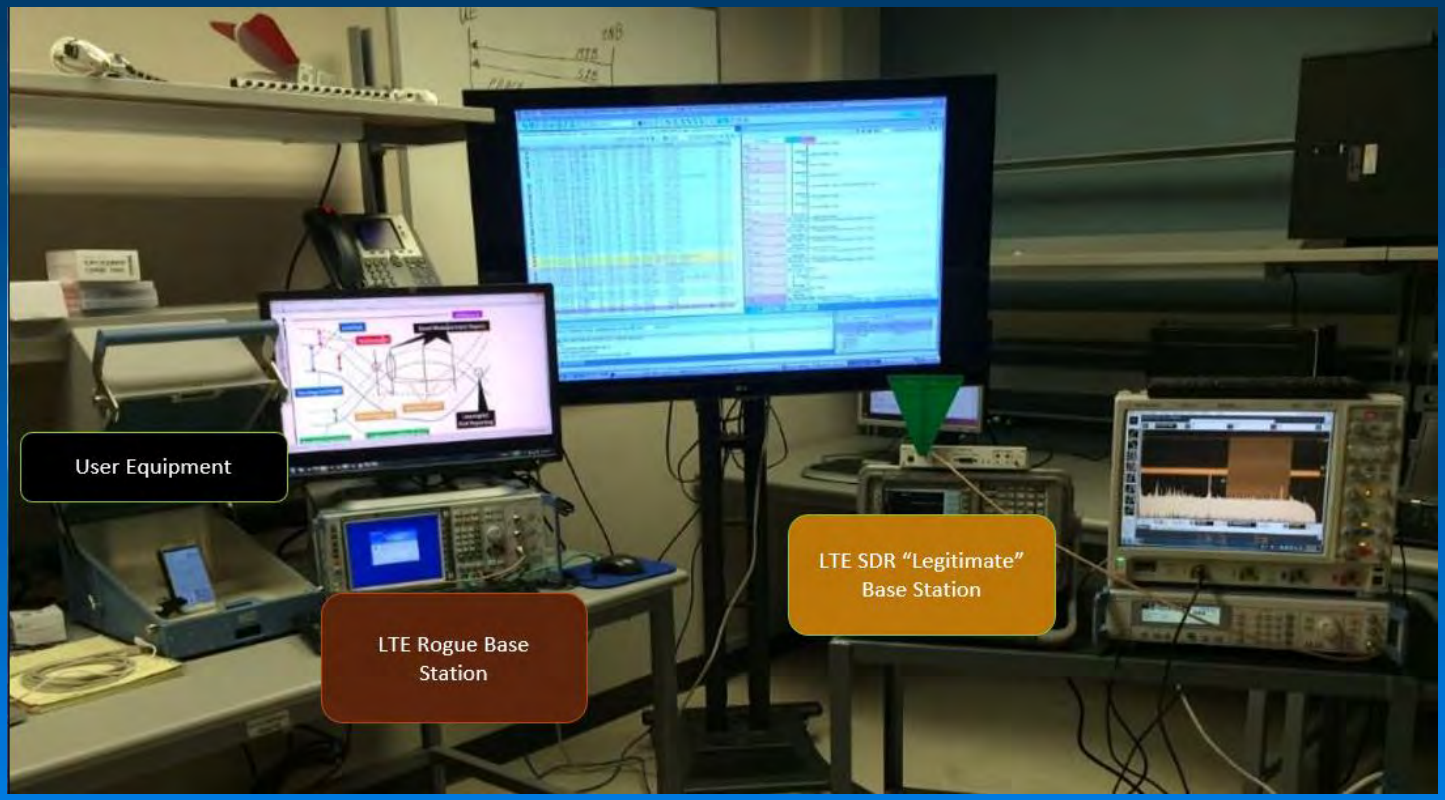
Rogue Base Station Attack Scenario



Rogue base stations could track users and intercept user data

How Hard is it to Hack a LTE Network?

- How real is the concept?



Cybersecurity “touch” Points:

Need to “worry” each of these…

- Field network
- Bluetooth
- Wireless networks
- Wired networks
- Vehicles
- Any device that is connected to one of the above

Connected Vehicle Environment

Potential Attacks

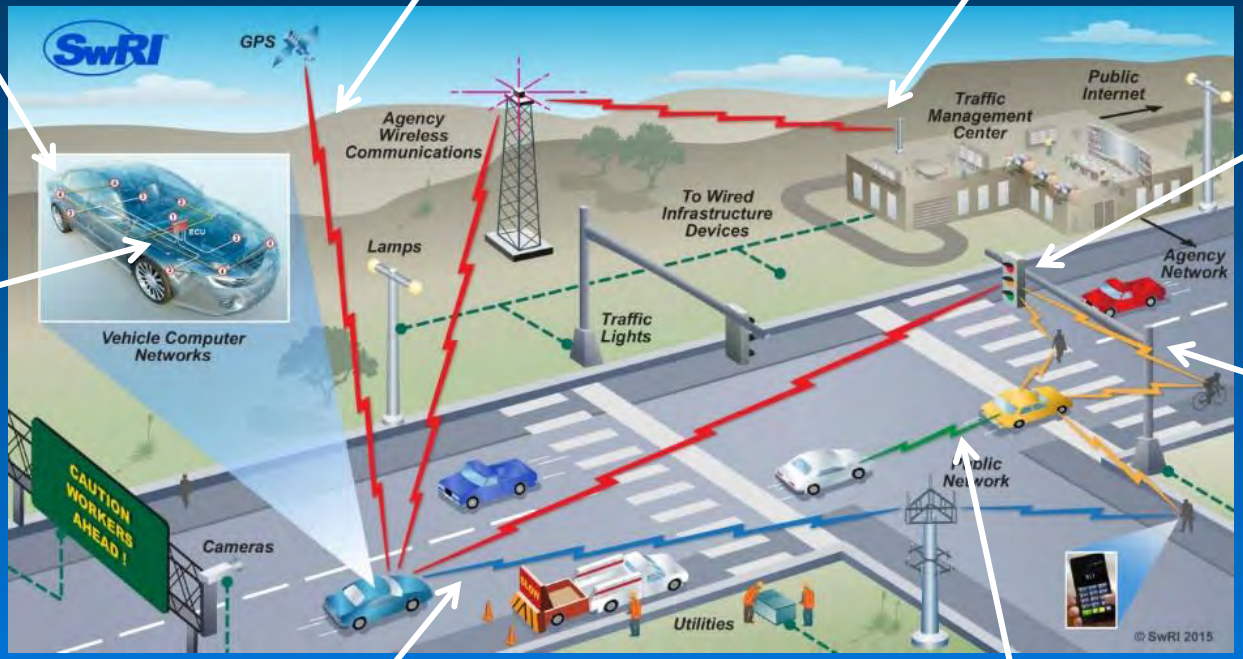
Injecting bad data that is then communicated over trusted comms

Spoofing, jamming, or subtle skew of GPS signal

Use roadway infrastructure to infiltrate TMC network

Hack RSE and alter SPAT/MAP messages

Using comms or physical means to hack vehicle and control it or obtain trusted security credentials



Broadcast incorrect messages to/from Vulnerable Road Users

Flood DSRC safety & control channels

Simulate vehicles that will trigger safety apps. Tough to detect if sensors are occluded

Summary

- Key takeaways:
  - Connected Vehicles are already here and the number of connected vehicles will increase in years to come
  - DSRC will add another “attack surface” for vehicles and infrastructure
  - Almost everything is “hackable” or “trackable”
  - DSRC standards are designed to make it much more difficult to hack or track than other communication mechanisms in the CV environment
- What can Texas do to prepare for DSRC deployment?
  - Extend security and data privacy systems, practices and policies to handle connected vehicle data and infrastructure
  - Small pilot deployments to analyze security and privacy impacts – this can inform a larger deployment in the future

Questions ?

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