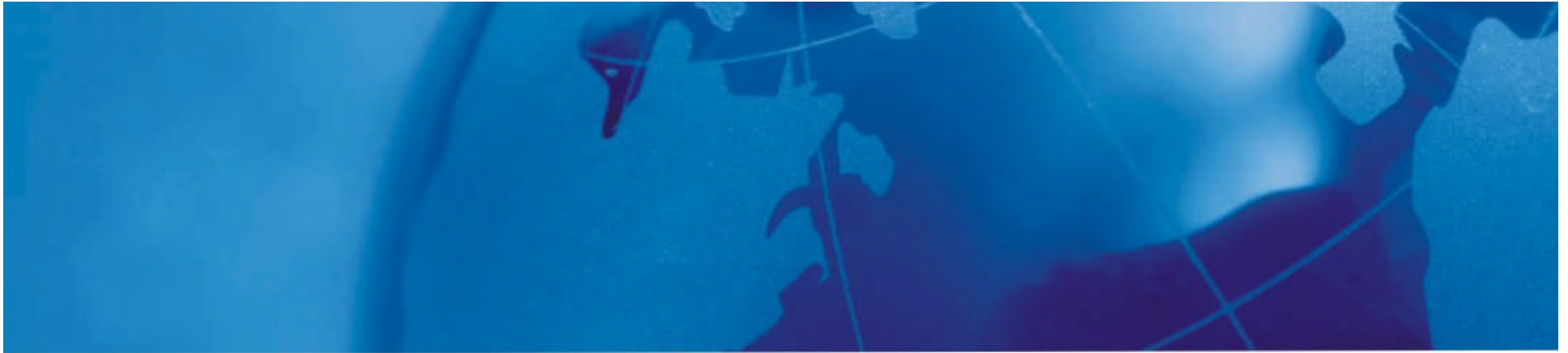


# The 'Autonomes' are Coming – This Will Fundamentally Change How We 'Do' Road Transportation

## ITE – Southern Alberta Section

Paul Godsmark, B.Sc., M.I.C.E., C.Eng.

[pgodsmark@eba.ca](mailto:pgodsmark@eba.ca)

15 January, 2013

creating & delivering | BETTER SOLUTIONS



# Transportation Just Got Really Exciting!

Frank and Ernest



My belief (glass half full!):

*We are on the cusp of two technological tidal waves that will result in a paradigm shift\* in how we do road transportation. (\*a radical change in underlying beliefs or theory.)*

- The challenges are immense, the potential benefits are transformative.

We need to:

- Make ourselves aware
- Decide if we need to make a response
- Act on our convictions (limited research and experience to guide us)

# Paradigm Shifts and Frequency

Paradigm Shifts in Telecoms (dates approximate):

- 1876 – Landline Telephone replaces telegraph
- 1973 - Cell Phone replaces Landline
- 1996 – Smartphone replaces Cell
- 2007 – First iPhone – App Store
- 2010 – Social Media Revolution

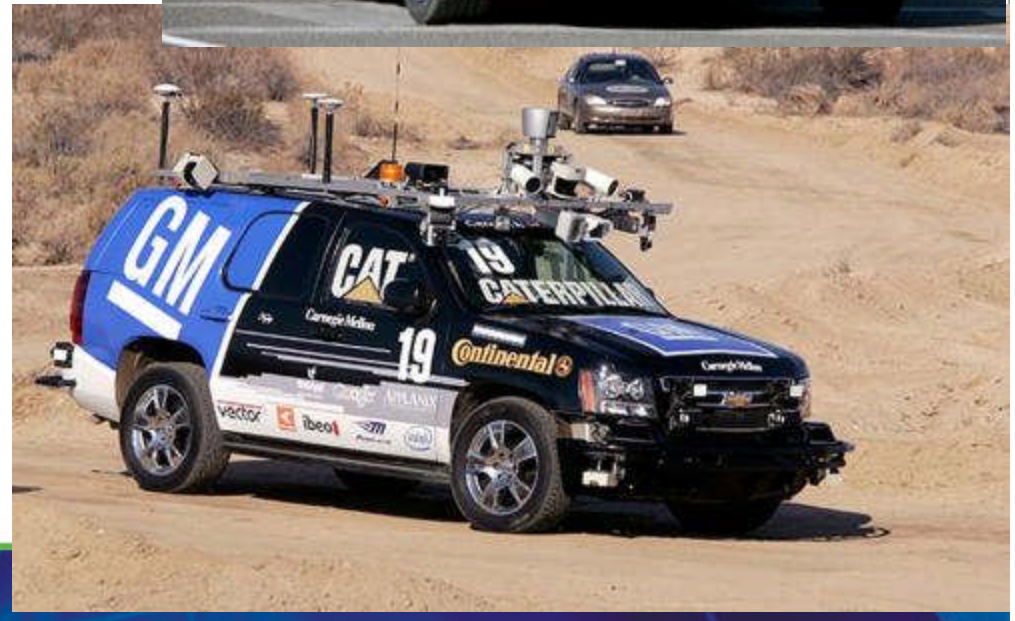
Paradigm Shifts in Road Transportation

- 1879 – Motor car (Daimler Benz) replaces horse and carriage  
(.....incremental improvements for over 130 years.....)

Conclusion – overdue a paradigm shift on our roads?

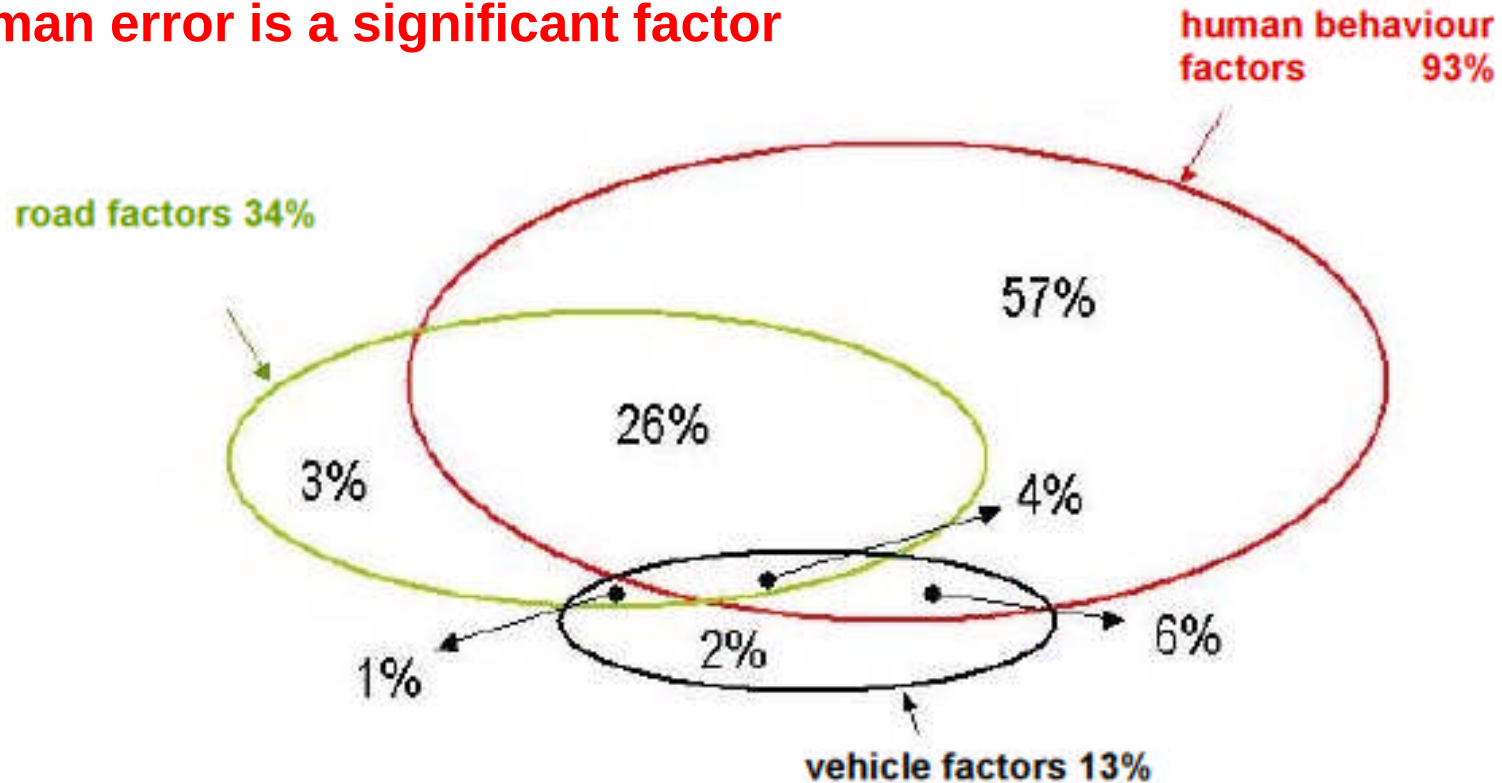
# Agenda

- The Problem
- The Technology 'waves'
- What autonomes are
- Ultimate Autonomie Vision
- Opportunities
- Challenges
- When might this all happen?
- Implementation Scenario
- Watch/wait or respond?



# Big Problems - need a Big Solution

- Every year approximately **1.2million people are killed** on the world's roads. (USA = 32,367<sub>[2011]</sub> – Canada = 2,227<sub>[2010]</sub> )
- It is estimated that in approximately **93% of collisions (accidents) human error is a significant factor**



(Source: PIARC Road Safety Manual, 2003)

# Big Problems - need a Big Solution

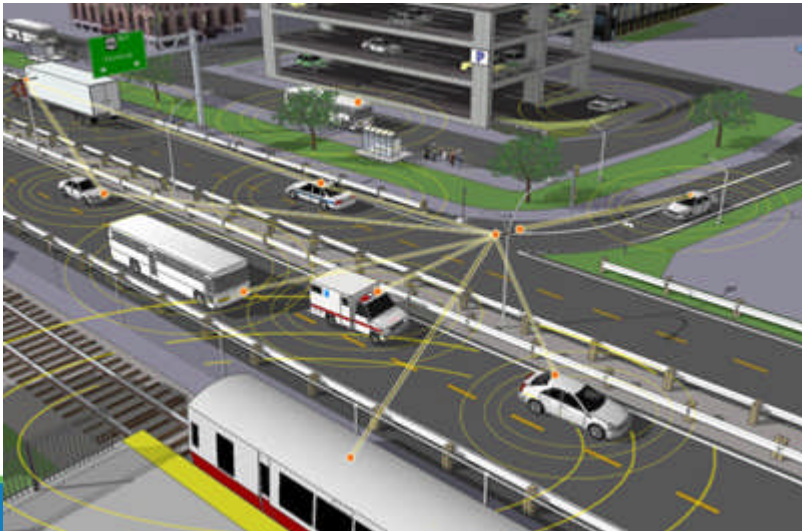
- **Congestion / 'lost time'** is a major problem – average commuter  $\approx 50$ mins/day (Canada \$63bn = 3.5% GDP)
- **Pollution** particularly in urban centers. (GHGs and particulates)
- The technology that will allow us to **virtually eliminate human error from the road system and significantly reduce road congestion and pollution** is already moving from 'science fiction' to 'science fact'.



# 1<sup>st</sup> Wave - Connected Vehicles (CV)

Electronic modules in vehicles and infrastructure:

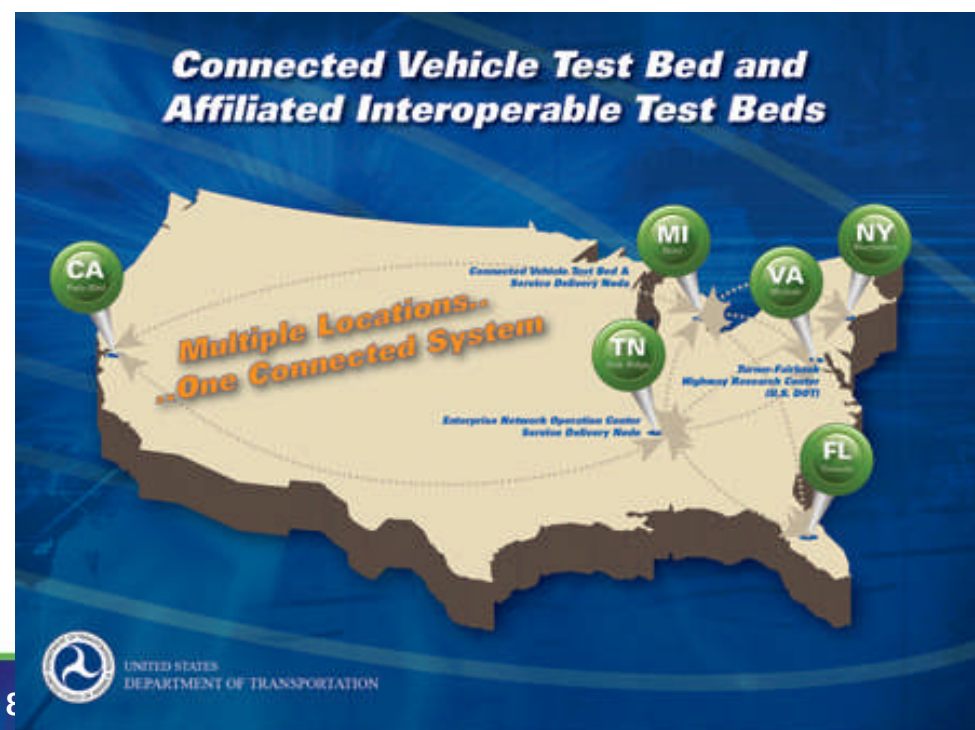
- Speed adaptation
- Collision avoidance
- Extended or revised traffic signal timing or phasing
- Emergency vehicle warnings
- Warning of red light runners
- Dynamic route selection or adjustment
- Platooning (SARTRE – Safe Road Trains for the Environment)



## 1<sup>st</sup> Wave - Connected Vehicles (CV)

NHTSA (US) will make a decision on CV tech in 2013 –  
**estimated to remove up to 48% of all collisions**

- RITA ITS pilot project, 3k cars –underway
- CV mandatory by 2018/19?
- SIGNIFICANT CONGESTION/SAFETY BENEFITS



# 1<sup>st</sup> Wave - Connected Vehicles (CV)

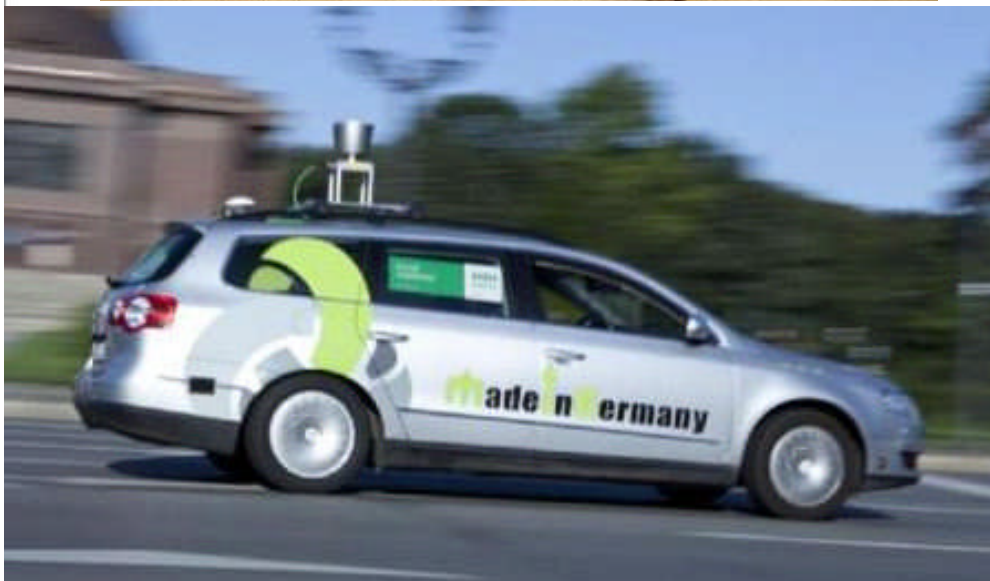
Some thoughts further to the TRB Workshop on 'The Future of Road Vehicle Automation', July 2012:

- ADAS to Semi-Autonomous = driver distraction = safe?
- Platooning has operational safety issues to address – getting vehicles in/out of dedicated high volume lanes efficiently is very challenging – could easily create the very congestion that it is meant to remove.
- If platoons are in in the RHS lane then they are a potential hazard – 13 vehicles sneaked through 10m gaps in European test at off-ramps.
- Platooning cars behind a truck get 'grit-blasted' – one way to make this work is if the autonomes are train carriage-like in shape with squared ends.

## 2<sup>nd</sup> Wave - Autonomes

- Autonomous Vehicles ('Autonome' non-acronym single word, noun)
- Nevada Law (1<sup>st</sup> Mar 2012)
  - "artificial intelligence" means the use of computers and related equipment to enable a machine to duplicate or mimic the behavior of human beings.
  - "autonomous vehicle" means a motor vehicle that uses artificial intelligence, sensors and global positioning system coordinates to drive itself without the active intervention of a human operator.
- DARPA Grand Challenge (2004/5) /Urban Challenge (2007)
- Key proponents joined Google Self-Driving Car Team
- Automakers: Continental, Audi, Volvo, GM, Mercedes, BMW, AutoNOMOS, VisLabs, Ford, Toyota etc.

# Examples

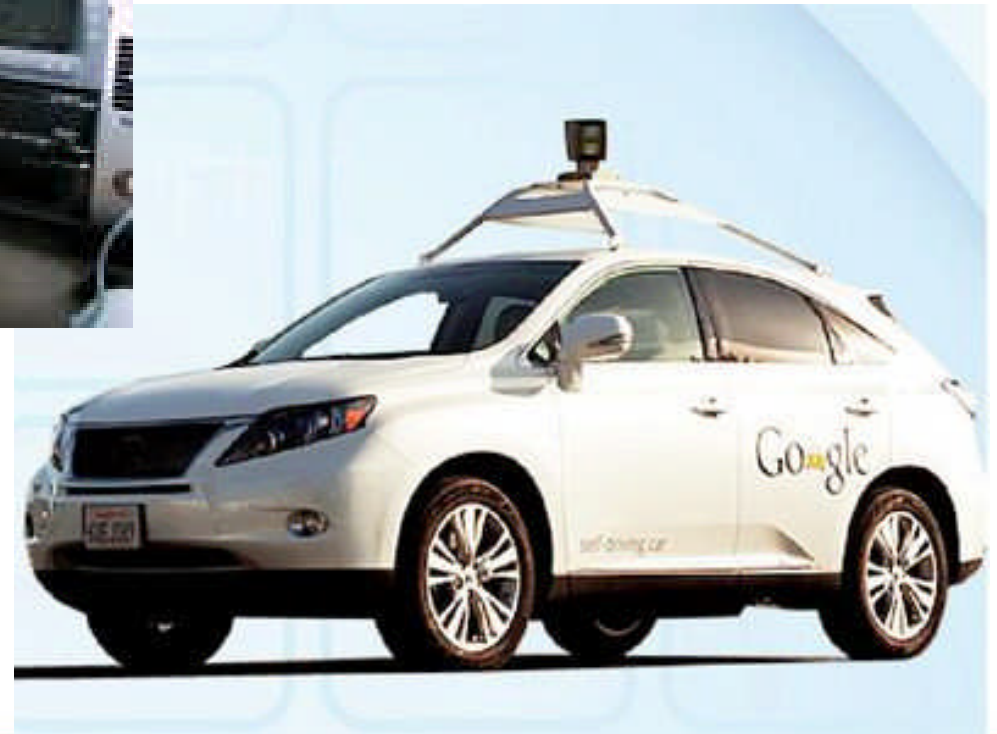


# The Google Self-Driving Car



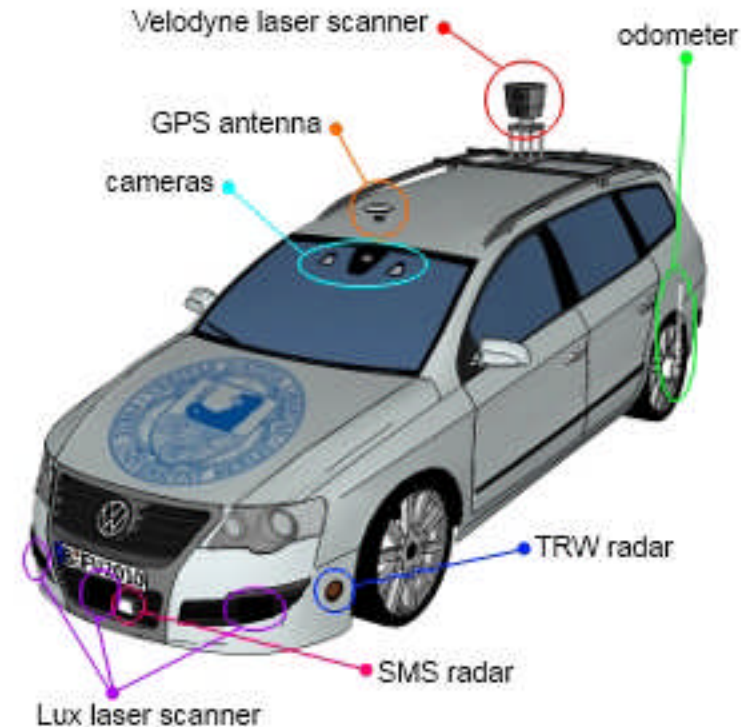
- Probably the most advanced civil autonome
- Key: Software-to-Hardware (traditional vehicle manufacturers Hardware-to-Software)
- Aims: 1 million miles unaided and Save 1 million lives
- Greater than 300k miles (Aug 2012) in self-drive mode – 50k miles without intervention... and counting?...
- Need 727k miles for 99% confidence crash less frequently, but 300million miles that cause less fatalities
- PG calc – Google can do 1million miles in 13 months.....
- Passenger No.1, Steve Mahan, San Jose, CA – 95% blind (well worth a watch on YouTube. Did you know? 20% USA disabled, 12% severe – this tech should be transformative)

# The Google™ Self-Driving Car

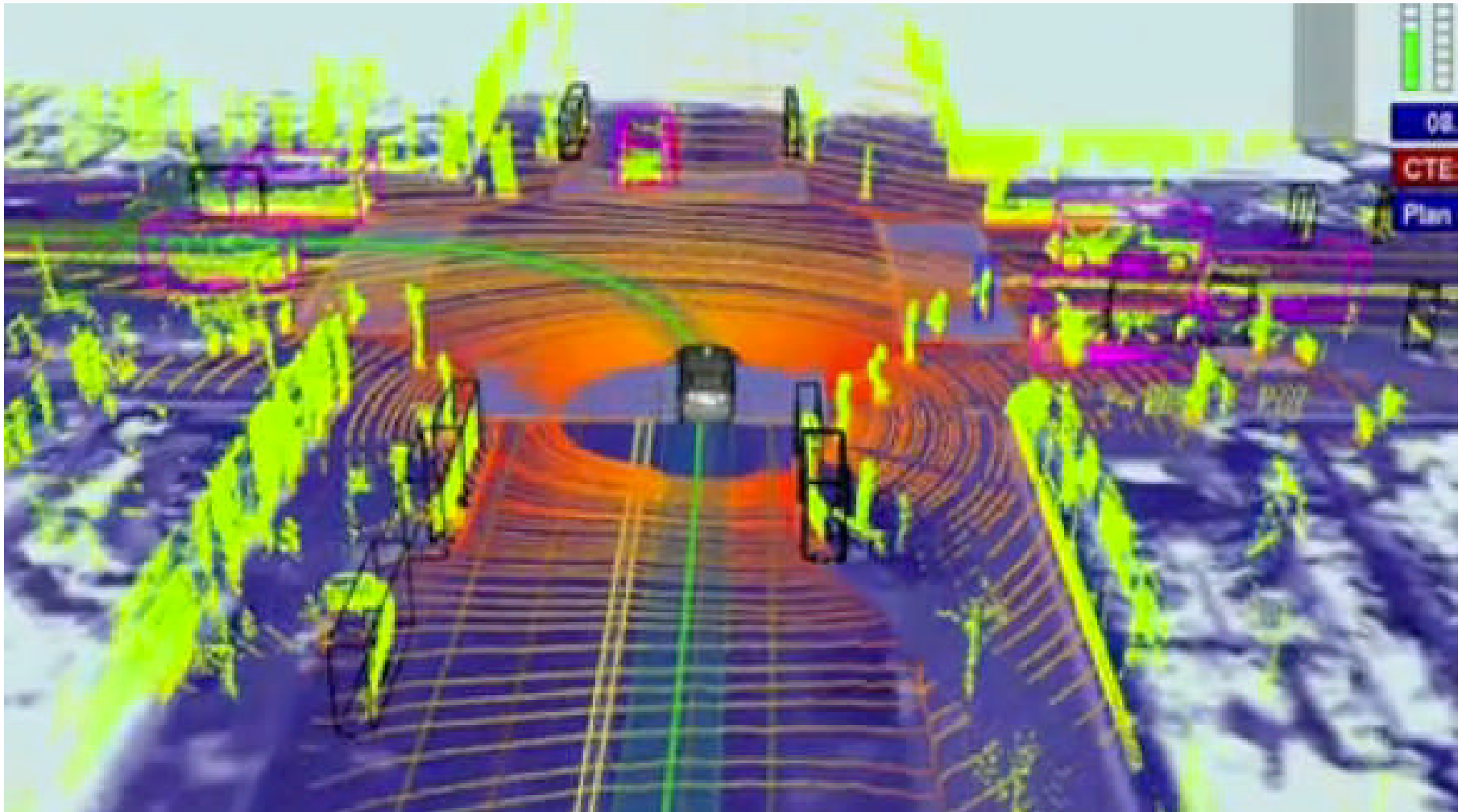


# Autonome Characteristics

- Sensors typically:
  - OPTICAL – includes stereo vision for 3D image
  - RADAR – may be an advantage with rain, dust, snow, foliage
  - LIDAR – 360 degree 'point cloud' tracks movement
  - INFRARED CAMERAS – night driving
  - GPS / INERTIAL MEASUREMENT – macro view/location
  - WHEEL ENCODER – precise distance
- COMBINATION = 360° view, improved sensing when visual obscuration. Monitors real time movements at  $\approx 10\text{-}20$  Hz



# The Point Cloud



# Autonome Characteristics

## DATA ANALYSIS / CONNECTIVITY

- Artificial Intelligence (AI)
- Develops algorithms to cope with new situations
- Connected – one 'learns', all 'learn', knowledge and experience dissemination
- Hive mind (CV) - platooning, intersections

## CONCLUSION

Combination of superior sensory info, real time hazard analysis, AI and rapid reactions = potentially the safest & most efficient road transportation today? (on **existing** infrastructure).



# Google Video May Follow Shortly.....

- Presented at TED conference March 2011
- Google car 140k miles at time of video / 300k Aug 2012

Google challenges where development needed:

- Reversing!
- Extreme weather
- Work zones
- Pedestrian prediction
- Reading facial expressions
- Rare events



# The Ultimate Autonomie Vision

## A Few of the Opportunities:

- Significant reduction in collisions – up to 93%
- Increase road capacity, reduce spaces, improve flows
- Driver now a passenger, can use travel time productively
- Environmental – reduced emissions, fewer vehicles
- Business efficiencies – improvements to logistics, time, fuel, insurances, less maintenance etc.
- Revolutionizes public transport/transit
- Environmental/real estate benefits – reclamation of excess paved areas (NY Times Jan 2012 – approx. 8 spaces/car in US, Houston approx. 30 spaces/car!)

## Autonome Fleets – Costs Go Down

‘Transforming Personal Mobility’ Earth Institute, Columbia University

- Car ownership costs approximately \$21/person/day
- Once autonomes certified safe for body out then can operate in coordinated fleets – costs \$8/person/day
- When autonomes optimized in size and weight costs drop to as low as \$2/person/day
- Compared to human driven cars:
  - Conventional autonomes 38% of car cost
  - Optimized autonomes 10% of car cost
- Savings – ave. household \$51k income (\$9.7k=19% Transp.)
  - Conventional \$6,000p.a. (\$76bn or 4.3% GDP)
  - Optimized \$8800p.a. (\$109bn or 6.2% GDP)

## Quantifying Opportunities (median)

- SAFETY – Canada societal cost of road collisions = (\$62bn 2007) 4.9% of GDP. Reduce by say, 60% **Saving >2.5% GDP?**
- BUSINESS EFFICIENCY – improves logistics, ‘lost time’, fuel etc. 50min commute value  $\approx$  \$63bn **Saving >3.5% GDP?**
- PUBLIC TRANSPORT – improves service, logistics, time, fuel, insurances. **Saving >0.5% GDP?**
- ENVIRONMENTAL – reduced emissions, less vehicles yet better level of service. **Saving >0.5% GDP?**
- SOCIETAL – Like the phone, landline cell to smart and the social media revolution..... The possibilities are immense.

**Long Term Total Saving >7.0% GDP?**

# The Ultimate Autonomie Vision

## Challenges:

- SECURITY – ‘missiles’ in a malicious entities hands
- LEGAL / REGULATORY – laws cover non-human driver.  
Policies, Rules and Standards
- SYSTEM RELIABILITY - MTBF



# Challenges

- INSURANCE/LIABILITY – define responsibilities and liabilities
- USERS – overcome trust issues/acceptance
- UNIONS / TEAMSTERS – jobs threatened: long haul drivers, taxi drivers, road safety experts, trauma surgeons etc. (reduction in organ donations)
- STANDARDIZATION – systems, protocols, inter-connectivity, cross-borders, integration etc.



# Transition from Drivers to Autonomes

There will be a (probably decades long) **transition period**, where man, and autonomes share the road space and learn to get along.

- Will we share harmoniously (drivers taking advantage)?
- Will/should drivers/autonomes be treated equally (Societal and legal viewpoint)?
- Can rules, regulations, standards and legislation be flexible enough to cope?
- Are we ready for the transition?



# When will Autonomes arrive?

- Under development now in at least 8 countries
- Licensed in Nevada – Google, Continental, Audi
- Continental predict full autonomy by 2025
- General Motors predict they could have autonomous vehicles on the road by **the end of the decade**
- Volvo autonomous up to 31mph in 2014, fully by **2020**
- What have Google said?



## When will Autonomes arrive?

Once Google have completed 1,000,000 miles, then:

*“Google could make an announcement **as early as next year** on when it might offer the self-driving technology, he [Levandowski] said.”* Quote from SAE (Society of Automotive Engineers) World Congress 2012 dated 26 April 2012.

*“He [Levandowski] said the car and hardware cost about \$100,000, but Google has just a handful of them. **When they go into mass production, he estimated an ordinary car could be retrofitted for a couple of thousand dollars.** Some cars already have many of the sensors the Google car uses, so the cost of retrofitting such cars would be much lower.”* Cato@Liberty “Googling around DC”, 17 May 2012.

## When will Autonomes arrive?

- 25 Sept 2012 California became the 3<sup>rd</sup> US State after Nevada and Florida to sign an Autonomous Vehicle Bill into law.

Sergey Brin (co-founder Google) said **“You can count on one hand the number of years it will take before ordinary people can experience this.”**



# Summary of the 2 Technologies

## Connected Vehicle

- (Congestion Busting) Improves Highway Capacity
- Reduce Collisions by up to 48%
- Full implementation approx. 2018-2019

## Autonome

- Reduce Collisions by up to 93%
- Minor highway capacity benefits
- Major benefits to businesses and environment
- Transformative for almost every aspect of society
- Full implementation approx. 2017

GOAL: Convergence = Ultimate Road Transportation (?)

## Possible Implementation Scenario

Assume 'body-out' legally acceptable:

1. Taxi/Trucking industry disrupts
2. Rental/Car Share/Ride Share models Adapt
3. Autonomie Fleets emerge
4. Early-adopter Entrepreneurs hire out autonomes
5. Competition - Transport as a Service (TaaS) develops
6. Bus service disrupts
7. Public Transit (LRT, BRT, Trams etc.) impacted
8. 'Accidents'/Collisions significantly reduced
9. Vehicle size/weight reduces - Catalyst for Electric cars
10. Reduced urban parking – streets reclaimed

# The future is already here?



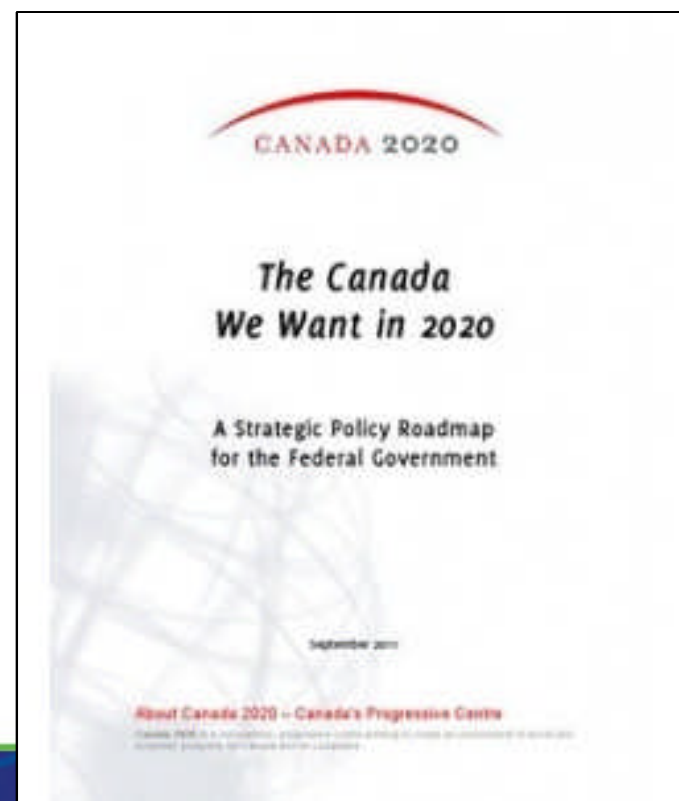
## Watch and Wait or Respond?

Ensure we are prepared for this **paradigm shift** in how we 'do' road transportation. **Disruptive tech does not work to a fixed program and is unpredictable!**

**We cannot un-invent this tech; it is a matter of 'when' and not 'if'.**

### Public Sector Suggestions:

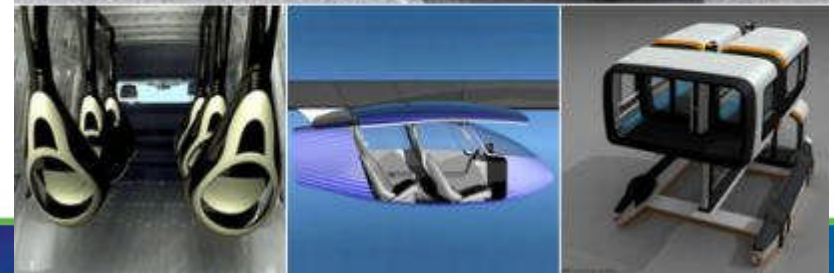
- Prepare a roadmap for implementation
- Modify policies, prepare laws, regulations, standards etc.
- Be aware of impact on public transport plans
- Assist/sponsor research



# Watch and Wait or Respond?

## Transportation Professionals Suggestions:

- Plan for a very different future starting in  $\approx 4$  years
- Consider review of forecasts (traffic flows, costs etc.)
- Consider impacts on public transport projects
- Get trained-up in this new tech.



# Watch and Wait or Respond?

## Suggestions for Businesses:

- Examine your business model
- Consider implications to vehicle fleet/development plans
- Note: “Incumbent players rarely do well when industries disrupt.” — Larry Burns, Co-Author of Reinventing the Automobile: Personal Urban Mobility for the 21<sup>st</sup> Century.
- Consider: Google are a \$240bn company with \$50bn cash. GM are a \$36bn company..... you do the math.

## All to Ponder

This is but the Dawn of the Robot Revolution – it will not only revolutionize our roads, but transform society

# Science Fact or Science Fiction?





A TETRA TECH COMPANY



**The Autonomes are Coming  
SOON!**

**This Will Fundamentally Change How We 'Do'  
Road Transportation**

**Thank You!**