The Future of Mobility Intelligence

Annie Cheng
VP of Engineering
Nauto
Transport Today: 99% waste

Connected:
Time & route shift & transit integration

Autonomous:
90% accident reduction

Electric:
85% efficient drivetrain

Shared:
50% utilization (70% with delivery at night?)
Why Would We Want Artificial Intelligence in Driving?

- Handle the boring stuff – traffic jams
- Never get distracted – 360 degree awareness
- Solve for disability – blind, elderly, kids
- Faster reaction time - safety
- Better coordination – learning from all cars
- Asset productivity – density, no parking, sharing, repositioning
Nauto learns from best drivers and learns to avoid the worst

- Build their driving into autonomy
- Prevent #1 cause of accidents: distraction
- Train or should not drive

Visual quality-based scoring, 5x better segmentation
Current OBDII based

Index of Loss

- 20% Safe Drivers
- 65% Average Drivers
- 15% Bad Drivers

Source: Progressive Snapshot study 2013 / Visual data: VTTI Naturalistic Driving Study 2013
Driver Behavior and Safety

- Distraction
- Speeding
- Tailgating
Not Just for the Autonomous Future - Increase Road Safety Today

Safety & Liability Improvement

• Provide Proof of Innocence

Drivers improve because they see hidden events:

• 3 of 4 crashes are not reported
• 10x more near misses than crashes
• 2 out of 3 drivers are unaware they were in a close call

When Drivers Improve, crashes decline:

• Up to 60% reduction in crash frequency
Thank You

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Agenda

1. Mercifully brief commercial introduction
2. V2X primer
3. A short video demo
4. Typical ASD conceptual implementation
5. Encouraging adoption
Savari in a nutshell: the V2X sensor company

- $8M Series A
- 70+ employees
- 6 offices: Santa Clara, Detroit, Munich, Bangalore, Seoul, Shanghai
- Smart City wins: Tampa, Shanghai, Ann Arbor
- OEM Deals: SAIC Motors, U.S. OEM (to be announced)
U.S. Headquartered – Global Presence

>70 employees in 5 global locations

**Silicon Valley**
- New product introduction (HW)
- V2X applications
- Cloud Services

**Detroit, US**
- V2X Safety/ADAS IP including applications
- ADAS R&D

**Munich, EU**
- BD office
- FAE and tech sale support
- ETSI and C2C interface

**India**
- Embedded Software development and validation
- Platform, radio, middleware/V2X stack

**China**
- R&D on LTE-V in collaboration with SAIC
- R&D and Innovation Lab at Tongji University (to be announced in Q4 2016)

**South Korea**
- BD office
- FAE and tech sale support
Obvious: Autonomous cars will get more & better sensors

<table>
<thead>
<tr>
<th>Autonomous car</th>
<th>Autonomy levels &amp; timeline</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>GPS</td>
<td></td>
</tr>
<tr>
<td>Lidar (Lidar light detection and ranging)</td>
<td></td>
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<tr>
<td>Camera</td>
<td></td>
</tr>
<tr>
<td>V2X</td>
<td>✓</td>
</tr>
<tr>
<td>Radar</td>
<td>✓</td>
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</tbody>
</table>

But, Lidar, Radar and high-end Camera systems are not easily installed as aftermarket units - ~90% of cars are older

Sources: NHTSA; U.S. Department of Transportation
What is unique about V2X? See beyond other sensors

New York City, Manhattan

Direct information from traffic light vs. indirect (other sensors)

Seeing 1000m ahead vs. MAX 300m (other sensors)

Seeing through buildings/objects vs. other sensors can only see what is in line of sight

Collaborative (sending and receiving data) vs. other sensors only observe
Most cars will not be autonomous (*for years …*)

**V2X** can help AVs see the non-AVs and help AVs “know” as well as “see”

- 3 seconds of path prediction
- Sense threats beyond line of sight (e.g. around a blind corner)
- Information vs. data = reduced driver latency (human OR AI)
- V2I (Infrastructure) communicates the signal phase and timing (SPaT).
- V2I can communicate super local mapping
- V2I can eliminate the “train” effect at signalized intersections
V2X | Communications between all traffic components

V2V | Vehicle-to-Vehicle
V2I | Vehicle-to-Infrastructure
V2P | Vehicle-to-Phone

Wireless real time communication using DSRC (802.11p) or LTE (Rel 14)

*P = Phone = People
V2X is a sensor that transmits *information* vs *data*

**Each Car has:**
- 2 way radio
- GPS
- CPU
- Security
- Inertial Guidance
- CAN
- 2 wire ethernet

Benefits at ~20% saturation – Excellent when >90%
Enables Connected and Cooperative Driving

*Information Broadcast 10 times/second*

Cooperative Driving is Safer and More Efficient
ASDs will enable all traffic to benefit from V2X

Two classes of V2X nodes, features and benefits

- VAD (Vehicle Awareness Device)
  - Sends vehicle location 10x/second
  - Aids in traffic management by accurately tracking vehicles in the grid
  - Allows “smart” intersection to react to cars with VADs
  - No in-vehicle interaction

- ASD (Aftermarket Safety Device)
  - Two-way communication Runs a rich variety of applications (apps)
  - Provides ADAS features (Advanced Driver Assistance System)
  - Interface with driver via HMI (Human Machine Interface)
  - Can be added to any vehicle
  - Enhances driver zone of awareness in both distance and time
An ASD may be based on an existing PND

Garmin Drive™ PND

Existing PNDs have most of the needed features
Advanced PND systems feature set

Dashboard camera
Back up camera
WiFi (updates via in-car hotspot)
Bluetooth interface to phone
Voice activation and audio feedback
Traffic notice
Camera-enhanced vision and object recognition
GPS/GNSS
Maps
Compact form factor with display and proven HMI
Add 802.11p or LTE R14, Savari V2X Software = ASD

Existing PNDs have most of the needed features

* Example only, not endorsed by Garmin
Additional features for V2X ASD

Designed to be achievable

- 802.11p (DSRC) or LTE Rel 14 radio
  - Alternately, a connection to one of the above
- Message Security (IEEE 1609.2)
- GPS with 10Hz update ability
  - 1.5m accuracy – “Lane Accurate”
- V2X software stack (messaging, filtering, applications)
- Sensor fusion software for camera system (if present)
- Extra credit: allow connection to additional cameras and sensors as available
- Target price <$300
How to encourage adoption?

The big question for V2X

- The “Stick” approach
  - Government mandate
  - Insurance compliance (e.g. no insurance payout if no V2X)
  - Vehicle registration / inspection
  - Inspection for compliance by police

- The ”Carrot” approach
  - Government subsidies
  - V2X only zones in cities and on freeways
  - Parking and tolling preferences
  - Insurance adjustments
  - HOV lane access
  - Your old car can be relevant again
    - Create a “cool” factor
  - Show proven savings in infrastructure equipped cities
Thank you for your time and attention!

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WHY MASSIVE DATA BETWEEN VEHICLES AND THE CLOUD?

**VEHICLE TELEMETRY, SAFETY AND FLEET ANALYTICS**
Manage product life cycle, improve safety, lower maintenance costs, maximize fleet ROI

**HIGH-BANDWIDTH INTERNET TRAFFIC**
Mobile Wi-Fi for passenger, content for onboard screens

**URBAN DATA FOR SMARTER CITIES**
Urban sensing using vehicles, IoT sensors, data APIs

**VIDEO CAMERAS**
Increase security and safety, reduce risks, build maps

**AUTONOMOUS VEHICLES**
Accelerate product and time-to-market
Maps, software updates, Internet traffic

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La Rambla, Barcelona (2017)
400 people
330 MB per hour
50 cars
0 MB per hour

La Rambla, Barcelona (2025)
400 people
1.6 GB per hour
20 AVs
160 GB per hour
How can we move terabytes of data between vehicles and the cloud?
THE OLD WAY OF THINKING ABOUT NETWORKS

Using networks as silos increases data costs and will leave you outside the upcoming urban mobility revolution

<table>
<thead>
<tr>
<th>Network</th>
<th>Purpose</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSRC (V2X)</td>
<td>Safety applications</td>
<td>$75Mhz of free spectrum and 27 Mbps of available bandwidth</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>Vehicle subsystems communications</td>
<td>Unsuitable for data offload on the move (5s connection setup time)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unsuitable for V2V communication (50m range)</td>
</tr>
<tr>
<td>4G LTE</td>
<td>Infotainment</td>
<td>Prohibitive cost at scale (100$/month on pax Wi-Fi for shared mobility cars)</td>
</tr>
<tr>
<td></td>
<td>Security OS Updates</td>
<td>Unsuitable for mission critical teleoperations (connection latency &gt; 100ms)</td>
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VENIAM PLATFORM
MULTI-NETWORK, MULTI-PURPOSE, UPGRADEABLE

10 YEARS OF R&D | AWARD-WINNING TECHNOLOGY | 80+ PATENTS
DEVELOPED IN PARTNERSHIP WITH MIT AND CARNEGIE MELLON

30M miles of connected vehicle data
Moving >1TB/vehicle/day

Get the most bandwidth out of all the wireless interfaces in your vehicle

1 TB of data upload in Porto with real-world public buses

V2I  V2V  DSRC  4G/LTE  Wi-Fi
10x
Longer Range than Classical Wi-Fi

100x
Faster Connection Setup

12x
Cheaper than Cellular

STANDARD WI-FI
50m

V2X

V2I

V2V
KEY HARDWARE, SOFTWARE, AND CLOUD COMPONENTS FOR CONNECTED VEHICLES

Our technology & IP solve the essential networking challenges in connecting moving things

- **Hardware**
  - Onboard Units
  - Access Points

- **Networking Software**
  - Connection Control Algorithms
  - Mobility Control Protocols
  - Delay-Tolerant Protocols
  - Mesh Networking & Multihop
  - Cyber-Physical Security

- **Cloud**
  - Network Control/Software Updates
  - Data Analytics
  - APIs Apps

**10 YEARS OF WORLD-CLASS R&D BY VENIAM TECH FOUNDERS AND THEIR TEAMS**
Veniam is 5G

- Manageability
- Mobility
- Diversity
- Low Latency
- Location & Context
- Network slicing
V2V MESH IS THE MOST COST-EFFECTIVE SOLUTION FOR OTA UPDATES

V2V MESH SOFTWARE UPDATES ARE 90% CHEAPER!

Monthly SW update size and cost for NYC for a top OEM

V2V Mesh only requires software updates via 4G in <5% of active fleet, leading to:

Full rollout in 1-2 days for shared mobility vehicles

Full rollout in 7 days for private consumer vehicles

*Model based on mobility patterns observed in Porto, Portugal

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The platform that moves terabytes of data between vehicles and the cloud.