College of Engineering- Center for Environmental Research & Technology

Adapting to Climate Change Using Intelligent Transportation Systems Technology

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ITS Technology is typically used to *mitigate* GHG emissions…

- **Build cleaner, more efficient vehicles:**
  - **make vehicles lighter (and smaller) while maintaining safety**
  - **improve powertrain efficiency**
  - **develop alternative technologies (e.g., electric vehicles, hybrids, fuel-cell)**

- **Develop and use alternative fuels:**
  - **Bio and synthetic fuels (cellulosic ethanol, biodiesel)**
  - **electricity**

- **Decrease the total amount of driving: VMT reduction methods**
  - **Better land use/transportation planning**
  - **Travel demand management**
- **Improve transportation system efficiency**
  - **Intelligent Transportation System (ITS) technologies**
  - **Connected Vehicles → Vehicle Automation**

Can ITS Technology be used for climate resiliency and adaption?…

- Better situational awareness through Sensing and Traffic Management Centers
  - Infrastructure sensors (embedded loop detectors, cameras, etc.)
  - Connected Vehicles as Probe Vehicles (travel times, road weather reporting)
- New traffic routing algorithms being developed and applied
  - traditional routing algorithms: minimize distance, travel time
  - Advanced routing algorithms now using energy, emissions, weather
  - Distributed Routing algorithms are also emerging
- Concept of Dynamic Low Emission Zones emerged from USDOT AERIS Program
  - Change traffic management parameters based on localized emissions

Connected Vehicles: providing better interaction between vehicles and between vehicles and infrastructure

- increased **Safety**
- better **Mobility**
- lower **Environment** impact

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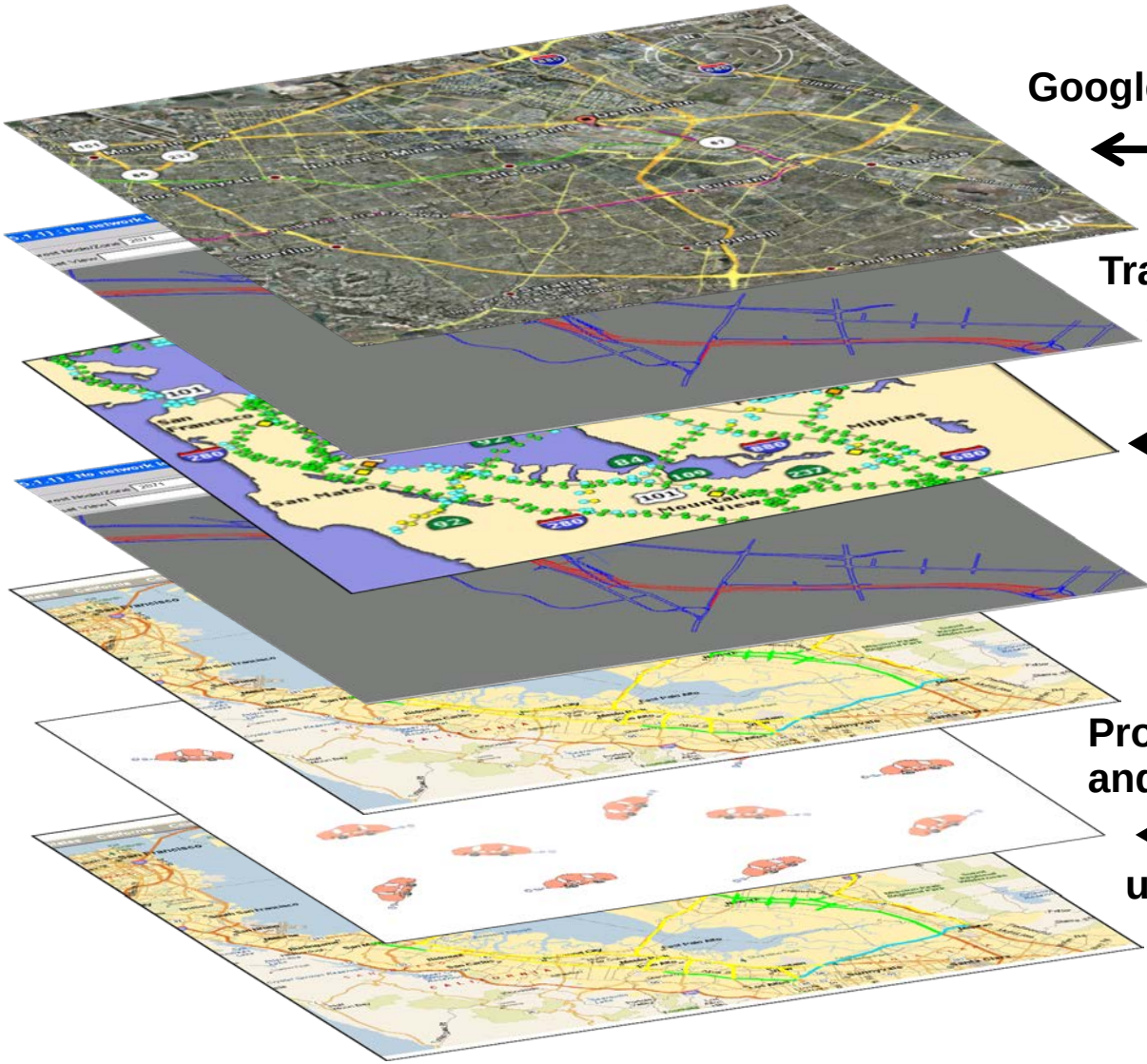
Better situational awareness through Sensing and Traffic Management Centers



Google Earth or Google Maps Interface

Traffic simulation data

Embedded loop detectors data (freeways)

Traffic signal/detector info

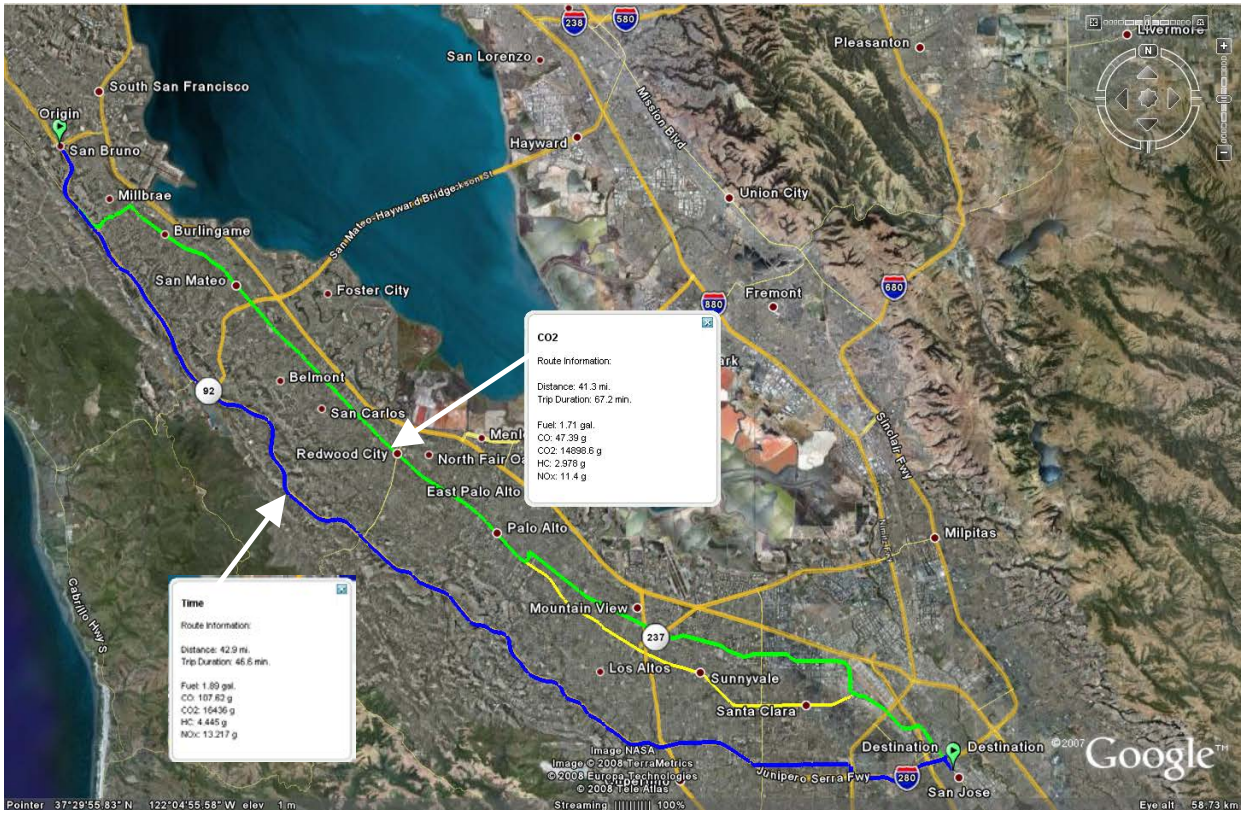
INRIX traffic data

Probe Vehicle network (arterials and freeways)

underlying network data

Navigation Tools: Routing on different variables:

- shortest-distance path without real-time traffic info
- shortest-duration path with traffic information
- Many other routing algorithms are now being developed based on minimizing energy consumption, emissions, inclement weather, and maximizing routing choices

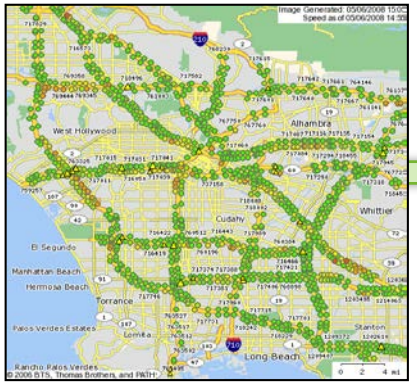


Routing based on Vehicle Type: Truck Eco-Routing

- **Route selection based on environmental constraints such as minimizing fuel consumption and emission production**
- **Accounts for important factors affecting heavy truck energy consumption and emission production**
  - **Vehicle weight, road grade and vehicle speed**

Network Link Cost Factors

Dynamic Network Information



real-time traffic speed
road grade

Fuel/Emission Model

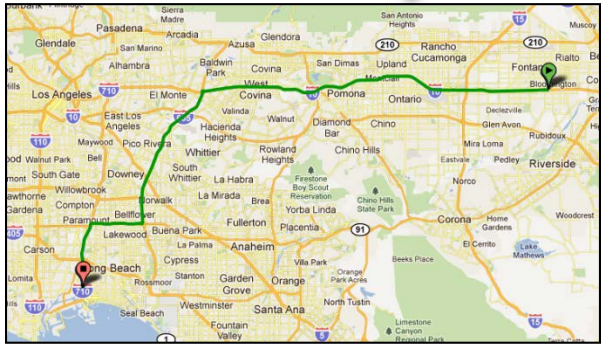
Update Link Cost Factors

Routing Algorithm

Vehicle Data

loaded weight
vehicle modeling parameters

Route Mapping



Traffic Management Centers are Typically Centralized, not Decentralized

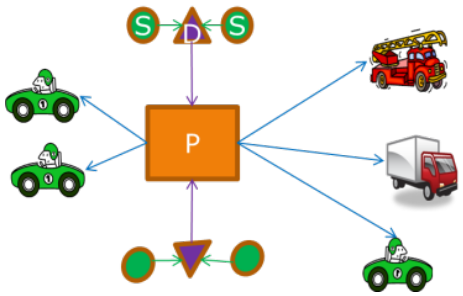
- **Many traffic management decisions can be handled locally between vehicles with communications capability**
- **A decentralized traffic management system is more robust to point failures**

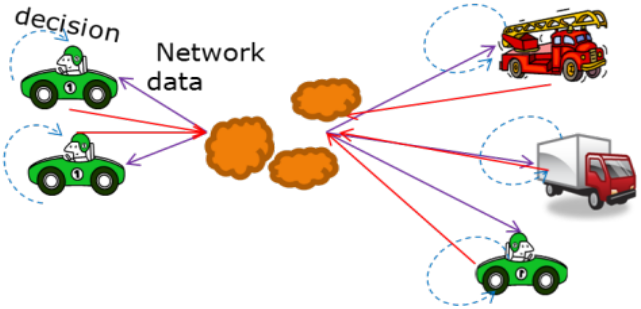
Information Acquisition

Centralized → *Distributed*

Processing Location ↓ *Distributed*

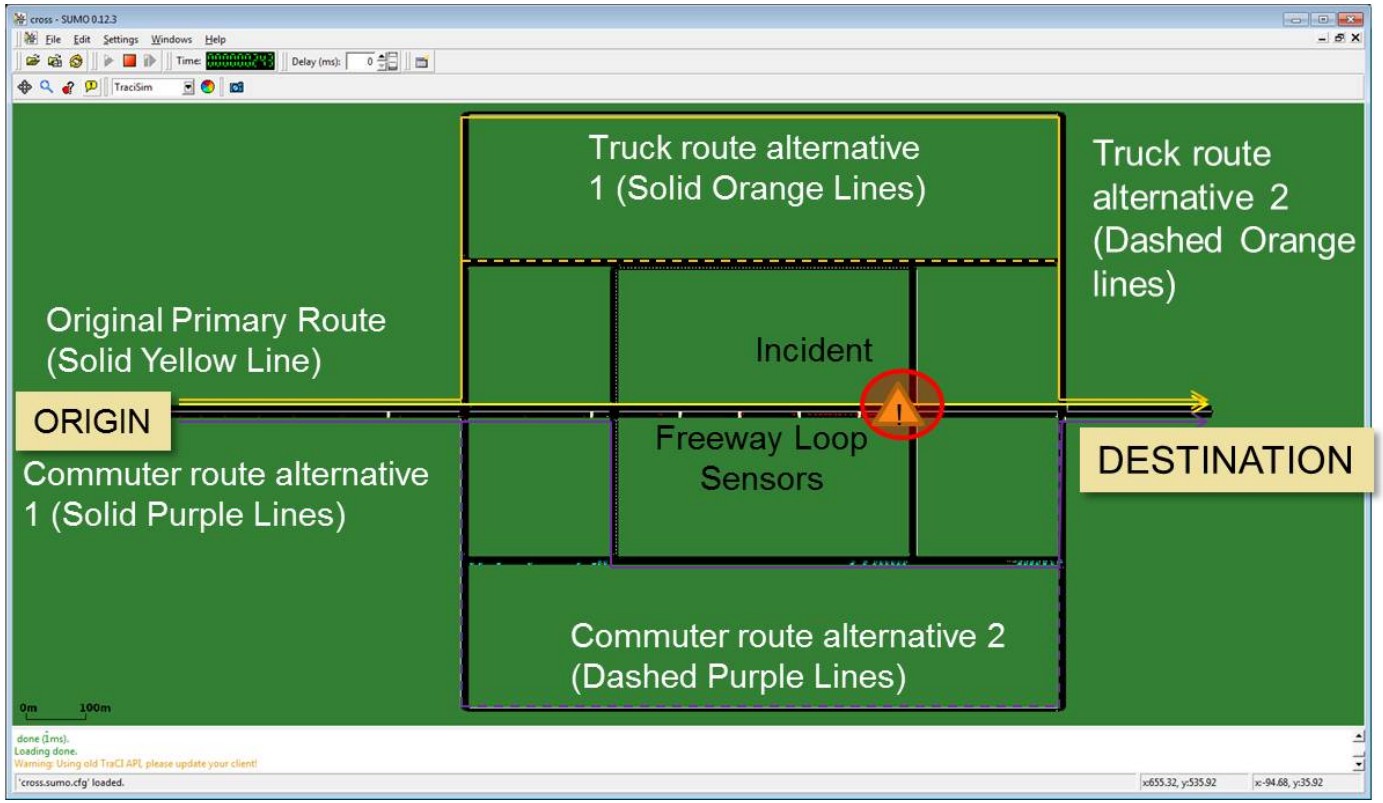
1 / (C,C)	2 / (CD,C)	3 / (D,C)
4/ (C,CD)	5/ (CD,CD)	6/ (D,CD)
7/ (C,D)	8/ (CD,D)	9/ (D,D)





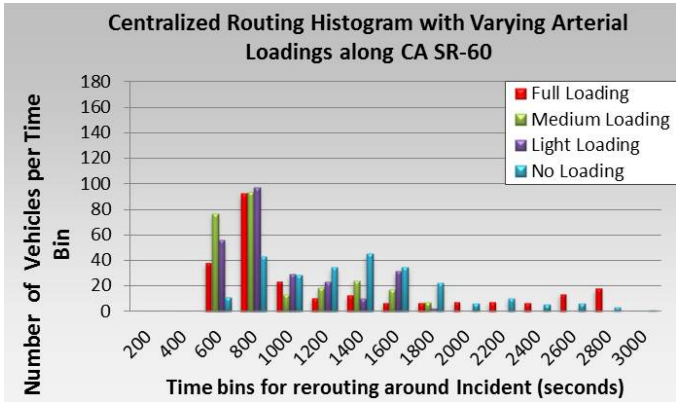
Emerging Paradigm: Distributed Routing

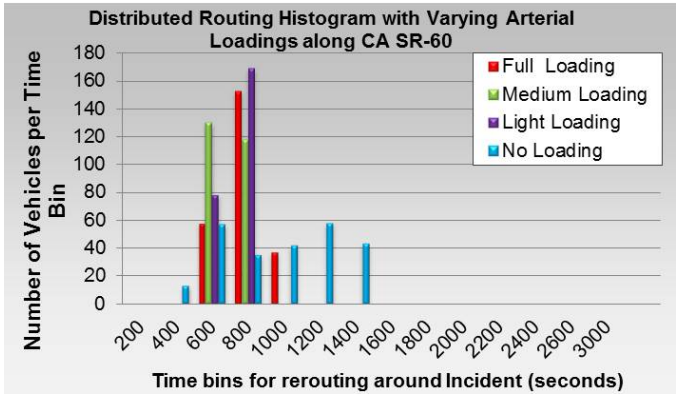
- **Traditional model is for all traffic to get the same routing advice, leading to shifts of congestion**
- **With connected vehicles and decentralized traffic management, routing advice can be distributed based on vehicle characteristics**
- **Distributed routing maximizes total system-level traffic throughput**



Distributed Routing in Southern California

(state route 60 in Riverside California)



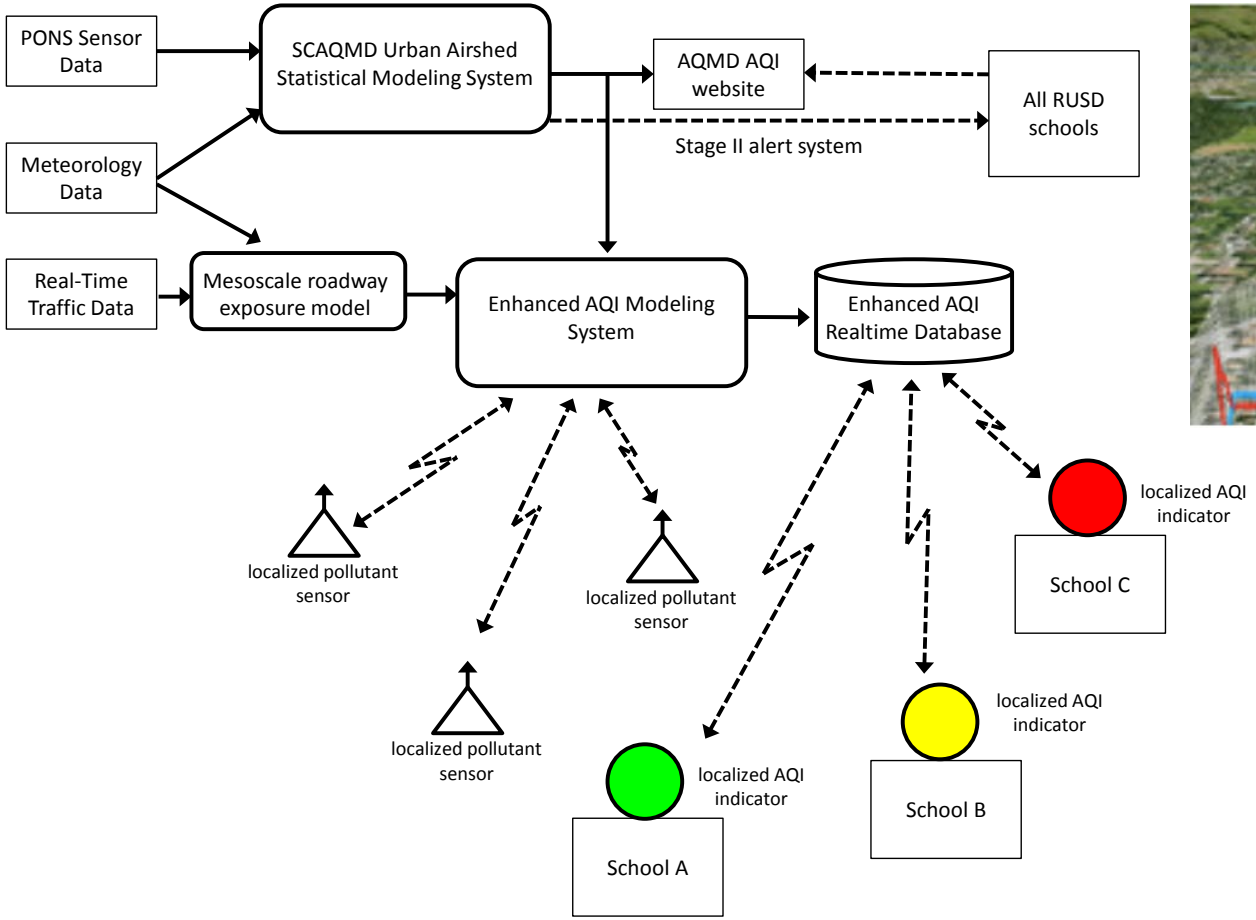


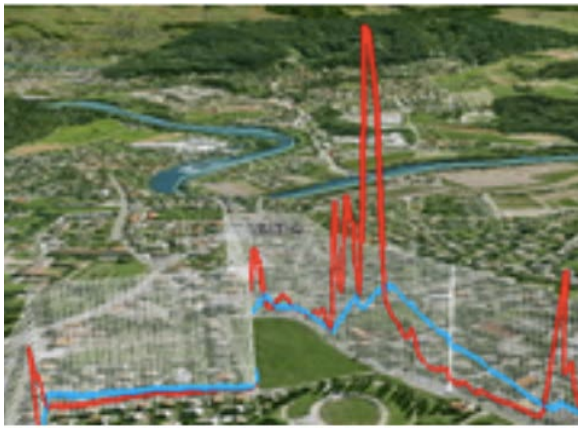
Building Better Air Quality Maps:

- **Traditional air quality prediction maps are coarse both spatially and temporally**
- **New low-cost air quality sensors are now becoming prevalent, allowing for localized measurements and predictions of air quality**

Building Better Air Quality Maps:

- **Regional and localized air quality maps can now be produced based on better local sensors and modeling**
- **Enhanced air quality maps can now be integrated with other traffic data**





USDOT AERIS Program: Low Emission Zones

- **USDOT carried out a 5-year research program to focus on environmental benefits of connected vehicles called AERIS (Applications for the Environment: Real-Time Information Synthesis)**
- **One of the AERIS concepts was Low Emission Zones**
- **Enables traffic responsive operations based on poor air quality**

Low Emissions Zones

- London has the largest Low Emissions Zones in the world covering almost all of greater London, targeting emissions from older diesel-engine lorries, buses, coaches, vans, minibuses and other heavy vehicles
- The cities objectives are to:
  - Reduce air pollutants (NO_2) and CO_2 emissions
  - Promote sustainable travel
  - Stimulate the low emission vehicle market
- The Mayor of London recently announced the intention to create an ultra low emissions zone where almost all the vehicles running during working hours are either zero or low emissions vehicles
- Low emissions zones are also currently in operation or being planned in Germany, Sweden, the Netherlands, Denmark, Italy, and Japan

Opportunities with Connected Vehicle Technologies

- Support Low Emissions Zones operations
- Allow for real-time data collection
- Allow for traffic responsive operations during Code Red Air Quality Days and special events

Source: Microsoft Clip Art

Conclusions and Future Work

- ITS Technology can be used for both climate change mitigation and adaptation
- Key driver: better and more diverse sensing capabilities
- New concepts of routing are emerging based on sensing
- Specific "applications" being developed to help travelers deal with a wide variety of incidents (disaster routing, etc.)
- Large concepts such as Low Emission Zones emerging on how to mitigate air quality and climate effects

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