

# Research in autonomous driving: a cutting-edge experience for a made in Italy challenge

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# The VisLab Research Team



21 researchers as of Feb 2010

# VisLab Expertise

- Perception
  - Multispectral Vision (Daylight, Near/Far IR)
  - Single or multiple vision sensors  
(Monocular, Stereo, Motion Stereo, Tetravision, data fusion)
- Data fusion (laser, radar, vehicle data)
- Real Time, multithreaded software environment

# VisLab's peculiarities (1 of 2)

- Not just 'signal processing', but: signal processing **for vehicular applications**
- Specific know-how on:
  - vibrations, illumination, automotive noise, calibration issues, low-cost, low-size, low-power, endurance specs, style constraints,...
- Successful in defining strategic trade-offs



# VisLab's peculiarities (2 of 2)

- Long experience on the field with:
  - Real prototypes: cars, trucks, off-road, mining, road construction, maritime, military
  - Different companies and governmental institutions worldwide

# VisLab's driverless vehicles



1998



2007



2005



2006

# The BRAiVE vehicle





# Two main approaches

- Common successful approaches are heavily based on:
  - very precise maps
  - expensive and invasive sensors
- VisLab's approach is based on **low-cost** and **highly integrated** sensors
  - Primarily artificial vision (cameras)

# Different technologies

## ■ Lidar

- Very precise and dense 3D data
- About 120m, 360 degrees
- 1 million 3D points per second
- Needs a high sensor mounting
- Expensive



# Different technologies

- Vision
  - 2D projection of objects colors
  - Indirect 3D measurement
  - Low cost and straightforward integration





# 3D perception



- 270.000 3D points (color and distance)

# 3D perception



- 1024x768 pxl, ~700.000 dist estimations

# 3D vision

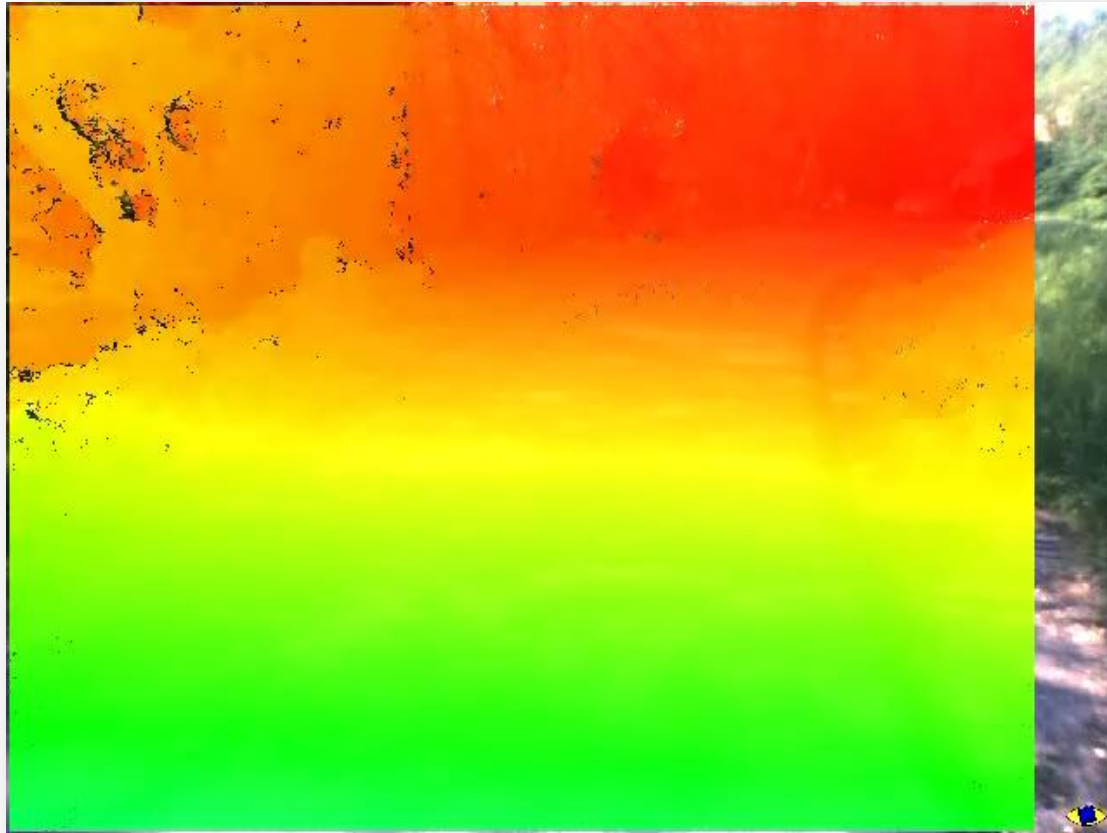
- 640x480 pxl @10Hz -> 3.000.000 pixels/s
- Stereo processing (with 90% density) delivers ~2.750.000 distance estimations per second



# Online calibration

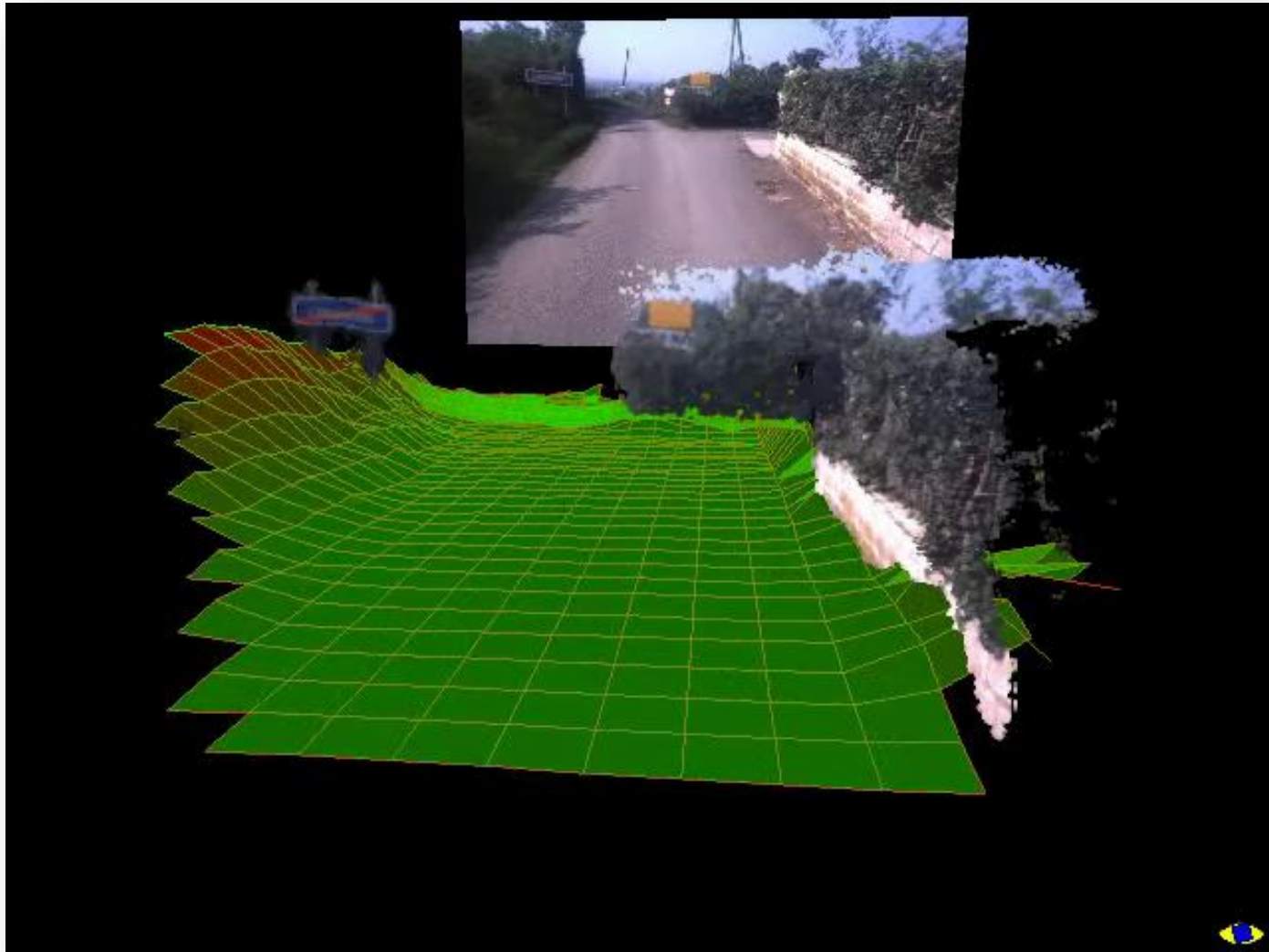


# 3D perception



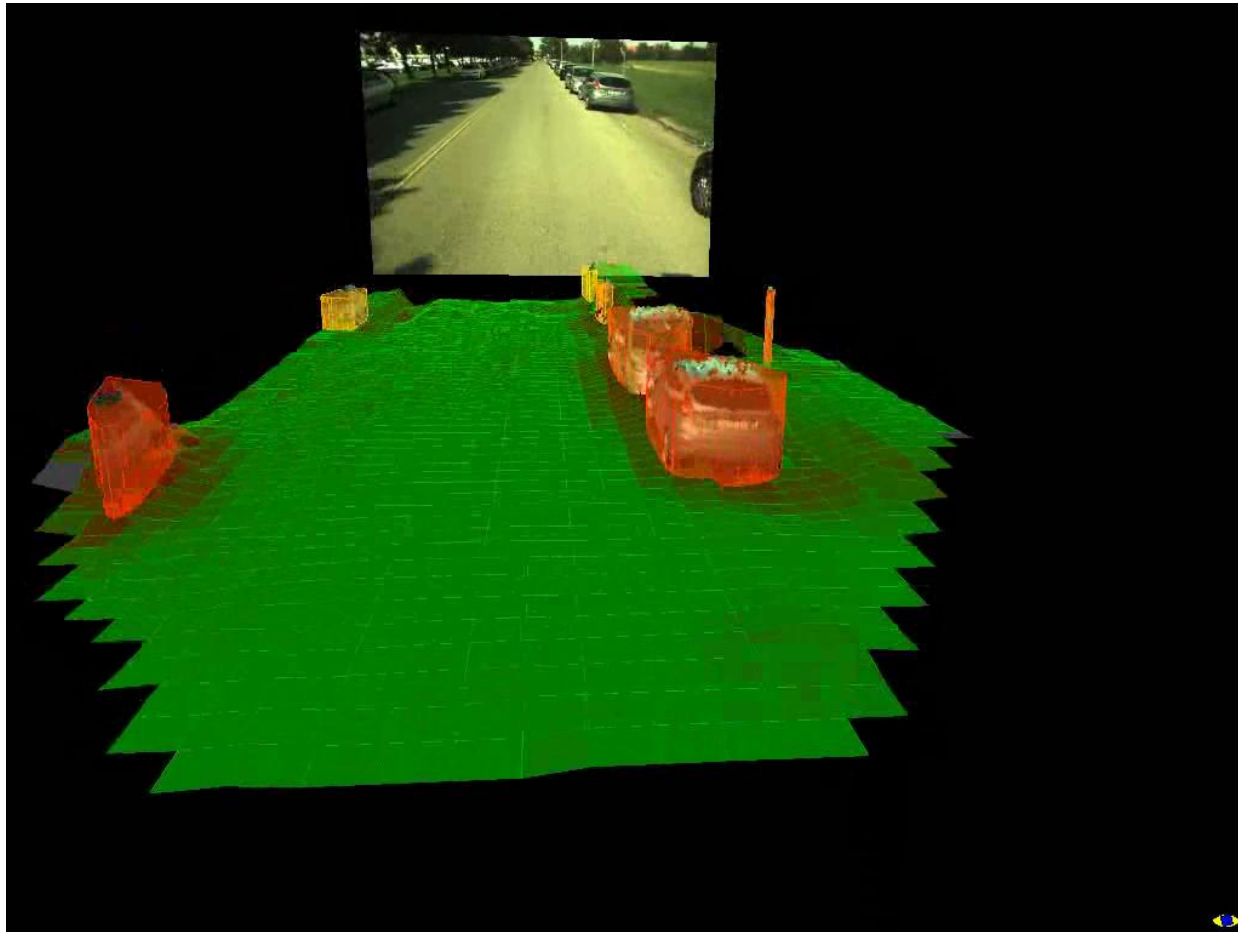
- 90% dense with distance estimations

# Terrain Mapping





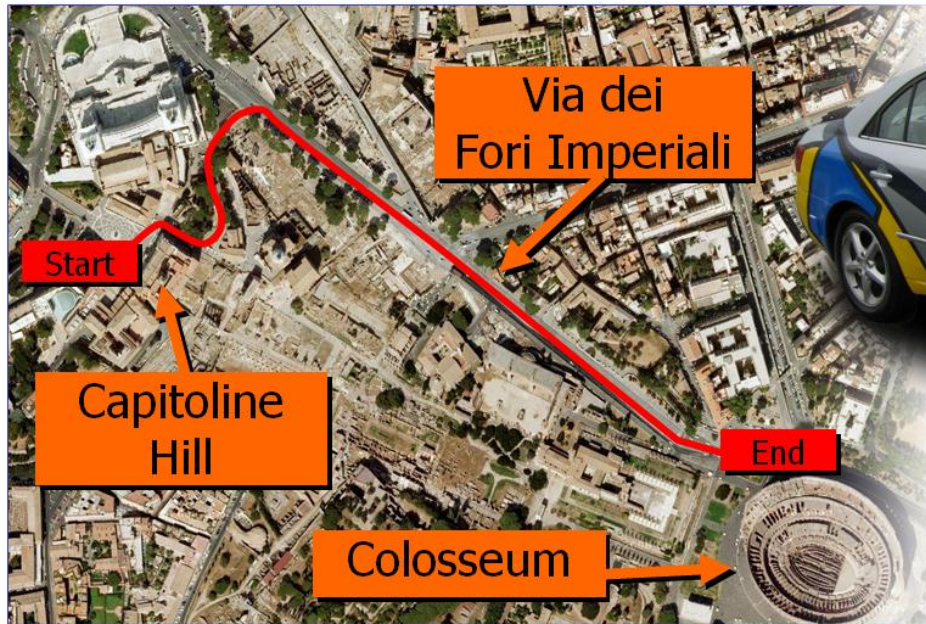
# Road Interpretation



# Road experiments



# Rome Test – Oct 2009



It works, but how reliable is this technology?



# An Out-of-ordinary Experiment:

## The VisLab Intercontinental Autonomous Challenge

13.000 km, 3 months trip,  
...no one driving



# Thorough Test

- The experiment is aimed at testing vision-based perception as well as autonomous operations in:
    - uncontrolled environments and
    - for a long time
- to determine possibly inconsistent behaviors and fix them

# The Challenge

- Test for 13,000 km
  - Including two very different continents (geographical morphology, traffic, weather, infrastructures)
- ... with small, electric,  
and driverless vehicles





# The Sensing Suite

- 7 cameras
- 4 laserscanners
- GPS
- V2V radio

+ Additional devices

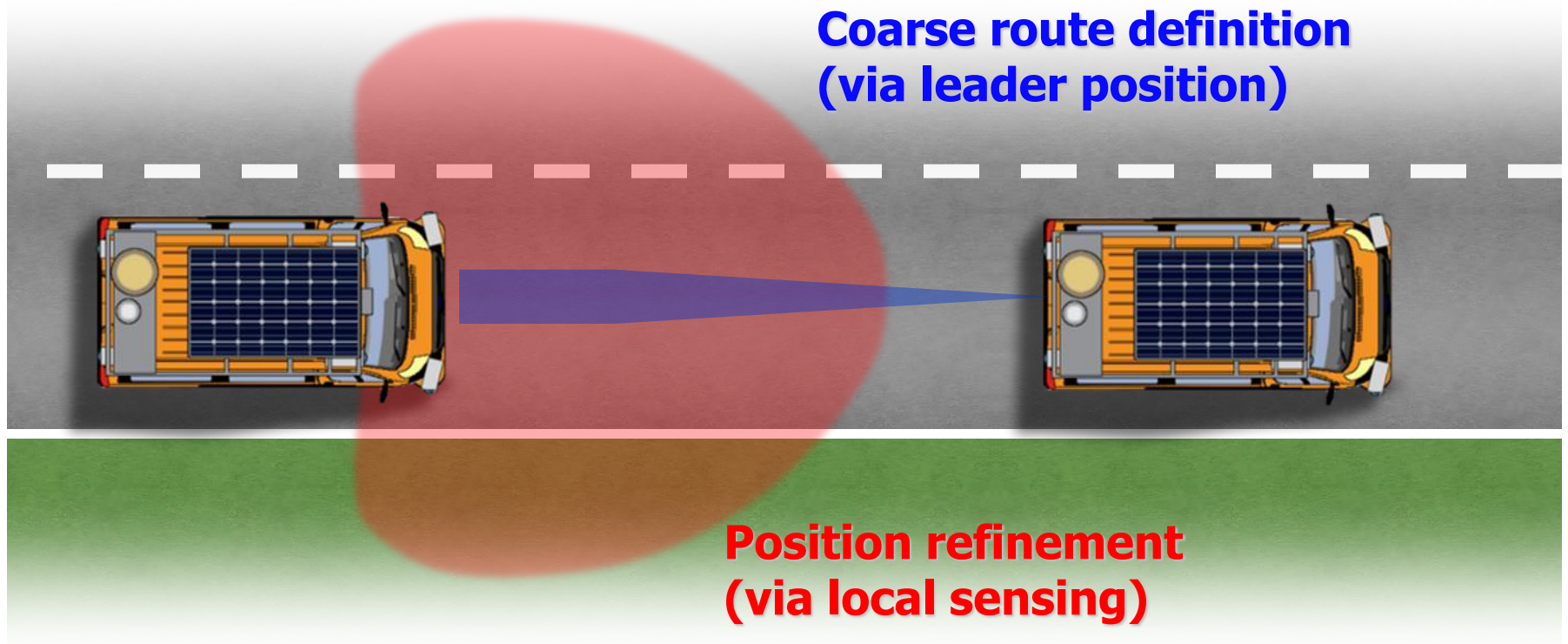


# Assumptions

- No assumptions on:
  - Road infrastructures
  - Availability of maps and GPS coverage
  - Correct behavior of other road participants

# Autonomous Driving

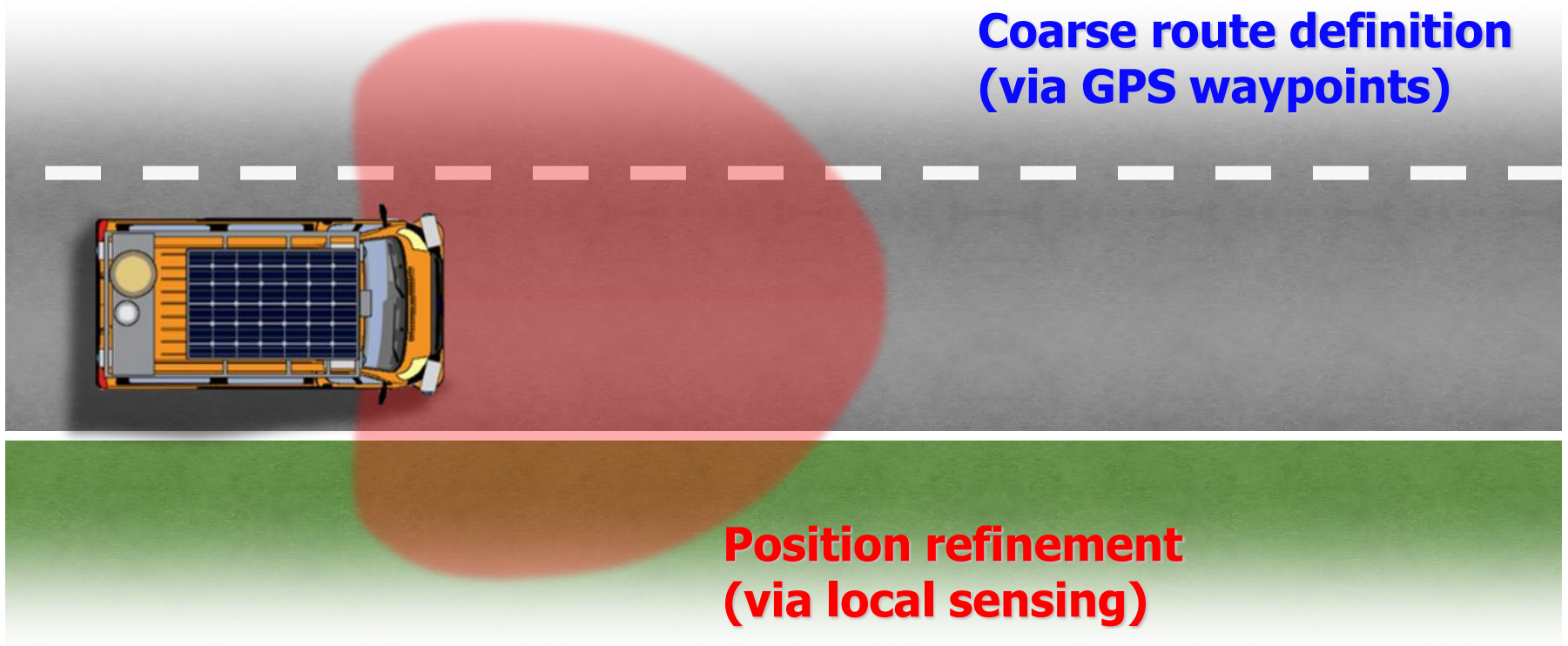
A leader vehicle defines the route





# Autonomous Driving

A leader vehicle defines the route



# The Trip

July 26, 2010 – October 28, 2010





# The Expedition



Autonomous vehicles:

- 2 vehicles travelling
- 2 vehicles as special backups



# The Expedition



## Autonomous vehicles:

- 2 vehicles travelling
- 2 vehicles as special backups

## Support (provided by *Overland Network*):

- 3 trucks (mechanic shop, storage,...)
- 4 RVs for overnight accommodation

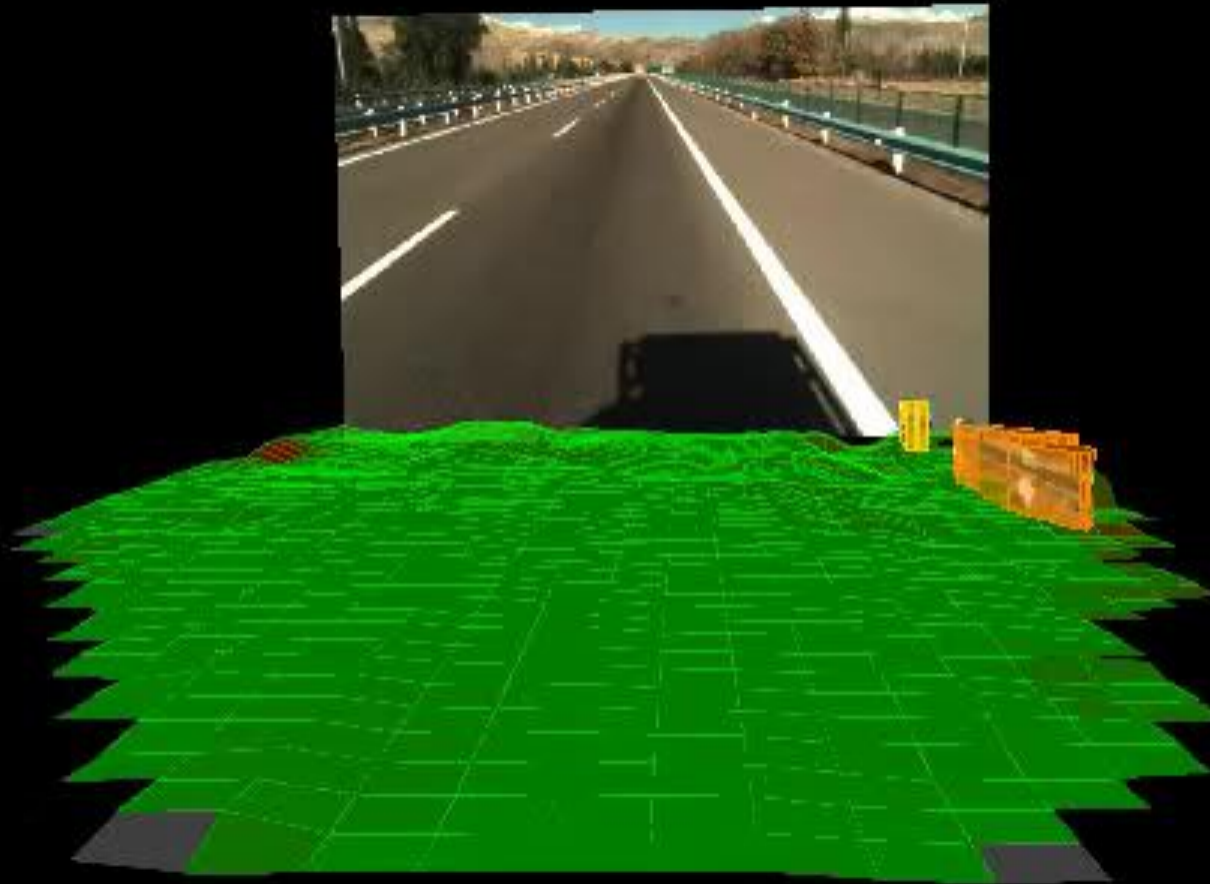




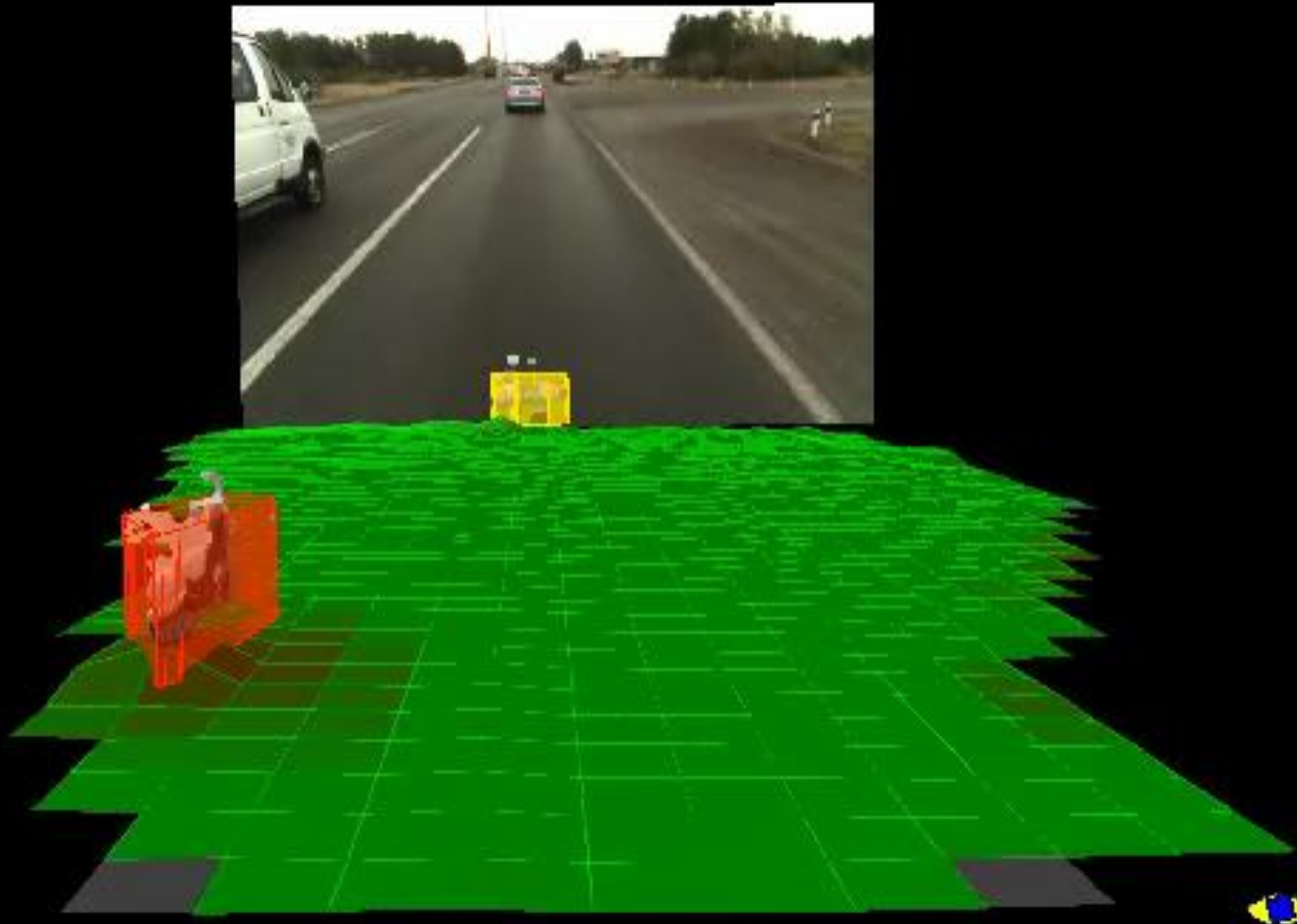




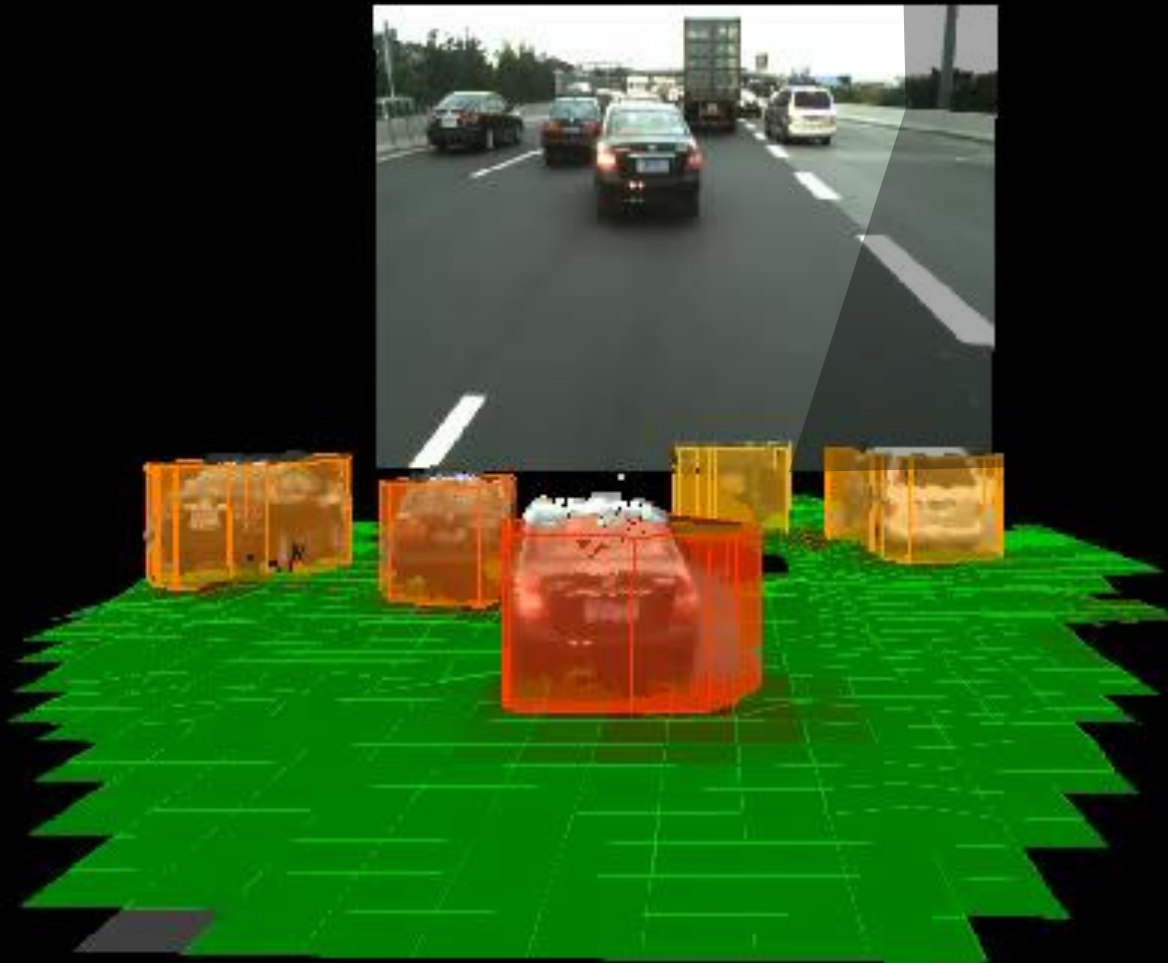
# Examples: easy scenario



# Examples: vehicle following

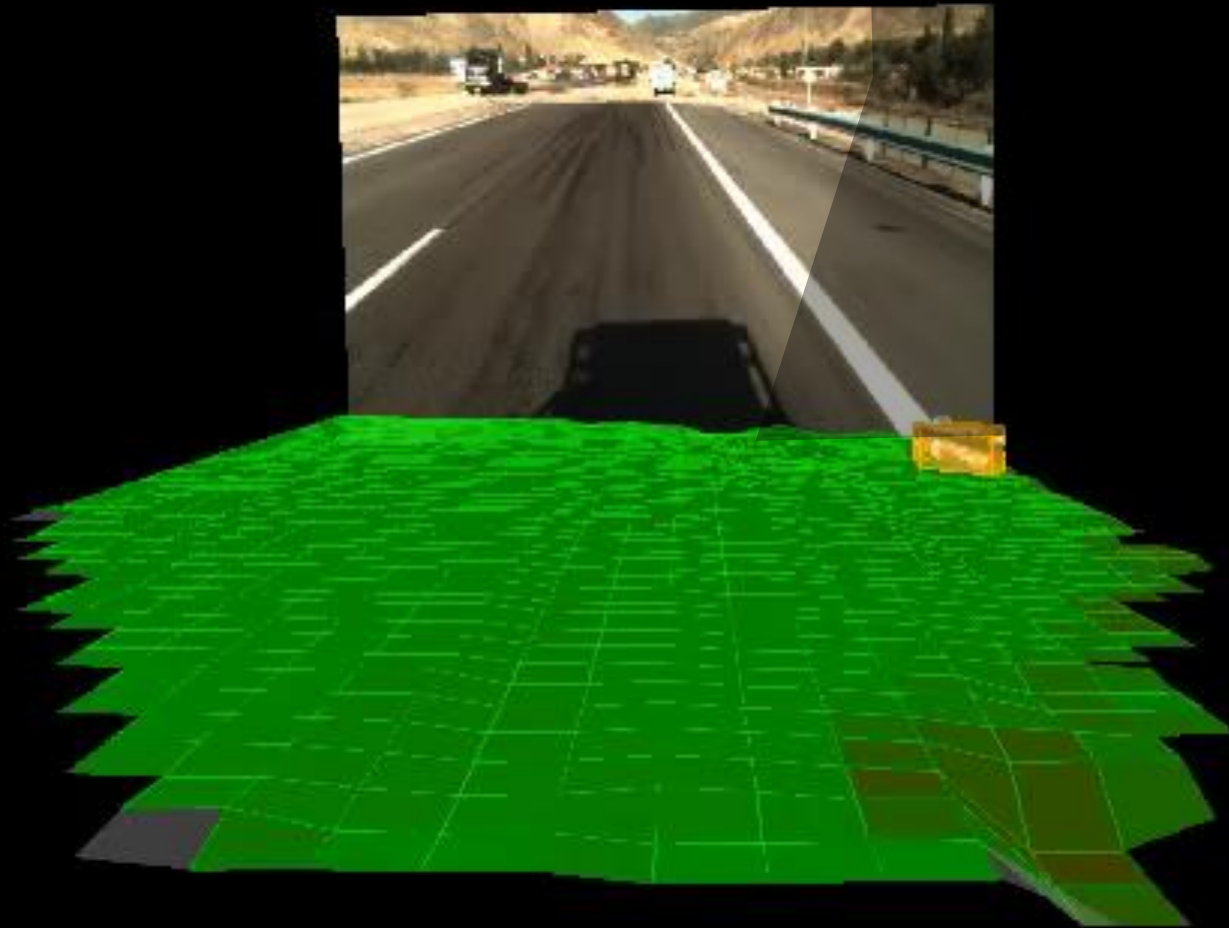


# Examples: traffic

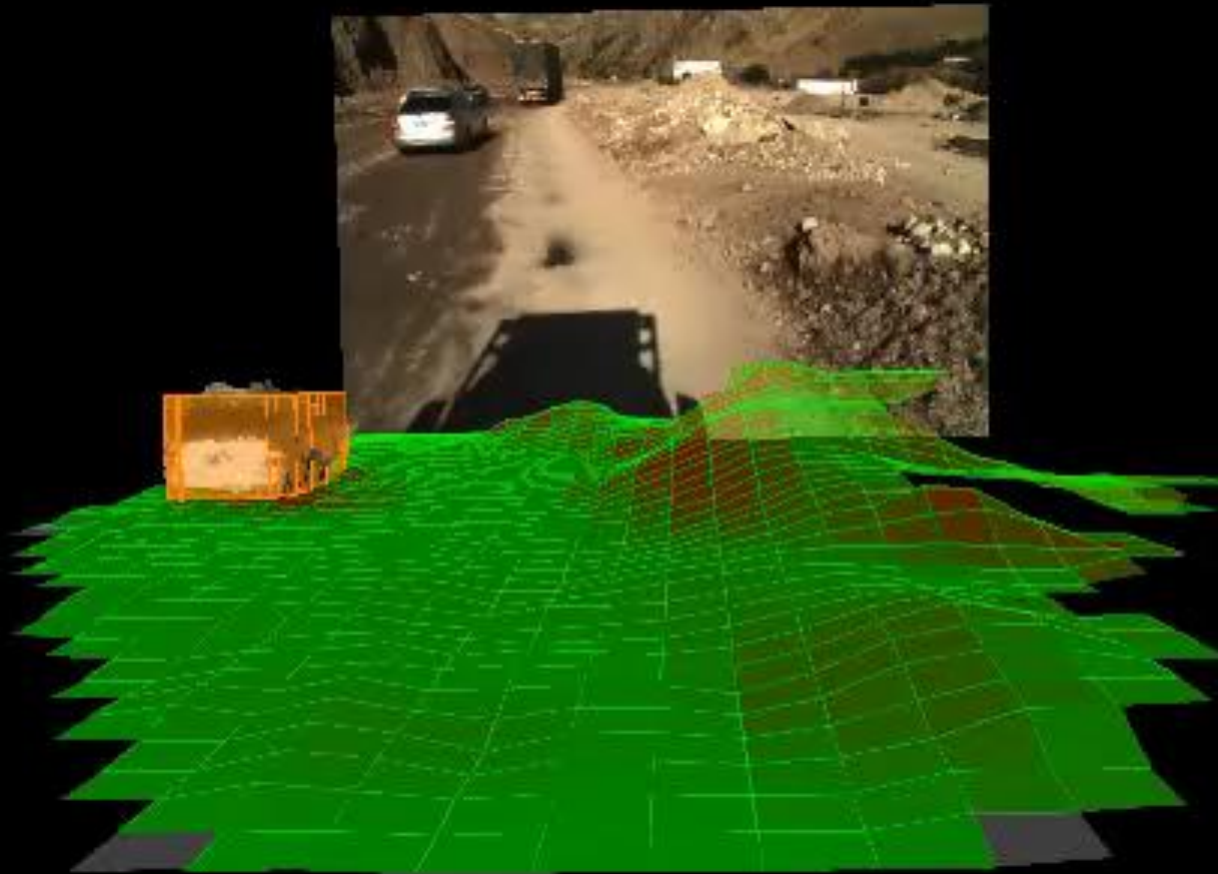




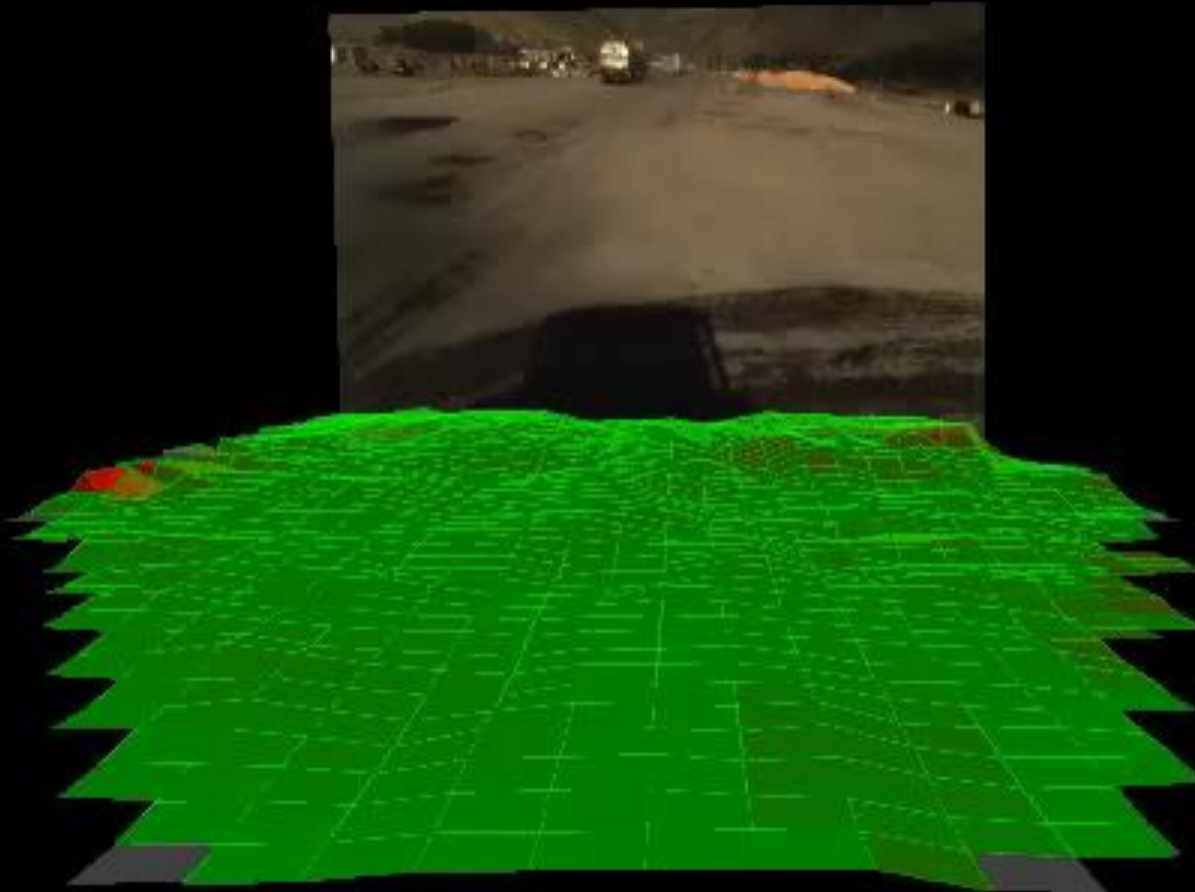
# Examples: offroad



# Examples: terrain mapping

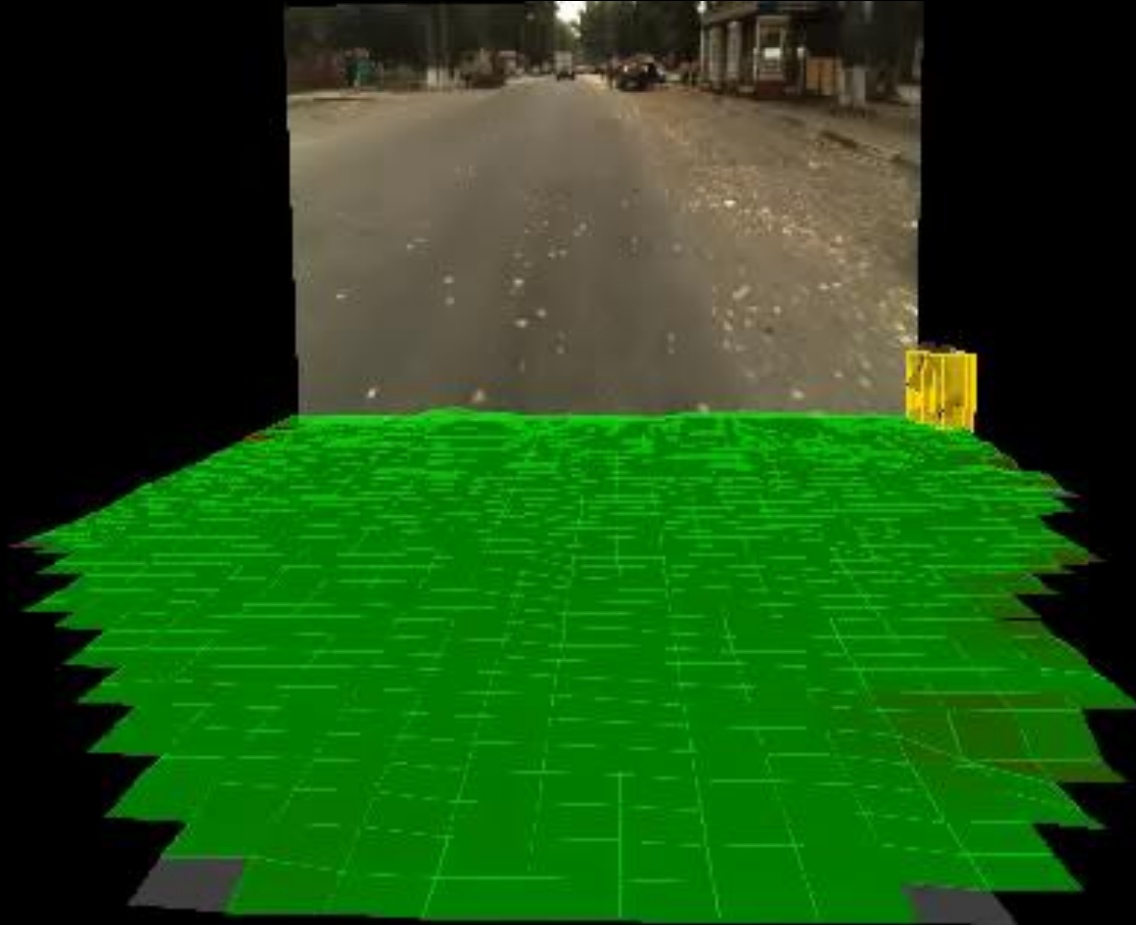


# Examples: dust/smoke

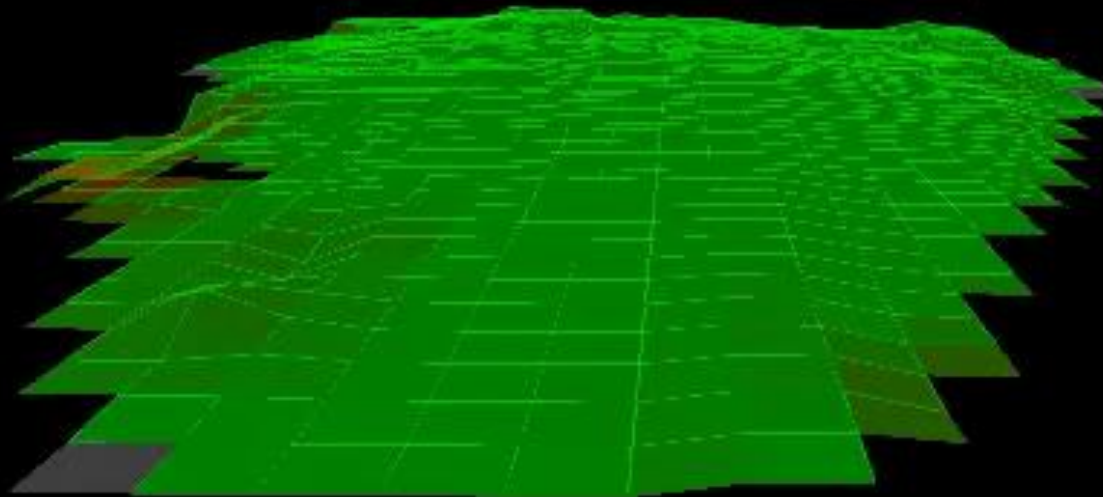




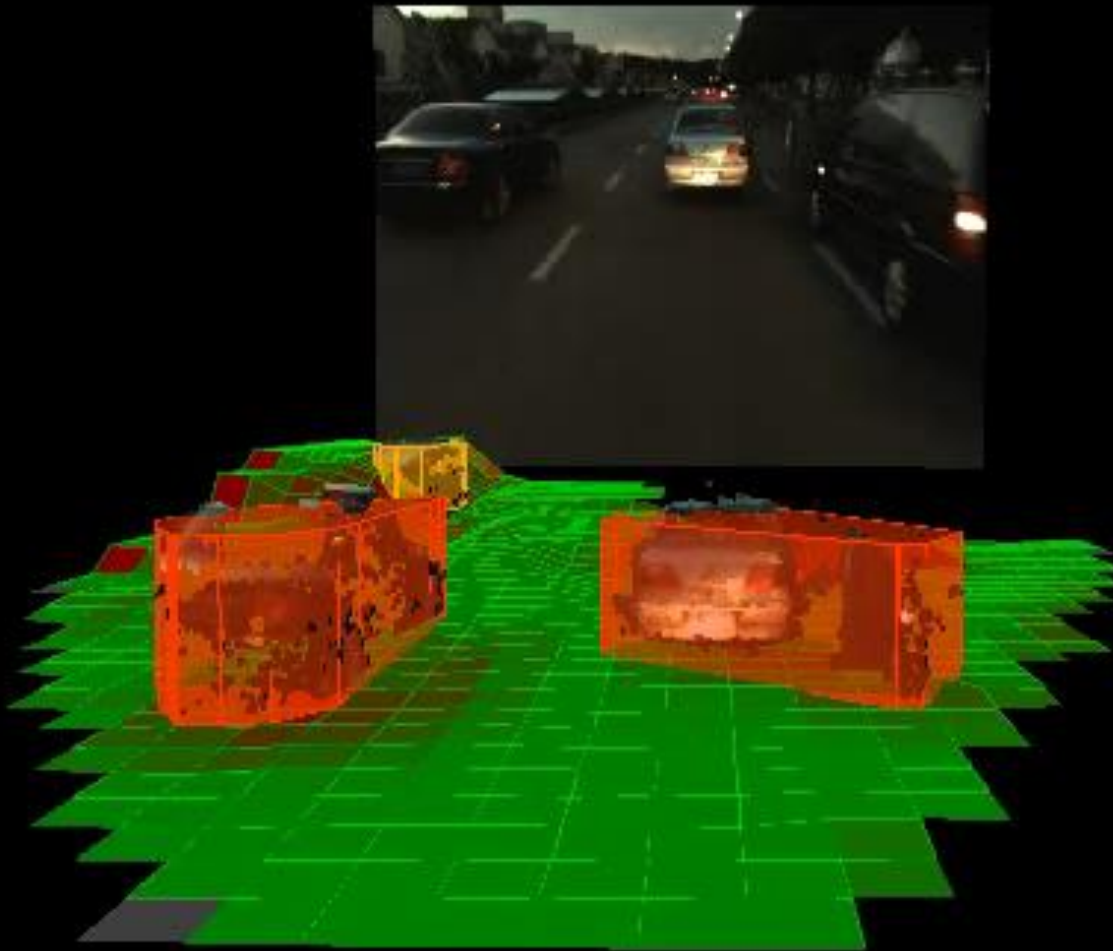
# Examples: village



# Examples: rain

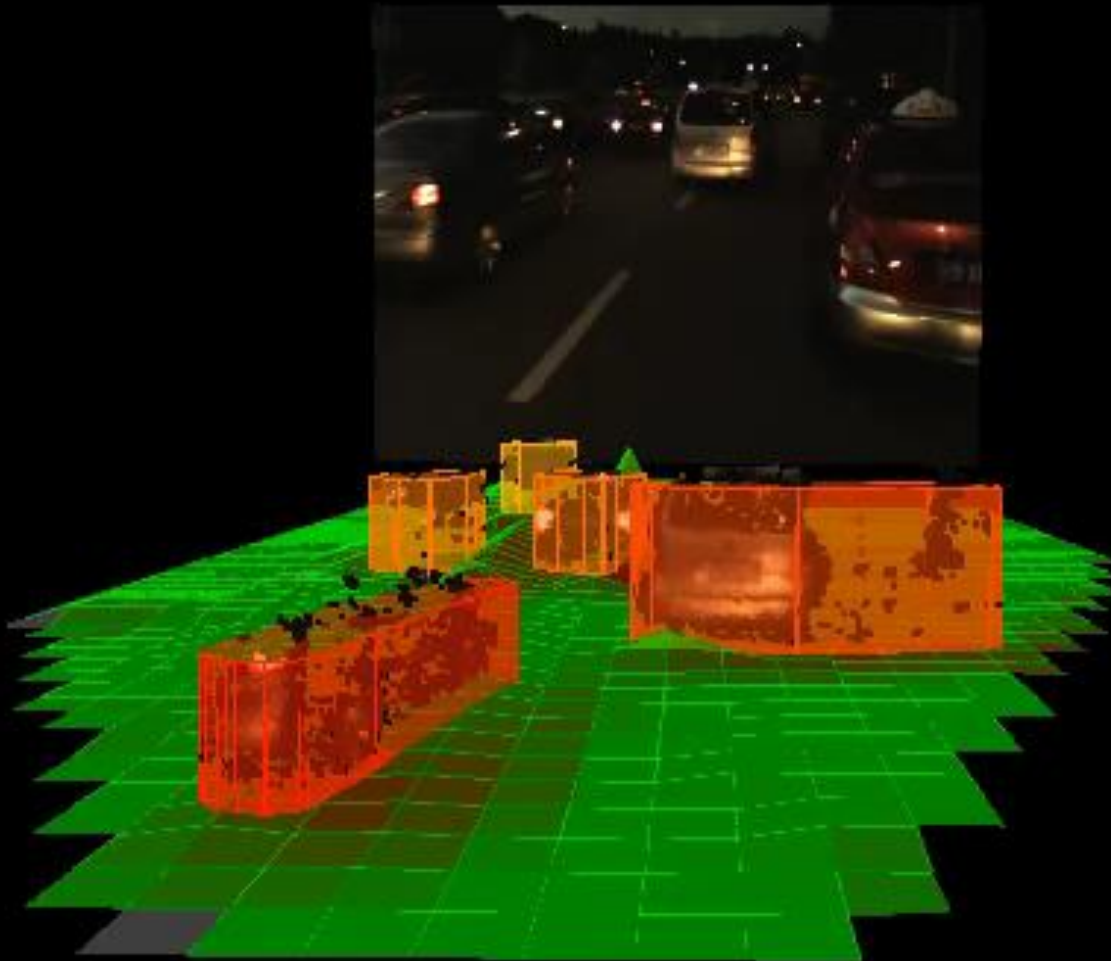


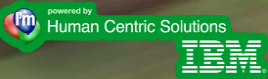
# Examples: traffic in the dark





# Examples: traffic in the dark 2





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