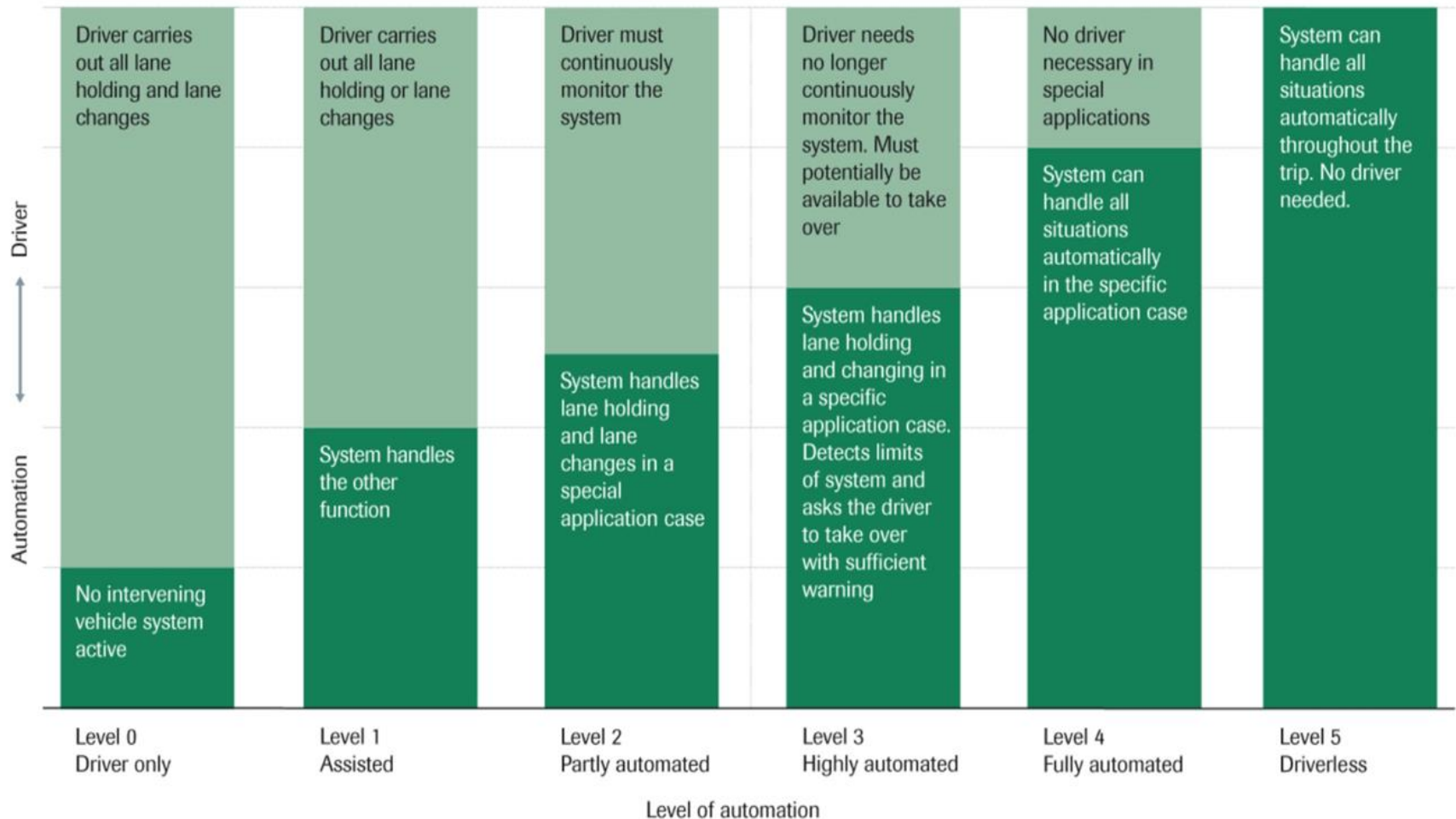# Nordisk Trafiksikkerhedsforum 2017
Gunnar Strøm, Norskilt

Minimum road marking requirements for autonomous vehicle.

Repeating the levels of automations –starting on level 0

Levels of automated driving

	Level 0 Driver only	Level 1 Assisted	Level 2 Partly automated	Level 3 Highly automated	Level 4 Fully automated	Level 5 Driverless
Driver	Driver carries out all lane holding and lane changes	Driver carries out all lane holding or lane changes	Driver must continuously monitor the system	Driver needs no longer continuously monitor the system. Must potentially be available to take over	No driver necessary in special applications	System can handle all situations automatically throughout the trip. No driver needed.
Automation	No intervening vehicle system active	System handles the other function	System handles lane holding and lane changes in a special application case	System handles lane holding and changing in a specific application case. Detects limits of system and asks the driver to take over with sufficient warning	System can handle all situations automatically in the specific application case	

Level of automation

Manuel driven = level 0 – road marking requirements. Visibility.
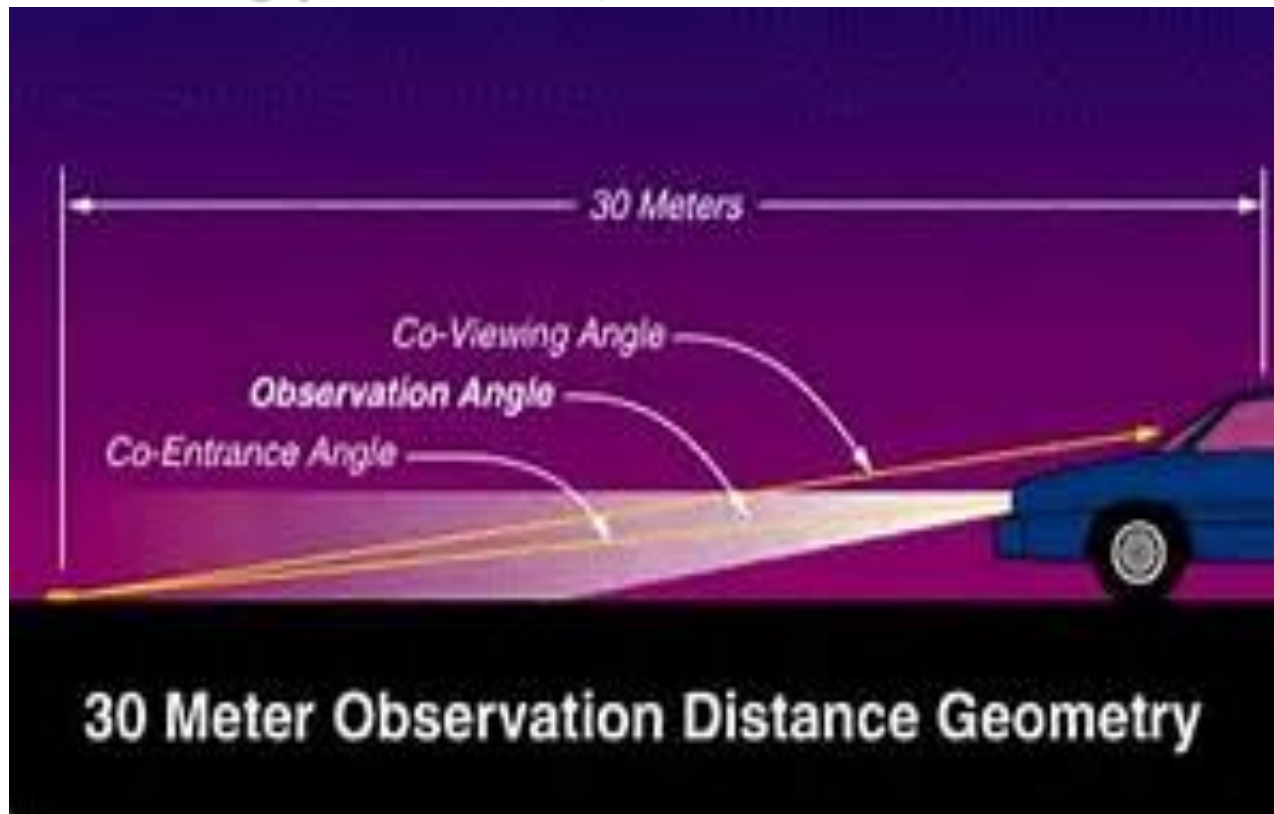
- Daytime Visibility : Qd ➔ mcd/lux/m²
- Based on diffuse light ~ overcast, clody
- Minimum= 100 mcd/lux/m²
- Night time Visibility: RL= retroreflectivity
- Minimum -100 – 200 mcd/lux/m²
- WetNightVisibility . Rainey weather
- Minimum -25 – 50 mcd/lux/m²

n**rskilt
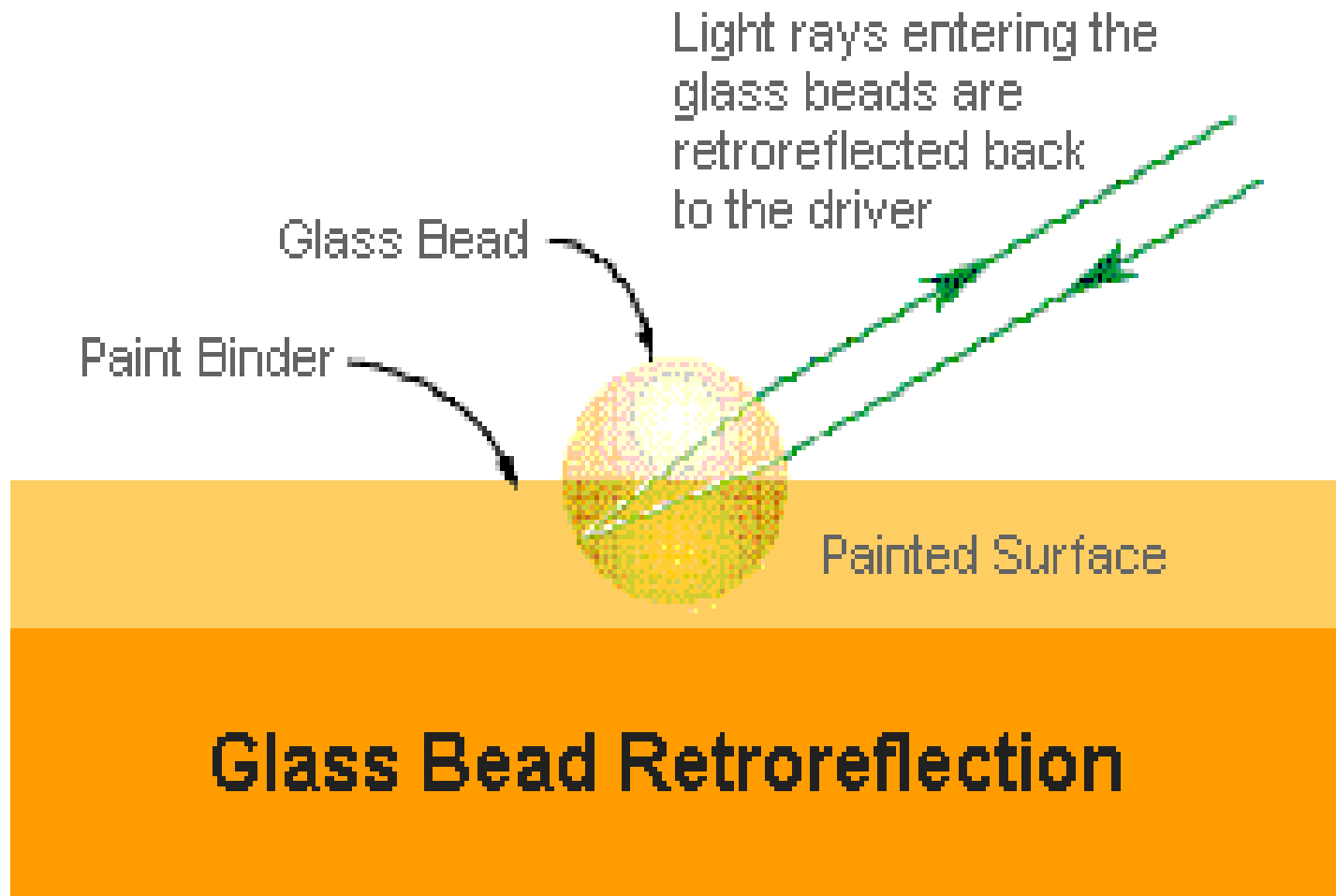
30 meter geometry

Lightsource → 0,65 m
Observation → 1,20 m
Reflecting point→ 30,00m

30 Meter Observation Distance Geometry

Reflecting glasbeads making lines visible at night

Light rays entering the
glass beads are
retroreflected back
to the driver

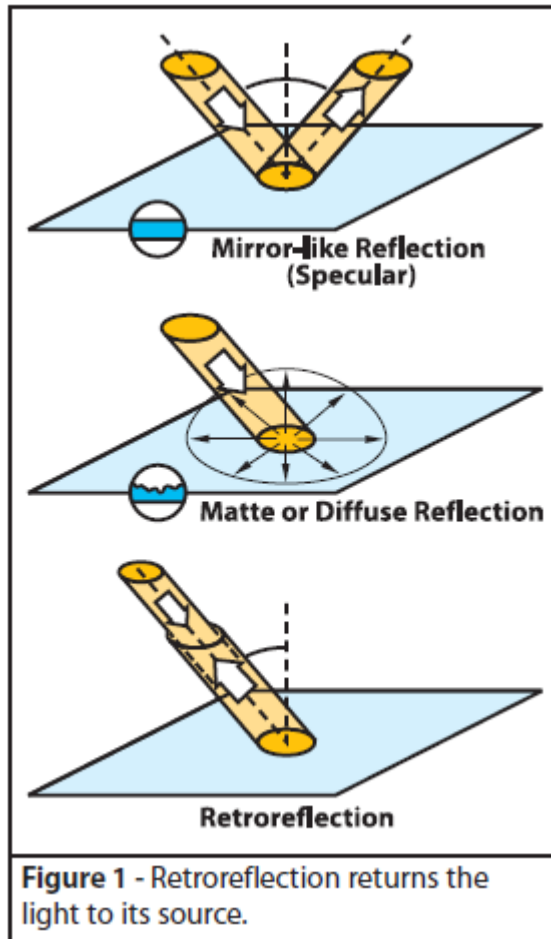Glass Bead

Paint Binder

Painted Surface

Glass Bead Retroreflection

3 types of reflected light

Reflecting mirror, total reflection = wet surface, night-time

Diffuse reflection = daytime visibility

Retroreflection = night time visibility (dry and wet)

Mirror-like Reflection
(Specular)

Matte or Diffuse Reflection

Retroreflection

Figure 1 - Retroreflection returns the light to its source.

The critical situation is to detect the lines when raining

How to see the wet lines ?

Produce lines with profiles, and with reflecting glass beads om vertical walls.

Some examples of profiled markings, who makes lines visible in rainey nights.
This will probably also be needed visibility on level 1,2 and 3

An estimated model of wet reflecting vertical walls on different markings

*VERTICALE FLADER ved 1 meter 30 cm linie

*Synlige lodrete flader, set fra bil.

| Navn | Ellementer | Markeret flade | | Udl. hast. | AREAL | Faktor | Typiske verdier | | |
							Ny RL-tørr	Ny RL-våt	2 år RL-våt
PLAN	1	3 000	100 %	6 -8	12 cm²	1,0	350	25	10
KAM	6	2 000	67 %	2 -3	44 cm²	3,6	250	50	25
LONG	5	1 500	50 %	2 -3	60 cm²	5,0	240	60	25
SKAK	60	1 500	50 %	2 -3	120 cm²	10,0	280	90	35
DropOn	192	2 176	73 %	10 -15	305 cm²	25,0	320	160	70
Rain-Line	50	3 000	100 %	6 -8	600 cm²	50,0	350	160	70

norskilt

How do we look for the minimum requirements for automotive vehicles?

And Infrared!

RETROREFLECTIVE MEASUREMENTS AT HIGHWAY SPEEDS- 400 sweeps/ sec

Complexity In Design – Simplicity in Operation™

Compairing Human Vision

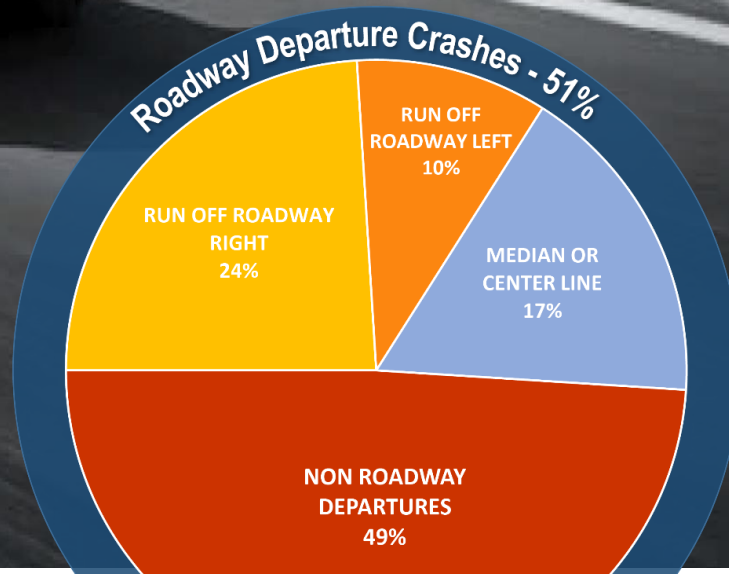Primarily dependent upon contrast and retroreflectivity

With Machine Vision

Primarily dependent upon contrast and infrared

Roadmarking vs Machine Vision-Needed level

- **FHWA - Vehicle manufacturers** such as General Motors have reported to Congress that **pavement markings** are one of the **most significant infrastructure** elements needed to **guide automated vehicles** and realize the estimated safety benefits of such vehicles. Knowing that **pavement marking** is one of the **key highway elements used to guide automated vehicles**

Roadway Departure Crashes - 51%

- RUN OFF ROADWAY LEFT 10%
- MEDIAN OR CENTER LINE 17%
- RUN OFF ROADWAY RIGHT 24%
- NON ROADWAY DEPARTURES 49%

LLG7 Vision System

- Simultaneously evaluates pavement markings for both human and machine vision.
- Deploys two lasers
  - One for measurement of Retroreflectivity for Human Vision
  - One for measurement of Infrared for Machine Vision
- Creates a separate .CSV file with same data as conventional LLG7 but with the IR readings instead of the Retroreflective readings.

LLG7 Vision System

- These values can then be placed in rating bins from 1-5 to determine quality.
- Studies in the process of correlating the values and the Mobileye's rating system used in latest transportation studies of automated vehicles.

2015/07/09
17:57:47

Images Courtesy of TTI

Mobile retroreflectivity can achieve accurate, comprehensive data, quickly and safely.
400 single full measurments pr. second !!

- Adaptable – Innovative Squid Mount and auto positioning system
- Simple Operation – Setup, calibration, and data extraction & management
- Affordable - Eliminates need of expensive or dedicated vehicles, personnel or electronic hardware
- Comprehensive – Data acquisition of Retroreflectivity, Line Width, RPM Count, Roadway Attributes, Mapping and Video/Data Overlay

Now with the Vision System can provide both machine and human vision assessment

Machine Vision

- A key tool in vehicle automation.
- The ability of a computer to see.
- Employs one or more video cameras
- Resulting data goes to a computer or robot controller.
- Action is initiated based on data and programing.
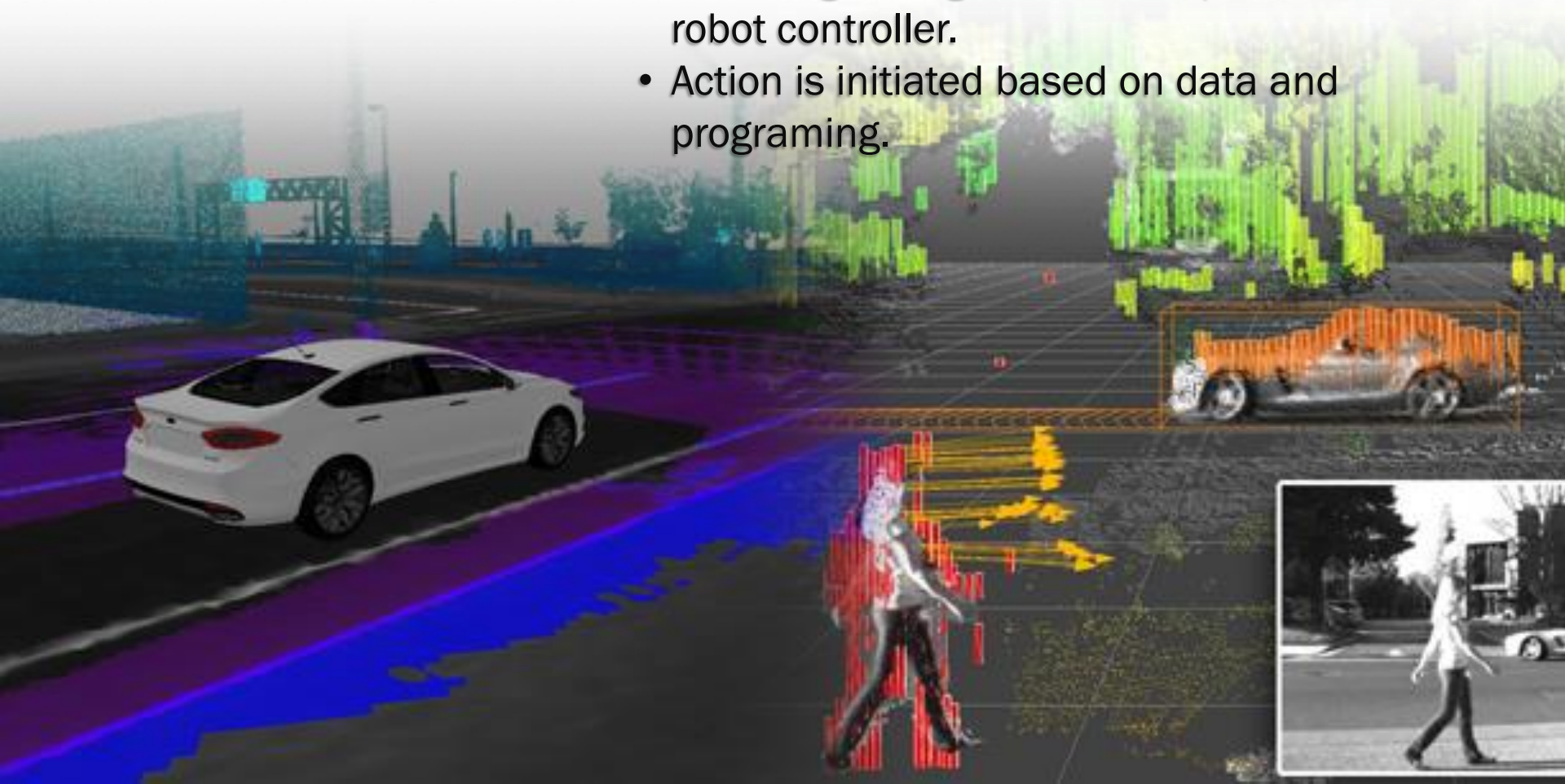
Ongoing documentation to be reported 2.Oct.2017 – hopefully give some answers.

- **Different types of markings is established on an old airfield in Texas**
- **Texas A&M Transportation Institute (TTI)**
- **Paul J. Carlson, Ph.D., P.E.**
  Senior Research Engineer

Levels of automated driving
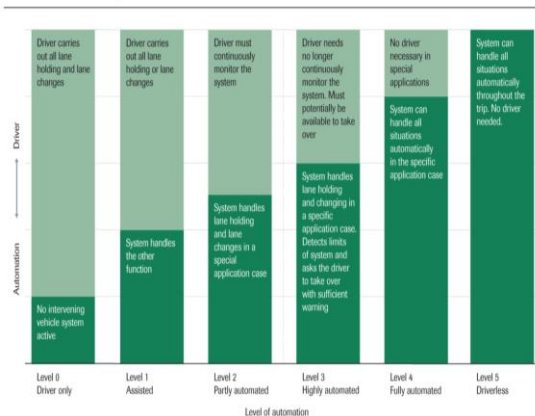
Still a lot of questions to be answered in the relationship between selves driven cars and roadmarking.

Takk for oppmerksomheten