Autonomous Driving: Constraints, Obstacles and Outlook

Swiss Federal Institute of Technology Zurich

Presentation at Institute for
Transport Planning and Systems

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Introduction

- Impressive videos and euphoric headlines of self-driving vehicles
- Expectation of driverless cars on public roads are upcoming
- Reality shows difficulties which are often not reported
- Presentation aims to
  - Show constraints and incidents in current tests
  - Describe non-technical obstacles
  - Try an outlook on:
    - How autonomous driving in future could be
    - Which effects on life and space might occur?

Introduction

Autonomous driving exists:

- On public roads restricted to situations of low speed:
  - Car parking assistance systems
  - Trucks provide self-driving mode in traffic jam
- Driverless vehicles in restricted area, e.g.:
  - Container transport in harbours
  - Delivery within industrial area in Germany
    - Operated since 2001
    - Semi-trailer backing to platform
    - Positioned and steered by induction fields in ground
    - Traffic area shared with human-driven vehicles

Test constraints

Current tests of autonomous vehicles show constraints:

- Restricted to specific and trained area
- Previously acquisition of (high quality) geo data (3D)
- Driver on board on public roads to intervene
- No snowy conditions tested (to-do in google report of December 2015)

Additionally, truck tests of Mercedes (D) and Freightliner (USA) are limited:

- Only motorway – no rural or urban roads
- No entrances or exists
- No lane change and overtaking

Test incidents

- Two kinds of incidents:
  - Crashes in which autonomously driving vehicles were involved
  - Control from system to driver:
    - System “gives in” because it cannot cope with situation
    - Driver decides to take control
- Google cars
  - Have been tested on 1.5 Mio km (according to Google)
  - Were involved in 20 crashes (according to monthly reports to California Department of Motor Vehicles, DMV)
  - Minor collisions, in the majority of cases rear-end collisions caused by others
- Reason? According to:
  - Google: other drivers were distracted
  - Nvidia CEO Jen-Hsun Huang: Because Google cars drive like computers
  - Google cars comply rules perfectly, but not compatible to human beings and behaviour, e.g. cars brake surprisingly to restore correct safety distance after being cut

Consequences

Test results of Google cars

- 341 incidents documented:
  - 272 disengagements (car gave control back to driver)
  - 69 cases in which google driver decided to take control
- Data reliability?
  - '**Google admits** that its drivers actually **took over from their vehicles "many thousands of times"** during the period. The company **is reporting only 69 incidents** because Google thinks California's regulations require it **only to report disengagements where drivers were justified in taking over**, and not those where the car would have coped on its own.'
  - Google decides on whether or not to report – based on their own simulations...

    (The Guardian, https://www.theguardian.com/technology/2016/jan/12/google-self-driving-cars-mistakes-data-reports)
- Further deficiencies of Google cars (wikipedia: self-driving cars):
  - Temporary traffic lights
  - Failed to recognise policeman showing stop…
- 0.84 sec average reaction time to take control
  - Confirms 1.4 sec of Daimler truck tests for unexpected command to take control*

* Based on discussions concerning ECE(steering equipment) R79 by World Forum for Harmonization of Vehicle Regulations of Inland Transport Division of the United Nations Economic Commission for Europe (UNECE)

Further test results

Car tests:

Company	Interventions	Kilometres
Bosch	**625**	**1504**
Mercedes	**967**	**2152**
Nissan	**106**	**2390**
Volkswagen	**260**	**24.052**

Source: Spiegel
"Statistik zu selbst-fahrenden Autos: Mensch, greif ein!"

Publication date:
January 13th, 2016

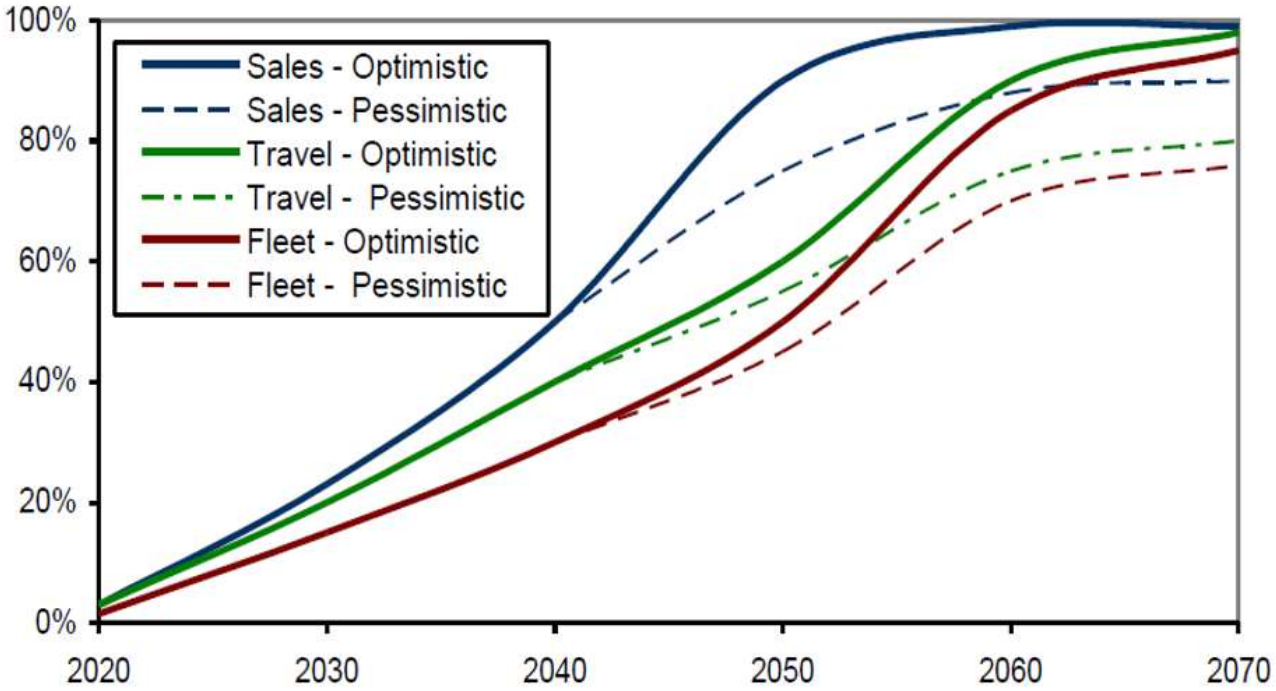
- Relatively few kilometres (except Volkswagen)
- Relatively often intervened
- Reasons often not clear – e.g. Mercedes: "for testing purposes"

Mercedes truck tests:

- Human interventions is part of philosophy to assist driver – not to replace
- Aim is to disburden driver on boring and tiring road sections

http://www.spiegel.de/auto/aktuell/google-auto-13-kritische-situationen-auf-680-000-testkilometern-a-1071800.html (accessed May 18th, 2016)

Fully autonomous driving in reality?



Survey of car insurance company Allianz (presentation at HSG, 2015)

Conclusions:

- **Decades of human-driven, semi-autonomous, and full-autonomous vehicles in parallel**
- **Driving systems have to be accustomed to human drivers (and vice versa?)**
- **Technical progress will solve known and unknown technical problems - whenever**

http://www.ifb.unisg.ch/~/media/internet/content/dateien/instituteundcenters/ifb/sim/1allianzbigdata.pdf

Is the solution of technical problems enough?

Incidents that influence...

Technically possible ≠ Reality

- Giga-Liner / EuroKombi
  - In use for decades in Scandinavia
  - Recently allowed in the Netherlands
  - Tests in some federal states of Germany
  - Strict no-go in Switzerland and Austria

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- Prototype of underfloor semi-trailer combination (1983):
  - Proved in several tests – just solveable problem (cooling, handling)
  - Highly relevant advantages:
    - Remarkably higher shipping volume
    - Higher flexibility to load/unload
    - Lower diesel consumption
    - Smaller turn radius
    - Position of axles avoids axle's overload
    - No blind spot (front, side)

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What decides if technology comes?

- MIT professor Brynjolfsson at WEF 2016:

  “Not technology”

- In case of fully autonomous (driverless) vehicles:
  - Political implications, financial consequences and voters’ concerns
  - Unsolved ethic and juristic questions
  - Possible ecological consequences
  - Economic calculation

Political obstacles

- Vienna Convention on Road Traffic (1968) is base of most of national traffic legislation
  - Human being on board and responsible
  - Car must have steering wheel and pedals
  - Automatic driving allowed <10km/h
- What could politics prevent from allowing fully autonomous vehicles?
  - Sudden increase of unemployment rate (national costs)
  - Eastern European countries would be affected most because of relatively high share on inner EU road transport
  - Voters' nightmare to be in hacked vehicle
  - Questions of privacy, data flow and control

Ethic and juristic questions

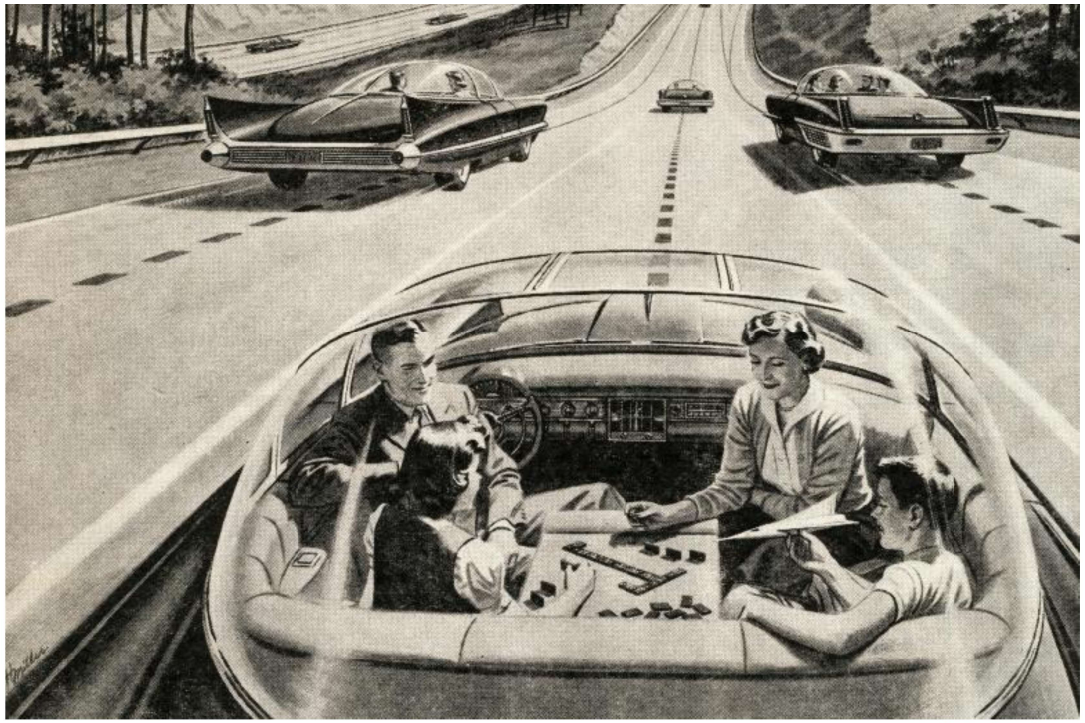
How to behave in situation of unavoidable accident?

- Example: Collision with cyclist with helmet or without helmet?
  - Obvious answer: person with helmet because of lower degree of injuries to be expected
    - Should we reward a careless person?
- Is fault relevant?
  - A drunken pedestrians crosses a red light and my car crashes into the wall to save him?
- May a driving system endanger and – eventually – kill:
  - Its' passengers to save others' lives?
  - Uninvolved persons?
- How would public (politics, media) react to a dramatic accident?
  - Kate Darling (MIT expert in robot ethics): "Even if fatal crashes happens less often, some spectacular cases could influence public opinion remarkably."
  - How would be the individual's reaction?
- Who decides on rules and verifies that implementations comply?
- Who is guilty:
  - Car manufacturer or software provider?
  - Person or organisation?

Ecological aspects

Increase of rides and traffic volume if self-driving vehicles:

- Are cheaper?
  - Cheaper Uber taxi allows more and longer rides than commercial taxi, stated by Tagesanzeiger
- Allow people on board to do whatever they want (cf. figure below, 1957)



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Economic calculation

- Driverless means no salaries **but** are they really relevant?

- Example:
  - Bottle of Italian wine in market in Dornbirn (A): EUR 6.99
  - 700km transport (Bologna-Dornbirn) is one day work
  - Eastern European driver
    - Earns EUR 1000 / month
    - Costs EUR 2000 / month => EUR 100 per day
  - 10’752 bottles on board of a standard European semi truck

    => Driver’s salary share = 1 cent

    => Driverless means EUR 6.98 instead of EUR 6.99
  - Calculation does not take into account costs of complex technology of driverless truck

ViaMichelin

Outlook

Future of autonomous driving and its impacts

Key message

- Highly autonomous driving is upcoming (2020-2025):
  - 99% percent of way will be done by driving computer (at least on motorways)
  - Driver with valid licence is on driver seat, responsible and takes control if system is unable to cope with situation
  - If human driver does not react, the driving system slows down to full stop
  - No crashes in systems' responsibility
  - Minor law amendments:
    - Speed limit of 10km in autonomous mode annulled
    - Steering wheel and pedals are not required any more => appropriate steering means
- New role "Person on driver's seat – hardly ever driving" (PODS-HED)

Consequences: cars

- PODS-HED:
  - Uses time in car to work (mobile office)
  - Every now and then distracted by the driving system asking for help
- Disappearing of public transports' USP ("Spend travel time usefully!")
- Time in car is work time – relevance of daily way to travel decreases
- Pressure will be put on:
  - Rural areas far away from cities or train stations
  - Road infrastructure to manage additional traffic

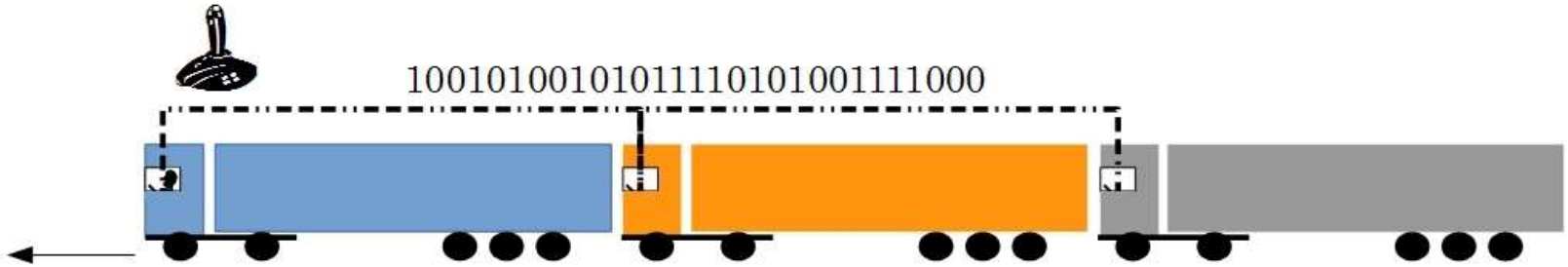
Consequences: transport

- PODS-HED in cab of truck uses time:
  - Dispatching for full capacity utilisation anytime
  - Technical manager of truck (maintenance planning, evaluation of new products,...)
  - Salesperson
  - Bookkeeping
- New role as Transportation Manager:
  - Cuts costs by replacing back office
  - Needs no juristic adoptions because “standby time” exists in current laws

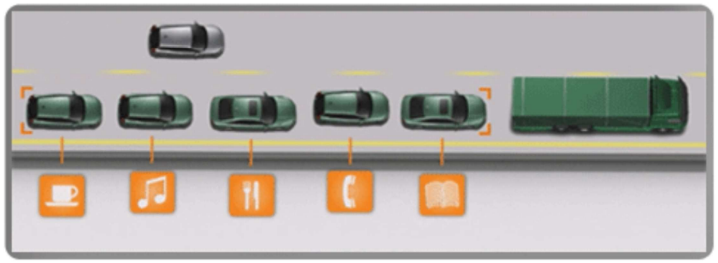
=> Not driverless trucks because:

- Avoids political and juristic conflicts
- Driver on board could restart system if hacked
- Still necessary for loading work
- Cut of costs happens in back office and by “Digital Convoy”

Outlook on “Digital Convoy”



- One driver operating several trucks digitally (digital drawbar)
- General feasibility proven by:
  - EU project “Promote Chauffeur” I (1999) and II (2003):
    - 2 trucks with electronic drawbar
    - Driving with distance of 6-15 meters
    - In 1999, the broad commercial launch was expected in 2007...
  - EU project SARTRE (2012, below) and current tests (right)



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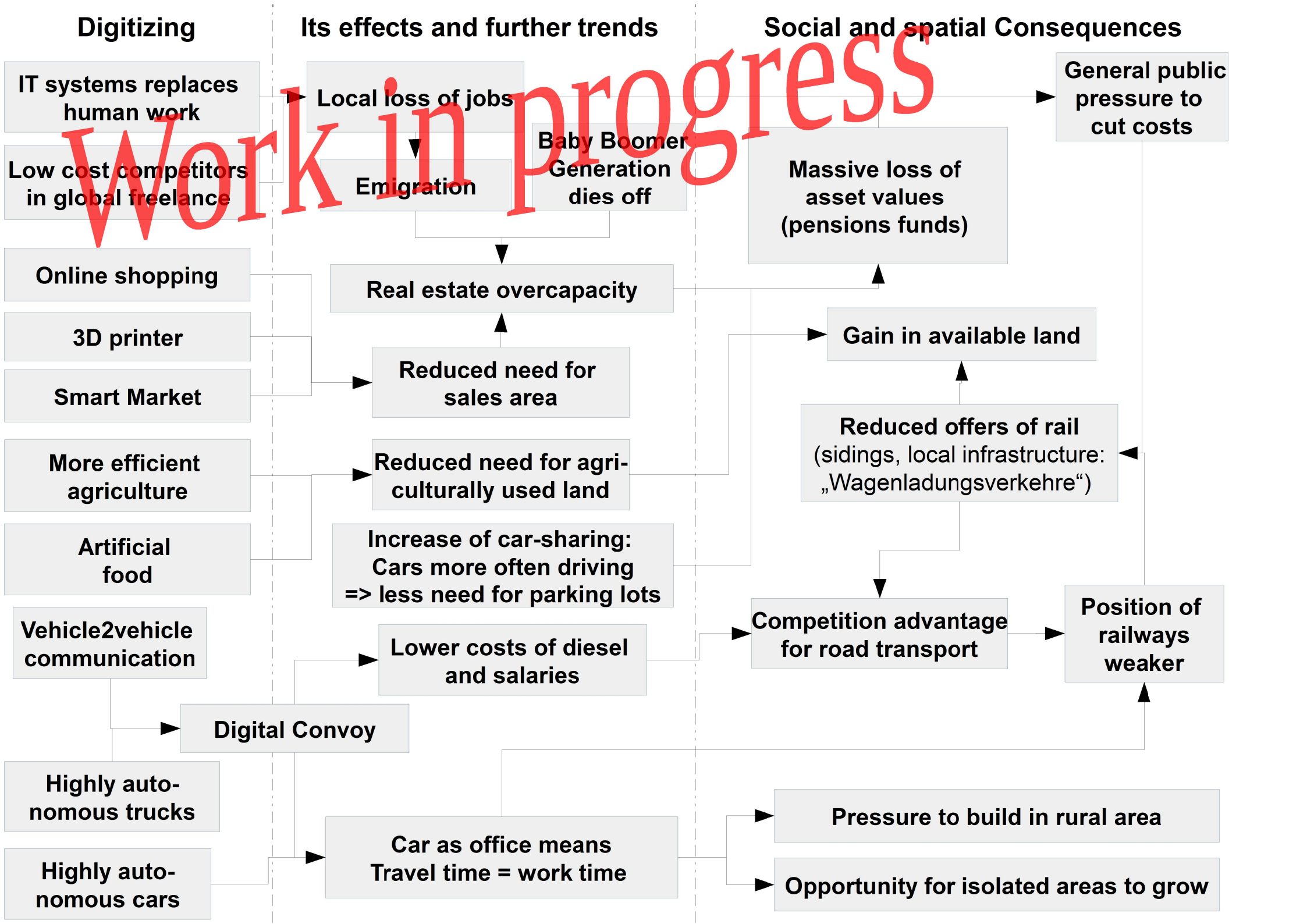
Digital Convoy

- Pre-conditions:
  - V2V communication is standard
  - Further progress is made, e.g. lane changes
- Advantages:
  - Lower fuel consumptions
  - Cut of costs achieved by reduced number of drivers required
  - Fits to decreasing number of drivers available (high political acceptance)
  - Maybe steering by speech input instead of steering wheel and pedals
- Risks:
  - Railroad competitiveness?
  - Further effects on space?

=> In general, “Digitizing / Big Data” will have various effects on geo-spatial situation

  - Topic in my presentation at GeoSummit2016
  - Preview on next slide: big picture


Digitizing
Its effects and further trends
Social and spatial Consequences
Work in progress
IT systems replaces human work
Low cost competitors in global freelance
Local loss of jobs
Emigration
Baby Boomer Generation dies off
General public pressure to cut costs
Massive loss of asset values (pensions funds)
Online shopping
3D printer
Smart Market
Real estate overcapacity
Reduced need for sales area
Gain in available land
More efficient agriculture
Artificial food
Reduced need for agri-culturally used land
Reduced offers of rail (sidings, local infrastructure: „Wagenladungsverkehre“)
Increase of car-sharing: Cars more often driving => less need for parking lots
Vehicle2vehicle communication
Lower costs of diesel and salaries
Competition advantage for road transport
Position of railways weaker
Digital Convoy
Highly auto-nomous trucks
Highly auto-nomous cars
Car as office means Travel time = work time
Pressure to build in rural area
Opportunity for isolated areas to grow

The End

- Thank you very much for the invitation
- Questions, feedback and comments?