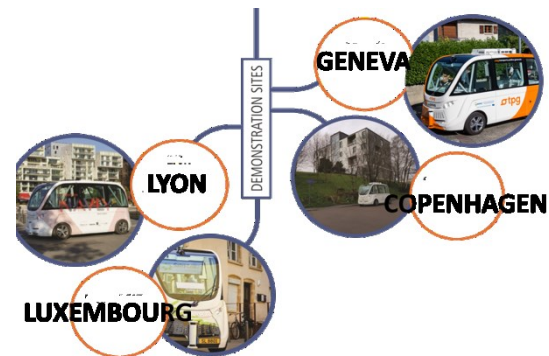# From demonstrator to public transportation service

Prof. Dimitri Konstantas

AVENUE project coordinator

AVENUE

AVENUE

Autonomous Vehicles to Evolve
to a New Urban Experience

DEMONSTRATION SITES

GENEVA

LYON

COPENHAGEN

LUXEMBOURG

A 4 year's project with mission to :

Prepare the adoption and deployment of Autonomous vehicles for public transportation.

*To seek out **new transport paradigms** and new business models.*

*To boldly test **disruptive public transport services** which no autonomous vehicle has done before!*

**4 year project
16 Partners – 4 sites
20 MEUR budget
          15.4MEUR EU Contr.
May 1st, 2018 – April 30, 2022**

UNIVERSITÉ DE GENÈVE   navya   CentraleSupélec   HS PF   tpg   bestmile *optimizing mobility*   SIEMENS *Ingenuity for life*   ceesar *Centre Européen d'Etudes de Sécurité et d'Analyse des Risques*

RÉPUBLIQUE ET CANTON DE GENÈVE *POST TENEBRAS LUX*   virtual vehicle   AVL   mobile_thinking *The power of many*   CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS   AUTONOMOUS MOBILITY   Sales-Lentz *moving people*   KEOLIS LYON

2

4 primary validation sites
(open street, mixed traffic, with regular public sewrvice

- ## Geneva – TPG
  Sept. 2018 – December 2020 Meyrin : regular service, 2 AVs
  Since Sept. 2020 - Bell-Idee
    On-demand, door-to-door, fleet of 3 Avs (opens to public in January 2021)
- ## Lyon – Keolis
  Since May 2018 – regular service at Confluence – 2 AVs
  Since November 2019 - Parc Olympique Lyonnais stadium
    Complex roads, hi-speed traffic, V2X – 2 Avs, Line N1
- ## Luxembourg – Sales-Lentz
  Since September 2018 – Pfaffenthal - 2 AVs
  Since Summer 2020 - Contern
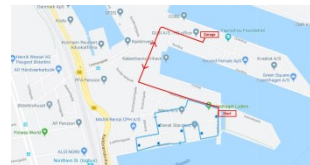   Complex road, link to train services, on-demand – 2 AVs
- ## Copenhagen – Holo
  May 2018 – Oslo, Gothenburg - 3 AVs
  Fall 2020 – Nordhaven
    On-demand – 2 to 4 Avs, fixed route

What is our target in AVENUE

Deploy Autonomous/Automated (SAE level 4) Vehicles for regular **commercial public transportation** services.

On-demand, Door-to-door public transportation service

We are **NOT** targeting a "simple" fixed root, on-demand bus-stop service.

We are **NOT** targeting a test deployment **BUT** a full regular, commercial service

We are **NOT** targeting a operator based vehicle, **BUT** a service with no operator intervention.

Deploying the real power of AVs in public transportation
The Geneva Belle-Idee site

A 36 hectares site with mixed traffic and population

- Patients, school kids, professionals
- Hospital, commercial area, school
- Cars, bicycles, pedestrians, patients

Today it is served with a bus line traversing the site

Transfers between buildings is done using the private cars

Full autonomous busses deployment

- Suppression of the bus line
- Transfer between buildings using Autonomous vehicles
  - 69 virtual bus-stops
  - All roads are covered
- Target : Busses operating 24/24
  - Inductive charging
  - Automated exit from hangar
- Operating today with no passengers
- Opening to public in January 2021

The Belle-Idee site (Geneva)
On-demand – door-to-door services

- **On demand, door to door travel**
  - No predefined routing, no predefined bus stops (with stop point exclusions), within a specific urban area, immediate or deferred

- **Intelligent planner**
  - Propose optimal travel planning, with traditional service coordination based on passenger personal needs and capabilities

- **In-vehicle services**
  - "follow your kid"
  - passenger security

Different videos are available at our YouTube channel

https://www.youtube.com/channel/UCbJkeigrQ-L7tSucSgpQWFQ
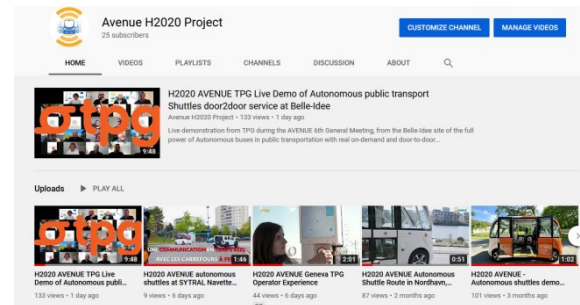
Barriers and obstacles

The road for Deploying Autonomous vehicles for commercial, regular public transportation is filled with obstacles ….

- Legal Barriers
- Technical shortcomings
- Transport Model changes
- Business models
- Passenger services

Setting up a demonstrator

Not a trivial situation … time consuming …

- Getting the required authorizations to operate in open roads (national, local …)

- Certifying the buses

- Mapping the area, setting up the itinerary ..

Not a commercial service, more a "tourist" attraction

Getting a license for
Public Transportation service

Starts becoming more complex :

Public transportation services are governed by an additional set of laws:

Vehicle standards to serve special needs passengers
- blind, handicapped access

Infrastructure obligations
- bus stop shelters, road signaling …

Deploying Public Transportation services with the _full power_ of Autonomous Vehicles

- Door-to-door shared public transportation services,
- On-demand operation

No-bus stops, no fixed itineraries, no time schedules, no intervention by the safety operator …

Legal framework not adapted ..

This service cannot really exist !!!

Final step : removing the safety operator

Not yet possible for accredited public transportation services on open roads !!!!

Lessons learned : 1

1. Do not underestimate the effort to obtain certifications

- Vehicle & itinerary homologation
  - Long and costly process specific to each country
  - Authority fragmentation in EU countries
  - Vehicle certification
  - Test site certification

- Procedure can take
  - From 1 to 3 years
  - From 100.000 EUR to 600.000 EUR

Some examples of the the Contents of the application !!

Denmark

Chapter	Information
Project description	• Introduction • Objectives • Methods • Partners
Legal framework	• Description of legal framework • Test-framework
Vehicle description	• Capabilities • Capacities • Technical aspects • Autonomous driving
Vehicle connectivity	• Basestation/N-trip • 4G
Route description	• Route length • Schedule • Garage route • Depot
Bus stop description	• Concessions • Positions • Identification
Organisation	• Roles • Trainers & training plans • Operators • Supervisors
Data description	• Data handling • GDPR • API • System descriptions
Risk handling (internal)	• Risk processes • Compliance • Crisis management
Risk-assessment (external)	• Risk identification • Potential pitfalls • Mitigating actions • Risk process

Switzerland

Chapter	Information
Project	• Description • Official waiver request • Objectives
Authorities	• Operator service agreement
Concessions	• Radio communication • Transport of passengers
Routes	• In-depth description
Bus stops	• Description • Identification
Vehicle	• Description of the vehicle • Transport capacity • Detailed documentation
Safety	• Operational safety measures • Legal bases • Derogation of traffic rules • Compensation measures for the derogations of traffic rules
Operations	• Concept • Principals • Timetable • Remote supervision • Documentation and procedures
Positions	• Expert • Trainer • Super operator • Operator
Operators	• Operator commitment • Operator instructions • Accident procedures

Training	• Theoretical training • Practical training • Trainers training • Assessment, Certification
IT	• Data security • Software • Embedded systems
Reporting	• Authorities
Communication	• Internal • External • Clients

Lessons learned : 2

2. Beware of Technical incompatibilities and shortcomings

- There are no standards for the APIs of AVs
  - Linking fleet orchestration system to a vehicle has many surprises !!

- GNSS/4G availability and coverage
  - Shadow areas in the city

Who controls the vehicle itinerary?

- The fleet orchestration service and AV operation is not always compatible
    - Fleet orchestration organizes the vehicle dispatching, given the passenger requests
    - AV is designed to go optimally from A to B
- It took us a year to align the 2 systems, with changes in both systems

GNSS/4G issues

AVs require centimetric localisation accuracy

- GNSS and 4G shadow areas exist in many places in an urban environment

- Visual driving
  - Not the main model of all AVs
- Own GNSS antenas – cannot install 4G antenas!

Lessons learned : 3

3. Convince authorities for new Public Transport Models

- Public transportation = fixed bus routes and fixed bus stops
    - From fixed bus stops to anyplace
        - Bus stop infrastructure?? (legal requirements)
- From large busses to fleet of small buses
    - Parallel service vs sequential

Policy and legal issues

Luxembourg : authorities do not want public bus reservations with mobile apps, nor buses without fixed itineraries.

Copenhagen: open road itinerary certification is so complex and costly that makes it prohibitive ask for any minor change.

Geneva: authorities provide authorisations for innovative services (some bureaucracy, but not major obstacles)

Lyon : ready to authorise innovative services (some bureaucracy, but not major obstacles)

"They shouldn't allow humans to drive!"

Policy and legal issues

Public transportation laws define that each bus stop must have an infrastructure.

On-demand, door-to-door services means that the bus can stop everywhere…

- *Cannot really install infrastructures everywhere*

Do the authorities allow a bus stop without infrastructure?
- Large interpretation of the law ….

Lessons learned : 4

4. Be careful of silent assumptions

Public transportation *service quality* depends for big part on the driver.

Full power AVs means operation without "driver" (safety operator).

Who offers the formal and informal services of a (non-existent now) bus driver?

Services offered by the driver

- Replying to passenger questions
- Assisting passengers to enter/exit to buss
- Ensuring the safety in the bus (aggressions, vandalism, lost objects …)
- Controlling the status of the bus (cleanness)
- Copes with incidents (accidents, mechanical failures ..)

Before you are able to offer a public transportation service, you must provide solutions for the driver services.

Some services provided in AVENUE

- "follow your kid" – identify a specific passenger (face recognition) and send a stream to the parent
- Passenger security – identify aggressions in the bus
- Vehicle safety – identify vandalism, littering, Forgotten objects

- Provide information to the passengers in-vehicle
- Buss-stop information points, on-line information points
- Buss identification – signaling the bus number to the waiting passenger
- Signaling to the mobile app next stop to exit – link with in-vehicle anonymous announcement

Lessons learned : 5

5. Not easy to create a Business model

Not yet clear how the business model can be profitable
- Driver costs – intervention team costs
- What is the critical mass of vehicles operating?
- Required technical infrastructure cost
- Ecological operation
  - Minimum 3 passengers
    - Impact to service quality?
- Vehicle life time – 6 years !!!
- Micro or macro economic model?

Loss of interest

Operators and municipalities are interested in the use of AVs, BUT the

- lack of profitable business opportunities

- low technology maturity

- lack of clear operation models and transport services

- High CAPEX and OPEX costs

Very hesitant to invest and adopt for public transport services

Thank you!!

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www.h2020-avenue.eu

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