Automated buses in Europe: An inventory of pilots

The AUTOBUS Project final webinar
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Personal background

Personal background

AUTOMATED SHUTTLES AS ACCESS AND EGRESS MODE OF MAIN PUBLIC TRANSPORT SYSTEMS

- Literature review
  - Existing pilots
  - Behavioural aspects
  - Integration aspects
- Scenario formulation
- Scenario simulation
  - Infrastructure
  - Operations
  - Supervision

The AUTOBUS project

Set of studies with the aim to bring automated shuttles on public roads

- Passenger experience and road user interaction [1]
- Interactions between cyclists automated shuttles [2]
- Surveys among the interaction of passengers, pedestrians, and cyclists with automated bus systems [3]
- Analyses of real-life observations of interactions between automated busses and other road users [3]
- Inventory of existing pilots in Europe [4]

  Aim: Complete overview of the current state-of-the-art on automated minibuses in Europe

[1] Heikoop, D. D., et al. (2020). Automated bus systems in Europe: A systematic review of passenger experience and road user interaction. In D. Milakis, N. Thomopoulos, & B. van Wee, *Policy Implications of Automated Vehicles Vol.5*. Elsevier.

[2] Hagenzieker, M., Heikoop, D., Nuñez Velasco, P., Boersma, R., & Bjørnskau, T. (2019). How do cyclists interact with automated buses? An overview of research findings. *International Cycling Safety Conference*. Brisbane, Australia.

[3] Bjørnskau, T., et al. (2019). Cyclists interacting with self-driving buses – hypotheses and empirical findings in real traffic. *International Cycling Safety Conference*. Brisbane, Australia.

[4] Hagenzieker, M., Boersma, R., Nuñez Velasco, P., Ozturker, M., Zubin, I., & Heikoop, D. Automated Buses in Europe.

Methodology

In- and exclusion criteria

- Driver-less shuttles operating on public roads with mixed traffic or on private roads
  - × Excluded: Demos or showcases operating in optimal condition
- Minibuses capable to transport people as public transportation
  - × Excluded: private automated cars
- Research concluded in January 2020

Low operating speed
- 15 – 25 km/h

Small passenger capacity
- Between 8 and 12 pax

SAE automation level 4+
- Driver-less operations
- No user interfaces
- No driver engagement
- Limited ODD

Methodology

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Step-by-step methodology

1. Main online sources consulted

Alessandrini, A. (2018). Implementing Automated Road Transport Systems in Urban Settings. Elsevier

Ainsalu, et al. (2018). State of the art of automated buses. Sustainability, 10, 1-34

Online inventory Bloomberg Group. Initiative on cities and autonomous vehicles (2020)

Blog on Cybercars by Parent (2019)

Project websites: Space UITP project, Avenue Project

Company websites: EasyMile, Navya

Methodology

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Step-by-step methodology

1. Main online sources consulted
2. Semi-structured review with snowballing technique

Keywords	Automated vehicle, autonomous bus, driver-less shuttle, self-driving people mover, public transport solution, road transport system, cybercars, cybernetic transport system
Languages	English, Dutch, French, Norwegian, Italian, Spanish and German
Area limitation	European countries

Methodology

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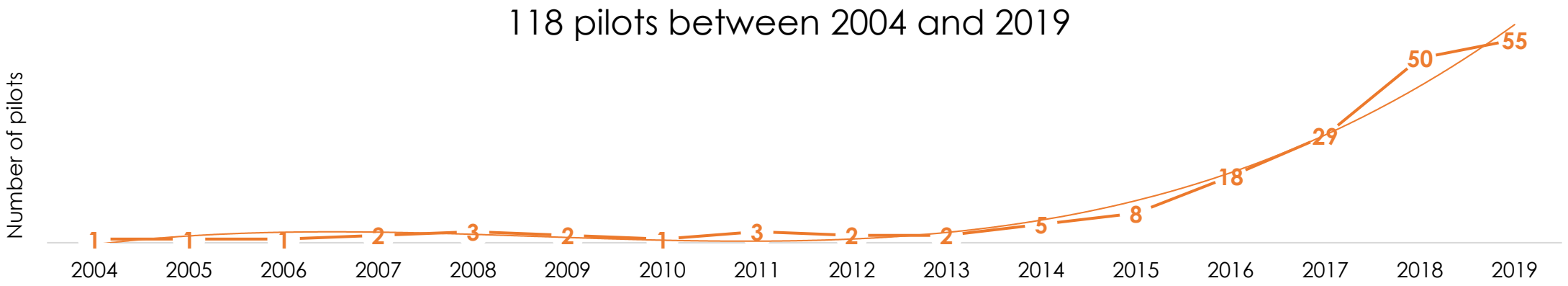
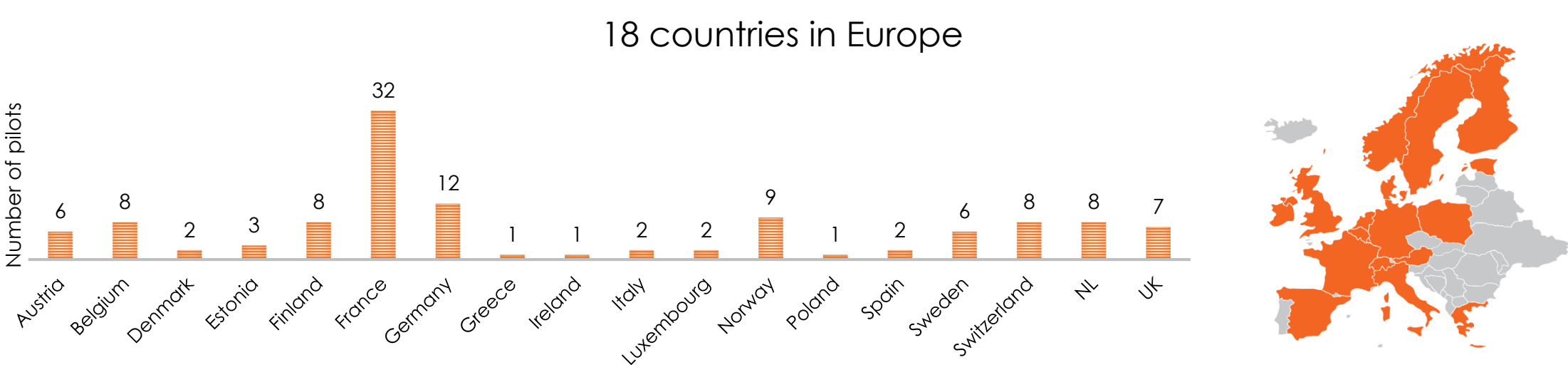
Step-by-step methodology

1. Main online sources consulted
2. Semi-structured review with snowballing technique
3. Authors' personal network

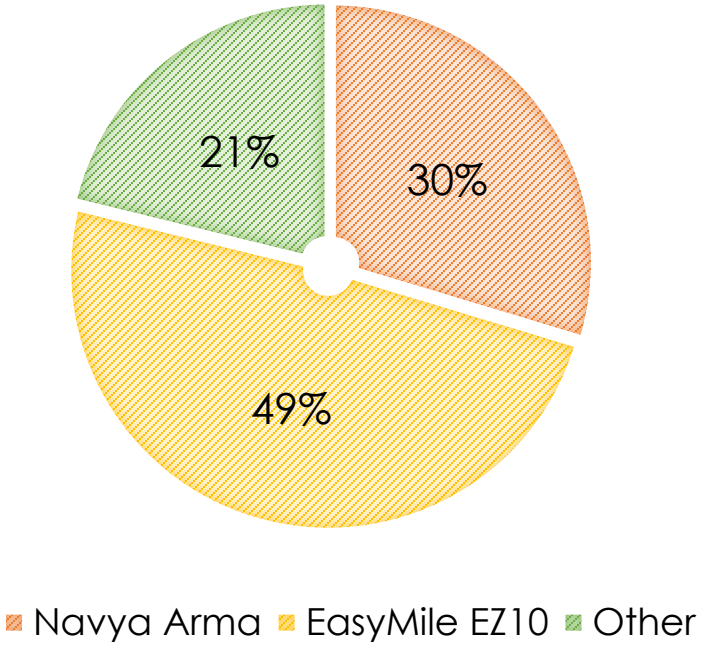
   Conferences, project meetings, workshops, interviews with relevant researchers and stakeholders, personal experience in the subject

Results


118 pilots between 2004 and 2019
Number of pilots
1
1
1
2
3
2
1
3
2
2
5
8
18
29
50
55
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019

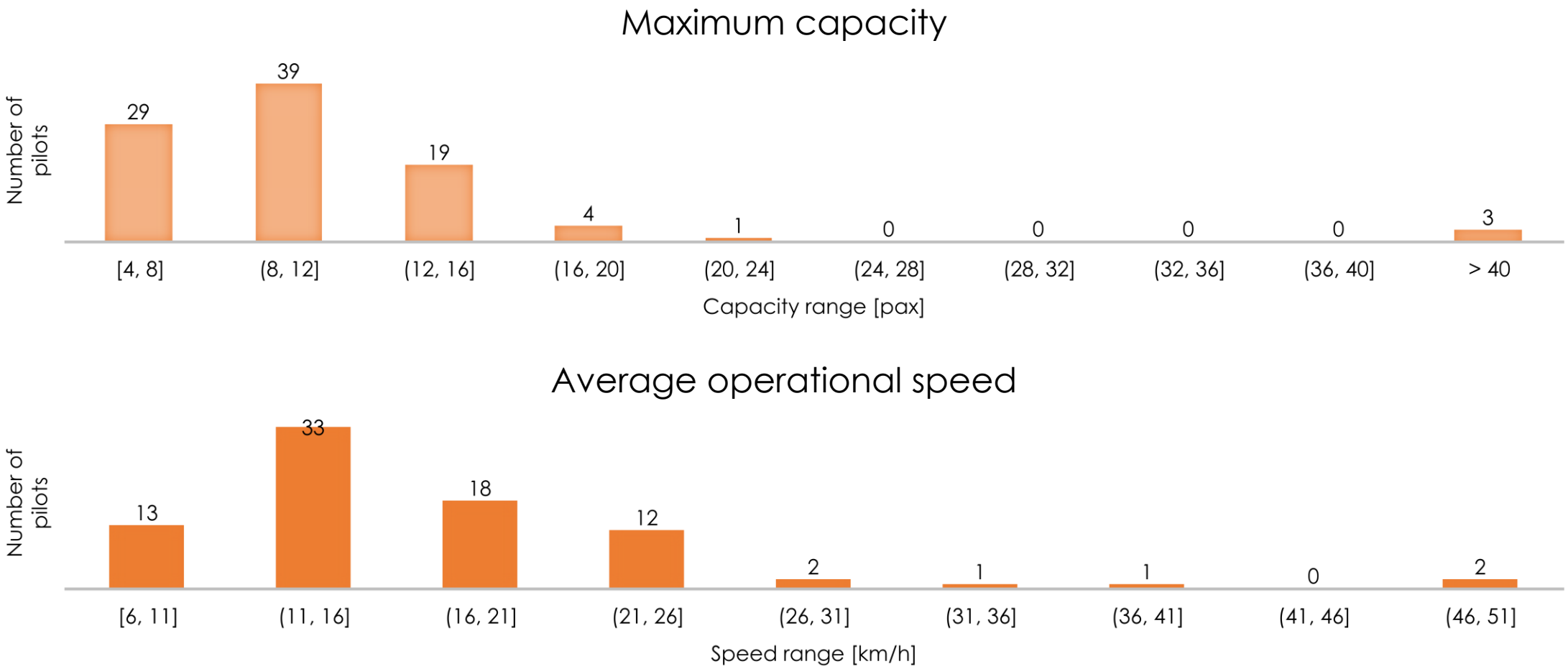

18 countries in Europe
Number of pilots
6
8
2
3
8
32
12
1
1
2
2
9
1
2
6
8
8
7
Austria
Belgium
Denmark
Estonia
Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Norway
Poland
Spain
Sweden
Switzerland
NL
UK

Results

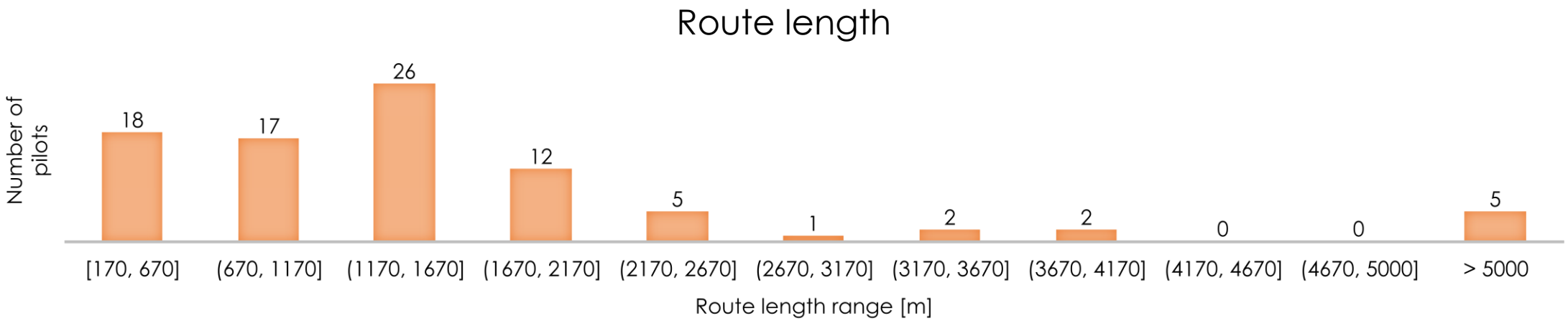


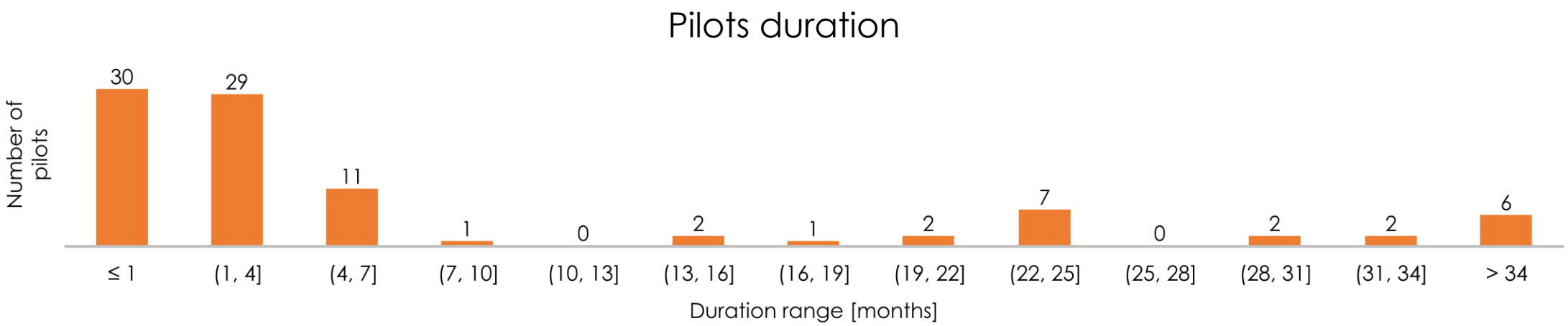
Vehicles used in pilots

Results


Maximum capacity
Number of pilots
29
39
19
4
1
0
0
0
0
3
[4, 8]
(8, 12]
(12, 16]
(16, 20]
(20, 24]
(24, 28]
(28, 32]
(32, 36]
(36, 40]
> 40
Capacity range [pax]
Average operational speed
Number of pilots
13
33
18
12
2
1
1
0
2
[6, 11]
(11, 16]
(16, 21]
(21, 26]
(26, 31]
(31, 36]
(36, 41]
(41, 46]
(46, 51]
Speed range [km/h]

Results


Route length
Number of pilots
18
17
26
12
5
1
2
2
0
0
5
[170, 670]
(670, 1170]
(1170, 1670]
(1670, 2170]
(2170, 2670]
(2670, 3170]
(3170, 3670]
(3670, 4170]
(4170, 4670]
(4670, 5000]
> 5000
Route length range [m]


Pilots duration
Number of pilots
30
29
11
1
0
2
1
2
7
0
2
2
6
≤ 1
(1, 4]
(4, 7]
(7, 10]
(10, 13]
(13, 16]
(16, 19]
(19, 22]
(22, 25]
(25, 28]
(28, 31]
(31, 34]
> 34
Duration range [months]

Results

Pilots mostly on existing infrastructure in a mixed environment

Most common infrastructural changes

- Road marking
- Warning signs
- Installation of V2X* communication equipment
- Temporary platform

* **Vehicle to Everything** communication equipment = communication between a vehicle and any entity that may affect, or may be affected by, the vehicle

Application cases

- First/last mile transport solution
- Major transport stops, university campuses, business districts, leisure facilities, airports, parking facilities, city centres

Discussion

Main conclusions

- Small documentation
  - 33% detailed documentation
  - 12% published research
- No clear ending date for many pilots, other documentation fragmented

- Pilots usually in closed environments to test capabilities

- Most steward on board due to legislation

Recommendations

- Proper research gathering relevant information and knowledge share

- Shift these pilots to larger and denser areas to serve actual transit lines, where there is actual demand for it
- Move from experimental to long term development

- Scenarios with no steward on board

Thank you for your attention

Questions?

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