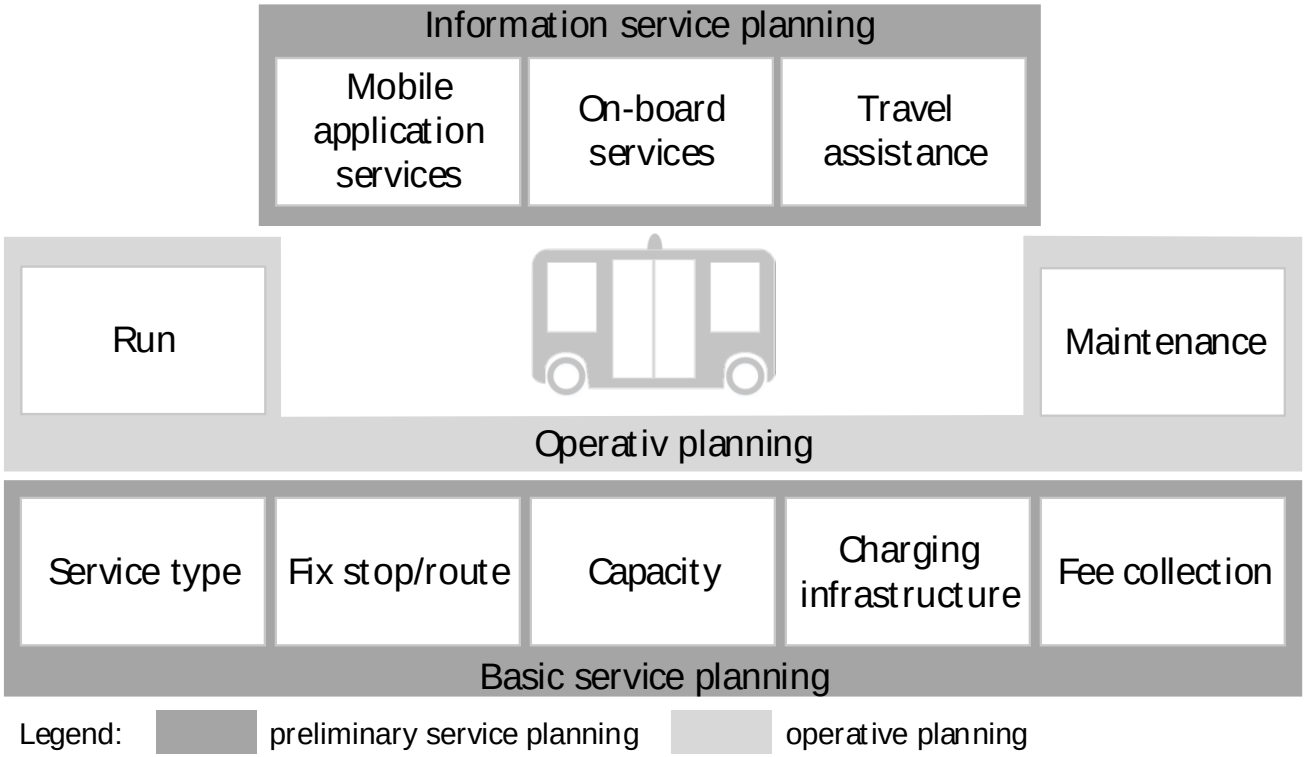
Planning and Operation of Mobility Services based on Autonomous Vehicles

Planning

novelties/challenges

- neglecting drivers' work regulation
- management of high volume of data
- no historical data about operation
- unknown user acceptance



Planning functions

Preliminary service planning

environmental friendly,
green energy

Service type
- determining service types
- based on travel demand and expectations

Fix stop/route
- determining stop and waiting points locations, route and service area
- based on travel demand – forecasting, willingness to walk
- spatial coverage higher in comparison to conventional public transport

Capacity
- planning timetable, vehicle number
- based on travel demand in peak hours – forecasting, willingness to wait

Charging infrastructure
- determining charging location
- goal: minimalize empty runs - parking (in the depot) + charging
- types: conventional: charging point (wired) – in the depo, in the street

who charges the vehicle?

automated charging - instant charging (pantograph)

inductive, wireless charging

Fee collection
- planning tariff structure and payment method; rate calculation method and variables
- dynamic rates – influencing demand
- based on current demand, capacities, sharing, ordering in advance

Mobile application services

- important! – passengers handling functions are aided (e.g. ordering, payment)
- planning service and quality regarding functions
- automatic real-time, personalized information

On-board services

- planning infotainment services (information + entertainment)
- personalized, location-based information

Travel assistance

- planning functions regarding the use of the service
- automated functions – replacing personnel attendance

<u>Operative planning:</u>

Run

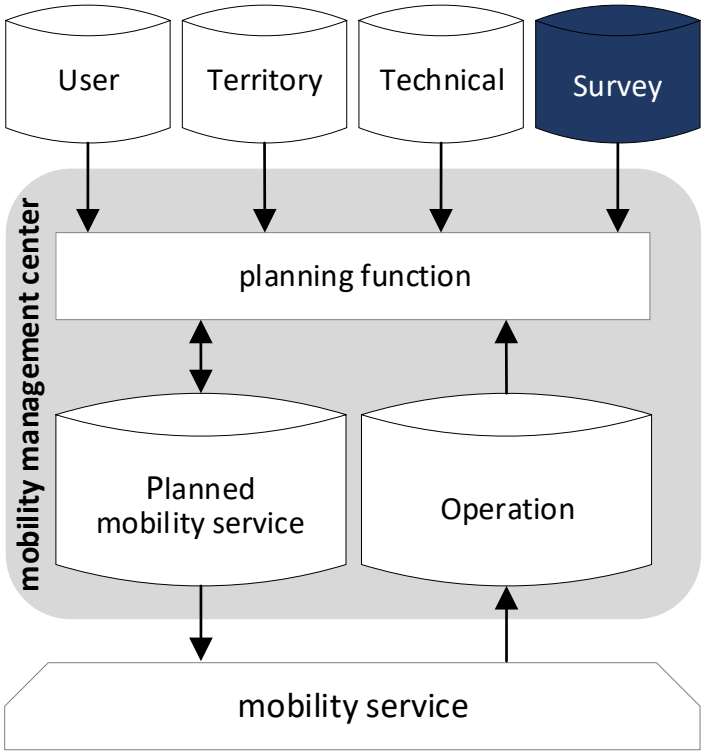
- planning runs wit and without passengers; operative timetable
- real-time demand-capacity coordination, planning of shared runs

Maintenance

- determining maintenance plans
- based on technical requirements, run mileage – forecasting, assumptions in the early phase

Model for the information system of planning

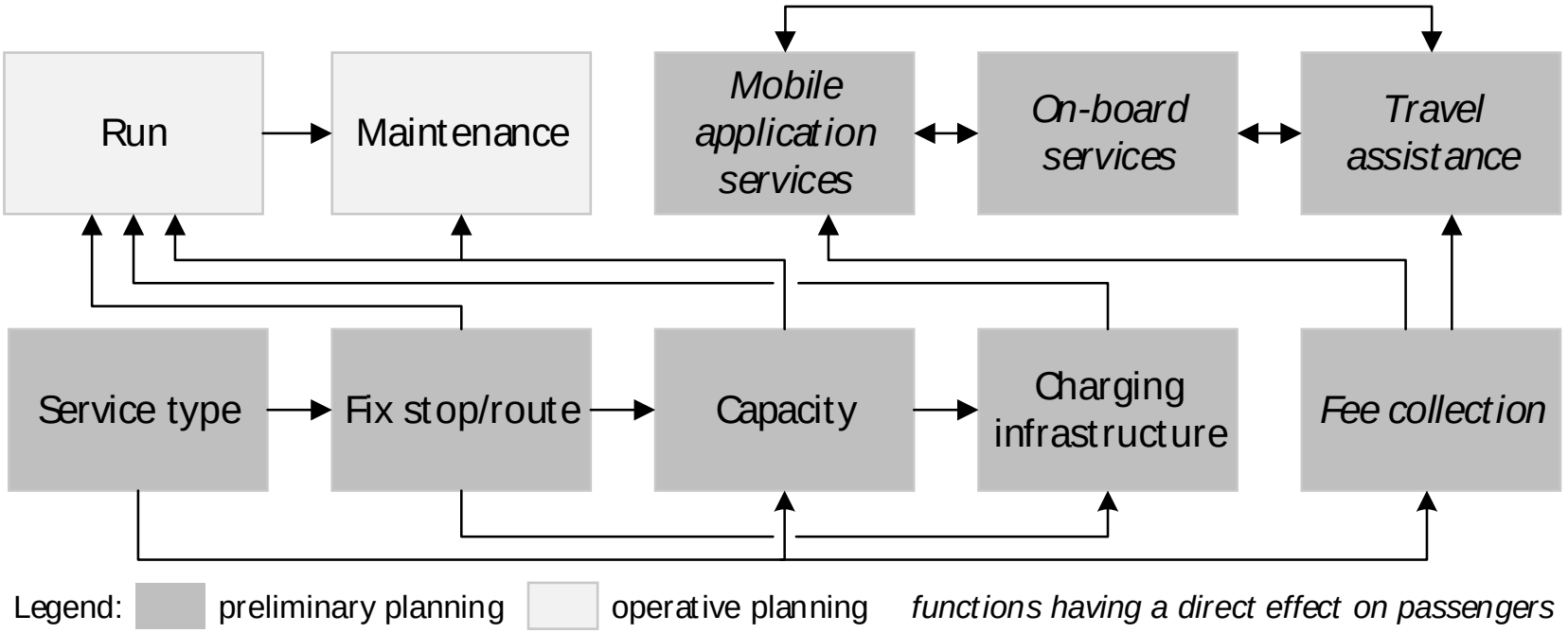
- service is planned by mobility management centre (or operator)
- close cooperation
- data collection, planning process aided by computer, highly automatized
- input data
  - external data sources (municipalities, operators)
  - survey – user expectations
  - operation
  - result of the planning (output)



Name	Description
User	Basic data of potential users (personal and mobility attributes) in a given territory
Territory	Territory attributes (e.g. Road network, fix stops)
Technical	Technical data about vehicles and charging facilities
Survey	Processed data from the survey about general user expectations
Operation	Operational data (e.g. Current vehicle location, data about orders)
Planned mobility service	Output of planning functions

Data groups

Connection of planning functions

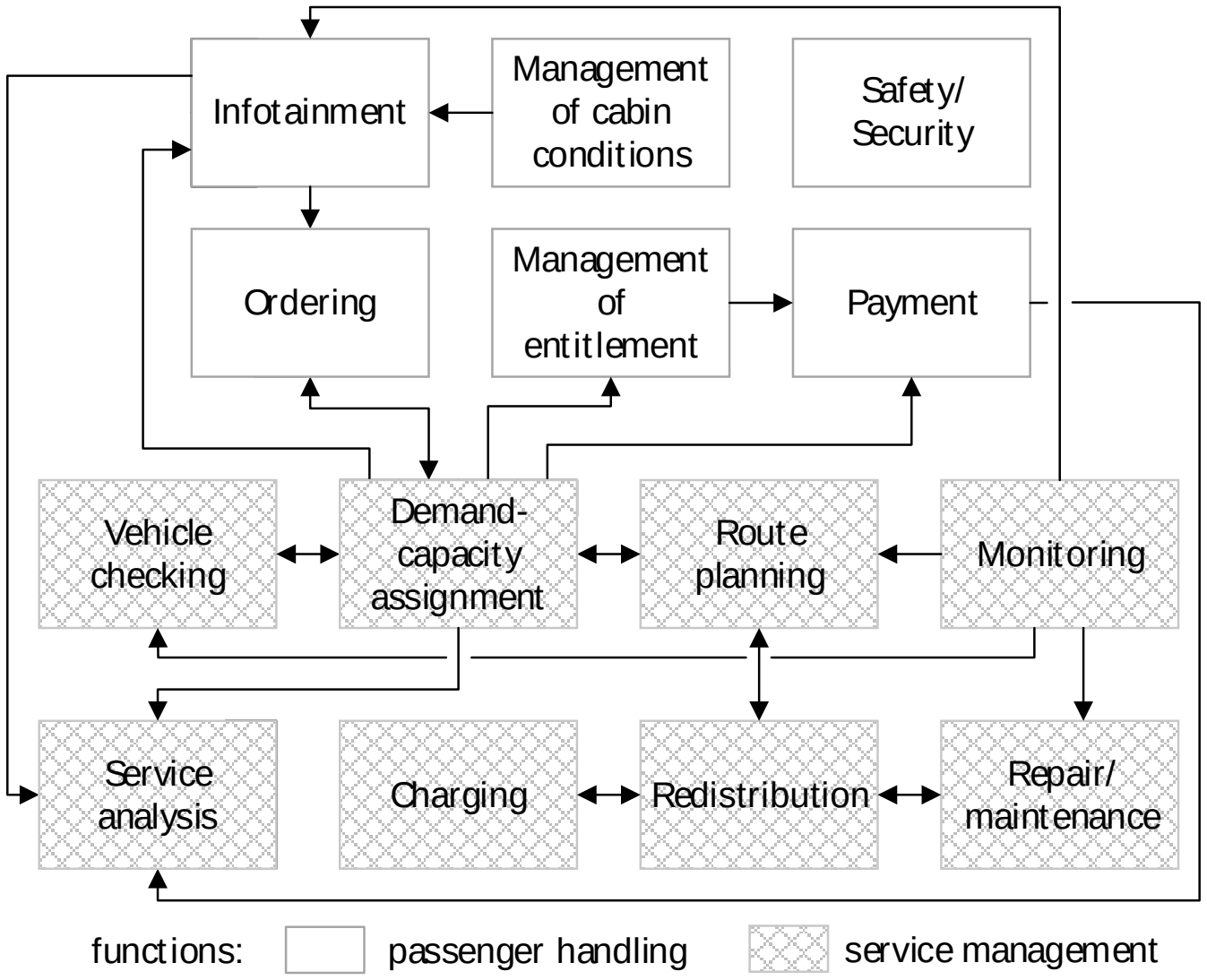


operative planning is persistent process

dynamism of planning functions approximates the dynamism of operational functions

Operation

- highly automated functions – humans are supervisors



Connection of operational functions

Service management:

Vehicle checking

- checking general attributes (e.g. level of status) - select potential vehicles

Demand-capacity assignment

- comparing current attributes of travellers and vehicles - select the vehicle
- iteration: ordering-demand capacity assignment
- passengers are informed

Route planning

- planning useful and empty runs
- based on historical, current and forecasted data
- by the mobility management centre
- iteration: demand-capacity assignment-route planning; redistribution-route planning

Monitoring

- monitoring vehicles and sections of runs
- managing unexpected situations – automatic but human attendance is required

Redistribution

- leading the vehicles to charing, parking spot or high demand zone

Charging

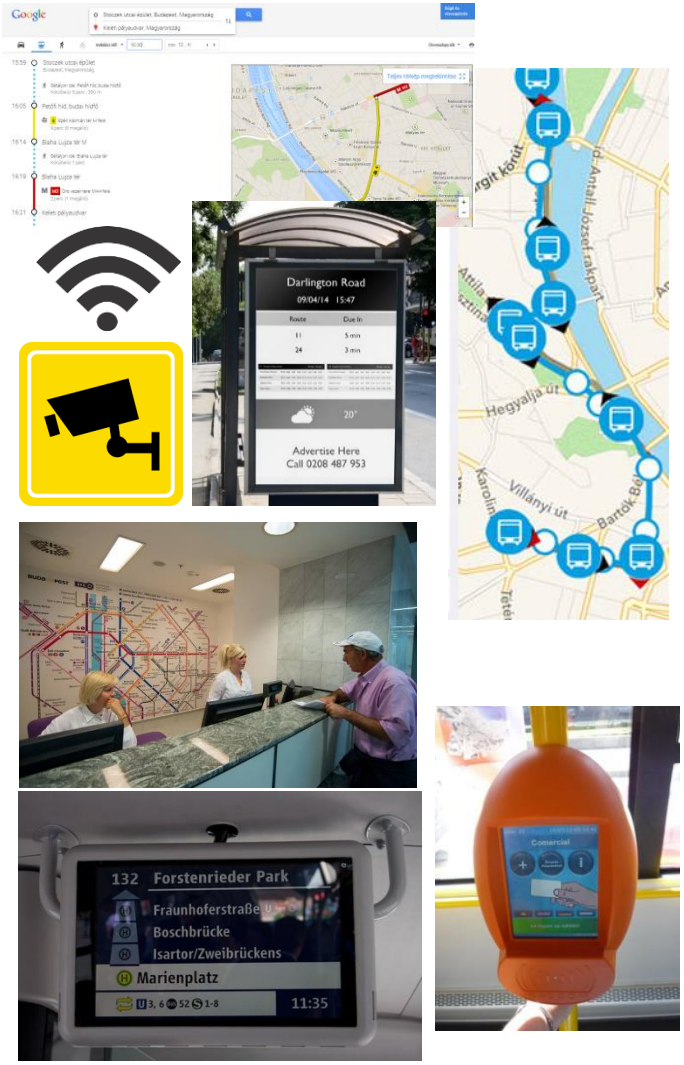
- smart technology (reservation, identification, payment)
- automatized process – to avoid human acts

Repair/maintenance

- constantly monitored vehicles – vehicles provide data
- managed by the operators and mobility management centre
- quick automatic re-disposition

Service analysis

Passenger handling



more automatized passenger handling functions

Function	Sub-function
Infotainment	Information about general conditions and supplementary services
	Information about current situation
	Journey planning and guiding/navigation
	Information provision by devices in the stop
	Information provision by onboard devices
	Information provision by individual's device
	On board complaining/ request information
	Route modification
	Communication between vehicle-passenger
	Entertainment
	Complaining
	Lost and found
	Crowdsourcing
Ordering	Demand announcement (seat-reservation)
Management of entitlement	'ticketing'
	Boarding (authentication)
	Alighting
Payment	Withdrawal
Management of cabin conditions	Management of comfort
Safety/ Security	Avoiding accidents
	Handling boarding (warning, open/close doors)
	Handling passengers in incidents (diseased conditions, emergency situations, failures)
	Life and property protection
	Emergency call

Infotainment

- automatic, customized, personalized information provision – mobile application based
- before: obtain general information about service
- on-board: travel-related, real-time information
  interactive touchscreen-based entertainment
- feedback
- lost luggage and belongings – automatic detection

Ordering

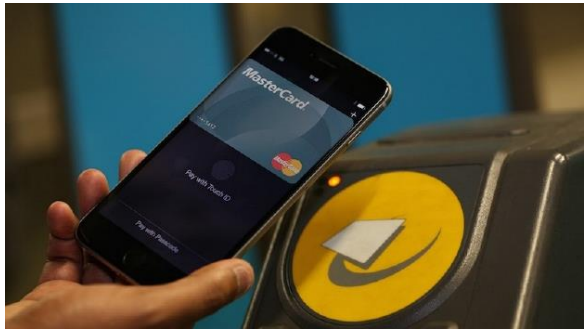
- mandatory advance ordering via application
- customization, based on real-time data

Management of entitlement

- authentication (touchless, virtual/tracking the traveller)
- opening the vehicle/boarding

Management of cabin conditions

- conditions are monitored constantly
- management – automatically, self-adjusted



Safety/security

- security: CCTV surveillance - automatic image detection
- safety: V2N communication; sensor detection
- emergency call can be replaced by automatic detections
- remote monitoring by humans + fast moving teams

Payment

- price calculation – considering current travel data, dynamic price factors (traffic, sharing, demand), discounts,
- mobile payment, automatic payment (based on location), monthly withdrawal

Personnel of the future public transportation

- supervision of the automated functions
- aided by machines
- number of humans max decline

- operation process are more efficient
- personal interactions are needed in the case of special passenger groups and situations
- types: dispatchers, supervisors, customer service, security team rescue team

Task of mobility management centre in detail

- handling user data and travel parameters,
- providing personalized information,
- organizing the processes, calculating routes,
- controling the processes (e.g. coordination of demands and capacities, timing of maintenance, booking of charging point), sending dispositions,
- fare calculation, managing payment process,
- evaluating the service and quality assessment.

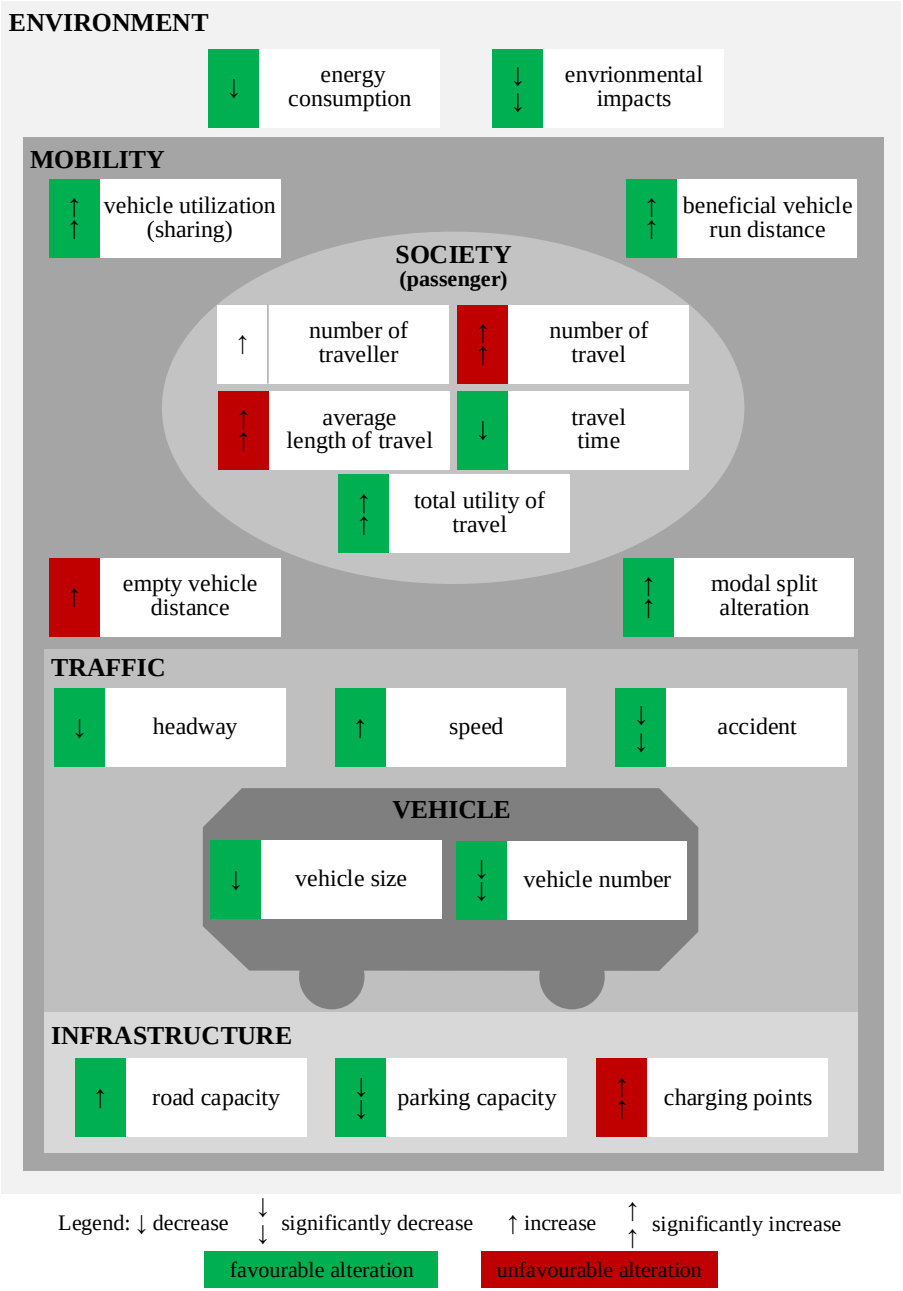
Complex automation levels of public transportation

- considering: process planning and management, control (vehicle, fleet, traffic), passenger handlings functions
- aims:
  - describe a mobility service in a complex way
  - define the development potentials

No.	Name	Description	Entity making decisions and executing
1	No automation	The human role (passenger, driver, other personnel) is unavoidable, they execute all processes; there is no direct machine support.	Human
2	Machine assistance	The human work is supported by the machine. However, the role of human is rather significant.	Human aided by machine
3	Partial automation	A significant part of the processes is executed by the machine. The human personnel monitor the processes.	Rather machine with human confirmation
4	Full automation	Processes are completely operated by a machine in an automatic way, the personnel attends as a supervisor.	Machine

Impacts of Autonomous Vehicles

- increasing demands
  - new user groups
  - total utility if travel increase
  - more and longer travels
- new, shared mobility forms
  - number of vehicles and size of vehicles decrease
  - empty vehicle runs increase
  - run mileage increase
  - daily performance increase
  - capacity utilization increase
- traffic parameters improve
  - headway decreases (platooning),
  - speed increases
- less accident → less injury
- land use improve
  - less lanes, parking spaces
  - more charging points
- environmental load decrease

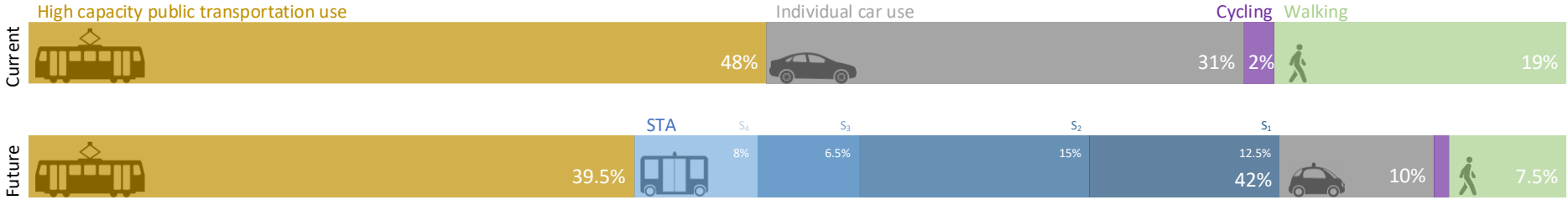


transitional periods (mix traffic)

- in automatization levels
- in traffic flows – proportion of AVs, proportion of different type of AVs -scenarios

modal share alteration

- individual car use and ownership decrease
- willingness to shift



Alteration in modal share in Budapest according to the willingness to shift based on survey; other impacts (e.g. promotion of soft mobility modes) were neglected.

land use:

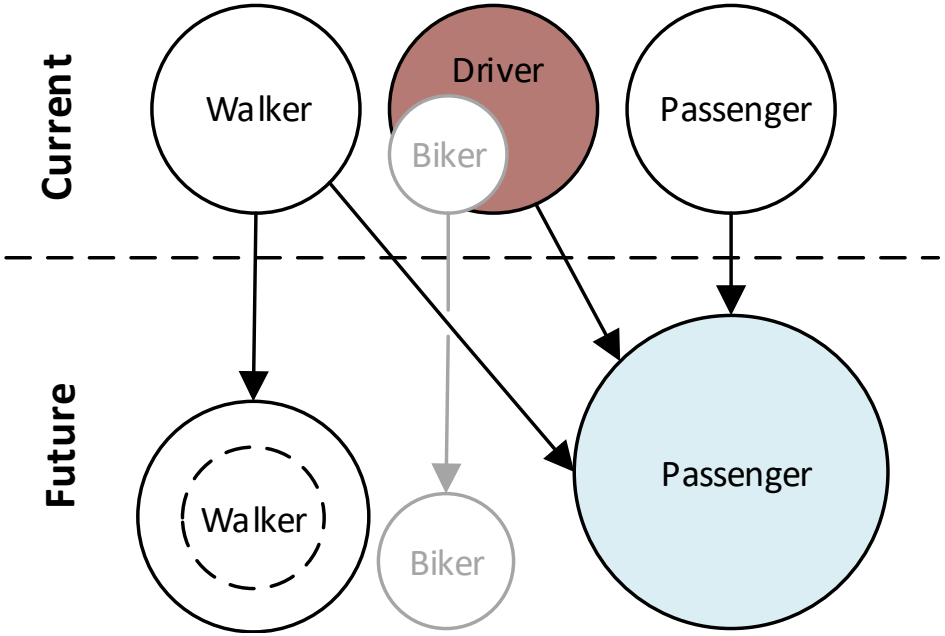
- strict boundaries between infrastructure elements diminish
- less space is necessary for road traffic
- number road signs/markers decrease/alter

  BUT! soft mobility modes
- shared road elements:
  - shared parking lots (Park and Charge, Load and Charge)
  - shared traffic lanes: in the peak hours for moving traffic, in the off-peak hours for parking

altering urban environment,

livable cities

share of traveller types

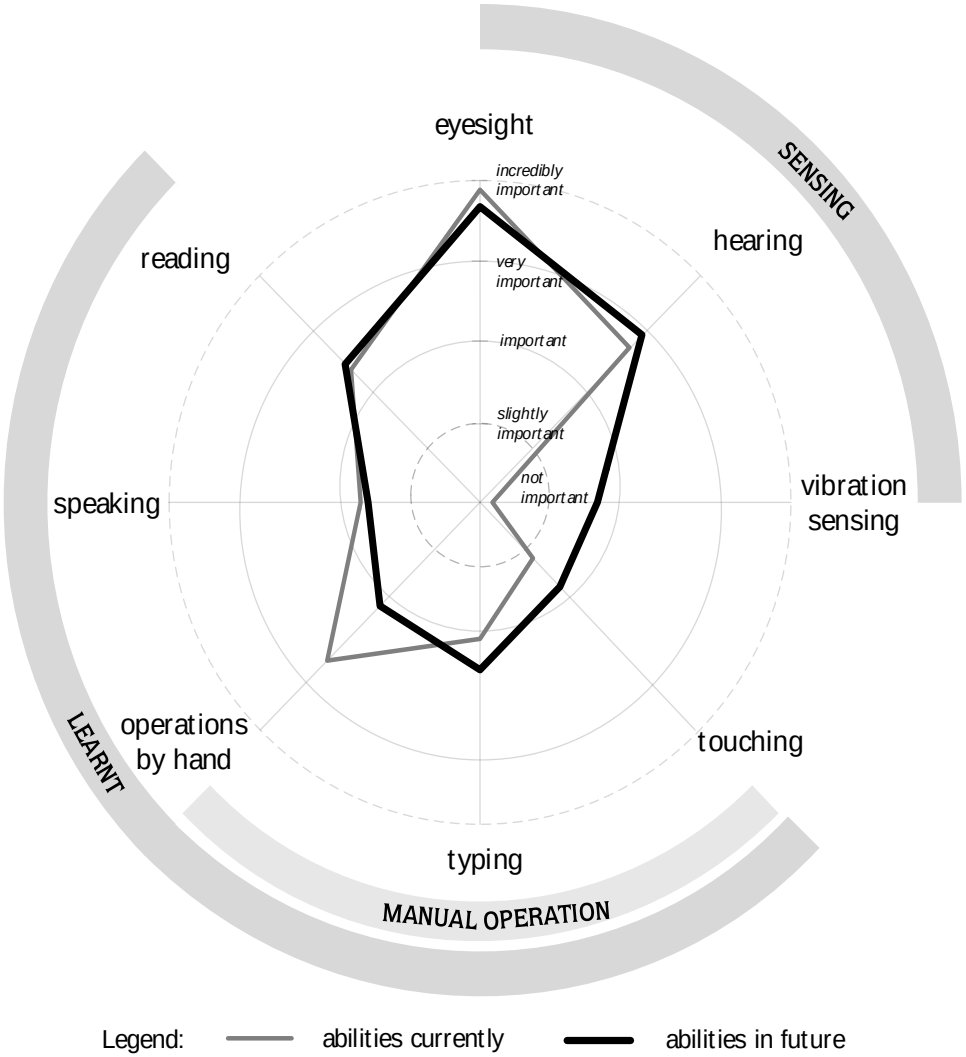


total individual utility of travelling is increasing

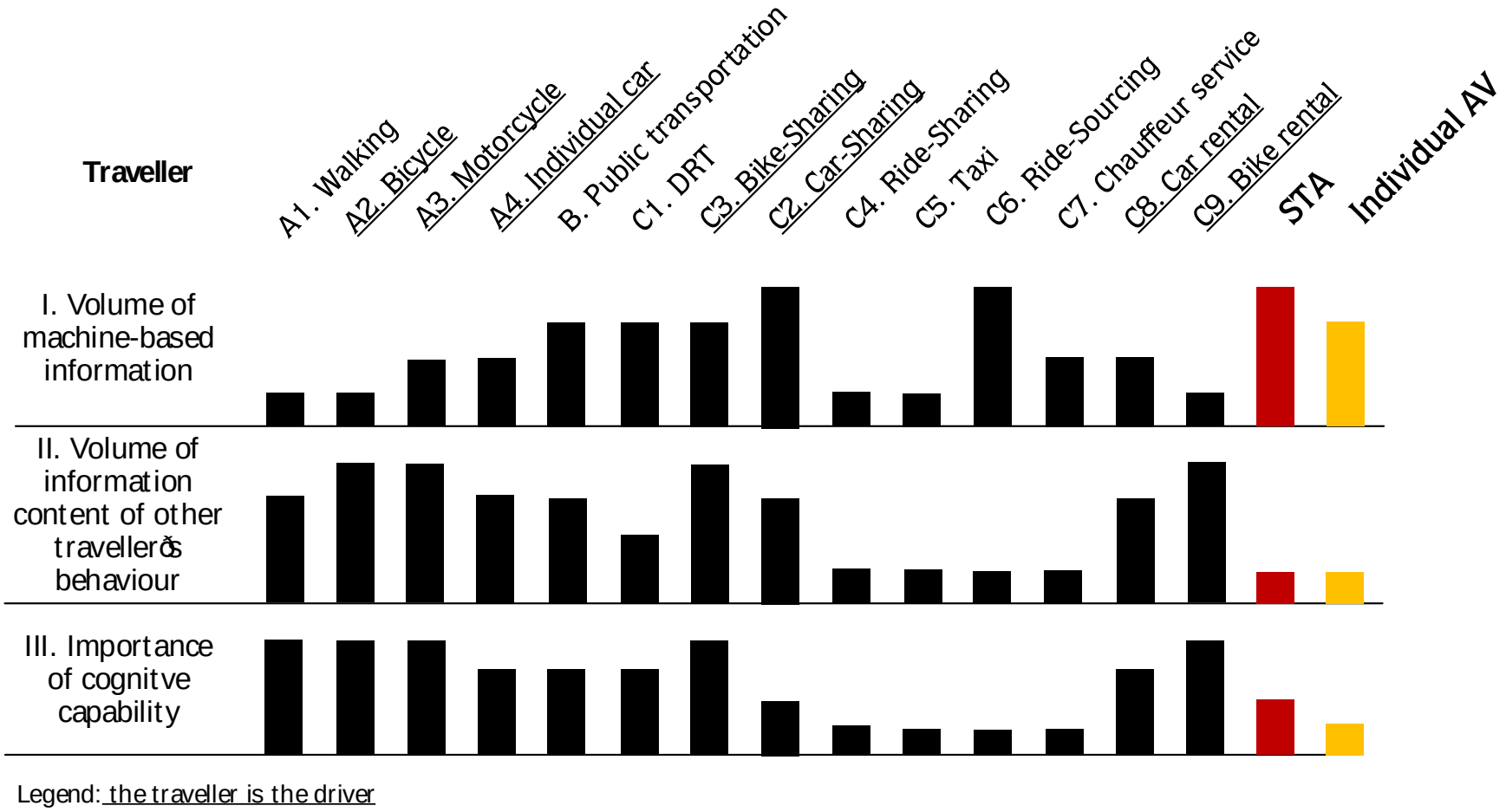
- useful activities during travel
- infotainment

Importance of required human abilities are altering

- mobile application related abilities increase
- detection and process information of other's behaviour reduce
- cognitive capability reduce



Information management of travellers - properties



Legend: the traveller is the driver

information management is different according to modes

Challenges

user acceptability

SAFETY

- improving traffic safety, less accident, new insurances
- several development areas remain

drivers, as labor, are replaced

→ **social tension**

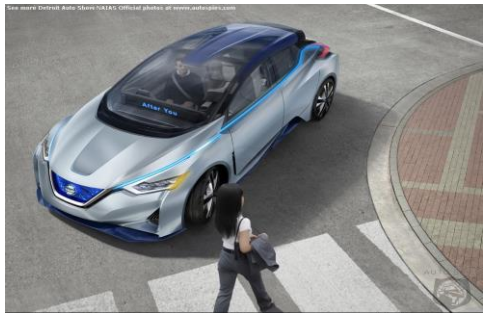
altering personnel groups

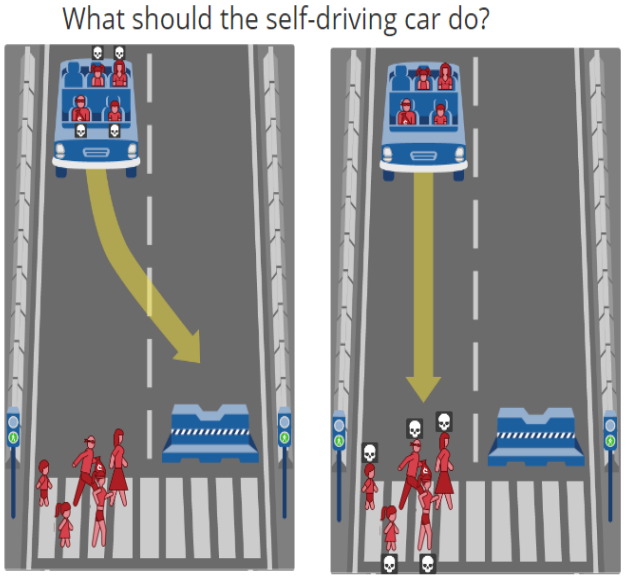
law should be altering

ETHICAL DILEMMAS

who is responsible? who makes decisions?

communication technology (hacking)





Socioeconomic benefits

- reason of automation
- motivation: potential of significant cost-efficiency
- improvement: adequate management, control procedures

	Impacts	Direct economic benefits	Social/ passenger benefits
Safety	Reduction of number and severity of accidents	■	■
	Reduction of injuries within vehicles	■	■
	Less insurance-related activity and cost	■	■
Traffic	Higher capacity of existing infrastructure	■	■
	Application of optimal speed profile	■	
	Improvement of public transportation priority	■	
Environment	Shifting to alternative fuels	■	■
	Reduction of energy consumption and emission	■	■
	Reduction of noise emission		■
	Increased passenger number, Reduction of private traffic	■	■
	Less parking space, more efficient land use and Altering urban patterns	■	■
Mobility service (operation)	Capacities and demands are coordinated better	■	■
	Improved efficiency of operator's decisions	■	
	Elimination of driver timing problem	■	
	Reallocation of personnel efforts	■	■
	Better maintenance operations	■	
Society (passengers)	Introduction of new mobility service concepts		■
	Shorter travel times	■	■
	Better accessibility of public transportation both in space and time		■
	Improved management of transfers		■
	Higher passenger satisfaction		■