CityMobil2
CITIES DEMONSTRATING AUTOMATED ROAD PASSENGER TRANSPORT

Automated road transport systems in European cities

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SEVENTH FRAMEWORK PROGRAMME

www.citymobil2.eu

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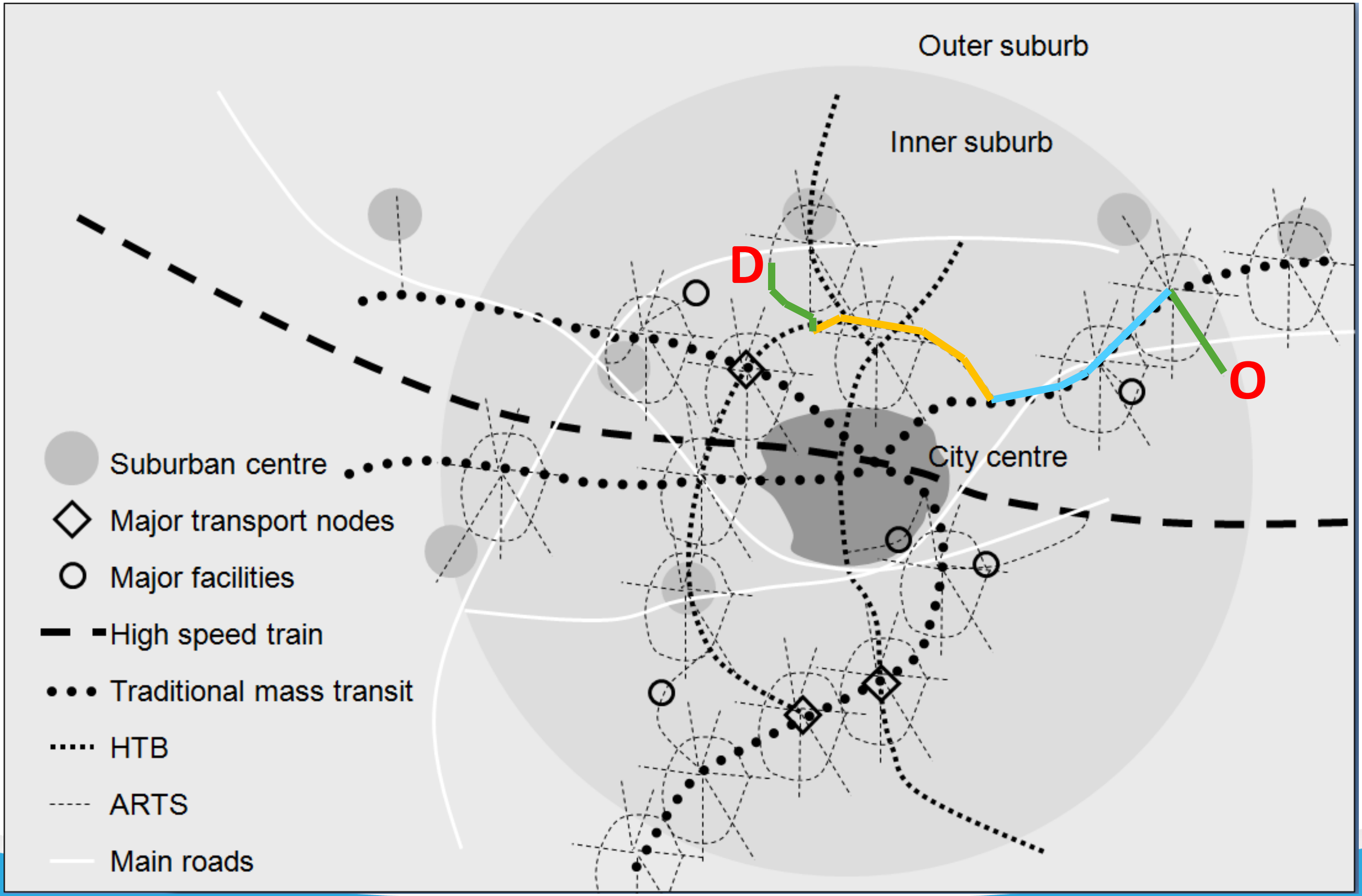
- EC funded research project
- Main goal: Remove the barriers to the deployment of fully automated urban road mobility
  - 45 partners
    - 12 cities
    - 5 Automated Road Transport Systems manufacturers,
  - 15 M€ budget,
  - 9.5 M€ EC funding, FP7
  - 48 months duration (2012-2016)

Complementing and integrating mass transits



Some figures to explain why driverless for last mile

	60-100 passenger bus	5 sit car very used often changed	4 sit car little used little changed	10 passenger automated minibus current prices	4 passenger automated car reduced price
Cost of a vehicle	€ 200,000.00	€ 30,000.00	€ 18,000.00	€ 100,000.00	€ 30,000.00
km per year	90000	40000	10000	25000	25000
occupancy rate (low)	5	1.2	1.3	0.65	0.65
occupancy rate (high)	25	1.2	1.3	3.5	1.4
Total cost per km	€ 2.12	€ 1.47	€ 4.94	€ 0.72	€ 0.27
Total cost per sit per km	€ 0.03	€ 0.29	€ 1.24	€ 0.07	€ 0.07
Cost per km excluding driver	€ 1.12	€ 0.34	€ 0.44	€ 0.72	€ 0.27
Cost per km per pax (low occ.)	€ 0.42	€ 0.28	€ 0.34	€ 1.11	€ 0.42
Cost per km per pax (high occ.)	€ 0.08	€ 0.28	€ 0.34	€ 0.21	€ 0.19

Main research aspects addressed by CityMobil2

- Legal aspects – lack of a legal framework
- Implementation of real systems in cities
  - Many cities want to be second but none first
  - 2 fleets of 6 10-passengers vehicles each selected
  - 7 ground breaking city demonstrations and 3 showcases are being implemented
- Socio-economic effects of vehicle automation

CityMobil2 up to date calendar

- 2014 summer – small demo Oristano (IT)
  - *completed*
- 2014 September – showcase in Leon (ES)
  - *completed*
- 2014-15 winter and spring large demo in Lausanne (CH)
  - *about to start*
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  - *about to start*
- 2015 summer small demo in Vantaa (FI)
- 2015 September showcase in Milan (IT)
- 2015 September showcase in CERN (Geneva-CH)
- 2015 October showcase at ITSWC (Bordeaux –FR) TBC
- 2015-16 summer, autumn and winter large demo Trikala (EL)
- 2016 timing to be confirmed small demo San Sebastian (ES)
- 2016 timing to be confirmed small demo Sophia Antipolis (FR)

First demo in Oristano completed

Demonstrator route

- *Seaside resort of "Torregrande"*
- *Pedestrian only waterfront promenade*
- *Alternate one-way ARTS lane with crossing point at stop 4*
- *Total line length: 2560 m*
- *Number of stops: 7; avg. distance 215m*

Legal status

- Site: being the site of the demonstrator a pedestrian area, a deliberation by the commander of the Local Police is sufficient to start the demonstrator.
- Vehicles: the vehicles are not certified to run on public roads; they have a "test" license plate for research and testing purposes
- Passengers registered as "testers" in order to be allowed on-board. Minors were allowed but had to be registered by a parent or a guardian.

Traffic congestion!

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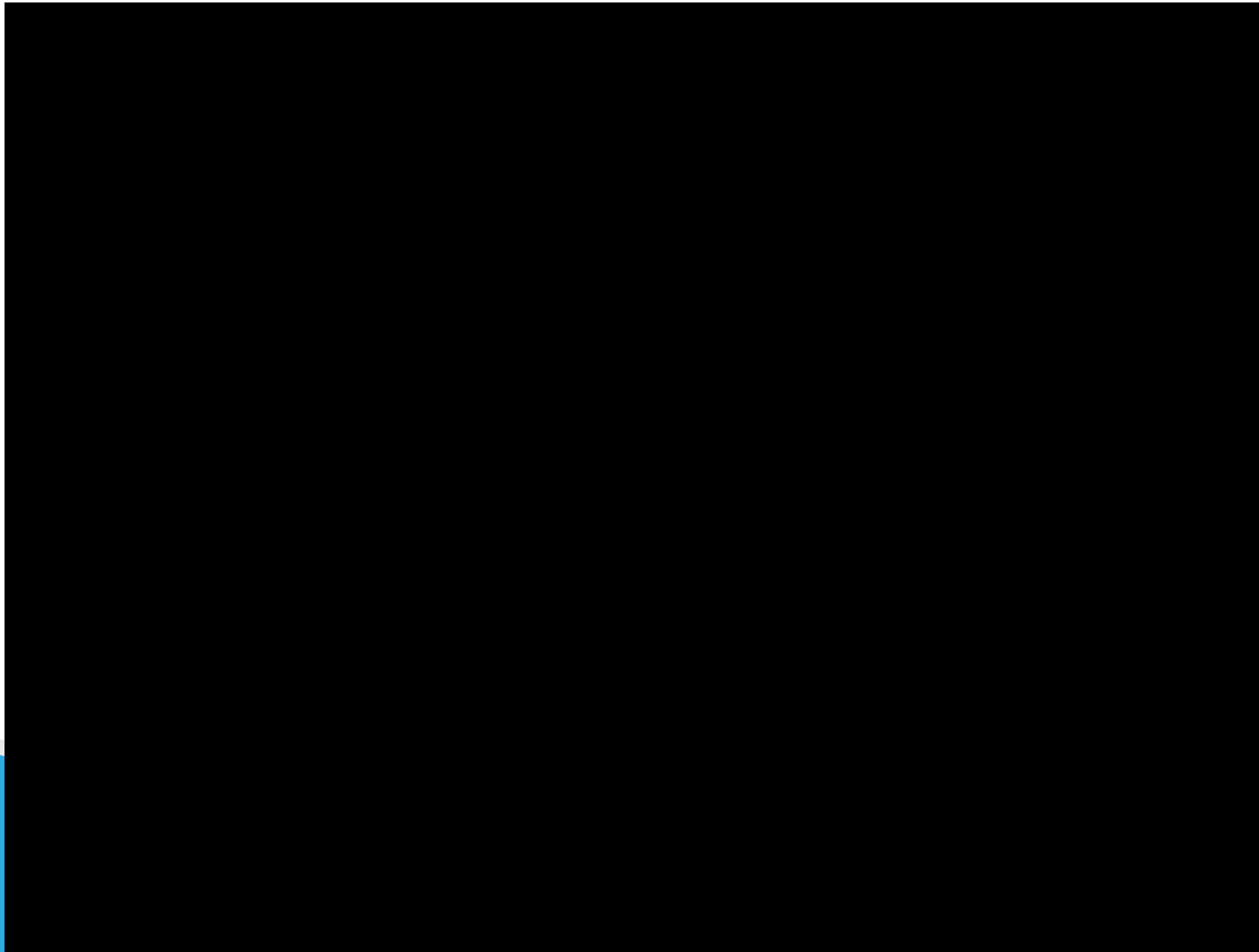
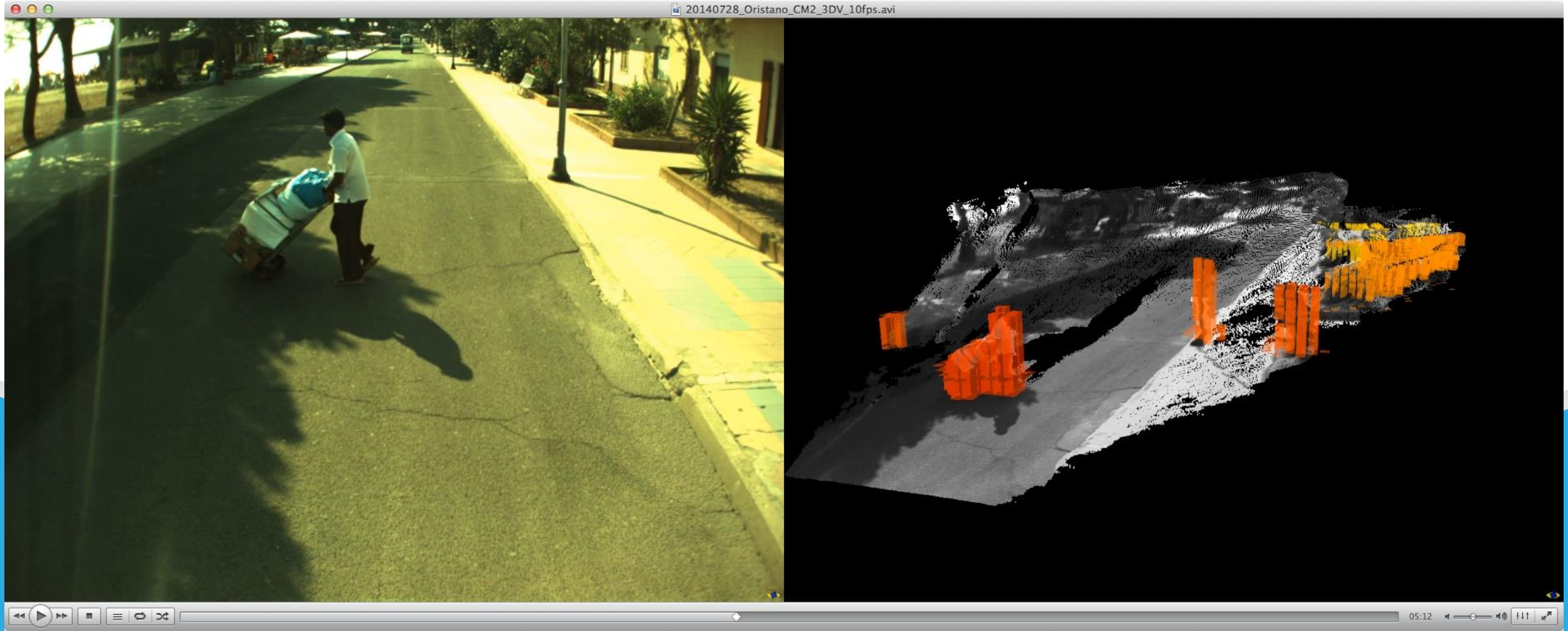
The news video of the demo



Research work to do on Oristano results

- Analysing data from the collected questionnaires to assess user reaction
- Analysing recored data from the vehicles to measure performances
- Analysing dat from cameras to assess non-user reactions



Initial statistics

- Operating days: 38
- Vehicle trips: 837
- Vehicle trips per day: 22
- Total distance covered: 1100 km
- Registered testers: 1600
- Total number of passenger trips: 3000
- Average daily passenger trips: 79
- Average vehicle occupancy: 3.5 (35%)
- Peak number of passenger trips in one day: 188 (31/7)
- Filled tester questionnaires: 330
- Average commercial speed: 5.5-8 km/h
  depending on pedestrian density

Business case reflections induced by Oristano early results

- With
  - 6.5 km/h average speed,
  - 5 days a week and 8 hours a day operations and
  - 35% occupancy rate
- the yearly mileage goes down to 13500 km/year and
- the cost per passenger kilometre goes up to 0.37 €/pkm
- No longer competing with private cars (0.28-0.34 €/pkm)
- Without even considering ARTS management costs and company profit

Which solution for ARTS business?

- With
  - 14.5 km/h average commercial speed,
  - Oristano operating times and
  - 35% occupancy rate
- the yearly mileage goes up to 30000 km/year and
- the cost per passenger kilometre down to 0.17 €/pkm
- Beating private cars (0.28-0.34 €/pkm) even with a 60% overhead to manage ARTS and have some company profits

Where then to demonstrate ARTS profitably?

- In California
  - where ARTS can be legal
- On a site where transport demand allows
  - 10 passenger vehicles and
  - 35% occupancy rate
  - and where infrastructures would allow 14.5 km/h commercial speed.
- Does a site like that exist?

Thank you for listening

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Technical issues

- Vehicles not equipped with lifting board and retention systems for wheelchairs
- Trees canopies limit GPS signal which is occasionally lost and required human intervention
- Mixed pedestrian traffic requires lower speed than forecasted
- Service & delivery vehicles occasionally occupy ARTS lane and require human intervention

Good points

- Media coverage above expectations
- Great curiosity and participation of local population
- Great involvement and enthusiams of bus drivers as on-board ”supervisors”
- Appreciated service to the elderly and the disabled
- Presence of ARTS on the boulevard generally accepted and tolerated, despite pre-demo criticism
- Enrolement of ”testers” above expectations

Robosoft's vehicle (final design)

LIGIERS's VIPA II (final design)

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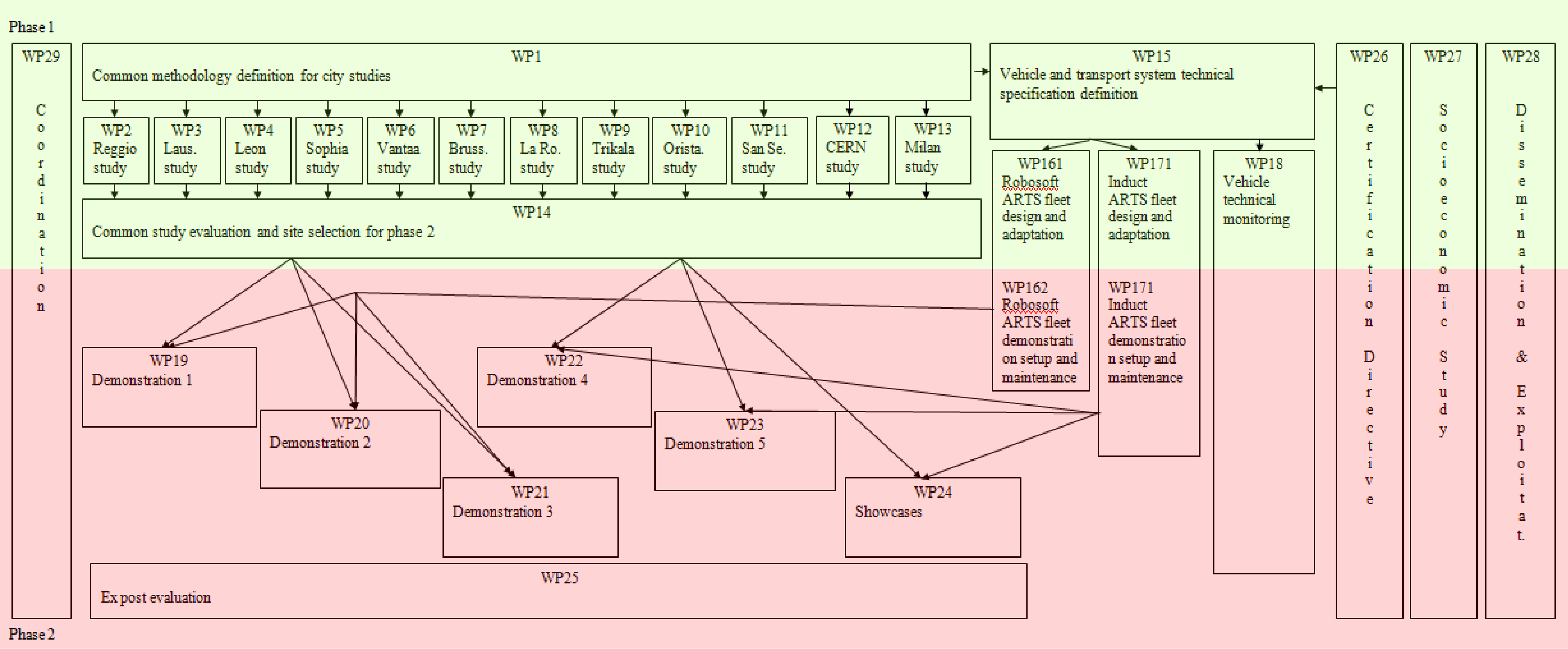
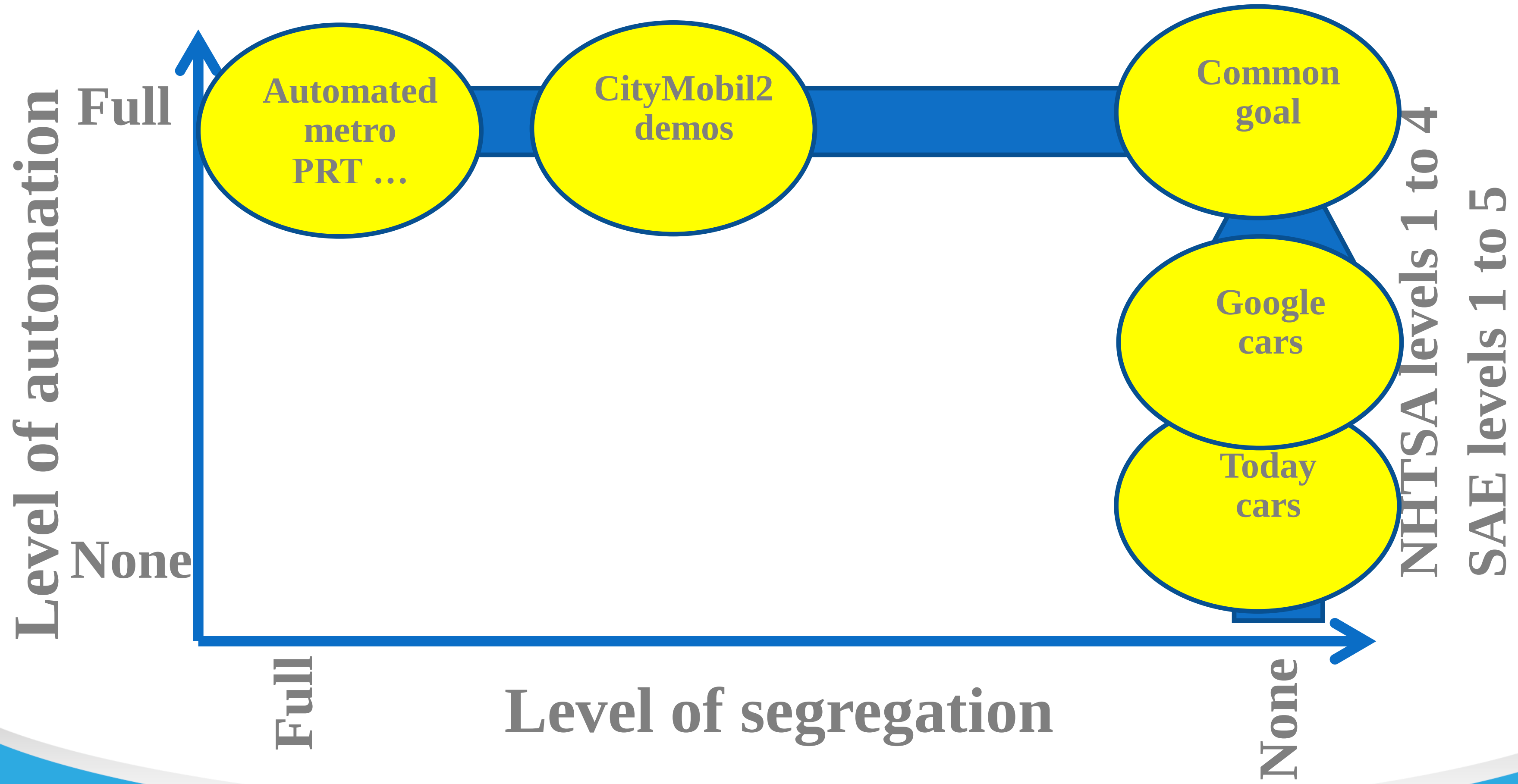
CityMobil2 WBS and phases



Levels of automation and how to get there



Road classification (TRB' HCM)

Road class	F	E	D	C	B	A
	Walkway	Collector street	Urban street	Arterial road	Highway	Freeway
Driveway/access density	-	Very high	High	Moderate	Very low	Very low
Parking Separate left-turn lanes	- -	Significant No	Significant Some	Some Usually	No Yes	No No
Signals/km Speed limit (km/h)	- 0	6-10 15-40	4-8 40-55	2-6 55-80	0.3-1.2 70-100	- 100-130
Pedestrian activity	Very Important	Important	Usually	Some	Very little	No
Roadside development	Very high density	Very high density	High density	Medium to moderate density	Low density	Very low density

Road classification applicable to CityMobil2

Road class	F	E	D	C	B	A
Belgium		20 / 30	50	70	90	120
Spain			50	70	80 / 90 / 100	100/120
Finland			50		80	100 / 120
France		30	50	70 / 80	80 / 90	100/110/ 130
Greece			50		70 / 90	90 /110/ 120
Italy			50	70	90	110 / 130
Switzerland		20 / 30	50	60 / 70	80	100/120

Scenarios analyzed for the CityMobil2 demonstrations

Infrastructure delimitation elements

Level	Elements	Category
0	No segregation	Shared
1	Horizontal marking	Dedicated
2	Guidance paving	
3	Differentiated lane paving	
4	Lane delimiter	
5	Surmountable curb	
6	Walkways (sidewalks)	
7	Traffic median	
8	Discontinuous urban furniture: Flower box / Trash can	
9	Discontinuous barriers: Bollards / Delimiter	
10	Continuous soft barriers: Vegetation	
11	Continuous barriers: Balustrade / Boundary barrier	Segregated
12	Continuous barriers: Pedestrian protection barrier	
13	Carriageway divider	

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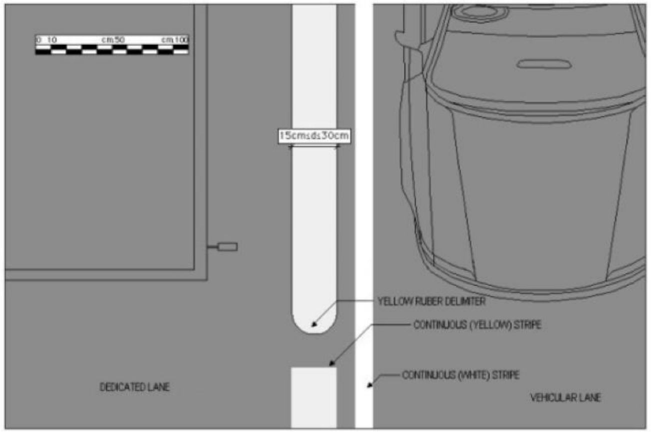
Delimitation elements (example for dedicated lanes)

4 - Lane delimiter: Fixed plastic or rubber element, solidly anchored to the ground with the objective of separating two motor vehicle streams or to delimit a dedicated lane. It must be surmountable, which is only allowed in case of emergency.

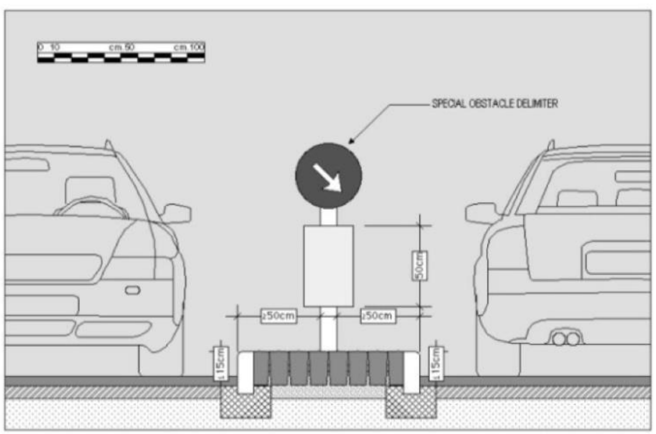
(a)



(b)

Delimitation elements (example for segregated lanes)

7 - Traffic median: Longitudinal area of the road not suitable for vehicle flow, whose function is to separate vehicular flows. Due to its function, it is not accessible except in case of emergency.



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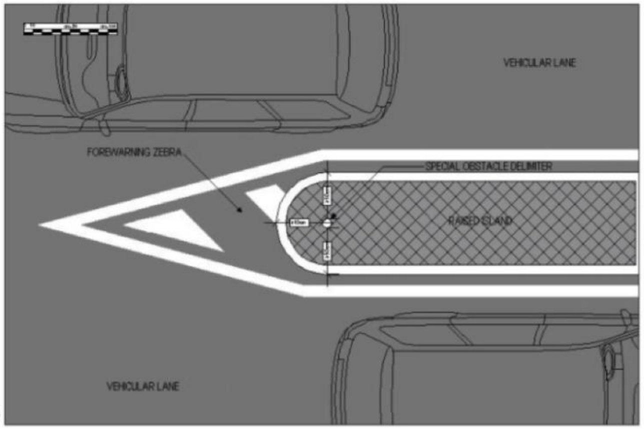


(b)

Delimitation applicable to CM2 scenarios

Road class		C				D				E				F	
		Arterial road				Urban street				Collector street				Walkway	
Road user		Pedestrians	Cyclists	Motorcyclists	Motor vehicle drivers	Pedestrians	Cyclists	Motorcyclists	Motor vehicle drivers	Pedestrians	Cyclists	Motorcyclists	Motor vehicle drivers	Pedestrians	Cyclists
0	Shared														
1	Dedicated					•	•			•	•	•	•	•	•
2	Segregated	•	•	•	•		•	•	•			•	•		

To better explain the work done let's look at what others do: Nissan autonomous emergency steer

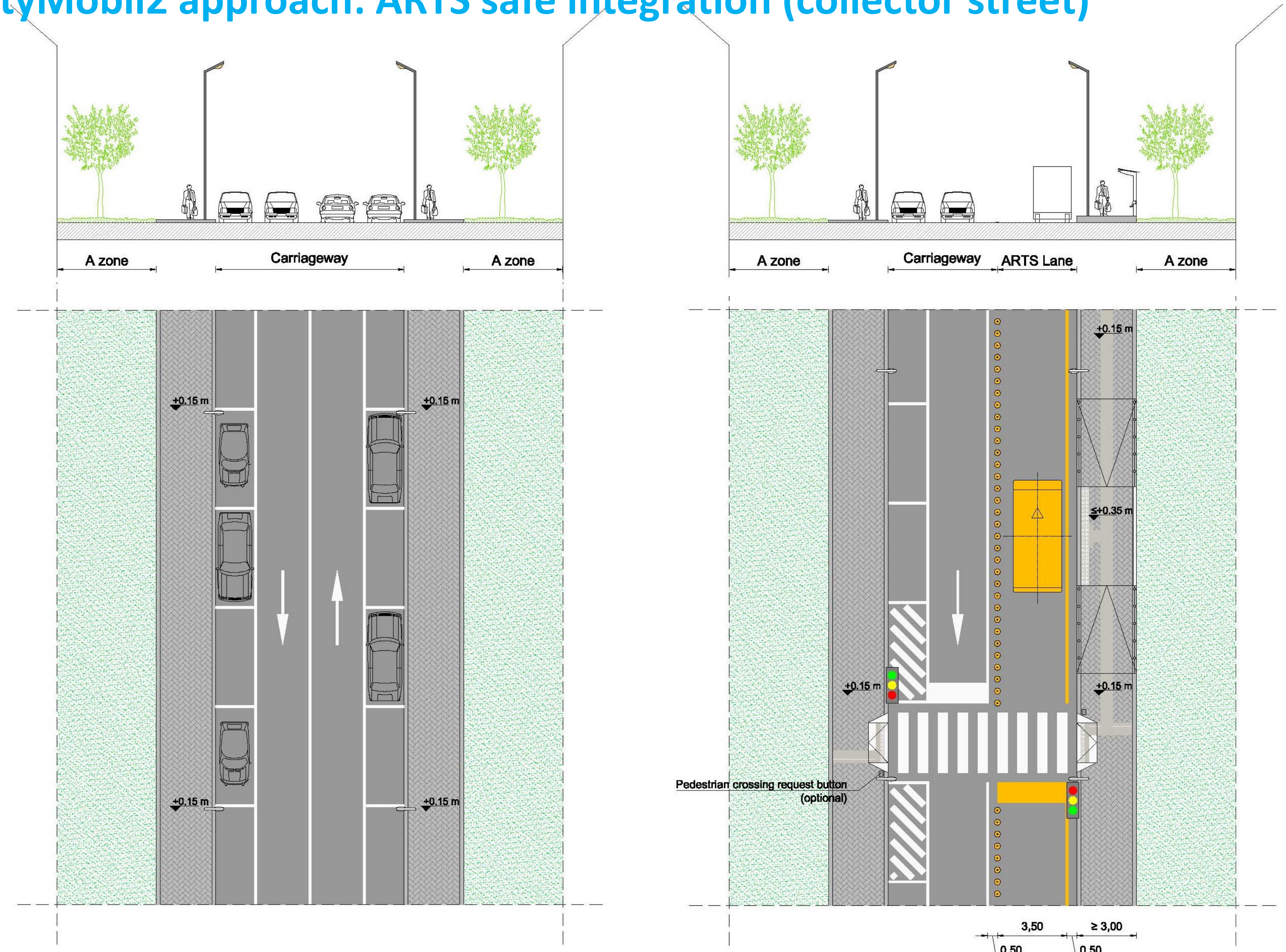
A cool bit of technology

But is it safer than manual driving?

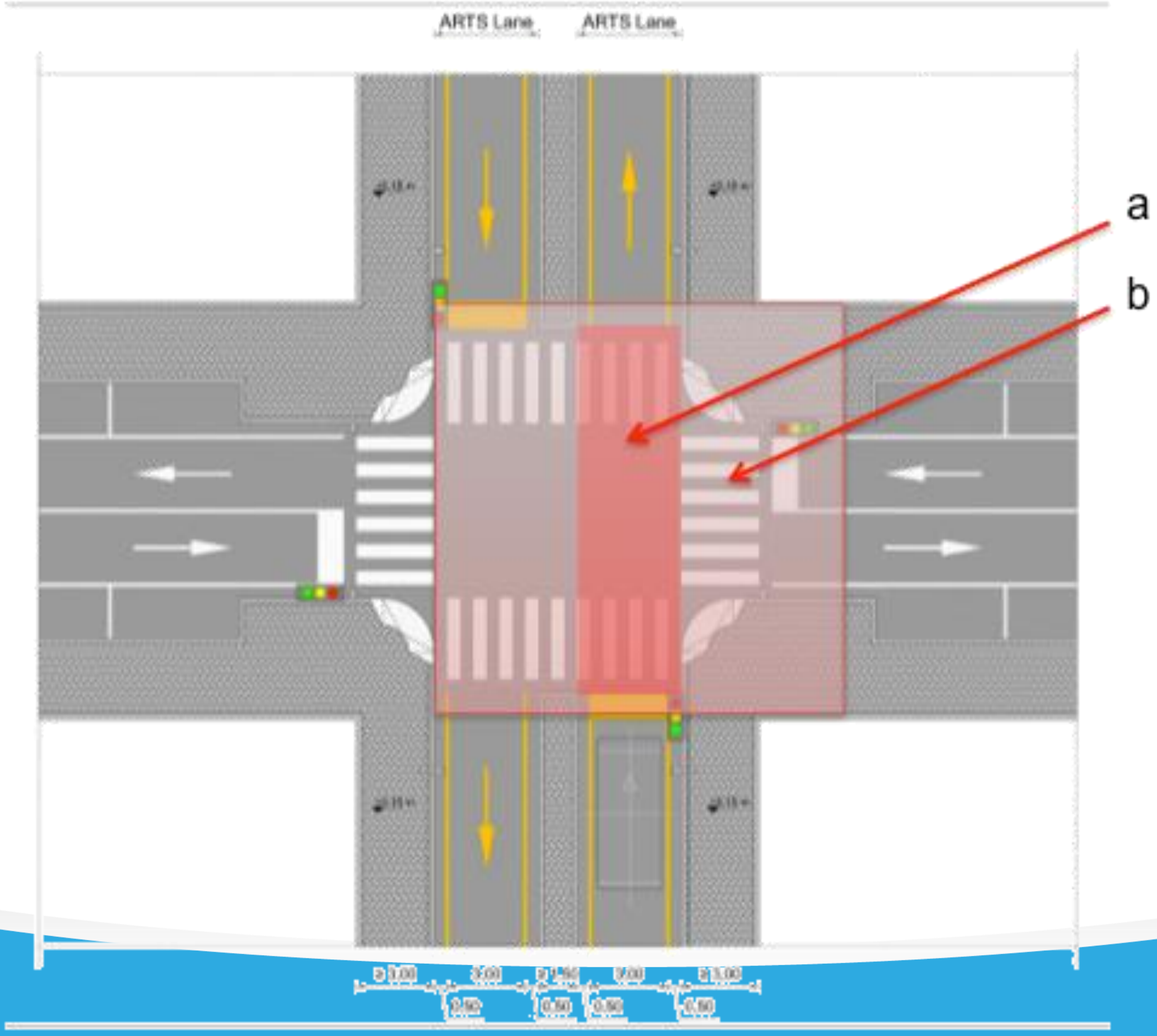
Can this bocome the standard requirement for ARTSs?

What would happen in this situation?

CityMobil2 approach: ARTS safe integration (collector street)



What to detect when approaching intersections from the vehicles or communicating with the infrastructure



Integration scenarios (road section drawings)

- 12 ARTS segregated/dedicated scenarios
- 4 crossing scenarios
- 5 driveway scenarios

Two contiguous but independent infrastructures

- ARTS have dedicated or segregated lanes
  - Intersections with manually driven vehicles are possible (always with traffic lights and road-side sensors that control respect of lights)
  - Access to manually driven vehicles possible (if they respect specific regulations)
  - Pedestrians and cyclists access possible
- Manually driven vehicles lanes are not accessible to ARTS vehicles

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Proposals for two separate regulations

1. Regulates the technical procedure for certification of ARTS (infrastructure, vehicles and all subsystems)
2. Regulates the civil and criminal liability for ARTS' manufacturers and operators, and for manually driven vehicles using ARTS lanes

Principles of the Technical Directive

- Based on EN50126's vehicle and infrastructure certification through a risk assessment
- Takes advantage of "Type approval" on motor vehicles Directives
  - Based on modular Use cases: specific interaction situations between ARTS, infrastructure, road users and surrounding environment
  - A certified use case doesn't require another certification if the same conditions repeat

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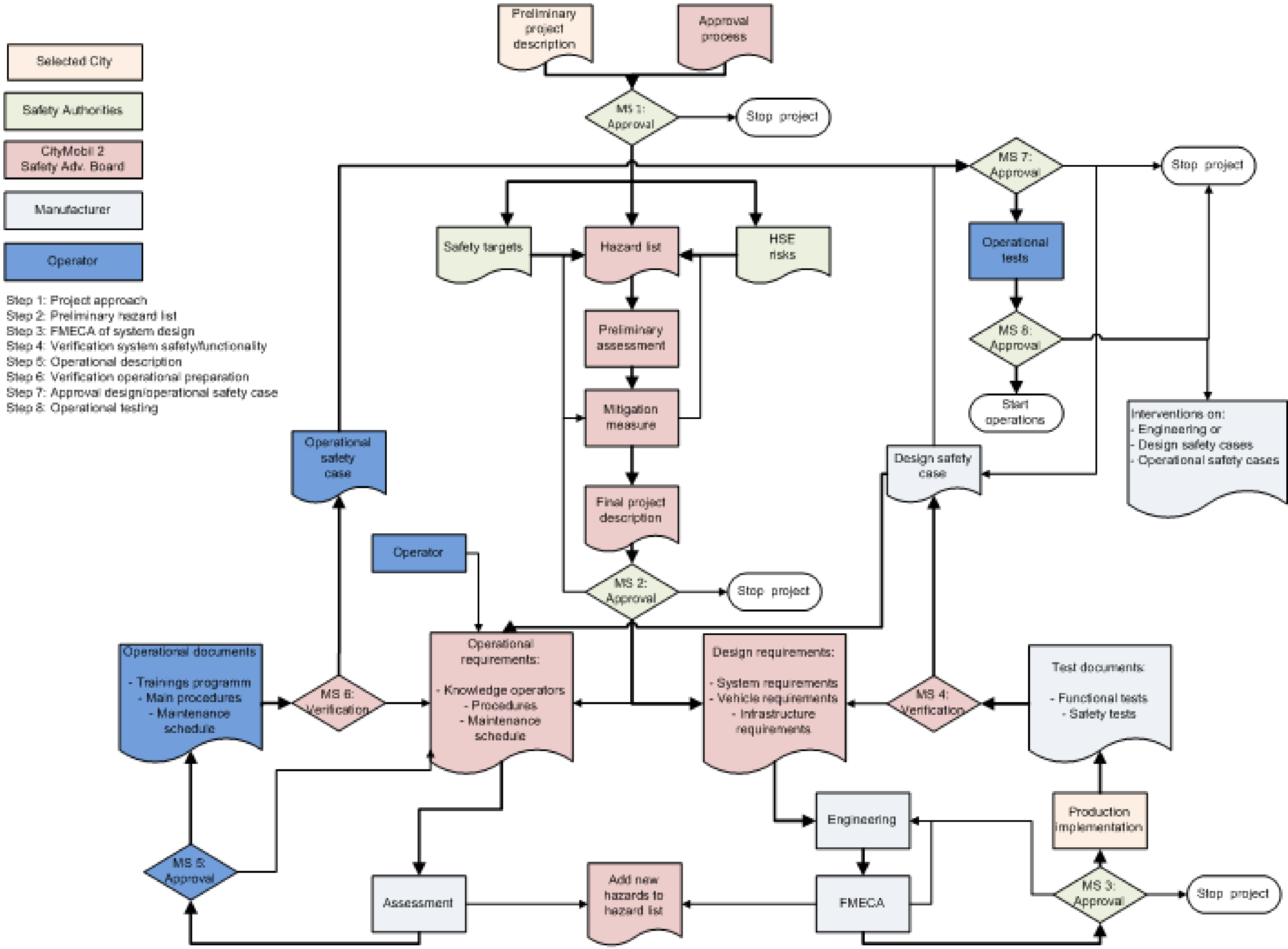

Selected City
Safety Authorities
CityMobil 2 Safety Adv. Board
Manufacturer
Operator
Step 1: Project approach
Step 2: Preliminary hazard list
Step 3: FMECA of system design
Step 4: Verification system safety/functionality
Step 5: Operational description
Step 6: Verification operational preparation
Step 7: Approval design/operational safety case
Step 8: Operational testing
Preliminary project description
Approval process
MS 1: Approval
Stop project
MS 7: Approval
Stop project
Safety targets
Hazard list
HSE risks
Operational tests
Preliminary assessment
MS 8: Approval
Mitigation measure
Start operations
Interventions on:
- Engineering or
- Design safety cases
- Operational safety cases
Operational safety case
Design safety case
Final project description
Operator
MS 2: Approval
Stop project
Operational documents
- Trainings programm
- Main procedures
- Maintenance schedule
MS 6: Verification
Operational requirements:
- Knowledge operators
- Procedures
- Maintenance schedule
Design requirements:
- System requirements
- Vehicle requirements
- Infrastructure requirements
MS 4: Verification
Test documents:
- Functional tests
- Safety tests
Engineering
Production implementation
MS 5: Approval
Assessment
Add new hazards to hazard list
FMECA
MS 3: Approval
Stop project

Step 1: Project approach

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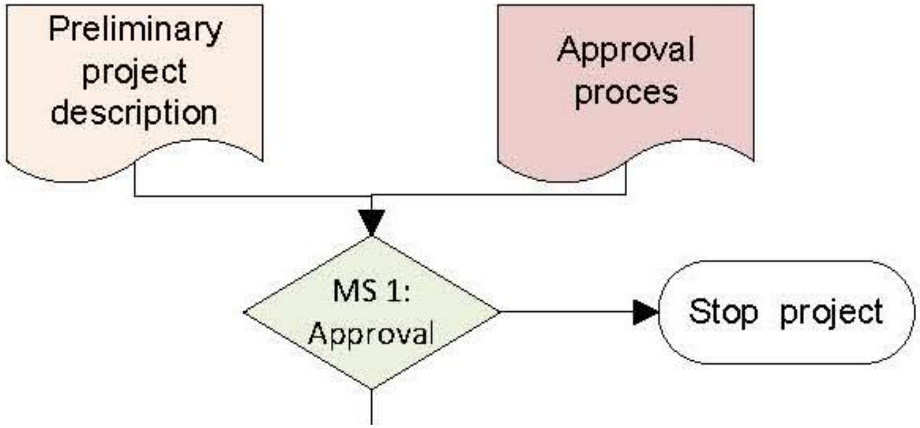

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Step 2: Preliminary hazard risks

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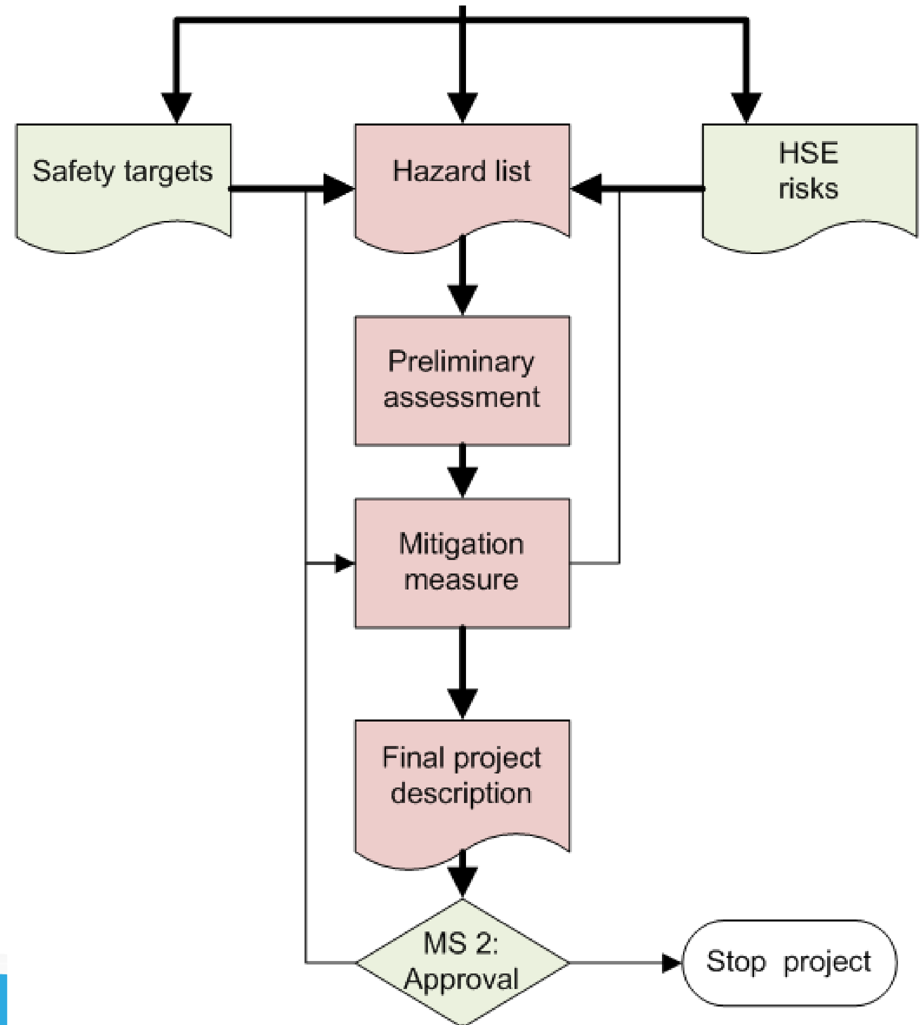

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Step 8: Operational testing

Step 3: FMECA and system design
Step 4: Verification of system safety/functionality

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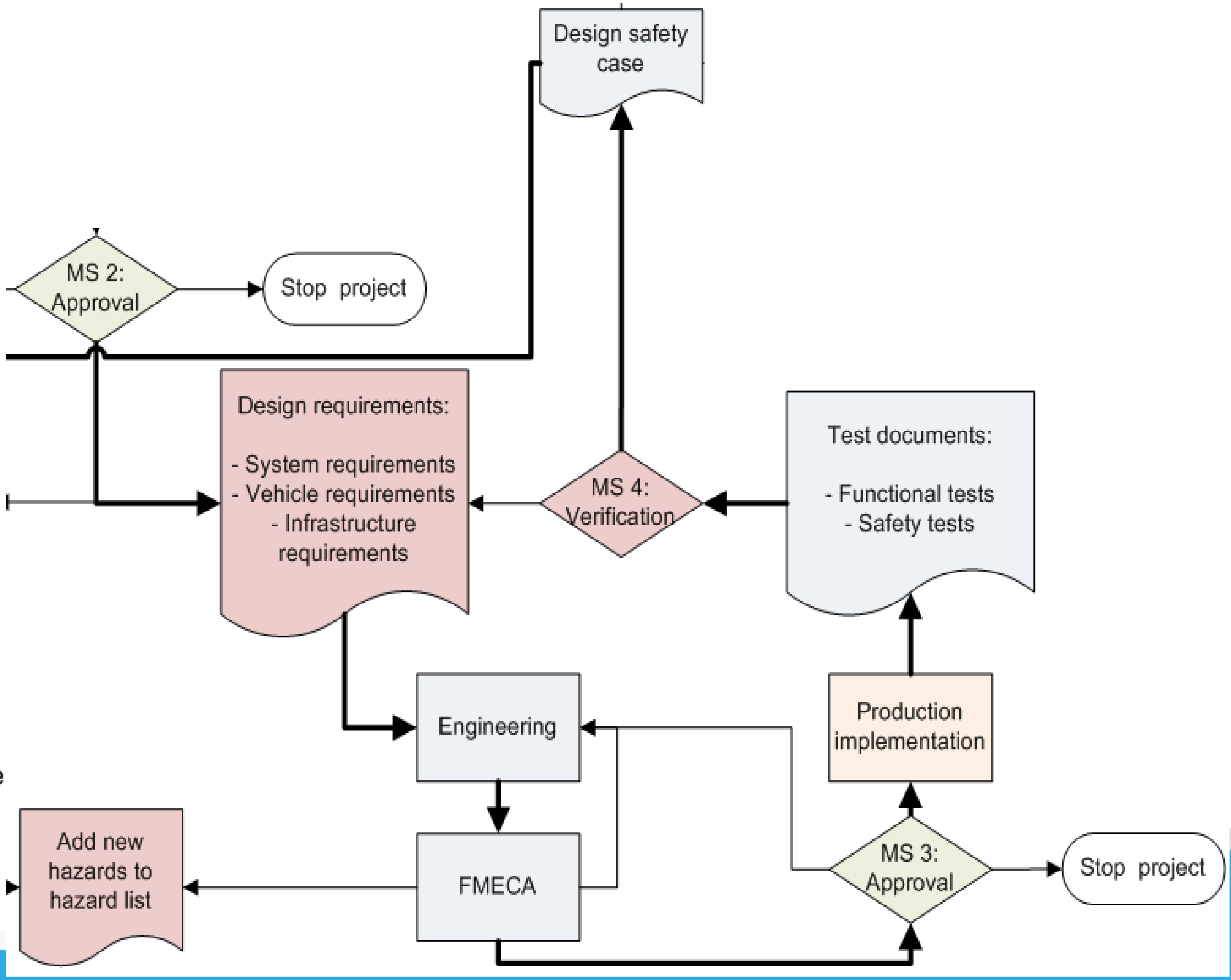

Step 5: Operational description
Step 6: Verification of operational preparation

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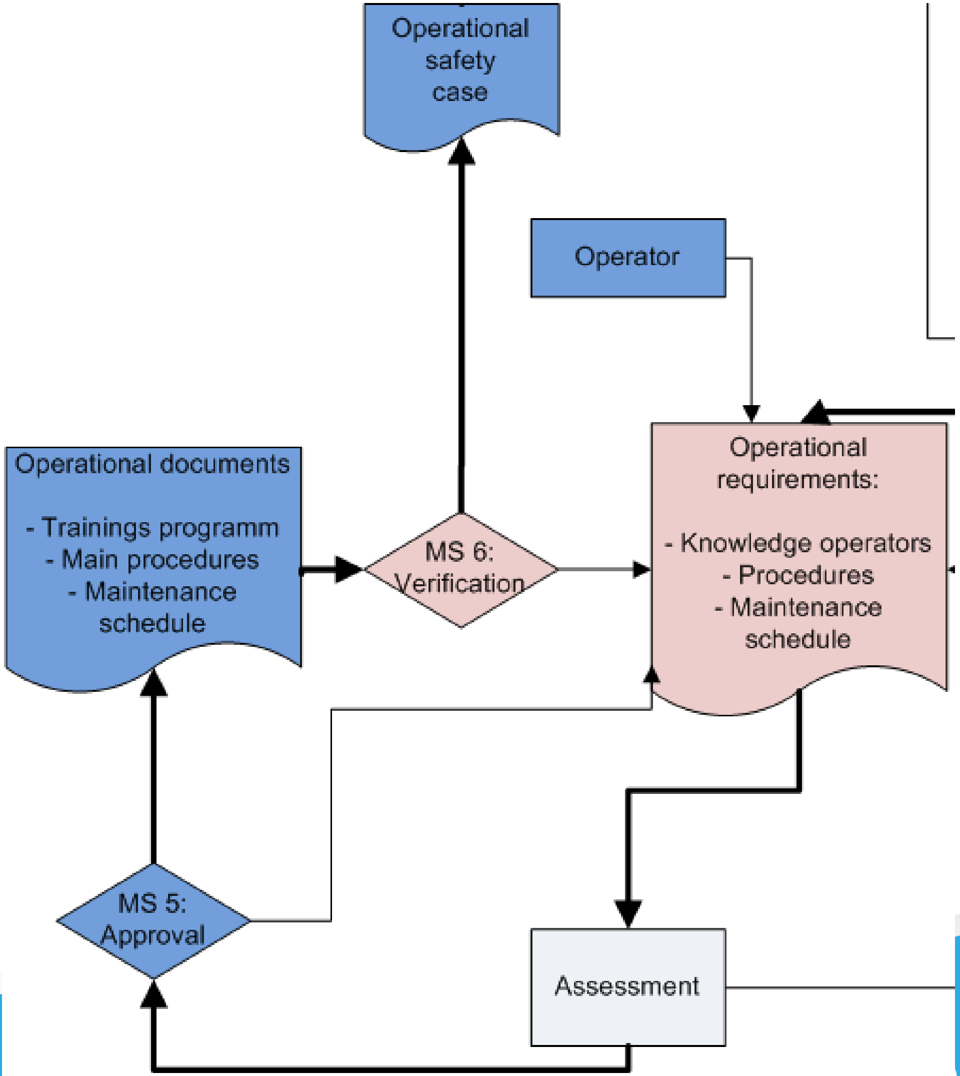

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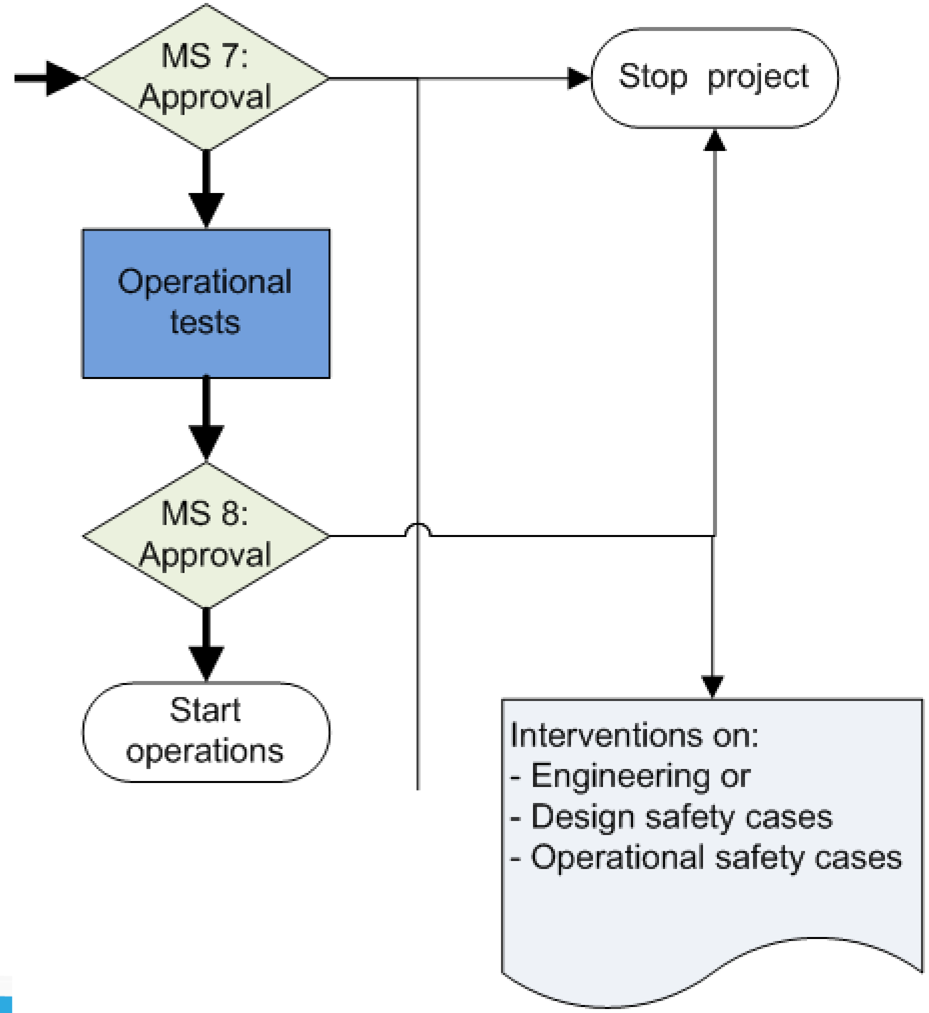

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