31st Annual INCOSE international symposium

virtual event

July 17 - 22, 2021

Using Models and Simulation for Concept Analysis of Electric Roads

www.incose.org/symp2021

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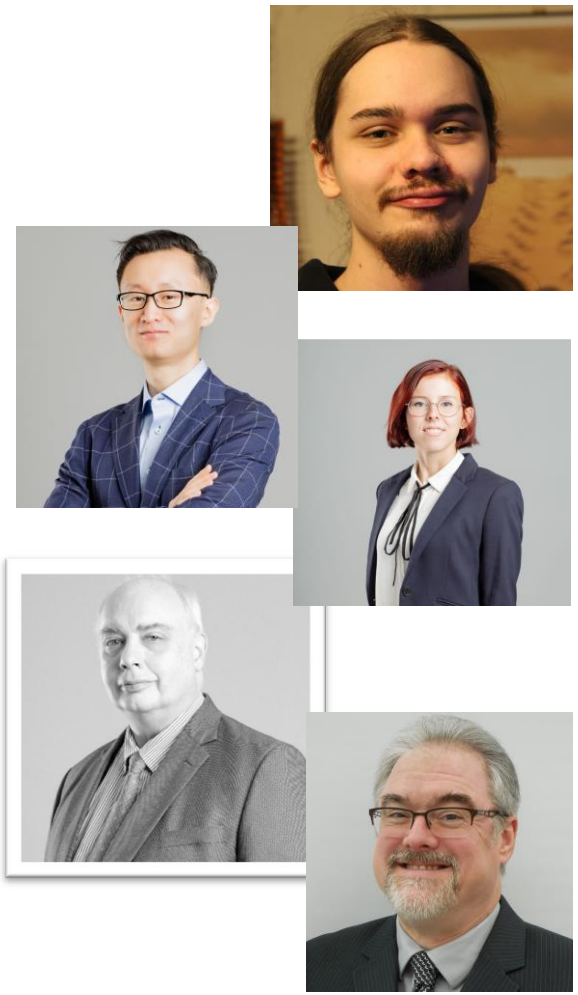
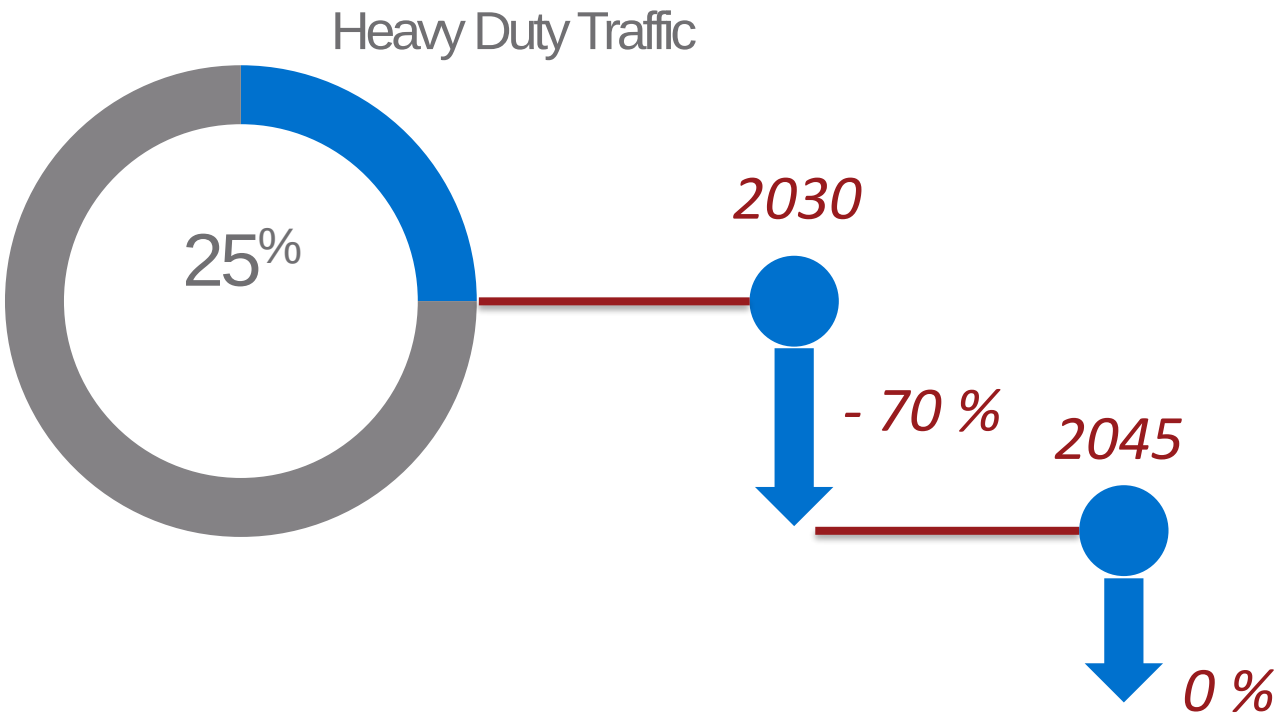


Background



UAF®
OMG UNIFIED ARCHITECTURE FRAMEWORK®

ELECTRIC ROADS IN SWEDEN

ELECTRIC ROAD STAKEHOLDERS

Swedish Energy Agency

TRAFIKVERKET

VINNOVA

RI. SE VIKTORIA

TRANSPORT STYRELSEN

THREE DISTINCT PHASES

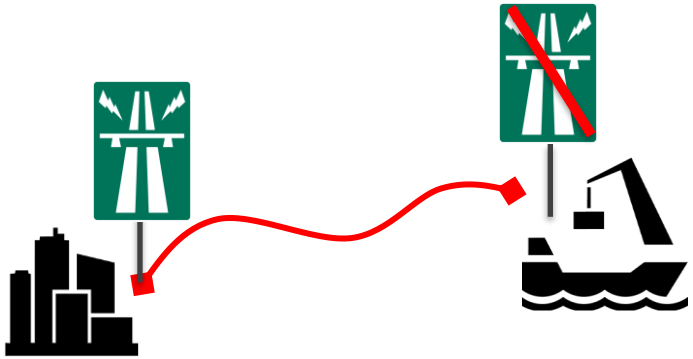
Technology demonstration

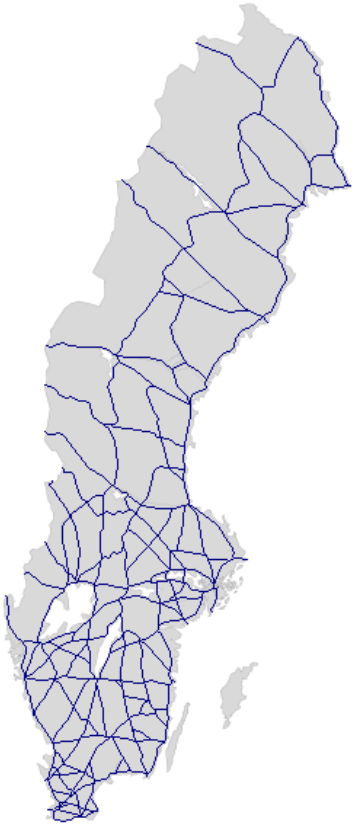
Pilot roads

Wire

Rail

Induction



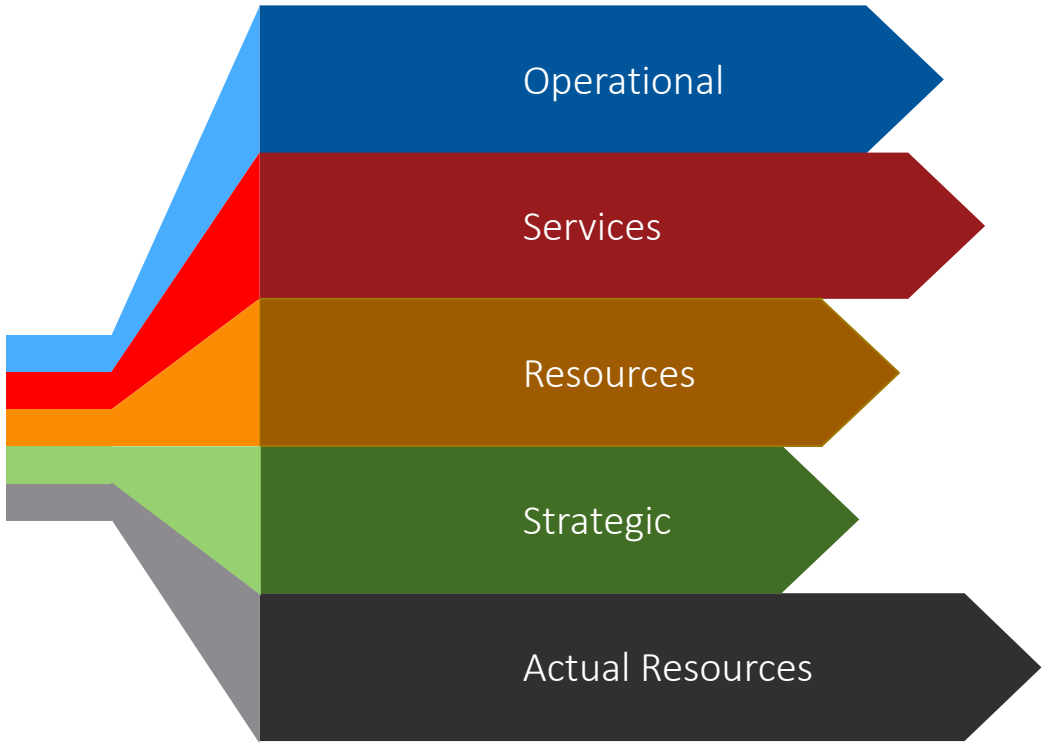


Demonstration → Pilot → Deployment

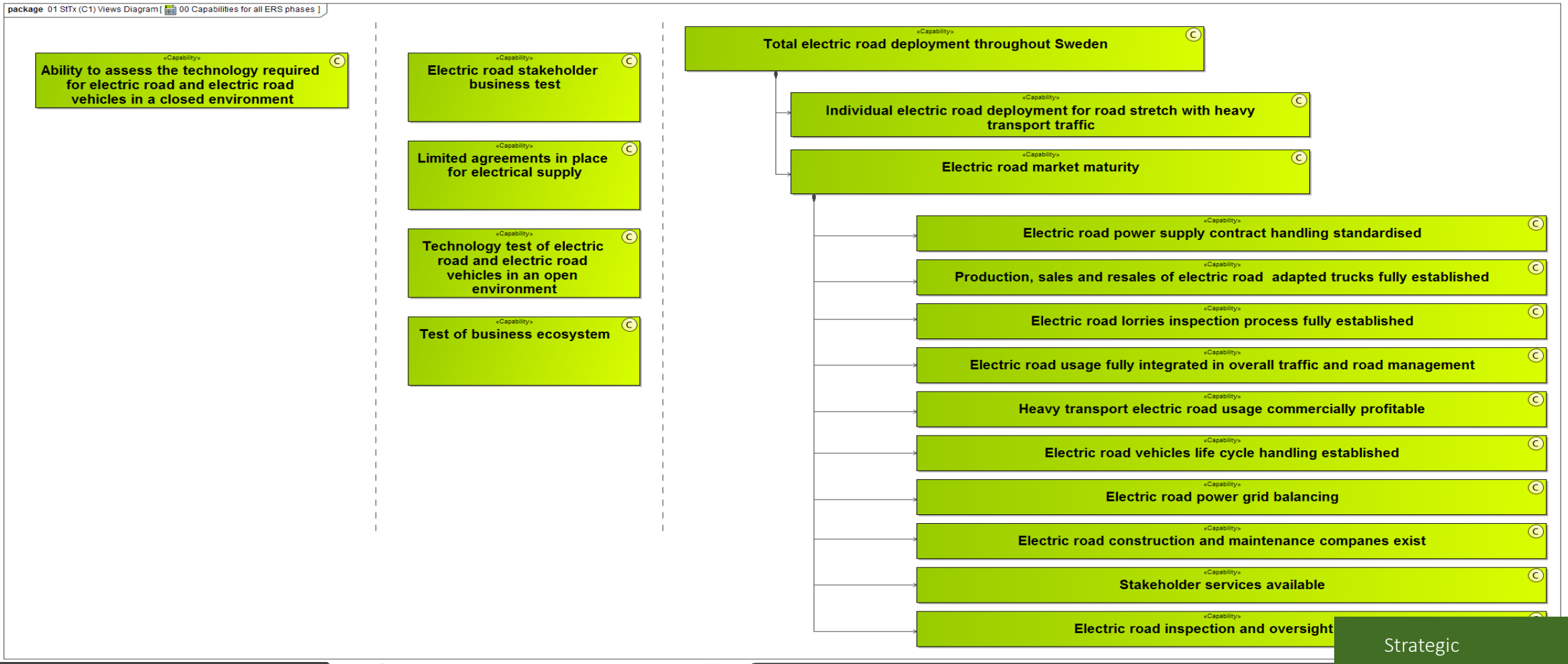
The scope of the model

UAF

Electric Road Model



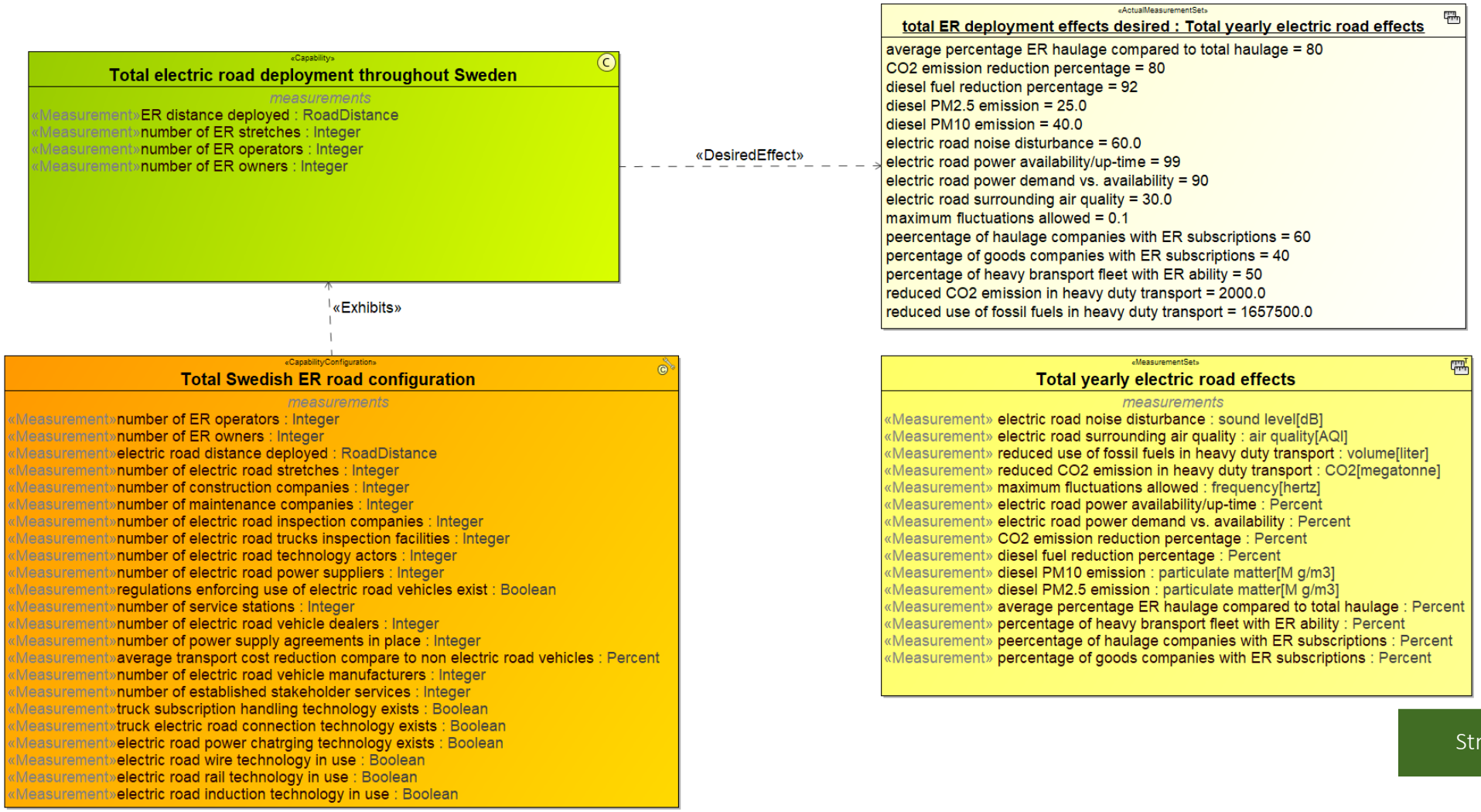
Capabilities of the different stages



Strategic

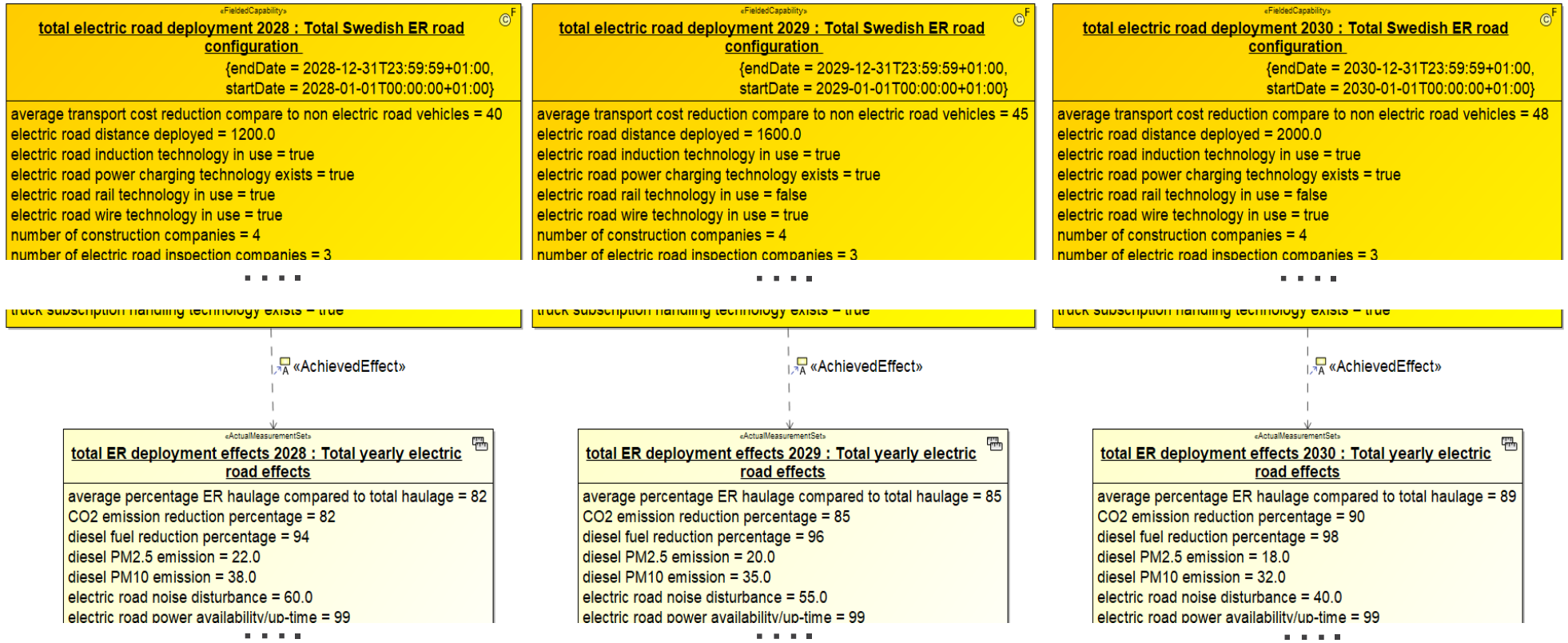
Demonstration ⇨ Pilot ⇨ Deployment

Desired effects



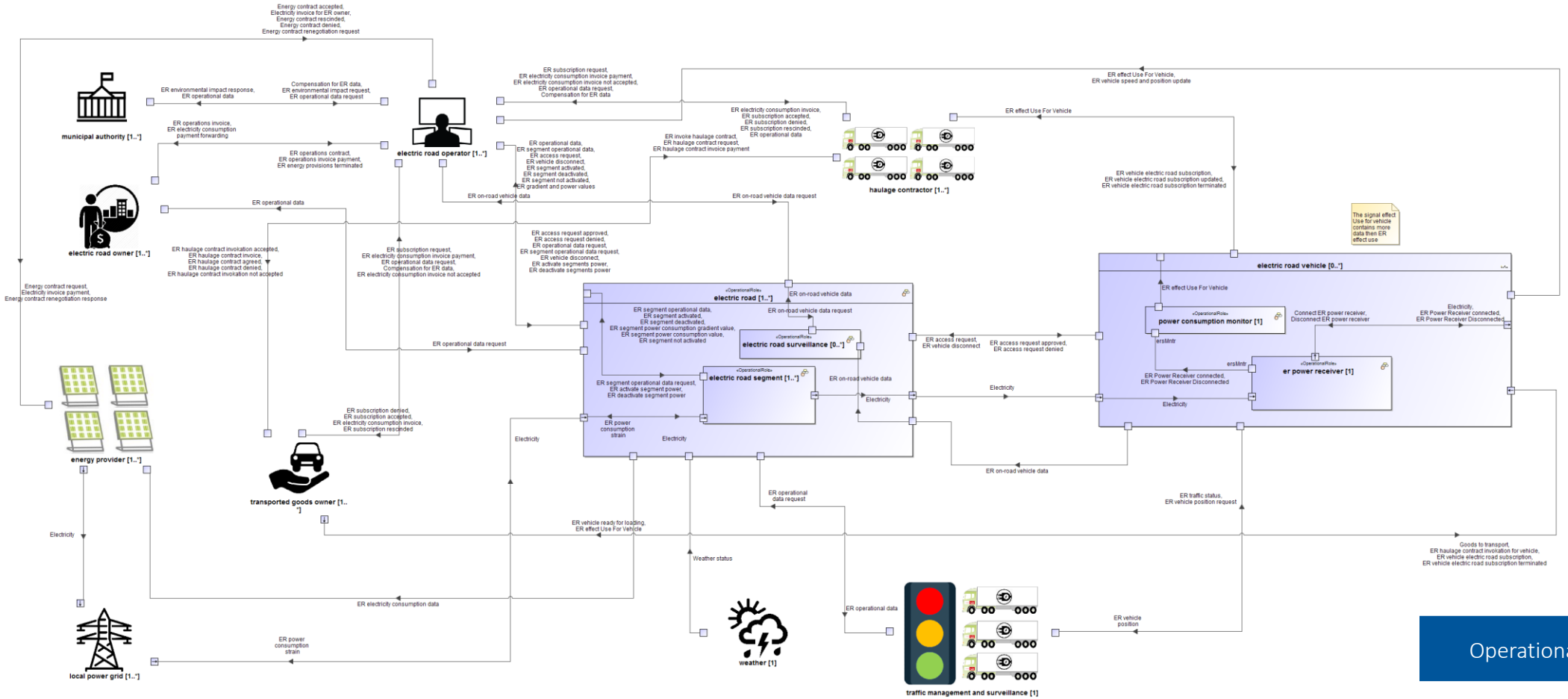
Strategic

Achieved effects

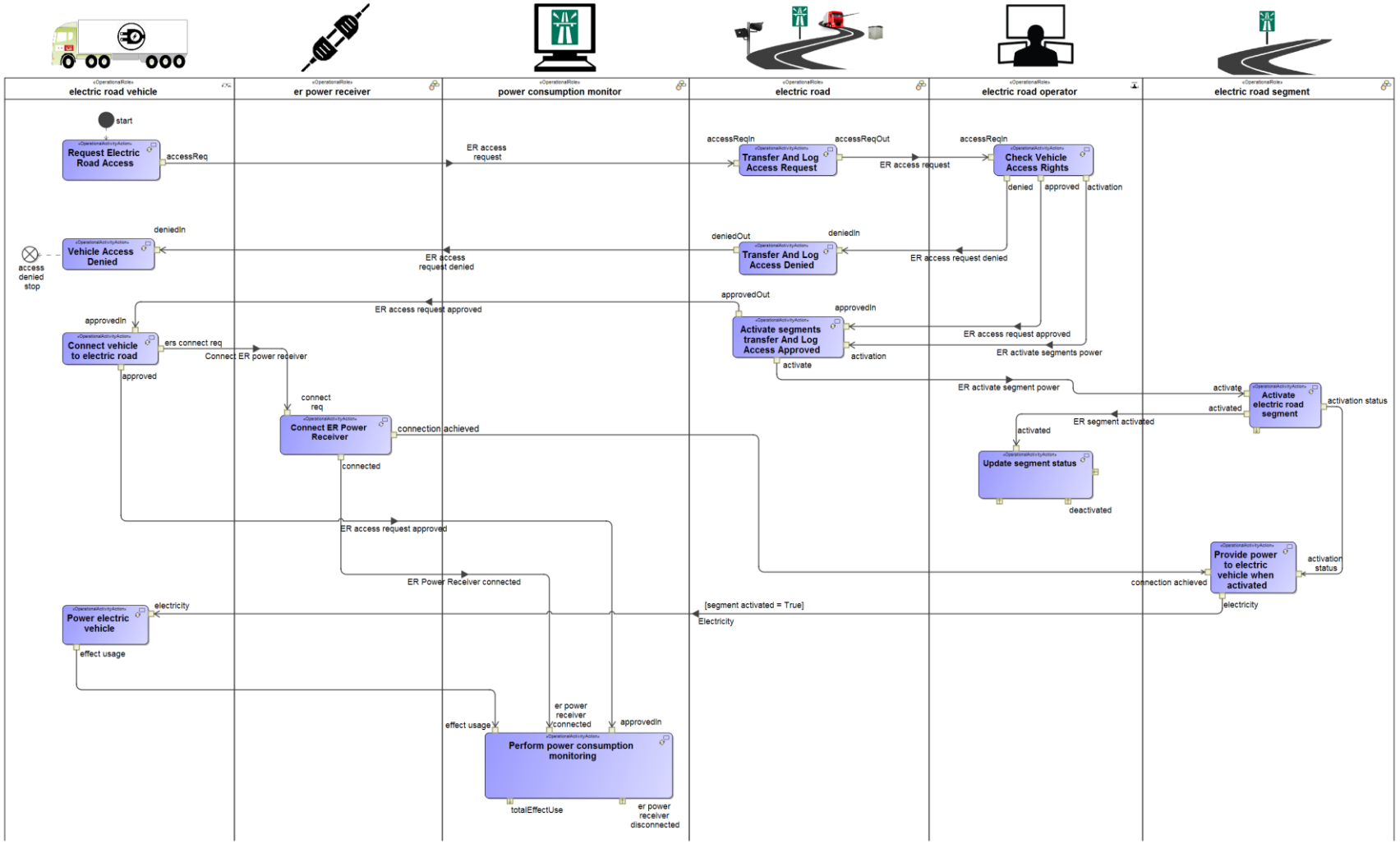


Strategic

Overall Operational Architecture

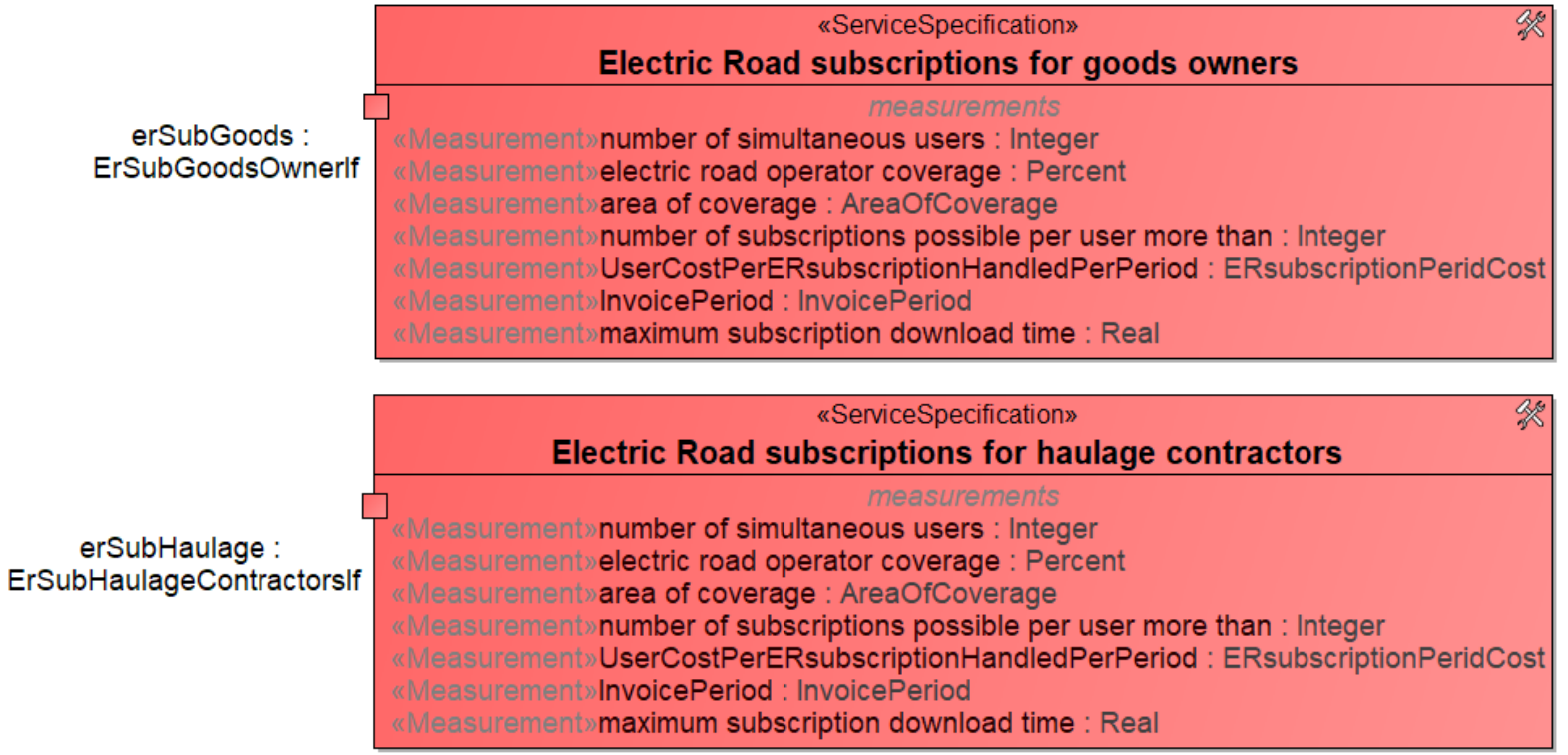


Activity diagrams - Usage start



Operational

Services – Measurement Values



Services – Required level

«RequiredServiceLevel»

required electric road subscriptions for goods owners : Electric Road subscriptions for goods owners

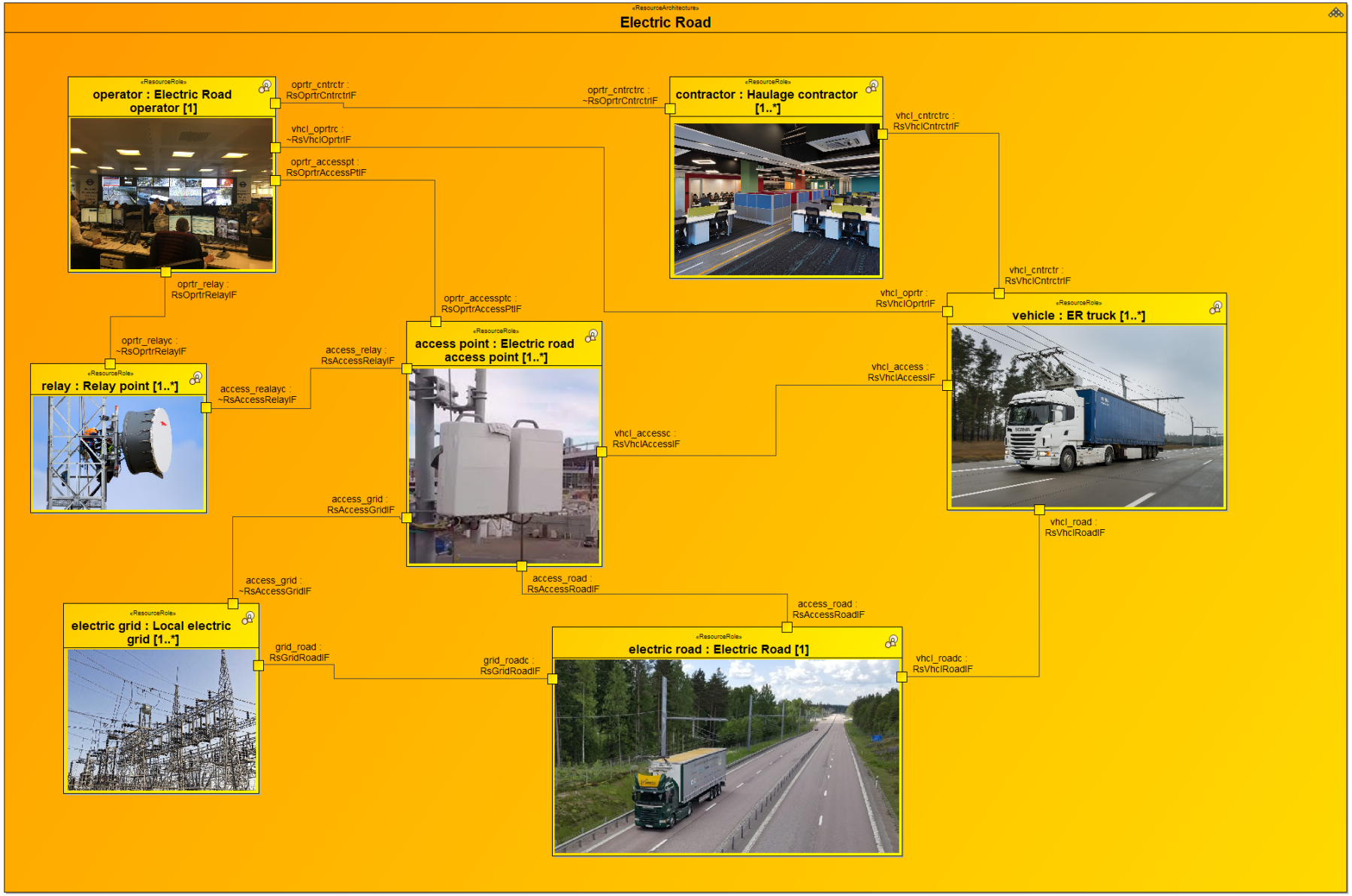
area of coverage = AtLeastTwoPartsOfSweden
electric road operator coverage = 80
InvoicePeriod = QuarterlyOrLess
maximum subscription download time in seconds = 2.0
number of simultaneous users = 20
number of subscriptions possible per user more than = 25
UserCostPerERsubscriptionHandledPerPeriod = 5.0

«RequiredServiceLevel»

required electric road subscriptions for haulage contractors : Electric Road subscriptions for haulage contractors

area of coverage = AtLeastTwoPartsOfSweden
electric road operator coverage = 85
InvoicePeriod = QuarterlyOrLess
maximum subscription download time in seconds = 2.0
number of simultaneous users = 30
number of subscriptions possible per user more than = 40
UserCostPerERsubscriptionHandledPerPeriod = 5.0

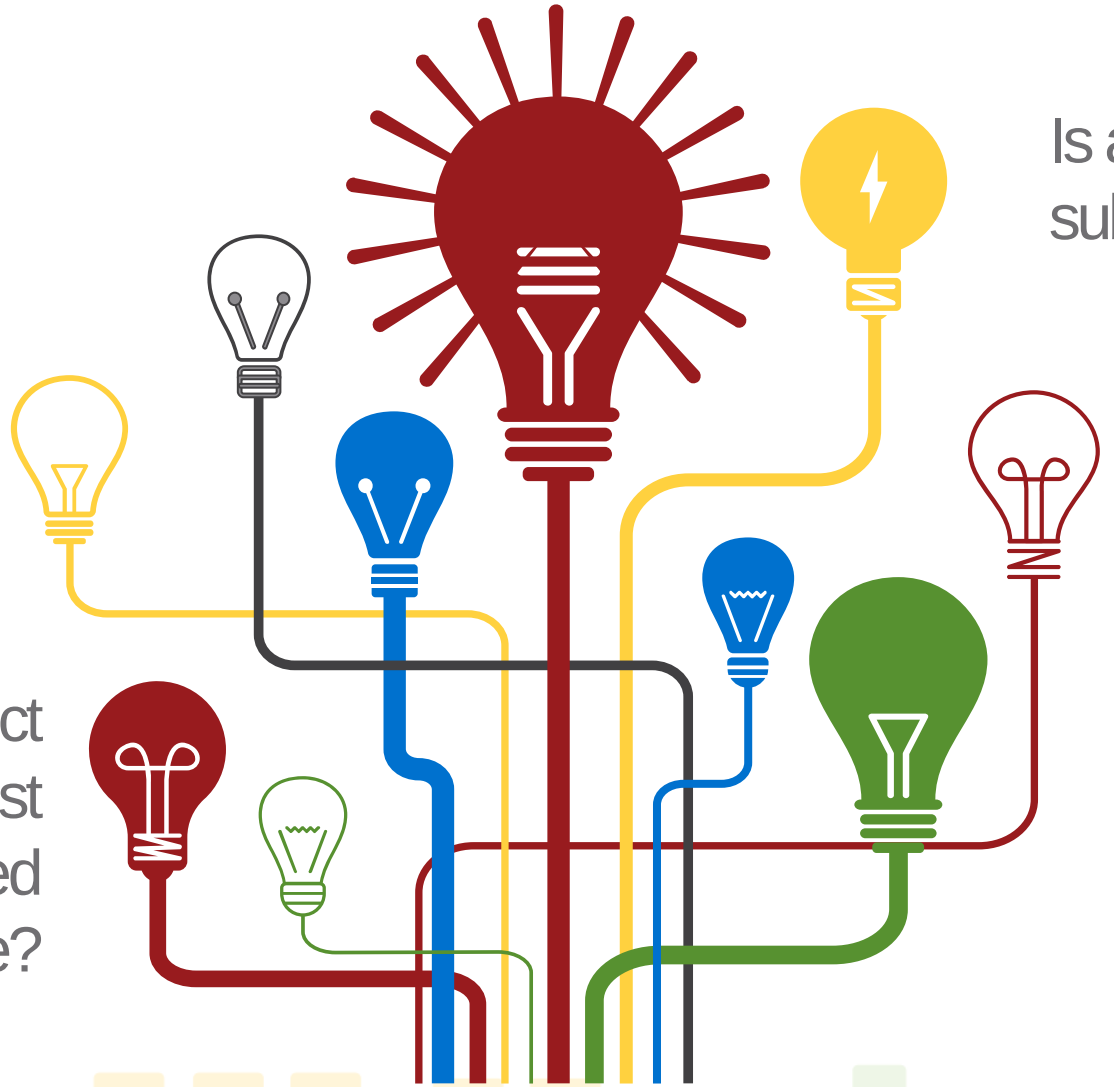
Services



Resources

- Electric Road

Issues and constraints



Is access subscription based?

Who should the subscriber be?

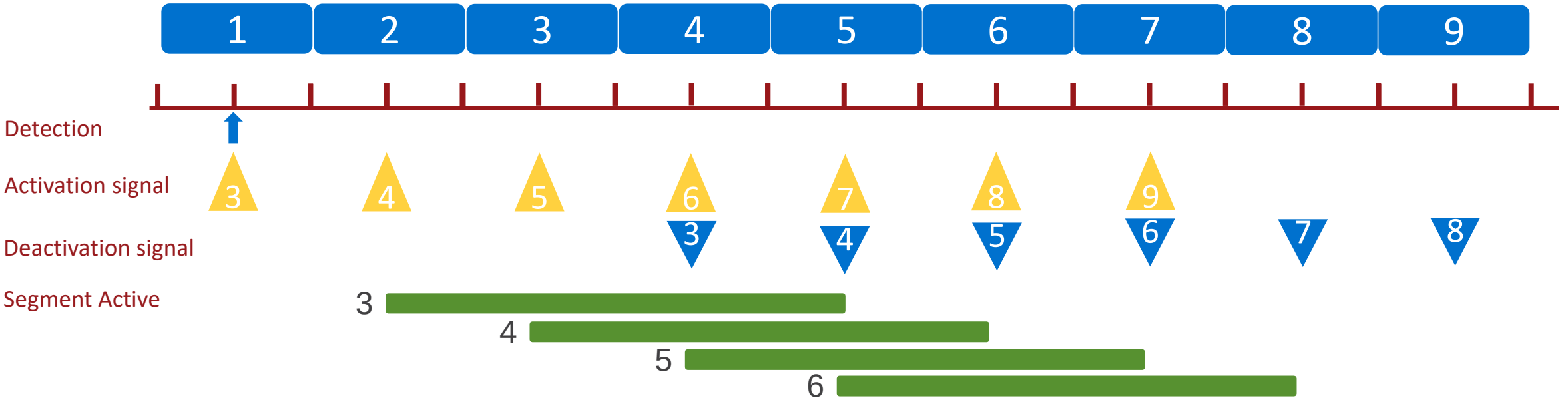
How are the stretches activated?

How to protect against unauthorized usage?

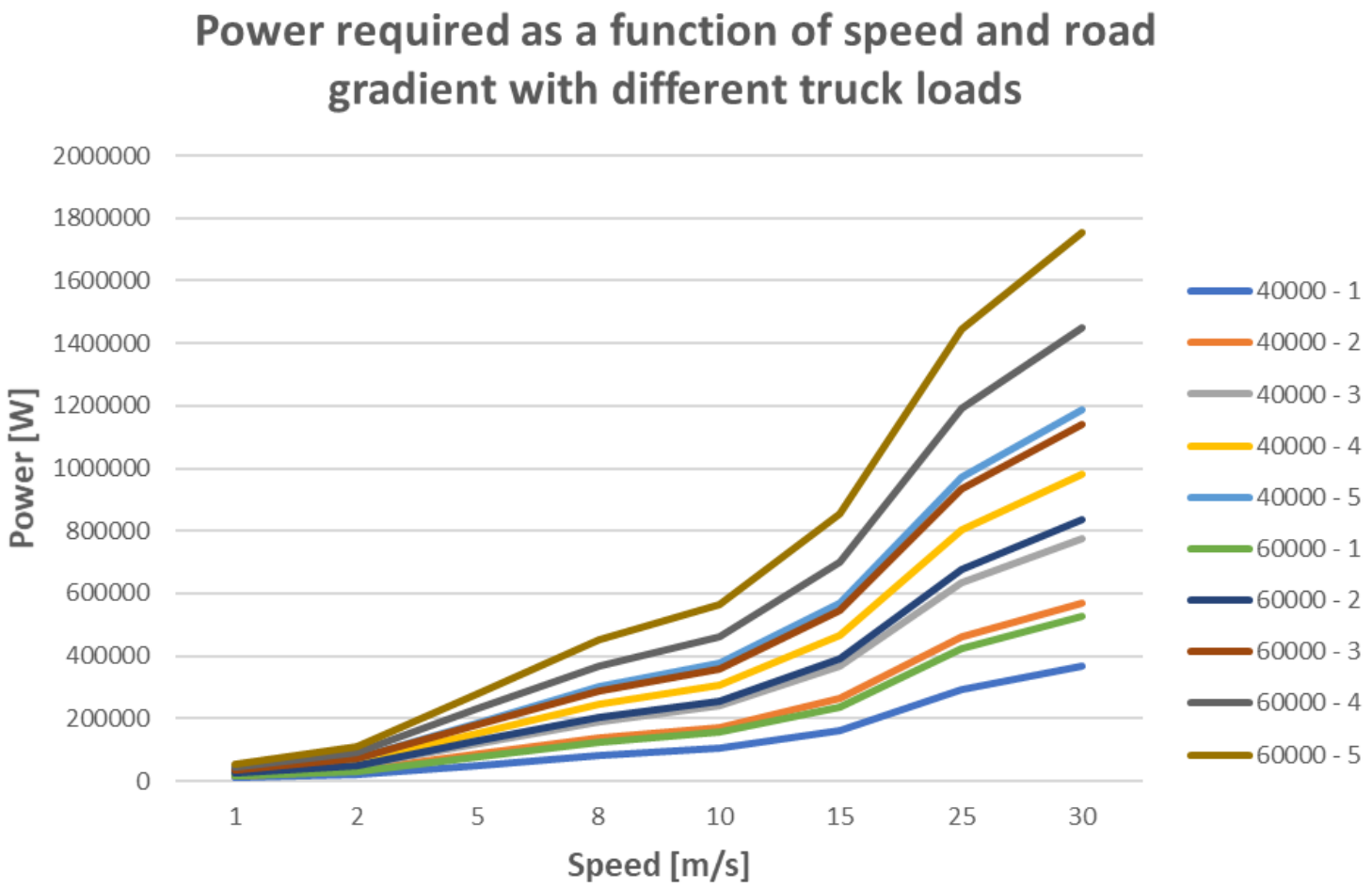
Who owns and operates the road stretch?

Actual figures

- Assumptions:
  - The truck connects with a speed of 90 km/h i.e. 25 m/s.
  - The segments are 10 m:s in length.
  - The truck updates its speed and position every 1/5 second, i.e. every 5 m.
  - It takes ½ second to activate or deactivate a segment.
  - The subscription connect request occurs 5 meters inside a segment.



Power Requirements: Gradient Influence



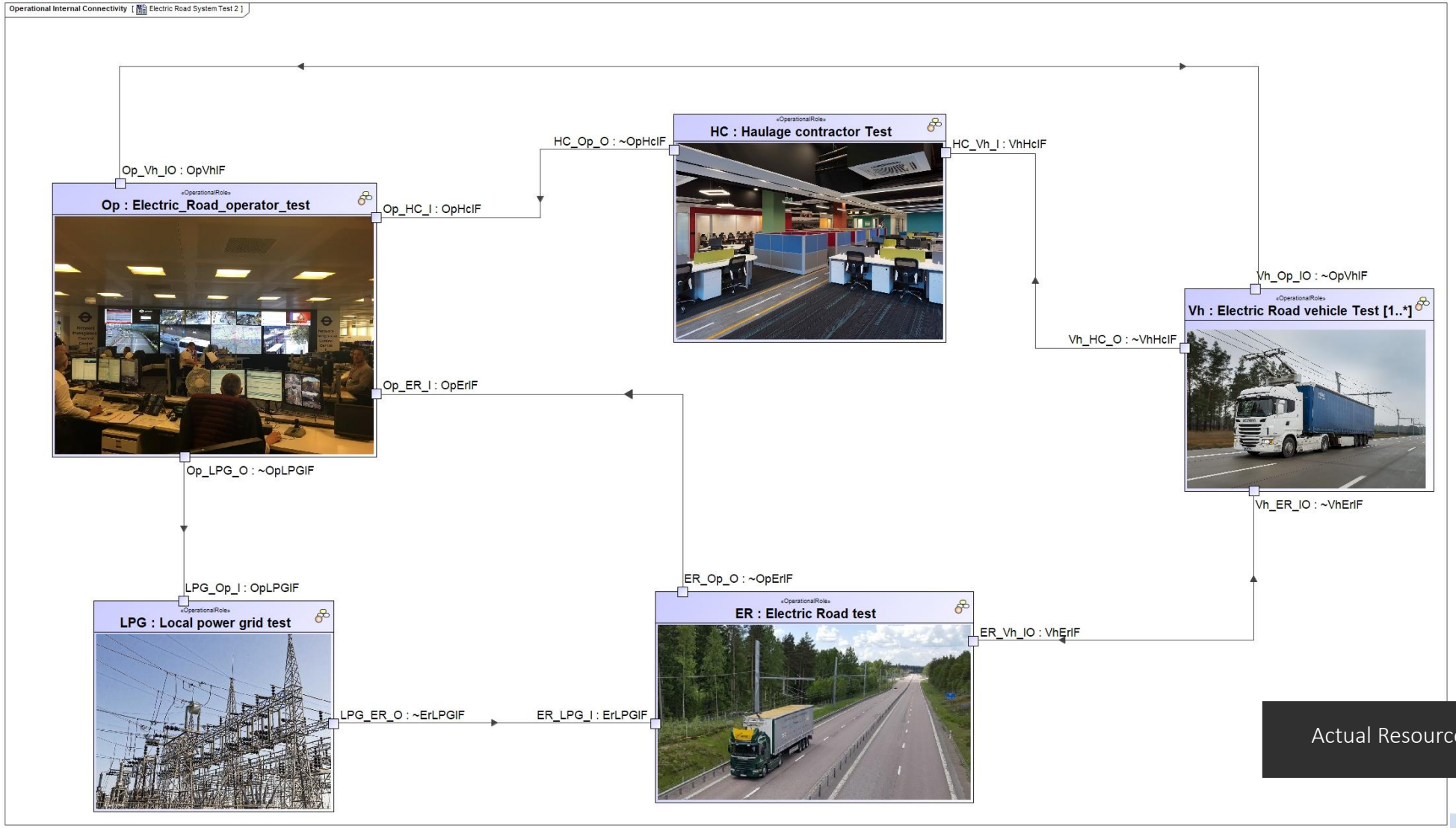
Purpose of simulation?

- Traffic scenarios
- Road topography
- Speed limits
- Effects of queues
- Local power grid limitations
- Overload handling
- Control system

Actual Resources

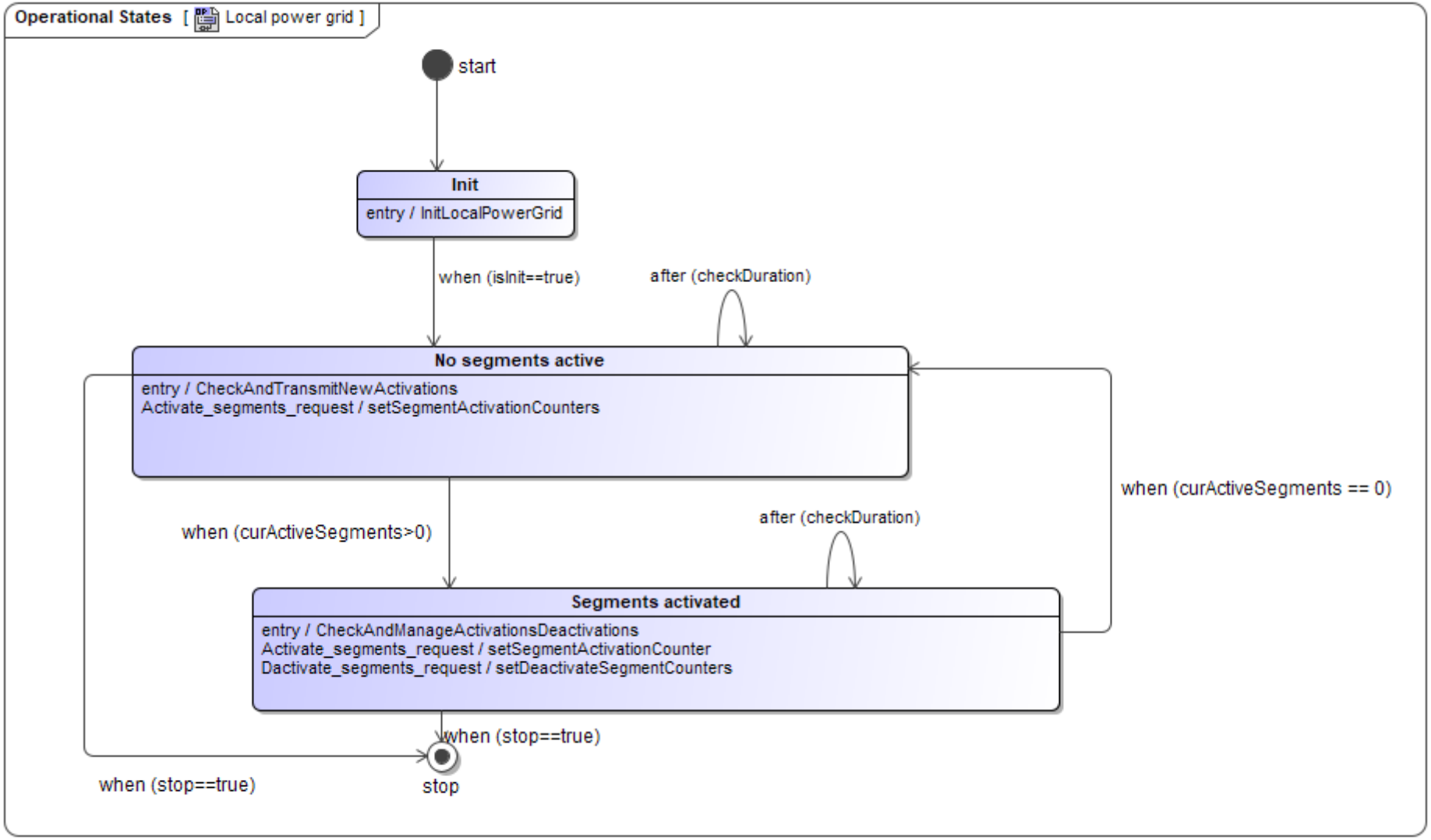
- Part of the simulation
- Makes use of state machines and activity diagrams.
- The tool used
  - Unified architecture Framework
  - Has abilities to perform simulations
  - A proprietary language
  - OMG standard named Action Language for Foundational UML (ALF).
- Pre-pre-release and pre-release.
- The complete simulation ability intended has not yet been achieved but preliminary results exist.

Model Overview



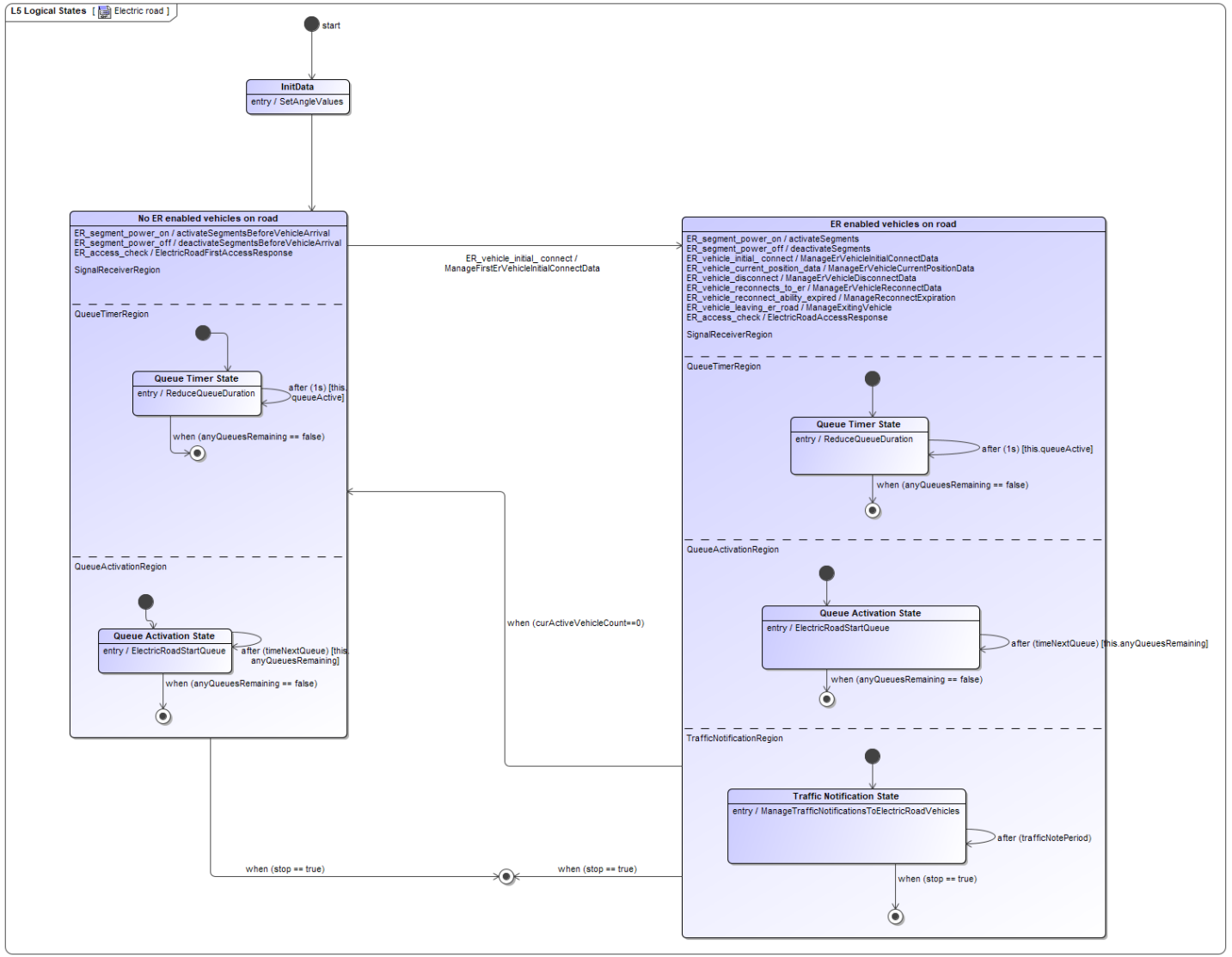
Actual Resources

Operational Performers



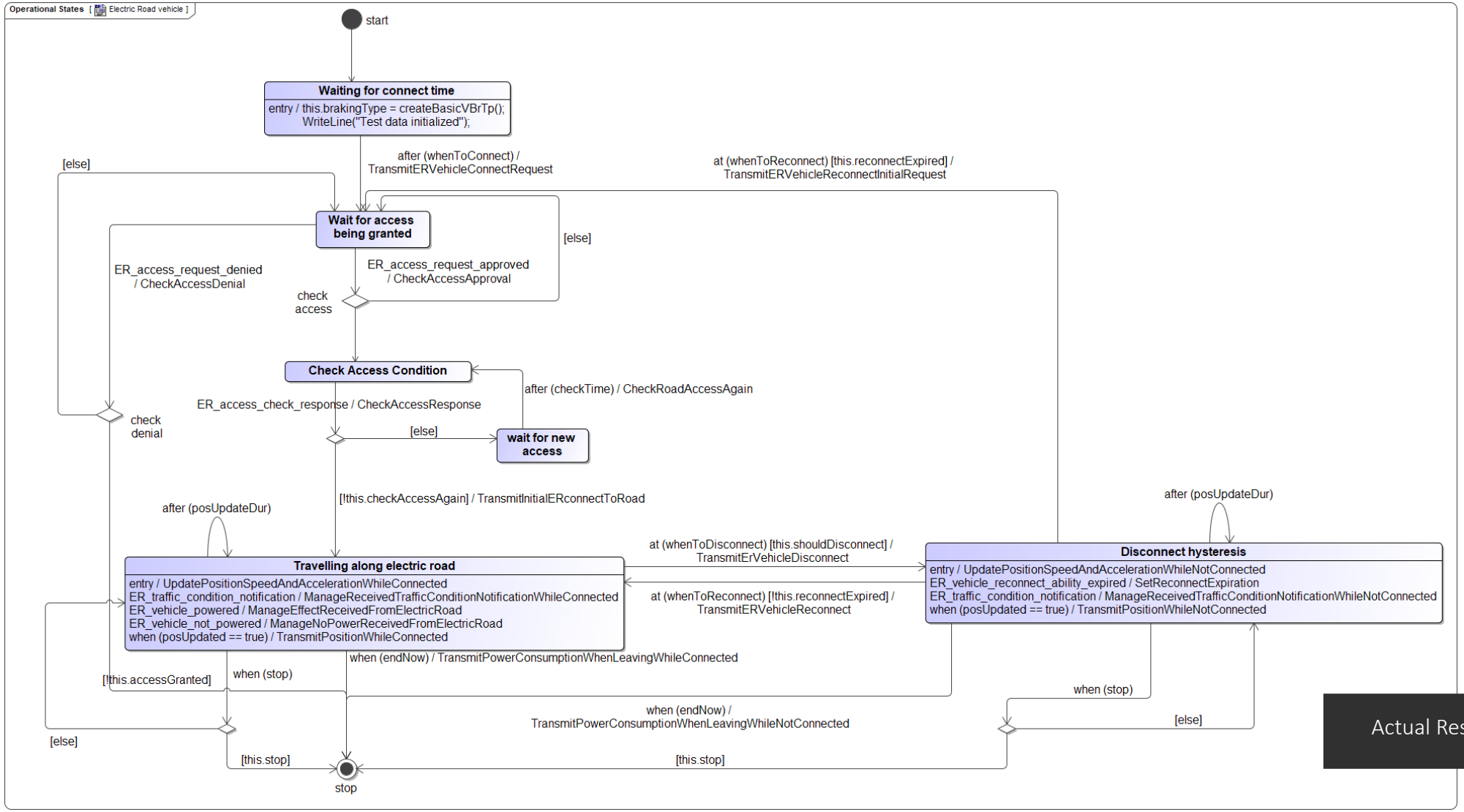
Actual Resources

Operational Performers



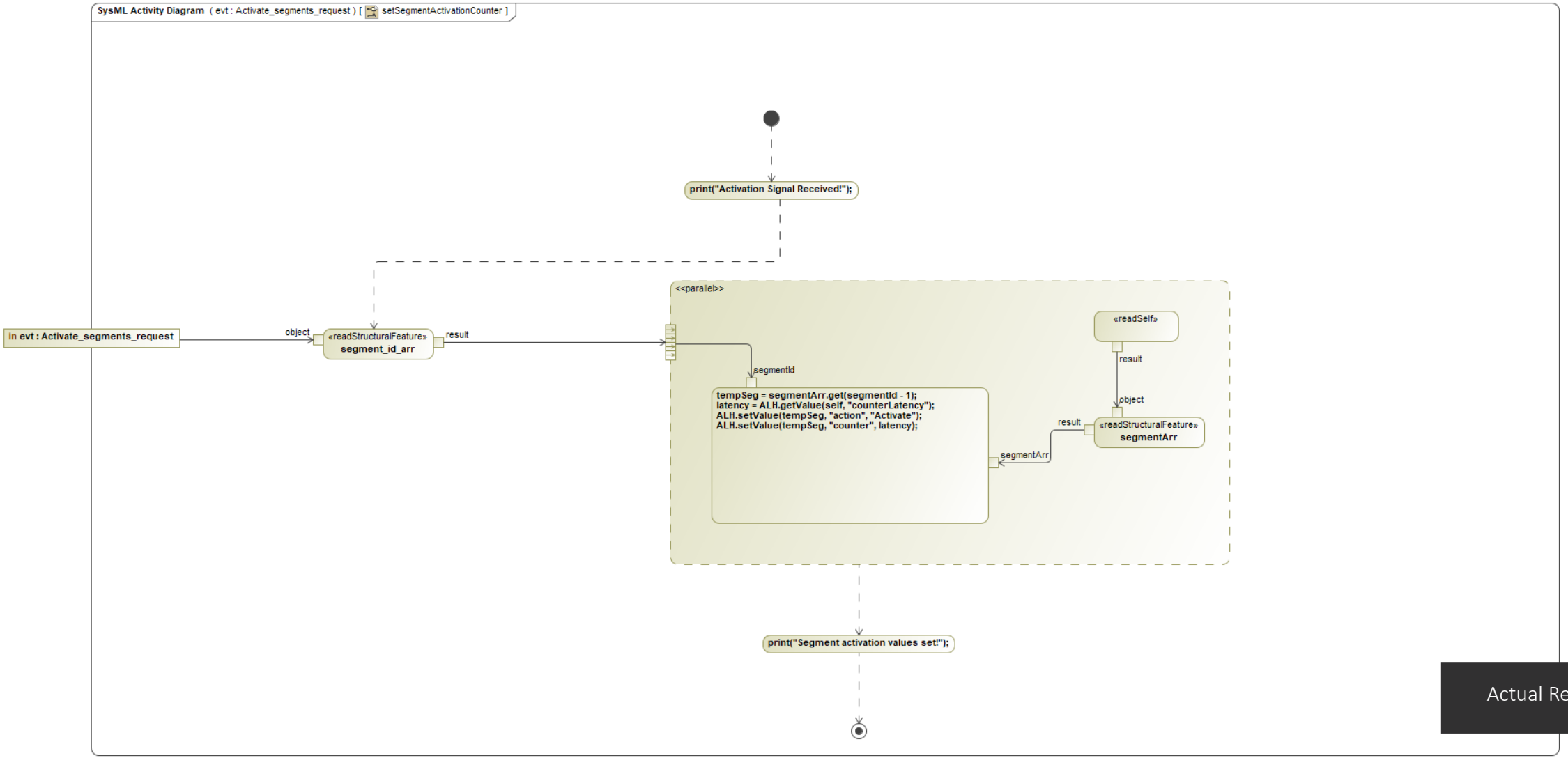
Actual Resources

Operational Performers



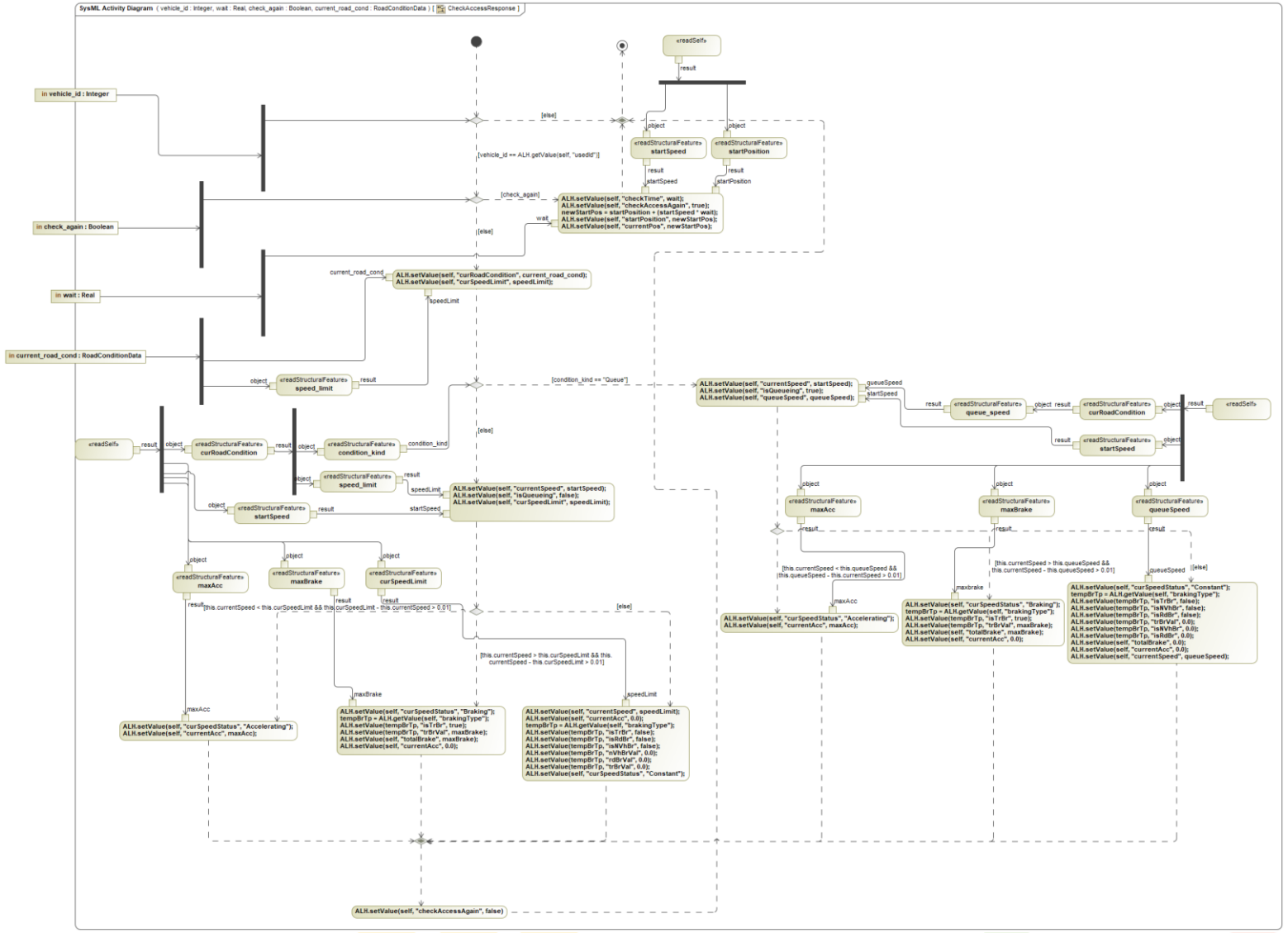
Actual Resources

Activity Diagrams



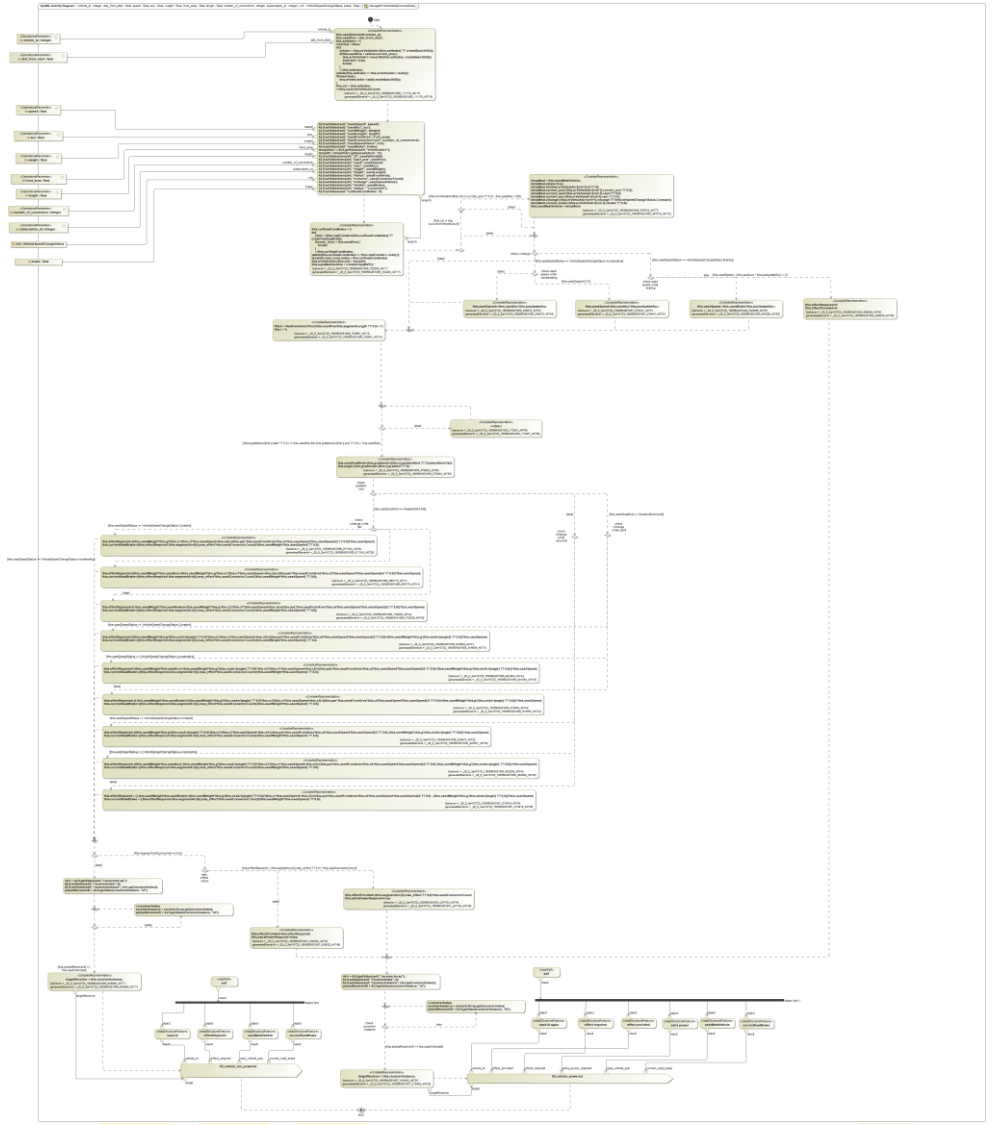
Actual Resources

Activity Diagrams



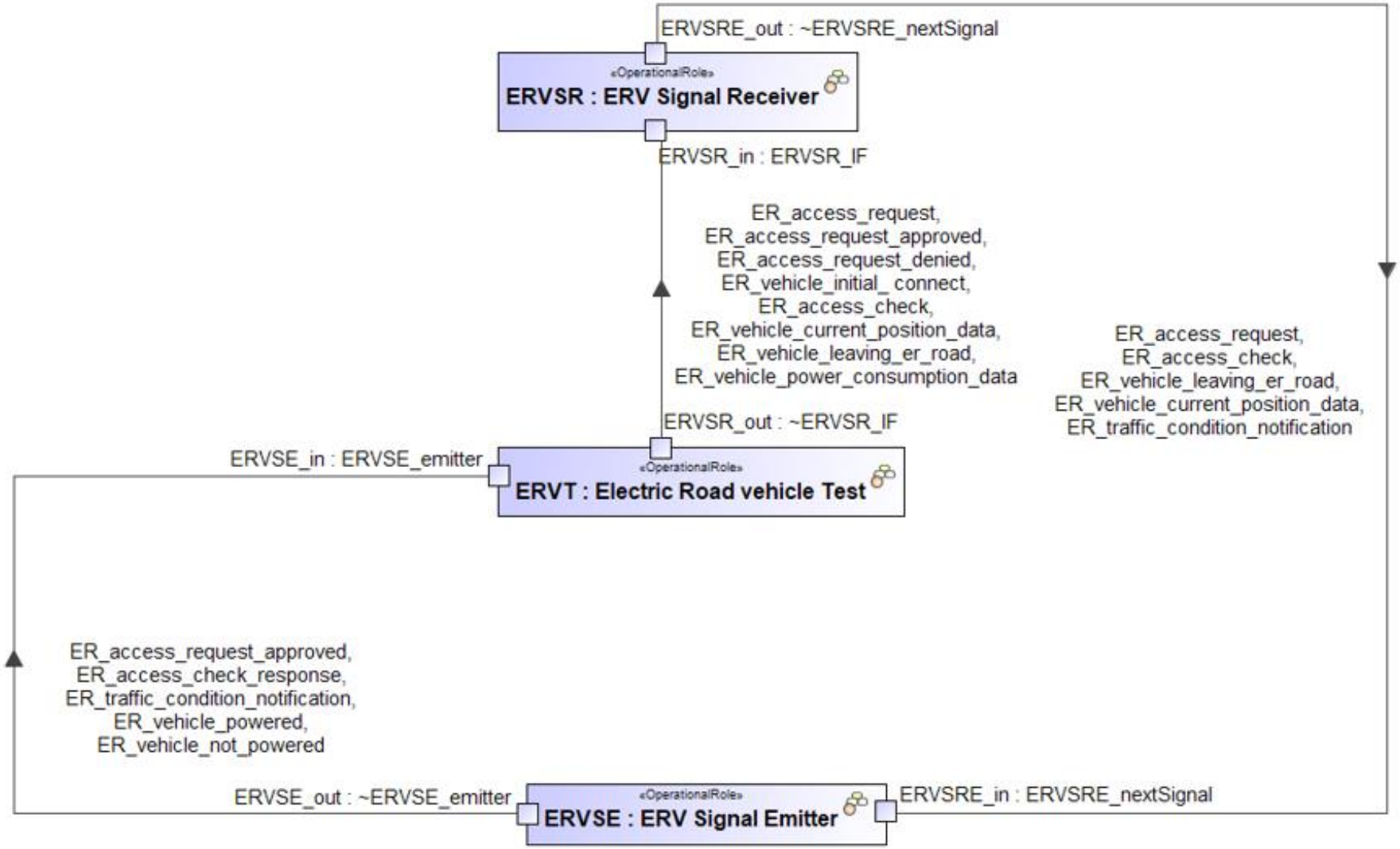
Actual Resources

Activity Diagrams



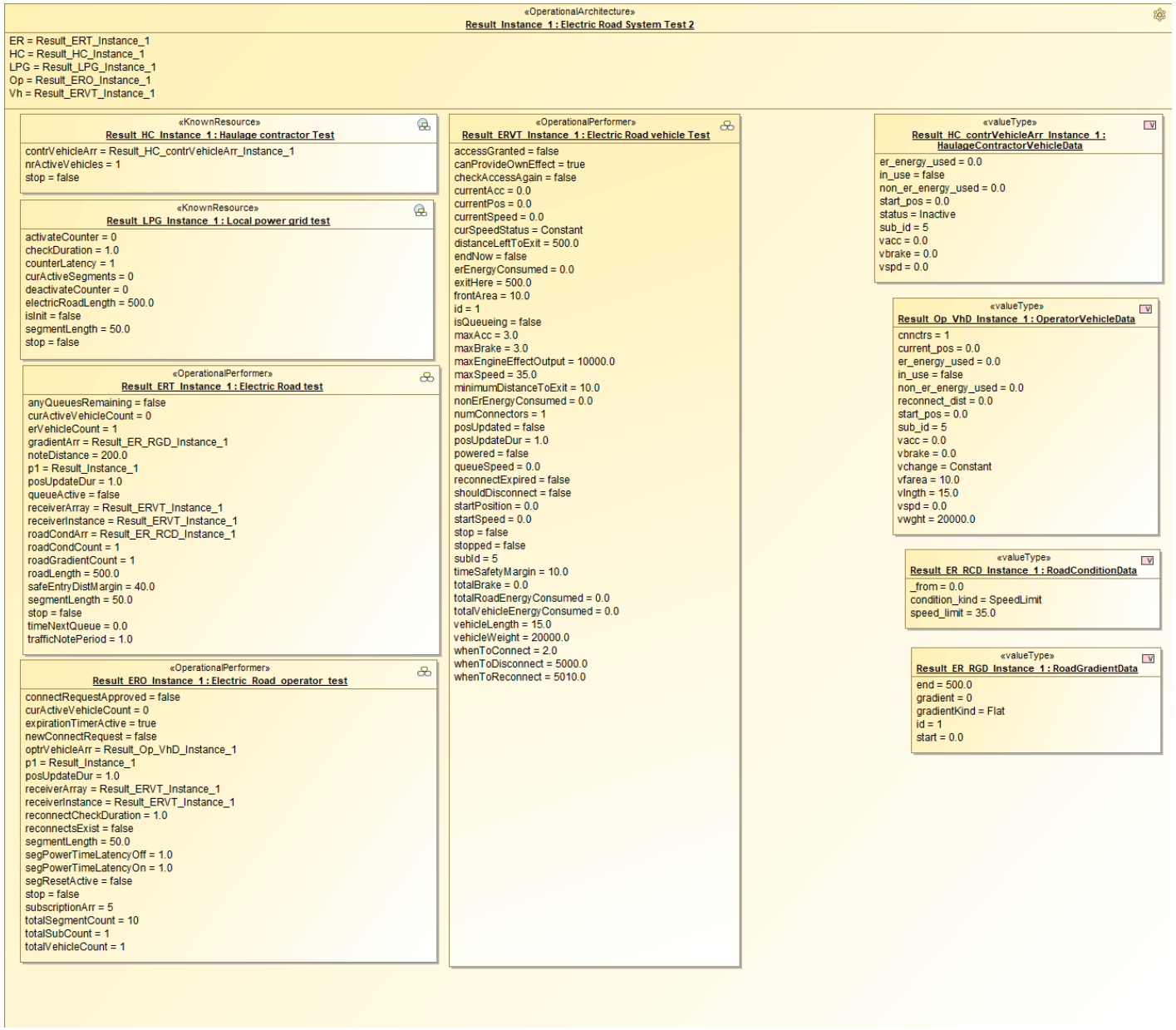
Actual Resources

Incremental Testing

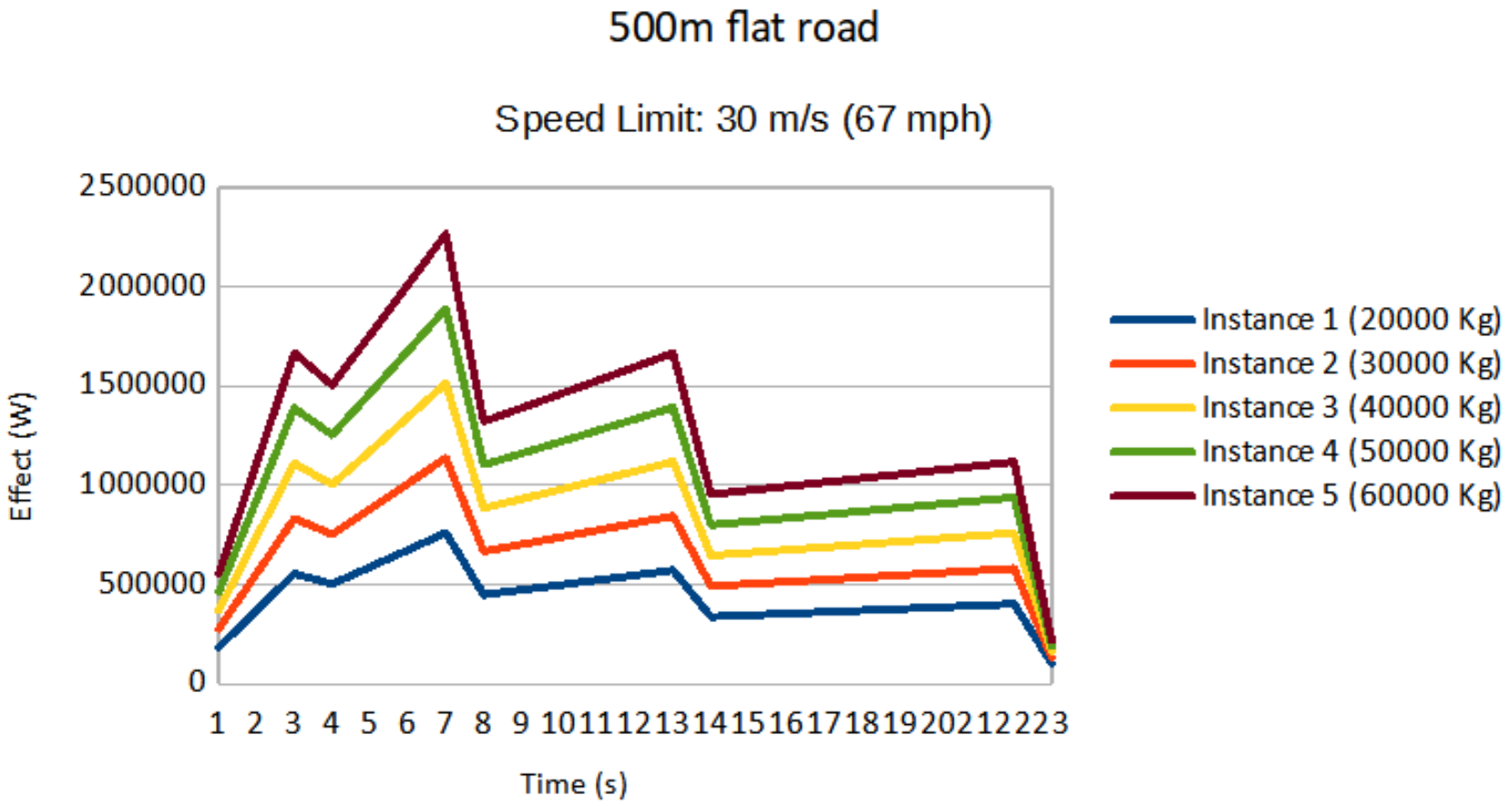


Actual Resources

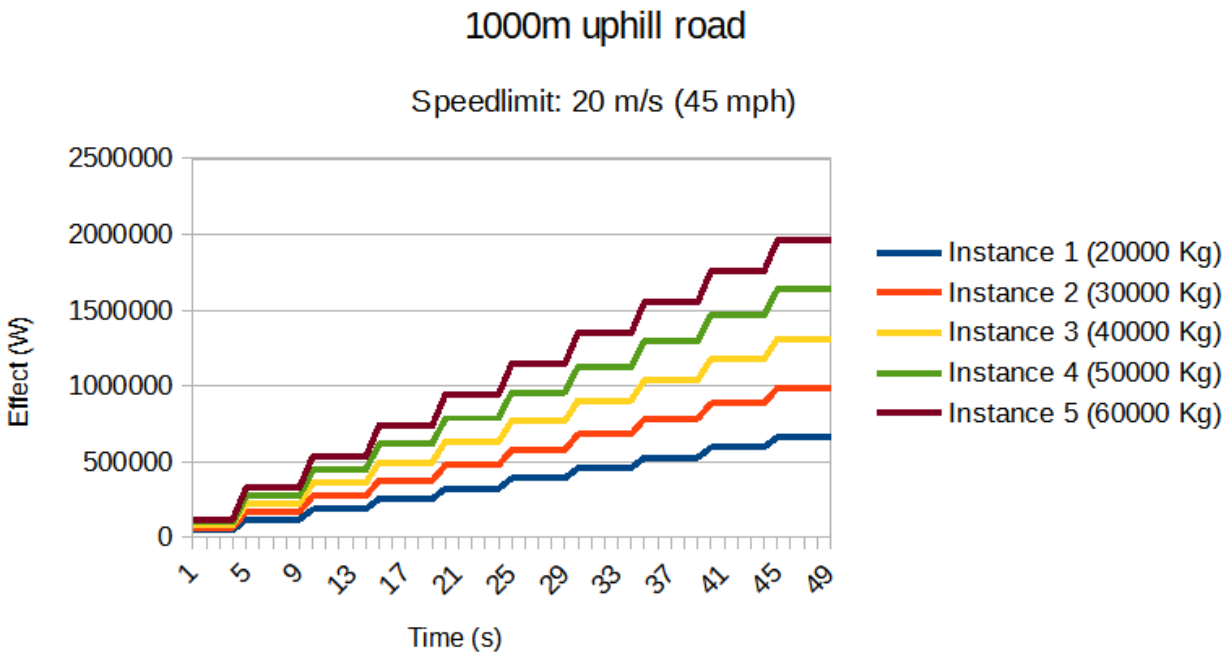
Instance Models – Simulation Setup

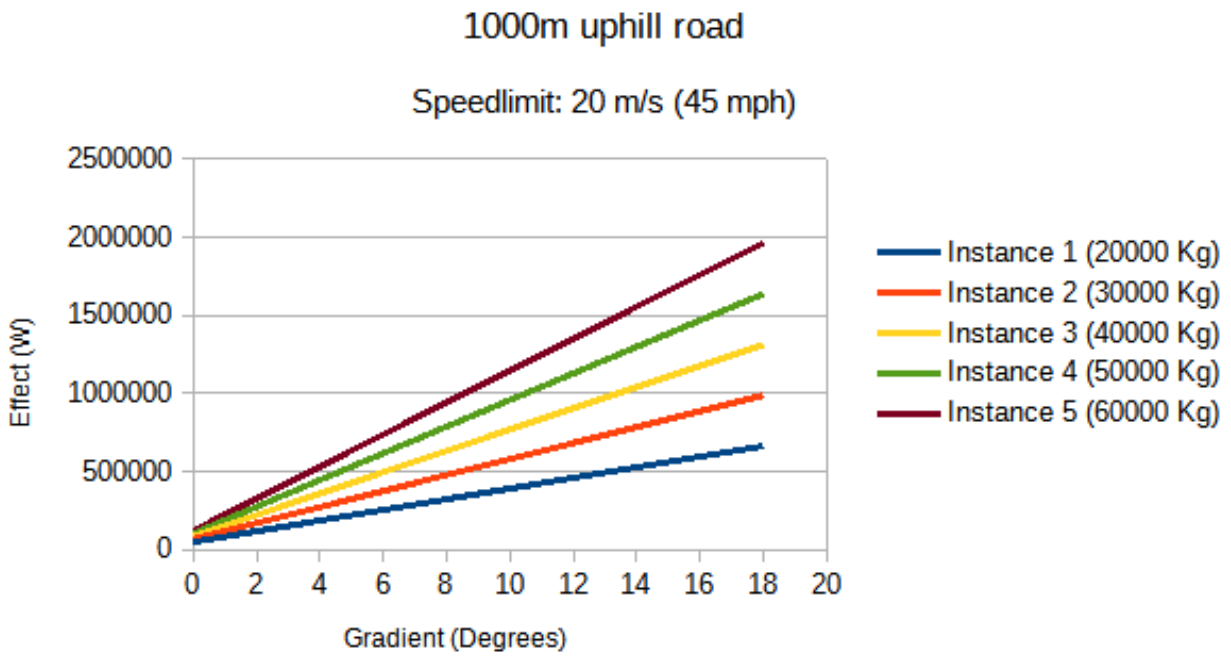


Results


500m flat road
Speed Limit: 30 m/s (67 mph)
Effect (W)
2500000
2000000
1500000
1000000
500000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time (s)
Instance 1 (20000 Kg)
Instance 2 (30000 Kg)
Instance 3 (40000 Kg)
Instance 4 (50000 Kg)
Instance 5 (60000 Kg)

Results


1000m uphill road
Speedlimit: 20 m/s (45 mph)
Effect (W)
2500000
2000000
1500000
1000000
500000
0
1
5
9
13
17
21
25
29
33
37
41
45
49
Time (s)
Instance 1 (20000 Kg)
Instance 2 (30000 Kg)
Instance 3 (40000 Kg)
Instance 4 (50000 Kg)
Instance 5 (60000 Kg)


1000m uphill road
Speedlimit: 20 m/s (45 mph)
Effect (W)
2500000
2000000
1500000
1000000
500000
0
0
2
4
6
8
10
12
14
16
18
20
Gradient (Degrees)
Instance 1 (20000 Kg)
Instance 2 (30000 Kg)
Instance 3 (40000 Kg)
Instance 4 (50000 Kg)
Instance 5 (60000 Kg)

Conclusions

- Pros of simulation:
  - Enables detailed analysis
    - Actual roads power requirements
    - Overload handling
    - Robustness analysis
  - Logical level – not depending on implementation
- More complex world – more simulations!

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