Slutrapport till Vinnova

Diarienummer

2018-02296

Inskickad

2019-04-03 10:56

PROJEKTUPPGIFTER OCH RESULTAT

Diarienummer
2018-02296

Projekttitel
SIMnVIS

Projektledare
Mia Xiaoyun Zhao

Koordinerande projektpart (Koordinator)
202100-3054 KUNGLIGA TEKNISKA HÖGSKOLAN
Institutionen för Maskinkonstruktion/Integrerad produktutveckling

Vinnovas handläggare
Eric Wallgren

Administratör på Vinnova
Lena Dalsmyr

Startdatum
2018-04-16

Slutdatum
2019-02-28

Startdatum för aktuell period
2018-08-01

Slutdatum för aktuell period
2019-02-28

Skicka in senast
2019-04-16

Vinnova bidrag totalt
400 000 kr

Projektresultat för Vinnovas bedömning

Projektsammanfattning - Utfall *

The simulation and visualization platform will enable a significantly shorter time, lower cost, and more flexibility of the analysis of new concepts of the future mobility system. With the open simulation platform it should be possible to study and visualize impacts of automated vehicles and integrated mobility services from several different perspectives.
The idea of this pre-study project is to investigate the prerequisites and the set the requirements for the simulation model platform. To create such a complex model, a modular approach has been taken. The work includes: investigating the model landscape and surroundings including scope and system boundaries; identifying the most suitable type of model architecture; identifying the relevant model techniques and necessary data; and identifying requirements on the models. The requirements on the model are of different types including stakeholder requirements (on usage); requirements on outputs and uncertainties; and technical requirements.
Efforts has also been put in how the model results can be visualized through 2D visualization, 3D visualization, and management dashboards to enhance communication of the new mobility concepts that are simulated.
Results of this pre-study projects are state-of the art analysis of current simulators, stakeholders, stakeholder requirements, KPI:s, model inputs, mock-up visualization and plan for next step.The pre-study project also identified research questions and formulated a larger project application following the findings of the pre-study project.

1342 / 1500 tecken

Mål för projektet - uppfyllelse *

The goals of this pre-study project is to conduct a state-of-the-art analysis to identify and compare the existing simulation tools, perform a stakeholder analysis, and formulate requirements on the open simulation and visualization platform.
The goals are mainly reached by conducting activities in mainly two phases. In Phase 1 the aim is to set the prerequisites and identify requirements. This phase include an overview of existing simulation tools and models; workshops, interviews and discussions with stakeholders in Sweden to identify the model system boundaries, underlying processes to model, other model requirements; and identification of a set of model outputs and KPI:s. Phase 2 aims at, based on phase 1 results, identify the modelling environment, identification of research and innovation gaps, a mock-up showing the vision for the visualization concept, and a project application for a main project with the aim to realize the simulation and visualization platform. The pre-study should also propose a first maintenance/host structure for the simulation platform.
In Phase 1, the state-of-the-art analysis was conducted with the main focus on comparing those representative simulation tools and model. One workshop and one meeting have been held to identify stakeholders, KPI:s corresponding to the stakeholder requirements.
In Phase 2, one meeting and one workshop have been held to set up the mock-up visualization, mapped on to current projects, and identified the scenarios, use-cases and needs for a further project application.

1321 / 1500 tecken

PROJEKTREFERAT FÖR PUBLICERING

Projektreferat för publicering på www.vinnova.se och som en del av öppen data.
Jag är medveten om att nedanstående uppgifter kommer att publiceras efter granskning och eventuell redigering av Vinnova *: Ja

Syfte och mål - uppfyllelse *

Förstudien är att samla intressenter och kartlägga deras krav på en plattform för simulering och visualisering av automatiserade fordon och mobilitet som en tjänst.
De mål som har uppfyllts genom detta förstudieprojekt är:
- Identifierade och jämförde befintliga simuleringsverktyg i en state-of-the-art analys.
- Formulerade krav på den öppna simulerings- och visualiseringsplattformen genom intressentanalys.
- Beskrev synen och så småningom visualiserades i en mock-up visualisering.
- Förfinade idéer och skapa ytterligare projektförslag i dialog.

478 / 500 tecken

Resultat och förväntade effekter - utfall *

Det finns fyra huvudsakliga resultat från förstudieprojekt.
Först, resultatet av intressentanalys (krav, KPI: s), modellarkitekturer och modellteknik inom system-of-system-perspektiv.
Andra, state-of-the-art analys som inspekterade modelleringsramarna som är tillgängliga och och deras egenskaper.
Tredje, visualiseringskrav och en mock-up visualisering som visar visionen.
Fjärde, ytterligare forskningsprojekt ansökan för att definiera kriterier för att skapa en "digital tvilling" lösning för automatiserade fordon och mobilitet som en tjänst.

483 / 500 tecken

Upplägg och genomförande - analys *

Projektet genomfördes huvudsakligen i två faser för att uppfylla målen.
- I fas 1 genomfördes state-of-the-art analysen med fokus på representativa simuleringsverktyg och modeller. En workshop och ett möte har hållits för att identifiera intressenter, KPI: er som motsvarar intressentkraven.
- I fas 2 har ett möte och en workshop hållits för att inrätta mockup-visualiseringen. Potentialen att kartlägga aktuella simuleringsrelaterade projekt till SIMnVIS. Fas 2 identifierade också scenarier, användningsfall och behov av systemeffekter för en ytterligare projektansökan.

497 / 500 tecken

Syfte och mål - uppfyllelse - på engelska *

The pre-study is to gather stakeholders and map their requirements on a platform for simulation and visualization of automated vehicles and mobility as a service.
- The goals that have been fulfilled through this pre-study project is:
- Identified and compared the existing simulation tools in a state-of-the-art analysis.
- Formulated requirements on the open simulation and visualization platform through stakeholder analysis.
- Described the vision and eventually visualized this in a mock-up visualization.
- Refined ideas and create further project proposals in dialogue.

493 / 500 tecken

Resultat och förväntade effekter - utfall - på engelska *

There are four main results gotten from the pre-study project.
First, the result of stakeholder analysis (requirements, KPI:s), model architectures and model techniques within a system-of-system perspective.
Second, state-of-the-art analysis that inspected the modelling frameworks that are available and and their characteristics.
Third, visualization requirements and a mock-up visualization showing the vision.
Fourth, further research project application to define criteria for the creation of a "digital twin" solution for automated vehicles and mobility as a service.

498 / 500 tecken

Upplägg och genomförande - analys - på engelska *

The project was conducted mainly in two phases to fulfill the goals.
- In Phase 1, the state-of-the-art analysis was conducted focused on representative simulation tools and models. One workshop and one meeting have been held to identify stakeholders, KPI:s corresponding to stakeholder requirements.
- In Phase 2, one meeting and one workshop have been held to set up the mock-up visualization. The potential of mapping current simulation related projects on to SIMnVIS. Phase 2 also identified the scenarios, use-cases and needs on system effects for a further project application.

494 / 500 tecken

Länkar till externa webbsidor

Finns det en webbsida för projektet, klicka på knappen "Lägg till länk" nedan för att skriva in en sökväg.

URL

0 / 250 tecken

Beskrivning

0 / 100 tecken

SÄRSKILDA VILLKOR

Särskilt villkor

1. Projektet ska vara representerat av minst en projektpart vid de konferenser och andra aktiviteter som anordnas inom det strategiska innovationsprogrammet för Drive Sweden.
2. Följande villkor ersätter § 7.3 i de allmänna villkoren. Vid information om projektet och vid varje offentliggörande av projektresultat ska det anges att arbetet utförts inom det strategiska innovationsprogrammet för Drive Sweden, en gemensam satsning av Vinnova, Formas och Energimyndigheten. Med offentliggörande avses t.ex. publicering oavsett medium och muntliga presentationer.
3. Forskningsinstitut inom RISE-koncernen får, när de deltar i sin icke-ekonomiska verksamhet, göra påslag för indirekta kostnader enligt den fullkostnadsprincip som de tillämpar och som godkänts av Vinnova.
4. Projektet ska delge programkontoret för Drive Sweden ett referat av projektet som kan publiceras på hemsidan för det strategiska innovationsprogrammet för Drive Sweden http://www.drivesweden.net/. Referatet ska kunna spridas och publiceras fritt och får således inte innehålla konfidentiella eller på annat sätt känsliga uppgifter. På samma sätt ska ett referat av projektresultaten i samband med slutrapportering skickas till programkontoret för publicering på det programmets hemsida.

Kommentarer

The whole process of the project followed all the above specific conditions.

65 / 1500 tecken

Anvisningar och rekommendationer

Projektet ingår inom det Strategiska innovationsprogrammet Drive Sweden och projektet ska samverka med programkontoret för programmet i genomförandet. Projektet ska rapportera och beakta synpunkter från det strategiska innovationsprogrammet för Drive Sweden vid minst två tillfällen i överenskommelse med programmet.

UPPARBETADE KOSTNADER

Nedan ska upparbetade, faktiska projektkostnader fyllas i för redovisningsperioden.

Kostnaderna ska fyllas i för den koordinerande projektparten (koordinatorn) och övriga projektparter. Om redovisningsperioden går över ett årsskifte ber vi dig fylla i kostnaderna i två kolumner då vi behöver veta fördelningen per kalenderår.

De förifyllda siffrorna i kolumnen "Budget" är hämtade från vyn "Projektparter, budget och finansiering" för aktuellt projekt.

Totalt för hela projektet

Totalt

	Upparbetade kostnader		Ack. kostnader	Budget	Återstår jfr med budget	
	2018-08-01	2019-01-01	2018-04-16	2018-04-16		
	2018-12-31	2019-02-28	2019-02-28	2019-02-28	kr	%
Personalkostnader	405 119	145 533	670 996	780 000	109 004	14.0%
Utrustning, mark, byggnader	0	0	0	0	0	0.0%
Konsultkostnader, licenser m.m	0	0	0	0	0	0.0%
Övriga direkta kostnader inkl. resor	34 739	7 226	46 340	0	-46 340	0.0%
Indirekta kostnader	94 545	32 726	159 291	20 000	-139 291	-696.5%
Totala kostnader	**534 403**	**185 485**	**876 627**	**800 000**	**-76 627**	**-9.6%**

Koordinerande projektpart (koordinator)

KUNGLIGA TEKNISKA HÖGSKOLAN

Institutionen för Maskinkonstruktion/Integrerad produktutveckling (202100-3054)

	Upparbetade kostnader		Ack. kostnader	Budget	Återstår jfr med budget	
	2018-08-01	2019-01-01	2018-04-16	2018-04-16		
	2018-12-31	2019-02-28	2019-02-28	2019-02-28	kr	%
Personalkostnader	135 991	24 315	191 793	280 000	88 207	31.5%
Utrustning, mark, byggnader	0	0	0	0	0	0.0%
Konsultkostnader, licenser m.m	0	0	0	0	0	0.0%
Övriga direkta kostnader inkl. resor	19 514	1 532	22 482	0	-22 482	0.0%
Indirekta kostnader	83 710	17 212	121 345	20 000	-101 345	-506.7%
Totala kostnader	**239 215**	**43 059**	**335 620**	**300 000**	**-35 620**	**-11.9%**

Projektparter

RISE Research Institutes of Sweden AB

IT-forskningsinstitut Viktoria AB (556464-6874)

	Upparbetade kostnader		Ack. kostnader	Budget	Återstår jfr med budget	
	2018-08-01 2018-12-31	2019-01-01 2019-02-28	2018-04-16 2019-02-28	2018-04-16 2019-02-28	kr	%
Personalkostnader	29 924	5 416	37 710	50 000	12 290	24.6%
Utrustning, mark, byggnader	0	0	0	0	0	0.0%
Konsultkostnader, licenser m.m	0	0	0	0	0	0.0%
Övriga direkta kostnader inkl. resor	9 767	1 768	11 535	0	-11 535	0.0%
Indirekta kostnader	0	0	773	0	-773	0.0%
Totala kostnader	**39 691**	**7 184**	**50 018**	**50 000**	**-18**	**0.0%**

Scania CV Aktiebolag

Scania CV Aktiebolag (556084-0976)

	Upparbetade kostnader		Ack. kostnader	Budget	Återstår jfr med budget	
	2018-08-01 2018-12-31	2019-01-01 2019-02-28	2018-04-16 2019-02-28	2018-04-16 2019-02-28	kr	%
Personalkostnader	30 000	50 000	100 000	100 000	0	0.0%
Utrustning, mark, byggnader	0	0	0	0	0	0.0%
Konsultkostnader, licenser m.m	0	0	0	0	0	0.0%
Övriga direkta kostnader inkl. resor	0	0	0	0	0	0.0%
Indirekta kostnader	0	0	0	0	0	0.0%
Totala kostnader	**30 000**	**50 000**	**100 000**	**100 000**	**0**	**0.0%**

Statens väg- och transportforskningsinstitut

Statens väg- och transportforskingsinstitut (202100-0704)

	Upparbetade kostnader		Ack. kostnader	Budget	Återstår jfr med budget	
	2018-08-01	**2019-01-01**	**2018-04-16**	**2018-04-16**		
	2018-12-31	**2019-02-28**	**2019-02-28**	**2019-02-28**	**kr**	**%**
Personalkostnader	9 937	14 944	34 818	50 000	15 182	30.4%
Utrustning, mark, byggnader	0	0	0	0	0	0.0%
Konsultkostnader, licenser m.m	0	0	0	0	0	0.0%
Övriga direkta kostnader inkl. resor	1 458	2 916	4 374	0	-4 374	0.0%
Indirekta kostnader	10 135	14 944	35 214	0	-35 214	0.0%
Totala kostnader	**21 530**	**32 804**	**74 406**	**50 000**	**-24 406**	**-48.8%**

Volvo Personvagnar Aktiebolag

61921 Connected Car IT Services Development (556074-3089)

	Upparbetade kostnader		Ack. kostnader	Budget	Återstår jfr med budget	
	2018-08-01	**2019-01-01**	**2018-04-16**	**2018-04-16**		
	2018-12-31	**2019-02-28**	**2019-02-28**	**2019-02-28**	**kr**	**%**
Personalkostnader	114 267	48 308	216 575	200 000	-16 575	-8.3%
Utrustning, mark, byggnader	0	0	0	0	0	0.0%
Konsultkostnader, licenser m.m	0	0	0	0	0	0.0%
Övriga direkta kostnader inkl. resor	0	0	0	0	0	0.0%
Indirekta kostnader	0	0	0	0	0	0.0%
Totala kostnader	**114 267**	**48 308**	**216 575**	**200 000**	**-16 575**	**-8.3%**

WSP Sverige AB

WSP Sverige AB, Bro och vattenbyggnad (556057-4880)

	Upparbetade kostnader		Ack. kostnader	Budget	Återstår jfr med budget	
	2018-08-01	**2019-01-01**	**2018-04-16**	**2018-04-16**		
	2018-12-31	**2019-02-28**	**2019-02-28**	**2019-02-28**	**kr**	**%**
Personalkostnader	85 000	2 550	90 100	100 000	9 900	9.9%
Utrustning, mark, byggnader	0	0	0	0	0	0.0%
Konsultkostnader, licenser m.m	0	0	0	0	0	0.0%
Övriga direkta kostnader inkl. resor	4 000	1 010	7 949	0	-7 949	0.0%
Indirekta kostnader	700	570	1 959	0	-1 959	0.0%
Totala kostnader	**89 700**	**4 130**	**100 008**	**100 000**	**-8**	**0.0%**

Återbetalningskrav eller kommande utbetalning

Det slutliga bidraget som en bidragsmottagare har rätt till är det lägsta av *Max stödnivå* × *Rapporterade kostnader* eller *Max bidrag*. Max stödnivå och Max bidrag framgår av vårt beslut. Rapporterade kostnader (ackumulerade kostnader) är de kostnader som rapporterats in av projektet via lägesrapporter och denna slutrapport. Tabellen nedan visar **preliminärt** återbetalningskrav eller vad som är kvar att betala ut.

Återbetalningskrav eller kommande utbetalning

Projektparter	Max bidrag	Max stödnivå	Budget	Rapporterade kostnader	Slutligt bidrag	Återkrav
KUNGLIGA TEKNISKA HÖGSKOLAN	300 000	100%	300 000	335 620	300 000	0
RISE Research Institutes of Sweden AB	50 000	100%	50 000	50 018	50 000	0
Scania CV Aktiebolag	0	0%	100 000	100 000	0	0
Statens väg- och transportforskningsinstitut	50 000	100%	50 000	74 406	50 000	0
Volvo Personvagnar Aktiebolag	0	0%	200 000	216 575	0	0
WSP Sverige AB	0	0%	100 000	100 008	0	0
Totalt	**400 000**	**-**	**800 000**	**876 627**	**400 000**	**0**
Belopp att betala tillbaka via Koordinatorn						**0**

KOMPLETTERANDE FRÅGOR

Vinnova vill gärna ha din uppfattning om hur väl följande frågor stämmer överens med vad du tycker. Svarsalternativen är graderade från 1 till 10, där 10 är högsta betyg och 1 det lägsta. Markera det alternativ som stämmer bäst överens med vad du tycker.
Då Vinnova ser över rapporteringen kan det upplevas att ni får svara på likartade frågor. Vi ber om överseende med detta.

1. Hur väl motsvarar projektresultatet förväntningarna vid projektstart? *

9

2. Hur enkelt har det varit att ansöka och rapportera i Vinnovas Intressentportal? *

8

3. Hur väl har Vinnovas vägledning och stöd fungerat under projektets gång? *

9

4. Hur nöjd är du med Vinnova som myndighet i sin helhet? *

9

5. Eventuella övriga kommentarer

0 / 500 tecken

6. Hur stor del av projektarbetet har utförts av män i %. *

99

BILAGOR

Här kan du ladda upp bilagor.

För ett stort antal av våra beslut finns särskilda krav på rapportering. Dessa framgår i så fall av beslutsmeddelandets särskilda villkor. Mallar till läges- och slutrapportering för utlysningar med särskilda rapporteringskrav finns på Rapportmallar

Revisorsintyg *

Om en bidragsmottagares maximala bidragsbelopp enligt beslutet uppgår till 3 miljoner kronor eller mer ska revisorsintyg från kvalificerad revisor avseende bidragsmottagaren bifogas slutrapporten. För kommun, landsting, statliga myndigheter, universitet och högskola accepteras också revisorsintyg från kommunal yrkesrevisor eller internrevisor. Kostnader för revisorsintyg kan tas upp i slutrapporten även om fakturan inte kommit.

Alla projektparternas bidrag understiger 3 miljoner vilket gör att revisorsintyg inte krävs.

Mall för revisorsintyg samt Instruktion för revisorns granskning av bidragsprojekt finns här: https://www.vinnova.se/sok-finansiering/regler-for-finansiering/allmanna-villkor/

Revisorsintyg

Övriga bilagor

- Övriga bilagor_1.pdf
- Övriga bilagor_2.pdf
- Övriga bilagor_3.pdf
- Övriga bilagor_4.pdf
- Övriga bilagor_5.pdf
- Övriga bilagor_6.pdf
- Övriga bilagor_7.pdf
- Övriga bilagor_8.pdf
- Övriga bilagor_9.pdf

UPPFÖLJNINGSFRÅGOR

Uppföljningsfrågor

Har projektet lett till ökade FoU- eller andra innovationsinvesteringar?

- (x) Ja
- ( ) Nej

Beskriv FoU-investeringarnas syfte, omfattning etc.

The project identified the stakeholders' needs and also identified KPI:s that needs to be made available within a system-of-systemperspective.

It also leads to define criteria for the creation of a "digital twin" solution for automated vehicles and mobility as a cervice.

The requirements for a visualization tool / platform which is flexible and has capability to provide "reliable answers" to various trafficrelated issues are examined.

All these aspects set up a mix of different assumptions and parameters used in the simulation and a tool based on virtual reality/hybrid reality shall also be

applicable on different scales with different conditions.

Bedömer ni att projektets resultat kommer att leda till ökade FoU- eller andra innovationsinvesteringar inom 5 år?

- ( ) Ja
- ( ) Nej
- ( ) Vet ej

Har projektet resulterat i nyanställningar?

- ( ) Ja
- (x) Nej

Uppskatta antalet nyanställningar som skett under projektets genomförande

	Totalt	Varav kvinnor
Antal nyanställda		
Andel nyanställda av totalt anställda (procent)		

Uppskatta antalet nyanställningar som skett efter projektets slut

	Totalt	Varav kvinnor
Antal varaktigt anställda		
Andel varaktigt anställda av totalt anställda (procent)		

Bedömer ni att projektets resultat kommer att generera nyanställningar inom 5 år?

- (x) Ja
- ( ) Nej
- ( ) Vet ej

Har projektet lett till nya eller utvecklade samarbeten av betydelse för FoU- och innovationsverksamheten?

- (x) Ja
- ( ) Nej

Beskriv dessa samarbeten, t.ex syfte, omfattning, vilken typ av organisationer som ingår etc..

This pre-study projects identified stakeholders and stakeholer requirements- From a system-pf-system perspective, acdemic part like KTH can put the effort on research questions. Trafikverket can focus on regulations, Scania, Volvo can act uopn the business models, demand modelling and vehicle modeeling. WSP, VTI, RISE can provide data for model validation from related projects and can also provide support on simulators. Overall, the system effects of transportation, environment, interaction human-smart vehicle-smart cities, land use, business models, policies can be evaluated trough the cooperation.

Bedömer ni att projektets resultat kommer att leda till nya FoU- eller innovationssamarbeten eller -nätverk inom 5 år?

- ○ Ja
- ○ Nej
- ○ Vet ej

Har projektet resulterat i publikationer?

- ○ Ja
- ◉ Nej

Ange antalet publikationer, klicka OK och fyll tabellen.

Antal publikationer

0

	Titel på publikation	Publikationsnummer	Artikel i tidskrift	Monografi	Konferensbidrag	Annat

Bedömer ni att ni inom 5 år kommer att göra publikationer baserade på projektets resultat?

- ◉ Ja
- ○ Nej
- ○ Vet ej

Har projektet lett till ansökningar om - eller godkända - patent eller andra immaterialrättsskydd?

- ○ Ja
- ◉ Nej

Ange antalet ansökningar om patent eller andra imaterialrättsliga skydd som projektet resulterat i. Klicka OK och fyll i tabellen.

Antal ansökningar

0

	Typ av skydd	IPR-nummer	Immaterialrättsligt skydd beviljat

Bedömer ni att ni inom 5 år kommer att ansöka om patent eller andra immaterialrättsskydd baserat på projektets resultat?

- ◉ Ja
- ○ Nej
- ○ Vet ej

Har projektet resulterat i nya eller väsentligt förbättrade, produkter (varor eller tjänster)?

- ○ Ja
- ◉ Nej

Ange antalet nya eller väsentligt förbättrade produkter (varor eller tjänster). Klicka på OK och fyll därefter i tabellen.

Antal produkter

0

	Vara	Tjänst	Annat	Beskriv kortfattat produkten

Bedömer ni att ni inom 5 år kommer att lansera nya eller väsentligt förbättrade produkter (varor eller tjänster) baserade på projektets resultat?

- (x) Ja
- ( ) Nej
- ( ) Vet ej

Har projektet resulterat i nya, eller väsentligt förbättrade, processer eller sätt att organisera verksamheter?

- (x) Ja
- ( ) Nej

Beskriv kortfattat processen eller sättet att organisera verksamheten.

Based on the results of this pre-study projects. A further continuation of larger project application will be formed. In the larger proposal, orgnizations like KTH, Trafikverket, RISE, WSP, VTI, Scania, Volvo will work together and also have specific foucs on scenarios, data library, model architecture, system effects, visualization. Ph.D. projects can be formed from this. New perspectives from cities, digitial infrastructure like Ericcsson will also be needed to build the simulation and visualization platform. Workshops, meetings, interviews, conferences can all be active forms to test hypothesis, find solutions and reach to a better undertanding of the system effects.

Bedömer ni att ni inom 5 år kommer att implementera nya, eller väsentligt förbättrade, processer eller sätt att organisera verksamhet baserade på projektets resultat?

- ( ) Ja
- ( ) Nej
- ( ) Vet ej

Har projektet resulterat i nya, eller väsentligt förbättrade, affärsmodeller eller strategier?

- ( ) Ja
- (x) Nej

Beskriv kortfattat affärsmodellen eller strategin och dess implementering i verksamheten.

Bedömer ni att ni inom 5 år att använda nya, eller väsentligt förbättrade, affärsmodeller eller strategier baserade på projektets resultat?

- (x) Ja
- ( ) Nej
- ( ) Vet ej

Har projektet resulterat i intäkter?

- ( ) Ja
- (x) Nej

Uppskatta det ekonomiska värdet som genererats det senaste året från försäljning av nya produkter (varor och tjänster)

	Kronor

Bedömer ni att projektets resultat inom 5 år kommer att generera intäkter?

Ja

Nej

Har projektet resulterat i utveckling av policy eller metoder i offentlig verksamhet eller politik?

Ja

Nej

Beskriv den utveckling av policy eller metoder i offentlig verksamhet eller politik som projektet resulterat i

Bedömer ni att projektet kan resultera i utveckling av policy eller metoder i offentlig verksamhet eller politik inom 5 år?

Ja

Nej

Vet ej

Har eller kommer projektet att leda till följdprojekt?

Ja

Nej

Beskriv karaktären på följdprojektet/-en.

A larger project proposal will be formed based on the results of the pre-study projects. The preliminary plan is send the application around June, 2019.

Kommer ni att söka finansiering från Vinnova för att vidareutveckla projektets resultat?

Ja

Nej

Vet ej

Bedömer ni att projektets resultat kommer att leda till följdprojekt inom 5 år?

Ja

Nej

Vet ej

Tack för er medverkan!

FÖRHANDSGRANSKA OCH SKICKA IN

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SIMnVIS Meeting

Simulation and Visualization platform for Automated Vehicles and Mobility Services

16 Nov 2018 | Gotheburg | First Hotel G
Venue: Cityexp | Nils Ericsonsplatsen 4, 411 03 Göteborg

AGENDA

09.30 - 10.00	Fika	30 min
10.00 - 10.05	Welcome to the meeting [Mia Xiaoyun Zhao] and Short self-intro [All]	5 min
10.05 - 10.40	KPI:s	35 min
10.40 - 10.55	State-of-the-art analysis: modelling frameworks [Hugo Badia Rodriguez]	15 min
10.55 - 11.00	Short break	5 min
11.00 - 12.00	Model techniques and Model environment	60 min
12.00 - 12.50	LUNCH BREAK at First Hotel G restaurant	50 min
13.00 - 13.30	Visualization requirements	30 min
13.30 - 14.00	Mock-up showing a vision for the visualization	30 min
14.00 - 14.15	Fika Break	15 min
14.15 - 14.45	Research project application	30 min
14.45 - 15.00	Summary	15 min
15.00	End	

State-of-the-art analysis: which modelling frameworks are available?

Hugo Badia Rodriguez hubr@kth.se

This document provides an overview of possible modeling frameworks for the development of a simulation tool. This tool should be usefull for the simulation-based analysis of self-driving vehicles and mobility services. Therefore, depending on the final objective of the analysis, we will require different kinds of approach. On the one hand, traffic simulation with a high level of detail allows the evaluation of the driving behavior and the interaction between vehicles on the road. In this way, the simulation will provide information about road capacity, speed, etc. On the other hand, from the transport planning perspective, we are interested in the competition between different mobility services and the demand behavior with regard to the supplied transport system. This will provide conclusions about the design of transport services, modal split, new mobility concepts, business models, etc.

With these goals in mind, we summarize some of the current traffic and transport simulators or simulation platforms that provide modelling frameworks on we can develop the future platform. These pre-existing tools can be improved in different directions to meet the requirements. For traffic simulation, three tools for the microscopic level of analysis are included: SUMO, AIMSUN and VISSIM. These simulators describe the dynamics of individual vehicles in a disaggregated way. The motion of each vehicle is determined by car-following models and lane-changing models. They describe the driver actions (safe distances, acceleration, deceleration and lane changes) in front of the traffic environment. VISUM is presented as a macroscopic simulator for transport planning. In this case, the modeling approach assumes that traffic flows are characterized in an aggregated way by the time-space relationship between macroscopic variables: density, volume and speed. Finally, MEZZO is a simulator at mesoscopic level of analysis. It is an intermediate solution based on simplifications of traffic flow dynamics of individual vehicles.

On the other hand, microscopic agent-based modelling for transport planning is introduced. Unlike the previous microscopic models, the term microscopic here refers to individual demand behavior of each person or agent. However, the level of detail in the traffic flow dynamics is less precise. MATSIM is a multi-agent transport simulator. Additionally, BEAM and AMODEUS are described. They are other tools developed on the MATSIM modeling framework. Alternatively, three modelling frameworks are presented for the development of agent-based models that can be applied to transport analysis: GAMA, POLARIS and ANYLOGIC.

The analysis of the tools has been done according to requirements previously included in other traffic simulation taxonomies and particular requirements related to the use cases dicussed in other sections: (i) virtual test environment for the automated vehicle driving process, and (ii) the operation of new mobility services. The aspects considered are:

- Software **category**. The distinction is between ***open source*** and ***commercial software***. The former group allows us the free use of the software and access to the source code. Therefore, other programmers can study, modify and improve the initial code for specific purposes and add new modules. Commercial software has a charge for use and the modification of the original code is not possible or has strong limitations.
- Software **portability**. In what operating systems the software can work. The main relevant operating systems are Windows, Linux and MacOS.

- Model **category**. There are three different levels of analysis in the simulation field: ***microscopic***, ***mesoscopic*** and ***macroscopic***.
- Model **edition** and **user interface**. Easy or complex interaction with the software. How can users build the simulation? By means of text files, XML files or graphical user interface. An intuitive graphical environment makes the tool user-friendly.
- **Infrastructure**. The road network on the simulation is composed by roads and intersections. Additionally, we should consider parking slots, drop-off and pick-up points or charging stations for electric vehicles.
- **Entities**. ***Type*** of vehicles: cars, motorbikes, buses, trams, trains, trucks, bikes, priority vehicles such as ambulances or police cars, etc. ***Characteristics*** of vehicles: dimension, speed limits, weight, height, width, etc. Other entities included are ***pedestrians***.
- **Mobility services**. Type of services included in the simulator: fixed routes of public transport, on-demand and/or door-to-door services, taxis, etc.
- **Demand** Model. OD matrices or activity-based model, and parameters to make choice mode decisions.
- **GIS**. The capability to import maps from geographic information systems to encode road network.
- **Outputs**. Data, statistics and files obtained at the end of the simulation. ***Environmental impact***, that is, the availability of the software to calculate fuel consumption, emissions and noise pollution.
- **Visualization**. In this item, we discuss how the software shows the results of the simulation. Two-dimensional (***2D***) or three-dimensional (***3D***) visualization and the level of realism.

Current tools satisfy most of the requirements of a simulation platform for the analysis of traffic and mobility. A future platform can take advantage of all of this previous work. However, new capabilities of automated vehicles will modify driving behavior and allow the implementation of alternative mobility services. Therefore, these aspects will require some improvements in the current tools to meet a correct description of future mobility.

SUMO

Simulation of Urban Mobility (SUMO) is open source software for the microscopic analysis. It was developed by the Institute of Transportation Systems at the German Aerospace Center. The SUMO package includes different applications: the microscopic model, a graphical user interface, network importer and generator from different formats, graphical network editor, route generator, demand assignment and calculators for different kind of metrics. As an open source, SUMO package can be extended by additional code. The original programming language is C++. There are applications to use Java or Matlab interfaces for this codification.

This software is compatible with Windows, Linux and MacOS. The format of files used is .xml (text editor) and its variants. In addition, the software has the capability to import files from other software such as VISUM, VISSIM, OpenDRIVE, MATSim, Shapefiles, etc. At the same time, there is the option to export the files to other formats.

The extension SUMO-GUI improves the initial software by means of a graphical interface. This application makes the construction of a scenario easier and provides a visualization tool.

This is a typical window-based application with a menu entry and different icons to do different tasks (open, start, stop, continue, save a simulation, load a network, etc.). The window displays the network and the simulation allowing the visual interaction even with multiple views. In this way, the interface allows the direct selection of network elements. The visualization can be customized with the appearance of streets, lanes, vehicles and pedestrians: color, size and shape with regard to category, position, speed, acceleration, time, occupancy, capacity, emissions, noise and energy consumption. Different colors indicate right of way for traffic lights and uncontrolled intersections.

A SUMO network is a direct graph composed of junctions or intersections, unidirectional edges or roads and streets, and districts or zones of transport. The edges are characterized by number of lanes, position, length, shape and speed limit. The junctions are defined by position, traffic lights and right of way regulations. Regarding control strategies, active traffic light programs allow users to extend green phase based on traffic conditions and different programs during the day. There is the option of variable speed signs along the day and V2V and V2I communication. At the same time, this tool includes parking areas.

For the demand modelling, there are different ways to generate the routes: by trips or flow, randomization, O-D matrices, flow and turning ratios, detector data, by hand, population statistics and other sources. Moreover, there are applications to import routes from other simulators. Regarding the routing, rerouting strategies exist, for example, in case streets or lanes are closed, or new destination, route or parking area are assigned.

Over the network, we can run a multi-modal traffic simulation. There are different kinds of entities defined by their physical properties and routes: private cars, emergency vehicles, taxi, buses, trucks, trailers, trams, rails, motorcycles, bicycles, and even pedestrians. For vehicles the physical properties are: length, color, maximum speed, acceleration and deceleration, safety distance and car-following model parameters.

An important aspect related to some kind of vehicles is the stop. We can have public transport stops, stops for logistics issues and stops equivalent to charging stations for electric vehicles. This last element shows that this simulator can work with electric vehicles apart of fuel vehicles. In the former the battery is an additional attribute of the vehicle.

Pedestrians can have three different stages: ride, walk or stop. In the first stage, pedestrian moves by a mode of transport. In the last one, they are waiting at stop for one transport mode. For walking, a specific pedestrian model is used to simulate the movement behavior. Furthermore, sidewalks can be defined for the pedestrian movement and definition of the crossing with regard to the rest of transport modes. Other segregated lanes can be defined for bikes and trains.

SUMO also estimates energy consumption (fuel or electricity), battery levels for electric vehicles and emission related to pollutants such as CO2, CO, HC, NOX and PMX.

Some elements that are missing in this simulator are: 3D visualization, automation and limitations of multi-modal trips.

AIMSUN

Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks (AIMSUN) is commercial software that originally included a microscopic model (time based discrete event simulation), but now the software incorporates a mesoscopic level (event oriented discrete simulation) of analysis and macroscopic functionalities. This simulator works with dynamic traffic assignment models based on either user equilibrium or stochastic route choice. Aimsun is applicable for offline traffic engineering problems and real-time or online traffic management.

This simulator is compatible with the three main operating systems Windows, MacOS and Linux. Aimsun platform has two main components. One is the kernel that contains all objects and their definition that are part of the application domain and the other is the graphical user interface (GUI) that contains all objects needed to implement/modify the user interface (such as dialogs, drawers and controls). As commercial software, it has a graphical user interface is intuitive.

An Aimsun model is composed of two elements: transport supply and demand. The first one is the infrastructure and services that people or goods use to travel. That infrastructure is described as a graph with the correspondent rules of turns. The graph represents the road shape. Each link is described by the number of lanes and the characteristics of those lanes. In each intersection, we define what kinds of turns are allowed and the priority rules in case of crossed movements, including pedestrian flows. These turns and movements can be regulated by fixed or dynamic traffic control plans in case of signalized intersections or ramp metering. The required information in one plan is duration, cycle length and times for each signal group and the associated turns. Finally, the last component of the transport supply is the public transport services included in the model. These services are basically defined by route, stops, frequency or timetables and stop-time.

The second input of the model is the traffic demand. There are two forms for the representation of this demand: OD matrices and traffic states. OD matrices require centroids and connections as entrance and exit of the traffic. These matrices can be defined by type of vehicle and periods of time. On the other hand, traffic states describe input flows for each entrance of the network and the turning percentages at each node.

Different kinds of results are obtained from the simulation, the most relevant are: flows, densities, speeds, travel times, delay times, queue lengths, stop times, pollution and fuel consumptions and trajectory data. These measures can be either global for the whole network or local for a small group of sections. Moreover, the simulation can be shown with 2D and 3D visualizations.

An important component of any simulator is the capability to add new functionalities according to future requirements. In this line, Aimsun allows users to work with external applications. There are three alternatives for this purpose: Software development kit (SDK) Aimsun platform, Micro API (APPI) and Micro/mesomodel software development kit. The first one is a collection of libraries, files, documents and samples for the development of applications in Aimsun. This option allows user to make change on the kernel or the graphical user interface. The micro API gives the ability to work with external applications that need to access to Aimsun during the simulation to get information about vehicles, detectors, statistical data, network, demand or traffic control plan. These external applications feed the original Aimsun with other traffic control strategies, vehicle-simulated data or vehicle driving where Aimsun provides a realistic scenario for the driving simulator. Finally, micro/meso model

SDK allows changes in the driving behavior models. The programming language for all of them is C++ or Python.

The input data can be imported from different sources. Regarding the network, Aimsun converts aerial images (PNG, JPG, GIF, TIFF, etc.), 3D models (3dsmax 3DS and Wavefront OBJ), CAD files, GIS (ESRI SHP among others), digital maps (Navteq), and input files from other transport or traffic simulators (SATURN, CONTRAM, VISUM, VISSIM, PARAMICS, TRANSYT and SYNCHRO). However, some of these file formats require certain refinement. Regarding demand, OD matrices can be imported from Excel, an ASCII file or any database via an ODBC connection. Finally, virtual detectors can model the control plans. An interface between Aimsun and a simulator for a detector (SCATS, UTOPIA, VS-PLUS, SICE and SCOOT) can interchange data.

VISSIM / VISUM

PTV developed two complementary simulation tools: VISUM and VISSIM. The former is a macroscopic model for analysis and forecast of traffic and transport systems. The latter is a microscopic model that simulates, evaluates and validates transport policies and control systems. Both are commercial software and require Windows operating system.

VISSIM

VISSIM is a microsimulator for the analysis and optimization of traffic flows. This is a behavior-based, multi-purpose and multi-modal traffic simulator for motorways and urban environments. As most of commercial software, VISSIM is complemented with an intuitive graphical user interface that makes the use easy without a high knowledge on computer or traffic flow models. The software is implemented in C++.

The simulator is composed of four elements: transport supply model, demand model, control model and the results of the simulation. The first one includes road and railway infrastructure: roads, tracks, sign posts, parking facilities, public transport stops and detectors for vehicles and pedestrians. A graph with nodes (intersections) and links (road segments) represents the road network. The properties of the links are planar coordinates, number of lanes, lane width, types of vehicles allowed in the link, gradient, toll cost and particular driving behavior settings. In the links, we can introduce spot objects such as speed limit sign, yield and stop sign, and signal head.

The demand model includes vehicle characteristics and traffic flows defined by origin-destination matrix or by generating traffic at links entries, the assignment model and path descriptions, and public transport lines. Private transport vehicles follow individual routes while public transport vehicles follow fixed routes with stops. However, buses on non-regular services should be modeled as private transport. Cars, trucks, bikes and pedestrians are the categories of private transport and are described by length, width, acceleration and deceleration rates, and maximum speed. Additionally, we can include weight, emission class or variable or fixed cost of vehicle usage. For public transport vehicles, besides the previous characteristics other properties are considered: type of line (bus, tram, and rail), timetable, dwell times, passenger service times and slack times.

The traffic control model considers different kind of rules for the management of the traffic at intersections: major/minor priority rules or signalized intersections. The first includes preferences for right side, continuing road, within the roundabout, major road, buses, etc. In the second case, the intersections are controlled by traffic lights.

The fourth component evaluates and processes the data from the previous three models. Some outputs are generated during the simulation: animated vehicles and states of traffic control, and statistical data from detectors and vehicle states. The animations can be in 2D and 3D and it is possible to create realistic videos (AVI format). These can be complemented with maps, photographs and CAD drawings. For even more advanced virtual reality visualization, the simulated traffic can be exported to Autodesk R 3DS Max software. Others measures of performance are shown at the end of the simulation: delay, travel time, stops, queues, speeds and densities. The user can choose what kind of data wants to report and how to summarize it based on time period, point location, intersection, path or the whole network, and transport mode, vehicle type or individual vehicle. The file format is ASCII or database and can be manipulated by Microsoft Access or Excel. This information is exportable to VISUM to complement the macroscopic analysis.

This software includes a programming interface (Microsofts Component Object Model) that can be used by different programming languages such as Visual Basic or Python. By means of this COM interface, users can add new functionalities and personalize the original software for specific requirements: network, vehicles, driver model, signal control and evaluations (for example, emissions).

<u>VISUM</u>

VISUM is a multimodal model capable to simulate private vehicles and public transport services in an integrated way. This simulator can develop different tasks: planning or construction measures to forecast traffic volumes, impacts of road tolls, capacity analysis, determination of environmental effects, planning of lines and timetables, cost-benefit analysis, modal split, operating cost calculation, etc.

Three elements compose the transport model: demand model, network model and impact model. The first one contains the travel demand data and OD matrices. To estimate the traffic flows and create travel demand matrices, there are three alternative models: the 4-step model, the EVA model and the tour-based model (or activity-based model) for people and freight. The demand could be distinguished by time interval, transport mode, person group or trip purpose. For person group, the model includes employed/not-employed people, apprentices, students, pupils, retired people, and people with/without car available. For trip purposes, it is considered for example work, shopping, education, recreation, home, etc. Each demand matrix represents a specific demand segment whose users have a homogeneous travel behavior.

The second component is the transport supply. This consists of zones of transport and connectors, links and nodes that represent roads or railways and the respective intersections. Additionally, public transport stops, lines and timetables complete this network model. Different properties describe each infrastructure element: capacity, free flow speed, minimum or maximum speed, specific speed for public transport systems or number of lanes. Different kinds of vehicle or mobility services are included: heavy goods vehicles, private cars and business cars, bikes, pedestrians, buses, trams, trains and demand responsive transport such as ride sharing, taxis and carpool services. Multimodal trips are simulated, between public transport services and between public transport and pedestrians or private car (park & ride).

Finally, the impact model provides an analysis of the transport supply according to specific demand requirements. This model simulates the travel behavior of public transport users and car drivers and determines traffic volumes and travel times. Moreover, this component estimates operational indicators (kilometers traveled, service hours, fleet size, operating costs and revenues considering different fare systems) for public transport systems, and there are different methods to assess environmental impacts (noise and pollution).

The simulation provides different kind of outputs: flow bundles, turn volumes at intersections, isochrones, shortest paths, skim matrices derived from the properties of the paths, lists of attributes for the network objects, and different kind of statistics for the assignment analysis and the quality of the assignment. A wide range of graphical and tabular options are available to show the resultant data of the simulation: lists, bars, classified display with attribute values, labeling, turn volumes, desire lines, stop catchment areas, public transport transfer relations, connections and transfer flows, lane allocation, schematic line diagram, signal time-space diagram, column charts. Some of these options are displayed in 2D visualization and others also in 3D. These visualization functionalities are supported by the geographic information system included in VISUM. The software supports ESRI shape files and Personal Geodatabase.

Finally, there is the option to adapt the software to specific requirements working with scripts. Some scripts can be edited directly in VISUM without a text editor. For other cases, it is needed an additional script language, for example Python.

Mezzo (BusMezzo)

Mezzo is open source software developed in the Transport Science Department at KTH. This is a discrete-event traffic simulation model in the mesoscopic scale, that is, road traffic is analyzed on the level of individual vehicles with an aggregated behavior. With this level of analysis, this tool is able to simulate large networks. At the same time, it is possible to create a hybrid model combining Mezzo with a microscopic simulator if we are interested in a detailed analysis for a specific area of the total network.

The software was developed in C++ and is compatible with the most general operative systems such as Windows, MacOS and Linux. The code is available to modify and add new functionalities. The input and output file format is .xml. It is possible to import networks from Visum software.

There is a version that includes a graphical user interface. This complement helps users to work with this software: open, close, save, run, pause, reset a simulation case, zoom, panning, select or find links and nodes, edit parameters, inspect routes or analyze outputs. Users can observe the evolution of the network during the simulation. The interface shows information for each link such as queue length or density However, this interface has limitations, for example, with regard to some output visualization.

The traffic network is composed of unidirectional links and nodes. The former are defined by type, number of lanes, in and out nodes, length, historical travel times and speed/density functions. Position, type (intersection, ramps, origin or destination of traffic), turning movements, delays and signal control plans characterize the nodes. Other inputs are the routes for all the OD pairs and their levels of demand for each period of time and vehicle category.

Therefore, it is required the description of the vehicles by type (trucks, cars, buses, etc.), percentage and length.

Regarding the outputs, the simulation provides speeds, flows, densities and queue lengths for the different links of the network for each period of time. At the same time, the simulation provides the travel times for the paths that connect each OD pair.

An extension of the preliminary software is focused on the simulation of public transport systems. This is called **BusMezzo** and is an agent-based simulation model for dynamic transit operations and assignment of passenger flows. Mezzo provides the traffic dynamics. The simulation can consider a multi-modal public transport networks simulating individual vehicles and passengers that make individual travel decisions.

Regarding transit operations, there are four components: transit network, dwell time, vehicle schedules and control and management strategies. The transit network lies on the physical road or rail network and includes routes, lines, stops and timetables. Vehicles are defined by length, seats, capacity and parameters of the dwell time function. Moreover, BusMezzo supports the implementation of advanced public transport systems. This includes different strategies: holding control for service regularity and coordination, and fleet management schemes as expressing, short turning and deadheading. On the other hand, the demand can be represented by boarding and alighting rates per stop and line or by different kinds of OD matrices per line, stop or spatial unit. Passengers make decision according to utility functions.

The outputs are obtained by stop, vehicle and passenger. The report related to stops includes arrival time, scheduled time and its deviation, dwell time and its variability, holding time, exit time, headway at departure and arrival and variabilities, passenger counts, and travel passenger times. The outputs of vehicle are distance from origin, and arrival/departure time. Regarding passengers, BusMezzo includes set of alternatives and their attributes and utilities, number of passengers per trip and line segment, share of travels per path and travel times per path and OD pair.

MATSIM

Multi-Agent Transport Simulation (MATSim) is open source software based on an activity, extendable, multi-agent simulation framework implemented in Java. Therefore, Java is a requirement to run the software. MATSim allows users to add different kind of modules in order to extend and customize the software for a range of functionalities: road pricing, multimodal simulations, signals, additional choice dimensions, or analysis modules. These extensions can be made using MATSim itself, scripts in Java or own extensions.

This software is compatible with Windows, Linux and MacOS operating systems. The graphical user interface allows users to open, configure and start a simulation. Alternatively, it is possible to use a command line tool. On the other hand, regarding transferability, files from EMME or VISUM can be converted to MATSim. Although this option has limitations since some scenarios require certain degree of adaptation.

This simulator can manage large-scale scenarios to model a single day, although a multiday scenario could be implemented. It is possible since MATSim works in parallel to accelerate the computing process. From the demand side, MATSim is based on the co-evolutionary principle. Every agent repeatedly optimizes its daily activity schedule while competes for space-time slots with all other agents on the transportation infrastructure. The travel demand is described by the agent's day plans: a list of people where each person has a list of plans and each plan contains a list of activities and legs. In a short way, MATSim works following an iterative process that starts by the resultant demand from the daily activity chains in the territory under study. Then, each agent optimizes its chain according to a memory with regard to plans of daily activity chain. Four dimensions are considered: departure time, route, mode, and destination. Finally, one agent chooses the plan that provides the best score before the mobility simulation.

Regarding the traffic model, MATSim works with a queue-based simulation approach, which loses resolution since car-following effects are not captured. Two internal mobility simulations are available in the software: QSim and JDEQSim (Java Discrete Event Queue Simulation); although external simulations can be used.

To build a scenario of simulation, the files required are related to the configuration of the simulation, the description of the network, and information about demand. The format of all of them is .xml. The network is represented by a directed graph described by attributes such as length, flow capacity, free speed, number of lanes, and modes for uni-directional links. Networks can be planning or navigation networks. The former is less detailed and is useful for initial simulations. The latter is detailed and distinguishes links for different modes. For network edition, users have the Java Open Street Map Editor. This plugin allows users to convert, preview, edit and save the network, including public transport networks, directly from the map.

Additionally, there is the capability to introduce time variability in the network attributes. This includes adaptative traffic control, variation of speed limits, driving directions of lanes, or even changes due to accidents. MATSim's traffic signal module simulates every traffic signal control strategy microscopically, either fixed-time traffic signal control, which periodically repeats the same schedule for signalization, or traffic-responsive signal control, which reacts dynamically to the prevailing traffic patterns to improve the junction or system performance.

MATSim is a multimodal transport simulator. A trip is divided into different legs where each one is covered by one of the modes listed in the simulation. Different kinds of vehicles are included: car, public transport, minibus, car sharing. Regarding cars, aspects like signals and lanes, parking, electric vehicles and road pricing are considered. Additionally, freight transport is simulated. The simulation allows us to work with different vehicle types with regard to a variety of aspects such as emissions, speeds, etc., for different persons, modes or trips.

Public transport modelling consists in running transit vehicles along routes where passengers board and alight at stops. We need to define lines, routes, departures, schedules, vehicles, and stop locations. MATSim can consider dynamic transport services with variable transit travel speed and vehicle type along routes and day. Moreover, it is possible to optimize the vehicle deployment planning by the use of one vehicle in different routes. Finally, transit passengers choose the best route with regard to the minimal cost by a specific route calculator. There are more than one router that takes into account aspects like congestion, occupancy levels, queues at stops, bunching, in-vehicle time, walking time, waiting time, number of transfers, and comfort level.

Alternatively, there is the option of minibuses for on-demand services or paratransit services where routes and schedules are not imposed. This capability to adapt supply to demand can be used to optimize the service in traditional public transport lines. It is in line with dynamic transport services, MATSim simulates dynamic multi-depot vehicle routing problem with time windows and time-dependent travel times and costs.

MATSim is also able to simulate car sharing systems. Three different business models are considered: round-trip based option where users pick up and drop off the car in the same station, one-way where users can pick up and drop off the car in different stations, and free-floating where users pick up and drop off the car in free parking slots within a defined service area.

There are two visualizers for MATSim: Via and OTFVis. The former is a commercial application, although there is a limited version available for free, that allows users the visualization and analysis of simulation results. Among the visualization functionalities, Via includes to record movies. In front of the disaggregated data produced by MATSim, this tool includes the capability to aggregate information by point or origin-destination pair in order to make conclusions from the simulation results. On the other hand, OTFVis is open-source visualizer with similar functionalities to Via. In this case, there is the option to extend its capabilities.

Other relevant features in MATSim are: parking modelling considering parking choice and parking search, electric vehicles, road pricing, freight traffic, evacuation scenarios, accessibility measures to describe availability and spatial distribution of activities and facilities within a given area. Moreover, there is the capability to estimate fuel consumptions and emissions based on the Handbook on Emission Factors for Road Transport (HBEFA), where warm and cold-start emissions are considered. Their estimations depend on driving speed, acceleration/deceleration, stop duration, and vehicle characteristics. The simulations derive the kinematic characteristics from the simulation and emission factors from HBEFA. Finally, the connection with UrbanSim (non open-source) is possible. MATSim provides the traffic simulation to UrbanSim.

There are some limitations in the current tool: multimodal trips are only composed of a motorized mode with a non-motorized mode (pedestrian or bike); no automation that allows other kind of operation in car sharing systems; 3D visualization; agent-based models require the management of a large volume of data; further dimensions, such as activity adding or dropping, or parking and group choices are currently under development and only available experimentally.

Two agent-based tools developed on the MATSim modelling framework are described below: BEAM and AMoDeus.

BEAM

BEAM is a model for the behavior, energy, autonomy and mobility. This is open-source software that provides a framework for research on transportation. It was developed at Lawrence Berkeley National Laboratory and the UC Berkeley Institute for Transportation Studies. This tool is modeled on MATSim modeling framework due to the extensibility of MATSim.

Initially BEAM was focused on the simulation of plug-in electric vehicles in the context of light-duty, personal vehicle transport, shared and autonomous fleets and the associated interactions with charging infrastructure and the electric grid. By integrating with MATSim, BEAM puts the utility and disutility of charging PEVs on the same scales as the utility and disutility of mobility in a transportation system. The operational decisions made by PEV drivers are modeled using discrete choice models, which can be parameterized based on the outcomes of stated preference surveys or reveled preference analyses.

The tool can be flexibly integrated with grid modeling software either through customized data exchanges or through API development that allows models to directly interface and influence each other.

AMoDeus

AMoDeus is open-source software for the analysis of autonomous mobility-on-demand systems. This tool internally utilizes the agent-based simulator MATSim. The traffic simulation in a city takes into account congestion and network effects inherent to transportation systems. At the same time, the agents change their transportation behavior based on arbitrary utility functions that may include tolerance to delay, travel time, cost, etc. Currently, the demand profile is static, but an extension to dynamic demand is expected in a next version of the software.

By means of this tool, users can implement their algorithms for the management of large fleets of robotic taxis in cities to pick up and deliver customers. Vehicles can operate on a large and complex network with varying travel times and congestion effects. Two main operational policies guide the behavior of these fleets: dispatching and rebalancing.

To facilitate the comparison of operational policies, AMoDeus contains fleet efficiency and service level analysis methods. The most important metrics are automatically included in a report. Furthermore, benchmark operational policies are included in AMoDeus which serve as a benchmark for new policies. Finally, AMoDeus has an in-built graphical viewer that allows in-depth insights into the system.

GAMA

GAMA (GIS Agent-based Modeling Architecture) is a platform for spatial multi-agent-based simulation environments. It was developed on Java. Among the possible applications of this software, we find transport and urban planning simulations. It has been developed under the IRD/UPMC international research unit UMMISCO where several teams have participated: MSI Research Team at Vietnam National University, UMR 6228 IDEES at CNRS/University of Rouen, UMR 5505 IRIT at CNRS/University of Toulouse 1, DREAM Research Team at University of Can Tho, UMR 8623 LRI at CNRS/University Paris-Sud.

This is open-source software and the access to the code allows users to modify it. The platform is compatible with Windows, MacOS and Linux. The language used in this platform is GAML, which is a language easily used by non-computer scientists. This is an object-oriented language like Java. The GAML editor is a text editor. There are tutorials and personal learning paths to learn about this language. In addition, there is a support team that answers possible doubts.

On the other hand, GAMA has an intuitive user interface. There are two fundamental concepts, the workspace where the different models are organized, and the workbench that contains the tools to create, modify or execute the models. For example, users can choose inputs and outputs of the simulation. Additionally, there is the possibility to modify and personalize the working environments according to their requirements.

The simulations and their results (agents, charts, texts, etc.) can be displayed in two-dimensional (Java) and three-dimensional (OpenGL) visualization. There is the option to control lights, cameras or adding textures and to show multiple displays for the same model. The software provides the possibility to load GIS files. Users can import data from different formats such as text files, CSV, Shapefile, OSM, images, SVG, 3DS and OBJ. Moreover, GAMA can be connected to databases and statistical tools such as R.

POLARIS

POLARIS is an open-source agent-based modeling framework that simulates large-scale transportation systems. It is composed of an integrated network-demand model. This model includes traffic flow simulator, activity based demand model, network/demand integration, event engine and visualization. All the travel decisions are considered: departure time, destination choice, route choice, planning and rescheduling.

This software has been developed by Argonne System Modeling and Control Group. Polaris is distributed under BSD license. This can be used for open source, closed source projects and commercialization. It is possible to modify the original code and to add new libraries. The language used is Python. Polaris requires Windows to be run, although the option of Linux is under development.

The main features of the software are: extensible model structure for the implementation of new models to include new mobility solutions and technologies; integration with other software to quantify energy impacts; and fast run times and real-time analysis for large scale systems due to an efficient memory usage.

ANYLOGIC

AnyLogic is commercial software to build agent-based models. This tool is able to develop large and complex simulation models and sophisticated animations, embedding models into various IT environments, and creating and using custom libraries for specific applications areas. AnyLogic provides a multimethod modeling environment including three simulation methods: discrete event, agent based and system dynamics. These methods can be combined to simulate different degrees of complexity. Moreover, various visual modeling languages are available: process flowcharts, state charts, action charts, and stock & flow diagrams. This software can be run on Windows, MacOS and Linux.

There are specific libraries for traffic, rail and pedestrian simulations that can be combined to simulate complex transport systems. The traffic library enables users to plan, design and simulate traffic flows, to model driving behaviors and to represent flow dynamics. Different driving regulations, physical parameters and behavior patterns are included in the predefined algorithms. Road traffic models simulate traffic on streets, highways, different types of intersections, parking slots and bus stops. They assess road capacity and congestion and traffic light schedules. Vehicles are distinguished by parameters such as speed, length, acceleration and behavior.

The pedestrian library simulates pedestrian dynamics in urban landscapes, open events, museums, shopping centers and transport hubs. The objective is to evaluate capacity, mobility and accessibility issues. Each pedestrian is defined by individual properties, preferences and states. Its behavior is defined by a process flowchart. The main outputs are counts of pedestrians, wait and service times and pedestrian flow densities. On the other hand, the rail library allows the simulation of the different components of a rail system. This includes operations planning, fleet management and train and maintenance scheduling. By means of a flowchart, users define the characteristics and behaviors of trains.

AnyLogic has an intuitive user interface. The workspace shows the graphical editor, current projects, palettes or list of model elements and properties of selected models. This workspace can be customized according to user preferences. Additionally, GIS Map shape allows users to import the Geographic Information System. GIS maps are used to define the GIS space in agent-based models. The GIS implementation is based on OpenMap.

This software has the capability to construct 2D and 3D animations and graphics. It is possible to import 3D models, images, CAD drawings and shape files into the simulations. Furthermore, AnyLogic works with any data storage such as Oracle, MS SQL, MySQL, PostgreSQL, MS Access, Excel and text files. Charts and histograms display the results in the form of PDF, CDF, etc.

This platform is extensible and customizable at Java level. There is no specific scripting language for AnyLogic and Java is the language for modelers. In Java users can define and manipulate data structures, develop efficient algorithms, and use numerous packages available. In short, users can design custom experiments according to special needs adding their own algorithms.

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SIMnVIS MEETING AGENDA

DATE: Wednesday, November 12,2018
TIME: 13.00---15.00
LOCATION: Skype

MEETING CHAIR: Mia Xiaoyun Zhao email: mia.xiaoyun.zhao@itm.kth.se
MEETING SCRIBE: Hugo Badia Rodriguez email: hubr@kth.se
MEETING TITLE: **SIMnVIS meeting for deliverables**

ATTENDEES PRESENT:

Mats Lundin	Andreas Tapani
Dirk van Amelsfort	Magnus Palm
Anna Pernestål	Hugo Badia Rodriguez
Frida Reichenberg	Mia Xiaoyun Zhao
Niklas Mellegård	

OBJECTIVES:

I. Discussion about the use cases
- We start with the use case that Mats and Dirk provided and then we discuss other ones
- Discuss the modelling environments, over-all modelling techniques, and KPI:s

II. Mock-up for visualization
- We choose one, maybe two use case for mock-up visualization
- Discuss how to do the mock-up

III. Research project application
- Discuss research and innovation gaps for the aim of application
- Discuss possible funders
- Discuss willingness of join and the form

IV. Go through the deliverables of the project and agree on what have been accomplished, what have not

Deliverables
1. Requirement analysis from the following perspectives:
   a) Stakeholder analysis
   b) Stakeholder needs
   c) Modelling environment
   d) Over-all modelling architecture
   e) Visualization requirements (e.g. real-time, 2D, 3D)
2. State-of-the-art analysis: has been conducted by Hugo Badia Rodriguez.
3. Draft version of KPI:s
4. A mock-up showing a vision for the vizualisation.
5. Research project application. Goal: May/June 2018.

SCHEDULE:

TIME	CONTENT DESCRIPTION
12:50 to 13:00	Attendance; Skype call to Order
13:00 to 14:00	Objective I
14:00 to 14:30	Objective II
14:30 to 14:55	Objective III& Objective IV
14.55 to 15.00	General administrative information
15.00	End

Please click on this link to join the meeting on Skype for Business

Join Skype Meeting---SIMnVIS

Describe some use cases that your institution/company would like to use SIMnVIS platform to solve.

USE CASE 1

1. Description of the use case. What's the question that you want to answer in this use-case?

What is the optimal deployment (business model) of a shared vehicle service in terms of vehicle type (level of automation, drive line, vehicle size) and service offer (waiting times, price, quality), and what are the traffic, economic and environmental effects of such a service.

2. Limitations found in the current simulation-visualization tools that are used by your institution/company to solve the proposed use-case? For example, functionalities, performance, inputs, outputs.

- The descriptions/syntax of services, vehicle types and vehicle behavior does not exist in existing simulation and visualization tools
- The description/syntax of infrastructure (both road, parking, drop-off and pick-up, charging) is insufficient/inappropriate to simulate the use of new vehicle types
- The description/syntax of behavioral choices, both on the level of choosing access to mobility (car ownership, buying subscription, etc) as well as on a trip/level are insufficient to describe market shares of different services and vehicle types.

3. What are the model requirements of the SIMnVIS platform for your use-case?
Considering the scope of the use case, assessing the optimal service deployment based on individual choices and societal outcomes, it is perceived that an activity-based agent-based simulation would be most appropriate since such a framework will be able to:

- Address all the relevant behavioural responses ranging from location choices, activity patterns to dynamic route choice changes
- Address key characteristics of new vehicles types and their behavior in a flexible manner and in mixed conditions (varying levels of market shares)
- Explicitly model the business model (dispatch model) of a shared vehicle service
- Address key characteristics of infrastructure changing and V2X communications in a flexible manner
- Simulate the flow of vehicles/traffic through the road network

For example, entities, model approach (like, activity-based model, trip-based model, agent-based model, etc.) level (micro, meso, macro), perspectives (demand, supply)

The SIMnVIS platform would be required to describe:

- Characteristics of new vehicle types
- Characteristics of a dispatch model of shared vehicles to users
- Characteristics of infrastructure components
- Choice behavior of consumers

4. How will you evaluate the use case? For example, data required, input parameters, KPI's etc.

Data requirements

- Infrastructure: digital description of roads, parking, etc.
- Population and employment data
- Land use data
- Vehicle characteristics and behavior
- Soci

Model syntax/processes

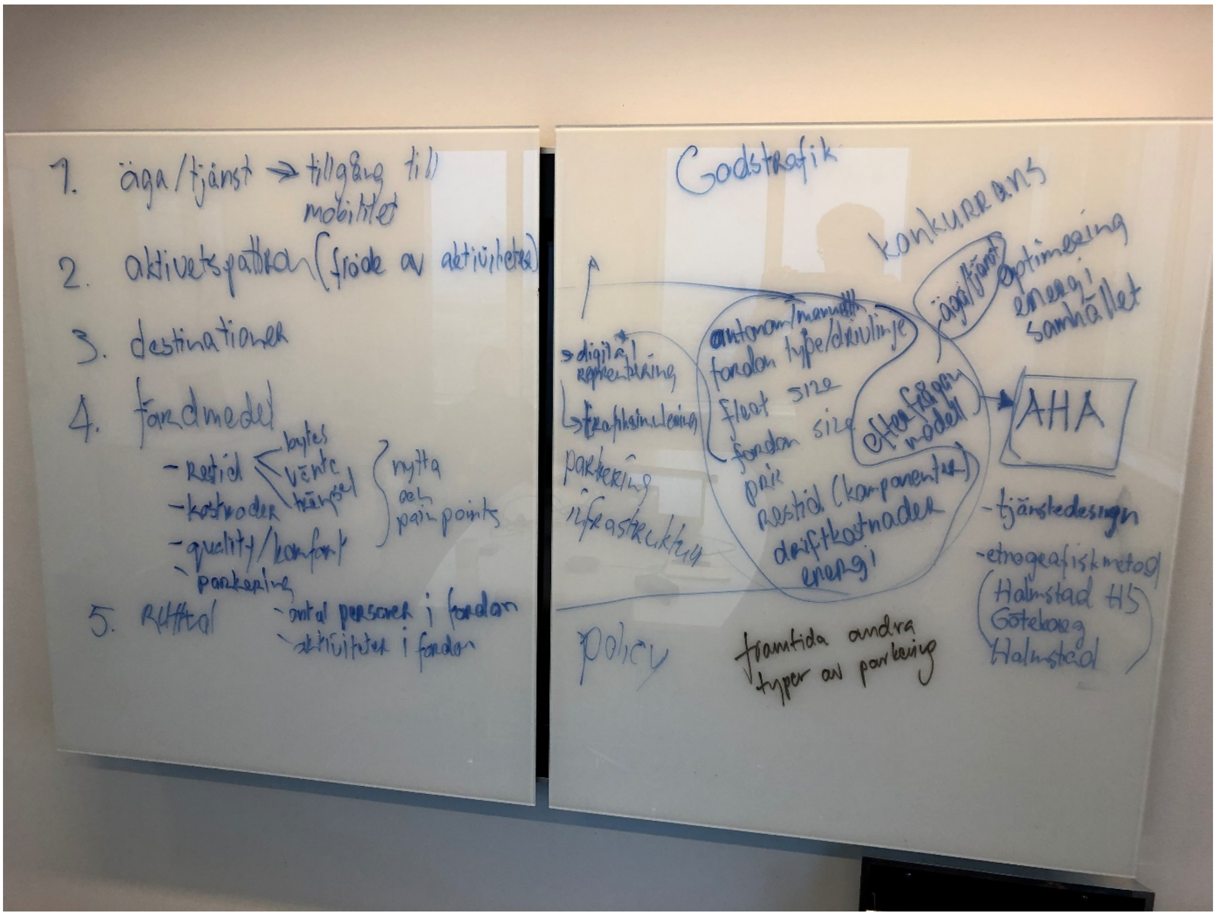
- Business model: a model component that includes the algorithms for sending out a vehicle with certain characteristics and price to a specific customer call for a trip
- Travel demand model: a model component that determines choices of individual on a variety of levels: access to mobility (ownership vs service), activity pattern, destinations, mode/service choice, departure times, route choice
- Infrastructure: connectivity algorithms and use cases, traffic/vehicle flow algorithms

Input parameters
- Policy parameters
- Business model and service design parameters
- Behavioural parameters

KPIs
- Market share
- Usage and occupancy levels of vehicles
- Revenues
- Operating costs
- Congestion / travel times
- Occupancy parking
- Energy use
- Emissions
- Distributional / equity effects

5. How will you disseminate the results? Visualization (real-time, 2D, 3D)

A combination of 2D, 3D and aggregated descriptive KPIs in tables and graphs would be appropriate to disseminate results from the simulation


1. äga/tjänst → tillgång till mobilitet
3. destinationer
4. färdmedel
- restid
- kostnader
- quality/komfort
parkering
nytta och pain points
- antal personer i fordon
- aktiviteter i fordon
Godstrafik
konkurrens
optimering energi samhället
fordon type/drivlinje
fleet size
fordon size
restid (komponenter)
driftkostnader
energi
AHA
parkering
infrastruktur
policy
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- tjänstedesign
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Göteborg
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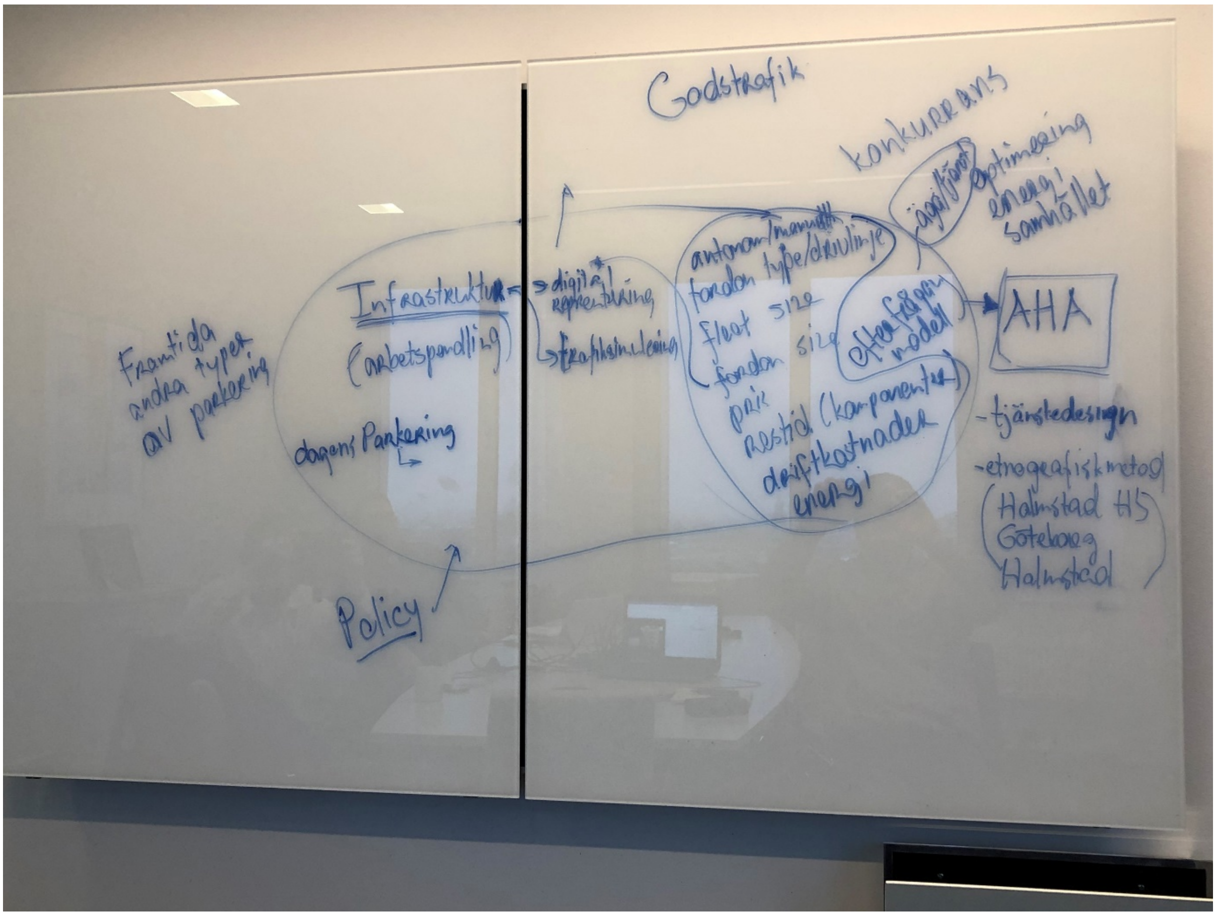
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av parkering
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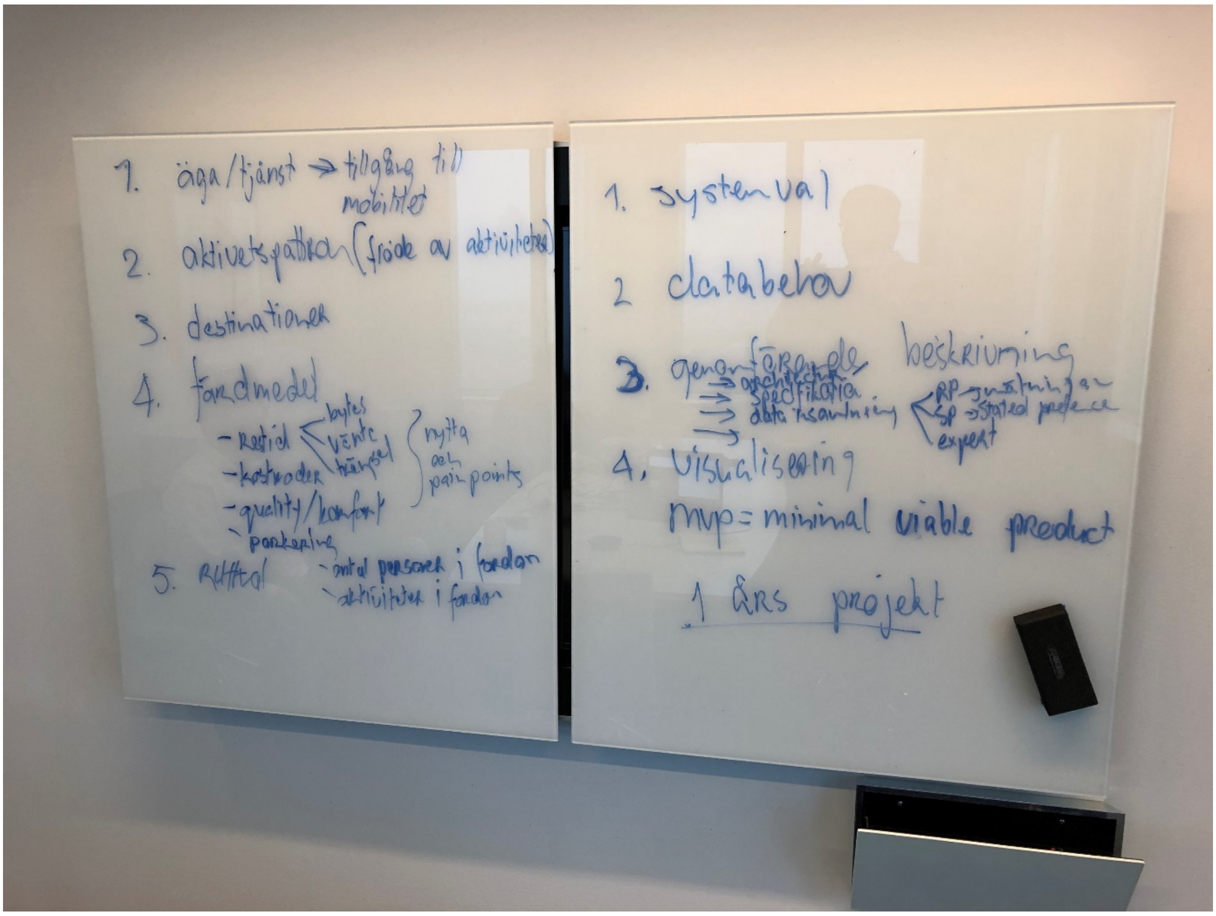
Policy
autonom/manuell
fordon type/drivlinje
fleet size
fordon size
restid (komponenter)
driftkostnader
energi
AHA
- tjänstedesign
- etnografisk metod
Halmstad HS
Göteborg
Halmstad



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Describe some use cases that your institution/company would like to use SIMnVIS platform to solve.

RISE Viktoria

USE CASE 1
1. Description of the use case. What's the question that you want to answer in this use-case?
A simulation- and visualization platform like SIMnVIS could be useful while training machine learning algorithms for autonomous driving. Having access to a virtual test environment where sensors can be simulated realistically would improve productivity and probably also quality.
2. Limitations found in the current simulation-visualization tools that are used by your institution/company to solve the proposed use-case? For example, functionalities, performance, inputs, outputs.
Realistic simulation of sensors and environment. Variability of environments (e.g. specific high-way driving cases, or cities around the world, different weather conditions etc.) and road participants.
3. What are the model requirements of the SIMnVIS platform for your use-case? For example, entities, model approach (like, activity-based model, trip-based model, agent-based model, etc.) level (micro, meso, macro), perspectives (demand, supply)
Probably, micro and meso level simulations of environment (road network and surrounding infrastructure and buildings) with realistic traffic flow (probably agent-based). For this case, training the algorithm requires realistic sensor input (typically using camera and radar) which would require hi-fidelity rendering.
4. How will you evaluate the use case? For example, data required, input parameters, KPI's etc.
As our use-cases typically involve developing, testing and demonstrating on-board vehicle software, evaluations are done as tests with new scenarios. For the autonomous driving case, evaluation would be done by letting the algorithm drive on a new road, or in weather or light conditions in which it was not trained.
5. How will you disseminate the results? Visualization (real-time, 2D, 3D)
Demonstration in a 3D-environment**.**

USE CASE 2
1. Description of the use case. What's the question that you want to answer in this use-case?
Study the impacts of cooperative intelligent transport systems (C-ITS) technologies from a function implementation perspective.

How would a GLOSA (Green Light Optimized Speed Advisory) or TTG (Time to green) function affect the traffic flow? How would it affect unsignalized side-street traffic? How would it affect vehicles without the function? Results from such simulation would pose requirements on the function to have the desired effects. In VICTA Lab such simulation would also provide a way to validate that the implementation complies to those requirements – i.e. simulating with the actual vehicle functionality in the loop.
2. Limitations found in the current simulation-visualization tools that are used by your institution/company to solve the proposed use-case? For example, functionalities, performance, inputs, outputs.
We need variability in: Environment models (big city, small city, high-way etc.) Penetration levels Type of traffic signal system (fixed time, adaptive) Traffic density Driver behavioural models Etc.
3. What are the model requirements of the SIMnVIS platform for your use-case? For example, entities, model approach (like, activity-based model, trip-based model, agent-based model, etc.) level (micro, meso, macro), perspectives (demand, supply)
- Environment models with detailed road network and infrastructure (micro and meso simulation). - Realistic simulation of infrastructure such as traffic signal timing etc. - Agent-based driver behaviour models for equipped and unequipped vehicles (GLOSA/TTG). - Agent-based simulations of various road participants (pedestrian, car, bus, bicycle etc.).
4. How will you evaluate the use case? For example, data required, input parameters, KPI's etc.
KPI:s: - Traffic flow - Travel time - Traffic light stop time - Fuel consumption - Penetration rate - Etc.
5. How will you disseminate the results? Visualization (real-time, 2D, 3D)
Results will typically be KPI:s rather than visualization.

USE CASE 3
1. Description of the use case. What's the question that you want to answer in this use-case?

A new type of urban waterway based logistic system, the new is that due to higher level automation, smaller quantities should be able to distribute by waterways. The barge, is also a form of micro hub for storage as an enabler for “hub and spoke” last/first mile delivery.
The question that we would like to see is IF we have such logistic/transportation system, what could the flows of goods look like, how much less traffic on the congested streets will a shift to waterborne logistic create. And effects /compatible on all types of emissions.

2. Limitations found in the current simulation-visualization tools that are used by your institution/company to solve the proposed use-case? For example, functionalities, performance, inputs, outputs.

Today, there is no model/simulation known to us that are dealing with Urban Waterway Logistics. Current models/simulations that involves shipping (TrV Samgods/Samtrans etc) is not even suitable for Costal/Short Sea Shipping and Inland water ways (a huge factor in EU region).
The concept is “similar” to an electrical truck and different types of trailers, some trailers are “dumb” and is used for transporting landfills/sand/pellets etc. other could be special and sophisticated floating hubs for last/first mile deliveries. They don’t occupy land area in the congested city centre, but they need city planners to keep current berthing/quay facilities or allow new ones.

This is the missing link in multimodal urban logistics.

Traditional simulators for Navigational and operational training (https://osc.no/), could be “incorporated” but they are mainly for training of ship handling, not “logistic flow”.

3. What are the model requirements of the SIMnVIS platform for your use-case?
For example, entities, model approach (like, activity-based model, trip-based model, agent-based model, etc.) level (micro, meso, macro), perspectives (demand, supply)

Urban waterway simulation.

4. How will you evaluate the use case? For example, data required, input parameters, KPI’s etc.

1. Gather data on current situation, could be types of vehicles passing road toll stations, counting vehicle movements visually on street level etc.

2. Test hypothesis if “1% of transport work from A 2 B was using A – load node – water way -Off loading node – B”.
Visualize water way route and transportation work, show reduction of transport work on road network. “Freeing up space, increasing flow on the roads etc.”

3. KPI are similar or same as

4. Reduction in road traffic could also have dimensions as: The city feels safer for pedestrians/bicyclists, children/elderly/impaired

5. How will you disseminate the results? Visualization (real-time, 2D, 3D)

Visualize water way route and transportation work, show reduction of transport work on road network. “Freeing up space, increasing flow on the roads etc.”

Sim n VIS

Describe some use cases that your institution/company would like to use SIMnVIS platform to solve.

USE CASE 1
1. Description of the use case. What's the question that you want to answer in this use-case?
What is the interaction between normal vehicles and cars with different level of automation in terms of queuing and congestions and jamming. And as a system effect, what are the effects in terms of external effects like pollution, accidents, etc.
2. Limitations found in the current simulation-visualization tools that are used by your institution/company to solve the proposed use-case? As an example, vehicle performance and level of service, knowledge about interaction effects.
• The data on relationships are not known today
3. What are the model requirements of the SIMnVIS platform for your use-case? Related to environment (transport infrastructure) travel speed, gaps between automated vehicles /and/or other vehicles. Also dependence of implementation of share of automated vehicles and their level of service
Interest in meso level and macro level. Meaning that simulation and effects regarding interaction between - other, normal cars and vehicle as today - consequences on different levels of share for sim car and normal vehicles - effects regarding queuing - effects regarding congestions and jamming - effects related on different types of transport environment, rural and urban, roads and streets, etc.
4. How will you evaluate the use case? For example, data required, input parameters, KPI's etc.
Data requirements - Transport infrastructure, links and intersection types - And quality of above, width, length, speed limits etc. **Model syntax/processes** **Input parameters** **KPIs** - Vehicle operating costs, including energy consumption - Congestion / travel times - Accidents risks - External effects, emissions
5. How will you disseminate the results? Table and diagram preferable, visualization

SIMnVIS WORKSHOP 2019-02-07

Simulation and Visualization platform for Automated Vehicles and Mobility Services

07 Feb 2019 | Gothenburg | VTI Gothenburg Address

AGENDA

09.45 - 10.00	WAKE-UP COFFEE	15 min
10.00 - 10.05	Welcome to the last WS [Mia Xiaoyun Zhao]	5 min
10.05 - 10.10	Round table: self-intro [All]	5 min
10.10 - 10.30	Current progress of SIMnVIS [Mia Xiaoyun Zhao]	20 min
10.30 - 11.00	**Objective 1**: Use-case analysis [Group Exercise]	30 min
11.00 - 11.05	Short break	5 min
11.05 -11.40	**Objective 2**: The on-going projects and simulators	35 min
11.50 - 12.50	LUNCH BREAK at Kooperativet Address	60 min
13.00 -14.00	**Objective 3**: Mock-up stories	60 min
14.00 - 14.10	SHORT FIKA BREAK	10 min
14.10 - 14.50	**Objective 4**: Further project application	40 min
14.50 - 15.00	FINAL SUMMARY of the day [Mia Xiaoyun Zhao]	10 min
15.00	THE END	

OBJECTIVES:

I. Use cases analysis

- We start with the two use cases and try to fill in the tables.
- We will work in two groups parallel, please check your group information below.

Use case: Read through the proposed one again, discuss and modify it.	
What model syntax should be used?	
What model semantics should be used?	
What model architecture should be formed? (Please draw the architecture if that's possible	
The KPI:s?	
What data are needed?	
How to get the data?	
How to validate the results?	
Other points…?	

Group 1: Mats Lundin (group leader), Magnus Palm, Frida Reichenberg, Andreas Tapani, Mia Zhao

Group 2: Niklas Mellegård (group leader), Per Eriksson, Ulf Ceder, Anna Pernestål, Hugo Badia Rodriguez

II. The on-going projects and simulators

- On-going projects within your institution or you have heard of.
- Fill in the table
- Do it together on the board, here, I suggest the representative from each partner list it, Hugo Badia can mainly fill in the on-going projects in KTH.

On-going projects	
Project name	
Project focus	
Which simulator (if any) is used?	
The possible link to SIMnVIS (e.g.: in which aspects, how)	

III. Mock-up for visualization

- Based on the use cases and the other on-going projects we form the mock-up story
- Work in group for the mock-up story.

Discuss on what current results can be used as a possible example (Last meeting, Volvo, Trafikverket, WSP and VTI all mentioned possible examples, so far we have one from WSP for your reference: https://www.dropbox.com/sh/cfg0wtfc9jken4c/AADFkpWHXuJKhp6WVmIV9ISaa?dl=0	
Mock-up story 1 (Group 1)	Mock-up story 2 (Group 2)

IV. Further project application

- End of the current projects
- Who should deliver what for the final report
- Discuss the further project application (consortium, responsibilities, form, requirements, etc.)

SIMnVIS WORKSHOP 2019-02-07

Simulation and Visualization platform for Automated Vehicles and Mobility Services

07 Feb 2019 | Gothenburg | VTI Gothenburg Address

NOTES:

1. **Use cases analysis**
   We agree on to have two use cases which use case 1 is mainly related to Macro level and use case 2 is mainly related to Micro level.
   Model architectures, KPI:s, data, validation are discussed within each group respective the two use cases.
2. **The on-going projects that can be mapped on SIMnVIS**
   SMART, iQMobility, NordicWay2, Drive me are listed and discussed.
   - **The project partners should deliver information about other projects that you know.** The information should cover at least the points listed in the table below.
   - **Please send it back to** mia.xiaoyun.zhao@itm.kth.se **latest 21 February. And please feel free to share with others within the group.**

Project	
Project name	
Project focus/aim	
Which simulator (if any) is used?	
Which level is focused (Macro, Meso, Micro, Nano)?	
Data?	
The possible link to SIMnVIS (e.g.: in which aspects, how)	
Feel free to add more points….	

3. **Mock-up for visualization**

We agreed on that we will have a mock up based on the SIMnVIS background story line and list some scenarios. It may be a presentation or a film (Mia will have a discussion with the communication colleagues in ITRL and decide on the final form)
In the mock-up, we will follow four levels, the model optimization, system effects, 2D visualization and 3D visualization. For each we can have snapshot of existing results.

- **Mats need to check the drive me materials and send to** mia.xiaoyun.zhao@itm.kth.se **for 2D visualization latest 21 February.**
- **If there is any other materials that can be used, all projects partners should send to** mia.xiaoyu.zhao@itm.kth.se **latest 21 February**

4. **Further project application**

We agreed on that we will have a joint proposal for the further application.

- KTH-ITRL will take the lead to hold the next workshop on forming the project proposal.
- The workshop will be at 2019-03-11, 10.00-16.00, ITRL, Stockholm. Further practical information will be sent out 2019-03-04.
- Before the workshop, KTH-ITRL need to prepare a sketch of the proposal and send it to all participants latest 2019-03-04.
- Before the workshop, each project partner need to prepare a concrete document that covers at least the points listed in the table below for us to have a good preparation for the workshop. The document need to be sent out to each other latest 2019-03-04:

Points to cover (but not limited to…)	
Use case(s)	
Inititives	
Modelling environments	
Expectations	
Roles?	
Feel free to add more points….	

Several possible funding bodies: Drive Sweden (roadmap 2019), EUTS, SOSSUM, SPETs, FFI-strategic, Trafikverket.

Small scale→Drive Sweden, Large scale →Spets (many resources have been distributed out and we need to polish, and it is horizontal view)

Step 1 can be good to use the innovation cloud to prove the concept.

Step 2 we look the partners in a much bigger platform.

The time line: spring (April, June). It could be possible that we split the funding from different sources. The model architecture work package could be related to Drive Sweden. The meet-up place is very important to exchange knowledge, share ideas, discuss and find cooperation opportunities.

If we agree on the idea to start the first step, getting the architecture in place, collecting the data, build the framework, create the meeting place, connect already on-going Ph.D. students and projects to this meet-up place, it would be good if we identify the use cases, one for goods and one for person transport.

Identify the use cases

The goods/logistic use case, because we also have temporal and spatial dependency. It is not necessarily representing here and now, but what we do here and now actually affects the future.

The person transport use case related to MaaS.

Electrification charging, geo fencing, policy, business model in the transport ecosystem.

Simulation and Visualization platform for Automated Vehicles and Mobility Services (SIMnVIS)

Project team (order by organization):

- Xiaoyun Zhao - Project coordinator Post Doctoral researcher, KTH ITRL
- Anna Pernestål – Ph.D. Director of ITRL, KTH ITRL
- Hugo Badia Rodriguez - Post Doctoral researcher, KTH ABE
- Mats Lundin - Senior Manager Research Strategy, Volvo Car
- Dirk van Amelsfort - Research Director International Transport Studies, WSP
- Andreas Tapani – Research Director, VTI
- Ulf Ceder – Senior Research Manager, Scania
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Date: 22-03-2019

The project is a collaboration of:

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1. Introduction

The development of automated vehicles and new mobility services lead us to a situation that we need to start thinking new models and platform to evaluate the system effects since the traditional syntax, terms and context will not apply anymore. To support its development, new and updated requirements of tools and methodologies are needed. However, it is very cumbersome, time consuming and costly to apply new vehicle concept on the road in reality. It is necessary to build an open, modular simulation and visualization platform, where the impacts of automated vehicles and integrated mobility services can be demonstrated, investigated and visualized. This platform can connect modeling environment, test technologies, identify efficient business model and evaluate impacts related to business models, increase resource efficiency on land use and construction of infrastructures.

In order to make the platform possible, we need to have common view, from both the technical aspects to the measurements (KPIs) and to the mock-up visualization for showing the outputs/results. The state of art analysis shows how the current tools are used, which modelling frameworks are available and how mature they are. The use cases set the application scenarios based on stakeholder's requirements and the mock-up visualization is built up through the vision.

2. State of the art analysis

The state of the art analysis[1] provides an overview of possible modeling frameworks for the development of a simulation platform. This platform should be a tool for the simulation-based analysis of self-driving vehicles and mobility services. Therefore, depending on the final objective of the analysis, we will require different kinds of approach. On the one hand, traffic simulation with a high level of detail allows the evaluation of the driving behavior and the interaction between vehicles on the road. In this way, the simulation will provide information about road capacity, speed, etc. On the other hand, from the transport planning perspective, we are interested in the competition between different mobility services and the demand behavior with regard to the supplied transport system. This will provide conclusions about the design of transport services, modal split, new mobility concepts, business models, etc.

With these goals in mind, we summarize some of the current traffic and transport simulators or simulation platforms that provide modelling frameworks on we can develop the future platform. These pre-existing tools can be improved in different directions to meet the requirements. For traffic simulation, three tools for the microscopic level of analysis are included: SUMO, AIMSUN and VISSIM. These simulators describe the dynamics of individual vehicles in a disaggregated way. The motion of each vehicle is determined by car-following models and lane-changing models. They describe the driver actions (safe distances, acceleration, deceleration and lane changes) in front of the traffic environment. VISUM is presented as a macroscopic simulator for

[1] More detail information can be found in a separate report.

transport planning. In this case, the modeling approach assumes that traffic flows are characterized in an aggregated way by the time-space relationship between macroscopic variables: density, volume and speed. Finally, MEZZO is a simulator at mesoscopic level of analysis. It is an intermediate solution based on simplifications of traffic flow dynamics of individual vehicles.

On the other hand, microscopic agent-based modelling for transport planning is introduced. Unlike the previous microscopic models, the term microscopic here refers to individual demand behavior of each person or agent. However, the level of detail in the traffic flow dynamics is less precise. MATSIM is a multi-agent transport simulator. Additionally, BEAM and AMODEUS are described. They are other tools developed on the MATSIM modeling framework. Alternatively, three modelling frameworks are presented for the development of agent-based models that can be applied to transport analysis: GAMA, POLARIS and ANYLOGIC.

The analysis of the tools has been done according to requirements previously included in other traffic simulation taxonomies. The aspects considered are:

- Software **category**. The distinction is between ***open source*** and ***commercial software***. The former group allows us the free use of the software and access to the source code. Therefore, other programmers can study, modify and improve the initial code for specific purposes and add new modules. Commercial software has a charge for use and the modification of the original code is not possible or has strong limitations.
- Software **portability**. In what operating systems the software can work. The main relevant operating systems are Windows, Linux and MacOS.
- Model **category**. There are three different levels of analysis in the simulation field: ***microscopic***, ***mesoscopic*** and ***macroscopic***.
- Model **edition** and **user interface**. Easy or complex interaction with the software. How can users build the simulation? By means of text files, XML files or graphical user interface. An intuitive graphical environment makes the tool user-friendly.
- **Infrastructure**. The road network on the simulation is composed by roads and intersections.
- **Entities**. ***Type*** of vehicles: car, motorbike, public transport, bikes, priority vehicles such as ambulances or police cars, etc. ***Characteristics*** of vehicles: dimension, speed limits, weight, height, width, etc. Other entities included are ***pedestrians***.
- **Demand** Model. OD matrices or Activity-based model.
- **GIS**. The capability to import maps from geographic information systems to encode road network.
- **Outputs**. Data, statistics and files obtained at the end of the simulation. ***Environmental impact***, that is, the availability of the software to calculate fuel consumption, emissions and noise pollution.

– **Visualization**. In this item, we discuss how the software shows the results of the simulation. Two-dimensional (***2D***) or three-dimensional (***3D***) visualization and the level of realism.

		Model Category			
		Micro		**Meso**	**Macro**
		TFD	***ABM***		
Software Category	**Open source**	SUMO	MATSim (BEAM; AMoDeus) GAMA POLARIS	Mezzo (BusMezzo)	---
	Commercial	AIMSUN VISSIM	AnyLogic	---	VISUM

Figure 1: Simulation tools that in software and model categories and run in micro, meso and macro levels

3. Stakeholder analysis

Stakeholders that are commonly listed include Trafikverket, Transportstyrelsen, cities, automakers, mobility service suppliers, OEM, academia, freight dispatchers, and infrastructure providers as is shown in Figure 2.

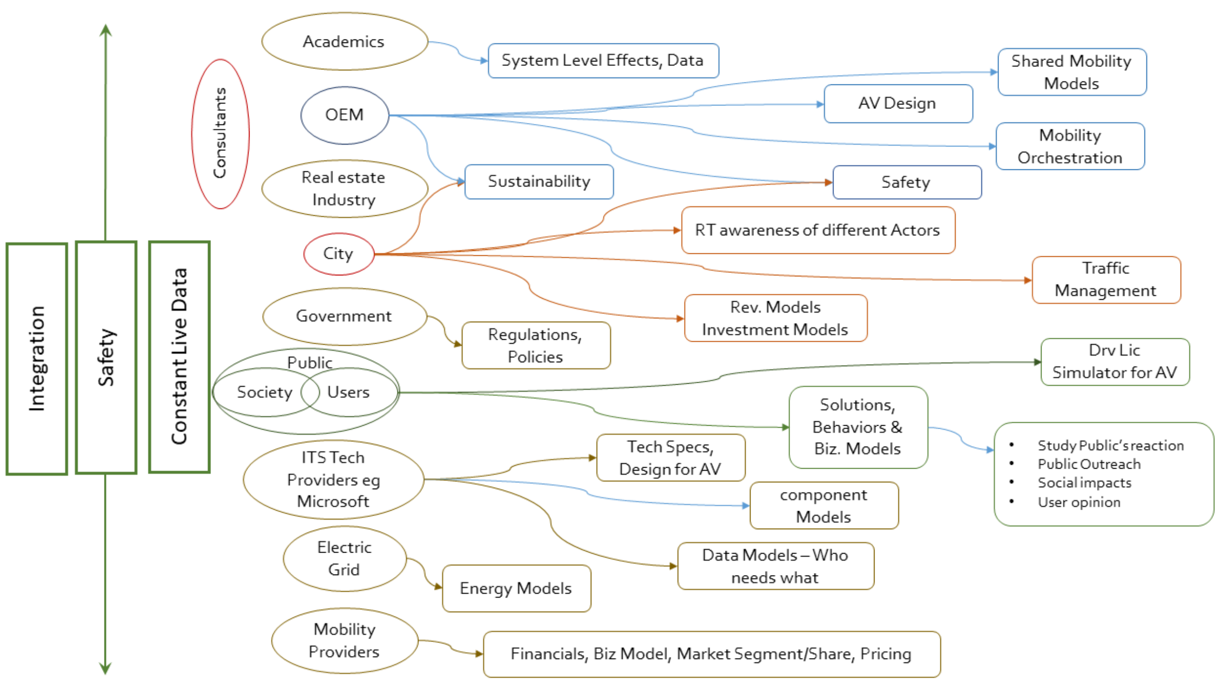

Figure 2: Stakeholders that can benefit from using SIMnVIS

The use-cases vary due to the dynamic of stakeholders' requirements. In general, regulation change, road infrastructure, vehicle design, business models related to automated vehicle and mobility services draw the common interests. In order to support the future types of vehicles and mobility services, there is a need to have a certain type of platform, where stakeholders from different areas can meet up, test new demo vehicles and services and optimize them prior to having them in reality. SIMnVIS plays also as such a platform, along the workshop and meetings in SIMnVIS, two use-cases have been identified as list in the tables below.

Table 1: Three use-cases that identified through SIMnVIS meet-ups

USE CASE 1

1. Description of the use case:

What is the optimal deployment (business model) of a shared vehicle service in terms of vehicle type (level of automation, drive line, vehicle size, driving environments) and service offer (waiting times, price, quality), and what are the traffic, economic and environmental effects of such a service.

2. Limitations found in the current simulation-visualization tools that are used to solve the proposed use-case?

- The descriptions/syntax of services, vehicle types and vehicle behavior does not exist in current simulation and visualization tools
- The description/syntax of infrastructure (both road, parking, drop-off and pick-up, charging) is insufficient/inappropriate to simulate the use of new vehicle types
- The description/syntax of behavioral choices, both on the level of choosing access to mobility (car ownership, buying subscription, etc.) as well as on a trip/level are insufficient to describe market shares of different services and vehicle types.

3. What are the model requirements of the SIMnVIS platform for the use-case?

Considering the scope of the use case, assessing the optimal service deployment based on individual choices and societal outcomes, it is perceived that an activity-based agent-based simulation would be most appropriate since such a framework will be able to:

- Address all the relevant behavioural responses ranging from location choices, activity patterns to dynamic route choice changes
- Address key characteristics of new vehicles types and their behavior in a flexible manner and in mixed conditions (varying levels of market shares)
- Explicitly model the business model (dispatch model) of a shared vehicle service
- Address key characteristics of infrastructure changing and V2X communications in a flexible manner
- Simulate the flow of vehicles/traffic through the road network

For example, entities, model approach (like, activity-based model, trip-based model, agent-based model, etc.)
level (micro, meso, macro), perspectives (demand, supply)

The SIMnVIS platform would be required to describe:

- Characteristics of new vehicle types
- Characteristics of a dispatch model of shared vehicles to users

- Characteristics of infrastructure components
- Choice behavior of consumers

4. How should we evaluate the use case?

Data requirements

- Infrastructure: digital description of roads, parking, etc.
- Population and employment data
- Land use data
- Vehicle characteristics and behavior
- Social

Model syntax/processes

- Business model: a model component that includes the algorithms for sending out a vehicle with certain characteristics and price to a specific customer call for a trip
- Travel demand model: a model component that determines choices of individual on a variety of levels: access to mobility (ownership vs service), activity pattern, destinations, mode/service choice, departure times, route choice
- Infrastructure: connectivity algorithms and use cases, traffic/vehicle flow algorithms

Input parameters

- Policy parameters
- Business model and service design parameters
- Behavioral parameters

KPIs

- Market share
- Usage and occupancy levels of vehicles
- Revenues
- Operating costs
- Congestion / travel times
- Occupancy parking
- Energy use
- Emissions

- Distributional / equity effects
5. How should we disseminate the results? A combination of 2D, 3D and aggregated descriptive KPIs in tables and graphs would be appropriate to disseminate results from the simulation.

USE CASE 2
1. Description of the use case. Study the impacts of cooperative intelligent transport systems (C-ITS) technologies from a function implementation perspective. How would a GLOSA (Green Light Optimized Speed Advisory) or TTG (Time to green) function affect the traffic flow? How would it affect un-signalized side-street traffic? How would it affect vehicles without the function? Results from such simulation would pose requirements on the function to have the desired effects. In VICTA Lab such simulation would also provide a way to validate that the implementation complies to those requirements – i.e. simulating with the actual vehicle functionality in the loop.
2. Limitations found in the current simulation-visualization tools that are used to solve the proposed use-case? We need variability in: Environment models (big city, small city, high-way etc.) Penetration levels Type of traffic signal system (fixed time, adaptive) Traffic density Driver behavioral models
3. What are the model requirements of the SIMnVIS platform for the use-case? - Environment models with detailed road network and infrastructure (micro and meso simulation). - Realistic simulation of infrastructure such as traffic signal timing etc. - Agent-based driver behaviour models for equipped and unequipped vehicles (GLOSA/TTG). - Agent-based simulations of various road participants (pedestrian, car, bus, bicycle etc.).
4. How should we evaluate the use case? KPI:s: - Traffic flow - Travel time - Traffic light stop time - Fuel consumption - Penetration rate
5. How should we disseminate the results?

Results will typically be KPI:s rather than visualization.

4. Projects that can link to SIMnVIS

The overall objective of identifying existing projects is to further understand today's traffic models to enable analysis of future transport systems of automated vehicles and mobility as a service. The project listed in the table below summarizes the project aim and the level that that the project focus on. The simulator used and the possible link to SIMnVIS helps to form a whole picture for SIMnVIS to evaluate the system effects.

Table 3: Projects that can link to SIMnVIS on different levels

Project 1	
Project name	**iQMobility Automated Bus Services**
Project focus/aim	To develop a prototype of a transport system for inner city traffic with automated buses. Within the scope of the project, the advancement in key technology areas will enable to demonstrate the following scenarios.
Which simulator (if any) is used?	BusMezzo
Which level is focused (Macro, Meso, Micro, Nano)?	Meso
Data?	-
The possible link to SIMnVIS (e.g.: in which aspects, how)	1. Automated depot handling 2. Autonomous driving in urban environments, with enhanced road user interaction; 3. On-line coordination of multiple busses in urban environments; 4. Coordinated autonomous driving of two vehicles, in urban environments.
Project 2	
Project name	**WSP New Mobility 2019**
Project focus/aim	To develop a planning tool to support the generation of macro scenarios for traffic models
Which simulator (if any) is used?	System Dynamics software + in-house developed python scripts
Which level is focused (Macro, Meso, Micro, Nano)?	Macro
Data?	-
The possible link to SIMnVIS (e.g.: in which aspects, how)	Concerning same type of issues (autonomous vehicles, shared mobility services). But modeling aggregated/total volumes over time, not traffic.
Project 3	
Project name	**Norra Djurgårdsstaden**

Project focus/aim	Applied project to check the traffic situation in an development area with 30 000 new workplaces and 10 000 new inhabitants. Existing harbors will remain in operation which is the main traffic challenge.
Which simulator (if any) is used?	Transmodeler
Which level is focused (Macro, Meso, Micro, Nano)?	Hybrid micro/meso
Data?	Demand data: Ferries, heavy transport, work, other. Network data: road, rail, signals, transit, bike.
The possible link to SIMnVIS (e.g.: in which aspects, how)	Provision of applied data and networks.
Project 4	
Project name	**Inner city model of Stockholm**
Project focus/aim	Simulation of Stockholm inner city
Which simulator (if any) is used?	Transmodeler
Which level is focused (Macro, Meso, Micro, Nano)?	Micro
Data?	Network: Car, bus, signals. Demand: cars, busses.
The possible link to SIMnVIS (e.g.: in which aspects, how)	A relatively large applied micro model that can be used.
Project 5	
Project name	**Kodning av regioncentrummodellen**
Project focus/aim	Development of a network model for the regional centre of Stockholm
Which simulator (if any) is used?	Transmodeler
Which level is focused (Macro, Meso, Micro, Nano)?	Meso
Data?	Network: car. Demand: Car (by 15-minute interwall), heavy
The possible link to SIMnVIS (e.g.: in which aspects, how)	Data that can be used in applications.
Project 6	
Project name	**CoEXist**
Project focus/aim	Development of AV-ready traffic and transport models and applying them on real use cases to assess the automation readiness of road infrastructure
Which simulator (if any) is used?	Vissim and Visum
Which level is focused (Macro, Meso, Micro, Nano)?	Micro and Macro
Data?	Field test of automated vehicles in Helmond Videobased measurements from a shared space in Gothenburg
The possible link to SIMnVIS (e.g.: in which aspects, how)	Development and application of simulation models for assessment of traffic performance of the introduction of automated vehicles

	Ongoing micro simulations of a shared space in Gothenburg and macro model evaluations of Gothenburg region using Visum.
Project 7	
Project name	**SMART**
Project focus/aim	Development of microscopic and mesosopic traffic simulation models to enable investigations of traffic performance effects of the introduction of autoamted vehicles and fleets of automated vehicles for first/last-mile service in a public transport system
Which simulator (if any) is used?	Sumo / Vissim / BusMezzo
Which level is focused (Macro, Meso, Micro, Nano)?	Micro and Meso
Data?	
The possible link to SIMnVIS (e.g.: in which aspects, how)	Development and application of simulation models for assessment of automated vehicles

5. Mock-up visualization

To develop a virtual transportation system simulation platform, in which city planners, architects, builders, manufacturers, researchers and other interested parties will be able to simulate and visualize different conditions of transportation scenarios. Such as travel patterns, emissions, road constructions, new mobility services, new types vehicles etc. The visualization platform is intended to give the opportunity to test different approaches and to make informed decisions before the plans are finalized and implementation started. The possibility of simulating in advance will not only be of help in the planning process but also improve cost and time efficiency, and aid in designing the best quality conditions in the interested areas of the stakeholders.
The mock-up visualization can be seen in the following link:
https://www.dropbox.com/s/ipseq8z2qol2s6z/Sequence%2001.mp4?dl=0

6. Conclusions & future research

The pre-study is to gather stakeholders and map their requirements on a platform for simulation and visualization of automated vehicles and mobility as a service.

- The goals that have been fulfilled through this pre-study project is:
- Identified and compared the existing simulation tools in a state-of-the-art analysis.
- Formulated requirements on the open simulation and visualization platform through stakeholder analysis.
- Described the vision and eventually visualized this in a mock-up visualization.
- Refined ideas and create further project proposals in dialogue.

There are four main results gotten from the pre-study project.
First, the result of stakeholder analysis (requirements, KPI:s), model architectures and model techniques within a system-of-system perspective.

Second, state-of-the-art analysis that inspected the modelling frameworks that are available and and their characteristics.
Third, visualization requirements and a mock-up visualization showing the vision.
Fourth, further research project application to define criteria for the creation of a "digital twin" solution for automated vehicles and mobility as a service.
The project was conducted mainly in two phases to fulfill the goals.

- In Phase 1, the state-of-the-art analysis was conducted focused on representative simulation tools and models. One workshop and one meeting have been held to identify stakeholders, KPI:s corresponding to stakeholder requirements.
- In Phase 2, one meeting and one workshop have been held to set up the mock-up visualization. The potential of mapping current simulation related projects on to SIMnVIS. Phase 2 also identified the scenarios, use-cases and needs on system effects for a further project application.

For the future work, we need to build the model plat form. Test the model platform in defined use cases, and validate the model by integrating data in data library. The system level effect will be evaluated and the visualization will be set through different ways according to the needs. Results dissemination, project management, platform maintenance and update will also be a focus that will be covered in the continuous future work.