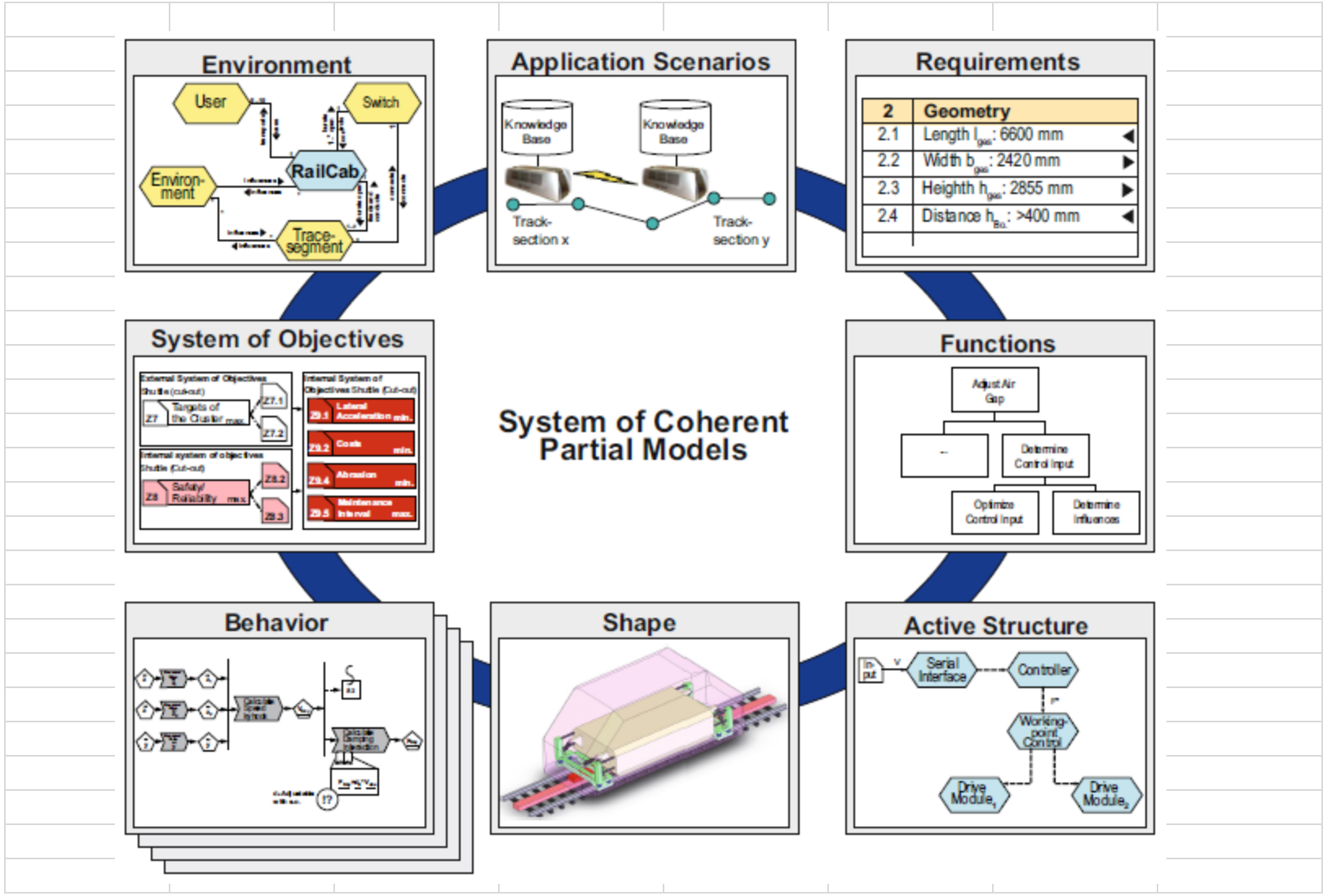
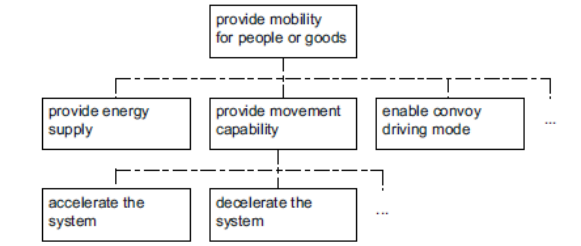

Environment
User
Switch
Environ-ment
RailCab
Trace-segment
Application Scenarios
Knowledge Base
Knowledge Base
Track-section x
Track-section y
Requirements
2 Geometry
2.1 Length l_geo: 6600 mm
2.2 Width b_geo: 2420 mm
2.3 Heighth h_geo: 2855 mm
2.4 Distance h_Bo.: >400 mm
System of Objectives
Functions
Adjust Air Gap
Determine Control Input
Optimize Control Input
Determine Influences
System of Coherent Partial Models
Behavior
Shape
Active Structure
Serial Interface
Controller
Working-point Control
Drive Module1
Drive Module2

Requriement list			
No	**Requriement description**		**Type (D/W)**
1	Geometry		
1.1	The gap between following trucks should be not more than 3 meters.		D
1.2	Road clearance of each truck should be not less than 30cm.		W
1.3	Turn radius of each truck should be less than 15m		D
1.4	The minimum load should be more than 10 tonns		W
1.5	Each fully loaded truck should be able to make a trip on a distance at least 1500km.		W
1.6	Size of trucks:		
1.6.1		lenght not more than 20m	W
1.6.2		width not more than 2.5 meters	D
1.6.3		height not more than 3.5 m	D
1.7	The length of a platoon should be limited to 7 vehicles		D
2	Communications		
2.1	All trucks should be able to broadcast and recieve platooning information through V2V		D
2.2	The system in the ego truck shall broadcast its actual and intended acceleration via V2V to enable following vehicles to detect emergency braking events.		D
2.3	The ego truck shall be informed in case of emergency braking events of the preceding trucks in the platoon. Therefore at least the requested and actual acceleration value of the preceding platoon truck must be received and to be compared with a defined acceleration threshold value.		D
2.4	All trucks should be able to use folowing protocols and standards for communication: Wifi, Bluetooth, LoRaWAN, EnOcean		W
2.5	All vehicles should be provided with secure communication channel according to the X.509 standard		D
2.6	Communication latency should be less than 10ms		D
2.7	Each platoon should assign roles to trucks in time less than 1 minute		W
2.8	If the leader truck disengages from the platoon, the former first follower truck becomes the leader truck		D
2.9	The system shall detect and broadcast a cut-in when detected.		D
3	Safety		
3.1	Emergency brake distance should be not more than 20m when the speed is not higher than 60 kmph		D
3.2	In case of failure of ADAS the drive control should be assigned to the driver in less than 2 seconds		D
3.3	Platoon should be able to proceed the route with the speed of side wind 20m/s		W
3.4	The system shall keep a time gap to the preceding truck such that it can avoid collision if the preceding truck is braking to standstill with its maximum deceleration capacity.		D
3.5	The system shall communicate the ego vehicle maximum brake deceleration capacity, if unknown: 8 m/s^2		W
3.6	The system shall never keep a closer time gap than 0.8 s to the preceding truck in the platoon.		D
3.7	The speed limit for platoon should be 100 kmph		W

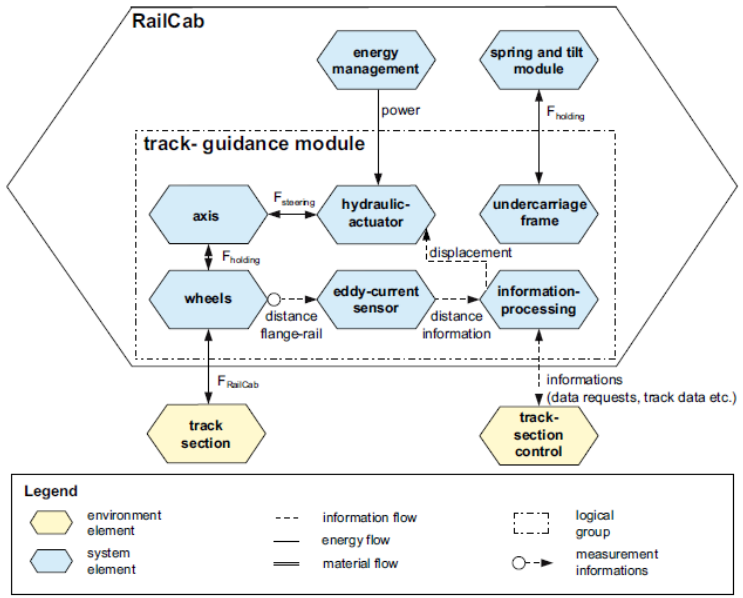
3.8	The system shall be able to inform the preceding truck that it cannot reach the intended time gap, i. e. the gap is too large, by communicating a desired maximum speed request.		D
3.9	The system shall be able to inform the preceding truck about its performance limitations by communicating a desired maximum acceleration request and a desired maximum speed request.		W
3.10	During platoon formation the truck shall detect preceding truck and measure the position of these with a longitudinal accuracy of 0.4m, a range of 200m and an opening angle of +/- 4° with an azimuth accuracy of 0.1°		D
3.11	The system shall not brake with a deceleration that is higher (stronger braking) than the maximum brake deceleration capacity communicated to the other platoon vehicles.		D
4	Driver satisfaction		
4.1	Cabin size		
4.1.1		the height should be not less than 1.8m	W
4.1.2		the lenght should be not less than 2m	W
4.1.3		the width should be not less than 2m	W
4.2	Vehicle Max speed should be not less than 90kmph		W
4.3	The vehicle should be equipped with an embedded refrigirator		W
4.4	The vehicle should have at least 2 sleep places		W
4.5	The vehicle should have easy access to the emergency mechanisms and exits		D
4.6	The vehicle should have customization of drive controls		W
4.7	The system shall not brake more than needed to keep the selected time gap to the preceding truck		W
4.8	Minimize sensitivity to the sidewind		W
5	System interaction		
5.1	The driver in a platoon should be able to recognize that the ego-truck has a platoon feature		D
5.2	The driver in a platoon can activate the platoon mode at any time. The system determines if and when parameters are met to start the search for other platoon trucks		D
5.3	The driver in a platoon shall be informed his role in the platoon driving as Leader, Follower		D
5.4	The driver in a platoon shall be informed about platooning system failures and their causes		D
5.5	The driver in the platoon shall be warned in case of an Emergency brake situation.		D

Requirements list		
No.	**Requirement description**	**D/W**
1	Geometry	
...	...	...
1.9	Entrance should be possible from both sides.	D
1.10	Optimal aerodynamics for single and convoi drive modes.	D
1.11	Modular construction.	D
...	...	...
2	Kinematics	D
2.1	The vehicle has a steering system.	D
...	...	...
7	Safety	
...	...	...
7.9	Provide emergency mechanisms and exits.	D
7.10	Minimize sensitivity to the side wind.	W
...	...	...

No	Name	Subclass		
1	Provide mobility for trucks carrying goods	Provide autonomous movement capability		
1.1			Provide ACC capabilities	
				Maintain a chosen velocity and distance between a vehicle and the vehicle ahead
				Avoid obstacles
				Automatically brake or accelerate
			Provide Lane keeping capabilities	
				Detect Lanes
				Maintain and control distance to lanes
			Provide Navigation system capabilities	
			Provide Blind spot monitoring capabilities	
				Detect and notify if any obstacles come close to the vehicle.
			Provide Crosswind stabilization	
				Distribute the wheel load in relation to the velocity and direction of the crosswind
		Provide platooning capability		
			Providing platoon formation	
			Disenanging from platoon	
			Engaging to platoon	
			Enable platoon braking mode	
			Enable platoon driving mode	
			Enable platoon searching mode	
		Provide secure communications		
			Encrypt messages between trucks	
			Decrypt messages between trucks	
			Provide communication according to local standards and regulations	
		Provide system interaction with driver		
			Provide mode selection: Manual or Autonomous	
			Provides GUI for interaction	
			Provides warnings and displays information	

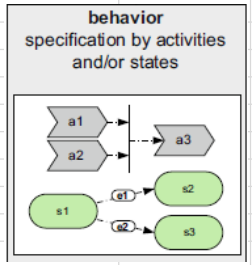


No	Name	Logical group	Type	Connection's name	Connection type	Connected to the No
1	Platooning system	main group	System element		Information flow	
1.1	ACC Module	acc group	System element		Information flow	1.2
1.2	Brake control system	break group	System element		Information flow	1.1
	Brake control system	break group	System element		Information flow	
	Hydraulic actuator	break group	System element		Information flow	
	GPS receiver	Communication g	System element		Information flow	
	on-board computer (OE	Communication g	System element		Information flow	
	Leading truck		environmental element			
					energy flow	
	Brake control system	break group	System element		energy flow	
	Hydraulic actuator	break group	System element		energy flow	
	Brakes	break group	System element		energy flow	
	Wheels	break group	System element		energy flow	
					material flow	
	Precipitations on road		environmental element		material flow	
	Wheels	break group	System element		material flow	
					measurement informations	
	Speedometer	break group	System element		measurement informations	
	Wheels	break group	System element		measurement informations	
	GPS antenna	Communication g	System element		measurement informations	
	GPS receiver	Communication g	System element		measurement informations	
			environmental element			

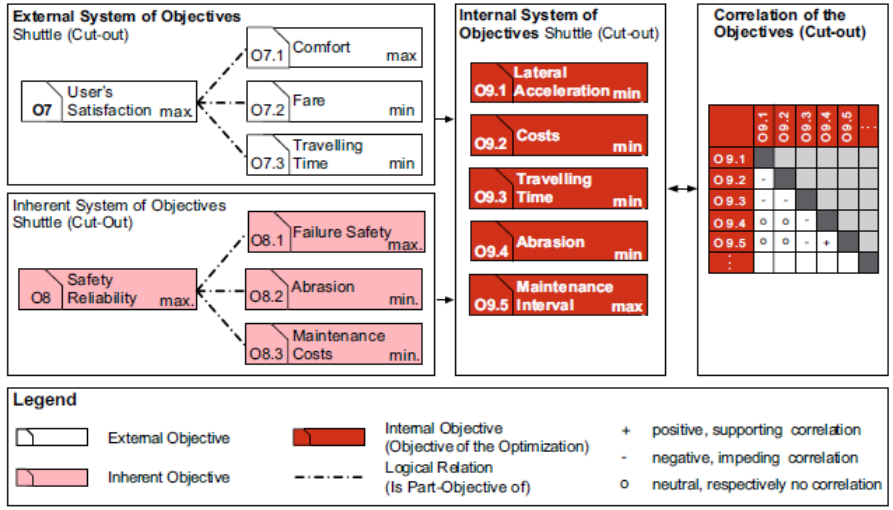


			Screenshots from Carla	
			difefrent views: frond, side, 3d	

we can use sequence diagram and state machine digram

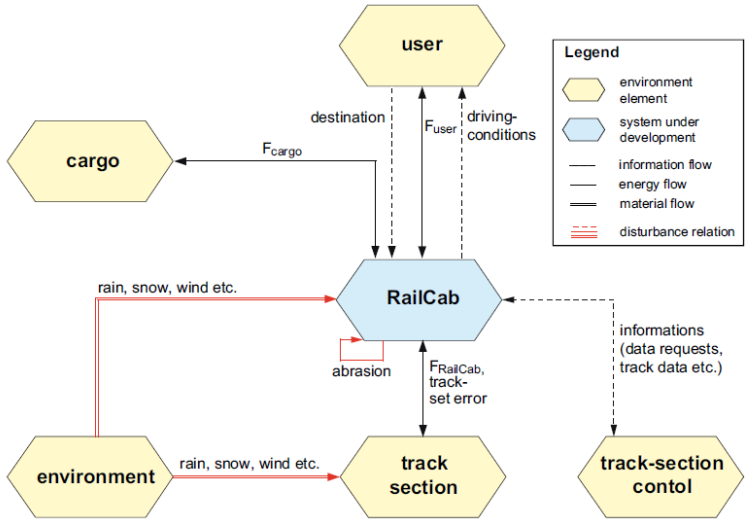


No	Type	System name	Objective
EO1	**External system of Objectives**		
EO1.1		*Driver satisfaction*	
EO1.1.1			Refuel stops (min)
EO1.1.2			Comfort (max)
EO1.1.3			Engage time (min)
EO1.1.4			Interaction with system (min)
EO1.1.5			Vehicle load (max)
EO1.1.6			Safety(max)
EO1.2		*Customer satisfaction*	Safety(max)
EO1.2.1			Vehicle load (max)
EO1.2.2			Delivery time (min)
EO1.2.3			Fuel consumption (min)
EO1.2.4			Platoon lenght (max)
InhO2	**Inherent system of Objectives**		
InhO2.1		*Reliability*	
InhO2.1.1			Failure safety (max)
InhO2.1.2			Abrasion (min)
InhO2.1.3			Maintenance cost (min)
InhO2.2		*Safety*	
InhO2.2.1			Communication quality (max)
InhO2.2.2			Platoon controllability (max)
InhO2.2.3			Platoon lenght (min)
IO3	**Internal system of Objectives**		
IO3.1			Selected route distance (min)
IO3.2			Abrasion (min)
IO3.3			Fuel capacity (max)
IO3.4			GUI usability (max)
IO3.5			Vehicle load (max)
IO3.6			Vehicle speed (max)
IO3.7			Telecom. security level (max)



	IO3.1	IO3.2	IO3.3	IO3.4	IO3.5	IO3.6	IO3.7
IO3.1							
IO3.2	+						
IO3.3	-	-					
IO3.4	0	0	0				
IO3.5	0	-	-	0			
IO3.6	0	-	-	0	-		
IO3.7	0	0	0	-	0	0	

No	Object	Connection name	Connection type	Connected to
1	Folowing truck	Control signals	information flow	Leading truck
	Leading truck			
	Driver	Manual control->, platoon system's conditions<-,	energy, information	
	Environment	impact from nature	material	
	Lane markup	car positioning	infrmation	
	Cargo	F cargo	energy,	
	Service Company	technical data	information	
	Folowing truck	abrasion	energy	

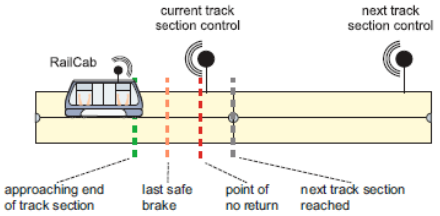


No	Scenario name	Date	Code	Description	Solution	References
1						
		in the google docs document				

A	Application Scenario Drive onto next track section	Jul. 17, 2010	AS12	Page: 1

Description of the partial development task AS12: When the RailCab is driving on a track section, it is at some point notified that it approaches the end of the track section. Then, the RailCab must obtain the information, whether it may enter the next track section, from the corresponding section control. This information must be available to the RailCab before the RailCab reaches the point of the last safe brake. This point precedes the point of no return, beyond which it cannot be guaranteed that braking will safely stop the RailCab before it enters the next track section.

Principle solution for AS12: The RailCab, when reaching the end of the track section, sends a request to enter the next track section to the section control responsible for the next track section. Then the section control replies, stating whether entering the track section is currently allowed or not. The reply is sent in time for the RailCab to receive it before it reaches the point of the last safe brake.



Reference to Application Scenario Specific Cut-out of
- Requirements
- Environment
- Active Structure
- ...

id	License Number	Destination	Distance	Platoon Destination	Platoon Number	Max Platoon Size	Platoon Size	Assigned role
1	1	Dortmund	400	Dortmund	1	1	1	searching
	2	Dortmund	400	Dortmund	1	2	2	searching
	3	Dortmund	400	Dortmund	1	3	3	searching
3	3	Dortmund	400					Lead
2	5	Dortmund	400	Dortmund	1	2	1	Follower
		Dortmund	100	Hamburg	1	2	2	Searching
4	4	Dortmund	400	Dortmund	1	2	1	Follower
5	5	Dortmund	400	Dortmund	1	3	1	Follower
6	6	Dortmund	400	Dortmund	1	3	2	Follower
7	7	Dortmund	400	Dortmund	1	3	3	searching
		Dortmund	400	Dortmund	1	2	3	Follower
		Dortmund	400	Dortmund				Lead
4	4							
5	5	Dortmund	100	Hamburg	1	2	1	Searching
6	6	Dortmund	100	Hamburg	1	2	3	Searching
7	7	Dortmund	100	Hamburg	1	2	3	Searching
8	8							

Assigned_Role	Assigned_Role_Id	Route_Destination	Distance	Platoon_Destination	Platoon_Destination_Id	Platoon_Number	Max_Platoon_Size	Platoon_Size	Distance_to_platoon	Weather_condition	Truck_load	Truck_load_limit	Timeout
Searching	0	Dortmund	400	Dortmund	1	1	1	1	200	1	20	20	0
Searching	0	Dortmund	400	Dortmund	1	1	2	2	100	1	10	20	0
Searching	0	Dortmund	400	Dortmund	1	1	3	3	100	1	20	20	0
Lead	1	Dortmund	400	0	0	0	0	0	0	1	10	20	0
Follower	2	Dortmund	400	Dortmund	1	1	2	1	2	1	20	20	0
Searching	0	Dortmund	100	Hamburg	2	1	2	2	500	1	10	20	0
Follower	2	Dortmund	400	Dortmund	1	1	2	1	50	1	20	20	0
Follower	2	Dortmund	400	Dortmund	1	1	3	1	10	1	10	20	0
Follower	2	Dortmund	400	Dortmund	1	1	3	2	2	1	15	20	0
Searching	0	Dortmund	400	Dortmund	1	1	3	3	40	1	10	20	0
Follower	2	Dortmund	400	Dortmund	1	1	2	3	2	1	10	20	0
Lead	1	Dortmund	400	Dortmund	1	0	0	0	4	1	12	20	0
Searching	0	Dortmund	100	Hamburg	2	1	2	1	40	1	14	20	0
Searching	0	Dortmund	100	Hamburg	2	1	2	3	20	1	10	20	0
Searching	0	Dortmund	100	Hamburg	2	1	2	3	30	1	20	20	0
Searching	0	Dortmund	10	Duisburg	3	1	5	2	12	2	10	20	0
Lead	1	Dortmund	10	Duisburg	3	1	5	2	12	2	10	20	1
Lead	1	Dortmund	10	Duisburg	3	1	5	2	12	2	10	10	1
Lead	1	Dortmund	10	Duisburg	3	1	5	2	12	2	10	15	1
Lead	1	Dortmund	10	Duisburg	3	1	5	2	12	2	10	20	1
Lead	1	Dortmund	10	Duisburg	3	1	5	2	12	2	15	20	1
Lead	1	Dortmund	10	Duisburg	3	1	5	2	12	2	20	20	1
Lead	1	Dortmund	10	Duisburg	3	1	5	2	12	2	15	20	1

Assigned_Role_Id	Route_Destination_	Distance	Platoon_Destination_Id	Platoon_Number	Max_Platoon_Size	Platoon_Size	Distance_to_platoon	Weather_condition	Truck_load	Truck_load_limit	Timeout
0	1	400	1	1	1	1	200	1	20	20	0
0	1	400	1	1	2	2	100	1	10	20	0
0	1	400	1	1	3	3	100	1	20	20	0
1	1	400	0	0	0	0	0	1	10	20	0
2	1	400	1	1	2	1	2	1	20	20	0
0	1	100	2	1	2	2	500	1	10	20	0
2	1	400	1	1	2	1	50	1	20	20	0
2	1	400	1	1	3	1	10	1	10	20	0
2	1	400	1	1	3	2	2	1	15	20	0
0	1	400	1	1	3	3	40	1	10	20	0
2	1	400	1	1	2	3	2	1	10	20	0
1	1	400	1	0	0	0	4	1	12	20	0
0	1	100	2	1	2	1	40	1	14	20	0
0	1	100	2	1	2	3	20	1	10	20	0
0	1	100	2	1	2	3	30	1	20	20	0
0	1	10	3	1	5	2	12	2	10	20	0
1	1	10	3	1	5	2	12	2	10	20	1
1	1	10	3	1	5	2	12	2	10	10	1
1	1	10	3	1	5	2	12	2	10	15	1
1	1	10	3	1	5	2	12	2	10	20	1
1	1	10	3	1	5	2	12	2	15	20	1
1	1	10	3	1	5	2	12	2	20	20	1
1	1	10	3	1	5	2	12	2	15	20	1
0	1	10	3	1	5	2	12	2	10	20	0
0	1	10	3	1	5	2	12	2	10	10	0
0	1	10	3	1	5	2	12	2	10	15	0
0	1	10	3	1	5	2	12	2	10	20	0
0	1	10	3	1	5	2	12	2	15	20	0
0	1	10	3	1	5	2	12	2	20	20	0
0	1	10	3	1	5	2	12	2	15	20	0
1	1	10	1	1	5	2	12	2	20	10	1
1	1	10	1	1	5	2	12	2	15	10	1
1	1	10	1	1	5	2	22	2	20	10	1

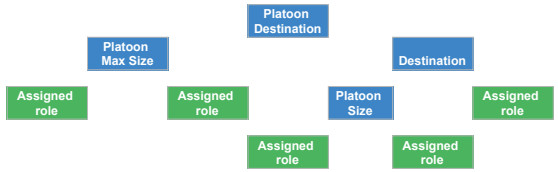
x	y
1	1
1	1
1	1
1	1
0	0
0	0
0	0
0	0

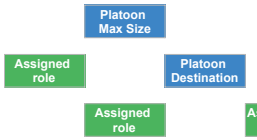
License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
1	Dortmund	Dortmund	1	0	Lead
2	Dortmund	Dortmund	2	1	Follower
3	Dortmund	Dortmund	1	1	Searching
4	Dortmund	Dortmund	2	2	Searching
5	Dortmund	Dortmund	3	3	Searching
6	Dortmund	Hamburg	2	1	Searching
7	Dortmund	Dortmund	?	3	Searching

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
2	Dortmund	Dortmund	2	1	Follower
3	Dortmund	Dortmund	1	1	Searching
2	Dortmund	Dortmund	2	1	Follower
1	Dortmund				Lead
4	Dortmund	Dortmund	2	2	Searching

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
7	Dortmund	Dortmund	2	1	Follower

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
8	Dortmund	Dortmund	2	?	?





Tree				Assigned role
1	Platoon Max Size	Platoon Destination		Lead
2	Platoon Destination	Destination	Platoon Size	Following
3	Destination	Platoon Max Size		Following

Assigned role	
Following	Lead
2	1

Final Prediction
Following

Final Prediction
Following

License Number	Final Prediction
5	Searching
6	Following

License Number	Platoon Max Size
5	Searching
6	Following
6	Following

Tree				Assigned role
1	Platoon Max Size	Platoon Destination		Lead
2	Platoon Destination	Destination	Platoon Size	Following
3	Destination	Platoon Max Size		Following

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
5	Dortmund	Dortmund	3	3	Searching
6	Dortmund	Hamburg	2	1	Searching

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
1	Dortmund	Dortmund	1	0	Lead
2	Dortmund	Dortmund	2	1	Follower
3	Dortmund	Dortmund	1	1	Searching
4	Dortmund	Dortmund	2	2	Searching
5	Dortmund	Dortmund	3	3	Searching
6	Dortmund	Hamburg	2	1	Searching
7	Dortmund	Dortmund	**?**	3	Searching

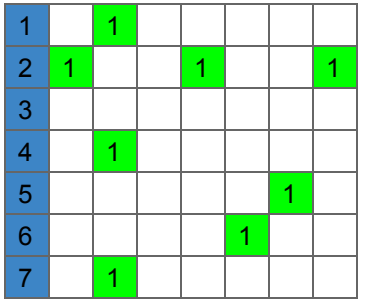
License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
1	Dortmund	Dortmund	1	0	Lead
2	Dortmund	Dortmund	2	1	Follower
3	Dortmund	Dortmund	1	1	Searching
4	Dortmund	Dortmund	2	2	Searching
5	Dortmund	Dortmund	3	3	Searching
6	Dortmund	Hamburg	2	1	Searching
7	Dortmund	Dortmund	**2**	3	Searching

Proximity Matrix

	1	2	3	4	5	6	7
1		2	1	1	1	1	1
2	2		1	2	1	1	5
3	1	1		1	1	1	1
4	1	2	1		1	1	0
5	1	1	1	1		3	0
6	1	1	1	1	3		0
7	1	5	1	0	0	0	

Proximity Matrix

	1	2	3	4	5	6	7



License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
5	Dortmund	Dortmund	3	3	Searching
6	Dortmund	Hamburg	2	1	Searching

Weighted proximity Matrix

	1	2	3	4	5	6	7
1		0.3	0.1	0.1	0.1	0.1	0.1
2	0.3		0.1	0.3	0.1	0.1	0.8
3	0.1	0.1		0.1	0.1	0.1	0.1
4	0.1	0.3	0.2		0.1	0.1	0
5	0.1	0.1	0.1	0.1		0.5	0
6	0.1	0.1	0.1	0.1	0.5		0
7	0.1	0.8	0.1	0	0	0	

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
8	Dortmund	Dortmund	**?**	3	**?**

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
8	Dortmund	Dortmund	**?**	3	**Searching**

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
8	Dortmund	Dortmund	**?**	3	**Following**

License Number	Destination	Platoon Destination	Platoon Max Size	Platoon Size	Assigned role
8	Dortmund	Dortmund	**?**	3	**Lead**