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Innovative Airside Simulation using PTV Vissim

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ch2m SM

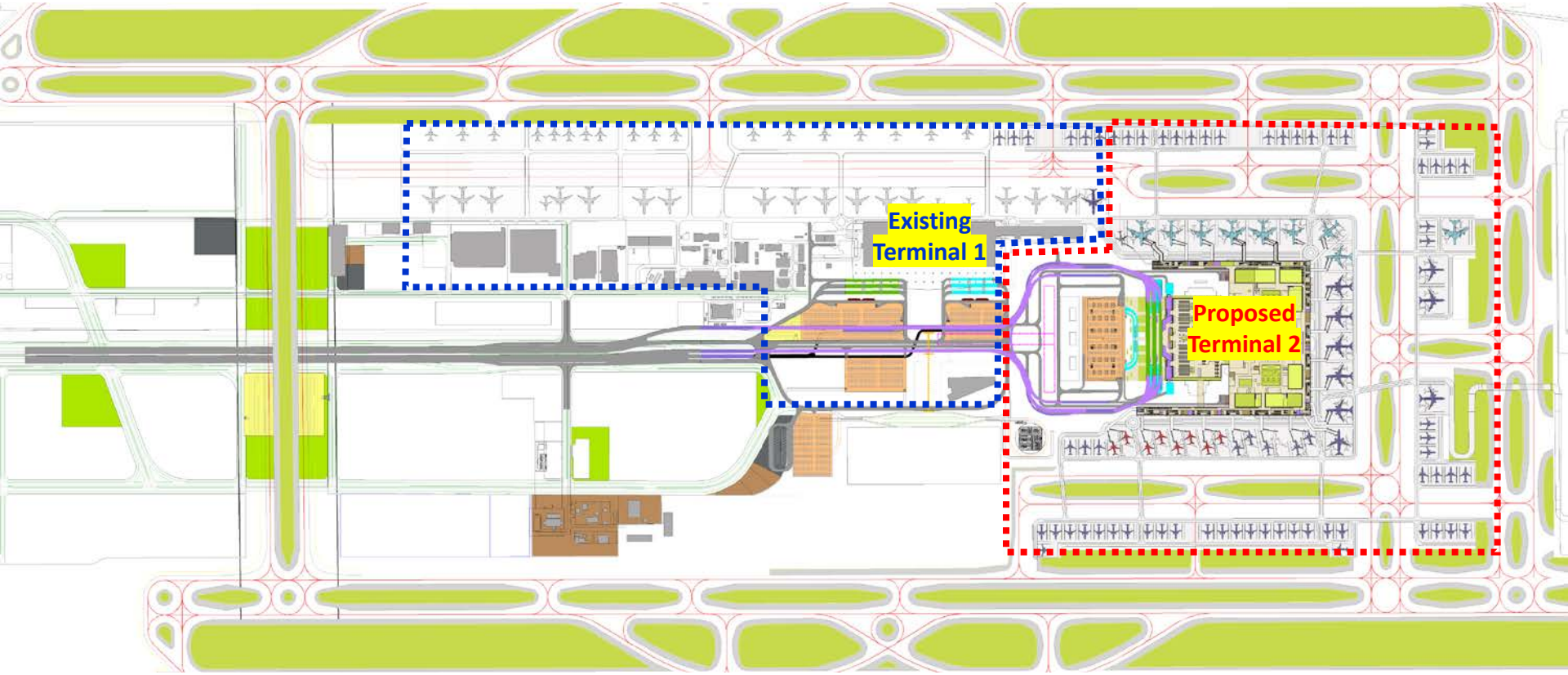
Presentation Structure

- **Study Background**
  - ✓ Project Scope
  - ✓ Study Objective
- **Study Approach and Methodology**
  - ✓ Parameters/Assumptions
  - ✓ Apron GSE Travel Pattern and Stand Circulation
- **GSE Simulation model**
  - ✓ Network Preparation
  - ✓ PT Lines and Schedules
  - ✓ Model runs and results
- **Key Takeaways**
  - ✓ Modelling Challenges
  - ✓ Potential Improvements

Study Background

Study Background

- ✓ Air Traffic at Bengaluru Airport growing exponentially during 10 years
- ✓ Existing Terminal 1 with 20 MPPA running soon at capacity and Airport is developing new Terminal 2 with more than double of the existing capacity in two phases
- ✓ Preliminary plans have been developed and detailed plan preparation is under progress



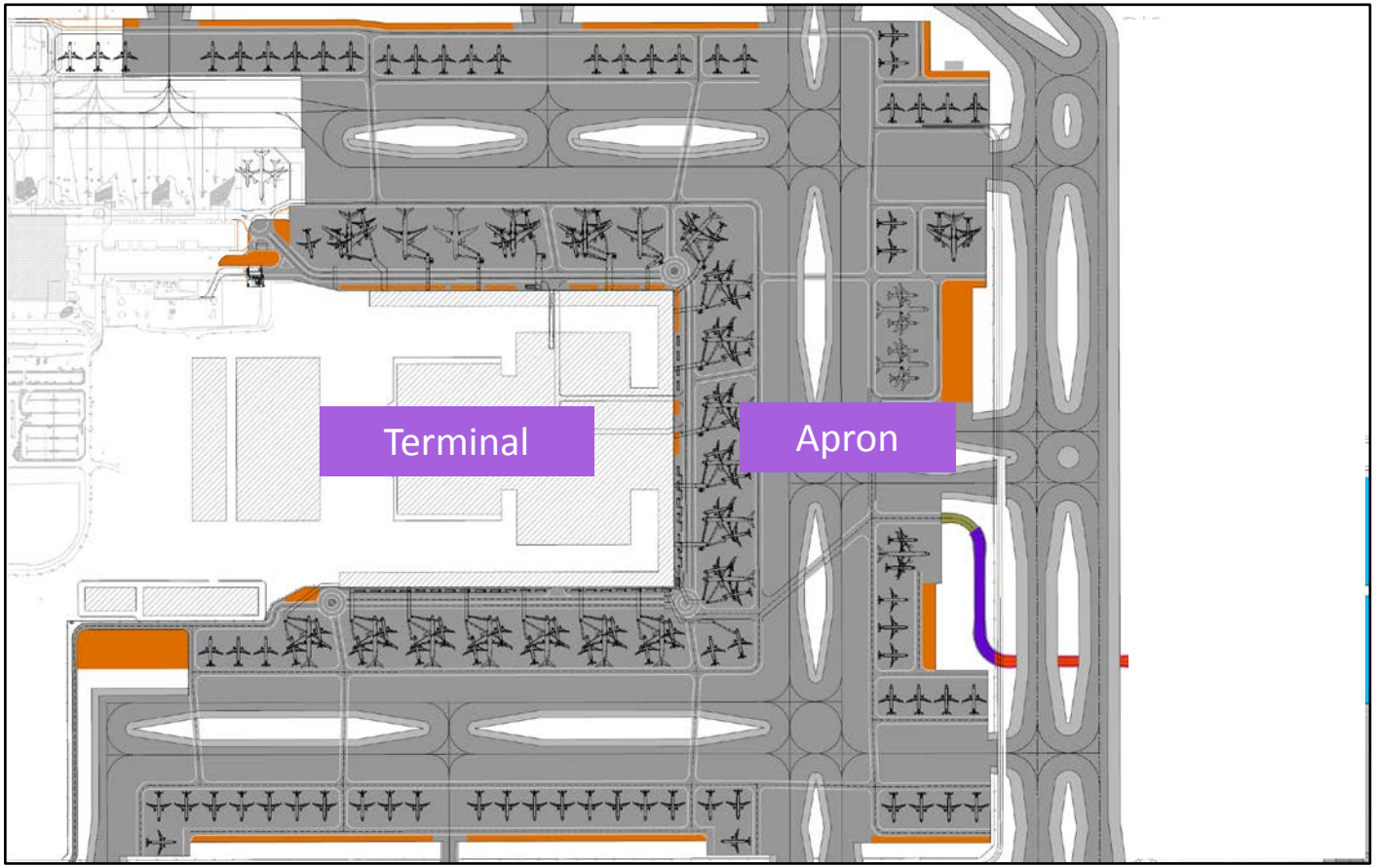
Study Background

- ✓ CH2M recently conducted a major simulation study for Bengaluru Airport for this new Terminal 2 with associated aircraft stands and landside access.
- ✓ CH2M developed simulation models for landside traffic, terminal passengers and airside Ground Service Equipment (GSE) vehicle movements to validate designs
- ✓ Vissim has been used for Landside Traffic and Airside GSE simulation.

Study Background

❖ **Objective**

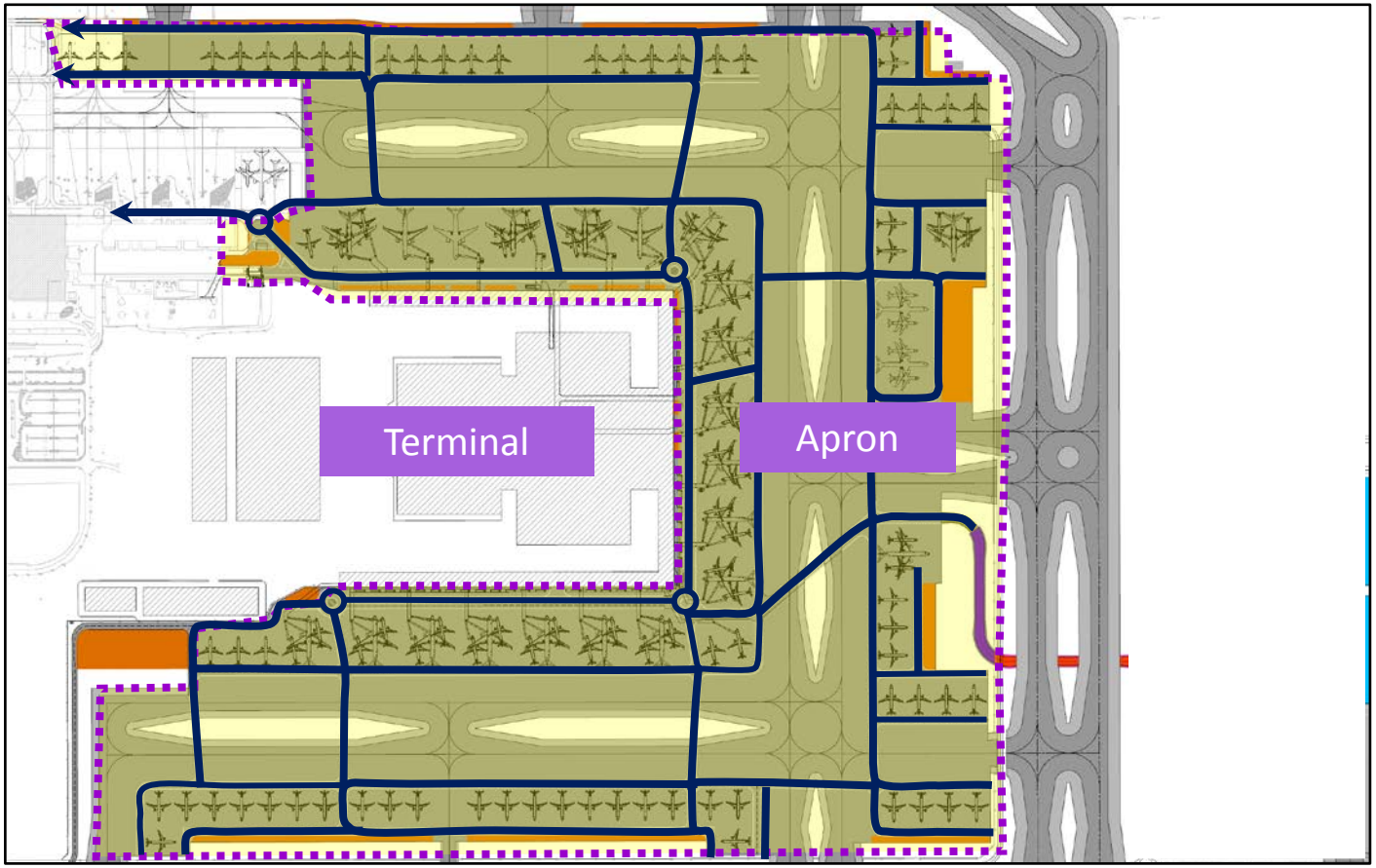
- ✓ Objective is to visualize and analyse GSE operations on apron roads to identify the capacity reserves and future bottlenecks to inform design changes or future operation management
- ✓ Actual vehicle flow on each aircraft stand and the aircraft movement modelling are outside the scope, but the impact is to be considered on apron roads
- ✓ Limited study duration of about 12 weeks for draft report



Study Background

❖ **Scope**

- ✓ Study network includes all proposed terminal apron roads along with connections to existing/future terminals and landside access roads
- ✓ GSE flow on apron during combined apron peak hour for different phases of terminal development is modelled. Final phase details (i.e. the most demanding case) are discussed under current context.



Study Approach and Methodology

Study Approach

- **GSE on Apron**
  - ✓ Simulation models developed for peak period with applicable GSE flows at contact and remote stands
  - ✓ Different vehicle categories decided based on GSE operations and servicing requirements
- **Peak Period and ATMs**
  - ✓ Design Day Flight Schedules (DDFS) analyzed to identify peak hours and corresponding Air Traffic Movement (ATMs)
  - ✓ Peak ATMs are identified by arrival/departure at contact and remote stands for modelling
- **GSE for Staging and Servicing**
  - ✓ GSE movement is schedule-based depending on flight schedules (arrival/departure times)
  - ✓ Deployment of various GSE for each ATM for servicing based on type of aircraft and stand location
  - ✓ Stand flow in line with positioning of GSE on either side of aircraft
  - ✓ Service times at stands include staging/waiting time and actual servicing time for each ATM
- **Travel Pattern and Assignment**
  - ✓ GSE is deployed from/to different stand locations, GSE areas, terminal bus bays, baggage handling locations and other parking/operational areas
  - ✓ Traffic assignment is done assuming likely routes and restrictions to generate GSE flows on apron roads

Study Methodology

❖ **GSE Vehicle Physical Dimensions**

- ✓ 19 GSE vehicle categories are identified based on likely operations at apron
- ✓ Physical parameters are taken from standard GSE equipment dimensions

S No	Vehicle Type	Vehicle Size	
		Length (m)	Width (m)
1	Tow Truck	9.99	4.50
2	Mobile Ground Power Unit	3.50	1.95
3	Catering Truck	9.42	2.49
4	Lower deck cargo loader	9.20	4.30
5	Fuel Pumping Truck	8.17	3.10
6	Conveyor Belt	7.88	2.09
7	Potable Water Vehicle	4.68	3.07
8	Baggage Bulk Train - Tractor	4.57	1.46
	Baggage Bulk Train - Trailer	3.16	1.32
9	Lavatory Vehicle	6.98	2.49
10	Belly Cargo ULD - Tractor	5.04	2.60
	Belly Cargo ULD - Trailer	3.16	1.32
11	Air Conditioning Unit	7.03	2.60
12	Passenger Stairs	11.20	2.91
13	Line maintenance car	4.40	1.80
14	Crew vehicle	4.96	2.05
15	Dispatcher/supervisor	3.65	1.64
16	PRM lift	8.50	2.55
17	PRM vehicle	4.96	2.05
18	Cleaning Truck	4.96	2.05
19	Remote Buses	13.92	3.00

Study Methodology

❖ Peak ATMs

- ✓ Flight schedules are taken from Design Day Flight Schedules (DDFS) developed by CH2M airport planners and agreed with client

Aircraft Type		Stand		ATM during Peak Period	Actual Flight Schedule (Hours)		Stand Duration
Aircraft	ICAO Code	Type	Number		Arrival time	Departure time	
Code C							
320	C	C	V14	Dep	8:25	9:00	0:35
73G	C	C	V14	Arr	10:15	11:05	0:50
737	C	C	V16	Dep	8:35	9:00	0:25
738	C	C	V16	Arr/Dep	9:20	9:55	0:35
DH8	C	C	V16	Arr	10:20	10:50	0:30

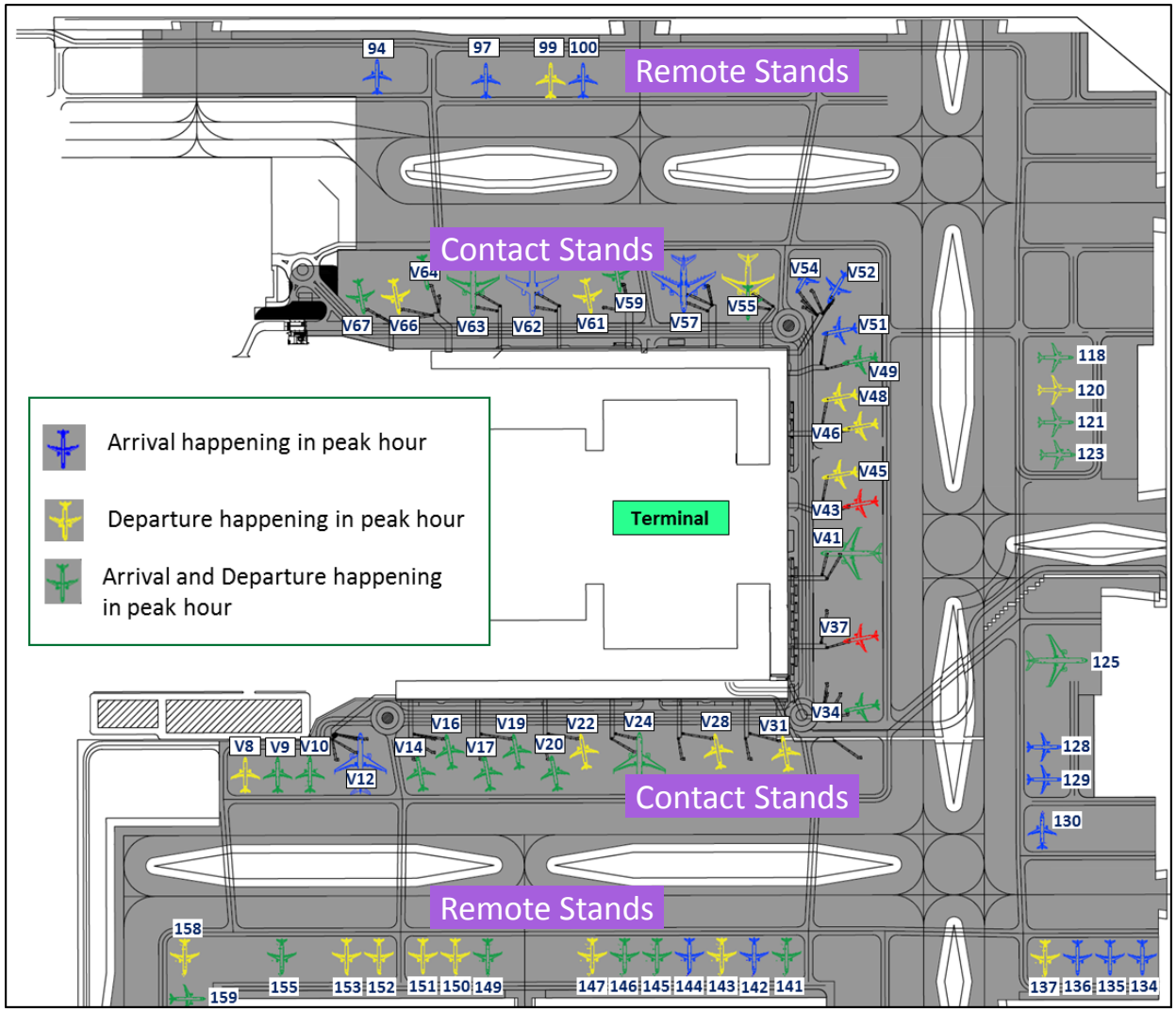
- ✓ Peak hour ATMs by type of aircraft and stand considered are related to combined peak hour on apron.
- ✓ Airport wide ATMs are close to 130 (T1-37 and T2 – 93).

Air Craft Type	Contact ATMs			Remote ATMs			Total ATMs		
	Arrival	Departure	Total	Arrival	Departure	Total	Arrival	Departure	Total
Code C	17	20	**37**	23	22	**45**	40	42	**82**
Code E	5	4	**9**	0	1	**1**	5	5	**10**
Code F	1	0	**1**	0	0	**0**	1	0	**1**
Total Peak Hour	**23**	**24**	**47**	**23**	**23**	**46**	**46**	**47**	**93**

Study Methodology

❖ Flights for Modelling

- ✓ Stand allocation details at contact and remote stands during peak hour are developed by airport planners based on expected demand
- ✓ All ATMs impacting peak GSE flow even outside peak hour are considered in the model



Study Methodology

❖ GSE Vehicle Deployment

- Each GSE required for arrival/departure sequence decided based on type of aircraft (Code C, E or F) and servicing requirements
- Cargo loader and belly cargo ULDs required for Code E & F aircraft only
- Ground power, Air conditioning unit, Passenger stairs, PRM lift/vehicle, remote buses required only for remote stands
- Rest of the vehicles required at both contact and remote stands

S No	Vehicle	Contact Stands						Remote Stands	
		Code C		Code E		Code F		Code C	
		Arrival	Departure	Arrival	Departure	Arrival	Departure	Arrival	Departure
1	Tug - without tow bar	-	1	-	1	-	1	-	1
2	Mobile Ground Power Unit	-	-	-	-	-	-	1	-
3	Catering Truck	1	-	2	-	3	-	1	-
4	Lower deck cargo loader	-	-	2	-	2	-	-	-
5	Fuel Pumping Truck	-	1	-	1	-	2	-	1
6	Conveyor Belt	2	-	-	-	-	-	2	-
7	Potable Water Vehicle	-	1	-	1	-	1	-	1
8	Baggage Bulk Train	2	2	3	3	4	4	2	2
9	Lavatory Vehicle	-	1	-	1	-	1	-	1
10	Belly Cargo ULD	-	-	3	3	4	4	-	-
11	Air Conditioning Unit	-	-	-	-	-	-	1	-
12	Passenger Stairs	-	-	-	-	-	-	2	-
13	Line maintenance car	-	1	-	1	-	1	-	1
14	Crew vehicle	1	1	1	1	1	1	1	1
15	Dispatcher/supervisor	1	1	1	1	1	1	1	1
16	PRM lift (not always)	-	-	-	-	-	-	0.3	0.3
17	PRM vehicle (not always)	-	-	-	-	-	-	0.3	0.3
18	Cleaning Truck	1	-	1	-	1	-	1	-
19	Remote Buses	-	-	-	-	-	-	3	3

Study Methodology

❖ GSE Stand Service Times

- ✓ GSE vehicle average stand service are considered based on standard servicing operations
- ✓ Service times are different for different types of aircraft
- ✓ Waiting time at bus bays near terminal
  - o Departure bays : 5 minutes
  - o Arrival bays : 2 minutes

S No	Vehicle	Service Time (Minutes)		
		Code C	Code E	Code F
1	Tow Truck - with tow bar	10	10	10
2	Ground Power Unit	45	60	90
3	Catering Truck	20	30	50
4	Lower deck cargo loader	30	40	60
5	Fuel Pumping Truck	15	25	40
6	Conveyor Belt	30	40	90
7	Potable Water Vehicle	10	18	30
8	Baggage Bulk Train	15	15	15
9	Lavatory Vehicle	15	15	25
10	Belly Cargo ULD	10	10	10
11	Air Conditioning Unit	45	60	90
12	Passenger Stairs	45	60	90
13	Line maintenance car	10	10	10
14	Crew vehicle	5	5	5
15	Dispatcher/supervisor	10	10	10
16	PRM lift (not always)	7	7	7
17	PRM vehicle (not always)	7	7	7
18	Cleaning Truck	20	45	90
19	Remote Buses	10	10	10

Study Methodology

❖ GSE Stand Schedule

- ✓ Scheduling and deployment of GSE done based on flight arrival and departure times and service times required for service including staging

❖ GSE Stand Sequence

- ✓ Arrival and Departure sequence for each type of aircraft at Contact and Remote Stands
- ✓ Code C aircraft total stand time : 45 min
  - o Arrival – 15 min
  - o Departure – 30 min

	Vehicle	Stand Type	GSE per ATM		Staging	Time After Arrival (min)			Aircraft Parked Period (Varies)	Time Before Departure (min)				Push Back
			Arr	Dep	-5	0	5	10		-20	-15	-10	-5	0
1	Tug	Contact	0	1									5 min	5 min
		Remote	0	1									5 min	5 min
2	Mobile Ground Power Unit	Contact	0	0		Not required as fixed power is provided								
		Remote	1	0		On stand for duration								
3	Catering Truck	Contact	0	1						20 min				
		Remote	0	1						20 min				
4	Lower deck cargo loader	Contact	0	0		Not required for Code C aircraft								
		Remote	0	0		Not required for Code C aircraft								
5	Fuel Pumping Truck	Contact	0	1						15 min				
		Remote	0	1						15 min				
6	Conveyor Belt	Contact	2	0		On stand for duration								
		Remote	2	0		On stand for duration								
7	Potable Water Vehicle	Contact	0	1							10 min			
		Remote	0	1							10 min			
8	Baggage Bulk Train	Contact	2	2	5 min	15 min				15 min				
		Remote	2	2	5 min	15 min				15 min				
9	Lavatory Vehicle	Contact	0	1						15 min				
		Remote	0	1						15 min				
10	Bulk Baggage Train	Contact	1	1	5 min	10 min				10 min				
		Remote	1	1	5 min	10 min				10 min				
11	Air Conditioning Unit	Contact	0	0		Not required as fixed pre-conditioned air is provided								
		Remote	1	0		On stand for duration								
12	Passenger Stairs	Contact	1	0		On stand for duration								
		Remote	2	0		On stand for duration								
13	Line maintenance car	Contact	0	1						10 min				
		Remote	0	1							10 min			
14	Crew vehicle	Contact	1	1	5 min	5 min				5 min				
		Remote	1	1	5 min	5 min				5 min				
15	Dispatcher/supervisor	Contact	1	1	5 min	10 min				10 min				
		Remote	1	1	5 min	10 min				10 min				
16	PRM lift (not always)*	Contact	0	0		Not required as passenger boarding bridge is available								
		Remote	0	0.3		7 min						7 min		
17	PRM vehicle (not always)*	Contact	0	0		Not required as passenger boarding bridge is available								
		Remote	0	0.3		7 min						7 min		
18	Cleaning Truck	Contact	1	0						20 min				
		Remote	1	0						20 min				
19	Remote Buses	Contact	0	0		Not required as passenger boarding bridge is available								
		Remote	3	3	5 min	10 min				10 min				

Study Methodology

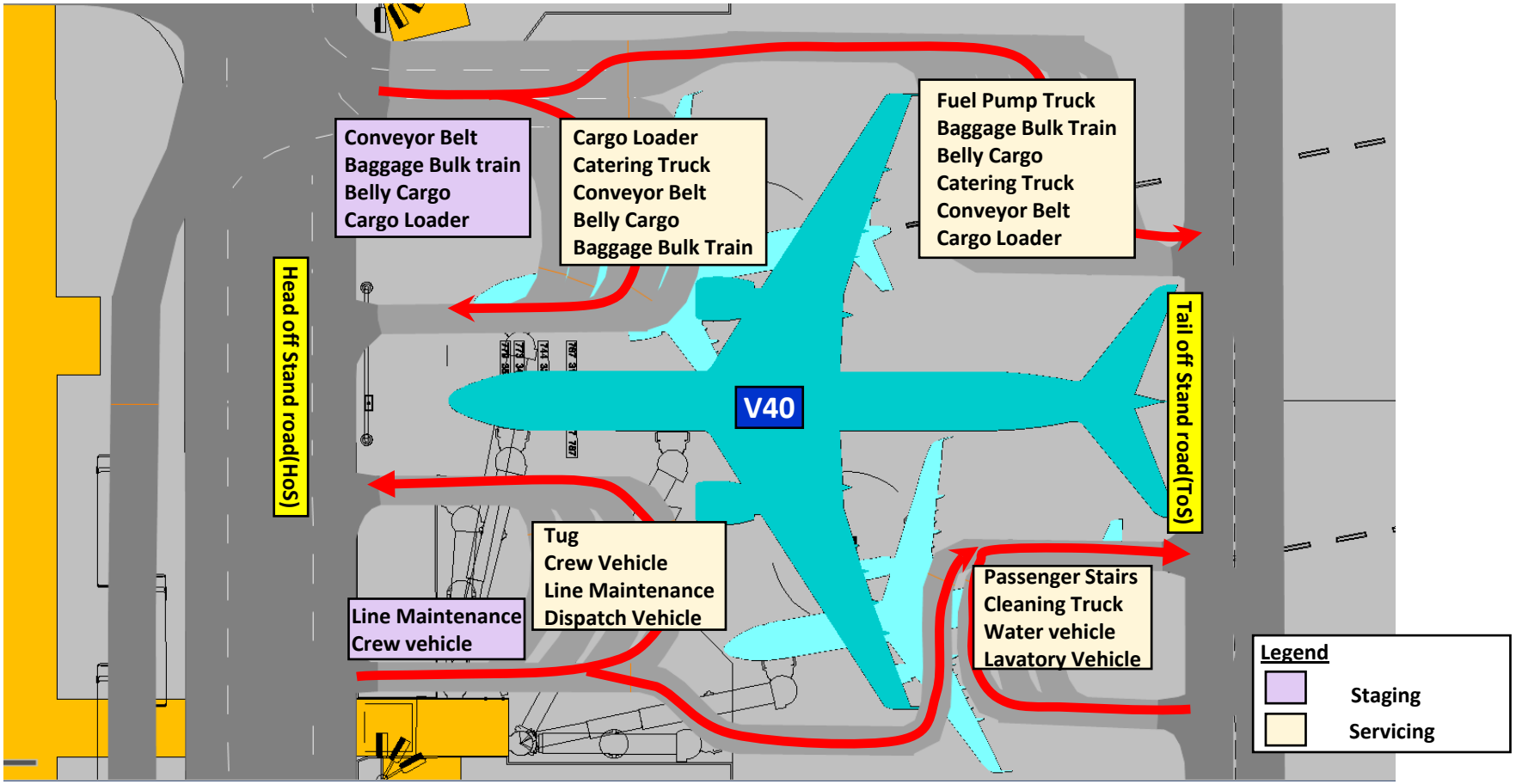
❖ **Apron Travel Pattern**

- ✓ GSE flow mainly happens between aircraft stands and the following locations:
  - o GSE parking areas
  - o Remote/contact stands
  - o Bus bays at terminal
  - o Baggage handling at terminal
  - o Airside/landside Gate
  - o Other parking/facilities on apron
  - o Alternate terminal areas

Study Methodology

❖ **Stand Circulation - GSE flow at Contact Stand**

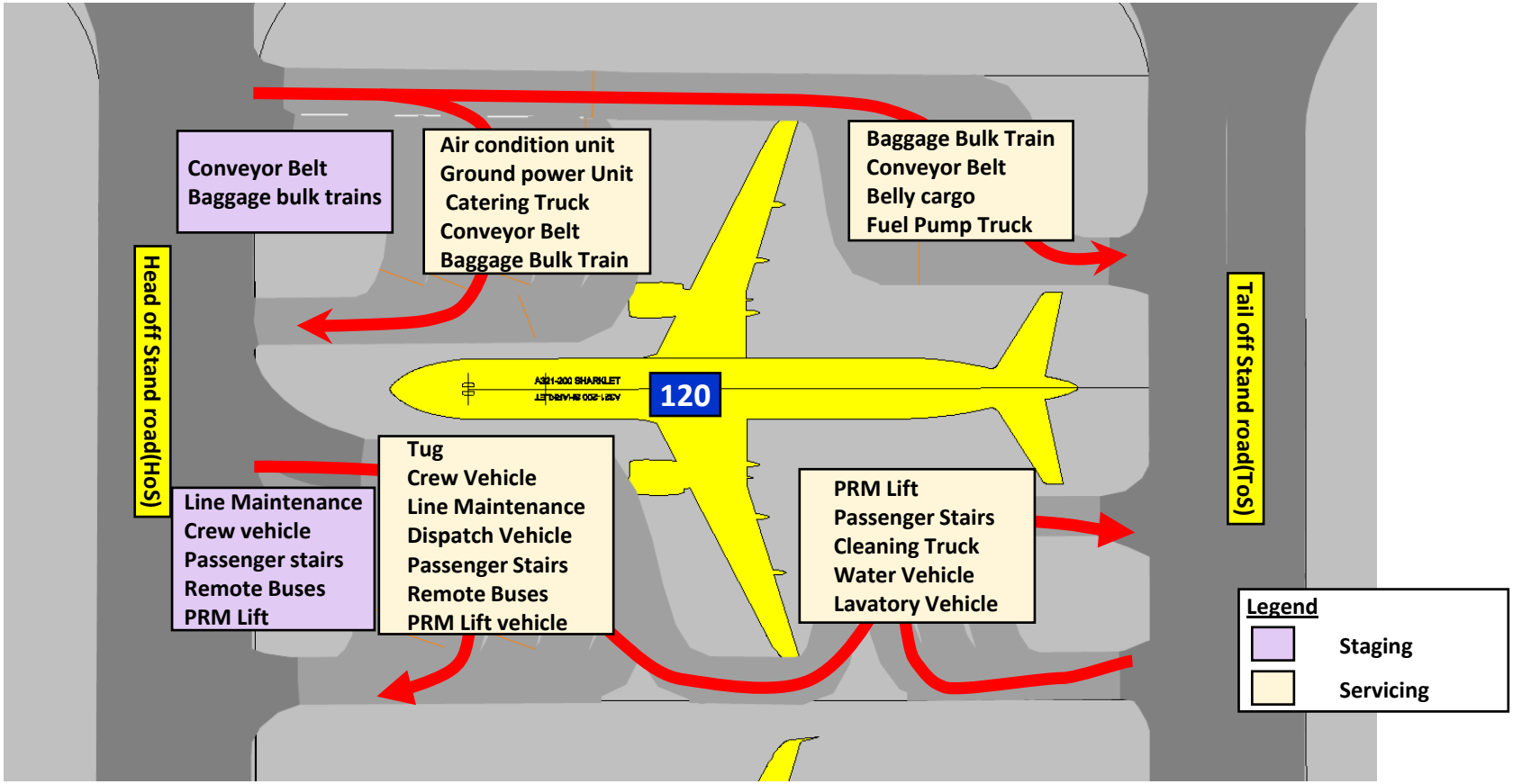
- ✓ One set of bulk baggage, conveyor belt, belly cargo and cargo loader, crew and line maintenance vehicles are added as staging
- ✓ One set of bulk baggage, conveyor belt, belly cargo, cargo loader and catering truck enter from HoS and exit to ToS. Rest enter and exit from either HoS/ToS roads



Study Methodology

❖ Stand Circulation - GSE flow at Remote Stand

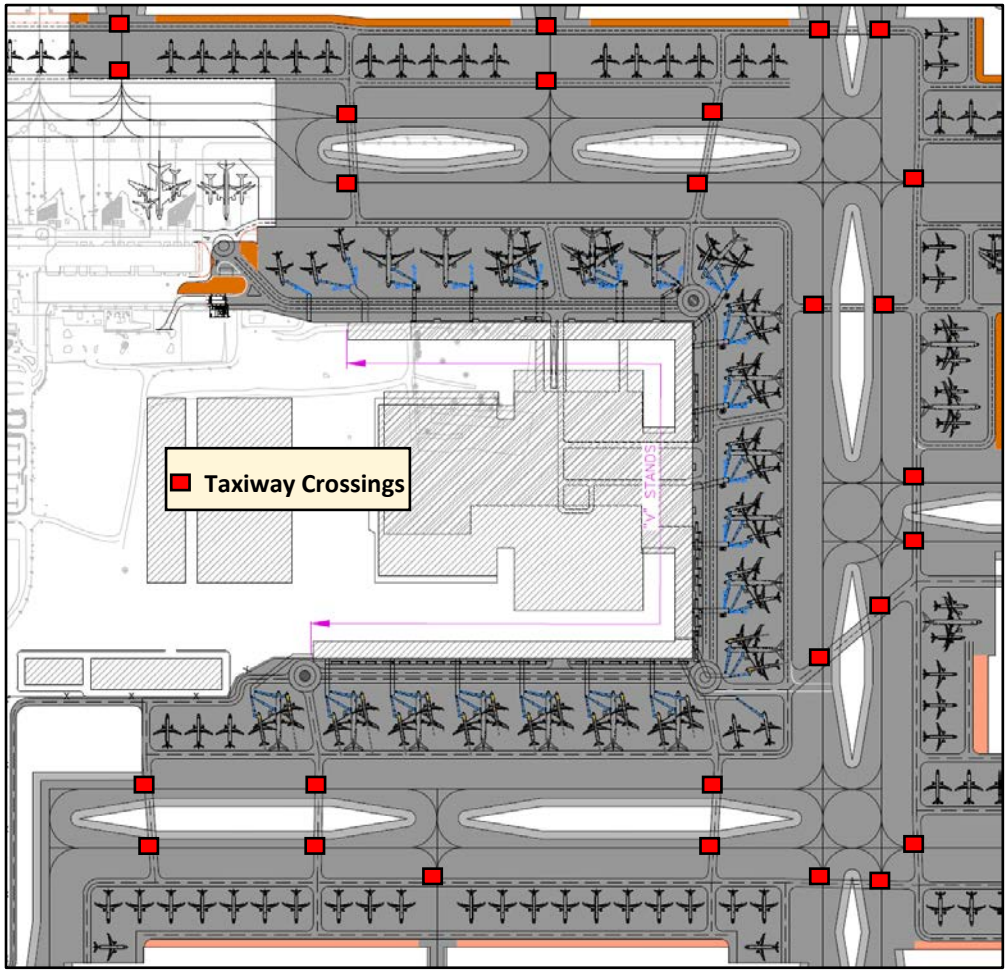
- ✓ One set of passenger stairs, bulk baggage, conveyor belt, remote buses, crew and line maintenance vehicles are added as staging
- ✓ Buses, PRM vehicles, One set of bulk baggage and conveyor belt, Lavatory and Water vehicles enter from HoS and exit to ToS. Rest enter and exit from either HoS/ToS roads



Study Methodology

❖ Other Assumptions

- ✓ Apron Speeds
  - o Buses are assumed to travel at 15 kmph on the apron
  - o Baggage trains/tugs at 10 kmph on average
  - o Rest of the vehicles would travel in the range of 10-20 kmph
  - o No vehicle would travel above 25 kmph
- ✓ GSE Flow across Taxiways
  - o Limited only to critical remote buses, baggage trains, catering trucks, crew, dispatch and supervision vehicles to minimize delays to aircrafts
  - o Average waiting time of 30 seconds for crossing taxiways/lanes for each vehicle



GSE Vissim Simulation Model

GSE Simulation Model

❖ Modelling Period

- ✓ Primarily one hour including necessary warm up and cool off periods
- ✓ All flights with likely GSE movement during peak hour considered in modelling
- ✓ Actual modelling period is up to 4.5 hours to consider all GSE vehicles required for flights within the actual aircraft movement peak hour

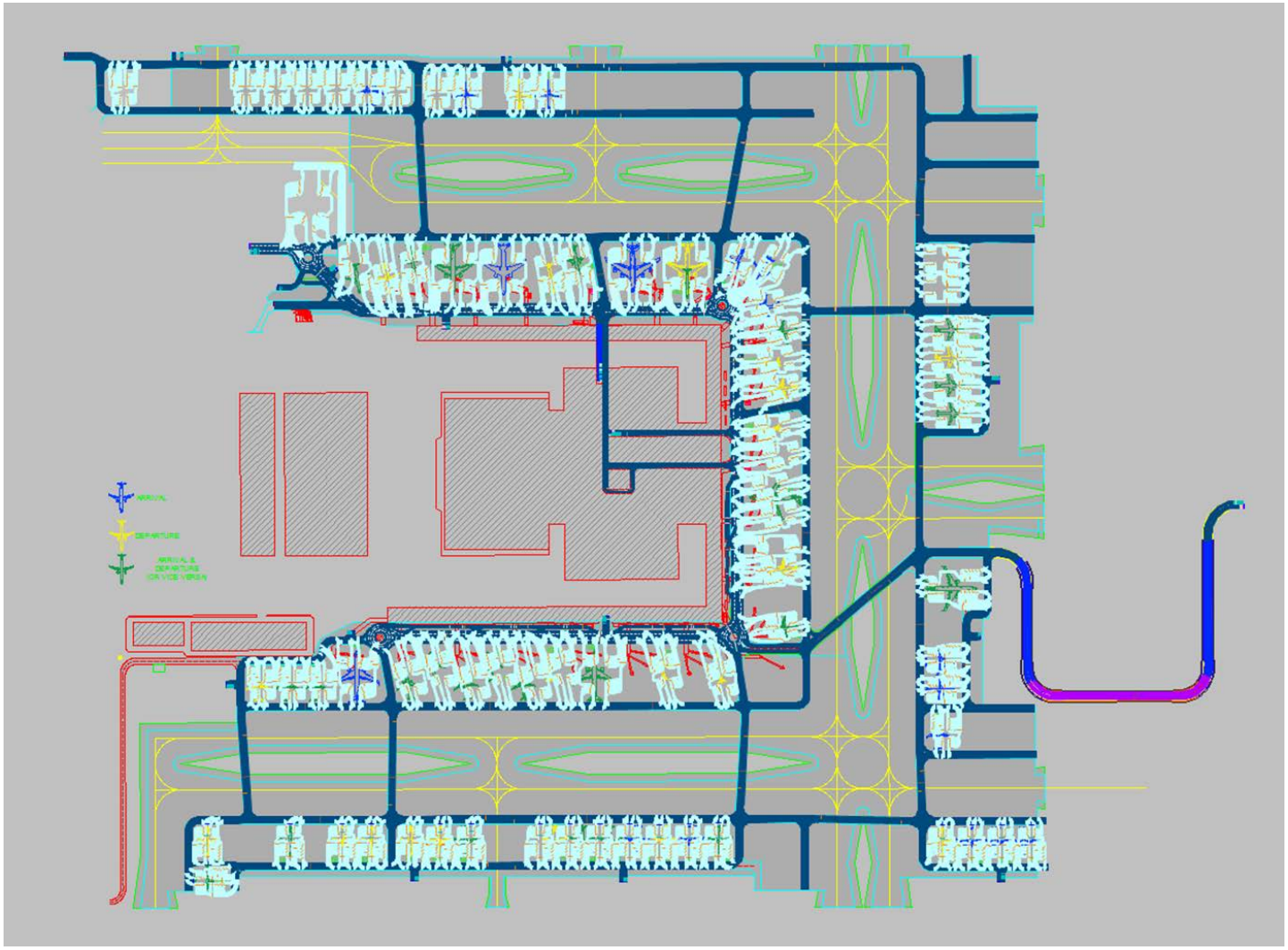
❖ Network Coding

- ✓ All apron roads are coded as normal road links
- ✓ Stand flow assigned to series of exclusive links and connectors to allow each GSE movement without any waiting
- ✓ Stop signs put on links to make each GSE wait for applicable service time
- ✓ Staging is done by stopping applicable GSE before aircraft arrival
- ✓ PT lines are considered separately for all stands for each GSE to move on apron as per schedule

GSE Simulation Model

❖ **Simulation Network – Apron Roads**

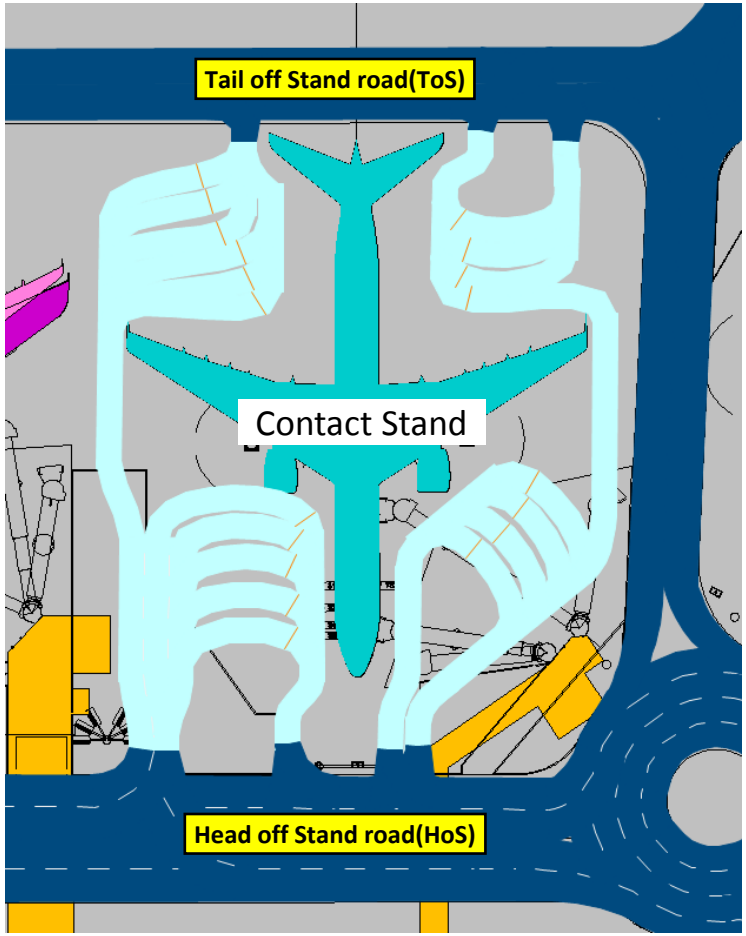
✓ Apron roads are coded as normal road links

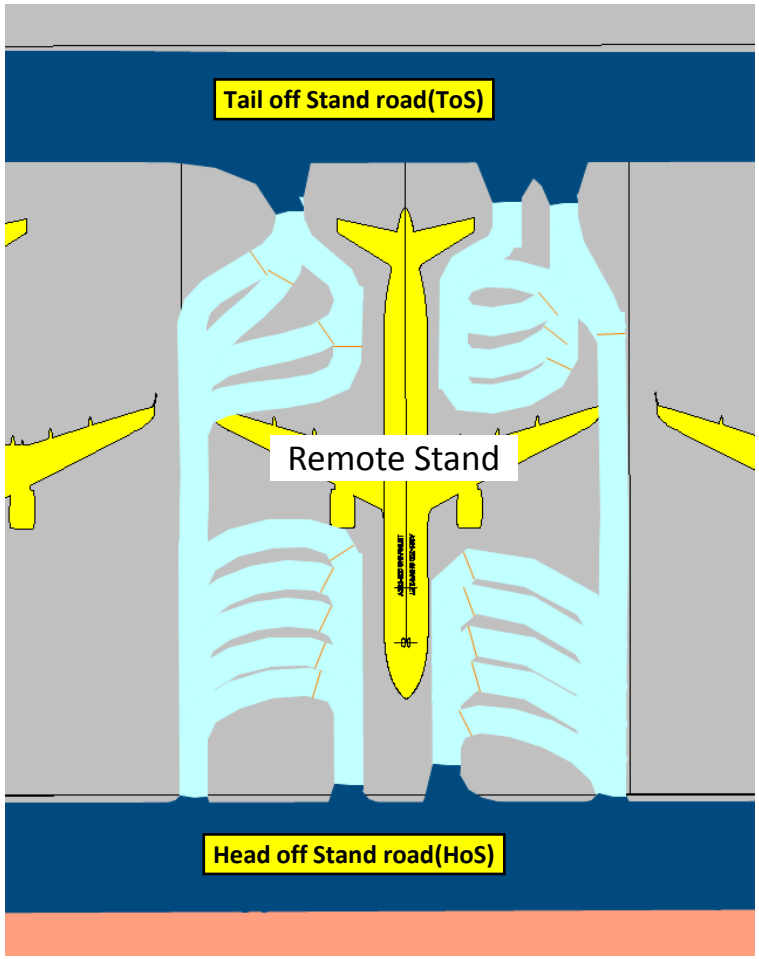


GSE Simulation Model

❖ **Simulation Network – Stand Connections**

✓ Stand connections allow waiting of GSE at flight and movement between ToS/HoS roads at contact and remote stands



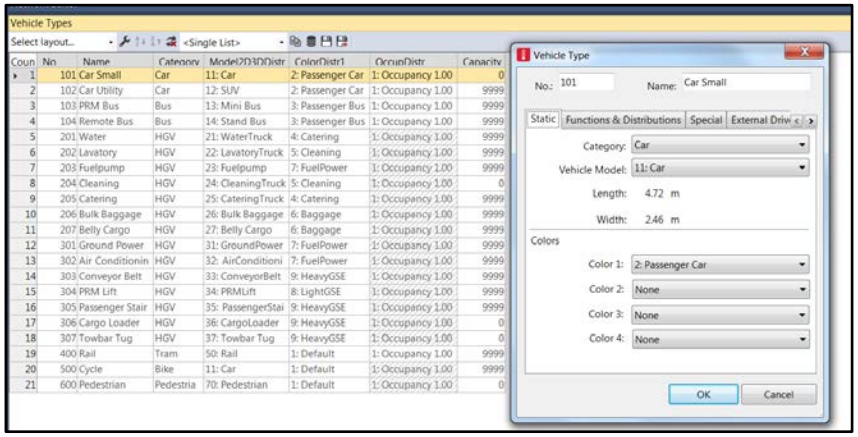


GSE Simulation Model

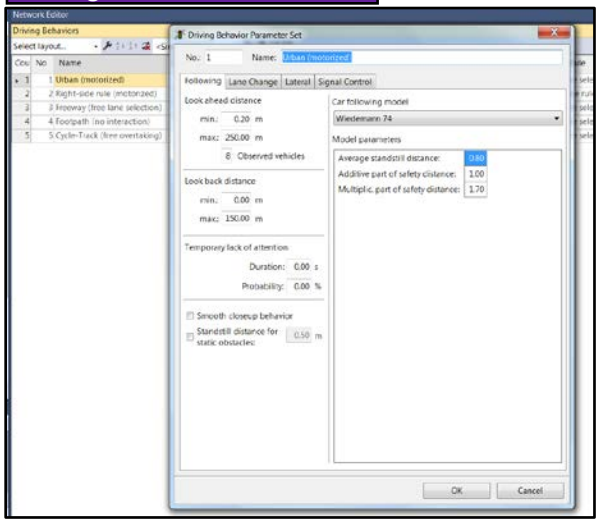
❖ GSE Vehicle Characteristics

- ✓ GSE vehicle characteristics and relevant 3D models are selected based on physical size and dimensions

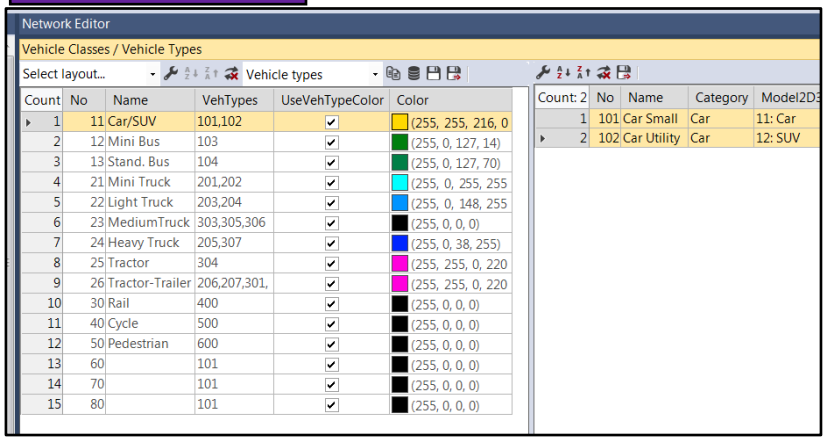
Vehicle Characteristics and Accelerations



Driving Behavior Parameters



Vehicle Classification



Count	No	Name	VehTypes	UseVehTypeColor	Color
1	11	Car/SUV	101,102	☑	(255, 255, 216, 0
2	12	Mini Bus	103	☑	(255, 0, 127, 14)
3	13	Stand. Bus	104	☑	(255, 0, 127, 70)
4	21	Mini Truck	201,202	☑	(255, 0, 255, 255
5	22	Light Truck	203,204	☑	(255, 0, 148, 255
6	23	MediumTruck	303,305,306	☑	(255, 0, 0, 0)
7	24	Heavy Truck	205,307	☑	(255, 0, 38, 255)
8	25	Tractor	304	☑	(255, 255, 0, 220
9	26	Tractor-Trailer	206,207,301,	☑	(255, 255, 0, 220
10	30	Rail	400	☑	(255, 0, 0, 0)
11	40	Cycle	500	☑	(255, 0, 0, 0)
12	50	Pedestrian	600	☑	(255, 0, 0, 0)
13	60		101	☑	(255, 0, 0, 0)
14	70		101	☑	(255, 0, 0, 0)
15	80		101	☑	(255, 0, 0, 0)

Count: 2

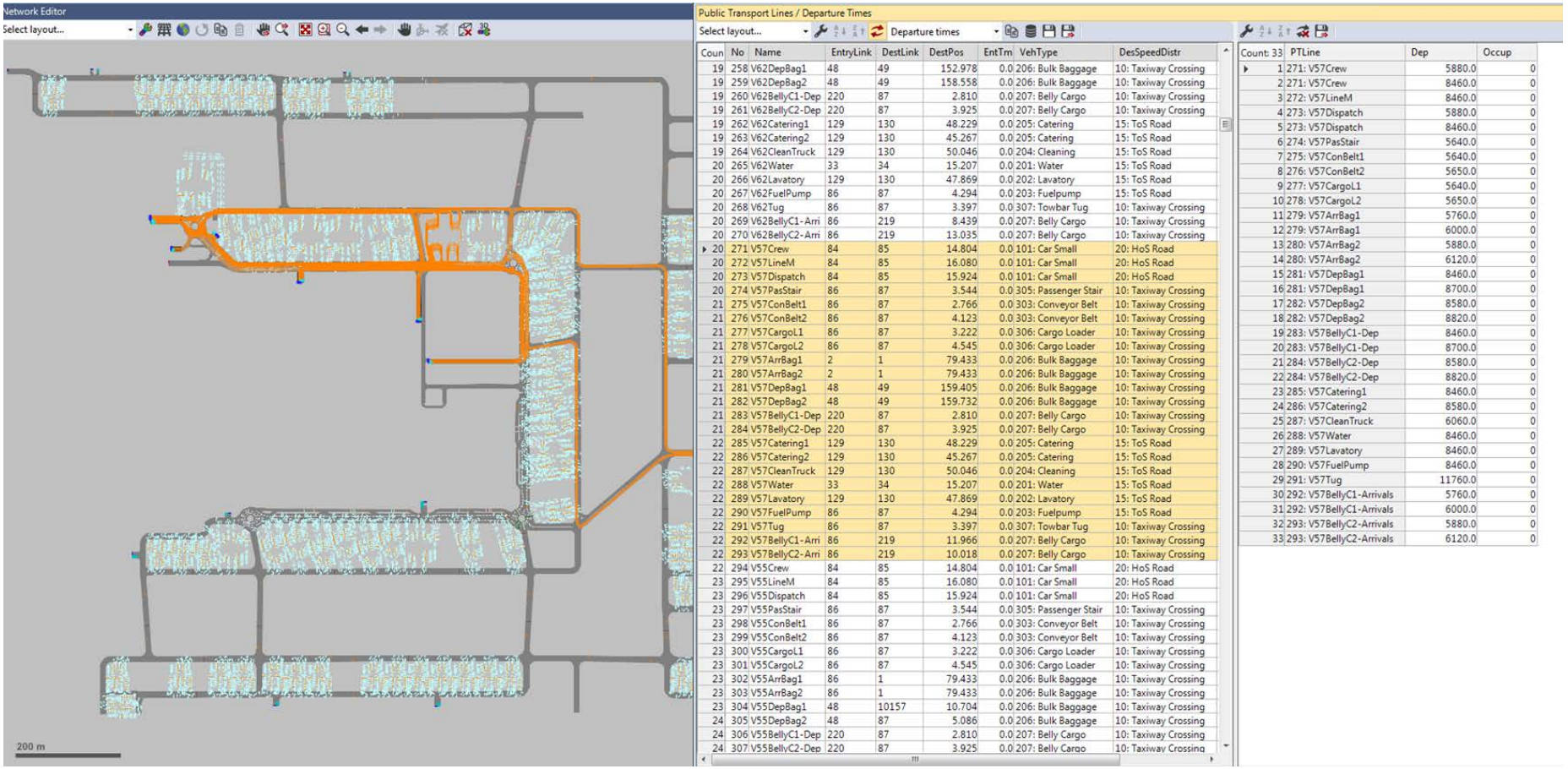
No	Name	Category	Model2D
101	Car Small	Car	11: Car
102	Car Utility	Car	12: SUV

3D Vehicle Models

GSE Simulation Model

❖ PT Lines and Schedules

- ✓ Each stand requires about 20-25 PT lines along with time schedule for staging and serving aircraft



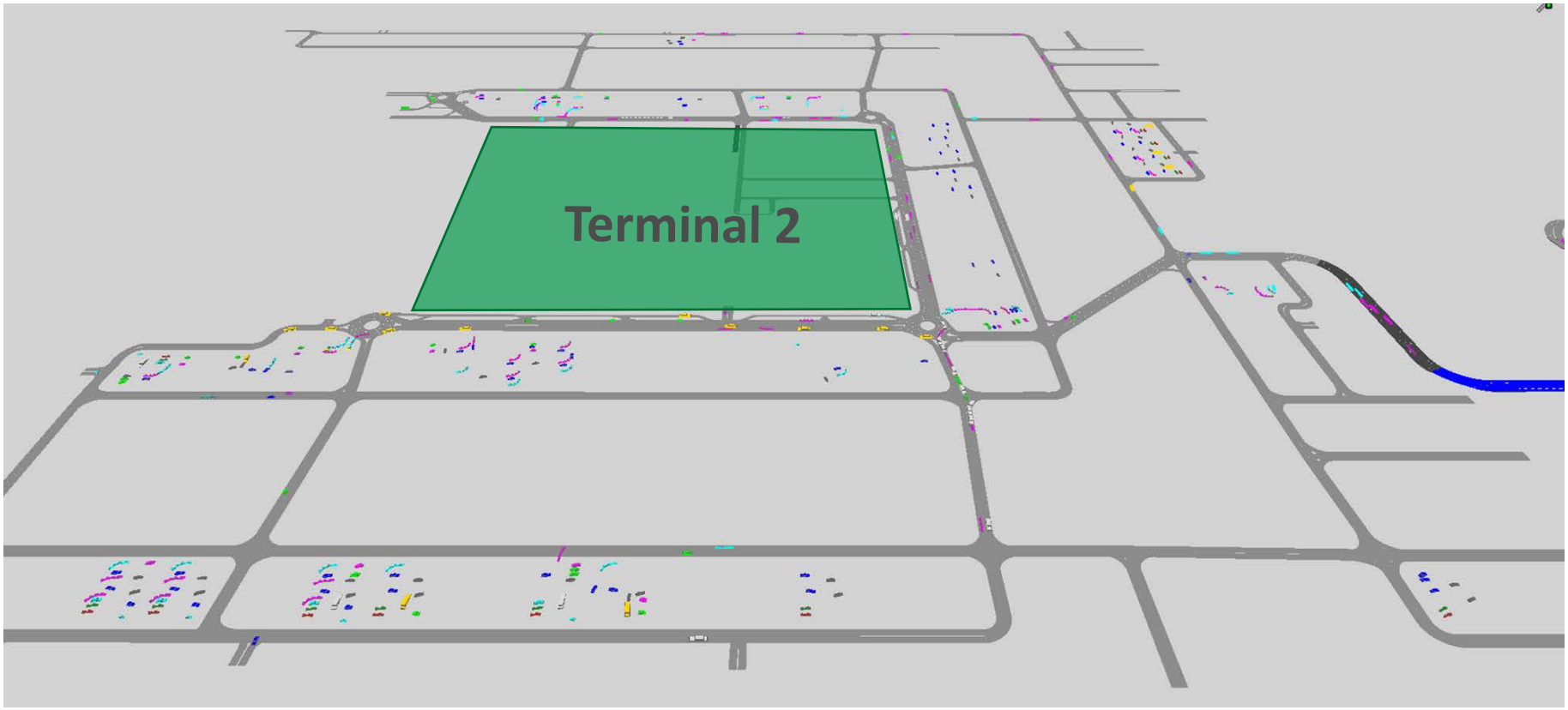
Coun	No	Name	EntryLink	DestLink	DestPos	EntTm	VehType	DesSpeedDistr
19	258	V62DepBag1	48	49	152.978	0.0	206: Bulk Baggage	10: Taxiway Crossing
19	259	V62DepBag2	48	49	158.558	0.0	206: Bulk Baggage	10: Taxiway Crossing
19	260	V62BellyC1-Dep	220	87	2.810	0.0	207: Belly Cargo	10: Taxiway Crossing
19	261	V62BellyC2-Dep	220	87	3.925	0.0	207: Belly Cargo	10: Taxiway Crossing
19	262	V62Catering1	129	130	48.229	0.0	205: Catering	15: ToS Road
19	263	V62Catering2	129	130	45.267	0.0	205: Catering	15: ToS Road
19	264	V62CleanTruck	129	130	50.046	0.0	204: Cleaning	15: ToS Road
20	265	V62Water	33	34	15.207	0.0	201: Water	15: ToS Road
20	266	V62Lavatory	129	130	47.869	0.0	202: Lavatory	15: ToS Road
20	267	V62FuelPump	86	87	4.294	0.0	203: Fuelpump	15: ToS Road
20	268	V62Tug	86	87	3.397	0.0	307: Towbar Tug	10: Taxiway Crossing
20	269	V62BellyC1-Arri	86	219	8.439	0.0	207: Belly Cargo	10: Taxiway Crossing
20	270	V62BellyC2-Arri	86	219	13.035	0.0	207: Belly Cargo	10: Taxiway Crossing
20	271	V57Crew	84	85	14.804	0.0	101: Car Small	20: HoS Road
20	272	V57LineM	84	85	16.080	0.0	101: Car Small	20: HoS Road
20	273	V57Dispatch	84	85	15.924	0.0	101: Car Small	20: HoS Road
20	274	V57PasStair	86	87	3.544	0.0	305: Passenger Stair	10: Taxiway Crossing
21	275	V57ConBelt1	86	87	2.766	0.0	303: Conveyor Belt	10: Taxiway Crossing
21	276	V57ConBelt2	86	87	4.123	0.0	303: Conveyor Belt	10: Taxiway Crossing
21	277	V57CargoL1	86	87	3.222	0.0	306: Cargo Loader	10: Taxiway Crossing
21	278	V57CargoL2	86	87	4.545	0.0	306: Cargo Loader	10: Taxiway Crossing
21	279	V57ArrBag1	2	1	79.433	0.0	206: Bulk Baggage	10: Taxiway Crossing
21	280	V57ArrBag2	2	1	79.433	0.0	206: Bulk Baggage	10: Taxiway Crossing
21	281	V57DepBag1	48	49	159.405	0.0	206: Bulk Baggage	10: Taxiway Crossing
21	282	V57DepBag2	48	49	159.732	0.0	206: Bulk Baggage	10: Taxiway Crossing
21	283	V57BellyC1-Dep	220	87	2.810	0.0	207: Belly Cargo	10: Taxiway Crossing
21	284	V57BellyC2-Dep	220	87	3.925	0.0	207: Belly Cargo	10: Taxiway Crossing
22	285	V57Catering1	129	130	48.229	0.0	205: Catering	15: ToS Road
22	286	V57Catering2	129	130	45.267	0.0	205: Catering	15: ToS Road
22	287	V57CleanTruck	129	130	50.046	0.0	204: Cleaning	15: ToS Road
22	288	V57Water	33	34	15.207	0.0	201: Water	15: ToS Road
22	289	V57Lavatory	129	130	47.869	0.0	202: Lavatory	15: ToS Road
22	290	V57FuelPump	86	87	4.294	0.0	203: Fuelpump	15: ToS Road
22	291	V57Tug	86	87	3.397	0.0	307: Towbar Tug	10: Taxiway Crossing
22	292	V57BellyC1-Arri	86	219	11.966	0.0	207: Belly Cargo	10: Taxiway Crossing
22	293	V57BellyC2-Arri	86	219	10.018	0.0	207: Belly Cargo	10: Taxiway Crossing
22	294	V55Crew	84	85	14.804	0.0	101: Car Small	20: HoS Road
23	295	V55LineM	84	85	16.080	0.0	101: Car Small	20: HoS Road
23	296	V55Dispatch	84	85	15.924	0.0	101: Car Small	20: HoS Road
23	297	V55PasStair	86	87	3.544	0.0	305: Passenger Stair	10: Taxiway Crossing
23	298	V55ConBelt1	86	87	2.766	0.0	303: Conveyor Belt	10: Taxiway Crossing
23	299	V55ConBelt2	86	87	4.123	0.0	303: Conveyor Belt	10: Taxiway Crossing
23	300	V55CargoL1	86	87	3.222	0.0	306: Cargo Loader	10: Taxiway Crossing
23	301	V55CargoL2	86	87	4.545	0.0	306: Cargo Loader	10: Taxiway Crossing
23	302	V55ArrBag1	86	1	79.433	0.0	206: Bulk Baggage	10: Taxiway Crossing
23	303	V55ArrBag2	86	1	79.433	0.0	206: Bulk Baggage	10: Taxiway Crossing
23	304	V55DepBag1	48	10157	10.704	0.0	206: Bulk Baggage	10: Taxiway Crossing
24	305	V55DepBag2	48	87	5.086	0.0	206: Bulk Baggage	10: Taxiway Crossing
24	306	V55BellyC1-Dep	220	87	2.810	0.0	207: Belly Cargo	10: Taxiway Crossing
24	307	V55BellyC2-Dep	220	87	3.925	0.0	207: Belly Cargo	10: Taxiway Crossing

Count: 33	PTLine	Dep	Occup
1	271: V57Crew	5880.0	0
2	271: V57Crew	8460.0	0
3	272: V57LineM	8460.0	0
4	273: V57Dispatch	5880.0	0
5	273: V57Dispatch	8460.0	0
6	274: V57PasStair	5640.0	0
7	275: V57ConBelt1	5640.0	0
8	276: V57ConBelt2	5650.0	0
9	277: V57CargoL1	5640.0	0
10	278: V57CargoL2	5650.0	0
11	279: V57ArrBag1	5760.0	0
12	279: V57ArrBag1	6000.0	0
13	280: V57ArrBag2	5880.0	0
14	280: V57ArrBag2	6120.0	0
15	281: V57DepBag1	8460.0	0
16	281: V57DepBag1	8700.0	0
17	282: V57DepBag2	8580.0	0
18	282: V57DepBag2	8820.0	0
19	283: V57BellyC1-Dep	8460.0	0
20	283: V57BellyC1-Dep	8700.0	0
21	284: V57BellyC2-Dep	8580.0	0
22	284: V57BellyC2-Dep	8820.0	0
23	285: V57Catering1	8460.0	0
24	286: V57Catering2	8580.0	0
25	287: V57CleanTruck	6060.0	0
26	288: V57Water	8460.0	0
27	289: V57Lavatory	8460.0	0
28	290: V57FuelPump	8460.0	0
29	291: V57Tug	11760.0	0
30	292: V57BellyC1-Arrivals	5760.0	0
31	292: V57BellyC1-Arrivals	6000.0	0
32	293: V57BellyC2-Arrivals	5880.0	0
33	293: V57BellyC2-Arrivals	6120.0	0

GSE Simulation Model

❖ **Model Runs and Results**

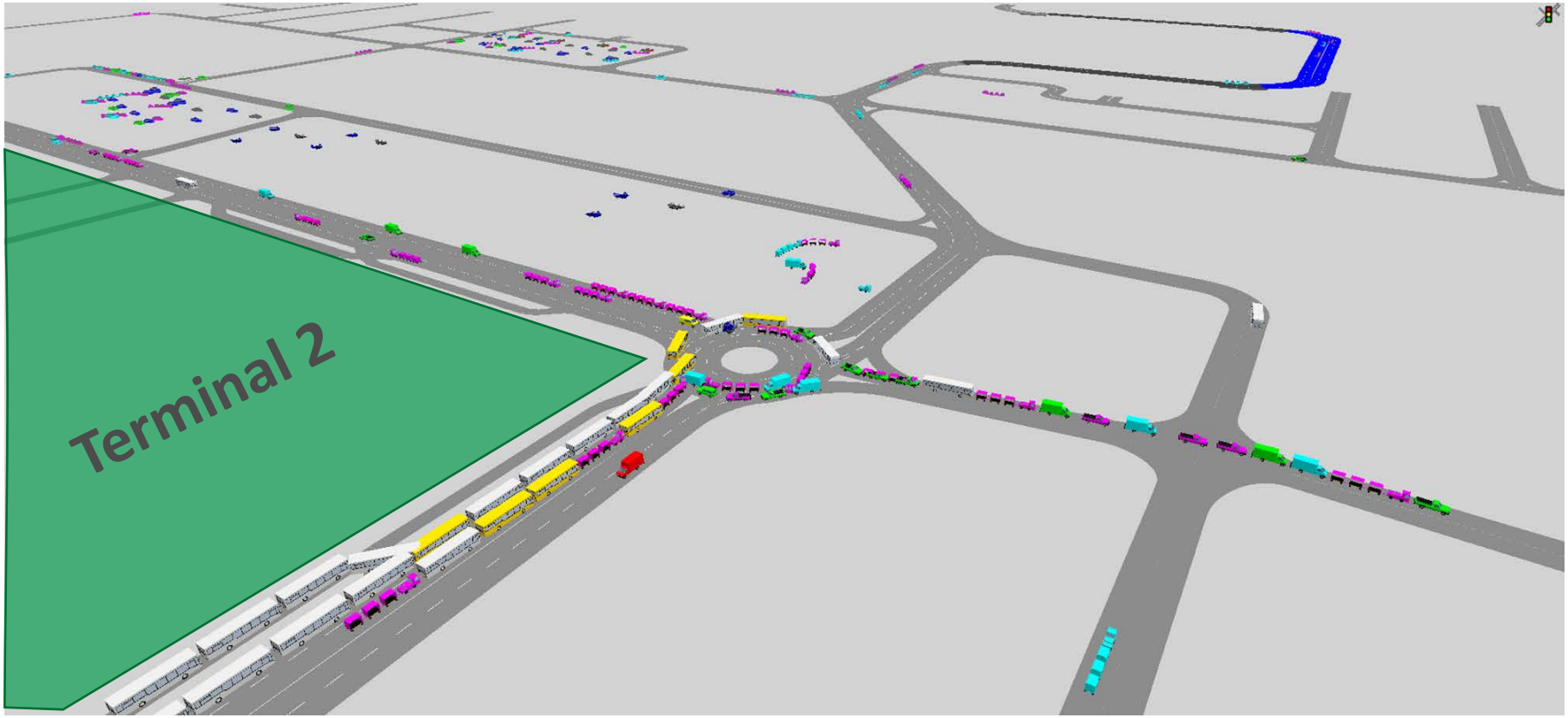
- ✓ Peak period simulation for entire apron area



GSE Simulation Model

❖ **Model Runs and Results**

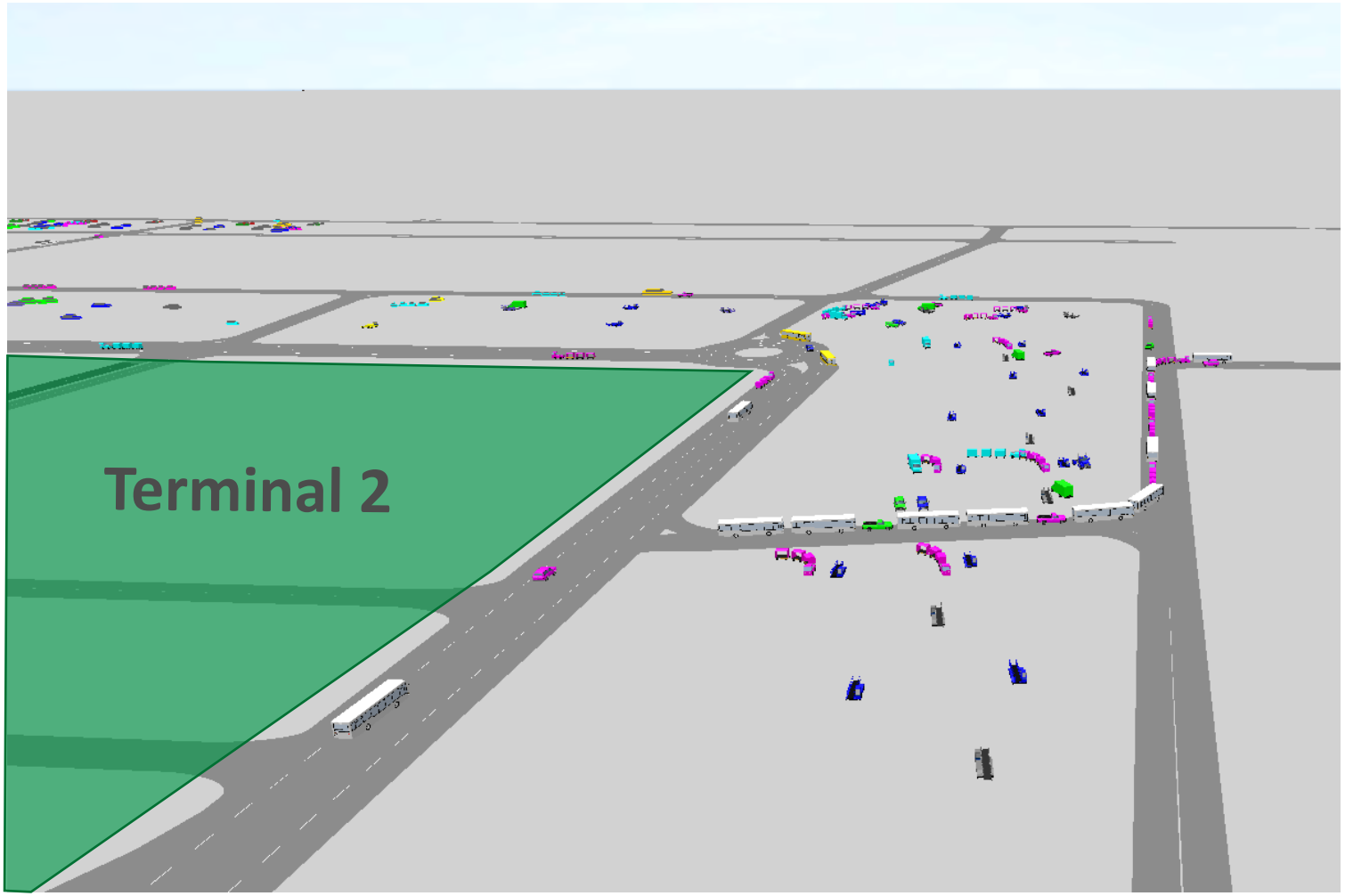
✓ Identification of GSE flow issues on HoS road near terminal



GSE Simulation Model

❖ **Model Runs and Results**

✓ Identification of other potential bottle necks



Key Takeaways

Key Takeaways

- **Modelling Challenges**
  - ✓ Network Coding
    - o Many connectors at frequent interval from/to apron roads causing critical conflict areas
    - o Maintaining too many PT lines and stop signs with different schedules
    - o Adjusting GSE schedules in line with flight arrival/departure times and GSE parking locations
  - ✓ Stand Networks
    - o Network coding for different flights in the same stand (one aircraft after another)
    - o Restriction of links to same stand to avoid overlap of links and connectors
  - ✓ Scenario Testing
    - o Cumbersome process to test alternate scenarios
- **Potential Improvements**
  - o Vehicles need to detect other vehicles/aircrafts in the stand areas as entire stand area (excluding aircraft parking area) can be used by GSE
  - o GSE modelling at stands to be done as in pedestrian modelling. Vehicles should behave as pedestrians on stand areas in line with restricted objects around flights/other GSE vehicles
  - o Overlapping of short links and connectors need to be managed with efficient conflict management.

Thank You

Contributed by Team of Airport and Transport Planners at CH2M

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- Srinivas Bandaru – Simulation Modeller/Transport Planning Expert
- Tayi Madhukiran – Transport Planner
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