TRACC_PB SOSS Integrated Traffic Simulation for CLT Ramp Operation

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Outline

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- Goals and work scope
- Approach
- TRACC adaptation & functionality for CLT ramp operation
- SOSS adaptation to TRACC trajectory
- TRACC_PB and SOSS integration for CLT
- Lessons learned & remaining tasks

Motivations

- Two different approaches have been developed by DLR and NASA Ames for surface ATM
- Collaboration **benefit for NASA** -- understand DLR's approach to surface traffic management (benefits and tradeoffs)
- Collaboration **benefit for DLR**: how TRACC 4D trajectory concept performs in US airport operation environment (high traffic demand)

Goals and Scope

- Evaluation of the two approaches in a same simulation environment – eliminate taxi speed discrepancy
- Focus on TRACC surface trajectory optimization capability – eliminate taxi route discrepancy
- Experiment area – CLT ramp area

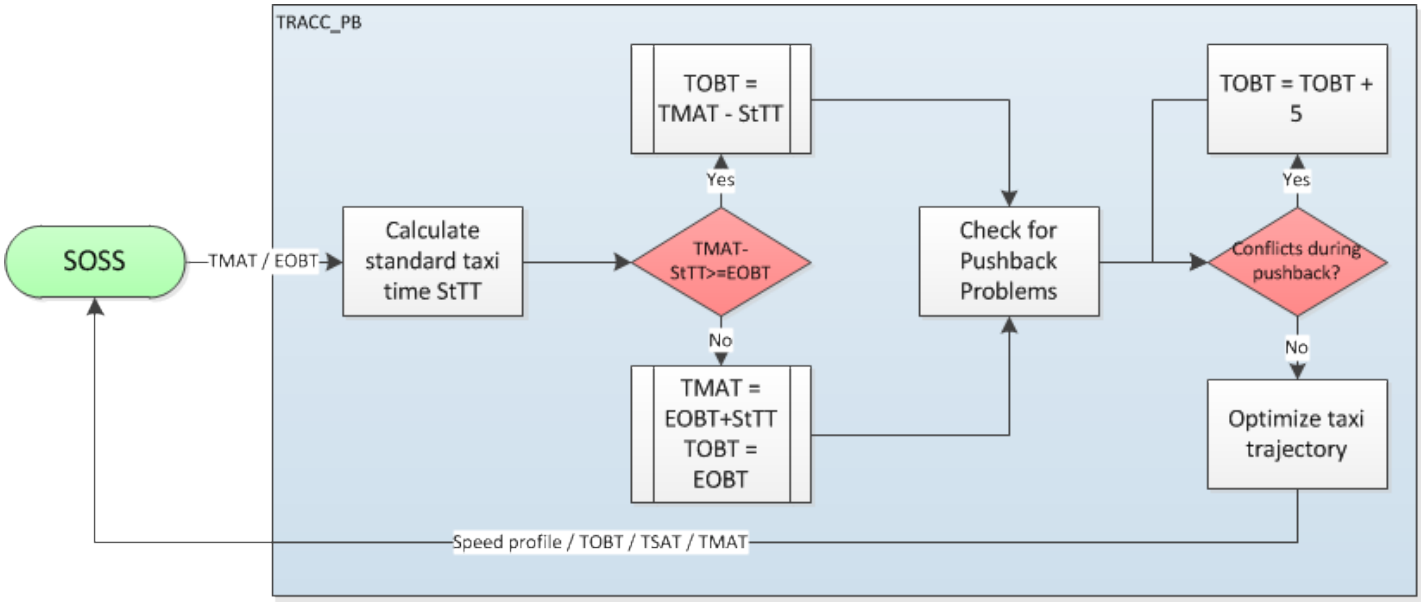
Approach

- Build a simulation environment by using selected TRACC functionality and NASA Ames SOSS fast time simulation platform
- Conduct simulations in an integrated TRACC_PB and SOSS environment
- Analyze simulation results to understand 4D trajectory operation concept , benefits and constraints, such as
  - TMAT compliance
  - Trajectory speed stability
  - Taxi conflicts analysis
  - Ramp traffic throughput
  - Gate hold

TRACC Adaptation for CLT Ramp Operation

- TRACC
  - Fast time simulation module and visualization of traffic
  - Conflict detection and resolution module
  - Flexible trajectory system (situation dependent trajectories based on route segments)
  - Applied to movements on ramp/apron
  - Holdings possible (speed=0)
- TRACC_PB
  - Simulation and visualization is carried out by SOSS
  - Conflict-free trajectories are created but not supervised
  - One predefined trajectory between each pair of position and spot, only speed profile is optimized
  - Applied to ramp only (between positions and spots).
  - Aircraft are held at the positions. No holdings on ramp area!

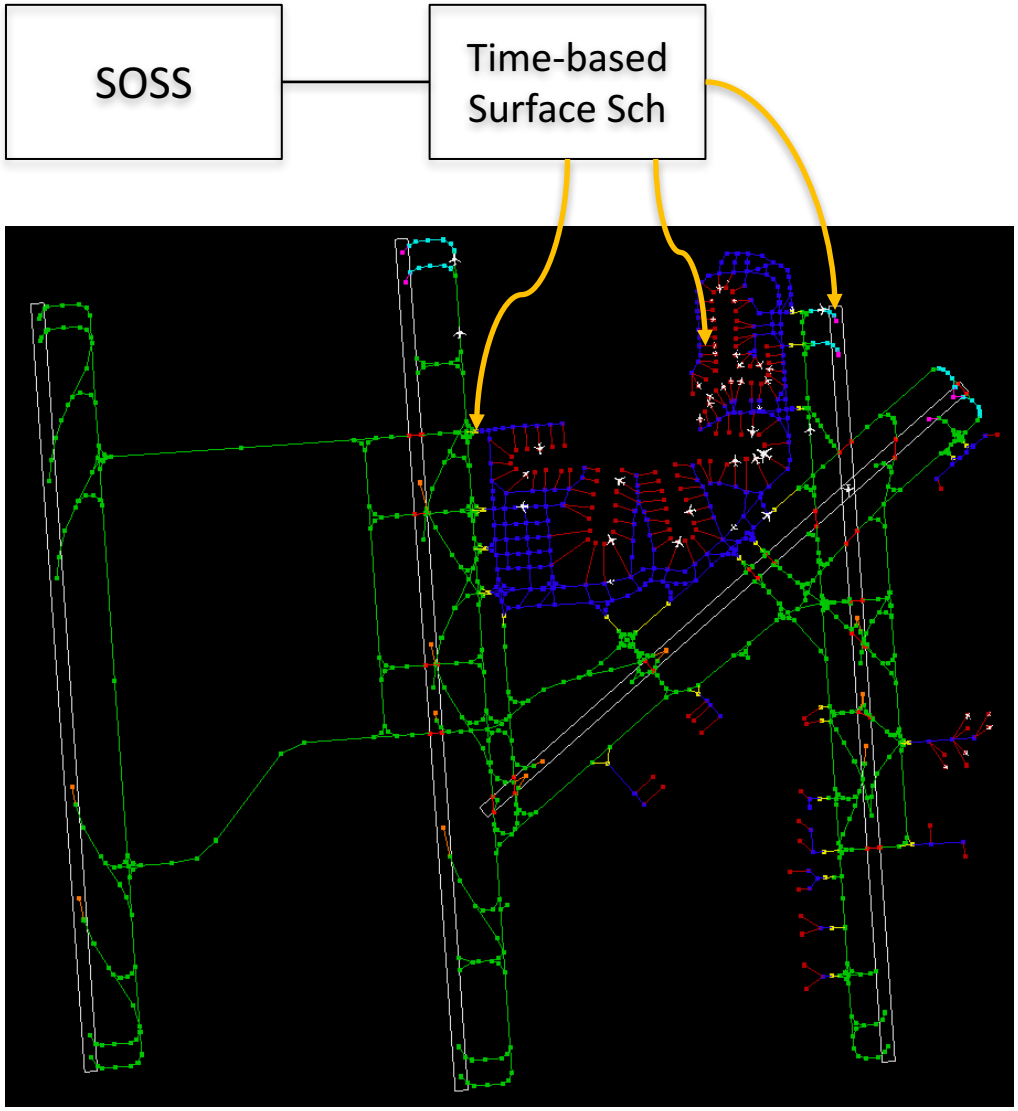
TRACC Functionality for CLT Ramp Operation



- Calculate conflict-free trajectories for flights in the ramp area
- Calculate Target Off-Block Time (TOBT) to meet TMAT at spot.
- If requested TMAT cannot be met with conflict-free trajectory, calculate and propose a TMAT update

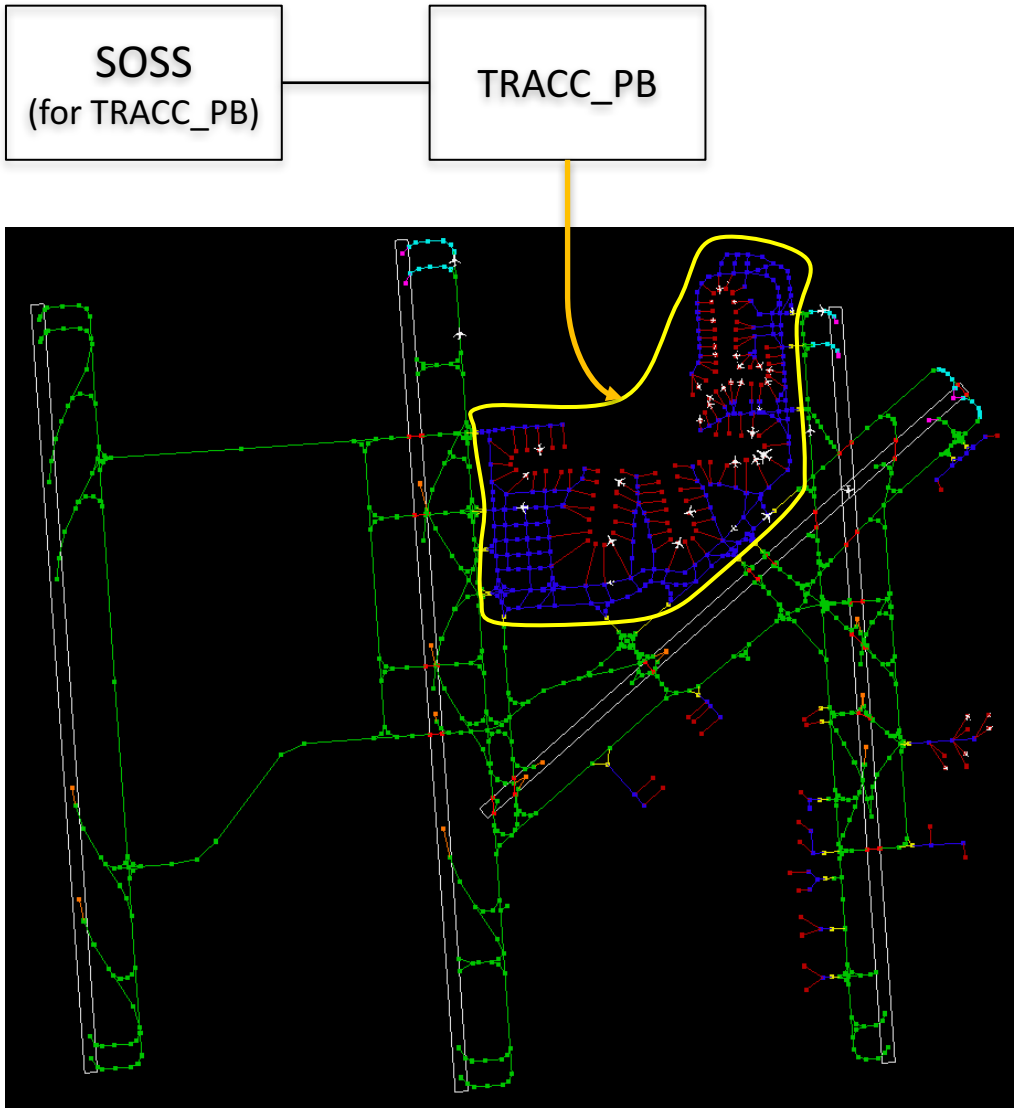
SOSS Adaptation to TRACC_PB Trajectory

- SOSS manages aircraft traffic over an airport node-link graph, consisting of gate, spot, runway , etc.
- In time-based operation, a scheduler issues taxi advisory, typically at gate, spot, and runway, to aircraft to manage the traffic
- SOSS handles taxi conflicts
- SOSS makes scheduling request with a fixed interval, e.g. 10 seconds



SOSS Adaptation to TRACC_PB Trajectory

- In trajectory-based operation, TRACC_PB issues taxi trajectory including speed profile for each node inside the **ramp**
- SOSS executes each flight speed profile inside the ramp
- SOSS monitor taxi conflicts inside the ramp
- Trajectory calculation request is triggered by events in SOSS, e.g., a TMAT is updated

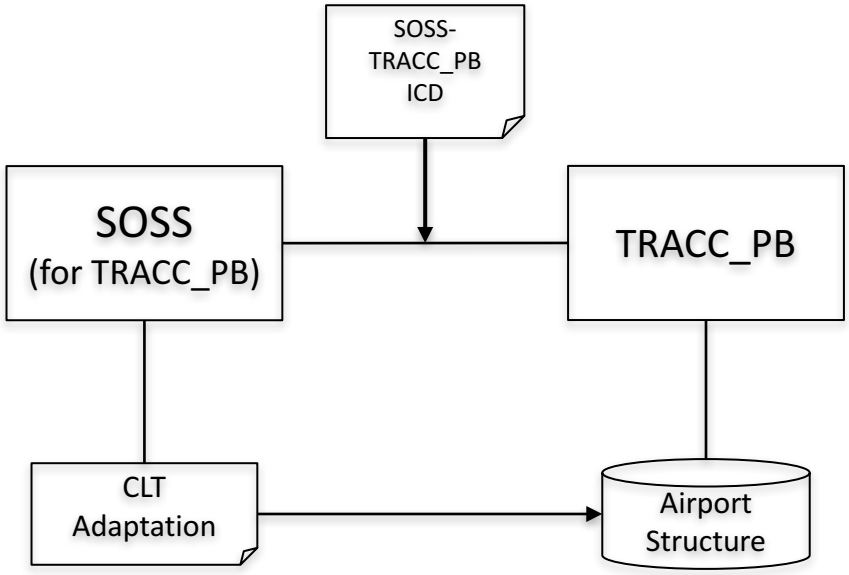


TRACC_PB and SOSS Integration for CLT

- Integration system setup
- Interface Control Document (ICD)
- Departure flight transition
- Arrival flight transition

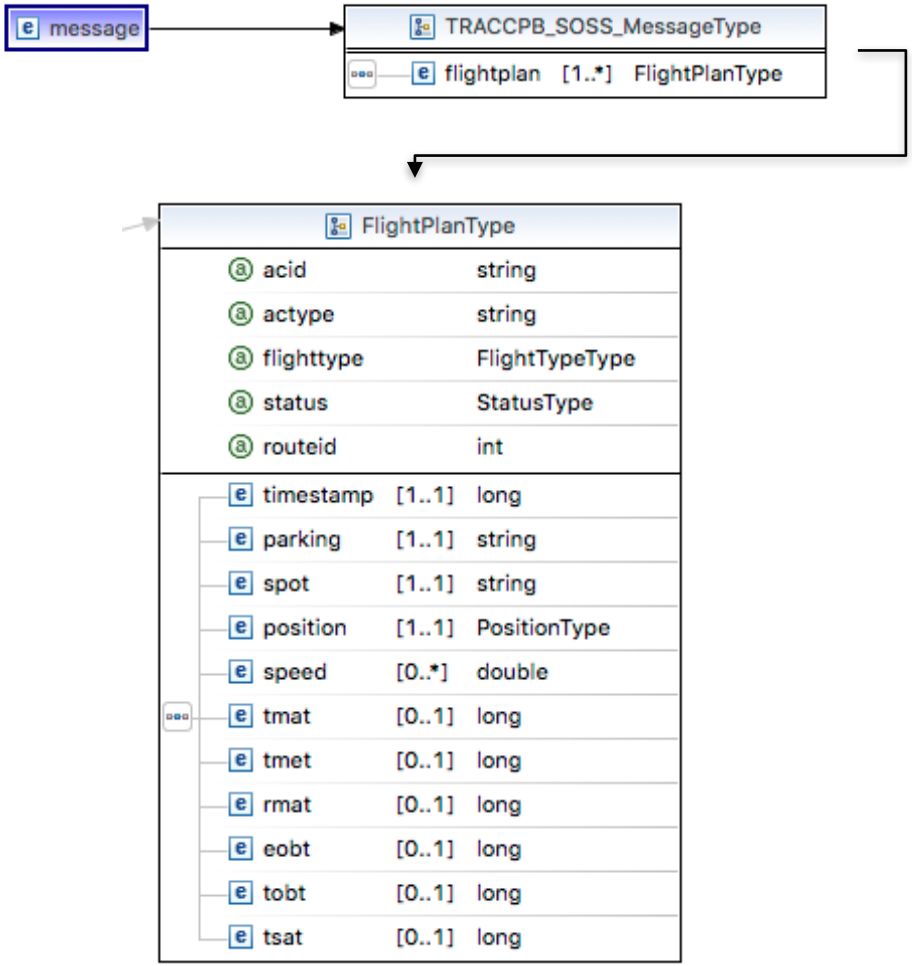
TRACC_PB and SOSS Integration for CLT

- SOSS connects to TRACC_PB during simulation
- SOSS sends ramp traffic data (or events) to TRACC_PB
- TRACC_PB responds with calculated taxi trajectories in the ramp
- SOSS uses the trajectories to move flights in the ramp
- CLT airport model used by SOSS is converted to TRACC recognized tables



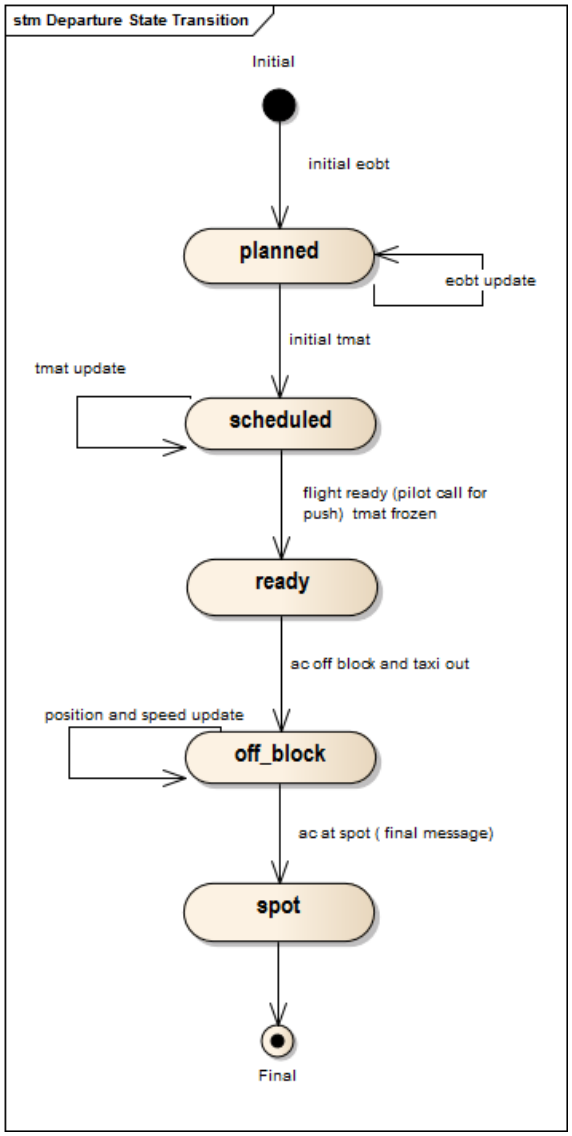
TRACC_PB and SOSS Integration for CLT

- ICD contains a data schema for messages between SOSS and TRACC_PB
- each flight is assigned a gate (or parking) and spot
- TMAT – target movement area time for departure, emulated by SOSS and sent to TRACC_PB
- TMET – target movement area exit time for arrival, emulated by SOSS and send to TRACC_PB
- EOBT -- earliest off-block time for departure
- TOBT – target off-block time calculated by TRACC_PB
- TSAT– equal to TOBT for pushbacks
- speed [0,*] – speed profile calculated by TRACC_PB along taxi trajectory



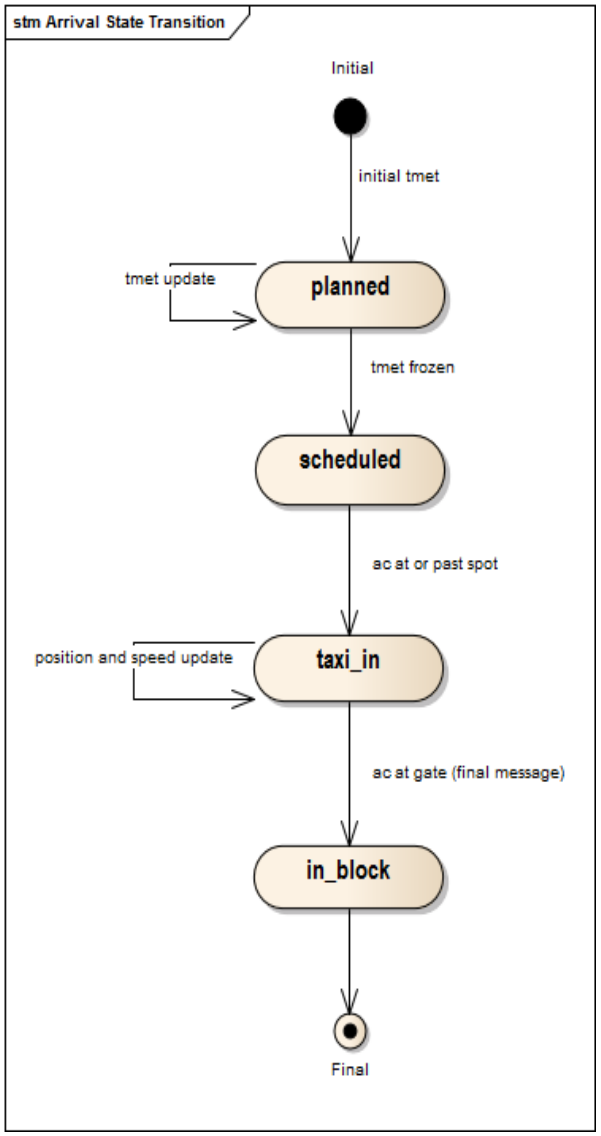
TRACC_PB and SOSS Integration for CLT

- Departure flight state transition by events
  - planned: initial EOBT issued
  - scheduled: initial TMAT issued
  - ready: call for push, TMAT frozen
  - off_block: push started
  - spot: spot reached



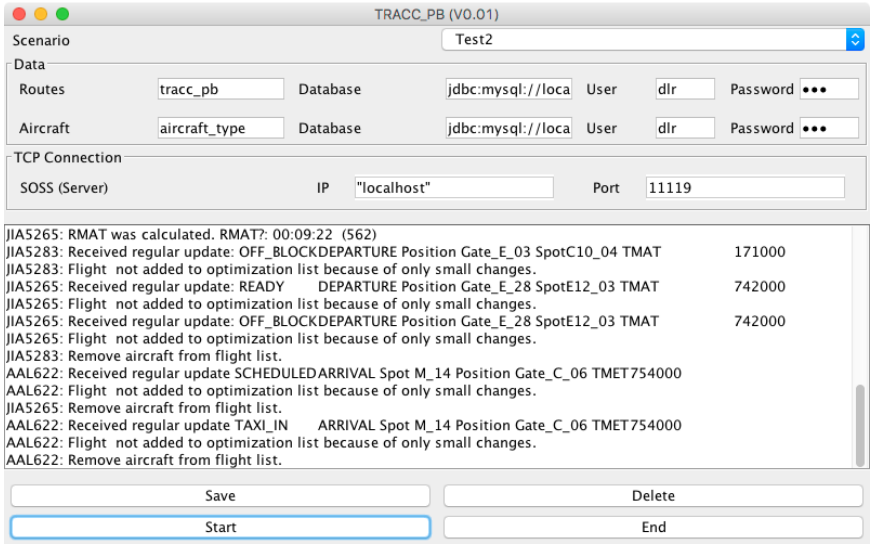
TRACC_PB and SOSS Integration for CLT

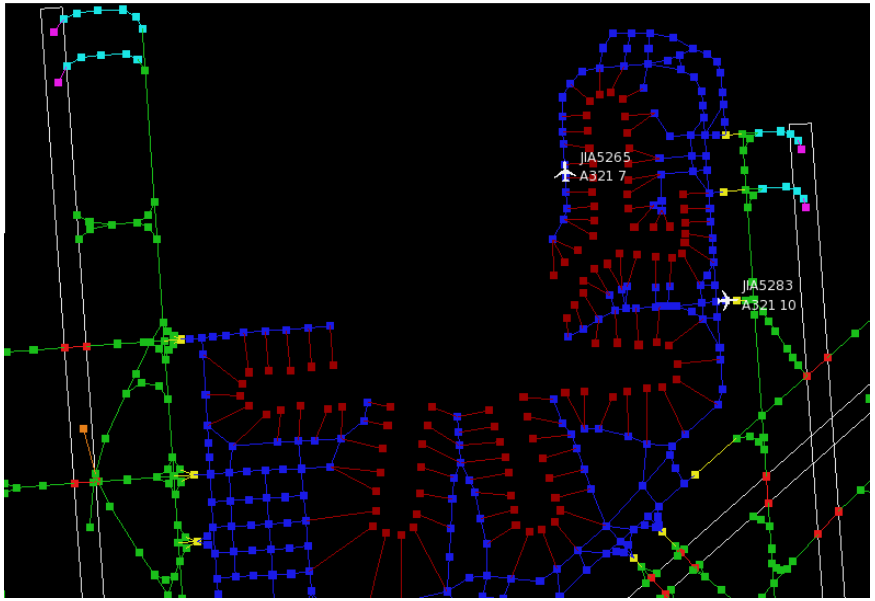
- Arrival flight state transition by events
  - planned: initial TMET issued
  - scheduled: TMET frozen
  - taxi_in: entering spot
  - in_block: at gate



TRACC_PB and SOSS Integration at CLT

- Test runs
  - Succeeded with 2 departures and 1 arrival; test show TRACC_PB's trajectories executed by SOSS
  - Failed with large traffic scenario: ~60 departures and ~60 arrivals in a 90-min scenario





Lessons Learned

- Concept of operations & simulations must be fully elaborated, such as
  - Gate pushback processes
  - Real time (HITL or not) vs fast time
- Integration interface control document is a must and has to be very detailed
- Lots of patience
  - Remote debug and output validation

Remaining Tasks

- Debug and finish current integration test with varying traffic loads
- Run designed simulation scenario(s)
- Collect data and document findings with benefits & constraints analysis

TRACC Adaptation: Possible Extensions

- Possible Extensions of TRACC_PB to increase the quality of simulation results:
  - Introduction of several different basic trajectories between all position and spots (and vice versa)
  - Introduction of holdings taking place on the ramp area