TRACC_PB SOSS Integrated Traffic Simulation for CLT Ramp Operation

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• Motivations
• 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!
• 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 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.
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
• Arrival flight state transition by events
  – planned: initial TMET issued
  – scheduled: TMET frozen
  – taxi_in: entering spot
  – in_block: at gate
• 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
• 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