Performance Evaluation of the Approaches and Algorithms Using Hamburg Airport Operations

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Outline

- Background & motivations
- Approaches and evaluation setups
- Results and analysis
- Summary and future work

Background

- Improving airport operation remains a challenge and draws research efforts in both Europe and the U.S.
- German Aerospace Center (DLR) and NASA research teams each has been testing new ATM concepts/tools
- A research collaboration of DLR and NASA started in 2013 in the area of airport surface operations

Motivations

- Evaluate two different approaches/algorithms (DLR's and NASA's) at same airport
- Inspect each approach's effectiveness in achieving its performance objectives
- Investigate applicability of the concepts and algorithms

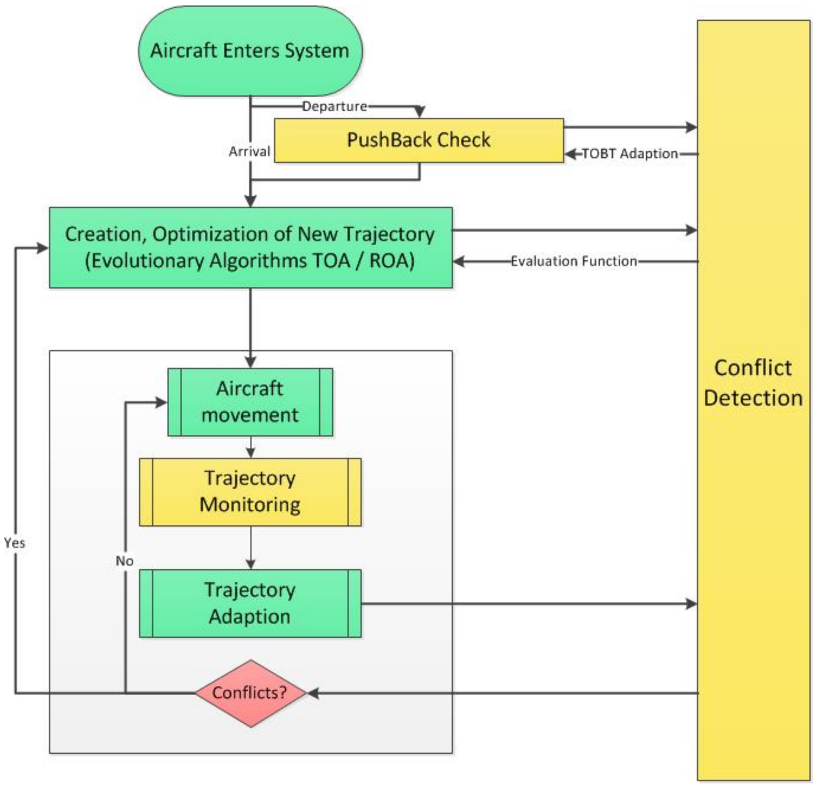
DLR's Approach

- Departure Management System
  - CADEO: Controller Assistance for Departure Optimization
  - Runway Scheduling
- Surface Management Systems
  - TRACC: Taxi Routing for Aircraft: Creation and Controlling
  - 4D Taxi Trajectory calculation
  - Conflict free
- Both are coordinated to benefit from their capabilities as a whole

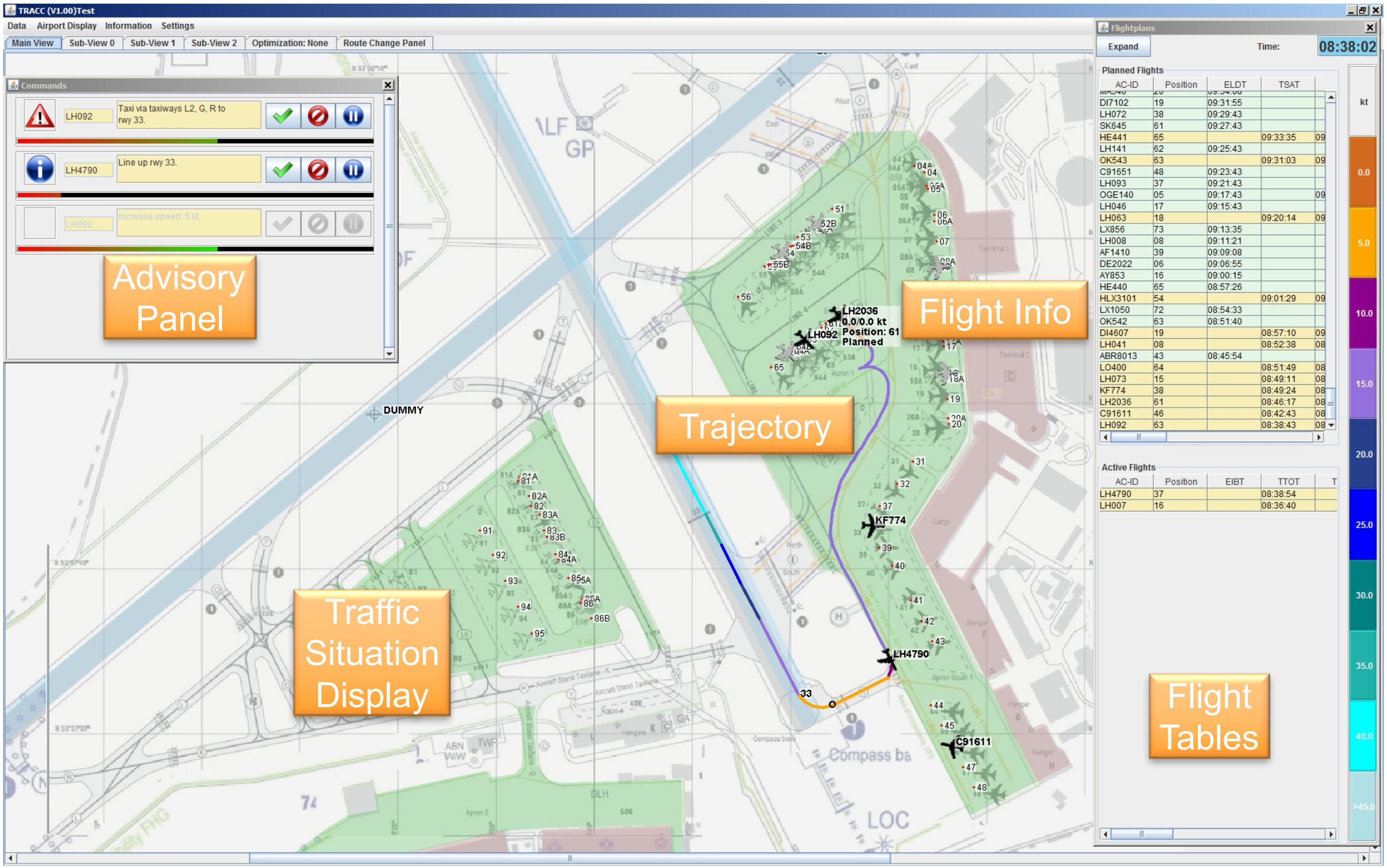
Surface Tool TRACC

Principles

1. "user pays":
   If an aircraft deviates from the advised trajectory only this aircraft's trajectory is re-planned.
2. "highest similarity / reliability":
   The newly created trajectory should differ as little as possible in relation to route and speed from the flight's default route.
3. "lowest workload":
   Changes for a trajectory, where the route is cleared already, should arise as seldom as possible.



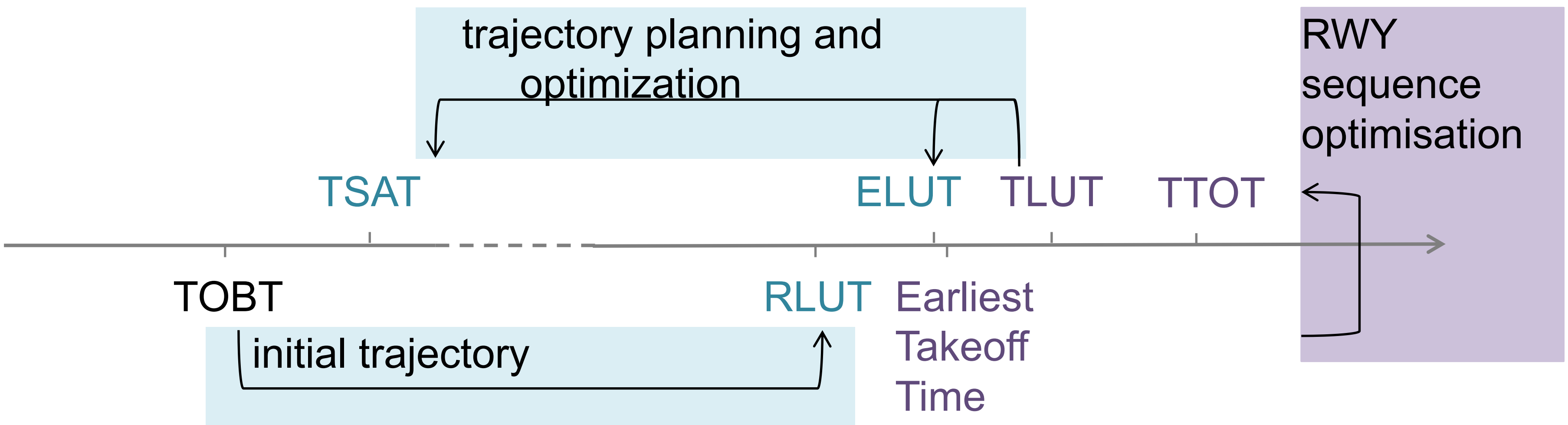
Surface Tool TRACC

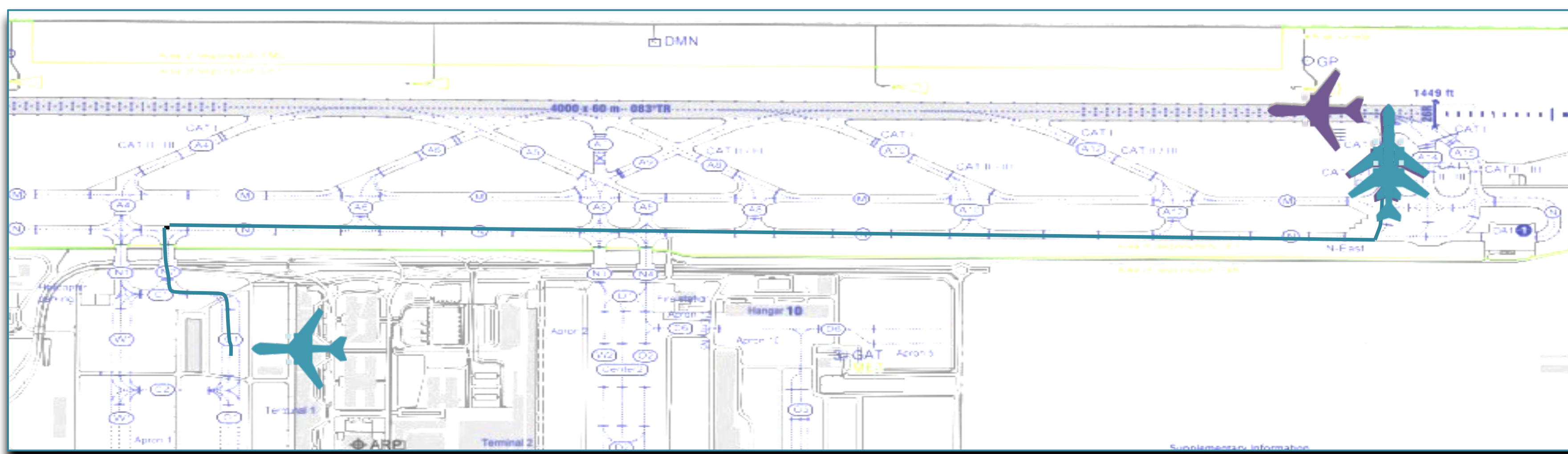


Departure Tool CADEO

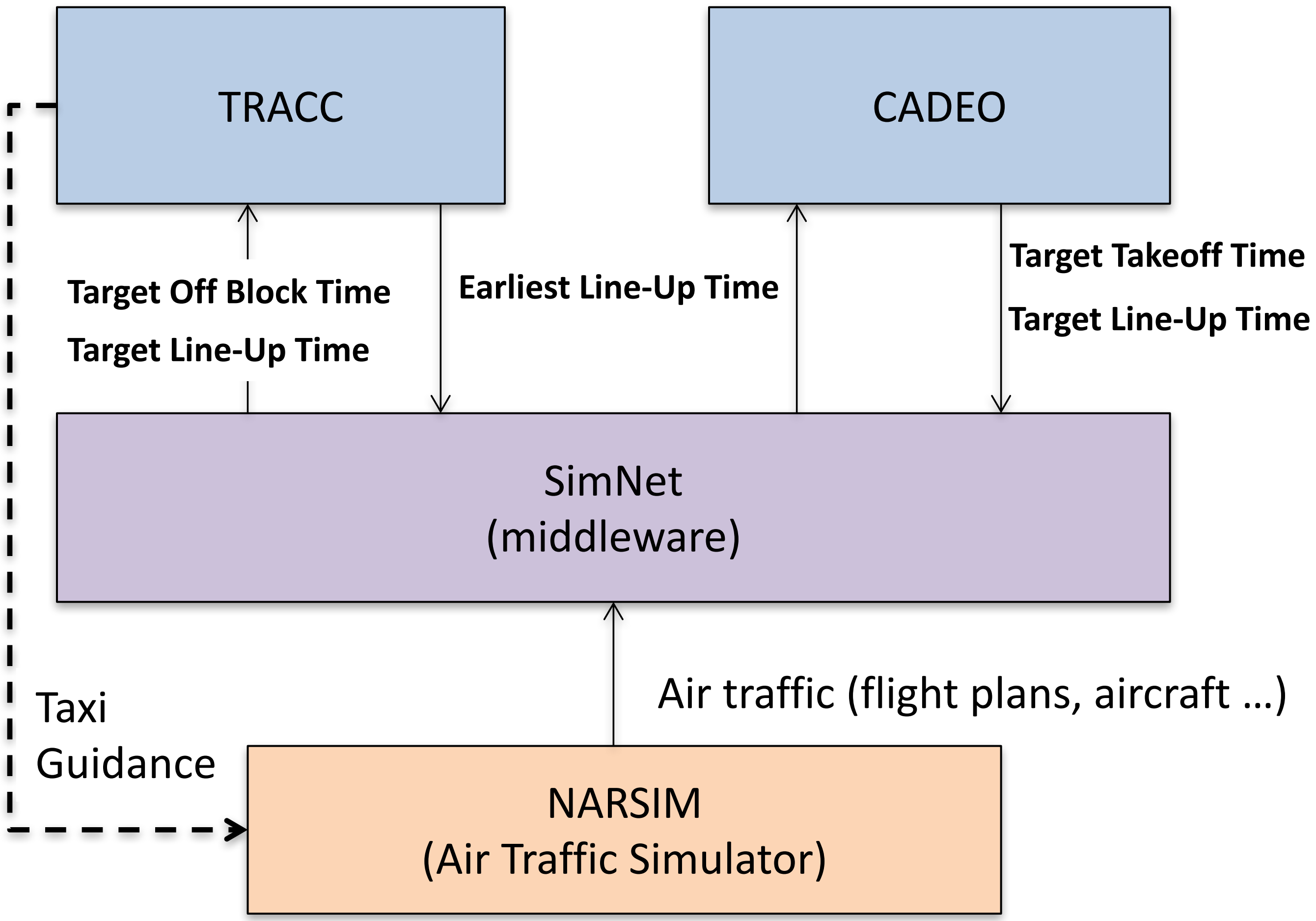
- Research prototype implementing "departure sequence optimization"
- Adaptive planning tool, supporting controller in implementing the proposed sequence
- Takes into account
  - landing times when using mixed mode
  - SID-separations
  - Wake vortex separations
  - Rwy occupancy times
  - SMAN calculations

CADEO TRACC Coupling





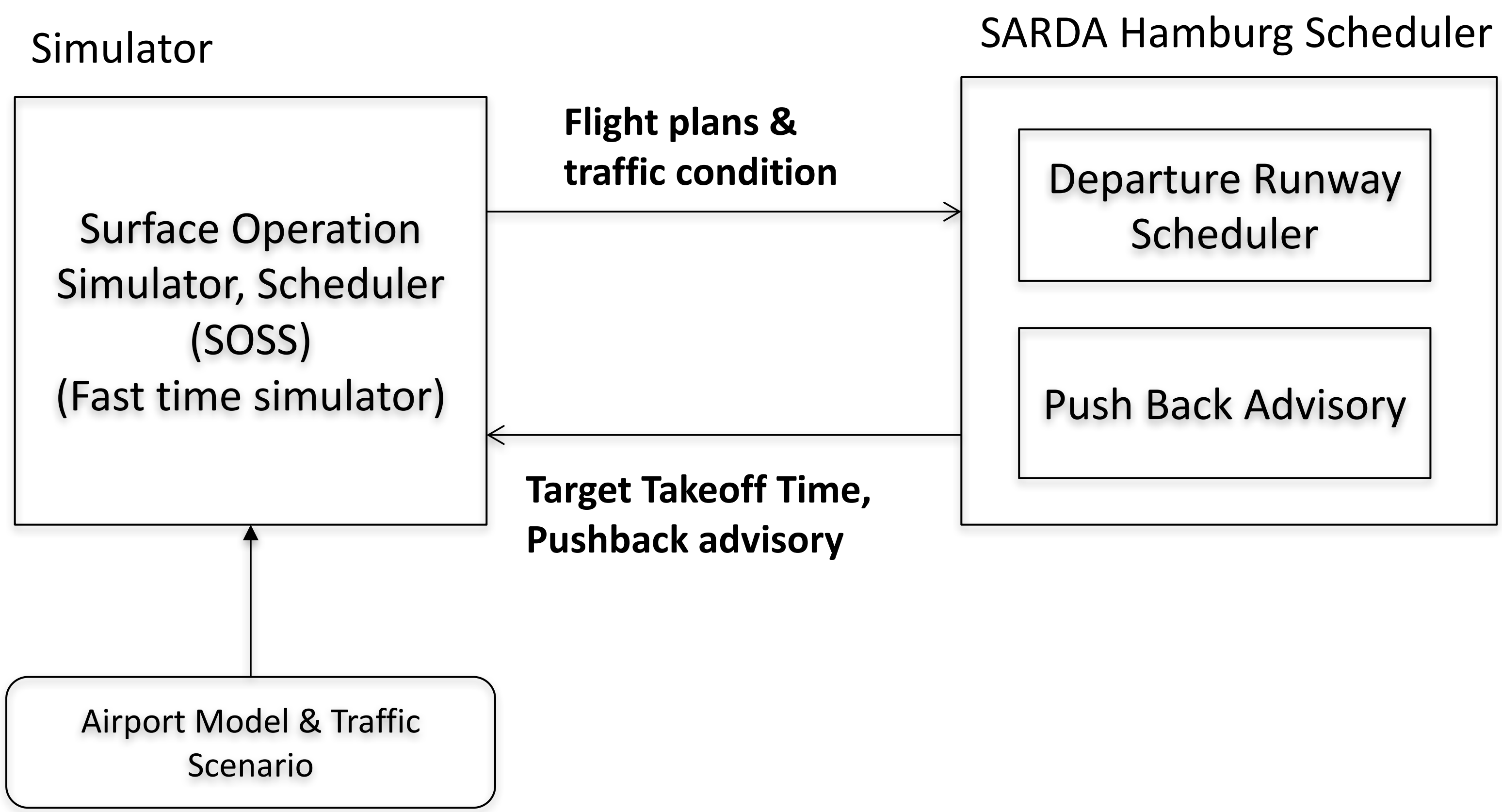
CADEO-TRACC Simulation Setup



NASA's Approach

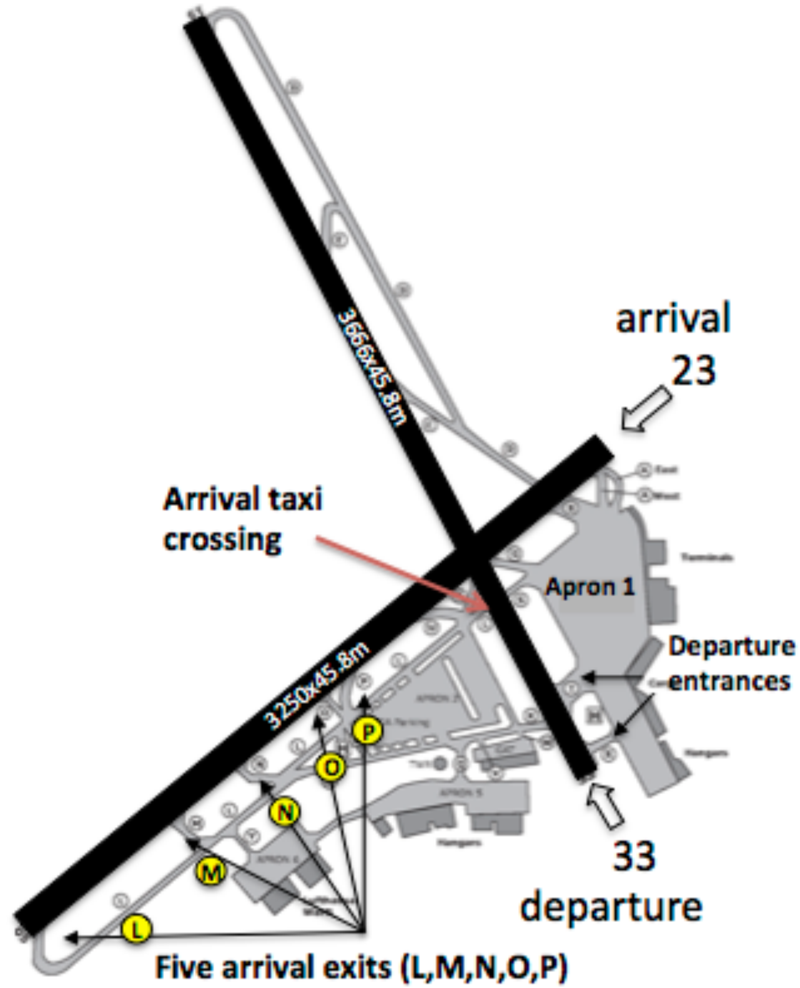
- SARDA -- Spot and Runway Departure Advisor
- A tactical decision support tool for controllers
- Optimized runway sequence for maximum throughput and reduction of taxi time
- Time-based taxi (spot/gate release) advisory

SARDA Simulation Setup

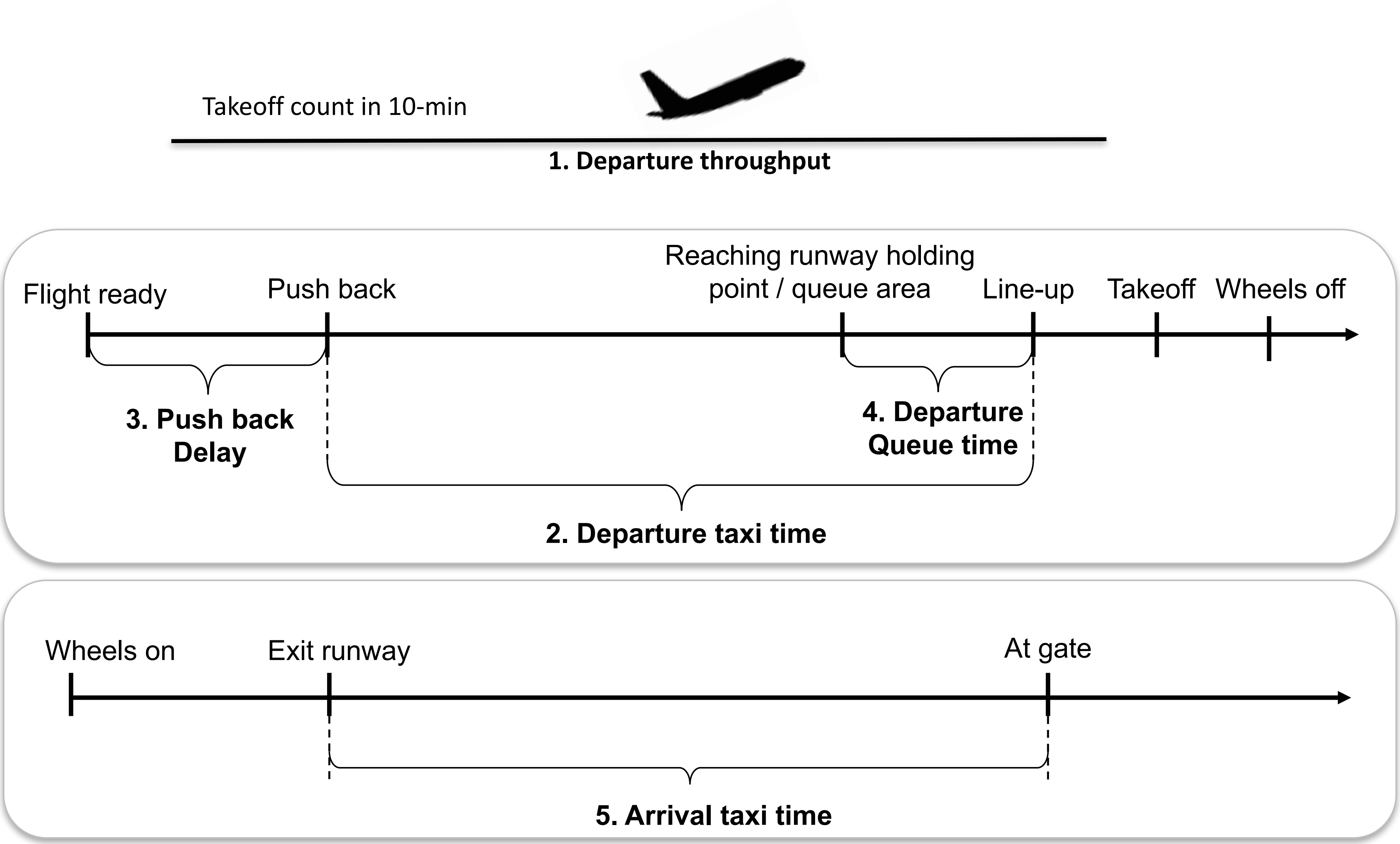


Hamburg Airport and Traffic Scenario

- Two intersecting runways
- Five arrival exits at left hand side
- Arrival aircraft cross departure runway before enter apron
- Two departure queues
- Control responsibilities: ATC – maneuvering area, Airport – apron
- A two-hour traffic scenario (35 departures and 34 arrivals)



Five Performance Metrics

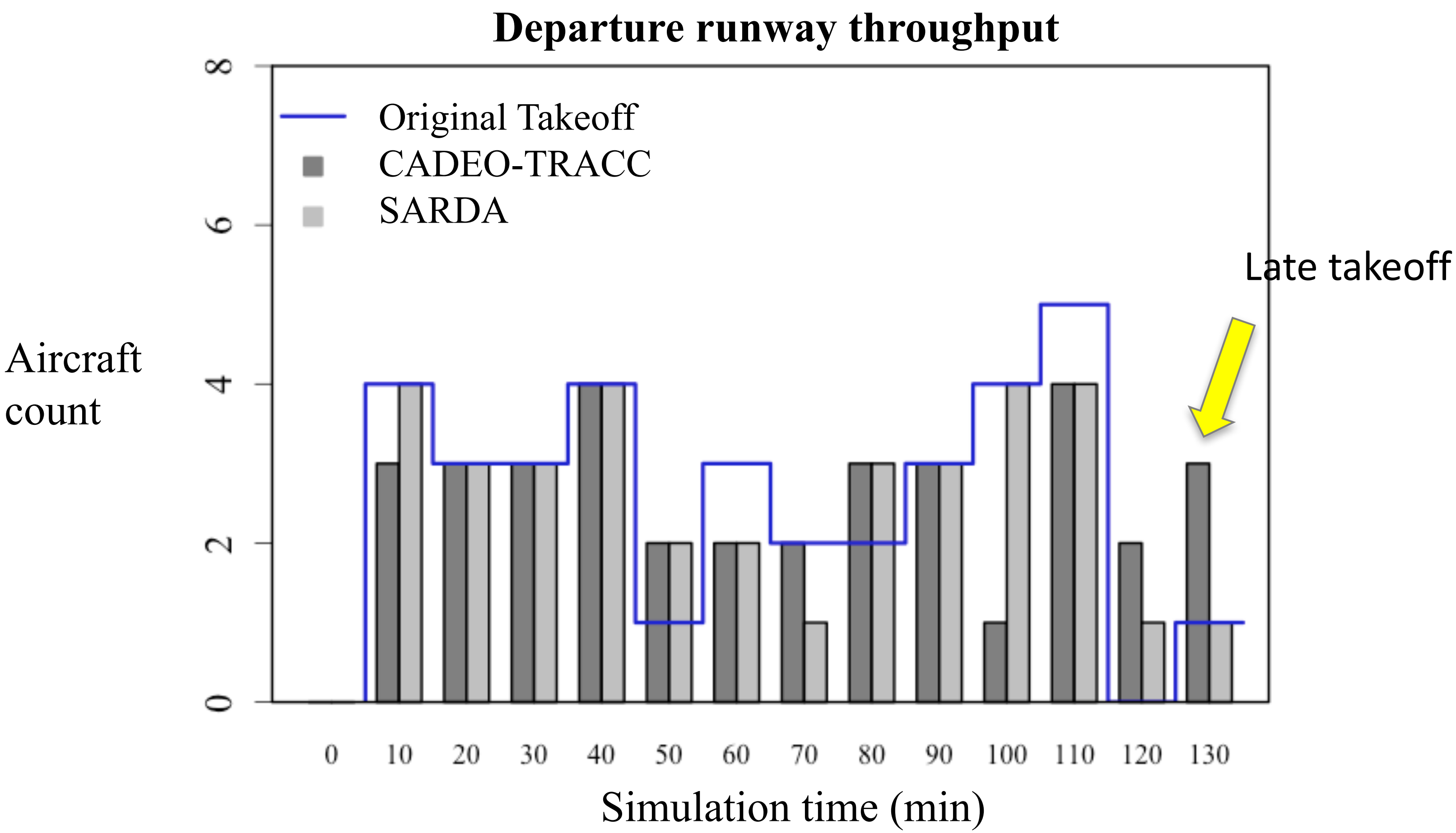


Noticeable Differences

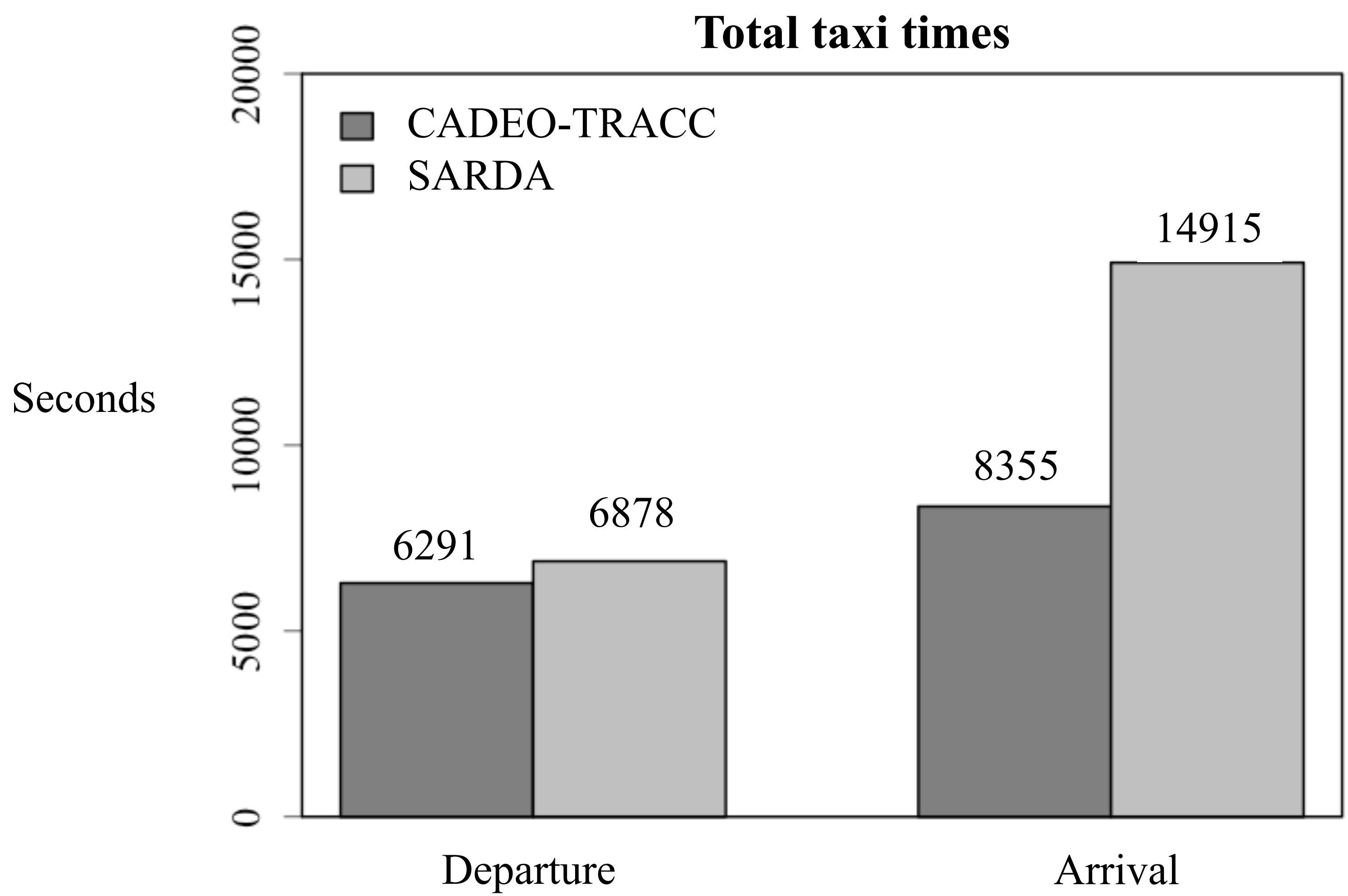
	CADEO-TRACC	SARDA
Taxi Advisory	Conflict-free taxi taxi guidance	Time-based gate push back guidance
Scheduling	Negotiation between CADEO and TRACC	Best effort in push back advisory to meet departure sequence

	NARSIM	SOSS
Maximum taxi speed	30/15 kts at maneuvering/apron area	15/10 kts at maneuvering/apron area
Arrival runway exit selection	Exit at P and O	Exit at M and N

Results and Analysis – Throughput



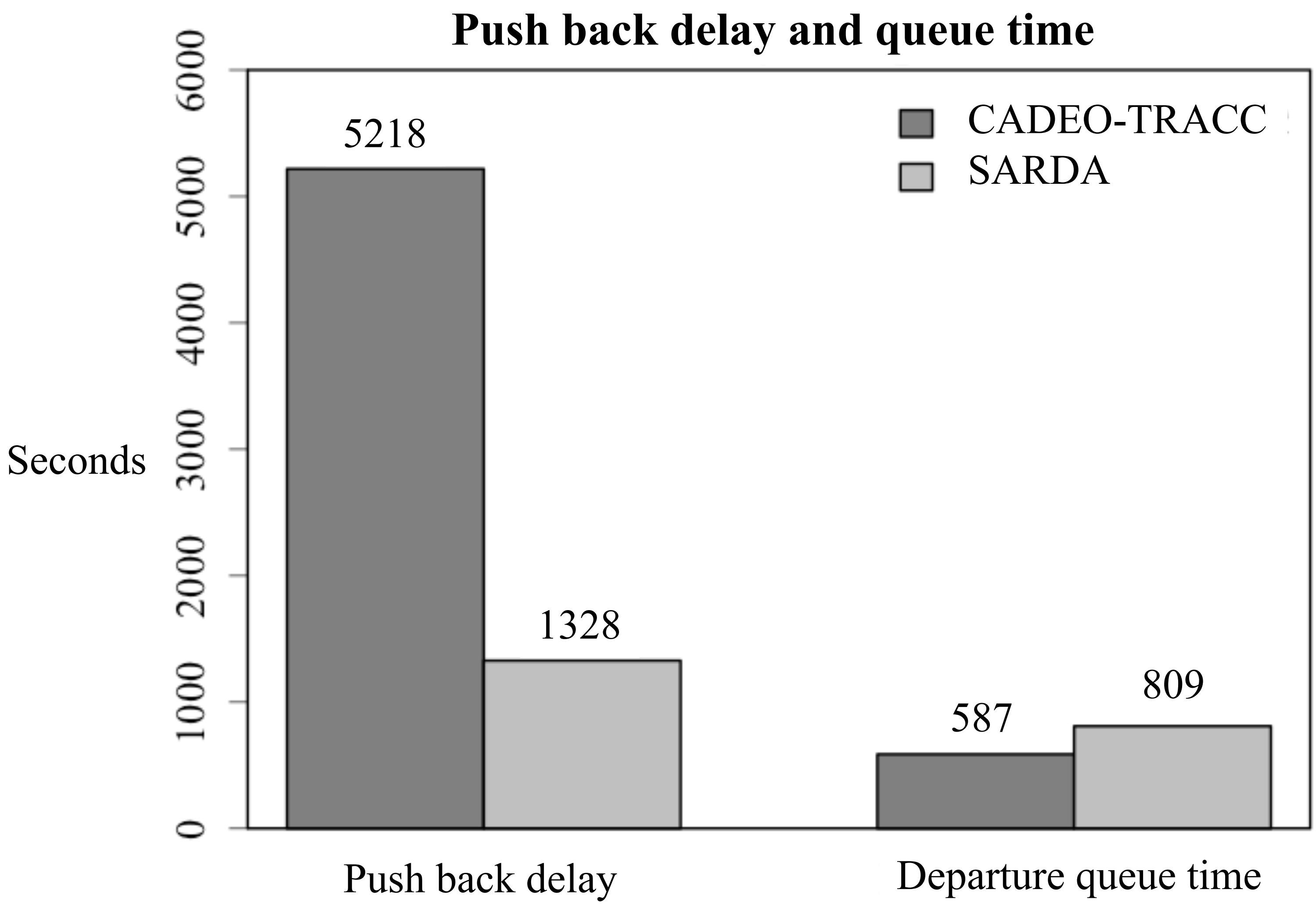
Results and Analysis – Taxi Times



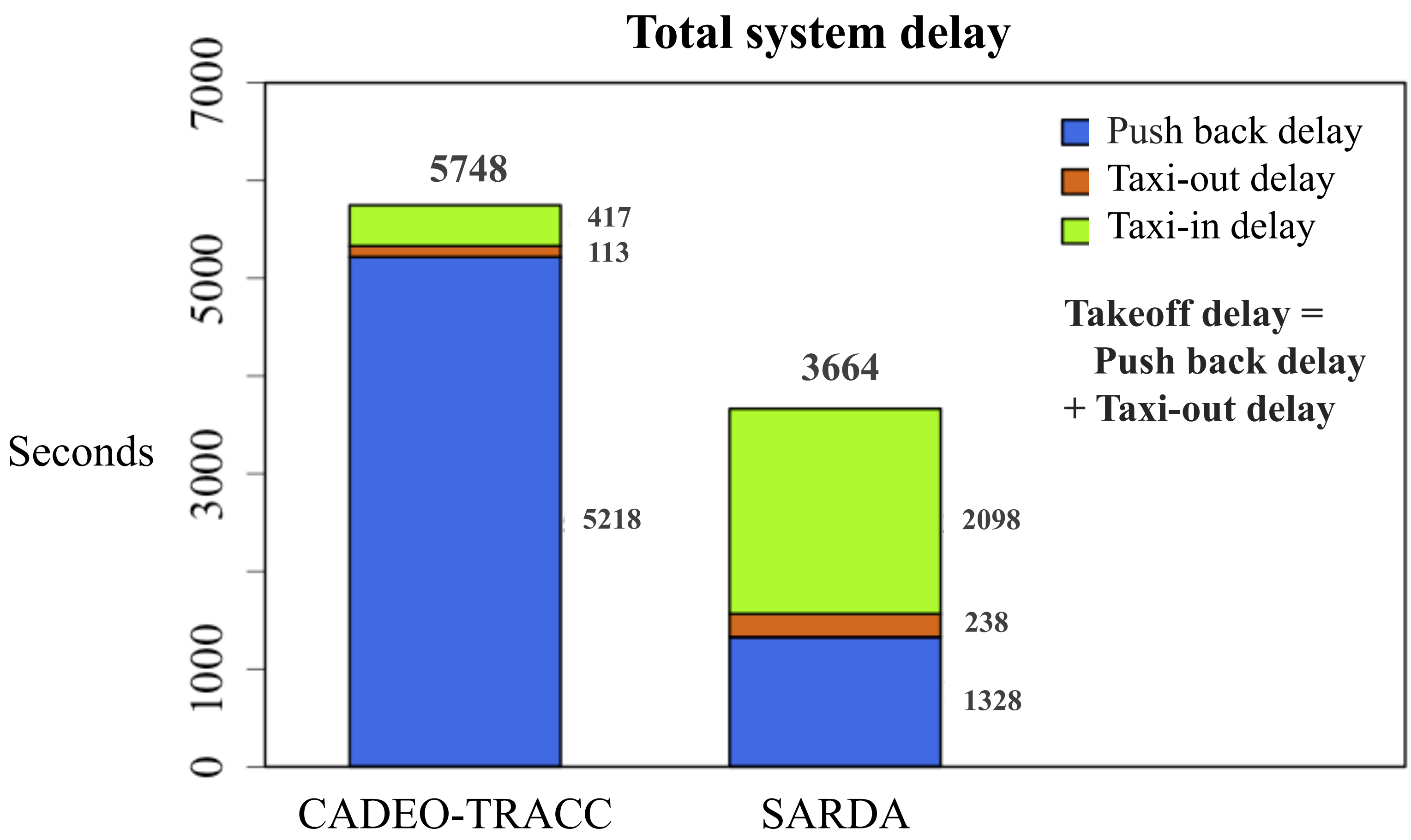
Results and Analysis – Unimpeded and Normalized Taxi Times

	CADEO-TRACC	**SARDA**
Departure unimpeded taxi time	6,178 seconds	6,640 seconds
Arrival unimpeded taxi time	7,884 seconds	12,877 seconds
Departure normalized taxi time	**1.018**	**1.036**
Arrival normalized taxi time	**1.06**	**1.16**

Results and Analysis – Gate Holding



Results and Analysis – System Delay



Summary

- Both systems used gate holding to shift the potential taxi delay to the gate
- Both systems sought to maintain maximum departure throughput
- The conflict-free taxi solution by TRACC led to less taxi times and longer gate holding
- SARDA's taxi advisories of releasing aircraft at gate/spot aimed to balance the surface traffic and runway pressure for throughput
- TRACC showed the ability of negotiating target takeoff time with CADEO for departure throughput trade-off

Future Work

- Evaluation of the two approaches in a same simulation environment
- Feasibility evaluation of conflict-free taxi concept at a busy US airport
- Impact on other constraints, e.g., controller/pilot workload
- Additional metrics, e.g., uncertainties/predictability

Questions