DRISI
CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Results

Centrally Coordinated Schedules and Routes of Airport Shuttles with Los Angeles Airport (LAX) Terminals as Application Area

Develop a Centrally Coordinated Shuttle system to effectively coordinate shuttle schedules and routes in order to minimize curb congestion at the pick-up and drop-off points.

Modal

APRIL 2023

Project Title: Aeronautics Research Support

Task Number: 3370

Completion Date: December 31, 2022

Task Manager:

Nathan Loebs
Senior Transportation Engineer (Electrical)
Nathan.Loebs@dot.ca.gov

DRISI Division Chief:

Prakash Sah, PE
prakash.sah@dot.ca.gov

WHAT WAS THE NEED?

A critical problem facing U.S. airports as they respond to growth in services and operations is the limitation of curbside parking for shuttles to pick-up and drop-off passengers during peak hours. Today, shuttle companies and airport operations work independently without any schedule coordination, leading to frequent congestion near the pick-up and drop-off points that negatively affects passenger traffic leading to unnecessary idling, delays, and congestion with negative impact on air quality and quality of service to passengers. Accurate prediction of arrival times at the pick-up and drop-off points depends on traffic conditions, which are time varying, as well as on the schedules of other shuttles sharing the same curbside spots. Without any form of central coordination, a single shuttle company cannot accurately develop a schedule that maintains a high quality of service at a reduced operational cost. This problem is exacerbated by existing and growing shuttle services provided by the airports themselves, centralized car rental facilities, and public transportation hubs. Furthermore, the transition from conventional to electric shuttles and the possibility of autonomous shuttles introduce additional complexities that necessitate a centralized shuttle coordination system for optimal performance.

WHAT WAS OUR GOAL?

The goal is to develop a CENtrally COordinated Shuttle system (CENCOS) which can effectively coordinate shuttle schedules and routes in order to minimize curb congestion at the pick-

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system.

ADA Notice: Users with accessibility issues may contact the California Department of Transportation, Division of Research, Innovation and System Information. For TTY assistance, call the California Relay Service at 711, email: pm2.communications@dot.ca.gov or write Caltrans, DRISI – MS-83, P.O. Box 942873 Sacramento, CA 94273-0001

up and drop-off points, reduce operational cost, improve quality of service with considerable benefits to mobility and environment. Such a system should also support emerging technology trends including burgeoning electrification and automation. CENCOS will be designed using a co-simulation load balancing approach where the digital twin of the traffic network is part of the optimization procedure in order to take into account complex traffic dynamics and interactions of vehicles and generate accurate predictions of traffic states at the various links to be used by the optimizer. The system will receive demands and desired schedules from all shuttle companies and generate schedules and routes that minimize the overall system cost while meeting the performance and operational cost goals of each shuttle provider.

WHAT DID WE DO?

In this project CENCOS is designed and evaluated by considering the recent development in theory, software and information technologies. The CENCOS system formulation is based on the combination of job assignment formulation and co-simulation optimization approach that combines real time traffic simulators with a route optimization algorithm in a feedback configuration. The system simulator captures the nonlinear impact of traffic loads on traffic flow which is then used in the optimization of the routes. Based on the more accurate predictions of traffic stated generated by the incorporated traffic simulator, the CENCOS system plans the schedules and routes of all shuttle vehicles in order to minimize curb congestion at the pick-up and drop-off points, reduce operational cost and improve quality of service. In the sight of emerging technology trends including burgeoning electrification and automation, the CENCOS system is designed to include multiple types of shuttles, such as electric shuttles and autonomous shuttles. The use of mixed fleet of shuttles powered by diesel and electricity, introduces additional constraints and cost criteria to be considered, since battery electric shuttles have a higher capital cost, shorter range, and longer refueling time than diesel shuttles.

The CENCOS system is demonstrated in a real road network combining a 'digital twin' of the Los Angeles World Airport (LAWA) traffic network and a macroscopic network covering the road network from Los Angeles International Airport (LAX) to Los Angeles (LA) downtown.

WHAT WAS THE OUTCOME?

The main outcomes of the project are listed as follows:

- The shuttles spend less waiting and traveling time in the airport area by participating in the proposed CENCOS system.
- The benefits generated by the CENCOS system depend on the background traffic and increase with heavy traffic.
- The CENCOS system shows savings in total cost of about 30% when compared with current shuttle management systems, where each shuttle company operates individually without any coordination.
- The total cost of shuttle assignment from the CENCOS system decreases as the number of electric vehicles increases.
- The emissions go down drastically as the number of electric vehicles increases in the fleet.

WHAT IS THE BENEFIT?

The research performed is a preliminary step toward a coordinated shuttle scheduling and routing system using load-balancing techniques and by no means captures the full complexity of shuttle transport. Some of the assumptions made need to be validated with experiments and some of the scenarios tested are rather simple when compared with the complexity of shuttle operations. This research, however, sets the foundations of the concept of a centrally coordinated shuttle management system by solving some challenging

The contents of this document reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the California Department of Transportation, the State of California, or the Federal Highway Administration. This document does not constitute a standard, specification, or regulation. No part of this publication should be construed as an endorsement for a commercial product, manufacturer, contractor, or consultant. Any trade names or photos of commercial products appearing in this document are for clarity only.

© Copyright 2026 California Department of Transportation. All rights reserved.

problems whose solutions point to the direction for future research for eventual implementation.

LEARN MORE

Final Report:
https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/ca23-task3370-a11y.pdf

IMAGES

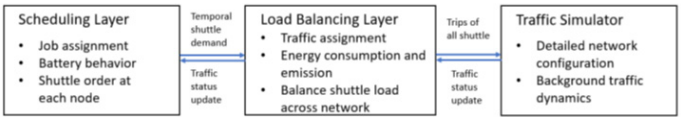


Image 1: The framework of CENCOS formulation.

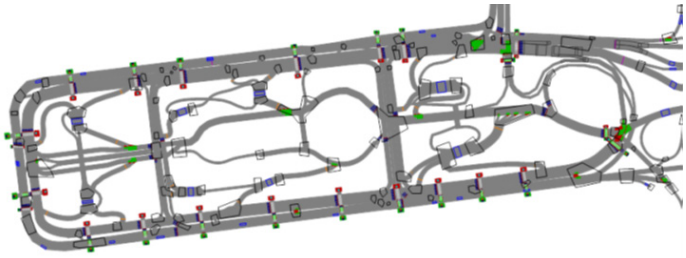


Image 2: Microscopic digital twin of the traffic flow network in the LAX area.

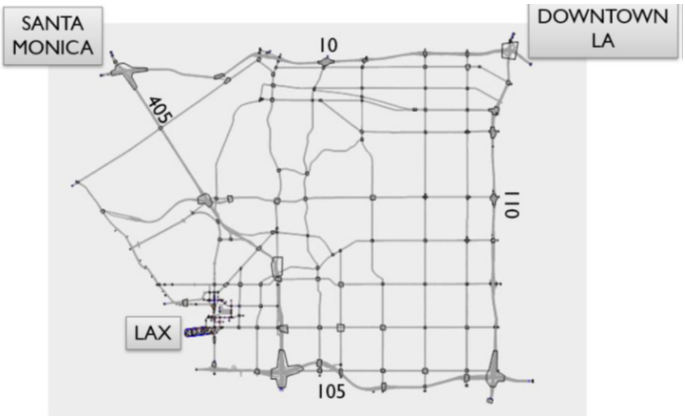


Image 3: LAX-LA downtown digital twin of the traffic network.

The contents of this document reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the California Department of Transportation, the State of California, or the Federal Highway Administration. This document does not constitute a standard, specification, or regulation. No part of this publication should be construed as an endorsement for a commercial product, manufacturer, contractor, or consultant. Any trade names or photos of commercial products appearing in this document are for clarity only.

© Copyright 2026 California Department of Transportation. All rights reserved.