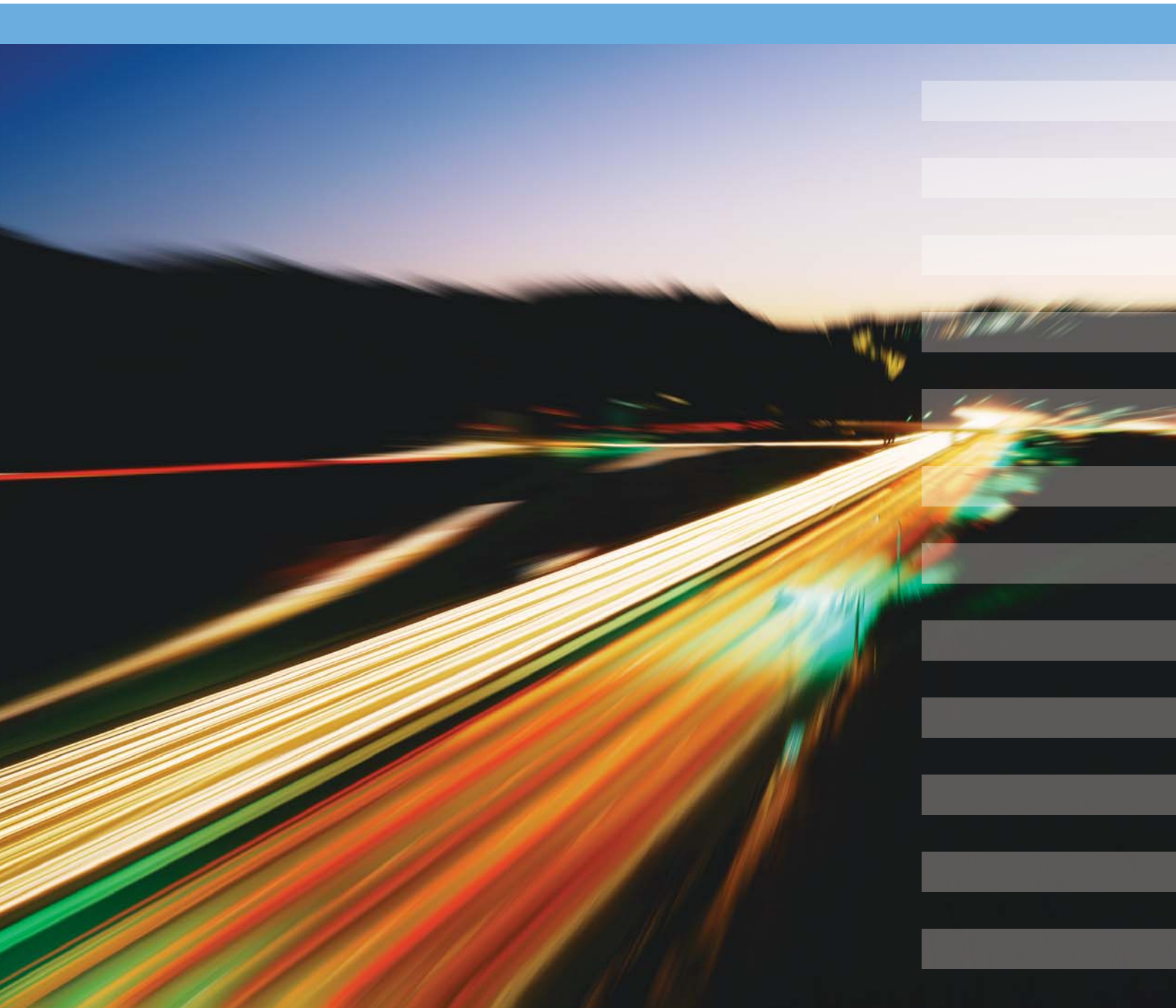


United States Postal Service

Highway Corridor Analytic Program (HCAP)
Program Overview



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Introduction

The transportation network of the United States Postal Service (USPS) is extremely large and complex, and accordingly the transportation planning process is an important and challenging component of USPS Logistics. USPS and IBM have recently teamed together to develop the Highway Corridor Analytic Program (HCAP) to assist in the transportation planning process. HCAP is an analytical model intended to aid transportation analysts in identifying cost savings opportunities within the USPS surface transportation network. The HCAP model utilizes ILOG, Inc.'s optimization software, ILOG CPLEX, as the underlying optimization engine, and incorporates a graphical user interface to facilitate the modeling process. HCAP was designed to use existing data sources so the HCAP model can be used for near-term identification of savings opportunities.

The HCAP model has been fully developed and tested, and has been deployed to USPS transportation analysts in USPS Headquarters and in the regional Area offices. Many of the recommendations that have been developed from HCAP model results have been implemented, resulting in annual transportation savings of over \$5 million already being realized at USPS during the early stages of HCAP deployment, with significant additional savings identified and currently under review.

Highlights

The United States Postal Service (USPS) operates a complex system of transportation networks to accommodate the many different services USPS offers to its customers. These multiple networks create significant challenges to USPS transportation planning.

Background

The USPS surface transportation network is actually comprised of many different networks, each designed for specific purposes. USPS delivers many different types of mail, including letters, flats (e.g, large envelopes for unfolded documents), parcels, and periodicals. Different types of mail have different characteristics which determine the processing requirements. For example, letters, flats, and parcels all have different sizes, shapes, and weights, resulting in the need for specialized processing operations to accommodate those differences. USPS also offers several different mail classes, including Priority, First Class (overnight, 2-day, and 3-day), and Standard mail classes. Each mail class has specific service standards that define the overall delivery timeframe for that mail class.

To accommodate the wide range of mail type and mail class options available to USPS customers, USPS has established many different transportation networks. For example, the bulk mail network transports bulk mail (e.g, standard parcels, periodicals, and other bulk mail) through Bulk Mail Centers (BMCs); the Hub and Spoke Program (HASP) is a transportation network that consolidates mail through HASP facilities for purposes of aggregating volumes; inter-plant transportation carries mail among Processing and Distribution Centers (P&DCs); and time-critical mail (e.g., Express mail and some First Class and Priority mail) is trucked from P&DCs to Air Mail Centers (AMCs) to enter the air transportation network.

Each of these transportation networks was designed to serve a particular purpose, but each network does not operate in isolation. Rather, significant overlap and redundancies exist among the various surface transportation networks. For example, inter-P&DC transportation may stop at a BMC en-route between P&DCs, to get bulk mail from the origin P&DC into the bulk mail network. Similarly, HASP transportation may additionally stop at P&DCs to pick-up and drop-off inter-P&DC mail along the HASP route.

Highlights

The vast size of the USPS transportation networks further complicates the planning process. On an average weekday, for example, USPS may dispatch over 75,000 trips among over 30,000 facilities in the highway transportation network.

USPS and IBM teamed together to develop the Highway Corridor Analytic Program (HCAP) to assist USPS in optimizing highway transportation. HCAP is an optimization model designed to minimize transportation costs, within specified business rules and operational constraints.

These multiple, intertwined transportation networks create significant complexities and challenges in USPS transportation planning. The vast size of the USPS transportation network further complicates the planning process. On an average weekday, for example, USPS may dispatch over 75,000 trips among over 30,000 facilities (including processing facilities, post offices, and other facilities) in the highway transportation network. USPS employs a variety of advanced analytical tools and techniques to address the challenges of managing such a large and complex network. USPS and IBM recently developed the HCAP model to serve as a robust analytical tool to assist in the transportation planning process.

The Highway Corridor Analytic Program (HCAP)

Overview

To address the transportation planning challenges within the complex postal network, USPS and IBM teamed together to develop HCAP. HCAP is an analytical model that utilizes ILOG's optimization software to assist USPS in analyzing transportation scenarios to identify cost savings opportunities. This initiative combined USPS's extensive postal logistics expertise and industry knowledge, IBM's operations research expertise and analytical focus, and ILOG's robust optimization solver capabilities, to create an effective optimization model tailored to the USPS transportation environment.

Specifically, HCAP is an optimization model designed to minimize highway transportation costs within specified business rules and operational constraints. The optimization model is bound by rigid constraints, including service standards which define the acceptable transportation timeframe, and delivery characteristics which define the origin facility, destination facility, volume of mail that must be transported from origin to destination, time/day mail is available at the origin, and time/day mail is required at the destination. The HCAP model identifies the optimal consolidation opportunities to minimize transportation costs within the specified constraints.

Highlights

HCAP has been deployed to the USPS Area offices and USPS Headquarters, and is currently being used to identify transportation savings opportunities.

The HCAP model was designed primarily to focus on consolidation opportunities within subsets of the existing USPS transportation network. HCAP also provides the capability of generating potential new trip options that the optimization could consider in identifying cost savings opportunities.

A graphical user interface was created for the HCAP model to automate data input and streamline the model-building process. The user interface also provides several reporting features to facilitate analysis of the results and assist in developing recommendations for implementation. HCAP has been deployed to the USPS Area offices and is currently being used to model specific scenarios of interest in those offices, as well as at USPS Headquarters.

Model Scope

The HCAP model is intended to optimize subsets of the existing USPS highway transportation network. Focusing on subsets of USPS transportation (rather than all USPS transportation at the national level) typically ensures reasonable run-times for the optimization as well as reasonable levels of effort and time required for USPS transportation analysts to build models and interpret the results. Each analyst has significant flexibility when defining the subset to model; subsets may be specified according to geographic regions (e.g., the Western Area, or the Chicago – Milwaukee corridor), type of transportation (e.g., HASP transportation, or inter-BMC transportation), or by specific facilities (e.g., all transportation out of the Southern California Surface Hub, or all trips that stop at Eastern Area P&DCs.) The scope of each particular scenario depends on the transportation subset of interest. Each scenario is individually defined by the analyst to assist in analyzing specific areas of transportation.

The HCAP model was primarily designed to focus on consolidation opportunities within existing USPS highway transportation. HCAP also provides the capability of generating potential new trip options that the optimization could consider in identifying cost savings opportunities, which may potentially increase the overall savings identified by the model. Generating new trip options, however, significantly increases the model size and typically lengthens the model run-time considerably. New trip options also create further challenges and complexities during implementation of the results. Thus, each analyst must consider the tradeoffs when defining the scope for the scenario of interest.

Development Team and Timeframe

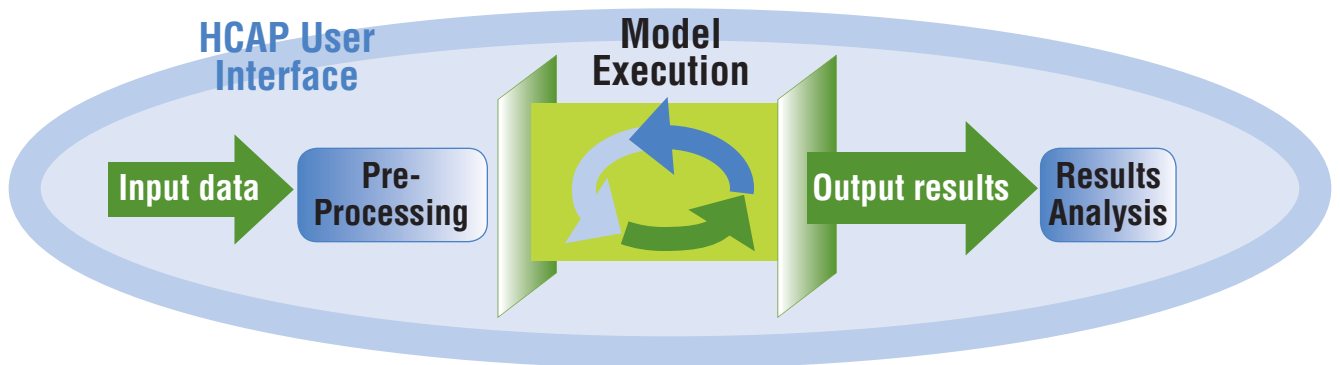
The development of the HCAP model involved an integrated project team, including team members from USPS Logistics and IBM Business Consulting Services. The team composition varied during successive stages of model development to efficiently meet the requirements of model development, but generally included approximately five core team members as well as input and expertise from a wide range of USPS subject matter experts. The development of the optimization model was completed within a five-month timeframe, and the user interface was subsequently developed within a six-month timeframe.

Analytical Approach

The HCAP modeling approach involves three primary components:

- 1. Data Input and Pre-Processing**
- 2. Model Run Execution**
- 3. Results Analysis**

This modeling approach is depicted in the following diagram.



Highlights

At the core of HCAP is a mixed integer program (MIP) optimization engine; this optimization engine considers all routing and scheduling options available within the model, identifies the optimal set of trips and determines how much mail volume should be assigned to each trip.

Data Input and Pre-Processing involves importing the data set, reviewing the data for accuracy and completeness, and correcting any inaccurate or missing data. During pre-processing, the analyst also defines the scenario of interest, establishes the desired constraints and business rules, and sets the modeling parameters.

At the core of the HCAP model is an optimization engine that considers all possible routing and scheduling options available within the model, and identifies the optimal solution to minimize costs while meeting all specified constraints. Specifically, this optimization model is a mixed integer program (MIP) that is solved using ILOG CPLEX optimization software to identify the optimal set of trips and to determine how much mail volume to assign to each trip.

The optimization model is defined as follows.

Objective: Minimize total transportation cost of scenario

Subject To Operational Constraints Including:

- All mail volumes must be delivered from the specified origins to the specified destinations
- No truck capacity may be exceeded
- Trucks may not depart the origin before mail is available
- Trucks must arrive at the destination by the mail required time/day

The analyst also has the option of including additional constraints, such as allowing/disallowing volumes to be split onto multiple trucks, and allowing/disallowing volumes to be displaced from the current truck onto a different truck in order to open up capacity for other volumes on the current truck.

Once the optimization has been run and has identified the optimal routes and schedules for the scenario, the optimization results are output to reports that are accessible through the user interface. The Results Analysis process involves thoroughly reviewing the results, assessing the feasibility of the model output, revising and refining the results as appropriate to develop recommendations for implementation, and following through with transportation specialists to implement the recommendations and realize cost savings.

Highlights

The HCAP model incorporates ILOG CPLEX optimization software which provides robust optimization capabilities coupled with the flexibility to appropriately model USPS's unique and complex transportation networks.

Optimization Software

Due to the size and complexity of the USPS transportation network it was critical that the software selected during the HCAP design phase be capable of successfully modeling various scenarios within the USPS transportation network. Several software options were evaluated during the HCAP design phase, including commercial off-the-shelf (COTS) packages and customizable optimization engines. The primary criteria in the selection process were: 1) Flexibility to appropriately model USPS's unique and complex transportation networks, 2) Solving Capacity to be able to solve large MIP problems to optimality within reasonable run-times, and 3) Cost. The ILOG CPLEX mathematical programming engine was selected as the optimization software that best met those criteria for the HCAP modeling project. ILOG CPLEX is relied upon extensively in the transportation industry and is actually the core optimization engine in many COTS optimization packages.

During the HCAP design phase, the flexibility of the optimization engine was critical to successful model development, allowing for accurate modeling of USPS's unique operations and business constraints. The fast and robust algorithms proved extremely effective, as most scenarios were solved very quickly—often within seconds.

Deployment and Sample Results

HCAP has been fully developed and tested, and has been deployed to transportation analysts at USPS Headquarters and in the USPS Area offices. These transportation analysts are currently using HCAP to optimize transportation subsets throughout the U.S. to identify cost savings opportunities. Each analyst is provided the flexibility within the HCAP model to define specific scenarios of interest, set the business constraints and model parameters, and analyze the results to develop recommendations for implementation. Several sample HCAP scenarios have already been completed at USPS Headquarters and in the Area offices, and many of the recommendations from those scenarios have been implemented or are in the process of being implemented.

Highlights

Transportation analysts at USPS Headquarters and USPS Area offices are using HCAP to model subsets of the USPS transportation network to identify cost savings opportunities. To date, USPS has already implemented many recommendations from the HCAP model runs, resulting in USPS already realizing millions of dollars in annual savings.

USPS has applied HCAP to model a wide variety of transportation scenarios.

USPS Headquarters, the Pacific Area office, and IBM worked together during HCAP development to model the Pacific Area transportation network including transportation among P&DCs, BMCs, AMCs, and HASPs. Many of the recommendations from this model run have already been implemented, resulting in approximately \$3.7 million annual savings to-date. These savings represent 24% of the cost of transportation that was eligible for elimination within the optimization model run. (In each model run, a portion of the trips are eligible for elimination and the rest are not. Eligibility depends on trip data availability and user-specified parameters.)

A separate scenario was developed for inbound and outbound transportation at the Busse HASP in Chicago. The implementation of recommendations from that model run has resulted in approximately \$1.3 million annual savings to-date. The HCAP model was also recently used in the Eastern Area, as HCAP was adapted to model local transportation at the Greensboro P&DC and was used to model HASP transportation in Pittsburgh. HCAP was responsible for helping identify approximately \$400,000 annual savings in those efforts.

Several other scenarios are currently in development at various other Area offices as well as at USPS Headquarters. In these scenarios, transportation analysts are exploring many different applications of the HCAP model, including using HCAP for renewal period to identify which trips should be renewed and which trips may be consolidated with other trips, planning for the holiday peak season, and helping identify alternative solutions in HASP transportation planning.

Highlights

HCAP is one example of the advanced analytical capabilities developed through the teaming relationship between USPS and IBM. This teaming relationship combines IBM's strong Operations Research expertise and analytical focus, along with USPS's extensive industry knowledge and postal logistics expertise, to create innovative solutions that address complex Postal transportation issues.

Other Optimization Initiatives at USPS

To address the challenges and complexities of transportation planning for one of the world's largest logistics networks, USPS employs a wide range of analytical approaches and modeling techniques. USPS has proactively identified the need for advanced modeling capabilities, including optimization, simulation, econometrics, statistics, and other analytical modeling techniques. Many advanced modeling capabilities have already been developed, and other initiatives are currently underway to develop a comprehensive set of analytical tools to assist USPS transportation planners.

The Air Optimizer, for example, is an optimization model that USPS and IBM developed to assist with commercial air mail planning. The Air Optimizer determines appropriate mail allocation among available commercial air lanes, considering the trade-offs between cost and performance and ensuring that overall performance goals are met. The Air Optimizer is run each week as part of the regular planning cycle, to help USPS in assigning mail volumes to available commercial airlines.

The Transportation Optimization, Planning, and Scheduling system (TOPS) is a large-scale optimization model currently being developed by USPS and IBM to optimize highway, rail, and air transportation for USPS at the national level. TOPS is similar to HCAP in design and objective, but has an expanded scope that will model the national USPS transportation network including multiple modes of transportation. Similar to HCAP, TOPS utilizes ILOG CPLEX as the optimization engine and has the objective of minimizing overall transportation costs while meeting all business rules and operational constraints.



Conclusion

USPS operates an extremely large and complex transportation network and, accordingly, transportation planning is a critical yet challenging facet of USPS Logistics. USPS is proactively developing a comprehensive set of analytic capabilities using advanced modeling techniques, to assist in the transportation planning process.

HCAP is an optimization model that USPS and IBM designed and developed to identify savings opportunities in USPS highway transportation. The HCAP model has been fully developed, tested, and deployed to transportation analysts at USPS Headquarters and in the regional Area offices. HCAP has been used to model many different subsets of USPS highway transportation, and many of the model results have been implemented, resulting in annual savings already being realized by USPS.

The HCAP optimization model is merely one example of recent USPS initiatives to assist in transportation planning. The development and deployment of HCAP underscores USPS's emphasis on developing advanced analytical capabilities to proactively plan for the future of Postal transportation.

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