IE 479 – Distribution Logistics Article Presentation
28 April 2020

OPTİMİZİNG TRANSPORTATİON BY INVENTORY ROUTİNG AND WORKLOAD BALANCİNG: OPTİMİZİNG DAİLY DRAY OPERATİONS ACROSS AN INTERMODAL FREİGHT NETWORK

Xiaoqing Sun, Manish Garg, Zahir Balaporia, Kendall Bailey, Ted Gifford

Presentators:
Alperen Nazım Demir
Said Ay
Irmak Özdemir

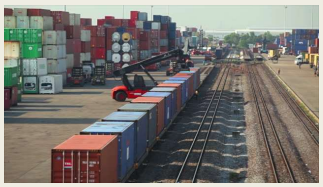
INTRODUCTION

«Increasing fuel prices and the geographic expansion of distribution networks have made ***intermodal freight transport systems*** *an increasingly competitive alternative to single-mode transportation services.»*

What is «intermodal freight transport»?

It refers to sequential movement of a container or full-truckload shipment across several modes of transportation.

Some prevalent examples of intermodal freight transportation:



Road-rail-road

Road-sea-road

To facilitate mode changes, freight is normally loaded into containers, with capacities ranging from 1,000 to 4,000 cubic feet that can be easily transferred between modes.

- The middle leg of the freight transport, train, or ship realized high **efficiency** by moving many containers to long distances at time.

- The end legs of it, called «**dreyage**», has much shorter transit distances and movement of individual containers to or from **time constrained** customer locations.

- The simultaneous arrival or departure of a large number of containers at a port or rail hub creates a **challenge** for dray transportation resources.

Although this activity is often outsourced to third-party draymen, which we refer to as foreign carriers in this discussion, **cost and environmental impact considerations** can make it attractive to employ a dedicated **fleet of tractors** and drivers and use route and **schedule optimization software systems to maximize the utilization of the fleet.**

SCHNEIDER NATIONAL, INC.

- Schneider National, Inc. operates a large intermodal freight transportation network.
- This network has:
- 24 Rail Hubs
- 1,300+ Trucks
- 14,000+ Containers
- 4,000+ dray shipments per day

Figure 1: This map depicts railroad routes for the intermodal freight network.

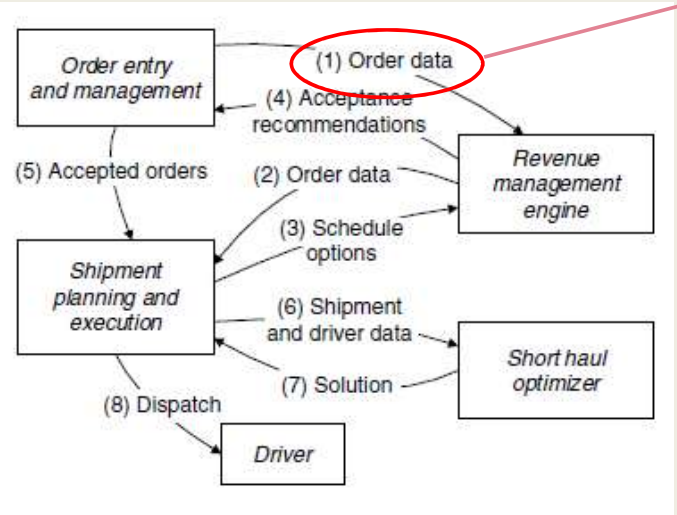
- Dray shipment distances varies between several miles to several hurders miles.
- Most drivers return home at the end of each daily shift.
- In addition to company drivers, freights are also movet with foreign carriers.
- They provide flexibility to support seasonal shifts – demand fluctuations.

This study aims to solve the problem of assigning drivers to **maximize driver productivity** and **minimize the total operation cost.**

- This study Consist of:

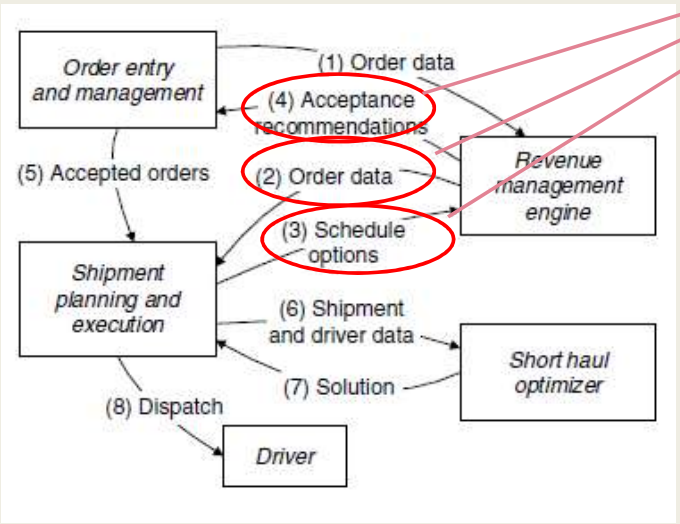
1. The development of a optimization model
2. The implementation of the model into an operational decision support system
3. The integration via near real-time data flows into a suite of commercial software systems
4. The development of corresponding business processes to realize significant tangible benefits.

Business Process for Intermodal Operations



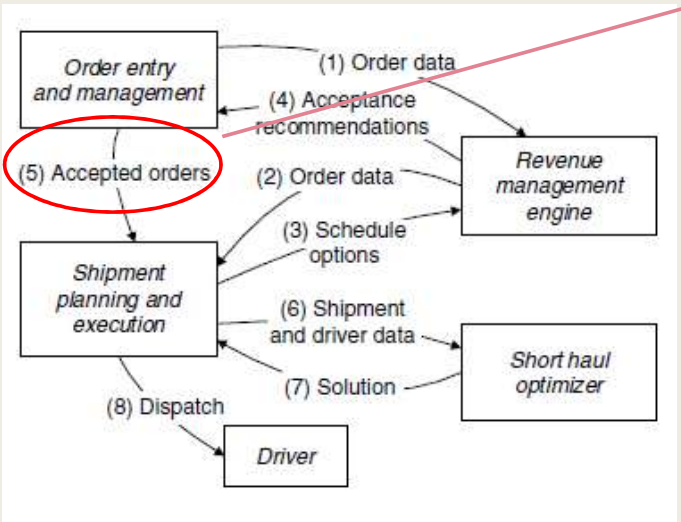
Intermodal freight orders are initially captured in the order entry system via either electronic transfer from a customer or direct entry with information received by fax or telephone

Business Process for Intermodal Operations



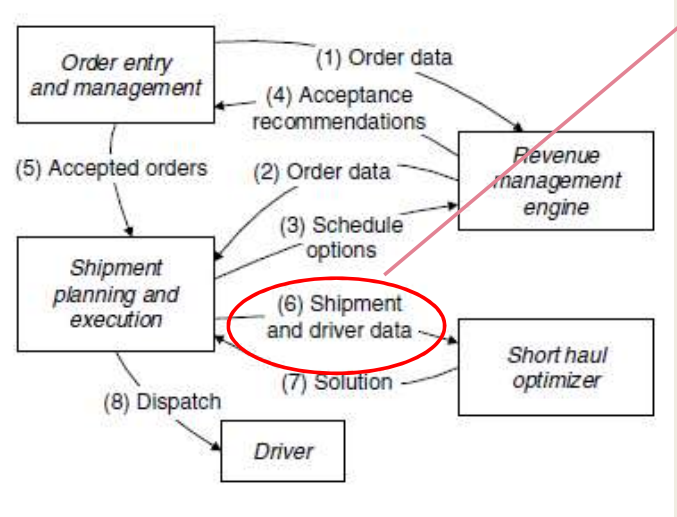
As part of the order acceptance process, the order is validated for geographic and transit feasibility, train options are determined, and preliminary profitability analysis is carried out

Business Process for Intermodal Operations



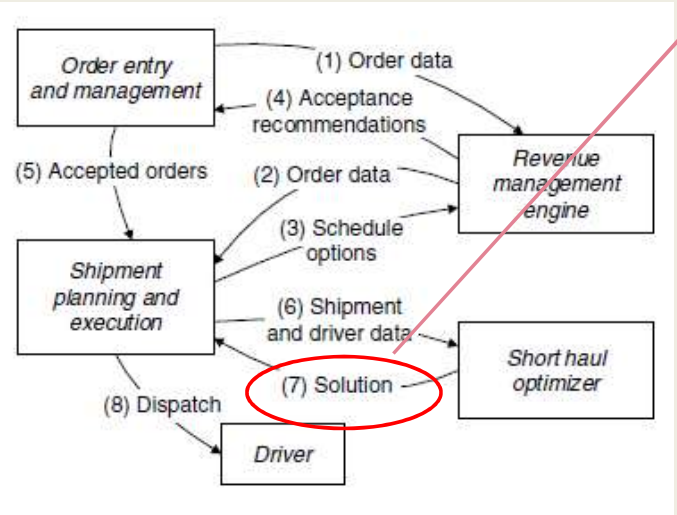
If the order is confirmed, it is passed to the transportation management system (TMS) for splitting into component shipments

Business Process for Intermodal Operations



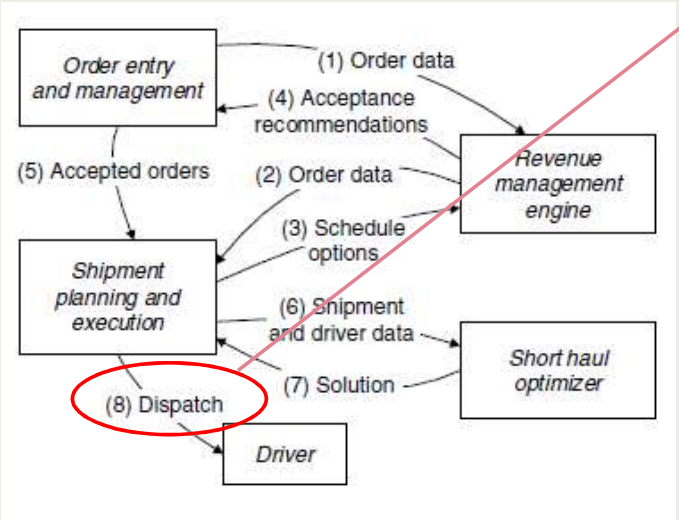
After shipment components planned using related data, corresponding dray shipments are grouped into subsets according to the rail hub regions and time frames that apply. The data integration process manages these shipments. (will be explained later)

Business Process for Intermodal Operations



The Short Haul Optimizer that includes all related data, provides an user interface that shows all shipments. The assignment optimization runs on 10- minute intervals. The interface Shows the summary of last optimization run and provides the detailed assigments.

Business Process for Intermodal Operations



The user is then able to accept SHO recommendations, and driver-shipment assignments are communicated back to the TMS for dispatch to the driver.

Literature Review and Solution Methodology Description

- Erera and Smilowitz (2008) provide a good overview of dray planning problems; in particular, they note that the problem is NP-hard.
- This study's work extends and refines the work of Ileri et al. (2006), particularly with respect to details and implementation of the tour generation process.

- At the beginning, it precomputed that the set of feasible assignments of drivers to shipments and transitions between shipments.
- The column-generation process can then follow these transitions and correspond to feasible tours that string together the sequential execution of one or more shipments for a single driver.
- Two types of tours generated. Those assigned to foreign carriers and those assigned to the company-managed fleet.
- The cost and operating characteristics of the former allowed to precompute the relatively small number of tours that are reasonable for them.

SHO

SHORT HAUL OPTIMIZER

Objective Function

Min Total Cost

- Drivers' Costs
  - Company Drivers
  - Foreign Carrier Costs
- Penalties
  - Leaving certain shipments unassigned

Company Drivers

- Driver pay
- Fuel costs
- Driver delays
- Stop-off(extra-stop) charges
- Equipment depreciation

Foreign Carrier Costs

Contractual agreements

- Various costs in the contracted rates

Other factors

- Tour robustness
- Chassis rental cost
- Ramp storage cost
- Equipment utilization

Penalties

2 Type

- High to ensure execution
- Modest penalty to encourage

Constraints

Driver Groups and Work Schedules

Container Management

Time

Driver Groups and Work Schedules

Local drivers transport shipments up to a maximum distance(150 miles) and return home each day

Regional drivers transport shipments subject to a minimum distance(100 miles) and are sometimes away

from home for one or two nights.

U.S. Department of Transportation hours-of-service rules

- must take a 10-hour sleep break
- no more than 11 driving hours or 14 total work hours

Container Management

24-hub rail network

Regions (Net inbound flow-Net outbound flow)

Specific requirements at individual customer locations

empty shipments

Intermediate stops

Additional Model Attributes

Tractor rule: Maintains tractor-location feasibility conditions relative to tractor types.

Drop pick: Enforces location-specific sequencing.

Hazmat: Enforces hazmat-certification feasibility.

Location delay: Specifies time delays for certain location combinations.

Outgate: Increases outgate time for certain shipments.

Last load: Allows for shipment carryover to next shift.

Priority appt: Pads times for priority shipment stops to decrease fail probability.

Priority stop: Applies stop-time penalty to encourage earliest delivery.

Time

Re-Solve 36 Hours (Dynamic System)
- About 10 min

Delays
Train cutoff time
Grounding time

Specify prearranged appointment – No tolerance

Open-ended--Only no-sooner-than or No-later-than directives

D = the set indexing the company fleet drivers
S = the set indexing the shipments
T = the set of tours generated for all drivers
T(k) = the subset of T associated with driver k,
T(j) = the subset of T that covers shipment j
C(i) = the execution cost (including preferences and penalties) of tour i
p(j) = penalty for not covering the shipment

Variables

X(i) = 1 if tour i ∈ T is selected in the solution
0 otherwise.
S(j) = 1 when shipment j is not covered
0 otherwise

$$\min \left\{ \sum_{i \in T} c_i x_i + \sum_{j \in S} p_j s_j \right\} \quad \text{(A1)}$$

$$\text{subject to: } \sum_{i \in T_j} x_i + s_j = 1 \quad \forall j \in S; \quad \text{(A2)}$$

$$\sum_{i \in T_k} x_i \leq 1 \quad \forall k \in D; \quad \text{(A3)}$$

$$x_i \in \{0, 1\} \quad \forall i \in T. \quad \text{(A4)}$$

Results

10% increase on fleet utilization

5% decrease on foreign carriers
- 60% expensive

$8-10 million savings

Additional Example (Intermodal Transportation)

DHL-F1 Partnership

- Time Limited and Important
- Air-Ship-Truck
- Precious Cargo

Ship and Road Cargo

- **5 Package**
  - None Crucial Items
    - Jacks
    - Trolleys
    - Kitchen Equipments
    - Hospitality Items
    - Fan-Zone Items
- **Shipment**

  Uk to
  - Australia-Bahreyn-China-Azerbeijan
- **Road**
  - UK to Spain

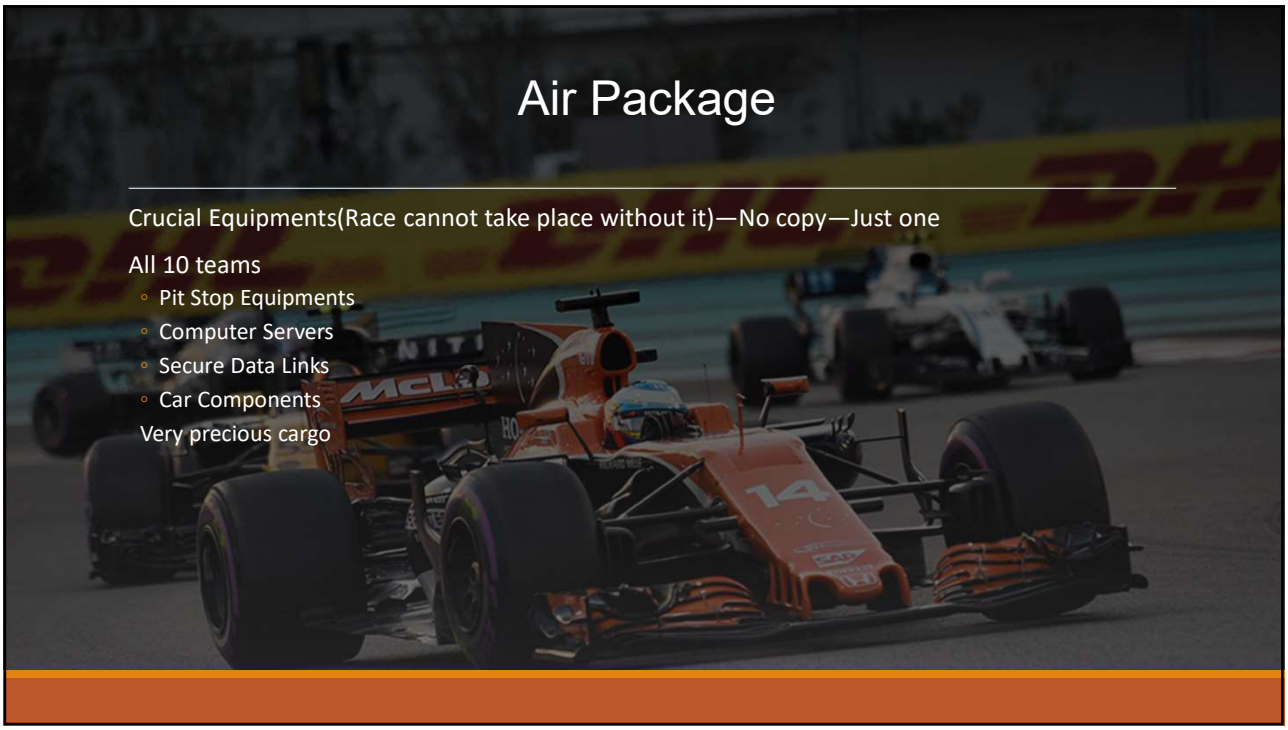
Air Package

Crucial Equipments(Race cannot take place without it)—No copy—Just one

All 10 teams

- Pit Stop Equipments
- Computer Servers
- Secure Data Links
- Car Components

Very precious cargo



https://www.youtube.com/watch?v=MH6Loko0BOA

ROOT-COLUMN GENERATION HEURISTIC

Find shortest paths regarding resource constraints

First, generic-base graph (regardless of specific drivers)

- Distance between stops and shipments
- Appointment windows
- Transit time
- Associated costs

Nodes = shipments

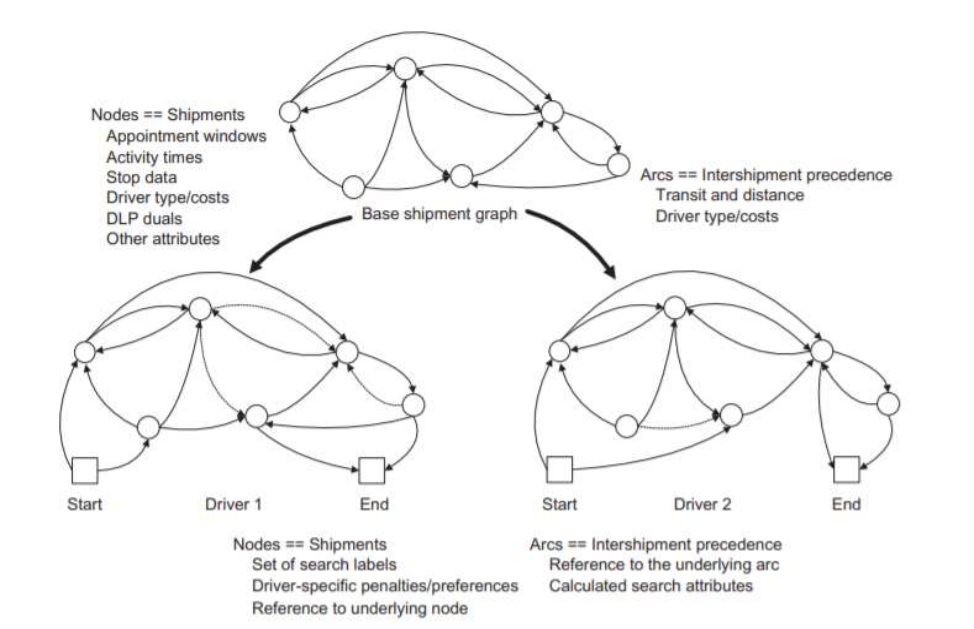
Arcs = feasible precedence of shipments

MEMORY MANAGEMENT… BEING MORE SPECIFIC (DRIVER-VIEW GRAPHS)

With driver-specific costs and feasibility adjustments…

Driver-dependent graphs:

- Related costs
- Preferences schedule
- Constraints
- Starting and ending positions



COLUMN-GENERATING STEP

Obtaining a set of shortest path (tours) with negative reduced costs

Achieved by depth-first search / labeling

(t,c)

t: elapsed time when the current shipment is completed

c: corresponding reduced cost

WHAT WAS THE REDUCED COST....

Given a system minimize $\mathbf{c}^T\mathbf{x}$ subject to $\mathbf{Ax} \leq \mathbf{b}, \mathbf{x} \geq 0$, the reduced cost vector can be computed as $\mathbf{c} - \mathbf{A}^T\mathbf{y}$, where $\mathbf{y}$ is the dual cost vector.

- Every node has labels corresponding to the distinct paths (that has been traversed to the node)
- When a node is searched

  a new label

  that captures time elapsed

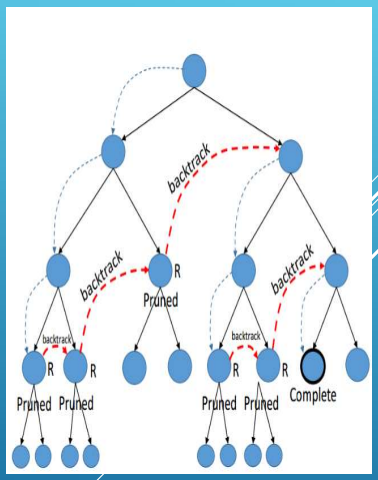
  new cost

If the new label is not dominated

($t_{old} \leq t_{new}$ and $c_{old} \leq c_{new}$) it is added to the set of labels

If it is dominated, the label is discarded and search backtracks

No cycles during the search... (no self-parents)!



LONG STORY SHORT...

We try to find the best thing that might happen

for every node

For each possible scenerio (in this case, different tours)

LP MENTIONED BEFORE IS SOLVED, THIS SEARCH HELPS TO IMPROVE OBJECTIVE FUNCTION

STEPS

1. INITIALIZATION
   - CONTRUCT DRIVER GRAPHS
   - REMOVE INFEASIBLE SOLUTIONS FROM PREVIOUS SOLUTION
   - ENUMERATE NEW SINGLE-SHIPMENT TOURS
2. SOLVE MASTER PROBLEM AS LP
3. COLUMN GENERATION
   - PERFORM DEPTH-FIRST SEARCHES (IN PARALLEL) ON DRIVER GRAPHS, FINDING NEW NEGATIVE-REDUCED-COST TOURS
   - ADD NEW COLUMNS TO MASTER PROBLEM
4. REPEAT (2) AND (3) OBJECTIVE IS NO LONGER IMPROVING THAN THE TRESHOLD (0.1%)
5. SOLVE MASTER PROBLEM AS AN IP

INTERMODAL TRANSPORTATION

involves using multiple modes of transportation such as rail, truck, and ship

The article is about road-rail-road transportation.

WHY INTERMODAL TRANSPORTATION? THE OBJECTIVE?

Maximizing productivity (the LP model and heuristic discussed)

Minimizing total operation cost

Railway is cheaper!

SCHNEIDER NATIONAL INC.

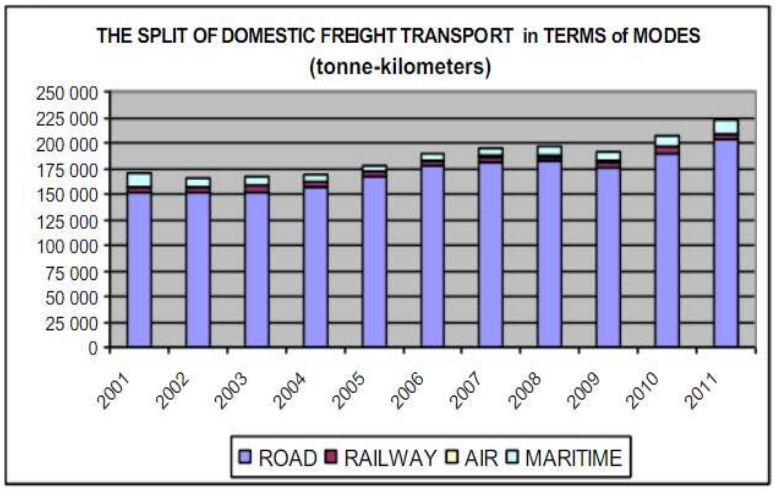
- From United States to Canada and Mexico
- 24 rail hubs
- Their fleet has more than 1,300 trucks
- 14,000 containers

- Moves more than 4,000 dray shipments per day (including pick-up, delivery,crosstown transfers)
- With foreign carriers and their fleet

FREIGHT TRANSPORTATION IN TURKEY

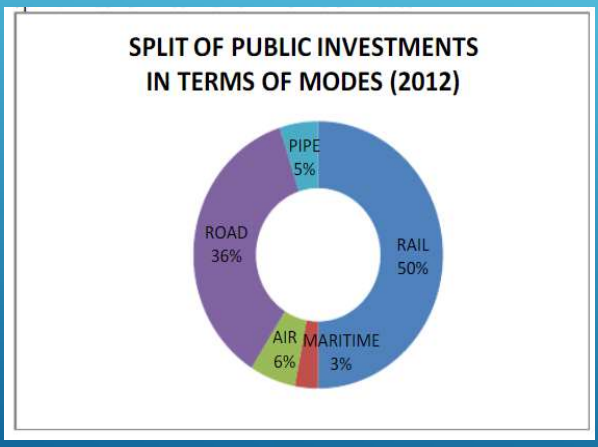
Can you guess the most convenient mode of transportion and its percentage?

ROAD TRANSPORTION WITH 85% (MINISTRY OF COMMUNICATION AND TRANSPORTATION, 2011)

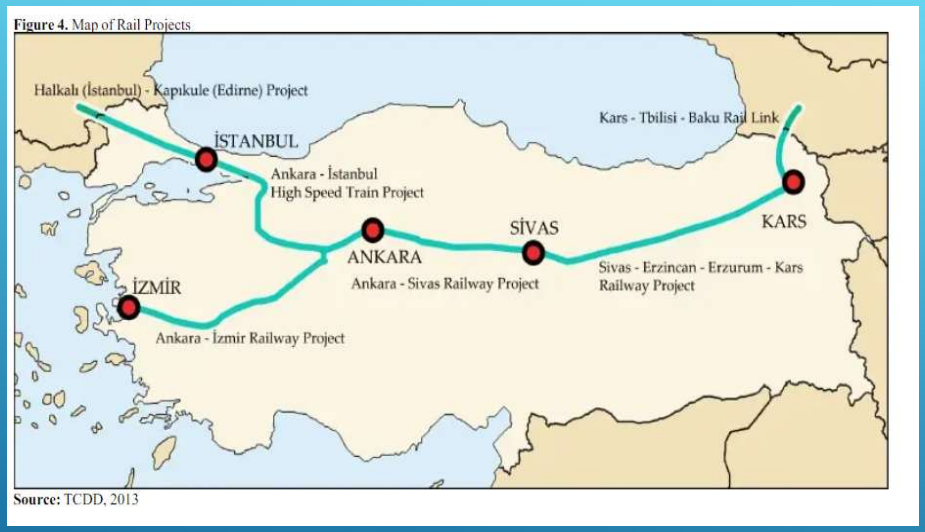


Source: TUIK, 2013

MODES OF TRANSPORTATION (OTHER THAN ROAD) ARE INVESTED MORE...



EXISTING RAILWAY MAP



AND MARMARAY... (2019)

DO WE HAVE INTERMODAL TRANSPORTATION?

Ulusoy's intermodal trailer train to depart from Cologne today

BY ONUR UYSAL ON 7 JUN 14

9 Votes

The first "intermodal trailer" train of Ulusoy Logistics in cooperation with DB Schenker Rail will depart from Cologne today.

This train will be the first "intermodal trailer" train departing from Turkey. Train is expected to complete the route between Cologne and Cerkezkoy in 6 days. Train will follow the route through Germany-Austria-Hungary-Romania-Bulgaria-Turkey, as used for block trains by DB Schenker for a long time.

Renault loads to Turkey by rail

BY ONUR UYSAL ON 22 JUL 14

1 Vote

Start of Derince-Tekirdag ferry service and opening of Derince-Eskisehir line speeds up new railway logistic projecsts.

Last week, the first swapbody train after months had arrived to Derince. By that, Oyak Renault, which seeks for a stable railway solution, had the chance to enter to "automotive companies using train" club with its loads from Germany.

Container trains from Turkey to Europe – I

The Spanish railway company Transfesa is the organizer of the train, where trucking is completely done by Schenker until Turkey. The swapbodies of Omfesa, the jv company of Transfesa and Omsan Logistics are used for the train. With 3mt inner height, swapbodies provide very similar usage to truck trailers.

REFERENCES

[1]"Intermodal freight transport," Wikipedia, 15-Apr-2020. [Online]. Available: https://en.wikipedia.org/wiki/Intermodal_freight_transport. [Accessed: 28-Apr-2020].

[2]"Freight rail transport in Turkey," Wikipedia, 14-Mar-2015. [Online]. Available: https://en.wikipedia.org/wiki/Freight_rail_transport_in_Turkey. [Accessed: 28-Apr-2020].

[3] O. Uysal, "Ulusoy's intermodal trailer train to depart from Cologne today," Rail Turkey En, 21-Sep-2017. [Online]. Available: https://railturkey.org/2014/06/07/ulusoy-intermodal-trailer-train/. [Accessed: 28-Apr-2020].

[4]O. Uysal, "Renault loads to Turkey by rail," Rail Turkey En, 21-Sep-2017. [Online]. Available: https://railturkey.org/2014/07/22/renault-swapbody-train/. [Accessed: 28-Apr-2020].

[5]S. M. Khosim, "THE ANALYSIS OF TURKEY'S FREIGHT TRANSPORT IN TERMS OF TRANPORT MODES," Academia.edu. [Online]. Available: https://www.academia.edu/6864383/THE_ANALYSIS_OF_TURKEYS_FREIGHT_TRANSPORT_IN_TERMS_OF_TRANPORT_MODES. [Accessed: 28-Apr-2020].