Opturion

Fuel Delivery Optimisation White Paper

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Introduction

This white paper describes an optimisation tool to plan and optimise fuel deliveries. It is suitable for both a Vendor Managed Inventory (VMI) scenario and a more traditional operation. It includes 3 basic applications:

- Payload optimisation (load building)
- Sales forecasting
- Scheduling and routing

We provide a detailed description of each application in what follows.

Background

Opturion has been working on opportunities to apply optimisation and forecasting technology to planning fuel deliveries for traditional and VMI (Vendor Managed Inventory) customers.

VMI customers provide daily dip readings for each fuel tank they manage. Based on this, the system creates a sales forecast and plan deliveries in the most efficient way while ensuring there are no stockouts. This delivery planning includes when to deliver (i.e. which days), how much for each fuel tank, on which truck with which driver, etc.

The first application is around scheduling and routing deliveries based on a given forecast of for VMI customers. Here we optimise which days to deliver, how much, and in what sequence, and using which vehicle. We use historical data on fuel deliveries, including data on dip readings, driver, and truck availability. It generates considerable savings in terms of KMs driven and driver shifts and vehicles required.

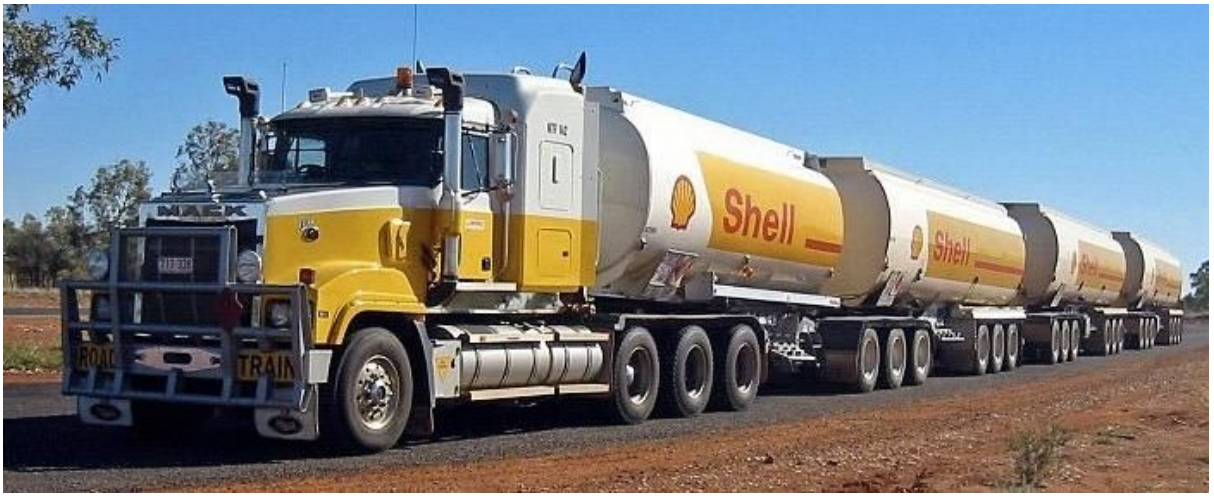
We can also optimise routes and schedules with traditional orders where the customer specifies the delivery quantities and the day of delivery. The savings are still worthwhile, but somewhat lower than VMI as the system has no scope to schedule that day od delivery; just the time during a given day.

There is also an application that builds payloads (allocation of fuel quantities to compartments on a vehicle), where we aim to maximise the delivered quantities while adhering to legislation and business rules on weight and stability. This aspect of the problem is one where we can deliver benefits quickly as it is currently a highly time consuming, highly manual process, and there is potential to achieve higher efficiencies by taking into account the latest product density information, and by maximising payloads to the fullest.

Load Building

Fuel tankers have multiple compartments on each of their trailers, that can be filled to varying volume limits. However, we cannot fill each compartment up to its limit because that would break rules on the maximum mass on each of the wheel bases. Furthermore, there are rules on volumes to ensure stability of the vehicle (e.g. minimum volume requirements for the ‘bookend’ compartments on each trailer), rules on which compartments to use for deliveries to particular sites/tanks (based on the physical layout of the service stations), particular road restrictions and stricter mass limits in

certain areas, etc. Different fuels have different product densities, and these densities can vary over time, with a daily figure being provided.



Fuel Road Train (Picture by Thomas Schoch): Fuel Trucks consist of a prime mover followed by one or more trailers, linked using fifth wheel coupling.

The load building task is typically a manual process in which volumes are allocated to compartments, and the adjusted if it breaks any of the applicable rules. There's a certain amount of expertise that goes into this process, to know what works and what doesn't, and it remains a time-consuming task, with planning times of 15 minutes per load being reported. During planning, it is normal to use conservative values for the product densities, and there is a belief that using more up to date measurements could improve productivity (i.e. allow more volume to be transported on each load).

Opturion has built a load optimiser that is now integrated within Freight2020, but can also be used as a standalone component. In the following section, we will list the functional requirements of the load optimiser.

Load Optimisation Problem

The load optimiser solves the following problem:

Inputs:

- a vehicle configuration (tractor + trailers) with compartment sizes, centre of gravity, location of pins and wheelbases, specific loading restrictions (e.g. bookend compartments must be filled up to save fill level), etc.
- one or more sites to visit, in a given order
- minimum, preferred and maximum volumes to be delivered to each fuel tank on each site, including fuel type, and restrictions on which compartments can deliver to which tank (e.g. only deliver to this site from front trailer)
- product densities
- applicable restrictions on each route leg (terminal to first service station, first service station to second, etc.)

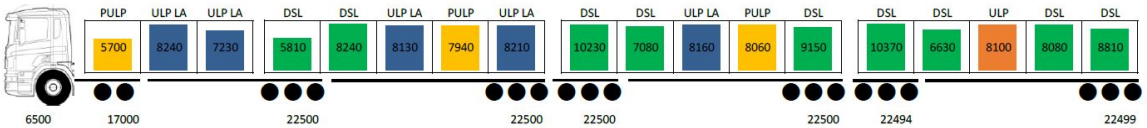
We normally assume that each compartment delivers to one fuel tank only, that is, we do not split compartments over multiple fuel tanks.

Fuel Station (Picture by Coolcaesar): a fuel station will have a number of tanks that each contain a particular fuel type, and can be filled up to a safe fill limit.

The optimiser produces a plan that satisfies all rules stated in the inputs, and is optimised for a given objective, which may consist of:

- maximise the volume delivered within the given limits
- prefer any extra volume (above the minimum required) to be of one or more fuel types, or for one or more tanks
- preferences on which compartment for which tank with regards to delivery efficiency
- preferences on which fuel type in which compartment with regards to loading efficiency at the terminal

The output is an allocation of a volume, fuel type, and target tank to each compartment, such that the applicable load restrictions apply to each leg of the route.



Example Load Plan for a Quad Road Train. Each load plan must ensure that weight limits are not exceeded on any of the axle groups, and that the gross combination mass does not exceed the applicable limit either. It must also comply with regulatory and otherwise applicable stability rules, and this for each leg on its journey.

Integration and Deployment

The optimiser runs as a standalone web service to be deployed on premise or in the cloud. It can run through Freight2020, in which case it receives data from Freight2020 and sends back an optimised plan, which is then displayed within Freight2020.

Forecasting

Vendor Managed Inventory can ultimately only be successful if we have an accurate forecast of future demand (sales). This allows for planning further ahead and reducing the number of visits or increasing the delivered quantities. Planners are typically informed by a basic forecast of the demand from the last 3 days and same time last week. We create and improve the forecast by using Machine Learning techniques and utilise characteristics of each day (day of the week, weekend day, public holiday, school holiday) and seasonal factors.

VMI and Route Optimisation

The final component uses the forecast and schedules and routes deliveries using the load building rules or a safe approximation of them. The forecast will tell us how much we **must** deliver to each site on each day, and how much we **can** deliver. The optimisation will then build routes for each day, allocating deliveries to the different sites onto those routes. They are to be built such that:

- There are never any stockouts (assuming the future takes place as per the forecast)
- We don't deliver more than each tank will hold (as per the forecast)
- We do not break any loading rules

In essence, the optimisation will combine three components:

- Routing and Sequencing: subject to travel times, loading and unloading, fatigue management and vehicle availability
- Vendor Managed Inventory: preventing stockouts and not delivering more than what will fit
- Load Management: creating feasible loads with respect to the vehicle configuration and regulatory and business rules

The inputs to this optimisation are vehicle and driver availabilities, and a forecast for each site and tank. The output is a multi-day plan consisting of a run sheet for each driver and shift that lists all of the stops to be made, and all of the quantities to deliver (at a minimum).

Typical Benefits

Benefits include:

- Reduction in number of vehicles and shifts by making maximum use of B-doubles and multi-drop deliveries. This can be up to 20%.
- In the combined VMI/Route Optimisation scenario, we can reduce further reduce the number of shifts required and kms driven by approximately 10%
- Increased payload by more accurate load planning. This increases revenue by around 1% on a consistent basis.

Use Cases

Here we will define a number of use cases for the proposed optimisation tools.

Day Ahead Load Planning For this use case, we'd be given a vehicle configuration, and a sequence of site visits (one or more), as well as minimum and maximum volumes to be delivered to each tank at each of the sites. For the day ahead planning, we may use conservative product densities to be on the safe side. There is the option to play around with preferences, e.g. preferred compartments for particular fuels/tanks and the planner could run multiple optimisation scenarios to gauge the impact of these (e.g. first see how much can be delivered, and then see if we can deliver the same amount with preferential fuel to compartment allocation). Also, in case the order of the site visits is flexible, each order can be tried in a separate optimisation scenario.

Pre-Loading Re-Optimisation Before loading the vehicle, we can do a quick re-optimisation taking into account the most recent product density readings. Because of time constraints, this is not possible with the current manual process, but the optimisation tool could achieve this task automatically in very little time, and as such increase delivery efficiency.

Delivery Date and Route Optimisation This is the VMI/Route Optimisation case: the forecasting combined with a fleet and driver roster, is used to make the decision of which sites to visit on which days/shifts, and which routes to take for each vehicle. The exact delivery quantities can then be further optimised as a second stage process.

Bid Optimisation The optimisation tools can be used to model the impact of taking on new business. Various scenarios can be modelled, giving the optimisation the flexibility to choose an appropriate vehicle mix and work pattern to achieve the transport requirements at the lowest cost.