Opturion

Fuel Delivery Optimisation White Paper

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Opturion Pty Ltd

Introduction

This white paper describes an optimisation tool used 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 plans 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' 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 with a VMI, as the system has no scope to schedule the day of 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, essentially manual process. There is also the potential to achieve higher efficiencies, by taking into account the latest product density information, and by maximising payloads to the fullest.

Application

The Opturion solution (based on the **Dynamic Transport Optimiser**) applies to three types of customers:

1. The operator of filling stations that has an in-house fleet for delivery
2. The operator that outsources the transport task, but still controls the deliveries directly by placing orders on the transport provider
3. The operator that outsources the inventory management responsibility to the transport operator, so that it is their job to determine to maintain filling station inventory by scheduling deliveries correctly. This is referred to as VMI in the industry

The first two types of customer have a range of optimisation problems:

- Load building, taking into account efficient loading (at the gantry) and unloading (at the filling station), maximising volumes and maintaining safe loading criteria and axle weights at the point of loading and throughout the delivery activity
- Routing and scheduling to maximise revenue and minimise the time taken and distance travelled (the delivery cost)
- Strategic (or long-term) optimisation where decisions around fleet size, fleet composition, pricing and budgeting can be made in a more methodical way

The third customer type has all of the above, and two additional challenges:

- The requirement to predict or forecast sales at each filling station to determine the earliest and latest opportunity to deliver loads of different volumes
- Based on the potential delivery volumes and delivery windows (above) construct a delivery schedule that maximises revenue and minimise the delivery cost

Load Building

Fuel tankers have multiple compartments on each of their trailers, that can be filled to varying volume limits. However, each compartment cannot be filled up to its limit because that would break rules on the maximum mass on each of the wheelbases. Furthermore, there are rules on volumes to ensure the 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.

Triple Road Train (source: Holmwood Group)

B-Double (source: Holmwood Group)

The 'load building' task is typically a manual process in which volumes are allocated to compartments, and 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 already integrated with a market-leading Transport Management System (TMS). Similarly, it can be integrated with any other TMS that supports CSV, XML, JSON or has an API, or 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, the 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 the first service station, first service station to second, etc.)

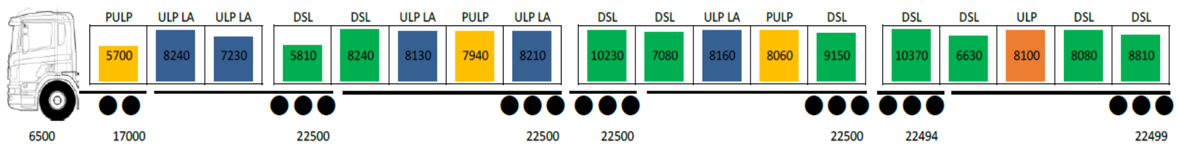
We normally assume that each compartment delivers to one fuel tank only, that is, we do not split compartments over multiple fuel tanks.

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

The ‘load 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.

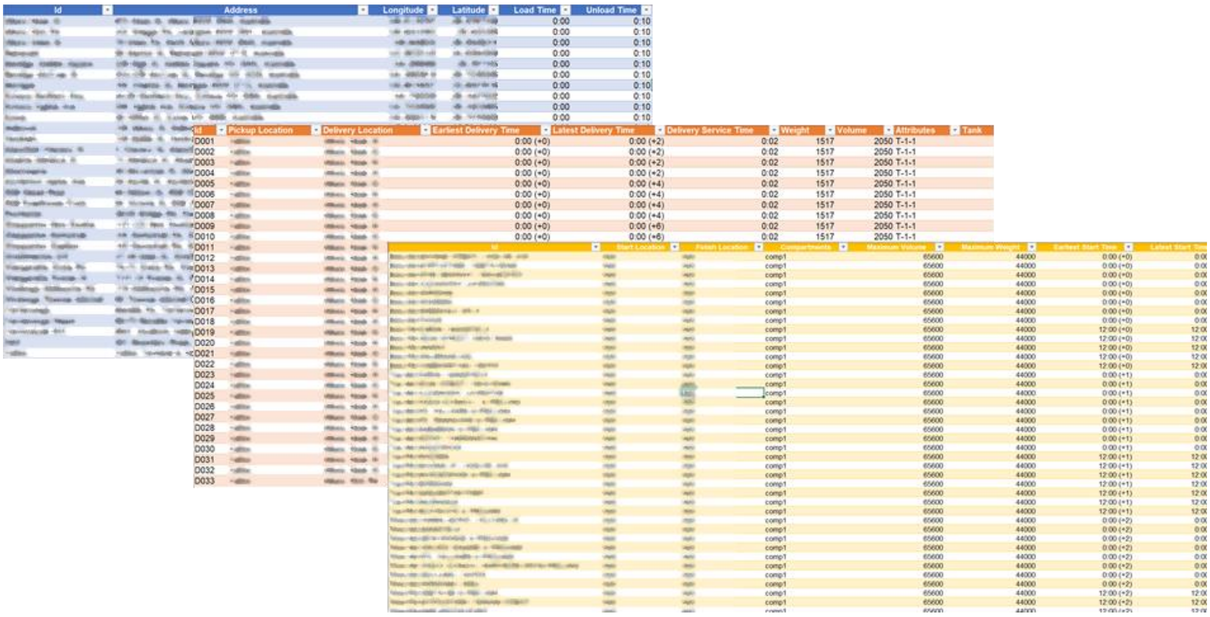
The Opturion load planner works for all combinations, quad road train, triple, B-Double and single. It can also optimise for the situation where trailers are removed for more localised delivery.

Integration and Deployment

The ‘load optimiser’ runs as a standalone web service to be deployed on-premise or in the cloud. It can run through any suitable TMS, in which case it receives data from that system and sends back an optimised plan, which is then displayed within it.

Forecasting

Vendor Managed Inventory (VMI) 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 the 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.



The ‘forecast’ modules take tank dips (levels) and create a schedule of potential delivery volumes, with earliest and latest delivery times.

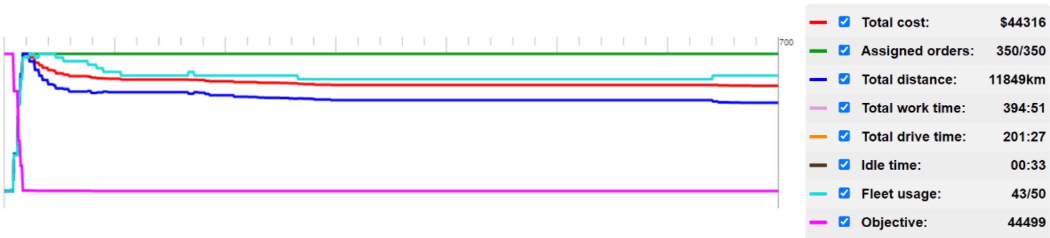
VMI and Route Optimisation

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 each day, and how much we **can** deliver. The optimisation will then build routes for each day, allocating deliveries to the different sites on 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, driver fatigue management and vehicle availability
- Vendor Managed Inventory: preventing ‘stockouts’ and not delivering more than what will fit
- Load Management: creating feasible loads for the vehicle configuration and regulatory and business rules

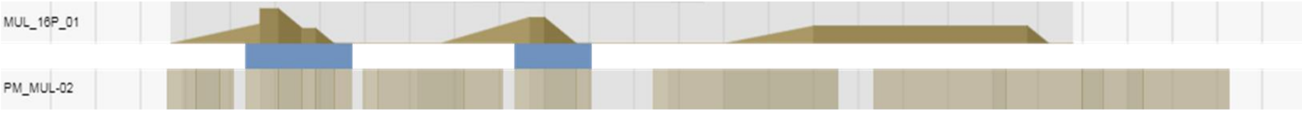


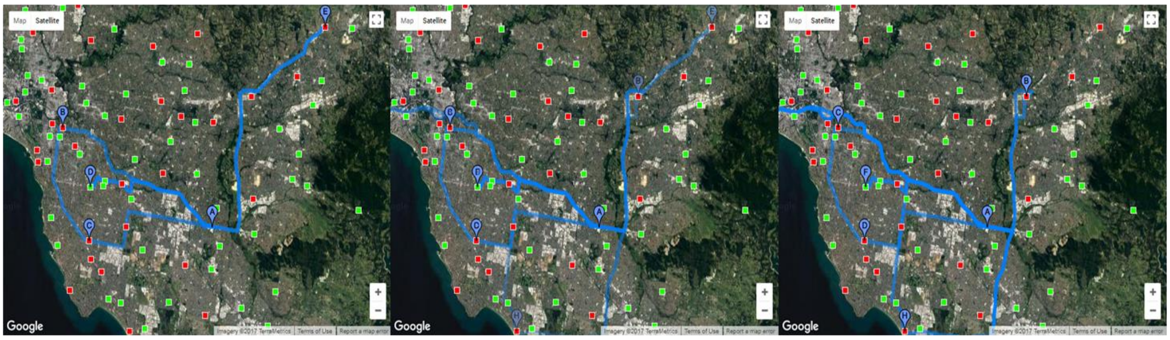
The optimiser progress chart (‘the worm’) shows how several KPI’s, such as fleet usage, working time, km driven and so on improve as the optimiser converges to a solution. It is important to note that the optimiser quickly finds a practical solution and then starts to reduce cost. As such, the solution is almost immediately useful if time is a factor.

Site	21-Oct	22-Oct	23-Oct	24-Oct	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	Total	Target	Shortfall
[illegible]	0	0	20,440	31,400	0	0	0	0	0	51,840	51,840	0
[illegible]	29,340	31,400	0	0	39,000	0	0	11,820	39,000	150,560	150,560	0
[illegible]	0	30,300	0	0	0	31,400	0	0	0	61,700	61,700	0
[illegible]	24,740	0	0	31,400	0	31,400	0	0	0	87,540	87,540	0
[illegible]	0	30,520	0	0	0	0	0	0	0	30,520	30,520	0
[illegible]	22,260	0	31,400	0	0	0	0	39,000	0	92,660	92,660	0
[illegible]	0	28,160	10,960	39,000	0	0	0	0	0	78,120	78,120	0
[illegible]	4,600	27,450	31,400	0	0	46,650	0	0	0	110,100	110,100	0
[illegible]	0	0	5,840	0	17,520	0	0	0	0	23,360	23,360	0
[illegible]	0	0	0	0	10,080	0	31,400	39,000	0	80,480	80,480	0
[illegible]	0	0	31,400	0	0	31,400	0	31,380	0	94,180	94,180	0
[illegible]	0	34,380	0	0	0	31,400	0	0	0	65,780	65,780	0
[illegible]	25,480	0	0	0	0	0	34,460	0	0	59,940	59,940	0
[illegible]	22,360	0	31,400	0	0	0	0	39,000	0	92,760	92,760	0
[illegible]	0	0	0	29,500	0	0	0	0	0	29,500	29,500	0
[illegible]	30,140	0	31,400	0	31,400	0	0	0	0	92,940	92,940	0
[illegible]	30,080	0	0	0	0	0	0	0	0	30,080	30,080	0
[illegible]	29,860	0	0	0	0	0	0	0	0	29,860	29,860	0
[illegible]	9,200	0	26,580	0	0	0	26,140	0	0	61,920	61,920	0
[illegible]	4,300	31,400	31,400	0	0	31,400	0	0	0	98,500	98,500	0
[illegible]	0	0	5,400	0	31,400	31,400	0	0	0	68,200	68,200	0
[illegible]	0	28,100	0	31,400	0	31,400	0	0	0	90,900	90,900	0
[illegible]	0	29,780	0	0	31,400	0	0	0	0	61,180	61,180	0
[illegible]	6,460	31,400	39,000	31,400	31,400	31,400	39,000	31,400	0	241,460	241,460	0
[illegible]	0	0	0	0	20,360	0	0	0	39,000	59,360	59,360	0
[illegible]	0	0	13,580	0	33,220	0	0	0	0	46,800	46,800	0
[illegible]	0	7,300	0	24,820	0	0	0	0	0	32,120	32,120	0
[illegible]	0	0	0	0	28,540	0	0	0	31,400	59,940	59,940	0
[illegible]	27,600	31,400	0	0	0	0	0	31,400	0	90,400	90,400	0

This is a typical output file showing locations, delivery times and volumes

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 be delivered (at a minimum).





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The optimiser can drive a map display showing stops, time, routes and other useful information.

Typical Benefits

Benefits include:

- Reduction in the 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 further reduce the number of shifts required and km driven by approximately 10%
- Increased payload by more accurate load planning. This increases revenue by around 1% consistently.

Use Cases

Here we will define several 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 decide 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.