

Opturion Dynamic Transport Optimiser Verison 2 – Data Formats

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OPTURION

Intelligent Decision Support

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1 Overview

This document specifies the input and output formats for version 2 of the Opturion Dynamic Transport Optimiser (DTO). The input and output to the DTO are given as a Microsoft Excel workbook.

2 Data Model

This section provides an overview of the major concepts in version 2 of the DTO data model.

2.1 Scenarios

An input to the DTO takes the form of a set of parameters, locations, vehicles and orders, called a *scenario*. A scenario is a representation of the transport optimisation problem you wish to solve. It includes a description of all the orders that need servicing, all available vehicles and their properties, location data and any order-vehicle restrictions as well as other optional data which is described in the following sections.

2.2 Solutions

A *solution* is a plan created by the optimiser. It consists of a schedule that assigns orders to vehicles.

2.3 Identifiers

Entities such as orders, locations and vehicles within a scenario must have a unique *identifier* (Id) that is used to refer to them.

Identifiers must contain at least one non-whitespace character and must not contain the semicolon (`;`) character. They are not case- or whitespace-sensitive.

For example, "`DEPOT2`", "`depot2`" and "`Depot 2 `" will all be treated as identifying the same entity by the optimiser because they only differ by case or the amount of whitespace they contain.

Even though they may be composed of digits, identifiers are not numeric. For example, the optimiser will treat "`1`" and "`001`" as being distinct identifiers.

(Users of the DTO-Excel format should be aware that there are Excel-specific restrictions on the specification of identifiers; see Section 3.1 for details.)

All references to an entity are made using its identifier.

2.4 Attributes

Attributes are labels that are attached to entities like orders, locations and vehicles to describe their properties. Attribute names, like identifiers, must contain at least one non-whitespace character and must not contain the semicolon (`;`) character. They are not case- or whitespace-sensitive.

Attributes may be used to define relationships between the entities in a scenario. (See Section 2.23 for further details.)

Note that an entity's identifier is automatically considered to be one of its attributes.

2.5 Weights and Volumes

Weights and volumes in a scenario can be specified in arbitrary units. However, the selected units must be used consistently throughout the scenario. Mixing units, giving order weights in kilograms and vehicle capacities in tons for example, will lead to errors.

2.6 Time and Dates

Times and dates can be separated into the following formats:

Type	Format	Example
Time	*hh:mm*	09:20
Date	*yyyy-mm-dd*	2026-03-31
Date Time	*yyyy-mm-dd'T'hh:mm*	2026-03-31T09:20
Zoned Date Time	*yyyy-mm-dd'T'hh:mmXXX'['VV']'*	2026-03-31T09:20+10:00[Australia\Sydney]

Table 1: Time and Date Formatting Example

The optimiser enforces strict chronological checks. For instance, no operational dates or times may occur before the scenario's defined start of operation. If a default time zone is not provided, then either all locations must specify a time zone or none can.

2.7 Costs and Hidden Costs

The optimiser deals with two kinds of cost: *actual* (i.e. monetary) costs and *hidden* costs.

Vehicles, orders and locations can have both actual and hidden costs associated with them.

Hidden costs are considered by the optimiser when making decisions, but they do *not* contribute to the actual costs reported by the optimiser. Hidden costs are nominally measured in the same units as actual costs.

Hidden costs have many uses. For example, they can be used to cause the optimiser to prefer the use of a particular subset of the fleet or to affect the "shape" of routes.

2.8 Addresses

DTO version 2 supports structured addresses. An address can be *Simple* (a single string), *Compound* (broken into lines, suburb, state, country, and postcode), or *Detailed* (specifying flat types, street numbers, suffixes, etc.).

2.8.1 Simple

A *simple* address encodes all of its information within a single text field.

2.8.2 Compound

A *compound* address provides a more structured address where the various components are encoded separately.

- **Address Line 1:** The first line in the address.
- **Address Line 2:** The second line in the address.
- **Suburb:** The suburb for this address.
- **State:** The state for this address.
- **Country:** The country for this address.
- **Postcode:** The postcode for this address.

2.8.3 Detailed

A *detailed* address provides the most highly structured address.

- **Flat Type:** The flat type, such as *Unit, Flat, ...*.
- **Flat Number:** The flat number.
- **Street Number First:** The first street number.
- **Street Number Last:** The second street number.

- **Street Name:** The name of the street.
- **Street Type:** The type of the street, such as *Road, Ave, ...*
- **Suburb:** The suburb for this address.
- **State:** The state for this address.
- **Country:** The country for this address.
- **Postcode:** The postcode for this address.

2.9 Configuration and Global Parameters

2.9.1 Start of Operation

The absolute earliest date and time from which scheduling can take place. Any times or dates defined in the scenario that occur before this value will trigger a strict validation error.

2.9.2 Default Time Zone

The default time zone for the scenario. Any locations missing a time zone will use this value.

Note that if the default time zone is missing then either **all** locations must have a time zone defined or **no** locations can have a time zone defined.

Description	Report Time Zones	Default Time Zone	Location Time Zone
Single Time Zone	✖	✖	✖
	✔	✔	✖
Multiple Time Zones	✔	Optional	✔

Table 2: Default Time Zone Example.

2.9.3 Iterations

The number of iterations that the optimiser will run for. Each iteration may result in an improved solution and hence a higher number of iterations increases the probability of finding a better solution. This comes at the cost of increasing the duration the optimiser will run for.

2.9.4 Batched Loads

Batched loads is a scheduling constraint that enforces a strict "Pickup - Delivery" cycle. Once a vehicle begins making deliveries, it cannot pick up new orders until it has delivered all its current orders.

2.9.5 Colocated Pickups

Colocated pickups require all orders in a load to originate from the same location.

2.9.6 Sticky Deliveries

When enabled, *sticky deliveries* encourages the optimiser to assign all orders for a specific location to the same vehicle. The intention of this is to reduce the number of different vehicles that make deliveries at a location.

2.9.7 Sticky Deliveries Benefit

When sticky deliveries is enabled, the optimiser applies a configurable hidden cost benefit for satisfying the constraint. A larger benefit increases the strength of the preference for assigning all orders for a given location to the same vehicle.

2.9.8 Scaling Factors

A scaling factor can be applied to speeds, costs, weights and volumes in the scenario. This allows the user to increase the effect that a particular variable has on the optimiser. A value of `0` means that no scaling is applied. The scaling factors include speed scale, cost scale, weight scale and volume scale.

2.9.9 Geofencing

The optimiser can be restricted to only consider orders and vehicles that are located within a specific geographic area. This area is called a *geofence* and it takes the form of a bounding box that is defined by the latitudes of its southern and northern boundaries and by the longitudes of its western and eastern boundaries.

The geofence can operate in one of two modes: *hard* and *soft*.

If the geofence is in *hard* mode, then the optimiser will report an error for any order that has pickup or delivery locations outside the geofence. It will also report an error for any vehicle that has start or finish locations outside of the geofence. In the event of such errors being detected, optimisation will *not* proceed.

If the geofence is in *soft* mode, then the optimiser will not assign any order whose pickup or delivery location is outside the geofence. It will not use any vehicle whose start or finish location is outside the geofence. In this mode optimisation will proceed using orders and vehicles that are within the geofence.

2.9.10 Maximum Neighbourhood Size

The maximum size of the neighbourhood for the optimiser. At each iteration of the optimiser, the solution is unpacked and changed to find a new solution with the neighbourhood being the amount to unpack. Smaller neighbourhoods are quicker to change but may result in worse quality solutions, while larger neighbourhoods need longer running time but may lead to better quality solutions. Note that the maximum neighbourhood size must be at least ten.

2.9.11 Unassigned Penalty Scheme

Each order that is *not* assigned by the optimiser incurs a hidden cost, called the *unassigned penalty*. Typically, you want the optimiser to assign all the orders in the input. Consequently, the unassigned penalty is usually very large relative to any other costs (monetary or hidden) in the scenario. There are multiple different methods for setting the value of the unassigned penalty for the orders in a scenario. Each method is called an *unassigned penalty scheme*.

The following unassigned penalty schemes are supported:

1. **Fixed**

   There is a fixed unassigned penalty for each order. You can set the size of this penalty in the input. This scheme is the default.

2. **Legacy**

   The unassigned penalty for each order is `4,500,000` divided by the number of orders in the scenario. This scheme is deprecated and will be deleted in a future release.

2.9.12 Order Splitting Strategy

Some orders may be too large or heavy to fit on a *compatible* vehicle in the fleet. *Order splitting* lets the optimiser automatically split up such orders into smaller orders that will fit on a vehicle. How this occurs depends upon the composition of the orders and is controlled by the optimiser's *order splitting strategy*.

Currently, the following order splitting strategies are supported:

1. **None**

   No order splitting is allowed.

2. **Split By Weight**

   Orders will be split into multiple orders, each of which will have weight equal to the maximum weight capacity of the largest compatible vehicle. Any remaining weight will be allocated to an additional order.

   Note: All orders *must* have zero volume to use this scheme.

3. **Split By Volume**

   Orders will be split into multiple orders, each of which will have volume equal to the maximum volume capacity of the largest compatible vehicle. Any remaining volume will be allocated to an additional order.

   Note: All orders *must* have zero weight to use this scheme.

Example:

Consider the case where we have an order with identifier `Order_1` and volume `24`. The largest vehicle in the fleet that is compatible with `Order_1` has a maximum volume capacity of `10`. If splitting by volume is enabled, then this order will be split into the three separate orders shown in Table 3. Each of the split orders is assigned a new identifier that consists of the identifier of the original order, followed by an underscore ("_") and then an integer "split index".

Id	Volume
Order_1_0	10
Order_1_1	10
Order_1_2	4

Table 3: Order Splitting Example

2.10 Locations

2.10.1 Identifier

Each location must have a unique identifier. This identifier acts as a reference to the location when referred to from other data (e.g. orders).

2.10.2 Name

Each location may have a name associated with it, for example a store or warehouse name.

2.10.3 Address

Each location may have a street address associated with it.

2.10.4 Time Zone

Each location may have a time zone associated with it. If none is defined, and the default time zone is present, then that time zone is used.

2.10.5 Coordinates

Each location *must* be provided with its geographic coordinates specified as latitude and longitude in decimal degrees.

2.10.6 Site Time

Site time is the time incurred by the vehicle when it arrives at the location. It is *only* incurred when the vehicle arrives at a location. Multiple consecutive pickups or deliveries at the *same* location without any intervening travel do not individually incur site time.

2.10.7 Load Time

Load time is the time incurred by the vehicle when it visits the location for a pickup or pickups. It is incurred only once per sequence of consecutive pickups at the *same* location. If the vehicle also has a positive load time, then the vehicle's load time will override this value.

2.10.8 Unload Time

Unload time is the time incurred by the vehicle when it visits the location for a delivery or deliveries. It is incurred only once per sequence of consecutive deliveries at the *same* location. If the vehicle also has a positive unload time, then the vehicle's unload time will override this value.

2.10.9 Operating Days

The Days of week a vehicle can pick up or deliver at the location.

2.10.10 Opening Time

The earliest time a vehicle can pick up or deliver at the location. If operating days are present, then this applies on each of those days.

2.10.11 Closing Time

The latest time a vehicle can pick up or deliver at the location. If operating days are present, then this applies on each of those days.

2.10.12 Time Windows

Time windows define spans of time when a vehicle can pick up or deliver at the location. Time windows may be a single span of time, such as 9:00–17:00 or multiple spans, such as 9:00–12:00 and 14:00–17:00.

2.10.13 Operating Times

The *operating times* are times at which a vehicle can pick up or deliver at the location. Operating times are defined by the operating days, opening time, closing time and any time windows.

2.10.14 Cost per Visit

This is a cost that is incurred whenever a vehicle visits the location.

2.10.15 Hidden Cost per Visit

This is a hidden cost that is incurred whenever a vehicle visits the location. This is used in the computation of a solution but will not be seen in the final output.

2.10.16 Loading Bays

The number of loading bays at a location limits how many vehicles can load or unload at the location at the same time. If all bays are occupied when a vehicle arrives, then it will be required to wait until a loading bay becomes unoccupied. At locations with no loading bays, any number of vehicles can load or unload at the same time.

2.10.17 Loading Bay Gap

This specifies the duration that must elapse between a vehicle leaving a loading bay and the arrival of the next vehicle at the same bay. This is used to model the time required to manoeuvre vehicles in and out of position.

2.11 Shifts

DTO version 2 breaks working schedules into *Shifts*. A shift definition specifies a start time, a maximum start delay, and a duration. These shift definitions are then assigned to either vehicles or drivers for specific dates. The optimiser strictly ensures that shifts assigned to the same vehicle or the same driver do not overlap in time.

2.11.1 Start Time

The clock time when the shift starts.

2.11.2 Maximum Start Delay

The maximum allowed delay from the "Start Time" that the shift can start.

2.11.3 Duration

The duration of the shift.

2.12 Vehicles

2.12.1 Vehicle Costs

Vehicle costs are specified in arbitrary units. The units used must be consistent across the scenario.

1. **Cost per Use**

   This is a cost incurred whenever the vehicle is used (i.e. has orders assigned to it) in a solution.

2. **Hidden Cost per Use**

   The hidden version of the cost per use. This is used in the computation of a solution, but it will not be seen in the final output.

3. **Cost per Hour**

   This is the cost per hour for the vehicle.

4. **Hidden Cost per Hour**

   The hidden version of the cost per hour. This is used in the computation of a solution, but it will not be seen in the final output.

5. **Cost per Kilometre**

   This is the cost per kilometre for the vehicle.

6. **Hidden Cost per Kilometre**

   The hidden version of the cost per km.

7. **Cost per Load**

   This is a cost that is incurred for each load a vehicle has in the solution.

8. **Hidden Cost per Load**

   The hidden version of the cost per load. This is used in the computation of a solution, but it will not be seen in the final output.

The following additional hidden costs (penalties) for vehicles are useful for controlling the "shape" of a vehicle's route.

1. Pickup segment penalties.
2. Delivery segment penalties.
3. Finish segment penalties.
4. Loaded volume distance penalties.
5. Loaded weight distance penalties.

2.12.2 Vehicle Capacities

Vehicles may have both a maximum weight capacity and maximum volume capacity. These are upper bounds on how much the vehicle can carry.

2.12.3 Vehicle Compartments

Vehicles may be divided into multiple *compartments*. Each compartment has its own capacities (e.g. maximum weight, maximum volume) and attributes. A *compartment scheme* is a list of compartments identified using a unique identifier. An individual compartment scheme can be applied to multiple vehicles.

2.12.4 Fatigue Management Scheme

This is an identifier that specifies the fatigue management rules that apply to the vehicle. Driver breaks inserted by the optimiser will satisfy all rules in the fatigue management scheme.

Note: Vehicle-specific fatigue management can only be used if you are running a scenario *without* drivers.

2.12.5 Loaded Breaks

A *loaded break* is a driver break that is scheduled while one or more orders are loaded on the vehicle. The optimiser can optionally prevent loaded breaks from being scheduled (i.e. driver breaks will only occur while the vehicle is not loaded).
Note: Vehicle-specific fatigue management can only be used if you are running a scenario *without* drivers.

2.12.6 Paid Breaks

A *paid break* specifies that the driver is paid for their break time.

Note: Vehicle-specific fatigue management can only be used if you are running a scenario *without* drivers.

2.12.7 Vehicle Maintenance

A vehicle is subject to maintenance if it has both an odometer reading and a maintenance scheme. The optimiser then schedules the vehicle's maintenance events as visits to maintenance locations. By default, a driver break that falls due during a maintenance visit may be taken during the visit; this can be forbidden for the vehicle. (See Section 2.18.)

2.12.8 Load Ordering

A vehicle's *load ordering* is an additional constraint on the pattern of pickups and deliveries made by the vehicle.

The following *load orders* are supported:

- **None:** There is no load order constraint.
- **LIFO:** A last-in-first-out ordering. This can be used to model vehicles that are loaded from the back.

  Example:

Stop Number	Stop Type	Order
1	PICKUP	Order1
2	PICKUP	Order2
3	PICKUP	Order3
4	DELIVERY	Order3
5	DELIVERY	Order2
6	DELIVERY	Order1

Table 4: Load Ordering Example

- **Weight Category:** The load ordering is weight sensitive where heavier items are picked up first but delivered last. The definition of a *heavy* item is specified using the heavy order threshold in the scenario.

  Example:

Stop Number	Stop Type	Order	Weight Category
1	PICKUP	Order1	Heavy
2	PICKUP	Order2	Heavy
3	PICKUP	Order3	Light
4	PICKUP	Order4	Light
5	PICKUP	Order5	Light
6	DELIVERY	Order4	Light
7	DELIVERY	Order3	Light
8	DELIVERY	Order5	Light
9	DELIVERY	Order1	Heavy
10	DELIVERY	Order2	Heavy

Table 5: Weight Category Example

2.12.9 Heavy Order Threshold

If a vehicle is using the weight category *load order*, then any order with weight greater than or equal to this value will be considered a *heavy* order.

2.12.10 Maximum Loads

If batched loads is enabled, then this is an upper bound on the number of loads the vehicle is allowed to do.

2.12.11 Maximum Drops per Load

If batched loads is enabled, then this is an upper bound on the number of locations a vehicle can deliver to per load.

2.13 Vehicle Shifts

2.13.1 Shift

The shift that the vehicle is working. A shift is given either as a shift template on a date or as an explicit start and finish time. When a shift template is used, a *latest finish* date-time may also be given: the shift then finishes at the earlier of the template's finish time and the latest finish.

2.13.2 Vehicle Locations

1. **Starting Location**

   This is the location of the vehicle at the start of its route.

   If this location differs from the first pickup location, then the vehicle is required to travel from the start location to the first pickup location. In such a case, the travel time and distance to the first pickup location are included in the solution.

   If no start location is specified, then the vehicle begins its route at the location of its first pickup.

2. **Finishing Location**

   This is a location to which the vehicle must return at the end of its route. The travel time and distance to return to this location are considered in the solution.

   If no finish location is specified, then the vehicle ends its route at the location of its last delivery.

2.13.3 Vehicle Times

1. **Minimum Paid Time**

   This is the minimum time that a vehicle will be paid for.

2. **Maximum Drive Time**

   This is the maximum time that a vehicle can spend in transit during a route.

3. **Maximum Work Time**

   This is the maximum time allowed between the start of the route and its completion. This includes the time needed for a vehicle to return to its finish location at the end of its route.

4. **Load Time**

   Load time is the time incurred by the vehicle when it begins a sequence of pickups at a location. A vehicle's load time will override a location's load time if *both* the vehicle's and location's load times are greater than zero.

5. **Unload Time**

   Unload time is the time incurred by the vehicle when it begins a sequence of deliveries at a location. A vehicle's unload time will override a location's unload time if *both* the vehicle's and location's unload times are greater than zero.

2.13.4 Vehicle Speed Scale

As all vehicles use the same time and distance matrices in computation of transit times and distance, applying a scaling factor allows the user to account for vehicles with varying speed. For example, if a vehicle was known to be 30% slower than the average vehicle in the fleet, a scaling factor of `0.7` (70%) could be applied. Similarly, if a vehicle was known to be 10% faster, a scaling factor of `1.10` (110%) could be applied.

2.14 Drivers

Drivers can be independently modelled. A driver has a cost per hour, a fatigue management break scheme, and an array of driver shifts. When drivers and vehicles are both used, the optimiser verifies a strict one-to-one conformity between the shifts claimed by drivers and the shifts available on vehicles.

2.14.1 Cost per Hour

The driver's hourly wage.

2.14.2 Hidden Cost per Hour

The hidden version of the cost per hour. This is used in the computation of a solution, but it will not be seen in the final output.

2.14.3 Fatigue Management Scheme

This is an identifier that specifies the fatigue management rules that apply to the driver. Driver breaks inserted by the optimiser will satisfy all rules in the fatigue management scheme.

2.14.4 Loaded Breaks

A *loaded break* is a driver break that is scheduled while one or more orders are loaded on the vehicle. The optimiser can optionally prevent loaded breaks from being scheduled (i.e. driver breaks will only occur while the vehicle is not loaded).

2.14.5 Paid Breaks

A *paid break* specifies that the driver is paid for their break time.

2.15 Driver Shifts

2.15.1 Date

The date that the driver is working.

2.15.2 Shift

The shift that the driver is working, given in the same way as for a vehicle shift (including an optional latest finish).

2.15.3 Driver Shift Times

A driver shift may give its own minimum paid time, maximum drive time and maximum work time. Each one given overrides the corresponding value of the vehicle shift.

2.15.4 Vehicle

The vehicle that the driver is driving.

2.16 Orders and Multi-Leg Orders

An order represents a demand to move goods from a pickup location to a delivery location. DTO version 2 supports *Simple* orders and *Multi-Leg* orders. A multi-leg order is composed of sequential legs, each defining its own pickup and delivery locations, service times, and time windows. Legs may also specify a *gap* duration that must elapse before the next leg can commence.

2.16.1 Locations

The pickup and delivery locations must be given for each order and must match a location identifier defined in the set of locations. (See Section 2.10.)

2.16.2 Times

1. **Earliest and Latest Times**

   The earliest pickup time is the earliest time that the order will be available at its pickup location. The earliest delivery time is the earliest time the same order is able to be delivered. This is analogous for latest times.

2. **Time Windows**

   The times when an order can be picked up and delivered can also be specified by time windows. If both earliest and latest times and time windows are specified, then *both* must be satisfied for the order to be picked up or delivered.

3. **Service Time**

   Each pickup and delivery may have an amount of service time associated with it. This is the amount of time incurred by the vehicle when the order is picked up or delivered. This time is *in addition* to any site, load or unload time incurred because of the location or vehicle.

2.16.3 Soft Time Window Penalties

If an order has soft time windows, then both fixed and variable penalties are incurred if these time windows are missed.

1. **Fixed Penalty**

   A constant penalty that is incurred if the soft time windows are missed. Note that if multiple soft time windows are defined, this penalty is still only incurred once.

2. **Variable Penalty**

   A penalty incurred for each minute the time window is missed. If multiple time windows are present, then the penalty is calculated based on the nearest soft time window boundary.

2.16.4 Maximum Duration

Orders can optionally have a *maximum duration* specified. The optimiser will not generate solutions that assign such orders in a way that the time needed to service them exceeds their maximum duration. (The *duration* of an order is defined to be the time that elapses from when its pickup commences up until the time when its delivery is complete.)

If the minimum service time needed by an order exceeds its maximum duration, then the order cannot be assigned by the optimiser.

2.16.5 Weight and Volume

The weight and volume of the order are given in arbitrary units which must be consistent with the respective vehicle capacities previously defined. For example, the volume may be measured in cubic metres, number of pallets or roll cages.

2.16.6 Assign Cost

This is a (monetary) cost associated with servicing the order. This can be used to prefer certain orders as the optimiser will attempt to find the solution with lowest cost. Negative costs can also be used.

2.16.7 Hidden Assign Cost

The hidden version of the assign cost. While this is used in the computation of a solution, it will not be seen in the final output.

2.16.8 Vehicle-Specific Assign Cost

An order can have costs associated with it that are only incurred when the order is assigned to a specific vehicle or set of vehicles. These costs are incurred in addition to any assign cost for the order.

2.16.9 Vehicle-Specific Hidden Assign Cost

An order can have hidden costs associated with it that are only incurred when the order is assigned to a specific vehicle or set of vehicles. These hidden costs are incurred in addition to any hidden assign cost for the order.

2.16.10 Order Precedences

Two orders can be associated with a precedence. This requires that the *delivery* of the first order must be completed before the *pickup* of the second. An optional duration that must elapse between the delivery and the pickup can also be specified. This duration is called the *gap*.

Precedences are often used to model cross-docking, where the first leg of the order must be delivered before the second leg can commence. For multi-leg orders, there is an implicit precedence that the delivery of a preceding leg *must* be completed before the pickup of the subsequent leg can occur.

2.17 Fatigue Management

A fatigue management scheme is a set of rules that specify the number of breaks of a certain duration that must occur within a given time interval (period). Each rule consists of the following:

1. **Number of Breaks**

   The number of breaks required by the rule.

2. **Duration of Break**

   The duration of the break.

3. **Interval of Break**

   The time interval (period) in which the break must occur.

Example: A fatigue management scheme may have the rule: A single `15`-minute break every `2` hours. Here, the number of breaks is `1`, the duration of the break is `15` minutes and the interval in which the break must occur is `2` hours.

2.18 Maintenance

The optimiser can schedule the servicing of vehicles, such as oil changes and inspections, that falls due as the vehicles accumulate distance. It does this by inserting *maintenance visits* into the vehicles' routes. Maintenance visits are not orders: they are planned by the optimiser to meet each vehicle's maintenance requirements.

2.18.1 Odometer Readings and Maintenance Schemes

A vehicle is subject to maintenance if it has both of the following:

1. **Odometer Reading**

   The reading of the vehicle's odometer at the start of its first shift.

2. **Maintenance Scheme**

   The identifier of the scheme that gives the vehicle's maintenance events. Several vehicles may use the same scheme.

A vehicle must have either both of these or neither of them.

A *maintenance scheme* is a list of maintenance events.

2.18.2 Maintenance Events

A *maintenance event* is either *fixed*, falling due once, or *periodic*, falling due at regular distances. (See Periodic Maintenance Events below.) Each maintenance event consists of the following:

1. **Id**

   An identifier for the event, unique within its scheme. Optional, unless another event supersedes it.

2. **Interval**

   For a periodic event only: the distance between its due points. Must be positive.

3. **Minimum Distance**

   For a fixed event, the odometer reading from which the event may be performed. For a periodic event, the offset from each due point from which an occurrence may be performed.

4. **Maximum Distance**

   For a fixed event, the odometer reading by which the event must be performed. For a periodic event, the offset from each due point by which an occurrence must be performed.

5. **Duration**

   The time the event takes at the maintenance location. Must be positive.

6. **Attributes**

   The attributes of the event, which determine the locations at which it can be performed. (See Maintenance Locations below.)

7. **Fixed Penalty**

   The penalty incurred once if the event overruns its maximum distance. Optional; must be nonnegative.

8. **Distance Penalty**

   The penalty per kilometre by which the event overruns its maximum distance. Optional; must be nonnegative.

9. **Supersedes**

   For a periodic event only: the identifiers of the periodic events of the same scheme that it supersedes. Optional.

An event that has either penalty, even a penalty of `0`, is *soft*; an event that has neither is *hard*. A missing penalty of a soft event counts as `0`, and a soft event whose penalties are both `0` may overrun its maximum distance at no cost. The minimum distance must not exceed the maximum distance. The minimum and maximum distances of a fixed event are odometer readings, not distances along the route, and must be nonnegative; the distance ranges of a scheme's fixed events may share an endpoint but must not otherwise overlap. Those of a periodic event are offsets, and may be negative.

Odometer readings and event distances are in kilometres.

2.18.3 Periodic Maintenance Events

A periodic event with interval I falls due at the odometer readings I, $2I$, $3I$, ... (its *due points*). Its k-th *occurrence* is due at kI, and may be performed while the odometer reading lies between $kI + m$ and $kI + M$, where m and M are its minimum and maximum distances: offsets from the due point, which may be negative. $M - m$ must not exceed I, so that the ranges of successive occurrences share at most an endpoint. Everything said in this section about an event applies to each occurrence of a periodic event, its range taking the place of the event's distances. Only the occurrences that a route reaches are considered, however long it is.

Example: A service due every 30,000 km that may be performed up to 1,000 km early has interval `30000`, minimum distance `-1000` and maximum distance `0`. For a vehicle with an odometer reading of `58200`, its next occurrence is due at `60000`, and may be performed between `59000` and `60000`; the following one is due at `90000`.

The due points are always multiples of the interval, whenever (or whether) the previous occurrence was in fact performed.

2.18.4 Superseding Maintenance Events

A periodic event may *supersede* other periodic events of its scheme, as a major service includes a minor one. Where an occurrence of an event is due at the same point as an occurrence of an event that supersedes it, only the latter is performed, with its own range, duration and penalties; the superseded occurrence is not performed and incurs no penalty. The superseded event's later occurrences are due as before. Supersession is transitive: if C supersedes B and B supersedes A, then C also supersedes A. An event must not supersede itself, directly or through other events.

Example: A scheme has a 30,000 km service and a 90,000 km service that supersedes it. At `90000`, `180000`, ... only the 90,000 km service is performed; at `30000`, `60000`, `120000`, ... the 30,000 km service is.

2.18.5 When a Maintenance Event Is Required

Consider a vehicle with odometer reading O at the start of one of its shifts, and one of its maintenance events, with minimum distance m and maximum distance M (for an occurrence of a periodic event, the odometer readings bounding its range).

- If $O > M$, then the event is taken to have been performed already, and it is ignored.
- If the vehicle's route on the shift does not take its odometer past M, then the event is not required.
- Otherwise, the vehicle must visit a location at which the event can be performed, and perform the event there, while its odometer reading lies between m and M.

For a hard event, a route that requires the event but on which the optimiser cannot schedule it within its distances (for example, because no location is compatible with the event, or no such location can be visited within the event's distances and the location's operating times) is not allowed. A soft event may instead overrun its maximum distance. (See Overrunning Maintenance Events below.)

Example: A vehicle has an odometer reading of `87500` and an event with minimum distance `91000`, maximum distance `94000` and duration `4:00`. If its route is less than `6500` km long, then the event is not required. Otherwise, the vehicle must spend four hours at a compatible location after it has travelled at least `3500` km and no more than `6500` km of its route.

2.18.6 Vehicles with Several Shifts

The odometer reading of a vehicle is its reading at the start of its first shift. When a vehicle subject to maintenance has several shifts, the shifts are solved in order of their start times: each shift starts from the

odometer reading at the end of the previous one, and a fixed event performed on an earlier shift is not required again.

2.18.7 Maintenance Locations

A maintenance event can be performed at any location in the scenario that is compatible with it under *maintenance-location* compatibility. (See Section 2.23.) The event's attributes are its requirements and the locations' attributes are their features, and the Null, Disjunction and Conjunction rules apply. In particular:

- An event attribute that is not part of the compatibility relationship imposes no restriction, so an event with no such attributes can be performed at any location.
- Since a location's identifier is one of its attributes, an event can be restricted to particular locations by giving the event an attribute that is compatible with those locations' identifiers.
- An event that has an attribute with no compatible location cannot be performed anywhere. For a hard event, a route must then not take the vehicle's odometer past the event's maximum distance; a soft event then overruns it instead.

Maintenance locations need not be the pickup or delivery locations of any order.

2.18.8 Maintenance Visits

The optimiser performs each required maintenance event during a *maintenance visit* between two consecutive stops of the route: the vehicle makes a detour to the maintenance location, performs the event there, and continues to the next stop. A visit to the location of either of the two stops involves no extra distance. Several visits may lie between the same two stops. Of the possible places for a visit (the stops it lies between and the location), the optimiser chooses the one that adds the least cost, given by the vehicle's cost per kilometre and cost per hour.

A maintenance visit must lie wholly within one of the operating times of its location. If the vehicle arrives before the location opens, then it waits. Arrival Only in Time Window does not apply to maintenance visits.

A maintenance visit appears in the solution as a `MAINTENANCE` stop at the maintenance location. Its arrival and departure times are the start and end of the event. A maintenance visit involves no site, load or unload time, and it does not change the vehicle's load.

2.18.9 Overrunning Maintenance Events

A required soft maintenance event may be performed after its maximum distance (*late*), or not at all on the route. The event then *overruns* its maximum distance:

- by the distance from its maximum distance to the stop at which it is performed, if it is performed late;
- by the distance from its maximum distance to the end of the route, if it is not performed on the route.

An overrun incurs the event's fixed penalty plus its distance penalty times the overrun distance. Like other penalties, these are considered by the optimiser but are not included in the costs reported in the solution.

For each required soft event, the optimiser chooses the cheapest of performing it on time, performing it late, and not performing it on the route, counting the cost of the detour and the penalty for any overrun. In particular, a soft event whose penalties are both `0` is only performed if doing so adds no cost. A soft event that is not compatible with any location is not performed, and the route incurs its penalty.

Soft events are useful in finding out whether, and by how much, maintenance is limiting the work that vehicles can do: the overruns in the solution show how far each vehicle would have to go past its maintenance limits.

2.18.10 Breaks During Maintenance

For a vehicle with a fatigue management scheme (its own or its driver's), a driver break that falls due during a maintenance visit may be taken during the visit. The break starts no earlier than the vehicle's arrival at the maintenance location (so it may start while the vehicle waits for the location to open) and ends no later than the end of the visit, so it adds no time to the route. In the solution, the `BREAK` stop then lies within the `MAINTENANCE` stop. Only the breaks that fall due are taken in this way: the rest of the visit counts as work.

This can be forbidden for a vehicle. A break that falls due during a visit is then taken before the event starts, and the event follows it.

If loaded breaks are forbidden, then a break is not taken during a maintenance visit while the vehicle is loaded.

2.18.11 Maintenance in the Solution

The solution reports the following for each vehicle shift, each load, each driver and the solution as a whole:

- **Maintenance time**: the time spent on maintenance visits. This is not included in the idle time. A break taken during a maintenance visit counts as both break time and maintenance time.
- **Maintenance detour distance**: the distance added by travelling to maintenance visits.
- **Maintenance detour time**: the transit time added by travelling to maintenance visits. This does not include the maintenance time.

These are only reported if the scenario has a vehicle subject to maintenance.

Each shift of a vehicle that is subject to maintenance also has a *maintenance summary*. This lists each fixed event, and each occurrence of a periodic event, that is performed on the shift or that the shift requires (because it takes the odometer past the maximum), other than superseded occurrences. Each entry gives the event, the occurrence (for a periodic event), its range of odometer readings, the stop at which it is performed and the odometer reading on arrival there (if it is performed on the shift), and its overrun.

2.19 Iteration Schemes

Iteration schemes provide finer-grained control over how the optimiser explores its solution space. An iteration scheme allows a single invocation of the optimiser to be split into a sequence of "batches", where each batch runs for a specified number of iterations with a specified maximum neighbourhood size. In the absence of an iteration scheme the optimiser will run with a single fixed maximum neighbourhood size for all the iterations.

An example iteration scheme is:

- `1000` iterations with a maximum neighbourhood size of `200`.
- `2000` iterations with a maximum neighbourhood size of `150`.
- `4000` iterations with a maximum neighbourhood size of `100`.

In this scheme, the optimiser will run for a total of `7000` iterations. For the first `1000` iterations the optimiser will use a maximum neighbourhood size of `200`; for the next `2000` it will use a maximum neighbourhood size of `150`; for the last `4000` it will use a maximum neighbourhood size of `100`.

Using an iteration scheme *may* improve performance as the optimiser is allowed a greater degree of freedom in the choices it makes at the beginning of a batch. Having multiple batches effectively increases the amount of time that the optimiser is afforded this greater degree of freedom.

Reducing the maximum neighbourhood size in later batches (as in the above example) reduces the likelihood of the optimiser straying too far from a good solution and failing to find any further improvements.

2.20 Day of Week

A day of the week represents the days *Monday* through *Sunday*.

If providing a list of days, then we allow the following shorthand expressions:

- `ALL`: A list comprised of all days of the week.
- `WORKDAYS`: A list of Monday to Friday inclusive.
- `WEEKDAYS`: A list of Monday to Friday inclusive.
- `WEEKEND`: Saturday and Sunday.
- `<START>-<END>`: A list of days from `START` to `END` inclusive. For example, *Tuesday - Thursday* would be Tuesday, Wednesday and Thursday.
- `<START>-<END>; <START>-<END>; ...`: A *semicolon separated* list of ranges. For example, *Tuesday - Thursday; Friday - Saturday* or *Tuesday - Thursday; Saturday*.

For example, the following are all equivalent:

- `WORKDAYS` or `WEEKDAYS`
- Monday - Friday
- [Monday, Tuesday, Wednesday, Thursday, Friday]
- [Monday - Wednesday; Thursday - Friday]

2.20.1 Allowed Day Abbreviations

The following are allowed abbreviations for the days:

Day of Week	Allowed Abbreviations
Monday	M, MO, MON
Tuesday	TU, TUE, TUES
Wednesday	W, WE, WED, WEDS
Thursday	TH, THU, THUR, THURS
Friday	F, FR, FRI
Saturday	SA, SAT
Sunday	SU, SUN

Table 6: Allowed Day Abbreviations

Note that lower case abbreviations are also accepted.

For example, the following are all equivalent:

- `WORKDAYS`
- MO - FR
- MON - FRI
- Mon - Fri
- Monday - Friday

2.21 Time Windows

Time windows represent a period of time within which either an order can be serviced or a location is open depending on the context.

Example: a location is open between 6:00–12:00, closed for lunch and open again between 13:00–17:00. It follows this pattern for each working day of the week. Table 7 shows how to represent this using time windows.

```
[
  {
    "dayOfWeek": "WORKDAY",
    "start": "06:00",
    "finish": "12:00"
  },
  {
    "dayOfWeek": "WORKDAY",
    "start": "13:00",
    "finish": "17:00"
  }
]
```

Id	Day of Week	Start	Finish
Day	WORKDAYS	06:00	12:00
Day	WORKDAYS	13:00	17:00

Table 7: Time Window Example.

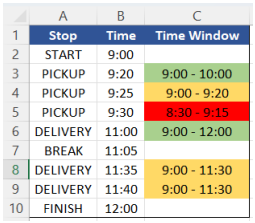
Note that time windows are merged by the system so that the following are equivalent to the 06:00–12:00 time window above.

Id	Day of Week	Start	Finish
TW 1	WORKDAYS	06:00	12:00
TW 2	Monday - Friday	13:00	17:00
TW 3	Monday - Wednesday	13:00	17:00
TW 3	Thursday - Friday	13:00	17:00

Table 8: Time Window Equivalence Example

2.21.1 Arrival Only in Time Window

Time windows have two modes of operation. The first ensures that every pickup or delivery occurs within the specified time window. This is the default behaviour. The second is called “Arrival Only in Time Window”. This mode of operation makes it so that the time window is satisfied for each pickup (or delivery) if the time window was satisfied upon the arrival of the vehicle at the location. This second mode of operation is only enabled when Batched Loads is also enabled.



	A	B	C
1	Stop	Time	Time Window
2	START	9:00	
3	PICKUP	9:20	9:00 - 10:00
4	PICKUP	9:25	9:00 - 9:20
5	PICKUP	9:30	8:30 - 9:15
6	DELIVERY	11:00	9:00 - 12:00
7	BREAK	11:05	
8	DELIVERY	11:35	9:00 - 11:30
9	DELIVERY	11:40	9:00 - 11:30
10	FINISH	12:00	

Figure 1: Example route with time windows to illustrate “Arrival Only in Time Window” behaviour. All pickups and all deliveries are at the same location. Time windows shaded green are satisfied normally. If “Arrival Only in Time Window” is enabled, then time windows shaded yellow are also satisfied, since the arrival stop is within the time window. The time window shaded red is violated with both schemes, since neither the stop nor the arrival stop is within the time window.

2.22 Soft Time Windows

Soft time windows apply only to orders. They represent a preferred time of service (i.e. pickup or delivery). The optimiser may schedule pickups or deliveries outside of any soft time windows but will incur a penalty for doing so.

A soft time window penalty has two components: a *fixed* component that is incurred if the soft time window is missed and a *variable* component that is a per-minute rate based on the number of minutes from the nearest time window boundary. The soft time window penalty acts as an additional form of hidden cost.

Example: Assume the time windows in Table 7 are delivery soft time windows and we have `200` and `5` as the fixed and variable penalty components respectively. In this case the hard time window exists from 6:00–17:00. If the order was delivered at 12:20, then we would incur a fixed penalty of `200` and a variable penalty of $5 \times 20 = 100$ for a total penalty of `300`.

2.23 Compatibility

Compatibility relationships are used to restrict what decisions the optimiser may make when generating a solution. The following kinds of compatibility relationships are supported:

- **Order-vehicle compatibility**: an order may only be assigned to a vehicle with which it is compatible.
- **Order-compartment compatibility**: an order may only be loaded in a compartment with which it is compatible.
- **Order-order compatibility**: orders may only be simultaneously loaded into a compartment if they are compatible.
- **Load order-order compatibility**: orders may only be simultaneously loaded on to a vehicle if they are compatible.
- **Location-vehicle compatibility**: a vehicle may only pick up or deliver orders to locations with which it is compatible.
- **Maintenance-location compatibility**: a maintenance event may only be performed at a location with which it is compatible (see Maintenance).

Compatibility relationships are specified using attributes. As an example, consider a fleet that consists of both refrigerated and non-refrigerated vehicles. To restrict an order that requires refrigeration to be assigned to only a refrigerated vehicle, we can label the order with the attribute REFRIGERATED and also label all the refrigerated vehicles with the attribute REFRIGERATED. We can then specify an *order-vehicle* compatibility relationship such that orders with the attribute REFRIGERATED must only be assigned to vehicles with the attribute REFRIGERATED.

Order\Vehicle	REFRIGERATED	TALL	LONG	VEHICLE1
REFRIGERATED	true			
TALL		true	true	
ORDER7				true

Table 9: Order-Vehicle Compatibility Example.

Table 9 is an example of an *order-vehicle* compatibility relationship, where `true` means that the attribute pair is compatible and an empty cell means that the attribute pair is *not* compatible.

Table 9 is interpreted as follows: for orders with the attribute REFRIGERATED, the compatible vehicles must have the attribute REFRIGERATED; for orders with the attribute TALL, the compatible vehicles must have **either** the attribute TALL or the attribute LONG; for the orders with the attribute ORDER7, the compatible vehicles must have the attribute VEHICLE1. For the last case, if ORDER7 is one of the order identifiers and VEHICLE1 is one of the vehicle identifiers, then this will restrict ORDER7 to only be compatible with VEHICLE1. If ORDER7 has other attributes that VEHICLE1 is not compatible with, then this means that the order cannot be assigned to any vehicle. (See **Conjunction Rule** below).

Three rules are applied when interpreting attributes and their compatibility. Here we use *order-vehicle* compatibility to illustrate them.

1. **Null Rule:** An order attribute that is not part of an *order-vehicle* compatibility relationship imposes no restriction on which vehicle the order can be assigned to. We can ignore this attribute or, equivalently, consider it compatible with all vehicle attributes.
2. **Disjunction Rule:** If an order attribute has multiple compatible vehicle attributes, then any vehicle having *one* of the attributes is a candidate compatible vehicle.
3. **Conjunction Rule:** If an order has multiple attributes, then a compatible vehicle for the order must have a compatible attribute for each of the order's attributes.

These rules are applied in only one direction: attributes are interpreted as requirements for orders and features for vehicles. An order does not need to have a compatible attribute for each of a vehicle's attributes to be compatible with that vehicle. For example, in Table 9, an order that has only one attribute, REFRIGERATED, is compatible with a vehicle that has attributes REFRIGERATED and LONG. These rules apply similarly

to *order-compartment*, *location-vehicle* and *maintenance-location* compatibility (for the last, attributes are interpreted as requirements for maintenance events and features for locations).

For *order-order* and *load order-order* compatibility, these rules must be applied in *both* directions, that is: for two compatible orders, each of them must have a compatible attribute for each attribute of the other order.

2.24 Preloading

Preloading is when a vehicle starts its plan already loaded and can depart from its start location immediately.

The following conditions are required to allow a vehicle to preload at a location:

- The location allows preloading.
- The vehicle allows preloading.
- The vehicle's *start location* is at the location.

When preloading occurs, no pickup service times and load time are incurred for the initial sequence of pickups. Site time *is* incurred as normal. This is because site time is intended for modelling activities that the driver needs to undertake regardless of whether the vehicle is preloaded or not (e.g. paperwork, briefings or safety inspections).

The number of vehicles that can be preloaded at a location is not restricted by the number of loading bays at that location.

2.25 Stops

In a solution, a vehicle's route consists of a sequence of stops, each with a time-of-arrival and time-of-departure. The different stop types are:

1. `START`: Denotes the start of the route.
2. `FINISH`: Denotes the end of the route.
3. `PICKUP`: Denotes an order pickup.
4. `DELIVERY`: Denotes an order delivery.
5. `BREAK`: Denotes a break for the vehicle.
6. `MAINTENANCE`: Denotes a maintenance visit (see Maintenance).

A route must begin with a `START` stop and end with a `FINISH` stop. These are the only positions in the route where `START` and `FINISH` stops can appear. Every `PICKUP` stop in the route must have a matching `DELIVERY` stop.

2.26 Loads

A *load* is defined to be a sequence of `PICKUP` stops followed by a sequence of `DELIVERY` stops such that once the first `DELIVERY` stop occurs, no further `PICKUP` stops can occur until the vehicle is empty.

Example:

Stop Number	Load	Not a Load
1	PICKUP	PICKUP
2	PICKUP	PICKUP
3	PICKUP	DELIVERY
4	DELIVERY	PICKUP
5	DELIVERY	DELIVERY
6	DELIVERY	DELIVERY

Table 10: Load Example.

2.27 Solution Times

In the solution generated by the optimiser, we have the following notions of times:

1. **Work Time**

   In the vehicle summary, this is the time between leaving the `START` stop and arriving at the `FINISH` stop in a vehicle's route. A vehicle's work time is the total time taken to complete the route, while a load's work time is the total time taken to complete the load.

2. **Site Time**

   A vehicle's site time is the sum of all site time incurred over the entire route, while a load's site time is the sum of all site time incurred during the load.

3. **Load Time**

   A vehicle's load time is the sum of all load times incurred over the entire route. If batched loads is enabled, then this measure is analogous for each of the vehicle's loads.

4. **Unload Time**

   A vehicle's unload time is the sum of all unload time incurred over the entire route. If batched loads is enabled, then this measure is analogous for each of the vehicle's loads.

5. **Service Time**

   A vehicle's service time is the sum of all service time incurred over the entire route. If batched loads is enabled, then this measure is analogous for each of the vehicle's loads.

6. **Idle Time**

   Idle time (wait time) is incurred by a vehicle if it arrives at a location outside of the location's time windows or if it arrives outside of the order's time windows. A vehicle's idle time is the sum of all idle time incurred over the entire route. If batched loads is enabled, then this measure is analogous for each of the vehicle's loads.

7. **Break Time**

   Break time is incurred if the vehicle has a fatigue management scheme specified (See Section 2.17). A vehicle's break time is the sum of all break time incurred over the entire route. If batched loads is enabled, then this measure is analogous for each of the vehicle's loads.

2.28 Unassigned Orders

If the solution generated by the optimiser contains orders that are not assigned to a vehicle, then the optimiser will do an analysis to try to determine the reasons for those orders not being assigned.

Examples of such reasons include:

- Orders not being compatible with any of the vehicles in the fleet.
- Orders with a weight or volume demand that exceeds the maximum vehicle weight or volume capacity of any vehicle in the fleet.
- Orders that need to be picked up or delivered *before* the start time of any of the vehicles in the fleet.
- Orders that require more time to complete than the maximum working time of any vehicle in the fleet.

Note that the focus of the analysis is on finding reasons that are likely to indicate errors or omissions in the input data. It is possible that the analysis will not find any definite reason for an order being unassigned.

2.29 Pickup Segments

A *pickup segment* is defined to be any two consecutive `PICKUP` stops in a route. (A route or load with only a single `PICKUP` stop has no pickup segments.)

The optimiser can optionally apply a penalty based on the pickup segments in a route. This penalty has two components: a *fixed* component based on the number of pickup segments in the route and a *variable* component proportional to the transit distance along the pickup segments. These penalties take the form of an additional hidden cost.

The pickup segment penalty is useful for "shaping" the route. The fixed component of the penalty may be used to reduce the number of pickup stops per load, while the variable component may be used to encourage the optimiser to cluster pickups more closely together.

The pickup segment penalty is only applied if the Batched Loads parameter is enabled.

2.30 Delivery Segments

A *delivery segment* is defined to be any two consecutive `DELIVERY` stops in a route. (A route or load with only a single `DELIVERY` stop has no delivery segments.)

The optimiser can optionally apply a penalty based on the delivery segments in a route. This penalty has two components: a *fixed* component based on the number of delivery segments in the route and a *variable* component proportional to the transit distance along the delivery segments. These penalties take the form of an additional hidden cost.

The delivery segment penalty is useful for "shaping" the route. The fixed component of the penalty may be used to reduce the number of delivery stops per load, while the variable component may be used to encourage the optimiser to cluster deliveries more closely together.

The delivery segment penalty is only applied if the Batched Loads parameter is enabled.

2.31 Finish Segments

The *finish segment* of a route is defined as the part of the route from the last `DELIVERY` stop to the `FINISH` stop. There may be intervening `BREAK` stops between these two stops.

The optimiser can optionally apply a penalty based on the transit time or distance of the finish segment of a route. These penalties take the form of an additional hidden cost.

Penalties applied to the finish segment are used to tell the optimiser to prefer solutions in which vehicles end their routes "close" to their finish locations.

2.32 Loaded Distance Penalties

A *loaded distance penalty* is a hidden cost that is scaled by both the distance travelled by a vehicle and the amount loaded on the vehicle while travelling.

More precisely, the loaded distance penalty for a vehicle over a single travel segment is defined as:

$$\text{TransitDistance} \times \text{LoadedQuantity} \times \text{PenaltyFactor}$$

where TransitDistance is the distance travelled in that segment (in kilometres), LoadedQuantity is the amount loaded on the vehicle over that segment and PenaltyFactor is a user-supplied value. The loaded distance penalty of a vehicle's route is the sum of the loaded distance penalties over all its individual travel segments.

Loaded distance penalties can be applied to either the weight loaded on the vehicle, the volume loaded on the vehicle or both.

2.33 Empty Distance Penalties

A *empty distance penalty* is a hidden cost that is scaled by the distance travelled by a vehicle when both the weight loaded on the vehicle and the volume loaded on the vehicle are zero.

2.34 Split Solving

Split solving is a divide-and-conquer strategy for the optimiser. Instead of solving one large scenario, it partitions the scenario into multiple independent sub-scenarios, optimises each one independently and then combines the sub-solutions into a final solution.

Partitioning is done according to time-window overlap. Orders and vehicles are split into groups whose maximal time windows overlap; groups that do not overlap in time end up in separate sub-scenarios, because they can never share a vehicle's route.

Split solving is beneficial primarily due to the reduction in combinatorial complexity. A scenario that is twice as large may take more than twice the time to solve. Partitioning a large scenario into independent sub-scenarios means each optimisation searches a smaller space, and the sum of these small searches finishes faster than one search over the whole. Additionally, the sub-scenarios can be optimised concurrently, so there may be a wall-clock gain in addition to the search-space gain.

2.34.1 Example

A regional carrier runs a fleet doing two disjoint shifts. Consider a day-plus-night operation: a morning depot has approximately 40 delivery orders all with time windows between 06:00 and 12:00, served by a set of vehicles whose shifts also sit in the morning. A separate batch of approximately 40 orders has windows between 18:00 and 23:00, served by an evening fleet whose shifts sit in the evening. There is a midday gap where nothing overlaps.

Here the time windows partition cleanly into a morning sub-scenario and an evening sub-scenario with no intersection.

3 Microsoft Excel Input

This section describes the Microsoft Excel input format for version 2 of Opturion DTO. Excel input must be either an Office Open XML workbook (`.xlsx`) or a macro-enabled workbook (`.xlsm`). The optimiser evaluates all formulas upon loading.

3.1 Identifiers in Excel

Identifiers and attributes in DTO-Excel may be provided as either text or numeric data. Identifiers given in text cells are taken *as-is* subject only to the rules concerning case and whitespace sensitivity. Identifiers given in numeric cells are *only* accepted by the optimiser if they are integer (i.e. their fractional part is zero). Formulas that evaluate to either text or (integer) numeric data may also be used to specify identifiers in Excel.

3.2 Times in Excel

In Excel, times are *stored* as decimal numbers, where `0` is `00:00:00` and `1` is `24:00:00`.

The integer component of the decimal represents a 24-hour period and is used to represent times greater than `23:59:59`. When using this representation, it is useful to think of the integer component as the day on which the time occurs, with times less than `24:00:00` occurring on *day zero*. For example, `1.50` would be `36:00`, or `12:00` on the second day.

In Excel, cells containing times may be formatted in various ways, for example, `hh:mm`, `d hh:mm` or `h:mm AM/PM`. Times may be given to the optimiser in any of the Excel time formats.

Value	hh:mm	[hh]:mm	dd/mm/yyyy hh:mm	d hh:mm
0.5	12:00	12:00	00/01/1900 12:00	0 12:00
1.5	12:00	36:00	01/01/1900 12:00	1 12:00

Table 11: Excel time formatting examples.

Note here that if using the `dd/mm/yyyy hh:mm` format, *day zero* occurs on `00/01/1900`, which is Excel's earliest recognised date.

3.3 Sheet: Configuration

This sheet is required. It contains global scenario parameters.

3.3.1 Column: Parameter

Required: Yes.
Type: Text.
Description: Parameters that control the settings of the scenario.

3.3.2 Column: Value

Required: Yes.
Type: Text, Boolean or Number.
Description: Values of the parameters.

3.3.3 Parameter: Name

Required: No.
Value Type: Text.
Description: A name for the scenario.

3.3.4 Parameter: Iterations

Required: No.
Value Type: Number (positive integer).
Default: `3000`.
Description: The number of iterations the optimiser will run for. (This parameter is ignored if the Iteration Scheme parameter is also specified.)

3.3.5 Parameter: Iteration Scheme

Required: No.
Value Type: Text.
Default: No iteration scheme used.
Description: The identifier of an iteration scheme defined in the Iteration Schemes sheet for the optimiser to use.

3.3.6 Parameter: Default Time Zone

Required: No.
Value Type: Text.
Description: The default time zone for all addresses in the scenario. If this is not present, then either all addresses must have a time zone, or none of them can.

3.3.7 Parameter: Region

Required: No.
Value Type: Text.
Description: The region in which the scenario operates. May be given as an ISO 3166-1 alpha-2 code (`AU`, `NZ`, `GB`, `CL`), an ISO 3166-1 alpha-3 code (`AUS`, `NZL`, `GBR`, `CHL`), or a display name (`Australia`, `New Zealand`, `Great Britain`, `Chile`). The region selects region-specific defaults such as address geocoding conventions.

3.3.8 Parameter: Start Of Operation

Required: Yes.
Value Type: Excel Date.
Description: The chronological start of the operational period. No dates or times in the scenario may occur before this value.

3.3.9 Parameter: Geofence North

Required: No.
Value Type: Number.
Description: The decimal degrees representing the northern boundary of the scenario's geofence.

3.3.10 Parameter: Geofence East

Required: No.
Value Type: Number.
Description: The decimal degrees representing the eastern boundary of the scenario's geofence.

3.3.11 Parameter: Geofence South

Required: No.
Value Type: Number.
Description: The decimal degrees representing the southern boundary of the scenario's geofence.

3.3.12 Parameter: Geofence West

Required: No.
Value Type: Number.
Description: The decimal degrees representing the western boundary of the scenario's geofence.

3.3.13 Parameter: Hard Geofence Errors

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then treat any errors produced by geofence violations as hard errors that halt optimisation.

3.3.14 Parameter: Batched Loads

Required: No.
Value Type: Boolean.
Default: `TRUE`.
Description: If `TRUE`, then enforce the batched loads constraint, ensuring strict pickup-delivery cycles.

3.3.15 Parameter: Sticky Deliveries

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then enable the Sticky Deliveries constraint.

3.3.16 Parameter: Sticky Vehicles

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then enable the *Sticky Vehicles* constraint, which requires all orders carried by a vehicle to originate from the same location (effectively locking the vehicle to that location).

3.3.17 Parameter: Colocated Pickups

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then enable the Colocated Pickups constraint.

3.3.18 Parameter: Sticky Deliveries Benefit

Required: No.
Value Type: Number (nonnegative integer).
Default: `5000`.
Description: The hidden benefit awarded for keeping a sticky delivery group together. (See Sticky Deliveries Benefit in Section 2.9.)

3.3.19 Parameter: Prune Locations

Required: No.
Value Type: Boolean.
Default: `TRUE`.
Description: If `TRUE`, then locations that are not referenced by any order, vehicle shift or driver shift are pruned from the scenario before solving.

3.3.20 Parameter: Cost Scale

Required: No.
Value Type: Number (positive).
Default: `0` (no scaling).
Description: Multiply all cost values by this number before solving. (See Scaling Factors in Section 2.9.)

3.3.21 Parameter: Weight Scale

Required: No.
Value Type: Number (positive).
Default: `0` (no scaling).
Description: Multiply all weight values by this number before solving. (See Scaling Factors in Section 2.9.)

3.3.22 Parameter: Volume Scale

Required: No.
Value Type: Number (positive).
Default: `0` (no scaling).
Description: Multiply all volume values by this number before solving. (See Scaling Factors in Section 2.9.)

3.3.23 Parameter: Maximum Neighbourhood Size

Required: No.
Value Type: Number (positive integer of at least ten).
Default: `200`.
Description: The value of the maximum neighbourhood size for the optimiser. (See Maximum Neighbourhood Size in Section 2.9.)

3.3.24 Parameter: Unassigned Penalty Scheme

Required: No.
Value Type: String (one of `FIXED` or `LEGACY`).
Default: `FIXED`.
Description: The unassigned penalty scheme to use.

3.3.25 Parameter: Fixed Unassigned Penalty

Required: No.
Value Type: Number (positive integer).
Default: `30000`.
Description: The value of the penalty for use by the `FIXED` unassigned penalty scheme.

3.3.26 Parameter: Rush Hour

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then use the rush hour periods defined in the Rush Hour sheet.

3.3.27 Parameter: Check Compartment Capacities

Required: No.
Value Type: Boolean.
Default: `TRUE`.
Description: If `TRUE`, the optimiser checks that the sum of compartment capacities does not exceed the vehicle's total capacity.

3.3.28 Parameter: Forbid Unrecognised Columns

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then treat any unrecognised column header as a strict error.

3.3.29 Parameter: Arrival Only in Time Window

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then the optimiser will enable the Arrival Only in Time Window behaviour.

3.3.30 Parameter: Order Splitting Strategy

Required: No.
Value Type: Text (one of the Order Splitting Strategy codes).
Default: `None`.
Description: The order splitting strategy to use.

3.3.31 Parameter: Split Solve

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then the optimiser will attempt to split solve the scenario.

3.3.32 Parameter: Split Solve Jobs

Required: No.
Value Type: Number (positive integer).
Default: 2.
Description: If split solve is `TRUE`, then the number of sub-scenarios to solve concurrently.
Note: This value is limited according to the installation and any value above this will be reduced to this limit.

3.4 Sheet: Excel Report Configuration

This sheet is not required.

3.4.1 Column: Parameter

Required: Yes.
Type: Text.
Description: Parameters that control the Excel report configuration.

3.4.2 Column: Value

Required: Yes.
Type: Text, Boolean or Number.
Description: Values of the parameters. Can be a number or text depending on the parameter.

3.4.3 Parameter: Unassigned Order Attributes

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then the Unassigned Order sheet will contain the `Attributes` column. This column contains order attributes for the unassigned orders.

3.4.4 Parameter: Order Vehicle Compatibility

Required: No.
Value Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then include the Unassigned Compatibility sheet in the output.

3.5 Sheet: Iteration Schemes

The **Iteration Schemes** sheet is used to define iteration schemes.

Each row in this sheet defines an iteration scheme batch. The order of the batches in each scheme is defined by the order of the rows. Note that this sheet can define multiple iteration schemes, although the optimiser can only use one at a time.

This sheet can be omitted.

3.5.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the iteration scheme to which this batch belongs.

3.5.2 Column: Iterations

Required: Yes.
Type: Number (integer).
Description: The nonnegative number of iterations in the batch.

3.5.3 Column: Maximum Neighbourhood Size

Required: Yes.
Type: Number (integer).
Description: The maximum size of the neighbourhood of the batch. Must be at least 10.

3.5.4 Column: Disable Simulated Annealing

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then simulated annealing is disabled for this batch, so the optimiser only accepts improving moves.

3.6 Sheet: Rush Hour

The **Rush Hour** sheet is used to define time periods where speed scaling takes effect. Note that this feature must be enabled by setting the value of the Rush Hour parameter to `TRUE`.

This sheet can be omitted if rush hour periods are not required.

3.6.1 Column: Day of Week

Required: No.
Type: Text (Day of Week).
Description: The days of the week on which the rush hour period applies.

3.6.2 Column: Start Date

Required: No.
Type: Excel date.
Description: Starting date of the rush hour period.

3.6.3 Column: End Date

Required: No.
Type: Excel date.
Description: Finishing date of the rush hour period. Must occur after Start Date and be nonnegative.

3.6.4 Column: Time Zone

Required: No.
Type: Text.
Description: A valid standard time zone string for the rush hour.

3.6.5 Column: Start

Required: Yes.
Type: Excel time.
Description: Starting time of the rush hour period.

3.6.6 Column: End

Required: Yes.
Type: Excel time.
Description: Finishing time of the rush hour period. Must occur after Start Time and be nonnegative.

3.6.7 Column: Speed Scale

Required: Yes.
Type: Number.
Description: The speed scaling factor to apply to transit times within the rush hour period.

NOTE: In each row of the sheet, either the 'Day of Week' *OR* both 'Start Date' *AND* 'End Date' should be defined but not both.

3.7 Sheet: Shifts

This sheet defines the time bounds and durations of operational shifts.

3.7.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: A unique identifier for the shift template.

3.7.2 Column: Start Time

Required: Yes.
Type: Excel time.
Description: The starting time for this shift.

3.7.3 Column: Maximum Start Delay

Required: No.
Type: Excel time.
Description: The maximum duration that the shift start can be delayed.

3.7.4 Column: Duration

Required: Yes.
Type: Excel time.
Description: The total duration of this shift.

3.8 Sheet: Locations

This sheet must be defined and contain at least one location.

3.8.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: A unique identifier for the location.

3.8.2 Column: Name

Required: No.
Type: Text or (integer) number.
Description: A descriptive name for the location.

3.8.3 Column: Address

Required: No.
Type: Text.
Description: The full string address of the location. Compound addresses can alternatively be provided using columns for `Address Line 1`, `Address Line 2`, `Suburb`, `State`, `Country`, and `Postcode`.

3.8.4 Column: Address Line 1

Required: No.
Type: Text.
Description: The first line of a compound address for the location.

3.8.5 Column: Address Line 2

Required: No.
Type: Text.
Description: The second line of a compound address for the location.

3.8.6 Column: Suburb

Required: No.
Type: Text.
Description: The suburb component of a compound address for the location.

3.8.7 Column: State

Required: No.
Type: Text.
Description: The state component of a compound address for the location.

3.8.8 Column: Country

Required: No.
Type: Text.
Description: The country component of a compound address for the location.

3.8.9 Column: Postcode

Required: No.
Type: Text or (integer) number.
Description: The postcode component of a compound address for the location.

3.8.10 Column: Time Zone

Required: No.
Type: Text.
Description: A valid standard Time Zone string for the location.

3.8.11 Column: Longitude

Required: Yes.
Type: Number.
Description: Longitude of the location in decimal degrees.

3.8.12 Column: Latitude

Required: Yes.
Type: Number.
Description: Latitude of the location in decimal degrees.

3.8.13 Column: Cost Per Visit

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost incurred each time a vehicle visits this location. (See Cost per Visit in Section 2.10.)

3.8.14 Column: Hidden Cost Per Visit

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost incurred each time a vehicle visits this location. (See Hidden Cost per Visit in Section 2.10.)

3.8.15 Column: Site Time

Required: No.
Type: Excel time.
Description: A fixed amount of time spent at the location on each visit, in addition to any load or unload time. (See Site Time in Section 2.10.)

3.8.16 Column: Load Time

Required: No.
Type: Excel time.
Description: The time taken to load at this location. (See Load Time in Section 2.10.)

3.8.17 Column: Unload Time

Required: No.
Type: Excel time.
Description: The time taken to unload at this location. (See Unload Time in Section 2.10.)

3.8.18 Column: Attributes

Required: No.
Type: Text.
Description: One or more attributes for the location, separated by semicolons. Used to express compatibility relationships.

3.8.19 Column: Operating Days

Required: No.
Type: Text (Day of Week).
Description: The days of the week on which the location is open.

3.8.20 Column: Opening Time

Required: No.
Type: Excel time.
Default: `00:00`.
Description: Earliest opening time for the location.
Note: If *Operating Days* is defined then this should **not** contain a date component as this time will apply on each of the operating days in the scenario. Conversely, if *Operating Days* is **not** defined then this **should** contain a date component. See Table 12 for an example.

Operating Days	Opening Time	Closing Time	Valid
Monday - Friday	9:00	17:00	TRUE
Monday - Friday	2026/09/04 09:00	2026/09/04 17:00	FALSE
	9:00	17:00	FALSE
	2026/09/04 09:00	2026/09/04 17:00	TRUE

Table 12: Location Operating Hours Example.

3.8.21 Column: Closing Time

Required: No.
Type: Excel time.
Default: No closing time.
Description: Latest closing time for the location.
Note: If *Operating Days* is defined then this should **not** contain a date component as this time will apply on each of the operating days in the scenario. Conversely, if *Operating Days* is **not** defined then this **should** contain a date component. See Table 12 for an example.

3.8.22 Column: Operating Times

Required: No.
Type: Text or (integer) number.
Default: No time windows.
Description: The identifier of the time window as defined in the Time Windows sheet. (See Location Time Windows in Section 2.10.)

3.8.23 Column: Allow Preloading

Required: No.
Type: Boolean.
Description: If `TRUE`, then vehicles can preload at this location. Batched loads must be enabled for this to be valid.

3.8.24 Column: Loading Bays

Required: No.
Type: Number (nonnegative integer).
Default: `0` (no limit).
Description: The number of loading bays at the location, limiting how many vehicles may load or unload simultaneously. (See Loading Bays in Section 2.10.)

3.8.25 Column: Loading Bay Gap

Required: No.
Type: Excel time.
Description: The minimum time that must elapse between successive uses of a loading bay. (See Loading Bay Gap in Section 2.10.)

3.8.26 Column: Allow Order Splitting

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then orders picked up or delivered at this location may be split. (See Order Splitting Strategy in Section 2.9.)

3.8.27 Column: Disable Sticky Deliveries

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then the Sticky Deliveries constraint is not applied at this location.

The following columns are populated by the geocoding and time-zone lookup services and are not required as inputs. When present, they are read back on subsequent runs.

3.8.28 Column: Geocoded Address

Required: No.
Type: Text.
Description: The full address returned by the geocoding service for this location.

3.8.29 Column: Geocoder Errors

Required: No.
Type: Text.
Description: Any errors reported by the geocoding service when resolving this location's coordinates.

3.8.30 Column: Time Zone Errors

Required: No.
Type: Text.
Description: Any errors reported by the time-zone lookup service when resolving this location's time zone.

3.9 Sheet: Orders

This sheet must be defined and contain at least one order.

3.9.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: A unique identifier for the order.

3.9.2 Column: Leg Id

Required: No.
Type: Text or (integer) number.
Description: If provided, identifies the leg of a multi-leg order.

3.9.3 Column: Name

Required: No.
Type: Text or (integer) number.
Description: A descriptive name for the order.

3.9.4 Column: Customer

Required: No.
Type: Text or (integer) number.
Description: A customer name or identifier associated with the order. Used for reporting only.

3.9.5 Column: Priority

Required: No.
Type: Number (nonnegative integer).
Default: `0` (highest priority).
Description: The priority of the order, where `0` is the highest priority. Lower-priority orders may be left unassigned in favour of higher-priority ones.

3.9.6 Column: Pickup Location

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Locations sheet.

3.9.7 Column: Pickup Service Time

Required: No.
Type: Excel time.
Description: The time required to service the pickup, in addition to any load time at the pickup location. (See Service Time in Section 2.16.)

3.9.8 Column: Earliest Pickup Time

Required: No.
Type: Excel date/time.
Description: The earliest time at which the pickup may commence. (See Earliest and Latest Times in Section 2.16.)

3.9.9 Column: Latest Pickup Time

Required: No.
Type: Excel date/time.
Description: The latest time at which the pickup may commence. (See Earliest and Latest Times in Section 2.16.)

3.9.10 Column: Pickup Time Windows

Required: No.
Type: Text or (integer) number.
Description: The identifier of a group of time windows, defined in the Time Windows sheet, that constrains when the pickup may occur.

3.9.11 Column: Pickup Soft Time Windows

Required: No.
Type: Text or (integer) number.
Description: The identifier of a group of soft time windows, defined in the Time Windows sheet, that the pickup should preferably occur within.

3.9.12 Column: Soft Pickup Constant

Required: No.
Type: Number.
Default: `0`.
Description: The fixed hidden penalty incurred when the pickup occurs outside its soft time windows.

3.9.13 Column: Soft Pickup Factor

Required: No.
Type: Number.
Default: `0`.
Description: The per-unit-time hidden penalty incurred, scaled by how far the pickup falls outside its soft time windows.

3.9.14 Column: Delivery Location

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Locations sheet.

3.9.15 Column: Delivery Service Time

Required: No.
Type: Excel time.
Description: The time required to service the delivery, in addition to any unload time at the delivery location. (See Service Time in Section 2.16.)

3.9.16 Column: Earliest Delivery Time

Required: No.
Type: Excel date/time.
Description: The earliest time at which the delivery may commence. (See Earliest and Latest Times in Section 2.16.)

3.9.17 Column: Latest Delivery Time

Required: No.
Type: Excel date/time.
Description: The latest time at which the delivery may commence. (See Earliest and Latest Times in Section 2.16.)

3.9.18 Column: Delivery Time Windows

Required: No.
Type: Text or (integer) number.
Description: The identifier of a group of time windows, defined in the Time Windows sheet, that constrains when the delivery may occur.

3.9.19 Column: Delivery Soft Time Windows

Required: No.
Type: Text or (integer) number.
Description: The identifier of a group of soft time windows, defined in the Time Windows sheet, that the delivery should preferably occur within.

3.9.20 Column: Soft Delivery Constant

Required: No.
Type: Number.
Default: `0`.
Description: The fixed hidden penalty incurred when the delivery occurs outside its soft time windows.

3.9.21 Column: Soft Delivery Factor

Required: No.
Type: Number.
Default: `0`.
Description: The per-unit-time hidden penalty incurred, scaled by how far the delivery falls outside its soft time windows.

3.9.22 Column: Weight

Required: No.
Type: Number.
Description: Weight of the order. Must be nonnegative.

3.9.23 Column: Volume

Required: No.
Type: Number.
Description: Volume of the order. Must be nonnegative.

3.9.24 Column: Assign Cost

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost of assigning (fulfilling) this order. (See Assign Cost in Section 2.16.)

3.9.25 Column: Hidden Assign Cost

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost of assigning this order. (See Hidden Assign Cost in Section 2.16.)

3.9.26 Column: Revenue

Required: No.
Type: Number.
Default: `0`.
Description: The revenue earned by fulfilling this order.

3.9.27 Column: Attributes

Required: No.
Type: Text.
Description: One or more attributes for the order, separated by semicolons. Used to express compatibility relationships.

3.9.28 Column: Maximum Duration

Required: No.
Type: Excel time.
Description: The maximum duration permitted between the pickup and the delivery of the order. (See Maximum Duration in Section 2.16.)

3.9.29 Column: Gap

Required: No.
Type: Excel time.
Description: The minimum duration that must elapse before this leg can commence. Must not be provided for simple orders or the first leg of a multi-leg order.

3.9.30 Column: Assignment Type

Required: No.
Type: Text (`BOTH`, `CONDITIONAL`, `ANY`).
Description: Defines how the leg must be assigned. Must not be provided for simple orders or the first leg of a multi-leg order.

3.9.31 Column: Allow Splitting

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then this order may be split across multiple vehicles or loads. (See Order Splitting Strategy in Section 2.9.)

3.10 Sheet: Drivers

Defines the driver resources available in the scenario.

3.10.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: A unique identifier for the driver.

3.10.2 Column: Name

Required: No.
Type: Text or (integer) number.
Description: A descriptive name for the driver.

3.10.3 Column: Cost Per Hour

Required: No.
Type: Number.
Description: The hourly operational cost of the driver.

3.10.4 Column: Cost Per Km

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost per kilometre travelled by the driver.

3.10.5 Column: Cost Per Load

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost incurred per load performed by the driver.

3.10.6 Column: Hidden Cost Per Hour

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost per hour worked by the driver.

3.10.7 Column: Hidden Cost Per Km

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost per kilometre travelled by the driver.

3.10.8 Column: Hidden Cost Per Load

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost incurred per load performed by the driver.

3.10.9 Column: Break Scheme

Required: No.
Type: Text.
Description: Must match an identifier in the Fatigue Management sheets.

3.10.10 Column: Paid Breaks

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then the driver's breaks are paid, so break time counts towards paid time. (See Paid Breaks in Section 2.14.)

3.10.11 Column: Forbid Loaded Breaks

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then the driver may not take breaks while the vehicle is loaded. (See Loaded Breaks in Section 2.14.)

3.10.12 Column: Forbid Breaks In Transit

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then the driver may not take breaks while the vehicle is in transit between locations.

3.10.13 Column: Attributes

Required: No.
Type: Text.
Description: One or more attributes for the driver, separated by semicolons. Used to express driver-vehicle compatibility.

3.10.14 Column: Ignored

Required: No.
Type: Boolean.
Description: If set to `TRUE`, then this driver will be ignored. Errors will still be reported.

3.11 Sheet: Driver Shifts

Assigns shift templates to specific drivers on specific dates.

3.11.1 Column: Driver Id

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Drivers sheet.

3.11.2 Column: Vehicle Id

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Fleet sheet.

3.11.3 Column: Date

Required: Conditional.
Type: Excel date.
Description: The date this shift is active. Required when the shift is referenced by *Shift Id*.

3.11.4 Column: Shift Id

Required: Conditional.
Type: Text or (integer) number.
Description: Must match an identifier from the Shifts sheet. Required when the shift is referenced by *Date*.

3.11.5 Column: Latest Finish

Required: No.
Type: Excel date/time.
Description: A finish time for the shift that is earlier than the shift template's: the shift finishes at the earlier of the two. Only allowed when the shift is referenced by *Date* and *Shift Id*. (See Shift in Section 2.13.)

3.11.6 Column: Start Time

Required: Conditional.
Type: Excel date/time.
Description: The explicit start time of the shift. Required when the shift is not referenced by *Date* and *Shift Id*.

3.11.7 Column: Maximum Start Delay

Required: No.
Type: Excel time.
Description: The maximum duration by which the explicit shift start may be delayed. Only used when the shift is referenced by *Start Time* and *Finish Time*.

3.11.8 Column: Finish Time

Required: Conditional.
Type: Excel date/time.
Description: The explicit finish time of the shift. Required when the shift is not referenced by *Date* and *Shift Id*.

3.11.9 Column: Minimum Paid Time

Required: No.
Type: Excel time.
Description: If given, overrides the Minimum Paid Time of the vehicle shift.

3.11.10 Column: Maximum Drive Time

Required: No.
Type: Excel time.
Description: If given, overrides the Maximum Drive Time of the vehicle shift. Must be nonnegative.

3.11.11 Column: Maximum Work Time

Required: No.
Type: Excel time.
Description: If given, overrides the Maximum Work Time of the vehicle shift. Must be nonnegative.

3.11.12 Column: Ignored

Required: No.
Type: Boolean.
Description: If set to `TRUE`, then this shift will be ignored. Errors will still be reported.

Note: In each row the shift may be referenced either by *Date* together with *Shift Id* (matching a shift template from the Shifts sheet on that date), or by an explicit *Start Time*, *Maximum Start Delay* and *Finish Time*. Exactly one of these two forms must be provided.

3.12 Sheet: Fleet

This sheet defines the physical vehicles available in the scenario.

3.12.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: A unique identifier for the vehicle.

3.12.2 Column: Name

Required: No.
Type: Text or (integer) number.
Description: A descriptive name for the vehicle.

3.12.3 Column: Attributes

Required: No.
Type: Text.
Description: One or more attributes for the vehicle, separated by semicolons. Used to express compatibility relationships.

3.12.4 Column: Compartment Scheme

Required: No.
Type: Text or (integer) number.
Description: The identifier of the compartment scheme used by this vehicle.

3.12.5 Column: Break Scheme

Required: No.
Type: Text or (integer) number.
Description: Must match an identifier in the Fatigue Management sheets. Only used when the scenario is run without drivers; otherwise the driver's break scheme applies. (See Fatigue Management Scheme in Section 2.12.)

3.12.6 Column: Paid Breaks

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then the vehicle's breaks are paid. Only used when the scenario is run without drivers. (See Paid Breaks in Section 2.12.)

3.12.7 Column: Forbid Loaded Breaks

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then breaks may not be taken while the vehicle is loaded. Only used when the scenario is run without drivers. (See Loaded Breaks in Section 2.12.)

3.12.8 Column: Forbid Breaks In Transit

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If `TRUE`, then breaks may not be taken while the vehicle is in transit between locations. Only used when the scenario is run without drivers.

3.12.9 Column: Odometer Reading

Required: No (unless `Maintenance Scheme` is given).
Type: Number (nonnegative integer).
Description: The odometer reading of the vehicle at the start of its first shift, in kilometres. Must be given together with `Maintenance Scheme`.

3.12.10 Column: Maintenance Scheme

Required: No (unless `Odometer Reading` is given).
Type: Text or (integer) number.
Description: The maintenance scheme for the vehicle. Must match a scheme identifier defined in the Maintenance Schemes sheet. Must be given together with `Odometer Reading`.

3.12.11 Column: Forbid Breaks During Maintenance

Required: No.
Type: Boolean.
Default: `FALSE`.
Description: If set to `TRUE`, then breaks will not be taken during the vehicle's maintenance visits.

3.12.12 Column: Load Time

Required: No.
Type: Excel time.
Description: The time taken by this vehicle to load at a location. (See Load Time in Section 2.12.)

3.12.13 Column: Unload Time

Required: No.
Type: Excel time.
Description: The time taken by this vehicle to unload at a location. (See Unload Time in Section 2.12.)

3.12.14 Column: Maximum Weight

Required: Yes.
Type: Number.
Description: Maximum physical weight capacity of the vehicle.

3.12.15 Column: Maximum Volume

Required: Yes.
Type: Number.
Description: Maximum physical volume capacity of the vehicle.

3.12.16 Column: Cost Per Use

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost incurred each time this vehicle is used. (See Cost per Use in Section 2.12.)

3.12.17 Column: Cost Per Hour

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost per hour this vehicle operates. (See Cost per Hour in Section 2.12.)

3.12.18 Column: Cost Per Km

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost per kilometre travelled by this vehicle. (See Cost per Kilometre in Section 2.12.)

3.12.19 Column: Cost Per Load

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost incurred per load performed by this vehicle. (See Cost per Load in Section 2.12.)

3.12.20 Column: Hidden Cost Per Use

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost incurred each time this vehicle is used. (See Hidden Cost per Use in Section 2.12.)

3.12.21 Column: Hidden Cost Per Hour

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost per hour this vehicle operates. (See Hidden Cost per Hour in Section 2.12.)

3.12.22 Column: Hidden Cost Per Km

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost per kilometre travelled by this vehicle. (See Hidden Cost per Kilometre in Section 2.12.)

3.12.23 Column: Hidden Cost Per Load

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost incurred per load performed by this vehicle. (See Hidden Cost per Load in Section 2.12.)

3.12.24 Column: Load Order

Required: No.
Value Type: Text (one of the Load Order codes).
Default: `None`.
Description: The load order strategy to use.

3.12.25 Column: Heavy Order Threshold

Required: No.
Value Type: Number (nonnegative integer).
Description: Any order with weight greater than or equal to this value is considered a *heavy* order for this vehicle if it is using a weight category *load order*. (See Heavy Order Threshold in Section 2.12.)

3.12.26 Column: Maximum Loads

Required: No.
Type: Number (nonnegative integer).
Default: `0` (means no constraint on the maximum number of loads).
Description: The maximum number of loads the vehicle can do. Must be nonnegative. This field is only applicable if batched loads is enabled.

3.12.27 Column: Maximum Drops Per Load

Required: No.
Type: Number (nonnegative integer).
Default: `0` (means no constraint on the maximum number of drops per load).
Description: The maximum number of delivery locations the vehicle can visit on a given load. Must be nonnegative. This field is only applicable if batched loads is enabled.

3.12.28 Column: Finish Segment Distance Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The per-unit distance component of the finish segment penalty for this vehicle. Must be nonnegative.

3.12.29 Column: Finish Segment Per Hour Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The per hour component of the finish segment penalty for this vehicle. Must be nonnegative.

3.12.30 Column: Pickup Segment Fixed Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The fixed component of the pickup segment penalty for this vehicle. Must be nonnegative.

3.12.31 Column: Pickup Segment Distance Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The per-unit distance component of the pickup segment penalty for this vehicle. Must be nonnegative.

3.12.32 Column: Delivery Segment Fixed Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The fixed component of the delivery segment penalty for this vehicle. Must be nonnegative.

3.12.33 Column: Delivery Segment Distance Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The per-unit distance component of the delivery segment penalty for this vehicle. Must be nonnegative.

3.12.34 Column: Loaded Weight Distance Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The weight scaled loaded distance penalty factor for this vehicle. Must be nonnegative.

3.12.35 Column: Loaded Volume Distance Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The volume scaled loaded distance penalty factor for this vehicle. Must be nonnegative.

3.12.36 Column: Empty Distance Penalty

Required: No.
Type: Number.
Default: `0`.
Description: The empty distance penalty factor for this vehicle. Must be nonnegative.

3.12.37 Column: Ignored

Required: No.
Type: Boolean.
Description: If set to `TRUE`, then this vehicle will be ignored. Errors will still be reported.

3.13 Sheet: Vehicle Shifts

Assigns shift templates to specific vehicles on specific dates.

3.13.1 Column: Vehicle Id

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Fleet sheet.

3.13.2 Column: Date

Required: Conditional.
Type: Excel date.
Description: The date this shift is active. Required when the shift is referenced by *Shift Id*.

3.13.3 Column: Shift Id

Required: Conditional.
Type: Text or (integer) number.
Description: Must match an identifier from the Shifts sheet. Required when the shift is referenced by *Date*.

3.13.4 Column: Latest Finish

Required: No.
Type: Excel date/time.
Description: A finish time for the shift that is earlier than the shift template's: the shift finishes at the earlier of the two. Only allowed when the shift is referenced by *Date* and *Shift Id*. (See Shift in Section 2.13.)

3.13.5 Column: Start Time

Required: Conditional.
Type: Excel date/time.
Description: The explicit start time of the shift. Required when the shift is not referenced by *Date* and *Shift Id*.

3.13.6 Column: Maximum Start Delay

Required: No.
Type: Excel time.
Description: The maximum duration by which the explicit shift start may be delayed. Only used when the shift is referenced by *Start Time* and *Finish Time*.

3.13.7 Column: Finish Time

Required: Conditional.
Type: Excel date/time.
Description: The explicit finish time of the shift. Required when the shift is not referenced by *Date* and *Shift Id*.

Note: In each row the shift may be referenced either by *Date* together with *Shift Id* (matching a shift template from the Shifts sheet on that date), or by an explicit *Start Time*, *Maximum Start Delay* and *Finish Time*. Exactly one of these two forms must be provided.

3.13.8 Column: Speed Scale

Required: No.
Type: Number.
Default: `0` (meaning no speed scale).
Description: Nonnegative speed scale multiplier for this vehicle for this shift.

3.13.9 Column: Start Location

Required: No.
Type: Text or (integer) number.
Description: The location where the vehicle begins its shift.

3.13.10 Column: Finish Location

Required: No.
Type: Text or (integer) number.
Description: The location where the vehicle ends its shift.

3.13.11 Column: Minimum Paid Time

Required: No.
Type: Excel time.
Default: `00:00`.
Description: A minimum amount of time that this vehicle's cost per hour will be incurred for this shift. If the actual working time for the vehicle for this shift is less than this, then the hourly cost will be this value multiplied by the cost per hour instead.

3.13.12 Column: Maximum Drive Time

Required: No.
Type: Excel time.
Description: Maximum time a vehicle can drive for this shift. Must be nonnegative.

3.13.13 Column: Maximum Work Time

Required: No.
Type: Excel time.
Description: Maximum time a vehicle can work for a shift. Calculated from the start time to finish time. Must be nonnegative.

3.13.14 Column: Allow Preloading

Required: No.
Type: Boolean.
Description: If set to `TRUE`, then this vehicle can preload orders at its start location for this shift.

3.13.15 Column: Penalty

Required: No.
Type: Number.
Default: None.
Description: The hidden cost incurred when this shift is used. Can be used to give preference to a shift.

3.13.16 Column: Ignored

Required: No.
Type: Boolean.
Description: If set to `TRUE`, then this shift will be ignored. Errors will still be reported.

3.14 Sheet: Time Windows

The **Time Windows** sheet may be used to define groups of time windows that can be associated with pickups, deliveries and locations.

This sheet can be omitted if no named groups of time windows are required.

3.14.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: An identifier giving the named group of time windows that this window is part of.

3.14.2 Column: Day

Required: No.
Type: Text (Day of Week).
Description: The days of the week on which the time window applies. The column may also be headed *Day of Week* or *Days*.

3.14.3 Column: Start

Required: Yes.
Type: Excel time.
Description: Starting time of the window. Must occur before the End time and be nonnegative.
Note: If *Day* is defined then this should **not** contain a date component as this time will apply on each of the days of the week throughout the scenario.

3.14.4 Column: End

Required: Yes.
Type: Excel time.
Description: Finishing time of the window. Must occur after the Start time and be nonnegative.
Note: If *Day* is defined then this should **not** contain a date component as this time will apply on each of the days of the week throughout the scenario.

3.15 Sheet: Compartments

This sheet defines the compartments that make up each compartment scheme. Rows sharing the same *Scheme Id* belong to the same scheme, which may then be referenced by the Compartment Scheme column of the Fleet sheet. (See Vehicle Compartments in Section 2.12.)

This sheet can be omitted if no compartments are required.

3.15.1 Column: Scheme Id

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the compartment scheme this compartment belongs to.

3.15.2 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: An identifier for the compartment, unique within its scheme.

3.15.3 Column: Name

Required: No.
Type: Text or (integer) number.
Description: A descriptive name for the compartment.

3.15.4 Column: Maximum Weight

Required: Yes.
Type: Number.
Description: The weight capacity of the compartment.

3.15.5 Column: Maximum Volume

Required: Yes.
Type: Number.
Description: The volume capacity of the compartment.

3.15.6 Column: Attributes

Required: No.
Type: Text.
Description: One or more attributes for the compartment, separated by semicolons. Used to express order-compartment compatibility.

3.16 Sheet: Simple Fatigue Management

This sheet defines simple fatigue management schemes. Each row defines one scheme consisting of a single break that must be taken within a window measured from the start of the shift. A scheme may be referenced by the *Break Scheme* column of the Drivers sheet (or the Fleet sheet when running without drivers).

This sheet can be omitted.

3.16.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: A unique identifier for the scheme.

3.16.2 Column: Duration

Required: Yes.
Type: Excel time.
Description: The duration of the break.

3.16.3 Column: Earliest

Required: Yes.
Type: Excel time.
Description: The earliest duration, measured from the start of the shift, at which the break may commence.

3.16.4 Column: Preferred

Required: Yes.
Type: Excel time.
Description: The preferred duration, measured from the start of the shift, at which the break commences.

3.16.5 Column: Latest

Required: Yes.
Type: Excel time.
Description: The latest duration, measured from the start of the shift, at which the break may commence.

3.17 Sheet: Standard Fatigue Management

This sheet defines standard fatigue management schemes. Each row defines one scheme requiring a number of breaks to be taken within an interval measured from the start of the shift. A scheme may be referenced by the *Break Scheme* column of the Drivers sheet (or the Fleet sheet when running without drivers).

This sheet can be omitted.

3.17.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: A unique identifier for the scheme.

3.17.2 Column: Number of Breaks

Required: Yes.
Type: Number (nonnegative integer).
Description: The number of breaks that must occur within the interval.

3.17.3 Column: Duration

Required: Yes.
Type: Excel time.
Description: The duration of each break.

3.17.4 Column: Interval

Required: Yes.
Type: Excel time.
Description: The duration, measured from the start of the shift, within which the breaks must occur.

3.18 Sheet: Maintenance Schemes

This sheet may be omitted if no vehicles are subject to maintenance. Each row defines one maintenance event. All rows with the same `Id` form one maintenance scheme, with its events in row order. A row with an `Interval` defines a periodic event, whose `Minimum Distance` and `Maximum Distance` are offsets from each due point; any other row defines a fixed event, whose distances are odometer readings. (See Section 2.18 for further information.)

3.18.1 Column: Id

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the maintenance scheme to which the event belongs.

3.18.2 Column: Event

Required: No (unless another event supersedes this one).
Type: Text or (integer) number.
Description: An identifier for the event, unique within its scheme.

3.18.3 Column: Interval

Required: No.
Type: Number (positive integer).
Description: If given, the event is periodic, falling due every `Interval` kilometres. `Maximum Distance` − `Minimum Distance` must not exceed it.

3.18.4 Column: Minimum Distance

Required: Yes.
Type: Number (integer).
Description: For a fixed event, the odometer reading from which the event may be performed; for a periodic event, the offset from each due point from which an occurrence may be performed. In kilometres. Must not exceed `Maximum Distance`. Must be nonnegative for a fixed event; may be negative for a periodic event.

3.18.5 Column: Maximum Distance

Required: Yes.
Type: Number (integer).
Description: For a fixed event, the odometer reading by which the event must be performed; for a periodic event, the offset from each due point by which an occurrence must be performed. In kilometres. Must be nonnegative for a fixed event; may be negative for a periodic event.
Note: The distance ranges of the fixed events in a scheme must not overlap.

3.18.6 Column: Fixed Penalty

Required: No.
Type: Number.
Description: The penalty incurred once if the event overruns its maximum distance. Must be nonnegative. If neither this nor `Distance Penalty` is given, then the event is hard; otherwise it is soft, even if both are `0`.

3.18.7 Column: Distance Penalty

Required: No.
Type: Number.
Description: The penalty per kilometre by which the event overruns its maximum distance. Must be nonnegative. If neither this nor `Fixed Penalty` is given, then the event is hard; otherwise it is soft, even if both are `0`.

3.18.8 Column: Duration

Required: Yes.
Type: Excel time.
Description: The time the event takes at the maintenance location. Must be positive.

3.18.9 Column: Attributes

Required: No.
Type: Text or (integer) number.
Description: The attributes of the event, which determine the locations at which it can be performed through the Maintenance Compatibility sheet. Multiple attributes are separated by semicolons. (Multiple attributes can only be specified in a text cell.)

3.18.10 Column: Supersedes

Required: No.
Type: Text or (integer) number.
Description: For a periodic event only (a row with an `Interval`): the `Event` identifiers of the periodic events of the same scheme that this event supersedes, separated by semicolons.

Id	Event	Interval	Minimum Distance	Maximum Distance	Fixed Penalty	Distance Penalty	Duration	Attributes	Supersedes
TRUCK	MINOR	10000	-500	500			2:00	WORKSHOP	
TRUCK	MAJOR	30000	-500	500	1000	5	8:00	WORKSHOP	MINOR
TRUCK			45000	50000			1:00	TYRES	

Table 13: Maintenance Schemes Example

3.19 Sheet: Locked Orders

This sheet locks orders to a specific vehicle and shift, forcing the optimiser to assign them exactly as specified.

In each row the shift may be referenced either by *Date* together with *Shift Id*, or by an explicit *Start Time* and *Finish Time*. Exactly one of these two forms must be provided.

This sheet can be omitted if no orders are locked.

3.19.1 Column: Order Id

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the order to lock. Must match an identifier from the Orders sheet.

3.19.2 Column: Leg Id

Required: No.
Type: Text or (integer) number.
Description: For a multi-leg order, the identifier of the leg to lock.

3.19.3 Column: Vehicle Id

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the vehicle the order is locked to. Must match an identifier from the Fleet sheet.

3.19.4 Column: Date

Required: Conditional.
Type: Excel date.
Description: The date of the shift the order is locked to. Required when the shift is referenced by *Shift Id*.

3.19.5 Column: Shift Id

Required: Conditional.
Type: Text or (integer) number.
Description: The identifier of the shift the order is locked to. Required when the shift is referenced by *Date*.

3.19.6 Column: Start Time

Required: Conditional.
Type: Excel date/time.
Description: The explicit start time of the shift the order is locked to. Required when the shift is not referenced by *Date* and *Shift Id*.

3.19.7 Column: Finish Time

Required: Conditional.
Type: Excel date/time.
Description: The explicit finish time of the shift the order is locked to. Required when the shift is not referenced by *Date* and *Shift Id*.

3.20 Sheet: Order Precedences

This sheet defines precedence relationships between orders. A precedence requires the *before* order to be delivered before the *after* order is picked up.

This sheet can be omitted.

3.20.1 Column: Before

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the order that must come first.

3.20.2 Column: Before Leg

Required: No.
Type: Text or (integer) number.
Description: For a multi-leg before order, the identifier of the relevant leg.

3.20.3 Column: After

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the order that must come second.

3.20.4 Column: After Leg

Required: No.
Type: Text or (integer) number.
Description: For a multi-leg after order, the identifier of the relevant leg.

3.20.5 Column: Gap

Required: No.
Type: Excel time.
Default: `0`.
Description: The minimum duration that must elapse between the departure from the before order's delivery and the arrival at the after order's pickup.

3.20.6 Column: Assignment Type

Required: No.
Type: Text (`BOTH`, `CONDITIONAL`, `ANY`).
Description: How the two orders must be assigned relative to one another. `BOTH` requires both to be assigned or both unassigned; `CONDITIONAL` allows the before order without the after order but not the reverse; `ANY` imposes no assignment restriction.

3.21 Sheet: Batch Order Precedences

This sheet defines precedence relationships that apply at the load (batch) level rather than between individual orders. A batch precedence requires the load containing the *before* order to be completed before the load containing the *after* order commences.

This sheet can be omitted and is only applicable when batched loads is enabled.

3.21.1 Column: Before

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the order whose load must come first.

3.21.2 Column: Before Leg

Required: No.
Type: Text or (integer) number.
Description: For a multi-leg before order, the identifier of the relevant leg.

3.21.3 Column: After

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the order whose load must come second.

3.21.4 Column: After Leg

Required: No.
Type: Text or (integer) number.
Description: For a multi-leg after order, the identifier of the relevant leg.

3.22 Sheet: Grouped Pickups

This sheet groups orders that must be picked up together. All orders (or order legs) sharing the same *Group Id* must be picked up by the same vehicle, at the same location, in the same visit.

This sheet can be omitted.

3.22.1 Column: Group Id

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of the pickup group.

3.22.2 Column: Order Id

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of an order belonging to the group. Must match an identifier from the Orders sheet.

3.22.3 Column: Leg Id

Required: No.
Type: Text or (integer) number.
Description: For a multi-leg order, the identifier of the leg belonging to the group.

3.23 Sheet: Order Vehicle Preferences

This sheet defines hidden rewards that make the optimiser prefer to assign particular orders to particular vehicles. Each reward is applied as a hidden benefit (a negative hidden cost) when the order or leg is assigned to the specified vehicle.

This sheet can be omitted.

3.23.1 Column: Order Id

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Orders sheet.

3.23.2 Column: Leg Id

Required: No.
Type: Text or (integer) number.
Description: For a multi-leg order, the identifier of the relevant leg.

3.23.3 Column: Vehicle Id

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Fleet sheet.

3.23.4 Column: Fixed Reward

Required: No.
Type: Number (integer).
Default: `0`.
Description: A fixed hidden reward applied when the order is assigned to the vehicle.

3.23.5 Column: Weight Reward

Required: No.
Type: Number (integer).
Default: `0`.
Description: A hidden reward scaled by the order's weight.

3.23.6 Column: Volume Reward

Required: No.
Type: Number (integer).
Default: `0`.
Description: A hidden reward scaled by the order's volume.

3.24 Sheet: Order Vehicle Costs

This sheet defines vehicle-specific costs for assigning particular orders to particular vehicles. (See Vehicle Costs in Section 2.16.)

This sheet can be omitted.

3.24.1 Column: Order Id

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Orders sheet.

3.24.2 Column: Leg Id

Required: No.
Type: Text or (integer) number.
Description: For a multi-leg order, the identifier of the relevant leg.

3.24.3 Column: Vehicle Id

Required: Yes.
Type: Text or (integer) number.
Description: Must match an identifier from the Fleet sheet.

3.24.4 Column: Cost

Required: No.
Type: Number.
Default: `0`.
Description: The actual (monetary) cost of assigning the order to this vehicle. (See Vehicle-Specific Assign Cost.)

3.24.5 Column: Hidden Cost

Required: No.
Type: Number.
Default: `0`.
Description: The hidden cost of assigning the order to this vehicle. (See Vehicle-Specific Hidden Assign Cost.)

3.25 Sheet: Order Vehicle Compatibility

This sheet defines order-vehicle compatibility as a matrix. The first column lists order attributes and the first row lists vehicle attributes. A cell containing `TRUE` means the corresponding attribute pair is compatible; an empty cell means it is not.

See Section 2.23 for the full interpretation of compatibility matrices, including the Null, Disjunction and Conjunction rules. The same matrix format applies to all of the compatibility sheets below.

This sheet can be omitted if no order-vehicle compatibility restrictions are required.

3.26 Sheet: Order Compartment Compatibility

This sheet defines order-compartment compatibility as a matrix, with order attributes down the first column and compartment attributes across the first row. An order may only be loaded into a compartment with which it is compatible. The matrix is interpreted as described in Section 2.23.

This sheet can be omitted.

3.27 Sheet: Order Order Compatibility

This sheet defines order-order compatibility as a matrix of order attributes against order attributes. Two orders may only be loaded into the same compartment simultaneously if they are compatible. As described in Section 2.23, the compatibility rules for this relationship are applied in both directions.

This sheet can be omitted.

3.28 Sheet: Load Order Order Compatibility

This sheet defines load order-order compatibility as a matrix of order attributes against order attributes. Two orders may only be loaded onto the same vehicle simultaneously if they are compatible. As with order-order compatibility, the rules are applied in both directions (see Section 2.23).

This sheet can be omitted.

3.29 Sheet: Location Vehicle Compatibility

This sheet defines location-vehicle compatibility as a matrix, with location attributes down the first column and vehicle attributes across the first row. A vehicle may only pick up or deliver at locations with which it is compatible. The matrix is interpreted as described in Section 2.23.

This sheet can be omitted.

3.30 Sheet: Driver Vehicle Compatibility

This sheet defines driver-vehicle compatibility as a matrix, with driver attributes down the first column and vehicle attributes across the first row. A driver may only be assigned to vehicles with which they are compatible. The matrix is interpreted as described in Section 2.23.

This sheet can be omitted.

3.31 Sheet: Maintenance Compatibility

This sheet defines maintenance-location compatibility as a matrix, with the attributes of maintenance events down the first column and location attributes across the first row. A maintenance event may only be performed at locations with which it is compatible. The matrix is interpreted as described in Section 2.23. (See Section 2.18.7 for further information.)

This sheet may be omitted if maintenance events may be performed at any location.

3.32 Sheet: Distance Matrix

This sheet optionally provides the travel distances between all pairs of locations in the scenario, overriding the distances the optimiser would otherwise compute. The sheet is a square matrix: the first column and first row both list the location identifiers (in the same order as the Locations sheet), and the cell at the intersection of a row and column gives the travel distance, in kilometres, from the row location to the column location.

This sheet can be omitted, in which case distances are computed from the location coordinates.

3.33 Sheet: Time Matrix

This sheet optionally provides the travel times between all pairs of locations in the scenario, overriding the times the optimiser would otherwise compute. The sheet is a square matrix: the first column and first row both list the location identifiers (in the same order as the Locations sheet), and the cell at the intersection of a row and column gives the travel time, in minutes, from the row location to the column location.

This sheet can be omitted, in which case travel times are computed by the optimiser.

3.34 Sheet: Matrix Override

The **Matrix Override** sheet may be used to override the routing times and distances between pairs of locations in the Locations sheet.

Times in route matrix overrides are affected by speed scaling and rush hour constraints as normal.

This sheet is optional. If omitted, then the optimiser will either use the provided matrices or compute them.

3.34.1 Column: Location 1

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of location from the Location sheet.

3.34.2 Column: Location 2

Required: Yes.
Type: Text or (integer) number.
Description: The identifier of location from the Locations sheet.

3.34.3 Column: Time Forwards

Required: No.
Type: Number (positive).
Description: The transit time, in minutes, when travelling from "Location 1" to "Location 2".

3.34.4 Column: Time Backwards

Required: No.
Type: Number (positive).
Description: The transit time, in minutes, when travelling from "Location 2" to "Location 1".

3.34.5 Column: Distance Forwards

Required: No.
Type: Number (positive).
Description: The transit distance, in kilometres, when travelling from "Location 1" to "Location 2".

3.34.6 Column: Distance Backwards

Required: No.
Type: Number (positive).
Description: The transit distance, in kilometres, when travelling from "Location 2" to "Location 1".

Location 1	Location 2	Time Forwards	Time Backwards	Distance Forwards	Distance Backwards
DEPOT	Hallam	0	0	0	0
DEPOT	Skye	0	0	0	0
DEPOT	Rowville	0	0	0	0

Table 14: Matrix Override Example

4 Microsoft Excel Output

This section describes the Microsoft Excel output format for version 2 of Opturion DTO. The Excel output will contain references (e.g. location identifiers, order identifiers) to the scenario from which it was generated. The optimiser generates output workbooks in Office Open XML format (`.xlsx`).

4.1 Sheet: Runsheet

This sheet provides a detailed, stop-by-stop itinerary for every vehicle shift in the solution.

4.1.1 Column: Vehicle

Type: Text.
Description: The identifier of the vehicle, as given in the Fleet sheet.

4.1.2 Column: Date

Type: Excel date.
Description: The date on which the shift starts.

4.1.3 Column: Driver

Type: Text.
Description: The identifier of the driver assigned to the shift.

4.1.4 Column: Shift

Type: Text.
Description: The identifier of the assigned shift.

4.1.5 Column: Load

Type: Text.
Description: The identifier of the load associated with this stop, if any.

4.1.6 Column: Stop Number

Type: Number.
Description: Numerical identification of a stop generated by the optimiser. Stops are numbered from `0` in increasing order within a shift.

4.1.7 Column: Time Zone

Type: Text.
Description: The time zone of the stop location.

4.1.8 Column: ETA Offset

Type: Number.
Description: The number of whole days to add to the shift's start date to obtain the calendar date of the ETA. This is non-zero when the arrival falls on a later day than the shift start.

4.1.9 Column: ETA

Type: Excel time.
Description: The estimated time of arrival at the stop, shown as a time of day in the stop's time zone.

4.1.10 Column: ETD Offset

Type: Number.
Description: The number of whole days to add to the shift's start date to obtain the calendar date of the ETD.

4.1.11 Column: ETD

Type: Excel time.
Description: The estimated time of departure from the stop, shown as a time of day in the stop's time zone.

4.1.12 Column: Stop

Type: Text.
Description: The identifier of the stop location, as defined in the Locations sheet.

4.1.13 Column: Order

Type: Text.
Description: The identifier of the order.

4.1.14 Column: Leg

Type: Text.
Description: For a multi-leg order, the identifier of the relevant leg.

4.1.15 Column: Customer Name

Type: Text.
Description: The customer associated with the order, if the stop is a pickup or delivery.

4.1.16 Column: Compartment

Type: Text.
Description: The identifier of the compartment the order is loaded into, if the vehicle uses a compartment scheme.

4.1.17 Column: Address

Type: Text.
Description: The address of the stop location.

4.1.18 Column: Volume

Type: Number.
Description: The total volume loaded on the vehicle on departure from this stop.

4.1.19 Column: Delta Volume

Type: Number.
Description: The change in loaded volume at this stop (positive for a pickup, negative for a delivery).

4.1.20 Column: Weight

Type: Number.
Description: The total weight loaded on the vehicle on departure from this stop.

4.1.21 Column: Delta Weight

Type: Number.
Description: The change in loaded weight at this stop (positive for a pickup, negative for a delivery).

4.1.22 Column: Site Time

Type: Excel time.
Description: The site time incurred at the stop.

4.1.23 Column: Load Time

Type: Excel time.
Description: The load time incurred at the stop.

4.1.24 Column: Unload Time

Type: Excel time.
Description: The unload time incurred at the stop.

4.1.25 Column: Service Time

Type: Excel time.
Description: The service time incurred at the stop.

4.1.26 Column: Transit Time

Type: Excel time.
Description: The transit time from the previous location.

4.1.27 Column: Transit Distance

Type: Number.
Description: The transit distance from the previous location.

4.1.28 Column: Order Attributes

Type: Text.
Description: The attributes of the order, separated by semicolons.

4.1.29 Column: Vehicle Attributes

Type: Text.
Description: The attributes of the vehicle, separated by semicolons.

4.1.30 Column: Time Window Start

Type: Excel time.
Description: The start of the hard time window applied to this stop.

4.1.31 Column: Time Window End

Type: Excel time.
Description: The end of the hard time window applied to this stop.

4.1.32 Column: Soft Time Window Start

Type: Excel time.
Description: The start of the soft time window applied to this stop.

4.1.33 Column: Soft Time Window End

Type: Excel time.
Description: The end of the soft time window applied to this stop.

4.1.34 Column: Soft Time Window Delta

Type: Excel time.
Description: The duration between the arrival time and the closest boundary of the soft time window.

4.2 Sheet: Vehicle Summary

This sheet summarises the activity of each vehicle across all of its shifts in the solution.

4.2.1 Column: Vehicle

Type: Text.
Description: The identifier of the vehicle, as given in the Fleet sheet.

4.2.2 Column: Used

Type: Boolean.
Description: `TRUE` if this vehicle was used in the solution, otherwise `FALSE`.

4.2.3 Column: Cost

Type: Number.
Description: The total actual (monetary) cost attributed to this vehicle.

4.2.4 Column: Revenue

Type: Number.
Description: The total revenue attributed to this vehicle.

4.2.5 Column: Profit

Type: Number.
Description: The profit (revenue minus cost) attributed to this vehicle.

4.2.6 Column: Peak Volume

Type: Number.
Description: The peak volume carried by this vehicle at any point during the shift.

4.2.7 Column: Total Volume

Type: Number.
Description: The total volume carried by this vehicle.

4.2.8 Column: Volume Capacity

Type: Number.
Description: The volume capacity of this vehicle.

4.2.9 Column: Peak Weight

Type: Number.
Description: The peak weight carried by this vehicle at any point during the shift.

4.2.10 Column: Total Weight

Type: Number.
Description: The total weight carried by this vehicle.

4.2.11 Column: Weight Capacity

Type: Number.
Description: The weight capacity of this vehicle.

4.2.12 Column: Transit Distance

Type: Number.
Description: The total transit (driving) distance for this vehicle.

4.2.13 Column: Average Speed

Type: Number.
Description: The average travel speed for this vehicle.

4.2.14 Column: Loaded Distance

Type: Number.
Description: The distance travelled by this vehicle while carrying at least one order.

4.2.15 Column: Empty Distance

Type: Number.
Description: The distance travelled by this vehicle while carrying no orders.

4.2.16 Column: Distance to Finish

Type: Number.
Description: The distance from the last delivery to the finish location for this vehicle.

4.2.17 Column: Time to Finish

Type: Excel time.
Description: The travel time from the last delivery to the finish location for this vehicle.

4.2.18 Column: Work Time

Type: Excel time.
Description: The total work time for this vehicle.

4.2.19 Column: Allowed Work Time

Type: Excel time.
Description: The maximum work time permitted for this vehicle.

4.2.20 Column: Transit Time

Type: Excel time.
Description: The total transit (driving) time for this vehicle.

4.2.21 Column: Allowed Transit Time

Type: Excel time.
Description: The maximum transit (driving) time permitted for this vehicle.

4.2.22 Column: Site Time

Type: Excel time.
Description: The total site time for this vehicle.

4.2.23 Column: Load Time

Type: Excel time.
Description: The total loading time for this vehicle.

4.2.24 Column: Unload Time

Type: Excel time.
Description: The total unloading time for this vehicle.

4.2.25 Column: Service Time

Type: Excel time.
Description: The total service time for this vehicle.

4.2.26 Column: Idle Time

Type: Excel time.
Description: The total idle (waiting) time for this vehicle.

4.2.27 Column: Break Time

Type: Excel time.
Description: The total break time for this vehicle.

4.2.28 Column: Maintenance Time

Type: Excel time.
Description: The total time spent on maintenance visits by the vehicle. Empty for a vehicle that is not subject to maintenance.

4.2.29 Column: Maintenance Detour Distance

Type: Number.
Description: The distance added by travelling to maintenance visits by the vehicle. Empty for a vehicle that is not subject to maintenance.

4.2.30 Column: Maintenance Detour Time

Type: Excel time.
Description: The transit time added by travelling to maintenance visits by the vehicle. Empty for a vehicle that is not subject to maintenance.

4.2.31 Column: Number of Drops

Type: Number.
Description: The number of delivery drops made by this vehicle.

4.2.32 Column: Number of Orders

Type: Number.
Description: The number of orders handled by this vehicle.

4.2.33 Column: Number of Loads

Type: Number.
Description: The number of loads carried by this vehicle.

4.3 Sheet: Vehicle Shift Summary

This sheet summarises the activity of each individual vehicle shift in the solution.

4.3.1 Column: Vehicle

Type: Text.
Description: The identifier of the vehicle, as given in the Fleet sheet.

4.3.2 Column: Date

Type: Excel date.
Description: The date on which the shift is active.

4.3.3 Column: Shift

Type: Text.
Description: The identifier of the assigned shift.

4.3.4 Column: Driver

Type: Text.
Description: The identifier of the driver assigned to the shift.

4.3.5 Column: Used

Type: Boolean.
Description: `TRUE` if this vehicle shift was used in the solution, otherwise `FALSE`.

4.3.6 Column: Cost

Type: Number.
Description: The total actual (monetary) cost attributed to this vehicle shift.

4.3.7 Column: Revenue

Type: Number.
Description: The total revenue attributed to this vehicle shift.

4.3.8 Column: Profit

Type: Number.
Description: The profit (revenue minus cost) attributed to this vehicle shift.

4.3.9 Column: Peak Volume

Type: Number.
Description: The peak volume carried by this vehicle shift at any point during the shift.

4.3.10 Column: Total Volume

Type: Number.
Description: The total volume carried by this vehicle shift.

4.3.11 Column: Volume Capacity

Type: Number.
Description: The volume capacity of this vehicle shift.

4.3.12 Column: Peak Weight

Type: Number.
Description: The peak weight carried by this vehicle shift at any point during the shift.

4.3.13 Column: Total Weight

Type: Number.
Description: The total weight carried by this vehicle shift.

4.3.14 Column: Weight Capacity

Type: Number.
Description: The weight capacity of this vehicle shift.

4.3.15 Column: Transit Distance

Type: Number.
Description: The total transit (driving) distance for this vehicle shift.

4.3.16 Column: Average Speed

Type: Number.
Description: The average travel speed for this vehicle shift.

4.3.17 Column: Loaded Distance

Type: Number.
Description: The distance travelled by this vehicle shift while carrying at least one order.

4.3.18 Column: Empty Distance

Type: Number.
Description: The distance travelled by this vehicle shift while carrying no orders.

4.3.19 Column: Distance to Finish

Type: Number.
Description: The distance from the last delivery to the finish location for this vehicle shift.

4.3.20 Column: Time to Finish

Type: Excel time.
Description: The travel time from the last delivery to the finish location for this vehicle shift.

4.3.21 Column: Start Time Zone

Type: Text.
Description: The time zone in which this vehicle shift starts.

4.3.22 Column: Actual Start Time

Type: Excel time.
Description: The actual start time chosen for this vehicle shift.

4.3.23 Column: Finish Time Zone

Type: Text.
Description: The time zone in which this vehicle shift finishes.

4.3.24 Column: Actual Finish Time

Type: Excel time.
Description: The actual finish time chosen for this vehicle shift.

4.3.25 Column: Work Time

Type: Excel time.
Description: The total work time for this vehicle shift.

4.3.26 Column: Allowed Work Time

Type: Excel time.
Description: The maximum work time permitted for this vehicle shift.

4.3.27 Column: Transit Time

Type: Excel time.
Description: The total transit (driving) time for this vehicle shift.

4.3.28 Column: Allowed Transit Time

Type: Excel time.
Description: The maximum transit (driving) time permitted for this vehicle shift.

4.3.29 Column: Site Time

Type: Excel time.
Description: The total site time for this vehicle shift.

4.3.30 Column: Load Time

Type: Excel time.
Description: The total loading time for this vehicle shift.

4.3.31 Column: Unload Time

Type: Excel time.
Description: The total unloading time for this vehicle shift.

4.3.32 Column: Service Time

Type: Excel time.
Description: The total service time for this vehicle shift.

4.3.33 Column: Idle Time

Type: Excel time.
Description: The total idle (waiting) time for this vehicle shift.

4.3.34 Column: Break Time

Type: Excel time.
Description: The total break time for this vehicle shift.

4.3.35 Column: Maintenance Time

Type: Excel time.
Description: The total time spent on maintenance visits during the vehicle shift. Empty for a vehicle that is not subject to maintenance.

4.3.36 Column: Maintenance Detour Distance

Type: Number.
Description: The distance added by travelling to maintenance visits during the vehicle shift. Empty for a vehicle that is not subject to maintenance.

4.3.37 Column: Maintenance Detour Time

Type: Excel time.
Description: The transit time added by travelling to maintenance visits during the vehicle shift. Empty for a vehicle that is not subject to maintenance.

4.3.38 Column: Number of Drops

Type: Number.
Description: The number of delivery drops made by this vehicle shift.

4.3.39 Column: Number of Orders

Type: Number.
Description: The number of orders handled by this vehicle shift.

4.3.40 Column: Number of Loads

Type: Number.
Description: The number of loads carried by this vehicle shift.

4.3.41 Column: Pickup Soft Time Window Early

Type: Excel time.
Description: The total time by which pickups for this vehicle shift occurred before their soft time windows.

4.3.42 Column: Pickup Soft Time Window Late

Type: Excel time.
Description: The total time by which pickups for this vehicle shift occurred after their soft time windows.

4.3.43 Column: Delivery Soft Time Window Early

Type: Excel time.
Description: The total time by which deliveries for this vehicle shift occurred before their soft time windows.

4.3.44 Column: Delivery Soft Time Window Late

Type: Excel time.
Description: The total time by which deliveries for this vehicle shift occurred after their soft time windows.

4.4 Sheet: Load Summary

This sheet summarises each batched load in the solution.

4.4.1 Column: Date

Type: Excel date.
Description: The date on which the shift is active.

4.4.2 Column: Shift

Type: Text.
Description: The identifier of the assigned shift.

4.4.3 Column: Driver

Type: Text.
Description: The identifier of the driver assigned to the shift.

4.4.4 Column: Vehicle

Type: Text.
Description: The identifier of the vehicle, as given in the Fleet sheet.

4.4.5 Column: Load Number

Type: Number.
Description: The sequential number of the load within the shift, starting from `0`.

4.4.6 Column: Cost

Type: Number.
Description: The total actual (monetary) cost attributed to this load.

4.4.7 Column: Revenue

Type: Number.
Description: The total revenue attributed to this load.

4.4.8 Column: Profit

Type: Number.
Description: The profit (revenue minus cost) attributed to this load.

4.4.9 Column: Volume

Type: Number.
Description: The total volume carried by the load.

4.4.10 Column: Volume Capacity

Type: Number.
Description: The volume capacity of this load.

4.4.11 Column: Weight

Type: Number.
Description: The total weight carried by the load.

4.4.12 Column: Weight Capacity

Type: Number.
Description: The weight capacity of this load.

4.4.13 Column: Average Speed

Type: Number.
Description: The average travel speed for this load.

4.4.14 Column: Loaded Distance

Type: Number.
Description: The distance travelled by this load while carrying at least one order.

4.4.15 Column: Empty Distance Before

Type: Number.
Description: The distance travelled empty before the first pickup of the load.

4.4.16 Column: Empty Distance After

Type: Number.
Description: The distance travelled empty after the last delivery of the load.

4.4.17 Column: Work Time

Type: Excel time.
Description: The total work time for this load.

4.4.18 Column: Transit Time

Type: Excel time.
Description: The total transit (driving) time for this load.

4.4.19 Column: Site Time

Type: Excel time.
Description: The total site time for this load.

4.4.20 Column: Load Time

Type: Excel time.
Description: The total loading time for this load.

4.4.21 Column: Unload Time

Type: Excel time.
Description: The total unloading time for this load.

4.4.22 Column: Service Time

Type: Excel time.
Description: The total service time for this load.

4.4.23 Column: Idle Time

Type: Excel time.
Description: The total idle (waiting) time for this load.

4.4.24 Column: Break Time

Type: Excel time.
Description: The total break time for this load.

4.4.25 Column: Maintenance Time

Type: Excel time.
Description: The total time spent on maintenance visits during the load. Empty for a vehicle that is not subject to maintenance.

4.4.26 Column: Maintenance Detour Distance

Type: Number.
Description: The distance added by travelling to maintenance visits during the load. Empty for a vehicle that is not subject to maintenance.

4.4.27 Column: Maintenance Detour Time

Type: Excel time.
Description: The transit time added by travelling to maintenance visits during the load. Empty for a vehicle that is not subject to maintenance.

4.4.28 Column: Number of Drops

Type: Number.
Description: The number of delivery drops made by this load.

4.4.29 Column: Number of Orders

Type: Number.
Description: The number of orders handled by this load.

4.4.30 Column: Pickup Soft Time Window Early

Type: Excel time.
Description: The total time by which pickups for this load occurred before their soft time windows.

4.4.31 Column: Pickup Soft Time Window Late

Type: Excel time.
Description: The total time by which pickups for this load occurred after their soft time windows.

4.4.32 Column: Delivery Soft Time Window Early

Type: Excel time.
Description: The total time by which deliveries for this load occurred before their soft time windows.

4.4.33 Column: Delivery Soft Time Window Late

Type: Excel time.
Description: The total time by which deliveries for this load occurred after their soft time windows.

4.5 Sheet: Maintenance Summary

This sheet is the maintenance summary of each vehicle shift whose vehicle is subject to maintenance. Each row describes one fixed maintenance event, or one occurrence of a periodic event, of the vehicle that is performed on the shift or that the shift requires (other than superseded occurrences). Distances are in kilometres. It is only present if some vehicle is subject to maintenance.

4.5.1 Column: Vehicle

Type: Text.
Description: The identifier of the vehicle.

4.5.2 Column: Date

Type: Excel date.
Description: The date on which the shift starts.

4.5.3 Column: Shift

Type: Text.
Description: The identifier of the shift.

4.5.4 Column: Driver

Type: Text.
Description: The identifier of the driver assigned to the shift. Empty if none.

4.5.5 Column: Event

Type: Text or number.
Description: The event's identifier, or, if it has none, its position (from `1`) in the vehicle's maintenance scheme: its row among the scheme's rows on the Maintenance Schemes sheet.

4.5.6 Column: Occurrence

Type: Number.
Description: For a periodic event, k for its k-th occurrence (due at k times its interval). Empty for a fixed event.

4.5.7 Column: Minimum Distance

Type: Number.
Description: The odometer reading from which the event (occurrence) may be performed.

4.5.8 Column: Maximum Distance

Type: Number.
Description: The odometer reading by which the event (occurrence) must be performed.

4.5.9 Column: Duration

Type: Excel time.
Description: The time the event takes at the maintenance location.

4.5.10 Column: Overrun

Type: Number.
Description: The distance by which the event overruns its maximum distance: up to the stop at which it is performed, or to the end of the shift if it is not performed on the shift. `0` if it does not overrun.

4.5.11 Column: Distance

Type: Number.
Description: The odometer reading on arrival at the stop at which the event is performed. Empty if the event is not performed on the shift.

4.5.12 Column: Location

Type: Text.
Description: The identifier of the location of the stop at which the event is performed. Empty if the event is not performed on the shift.

4.5.13 Column: Stop

Type: Number.
Description: The stop number (see the Runsheet sheet) of the stop at which the event is performed. Empty if the event is not performed on the shift.

4.5.14 Column: Time Zone

Type: Text.
Description: The time zone of that stop's location. Empty if the event is not performed on the shift.

4.5.15 Column: Arrival Time

Type: Excel date/time.
Description: The start of the event at that stop. Empty if the event is not performed on the shift.

4.5.16 Column: Departure Time

Type: Excel date/time.
Description: The end of the event at that stop. Empty if the event is not performed on the shift.

4.6 Sheet: Driver Summary

This sheet summarises the activity of each driver across all of their shifts in the solution.

4.6.1 Column: Driver

Type: Text.
Description: The identifier of the driver assigned to the shift.

4.6.2 Column: Revenue

Type: Number.
Description: The total revenue attributed to this driver.

4.6.3 Column: Total Volume

Type: Number.
Description: The total volume carried by this driver.

4.6.4 Column: Total Weight

Type: Number.
Description: The total weight carried by this driver.

4.6.5 Column: Transit Distance

Type: Number.
Description: The total transit (driving) distance for this driver.

4.6.6 Column: Average Speed

Type: Number.
Description: The average travel speed for this driver.

4.6.7 Column: Loaded Distance

Type: Number.
Description: The distance travelled by this driver while carrying at least one order.

4.6.8 Column: Empty Distance

Type: Number.
Description: The distance travelled by this driver while carrying no orders.

4.6.9 Column: Distance to Finish

Type: Number.
Description: The distance from the last delivery to the finish location for this driver.

4.6.10 Column: Time to Finish

Type: Excel time.
Description: The travel time from the last delivery to the finish location for this driver.

4.6.11 Column: Work Time

Type: Excel time.
Description: The total work time for this driver.

4.6.12 Column: Transit Time

Type: Excel time.
Description: The total transit (driving) time for this driver.

4.6.13 Column: Site Time

Type: Excel time.
Description: The total site time for this driver.

4.6.14 Column: Load Time

Type: Excel time.
Description: The total loading time for this driver.

4.6.15 Column: Unload Time

Type: Excel time.
Description: The total unloading time for this driver.

4.6.16 Column: Service Time

Type: Excel time.
Description: The total service time for this driver.

4.6.17 Column: Idle Time

Type: Excel time.
Description: The total idle (waiting) time for this driver.

4.6.18 Column: Break Time

Type: Excel time.
Description: The total break time for this driver.

4.6.19 Column: Maintenance Time

Type: Excel time.
Description: The total time spent on maintenance visits by the driver.

4.6.20 Column: Maintenance Detour Distance

Type: Number.
Description: The distance added by travelling to maintenance visits by the driver.

4.6.21 Column: Maintenance Detour Time

Type: Excel time.
Description: The transit time added by travelling to maintenance visits by the driver.

4.6.22 Column: Number of Deliveries

Type: Number.
Description: The number of deliveries made by this driver.

4.6.23 Column: Number of Orders

Type: Number.
Description: The number of orders handled by this driver.

4.6.24 Column: Number of Loads

Type: Number.
Description: The number of loads carried by this driver.

4.6.25 Column: Number of Shifts

Type: Number.
Description: The number of shifts worked by this driver.

4.7 Sheet: Driver Shift Summary

This sheet summarises the activity of each individual driver shift in the solution.

4.7.1 Column: Driver

Type: Text.
Description: The identifier of the driver assigned to the shift.

4.7.2 Column: Date

Type: Excel date.
Description: The date on which the shift is active.

4.7.3 Column: Shift

Type: Text.
Description: The identifier of the assigned shift.

4.7.4 Column: Revenue

Type: Number.
Description: The total revenue attributed to this driver shift.

4.7.5 Column: Total Volume

Type: Number.
Description: The total volume carried by this driver shift.

4.7.6 Column: Total Weight

Type: Number.
Description: The total weight carried by this driver shift.

4.7.7 Column: Transit Distance

Type: Number.
Description: The total transit (driving) distance for this driver shift.

4.7.8 Column: Average Speed

Type: Number.
Description: The average travel speed for this driver shift.

4.7.9 Column: Loaded Distance

Type: Number.
Description: The distance travelled by this driver shift while carrying at least one order.

4.7.10 Column: Empty Distance

Type: Number.
Description: The distance travelled by this driver shift while carrying no orders.

4.7.11 Column: Distance to Finish

Type: Number.
Description: The distance from the last delivery to the finish location for this driver shift.

4.7.12 Column: Time to Finish

Type: Excel time.
Description: The travel time from the last delivery to the finish location for this driver shift.

4.7.13 Column: Start Time Zone

Type: Text.
Description: The time zone in which this driver shift starts.

4.7.14 Column: Actual Start Time

Type: Excel time.
Description: The actual start time chosen for this driver shift.

4.7.15 Column: Finish Time Zone

Type: Text.
Description: The time zone in which this driver shift finishes.

4.7.16 Column: Actual Finish Time

Type: Excel time.
Description: The actual finish time chosen for this driver shift.

4.7.17 Column: Work Time

Type: Excel time.
Description: The total work time for this driver shift.

4.7.18 Column: Transit Time

Type: Excel time.
Description: The total transit (driving) time for this driver shift.

4.7.19 Column: Site Time

Type: Excel time.
Description: The total site time for this driver shift.

4.7.20 Column: Load Time

Type: Excel time.
Description: The total loading time for this driver shift.

4.7.21 Column: Unload Time

Type: Excel time.
Description: The total unloading time for this driver shift.

4.7.22 Column: Service Time

Type: Excel time.
Description: The total service time for this driver shift.

4.7.23 Column: Idle Time

Type: Excel time.
Description: The total idle (waiting) time for this driver shift.

4.7.24 Column: Break Time

Type: Excel time.
Description: The total break time for this driver shift.

4.7.25 Column: Maintenance Time

Type: Excel time.
Description: The total time spent on maintenance visits during the driver shift.

4.7.26 Column: Maintenance Detour Distance

Type: Number.
Description: The distance added by travelling to maintenance visits during the driver shift.

4.7.27 Column: Maintenance Detour Time

Type: Excel time.
Description: The transit time added by travelling to maintenance visits during the driver shift.

4.7.28 Column: Number of Drops

Type: Number.
Description: The number of delivery drops made by this driver shift.

4.7.29 Column: Number of Orders

Type: Number.
Description: The number of orders handled by this driver shift.

4.7.30 Column: Number of Loads

Type: Number.
Description: The number of loads carried by this driver shift.

4.8 Sheet: Solution Summary

This sheet aggregates global KPIs across all vehicles and shifts. The sheet has two columns: *KPI*, naming each metric listed below, and *Value*, giving its value.

4.8.1 Column: KPI

Type: Text.
Description: The name of the key performance indicator, taking one of the values enumerated below.

4.8.2 Column: Value

Type: Number or Excel time.
Description: The value of the corresponding key performance indicator.

4.8.3 Name

Type: Text.
Description: The name of the scenario, if one was provided.

4.8.4 Cost

Type: Number.
Description: The total cost for all routes in the solution.

4.8.5 Revenue

Type: Number.
Description: The total revenue generated in the solution.

4.8.6 Profit

Type: Number.
Description: The total profit (revenue minus cost) in the solution.

4.8.7 Distance

Type: Number.
Description: The total transit distance of all routes in the solution.

4.8.8 Delivery Distance

Type: Number.
Description: The total transit distance while making deliveries.

4.8.9 Maximum Delivery Distance

Type: Number.
Description: The maximum delivery distance reached in the solution.

4.8.10 Loaded Distance

Type: Number.
Description: The total transit distance travelled while vehicles are carrying at least one order.

4.8.11 Empty Distance

Type: Number.
Description: The total transit distance travelled while vehicles are empty.

4.8.12 Work Time

Type: Excel time.
Description: The total work time for all routes in the solution.

4.8.13 Transit Time

Type: Excel time.
Description: The total transit time for all routes in the solution.

4.8.14 Idle Time

Type: Excel time.
Description: The total idle time for all routes in the solution.

4.8.15 Break Time

Type: Excel time.
Description: The total break time for all routes in the solution.

4.8.16 Maintenance Time

Type: Excel time.
Description: The total time spent on maintenance visits for all routes in the solution. Only present if some vehicle is subject to maintenance.

4.8.17 Maintenance Detour Distance

Type: Number.
Description: The total distance added by travelling to maintenance visits for all routes in the solution. Only present if some vehicle is subject to maintenance.

4.8.18 Maintenance Detour Time

Type: Excel time.
Description: The total transit time added by travelling to maintenance visits for all routes in the solution. Only present if some vehicle is subject to maintenance.

4.8.19 Weight

Type: Number.
Description: The cumulative weight carried in all routes in the solution.

4.8.20 Volume

Type: Number.
Description: The cumulative volume carried in all routes in the solution.

4.8.21 Average Speed

Type: Number.
Description: The global average speed of the vehicles in the solution.

4.8.22 Assigned Orders

Type: Number.
Description: The number of successfully assigned orders.

4.8.23 Unassigned Orders

Type: Number.
Description: The number of orders that could not be assigned.

4.8.24 Total Orders

Type: Number.
Description: The total number of orders in the scenario.

4.8.25 Used Vehicles

Type: Number.
Description: The total number of unique vehicles utilised.

4.8.26 Total Vehicles

Type: Number.
Description: The total number of available vehicles in the scenario.

4.8.27 Used Vehicle Shifts

Type: Number.
Description: The number of vehicle shifts that were used in the solution.

4.8.28 Total Vehicle Shifts

Type: Number.
Description: The total number of available vehicle shifts in the scenario.

4.8.29 Loads

Type: Number.
Description: The total number of batched loads in the solution.

4.8.30 Km Per Load

Type: Number.
Description: The average transit distance per load.

4.8.31 Hours Per Load

Type: Excel time.
Description: The average duration per load.

4.8.32 Drops Per Load

Type: Number.
Description: The average number of delivery drops per load.

4.8.33 Total Sticky Delivery Groups

Type: Number.
Description: The total number of groups considered for sticky deliveries.

4.8.34 Broken Sticky Delivery Groups

Type: Number.
Description: The number of sticky delivery groups that could not be kept together.

4.8.35 Pickup Soft Time Window Early

Type: Excel time.
Description: The total time pickups occurred before their soft time windows across the solution.

4.8.36 Pickup Soft Time Window Late

Type: Excel time.
Description: The total time pickups occurred after their soft time windows across the solution.

4.8.37 Delivery Soft Time Window Early

Type: Excel time.
Description: The total time deliveries occurred before their soft time windows across the solution.

4.8.38 Delivery Soft Time Window Late

Type: Excel time.
Description: The total time deliveries occurred after their soft time windows across the solution.

4.8.39 Version

Type: Text.
Description: The version of the optimiser that produced the solution.

4.9 Sheet: Unassigned Orders

If any orders cannot be assigned, they are listed here together with their details.

4.9.1 Column: Order

Type: Text.
Description: The identifier of the unassigned order.

4.9.2 Column: Leg

Type: Text.
Description: For a multi-leg order, the identifier of the unassigned leg.

4.9.3 Column: Order Attributes

Type: Text.
Description: The attributes of the order, separated by semicolons.

4.9.4 Column: Customer Name

Type: Text.
Description: The customer associated with the order.

4.9.5 Column: Weight

Type: Number.
Description: The weight of the order.

4.9.6 Column: Volume

Type: Number.
Description: The volume of the order.

4.9.7 Column: Pickup Location

Type: Text.
Description: The identifier of the order's pickup location.

4.9.8 Column: Delivery Location

Type: Text.
Description: The identifier of the order's delivery location.

4.10 Sheet: Unassigned Compatibility

For each unassigned order, this sheet lists the vehicles that the order is compatible with, to help diagnose why it could not be assigned.

4.10.1 Column: Order

Type: Text.
Description: The identifier of the unassigned order.

4.10.2 Column: Leg

Type: Text.
Description: For a multi-leg order, the identifier of the relevant leg.

4.10.3 Column: Vehicles

Type: Text.
Description: A semicolon-separated list of the vehicles with which the order is compatible. This helps diagnose why an order that is compatible with some vehicles was nonetheless left unassigned.

4.11 Sheet: Location Summary

This sheet aggregates the activity at each location across the solution.

4.11.1 Column: Location

Type: Text.
Description: The identifier of the location, as defined in the Locations sheet.

4.11.2 Column: Address

Type: Text.
Description: The address of the location.

4.11.3 Column: Total Site Time

Type: Excel time.
Description: The total site time spent at the location across all visits.

4.11.4 Column: Total Pickups

Type: Number.
Description: The total number of pickups made at the location.

4.11.5 Column: Total Deliveries

Type: Number.
Description: The total number of deliveries made at the location.

4.11.6 Column: Total Volume

Type: Number.
Description: The total volume picked up and delivered at the location.

4.11.7 Column: Total Weight

Type: Number.
Description: The total weight picked up and delivered at the location.

4.11.8 Column: Total Service Time

Type: Excel time.
Description: The total service time spent at the location across all visits.

4.11.9 Column: Number of Vehicles Visited

Type: Number.
Description: The number of distinct vehicles that visited the location.

4.11.10 Column: Total Number of Visits

Type: Number.
Description: The total number of visits made to the location.

4.11.11 Column: Unassigned Pickups

Type: Number.
Description: The number of pickups at the location that were left unassigned.

4.11.12 Column: Unassigned Deliveries

Type: Number.
Description: The number of deliveries at the location that were left unassigned.

4.12 Sheet: Order Summary

This sheet summarises the outcome for each order in the scenario.

4.12.1 Column: Order

Type: Text.
Description: The identifier of the order.

4.12.2 Column: Assigned Vehicle

Type: Text.
Description: The identifier of the vehicle the order was assigned to, or blank if the order was not assigned.

4.12.3 Column: Duration

Type: Excel time.
Description: The elapsed time between the order's pickup and its delivery.

4.12.4 Column: Compartment

Type: Text.
Description: The identifier of the compartment the order was loaded into, if applicable.