Advanced Analytics &
Business Consultancy

# Analytical Revenue Management

## Webinar

April 2023

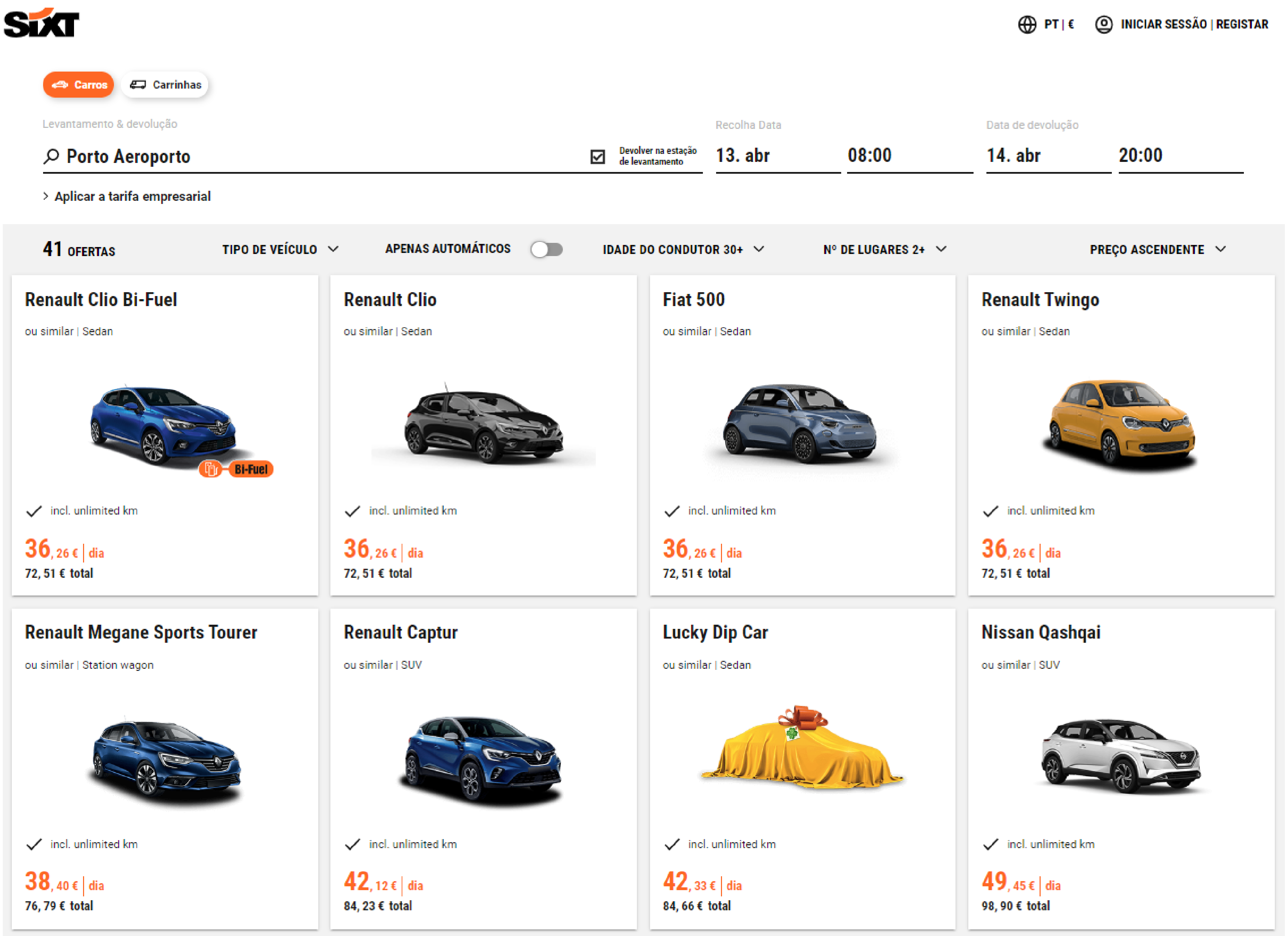
# Agenda

## Analytical Revenue Management

- **Revenue management and fleet rotation at Sixt**
- Modeling revenue management and fleet rotation
- Implementation details
- Conclusions

# SIXT PORTUGAL

- **Rent-a-car company**, one of the top rent-a-car companies in Europe
- Franchising in **Portugal**, since 2015
- **~40 stations**, organized in pools
- ~10,000 cars, organized in **52 vehicle groups** (Ex. Family, SUV, etc)
- **Pricing** sets the prices and **fleet rotation** distributes the fleet among the stations


SIXT
PT | €
INICIAR SESSÃO | REGISTAR
Carros
Carrinhas
Levantamento & devolução
Porto Aeroporto
Devolver na estação de levantamento
Recolha Data
13. abr
08:00
Data de devolução
14. abr
20:00
Aplicar a tarifa empresarial
41 OFERTAS
TIPO DE VEÍCULO
APENAS AUTOMÁTICOS
IDADE DO CONDUTOR 30+
Nº DE LUGARES 2+
PREÇO ASCENDENTE
Renault Clio Bi-Fuel
ou similar | Sedan
Bi-Fuel
incl. unlimited km
36, 26 € | dia
72, 51 € total
Renault Clio
ou similar | Sedan
incl. unlimited km
36, 26 € | dia
72, 51 € total
Fiat 500
ou similar | Sedan
incl. unlimited km
36, 26 € | dia
72, 51 € total
Renault Twingo
ou similar | Sedan
incl. unlimited km
36, 26 € | dia
72, 51 € total
Renault Megane Sports Tourer
ou similar | Station wagon
incl. unlimited km
38, 40 € | dia
76, 79 € total
Renault Captur
ou similar | SUV
incl. unlimited km
42, 12 € | dia
84, 23 € total
Lucky Dip Car
ou similar | Sedan
incl. unlimited km
42, 33 € | dia
84, 66 € total
Nissan Qashqai
ou similar | SUV
incl. unlimited km
49, 45 € | dia
98, 90 € total

# Pain-points

**Tactical and operational** decisions are **not integrated**


Pricing is defined **empirically**, depending on fleet occupancy rate and competition rates

**Fleet allocation and pricing** are **not integrated**


**Lack of ability** to make pricing and fleet decisions (and operationalize) in **real time**

# ARM focused on developing a *revenue management* analytics platform

Starting Point

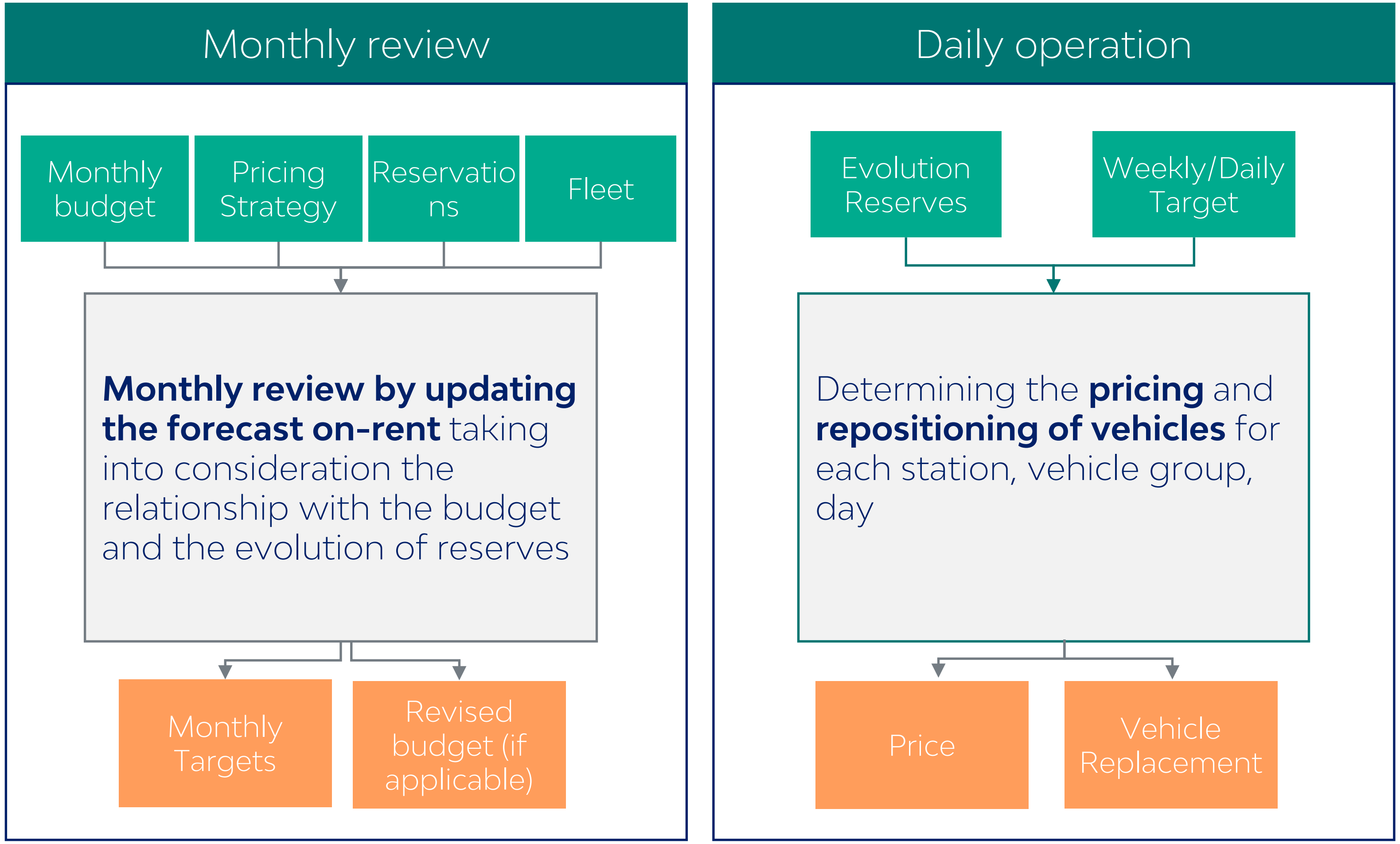

**Analytical Revenue Management** Platform

- ✓ On-rents **predictive capability**
- ✓ **Dynamic and granular** optimization of **pricing**
- ✓ **Synchronization** between **pricing strategy** and its operationalization
- ✓ **Coordinated management** between **fleet and price**

1 Scope: *Retail* and *Leisure*, the most dynamic and price-sensitive segments, constituting ~70% of total revenue

# ARM supports both medium- and short-term planning

Inputs Outputs



# The revenue management platform has 3 main analytical modules behind the various decisions managed

Data

## A On-rents forecasting module

Forecast of on-rents for the **long term and short term,** taking into account existing **reservations**

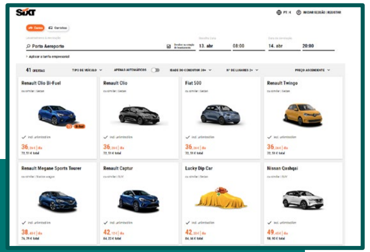
## B Price and Fleet Optimization Module

Operational level pricing and fleet definition

## C Repositioning Module

Suggested fleet repositioning between stations to comply with the fleet changes suggested in B

**Analytical modules supported by customized interfaces with users and dashboards**



**Pricing platform**

**Automatic**

**Fleet RotationTeam**

Details of the methodology explored in the "methodology" section

# A The causal predictive model takes into account a broad set of drivers that will impact the forecast generated

## Factor Identification

**20+ features tested** to select the ones that influence on-rents (e.g. historic on-rents, prices, fleet, budget)

Selection and collection of the factors that have a **direct influence on** on-rents

## Estimation of the impact of the factors

Advanced Causal Engine (*machine learning* )[1]

Reservations in History

On-rents for the one-year horizon

Evaluation of the impact of each factor on expected reserves, through an analysis of historical information, and **estimation of expected reserves as a function of the value attributed to each factor**

## Generating outputs and gaining *insights*

Forecast on-rents for a given date / vehicle group / station

*Insights* into the influence of different factors on forecasts

Using the Predictive Model to (1) predict on-rents (2) generate insights

1 *Gradient Boosting Machine and Random Forest* models

# Agenda

ARM Project

Revenue management and fleet rotation at Sixt

**Modeling revenue management and fleet rotation**

Implementation details

Conclusions

# LTP is a boutique analytical-driven management consultancy

Advanced Analytics & Business Consultancy

A **proven data-driven approach** enables LTP to address the complex challenges faced by its clients.

LTP combines **advanced analytics with business expertise** to deliver significant and sustainable impact in **bottom line profitability**.

**70+ consultants + extended network**

**300+ projects**

**15+ countries**

**>25% annual growth[1]**

1 Annual growth rates always above 25% in the past 5 years

# The revenue management platform has 3 main analytical modules behind the various decisions managed

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A **On-rents forecasting module**

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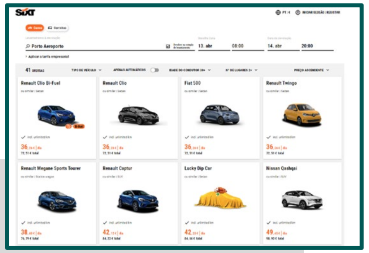
B **Price and Fleet Optimization Module**

Operational level pricing and fleet definition

C **Repositioning Module**

Suggested fleet repositioning between stations to comply with the fleet changes suggested in B

**Analytical modules supported by customized interfaces with users and dashboards : management, fleet**



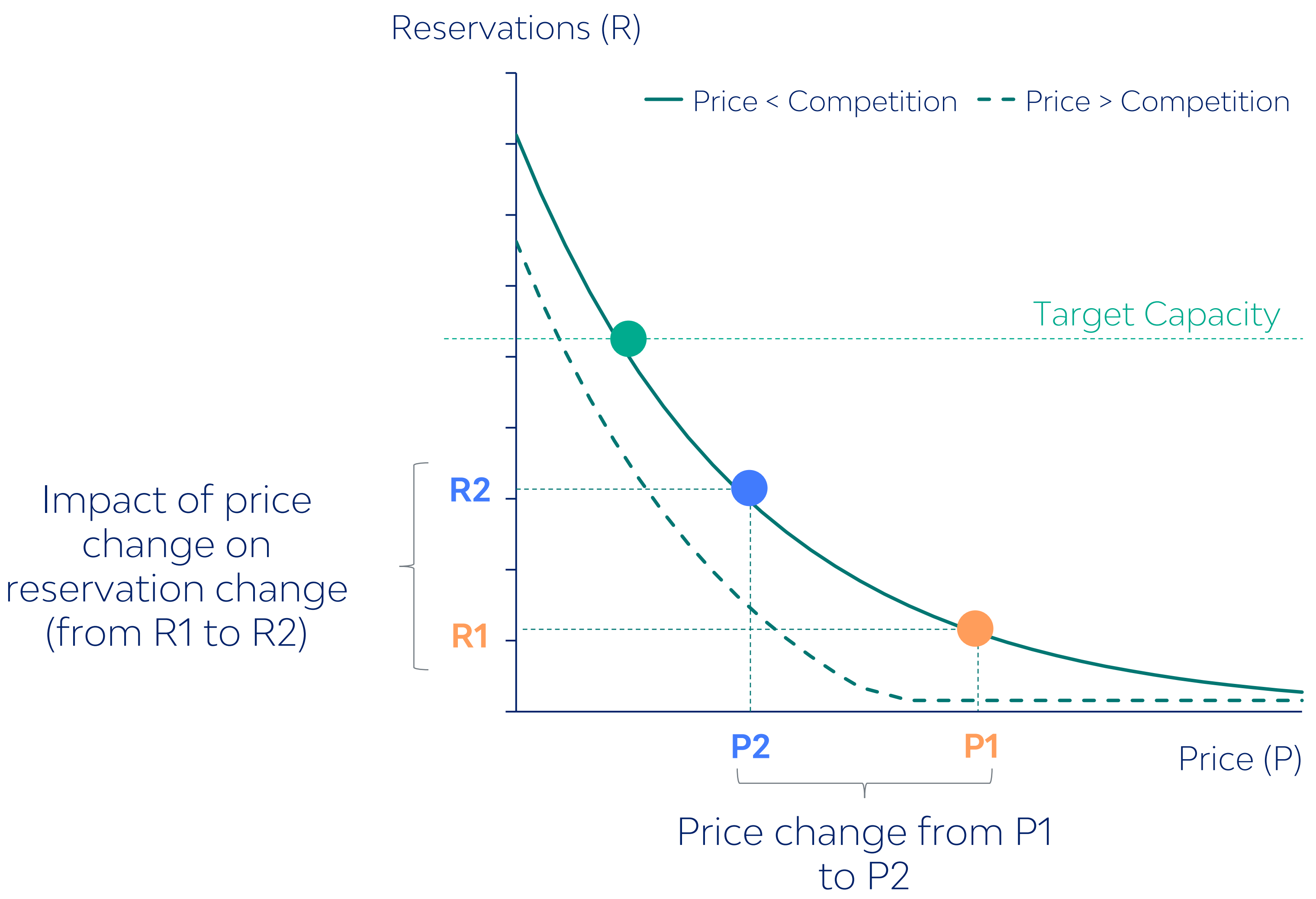
**Pricing platform**

**Automatic**

**Fleet RotationTeam**

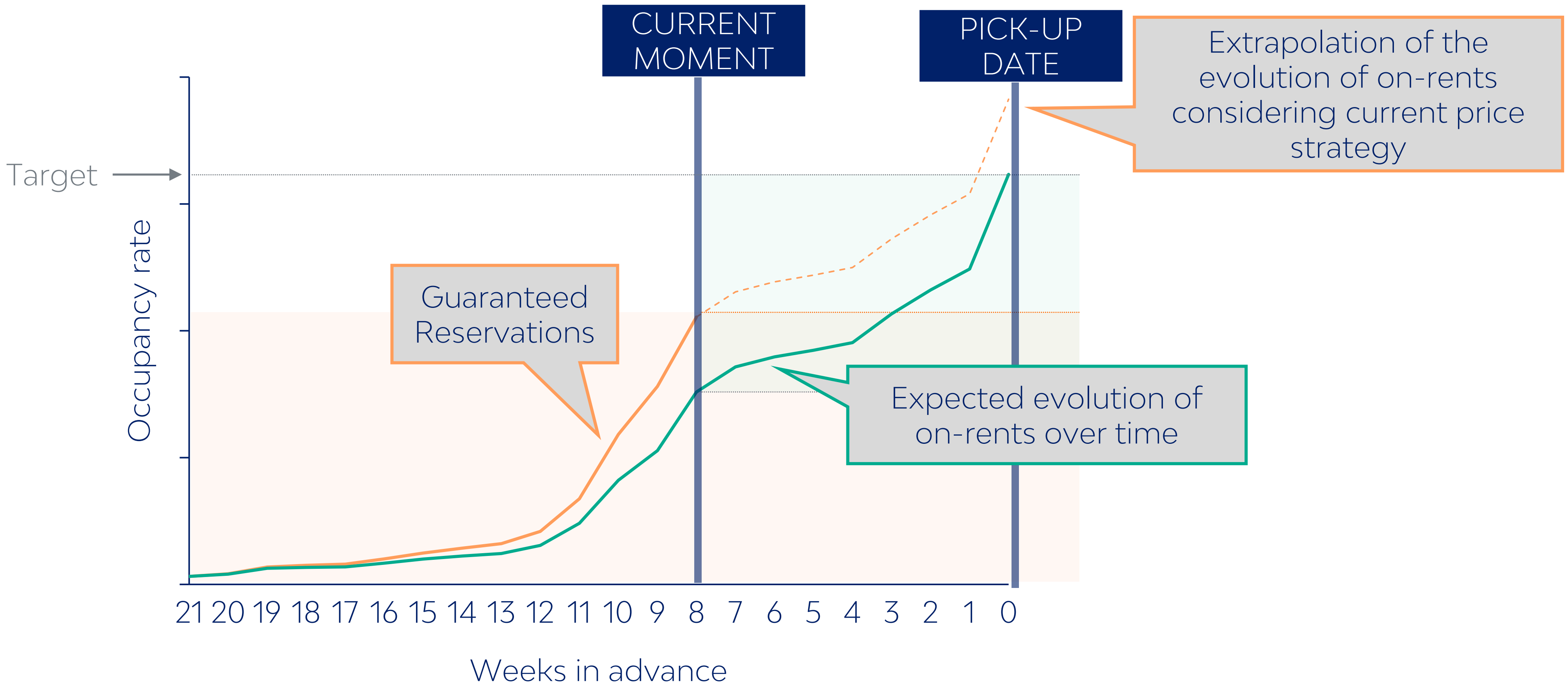
Details of the methodology explored in the "methodology" section

# The price elasticity curve allows to assess the extent to which reducing the price leads to a revenue increase



# The new approach to pricing and fleet distinguishes itself by its dynamism and target occupancy rate

Evolution of fleet occupancy rate for a given day, along the reservation period

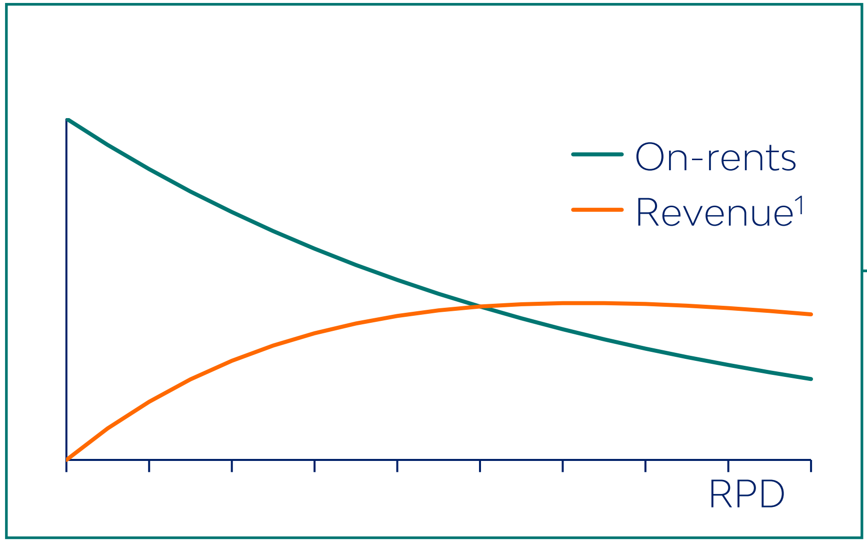


# Three main inputs feed the recommendations made, at the station and fleet level

## Forecast on-rents

**A On-rents forecasting module**

## Elasticity curves




## Parameterizations

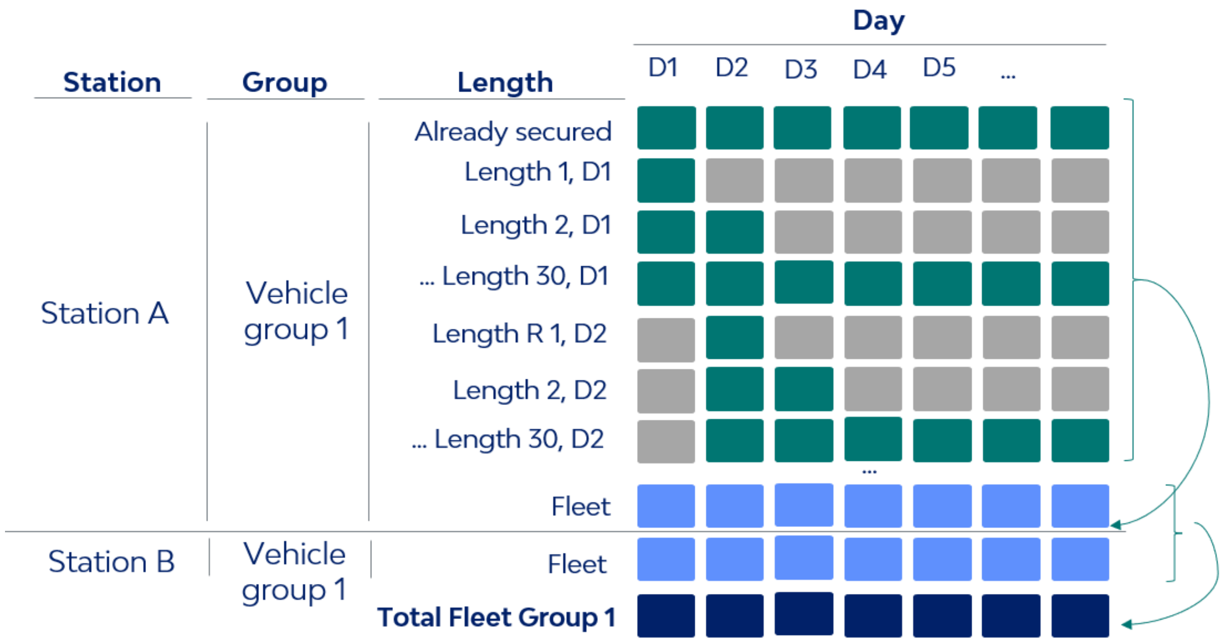
Relative to operational constraints and strategic objectives

| Station | Fleet | RPD |
|---|---|---|
| Station A | +153 | 19,1€ |
| Station B | +97 | 15,2€ |
| Station C | +66 | 15,2€ |
| Station D | -19 | 15,8€ |
| Station E | -72 | 16,9€ |
| Station F | -270 | 15,1€ |

Weighted average values

# The optimization model allows to holistically manage the price while safeguarding constraints between groups and days

| | |
|---|---|
| Decisions | • **Price** to apply each pickup day, station, group, length of rental<br>• **Fleet** needed at each station, vehicle group, day |
| Objective | • **Revenue/profit** maximization |
| Constraints | • Compliance with **expected targets** (with thresholds for exploitation of goal)<br>• **Minimum/maximum price** to apply<br>• **Relationship between** the **prices** of the vehicle groups<br>• **Minimum/maximum fleet** at each station<br>• **Operational Capacity** |




LTP SIXT

# The use of price steps allowed us to linearize the non-linear price-demand relation

## Sets and subsets

| | |
|---|---|
| $K$ | Price Steps |
| $L$ | LORs |
| $V$ | Vehicle groups |
| $P$ | Pools |
| $S$ | Stations |
| $S_p \subset S$ | Subset of stations that belong to pool $p$ |
| $R$ | Set of reservation days in the time horizon |
| $U$ | Set of pick-up days in the time horizon |

## Decision variables

| | |
|---|---|
| $d_{vsluk}$ | Price step $k$ selected for vehicle group $v$ in station $s$, with LOR $l$, on pick-up day $u$. Each price step has a given revenue per day price. If price step $k$ is selected, then $d_{vsluk} = 1$. If not, $d_{vsluk} = 0$. |
| $f_{vsr}$ | Fleet level for vehicle group $v$ in station $s$, on reservation day $r$. This decision variable will be an input for the vehicle repositioning model. This decision variable defines the target fleet of vehicle group $v$ to have in station $s$ on reservation day $r$. |
| $w_{vpr}$ | Fleet decrease for vehicle group $v$ in pool $p$, on reservation day $r$. This variable represents the number of vehicles $v$ that the car rental company should remove from pool $p$. |
| $x_{vpr}$ | Fleet increase for vehicle group $v$ in pool $p$, on reservation day $r$. The variable represents the number of vehicles $v$ that the car rental company should bring to pool $p$. |
| $y_{vsr}$ | Fleet decrease for vehicle group $v$ in station $s$, on reservation day $r$. This variable represents the number of vehicles $v$ that the car rental company should remove from station $s$. |
| $z_{vsr}$ | Fleet increase for vehicle group $v$ in station $s$, on reservation day $r$. The variable represents the number of vehicles $v$ that the car rental company should bring to station $s$. |

# The objective function maximizes overall profit by considering the revenue generated by future reservations minus costs

## Objective function

$$\max \sum_{v\in V}\sum_{s\in S}\sum_{r\in R}\left[\sum_{l\in L}\sum_{u\in U}\sum_{k\in K}(d_{vsluk}\times RP_{vsluk}\times(RPD_{vsluk}-CPD_{vsluk})\times\alpha_{rlu})\times(1-OR_{vsr})\right]$$

$$-\sum_{v\in V}\sum_{s\in S}\sum_{r\in R}((M_1\times\delta_r+CS_s)\times z_{vsr})$$

$$-\sum_{v\in V}\sum_{p\in P}\sum_{r\in R}((M_1\times\rho_r+CP_p)\times x_{vpr}) \quad (4.1)$$

1 Expected future profit

2 Overall fleet repositioning costs between stations and pools

# The model contains 7 major groups of constraints mostly related with fleet constraints, target on-rents and price orders

Constraints (1/3)

$$\sum_{k \in K} d_{vsluk} = 1 \qquad \forall v \in V, s \in S, l \in L, u \in U \qquad (4.2)$$

1 Only one **price step**

$$AF_{vsr} - AF_{v,s,r-1} + f_{v,s,r-1} + z_{vsr} - y_{vsr} = f_{vsr} \qquad \forall v \in V, s \in S, r \in R \qquad (4.3)$$

$$\sum_{s \in S_p} (AF_{vsr} - AF_{v,s,r-1}) + f_{v,p,r-1} + x_{vpr} - w_{vpr} =$$

$$\sum_{s \in S_p} f_{vsr} \qquad \forall v \in V, p \in P, r \in R \qquad (4.4)$$

$$\sum_{s \in S} AF_{vsr} = \sum_{s \in S} f_{vsr} \qquad \forall v \in V, r \in R : \delta_r = 1 \qquad (4.5)$$

$$FS_s \leq \sum_{v \in V} f_{vsr} \qquad \forall s \in S, r \in R : \delta_r = 1 \qquad (4.6)$$

$$FP_p \leq \sum_{v \in V} \sum_{s \in S_p} f_{vsr} \qquad \forall p \in P, r \in R : \delta_r \times \rho_r = 1 \qquad (4.7)$$

2 **Fleet constraints:**

- Fleet size at each station depends on previous transfers and existing vehicles
- Total fleet size
- Minimum station fleet and pool fleet

# The model contains 7 major groups of constraints mostly related with fleet constraints, target on-rents and price orders

## Constraints (2/3)

$$\sum_{l\in L}\sum_{k\in K}\sum_{u\in U}(d_{vsluk} \times RP_{vsluk} \times \alpha_{rlu})\times (1-OR_{vsr}) + \sum_{l\in L}\sum_{u\in U}(RC_{vslu} \times \alpha_{rlu}) \geq f_{vsr} \times OG^{-}_{vsr} \qquad \forall v \in V, s \in S, r \in R \qquad (4.8)$$

$$\sum_{l\in L}\sum_{k\in K}\sum_{u\in U}(d_{vsluk} \times RP_{vsluk} \times \alpha_{rlu})\times (1-OR_{vsr}) + \sum_{l\in L}\sum_{u\in U}(RC_{vslu} \times \alpha_{rlu}) \leq f_{vsr} \times OG^{+}_{vsr} \qquad \forall v \in V, s \in S, r \in R \qquad (4.9)$$

3 Total **on-rents per day** between minimum and maximum target occupancy **target**

$$\sum_{v\in V}\Big[\sum_{l\in L}\sum_{k\in K}\sum_{u\in U}(d_{vsluk} \times RP_{vsluk} \times \alpha_{rlu})\times (1-OR_{vsr})\Big] + \sum_{v\in V}\sum_{l\in L}\sum_{u\in U}(RC_{vslu} \times \alpha_{rlu}) + SF_s \geq \sum_{v\in V} f_{vsr} \qquad \forall s \in S, r \in R \qquad (4.10)$$

$$\sum_{v\in V}\sum_{s\in S_p}\Big[\sum_{l\in L}\sum_{k\in K}\sum_{u\in U}(d_{vsluk} \times RP_{vsluk} \times \alpha_{rlu})\times (1-OR_{vsr})\Big] + \sum_{v\in V}\sum_{s\in S_p}\sum_{l\in L}\sum_{u\in U}(RC_{vslu} \times \alpha_{rlu}) + PF_p \geq \sum_{v\in V}\sum_{s\in S_p} f_{vsr} \qquad \forall p \in P, r \in R \qquad (4.11)$$

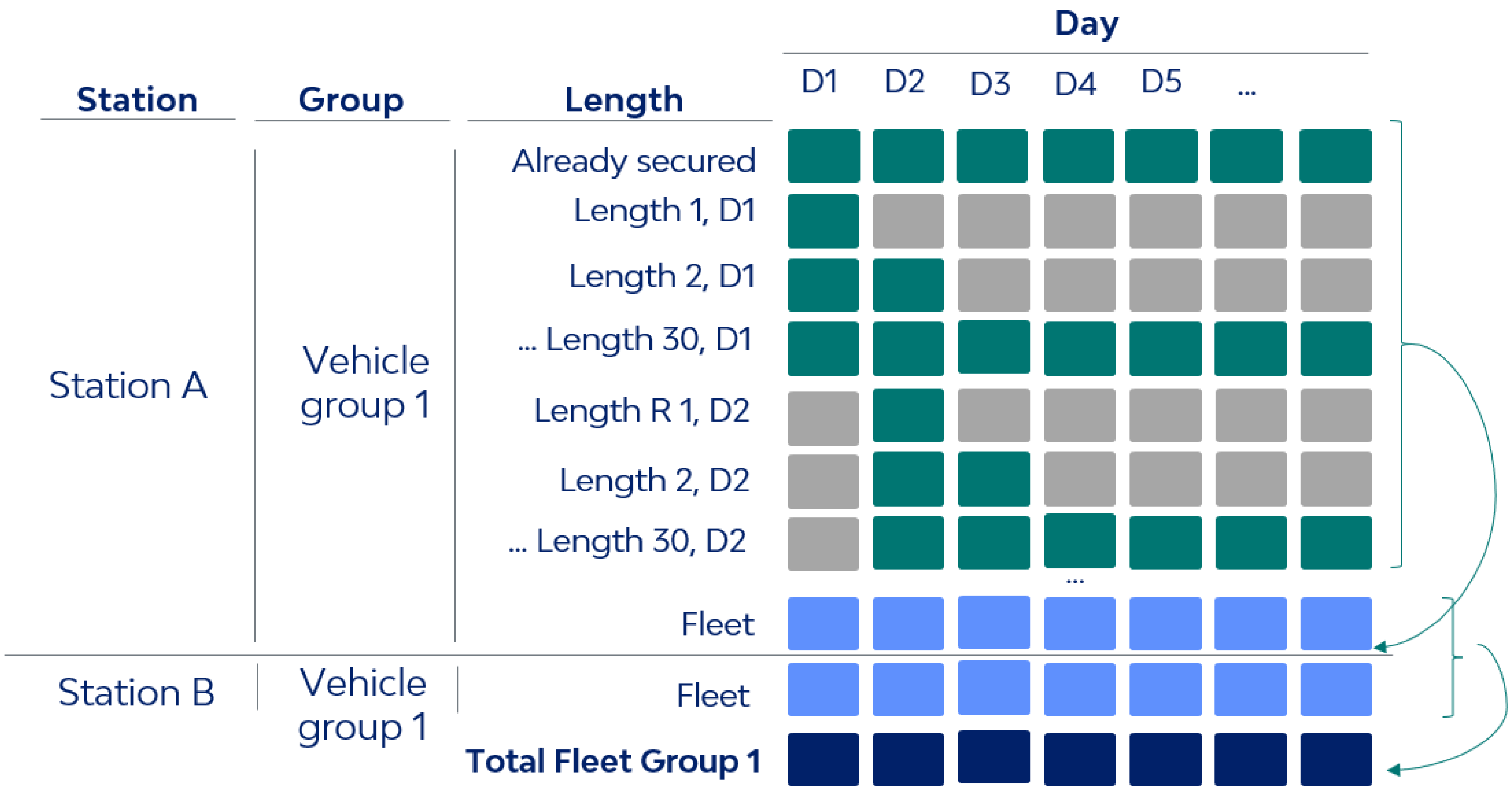
4 **Maximum fleet** parked at the same time at each station

$$\sum_{v\in V}\sum_{s\in S} z_{vsr} \leq TD \qquad \forall r \in R \qquad (4.12)$$

$$\sum_{v\in V}\sum_{s\in S_p} z_{vsr} \leq PD \qquad \forall p \in P, r \in R \qquad (4.13)$$

5 **Maximum transfers** between stations and pool

# Total on-rents per day



# The model contains 7 major groups of constraints mostly related with fleet constraints, target on-rents and price orders

Constraints (3/3)

$$\sum_{v\in V}\Big[\sum_{l\in L}\sum_{k\in K}(RP_{vsluk}\times d_{vsluk})\times(1-OP_{vsu})\Big]+\sum_{v\in V} RC_{vslu}\leq OC_s \qquad \forall s\in S, u\in U \qquad (4.14)$$

6 Daily **operational capacity**

$$\sum_{k\in K} d_{v_L sluk}\times RPD_{v_L sluk}\leq \sum_{k\in K} d_{vsluk}\times RPD_{vsluk} \qquad \forall v\in V, v_L=VL_{vslu}, s\in S, l\in L, u\in U \qquad (4.15)$$

$$\sum_{k\in K} d_{vsluk}\times RPD_{vsluk}\leq \sum_{k\in K} d_{v_H sluk}\times RPD_{v_H sluk} \qquad \forall v\in V, v_H=VH_{vslu}, s\in S, l\in L, u\in U \qquad (4.16)$$

7 **Price order** between vehicle groups

$$d_{vsluk}\in(0,1) \qquad \forall v\in V, s\in S, l\in L, u\in U, k\in K \qquad (4.17)$$

$$f_{vsr}\in\mathbb{R}_0^+ \qquad \forall v\in V, s\in S, r\in R \qquad (4.18)$$

$$w_{vpr}\in\mathbb{R}_0^+ \qquad \forall v\in V, p\in P, r\in R \qquad (4.19)$$

$$y_{vsr}\in\mathbb{R}_0^+ \qquad \forall v\in V, s\in S, r\in R \qquad (4.20)$$

$$x_{vpr}\in\mathbb{R}_0^+ \qquad \forall v\in V, p\in P, r\in R \qquad (4.21)$$

$$z_{vsr}\in\mathbb{R}_0^+ \qquad \forall v\in V, s\in S, r\in R \qquad (4.22)$$

# Agenda

## ARM Project

- Revenue management and fleet rotation at Sixt
- Modeling revenue management and fleet rotation
- **Implementation details**
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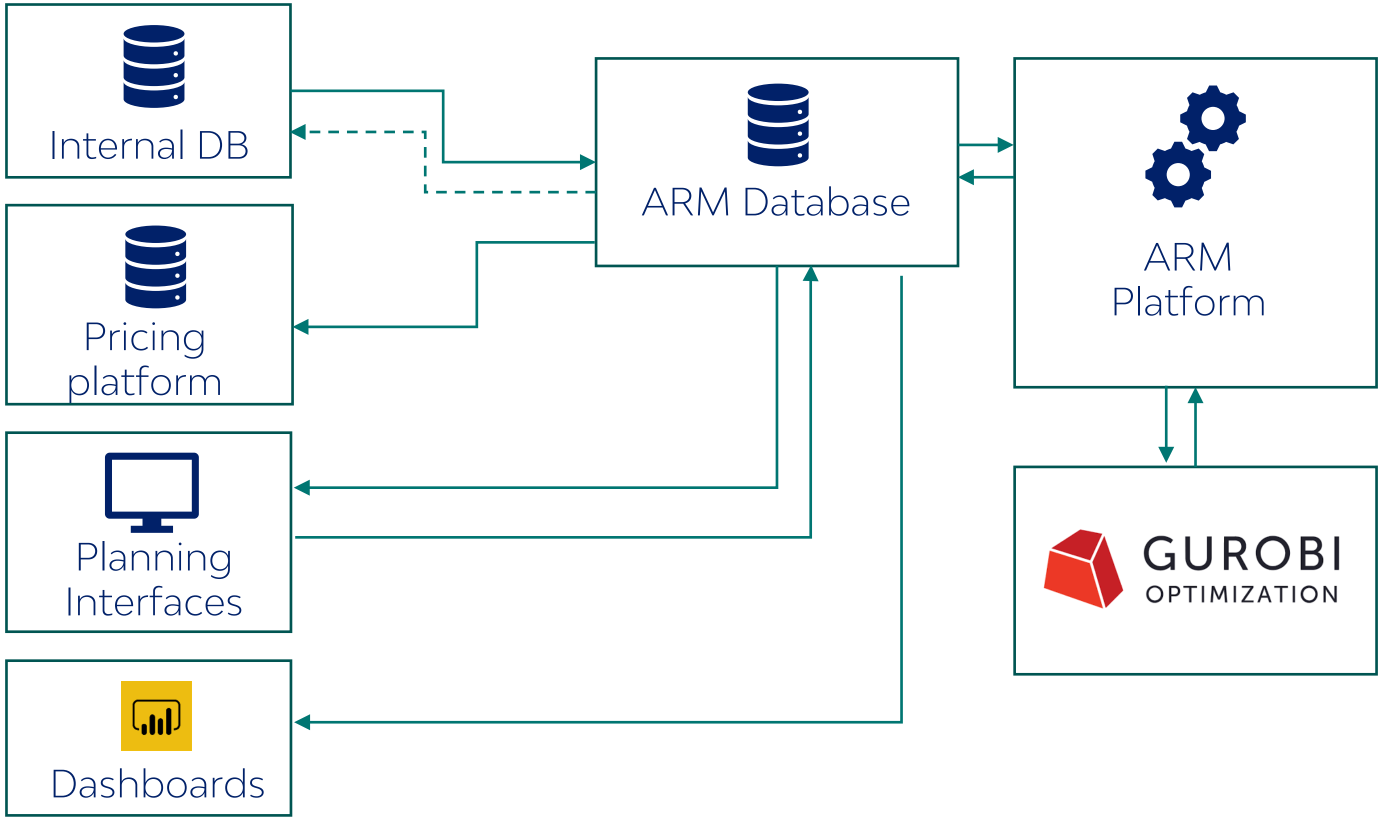
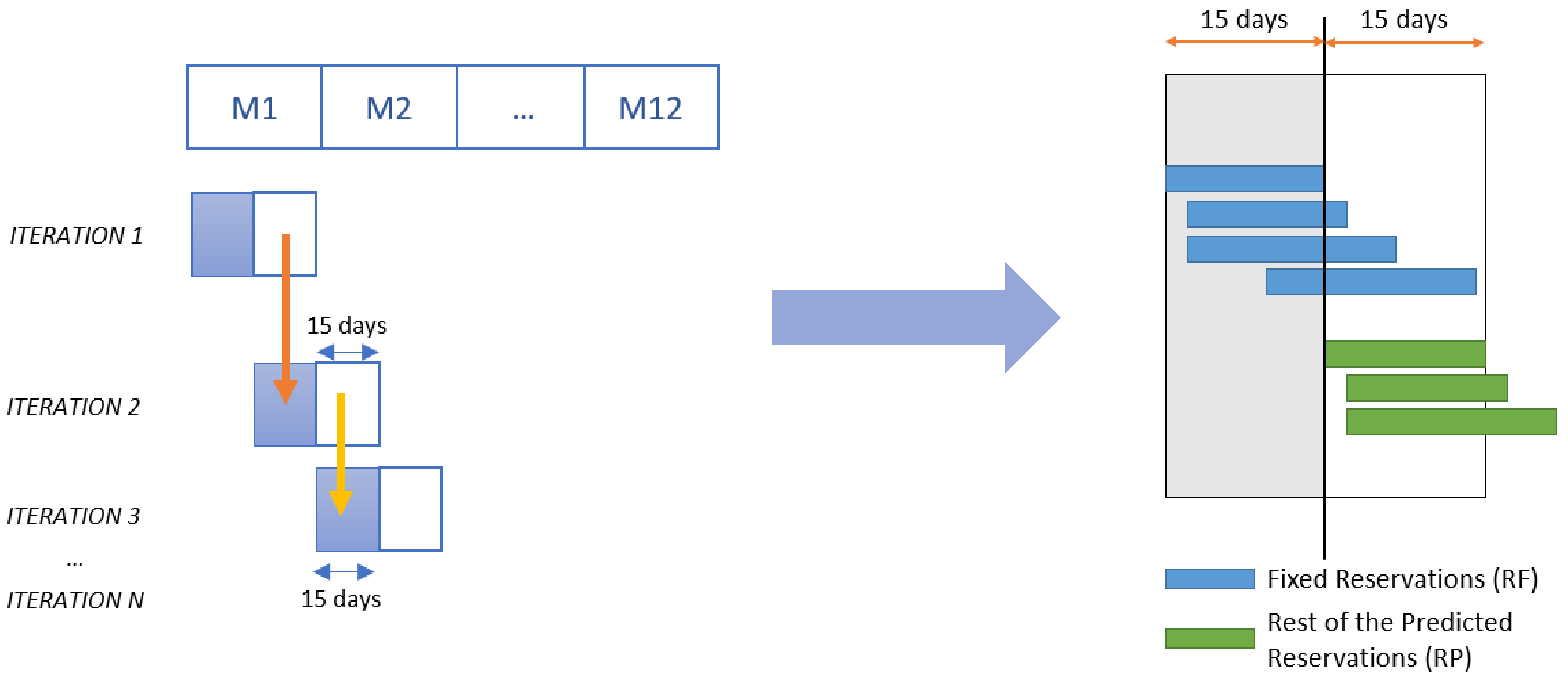
# The ARM platform is integrated with Sixt's servers




- **Python** – use of **Pulp open library** to model and run using Gurobi
- Gurobi runs on a **Kubernetes cluster**
- **Automatic triggers** to read new data, execute all processes, solve the models using Gurobi

# A relax-and-fix method was implemented to tackle the model complexity challenge



# A solution approach was developed to tackle the challenges in the implementation of the model

## Data Issues

**Add gaps** to the model.

- $o_{su}$ — Operational capacity gap.
- $b_{pr}$, $h_{sr}$ — Minimum fleet gap for pools and station.
- $a_{pr}$, $g_{sr}$ — Maximum available fleet gap for pools and stations.
- $m_{vsr}$, $n_{vsr}$ — Minimum and maximum occupation gaps.

## Time Execution Challenge

| | |
|---|---|
| BigM | **Reevaluate** the BigM of the objective function |
| Parameters | **Finetune** the parameters |
| Decision Variable | **Transform** all decision variables in **continuous** |
| Server | **Improve server's specifications** |
| Planning Horizon | **Reduce** the number of months to output new values **daily** |

**x9** Faster

# Agenda

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# Conclusions

- More information, with greater granularity that allow Sixt to make **more, better and faster decisions** – potential to generate **1.5 million of prices per day**
- **Greater control**, provided by the tactical integration and the alarmistic system that ensure the necessary validation of extreme cases
- **Faster and semi-automatic reaction** to price/occupancy rate variations
- Preliminary projections point to a **2% to 8% revenue increase**
- **Change of paradigm** with high impact on the team

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