FLiX

Practical challenges in building an ML- and OR-based decision support tool for network planning at Flix

EURO Practitioners' Forum 5th Annual Conference October 2024

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FLiXBUS FLiXTRAIN Greyhound KAMILKOÇ 1926

Disclaimer

Flix drives sustainable and affordable travel for everyone

launched in 2013

EUROPE, NORTH AMERICA,
BRAZIL, CHILE, INDIA

since 2018

GERMANY

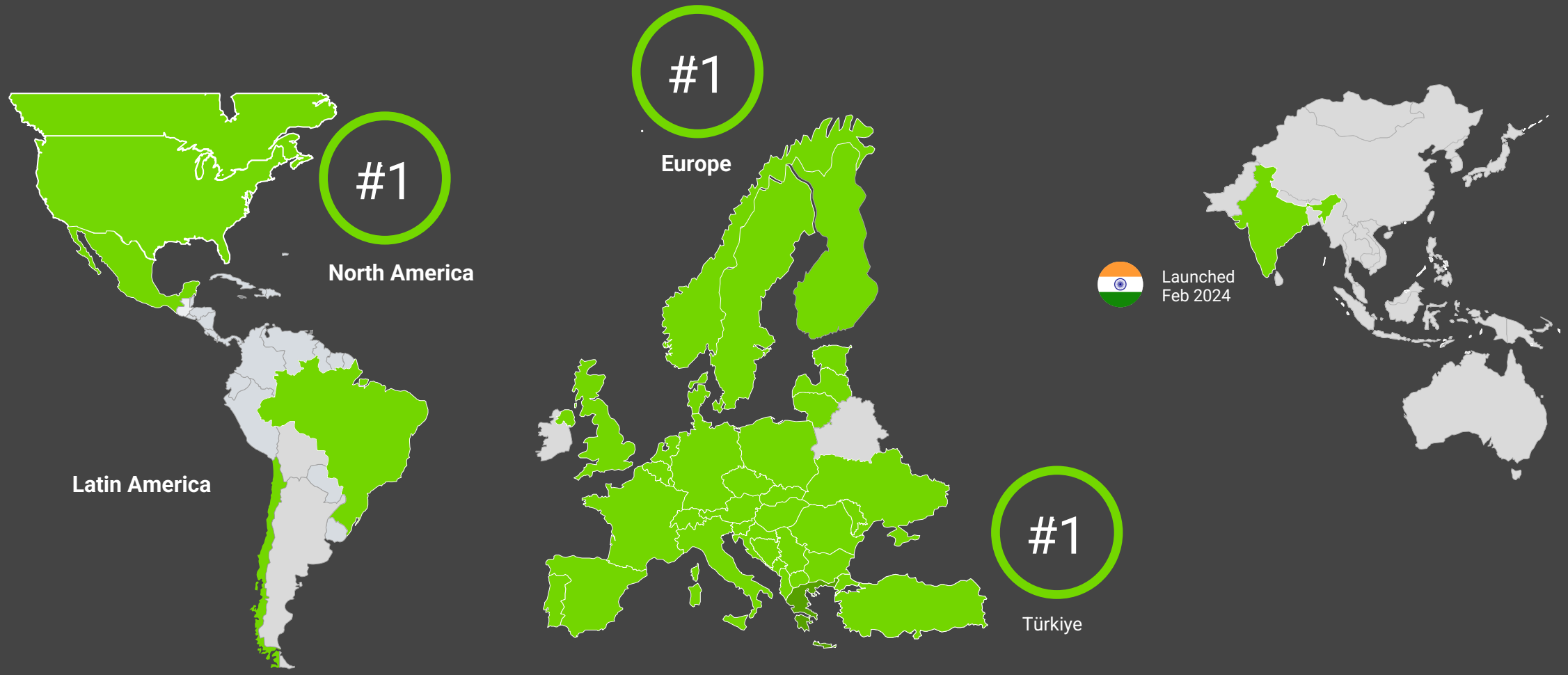
since 2019

TÜRKIYE

since 2021

NORTH AMERICA,
CANADA, MEXICO

› Flix is a global travel-tech champion winning in its core geographies



Source: OC&C Long-distance Travel Market Study 2023, Preliminary Company analysis

Flix today in numbers around the world

44
countries

5,600+
destinations

1,000+
operating partners

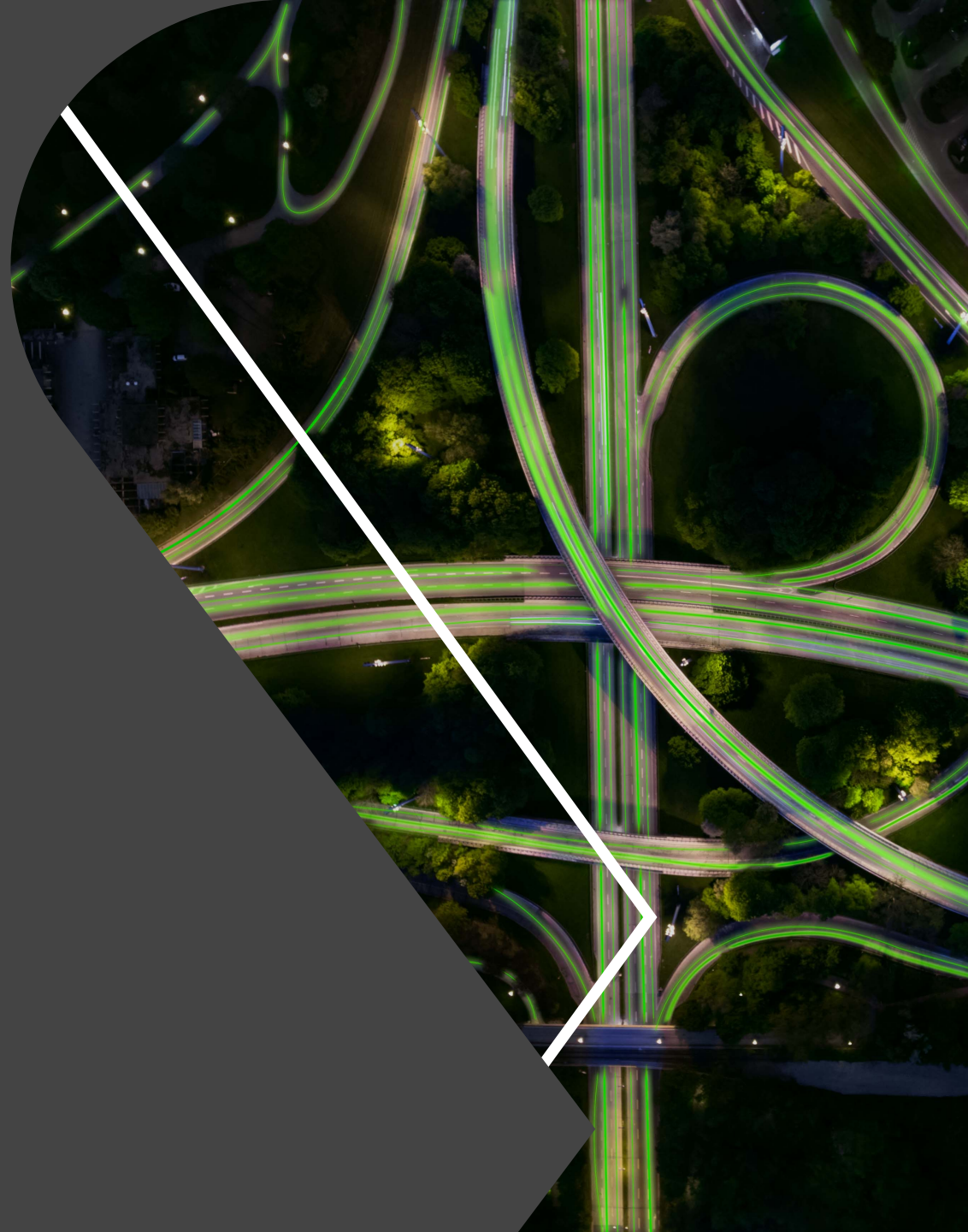
5,500+
Flix employees

81m
passengers*

0.5 - 53h
Line duration

5,500+
FlixBuses on the road

10+
FlixTrains on the rail



*Number of passengers only in 2023

FLIX

› Outline of today's talk

- Network planning at Flix
- The business problem - Line-level optimization in a network context
- Demand-supply interaction as methodological and software-technical challenge
- Iterative discovery and development as key lever to create impact

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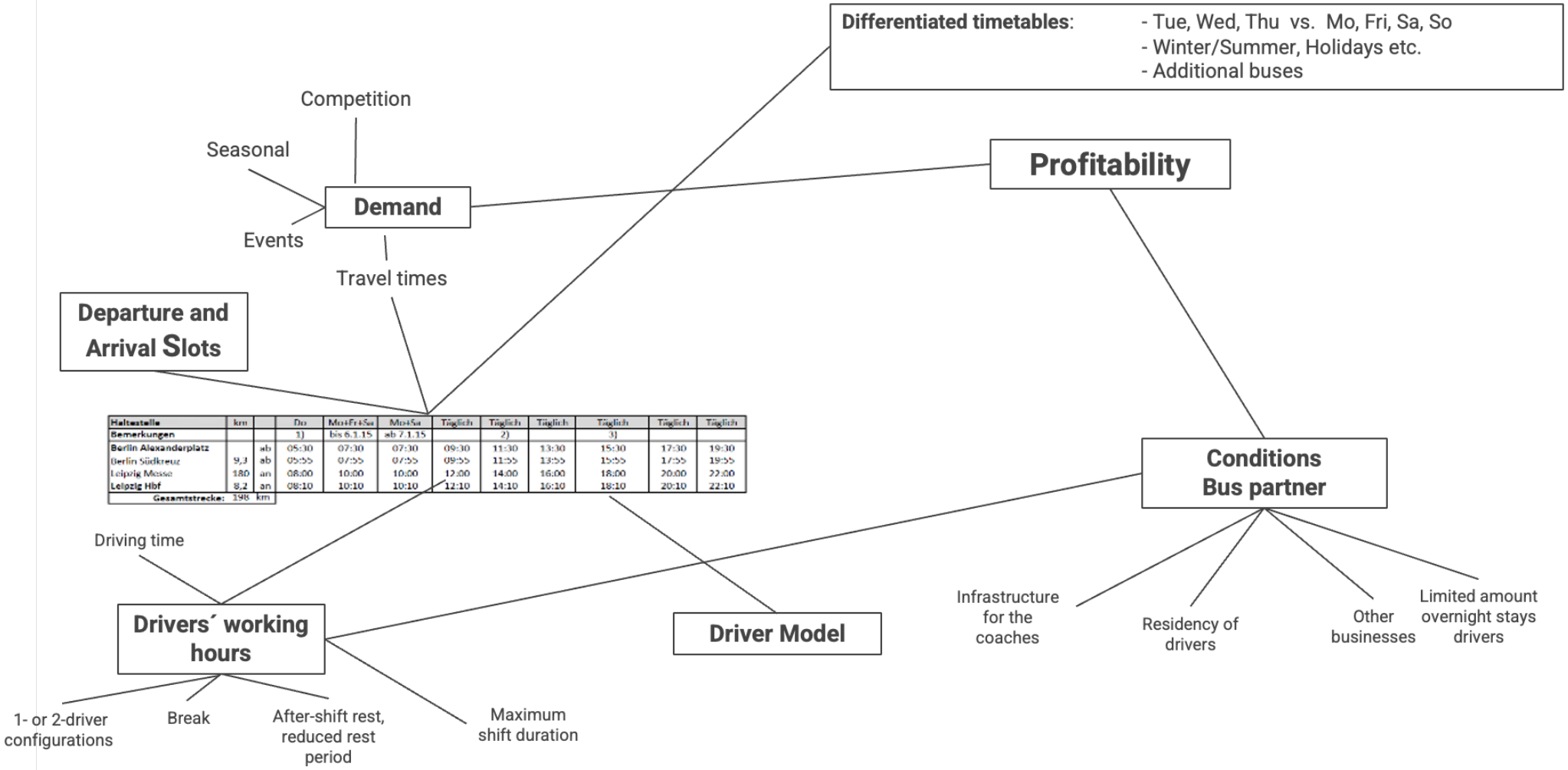
Network planning at Flix

Putting ML and OR within the bigger picture

Network planners work in a complex environment with many conditions, taking a holistic approach to line planning, timetabling and bus and driver scheduling



Haltestelle	km		Do	Mo+Fr+Sa	Mo+Sa	Täglich	Täglich	Täglich	Täglich	Täglich	Täglich
Bemerkungen			1)	bis 6.1.15	ab 7.1.15		2)		3)		
Berlin Alexanderplatz		ab	05:30	07:30	07:30	09:30	11:30	13:30	15:30	17:30	19:30
Berlin Südkreuz	9,3	ab	05:55	07:55	07:55	09:55	11:55	13:55	15:55	17:55	19:55
Leipzig Messe	180	an	08:00	10:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
Leipzig Hbf	8,2	an	08:10	10:10	10:10	12:10	14:10	16:10	18:10	20:10	22:10
Gesamtstrecke:	198	km									

As team Network Planning Optimization, we develop an OR-powered product to support network planners in creating profitable networks

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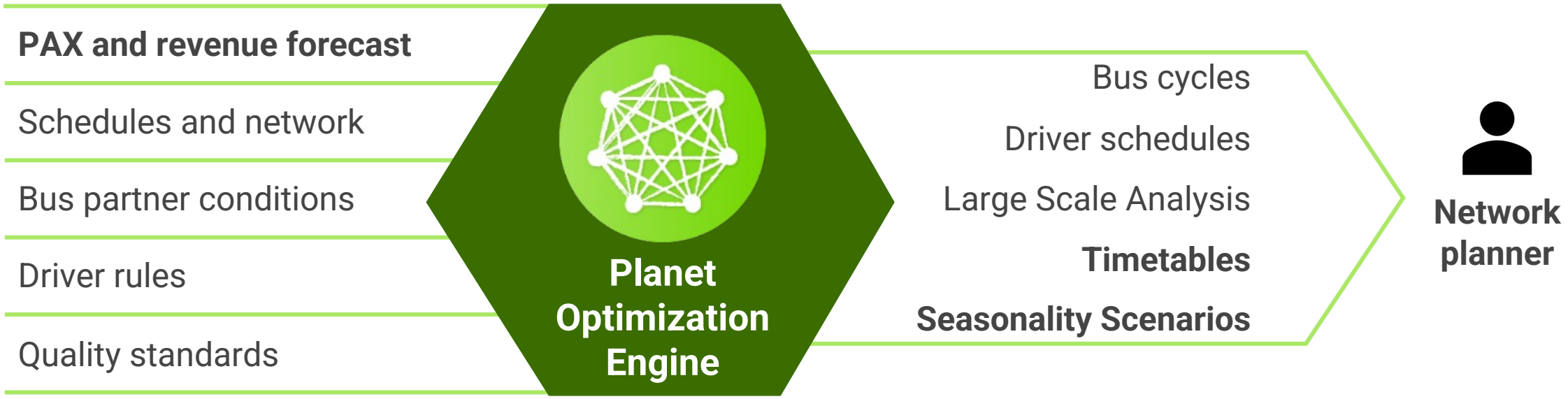
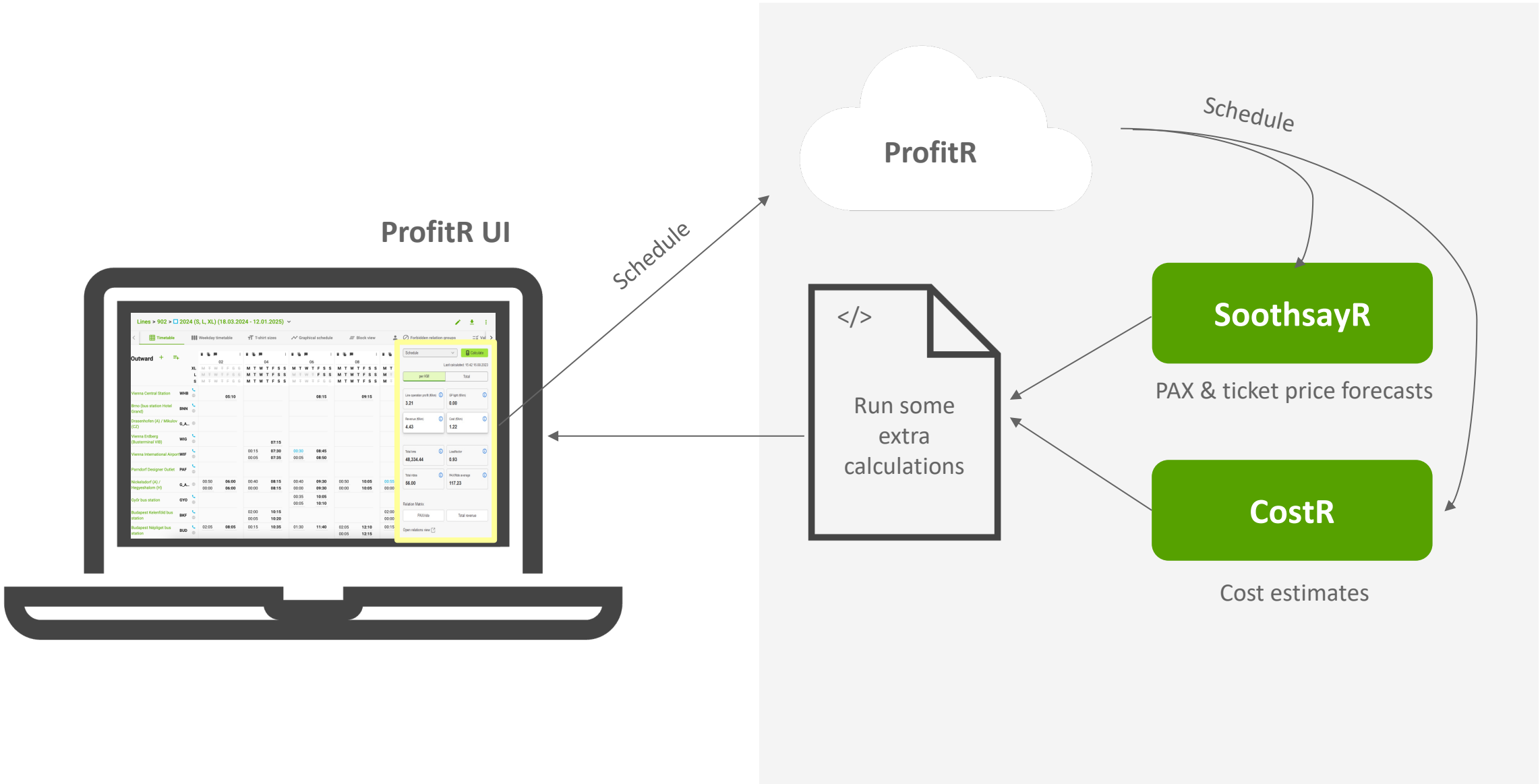
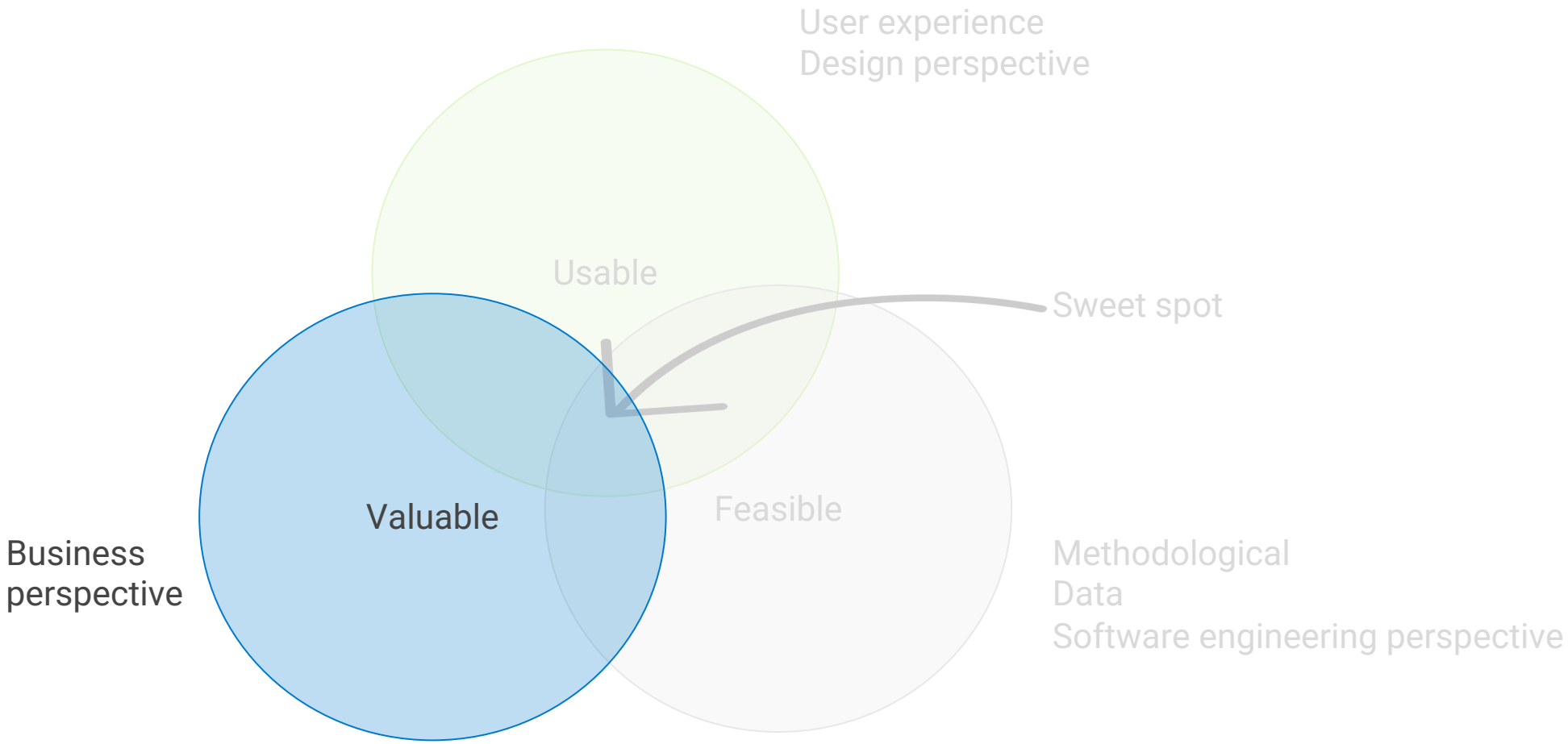


Network planners can get a schedule-level profitability forecast at any point in the planning process



What makes an advanced analytics-powered software product successful?



Adapted based on Marty Cagan, Insored (1st edition)

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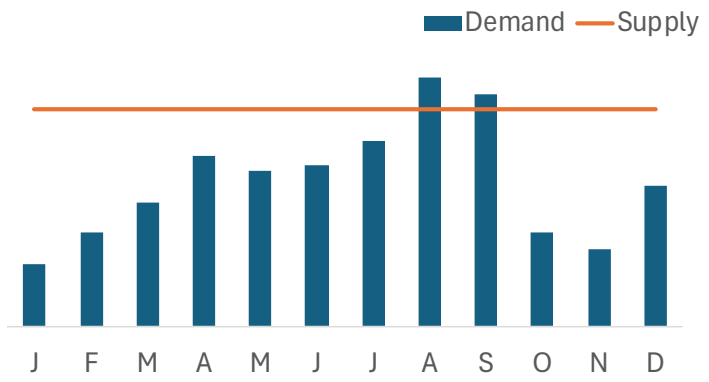
First things first – the business problem

Line-level optimization in a network context

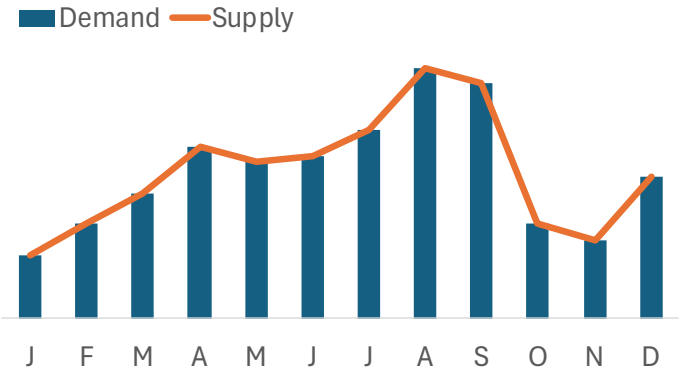
Profitability optimization requires a careful balance between supply and demand – the question is: to what degree?

Flat supply



- Easy to manage
- Difficult to set the right supply offer
- Design for peak is expensive

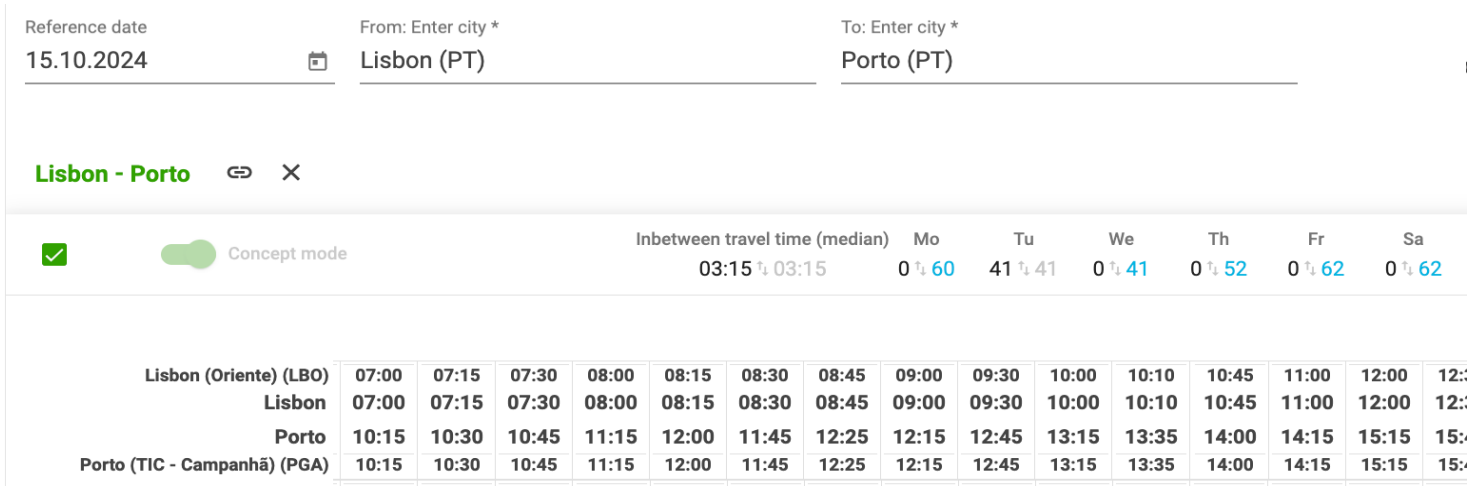
Supply matches demand “as a glove”



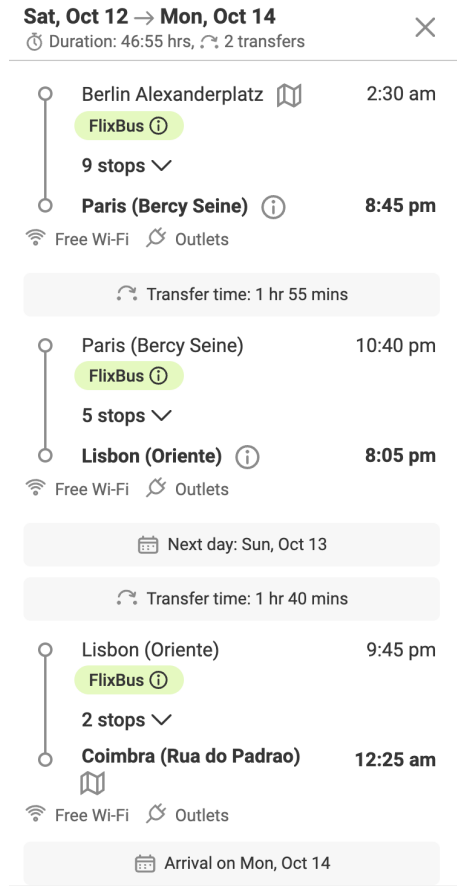
- Profitability goes up
- Driver contracts, fixed bus cost
- Difficult to manage and coordinate

Proper line-level optimization requires a holistic approach to demand forecasting and profit optimization

Internal competition across different lines (cannibalization)



(Multi-) IC offer involves multiple lines by nature



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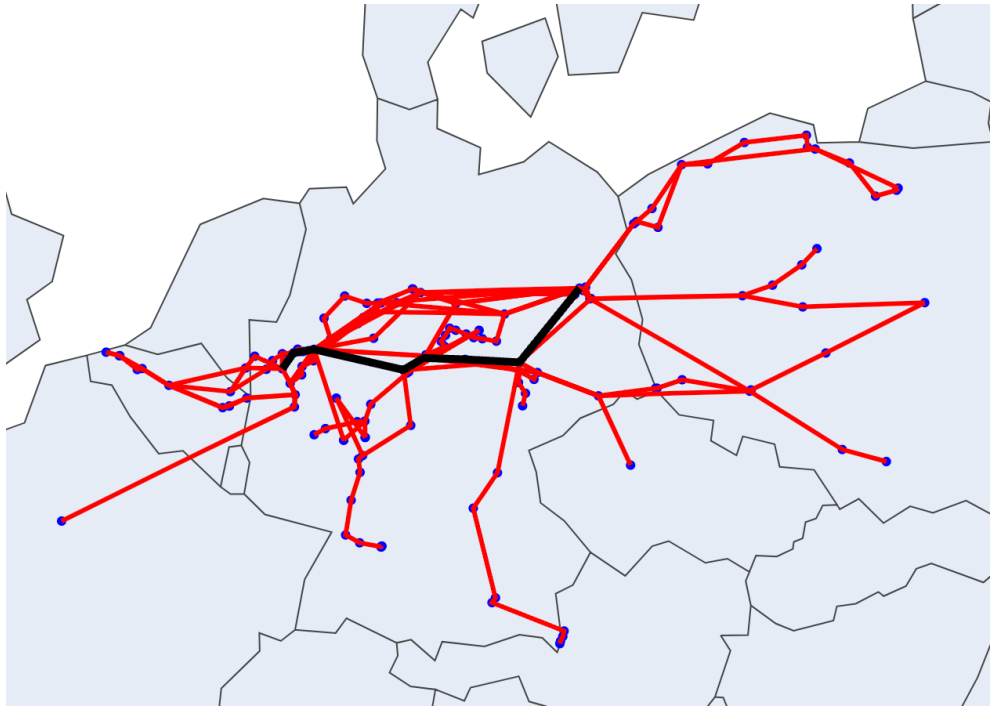

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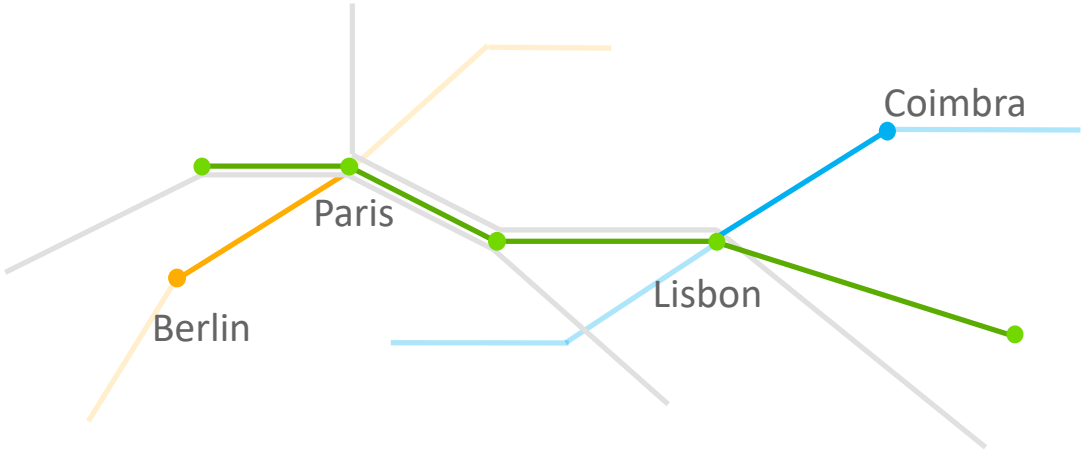
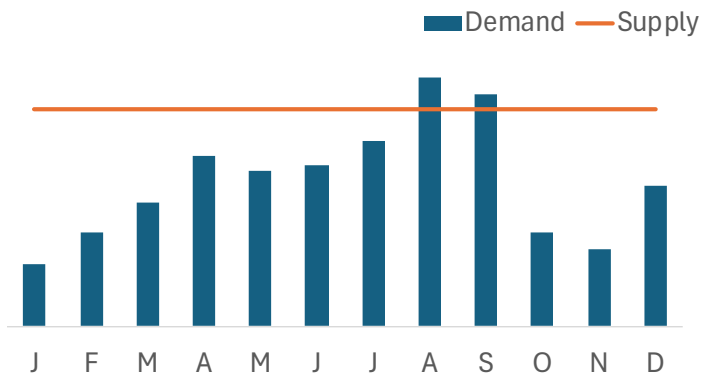


Network planners design and distribute a set of discrete levels of supply to strike the right balance between both extremes

Flat supply



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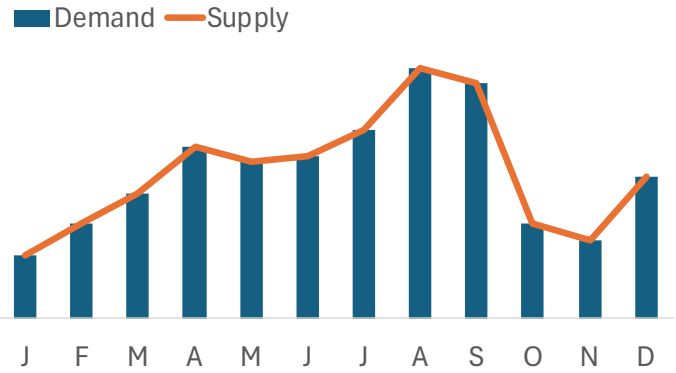


PAX, revenue and profit forecast during planning

Feasible and profitable schedule creation

Separation of concerns between both products and teams goes beyond the traditional ML / OR boundary

MVP

PAX, revenue and profit forecast during planning

- Cannibalization
- Multi-IC
- Ride-level demand forecast
- Yield forecast
- Revenue-maximizing capacity-capping
- Line-level cost estimation

??

Network planner

- Timetable design

Feasible and profitable schedule creation

- Seasonality distribution

FLiX

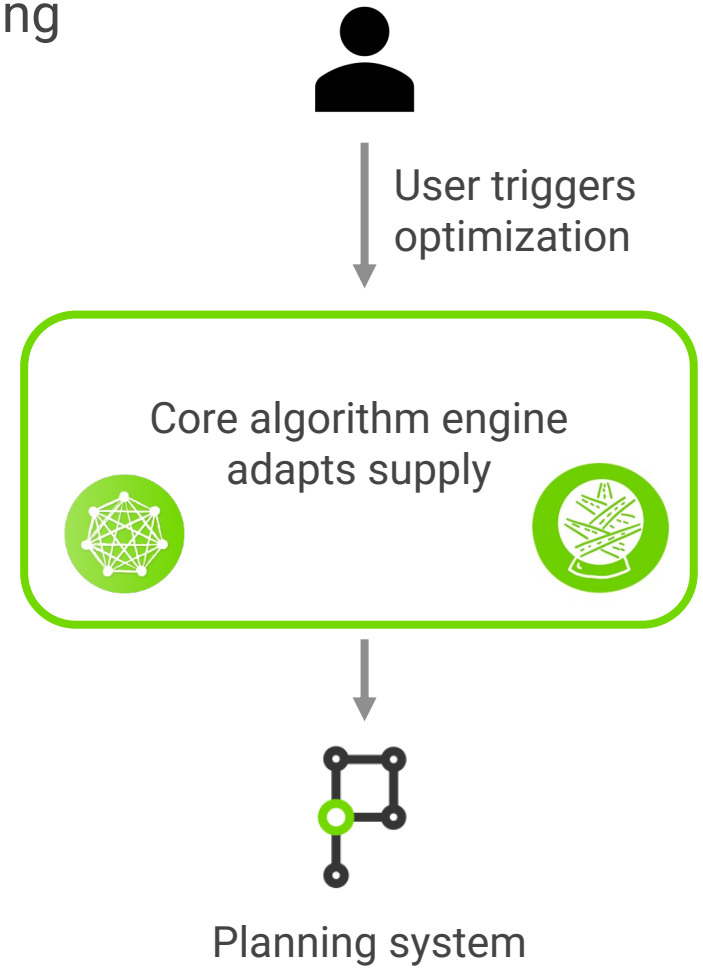
Dealing with supply-demand interdependency

Where methodological and software-architectural challenges meet

Software-architectural considerations pose a challenge to the ideal ways of modelling demand-supply interaction

Option 1 Fully embedded PAX and revenue (re-)forecasting

- \+ Methodologically sound
- \+ No coupling between systems in production
- − ML model and underlying data too complex
- − Dealing with versioning and releases

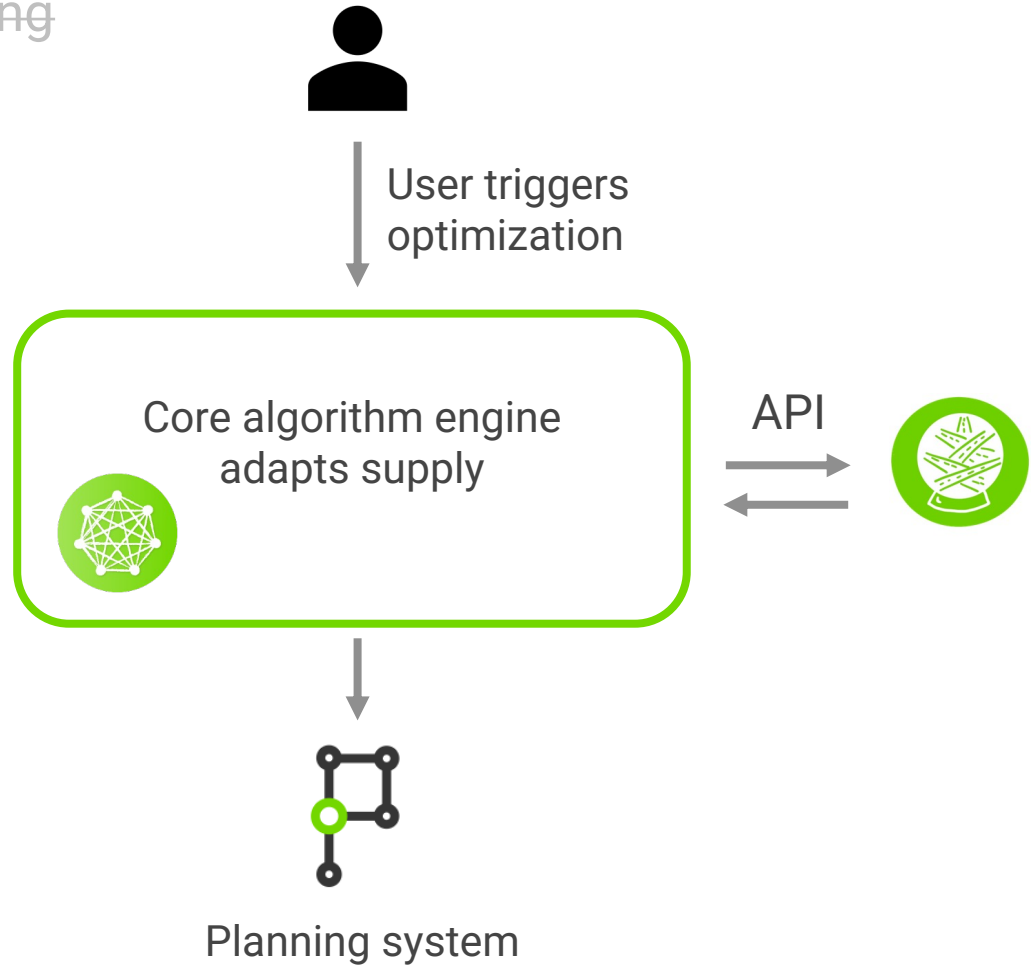


Software-architectural considerations pose a challenge to the ideal ways of modelling demand-supply interaction

~~*Option 1* Fully embedded PAX and revenue (re-)forecasting~~

Option 2 On-the-fly re-forecasting using API

- \+ Methodologically sound
- − Creates coupling between systems
- − Slows down algorithm iterations
- − High database cost for forecast

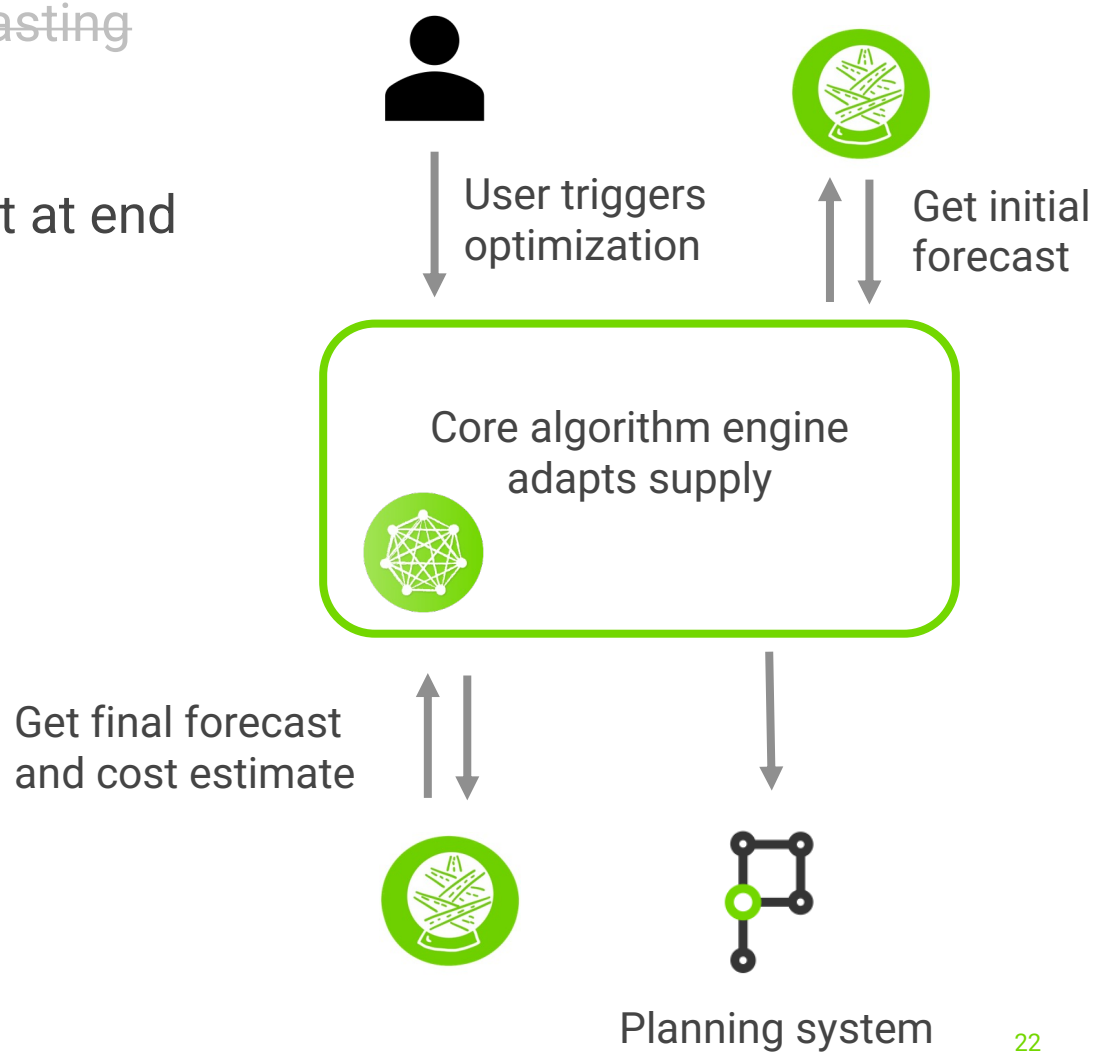


Software-architectural considerations pose a challenge to the ideal ways of modelling demand-supply interaction

~~*Option 1* Fully embedded PAX and revenue (re-)forecasting~~
~~*Option 2* On-the-fly re-forecasting using API~~

Option 3 Generate multiple solutions and call forecast at end

- \+ Limited technical coupling of systems
- \+ User gets to see consistent results
- − Optimization might go wrong direction
- − High database cost for forecast

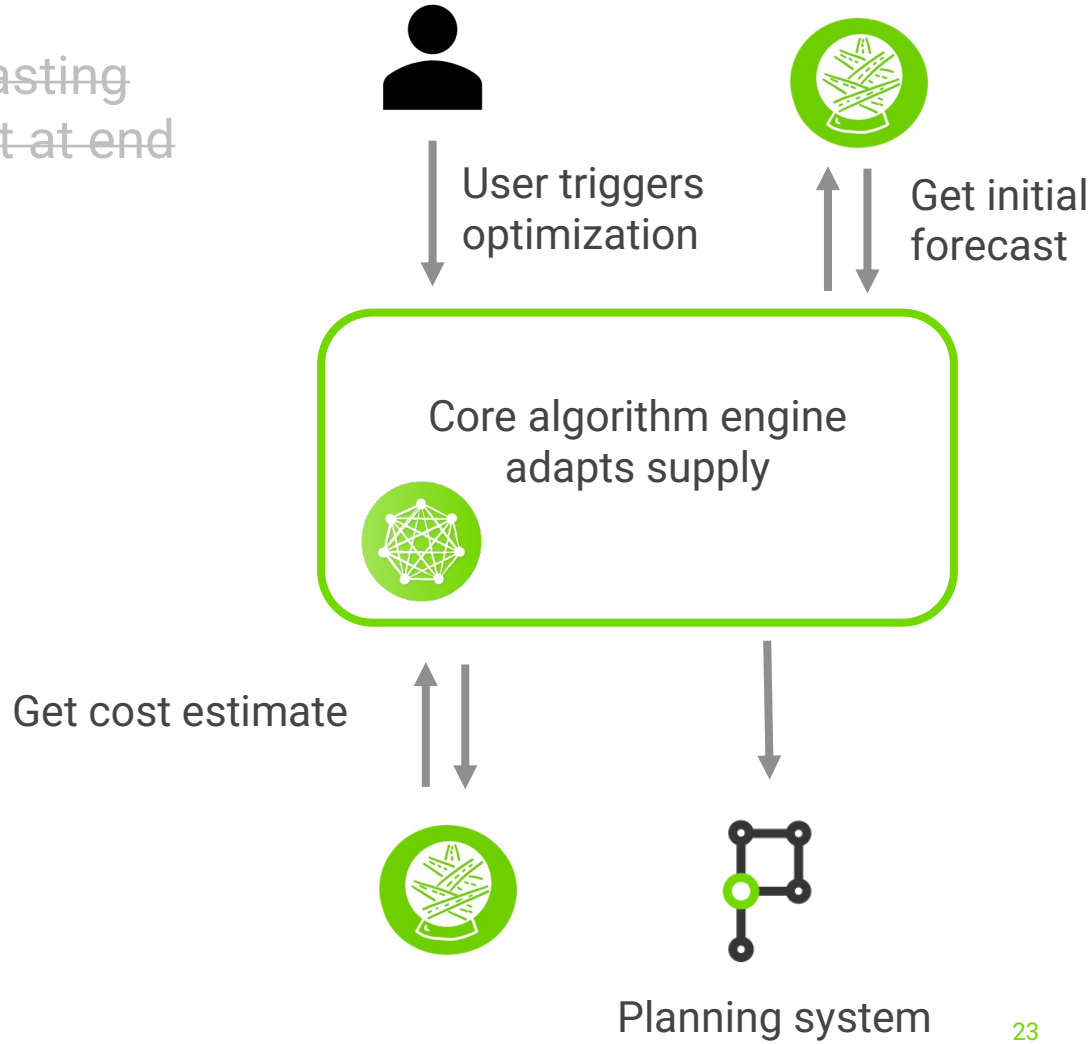


Revisiting the algorithm methodology leads to an acceptable solution from all perspectives

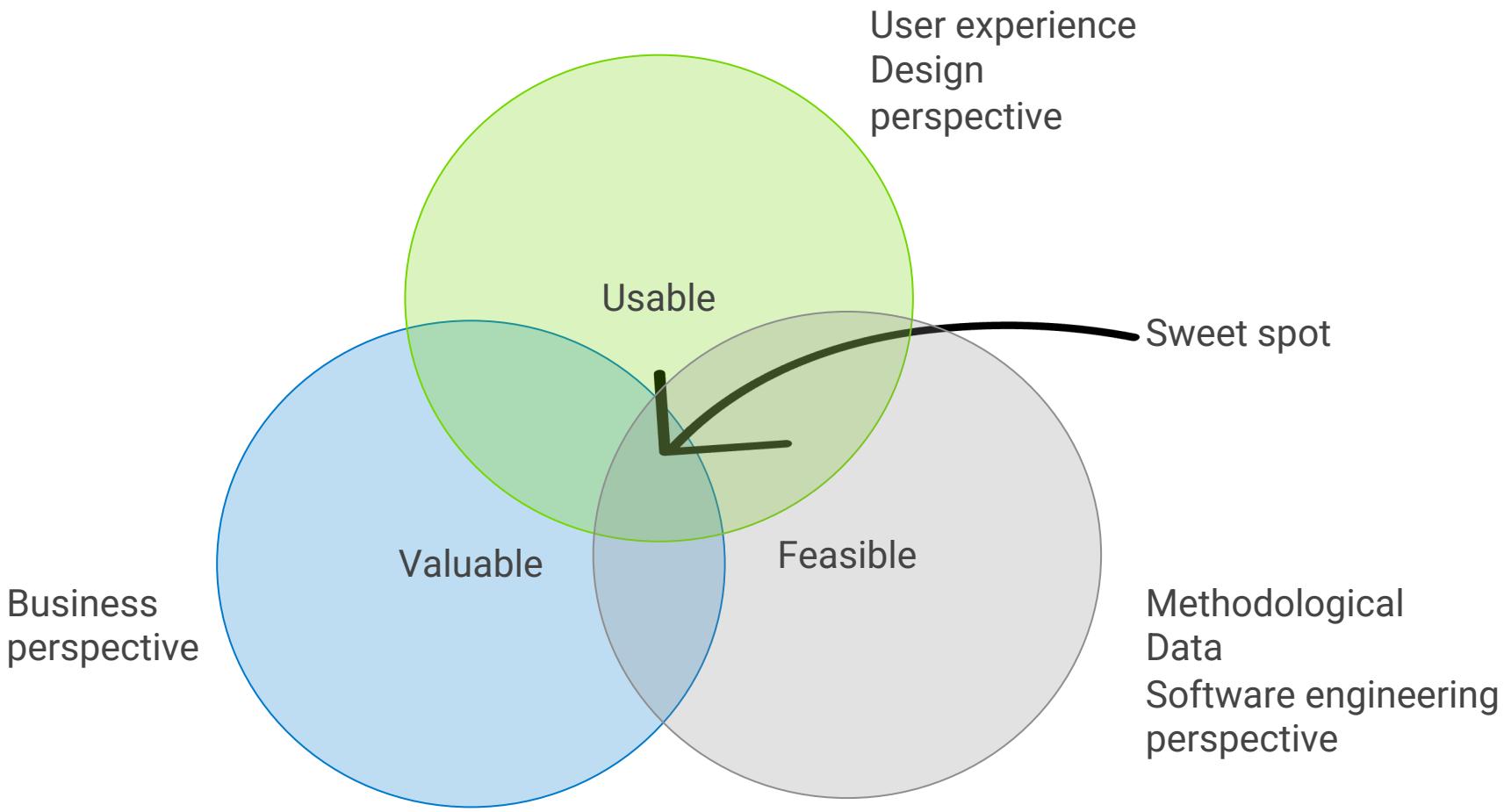
~~*Option 1* On-the-fly re-forecasting using API~~
~~*Option 2* Fully embedded PAX and revenue (re-)forecasting~~
~~*Option 3* Generate multiple solutions and call forecast at end~~

Option 4 Leverage how business plans to alter the algorithm methodology

- Limited technical coupling of systems
- Acceptable database cost
- Minor loss of optimization potential
- Users accept minor loss in consistency



After cracking the technical nut and understanding the business problem, we take a holistic view at final picture



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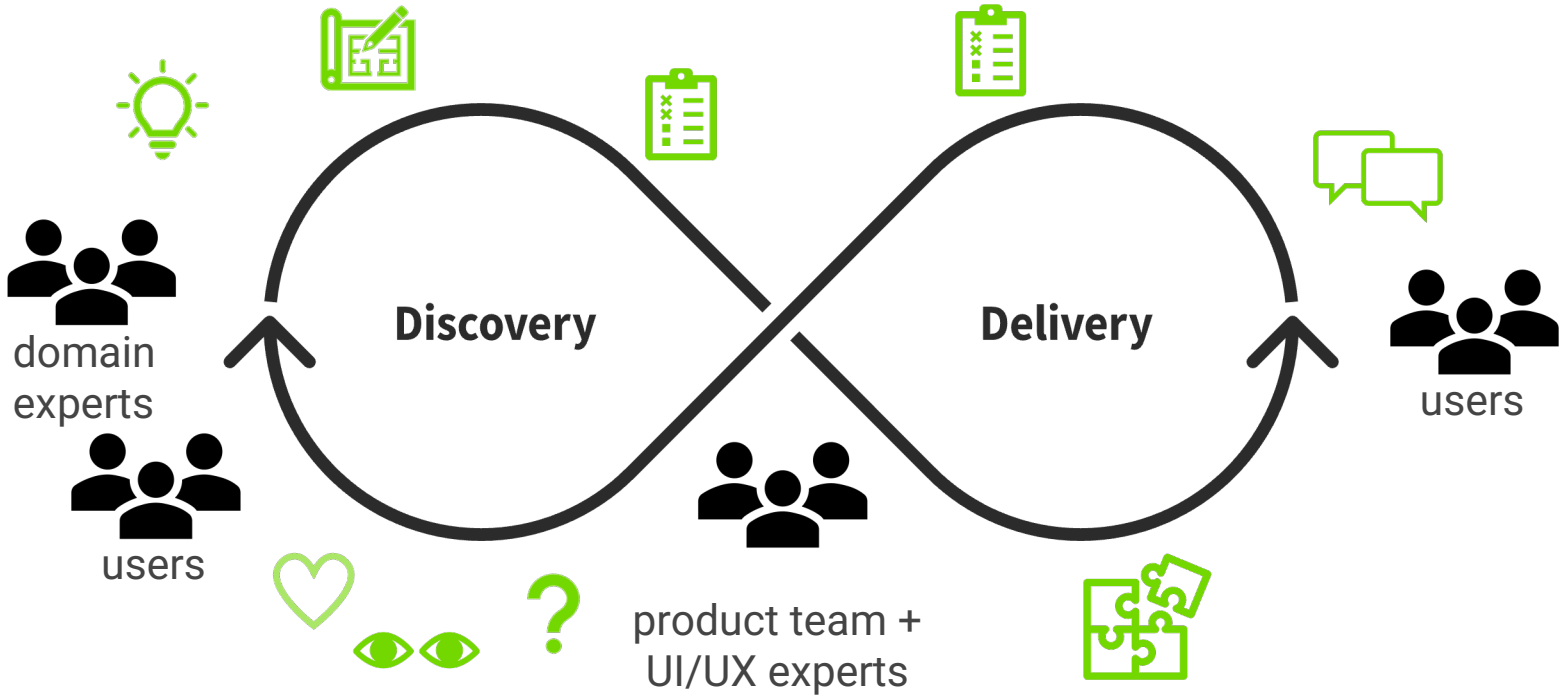
Iterative discovery and development

as key lever to deliver actual business value

Iterative product discovery and delivery cycles to continuously observe, learn, ideate and adapt our scope and ideas



Iterative product discovery and delivery cycles to continuously observe, learn, ideate and adapt our scope and ideas

User interviews

Focus on desirability and viability

- Current planning practice
- Pain points in existing process

Our market is mature. We know the holidays and have good past data, which helps us in defining supply levels.

I would want PlaNet to suggest some supply levels on its own, e.g. "you need X levels and they have to be used in these weeks'"

Iterative product discovery and delivery cycles to continuously observe, learn, ideate and adapt our scope and ideas

User interviews

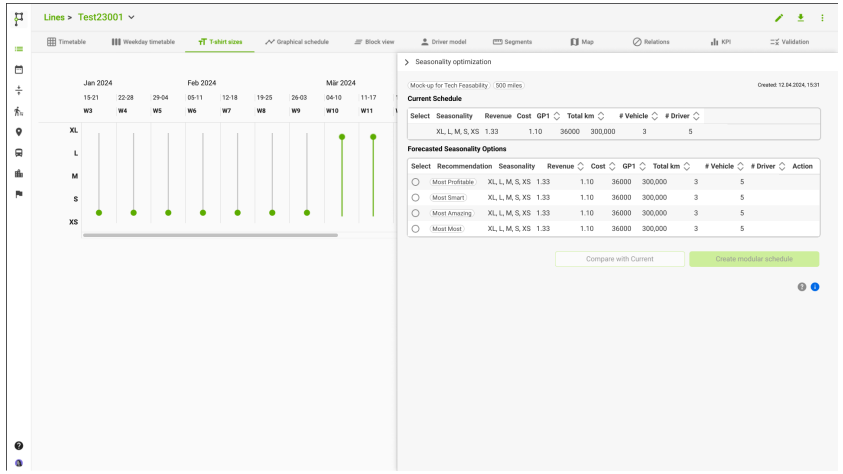
Usability testing

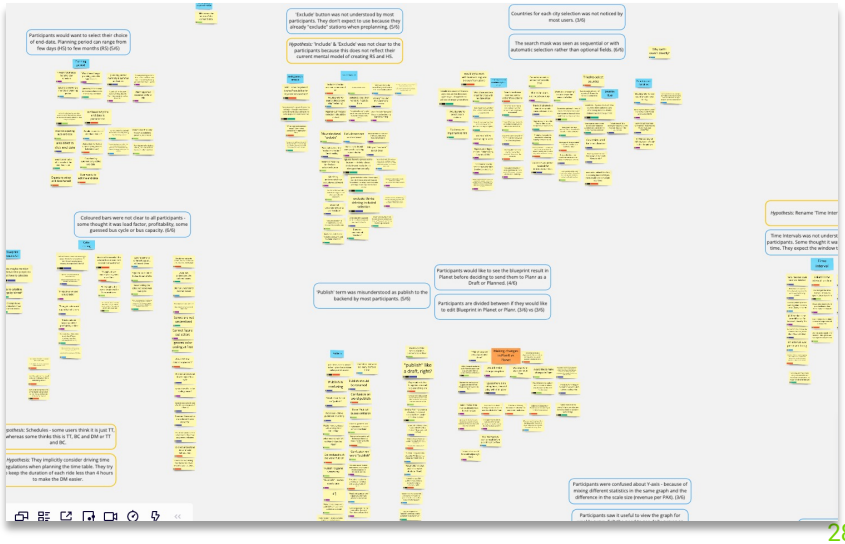
Focus on desirability and viability

- Current planning practice
- Pain points in existing process

Focus on usability and integration

- Integration in existing tool-scape and flow
- Which information does the user need?





If I like the KPIs of more than 1 option, I will select multiple options and create draft schedules in PlanR to compare.

Iterative product discovery and delivery cycles to continuously observe, learn, ideate and adapt our scope and ideas

User interviews

Focus on desirability and viability

- Current planning practice
- Pain points in existing process

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Focus on usability and integration

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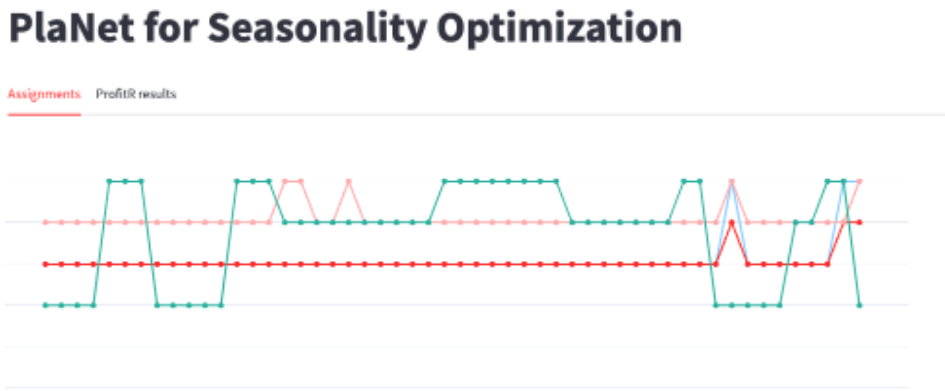
Algorithm testing

Focus on acceptability and usability at scale

- User feedback on algorithm results
- Result analysis with actual results



Key takeaways

Think beyond the silos
A business problem is not split between OR models for optimization and ML models for forecasting. We should rather focus on product scopes and shift boundaries so that they make sense.

Focus on de-risking
If data- or software-technical aspects are potential breaking points, then don't spend (too much) time on the algorithmic part yet.

OR in collaboration goes beyond analytical fields only
Building successful solutions requires a collaborative effort between operations research, data science, software engineering, design, product, and business.

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