Case study – Taking network forecasting accuracy to the next level during the COVID crisis

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Amadeus Airline Platform

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Speake Bios

Kaori Bray – Kaori is the Network Manager in Network Planning at Southwest Airlines, responsible for network forecasting and strategy. She has 16 years of airline experience including Network Planning, Revenue Management, Sales, and Marketing. Kaori has an MBA from Northwestern University and a BA from Osaka University. Prior to joining the airline industry, Kaori was a strategy consultant with Booz Allen Hamilton in Tokyo.

Lonny Hurwitz – Lonny is an Advisor in Network Planning at Southwest Airlines. His 26-year tenure at Southwest includes leadership and individual contributor roles in both operations and business planning. His primary focus centers on Network Planning's advancement in information management, enhancement of analytical abilities and optimization of the route network. Lonny earned a B.S. Degree in Aeronautics from Parks College of St. Louis University including over 250 hours of flight experience in single and multi-engine aircraft

Reza Baharnemati – Reza is Director of Product Management in Amadeus. He is responsible for SkyCAST and SkyPLAN products. In the past 10 years, he has been involved in the development of different products as part of Sky suite. Reza received his Ph.D. in Industrial Engineering from University of Houston.

Agenda

1) Southwest Airlines and overall industry challenges and pain points
2) Network forecasting process
3) How to tackle this challenge
   - Special COVID calibration
   - Special market size generation process
4) Example use cases
   - Effective capacity factor
   - Forecasting two capacity sets
   - Network forecast engine integration with Revenue Management system
5) Benefits
6) Lessons learned
7) Future enhancements and use cases

Airline and industry challenges and pain points

- Due to COVID related restrictions, air traffic is significantly impacted and not many are flying. How can airlines minimize their risk and maximize their revenue by investing in markets with highest rate of return?
  - Where do people want to fly?
  - How to react to dynamic nature of markets?

- In the middle of COVID, trying to improve network forecast accuracy while high quality data was not accessible
  - Could we use new data sources?
  - How to use incomplete data to calibrate the forecast tool?

Network forecasting process

How to accurately forecast the total airline network traffic, revenue, cost and profit?

Historical data

- Airline post departure data (traffic and fare)
- Industry traffic and fare data
- Host schedules
- Other airline schedules

Calibration engine

- Calibration of network builder parameters
- Simultaneous calibration of customer choice model coefficients and parameters
- Calibration of traffic model coefficients and parameters

Forecast engine

Data Processor

- Flight schedule for all airlines worldwide
- Codeshares and marketing relationships
- Static data

Network Builder

- Build valid itineraries for all O&D's worldwide including Nonstops, Thrus, Single Connects, Double connects, Interline, Codeshare

Demand Model

- Estimate unconstrained demand for all OD services

Traffic Model

- Run spill and recapture
- Estimate traffic for all OD services
- Estimate traffic and passenger mix for all flight legs

Revenue Model

- Estimate revenue (ancillary, cargo, mail) for all industry services and flight legs

Cost & Profit

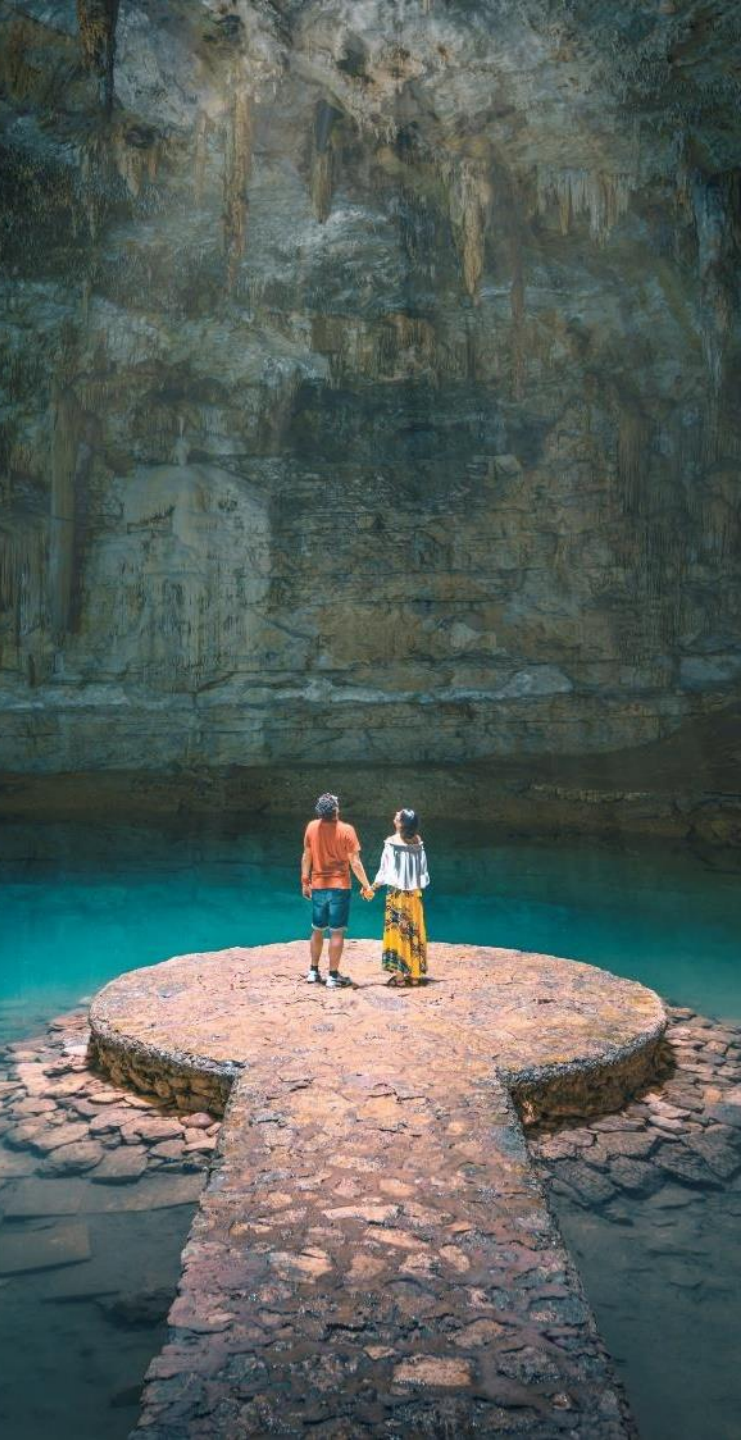
- Estimate cost allocation for all flight legs

How to tackle the airline’s challenge

Helping Planners model in a complex environment

Methodology options

Inputs	Option 1	Option 2	Option 3
Market sizes	**System wide adjustment model** a.k.a "The Haircut" • Simply reduce every O&D market by same chosen percentage • Extremely fast to adjust and easy to understand, but also prone to the most error, as markets are not consistently changing	CGMA traffic adjustment a.k.a. "COVID Adjustments" • Use current, future and historical data to train a decision tree model at the O&D Market Level • Steerable to system wide percentage choices	Individual Market Choices a.k.a. "Juicing Market Sizes" • The Planner individually changes a market size when all other options are unrealistic • Relies on Planner experience and knowledge not described in the model
Industry capacity	Effective Capacity Factor Adjustment • Does not adjust Industry Schedule • Uses Spill logic in the model as a proxy for airline's blocking middle seats • Can control by specific airline & equipment type	SSIM Replacement Schedules • Mix-n-match any airline, week of service, or SSIM file • Relatively easy to create • More realistic than forecasting with the uncut published schedule	SSIM Surgery • Manual adjustment to other airline's schedules • Extremely granular and time consuming • Model an extremely specific situation
Fare adjustment	System wide adjustment • Adjust fares as a percentage of historical industry fares • Quick and easy to understand & describe	CGMA with fare adjustment • Adjust revenue on an O&D level basis by using recent historical and current data	Revenue Management Fare forecast • In progress



Special COVID calibration process

1. Studied more recent actual data (various data sources) from different aspects and compared them with older historical data
2. Identified areas that forecast engine was lacking in generating accurate forecast
   - Due to changes in customer behavior, some factors of customer choice models such as service type, airline preference, time of week preference, etc. identified for partial calibration
3. Prepared required data for special calibration of the forecast engine
4. Partially calibrated the customer choice models and measured many KPIs to ensure the forecast engine outputs meet all acceptance criteria
5. Deployed new calibrated datasets to the production environment

Example of COVID calibration data input

Normal market size input data (Pre 2020)
MIDT / international traffic data source
Db1B
WN internal traffic data

Normal market size input data (COVID)
International traffic data source
WN internal traffic data

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Special market size generation process

Infusing machine learning into market size process

1. Amadeus worked with Southwest team and enhanced the existing market size generation process by incorporating some machine learning approaches to learn more from more recent actual data (2020) and predict future looking market sizes

2. Tested the quality of new market sizes by running forecast for the past few weeks and measuring accuracy KPIs and ensuring everything is in the acceptance range

3. Deploy the new market sizes to the production environment

High-level forecast with CGMA process

Running CGMA adjusted forecast is an iterative process

Forecast Round1: out-of-box (run most current schedule with 2019 market sizes)

The Forecasting process

Schedule/ Data Processor → Network Builder → Demand Model → Traffic Model → Revenue Model → Cost Model → Reporting and Analysis → Forecasted Itinerary data for WN

May use additional input override based on the analysis for:

- Industry schedule (different time range, or capacity discount)
- WN schedule

•WN booking data (June/20~ present)
•Non-WN MIDT data for the industry

→ CGMA 2.0 → CGMA O&D **passenger forecast**

→ CGMA **override market growth file** (for forecast round2)

CGMA process (internally built tool)

Forecast Round 2: run forecast with CGMA market growth file

The Forecasting process

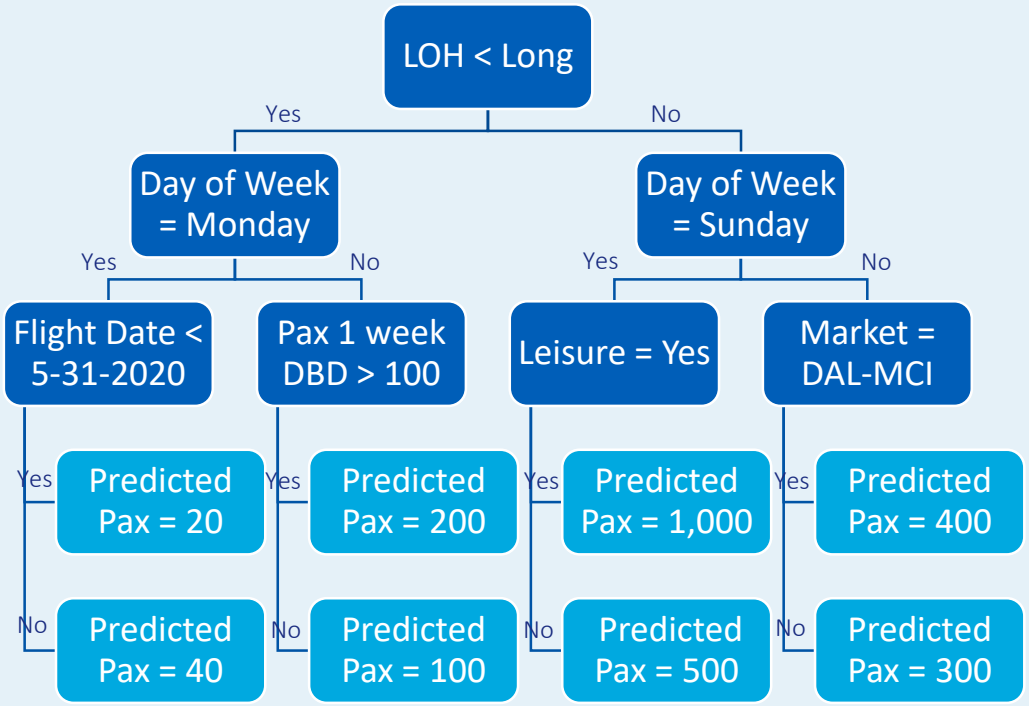
Schedule/ Data Processor → Network Builder → Demand Model → Traffic Model → Revenue Model → Cost Model → Reporting and Analysis → Forecasted flight and itinerary data for WN

If the output isn't realistic, rerun forecast

Estimating market size - CGMA model: decision tree

Breaking down a dataset into smaller subsets to make a final prediction

Abbreviated example
3-layer decision tree



Model details

Target variable: Actual O&D Passengers
Predictor variable examples:

- Day of week
- Airport regions
- Distance
- Business / leisure market designation

Algorithm: Rpart
Max tree depth: 20 nodes (layers)
Pruning: 10 fold cross validation

The core of the process is the machine learning decision tree model that learns how markets behave through training data to predict the test set.

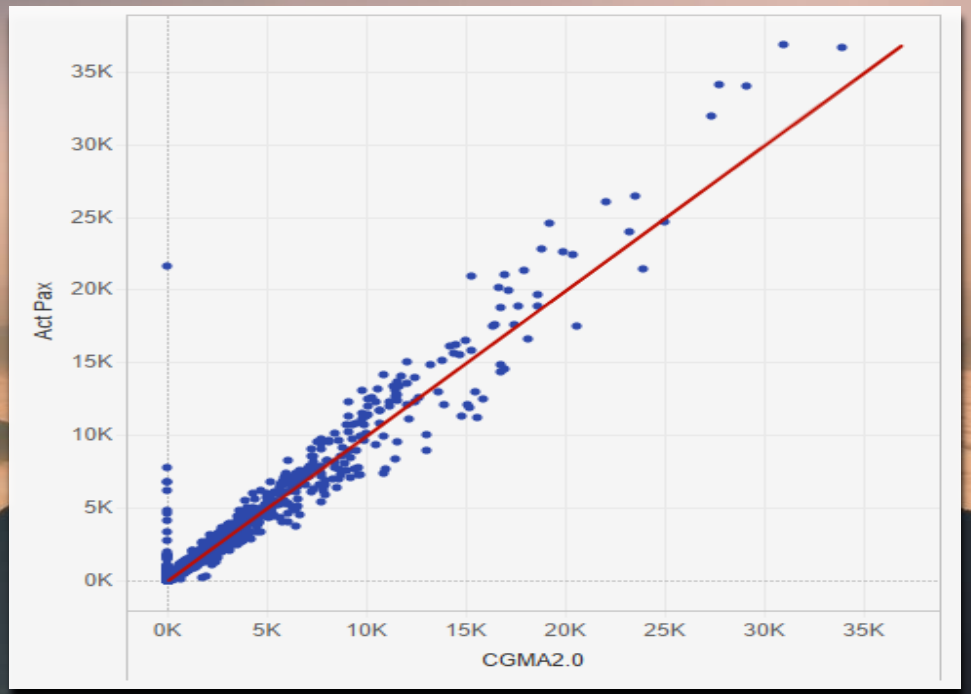
Measuring results and visualizations

Interactive scatterplots helped users to troubleshoot markets drastically out of line

Methods of measurement

- Comparing 3-months, 2-months, 1-month out forecast results to actual
- Historical forecast (backcasting)
- System, DOW, Flight and O&D level accuracy
- Planner knowledge, intuition & experience

CGMA 2.0 Forecast vs. Actual pax



Each dot represents a non-directional O&D market

Accuracy of COVID time forecast kept improving as Southwest and Amadeus Team continued the dialogue and fine-tuned the inputs, and the learnings are being invested as we develop the next version of forecast engine.

Example of use cases

Use case #1

Use of effective capacity factor to simulate social distancing

- Due to COVID-19, airlines applied some **restrictions with respect to selling middle seats**. To model this in the forecast engine, Southwest Airlines tried different approaches.
- Some approaches such as modifying schedule SSIM files and adjusting ACVs, using different aircraft configurations, or different aircraft seat files were tested and because of amount of time it took to setup the scenarios were set aside.
- Southwest Airlines **leveraged Effective Capacity feature** of the forecast engine to successfully block middle seats for the airlines that have practiced this strategy.
- In spill model, maximum number of sellable seats that are allocated to each flight leg is called effective capacity.

Effective capacity factor: tracking industry seat policy

Accurately modeling seat share by adjusting effective capacity factor in the spill model

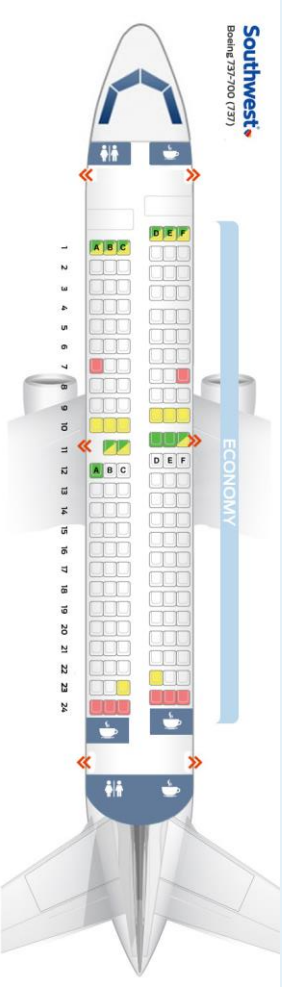
_ As Southwest implemented no middle seat policy, effective seats reduced by 35%

_ Some carriers had similar policy to block middle seats while others didn't

Example of middle seat policy for US carriers: 2020

Carrier	June	July	August	September	October	November	December
AA		na	na	na	na	na	na
AS	65%	65%	65%	65%	65%	65%	65%
B6	60%	60%	60%	60%	60%	70%	na
DL	60%	60%	60%	60%	75%	75%	75%
WN	65%	65%	65%	65%	65%	65%	na
UA	na	na	na	na	na	na	
F9	na	na	na	na	na	na	na
G4	na	na	na	na	na	na	na

Source: carrier press releases



Southwest
Boeing 737-700 (737)

Use case #2

Forecasting two capacity sets

- Due to COVID-19, airlines forced to **restructure their network and keep operating** in the markets that have highest profitability

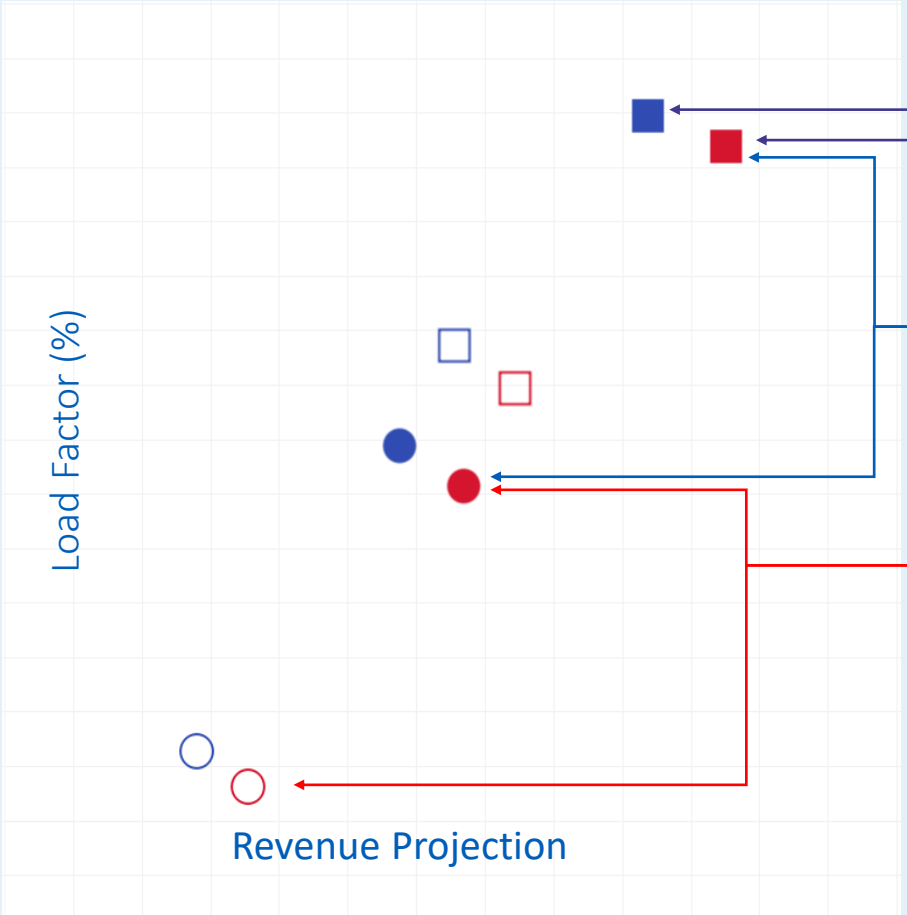
- **Identifying right capacity set with various uncertainties makes decision challenging**
  - Uncertainties of demand change at the last minute due to government restrictions and confidence in travel
  - Other airlines making schedule revisions very late

- **Southwest Airlines was able to create various scenarios to determine right capacity set** using the forecasting tool and pick ones that have lowest risk and highest rate of return
  - Adjusting industry capacity using various options
  - Adjusting market size recovery factor using RM booking data information

Understanding different forecast inputs

Forecasting tool illustrated the impact of our capacity choices compared to other factors

System-level forecast evaluation (illustrative)



Eight scenarios showed the relative impact of different assumptions

- Two different Southwest capacity sets slightly moves Load Factor and Revenue
- Forecasting using the industry's published schedule versus a more realistic proxy schedule made a huge difference in our expected results
- A ~10pp change in passenger recovery rate also made a huge difference in our expected results.

Legend				
Our Schedule	Low Capacity	**Blue**	High Capacity	**Red**
Industry SSIM	Published Schedule	● ○	Proxy Schedules	■ □
Market Recovery	Low Recovery	□ ○	High Recovery	■ ●

Use case #3

Network forecast engine integration with Revenue Management system

- Due to COVID-19, **airline changes their schedule as it is getting closer to departure day more dramatically**. Though Southwest Airlines was aware of their schedule changes, published OA schedules were not that reliable to be used in forecasting tools.
- **Southwest Airlines leveraged different techniques to create different possible scenarios** that published OA schedule may change far ahead of departure day and utilized the forecasting tool to do what-if analysis.
- **The forecasted results are shared with the RM system to align network planning decisions with RM system decision**. This was very important integration as the forecast tool used in the network planning department was more aware of industry schedule changes than the RM system.
- As a results, **Southwest Airlines were more robust with respect to possible future changes in OA schedules.**

Sharing data with revenue management

Building new ways to share data with each other

Network Planning

- Network Planning forecasts
  - By departure date for all published inventory
  - Flight Level ~4K flights per day
  - Itinerary Level ~50K+ itineraries per day
- Benefits to Revenue Management
  - Provides forecasted traffic estimates before we open inventory for sale so yield management Teams can prioritize key O&Ds
  - Gives visibility to local & flow strength
  - Revenue Management Estimates gain accuracy when booking curves are established

- Benefits to Network Planning
  - Close in schedule adjustments
  - Follow strong booking trends
  - Estimate fares more accurately
  - Shopping data uncovering excess demand
- Revenue Management provides
  - Booking data
  - Fare data
  - Shopping data

Revenue Management

The changes in this past year have increased our ability and need to adjust the schedule close in

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Benefits & lessons learned

Benefits

- **Evaluate multiple forecasting scenarios simultaneously with high accuracy**
  - Roll up to system level
  - Detailed at itinerary level

- **Ability to look at any industry schedule** vs. RM tools are more centred on the own airline bookings without this broader market view

- **Deployment within Network and Schedule Planning team and Financial planning and analysis department** – critical during 2020 as industry was keen on daily cash burn

Lessons learned

- Large magnitude change (like COVID) require a reset. We focused on immediate reality instead of long past records.
- Extensive time and collaboration from different teams within SWA and Amadeus were required to address this forecasting challenge.
- Agility and creativity were a key factors in the success of the network forecasting in Southwest, with Southwest and Amadeus teams working hand in hand.
- COVID crisis brought Network Planning and RM departments closer together:
  - Sharing their forecasts
  - Sharing itineraries that have flights
  - Changes were made much closer to operational window (as little as 30 days in the future vs. 200 days)

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Future envisaged enhancements and use cases

- Further collaboration with RM department
- Use of forecasting tool closer to operational window
- Use of potential new data sources (Shopping data)
- Use of live or near live data for automated calibration of forecasting tool
- Integration of AI into forecasting tool

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Thank you!

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