Operations Research at WestJet

Glen Phillips,
Senior Manager Operations Research (Ret)

Topics

- A Short Introduction to WestJet
- Our Corporate Strategy
- A Service Organization
- Problems and Issues

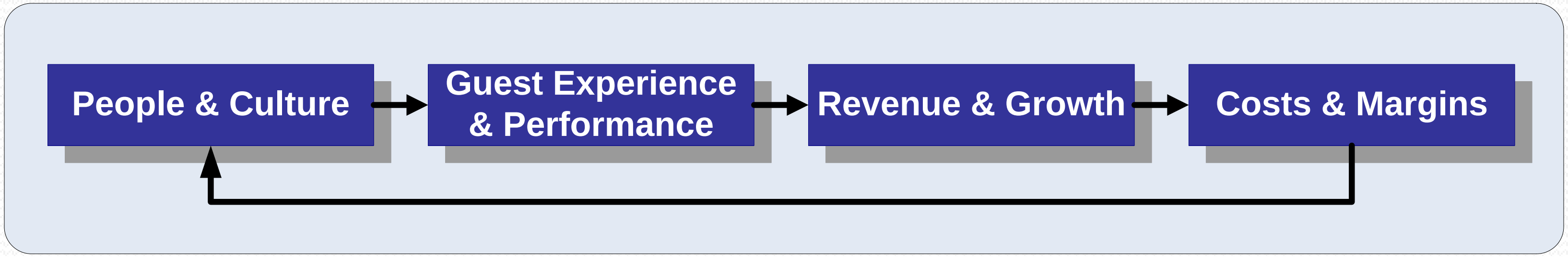
WestJet

- Founded in 1996
  - 3 aircraft
  - 5 cities in western Canada
  - 200 employees
- WestJet 2019
  - 126 Boeing 737 aircraft, 47 Bombardier Q400 aircraft and 4 Boeing 767 and 1 Boeing 787 Dreamliner
  - 104 cities in Canada, US, Mexico, the Caribbean and Europe
  - Over 12,000 employees
  - 2018 Full Year revenue over $4.7 Billion

Corporate Strategy

Our strategic plan is built on four pillars that will drive long-term success:

- People and Culture
- Guest Experience & Performance
- Revenue & Growth
- Margins & Costs



The Operations Research Team

- Our Mission:
  - To assist management in making complex business decisions by:
    - Providing complex, quantitative analysis
    - Identifying options and recommendations
    - Reducing risk
    - Improve the quality of recurring decisions
    - Adding value to the organization

The Operations Research Team

- Areas of expertise:
  - Optimization
  - Simulation
  - Statistical analysis
  - Revenue Management
- Approach:
  - In partnership with management to identify and prioritize issues
  - Focus on business impact
  - Build an objective, quantitative framework for analysis
  - Transfer technology


Competitive Advantage
What's the best that can happen?
Optimization
What will happen next?
Predictive Modeling
What if these trends continue?
Forecasting
Why is this happening?
Statistical Analysis
Alerts
What actions are needed?
Query Drilldown
Where exactly is the problem?
Ad hoc Reports
How many, how often, where?
Std. Reports
What happened?
Degree of Complexity
Operations Research Domain

Analytics Examples

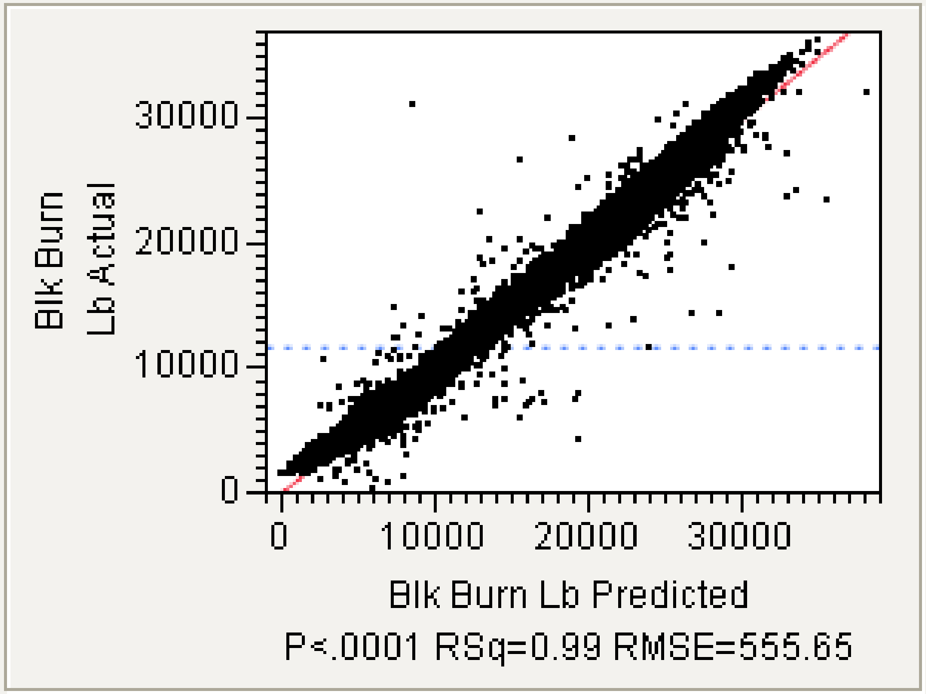
- Fuel Consumption Forecasting
- Airport Check-in Layout
- Customer Service Agent Scheduling
- Network Operations

Fuel Consumption Model

- A regression model has been built for fuel consumption
- Burn consumption is determined by the following 3 factors:
  - Aircraft Zero Fuel Weight
  - Fuel on Board
  - Block Burn minutes

Model Results

Actual by Predicted Plot



Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-7797.612	31.97948	-243.8	<.0001*
Blk Burn Mins	69.900272	0.062687	1115.1	<.0001*
ACARS FOB Fuel Lb	0.1373928	0.00075	183.29	<.0001*
ZFW Lb	0.0587773	0.000291	201.77	<.0001*

Observations (or Sum Wgts)	107204

Separate models were built for Each of the 600, 700 and 800 series

2016 Schedule

- The calculated burn rate (Litres per Hour) for each series is:
  - 737-600: 2,572
  - 737-700: 2,678
  - 737-800: 3,057

Conclusion

- Changes to the aircraft configurations (IFE for example) will impact the overall weight of the aircraft.
- We will see an upward drift in the system burn rate due to the composition of the fleet shifting towards the 800s and away from the 700s

Airport Check-in Layout

- Nobody likes waiting in line and the less time the better
- Staffing check-in counters is expensive
- Study Mandate: Redesign the check-in service delivery system
- Objective: Make the check-in experience better by reducing the time it takes and do it at a lower cost!

Proposed Changes

- Introduce a self-serve kiosk that allows a guest to check-in, select their seat, indicate the number of bags they are checking print their boarding pass and drop off their bags.
- Did not involve the elimination of the full-service counter

Questions

- How many kiosks should be installed?
- How many bag drop stations should be installed?
- How many CSA should remain on the counters?
- How would the total time required to check-in change?
- How would costs change?
- What are the impacts on future growth?

Modeling Process

- Study definition
  - Prior to any analysis taking place we had to meet with the various stakeholders to identify the scope of the project, what the deliverables were, define what was in scope and what was out of scope and set the timelines for completion
- Model definition
  - Simulation was identified as the tool to be used to conduct the study
  - A initial model was constructed in order to identify the data requirements for the study

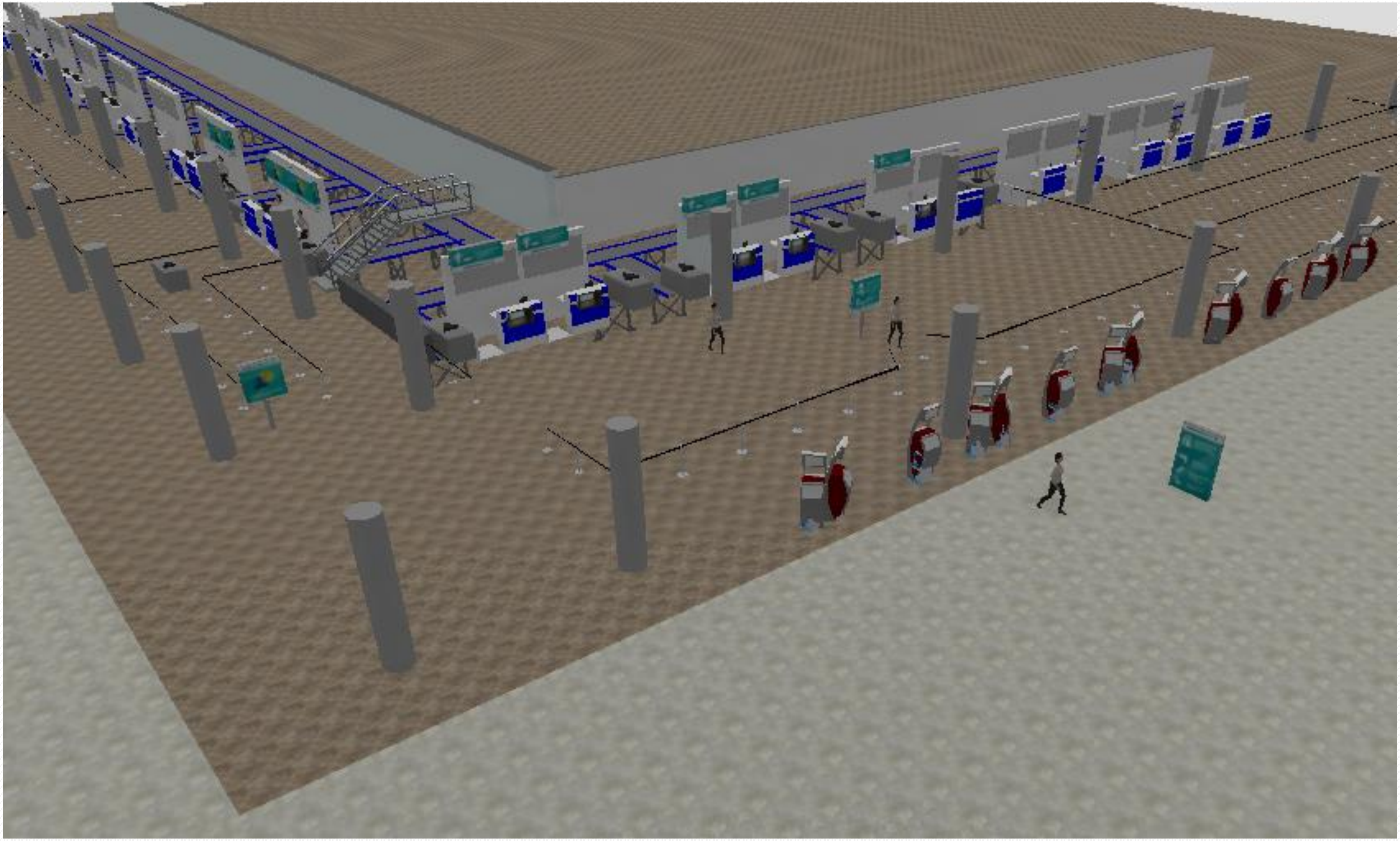
Modeling Process

- Data collection
  - Using the initial model, time studies were setup to determine the time required to complete each of the steps in the process (as well as the variability of these times)
  - These observed timings were then fitted to theoretical distributions.

Modeling Process

- Model Validation
  - Using the data collected, the model was tested to ensure that when the original configuration was run the model output closely reflected the actual system performance

YUL Layout

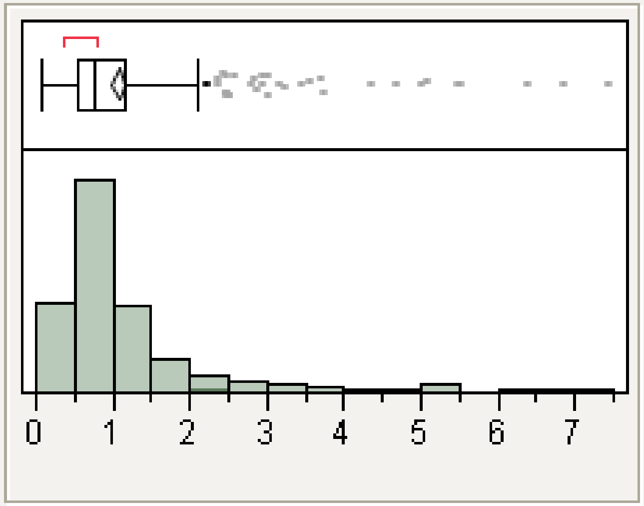


YHZ Layout

Time per bag

Distributions

Time per bag



Quantiles

100.0%	maximum	7.4101
99.5%		6.93272
97.5%		4.12507
90.0%		1.96256
75.0%	quartile	1.17633
50.0%	median	0.75293
25.0%	quartile	0.54855
10.0%		0.43044
2.5%		0.31157
0.5%		0.22522
0.0%	minimum	0.06805

Moments

Mean	1.0728898
Std Dev	0.9701854
Std Err Mean	0.0502343
Upper 95% Mean	1.1716686
Lower 95% Mean	0.974111
N	373

Time By Number of Bags Per Guest

	Element	Number of Bags	N Rows	Median(Normal Time)	N(Element)
1	Assistance	1	7	2.4683833333	7
2	Assistance	2	3	2.84555	3
3	Assistance	3	3	1.45135	3
4	Kiosk Bag Tag	1	25	2.4524833333	25
5	Kiosk Bag Tag	2	17	3.4309333333	17
6	Kiosk Bag Tag	3	8	4.3442416667	8
7	Kiosk Bag Tag	4	1	4.2009166667	1
8	Kiosk Bag Tag	5	3	6.78285	3
9	Self Serve Activation	1	171	0.7212833333	171
10	Self Serve Activation	2	94	1.291075	94
11	Self Serve Activation	3	25	1.75445	25
12	Self Serve Activation	4	13	2.7218166667	13
13	Self Serve Activation	5	2	2.70945	2

YHZ Configuration

- The objectives are to have:
  - No wait time at the kiosks,
  - No wait time at the bag drops
  - No (minimal) wait time at counters
- Number of Service Counters – 3
- Number of Bag Drop Stations – 5
- Number of Self-Serve Kiosks – 10

YHZ Results – Counter 3

Category	Data Item	Statistic Type	Average	Minimum	Maximum	Standard Deviation
Content	Number In Station	Average	0.17	0.01	0.46	0.08
Entry Queue	Number Waiting	Average	0.04	-	0.22	0.04
Entry Queue	Time Waiting	Average (Minutes)	0.73	-	4.39	0.77
Holding Time	Time In Station	Average (Minutes)	3.70	1.19	8.95	1.38

YHZ Results – Bag Drop 333

Category	Data Item	Statistic Type	Average	Minimum	Maximum	Standard Deviation
Content	Number In Station	Average	0.39	0.29	0.51	0.04
Entry Queue	Number Waiting	Average	-	-	-	-
Entry Queue	Time Waiting	Average (Minutes)	-	-	-	-
Holding Time	Time In Station	Average (Minutes)	1.29	0.96	1.84	0.13

YHZ Results – Kiosk 340

Category	Data Item	Statistic Type	Average	Minimum	Maximum	Standard Deviation
Content	Number In Station	Average	0.34	0.20	0.50	0.05
Entry Queue	Number Waiting	Average	-	-	-	-
Entry Queue	Time Waiting	Average (Minutes)	-	-	-	-
Holding Time	Time In Station	Average (Minutes)	3.61	2.43	5.42	0.48

YHZ Results – Guest

Category	Data Item	Statistic Type	Average	Minimum	Maximum	Standard Deviation
Content	Number In System	Average	14.54	10.03	22.26	2.23
Flow Time	Time In system	Average (Minutes)	9.75	7.53	13.58	1.07

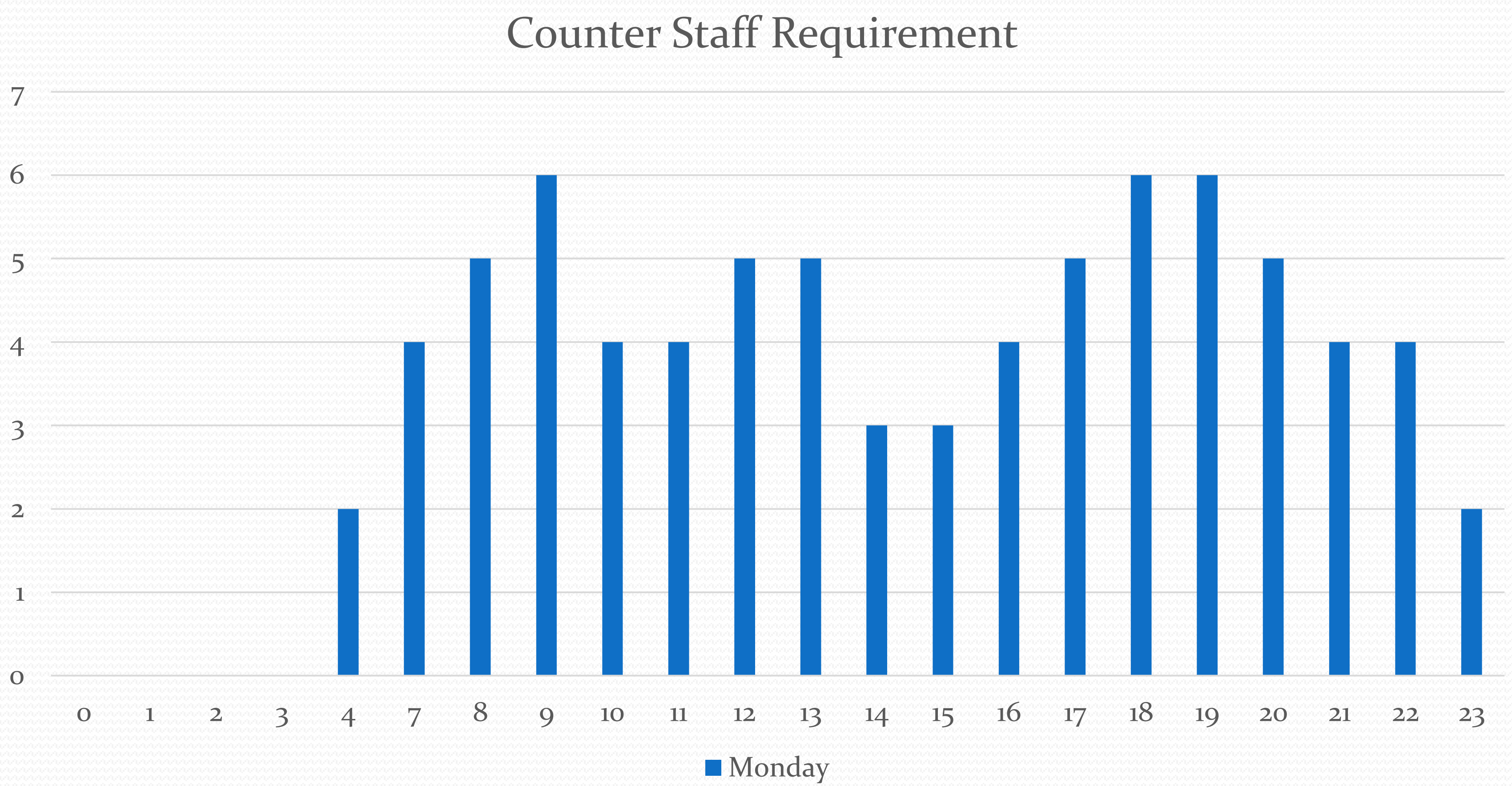
Airport Staff Scheduling

- Once the required resourcing has been determined we need to staff these requirements
- This is a 2-step process:
  - Step one involves creating shifts that will be worked
  - Step two then assigns these shifts to individual workers

Shift Creation – Conceptual Approach

- The creation of workable shifts involves fitting the fewest possible "legal" shifts into the resource requirement.
- Legal shifts are shifts that meet all of the mandatory labour requirements as well as all agreed to work rules
- Examples:
  - The standard shift is 8 hours, excess hours are paid at 1.5x
  - No shift is longer than 10 hours
  - No shift is shorter than 4 hours
  - Shift lengths of 5 hours or more must include a ½ hour lunch break
- Commercial LP software is used.

Resource Requirement Profile



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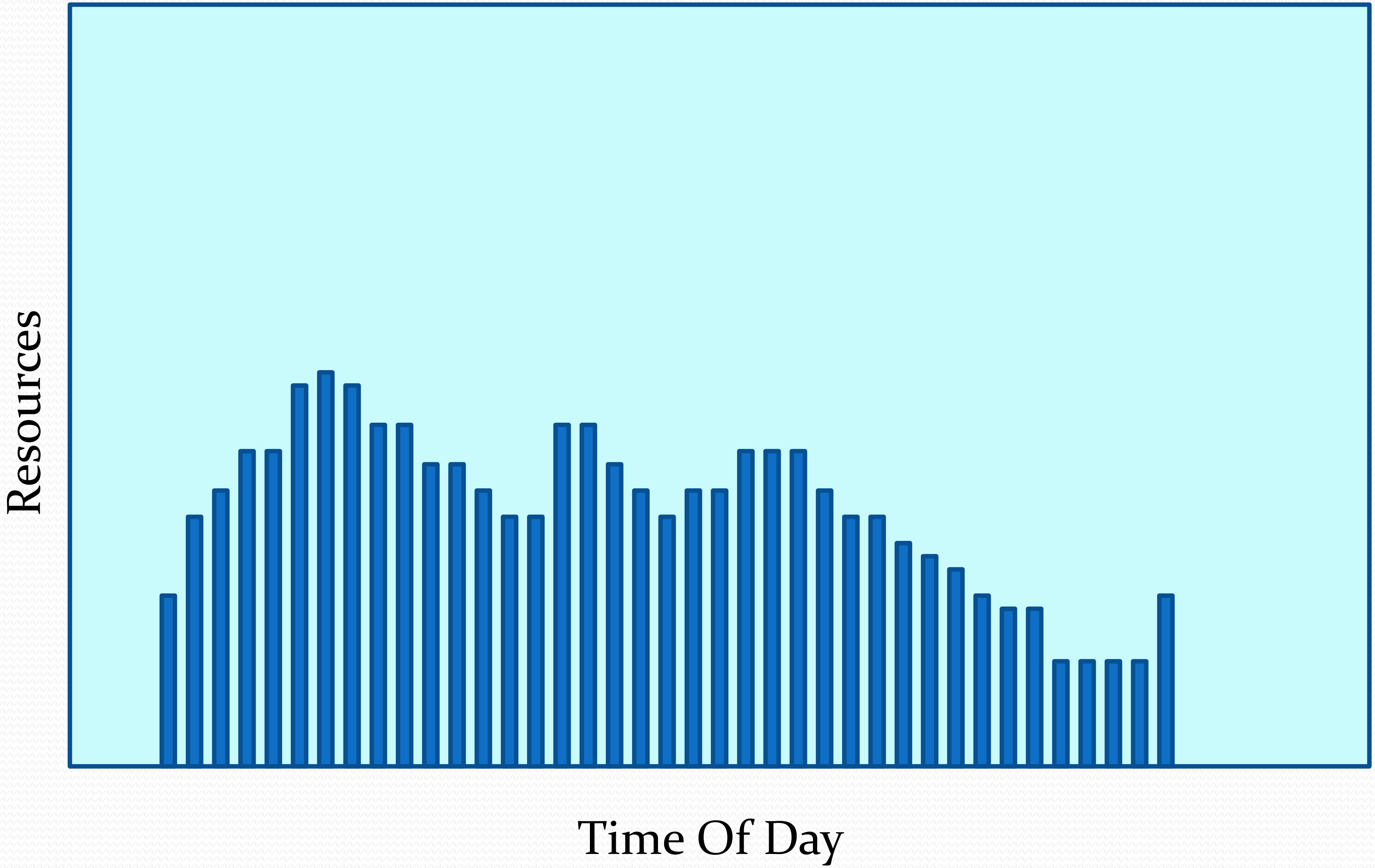

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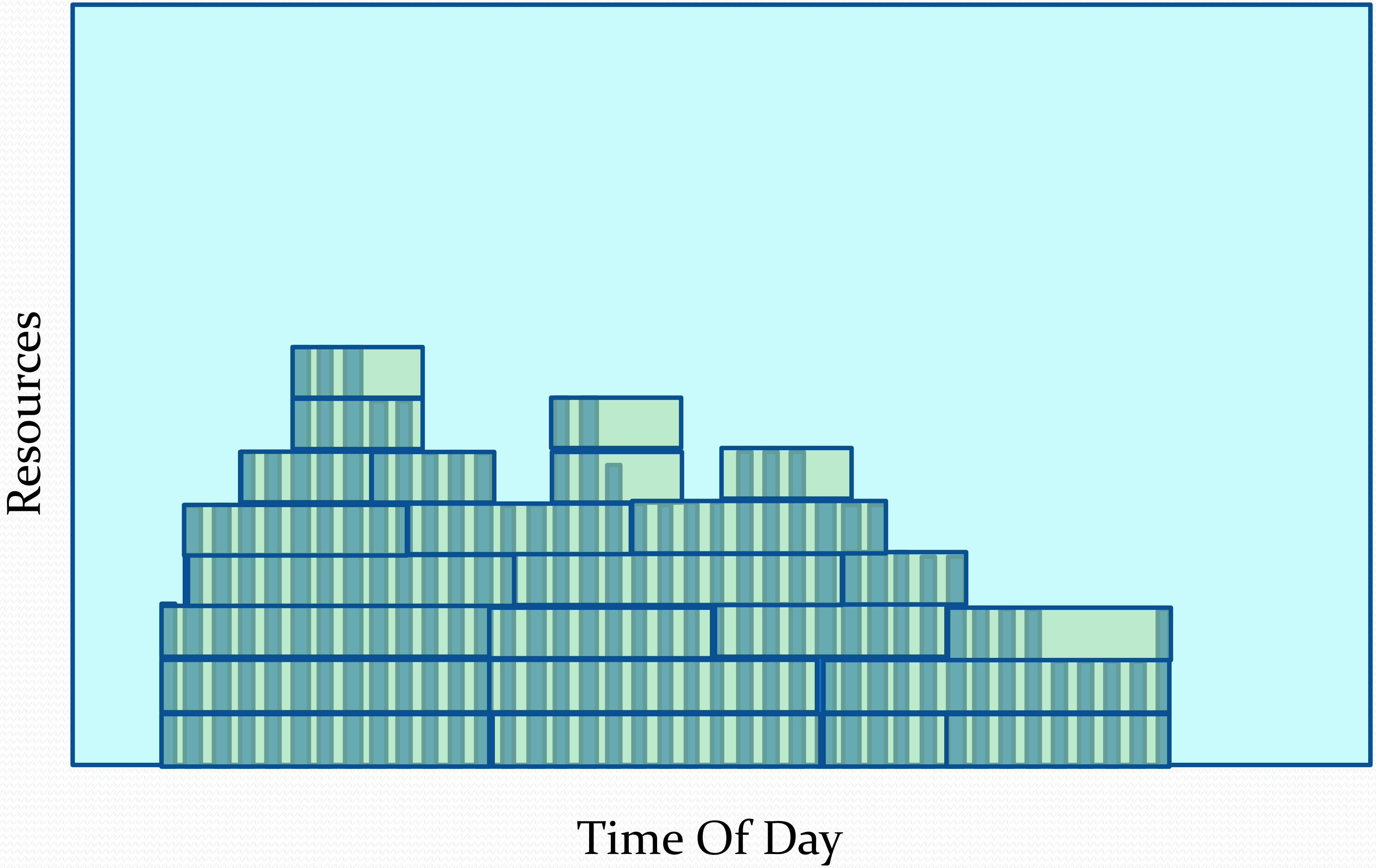


Bundling into Shifts

- Individual workday blocks are combined into shifts
- Each shift must:
  - Comply with all work rules
  - Offer consistency from day to day
  - Recognize resource availability restrictions
- The number of shifts created must equal the number of staff that will be bidding on the shifts
  - This may create a need for "on-call" shifts, training shifts, etc
- The output of this phase is a list of shifts that will be offered to the workforce

Shift Assignment

- Once the shift description list has been created it is published out to the workforce.
- Each member of the workforce is then invited to rank the shifts in order of desirability
  - Some staff may only want day time shifts that are roughly similar to a traditional 9-5
  - Others may want only evening shifts
  - Part-timers may only want evenings and weekends
- We then had a list of X shifts and we had X employees' ranks

Shift Assignment – Old Method

- When a WestJetter entered that work group they were assigned to a bidding bin
- For each bid period the order of bid consideration was rotated
- Bids were ranked within their bin in the order that they were received
- Once all of the bids were received an analyst would work through each bin assigning the most desirable unassigned shift. This continued until all shifts were assigned

Shift Assignment – Old Method

- Under this method:
  - 2 analysts took 2 days to complete the process
  - On average people were getting assigned their 9^{th} preference
  - The lowest assigned preference was the 39^{th} choice

Shift Assignment – New Method

- The new approach was to combine all of the preferences into a single list
- This and the shift list were then input into a simple LP model
- There are two square matrices with the dimension equal to the number of WestJetters (and shifts)
- The rows represent the shifts and the columns the WestJetters
- Matrix P gives the preference ranks
- Matrix X is binary where 0 is unassigned and 1 is assigned

Shift Assignment – New Method

- The objective function becomes:
- Min $\sum_{i=1}^{n}\sum_{j=1}^{n} P_{ij}X_{ij}$
- s.t. Each shift must be assign once and only once

$\sum_{i=1}^{n} P_{ij}$ = 1 for each j

Each WestJetter must be assigned one and only one shift

$\sum_{j=1}^{n} Pij = 1 \; for \; each \; i$

Shift Assignment – New Method

- Under this method:
  - 1 analysts took ¼ days to complete the process
  - On average people were getting assigned their 4th preference
  - The lowest assigned preference was the 13th choice
- The new approach was thus faster and far more equitable

Network Operations / Schedule Planning

- Corporate Objective: Achieve better than 85% OTP
- Network Operations Performance Team (NOPT) was formed to ensure that we achieve the target
- As part of the NOPT, the O/R department was tasked with the task of evaluating various proposed changes to our schedule and their impacts on OTP
- Simulation was used as the evaluation tool

Approach to Modelling

- In building a model of this system it was important to identify what we want out of it – in others words:
  - What questions will it help us answer?
- The primary use of the model was determined to be an analysis of our On-Time Performance
- Our statistics of interest are the D0 and A15 metrics (including head start subsets)
- If we were able to execute the schedule exactly as planned, then all flights would depart on time and arrive on time thus our D0/A15 would be 100%
- Since our operations do not go exactly as planned sources of variability were identified

Approach to Modelling (cont.)

- It was decided that for the purposes of the model, the schedule that we would use would be the planned schedule.
- No effort would be made to incorporate day-of considerations (including decisions such as tail swaps.)
- The model would not incorporate "extreme" situations such as an aircraft "going mechanical", airport closures or severe weather events.

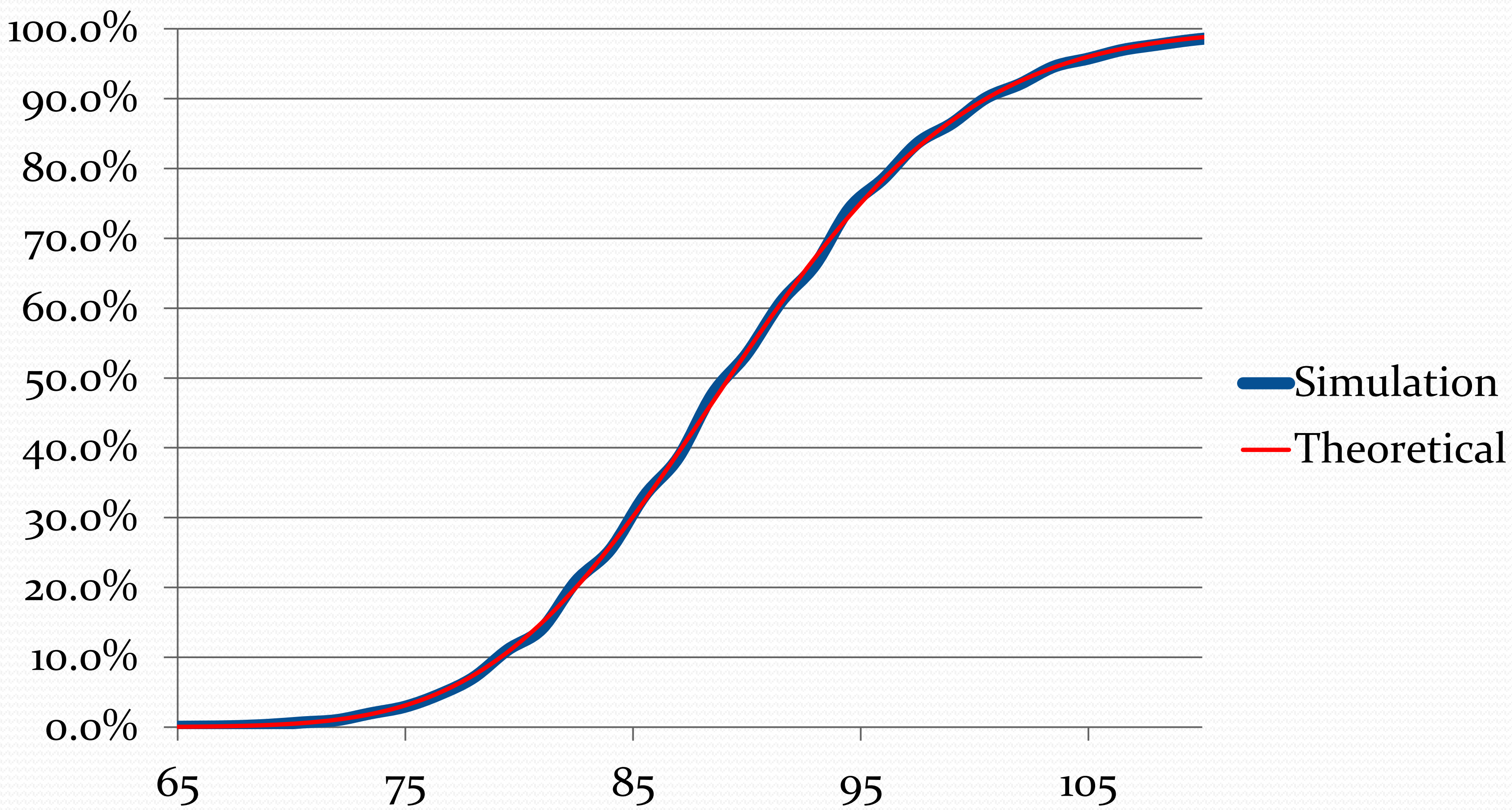
Model Formulation

- Once we've decided what we want the model to address, then next step in the process is to identify how we are going to formulate the model.
- The approach the was selected is Monte Carlo simulation.
- Using simulation will allow us to quickly and easily incorporate historical data
- It will allow us to make many different types of changes including:
  - Network structure
  - Scheduling parameters
  - Operating rules

Areas of Variability

- There are two main areas where variability is introduced into the operation of the system
  - Block times
  - Turn times
- Each of these areas can incorporate several sources of this variability including factors such as weather, loads, mechanical issues, etc

YYC-YVR 737-700 Blocktimes Theoretical vs Simulation



Based on 5,200 Simulation Trials

Schedule

- A 1 week schedule is used for the simulation
  - This allows for 1 complete “cycle” of the schedule
- Tails are linked so that lines of flying are maintained (no swaps)
- All scheduled departure and arrival times are expressed in Zulu time

Assumptions

- Aircraft depart at the later of the scheduled departure time or when the aircraft is ready
- No departure is held for late guests
- Crew are assumed to always be available
- No aircraft ever "goes mechanical"
- Holds such as de-icing or ATC are assumed to be part of the block time distribution
- Turns and blocks are assumed to NOT be responsive to network conditions
  - i.e. turns are not executed faster if the plane is running late.

Running the Simulation

- The simulation model is run a minimum of 100 times (and as many as 1,000 times)
- All of the results are aggregated into a single profile
- We end up with at least 500,000 total flights from which to draw conclusions
- These results will tend to be “typical” for any given week.

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Outputs

- We can examine any delay distribution
  - System, aircraft type, station, arrivals, departures, etc.
- We can answer the questions:
  - What should we expect the A15 performance to be next winter?
  - What will be our worst performing flight?
  - How will our head starts perform?

Uses

- The most interesting part is when we start to look at ways to improve the network OTP
- What would our OTP be if we added 5 minutes to all Tier 1 station turns?
- How would our OTP be impacted if we flew the Q400s slightly slower?
- What would happen to our OTP if we added 10 minutes to the middle turn in a long line of flying?
- What if we added 5 minutes to all turns immediately following a YYZ head start.