



# Airline Maintenance Schedule Optimization





# Introduction



F-2428



Preventive Maintenance –  
As late as possible

Repair Defects – As soon  
as possible



# Problem Description

Ground Times

Block Times





## Problem - Hardness

- Matching task duration with a ground time
- Limited resources to perform tasks in an airport
- Assigning FIN Number to ground time
- Optimize yield remaining

Yield Remaining – Time until due date



## Data

### Ground times –

Flight Date	Fleet Type	Departing Station	Inbound Arrival Local Time	Ground Minutes
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### Maintenance Tasks –

Fleet Type	DUE_DATE	MAN_HOURS_VALUE
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### Defect Repairs –

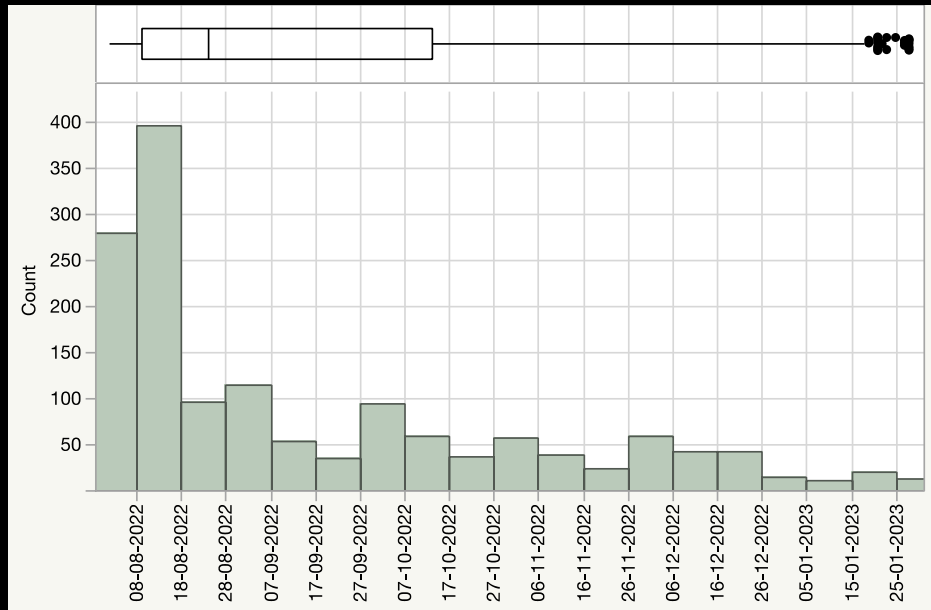
Fleet Type	DEFECT_TYPE	DEFECT_ITEM	PLAN_PROJECTED_DUE_DATE	MAN_HOURS_VALUE
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### Resource Availability –

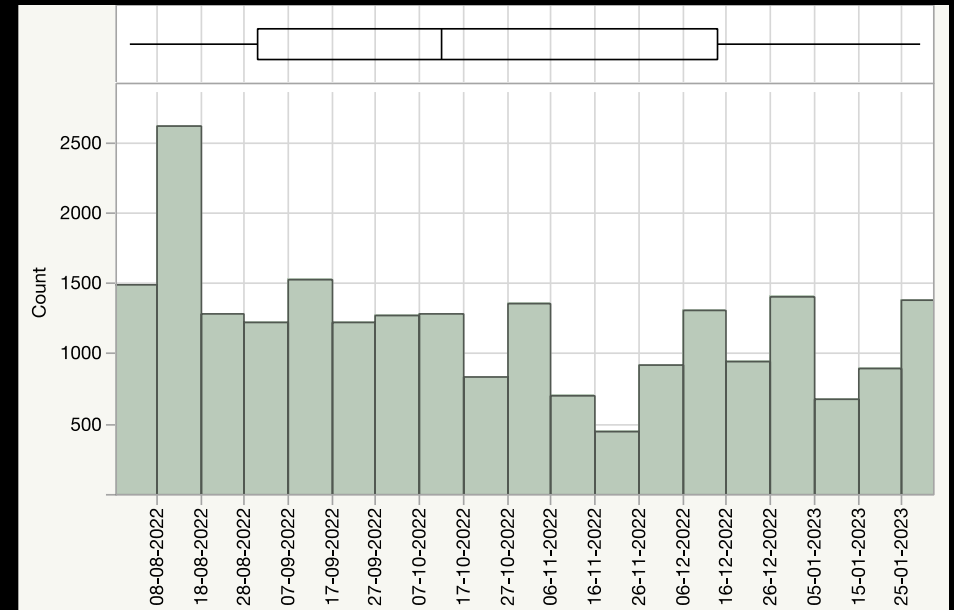
Month	Cycle	Location	Fleet	Headcount
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# Data Analysis – Due Dates



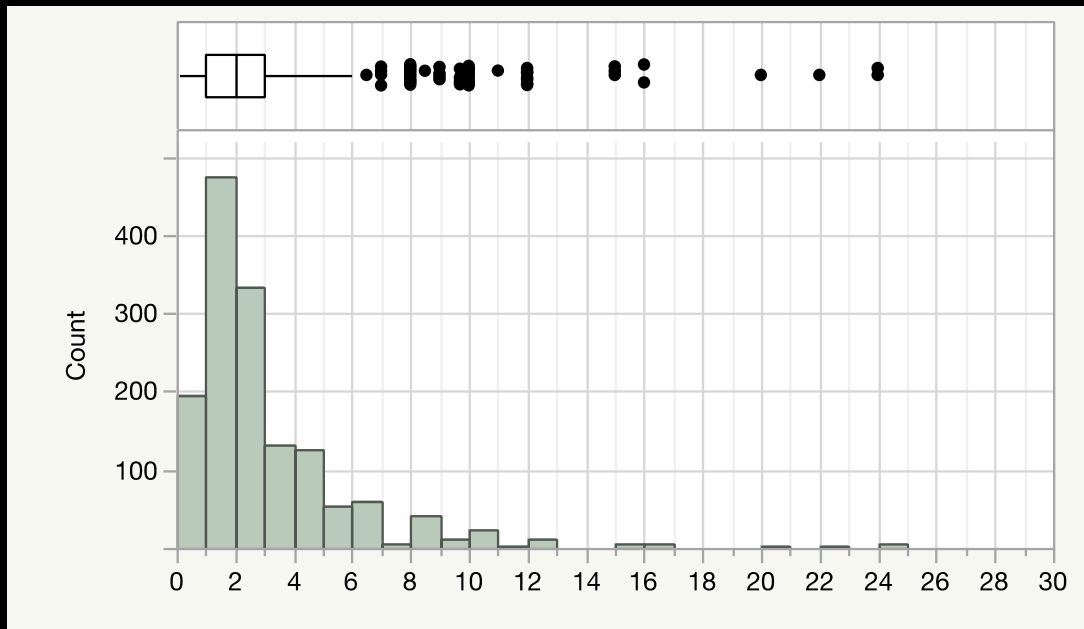
Distribution – Due date for Repair tasks



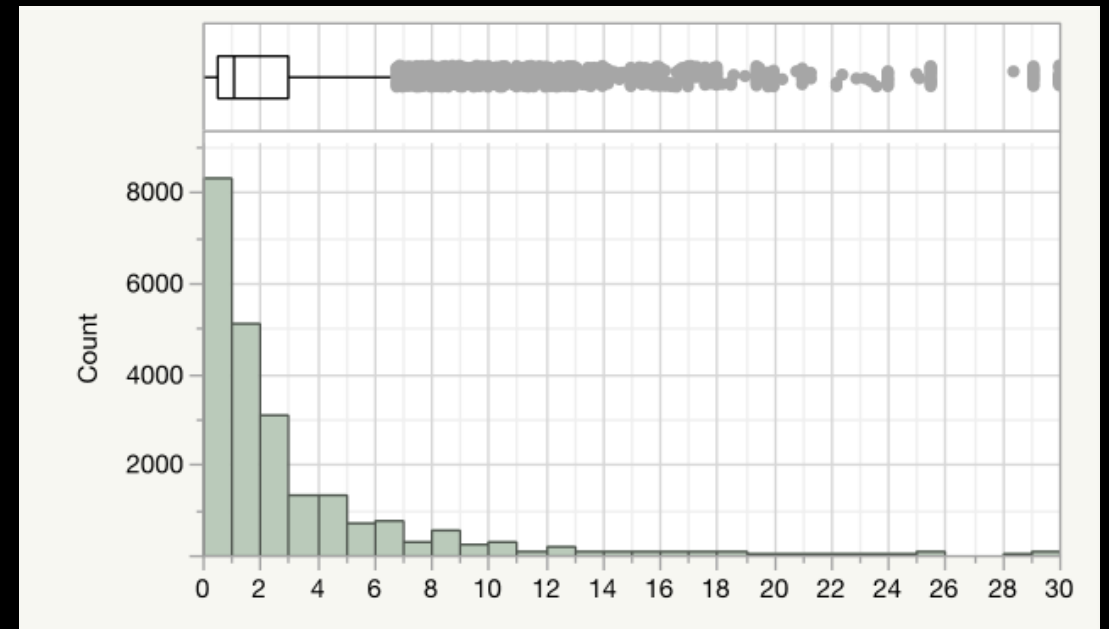
Distribution – Due date for Maintenance tasks



# Data Analysis – Task Times



Distribution – ManHours requirement in hours for repair

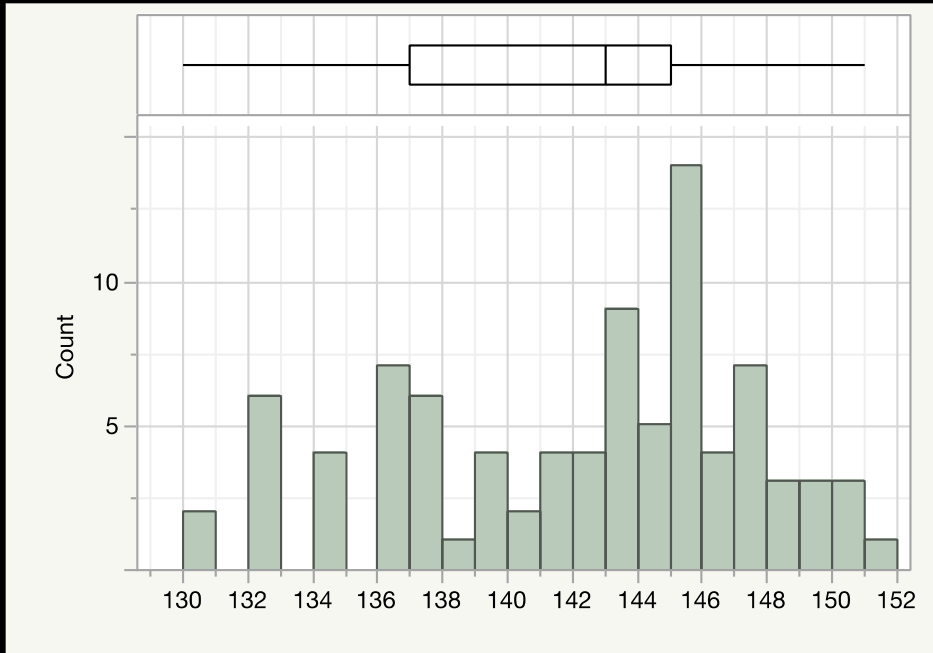


Distribution – ManHours requirement in hours for maintenance

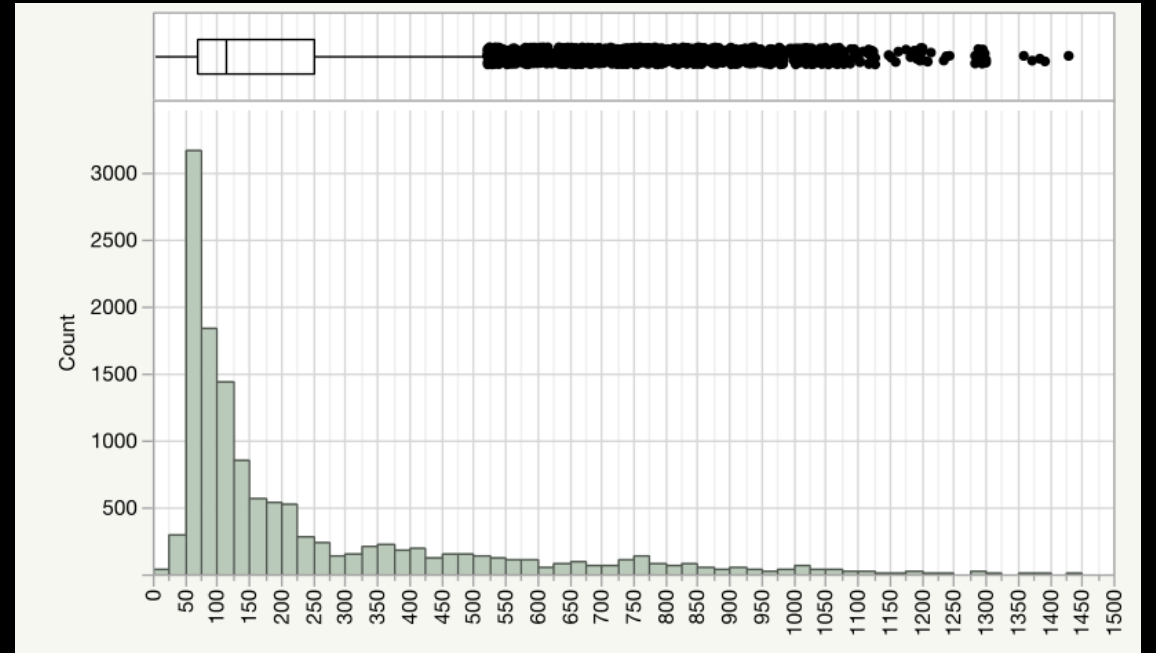




# Data Analysis - YYZ



Distribution – Volume of flights per day



Distribution – Ground time available in minutes



## Data Analysis - Manpower

Location	FLEET						
	F670   F192   F546	F295	F690	F855	F630	F231	F286
YUL	41	20	5	15	22	11	16
YYT	2	0	0	0	0	0	1
YOW	2	1	0	0	0	0	1
YHZ	2	2	0	0	0	0	2
YQB	1	0	0	0	0	0	2
YYZ	98	60	20	40	49	38	35
YVR	36	18	4	12	19	12	15
YYC	6	2	0	2	4	3	3
YEG	2	2	0	0	0	0	1
YWG	2	1	0	0	0	0	1

Number of employees available at each airport



## **Solution Approach**

- Decompose by fleet
- Shift Profile – Assign employees to shifts
- Task Assignment – Assign tasks to ground times
- Resource Usage – Assign employees from a shift to a task



## Shift Profile

- Given – available manpower in an airport
- To divide the manpower within 4 shifts.

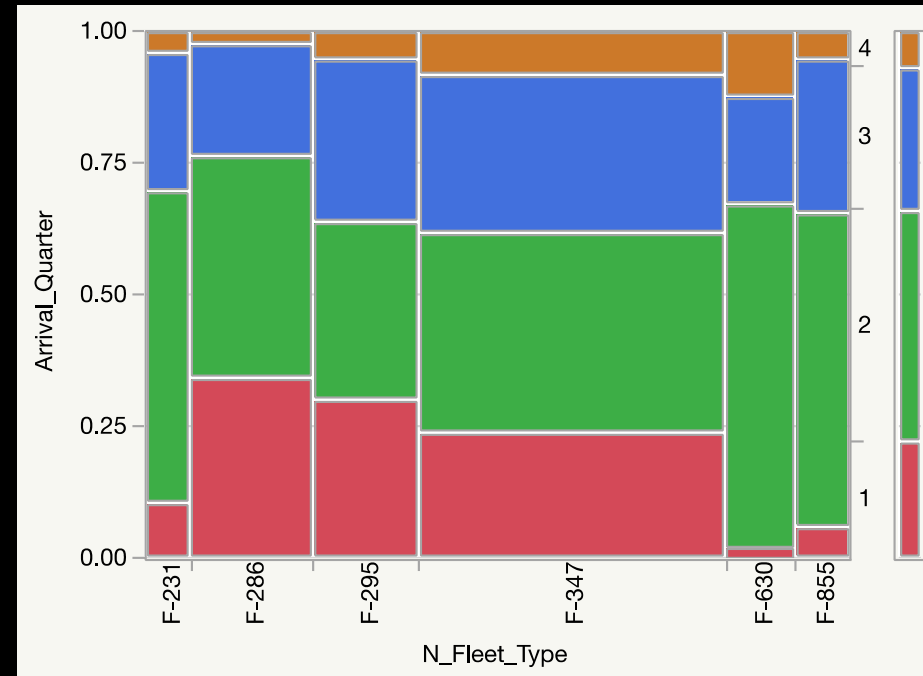
Shifts			
Morning	Afternoon	Evening	Night



## Shift Profile - YYZ

Month	Cycle	Location	F347	F295	F690	F855	F630	F231	F286
August	1	YYZ	92	50	15	36	49	33	35
August	2	YYZ	92	50	15	36	50	32	35

- Shifts do not have balanced volume of flights to handle
- Distribute manpower in a manner proportional to the volume of flights





## Task assignment – First Approach

Integer programming

Issues :

- Constraining resource usage on overlapping ground times

May be revisited in the future...

- Discretizing time
- Forbid teams to work other ground times
- Constraint Programming (Interval Sequencing)
- Preassigning manpower to ground times



# Task assignment

Greedy heuristic

Rank tasks by their score (combination of priority manhours, and due date)

Rank ground times by date

Assign tasks to ground times:

- Defect as early as possible
- Maintenance as late as possible

Respect assigned FIN numbers

Log tasks that cannot be assigned at all



## Task assignment

Integer programming

Issues :

- Constraining resource usage on overlapping ground times

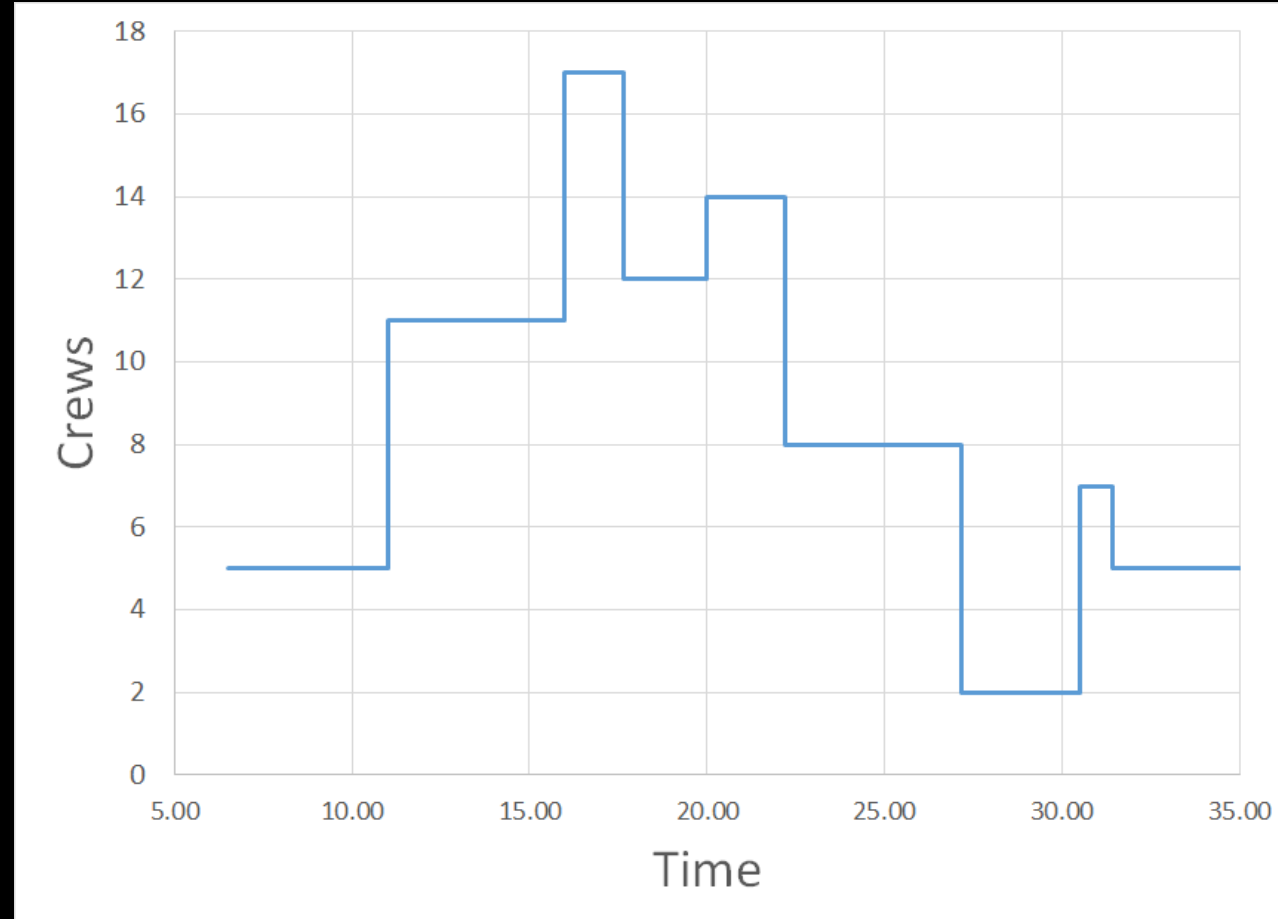
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- Discretizing time
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- Constraint Programming – (Interval Sequencing)
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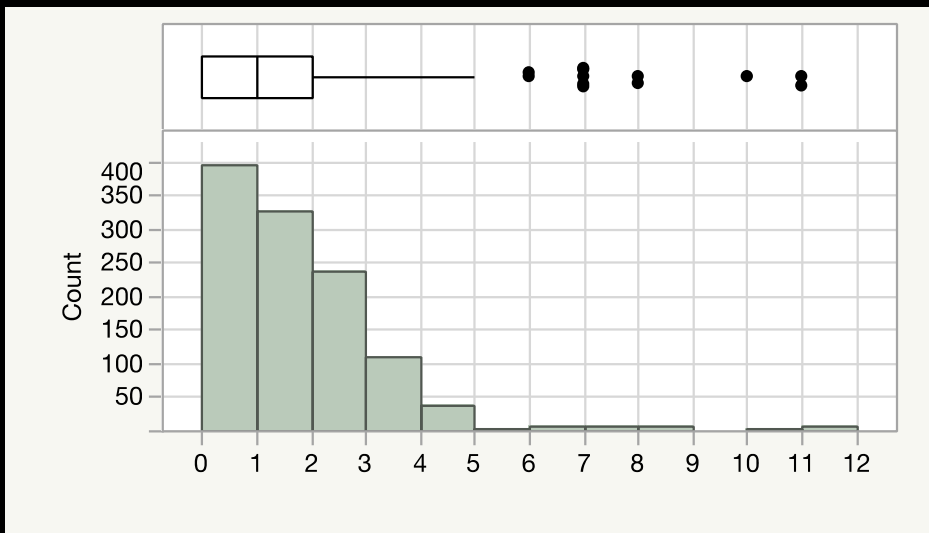


# Resource Usage

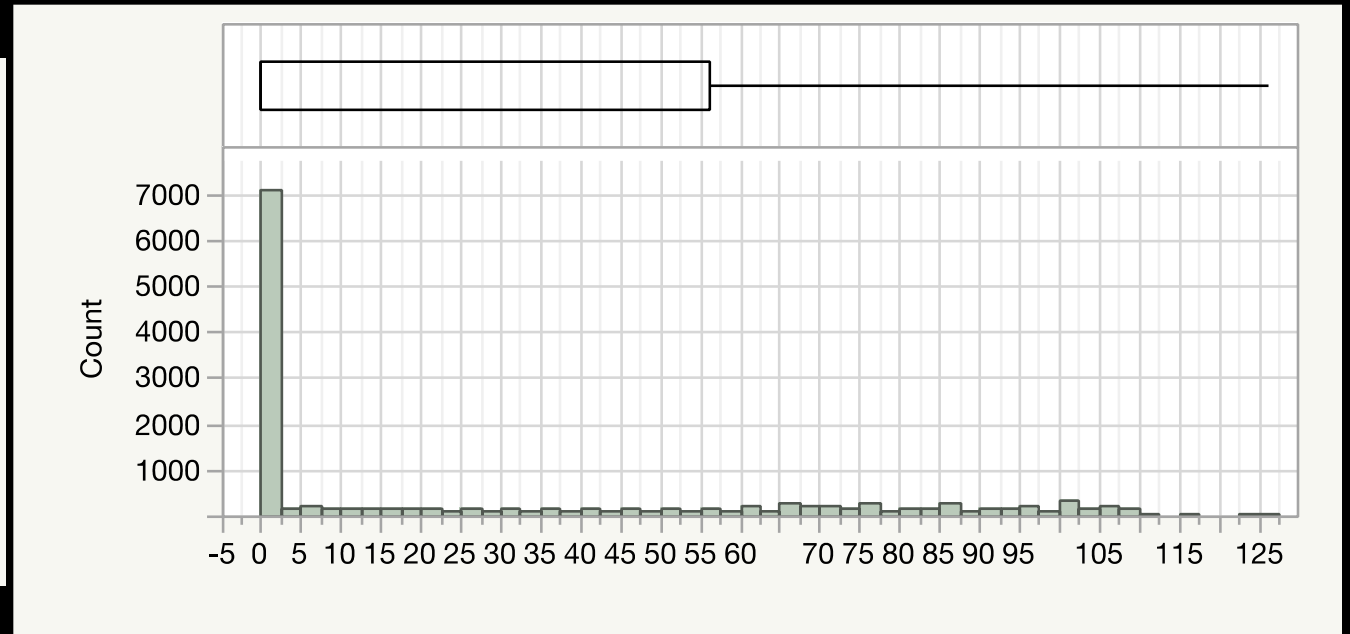




# Results



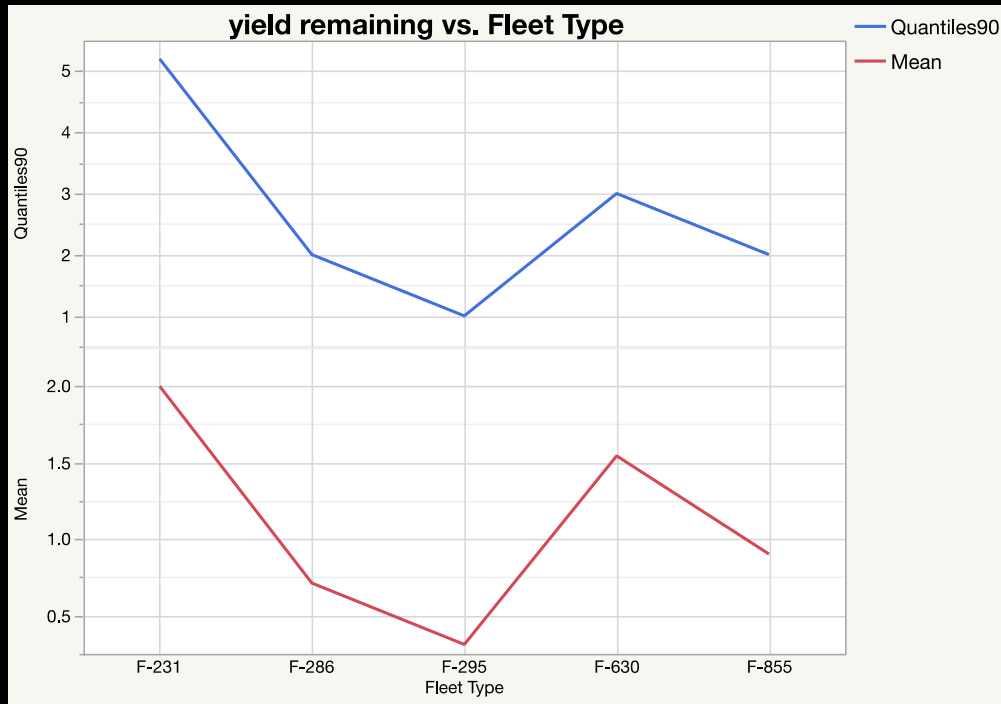
Distribution – yield remaining for repair tasks



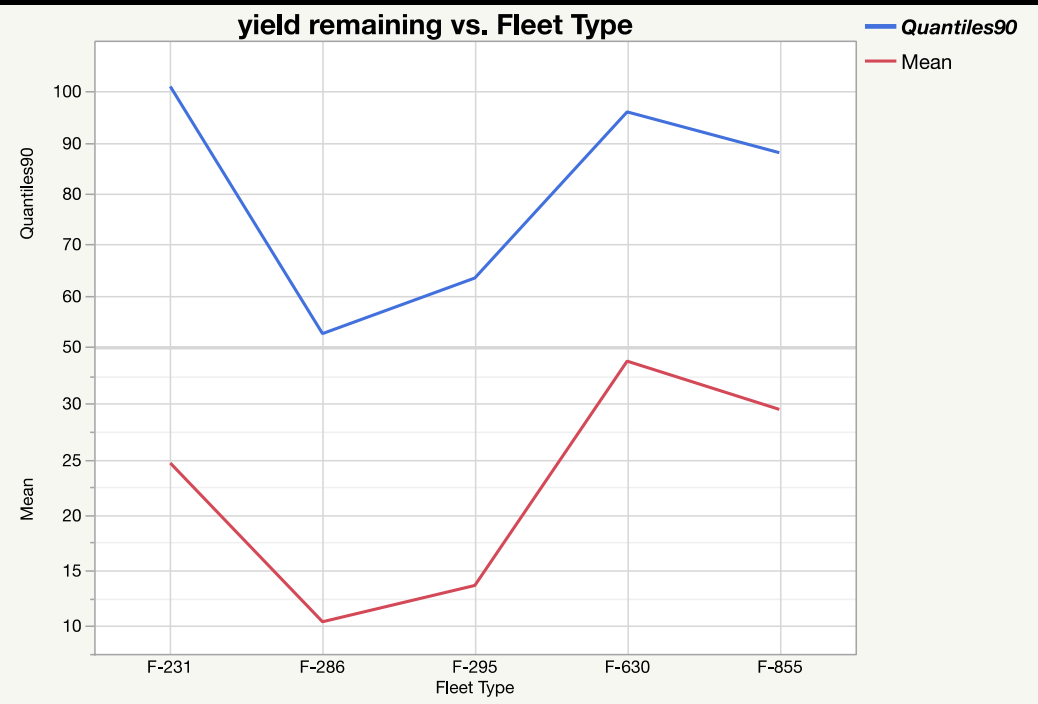
Distribution – yield remaining for maintenance tasks



# Results



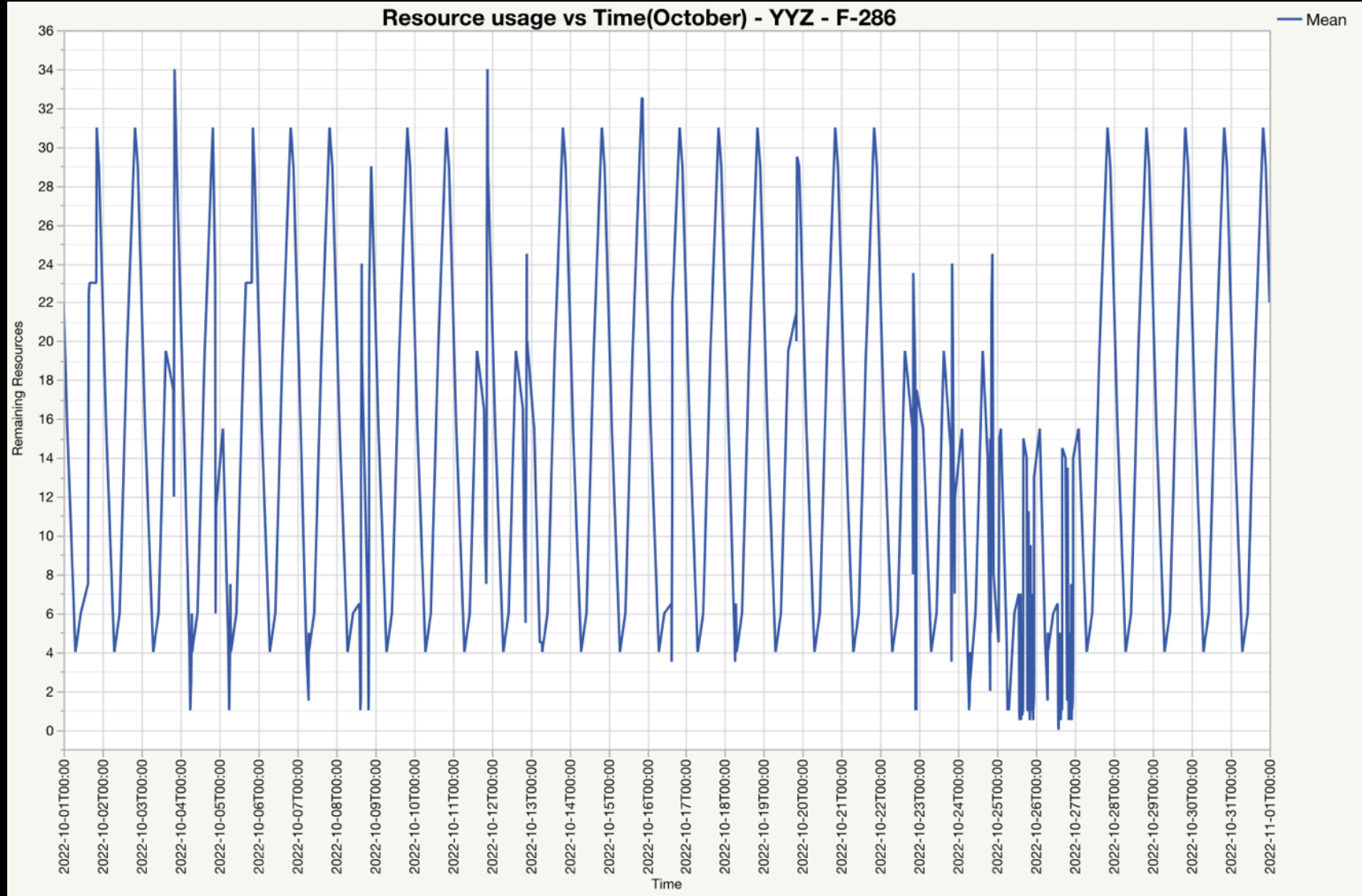
Mean yield remaining for repair tasks



Mean yield remaining for maintenance tasks



# Results





## Results

Fleet type	Runtime (minutes)
F-231	11.2
F-286	15.1
F-295	17.7
F-630	25.4
F-855	8.1



## Final remarks

- The generation of the shift profile based on ground times gives appropriate results
- The greedy heuristic finds good feasible solutions in a reasonable amount of time
  
- The greedy heuristic can thrive with a more detailed implementation of the algorithm
- The integer programming idea can be further developed to better describe the problem
- The greedy heuristic can profit from having better set parameters (e.g., task scoring)
- There could also be some sensitivity analysis on the change of shift profile
- There could be a local search outside of the greedy heuristic to decide the shift profile



Thank you  
Merci

# Problem Statement

At Air Canada Maintenance we must maintain our aircraft through a defined preventative maintenance program using accumulated hours/cycles and/or calendar days on our assets since their last maintenance activity. We incidentally also have defects that occur along the way and naturally we must fix those within similar constrained thresholds of hours/ cycles or calendar days.

We must plan the maintenance program items down to the day of execution without losing yield, whereas we must plan to rectify the defects as soon as possible without overrunning the due dates derived from the limits on the hours/ cycles or calendar days, while accounting for a limited number of resources available to perform the work required at multiple locations.

The objective of this problem is to build a forecasted maintenance plan that combines competing goals: minimize the yield remaining at the due date for a given task per asset and maximize the yield remaining for a defect that has occurred along the way. Upper bounds on available resources and ground time availability at multiple stations must also be considered.







**Maintenance Program**

Limits set by the Original Aircraft Manufacturer (OAM) and Equipment Manufacturer of our components (OEM) and ensure we maintain the structural integrity, reliability,

Airworthiness of our fleet.  
**Defined in Trax as**

Engineer Controls (EC's), PN  
Engineering Controls (PN EC's), PN  
Controls

**Thresholds controlled by**

Hours, Cycles or Calendar Days

**Created By**

ACM Engineering and System Configuration

**Taxonomy**

*Input data* - Mostly Structured and reliable

*Output data* - Historical is paper based with digital starting Q4 2022

**Defining our Limits**

Through combining our maintenance planning document with our aircraft utilization ratio and calendar days we derive the maintenance program and defect due dates for our engines, airframe events, landing gear removals, component removals, as well as our line maintenance resource requirements to maintain our fleet... all the while applying our objective functions to obtain an optimal strategy.

**Defects**

In spite of having a well-defined preventative maintenance program, things still break along the way. We call these defects, and/or snags at Air Canada

(Also known as squawks or complaints outside of AC).

**Defined in Trax as**

Defect Type L, M, C or E

**Thresholds controlled by**

Hours, Cycles, Calendar Days or inherent EC

**Thresholds defined by**

Minimum Equipment List (MEL)  
Defect type L & MEL Category A, B, C or D

Non-MEL

Defect Type C, M or E

**Reported By**

Anyone that identifies the defect

**Taxonomy**

*Input/Output is paper based but digitalized post initial report...  
Taxonomy is unreliable*

**Corpus for the 2022 IPSW**

Will be provided if you select this problem to solve



# MAINTENANCE PLANNING

## Input

- **Due dates for both maintenance program and defects**
- **Ground time per aircraft, opposite the block time (Commercial Schedule )**
- **Available man hours and available defects man hours**
- **Location:** man-hours available by location by skill
- **Cost of yield loss per task** (to be derived)
- **Aircraft type to home base assignment** (to be derived)



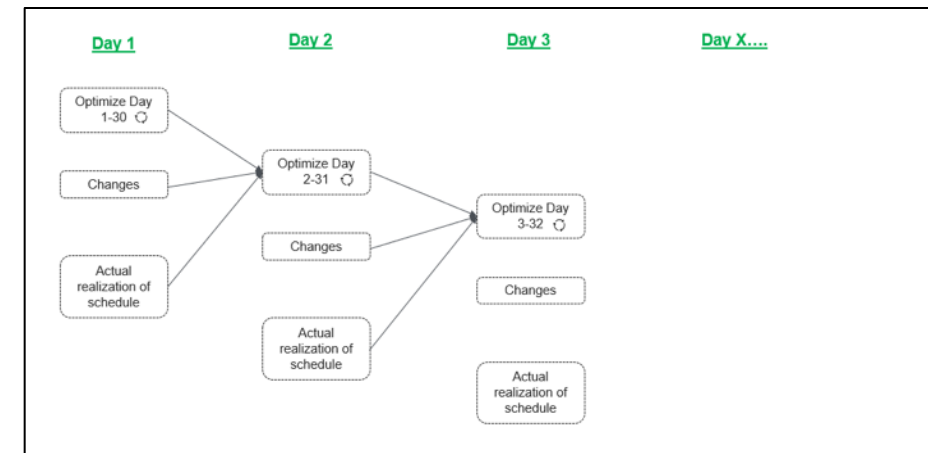
Engine Maintenance Planner



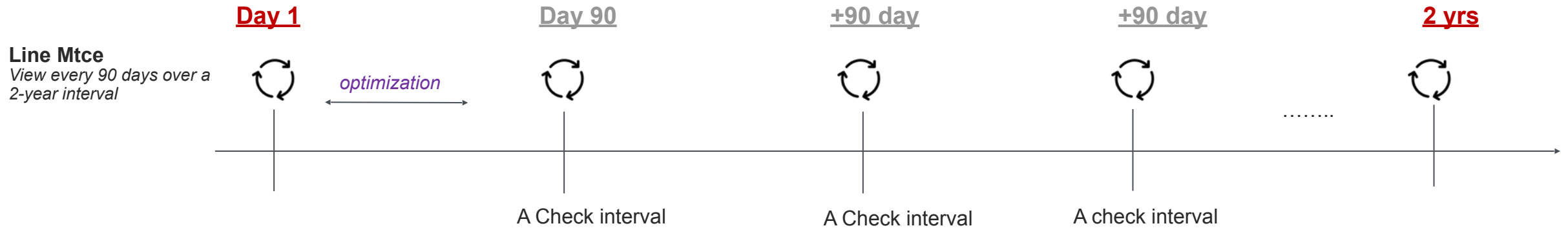
## Output

- **Scheduled Maintenance Events** for 30 days, and give feasible solution for 31 days to 2 years
- **When** (24h 7w 365d) and
- **where** (what location) to fix everything (based on ground time availability at location)  
Identify where work can be performed considering constraints, and lost opportunities

Short term view



# Closer look at the LT horizon view for the bigger picture we have to solve





# Appendix

## Cost of Yield Loss

Consider the total cost of ownership for any asset increases the more times your maintenance events repeat.

An aircraft can operate for over 30 years, many tasks have repeat intervals, just like changing the oil in your car.

Performing a MPD task earlier than its due date might mean that you will have to do it more than once prior to the aircraft retirement.

It is favourable then to minimize the yield remaining at that due date, however at times, the ground time and resource availability and the competing objective functions might not allow for that to occur.

Therefore, it is important to provided a weighted cost of loss in yield into the model to ensure that the weighted cost is used to solve for optimality.



# Aircraft Type Home-Base

## How to Derive the Aircraft type home-base

Through constant iteration of planning our maintenance schedule day over day and year over year it quickly becomes apparent where the Aircraft type home-base is located through repetitive opportunities constantly occurring in the same location.

Algorithmically defining it however is a slightly different challenge. To derive it, consider the following. Every aircraft will fly multiple missions throughout the course of a single day. As soon as that flying schedule allows for more than 4 hours of ground time at XXX location considering all available FINs within the same aircraft type, we can build an entire overnight work order package at that location. The instantiation of most of the available ground time opportunities where that criteria is met, allows us to declare XXX location as the Home-Base. Consider that a single aircraft rolls up into an Aircraft type, and all fins that are of the same aircraft type share the same flight schedule.

Ground time availability does not designate touch time on the Aircraft. A minimum 1-hour buffer should be applied to the ground time.





# About Air Canada



**TRAVEL POLICY FOR BOOKING WITH COMPLETE CONFIDENCE**

Air Canada’s new refund policy applies to all tickets purchased. The airline offers options including a refund to the original form of payment, an Air Canada travel voucher or the equivalent in Aeroplan points plus an additional 65% bonus if Air Canada has to cancel a flight or change the schedule by more than three hours.

**ARE YOU TRAVELLING ABROAD?**

Passengers are responsible for making sure they meet all government entry requirements, including all required travel documents, visas, health certificates and comply with all other checks at Air Canada’s [Travel Ready Hub](#) for the most recent government entry requirements. Government requirements may change at short notice.

**SCAN YOUR COVID-19 TRAVEL DOCUMENTS**

Air Canada’s digital solution is available on select routes through its mobile app for customers to securely upload and verify their COVID-19 test results. This feature will help travellers conveniently validate compliance with government health travel requirements prior to arriving at the airport.

**New On-board Safety**

[Video Canada](#) is Air Canada’s new on-board flight safety video that takes customers on a stunning journey across Canada from coast-to-coast-to-coast to each province and territory through all four seasons while presenting aircraft safety instructions in an compelling way.



Privileged and Confidential

**In the community**

Air Canada has been part of Canadians’ lives and given back to communities across Canada for over 80 years. Established as a registered charitable organization in 2012, the Air Canada Foundation’s mission is focused on the health and well-being of children and youth in Canada and on helping connect sick children to the medical care they need away from home, granting children’s wishes and alleviating child poverty.

The Foundation works towards its mission by:

- Offering financial and in-kind support to Canadian registered charities.
- Donating Aeroplan points to 15 paediatric hospitals across Canada, enabling children to access the medical care they need away from home.
- Supporting employees’ philanthropy in their local communities by providing airline tickets for charity fundraising.
- Raising funds through its Every Bit Counts program, which encourages customers to donate spare change of any denomination on board flights or through airport collection containers.
- Holding an annual golf tournament to raise funds; its ninth annual golf tournament in 2021 netted over \$765,000 in support of children’s organizations.

The Air Canada Foundation also partners with Canadian NGOs in times of disaster, both locally and internationally, and supports major health-related causes.

Donate cash or Aeroplan points today at [aircanada.com/foundation](http://aircanada.com/foundation)







FLEET AND OPERATIONS



INNOVATION



SAF AND CLEAN ENERGY



CARBON REDUCTION AND REMOVALS

## Commits to Net Zero Emissions by 2050

Air Canada has committed to a net zero emissions goal from all global operations by 2050, demonstrating its long-term commitment to advancing climate change sustainability throughout its business. To reach this, Air Canada has set absolute midterm GHG net reduction targets by 2030 in its air and ground operations compared to its 2019 baseline.

## Aeroplan

Air Canada's Aeroplan is Canada's leading travel loyalty program, chosen by millions of travellers worldwide. Aeroplan helps members travel more and offers the ability to earn or redeem points on all Air Canada flights as well as the world's largest airline partner network, encompassing over 40 airlines serving hundreds of destinations across the globe.

Members earn points with Aeroplan's 150+ financial, retail, and travel partners, including online shopping via the Aeroplan [eStore](#). In addition to flights, members also have access to an extensive range of merchandise, hotel and car rental rewards.

Aeroplan offers members exceptional benefits including obtaining flight rewards more quickly by combining points with Aeroplan Family Sharing, and saving on redemptions with no additional cash surcharges on Air Canada flights. Aeroplan's unique everyday partnerships with Uber Canada, Starbucks®, and LCBO enable members to earn points directly when making a purchase.

Plus, Aeroplan Elite™ Status Members and eligible Aeroplan credit cardholders have access to additional benefits, such as preferred pricing on flight rewards, lounge access, and more.

[aircanada.com/aeroplan](https://aircanada.com/aeroplan)



## Air Canada Cargo Business

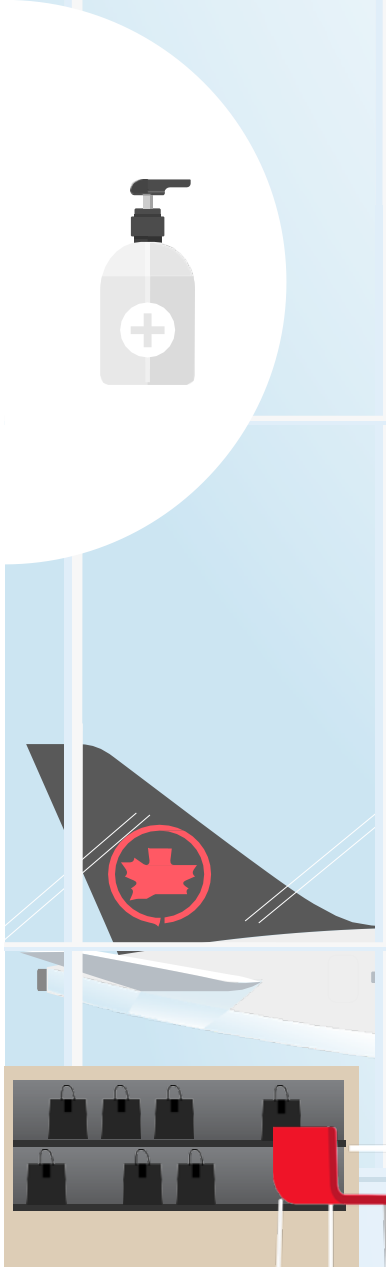
Air Canada Cargo, the freight division of Air Canada, provides services within Canada and to major cities around the world. In March 2020, it re-engineered its business model from primarily transporting cargo in the belly of passenger aircraft to launching cargo-only flights, including temporarily modifying several widebody aircraft to double cargo capacity. To date, over 14,000 cargo flights have been completed, playing a valuable role in maintaining the global supply chain by providing critical capacity that allows medical supplies, food and consumer goods to reach communities around the world.

In late 2021, the first dedicated Boeing 767-300ER freighter aircraft joined the Air Canada fleet to provide consistent capacity on key air cargo routes such as Toronto to Miami, Quito, Lima, Mexico City and Guadalajara, with more routes being added as additional aircraft enter service.

Air Canada Cargo's robust network connects through its main hubs in Toronto, Montreal and Vancouver.

[aircanada.com/cargo](https://aircanada.com/cargo)





## Air Canada CleanCare+

Air Canada is committed to end-to-end health and safety protocols. Using leading biosafety standards and enhanced preventive measures, the airline has refined its processes to keep customers safe throughout the travel experience, putting safety first always.

### Check-in

Health screening questions, touch-free check-in processes, and validation of health and travel documentation pre-travel on select routes, as well as the disinfection of frequently touched areas such as check-in counters and kiosks, are just some of the measures implemented for customer safety.

### Boarding

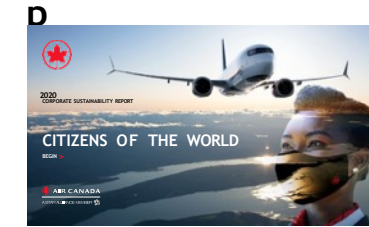
Ongoing cleaning at gate areas, regular health screening questions for all customers, adjusted boarding processes facilitating physical distancing, and mandatory face coverings for all employees and customers are steps we take to protect everyone on board.

### On board

All high-touch areas are sanitized with a hospital-grade disinfectant before every flight, and each time an aircraft overnights it receives a thorough cleaning. Additional preventive measures like mandatory face coverings, personal sanitization, and adjusted onboard services are also in place to better protect our customers and employees.



## Corporate Citizenship



*“I feel proud to have supported our country and fellow Canadians during these unprecedented times. Working with the Red Cross gave me a chance to give back in a meaningful way.”* - Air Canada employee Ameena Youssef on working with the Canadian Red Cross in their fight against COVID-19

With the help of employees like Ameena and others, Air Canada supports communities in need across the country for various causes. This is one example of many other actions and accomplishments outlined in Air Canada’s 2020 corporate sustainability report, [Citizens of the World](#).

As a global airline and as citizens of the world, Air Canada aims – in everything it does – to integrate economic, environmental, and social factors organized into three sustainability pillars: Our Business, Our People and Our Planet.

([aircanada.com/CSR](https://aircanada.com/CSR)).



## Principal Hubs

Air Canada's three hubs, Toronto (YYZ), the primary global hub, Montreal (YUL), a principal gateway to French and other international markets, and Vancouver (YVR), the airline's premier gateway to the Asia-Pacific, offer Air Canada customers convenient connections under one roof.

## Fleet Renewal

Air Canada's fleet modernization program began in 2014 by adding next-generation, fuel efficient aircraft with industry leading customer amenities.

The ultra-efficient 787 Dreamliners now comprise nearly 50 per cent of the wide body fleet and deliver an approximate 20 per cent improvement in fuel efficiency over the aircraft they replaced. The Airbus A220-300 (formerly known as the Bombardier C Series) and 737 MAX 8 aircraft feature similar product specs and in-flight entertainment as the 787 Dreamliner. They are also expected to average approximately 20 per cent less fuel consumption per seat and emit 20 per cent less CO<sub>2</sub> and 50 per cent less nitrogen oxides than the aircraft they replace.

## Premium Offerings

**Air Canada Signature Service** is an end-to-end premium service with lie-flat seats, access to airport concierge services at many airports, expedited check-in and security clearance (where available), priority baggage handling and preferential boarding. Customers also enjoy

Air Canada Maple Leaf Lounge pre-flight and access to the exclusive Air Canada Signature Suite.

**Premium Economy** cabin features enhanced comfort and amenities and is offered on all wide-body aircraft: 787 Dreamliners, Boeing 777-300ERs and -200LRs, and Airbus A330-300s.

**Preferred Seats** are offered in the Economy cabin for those who would like extra space between seats (up to 10 cm more) and convenience to board earlier and exit sooner on arrival.

The **Air Canada Signature Suite** has raised the bar with its five-star dining experience, setting a new standard for premium travel in North America. It is located in Terminal 1 at Toronto

Pearson and at Vancouver International Airport for select Signature Service customers travelling to international destinations.

**Maple Leaf Lounges** are a comfortable way to relax or catch up on work before take-off with services and amenities to make the pre-flight experience more pleasurable and productive. Lounge services also offer several touchless features, including presentation of all reading materials in digital format through PressReader and our *AC @La Table* menu ordering app that allows customers to order hot snacks directly from their seat by simply scanning a QR code or tapping an NFC chip.

**Air Canada Café**, at Toronto Pearson offers a wide selection of specialty beverages to grab and go or to be enjoyed with complimentary Wi-Fi in a relaxed, bistro-type setting.

**Air Canada Concierge** services at 50 airports worldwide are available to Aeroplan Super Elite Members and, on day of travel at the airport, to Signature Service customers. Concierges are an immediate resource in-person at select airports and by phone 24/7 for all travel and airport-related matters, personalized services and priority.





## Culinary and Wine Talent

Air Canada’s panel of celebrated Canadian culinary and wine talent have designed award-winning food and wine options that guide the airline’s caterers.



**Chef David Hawksworth** creates signature dishes with Canadian flair that are exclusively featured on Air Canada flights to Europe, Africa, and the Middle East in Signature Class and the Air Canada Signature Suite.



**Chef Jérôme Ferrer** prepares destination-inspired menu that are presented on select Air Canada flights from Canada to Asia and South America, as well as in Signature Class - North America.



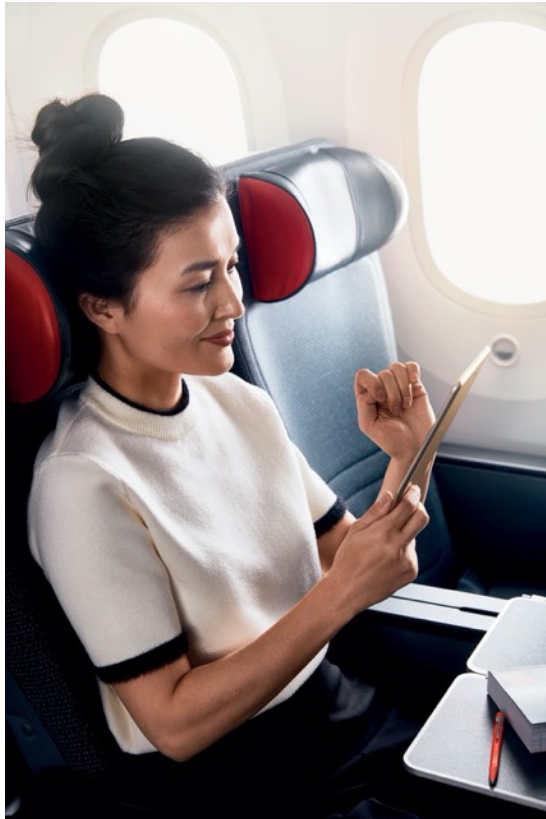
**Chef Jérôme Ferrer** designs meals for the airline’s Premium Economy and Economy Class customers on all flights departing Canada for Europe and Asia, as well as Australia and South America.



**Chef Vikram Vij** creates modern Indian dishes for all cabins of service on Air Canada’s Canada-India flights from Toronto and Vancouver.



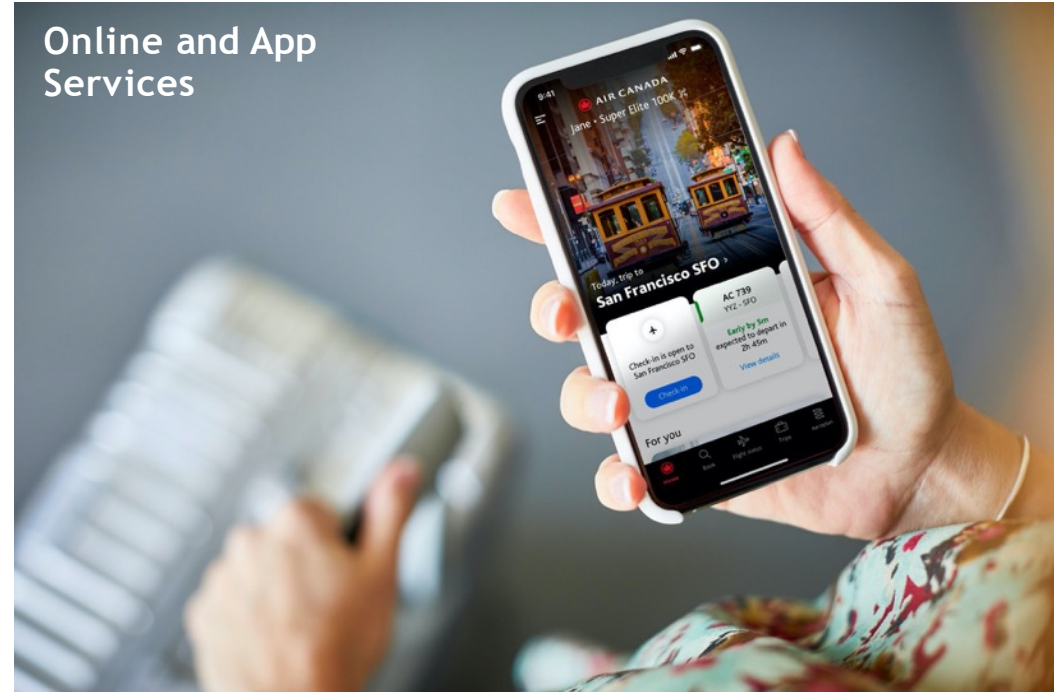
**Sommelier Véronique Rivest** is Air Canada’s sommelier. Her carefully hand-picked wines pair with food at 30,000 feet.



### Wi-Fi

Air Canada offers Wi-Fi access on select North American, Caribbean and international flights. Customers can save by purchasing access before their flight or buy on board. With a Wi-Fi purchase, customers also receive complimentary access to 7,000+ magazines and newspapers through the PressReader app. Find out if Wi-Fi is available on your next flight: ([aircanada.com/wifi](https://aircanada.com/wifi))

### Online and App Services



**Book flights, car rentals and hotel stays** as well as purchase gift cards, flight passes and more online.

**Self-service** features are available to modify itineraries and purchase upgrades.

**Check-in** and verify flight status 24 hours prior to departure and confirm your contact information. Kiosks at most airports provide self-service at airport arrival.

**Stay in contact** with real-time mobile app updates. You will also be automatically signed up to receive alerts including gate and time information.

**Self-manage** your itinerary during severe weather and irregular operations with the “Self-Service Rebooking Tool” and follow travel alerts at [aircanada.com/operationaloutlook](https://aircanada.com/operationaloutlook).



## Air Canada Rouge

Air Canada Rouge service includes complimentary streaming entertainment, a premium cabin, specialized customer service, high-speed satellite Internet on-board its Airbus A319, A320 and A321 fleet. With flights to leisure destinations in the U.S., the Caribbean and within Canada, Air Canada Rouge has served more than 30 million customers since launching on July 1, 2013.

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## Air Canada Express

Air Canada enhances its North American domestic and transborder network through a capacity purchase agreement with Jazz Aviation LP. This Canadian regional carrier operates flights on behalf of Air Canada under the Air Canada Express brand.



New Rouge  
Uniforms (2021-09)



## Specialized Services

**Family Travel** - Customers with young children may take advantage of dedicated check-in counters at major hubs, complimentary on-board travel goodies, fun children’s meal options, and early boarding. Customers can register their children for free online at Air Canada Skyriders to receive additional travel goodies. ([aircanada.com/familytraveltips](https://aircanada.com/familytraveltips))

**Air Canada Vacations** is a leading Canadian tour operator, offering all-inclusive packages featuring accommodation, roundtrip airfare on board Air Canada,

Air Canada Rouge, and its Star Alliance partners, Aeroplan flight rewards, as well as a wide assortment of cruises, tours and excursions. A repeat recipient of the *Travel Media Agents’* “Choice Award for Favourite Tour Operator,” Air Canada Vacations offers hundreds of destinations in the Caribbean, Mexico, Central and South America, Asia, Europe, and the U.S. ([aircanadavacations.com](https://aircanadavacations.com))

**Jetz** is Air Canada’s premium charter aviation service provider delivering superior Business Class service to satisfy the travel needs of professional sports teams, entertainment groups and corporate clients. ([aircanada.com/jetz](https://aircanada.com/jetz))

## Awards

- In 2021, Air Canada was recognized for its people, products and services at the **2021 Skytrax World Airline Awards** with honours for: **Best Airline Staff in North America, Best Airline Staff in Canada, Best Business Class Lounge in North America, and Excellence for COVID-19.**
- In 2021, Air Canada received **APEX’s Diamond Status Certification** for the Air Canada CleanCare+ biosafety program for managing COVID-19, the only airline in Canada to attain the highest APEX ranking.
- Air Canada was named the **2018 Eco-Airline of the Year at the Air Transport World (ATW) 44th Annual Airline Industry Achievement Awards** for being the first airline in the world to voluntarily join the World Bank’s IMF Carbon Pricing Leadership Coalition.
- Air Canada is routinely at the top of employer awards, including **Forbes World’s Best Employers, Mediacorp’s Montreal Best Employers** and **Best Diversity Employers and Achiever’s Most Engaged Workplaces**, among others.



**Fleet** As of March 1, 2022

Air Canada			Air Canada Rouge			Air Canada Express		
	ON ORDER	OPERATING		ON ORDER	OPERATING		ON ORDER	OPERATING
Boeing 777-300ER		18	Airbus A321		14	Embraer 175		25
Boeing 777-200LR		6	Airbus A320-200		5	Mitsubishi CRJ-900		35
Boeing 787-8		8	Airbus A319		20	Mitsubishi CRJ 200		15
Boeing 787-9	3	29				De Havilland Dash 8-400		39
Boeing 737 MAX 8	8	32						
Airbus A330-300		16						
Airbus A321		15						
Airbus A320		18						
Airbus A319		6						
Airbus A220-300	18	27						
<b>TOTAL</b>	<b>29</b>	<b>175</b>		<b>-</b>	<b>39</b>		<b>-</b>	<b>114</b>



[aircanada.com](http://aircanada.com)

Overview is produced by: Air Canada Corporate Communications

[aircanada.com/media](http://aircanada.com/media)



First flight from  
Vancouver to Seattle

September 1  
**1937**

First airline to install  
alcohol de-icing nozzles



**1938**

First trans-Atlantic flight,  
Montreal to Prestwick



1943

TCA's  
3 millionth passenger

July  
**1950**



Installation of  
anti-skid  
brakes



**1950s**

1960s



Introduction of jet aircraft

1963



Computerized reservation system

1965



Covered walkways



First female pilot,  
Captain Judy Cameron

**1977**



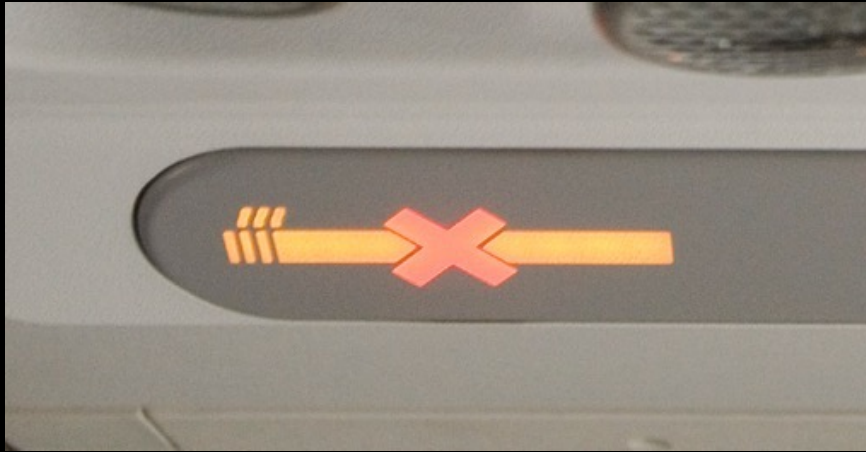
**2015**





1988

Privatization of  
Air Canada



First carrier to make its European flights non-smoking

**1990s**

Debut of self-service kiosks



Merger with Canadian Airlines



SARS



Hostile takeover bid



2000s

9-11





**Celebrating over 80 years**

A photograph of an Air Canada Boeing 737 MAX 8 aircraft on a tarmac. The aircraft is white with a black tail fin featuring a red maple leaf logo. The registration number C-FSIQ is visible on the fuselage. In the foreground, a group of approximately 20 pilots in white uniforms and black ties are standing in a loose formation on the tarmac. The sky is clear and blue.

# 2020 – Covid 19

*Unprecedented in Aviation history*