Optimization of Scheduling Problems on Runways

Ayumu Masaki Abe Haruhito
Mail:s2146040@stu.musashino-u.ac.jp
Musashino-University
Department of Mathematical Engineering,Faculty of Engineering,
Musashino-University undergraduate student

この辺にロゴを入れる予定です

Purpose

Currently, aircraft delays at airports are eliminated primarily through management by the control tower.

The Fukuoka Airport is designated as a **"congested airport"** where air demand greatly exceeds the airport facility capacity.
Flight delays are especially chronic during the peak morning and evening hours.

The Fukuoka Airport is congested airport !







We **express the creation of the take-off schedules for multiple** aircraft at the Fukuoka Airport using mathematical formulas.
We **developed an algorithm that mechanically resolves delays that occur owing to various reasons,** such as **weather conditions** or **delays in the arrival of the next aircraft to be used.**

Original timetable

Departures			
Flight	Time	Gate	~
2340	8:42	S16D	~
470	9:05	D5	~
396	9:28	DB10	~
~	~	~	

Weather Conditions Or Other Problems → **New timetable**

7:10	ANA
7:20	ANA
7:30	ANA
7:40	JAL
7:50	JAL
8:00	JAL

ANA is given priority

7:10	ANA
7:20	JAL
7:30	ANA
7:40	JAL
7:50	ANA
8:00	JAL

In addition,
a systematic aircraft arrival order is **considered to reduce airline and passenger frustrations**.
We plan to allow the two aircraft of All Nippon Airways Co., Ltd. and Japan Airlines Co.,Ltd. **to alternately use the runway as much as possible.**

Method

costs(objective function);∑{g_i max(0,t_i-x_i)+h_i max(x_i-t_i,0)}

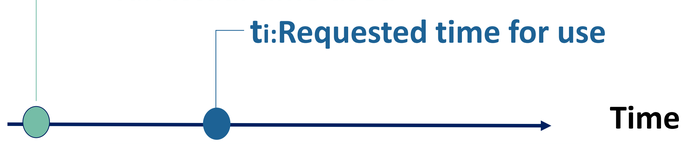
○ Formula Overview

→**Make it as small as possible**

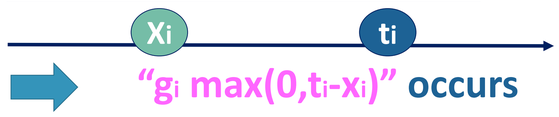
A set of airplanes "P"



x_i: Actual time used
t_i:Requested time for use

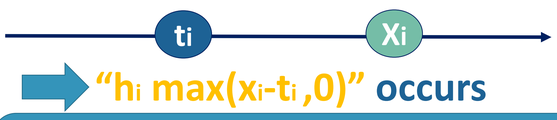


When used **earlier** than requested time



"g_i max(0,t_i-x_i)" occurs

When used **later** than requested time



"h_i max(x_i-t_i ,0)" occurs

※gi,hi are constants
gi enlarge→**Earlier** than requested time increases costs.
hi enlarge→**Later** than requested time increases costs.

○Constraint

- **Not too far from the desired time of use**

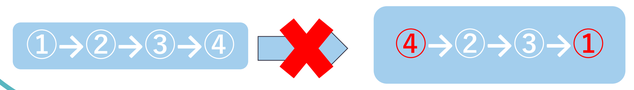
(ei<xi<li)



- **At least 2 minutes between each aircraft.**



- **Not too many changes from the original order.**



- **Make the sum of the order of each piece of equipment as equal as possible.**

The sum of ANA:9

The sum of JAL:12

7:10	①	ANA
7:20	②	JAL
7:30	③	ANA
7:40	④	JAL
7:50	⑤	ANA
8:00	⑥	JAL

etc.

Results

By taking into account the constraints, we were able to calculate a new timetable that improved upon the existing timetable at Fukuoka Airport.
When focusing on the 30-minute timetable, the order of the aircraft, without the constraint condition There was an inequity of about 10 minutes.

With the new timetable with constraint conditions added, the unfairness of the order of aircraft was eliminated.

Original timetable

	time	time-function	departure	No	company
0	7:00	7.000	departure	0	jal
1	7:00	7.000	departure	1	ana
2	7:00	7.000	departure	2	jal
3	7:00	7.000	departure	3	ana
4	7:00	7.000	departure	4	jal
5	7:05	7.083	departure	5	ana
6	7:10	7.167	departure	6	ana
7	7:10	7.167	departure	7	jal
8	7:15	7.250	departure	8	jal
9	7:20	7.333	departure	9	ana
10	7:30	7.500	departure	10	jal
11	7:30	7.500	departure	11	ana

Optimisation →

0	7.4485
1	7.2320
2	7.1000
3	7.1330
4	7.1660
5	7.1990
6	7.2980
7	7.2650
8	7.3310
9	7.3640
10	7.4155
11	7.5000

Descending order →

New timetable

2	7.1000	jal
3	7.1330	ana
4	7.1660	jal
5	7.1990	ana
1	7.2320	ana
7	7.2650	jal
6	7.2980	ana
8	7.3310	jal
9	7.3640	ana
10	7.4155	jal
0	7.4485	jal
11	7.5000	ana

Discussion

○Program operation becomes **heavy** and **cannot be implemented with big data.**
→Use the penalty method, etc. to lighten the program operation.

I want to calculate with **a daily** timetable.

○Timetables cannot be calculated neatly.
→Program to convert the calculated value to time.

7:15 ×24 → 7.250 Could!
7.250 ÷24 → 7:15 Couldn't…

Reference materials

Satoshi,Takahashi.Yuka,Matsueda."Aerial Runway Scheduling - Considering Multiple Runways."
***Operations Research*.63.11(2018);693～695**