

Optimization in the aviation industry

Mattias Lindby, Moa Samuelsson

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Agenda

Introduction to Jeppesen and aviation business

- Fleet planning
- Applied optimization



The presenters



Mattias Lindby

- Master's in Engineering Mathematics
- 2 Years at Jeppesen
- Product Owner Rostering Optimization

Moa Samuelsson

- Master's in Engineering Mathematics
- 2 Years at Jeppesen
- Client Solution Owner Tail Assignment







The New Kangaroo Route 2018 | Qantas and the 787 Dreamliner



Crew & Ops Management customers





Product suite



Manpower

Crew pairing

Crew rostering

Crew tracking



Tail assignment

Ops control

Time



Change Management





Tail assignment – the optimization problem



- Operational restrictions
- Aircraft restrictions
- Improve aircraft utilization
- Improve maintenance utilization
- Reduce fuel cost
- Increase passenger/payload revenue





What we actually do



- The minimum turn time is 35 minutes
- Would it be **impossible** to turn in 34 minutes?
- Ehm no.. It could work but should be avoided!
- Okey, so what is the **actual** minimum turn time?

rule minimum_turn_time =
%turn_time% >= %minimum_turn_time%;
remark "Minimum turn time";
end

export %minimum_turn_time% =
parameter 0:35;
remark "Minimum turn time";
end

%turn_time% = next(leg(chain), %departure%) - %arrival%;





Applied Optimization



Model

In general:

Minimize objective function Such that All given restrictions are respected

Volume of a soda can

Use as little material as possible

```
Minimize area
Such that: volume = V
```

Minimize $2\pi r^2 + 2\pi rh$ Such that: $\pi r^2 h = V$ $r \ge 0, h \ge 0$



Problem types and solution techniques

- Set partioning problems
- Network flow style problems
- General Mixed Integer Programs
- Shortest path problems
- Column generation
- Local Search
- Constraint programming



min	C ₁	C ₂	C ₃	C ₄	C ₅		
task 1	1	1	0	1	0	=	1
task 2	1	1	0	0	0	=	1
task 3	0	0	1	0	1	=	1
task 4	0	1	1	1	0	=	1
task 5	1	0	1	1	1	=	1



Tail assignment example



Optimization problem

- Objective
 - $-z^* := \min\{c^t x : Ax = e, x \in \{0,1\}^n\}$
 - $-x \in \{0,1\}^n$ is a decision variable whose *j*th entry is 1 if schedule R_j is chosen.
- Solution method
 - Solve it iteratively through Column generation
 - Two step process
 - Many subproblems
 - One master problem



Column Generation





Subproblem: Generating schedules

• Find the best possible schedule based on cost modelling and duals from master problem.



- Nodes are flights
- Add edges
- Remove illegal flight-flight connections
- Append costs in graph
 - Cost = schedule cost duals
- Find shortest path
 - Nodes in the path are flights on the schedule



Solve the puzzle!

- Each optimial solution per aircraft is not a global feasible solution.
 - One flight can only be on one schedule
 - Some flights can only be operated by certain aircraft subtypes



1505VL	467:56		967		726	727		DAILY			64	765	186	187						724	73	25	176	177		706	7	15	DAILY		180	18
'4 <mark>320</mark>	174	1237	1833	MEX 1933	3 2058	2135 0049	0104	0623		MEX					MEX				ME	X0617 0742	0823	1137 MEX			MEX	1857 2118	2213	0040 0040		0648		
1506VL	479:21	996	6		902			993		99	2			903		91	70		971		986		987	,	24	40	241		WEEKLV			
'4 <mark>32</mark> 4	179		1706 GDL	GDL 195	50	2200, OA	K OAK DO	010 0610 B	BJX BJ	X 0940		200 OAK	1320	191	16 GDL 1	2020	2235 S	MF 2350	0544 0	GDL GDL 08	817	1049 DEN	1219	1650 GD)L 1750	1911 19	47 2302	2342			0850	
1507.VL	402:48	785		762		763			792 79	33	798	799		718		711		DAILY		81	5	8	316			768	769		WEEKLV			
'4 <mark>32</mark> 4	179		MEX MEX 18	00 18	55 193	4 0013 MI	EX .	MEX 053	5 0647 0723	1022			MEX 1	1645 190	6 19	51 2218	2257		0522	0641	0827	TIJ 0914	. 1447 MB	ΞX	MEX	(2	2310			1	/01 <u>9</u>
1508VL	479:14	958	959		91	16 DA	ML.	917	890	8	91		42	23	4	24	429		D/	ALV	41	10	878	879		671		429	540		541	1
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1509VL	452:11		965		184	185			815		816	i		813		818					954			955		819			DAILY		844	
'4 <mark>32</mark> 4	179	145	4 1706 MEX	MEX		, MI	8	ME	X 0641	0827 TIJ 09	4	1447	1527	171	13 TIJ 18	301	2334 MEX			MEX0715		1139 ORD	1335	18	802 MEX	(1903	2049 TIJ	2136		0428	0525 09	308
1510VL	481:56	799		82	8	829			608	609		836		837		7	752	751		750		753			824	825		WEEK	LY		750	
'4 <mark>32</mark> 4	179		MEX	MEX	2	1550001 ME	x	1	MEX0715 084	4 0920 1	237	1326 153	2 160	18 1834 N	иех ме	X 2050	2223	2303	0423 MEX	0601 0	0734 0	805 13	25 MEX	MEX 164	31849	1920 214	46 21 46		055	4 0601	0734	4

