Linköping University
Fall 2017
Communications and Transport Systems
Department of Science and Technology
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Exam
Air traffic and air transportation
TNFL01
TEN1
17.10.2017

- Time: 14-18
- Number of questions: 8
- Total number of points: 80
- Grades: <40:UK, 40-53: 3, 53,5-66,5: 4, 67-80: 5
- Examinator: Christiane Schmidt
- Jourhavande lärare: Christiane Schmidt, tel 011-36 3212
- Hjälpmedel: Räknedosor som ej kan lagra text, alt. med tömda minnen är tillåtna. Ordböker engelsa-svenska är tillåtna. Inga andra hjälpmedel.
- Results will be published latest on November 14

Please note:

- Carefully account for your computations and solution methods.
- Give reason/facts/motivation for all your claims.
- Always use the standard methods as presented in the course.
- You will rarely get full points on a question by just reciting facts from literature and lectures; discussion, showing up connections and examples are necessary.
- You are allowed to use English-Swedish, Swedish-English dictionaries.
- You can write in either English or Swedish.
- Communications devices of any kind (phones, computers, etc.) are not allowed.
- You may use only one side of your paper for your answers.
- Use one sheet of paper for a single answer only.
- Use a maximum of an A4 page per question. In case figures and computations are included, you may use several pages.
- This exam consists of 5 pages.
- With 40 of 80 points you will pass the exam.
- You may not use a *red* pen for any written answers.
- You have 240 minutes to complete this exam.
- Sort your sheets of paper in the order of the given questions.
- Mark the problems you worked on on the envelope.

· Check how many papers you submit, and fill in the number on the envelope.

Problem 1: Lufthansa and Air Berlin **10 points**

The airline Air Berlin had to file for bankruptcy in August. Lufthansa wants to take over parts of Air Berlin to extend its subsidiary company Eurowings. With a fast take-over of the Air Berlin flights Lufthansa can avoid that slots are reallocated (currently, continous operation is financed via a public-sector loan from the German government). For all of Germany, Air Berlin (and their subsidiary Niki) holds about 12% of all slots, in Berlin Tegel the share is 45.6%, in Düsseldorf 28.1%. Figure 1 shows the distribution of "grandfathered" and newly-allocated slots at large German airports.

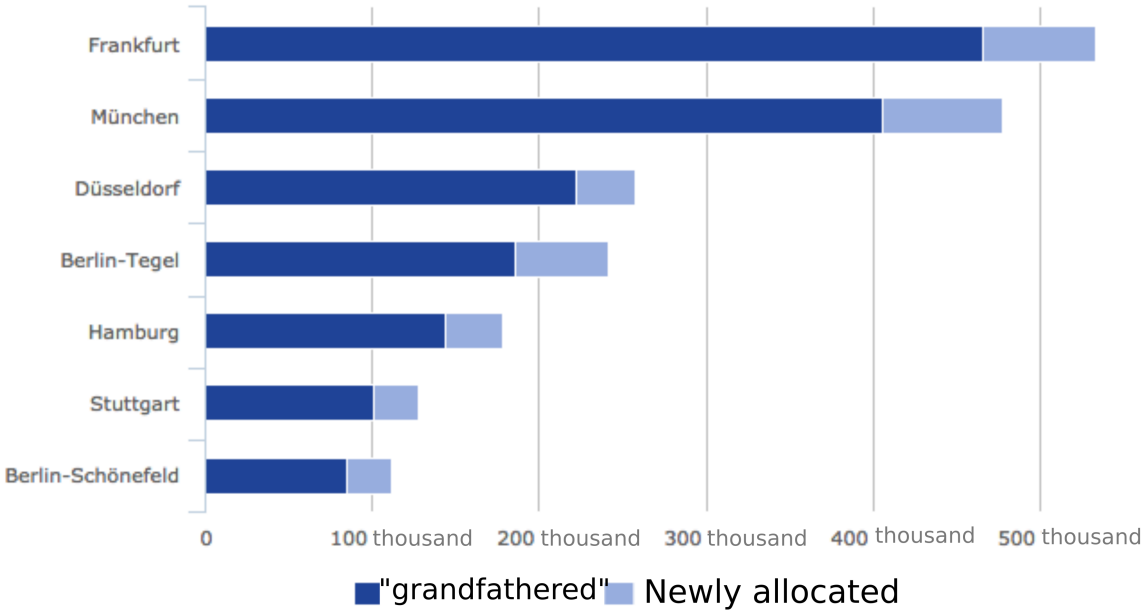

Figure 1: Allocated slots for arrivals and departures and German airports in the winter time table 2016/17 und summer time table 2017; "grandfathered" slots, that is, slots that are allocated to the same airline that did hold that slot before, are shown in dark blue, newly allocated slots in light blue. source: Flughafenkoordination der Bundesrepublik Deutschland.

Explain how slots are allocated at a level 3 airport, and then detail why a fast take-over of the Air Berlin flights would be beneficial for Eurowings/Lufthansa.
Possible solution:

Slot allocation at level 3 airport: First historic precedence = "grandfathered" slots (historic precedence applies to a series of slots that was operated at least 80% of the time during the period allocated in the previous equivalent season). Second slot pool: Once historic slots and changes to historic slots have been allocated, the coordinator will establish a slot pool, including any newly created slots. Slots available in the pool are allocated to airlines requesting a slot. 50% of the slots contained in the pool at initial slot allocation must be allocated to new entrants, unless requests by new entrants are less than 50% Within each category a request to extend an existing operation to operate on a year round basis should have priority over a new slot request.
With a fast take-over, Eurowings can claim historic precedence on the slots used by Air Berlin until now. Thus, those slots will not end up in the slot pool of the airports served by Air Berlin, which would mean that 50% of these slots are allocated to new entrants.

This is particularly interesting, as only few slots are newly allocated via the slot pool in large German airports. For example, in Berlin-Tegel, only about 50.000 of 240.000 slots were reallocated during the last year. But as Air Berlin holds 45.6% of the existing slots, this would directly give Eurowings 45.6% of these 240.000 slots, that is, about 110000 slots.

Problem 2: Crew planning **10 points**

The small airline FlyNow has the following timetable:

Flightnr	Dep time	Arr time	Dep AP	Arr AP
1	450	900	ARL	LLA
2	1000	1230	ARL	GOT
3	1020	1410	ARL	LLA
4	1810	2200	ARL	LLA
5	510	840	LLA	GOT
6	1030	13:55	LLA	UME
7	1510	1810	LLA	GOT
8	2020	22:20	LLA	ARL
9	615	800	UME	ARL
10	1545	1740	UME	ARL
11	1745	1930	UME	LLA
12	2000	2310	UME	GOT
13	430	09:10	GOT	ARL
14	920	1250	GOT	UME
15	1330	1640	GOT	UME
16	1920	2250	GOT	UME

Figure 2: Timetable.

The timetable is cyclic, with a cycle time of one day. This means that each flight in the table should be flown once each day (including weekends).
For each flight two pilots are needed. FlyNow managed to negotiate few, simple rules for the rest periods of their pilots:

- Maximum 10 flight hours per day.
- Minimum 16 hours rest between last flight of a day and the first flight of the next day.
- Maximum 40 hours flight within an arbitrary 7 day period.
- Minimum 24 hours time off (uninterrupted) at home base within an aribtrary 7 days period.

Moreover, all nights that are not spent at the home base incur additional cost for FlyNow. Deadhead flights are allowed, but should be avoided as they cost extra as well.
Use the above timetable and rules to explain how the crew planning problem for FlyNow's pilots can be solved. You do not have to do the complete planning (and cannot do so, as you do not have all information). Describe the different steps usually applied in crew planning, and use the timetable and rules to come up with examples for what you describe. Which objectives will FlyNow try to achieve?

Possible Solution: Crew planning is often solved in several steps. Usually the first step in crew planning is to construct so called "duty periods", which represent working days, and can be combined

for so called "pairings" of several days. Each duty must fulfill all the rules for rest periods, and the same holds for each pairing. A pairing always starts and ends at the home base.
If we assume that all pilots can fly on all flights (because we have only a single aircraft type) possible duties are:

- 1, 6 (flight time of 7:35, which is less than 10 hours)
- 2, 15 (flight time of 5:40)
- 9, 3, 8 (flight time of 7:35)

Duties can then be combined for pairings. If we assume that Arlanda is the home base, a pairing could be: ARN, 1, 6, rest of 16h20mins, 9, 3, 8, ARN
Each pairing causes cost, the cost depends on the number of night stays not at the home base, deadhead flights, etc. FlyNow will be interested to minimize the cost, that is, to find the pairings that minimize the total cost for the airline, such that a pilot is assigned to each flight.
Once pairings are chosen, these need to be combined to a monthly working schedule, which is then assigned to a specific crew member. This can be done with different methods, examples are rostering and bidline.

Problem 3: Low-cost carriers **10 points**

A new manager, Z, starts at the low cost carrier FlyNow, he wonders how FlyNow is able to offer tickets that are more than 50% cheaper than those of competing full service carriers. Explain to Z in a broad picture what factors result in these ticket prices. Do not focus on a single area, but make sure that you highlight various sectors.

Possible Solution.
FlyNow has reduced cost in various sectors when compared to a full service carrier, this includes, for example:

- Higher Aircraft Utilisation: A/c are used for more flight hours per day.
- No In-Flight Catering/Sales on Board: all food and drinks must be bought.
- No Agent Commission: tickets are sold via the internet, direct contact to customer, no agents.
- Cheaper Airports/Landing Fees: FlyNow flies from smaller airports, not located direct in metropolitan areas.
- Seat Density: more seats are used on the same a/c type.
- One a/c type: crew and maintenance don't need to be qualified for several types.
- Lower Crew Cost and longer working hours.
- High Cabin Factor: different prices to reach high cabin factor in the end.

Because of reduced cost, it can offer cheaper tickets.

Problem 4: Landing sequence **10 points**

The following sequence of aircraft requests to be allowed to land on a specific day at Winterville International Airport. It is your task to assign all aircraft an allocated time of landing (ATA), motivate

your choice and discuss which goals and requirements exist for a landing sequence.

Flight Nr.	TA	ETL	STL	LTL	A/C type
1	37	47	59	76	M
2	40	50	55	80	L
3	42	52	60	81	H
4	42	52	62	82	L
5	42	52	58	81	L
6	43	53	63	84	H
7	45	55	64	84	H
8	46	56	69	85	M
9	47	57	72	86	L
10	47	57	72	85	M
11	48	58	74	87	L

TA=time (in minutes) when a/c calls the tower
ETL=earliest time of landing
STL=landing time according to schedule
LTL=latest time of landing
ATA=allocated time of landing.

lead	follow	distance [in minutes]
L	L	2
L	M	1
L	H	1
M	L	2
M	M	2
M	H	1
H	L	3
H	M	2
H	H	2

Wake vortex separation.

Possible solution:

Flight Nr.	TA	ETL	STL	LTL	A/C type	ATA
1	37	47	59	76	M	59
2	40	50	55	80	L	54
3	42	52	60	81	H	60
4	42	52	62	82	L	56
5	42	52	58	81	L	58
6	43	53	63	84	H	62
7	45	55	64	84	H	64
8	46	56	69	85	M	69
9	47	57	72	86	L	73
10	47	57	72	85	M	71
11	48	58	74	87	L	75

The most important requirement is that the required saftey distance for vortex separation is never undercut. The distance differs depending on the size of leading and following aircraft, as heavier aircraft generate more wake vortex than lighter planes, plus lighter aircraft are more sensitive to the resulting winds than heavier ones. By planing the sequence such that the total safety distance is minimized, the flow can be increased, that is, more aircraft can land in a certain window of time. A good rule for the given sequence can be to try to circumnavigate having a light plane landing after a heavy one (safety distance of 3 minuntes). The goal then is to maximize the flow. A secondary goal is to have the landing time as close as possible to the planned time of landing (and if this is necessary to rather arrive a bit earlier than later). For example, I chose to assign later times for the last four aircraft than would have been possible due to the separation, to have the landing time closer to the planned time–instead of following the main goal of maximizing the flow.

Problem 5: Check-in **10 points**

The check-in hall for international passengers at Moonriver International airport is classified as level C (IATA Level of service C). Actually, only during peak hours, that is weekdays 7am-9am, the check-in hall fails to qualify for level B.
Explain what may cause Moonriver airport to fail the level B requirements, and propose several actions the airport could take to be classified as level B all of the time.

Possible solution:
Too many people in the check-in hall result in Moonriver airport failing the requirements for level B during peak hours. IATA LOS C allows for less area per pax than IATA LOS B (1,5 square meter per person opposed to 1.7 square meter per person). Possible suggestions to fulfill the level B requirements all of the time are:

- Build a larger check-in hall, but that requires a large investment.
- Decrease check-in time during peak hours. For example by opening more check-in desks, mount check-in kiosks (or if they already exist, mount additional kiosks), cooperate with airlines to allow for check-in via internet, etc.
- Make sure that no queues from (slow) security spill to the check-in hall.
- Consider the arrival of passengers: ensure that not many trains and busses arrive in parallel, that is, even out the inflow of pax.
- Give incentives to the airlines to change flight times (e.g., by increasing prices for peak flights), but if the check-in hall is the only restricting factor, that is most likely not the best idea. In case also the runway is a bottleneck, this is a good suggestion.

Problem 6: Safety Management Systems **10 points**

Nordic Flights is a new small Swedish airline that will offer domestic flights. Before they are allowed to start they have to establish a safety management system. Explain what such a safety management system encompasses and give an example how Nordic Flights could apply it.
Possible solution. A safety management system (SMS) is a systematic approach to managing safety,

including the necessary organisational structures, accountabilities, policies and procedures. For Nordic Flights this could include:

1. They describe which security risks they need to manage (e.g., human error because of fatigue or incompetence, pilots not following company guidelines, maintenance crew working negligent, etc.) and how the company should handle them. They may also establish security related goals, for example that the number of incidents should not be higher than a certain threshold.
2. Then the company has to work according to the first point.
3. The work must be documented carefully.
4. Relevant measures should be used to see whether the goals according to point 1 have been reached. The number of incidents per year could be such a measure.
5. If the goals could not be reached, for example, if the number of incidents exceeds the threshold, they have to identify the reasons, find counteractions, change the procedures, and update the SMS if necessary.

Problem 7: Differential Pricing **10 points**

You and your partner Mister Easy bought a small airline, FlyXY, which is serving a single route between two European capitals. Mister Easy suggests to simply sell all tickets for the same price P. You know that this is not a good idea, and want to give a detailed argument why you should indeed use differential pricing. To make your argument to Mister Easy you may assume that you have a simple price-demand curve, and have exact knowledge about how many people have what willingness-to-pay (WTP).

Explain what differential pricing is. Argue for a start why it will be beneficial for FlyXY to sell tickets at two different prices, P_1, P_2, with $P_1 < P < P_2$, and why your customers will be satisfied with that as well.

Possible solution:

Usually, business travellers are willing to pay higher fares in return for more convenience and fewer restrictions on the purchase and use of tickets. On the other hand, leisure travellers are less willing to pay higher prices, but accept the disutility costs of restrictions on low-fare products, longer travel times, and lower quality of onboard services.

If we assume that we have a linear (thus, simple) price-demand curve, selling tickets for price P will mean that we can sell a specific number of tickets, Q. If, on the other hand we sell at least for two different prices: P_1, P_2, with $P_1 < P < P_2$, we can generate additional revenue. Let the number of passengers with a WTP of P_1 be Q_1 and the number of passengers with a WTP of P_2 be Q_2. Then FlyXY will generate additional revenue by the $Q_1 - Q$ passengers that would not have bought a ticket for Q (and we would have higher income from the Q_2 passengers paying P_2). Altogether, FlyXY attracts more passengers.

From the passenger perspective, the $Q_1 - Q$ passengers who would not have been able to fly at all for P are certainly happy. The $Q - Q_2$ passengers, who would have been willing to pay P, but must only by P_1 now, save money, and are satisfied as well. The remaining Q_2 have to pay P_2, and thus more than P, but they benefit from the additional low-fare passengers presence as the airline can for example offer a higher frequency of flights than without these low-fare passengers.

Problem 8: Nine freedoms of the air **10 points**

FlyNow, a small Swedish airline, has new employees, and it is your job to explain the nine freedoms of the air to them. Give a general definition, and name at least 3 freedoms and what they could enable FlyNow to do.

Max. one A4 page text!

Possible Solution.

The nine freedoms of the air are a set of commercial aviation rights granting a country's airlines the privilege to enter and land in another country's airspace, formulated as a result of disagreements over the extent of aviation liberalisation in the Convention on International Civil Aviation of 1944, known as the Chicago Convention.

One freedom grants an airline to fly from one's own country to another. FlyNow could operate the route Arlanda-London, arriving in the UK.

Another freedom grants an airline the right to fly over a foreign country without landing. FlyNow could for example operate the route Arlanda-London, overflying Denmark without landing in Denmark.

Another freedom grants an airline the right to fly inside a foreign country without continuing to one's own country. FlyNow could operate a flight Paris-Marseille, without offering any flight from Marseille to Sweden.

Good Luck!!!