Linköping University
Fall 2016
Communications and Transport Systems
Department of Science and Technology
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Exam
Air traffic and air transportation
TNFL01
26.10.2016

- 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. 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: Crew rest time **10 points**

Pilot X works for airline FlyFast. Because of good contacts to the unions, FlyFast managed to negotiate few, simple rules for the rest periods of their pilots:

- Maximum 10 flight hours per day. Those 10 hours can be exceeded by maximum 2 hours. This holds only if the night rest is extended by $2\times$ extension. If the rest period in the night before was longer than 16 hours, up to 1 hour can be assigned to the night rest of the prior night with: $\min\{(\text{extra night rest night before})/3, 1\}$ hours.
- 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.

Pilot X had 9 flight hours on October 5, October 6-8 he had time off ad his home base LHR, on October 9 he flew 5 flight hours, with the last flight ending at 14:00 UTC.
On October 10 he flew:

- LHR-MAD, 2h 30 min flight time, 07:00-09:30 UTC
- MAD-LHR, 2h 20 min flight time, 10:30-12:50 UTC
- LHR-FCO, 2h 30 min flight time, 13:30-16:00 UTC
- FCO-LHR, 2h 40 min flight time, 17:00-19:40 UTC

Unfortunately, FlyFast's pilot Y is sick on October 10. Amongst others he was scheduled to fly flight FF234, LHR-CDG, 1h 20 min flight time, 20:30-21:50 UTC. The crew controller plans that pilot X takes over flight FF234.

(a) According to the rules for rest periods: Is it possible that pilot X flies on flight FF234, is it a feasible pairing? If yes, what is the earliest time a flight he is scheduled for can depart on October 11?

Possible solution. The last two rules aren't influenced by the additional flight. The originally scheduled flights for X have a total of 10h flight time. According to the first rule this can be exceed by max 2 hours. 1h 20min = 80 min $<$ 2h, thus, it is possible to schedule X for flight FF234. In the night October9-October10, X had 17 h rest, this exceeds 16h by one hour, according to the formula $\min\{1/3, 1\}h = 1/3$h = 20 min can be assigned to that night. This leaves 1 hour to be charged to the night October 10-October 11, and it needs to be charged with twice its value: 2hours. Thus, X must have 18h of rest. Consequently, the first flight on October 11 for X could start at 15:50 UTC.

(b) If X is used on flight FF234, what other consequences result for crew planning?

Possible solution. X arrives at CDG, which is not his home base, a hotel night needs to be added. Moreover, X will not be at LHR on October 11, where his next flight would have started, either a dead-head flight needs to be planned, or he needs to get a new duty starting at CDG. Moreover, instead of 19:40 UTC + 16h = 11:40 UTC, he can now only start his next duty at 15:50 UTC. Possibly other pilots will receive a new duty to take over X's original flights from October 11, this may have further consequences for the crew planning for the following days.

Problem 2: 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.

Max. one A4 page text!

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 3: Planning of aircraft routes **10 points**

A small Swedish airline focusing on domestic traffic has the following timetable:

Flight Nr.	Dep. Time	Arr. time	Dep. AP	Arr. AP	E[Pax]
1	07:00	09:50	A	D	41
2	11:15	13:05	A	C	16
3	08:30	10:10	B	D	35
4	16:30	17:40	B	C	28
5	05:50	06:45	C	B	44
6	16:20	17:30	C	D	31
7	8:25	11:30	D	A	19
8	13:20	15:00	D	B	39
9	14:25	17:30	D	A	25

Dep AP = Departure airport
E[Pax] = Expected (forecasted) number of passenger

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).

Fleet. The aircraft fleet consists of two types of aircraft, two Jetstream 31 (J31) and two Fokker 50 (F50). The F50 has a capacity for 50 passengers and requires 50 minutes from landing until it can start again (i.e., turn-around time). The J31 can take 18 passengers and needs 30 minutes of turn-around time.

Maintenance. The same rules for maintenance applies to both aircraft types. After a maximum of 30 hours in flight, a maintenance check has to be performed. This takes five hours. The maintenance base for the J31 is located at airport A, while the base for the F50 fleet is located at airport C.

Task. Your assignment is to create a feasible aircraft schedule for the next summer season. Discuss advantages and disadvantages of the schedule.

Possible Solution.
The two jetstreams and the two Fokkers both fly a loop together.
Fokker 1: A-07:00-flight1-09:50-D D-13:20-flight8-15:00-B B-16:30-flight4-17:40-C MAINTENANCE (every 2nd cycle)
Fokker 2: C-05:50-flight5-6:45-B B-08:30-flight3-10:10-D D-14:25-flight9-17:30-A

Jetstream I: D-8:25-flight7-11:30-A MAINTENANCE (every 4th cycle)
Jetstream II: A-11:15-flight2-13:05-C C-16:20-flight6-17:30-D

Advantages: long turn-around times, thus, robust schedule. Possiblity for more maintenance. A/c of same type used the same.
Disadvantages: Jetstreams hardly used (maybe plan more routes, or replan and then lease out one?). A few pax lost on flights 6 and 7.

Problem 4: 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 what factors result in these ticket prices.

Max. one A4 page text!

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 5: No CDM **10 points**

The airport Neudorf has two runways with a peak capacity of 60 movements per hour. An incident resulted in one unusable runway. This limits the capacity to ca. 25 movements per hour for the foreseeable future. Within the next hour 33 arriving a/c and 26 departing a/c are expected at Neudorf. Explain how the airport and ATC will handle the departing and arriving traffic, given that no system for Collaborative Decision Making is implemented at Neudorf.

Max. one A4 page text!

Possible Solution.
As the runway capacity is not sufficient, som flights need to be delayed, alternatively, if possible, flights can be routed to close alternative airports and ground transport must be organized for the passengers.
Otherwise, arriving traffic is usually delayed by holding, in case it is not possible to reach the pilots to reduce speed (which is preferable both from an environmental and a cost perspective). Departing traffic can be delayed on the ground (without inflicting cost or environmental effects). Thus, it might be preferable to prioritize incoming traffic, and let the departing a/c wait. Prioritizing arriving flights

also ensures that arriving pax and crew with flight connections manage to arrive in time before they need to start again. Before choosing this option it has to be checked whether enough space is available for all aircraft that will be located at the airport.
As the capacity is reduced it is also important that it is fully used. This can be achieved by sequencing the traffic such that the saftey margin due to wake vortex can be as small as possible.
For a longer time interval, NMOC will send out CTOT (slots) to flights that haven't started, but will land in Neudorf, to reduce the pressure on the airport.

Problem 6: CDM **10 points**

The airport Neudorf has two runways with a peak capacity of 60 movements per hour. An incident resulted in one unusable runway. This limits the capacity to ca. 25 movements per hour for the foreseeable future. Within the next hour 33 arriving a/c and 26 departing a/c are expected at Neudorf. Explain how the airport and ATC will handle the departing and arriving traffic, given that a system for Collaborative Decision Making is implemented at Neudorf, and explain how the interaction with other players can turn out.
Max. one A4 page text!

Possible Solution.
Essentially, the management will be similar than without CDM, but it becomes easier for all players to influence the decisions of other players. For example, the airlines can send requests to the ATC which aircraft (both in the arriving and the departing queue) should be prioritized.
CDM includes a good system for information sharing at the airport. This includes that potential problems with many aircraft on the ground, poor control over where certain aircraft, or ground handling vehicles, are located, can be avoided.
In addition, such incidents results in the need of replanning for all players, for example, gate allocation, refueling, cleaning etc. With CDM this planning can be based on accurate data about the current situation, and it can be communicated to other affected partners. For example, if an airline requests from ATC to prioritize a specific aircraft, they can send this information to the handling companies, who will then be ready at the gate.
The CDM procedure substitution on cancellation can be used, that is, airlines that have flights to Neudorf that haven't started yet, and thus get an CTOT, will cancel their flights to Neudorf and can still keep their slots at the airport.

Problem 7: Refueling **10 points**

Refueling at Neudorf lies within the responsibilty of FuelNow. FuelNow has two fuel trucks. They have the following jobs:

Flight Nr.	Earliest start	Must be finished at	Estimated refueling amount in kg
1	6:00	6:25	8000
2	6:10	6:25	1600
3	6:10	6:35	12000
4	6:20	7:00	6400
5	6:50	7:15	5600
6	7:10	7:55	16000
7	7:40	8:10	2400
8	7:30	8:10	12000

The smaller truck has a volume of $10m^3$, the larger truck has a volum of $15m^3$.

The estimated time to move from one aircraft to another, or between an aircraft and the depot, where the trucks can refuel, is 5 minutes.

Both vehicles can be used for a single flight, though at any point in time only one vehicle can be actively refueling this aircraft.

The refueling process can be performed with $1m^3$ per minut, both for the aircraft and for the vehicles at the depot.

The fuel density is $0,8$kg/liter.

Visualize the jobs with a gantt chart. Decide how the two trucks should serve the eight flights. Discuss advantages and disadvantages of your solution.

Possible Solution.
The larger truck has a capacity of 15000l, the smaller of 10000l. The density is 0.8kg/liter, thus the required amounts for the flights are: flight 1 10000l, flight 2 2000l, flight 3 15000l, flight 4 8000l, flight 5 7000l, flight 6 20000l, flight 7 3000l, flight 8 15000l.
Thus, the refueling time for, for example, flight 1 is 10 minutes.
The gantt chart, Figure 1, shows the starting and end times of refueling processes and of driving. Red indicates the small truck, green the large truck. The indicated times show start and end times.
In the presented solution all flights are served in time. Sometimes there is no buffer time, e.g., flight 8 is served until 8:10. Any delay will then result in a delay of the entire turn-around process.

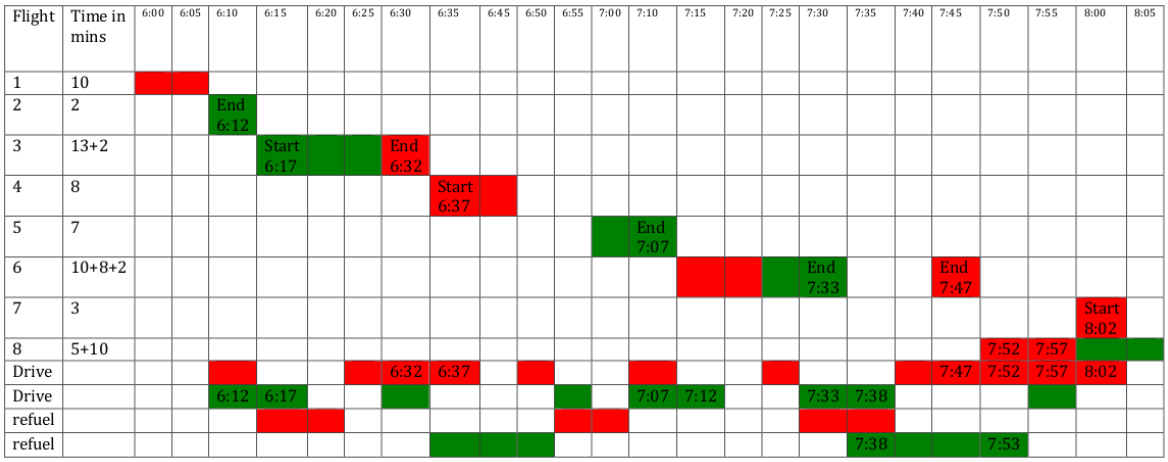

Figure 1: The gantt chart shows when which truck serves which flight. In some cases both trucks are needed for a single aircraft. Black times indicate start and end times.

Problem 8: Revenue Management — 10 points

Nordic Flights started its operations, and after a brief period the management decides that it will have to introduce revenue management (RM). Explain to them what revenue management is, which goals are pursued with RM, and what input data is needed such that Nordic Flights can have a RM.

Max. one A4 page text!

Possible solution.
Revenue Management tries to "offer the right product, to the right price to the right customer at the right time in the right market". In doing so it tries to maximize an airline's revenue. To do so, it has to decide the pricing structures, that is, the possible ticket prices and rules given the demand, competitors, premium, partners etc., and then optimize the daily price, that is, choose the valid booking classes given the demand, competitors, premium, partners etc..
A short term goal can be to maximize the yield, that is the revenue/income per revenue passenger kilometre. A long term goal can be the gain of market shares, which can be measured in high cabin factors, that is the revenue seat kilometers divided by the available seat kilometers (pax/seats). The first goal may result in passengers choosing other airlines due to high ticket prices, which will not result in the maximum possible revenue. The second goal may result in ticket prices lower than desired, again not resulting in the max possible revenue. Thus, the main goal, balancing revenue and volume, will be to maximize the RASK, that is, the revenue per available seat kilometre, while ensuring volumes.
RM needs detailed input on the estimated demand: a demand forecast for each origin-destination pair, and possibly on the willingness to pay. These data is needed each day prior to the actual flight, such that the seats can be allocated each day.

Good Luck!!!