Linköping University

Communications and Transport Systems
Department of Science and Technology
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Exam
Air traffic and air transportation
TNFL01
TEN1
30-08-2018

· 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
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· 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 September 13

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: Cabin factor and yield **10 points**

On the flight Arlanda-Kastrup (550km) FlyNow had the following information:

	PAX	income
monday	50	49000
tuesday	34	36800
wednesday	41	43600
thursday	39	38300
friday	29	31500
saturday	11	10100
sunday	38	42700

The route is served by a F50 with a capacity of 50 passengers.
Compute the average cabin factor and yield for the given week.

FlyNow realized that the demand on Saturdays is too low to keep serving the route on that day. Discuss possible measures FlyNow can take.
Max. one A4 page text!

Possible solution:
cabin factor = share of seats occupied by paying pax = $(50+34+41+39+29+11+38)/50/7 = 69\%$
yield=income per paxkm = $(49000/50+36800/34+43600/41+38300/39+31500/29+10100/11+42700/38)/550/7 = 1,879$ kr/paxkm
Alternatives for Saturdays are, e.g., to shut down the route on Saturdays and to use the aircraft for a more profitable route, or to use a smaller aircraft on this route. Any such solution also must consider that a balance has to be kept: if there are, e.g., flights Kastrup-Arlanda on Saturday, also that one must either be shut down or flown with a smaller aircraft. Another possibility is to try to increase the demand for the flight by moving the departure time, reducing the price (probably not profitable), or with other marketing measures. Alternatively, maybe it is possilbe to increase the price without losing much demand, which again makes the flight more profitable.

Problem 2: Change of plans **10 points**

FlyNow has a fleet of two J31 (capacity 18 pax) and four F50 (capacity 50 pax). At 16:00 a routine control detects that one of the F50, which is currently located at airport B is damaged by hail. This can be fixed, but it is expected to take 12 hours. Figure **??** shows a screenshot of the system used for the daily planning and surveillance of flights and aircraft at FlyNow.
The flight controller at FlyNow has a suggestion for the current situation: swap the flight B-D and the later flight D-C that F501 should have served and let F502 operate them, which results in about 6.5 hours delay for the flight B-D. Then, F501 will operate F502's flight B-C.
Discuss how this suggestions influences the crew planning, maintenance planning and passenger planning. Make sure that you do not focus on just a single area, but give a broad picture of the possible consequences!
Max. one A4 page text!

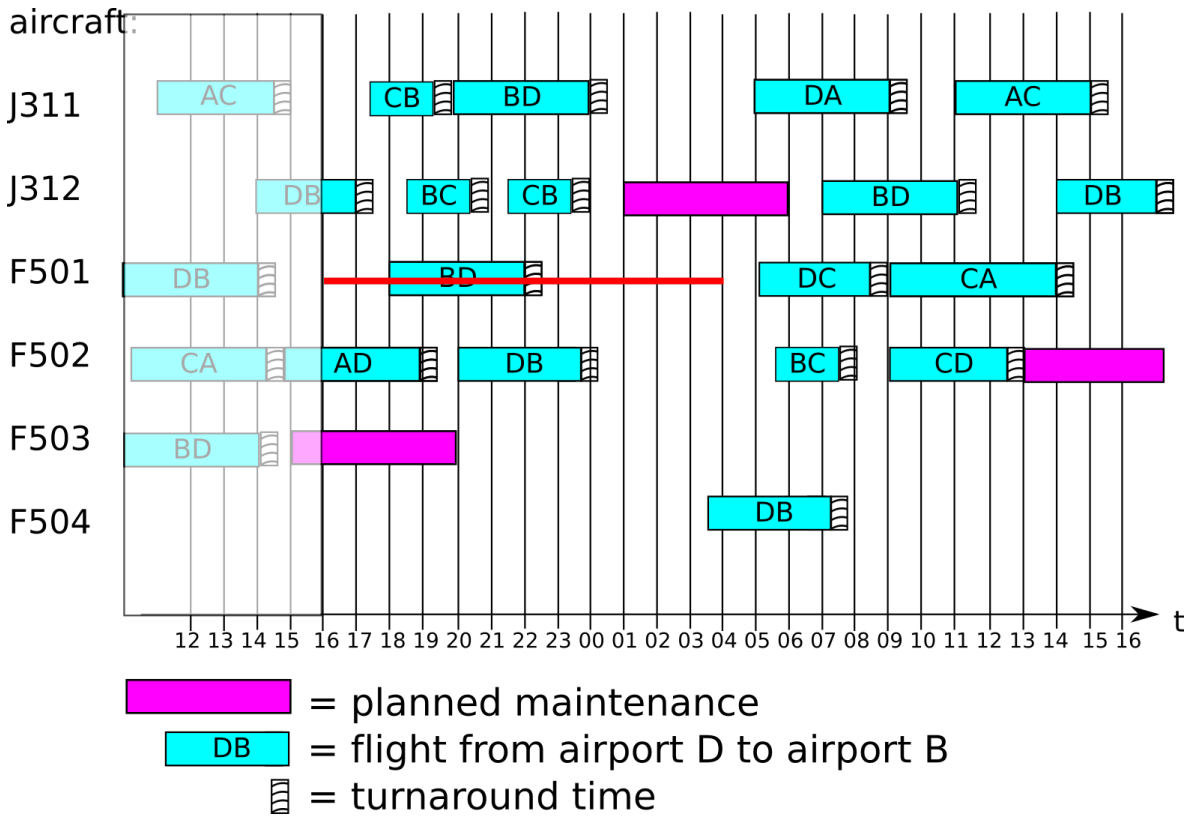

Figure 1: Screenshot of planning at 16:00.

Possible solution: **Crew planning:** We can assume that the crew who should have flown on the F501 is able to operate the F502. They will have to handle a delayed departure. Plus, they probably will have left for home and night rest at about 10:30 pm, which will now be about 5 am. That might influence their possibilites to continue their planned scheme after the night res—they will have to delay the end of their night rest by 6.5 hours. If they would have worked over the night anyway and would have operated the flight D-C with the F501, the change shouldnt influence them a lot. The crew who should have flown the B-C flight with the F502 and will now operate it with the fixed F501 shouldnt be influenced at all. **Maintenance planning:** The F502 will increase the flight time by about 5.5 hours—in comparison to the planned scheme. That might result in the need for maintenance earlier than planned originally. In the worst case, it might not be able to serve the additional flights at all. The next maintenance was scheduled after about 12 more flight hours, so, adding 5.5 flight hours might result in a violation of a rule for the max allowed flight hours inbetween maintenance. For the F501: the flight hours will be decreased by the schedule change, so, it wont violate any maintenance rules. Moreover, maybe it is possible to perform a service check during the reparation, which might postpone the next necessary maintenance. **Passenger planning:** The only passengers that will be influenced by the change are those that are booked on the flight B-D that should have been operated by the damaged F501 (original flight time 18:00-22:00). But the delay will probably be perceived as very inconvenient, as they will now land at 4:30 in the morning. The airline must check that the airport is open at that hour. The new arrival time might result in transport problems (leaving the airport) for the passengers etc. Possibly, the airline can help with ground transport, hotel or the like to reduce the bad-will.

Problem 3: 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 4: 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 5: 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 present the airline a draft of a safety management system that they could implement directly. Do not forget that they do not know anything about Safety Management Systems, hence, make sure you give them a step by step guide.

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 6: Route network — 10 points

An airline's route network is often a mix of pure hub-and-spoke and pure point-to-point systems. Discuss how an airline can exploit the advantages and avoid the disadvantages of those two extremal network types by using a mixed route network.

Max. one A4 page text!

Possible Solution.
One of the biggest advantages of a point-to-point system is that passengers appreciate travel without switching planes. By creating direct flights for important, profitable routes, an airline can obtain higher occupancy or yield.

To make use of the advantages of a hub-and-spoke system, like a common maintenance base, a common home base for the crew, etc., the network must be connected to the base, such that it is possible to have overnight stays there as often as possible. For a big airline it is an option to use multiple hubs, which reduces the network's vulnerability to a certain degree, in case the hub is affected by some incident. To be able to make us of the advantage of having many possible flights in a hub-and-spoke system, it is also important to temporally connect direct flights, such that is its possible to use them as connecting flights.
In general, it should first be identified which flights should be offered as point-to-point due to high demand, and then the rest of the schedule will be planned w.r.t. those fixed flights and w.r.t. the (one or multiple) hub(s). This combination will nevertheless result in a loss of robustness in comparison to a full point-to-point system: if one flight is disrupted, this will also affect other flights. So, it is not possible to simply obtain all advantages and to avoid all disadvantages at the same time.

Problem 7: Dichotomy of Demand **10 points**

You are working for a large, international airline. In conversation with a representant of a large dairy company at a conference, said representant asks you to quantify demand and supply on the route Arlanda-Newark. He is surprised to hear that you cannot easily quantify the demand and supply, as he easily can for, for example, milk with 3,25% fat in Stockholm in January. Give the dairy representant a detailed explanation on dichotomy of demand and supply in the airline industry.
Max. one A4 page text!

Possible Solution:
The dichotomy of demand and supply describes the inherent inability to directly compare demand and supply in an individual origin-destination (O-D) market like Arlanda-Newark. The demand is generated at the level of an individual passengers O-D trip, while the airline provides the supply in form of flight leg departures on a network of scheduled flight operations. One flight leg provides joint supply of seats to many O-D markets simultaneously. That is, a flight leg Arlanda-Newark might be used by passengers traveling on various O-D trips, e.g., Arlanda-Newark, Arlanda-LAX, Kiruna-Newark, Kiruna-LAX, etc.. Thus, the total number of seats on a flight leg from Arlanda to Newark does not represent the supply of air transportation to the single O-D market Arlanda-Newark. As many airlines offer various airline paths/flight leg combinations (nonstop, one-stop, and connecting) that can be used to serve a specific O-D market, it is not practically possible to determine accurately the actual number of seats supplied to each O-D market, and, in particular, it is not practically possible to determine the number of seats supplied to the Arlanda-Newark market. On the other hand, the volume of the Arlanda-Newark demand cannot be determined by simply counting the number of passengers on nonstop flights operating between the Arlanda and Newark. Detailed ticket samples of all passengers would be necessary to determine the complete demand.

Problem 8: From Flight Schedule to Routing **10 points**

Your colleague missed the lectures on how an airline with a given (i.e., already computed) flight schedule for a season assigns aircraft to all flights for each day in the schedule. Explain to him/her in detail what makes this a complicated problem, and how it is handled in practice. What are the substeps taken to solve this? What are the requirements for a solution?
Max. one A4 page text!

Possible Solution:
Due to the number of flights in the schedule and the number of available aircraft, assigning aircraft to all flights for each day of the season is a large problem, and, for larger airlines, it can not be solved as is.
Thus, the problem is decomposed: Usually, this is done by aircraft type. First, the complete fleet of the airline is split into subfleets of interchangeable aircraft. Then, the so called **fleet assignment** problem is solved: for given flight schedule and fleet sizes, a fleeting is computed, that is, all flights are assigned to a subfleet, without determining which aircraft should serve which flight. For a solution of the fleet assignment problem we can aim for maximizing the number of passengers, for minimizing the costs, or for obtaining a robust solution. Several requirements must be fulfilled by any such solution: We need to obey airport limitation on aircraft type, crew and maintenance limitation on the aircaft type, and need to balance the use of all aircraft.
After that step, we are still left with a routing problem, that is, we still need to assign aircraft to flights, but both the number of aircraft and the number of flights is now significantly reduced in each subproblem (for each subfleet). As the second step, the so called **aircraft routing** problem is solved, which assigns a route to each aircraft. Here, we are given a one-fleet schedule, the matching subfleet, maintenance constraints, and other operational conditions, and we want to compute a route for each aircraft. That is, after this step an aircraft has been assigned to each flight of the season in the airline's schedule. With a solution of the aircraft routing problem we aim for a feasible assignment that is robust, that is, small perturbations do not have effects for a long time or in large parts of the airline's network.

Good Luck!!!