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DEVELOPING OF AIRCRAFT DE-ICING OPERATIONS AT HELSINKI AIRPORT

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Tiivistelmä

Kylmien ja kosteiden sääolosuhteiden vallitessa voi lentokoneen pintaan kerrostua lunta ja jäätä. Turvallisuussyistä on lumi ja jää poistettava lentokoneen pinnasta ennen lentoonlähtöä, sillä ne voivat heikentää lentokoneen suorituskykyä ja ohjattavuutta. Pahimmassa tapauksessa lentokoneen pinnasta irtoava jää voi joutua moottoriin ja rikkoa sen.

Opinnäytetyön tavoitteena oli tutkia mahdollisuuksia kehittää lentokoneiden jäänpoisto-operaatioita Helsinki-Vantaan lentokentällä entistä tehokkaammaksi ja ympäristöystävälliseksi, sekä levittää yleistä tietoutta jäänpoisto-operaatioista henkilökunnan kesken. Tavoitteen saavuttamiseksi oli perehdyttävä nykytilanteeseen Helsinki-Vantaalla sekä tutkittava mahdolliset parannusmahdollisuudet toimintatapoihin liittyen. Nykytilanne selvitettiin useilla vierailuilla lentokentällä, palavereilla sekä haastattelemalla asianmukaista henkilökuntaa. Parannusmahdollisuudet selvitettiin käyttämällä vertailuanalyysia (benchmarking) useisiin eri lentokoneiden jäänpoistotoimintaa harjoittavaan yritykseen ympäri maailmaa.

Tämän opinnäytetyön tarkoituksena ei ollut keksiä mitään uutta ja ihmeellistä, mutta tutkia jo olemassa olevia toimintamalleja muilta lentokentiltä ja yrittää sovittaa niitä Helsinki-Vantaan lentokenttään sopiviksi. Tutkimuksen tuloksena tuli esiin ideoita ja toimintamalleja, joita voidaan käyttää hyödyksi tulevaisuudessa jäänpoistotoimintaa kehittäessä. Tätä opinnäytetyötä voi tulevaisuudessa käyttää myös osaksi koulutusmateriaalina henkilökunnalle.

Avainsanat (asiasanat)
Ilmailu, Jäänpoisto, Lentokone, EFHK, Helsinki-Vantaa lentokenttä, Finavia

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Abstract

For safety reasons, the removal of ice and snow from all critical surfaces of an aircraft is crucial before take-off. Ice can destroy the plain airflow and can jam control surfaces. In the worst case ice can cause noticeable damage to the engine.

The goal of this thesis was to do a research about developing of de-icing operations at Helsinki Airport in order to make de-icing operations more efficient and environmental friendly. In addition, this thesis gives an opportunity to spread the general knowledge about de-icing operations amongst the staff working at Helsinki Airport.

The purpose of this thesis was not to figure out something totally new and marvelous, but to research the already existing models of operations from other airports and try to adapt them to Helsinki Airport. In order to accomplish the given goal, the first step was to get to know the current situation at Helsinki Airport. The current situation was surveyed by visiting the airport several times during the research. In addition, interviews, phone calls, e-mail and benchmarking were used to give a boost to the theoretical background.

As a result of this thesis, a lot of new ideas for further development of de-icing operations came up. Without a doubt, this thesis offers a good starting point for further development of de-icing operations at Helsinki Airport. In future, this thesis can also be used as a valuable training material for the personnel.

Keywords
Aviation, De-icing, Aircraft, EFHK, Helsinki Airport, Finavia

Miscellaneous

ABBREVIATIONS

PG	Propylene Glycol
ATC	Air Traffic Control
EASA	European Aviation Safety Agency
CASA	Civil Aviation Safety Authority
FAA	Federal Aviation Administration
TC	Transport Canada
CAA	Civil Aviation Authority
JAA	Joint Aviation Authorities
AOPA	Aircraft Owners and Pilots Association
AEA	Association of European Airlines
HOT	Holdover Time
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
AIP	Aeronautical Information Publications

DEFINITIONS

For the purpose of this thesis, the following definitions apply. (AEA 2009).

Active frost: Active frost means forming of frost. Occurring when aircraft surface temperature is at or below 0 C° and at or below dew point.

Anti-icing: Provides protection against the formation of ice and frost. Prevents from snow and ice accumulations for a limited time period (holdover time).

Anti-icing fluid:

a) Type I fluid;
b) Mixture of water and type I fluid;
c) Type II fluid, type III fluid, or type IV fluid;
d) Mixture of water and type II fluid, type III fluid, or type IV fluid.

NOTE: Fluids mentioned in a) and b) must be heated to ensure a temperature of 60 C° minimum at the nozzle.

Contamination: All forms of frozen or semi-frozen moisture (e.g. frost, snow ice or slush)

Contamination check: Check of aircraft surfaces for contamination.

Defrosting: The removal of frost from an aircraft's critical surfaces.

De-icing: Procedure by which frost, ice, slush or snow is removed to provide clean surfaces.

De-icing fluid:

a) Heated water;
b) Type I fluid;
c) Mixture of water and type I fluid;
d) Type II, type III, type IV fluid;

e) Mixture of water and type II, type III, or type IV fluid.

NOTE: De- icing fluid is normally applied heated in order to assure maximum efficiency.

Critical surfaces: The wings, control surfaces, rotors, propellers, horizontal stabilizers, vertical stabilizers, or any other stabilizing surface on an aircraft and, in the case of an aircraft that has rear-mounted engines, includes the upper surface of its fuselage.

Apron: That part of an aerodrome, other than the maneuvering area, intended to accommodate the loading and unloading of passengers and cargo, the refueling, servicing, maintenance and parking of aircraft, and any movement of aircraft, vehicles and pedestrians necessary for such purposes. (Aviation glossary 2009).

Holdover time (HOT): Holdover time is the estimated time that an application of anti-icing fluid is effective in preventing frost, ice, slush or snow from adhering to treated surfaces. HOT is calculated as the beginning of the final application of the anti-icing fluid, and as expiring when the fluid is no longer effective. (Transport Canada)

Separation: a term used to prevent aircraft from coming too close to each other. Used by lateral, vertical and longitudinal of separation minima. (Wapedia 2009).

1 INTRODUCTION

1.1 Purpose of the Thesis

Researching the potential improvement ideas for de-icing operations at Helsinki Airport (EFHK) was the main goal of this thesis. The study was started out by gathering information about the current situation of de-icing operations at EFHK. The study continued by expanding the author's own knowledge about de-icing operations.

The final results and development ideas presented in this thesis can be used for further development of de-icing operations. Some chapters of this thesis can be used as literary material for airport documents and a valuable training material for the personnel.

1.2 Research Methods

In order to of reach the main goal, experience in the field and theoretical research was needed. In the field experience was achieved by visiting the airport several times during the research. Theoretical background was based on interviews, numerous phone calls, e-mails, meetings, Finavia's documents, aviation regulations, Internet based documents, e-books and books.

In chapter 4 benchmarking is introduced. Benchmarking was used to give a boost to the theoretical background. Benchmarking is a process, which compares an organization's practices to the best practices available. Accomplished in a reasonable way, benchmarking can be a very effective tool to increase the efficiency of de-icing operations.

1.3 Objectives of the Study

1.3.1 Finavia

Finavia maintains Finland's network of airports and the air navigation system. Finavia's airport network consists of 25 airports and it is currently employing around 2 500 people. In 2008, 17 500 000 air traveler's passed through Finavia's airports. Finavia is committed to safety and accountability in all of its operations. Finavia's objective is to be a customer-oriented and profitably growing state-owned service enterprise that is constantly reforming its operations. (Finavia 2009).

1.3.2 Helsinki Airport

Helsinki airport (IATA: HEL, ICAO: EFHK) is the biggest airport in Finland and fourth largest airport in the Nordic countries. It is known for the high quality and reliability of its modern services. Airport has been ranked at the top of the league in Europe in passenger surveys for ten years running. (AIP Suomi 2009; Finavia 2009.)

Basic Facts:

- Passengers: 12,6 million (2009)
- Takeoffs and landings: 171,000 (2009)
- Runways: 3
- Terminals: 2
- Airlines: 33
- Employees: 20,000
- Companies: 1,500

1.4 Importance of De-icing Operations

It is not a question whether de-icing an aircraft is important or not – de-icing an aircraft is essential because of flight safety. During freezing conditions, ice can destroy the plain airflow and cause increased drag while decreasing the ability to create lift. De-icing operations are planned and accomplished for frost, ice or snow deposits, which can seriously affect the aerodynamic performance and controllability of an aircraft. In addition, ice can cause engine stoppage by either icing up the carburetor or blocking the engine's air source. (AOP 2009; Caliskan 2007.)

Various local rules concerning aircraft cold weather operations are very specific and shall be strictly adhered to. All general rules and regulations concerning de-icing operations can be found in AEA documents, which establish the minimum requirements for ground-based aircraft de-icing.

Following is a quotation from AEA de-icing training manual:

"A pilot shall not take off in an aircraft that has: frost, snow, slush or ice on any propeller, windshield or power plant installation or on airspeed, altimeter, rate of climb or flight altitude instrument systems; snow, slush or ice on the wings or stabilizers or control surfaces, in gaps between the airframe and control surfaces, or in gaps between control surfaces and control tabs, or any frost on the upper surfaces of wings or stabilizers or control surfaces."(AEA 2009)

According to wind tunnel tests frost, snow, and ice accumulations just thick as a piece of coarse sandpaper can reduce lift by 30% and increase drag up to 40%. See Appendix 1 for a summary of one accident that was caused by un-awareness of a pilot and inappropriate de-icing. (CAA 2009; AOPA 2009)

1.4.1 De-icing Methods

De-icing can be accomplished by mechanical methods, with the help of heat, by use of chemicals (de-icing fluids) or by combining all these techniques. Many modern aircraft nowadays use anti-icing systems on the leading edge of wings or engine inlets using warm air. Warm air is led from engines and ducted into a cavity beneath the surface to be anti-iced. During flight the warm air is heating all surfaces up to a few degrees above zero preventing ice from forming.

Currently at EFHK there are propylene glycol fluids in use for de-icing an aircraft. Such fluids are not classified hazardous but can cause some unpleasant environmental issues if not recycled in a right way. The following chapter introduces some of the most common influences onto the environment. (Wikipedia 2009).

2 ENVIRONMENTAL ISSUES

The most consequential influences in the environment are the emissions to soil and water system. Most of these emissions are from aircrafts and other vehicles in use (apron vehicles). Nitrogen oxides (NO_x) and carbon dioxide (CO^2) are the most common trouble causing emissions. (Finavia 2009).

2.1 De-Icing Fluids

Propylene glycol fluids are the most crucial environmental issues. Such fluids are used for de-icing operations also at EFHK. The usage of glycol-based fluids is annually between 2 800m^3–4200m^3. (Finavia 2009).

Several fluid manufacturers providing certified fluids for the market exist, and the composition of the fluid varies by region, by manufacturer and also depending on the use of the glycol (aircraft de-icing or apron, taxiway and runway de-icers). Glycol based fluids used at EFHK are produced and delivered by Clariant GmbH, Germany.

Propylene glycol itself is not classified as a hazardous substance, but if let into waterways it consumes oxygen and emits an unpleasant odor when decomposing. See Appendix 2 (AEA 2009; Finavia 2009.)

2.1.1 Types I, II, III and IV Fluids

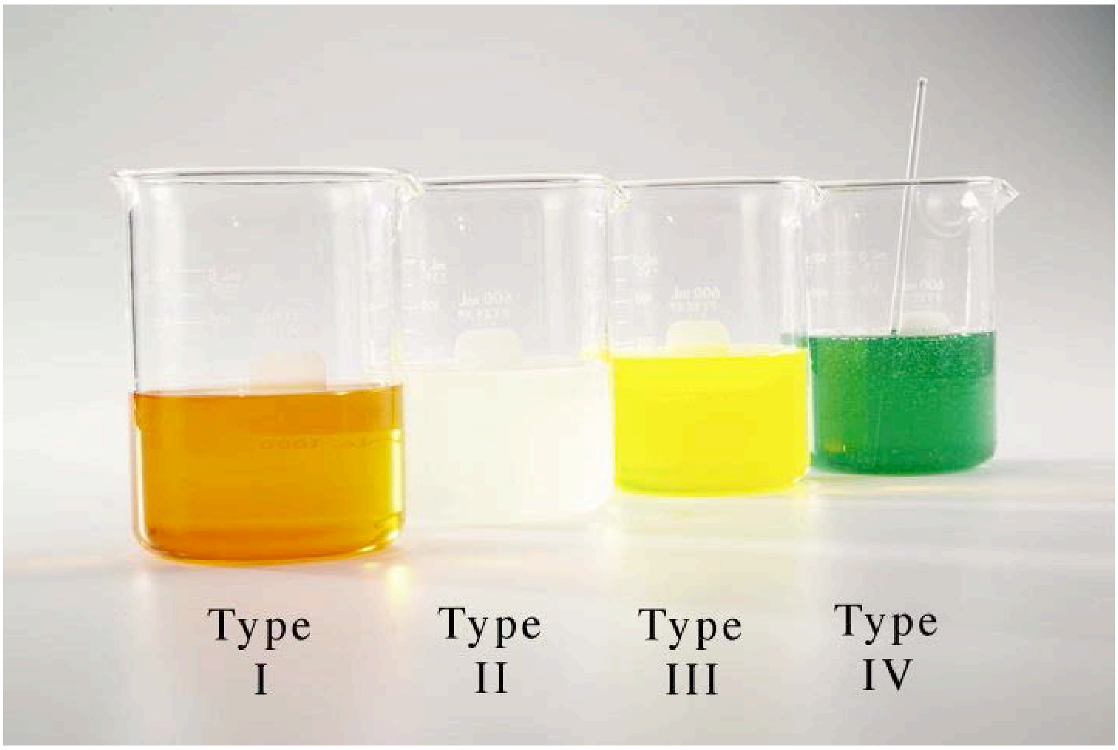

FIGURE 1. Types I, II, III, and IV fluids (NASA, 2009)

De-icing and anti-icing fluids are specially formulated to remove ice, snow and frost from the exterior surfaces of aircraft. Such fluids are also known as freezing point depressant fluids and only certain fluids are qualified for use on aircraft. Fluids are tested for material compatibility and aerodynamic acceptance to ensure there are no reactions between the fluid and materials, nor they compromise the aerodynamics of the aircraft.

The Society of Automotive Engineers publishes standards for four different types of aviation deicing fluids (SAE AMS 1428 & AMS 1424):

- Type I fluids have a low viscosity, and are considered "non thickened". They provide only short-term protection because they quickly flow off surfaces after use. They are typically sprayed on hot (55 C° - 80 C°) at high pressure to remove snow, ice, and frost. See Appendix 3 for FAA type I holdover guidelines.

- Type II fluids are "pseudo plastic", which means the fluid contain a certain type of thickening agent to prevent fluids immediate flow off aircraft surfaces. See Appendix 4 for FAA type II holdover guidelines.

- Type III fluids can be thought of as a compromise between types I and type II fluids. These fluids are intended for use on slower aircraft, with a rotation speed of less than 100 knots. Type III fluids are generally light yellow in color. See Appendix 5 for FAA type III holdover guidelines.

- Type IV fluids, commonly referred to as anti-icing fluids because an aircraft must first be de-iced prior to a Type IV fluid application, meet the same viscosity specifications as type II fluids, but they provide a longer holdover time. They are typically dyed green to aid in the application of a consistent layer of fluid. See Appendix 6 for FAA type IV holdover guidelines.

NOTE. De-icing fluids containing thickeners (types II, III, and IV) are also known as anti-icing fluids, because such fluids are used primarily to prevent icing from re-occurring after an initial de-icing with a type I fluid.

2.2 Usage of De-icing Fluids at EFHK

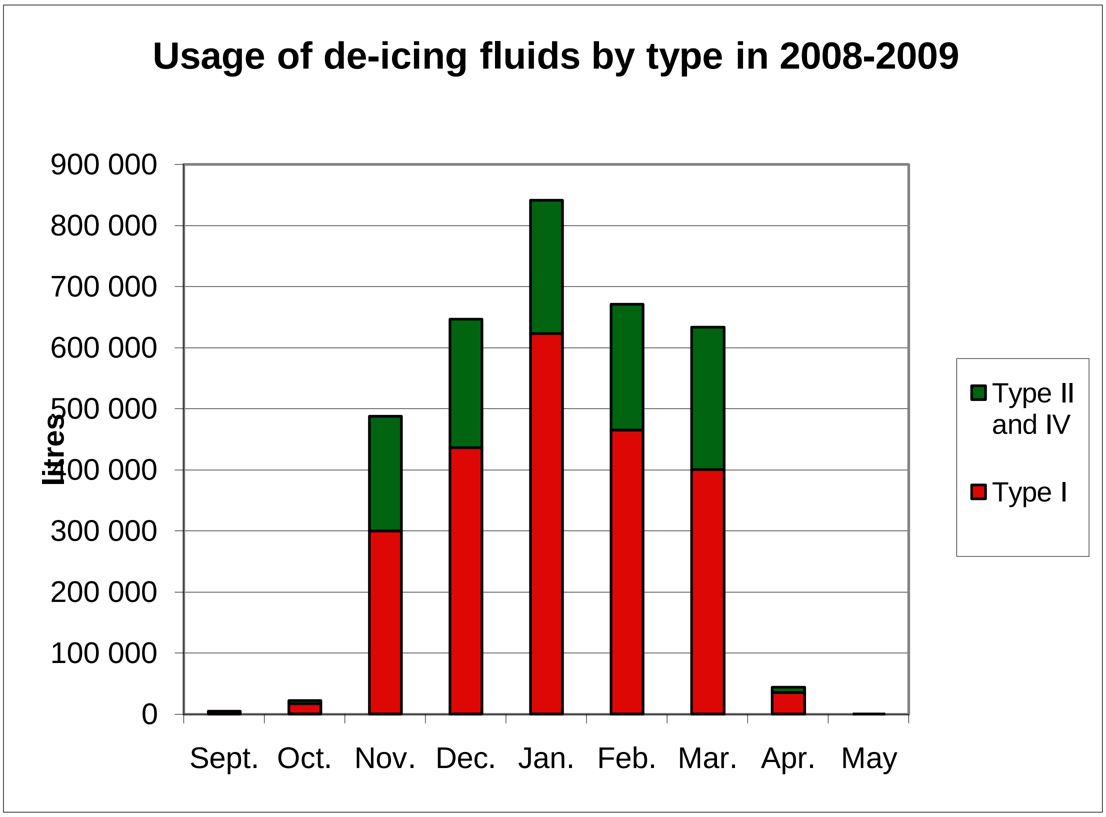

FIGURE 2. Usage of de-icing fluids by type in 2008 – 2009 (Finavia, 2009)

FIGURE 2 shows that in years 2008 – 2009 the main usage of de-icing fluids were concentrated on time period from November till March, but in real life it is impossible to forecast the weather so accurately that a long-term usage of de-icing fluids would be possible.

2.3 Designated Areas for De-icing at EFHK

For environmental reasons, EFHK has designated areas where de-icing procedure is permitted, most of which are provided with drains connected to the wastewater sewer system. In other areas, suction sweepers collect the de-icing fluid after procedure. De-icing fluid collected will be taken to a wastewater procedure or digestion plant. Snow containing de-icing fluid is collected separately from the apron area and taken to two dumps, where the melt water is conducted into the wastewater drainage system.

In 2007 a new glycol water pool was built. From the pool, water is transported straight to Viikinmäki for utilization. In 2008 Finavia brought into play a new remote area (APN6) for de-icing operations. APN6 is connected to runway 3. (Ympäristölupavirasto 2008; Finavia 2009.)

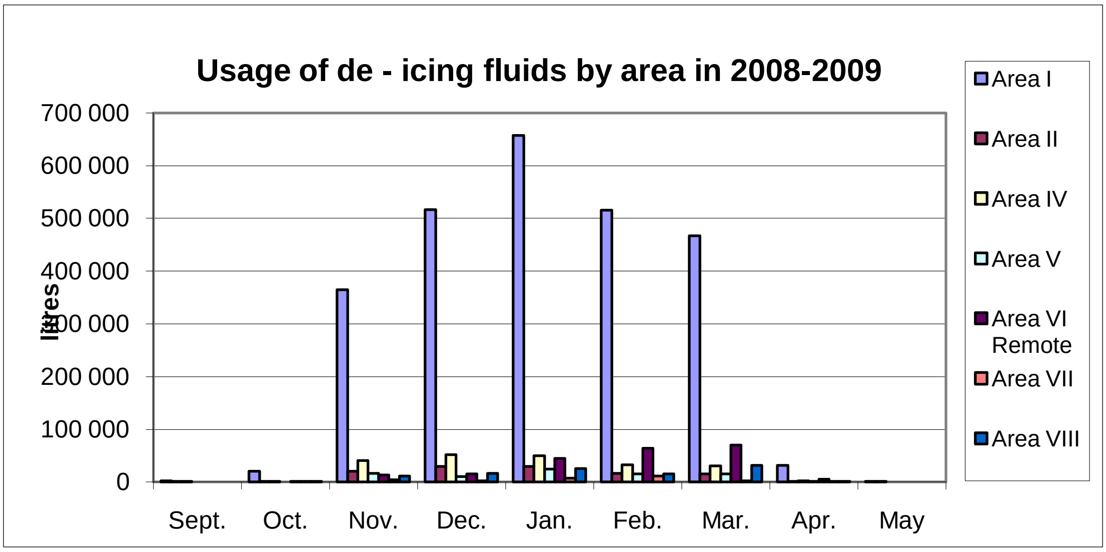

FIGURE 3. Usage of de - icing fluids by area in 2008-2009 (Finavia, 2009)

In Figure 3 can be seen how de-icing operations and fluid usages are divided between different areas in 2008 – 2009.

NOTE. Most of the operations were finished on area 1, which leads to enormous environmental burdening of the area.

2.4 Sampling

Impacts of de-icing fluids are monitored through regular sampling. Samples are taken from surface and groundwater in order to examine issues such as chemical oxygen consumption, nitrogen compounds and oxygen levels. The use of de-icing fluids during winter season is seen as risen oxygen consumption in ground waters as shown in Figure 4. (Kauppila 2009)

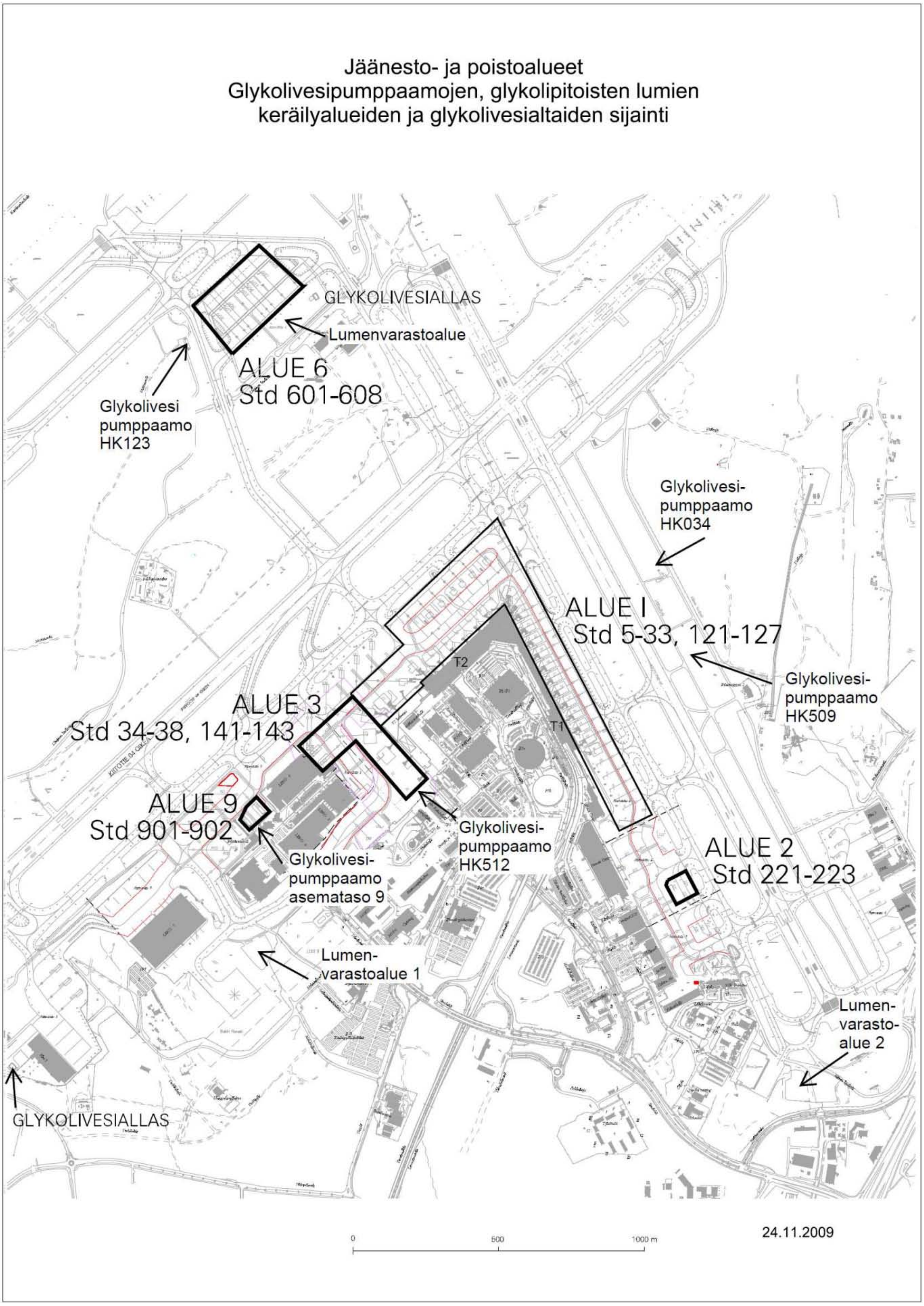

FIGURE 4. Designated areas for aircrafts de-icing operations. (Finavia 2009).

2.4.1 Description of Ground Water Condition

Airport runways 1, 2, 3, taxiing ways and all buildings are located in restricted highland area, surrounded by boulders in order to protect ground water areas. The highland area is divided into several drainage-areas, which are equal to ground water drainage-areas. There are two groundwater areas around EFHK: “Lentoasema” and “Lavanko”. Drinking water for the entire airport is extracted from groundwater intake plants. In 2007, 305 000m^3 of water were extracted, of which around half went for airport use and the remaining for companies operating at the airport. (Finavia 2009).

Runway 3 was built in 2002. Afterwards there has been a lot of discussion about environmental issues concerning the possible hazardous substance leaks to the Päijänne-tunnel. Päijänne-tunnel is located straight under the runway 3 and is transporting drinking water for 1000 000 people around the capital area. However, Päijänne-tunnel is protected with the strictest regulations and with the newest technology available and should not be a safety risk. (Finavia 2009).

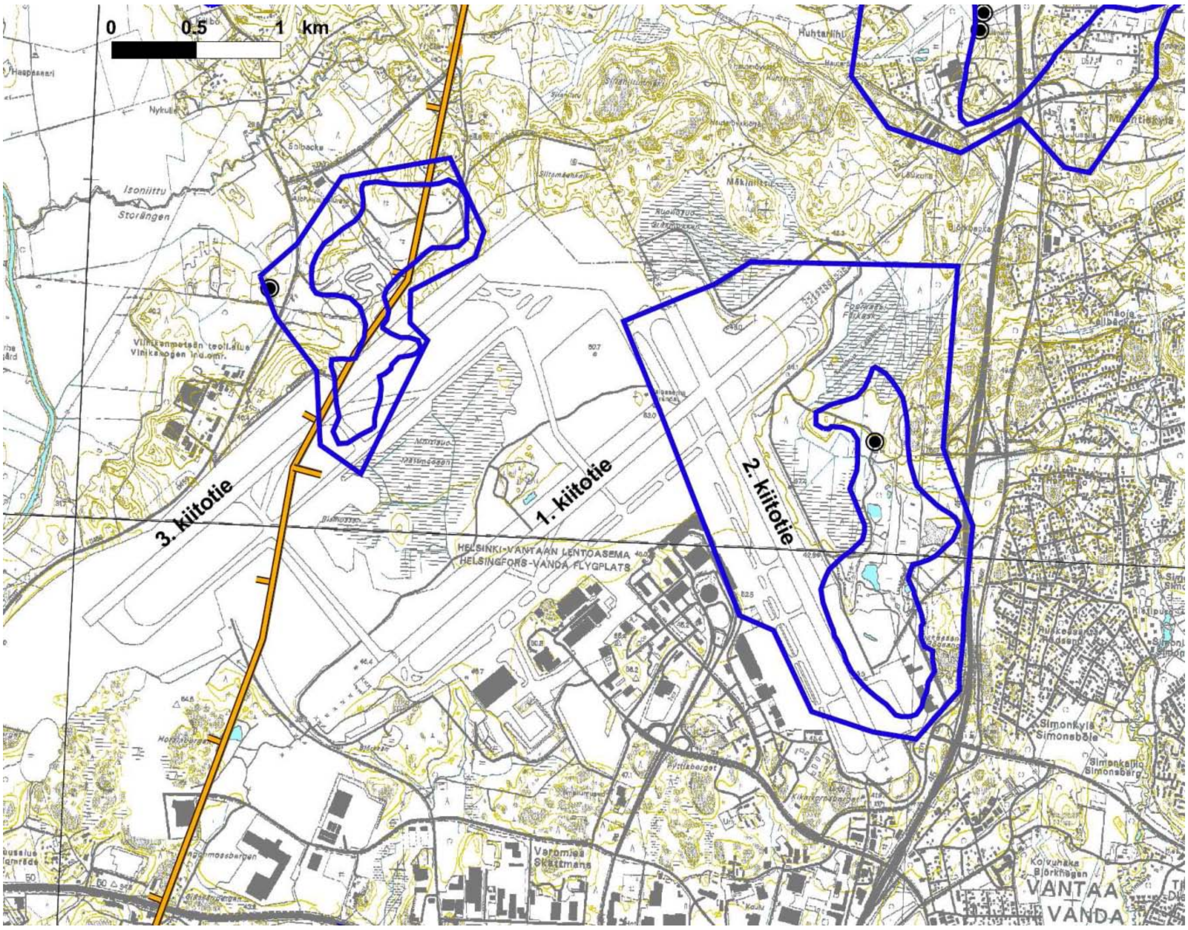

FIGURE 5. Ground water areas at EFHK. "Lentoasema" ground water area is located on east side of runways 1 and 2 (marked with blue lines). "Lavanko" ground water area is located on north side of runway 3. "Päijännetunneli" is marked with orange color and goes through runway 3.

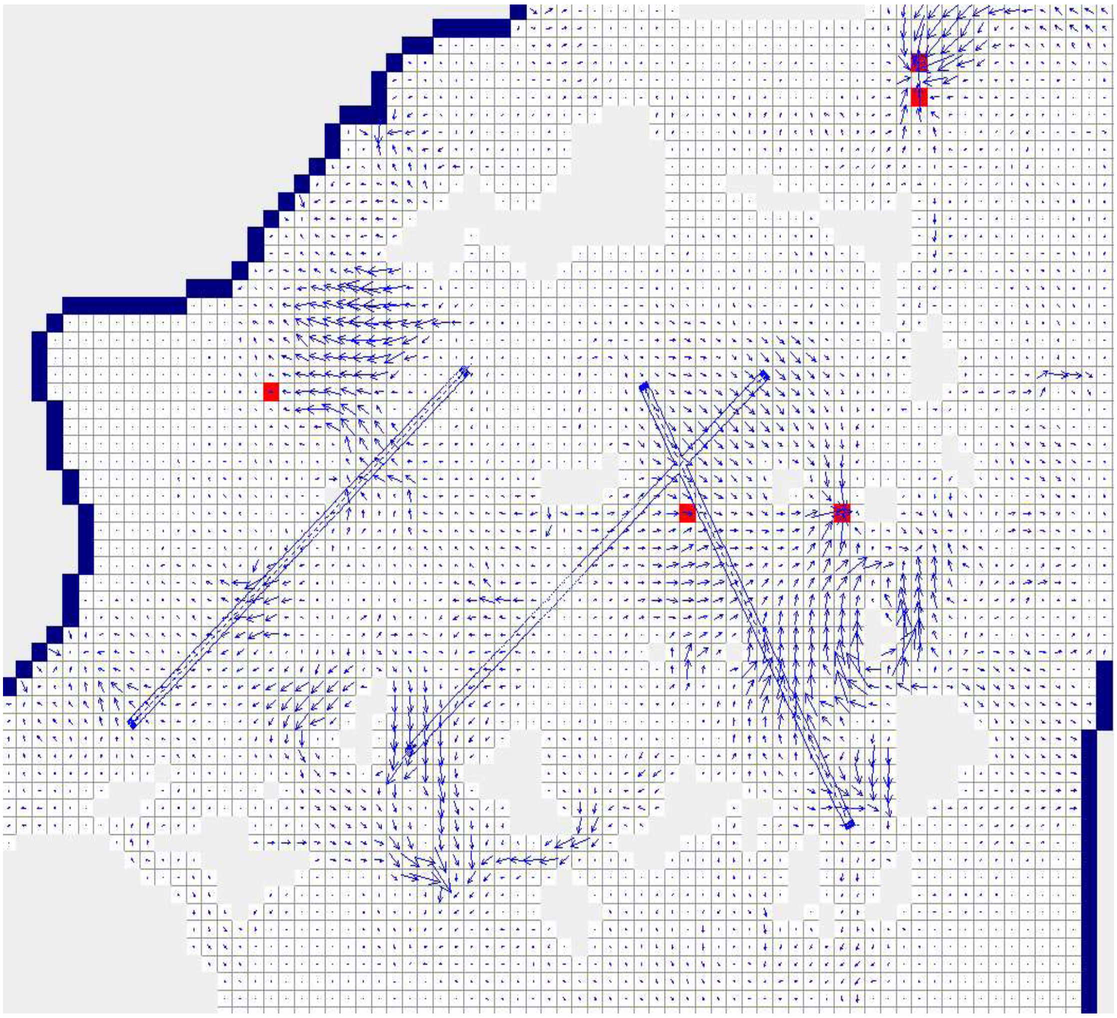

FIGURE 6. Flow directions with speeds of ground water in the airport area. Red squares are implicating ground water intake areas.

3 DESCRIBTION OF OPERATIONAL ENVIRONMENT

According to Furman (2009), the airline network is one of the world's most sophisticated, yet very complex, networks. Airline planning and scheduling operations have posed many great logistics challenges to operations researchers. Optimizing flight schedules, maximizing aircraft utilization, and minimizing aircraft maintenance costs can drastically improve the airlines resource management, competitive position and profitability. However, optimizing today's airline complex networks is not an easy task. Different organizations and parties involved in operations are introduced in this chapter. (Furman 2009).

3.1 Organization Involved in Flight Operations

Organizations involved in flight operations:

- Air Traffic Control

Air traffic control (ATC) is a service provided by ground-based controllers who direct aircraft on the ground and in the air. The primary purpose of ATC systems worldwide is to separate aircraft to prevent collisions, to organize and expedite the flow of traffic, and to provide information and other support for pilots when able.

- Ground Control

Ground control is responsible for the airport "movement" areas, as well as areas not released to the airlines or other users. This includes all taxiways, inactive runways, holding areas, and some transitional apron areas or intersections where aircraft arrive, having vacated the runway or departure gate.

- Local Control

Local Control (known to pilots as “tower”) is responsible for the active runway surfaces. Local Control clears aircraft for takeoff or landing, ensuring that prescribed runway separation will exist at all times.

- Flight Data / Clearance Delivery

Clearance Delivery is the position that issues route clearances to aircraft, typically before they commence taxiing. These contain details of the route that the aircraft is expected to fly after departure.

- Approach and terminal Control

Many airports have a radar control facility that is associated with the airport. Terminal Controllers are responsible for providing all ATC services within their airspace. Traffic flow is broadly divided into departures, arrivals and over flights. Terminal Control is also responsible for ensuring that aircraft are at an appropriate altitude when they are handed off, and that aircraft arrive at a suitable rate for landing. (Wikipedia 2009).

3.2 Ground handling at airport

“Ground handling” means the services provided to aircraft operators at airports as described in the Annex to EU Council Directive 96/67/EC. Ground Handling is provided by a handling company and includes all services at the airport, which will be offered to the user of the aircraft. De-icing is one of the services provided, if needed. This chapter covers shortly the most common ground handling activities described in Aviation Regulation GEN M1-3.

3.2.1 Ramp Handling

- Aircraft marshalling on the ground

The pilot-in-command or an aircraft maintenance technician with taxi rating is responsible for the aircraft when it is moved at the apron under its own power. Where a "Follow me" car or visual docking guidance system is used or the aircraft is marshaled with hand signals, the pilot-in-command or technician shall follow the guidance given as far as safety considerations permit. (GEN M1-3)

- Parking Assistance

Opening and closing of aircraft cargo doors, installation and removal of wheel chocks, landing gear and control surface locks, tail struts, pitot/static covers, heater, ground power unit, pneumatic ground starting unit and passenger/crew stairs, as well as other similar duties must be carried out in accordance with instructions given by the aircraft operator. Power in the ground power unit plug must be off when it is attached to the aircraft or removed from it. Safe movement of passengers at the apron must be ensured. When refueling or defueling an aircraft, necessary precautions shall be taken with regard to passenger movements if passenger stairs are equipped with wheels, they shall be locked in place or otherwise secured before use to prevent movement.(GEN M1-3)

- Loading and unloading

Engines must be shut down before loading or un- loading an aircraft. However, in situations where both the ground power unit and auxiliary power unit (APU) are temporarily unserviceable or missing, loading and unloading may be carried out while the engine on the opposite side or the centre engine is running. After unloading, the cargo holds shall be inspected for damage, leakage or any remaining items. (GEN M1-3)

- Engine starting

When starting up aircraft engines, a sufficient dry powder extinguisher or equivalent means for firefighting must be available at the airport.(GEN M1-3)

- Towing and push-back

Aircraft towing and push-back shall be carried out under the supervision of a person assigned to this task by the aircraft operator. The supervisor shall be responsible for the safety of the operation. He/she must ensure that there is no risk of collision and that the aircraft is not inadvertently moved to the maneuvering area. During towing and push-back, there must always be an appropriately trained person in the cockpit, who is authorized by the aircraft operator. (GEN M1-3)

3.2.2 Aircraft Servicing

During turnaround at the air terminal, certain services must be performed on the aircraft, usually within a given time to meet flight schedules. See Appendix 7 for an example of servicing arrangement for Embraer 170 jet. Services included:

- External and internal cleaning, heating, toilet and water services

These services shall be carried out in accordance with the aircraft operator's instructions, with special regard for cockpit cleaning instructions. Heating appliances used must be suitable for use in aircraft and in the particular aircraft type. Before flight, the aircraft operator shall ensure that cleaning, heating and toilet and water services have been carried out properly, in the interest of flight safety.(GEN M1-3)

- De-icing and anti-icing

De-icing and anti-icing operations include removal of snow, ice and frost from the aircraft. The operations shall meet the requirements contained in Aviation Regulations or set by the aircraft operator. The pilot-in-command shall be responsible for de-icing whether de-icing is needed. The supplier of ground handling services who carries out de-icing shall be responsible for:

a) Ensuring that de-icing fluids are handled in accordance with the manufacturer's instructions.
b) Ensuring that personnel involved in aircraft de-icing are suitably trained and qualified for de-icing procedures.
c) Ensuring that the operational provisions and instructions given by the managing body of the airport are complied with.

After de-icing procedure the pilot-in-command shall give an oral or written report, stating that the critical aircraft surfaces have been inspected and found to be clear of snow, ice and frost. The report must contain at least the following information: type of anti-icing fluid used, fluid/water mixture ratio, in terms of percentage by volume, starting time of the last phase of de-icing procedure (application of anti-icing fluid) and confirmation that the procedure has been completed. (GEN M1-3)

3.2.3 Fuel and oil handling

Detailed requirements concerning fuel and oil handling are given in Aviation Regulation AIR M1-12.

3.3 Traffic Pattern

Traffic pattern is used to assure smooth traffic flow between departing and arriving traffic. It is widely used for airports. Traffic pattern consists of five "legs" that form a rectangle, meaning two legs and the runway form on side, with the remaining legs forming three more sides. Each leg is named (see Appendix 8), and ATC directs pilots on how to join and leave the circuit. Standard traffic patterns are left-handed, meaning all turns are made to left so the pilot has better visibility out of the left window. (http://wapedia.mobi)

3.4 Maintenance Operations

The primary function of maintenance operations is to maintain the continuous airworthiness of aircrafts. The aircraft maintenance is highly regulated. There are various airworthiness authorities around the world. The major airworthiness authorities include: (Järvinen, M)

- Civil Aviation Safety Authority (CASA) Australia
- European Aviation Safety Agency (EASA) Europe
- Federal Aviation Administration (FAA) United States
- Transport Canada (TC) Canada

3.5 Airlines and Types of Aircrafts Operating at EFHK

3.5.1 Airlines

There are dozens of airlines, which use EFHK facilities for their scheduled and charter traffic. The airline companies are responsible, in addition to transporting passengers and baggage, for many airport services such as check-in, luggage handling, services at the departure gate as well as the use of boarding bridges and passenger stairs. Companies providing ground-handling services manage these tasks for the airlines. Airlines operating at EFHK are:

AerLingus (EI), Aeroflot Russian Airlines (SU), Air Åland (Avitrans Nordic), Air Berlin (AB), Air Canada (AC), Air China (CA), Air Finland (OF), Air France (AF), airBaltic (BT), Alitalia (AZ), American Airlines (AA), Austrian Airlines (OS), AviakompaniaSeverstal (D2), Blue1 (KF), BMI (BD), British Airways (BA), Brussels Airlines (SN), Bulgaria Air (FB), Cathay Pacific* (CX), ChinaSouthern Airlines (CZ), City Airline (CF), Continental Airlines (CO), Croatia Airlines (OU), Cyprus Turkish Airlines (YK), Czech Airlines CSA (OK), Delta Airlines (DL), easyJet (U2), Etihad (EY), Finnair (AY), Finnairkaukolennot / fjärrflyg / long-haul flights (AY), Finncomm Airlines (FC), Iberia (IB), Icelandair (FI), Japan Airlines (JL), KLM Royal Dutch Airlines (KL), , Polish Airlines (LO), Lufthansa (LH), Malaysia Airlines (MH), Malev Hungarian Airlines (MA), Meridiana fly (IG), Northwest Airlines (NW), Nouvelair Tunis (BJ), Primera Air (PF), Rossiya Airlines (FV), SAS Scandinavian Airlines (SK), Singapore Airlines (SQ), Spanair (JK), Sun-Air of Scandinavia (BA), SunExpress (XQ), Swiss International Air Lines (LX), TAP Portugal (TP), Thai Airways (TG), Thomas Cook Airlines (DK), TUIfly Nordic (Finnmatkat) (BLX), Turkish Airlines (TK), Ukraine International Airlines (PS), United Airlines (UA), Ural Airlines (U6), US Airways (US), Wingoxprs (Jet Air) (O2). (Finavia 2009.)

3.5.2 Types of Aircrafts

Types of aircrafts operating at EFHK are described in Table 1.

*TABLE 1. Aircrafts operating at EFHK (including number of operations) in 2007.(*Finavia 2009.)

Helsinki-Vantaan lentoasema **Konetyypit tarkastelujaksolla**	Operaatioita vuodessa
A320 -sarja, suihkumatkustajakone	55283
Embraer E170, suihkumatkustajakone	20221
Muut suihkumatkustajakoneet	15020
ATR72, 2-moott. potkuriturbiinikone	14908
Avro Regional Jetlines 85, suihkumatkustajakone	11988
AT45, 2-moott. potkuriturbiinikone	10673
B752 -sarja, suihkumatkustajakone	8172
SF340, 2-moott. potkuriturbiinikone	7083
B733 -sarja, suihkumatkustajakone	6333
2-moott. potkuriturbiinikoneet	6114
MD90, suihkumatkustajakone	5919
Avro Regional Jetlines 100, suihkumatkustajakone RJ1H	4903
MD11, suihkumatkustajakone	4419
E145, suihkumatkustajakone	3807
MD80 -sarja, suihkumatkustajakone	2922
1-moott. potkuriturbiinikoneet	1766
A340-300, suihkumatkustajakone	1362
2-mäntämoott. potkurikoneet	1230
3+ -moott. potkuriturbiinikoneet	446
1-mäntämoott. potkurikoneet	267
SB20, 2-moott. potkuriturbiinikone	6
Yhteensä	182842

4 COORDINATION OF DE-ICING OPERATIONS

According to Veryard (1994), it is easier to define coordination negatively rather than positively. Most of the time coordination is invisible, and we can only recognize it in its absence. Lack of coordination forces itself on our attention – when you have to wait two hours to change trains because the timetables are not synchronized – when there is no date within the next three months on which all six members are available for a meeting – when your are late of the most important meeting because there was half an hour delay in flight. Coordination is one of the things that people in organizations find most difficult.

Veryard (1994) also points out that three most common symptoms of the lack of coordination are waiting, duplication or waste of effort, and confusion/misunderstanding. All organizations need both internal and external coordination. Internal coordination is between the parts of the organization itself, and the systems directly supporting the organization. External coordination is with other organizations.(Veryard 1994).

4.1 Parties Involved in De-icing Operations at EFHK

All of the following information is described more detailed in Finavia's operating procedures in de-icing of aircraft at EFHK.

4.1.1 Helsinki De-icing Coordinator

Helsinki de-icing coordinator is the person in charge of coordinating all de-icing operations at the EFHK. The most important tasks Helsinki de-icing coordinator is requested to do:

- To receive all de-icing orders from pilots and forwards them to adequate directions.
- To define and coordinate proper slots for de-icing procedure.
- To work in cooperation with all persons related to de-icing operations. E.g. Airport units, airliners, de-icing companies etc. (Finavia 2009).

4.1.2 Remote De-icing Coordinator

Remote de-icing coordinator is responsible for the appropriate allocation of de-icing stands in the remote area (APN6) and for guiding aircraft to whichever stand is suitable in any given situation. Remote de-icing coordinator is requested to do following tasks:

- To plan the use of remote area on the basis of advance information (de-icing events ordered from the de-icing coordinator and allocated to the remote de-icing area) received from the de-icing coordinator.

- To direct aircraft within remote area (APN6) to whichever de-icing stand is suitable in any given situation.

- Keep in touch with the de-icing companies operating in the area to ensure that aircraft moving in the area do not constitute a hazard to themselves or to other aircraft or vehicles moving nearby.

- To monitor all operations remote area and to inform Helsinki de-icing coordinator immediately of any significant changes. (Finavia 2009).

4.1.3 De-icing Companies

At EFHK there are several different companies providing de-icing services - Northport, SAS Ground Services Finland, Inter Handling, Servisair and Nordic Airport Services. Every company providing de-icing services has their own airliners they are responsible for. De-icing companies are responsible for:

- participating in the development of coordination tools and coordination procedures.

- placing their equipment and personnel at the de-icing locations as planned for de-icing operations.

- operating under control of the current de-icing coordinator (Finavia 2009).

4.1.4 Airlines

Airlines are allowed to engage to further development work of de-icing operations. Airlines have the possibility to prioritize the de-icing operations in accordance with de-icing coordinator and ATC. (Finavia 2009).

4.1.5 Helsinki Airport

Main responsibilities belonging to Helsinki Airport are:

- Supervising that de-icing operations are accomplished in accordance with all regulations and directives specified.

- Specifying the use of runways in accordance with the environmental regulations. (Finavia 2009).

4.1.6 Air Traffic Control

Air traffic control is participating in de-icing operations as a consultant of planning the coordination, education and implementation. Air traffic control is also responsible for all the traffic at the apron area. (Finavia 2009)

4.2 Coordination at EFHK

Coordination of de-icing operations is based on aviation regulations and internationally approved standards (e.g. AEA). All airliners obligate the use of approved procedures on de-icing operations. Finavia is in charge of carrying out the de-icing procedures at EFHK. (Finavia 2009)

4.2.1 General Approach to De-icing Coordination

- Basic principles:

The decision to de-ice an aircraft is made by the aircrafts' pilot. For ordering de-icing procedure the pilot contacts Helsinki de-icing coordinator on frequency of 127.025 MHz. Pilot has to notify all de-icing services needed to Helsinki de-icing coordinator. Notification must contain all parts of the aircraft, which shall be de-iced (e.g. wings, under wings, stabilizers, etc.). After receiving the notification for de-icing will Helsinki de-icing coordinator advise the pilot with available de-icing spot/area and forwards the order to the company service provider. Pilot shall maintain constant radio connection with the de-icing coordinator on frequency of 127.025 MHz in order to keep up with the possible changes. (Finavia 2009).

- Determining of the de-icing area

Determining of proper de-icing area is a result of many factors. The actual de-icing spot is determined according to runways in use, which is controlled by ATC. Remote area (APN6) is primarily in use when runway 22r or 15 are in use as a departing runway. There is a possibility to negotiate with the airliner about the primary use of remote or gate area as a de-icing treatment area. (Finavia 2009).

- Forwarding the de-icing order

Helsinki de-icing coordinator forwards the de-icing order in accordance with the given de-icing area whether to remote coordinator (remote procedure) or to the company providing de-icing services (gate and stand procedure). (Finavia 2009).

- Coordination of the de-icing area

Helsinki de-icing coordinator forwards information about the current de-icing area to ATC. (Finavia 2009).

4.3 Operational Limitations

In order to maintain efficient de-icing operations, a logical and anticipant use of de-icing areas is necessity. There are many operational limitations, which make coordination and planning of de-icing operations a bit complicated. Not only limitations are because of strict environmental laws and regulations, but also because of many safety factors and varying weather conditions.

Some typical operational limitations having an immediate influence on operations are: types of aircrafts, usage of runways, communication between parties, companies involved in operations, customers, economics, and weather. Following subchapter describes some essential doctrines about limitation factors. Most of the following information is gathered from Finavias' documents and DICO records.

4.3.1 Under Wing Procedure

Under wing de-icing procedure is done manually using adequate equipment. If the aircraft has been moved from area where de-icing procedure is not permitted, becomes shutting down the engines of an aircraft mandatory.

According to AEA (2009): ”Clear ice can form on aircraft surfaces, below a layer of snow or slush/sleet. It is therefore important that surfaces are closely examined following each de-icing operation, in order to ensure that all deposits have been removed. Significant deposits of clear ice can form, in the vicinity of the fuel tanks, on wing upper surfaces as well as under-wing.”

However, AEA doesn’t regulate the method how to do it. Currently at apron area, person responsible of de-icing will check visually the quality of procedure. Under wing treatment is possible to complete with some of the current vehicles (Safeaero). Problem is however; it’s not possible to see under the wing from the chassis of the vehicle.

4.3.2 Opening and Closing of Remote Area (APN6)

Logical and anticipant use of de-icing areas is crucial for efficient overall accomplishment of de-icing operations. Equipments used for de-icing are very expensive and resources are limited and not all de-icing areas can be in use at the same time because of the lack of capacity.

De-icing coordinator is planning de-icing operations according to the runway combination in use. Since long-term planning of runway usage is impossible, becomes the planning of de-icing operations impossible at the same time. Hence the availability of remote area is only affecting to operative side of de-icing operations and the coordination of operations, it has no influence on human resources.

After the decision has been made of opening the remote area, is de-icing coordinator required to notice all de-icing companies, determine the operational condition of remote area, arrange the alienation of necessary equipment to remote area, arrange needed resources for the use of de-icing operations, and cooperate with the maintenance department. At the same time are de-icing companies required to move all adequate equipment and personnel to the remote area. De-icing coordinator allocates first operation at remote area not until the area is in full operational availability.

4.3.3 Runways Having an Effect on Operations

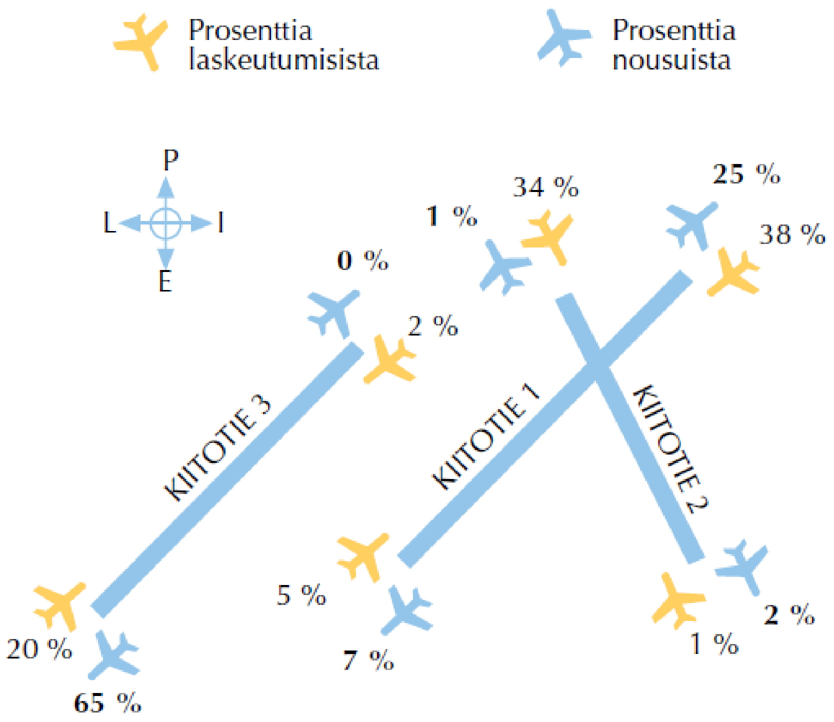

FIGURE 7. Usage of runways (2008). As shown in the figure, runway usage is divided so, that 65% of departing traffic is using runway 3 (22r), which is the only possible runway for departing traffic to use remote area for de-icing.

There are three runways at EFHK: (see appendix 8)

- 04R/22L (runway 1), dimensions: 3 440 m × 60 m
- 15/33 (runway 2), dimensions: 2 901 m × 60 m
- 04L/22R (runway 3), dimensions: 3 060 m × 60 m

Multiple factors are having immediate influence on ATC choosing the departing runway, but two of the most important factors are: prevailing winds and environmental reasons. In an ideal situation there's 22R as a departing runway and 15 as a landing runway. When using both 22s on parallel, there's 22R as a departing runway and 22L as a landing runway. Using 04 as a parallel, there's 04L a landing runway and 04R as a departing runway. Primary order on using runways is for departing traffic: 22R, 22L, 04R,33, 04L, 15. And for landing: 15, 22L, 04L, 04R, 22R, 33. In night time there's always combination 22R for departing traffic, and 15 for landing, in order to decrease noise pollution.

Some of the jet- aircrafts are using 22L instead of using 22r as a departing runway after 10pm. That leads to decreased use of remote area. The use of different runway combinations is causing challenges to those de-icing companies who have prepared to handle all customers at the remote area.

4.3.4 Communication and Companies Involved in De-icing Operations

As mentioned earlier, there are many parties involved in de-icing operation coordination process. When talking about the safety and economics of aviation operations, the fact is that communication between different parties should work without any gaps in information flow. Every organization involved in operations should get the same information at the same time in order to meet the requirements of efficient de-icing operations. Monitoring of such operations is not as easy as it seems to be and more effort should be put on developing communication systems and information flow.

Lack of cooperation between companies can be huge misuse of resources in some cases (e.g. two aircrafts from same airline are queuing for a de-icing procedure and same time there's unsuitable de-icing company without work). Cooperation between companies should be made tighter and cross procedures should be enabled (meaning every company could de-ice any aircraft).

4.3.5 Aircraft type Limitations at Remote Areas

De-icing during engines running is causing some special requirements, which are depending on the company, type of aircraft etc. Jet engines could be divided into three categories in de-icing operations:

- Wing mounted engine aircrafts (A320, A330)
- Tail mounted engine aircrafts (F70/100, MD80-90)
- Three or more engines –aircrafts (MD11, A340)

The location of engines is the only effect connected to wing mounted engine aircrafts. It can cause some glycol absorbing from ground to the turbine. Factors having effect on tail mounted engine aircrafts are related to the hands-on check accomplishment, which is a safety risk while engines are running. With aircrafts having three or more engines it is recommended by AEA that the outermost engines will be shut down during de-icing procedure. Another point worth mentioning is that these aircrafts usually are much bigger and heavier than the other aircrafts so the load caused by snow and ice can become significant.

De-icing of propeller engine aircraft differs from de-icing of jet engine aircrafts. Propeller engine aircrafts are all aircrafts equipped with piston engines or turboprops, both single engine and multiple engine aircrafts.

Most of the time de-icing of propeller aircraft goes exactly like jet engines. Exceptions exist though, for example: separate de-icing of propeller blades. According to AEA regulations de-icing of propeller engine aircrafts shall be accomplished starting from nose of the aircraft, moving towards tail, however the location of de-icing vehicle is undefined.

NOTE. It is requested to have external person for watching over, if the engines of aircraft will be shut down during the de-icing procedure. External person can be either de-icing truck driver or person having a start up communication training. Propellers of aircraft can be start up by using external power unit or by using battery. It is said though, that the battery doesn’t last very long if used regularly for starting up the engines.

5 DEVELOPMENT WORK

This chapter is to introduce different kinds of development ideas and results of this research. For that purpose, the author collected and reviewed data from a variety of sources, including several airports, airlines and technology suppliers providing de-icing systems for improved coordination and accomplishment of de-icing operations.

5.1 Benchmarking

Benchmarking was used as a part of developing work. All information related to benchmarking was gathered from other airports documents and/or persons involved in de-icing operations. The main idea for benchmarking was not to steal ideas from other airports nor get anything served ready to table, but to get familiar with different kinds of approaches and to see how things could be done differently, nonetheless operate smoothly.

At the beginning of operation descriptions there is a short overview of the airport for understanding the big picture. For benchmarking, the author mailed a list of questions for each airport representative. This list of questions requested information about airports regarding aircraft de-icing operations, in addition to airport structure and basic information. Airports were asked to answer the to questions related to the following topics:

- Use of remote and/or gate area
- Environmental issues
- Fluids used for de-icing the aircraft
- Problems detected in de-icing operations
- Use of de-icing management software
- Use of resources and equipment

5.1.1 Pulkovo Airport St. Petersburg (Russia)

In 2008 Pulkovo airport provided service for more than 7 000 000 passengers, which represents 15.2% growth since 2007. An average 258 take-offs and landing operations and around 19 000 passengers are transported daily. Pulkovo airport has two separate runways and two passenger terminals.

At Pulkovo airport there are no remote areas in use for de-icing operations at the moment.In near future the airport is facing large infrastructural renovations according to ecological safety requirements. New plans involve special aircrafts de-icing areas equipped with containers for dangerous chemicals and remote pads for de-icing operations, hence they're moving to centralized de-icing operations in order to take care of environment and safety.

Pulkovo Airport had formed its own aviation ground handling service in 2006. Before this step ground handling for all airlines was provided by special department of JSC "STC Rossiya".

The only problem reported was delays in delivering fluids, but according to mr.Baranovskioy their problem was solved. Types I and IV fluids are in use and the manufacturer for such fluids is Octafluid. Currently no de-icing management software in use but in the future it becomes essential.
(e-mail conversation with Mr. Baranovskioy on 3rd November 2009; Pulkovo airport annual report 2008.)

5.1.2 Saint Paul International Airport Minneapolis, MN (USA)

Saint Paul International airport is the sixteenth busiest airport in United States. In 2008 airport served around 34 000 000 passengers. Airport has four separate runways and two terminals.

Ground handling services are provided by Northwest/Delta airlines. According to Delta airlines representative Doug Witt, their de-icing operations are one of the most efficient in the world.

Around 85% of de-icing operations are made at separate remote de-icing pads, which are located just before take off in order to keep ramp congestion to a minimum. That way used excessive glycol is also easier to collect and it is more environmental friendly than gate area de-icing. Other aircrafts are de-iced after the ramp crew push's the aircraft back from the gate, but before engine start.

On some occasions they use anti-icing fluid (type IV) to treat some aircrafts before a storm in order to speed up the de-icing process in the morning.
They have 31 de-icing trucks and other support equipment to keep their operations running normal even during a snowstorm. 3 different makes of de-ice trucks are in use: FMC's, Premiers and Trumps. Also Glycol Recovery Vehicle is in use for sweeping up glycol in certain areas where are no drains for waste water. The fluid is collected and partially recycled to sell on secondary market. Attempts were made to recycle the used glycol and return it to use on aircraft de-icing again, but it was found to be too expensive to produce pure glycol that is required for de-icing operations.

Despite the fact they have 21 meteorologists working on getting accurate forecasts, according to Mr. Witt their biggest challenge is getting accurate forecasts in order to plan accordingly for de-icing. Staffing for de-icing operations are coming from other parts of their airline operations, so many of their operations are short staffed if they need to utilize them for de-icing.

Airport has their own internal software, which is custom designed for de-icing operations. It includes aircraft monitoring on the ground, gate location, departure times, de-ice inspections, de-icing locations, what trucks are in use/out of service, start and finish times etc. (e-mail conversation with Mr. Witt).

5.1.3 Oslo Airport (Norway)

Oslo Airport is Norway's main airport. The Airport serviced 18 100 000 passengers in 2009. Oslo airport has been named Europe's most punctual airport three times by the AEA.

De-icing at Oslo Airport is performed on three remote de-icing pads, which are located quite close to entry points to their two runways. There are collection systems that collect excess water and deicing chemicals by all the de-icing platforms and alongside the taxiways and at the start of the runways.

Approximately 80 % of the deicing chemicals used are collected. The remaining 20 % are spread over the area alongside the runways or carried farther afield by the aircraft. Two handling companies are performing aircraft de-icing operations at Oslo Airport: SAS Ground Services AS and Nordic Aero AS.

Oslo Airport has two models of de-icing trucks in use; Safeaero 220 and My elephant. My elephant is only used for anti-icing the aircrafts and snow blowing.

The only problem faced in Oslo Airport is with freezing rain conditions, which is special geographic problem.

They have a self-developed de-icing coordination management system, which is continuously improvement. (e-mail conversation with Mr. Ruud).

5.1.4 Stockholm-Arlanda (Sweden)

During 2008 18.1 million people traveled to or from Stockholm-Arlanda Airport. Airport has three runways and one remote pad for de-icing aircrafts.

At Stockholm-Arlanda almost 90% of the de-icing operations are done at the gate area. Rests 10% are done at the remote area. As de-icing management software they have their own developed system called "FAS" (Flight Assignment System) Nordicaero is responsible for ground handling activities at Stockholm-Arlanda airport. According to mr.Genmark from Nordicaero, they use most of the time gate de-icing because that way they can perform multiple de-icings at the same time. Only problem mentioned is that they have to remove excessive glycol from the ground after de-icing. In addition to normal de-icing vehicles, they have an excessive glycol remover "The Recycler" in use. The Recycler has been in use for 5 years and it's part of the R&D project.

Water that comes from vehicle washing facilities at the airport often contains metals. At Stockholm-Arlanda Airport there are three water treatment units that removes harmful metals before the water is piped to a municipal wastewater treatment plant. (E-mail conversation with Mr.Genmark).

5.2 De-icing Management Systems

De-icing management system is designed to improve the efficiency of overall de-icing operation. With the help of well-designed system, overall de-icing monitoring and operation accomplishment can be more efficient in the end. Efficiency is improved primarily through greater operator productivity in managing the flow of aircraft through the process and an overall heightened awareness of operational status, which leads to more efficient decision-making.

Good de-icing management system includes certain features in means of taking the maximum coordination advantage out of it. To name a few, there should be at least possibility to: monitor all aircrafts that are on the ground, full gate location data, departure times, de-ice inspections, location and time information (where and when the aircraft will be de-iced), what trucks are in use, what trucks are out of service etc.

As a part of this study, author introduces the current de-icing management system called CAPCO, and compares it to alternative system available called DECO.

5.2.1 CAPCO

Currently at EFHK there's a de-icing management system named CAPCO in use for coordination and work supervision.

The main principle of CAPCO is very simple. De-icing coordinator conveys the information on an aircraft's de-icing stand to ATC through the CAPCO system. The system automatically enters the information into the ATC information database. CAPCO is a management tool, which shows user all necessary information (e.g. received de-icing orders, ongoing processes, history data etc.) Benefits of CAPCO include: easy to use, data communication to and from de-icers and clear layout. See Appendix 10. (Vainio 2009).

5.2.2 DECO

DECO is a well-proved, advance de-icing management system for coordination of de-icing operations. It consists of a database system with a server, and 1-4 coordinator operator computers, as well as wireless communication system to de-icing trucks, preventive de-icing units and final release trucks. DECO makes automatic reports (including environmental reports), statistics, graphics and files for invoicing. It has also integrated queue status information. See Appendices 11 and 12.

5.3 Benefits of Centralized De-icing Operations

In the beginning of 2008 Finavia took in use a new de-icing remote area (APN6) for de-icing operations. The goal was to make de-icing operations more environmental friendly for EFHK. According to Finavia, the goal was to centralize a remarkable part of de-icing operations, which meant that almost 50% of the operations could be done at centralized area. But in 2008-2009, only a small percentage of de-icing operations were done at remote area APN6 and most of the operations were concentrated on gate areas. (Finavia 2009).

Benefits for centralizing de-icing operations are unbeatable compared to operations made at gate areas. Largest reason for airports around the world moving to centralized operations is connected to environment and safety. It is obvious that collecting of excessive glycol from one centralized area (de-icing pad) is easier than collecting from many different areas all around the airport. At the same time storing of equipment and liquids becomes effortless, and monitoring of de-icing operations will be smooth and natural. Safety plays a vital role also in de-icing operations. By centralizing most of the operations the traffic can be moved from already congested areas to external de-icing areas (remote areas).

5.4 The Recycler

Taking care of glycol falling on to the apron and runway is today on the agenda at the most airports in the world. Nordic Aero is recommending "The Recycler" as a flexible solution for stricter environmental regulations.

The process is a multi stage full distillation technique that separates heavy metals, such as cadmium, also polymers and salts out in the process. The process consists of five stages, the first three stages evaporate the water, and the fourth stage effectively distills the glycol. Fifth stage is a booster that guarantees that the final product will have a glycol content of 99.5% or higher. The end product is as good as the virgin glycol available in the market.

From the initial start-up until the glycol is ready to be tanked, takes around 3-4 hours. It is designed to minimize power consumption, with optimum low production costs.

The Recycler – Glycol Recycling system

5.5 Preventive Anti-icing

Preventive anti-icing is an optional method that is mainly used for an aircraft which is scheduled to remain at the airport for some time. Preventive anti-icing procedure takes place when the aircraft arrives at the airport. Experience has shown that by applying the glycol just after landing prevents the formation of thick layers of ice while reduces the amount of glycol used before actual take-off. Anti-icing can be also used for aircrafts with shorter turn-around time. In best-case, anti-icing fluid applied just after landing can eliminate the need of de-icing fluid. This leads to savings in fluid usage. One problem with anti-icing is that it is almost impossible to get so accurate forecasts that planning of preventive anti-icing would be possible in a long run.

5.6 Cooperation Between Companies

Cooperation between companies is widely practiced today and is becoming more and more popular among organizations. Reason for tightening the bonds between companies is, that by cooperating it is possible to afford benefits that can't be achieved alone.. The potential benefits gained by cooperating include reducing costs, decreasing lead times, and improving service levels. For example, collaboration among companies providing de-icing services will increase the efficiency and profitability of de-icing operations due to integrated rules, regulations and possibility to faster handling of aircrafts.

6 RESULTS AND FINAL ANALYSIS

Before getting into the real results, a couple of notes are worth mentioning when implementing possible innovations and improvements. Attention should be paid not only to direct costs but also to all available resources. As a result a total balance must be found between the total costs and value.

Making this study has shown, that there are three basic approaches to cost savings, environmental friendliness and better coordination in de-icing operations:

- Minimization of the amount of glycol applied to aircraft.
- Developing of glycol recovery and recycling methods.
- Developing of de-icing management systems.

This has led to the fact that more technology suppliers are bringing de-icing equipment, de-icing management systems and recycling vehicles to the market. This kind of competition between suppliers is very welcome, since it reduces the costs of needed equipment and services and makes them affordable and easier to get.

6.1 Benchmarking Results

When using benchmarking as a tool to improve the efficiency of operations, it is necessary to keep in mind the structure of an airport. Every airport is different and implementing straightly a new model using examples from other airports is impossible. In purpose of benchmarking, the author focused on four different airports with potentially significant de-icing operations. These airports are different in terms of climate, location, size and infrastructure. The following presents a summary of the benchmarking results including the author's own points of view and ideas for the future.

The lesson learned from other airports around the world is that it is crucial to understand the reasons for the occurrence of bottlenecks in ground handling activities. These problems are many times caused by constant changes of weather (ice and snow on the airport), limited capacities or a limited number of staff, vehicle or de-icing equipment. Nevertheless, delays caused by the above mentioned reasons can be prevented or reduced by completing all preliminary operations related to overall ground handling operations. This means that anticipated and organized planning for de-icing operations must be taken seriously.

In general, the author found the following trends among ”benchmarked” airports:

- No major problems have occurred in de-icing operations lately
- Environmental related issues are a big part in de-icing operation developing process
- Centralized de-icing operations are becoming popular
- Effort has to be put in the use of resources due to lack of them
- Planning plays vital role in de-icing operations
- Self-developed de-icing management systems are popular
- Planning for de-icing operations is very difficult due to unpredictable weather conditions
- Need for cost-effective de-icing liquid recycling system.

Author found that the same "problems" all around were the same. Because of the safety reasons environment is a subject which is widely researched and under all-time improvement. More and more methods for recycling the excessive glycol are being researched. Author found out that there are several glycol-recycling systems in the market, but none of them offer enough value compared to the prices they causes. One glycol recovery system "The Recycler" was researched as a part of this study. More detailed information about "The Recycler" recycle system is found in Chapter 4. However, attempts have been made to recycle the used glycol and return it to the use of aircraft de-icing again (e.g. St. Paul International) but it was found to be too expensive to recycle the product to make the pure glycol, which is required for de-icing aircraft.

Author found out that at most of the airports de-icing operations are centralized. More and more airports are moving towards centralized operations due to stricter environmental regulations. However, that is not the only reason for centralizing operations. Author believes, that the largest cost to the airlines with aircraft de-icing is the cost of delays with the aircraft. Therefore, the airlines have a great interest in providing cooperative help in developing operations. For instance, the use of centralized de-icing operations may potentially reduce departure delays. It is not a coincidence that 9 out of 10 airports have changed over 50% of operations, or are going to change, to operations made on remote pads nearby runways.

Author's recommendation is to look for more examples from the United States and use benchmarking more widely there. United States is not just the Mecca of aviation, but it is full of professional people in the field of air industry. People in general are different because of the cultural differences and that is one way to catch new ideas and perspectives on things.

Another thing worth mentioning is what Mr. Baranovsky from Pulkovo Airport said – Pulkovo Airport is facing huge infrastructural renovations and the new plans involves remote areas for de-icing operations. So basically their airport is reconstructing the whole de-icing scene and that leads to enormous changes in operations. Author believes that now if ever is the time for us to learn something from them, and vice versa.

Seeking for new ideas and thoughts from other parts of the world, especially out of Europe and Scandinavian countries is not a bad idea in the end. It is a way to get more contrast on things, which most likely makes people think differently.

6.2 Visions for the Future

The second step is to reconsider the general layout of de-icing areas. According to Finavia, a new remote area is under construction and should be available for use in 2011. There will be 2 remote pads quite close to entry points to main runways, where most of the departing traffic takes off. That will enable the airport to give up some of the gate area de-icing spots and centralize operations. But the airport should absolutely keep doing some of the de-icing operations at the gate area in order to keep remote pads from getting too busy during heavy departure schedule. Author thinks that one option in this matter will be to use some of the individual parking spots near the departing runways in case of remote areas cannot be used for some reason. Increased traffic at gate area is always a safety risk but using individual parking spots the traffic will be able to transfer out of the gate area, thus maintain safe operations. Using only 2 remote areas most of the time and some of the gate area spots will enable the overall de-icing operations to be more environmental friendly, and makes the coordination of operations easier with all the equipment and staffing at the same place. As mentioned, it is also important that re-fill sites at remote areas are designed so, that de-icing trucks can be filled with de-ice fluid and fuel in short time. Many times there is no room for trucks wasting time for filling or waiting on the "wrong" side of the airport.

There's never room for extra traffic on the apron area. Author estimates that, by centralizing operations, collecting of excessive glycol will be easier and overall traffic will be reduced to minimum in the apron area. That leads to more safe and environmental friendly operations and saves parking spots at gate area. In addition, all the equipment, liquid, fuel and staff could be held at the same place all the time. The fact that customer will come for de-icing and not other way round will also make operation monitoring more smooth.

Author has been learned that time between de-icing and takeoff should be minimized in order to agree with glycol holdover times. By de-icing at the remote area nearby runway will shorten the time before aircraft takes off so the holdover time with the fluid is not in jeopardy. As an example: Type I fluid, which is used the most at EFHK, is only considered to be effective after 6-11 min of spraying on the aircraft. The time of protection in heavy weather conditions will be shorter than in normal conditions. Effect can be immediate and caused by heavy precipitation rate or high moisture content. Also high wind velocity or jet blast may reduce holdover times. Hereby the taxiing time of an aircraft have to be kept as short as possible. This matter will get even more highlighted in future, since overall traffic is expected to steadily increase at EFHK.

Biggest part of flight activity at EFHK is concentrated on the morning and afternoon rush hours. If there's a snowstorm added, the trouble is on. During critical hours the importance of cooperation between companies gets highlighted and determining priority orders for aircraft's becomes a necessity. Therefore, author thinks that all companies providing de-icing services have to be integrated with common rules and regulations in order to maximize the use of given resources. Assuming that by centralizing operations the overall coordination will become significantly efficient and more staff could be concentrated on better and accurate planning. However, if cooperation between companies doesn't work and resources are not used effectively, it is a misuses of resources and hereby, a waste of money. Cooperation between organizations is essential for smooth overall accomplishment of operations.

Referring to benchmarking results and authors own experiences, it is very rare to have so many companies responsible for de-icing operations at the airport than EFHK has. This can be turned into huge advantage by tightening the alliance. Author believes, that if the de-icing companies had the possibility to cross operate with all the aircrafts, the continuance of de-icing operations would be guaranteed despite the variable circumstances.

As a part of this study, alternative de-icing management system was researched in terms of improving de-icing operations coordination at EFHK. Assuming that implementation of new system would be not only very expensive, but also effortful, author strongly believes that there's no need to change the current software (CAPCO), as it is performing its tasks as planned. If in the future when bigger development ideas are in mind (network structure will be changed) and new plans involve a need for more sophisticated de-icing management system, airport may take into account DECO de-icing management system. It may become a good option because of its comprehensive features and coordination skills. However, more flexible and cost-effective solution is to make improvements in already existing system, CAPCO. Using current resources enables continuous development of CAPCO, besides that, training of already well-known system is effortless. Author believes, that benefits using an old system are not limited to already well-known operating system, but also the cost effectiveness of the system. New system always causes a lot of work and staff training in order to get it work properly.

There's no doubt that The Recycler is a flexible solution for stricter environmental regulations, but at the given moment this glycol recycling system doesn't offer enough value compared to overall costs it causes. Especially in the given economical circumstances the need of The Recycler becomes unconditional in this matter. Author believes though, that effort must be put more on finding ways to recycle the excessive glycol. This matter will get even more highlighted, when overall traffic at EFHK will increase and environmental regulations becomes stricter.

Author strongly believes that preventive anti-icing should be taken into serious consideration, especially during severe weather conditions. Assuming that preventive anti-icing procedure will make the actual de-icing procedure a bit faster, while reducing the need of fluid applied, author believes, that preventive anti-icing will become good option in terms of cost savings and saving the environment. For example, during severe weather conditions a queue might easily form because of heavy departure schedule. However, if some of the aircrafts are already treated, time will be saved in a long run.

Author found out that the under wing procedure is possible to accomplish with the equipment used at EFHK. All surfaces have to be examined according to the AEA regulations after the procedure. However, the fact is that with the current equipment, it's impossible to see under wing from the chassis of de-icing vehicles. For this reason, it's necessary that de-icing vehicle driver or some external person do the visual examination. Necessarily bringing external visual examination person doesn't solve the problem, but one option in this matter would be to use under wing de-icer, made by Vestergaard, that is specialized to facilitate remote de-icing with engines running. Author found out that the visual inspection could be done straight from the vehicles chassis because the actual de-icer is built on a standard pick- up truck. Such vehicle is equipped with a stainless steel tank, a hydraulic pump and a diaphragm pump for handling of all types of fluid. (Vestergaard, 2010)

Biggest influence having an effect on usage of runway combination has in the hands of air traffic control. For that reason, author's opinion is that it will become mandatory to research if there's any possibility to increase use capacity of runway combination 22r, 15. The attention should be paid to the overall accomplishment of operations in terms of noise pollution, environmental impacts and use of resources. Possibility to integrate rules about the usage of runways with Finavia's environmental department, air traffic control and the airport, has to be examined. Increasing the use capacity of runway combination 22r, 15 would result in greatly increased volumes of remote area use, as well as increase in centralized collection of excessive glycol. In addition, the cooperation between companies will continue grow since centralized operations promote organizations for better cooperation. Finally, author thinks that as a result the efficiency of overall operations and safety of apron area will increase while impacts on environment will decrease significantly.

In future the opening of second remote area enables more comprehensive centralization of de-icing operations, but unfortunately that is just one side of the coin. There's the other side - it will make de-icing operations even more complicated to coordinate. If misuse of resources occurs and cooperation's of companies is not being tightened, starts the poor coordination to do harm and that can lead to unwanted results at some point. That's why staff training and operations planning has to take place in times when de-icing is not needed (e.g. in summer time)

Cross handling would promote the de-icing of customers at every single area where de-icing procedures are permitted. (Gate and remote areas)
For wing mounted engine aircrafts there are no significant limitations. For certain tail mounted engine aircrafts in certain circumstances the hands on check limitation is hampering the use of remote area. Possibility to shut down the engines during procedure should be researched. De-icing of aircrafts with three or more engines can be accomplished normally, taking care of the load caused by snow and ice.

7 CONCLUSIONS AND FINAL DISCUSSION

Main goal of this thesis was to do a research, which would help Finavia in finding potential improvement ideas for de-icing operations. From the beginning, the goal wasn't to invent anything unseen, but to enable reader to think differently with the help of several improvement ideas and thoughts presented. Different kind of methods and development ideas came up during the research, and continuing the development work will be more effortless in the future. In the end, question is about already existing ideas and operating according to the changing environment. Difficult part is however, to fit such ideas and patterns into Helsinki Airports' de-icing operations as a supportive element, without affecting to operational reliability negatively. Many of the available options introduced in this research will need money investments to utilize in use; hence for many of them, a further study in future is needed. Frankly speaking, many of the ideas presented in this thesis are not even possible to adapt directly in use at Helsinki Airport.

First, it is necessary to understand, that the airports operations are made to operate according to certain formula, which is keeping up the airport and operations running from day to day. Second, it is have to be understood, that it is impossible to do major modifications to airports layout without changing the whole operational procedure. Because of these two reasons, is developing a de-icing operation coordination, which is one part of the overall flight operations, remarkably difficult task. Developing process should be carried out by building up a development plan, which concentrates on developing different kind of areas of de-icing operations separately. Second step is to consider the use of resources – author finds it reasonable to use outsourced resources while using own, already existing resources, as a supportive element. By outsourcing this kind of projects, can already existing staff concentrate on their own tasks better, and no operation will be short staffed. After finding the staff and building up the development plan, it will be finally good time to execute.

This thesis introduces vital information and facts about the most important factors, which have an immediate impact on de-icing operations accomplishment. These factors can be divided into four different areas: environment, operational environment, safety and variety of companies involved in operations. Best results can be achieved only when the big picture is clear for everybody. It takes a lot of time and money to concentrate on every single part of the operation and get it work properly. That is why efficient planning and staff training plays a vital role also when developing de-icing operations.

Nevertheless, this thesis offers a good starting point with very valuable contact information and details of airports around the world. With the help of this thesis, it is possible to start to build clearer mindset about *how* to continue de-icing operation developing work in future. In other words, this thesis can be used as a draft script for future development plans.

Even though only a surface has been scratched, a lot has happened from the beginning until this day. Airports and airliners all around the world have faced many changes and challenges due to unstable economical situation and unprecedented natural forces. However, many changes at EFHK have been done concerning de-icing operations. Some of the most important cornerstones so far have been:

- Implementing of frost removal period
- Increased amount of centralized de-icing operations
- De-icing coordination rearrangements
- Excursion to Zurich Airport – benchmarking in action

Frost removal period was implemented to ensure more economical de-icing operations before wintertime, when the amount of liquid use is limited. Main benefit in frost removal period is, that quite big piece of the environmental costs can be cut. New plans involved only four different areas where de-icing was allowed to do (34-38, 141-143, 221-223, Remote APN6 and 901-902). Use of such areas was coordinated centrally.

Use capacity of remote area (APN6) was increased. It was forced to increase by directing all de-icing operations possible, to remote area. In a long run, this will lead to more environmental friendly and efficient de-icing operations at EFHK.

Tasks of Helsinki de-icing coordinator will be moved to Finavia's responsibility from 15.2.2010. According to new agreement, Finavia is responsible for the tasks of Helsinki de-icing coordinator. The alienation to Finavia's command will be executed in stages, beginning 25.1.2010. (See appendix 13.) Nevertheless, Northport Oy is still responsible for de-icing operations made on remote area APN6.

A group of representatives from Helsinki Airport visited Switzerland to get new perspectives on things, and to see how de-icing operations are accomplished at Zurich Airport. Visit took place in 19.2.2010. From here, the development work will continue accordingly.

For the author, this thesis has been an eye-opening experience in field of aviation. Making of this thesis has shown how superficially many things may seem like everything is going fine, but at the same time behind the curtains there can be total disaster going on. Worlds economical situation, natural disasters and of course our own actions are continuingly modifying the status of aviation industry. It is very important to keep up with the varying conditions and move on accordingly. Aviation industry is changing all the time, and unfortunately the consequences are always not very praiseworthy and airliners have done a huge job in order to stay competitive. As a result, some cutbacks in service have been made, which can be seen as a risen anger among air travelers – the same beverages and food which some time ago was free of charge have become chargeable, delays in flights, bad service and long lines. At some point we will face another huge problem with too few and small airports due to increasing air traffic. Airports, airliners and all companies involved to operations are under tremendous pressure because of reasons mentioned before.

Nevertheless, travelers at Helsinki Airport have reached their destinations down to this day and will reach also in future. As mentioned earlier in chapter 3, the airline network is one of the complicated networks in the world and planning accordingly for such network is not an easy task.

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APPENDICES

Appendix 1 Story of Challenger 604(www.caa.co.uk/docs/33/factor200439.pdf)

Birmingham, England, January 4, 2002 – Story of Challenger 604:

"Immediately after takeoff from runway 15 at Birmingham International Airport the aircraft began a rapid left roll, which continued despite the prompt application of full opposite aileron and rudder. The left winglet contacted the runway shoulder, the outboard part of the left wing detached and the aircraft struck the ground inverted, structurally separating the forward fuselage. Fuel released from ruptured tanks ignited and the wreckage slid to a halt on fire; the Airport Fire Service was in attendance less than 1 minute later. The accident was not survivable."

Appendix 2 An example of negative environmental impacts

(http://www.hs.fi/kaupunki/artikkeli/Lentokoneiden+j%C3%A4%C3%A4nestoaine+l%C3%B6yhk%C3%A4%C3%A4+Ilolassa/HS20080503SI1KA02nh0)

Kevät on hempeimmillään Kylmäojan varrella Vantaan Ilolassa. Linnut laulavat, valkovuokot kukkivat ja puro solisee somasti.

Niin solisee, mutta löyhkää samalla. Mitä kovempi virta, sitä haisevammat terveiset se tuo Helsinki-Vantaan lentoasemalta.

Kylmäojassa on happi loppu ja se mätänee. Syyllinen on lentokoneiden jäänestoaineena käytettävä propyleeniglykoli, jota pääsee maastoon.

"Haju on pahimmillaan sateella, kun purossa on paljon vettä. Silloin ei voi pitää ikkunoita auki", puron varrella omakotitalossa asuva Seppo Kaarela kertoo.

Vanhemmat asukkaat muistavat, että Kylmäojassa oli ennen hyvin kalaa, jopa taimenta.

Asukkaat ja ympäristöviranomaiset ovat ihmeissään, kun mikään ei auta. Vähän aikaa sitten asukasyhdistys ja kaupunginvaltuutettu Timo Auvinen (sit.kesk) tekivät likaamisesta rikosilmoituksen.

"Todella epämiellyttävää. Ei sellaista pidä hyväksyä", ylitarkastaja Marjo Vuola Uudenmaan ympäristökeskuksesta sanoo.

Huhtikuussa ympäristökeskus lähetti Finavialle kovasanaisen kirjeen. Sen pitää lokakuun loppuun mennessä antaa selvitys toimista, joihin se ryhtyy Kylmäojan ja muiden purkuojien hajuhaittojen poistamiseksi.

Edellisen kerran ympäristökeskus huomautti asiasta viime vuonna. Myös Vantaan ympäristölautakunta ja ympäristöviranomaiset ovat ihmeissään lentoaseman piittaamattomuudesta.

Lentoaseman ympäristölupa on katkolla. Finavia jätti hakemuksen uudesta luvasta viime vuoden lopulla.

Siinä se ilmoittaa, että kentällä otetaan käyttöön pesualueita, joilla jäänesto tapahtuu keskitetysti.

Yksi pesupaikka otettiin käyttöön maaliskuun puolivälissä, mutta siitä ei ole ollut apua.

Jäänestoaineena käytettävä propyleeniglykoli on sinänsä myrkytön ja luonnossa hajoava aine, mutta näistä ominaisuuksista ei ole paljon etua, kun se syö hajotessaan hapen.

Myös kentän liukkaudentorjuntaan käytettävää formiaattia valuu luontoon. Sekin kuluttaa happea hajotessaan.

Finavian ympäristöjohtaja Mikko Viinikaisen mukaan glykolia päätyy jonkun verran pintaveteen, ja siihen on lupa.

Appendix 3 FAA Type I HOT Guidelines

FAA TYPE I HOLDOVER TIME GUIDELINES

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow/Snow Grains: Very Light**	Snow/Snow Grains: Light **	Snow/Snow Grains: Moderate**	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
below -3 to -6	below 27 to 21	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
below -10	below 14	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
‡ Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

Appendix 4 FAA Type II HOT Guidelines

FAA TYPE II HOLDOVER TIME GUIDELINES

TABLE 2. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKE OFF CHECK PROCEDURES.

Outside Air Temperature		Type II Fluid Concentration Neat-Fluid/Water	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	Degrees Fahrenheit	(Volume %/Volume %)	Freezing Fog	Snow/ Snow Grains	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:05-0:40	
		75/25	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20-1:05	0:15-0:30	***0:20-0:45	***0:10-0:20		
		75/25	0:25-0:50	0:10-0:20	***0:15-0:30	***0:05-0:15		
Below -14 to -25 or LOUT	Below 7 to -13 or LOUT	100/0	0:15-0:35	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

Appendix 5 FAA Type III HOT Guidelines

FAA TYPE III HOLDOVER TIME GUIDELINE

TABLE 3. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE III FLUID MIXTURE AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE.

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)								
Degrees Celsius	**Degrees Fahrenheit**	**Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)**	**Freezing Fog**	**Snow/Snow Grains**			**Freezing Drizzle***	**Light Freezing Rain†**	**Rain on Cold Soaked Wing****	**Other‡**
				Very Light	**Light**	**Moderate**				
-3 and above	27 and above	100/0	0:20 - 0:40	0:35 - 0:40	0:20 - 0:35	0:10 - 0:20	0:10 - 0:20	0:08 - 0:10	0:06 - 0:20	
		75/25	0:15 - 0:30	0:25 - 0:35	0:15 - 0:25	0:08 - 0:15	0:08 - 0:15	0:06 - 0:10	0:02 - 0:10	
		50/50	0:10 - 0:20	0:15 - 0:20	0:08 - 0:15	0:04 - 0:08	0:05 - 0:09	0:04 - 0:06		
below -3 to -10	below 27 to 14	100/0	0:20 - 0:40	0:30 - 0:35	0:15 - 0:30	0:09 - 0:15	0:10 - 0:20	0:08 - 0:10		
		75/25	0:15 - 0:30	0:25 - 0:30	0:10 - 0:25	0:07 - 0:10	0:09 - 0:12	0:06 - 0:09		
Below -10	below 14	100/0	0:20 - 0:40	0:30 - 0:35	0:15 - 0:30	0:08 - 0:15	CAUTION: No holdover time guidelines exist			

SAE Type III fluid may be used below -10 °C (14 °F), provided the freezing point of the fluid is at least 7 °C (13 °F) below OAT and aerodynamic acceptance criteria (LOUT) are met.

Consider the use of **SAE Type I** when **Type III** fluid cannot be used.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

** This column is for use at temperatures above 0 °C (32 °F) only

‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, and hail

† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

Appendix 6 FAA Type IV HOT Guidelines

FAA TYPE IV HOLDOVER TIME GUIDELINES

TABLE 4. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

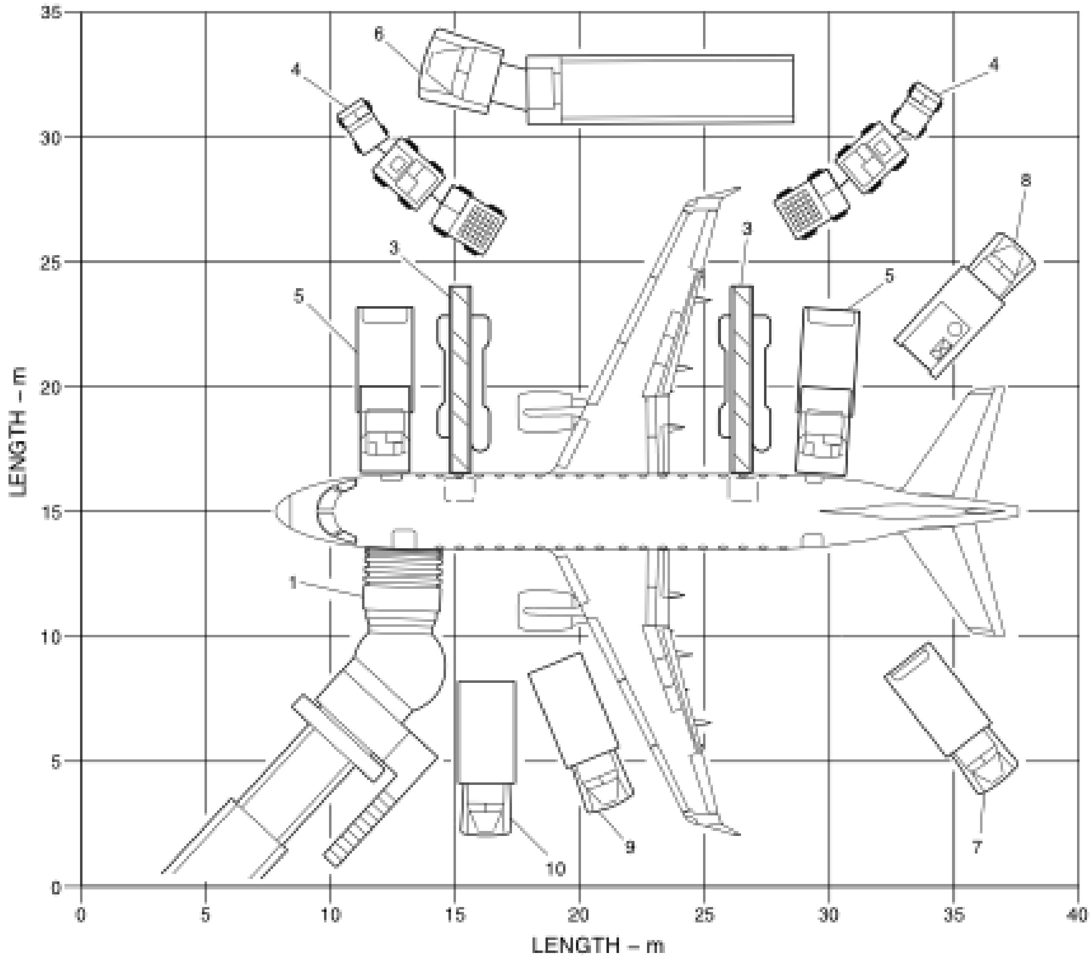
CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit	Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog	Snow/Snow Grains	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:20-0:40	***0:20-0:45	***0:10-0:25		
		75/25	0:25-0:50	0:15-0:35	***0:15-0:30	***0:10-0:20		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15-0:40	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

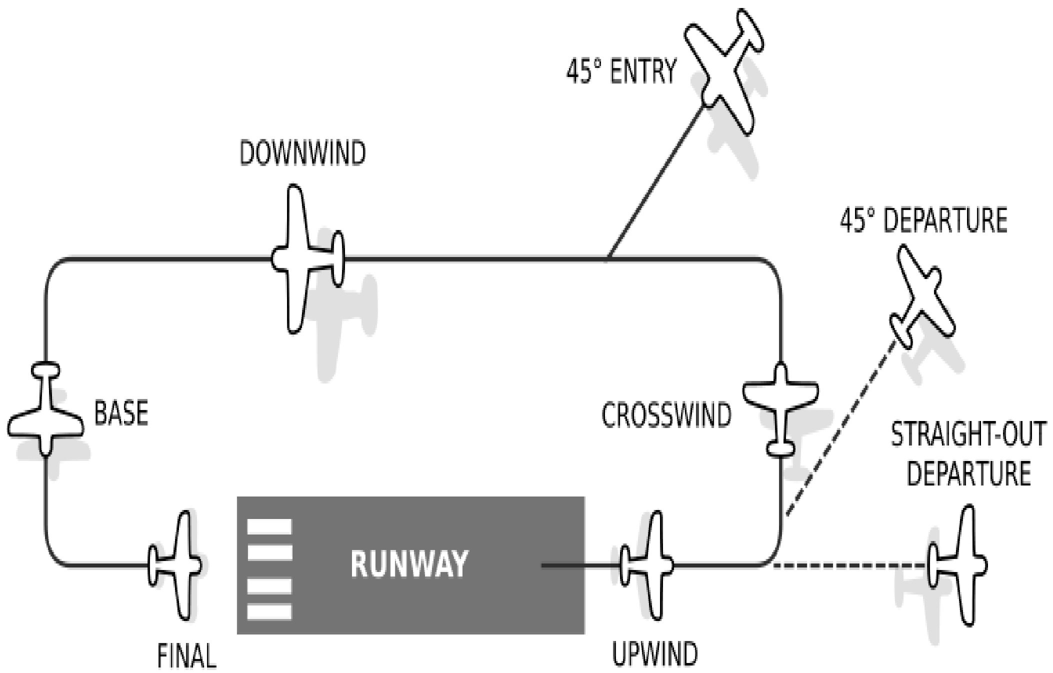
* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
***No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

Appendix 7 Servicing Arrangement with Passenger Bridge

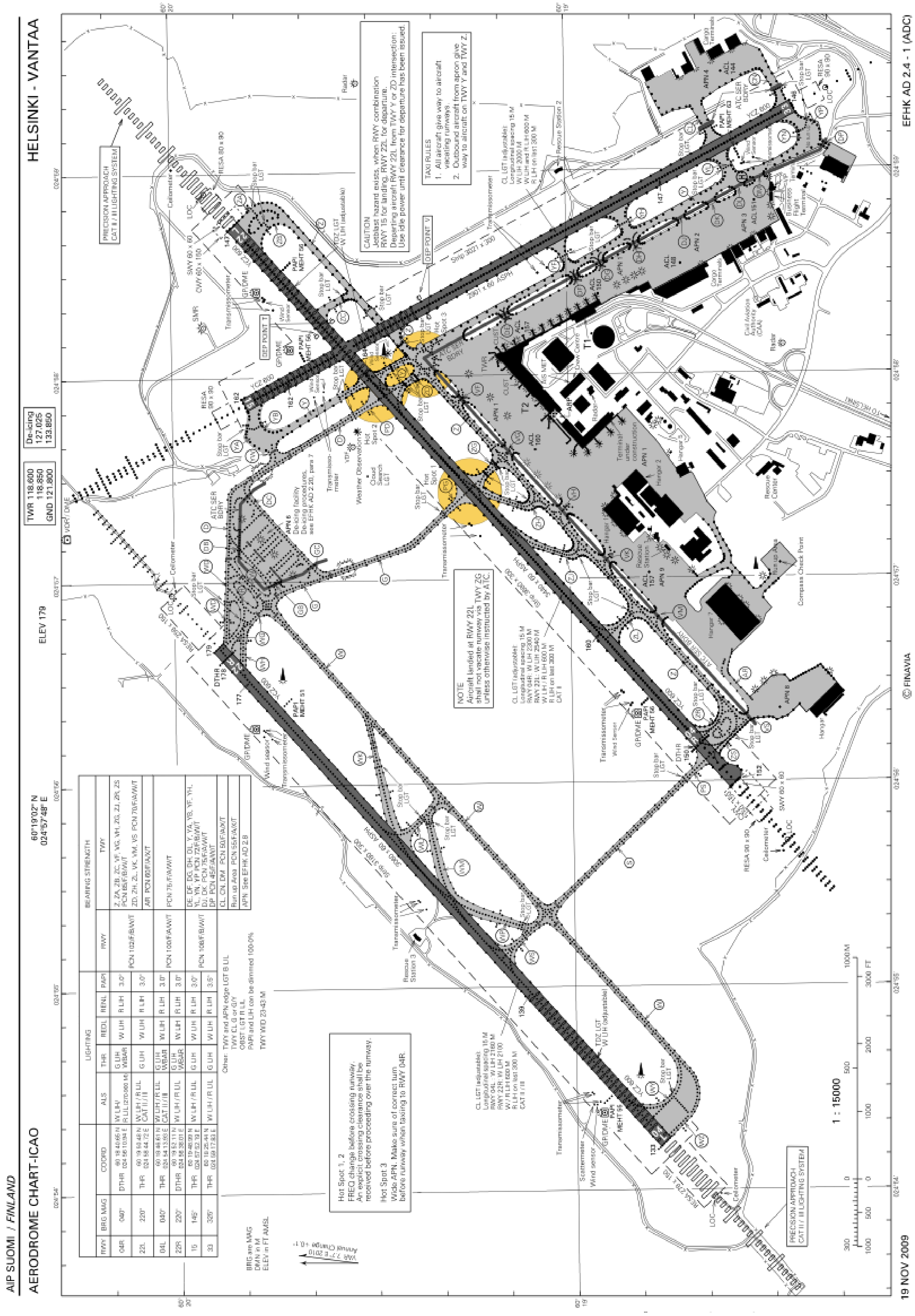


1. Passenger Bridge
2. Cargo Loader
3. Baggage / Cargo trolley and Tug
4. Galley Service Vehicle
5. Fuel Service
6. Potable Water
7. Lavatory Servicing Vehicle
8. Air Condition Unit
9. Pneumatic Starter

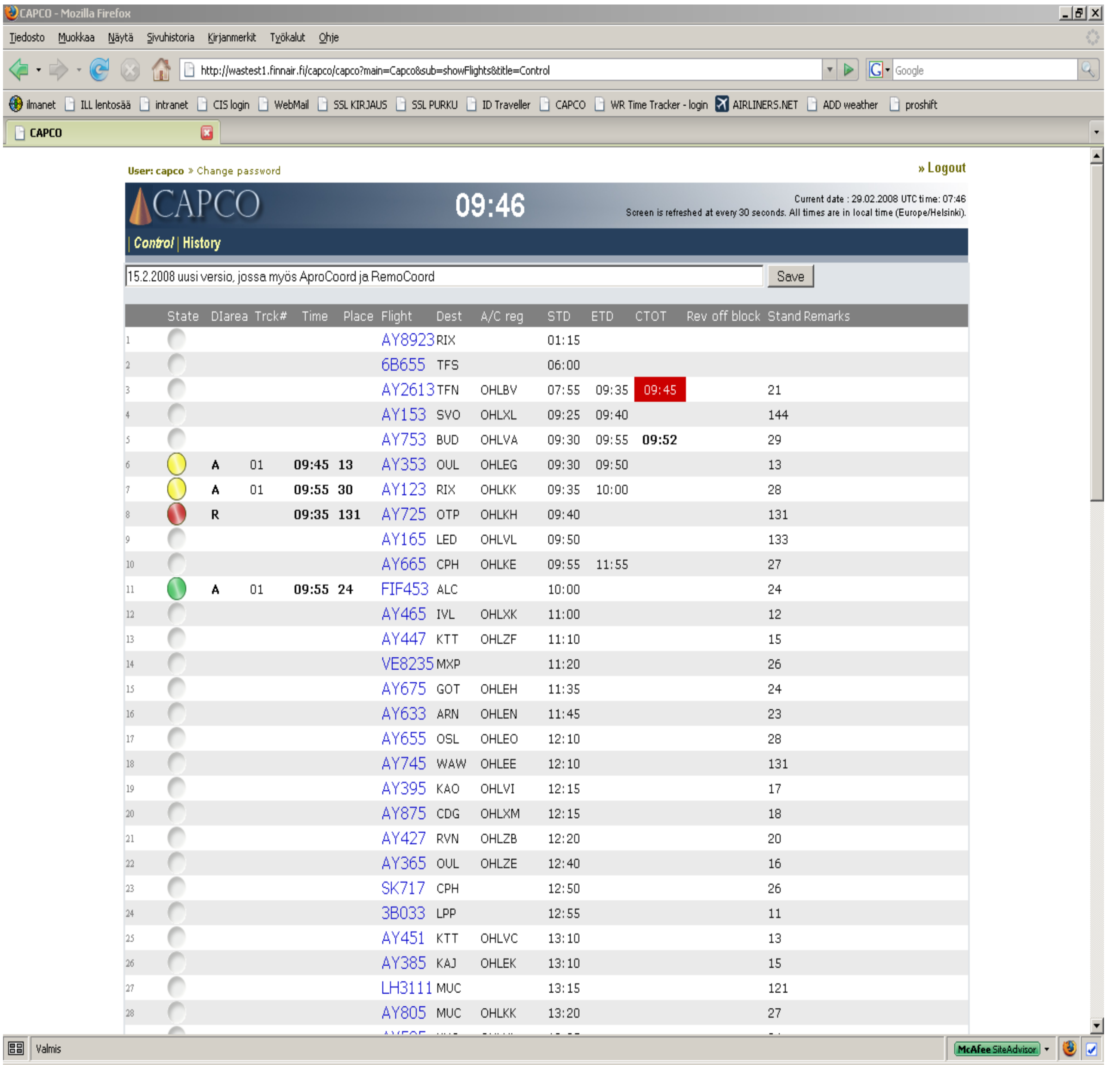
Appendix 8 Airfield Traffic Pattern



Appendix 9 Map of EFHK

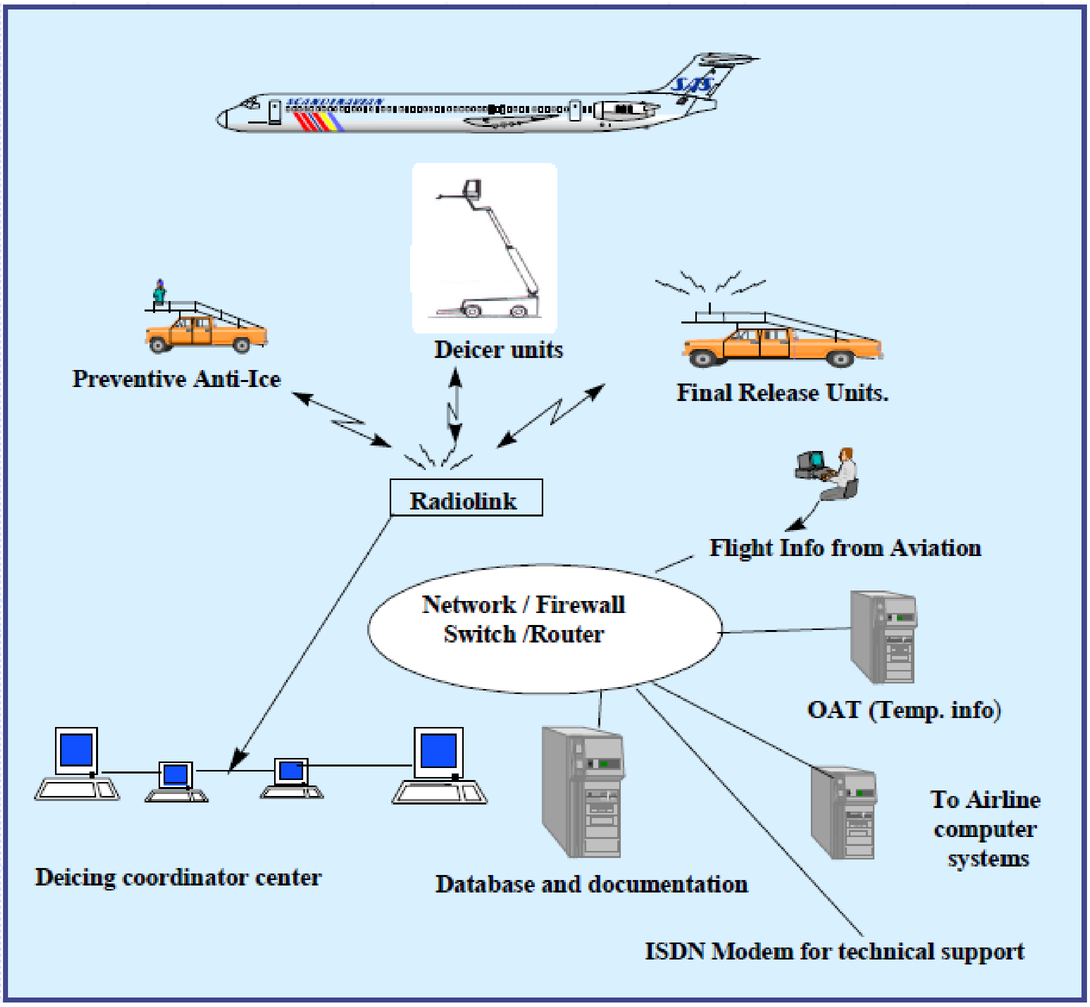


Appendix 10 CAPCO Screenshot NOTE. A yellow dot implicates on-going de-icing. Red dot implicates incoming order and green dot implicates finished de-icing.

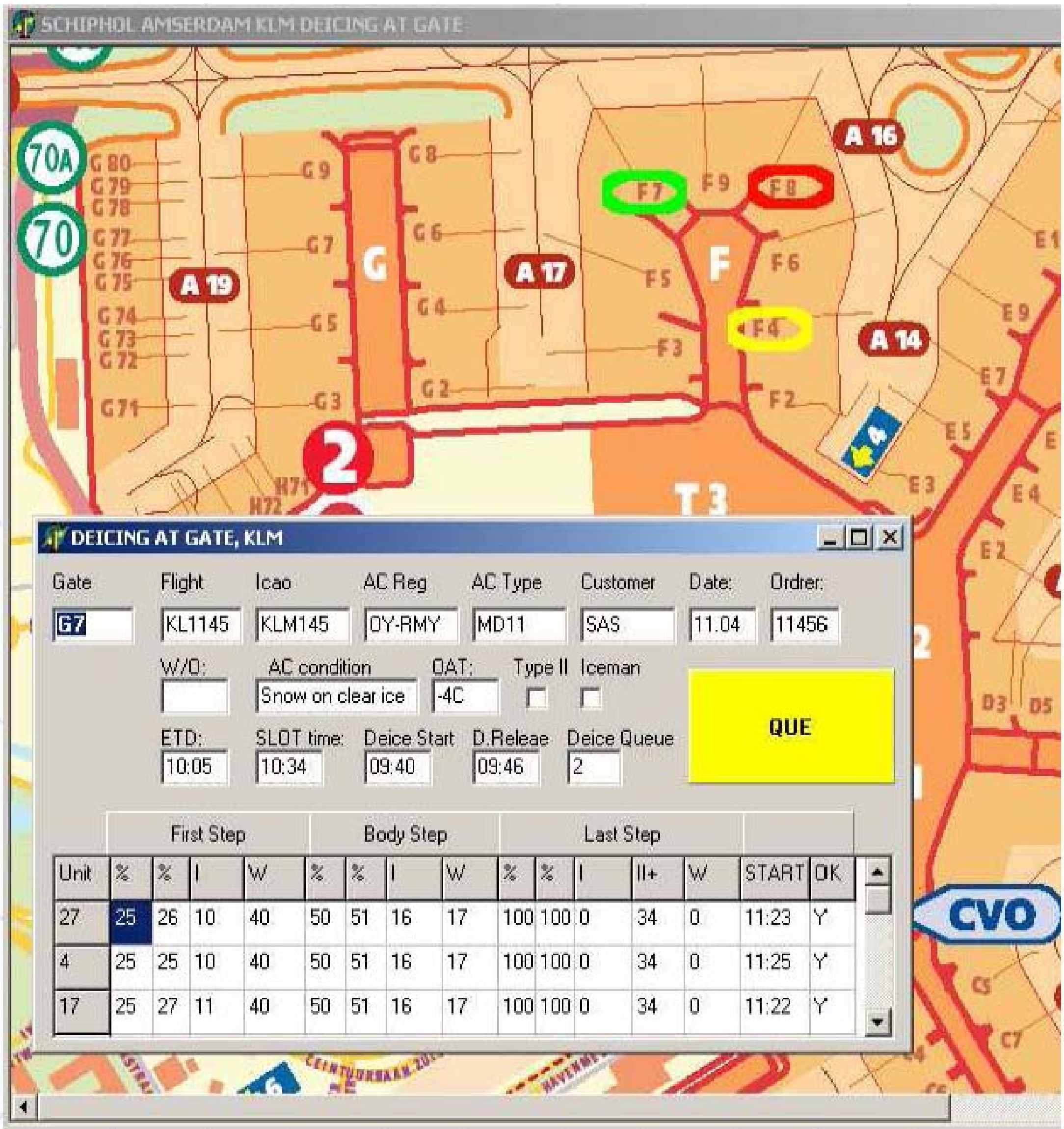


	State	DIarea	Trck#	Time	Place	Flight	Dest	A/C reg	STD	ETD	CTOT	Rev off block	Stand	Remarks
1						AY8923	RIX		01:15					
2						6B655	TFS		06:00					
3						AY2613	TFN	OHLBV	07:55	09:35	09:45		21	
4						AY153	SVO	OHLXL	09:25	09:40			144	
5						AY753	BUD	OHLVA	09:30	09:55	09:52		29	
6		A	01	09:45	13	AY353	OUL	OHLEG	09:30	09:50			13	
7		A	01	09:55	30	AY123	RIX	OHLKK	09:35	10:00			28	
8		R		09:35	131	AY725	OTP	OHLKH	09:40				131	
9						AY165	LED	OHLVL	09:50				133	
10						AY665	CPH	OHLKE	09:55	11:55			27	
11		A	01	09:55	24	FIF453	ALC		10:00				24	
12						AY465	IVL	OHLXK	11:00				12	
13						AY447	KTT	OHLZF	11:10				15	
14						VE8235	MXP		11:20				26	
15						AY675	GOT	OHLEH	11:35				24	
16						AY633	ARN	OHLEN	11:45				23	
17						AY655	OSL	OHLEO	12:10				28	
18						AY745	WAW	OHLEE	12:10				131	
19						AY395	KAO	OHLVI	12:15				17	
20						AY875	CDG	OHLXM	12:15				18	
21						AY427	RVN	OHLZB	12:20				20	
22						AY365	OUL	OHLZE	12:40				16	
23						SK717	CPH		12:50				26	
24						3B033	LPP		12:55				11	
25						AY451	KTT	OHLVC	13:10				13	
26						AY385	KAJ	OHLEK	13:10				15	
27						LH3111	MUC		13:15				121	
28						AY805	MUC	OHLKK	13:20				27	

Appendix 11 DECO System Overview



Appendix 12 DECO – De-icing Coordination Screen Shot



Appendix 13 De-icing Coordination Rearrangements Schedule

	Tammikuu 1.1 - 31.1.2010	Helmikuu 1.2 - 28.2.2010	Maaliskuu 1.3 - 31.3.2010	Huhtikuu 1.4 - 30.4.2010
Finavia		Käyttöönotto 25.1 -15.2.2010	1/2 Koordinointi (lennonjohtotorni)	1/1 Koordinointi
Northport	Koordinointi	Koordinointi	1/2 Koordinointi (Remote-torni)	Tuki