Eesti Lennuakadeemia

Lennunliiklusteeninduse õppekava

Gete Suurraid

INIMTEGURI MÕJU LENNUINFORMAATORILE MULTITORNI KESKKONNAS TÖÖTADES

Lõputöö

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Tartumaa 2023

Autorideklaratsioon

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Autor: Gete Suurraid

Juhendaja kinnitus lõputöö kaitsmisele lubamise kohta

Kinnitan, et töö vastab Eesti Lennuakadeemias kehtivatele lõputöödele esitatud nõuetele.

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SUMMARY

Human factor risks for aerodrome flight information services officer working in a multiple remote tower environment

The purpose of this diploma thesis is to find out to what degree do human factors contribute to the work of AFISO in a multiple remote tower environment and how can these risks be alleviated. To accomplish the purpose of this, the author created three research questions:

1. To what extent do different human factors affect aerodrome flight information service officers' work quality while working in a multiple remote tower environment?
2. How can these human factors be alleviated for aerodrome flight information services officer?
3. What kind of changes does the aerodrome flight information services officer have to adapt when going from a single remote air traffic control tower to a multiple remote tower environment?

The thesis consists of three chapters. The first chapter gives an overview of the topic. It explains the concept of a single remote tower and multiple remote tower. Additionally, the author examines the human factors given out by EASA going from a remote tower to a multiple remote tower.

The second chapter addresses the research methods and the participants involved.

The third chapter presents the findings of the research, as it compares the results from conducted interviews and experiments. At the end of the chapter the author analyses the results all together and brings up the utmost important results.

The results show that the degree of which human factors affect AFISO while working in a multiple remote tower environment affect greatly. First thing to keep in mind while starting to operate in a multiple remote tower is to give the workers time to adjust and gain experience in said environment. It takes time to work out a system and feeling comfortable while working. The second most important is the layout of the user interface and the video wall. The information received from it must be unambiguous and quickly accessible. This can be achieved by colour coordination for the aerodromes in the user interface. The biggest change for AFISO going from a traditional air traffic control tower to a multiple remote tower will be the change in the environment.

The author of this thesis paper sees that there is still a lot of research to be conducted during trial runs concerning the human factors affecting AFISO in a multiple remote tower environment. It is useful

to try different approaches in alleviating human factors, to find out what works best for given aerodromes. The results can be used by EANS while developing its' multiple remote tower concept.

The author would like to express her gratitude to the supervisor Kristjan Kõrgesaar and advisor Teele Kohv, without whom this paper would not have been possible.

SISUKORD

KASUTATUD LÜHENDID JA TÄHISED

ANSP *Air Navigation Service Provider,* lennuliikluse juhtimise teenuseosutaja

ATCO *Air traffic control officer,* lennuliikluse lennujuht

AFISO *Aerodorme flight information service officer,* lennuvälja lennuinformaator

EASA *European Union Aviation Safety Agency,* Euroopa Liidu Lennunduohutusamet

EANS Lennuliiklusteeninduse AS

EEKE Kuressaare lennuvälja ICAO tunnus

EETU Tartu lennuvälja ICAO tunnus

ELA Eesti Lennuakadeemia

ICAO *International Civil Aviation Organization*, Rahvusvaheline Tsiviillennunduse Organisatsioon

PTZ *pan tilt and zoom;* panoraamimis-, kallutamis- ja suumimisfunktsiooniga

SISSEJUHATUS

Tehnoloogia areneb terves maailmas meeletul kiirusel ja lennuliiklusteenused ei ole siinkohal sugugi erandiks. Võimalus juhtida õhusõidukeid, olles ise sadu kilomeetreid eemal, tundus pikalt võimatu ideena. Aastaks 2023 on sellisest kontseptsioonist saanud aga reaalsus väga mitmete lennuväljade jaoks.

2015. aastal hakati esimest korda pakkuma Örnsköldvikis lennujuhtimisteenust 150 km lennuväljast eemal Sundsvallis (Luftfartsverket, 2023). Sellest ajast saadik on mitmed väiksemad lennuväljad läinud üle kaugteenuse pakkumisele. 2023 aasta aprillis hakati esimest korda Eesti pakkuma lennuinfoteenust Tallinna irdtorni keskusest (EANS, 2023).

Irdtornist edasi liikudes jõuame multitornini. Tegu on kontseptsiooniga, kus üks lennujuht/-informaator pakub lennuliiklusteenust mitmel lennuväljal korraga (Kearneya & Li, 2018). Seda kontseptsiooni ei ole veel rakendatud üheski riigis, seega teadmised inimteguritest ning nende mõjust lennuinformaatorile multitorni keskkonnas reaalselt töötades veel puuduvad. Irdtorn ning multitorn on nii lennujuhtimisteenusele kui ka lennuinfoteenusele sobilikud. Selle töö raames keskendutakse lennuinformaatoritele, kuid teooria osas on näiteid ka lennujuhtimisest ning muudest valdkondadest. Töö keskendub lennuinfomaatoritele, kuna Eestis hakkavad ainult lennuinformaatorid töötama irdtornis ning multitornis.

Aastal 2019 on läbi viidud Lennuliiklusteeninduse AS (edaspidi EANS) ja Eesti Lennuakadeemia (edaspidi ELA) koostöös multitorni simulatsioonid. Autor sai antud teema EANSi poolse sisendina, töö tulemused aitavad kaasa EANSi multitorni arenduses.

Käesoleva uurimistöö eesmärk on välja selgitada, millisel määral mõjutavad erinevad inimtegurid lennuinformaatori poolt pakutava teenuse kvaliteeti multitorni keskkonnas töötades ning kuidas on võimalik nendest tekkinud riske leevendada. Eesmärgi saavutamiseks sõnastas autor järgnevad uurimisküsimused:

1. Millisel määral mõjutavad erinevad inimtegurid lennuinformaatori poolt pakutava teenuse kvaliteeti multitornis töötades?
2. Kuidas on võimalik inimtegurist tingitud riske leevendada lennuinformaatori jaoks?
3. Milliste muutustega peaks lennuinformaator arvestama minnes irdtornist üle multitorni tööle?

Uurimistöö koosneb kolmest osast. Esimeses osas tutvustab autor irdtorni ning multitorni kontseptsioone. Lisaks toob autor välja Euroopa Liidu Lennundusohutusameti (edaspidi EASA)

irdtorni juhendmaterjalist inimtegurid, millega peaks arvestama üleminekul irdtornist multitorni. Teises osas kirjeldab autor kasutatud metoodikat ning tutvustab valimit. Kolmandas osas tutvustab autor intervjuudest ning eksperimentidest saadud tulemusi ning analüüsib nende omavahelisi seoseid.

1 IRDTORN, MULTITORN JA INIMTEGURI FAKTORID LENNULIIKLUSTEENUSTES

Järgnevas kahes peatükis kirjutab autor lahti kontseptsioonid „irdtorn“ ning „multitorn“. Seejärel keskendub autor inimteguritele lennuliiklusteenustes ning keskendub aspektidele, mis on EASA juhendmaterjalis välja toodud olukorrad, kui lennujuht vahetab töö keskkonna silmsidest virtuaalse vaate vastu.

EASA juhendmaterjal irdtorni ning multitorni arendamiseks on loodud erinevate osapoolte panusel. EASA kaasas materjali koostamisel irdtorni rakendamise kogemusi erinevatest riikidest. Lisaks kaasati tehnoloogia ja operatsioonilisi arendusi ning uuendusi. Samuti kaasati erinevate huvipoolte tagasisidet. (European Union Aviation Safety Agency, 2023)

1.1 Irdtorn

Irdtorn on lennuliiklusteenuste valdkonnas uus tehnoloogia, mille abil on võimalik lähilennujuhil või lennuinformaatoril teostada lennujuhtimist/-informeerimist asukohas, kus on väljaarendatud irdtornikeskus. Irdtorni kontseptsioon põhineb video- ja audiosüsteemidel, mis võimaldavad tuua lennujuhini/informaatorini (edaspidi ATCO/AFISO) kogu lennuvälja visuaalse pildi, raadioside ning olla ühenduses lennuväljaseadmetega. Irdtorni lahendus muudab lennuliiklusteenused paindlikumaks ning kuluefetiivsemaks (Lennuliiklusteeninduse AS, 2023). Irdtorni kasutuselevõtt aitaks väikestel lennuväljadel vähendada opereerimis- ning hoolduskulusid (Deutsches Zentrum für Luft- und Raumfahrt; DLR, 2019). 2015. aastal alustas tööd esimene irdtorni keskus Sundsvallis, kust hakati juhtima Örnsköldsvik lennujaama lende. Örnsköldviki lennuväli asub 150 km Sundvallist eemal (Luftfartsverket, 2023). Tänaseks on Euroopas kokku 63 erinevates faasides olevaid irdtorni projekte. Töötavaid/sertifitseerituid irdtorni võimekusega lennuvälju on 21. Arendus/testimisfaasis olevaid irdtorni lahendusi on 29 ning 13 irdtorni lahendust on planeerimisefaasis (Think Research Ltd, 2023).

Irdtorniga kaasnevad abistavad süsteemid, mis võimaldavad näha pimealadesse. Lisaks toetavad need süsteemid lennujuhti halbade ilmaolude korral. Seetõttu eelistatakse traditsioonilist lennujuhtimistorni aina vähem, kus nägemine baseerub vaid aknast välja vaatamisel. Kuigi see tähendab võimalikult sarnase irdtorni kontseptsiooni loomist, et erinevate taustadega (traditsioonilise torni kohalik töötamise kord) lennujuhid suudaksid võimalikult kiiresti kohaneda ümber irdtorni keskuses. Standardiseeritud seadmestik ning selge operatsiooniline käitumisjuhend saab olema aluseks irdtorni keskuste vastuvõtule ja informatsiooni ning abistavate süsteemide kiirele mõistmisele (Oehme & Schulz-Rueckert, 2010). Traditsioonilistel tornidel on võimalik saada kasu irdtorni kontseptsioonist ettenägematutes olukordades. Inglise keeles on sellise kontseptsiooni kohta mõiste

contingency tower. Kõnealune kontseptsioon võimaldab juhtida lennuliiklust lennuväljast sadu kilomeetreid eemal, nagu tehakse seda irdtornist. *Contingency tower*-it saavad lennuväljad kasutada kahel võimalusel: planeeritud kasutamine hooldustööde ajal ning mitte planeeritud kasutamine eriolukorra ajal, seega on tegemist varulahendusega tavatornile. Sellisel viisil irdtorni võimaluse kasutamine aitaks minimeerida tulude kadumist lennujaama täielikul sulgemisel (Noracon, 2011).

2022 aastal viidi läbi uuring, kus uuriti nõudeid lennujuhi/-informaatori võimekusele tavalises lennujuhtimiskeskuses võrrelduna irdtorni keskusega. Uuringus selgus, et kuna töö iseloom ning vastutus erinevates keskkondades püsib samasugusena, siis praegu nõutavad võimekused lennujuhilt/-informaatorilt on piisavad ka kaugjuhitavas keskuses. Jõuti järeldusele, et ainuke erinevus on vahendites, mida kasutatakse töö tegemisel. (Heintza & Eißfeldtb, 2022)

1.2 Multitorn

Multitorni kontseptsioon põhineb üksikul irdtornil – tegu on kahe või enama lennuvälja lennuliikluse juhtimisega ühest irdtorni positsioonist ühe lennujuhi poolt (Kearneya & Li, 2018). Multitornis töötamine võimaldaks kasutada lennujuhte rohkem kuluefektiivsemalt (Papenfuss & Friedrich, 2016). Eriti oluliseks tõuseb siinkohal *supervisor*i ehk vahetusevanema roll multitorni keskkonnas. Tema ülesandeks jääb monitoorida kõikide lennuliikluse lennujuhtide/lennuvälja lennuinformaatorite (edaspidi ATCO/AFISO) töökoormust ning vajadusel positsioone ümber tõsta. Vahetusevanem vastutab, et kõikide töökoormus on piisav töötamiseks, sest see on aluseks nii ohutusele kui ka töörahulolule. (Jakob & Drews, 2023)

Multitorni kontseptsioonis peab olema võimalus lisada ja eemaldada lennuvälju moodulitest vastavalt liiklusmahule (Deutsches Zentrum für Luft- und Raumfahrt; DLR, 2019).

Näide võimalikest variantidest multitorni ekraanide paigutusel. Joonis 1 Joonis 1. Multitorni üks võimalikest teostustest (Deutsches Zentrum für Luft- und Raumfahrt; DLR, 2019)on tehtud Saksamaal Braunschweigis multitorni simulatsiooni katse ajal aastal 2019. Joonis 2 on tehtud Dublini lennujaamas irdtornikeskusest, kus korraga on näha Corki ja Shannoni lennujaamade pilte.

Joonis 1. Multitorni üks võimalikest teostustest (Deutsches Zentrum für Luft- und Raumfahrt; DLR, 2019)

Joonis 2. Multitorn teine võimalik teostus (Kearneya & Li, 2018)

1.3 Inimtegurid lennuliiklusteenustes multitorni keskkonnas

EASA on oma irdtorni juhendmaterjalis välja toonud 25 inimtegurit, mida peab jälgima, kui ATCO/AFISO töötaja vahetab oma töökoha silmsidest virtuaalse vaate vastu. Lisaks irdtorni inimteguritele on välja toodud 7 inimtegurit, mida peab jälgima multitorni keskkonnas töötades (European Union Aviation Safety Agency, 2023). Järgnevalt toob autor välja need 7 inimtegurit koos näidetega, mida peaks eriti hoolikalt jälgima ATCO/AFISO, kes töötab multitorni keskkonnas.

1.3.1 ATCO/AFISO võimekus hoida järjepidevat ülevaadet kõikidest lennuoperatsioonidest lennuväljal ning selle läheduses, lisaks veel sõidukid ning inimesed manööverdusalal kõikidel lennuväljadel nende vastutusalal

Keeruliseks olukorraks ATCO/AFISO jaoks loetakse seda, kui ühel lennuväljal peab lahendama liikluses tekkinud konflikti ning teisel lennuväljal haldama rutiinseid lende (Josefsson, et al., 2018). ATCO/AFISO töö on tugevalt mõjutatud sellest, kuidas on informatsioon paigutatud, informatsiooni

keerukus ja multitornis ümbritsev keskkond. 2018 aastal läbi viidud katsetuste ajal selgus, et ATCO/AFISO töötajal oleks kergem hoida järjepidevat ülevaadet kõikidest operatsioonidest, kui vähendataks operatsioonide arvu ühes ajaühikus ning lennukite külghajutust suurendataks. Kõige keerulisem on ATCO/AFISO töötajal sellel hetkel, kui mõlemas lennujaamas on korraga sõidukite liiklus manööverdusalal ning aktiivsed lennuoperatsioonid lennuvälja läheduses (Li, Kearney, Braithwaite, & Lin, 2018). Iirimaal viidi aastal 2018 läbi multitorni katsetused, kus tõestati, et multitorni keskkonnas on võimalik ATCO-l teha tööd nii, et situatsiooniteadlikkus ei saa kannatada (Kearneya & Li, 2018).

1.3.2 Jagatud tähelepanu

EASA on toonud oma juhendmaterjalis kahe madala tihedusega lennuvälja korraga opereerimisel välja, et erinevate lennuväljade kohalikud protseduurid võivad hakata segama ATCO/AFISO tähelepanu jaotamist lennuväljade vahel (Sesar joint undertaking, 2015). Keeruliseks muutub olukord siis, kus multitornis töötades tekib olukord, millega varem ei ole kokku puututud ning selle jaoks ei ole väljatöötatud kindlat reeglistikku, mille järgi käituda. Need reeglid võivadki tekkida töö käigus või võivad olla juba varasemalt ette planeeritud ning läbiharjutatud ATCO/AFISO poolt (Josefsson, et al., 2018). Kuid 2020 aastal viidi Rootsis läbi eksperiment, kus testiti 8 ATCOd multitorni keskkonnas. Hüpoteesiks oli, et suurenenud töömaht multitorni keskkonnas vähendab situatsiooni teadlikkust, seega ATCO ei suuda oma tähelepanu jagada kahe lennuvälja vahel võrdselt. Tulemustes leiti, et ei ole vahet, kas ATCO töötab irdtorni või multitorni keskkonnas, katsealustel ei vähenenud situatsiooni teadlikkus. ATCOd olid võimelised juhtima korraga kahte lennuvälja kõrge intensiivsusega. Seega võis järeldada, et jagatud tähelepanu ei tekitanud ebaturvalisi olukordi (Peukert, Meyer, & Josef, 2020).

1.3.3 Potentsiaalsed segadused ja ruumilise orientatsiooni kadumine, erinevatest lennuvälja vaadetest

Euroopa agentuuri poolt koostatud uuringus pakkusid ATCO/AFISO töötajad välja, et lennuväljad, mida kasutatakse multitornis, võiksid olla sarnaste rajanumbritega. Lisaks toodi välja, et visuaalsed abivahendid õhusõiduki tuvastamisel on abiks potentsiaalsete segaduste vältimisel (Sesar joint undertaking, 2015). Sarnane uuring viidi läbi Taiwani hävituslennuki pilootide peal, kui uuriti ruumilise orientatsiooni kadumise ning kokpiti ülesehituse vahelisi seoseid. Uuringus selgus, et kõige enam mõjutas hävituslennuki piloote teadmatus kokpitis asetsevatest instrumentidest. Teisel kohal oli kokpiti kuju ning kolmandal kohal oli instrumentide paigutus kokpitis. Uuringu autor soovitas, et enne uue lennukiga lendamist oleks hea pilootidel läbida loeng disaini erinevustest lennukites, selleks et vältida ruumilise orientatsiooni kadumist. Lisaks mainiti, et erilist tähelepanu peaks pöörama

instrumentidel olevate funktsioonide võimalustele (Wang, Li, & Lin, 2019). Samamoodi nagu ei ole hävituslennuki piloot uue lennuki ülesehitusega tuttav ei ole ka ATCO/AFISO multitorni ülesehituse ega kasutajaliidesega tuttav. Lisaks kasutajaliidese uudsusele on sellega kaasnevad funktsioonid ning võimalused esmakordsed ATCO/AFISOle.

1.3.4 Potentsiaalne segadus häälkommunikatsioonil (pilootidel, sõiduki juhtidel, ATCO/AFISOle kõne algataja, kõneside edastamine ja taasedastamise sagedus, samaaegsed kõned, kõnejaama nimetaja (kaug- või tavanimetaja), liidese kujundus)

Tavaliselt juhtuvad segadused raadiokommunikatsioonis olukorras, kus õhusõidukite kutsungid kõlavad sarnaselt. Tagasilugemisel võivad tekkida vead olukorras, kus sõnad või numbrid kõlavad sarnaselt (Shorrock, 2007). ATCO/AFISOl on jäetud võimalus paluda piloodil muuta oma kutsungit ATCO/AFISO poolt määratud kutsungi vastu, kui on oht, et tekib segadus õhuruumis lennukitega suhtlemisel (SKYbrary, 2023). Oluline on, et piloot ei tohi ise hakata enda kutsungit lühendama. Seda võib algatada ainult ATCO/AFISO, kes on veendunud, et lühenduse tagajärjel ei teki ohtlikke olukordi (Hardie, et al., 2020). Töötades mitme lennuväljaga korraga tõuseb sarnaste kutsungite samaaegse kasutamise oht veelgi enam ning ATCO/AFISO peab hoolikalt jälgima, et õhuruumides ei tekiks segadusi.

1.3.5 Diferentseerimine erinevate lennuväljade vahel (meteoroloogilised tingimused)

EASA on selle inimteguri all mõelnud olukordi, kus erinevad ilmastikuolud lennuväljadel hakkavad raskendama teenuse pakkumist. Ilmastikutingimused mõjutavad tugevalt ATCO/AFISO töötajat, kuna raskendatud olud nõuavad erinevaid käitumisi. Selge on, et raskendatud ilmastikutingimused tõstavad töökoormust, suureneb raadiosidede arv nii maapeal kui ka õhus. Eriti rasketes ilmaoludes tõuseb maaliiklusega suhtlemise olulisus kõige enam (Hernández-Romero, Josefsson, Lemetti, Lemetti, & Schmidt, 2022).

1.3.6 Ekraanide paigutus visuaalse vaate jaoks ning ekraanid teiste ATS süsteemide/funktsioonide jaoks (nt ekraanide arv ja nende funktsioonid, ekraanid nurgad)

2022 aastal viidi läbi uuring, kus võrreldi ATCO võimekust objektide tuvastamisel 43-tollisel ekraanil ning 55-tollisel ekraanil, selleks et välja selgitada, kumb suurus on parem irdtorni visuaalse pildi edastamiseks. Tulemustes tulid välja suured erinevused silma fikseeritud punktide koguarvus,

fikseeritud punkti vaatamiseajas, silma liikumise ajas ühest punktist teiseni ning reaktsiooniajas. Suurt erinevust ei leitud pupillide suurenemisel (pupillide suurenemine viitab mentaalse töökoormuse kasvule (Ahlstrom & Friedman-Berg, 2006)) ega tajutaval töökoormusel. Uuringus osalenud 15 ATCOd jagunesid ekraani suuruse eelistuse osas peaaegu pooleks (7 eelistas 43 tolliseid ekraane ning 8 eelistasid 55 tolliseid ekraane). Kokkuvõttes selgus, et suuremad ekraanid ei toonud paremaid tulemusi ATCOdel objektide tuvastamisel (Wen-Chin, Moore, Zhang, Lin, & Kearney, 2022). Seega ei too suurem ekraan alati suuremat situatsiooniteadlikkust.

2023 aasta jaanuaris viidi Jaapani kontrotitöötajate seas läbi uuring kaelavalude ja töökoha ekraanide ülesehituse omavaheliste seoste leidmiseks. Leiti, et ekraanid lähemal kui 40 cm osaleja silmadest põhjustasid tugevamat kaelavalu. Täheldati, et mitte ükski muu tegur (monitori positsioon, nurk mille alt seda vaadati jne) monitori ülesseadmisel ei olnud mõjutavaks faktoriks kaelavalul (Nakatsuka, et al., 2023). Selliste teguritega peab kindlasti arvestama multitorni ülesseadmisel, kuna ATCO/AFISO peab olema suuteline seal töötama pikema perioodi jooksul ilma, et ta saaks ise oma töökoha ülesehitust muuta.

1.3.7 Lennuvälja heli päritolu

EASA on oma juhendmaterjalis väljatoonud, et kui ATCO/AFISO hakkab töötama irdtornis, siis välisheli olemasolu on valikuline. Heli olemasolu vajalikkus sõltub kohalikest tingimustest. Lennuvälja heli olemasolu aitab kaasa kõrgendatud situatsiooni teadlikkusele, näiteks olukordades kus on halb nähtavus või hädaolukorrad. Heli olemasolu on olnud abiks väikeste lennuväljade puhul, kus heli kuulmine viib ATCO/AFISO tähelepanu õigesse kohta. Suuremate lennuväljade puhul on lennujuhtimistornid ehitatud võimalikult helikindlaks, et suurematelt lennukitelt või hävituslennukitelt tekkinud heli ei segaks töö tegemist. (European Union Aviation Safety Agency, 2023)

Multitornis töötades nägi EASA samuti kasutegurit lennuvälja heli olemasolul, kuid sellega kaasnes kaks tingimust. Esiteks peab heli kuulmine olema vastavuses lennuvälja pildiga ning teiseks peab heli olema reguleeritav iga lennuvälja puhul eraldi. Seega ATCO/AFISOl peab olema võimalus keerata heli ühel lennuväljal juurde ning samal ajal keerata teisel lennuväljal heli täiesti maha. See aitab eemaldada ebavajalikke taustahelisid kui selleks on vajadus. (European Union Aviation Safety Agency, 2023)

Autor otsustas seda inimtegurit uurida ainult intervjuude käigus, kuna välisheli olemasolu on ainult soovituslik funktsioon irdtornis ja multitornis ning katsete ajal puudus võimalus tagada vastavalt soovitustele heli olemasolu. Seega otsustas autor katsete ajal seda inimtegurit mitte töösse kaasata.

2 METOODIKA

Käesolevas uurimistöös kasutati kahte erinevat meetodit. Alguses viidi läbi kvalitatiivne uuring, millele järgnes kvantitatiivne uuring. Autor viis läbi neli poolstruktureeritud intervjuud ning kaheksa eksperimenti. Intervjuude eesmärk oli kaardistada inimtegurite mõju AFISOle multitorni keskkonnas töötades ning võimalusi nende leevendamiseks. Eksperimentide käigus simuleeriti multitorni keskkonda ning kaardistati AFISO õpilaste taju erinevate inimtegurite suhtes. Uuringutega soovis autor võrrelda intervjuude vastuseid AFISO õpilaste vastustega simuleeritud multitorni keskkonnas. Järgnevates alapeatükkides kirjeldab autor intervjuude ning eksperimentide läbiviimise metoodikaid ning valimeid.

2.1 Uurimismeetod

2.1.1 Intervjuud

Intervjuud viidi läbi kolmel päeval veebruari ja märtsi kuu jooksul. Intervjuude läbiviimiseks kasutati Google Meets ning Microsoft Meets keskkondi. Kõiki intervjuusid salvestati OBS Studio rakendusega. Intervjuud viidi läbi poolstruktureeritud kujul, et oleks võimalik vajadusel küsimust laiendada või ümber sõnastada. Intervjuu alguses palus autor kõikidel osalejatel välja valida 25-st inimtegurist, mida peab jälgima, kui ATCO/AFISO töötaja vahetab oma töökoha silmsidest virtuaalse vaate vastu, 3 kõige olulisemat ning palus neid põhjendada. Seejärel põhinesid küsimused 7 inimteguri ümber, mis olid välja toodud spetsiifiliselt multitornis töötamise kohta. Poolstruktureeritud intervjuud valiti sellepärast, et intervjuude käigus oleks võimlik küsimusi ümber sõnastada ning tuua näiteid, et ilmestada küsimuse sisu. Intervjuu küsimused olid koostatud EASA irdtorni juhendmaterjali abil (European Union Aviation Safety Agency, 2023), millest kasutati just multitornile spetsiifiliselt väljatoodud inimtegureid, mis mõjutavad ATCO/AFISOd, vahetades töökeskkonda irdtornist multitorni vastu (vt Lisad). Kõikidele intervjueeritavatele saadeti küsimused ette ning hoiatati, et intervjuud salvestatakse lõputöö eesmärgil.

2.1.2 Eksperimendid

Eksperimendid viidi läbi kahel märtsi päeval Eesti Lennuakadeemia lennujuhtimistorni simulaatoris. Simulaatoris on kaheksa ekraani, mis jaotati pooleks, seega 4 ekraani näitasid Tartu lennuvälja pilti ning 4 ekraani näitasid Kuressaare lennuvälja pilti. Keskkondade eristamiseks asetati ekraanide poolituskohtadele lipud. Lisaks oli mõlema lennuvälja ühe ekraani ülemisel serval kuvatud ilmainfo, et vajadusel saaks osaleja „aknast välja vaadates“ ka edastada vajaminevat ilmastiku infot. Osalejatele oli laua peale asetatud kaks stripilauda (üks Kuressaare ja teine Tartu õhuruumi jaoks), mille peal tööd teha. Stripilaudade ette olid asetatud lennuväljade kaardid, kuna kõikidel osalejatel puudus

kogemus Kuressaare (edaspidi EEKE) või Tartu (edaspidi EETU) lennuväljal töötamisega. Samuti olid osalejatele laua peale asetatud monitorid, millelt kuvati ilmastikuolusid ning näidati lennuraja asetust kompassiroosi suhtes. Monitoride pealt said osalised ka vajadusel lennuvälja tulesid reguleerida. Osalejatel puudusid EEKE ja EETU radarpildid.

Harjutused koosnesid ainult lennuinfoteenuse pakkumisest EEKE ja EETU õhuruumis. Iga osaleja peal viidi läbi kaks harjutust, mis kestsid mõlemad 45 minutit. Enne harjutuse algust anti osalejale harjutuselehed liikluskoormusega tutvumiseks ning tutvustati simulaatori eripärasid. Näiteks mainiti osalejatele, et sagedused on ühendatud, seega kõik piloodid kuulevad AFISO sidesid korraga ja ei teki olukordi, kus raadiosided üksteist blokeeriks. Osalejad ei pidanud tegema kõnesid Tallinnas asuvale lennuteabe osakonnale saabuvate/väljuvate lendude osas, kuna hetkel Eestis töötavad AFIS üksused teevad seda elektrooniliselt ning eesmärgiks oli võimalikult sarnane keskkond luua.

Harjutuselehed koostas autor EANSi poolt aastal 2019 läbiviidud multitorni simulatsioonide põhjal (allikas pole juurdepääsetav). Põhjus, miks autor ei kasutanud eelmise uuringu andmeid enda töös oli seetõttu, et autor palus iga harjutuse lõpus osalejatel täita küsimustiku kogetu kohta. Küsimustik koosnes väidetest inimtegurite kohta, mis tulenesid intervjuudeks koostatud küsimustest. Küsimustik oli koostatud Likerti skaalat kasutades 10 palli süsteemis. Põhjus, miks autor valis Likerti skaala on see, et seda peetakse üheks usaldusväärsemaks inimeste hoiakute hindamiseks (Osula, 2008). Lisaks oli kõikidel osalejatel võimalus lisada omapoolseid emotsioone/tundeid vabas vormis küsimustiku lõpus. Kahe harjutuse küsimustikud erinesid ainult ühe väite võrra. Kuna ilmastikuolud erinesid ainult teises harjutuses, siis lisandus ka selle kohane väide (vt Lisad).

Esimese harjutuse koormus oli 5 lennukit mõlemal lennuväljal, seega 10 lennukit kokku. Teise harjutuse koormus oli 9 lennukit mõlemal lennuväljal, mille hulgas olid ka üks treeninglend ning üks vaatamisväärsustega tutvumislend, seega 18 lennukit kokku. Koormus tõusis 8 lennuki võrra kahe harjutuse vahel. Esimese harjutuse eesmärgiks oli tutvumine loodud keskkonnaga. Mõlemal lennuväljal oli nähtavus üle 10 km ning erilise pilvisuseta. Teise harjutuse eesmärgiks oli liikluskoormuse suurendamine, et näha kuidas osalejad sellega toime tulevad. EEKE lennuväljal oli täispilvisus ning sadas, EETU lennuväljal oli kohatine pilvisus ning päike paistis. Harjutustest puudusid eriolukorrad ning maaliiklus. Mõlemas harjutuses kasutati rada 17 EEKE lennuväljal ning 26 EETU lennuväljal. Autor otsustas kasutatavaid lennuradu mitte vahetada harjutuste vahetudes, selleks et osalejatel oleks tuttavam keskkond teise harjutuse ajal.

2.2 Valim

2.2.1 Intervjuu valim

Intervjuude valimis kasutas autor ettekavatsetud valimit kombineerituna mugavusvalimiga (Õunapuu, 2014). Valim moodustati nelja erineva riigi lennuliikluse juhtimise teenuseosutaja (edaspidi ANSP) esindajast, kes töötasid järgnevatel ametikohtadel: ohutuse ekspert, irdtorni ning multitorni regulatiivsete suhete juht, irdtorni ning multitorni seenior ATM nõustaja ning inimtegurite ekspert irdtorni projektis. Konsultant andis nelja riigi kontaktid autorile, misjärel võeti nendega ühendust. Kolme riigi kontaktid olid nõus ise intervjuud osalema ning ühe riigi kontakt suunas autorit ettevõtte siseselt edasi. Eestis olevaid eksperte ei hakatud intervjueerima, kuna töös leitavad tulemused ning andmed edastatakse EANSile multitorni projekti edasiseks arendamiseks. See on põhjus, miks tehti teadlikult valik viia läbi intervjuud ainult välisriigi ekspertidega. Intervjueeritavate soovil on kõikide vastajate nimed lisaks ANSP nimetustele jäetud anonüümseks.

2.2.2 Eksperimendi valim

Eksperimentides kasutati mugavusvalimit (Õunapuu, 2014), selleks et katsed oleks võimalik sooritada kindla ajavahemiku jooksul. Kokku pöördus autor 7 praeguse ning endise lennujuhiõpilase poole, kellest neljal oli võimalik katsel osaleda. Kõikide lennujuhiõpilaste kokkupuude AFISO tööpositsiooniga oli samasugune ehk õpingute ajal oli läbitud 7 EAP mahuline aine, mis lõppes edukalt sooritatud eksamitega. Kõikidel puudus varasem töökogemus traditsioonilises AFISO töökeskkonnas kui ka irdtorni/multitorni keskkonnas.

3 UURIMISTULEMUSED

Selles peatükis esitab autor uurimistulemused inimtegurite kaupa. Tulemuste analüüsis kasutas autor juhtumiülest analüüsi intervjuude puhul (*cross-case analysis*) selleks, et leida inimtegurite kaupa läbivaid teemasid ning seoseid (Kalmus, Masso, & Linno, 2015). Seejärel toob autor välja eksperimentide käigus saadud tulemused ning võrdleb neid intervjuus leitud tulemustega.

Autor kasutab eksperimendi tulemuste võrdlemiseks aritmeetilist keskmist, selle kaudu on võimalik näha üldise keskmise muutust.

3.1 Kolm faktorit, mis on kõige olulisemad, minnes silmsidest virtuaalse vaate vastu

Intervjuude alguses palus autor kõikidel intervjueeritavatel tuua välja 3 inimtegurit, mis nende hinnangul kõige enam vajavad tähelepanu, kui ATCO/AFISO läheb irdtornist multitorni. Intervjueeritavatele oli ette antud 25 üksiku irdtorni spetsiifilist inimtegurit (EASA irdtorni juhendmaterjalist), mille vahel tehti valik (vt Lisad).

Valitud faktorid kujunesid järgnevad:

- situatsiooniteadlikkus (selle valisid intervjueeritavad 1, 3 ja 4),
- sisendseadmete kasutatavus (selle valisid intervjueeritavad 1, 2 ja 4),
- töökoormus (selle valisid intervjueeritavad 1 ja 3),
- ekraanide paigutus (selle valisid intervjueeritavad 2 ja 3),
- ATCO/AFISO töökoha ergonoomilisus (selle valis intervjueeritav 2),
- potentsiaalne segadus erinevate vaadete osas, mis ATCO/AFISOle on antud ja näitavad sama kohta erinevate nurkade alt (selle valis intervjueeritav 4).

Kuuest väljavalitud inimtegurist neli puudutavad töökeskkonda. Valik on loogiline, kuna üksiku irdtorni ning multitorni ülesehitus on erinev. Intervjueeritav 3 ütles, et kõik algab multitorni kasutajaliidese disainist. Kui on tagatud hea ülesehitusega töö keskkond, siis on töötajal kergem hoida situatsiooniteadlikkust lennuväljadel. Intervjueeritav 1 tõi välja, et nemad kasutasid oma simulatsioonides ühte suurt kasutajaliidest kõikide lennuväljade haldamiseks. Samuti peaks samasugune informatsioon olema kuvatud samamoodi (nt ilmapaneel asetseb lennuvälja muu info suhtes samal kohal mõlema lennuvälja jaoks). Suurimaks probleemiks oli ATCO/AFISO harjumine uuel positsioonil, rääkis intervjueeritav 2. Töötaja jaoks on tegu uue töökeskkonnaga seega harjumine ning mugavalt tundmine võtab aega. Nende katsetuste käigus selgus, et väiksemad ekraanid toimisid paremini, kui ekraanid, mis asusid 5-7 meetri kaugusel töötajast.

Lisaks nähti, et võrreldes irdtorniga on multitornis vaja kõrgendatud situatsiooniteadlikkust ning tõenäoliselt kasvab ka töökoormus. Ühe lennuvälja puhul ei mängi situatsiooniteadlikkus nii suurt rolli. Keeruliseks muutub olukord siis, kui korraga on liiklus õhus ja maal, maaliiklus soovib suhelda ning on vajadus koordineerida kõrval sektoritega. Sellises olukorras on multitornis situatsiooni teadlikkus äärmiselt oluline, mainis intervjueeritav 1. Intervjueeritav 3 mainis, et situatsiooniteadlikkust peaks enne multitornis tööle asumist treenima simulaatorites. Selleks, et tunda end mugavalt isegi paralleelse liiklusega lennuväljadel, peaks ATCO/AFISO olema teadlik, mis hetkel millele tähelepanu pöörata. See tähendab teadlikku jälgimist ning teadlikku mittejälgimist lennuväljadel. Intervjueeritav 4 tõi välja asjaolu, et ATCO/AFISO peab treenima enda mõtteviisi selleks, et ta oleks suuteline lennuväljasid eristama ning hoidma situatsiooni teadlikkust, kuna suure tõenäosusega võivad olla nende ruleerimisteed ning parkimiskohad sarnaste tähistega. Samuti tõi intervjueeritav välja, et kõige kergemini suudab inimene enda jaoks asju meelde jätta või eristada siis, kui see tekitab emotsiooni. Seega, võimalusel peaks ATCO/AFISO kasutama erinevaid mälutehnikaid, selleks et eristada lennuväljasid enda peas ning hoidma situatsiooniteadlikkust kõrgel.

Kasvava töökoormuse suurimaks faktoriks peab intervjueeritav 1 erinevaid lennuvälja protseduure. Võimalusel peaksid protseduurid olema ühtlustatud (nt lennuvälja ringi kõrgus, kordusringile mineku protseduur jne). Intervjueeritav 3 tõi välja, et multitornis kasvab töökoormus iseenesest mõistetavalt, aga oluline on, et tekkiv töökoormus oleks siiski hallatav.

3.2 ATCO/AFISO võimekus hoida järjepidevat ülevaadet kõikidest lennuoperatsioonidest lennuväljal ning selle läheduses, lisaks veel sõidukid ning inimesed manööverdusalal kõikidel lennuväljadel nende vastutusalal

3.2.1 Intervjuu tulemused

Intervjueeritavad 1, 2 ja 3 nõustusid, et sellist asja nagu rööprähklemine ei eksisteeri. Inimene suudab lühikese aja jooksul vahetada oma tegevusi kiiresti, kuid selleks peab olema eelnevalt loodud soosiv keskkond selle tegemiseks.

Intervjueeritav 1 tõi välja, et kui lennuväljad asetsevad multitornis üksteise kohal, siis see tagab ATCO/AFISOle soodsamad tingimused lennuväljade skännimiseks. Sellisel juhul asetsevad kõikide lennuradade läved ekraanide otstes ning keskel oleksid ruleerimisteed ning perroon. Selle mõttega nõustus ka intervjueeritav 3, kuid lisas, et video seinale peaks kuvama kõige olulisemat infot. Ta tõi välja nt lennuvälja indikaatori, tuule info ning kompassi roosi orientatsiooni jaoks. Intervjueeritav 3 mainis, et kasutajaliides peaks olema disainitud nii, et seal saaks skännides omandada informatsiooni väga kergesti ning kiiresti.

Intervjueeritav 2 rääkis, et nemad on praktiseerinud sellise tehnilise toega nagu „*event manager*“. Tegu on automaatse süsteemiga, mis oskab ära tunda ning annab märku standardolukordadest. Katsetuste ajal selgus, et kolme lennuvälja jälgimine ilma sellise tehnilise toeta oli väga keeruline. Loodud tehniline tugi jaotas iga lennuetapi ühte kolmest kategooriast: roheline, kollane ning punane olukord. Rohelise olukorra ajal ei pea ATCO koheselt reageerima (nt õhusõiduk küsib ruleerimisluba ning ATCO ei vasta koheselt). Kollase olukorra ajal võiks ATCO oma tähelepanu sinna pöörata ja jälgida kindlat kohta ekraanil (nt õhusõiduk on lühikeses finaalis ning õhusõidukile on antud maandumisluba). Punase olukorra ajal on tegu ohtliku olukorraga (nt õhusõiduk on tulemas maanduma ilma loata). See tuli on kuvatud kõikidel ekraanidel, selleks et juhtida ATCO tähelepanu. Intervjueeritav 4 tõi samuti välja, et nemad kasutasid kindlaid värve lennuväljade eristamiseks. See tähendab, et nt lennuvälja A stripid ning muu info oli alati kuvatud sinisena ning lennuvälja B info kollasena. Lisaks värvidega eristamisele, tõi intervjueeritav välja, et ATCO peaks töötama justkui ringiratast. ATCOl peaks peas olema kindel järjekord, mida ta millal teeb ning peale mis tegevust ta jõuab tagasi eelmise tegevuse juurde, nii jõuaks töötaja iga lennuväljani kindla aja tagant tagasi.

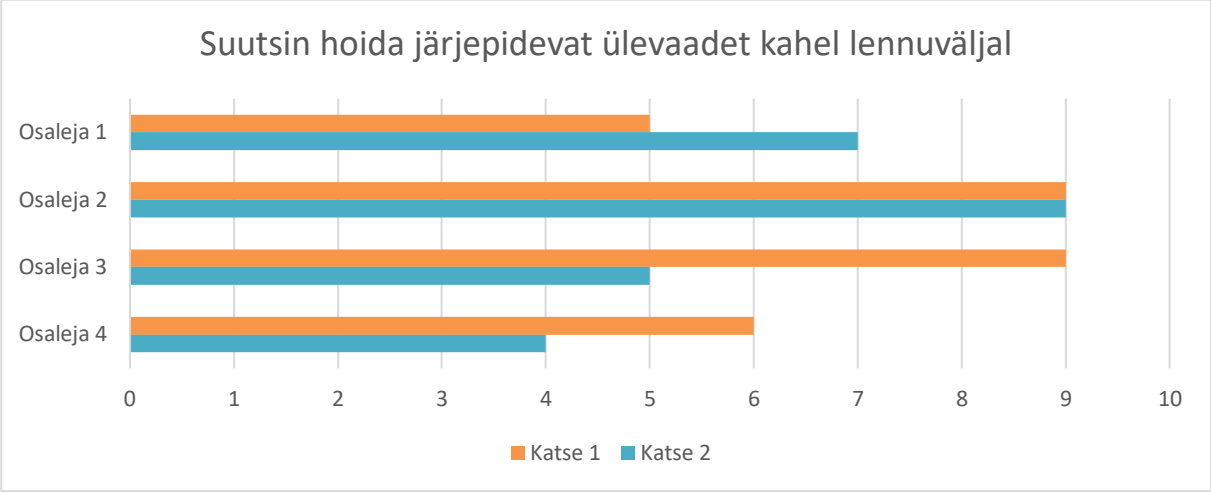
Olukorras, kus ei ole võimalik näidata 360 kraadist vaadet ATCO/AFISOle peaks paigas olema varuplaan, rääkisid intervjueeritav 1 ning 2. See plaan peaks ära määrama lennuliikluse uue mahu ajaühiku jooksul. Intervjueeritav 3 rääkis, et kui tegu on multitorni mooduli ekraani veaga, peaks liigutama lennuvälja pildi liigutama kõrval moodulisse. Kui peaks midagi kaameratega juhtuma, siis need protseduurid, kuidas käituda, peaksid olema paigas juba irdtorni kontseptsiooni loomisest alates.

Intervjueeritav 1 mainis, et radarekraanide olemasolu aitaks kindlasti kaasa järjepideva ülevaate hoidmisele. Probleemseks kohaks on radar võimekuse tagamine. Üldiselt lennuväljad, mida hakatakse multitornis kasutama, on väga väikesed ning nendel tegutsetakse enamjaolt ainult visuaalsetel tingimustel, enamasti puuduvad sellistel lennuväljadel radarpildi võimekused. Intervjueeritav 3 ütles, et nendel lennuväljadel, mida nemad kasutasid oma katsetustes, olid radarpildi võimekused olemas ning see oli suureks abiks ATCO/AFISOdele. Esialgu ei olnud kõikidel lennuväljadel, mis viidi üle irdtorni, radarpildi võimekust ning otsus lisada see võimalus oli teadlikult tehtud parema jälgitavuse tagamiseks. Intervjueeritav 2 mainis, et neil on alati radarpilt olemas olnud ja nende töötajatel on vastavad litsentsid, mis lubavad vajadusel kasutada radarpilti hajutamise eesmärgil. Radarpildi olemasolu on väga suureks abivahendiks nende töökeskkonnas.

3.2.2 Katsete tulemused

Joonis 3 on näha osalejate vastuseid väitele „Suutsin hoida järjepidevat ülevaadet kahel lennuväljal“, kus 1 = ei suutnud üldse ning 10 = suutsin hoida järjepidevat ülevaadet. Peale esimest katset oli $A = 7{,}75$ ning peale teist katsed oli $A = 6{,}25$. Osalejate taju enda suutlikkusest hoida ülevaadet langes

19,4% võrreldes esimese harjutusega. Keskmise väärtuse langemise põhjuseks võime eeldada, et oli suurenenud liikluskoormus teise harjutuse ajal.



Joonis 3. Väite „Suutsin hoida järjepidevat ülevaadet kahel lennuväljal“ tulemused (autori koostatud)

Katsealuste peamine kommentaar oli, et radapildi olemasolu multitorni keskkonnas aitaks kaasa järjepideva ülevaate hoidmisele. Eriti olukorras, kus õhusõiduk on lennuinfotsoonis sees kuid ei ole veel ettekandnud lennuväljaringi osa.

3.2.3 Intervjuutulemuste ja katsetulemuste ühisosa

Nii ekspertide kui ka katsealuste arvates võiks multitornis olla radarpildi võimalus, kui see on tehniliselt võimalik. Radarpildi olemasolu aitab tõsta situatsiooniteadlikkust ning annab kiirema ülevaate liiklusolukorrast õhus. Samuti peab panema suurt rõhku multitorni keskkonna disainimisele, et see tagaks võimalikult kiire info kättesaadavuse. Multitorni näol on tegemist uue keskkonna loomisega, seega info kiire kättesaadavus on üheks suuremaks probleemiks, mis vajab lahendamist. Suureks abiks on erinevate värvide määramine lennuväljadele, seega ühe lennuvälja stipid, ilmainfo ja muu oleks kõik samasuguse värvi taustaga. See aitab luua ATCO/AFISO peas seosed värvi ning lennuvälja vahel. Veelgi enam aitaks kaasa kui seostatud värvid tekitaksid emotsioone. Näiteks EEKE lennuvälja info oleks kuvatud kollasel taustal, kuna Kuressaare on päikesepealinn. Selline seos tekitab emotsiooni ja aitaks töötajal hoida peas lennuväljasid eraldi.

3.3 Jagatud tähelepanu

3.3.1 Intervjuu tulemused

Intervjueeritav 1 tõi välja, et vahetusevanema positsioon mängib multitornis töötamisel suurt rolli. Sellel hetkel, kui ühel lennuväljal juhtub midagi ning töökoormus kasvab väikese aja jooksul väga suureks, ei suuda ATCO/AFISO enam tähelepanu võrdselt jagada. Seega peab lennuväljasid hakkama

jagama teistesse irdtorni moodulitesse. Intervjueeritav 3 nõustus, et vahetusevanem on see, kes hakkab jälgima töökoormusi ning vajadusel lennuväljasid kõrval moodulitesse tõstma.

Intervjueeritav 2 ja 3 nõustusid, et lennuvälja protseduurid peaksid olema ühtlustatud. Vahet ei ole kas tegu on suure või väikse lennuväljaga, lisas intervjueeritav 2. Intervjueeritav 1 leidis, et ainult eriolukorra ning hädaolukorra protseduurid võiksid olla ühtlustatud lennuväljadel, mis on multitornis.

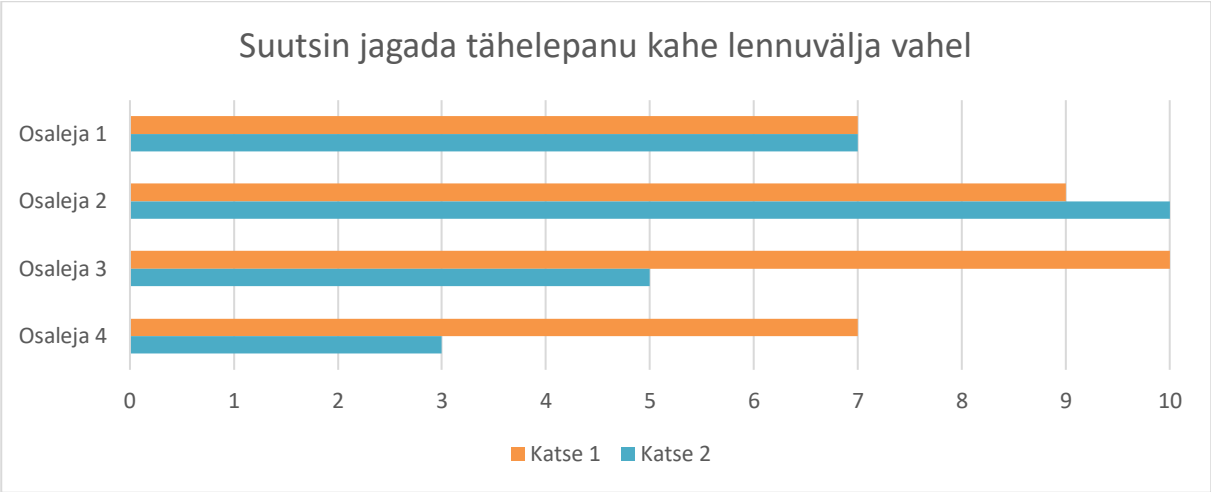
Intervjueeritav 4 ei nõustunud selle mõttega, et protseduurid peaksid olema ühtlustatud. Ta leidis, et ATCO/AFISOl on kergem hoida lennuväljasid oma peas eraldi, kui need ei ole ülemäära sarnased. Tuues välja, et ümberlülitamise aeg lennuväljalt A lennuväljale B on väiksem, kui protseduurid ei ole samasugused. Kui ühtlustada protseduure, võib juhtuda olukorda, kus kõik mõjub samasuguselt ja lennuväljasid ei erista enam mitte midagi. Kõik asjad, mis tekitavad emotsiooni, jäävad inimesele paremini meelde, olgu selleks mingi märgised või erinevad protseduurid või midagi muud.

Intervjueeritav 2 mainis taaskord „*event manager-i“*, mille nemad olid loonud multitorni jaoks. Intervjueeritav mainis, et selline lahendus ei ole abiks ainult kahe lennuväljaga multitornis, vaid muutis väga reaalseks ka kolme lennuväljaga multitorni. Süsteemi võimekus on äärmiselt oluline. Intervjueeritav 3 mainis, et kõik algab süsteemi disainist. Informatsioon peab olema esitatud sellisel moel, et see oleks võimalikult kiirelt kättesaadav.

Kui süsteemi võimekus on paigas, peaks järgmise asjana tekkima ATCO/AFISOl rutiin töö tegemiseks. Kui lennuväljal A toimub liiklus, kuid lennuväljal B ei ole planeeritud liiklust lähiajal tulemas, on mõistlik suunata enamus tähelepanu lennuväljale A. Sellele lisaks peavad töötajad saama vastavad koolitused ning treeningu mitme lennuvälja samaaegseks teenindamiseks, rääkis intervjueeritav 3.

3.3.2 Katsete tulemused

Joonis 4 on näha tulemusi väitele „Suutsin jagada tähelepanu kahe lennuvälja vahel“, kus 1 = ei suutnud jagada tähelepanu kahe lennuvälja vahel ning 10 = suutsin jagada tähelepanu kahe lennuvälja vahel. Peale esimest katset oli $A = 8{,}25$ ning teise katse järel oli $A = 6{,}25$. A väärtus kahe harjutuse vahel langes 24%. Jooniselt on ka näha, et katsealustel 3 ja 4 muutus suutlikkus kehvemaks, kuid katsealusel 1 püsis see sama ning katsealusel 2 tõusis. Tõenäoliselt põhjus, miks tähelepanu jagamine oli kõrgem esimese katse ajal, on seotud liikluskoormusega, kuna AFISO õpilane pidi sama aja jooksul teenindama vähem lennukeid.



Joonis 4. Väite „Suutsin jagada tähelepanu kahe lennuvälja vahel“ tulemused (autori koostatud)

Katses osalenud AFISO õpilastel puudus varasem kogemus multitorni keskkonnas, seega neil ei olnud veel väljakujunenud kindlaid töövõtteid ega rutiine töö tegemiseks, et tähelepanu jagamine ei tuleks nii raskelt. Katsealune 4 mainis peale teist harjutust, et alguses oli tempo väga kiire ning ei jõudnud väljumiste-saabumiste plaani paika panna. Katsealune 3 kommenteeris, et võrreldes esimese harjutusega hajus tähelepanu päris mitmel korral. Joonisel 4 on näha suurt langust katsealuse 3 ning 4 tulemustes. Selleks, et saaks tekitada enda peas plaani, peab olema kogemust ning multitornis töötamiseks süsteem loodud enda jaoks.

3.3.3 Intervjuutulemuste ja katsetetulemuste ühisosa

Tulevases multitorni keskkonnas võiks kindlasti olla vahetusevanema positsioon, kes haldab töökoormuse jaotamist moodulite vahel. Protseduuride ühtlustamisele tasub läheneda ettevaatlikult ning vaadata üle, millised protseduurid on mõistlik ühtlustada. Hädaolukorra käitumisjuhend võiks kõikidel lennuväljadel olla sama, et vastavas olukorras ei peaks ATCO/AFISO mõtlema, mis reeglid vastaval lennuväljal kehtisid. Töökeskkonda tasub tuua erinevaid tehnilisi abivahendeid ATCO/AFISO abistamiseks ja paremaks tähelepanu hoidmiseks. Lisaks on võrdsema tähelepanu jagamisel abiks kogemus, et tekiks rutiin töö tegemiseks.

3.4 Potentsiaalsed segadused ja ruumilise orientatsiooni kadumine, erinevaid lennuvälju vaadates

3.4.1 Intervjuu tulemused

Intervjueeritav 2 ütles, et nemad ei kogenud oma katsete ajal, mis viidi läbi 3 aasta jooksul, ruumilise orientatsiooni kadumist ATCOdel, katsetustel osales kokku 30 ATCOt. Intervjueeritav 3 mainis, et nende katsetuste ajal tekkis paar juhtumit seoses ruumilise taju kadumisega. Intervjueeritav 3 mainis, et peale harjumis/kohanemisperioodi simulaatoris probleemid kadusid. Seega oluliseks faktoriks oli

kogemuse saamine simulaatorkeskkonnas ning teadlikkus info leidmisel. Edaspidi peaks samuti lähtuma põhimõttest, et mida rohkem on töötajal kogemust seda vähem on temaga probleeme ja inimestele tuleb anda aega uue süsteemiga kohanemiseks, et nad saaksid kogemust. Intervjueeritav 4 ütles samuti, et väga olulisel kohal on treeningud multitorni keskkonnas. Oluline on, et töötajal tekiks kindlad põhimõtted ning reeglid, mille järgi tegutseda. Selle mõttega nõustus ka intervjueeritav 1, kes ütles, et ATCO/AFISOle peab andma piisavalt aega uute tingimustega kohanemiseks ja seejärel tulevad soovitud tulemused.

Intervjueeritav 3 mainis, et arendustööd ei tohiks peatuda peale multitorni valmimist vaid seejärel peaksid jätkuma monitooringud. Kui selgub, et järjepidevalt ATCO/AFISOd eksivad mingi kindla reegli vastu, peaks analüüsima, miks nii juhtus ning tegema vajadusel muudatusi süsteemis nende edaspidiseks välistamiseks.

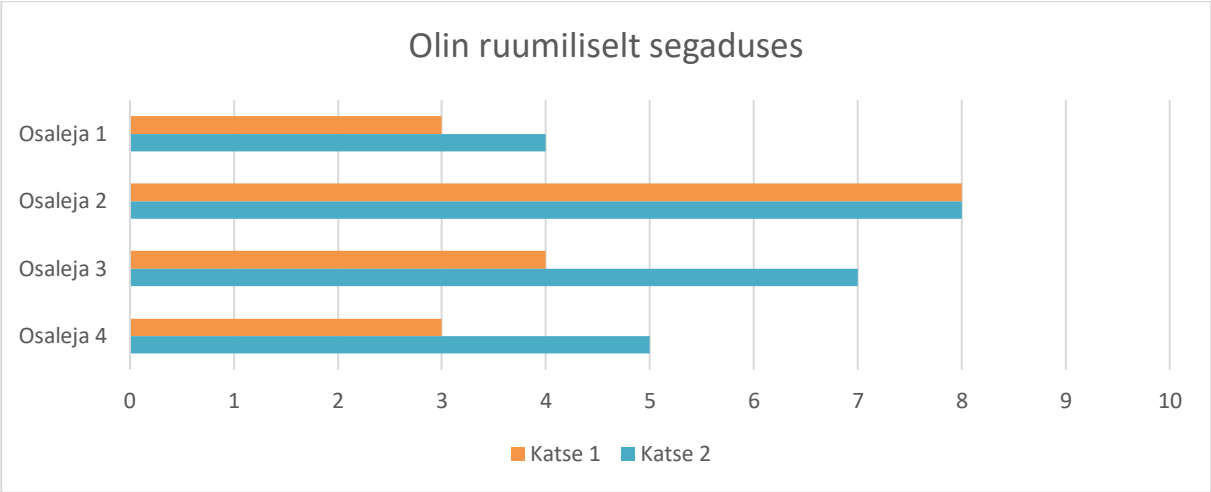
Olukorrale, kus töötaja avastab, et ta on ruumilise orientatsiooni kaotanud, võiks ta intervjueeritava 1 arvates teha pausi, ehitada enda jaoks pildi peas uuesti ette ja seejärel jätkata tööga. Intervjueeritav 2 oli samal arvamusel, võimalusel peab korraks peatuma (nt maapealsetele lennukitele öelda, et nad ootaks), et koguda ennast ja seejärel jätkata töö tegemisega. Intervjueeritav 4 tõi välja, et põhjus ruumilise orientatsiooni kadumisel võib olla ka mentaalses väsimuses. See võib viidata ületöötamisele ning võimalusel võiks sellest arutada kellegagi töö juurest.

Võimalustele kuidas vältida ruumilise orientatsiooni kadumist, toodi järgnevaid lahendusi:

1) video panoraamile märkida ilmakaared või lisada kompassi roos;
2) PTZ kaamerate kasutamine, lisaks nende ekraanidele lisada kompassi roos;
3) maaliikluse jaoks radarpilt;
4) mälutehnikaid kasutades (kindlad märgid viitavad kindlale ilmakaarele, nt kirik mis asub alati põhja suunas lennurajast);
5) lennujaama tundmine eelnevalt või simulatsioonide käigus selle tundma õppimine;
6) kasutajaliidese disain teha võimalikult üheselt mõistetavaks.

3.4.2 Katsete tulemused

Joonis 5 on näha väite „olin ruumiliselt segaduses“ tulemusi, kus 1 = olin terve aeg segaduses ning 10 = ei sattunud kordagi ruumiliselt segadusse. Peale esimest katset oli $A = 4{,}5$ ning peale teist katset oli $A = 6$. Seega peale teist harjutuse tõusis A väärtus 33,33%. Mõlemas harjutuses kasutati samasid lennuväljasid ja samasuguseid radu lennuväljadel, seega osalejatel oli teiseks harjutuseks tekkinud arusaam ruumilisest orientatsioonist.



Joonis 5. Väite „Olin ruumiliselt segaduses“ tulemused (autori koostatud)

Kõikide osalejate puhul täheldas autor, et esimese harjutuse ajal üritasid katsealused endale selgeks teha, mis pidi õhusõidukid lendavad, liigutades iseennast vastavalt õhusõiduki suunale. Katsealused 1, 2 ja 4 tõid välja, et alguses tekitas segadust EETU raja asetus, kuna Dorpat keskkonnas (kus õpingute ajal harjutused toimuvad) asub lennujuhtimistorn rajast lõuna pool, kuid EETUs asub lennujuhtimistorn rajast põhja pool. Samuti mainisid katsealused 1, 3 ja 4, et radarpildi olemasolu oleks väga tugevalt kaasa aidanud ruumilise orientatsiooni hoidmisel. Katsealune 2 tõi välja asjaolu, et lennuväljade varasemalt tundma õppimine oleks olnud suureks abiks.

3.4.3 Intervjuutulemuste ja katsetulemuste ühisosa

Saame järeldada, et intervjueeritavate väide, et kogemusega väheneb potentsiaalse ruumilise taju kadumine, peab paika. Teise katse ajal tõusnud liikluskoormus ei vähendanud ruumilist taju, vaid tõstis seda 1/3 võrra. Põhjuseks võib pidada varasemalt materjalidega tutvumist ning ühe eelneva harjutuse kogemust, mille jooksul oli aega harjuda keskkonnaga ning lennuväljadega. Autor usub, et kui katsete ajal oleks läbiviidud veel mõned harjutused, oleks keskmine tulemus veelgi rohkem tõusnud.

Kui ühel hetkel hakkab tööle esimene multitorn, tuleb alguses panna suurt rõhku esiletõusvatele kitsaskohtadele. Juhul, kui ATCO/AFISO teeb vea töö käigus, peab uurima, kust selline viga tekkis – kas probleem on väheses kogemuses või viitab see mingile süsteemi veale. Töötajatel peab tekkima kindlustunne multitorni töötamisel enne, kui tekib mugavus ning rutiin töö tegemiseks.

3.5 Potsentsiaalne segadus häälkommunikatsioonil (pilootidel, sõiduki juhtidel, ATCOs/AFISOs kõne algataja, kõneside edastamine ja taasedastamise sagedus, samaaegsed kõned, kõnejaama nimetaja (kaug- või tavanimetaja), liidese kujundus)

3.5.1 Intervjuu tulemused

Potentsiaalse segaduse vältimiseks häälkommunikatsioonis pilootide puhul tõid kõik intervjueeritavad välja, et piloodid peaksid lennuvälja indikaatorit mainima igas sides, mitte ainult kriitilistes lennufaasides. Intervjueeritav 1 usub, et sellest saab tulevane nõue multitorni keskkonnas, kuna sellega annab piloot märku teistele, et on opereerimas sama ATCO/AFISOga. Eriti kriitiliseks muutub see olukorras, kus erinevatel lennuväljadel on samasugused rajatähised (nt Tallinnas ja Tartus on rajad 08 ning 26) ning mõlemal lennuväljal toimuvad õhku tõusud või maandumised, ütleb intervjueeritav 2. Kõik intervjueeritavad nõustuvad, et raadioside sagedused peaksid olema ühendatud, sest see tagaks teadlikkuse pilootidele olukordades, kui teiselt lennuväljalt piloot suhtleb ATCO/AFISOga.

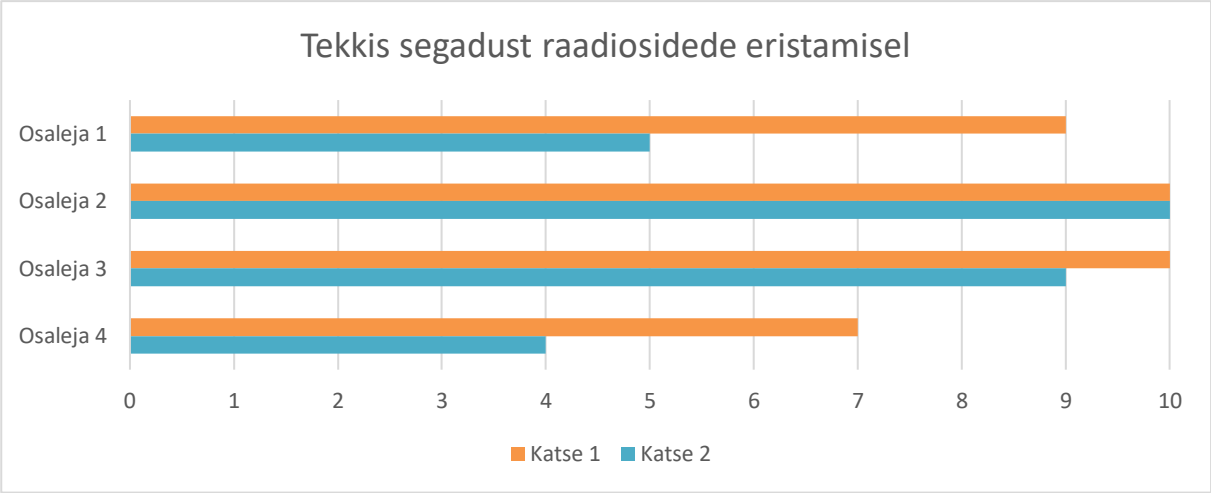
Sõidukijuhtide puhul toodi samuti välja vajadust mainida lennuvälja indikaatorit igas sides. Intervjueeritav 3 ütles, et nemad olid otsustanud ühendada maaliikluse sagedused omavahel. Selline lähenemine ei ole laialdaselt kasutusel. Intervjueeritav 2 tõi välja, et transpondri olemasolu peaks olema tagatud kõikidel sõidukitel. Maaradari olemasolu aitaks hoida ATCO/AFISOl paremat ülevaadet sellest, mis toimub lennuväljal maa peal. Intervjueeritav 4 mainib, et üks võimalus maaliikluse eristamiseks on lisada lennuvälja indikaator kutsungisse. Näiteks, kui enne oli lennuväljal sõiduk „Rajameister“, siis multitorni keskkonnas võiks tema kutsung olla „EETU Rajameister“ või „Tartu Rajameister“, et tekiks veelgi selgem erinevus liikluste vahel. Intervjueeritav 3 näeb, et tulevikus võib tekkida olukord, kus ATCO/AFISO ütleb maaliiklusele, et ei saa hetkel suhelda, kuna lennuväljadel olev liikluskoormus on liiga suur.

Kõrval sektorite ning ATCO/AFISO vahelises suhtluses ei pea nii rangelt lennuvälja indikaatorit kasutama. Intervjueeritav 2 rääkis, et kui õhusõiduki kutsung on väga konkreetselt eristatav, siis ei näe ta põhjust, miks peaks mainima lisaks kutsungile veel lennuvälja indikaatorit. Samas tõi intervjueeritav 1 välja, et kui naabersektor on kahel lennuväljal sama, siis peaks kasutama lennuvälja indikaatorit. Kui naabersektorid on erinevad, ei näinud intervjueeritav selles enam vajadust. Intervjueeritav 4 näeb vajadust igas telefonikõnedes naabersektoritega mainida lennuvälja indikaatorit, kuna see tõstab teadlikkust ning tähelepanu ATCO/AFISO jaoks.

Intervjueeritav 4 tõstatas mõtte, et lennuvälja indikaator ei tohiks olla miski, mis tundub tobe/ebavajalik (pilootidele, maaliiklusele või teistele sektoritele), vaid sellest võib saada see, mis saab määravaks hädaolukorras.

3.5.2 Katsete tulemused

Joonis 6 on näha tulemusi väitele „tekkis segadust raadioside eristamisel“, kus 1 = olin koguaeg segaduses ning 10 = ei tekkinud ühtegi segadust. Peale esimest katset oli $A = 9$ ning peale teist katset oli $A = 7$. Seega teise harjutuse ajal langes A väärtus 22,22%.



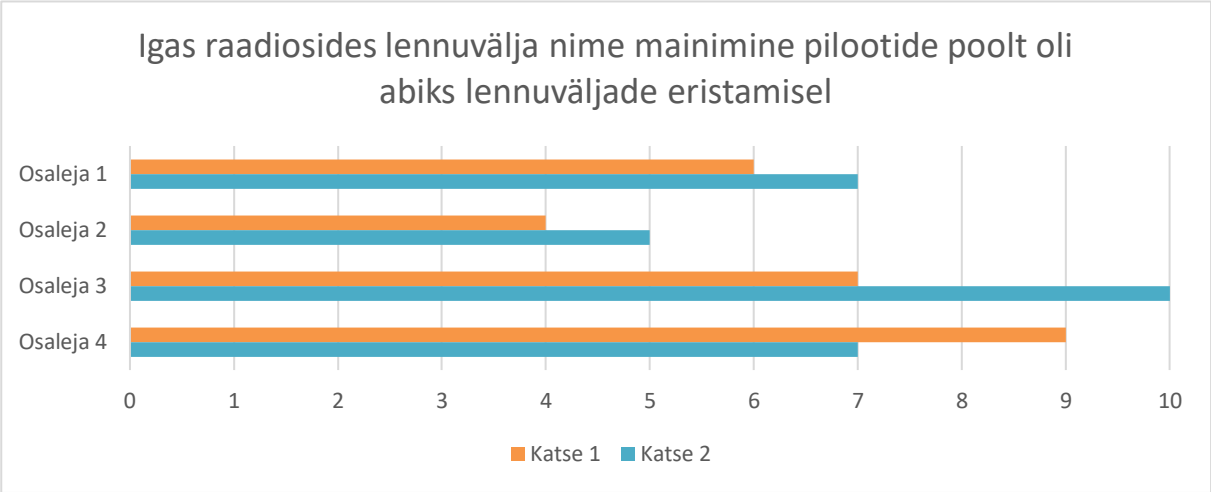
Joonis 6. Väite „Tekkis segadust raadiosidede eristamisel“ tulemused

Negatiivne keskmise näitaja muutus oli tõenäoliselt tingitud liikluskoormuse tõusmisest. Suurenenud liikluskoormusega kaasnes suurem vajadus suhelda naabersektoritega. Naabersektori kõne vastuvõtmisega viivitasid kõik katsealused, kuna tegelesid samal ajal lennuliiklusega.

Esimeses harjutuses olid kutsungid ES-VCW ning ES-WCW, mis lendasid erinevatel lennuväljadel. Eesmärgiks oli näha, kas katsealune näeb selle olukorra läbi ja ei lühenda mõlemat kutsungit E-CWiks. Katsealused 1 ja 4 lühendasid kutsungid ilma mõtlemata ära ning seejärel sattusid segadusse, milline lennuk neile parasjagu vastas. Katsealune 3 alguses lühendas kutsungid ja seejärel märkas, et kaks kutsungit on liiga sarnased ning edaspidi kasutas täispikkuses kutsungeid ja katsealune 2 nägi koheselt sarnaseid kutsungeid ning ei lühendanud neid kordagi. Teises harjutuses olnud FIN3421 ning FIN4231 ei tekitanud üheski katsealuses segadusi.

Harjutuste ajal oli pseudopilootidel nõue kasutada igas oma raadiosides lennuvälja indikaatorit, millises raadioside osas seda mainiti, oli pilootide enda otsustada. Üldiselt kasutasid pseudopiloodid lennuvälja indikaatorit raadioside esimeses pooles. Samuti mainisid kõrval sektorid igas kõnes lennuvälja indikaatorit, kuhu helistati.

Joonis 7 on näha tulemusi väitele „igas raadiosides lennuvälja nime mainimine pilootide poolt oli abiks lennuväljade eristamisel“, kus 1 = lennuvälja nime mainimine ei olnud üldse abiks ning 10 = lennuvälja nime mainimine oli suureks abiks. Peale esimest katset oli $A = 6{,}5$ ning teise katse järel oli $A = 7{,}25$. Kokku tõusis A väärtus 16%, mis tähendab, et suurema liikluskoormuse ajal hinnati pilootide poolt lennuvälja indikaatori mainimist kõrgemalt.



Joonis 7. Väite „Igas raadiosides lennuvälja nime mainimine pilootide poolt oli abiks lennuväljade eristamisel“ tulemused (autori koostatud)

Kahe väite tulemusena saame järeldada, et suurenenud liikluskoormus raskendab ATCO/AFISO võimekust eristada, kus õhuruumis piloot asub, kuid seda olulisem on lennuvälja indikaatori mainimine igas raadiosides. See aitab viia ATCO/AFISO tähelepanu vastavale lennuväljale. Suurenenud liikluskoormuse ajal on samuti olulisel kohal raadiosageduste ühendamine. See annab pilootidele teadlikkuse, mis hetkel tegeleb ATCO/AFISO teise lennuväljaga ning mis hetkel on raadiosagedusel vaikne hetk.

3.5.3 Intervjuutulemuste ja katsetulemuste ühisosa

Läbiviidud harjutustes maaliiklus puudus, kuid autor leiab, et kõige mõistlikum on maaliikluse nimedesse põimida lennuvälja indikaator sisse, seega edaspidi ATCO/AFISOga suheldes ei pea maaliiklus enam mõtlema lennuvälja indikaatori eraldi mainimise peale. Lisaks aitaks see vähendada riske, mis võivad tekkida sarnaste maaliikluses kasutusel olevate nimedega.

Kõrval asuvate sektorite puhul näeb autor, et multitorni alustamise ajal tasuks mainida igas sides lennuvälja indikaatorit. See tõstataks tähelepanu ATCO/AFISOs ning alguses leevendaks inimtegurist tingitud riske. Kui multitorn on pikemat aega töös olnud, võib mõelda kõrval sektorite puhul lennuvälja indikaatori mainimise kaotamise peale.

3.6 Diferentseerimine erinevate lennuväljade vahel (meteoroloogilised tingimused)

3.6.1 Intervjuu tulemused

Ükski intervjueeritav ei näinud, et erinevad ilmastikutingimused erinevatel lennuväljadel põhjustaksid suuri probleeme lennuväljade diferentseerimisel multitorni keskkonnas. Kuid kaks intervjueeritavad tõid välja kitsaskohad, mis võivad tekkida.

Intervjueeritav 1 tõi näite, olukorrast, kus lennuväljadel puudub ATIS võimekus ja tegu on talvise ajaga. Sellisel juhul tõuseb lennuinformaatori töömaht märgatavalt seoses lumekoristuse ning raja hooldusega. See võib viia selleni, et ATCO/AFISO on harjunud juba andma ilmainfot ning raja hõõrdetegurit, seega hakkab ta seda tegema iga õhusõiduki puhul, isegi kui tegelikkuses asub õhusõiduk mingil muul lennuväljal. Samuti võib selline olukord tekitada viivitusi lennujamas A, kuna ATCOl/AFISOl on vaja tegeleda lumekoristusega lennujaamas B. Intervjueeritav 4 tõi välja, et raskusi võib tekkida olukorras, kus mõlemal lennuväljal on udu, kuid ühel on tugevam ja teisel nõrgem, kuid ekraanil mõjuvad mõlemad sama tugevalt. Samasugune olukord võib juhtuda ka vihmasajuga, kus ekraanilt kuvatav pilt on petlik.

Samuti ei näinud kolm intervjueeritavat neljast probleemi erinevate maastikega lennuväljade kokku panemist. Ainukesena mainiti probleemse kohana samasuguste maastikega lennuväljade kokku panekut. Intervjueeritav 3 tõi välja asjaolu, et enne lennuväljade ühendamist peaks kaaluma ilmafaktorit sellisel kujul, et kui lennuväljad asuvad lähestikku, on oht, et mõlemal lennuväljal on korraga kehv ilm. Juhul, kui kõigil lennuväljadel peaksid toimuma lumekoristused samal ajal, siis tekiks liiga suur töökoormus ühe töötaja jaoks.

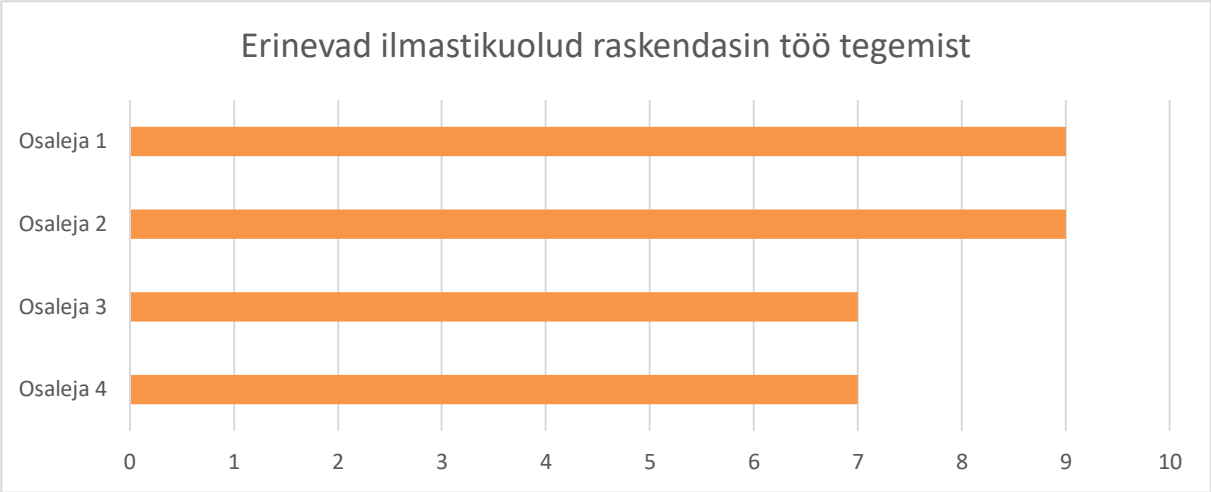
Intervjueeritavad 2, 3 ja 4 nõustusid, et erinevate maastikega lennuväljade kokku panemine ei tohiks saada suureks probleemiks, kuid mainiti, et sellest tingituna erinevate ilmastikuoludega töötamist ning lennuväljade eristamist ei ole siiani veel liiga põhjalikult uuritud.

Ainukesena nägi probleemi intervjueeritav 1, kes ei paneks mägede vahel asuvat lennuvälja rannikuäärse lennuväljaga kokku, põhjendades, et sellises olukorras ei saa protseduure ühtlustada ning see tekitaks töötajale liigselt lisakoormust.

3.6.2 Katsete tulemused

Joonis 8 on näha tulemusi väitele „erinevad ilmastikuolud raskendasid töö tegemist“, kus 1 = töö tegemine oli väga raskendatud ning 10 = erinev ilm ei seganud töö tegemist. Väide esitati ainult peale

teist katset, kuna esimesel katsel olid ilmastikutingimused samasugused mõlemal lennuväljal. Teise katse järel oli $A = 8$. Katses osalejad ei tundnud, et erinev ilm oleks väga palju nende töö tegemist mõjutanud. Autor märkas katsete ajal, et ükski osaleja ei maininud vihma EEKE lennuväljal ega hoiatanud, et rada võib libe olla.



Joonis 8. Väite „Erinevad ilmastikuolud raskendasid töö tegemist“ tulemused (autori koostatud)

Katse tulemused kinnitasid ekspertide üldist arvamust. Osalejad ei täheldanud, et nende võimekus teenuse pakkumiseks oleks muutunud erinevate lennuväljade ilmaolude tõttu.

3.7 Ekraanide paigutus visuaalse vaate jaoks ning ekraanid teiste ATS süsteemide/funktsioonide jaoks (nt ekraanide arv ja nende funktsiooni, ekraanide nurgad)

Intervjueeritav 2 tõi oma intervjuus välja, et nende katsetuste ajal leiti, et väiksemad ekraanid mõjusid paremini kui ekraanid, mis olid suuremad ning asusid 5-7 meetri kaugusel ATCO/AFISOst. Intervjueeritav 1 mainis, et lennuväljade üksteise kohale paigutamine toimis kõige paremini. Kuid ta mainis, et on kasutusel ka lahendusi, kus kahe lennuvälja vaated asuvad kõrvuti ning kolmanda lennuvälja vaade on nende kohal.

Intervjueeritav 3 tõi välja, et nemad kasutasid ühte kasutajaliidese süsteemi, mis haldas kogu vajaminevat informatsiooni. Lisaks mainis intervjueeritav 3 katsetusi, kus kasutati mitut ekraani informatsiooni kuvamiseks. Samuti tõi intervjueeritav välja, et väga olulisel kohal on ülesehituse disain, kuna see peab võimaldama võimalikult kiire informatsiooni kättesaadavuse.

Selle kohta ei esitanud autor väidet katsetel osalenutele, kuna tegu oli lihtsustatud multitorni ülesehitusega. Lisaks puudus kõikidel osalejatel varasem kokkupuude ird-/multitorniga, seega puudus võrdlusmoment.

3.8 Lennuvälja heli päritolu

Ainult intervjueeritav 4 oli kindlal arvamusel, et kohaliku lennuvälja heli olemasolu võiks kindlasti olemas olla, tuues välja, et see on järjekordselt miski, mis tõstatab ATCO/AFISOl tähelepanu, kus tegevus toimub. Intervjueeritav tõi paralleeli heli olemasolu ning lennuvälja indikaatori valjult välja ütlemisega, sest mõlemad on faktorid, mis tõstatavad tähelepanu olukorrale. Samuti tõi intervjueeritav välja, et heli olemasolu saab olla võimalik ainult siis, kui on olemas ka erinevad kõlarid erinevate lennuväljade jaoks.

Intervjueeritavad 1, 2 ja 3 kõik nõustusid, et multitorni kontekstis ei ole oluline omada lennuvälja kohalikku heli. Peamiseks põhjenduseks toodi välja, et multitornis on raske aru saada, kust kohast täpsemalt heli pärineb. Olukorda raskendavad ka lennuvälja suurused ning multitornis olevate lennuväljade arv.

Kuigi kolm intervjueeritavat nõustusid, et lennuvälja kohaliku heli kuulmine ei ole multitornis esmatähtis, siis intervjueeritavad 1, 2 ja 4 mainisid, et kui lennuvälja heli on võimalik kuulata, peaks sellega kaasnema korralik helisüsteem nii, et igal lennuväljale on määratud kõlarid, mis on lennuvälja pildiga joondutud. Ainult sellisel juhul omab lennuvälja heli olemasolu efekti. Kui multitorni moodulis on ainult üks komplekt kõlareid, kust kostub kolme erineva lennuvälja heli, ei ole selle omamisel mõtet.

Samuti leiti, et lennuvälja heli kuulmine võiks olla valikuline. See eeldaks, et kasutajaliideses on võimalik iga lennuvälja kohalikku heli sisse ja välja keerata. Sellisel juhul saaks töötaja ise otsustada, kui oluliseks peab ta kohaliku heli kuulmist.

Intervjueeritav 2 tõi välja, et heli kuulmine võiks olla eriti kasulik piirkondades, kus on palju helikopteriliiklust, tuues välja põhjuseks, et helikopteri käivitudes hakkab esmaselt tegema häält mootor ning seejärel hakkab alles rootor pöörlema. See võimaldaks ATCO/AFISOle juba ennetavalt olla valmis helikopteriliikluseks.

Selle kohta ei esitanud autor väidet katsetel osalejatele, kuna eksperimendi ajal puudus võimekus kasutada lennuvälja heli.

Seega võib öelda, et heli olemasolu võiks tulevikus olla kasulik multitorni keskkonnas, kuid sellest ei saa nõuet. Heli kuulmine tõstab ATCO/AFISO tähelepanu, kuid selle jaoks peab olema vastava võimekusega helisüsteem. Heli süsteem peab olema kohakuti lennuväljadega ning sellel peab saama valida, milliste lennuvälja kui valjult soovib töötaja kuulata. Sellise süsteemi puudumisel ei ole

lennuvälja heli kuulmisest kasu. Lisaks võiks olla kasutajaliideses võimalik (helisüsteemi olemasolul) ATCO/AFISOl valida, kas ta soovib heli kuulda ja kui ta soovib kuulda, siis millise lennuvälja heli.

3.9 Järeldused

Siinkohal toob autor välja intervjuude ning eksperimendi käigus saadud tulemuste järeldused. Kõigepealt esitab autor soovitused multitorni ülesehituse ning kasutajaliidese disaini osas. Seejärel annab autor soovitusi multitorni keskkonna loomisel. Katsete tulemused kinnitasid ekspertide arvamusi erinevate inimtegurite mõjust lennuinformaatori poolt pakutava teenuse kvaliteedile multitornis töötades.

Ekspertide meelest mängib kõige suuremat rolli silmsidest virtuaalse vaate vastu minnes keskkonna muutus. Samuti on keskkonna ülesehitus ning kasutaja liidese disain väga olulisel kohal multitorni puhul. Multitorni ülesehitus ja kasutajaliidese disain mängivad suurt rolli kõikide 7 multitorni spetsiifilise inimteguri puhul. Mida kiiremini ja üheselt mõistetavalt on informatsioon kättesaadav seda kergem on hoida järjepidevat ülevaadet ning jagada tähelepanu lennuväljade vahel. Järgnevalt esitab autor nimekirja meetoditest, mis aitavad leevendada inimteguri riske ülesehituse ja kasutajaliidese poole pealt:

1. radarpildi olemasolu kasutajaliideses, see kehtib nii õhusõidukite, kuid võimalusel ka maaliikluse kohta. See annab AFISOle kiirema ülevaate aktiivsest liiklusest ja aitab hoida situatsiooniteadlikkust;
2. eristada lennuväljasid videoseinal kui ka kasutajaliideses erinevate värvidega. Siin on hea kasutada värvi, mis oleks seotud lennuväljaga, kuna kõik, mis tekitab emotsiooni, on kergem meelde jätta. Näiteks kasutada kollast tooni EEKE puhul, kuna Kuressaare on päikesepealinn;
3. info peab olema samasuguselt esitatud kasutajaliideses iga lennuvälja kohta ehk näiteks ilmapaneel peab asetsema võrreldes strippidega kõikidel lennuväljadel sama koha peal. See aitab kaasa info kiirel ülesleidmisel;
4. videoseina puhul tasub meeles pidada, et suuremad ekraanid ei too alati paremaid tulemusi. Mida suurem on ekraan, seda kaugemale peab ekraanid töötajast viima. Lisaks tasub proovida ekraanide erinevaid paigutusi, võimalik on ekraane asetada üksteise peale või kõrvuti;
5. videoseinal peab kuvama ilmakaari, see võib olla esitatud kas sõnaliselt või kompassi roosina. Ilmakaarte kuvamine aitab ruumilise orientatsiooni hoidmisele kaasa.

Järgnevalt toob autor välja multitorni ülesehitusest ning kasutajaliidesest sõltumatud tegevused, mis aitavad leevendad inimtegurist tingituna tekkinud riske:

1. lennuvälja indikaatori mainimine;
    a. õhusõidukid peavad mainima igas sides ja soovituslikult side esimeses pooles
    b. maaliiklusel on soovituslik lennuvälja indikaator nimega ühendada, seega oleks „Tartu traktor“
    c. kõrvalsektoritel on tugevalt soovituslik multitorni käivitumise alguses mainida igas sides lennuvälja indikaatorit, millest jutt käib. Peale mõnda aega võib mõelda selle nõude kaotamise peale, ent seda peab vaatama vastavalt lennuväljadele.
2. Raadiosideks kasutatavad sagedused on soovituslik hoida ühendatud, selleks et tagada kõikidele pilootidele teadlikkus AFISO reaalsest töökoormusest;
3. lennuväljade protseduure tasub ühtlustada mõistlikkuse piires. Kindlasti ei ole vaja kõiki lennuväljasid täielikult ühtlustada, vaid võib kaaluda ainult häda- ning eriolukordade protseduuride ühtlustamist;
4. AFISOdele peab andma piisavalt aega harjutamiseks ja harjumiseks multitornis töötamisega. See periood peab olema piisavalt pikk, et AFISOl tekiks rutiin ning kindlad töö võtted multitornis teenust pakkudes;
5. soovituslik on kaasata vahetusevanem multitorni positsioonide juurde. Tema ülesandeks jääks töökoormuse võrdne jaotamine moodulite vahel.
6. olulisele kohale tõuseb lennuväljade valik multitorni. Kui lennuväljad asuvad liiga lähestikku, võib see halva ilma korral tõsta töömahtu.

KOKKUVÕTE

Käesoleva uurimistöö eesmärk oli välja selgitada, millisel määral mõjutavad erinevad inimtegurid lennuinformaatori poolt pakutava teenuse kvaliteeti multitorni keskkonnas töötades ja kuidas on võimalik nendest tekkinud riske leevendada. Eesmärgi saavutamiseks sõnastas autor järgnevad uurimisküsimused:

1. Millisel määral mõjutavad erinevad inimtegurid lennuinformaatori poolt pakutava teenuse kvaliteeti multitornis töötades?
2. Kuidas on võimalik inimtegurist tingitud riske leevendada lennuinformaatori jaoks?
3. Milliste muutustega peaks lennuinformaator arvestama minnes irdtornist üle multitorni tööle?

Kõik püstitatud uurimisküsimused said töö käigus vastatud. Uuringu tulemusena selgus, et inimtegur mõju suurus lennuinformaatori poolt pakutava teenuse kvaliteedile multitornis töötades on alguses suur. Inimteguri olemasolu on vältimatu, kuid täiesti uues keskkonnas töötades on selle mõju rohkem kui traditsioonilises lennujuhtimistornis. Selleks, et inimteguri mõju hakkaks vähenema, on vaja aega ning kogemust. Mida kauem on AFISO uues keskkonnas töötanud, seda rohkem suudetakse tuvastada kitsaskohti, mida muuta/parandada. Inimteguri riskide leevendamiseks on mitmeid lahendusi. Kõige olulisemal kohal on pilootide poolt lennuvälja indikaatori mainimine igas raadiosides, see aitab viia AFISOl tähelepanu õige lennuvälja peale ning hoida paremat ülevaadet lennuväljal toimuvast. Teiseks kõige olulisemaks võimaluseks riskide leevendamisel on multitorni ülesehitus. Multitorni videosein ja kasutajaliides peavad olema toeks AFISOle, informatsioon peab olema loogiliselt ning kergesti kättesaadav. Võimalus on kasutada erinevaid värve lennuväljade eristamiseks kasutajaliideses. Suurim muutus üleminekul irdtornist multitorni saab olema töökeskkond. Sellega harjumine võib võtta aega, peamine on, et AFISOl tekiksid harjumused ning kindel rutiin töö tegemiseks. Nii suudab üks inimene hallata mitut lennuvälja korraga.

Töö koostaja näeb, et see valdkond vajab veel reaalseid katsetusi simulatsioonides. Tasub proovida erinevaid töös väljatoodud lahendusi ja leida, mis toimib kõige paremini just enda lennuväljade puhul. Samuti tasub meeles pidada, et peale multitorni kasutuselevõttu võib see vajada täiendavaid muudatusi. Uuringu tulemusi saab rakendada EANS oma edasise multitorni arendustööde käigus.

Lõputöö autor soovib tänada juhendajat ning konsultanti, ilma kelleta see lõputöö ei oleks valminud, Kristjan Kõrgesaart ja Teele Kohvi. Lisaks soovib autor tänada kõiki intervjuudes ja katsetes osalejaid, kes võtsid aja oma päevast, et aidata kaasa lõputöö valmimisele. Autor soovib tänada veel kõiki, kes töötasid katsete ajal pseudopilootidena.

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LISAD

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INIMTEGURI MÕJU LENNUINFORMAATORILE MULTITORNI KESKKONNAS TÖÖTADES

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/allkirjastatud digitaalselt/

Autor: Gete Suurraid

Lisa 1. Küsimused intervjuus

1. EASA has outlined 25 different human factors concerning remote tower. Please choose 3 human factors that have the biggest difference going from single remote tower to a multiple remote tower environment. If possible, please send these 3 factors to me before the interview (you don't have to include the question a-c). (The list of 25 different human factors can be found at the end of the questions.)
    a. Reason why you chose this factor
    b. What impact can be seen
    c. How can we mitigate this factor
2. What could possibly help ATCO/AFISO (regarding user interface) to keep continuous watch over two or more aerodromes at the same time? What factors might arise from keeping a continuous watch over two or more aerodromes at the same time? How can we alleviate these factors?
3. How can third parti (pilots, ground operational personnel) support ATCO/AFISO, to maintain a continuous watch over two aerodromes? What prerequisites/requirements can be expected to be in the future for different stakeholders in a multi remote tower concept?
4. Which methods/resources could be used to "maintain" full situational awareness of the whole responsibility area? (In situations where the screens do not show 360 degree view)
5. How can we alleviate potential spatial disorientation happening in a two aerodromes multi remote tower? How should ATCO/AFISO act when she/he discovers they are spatially disoriented? (Example ATCO/AFISO gets confused which way is north and south in regards of the aircraft)
6. What can be done with user interface to help ATCO/AFISO to maintain spatial orientation?
7. What factors could distributed attention between two aerodromes bring? How can we help ATCO/AFISO in this situation?
8. What might alleviate potential confusion in voice communication? (From the pilots, vehicles and other sectors)
9. What can cause difficulties in differentiating aerodromes regarding meteorological conditions?
10. Would the ability to hear aerodrome local sounds help the ATCO/AFISO worker? Under what conditions would the outside sounds give any benefit to the worker?
11. When can we expect the first multitower to start working?

List of 25 different human factors by EASA:

1. ATCO/AFISO ability to ‘maintain a continuous watch on all flight operations on and in the vicinity of an aerodrome as well as vehicles and personnel on the manoeuvring area’[78];
2. ATCO/AFISO situational awareness;
3. ATCO/AFISO perception;
4. ATCO/AFISO workload;
5. ATCO/AFISO fatigue and boredom;
6. impact of augmented reality;
7. usability of input devices;
8. effect of time delays on visual presentation in all situations, with special attention to emergency situations (e.g. runway incursions);
9. potential confusion over the different views that an ATCO/AFISO could suffer from having images originated from different cameras with different locations and angles of view on the manoeuvring area (e.g. positioning cameras on both sides of a runway);
10. differences in brightness between ground and sky in the screen views;
11. differences in brightness between reality and the presented view;
12. partial limitation of view in the visual presentation caused by glare e.g. during low-standing sun;
13. contrast of screens with the background;
14. colour balance with different daylight configurations;
15. combining video images from different sources such as visual cameras, infrared cameras, etc;
16. screens arrangement (e.g. number of screens, angles of screens, edges of screens, multiple views);
17. ATCO/AFISO workspace ergonomics (e.g. seated versus standing, distance from desk to screens);
18. capability of the cameras to capture and transmit blinking beacon images;
19. specific local conditions affecting the visibility (e.g. deficiencies in image capture due to seawater splash);
20. if made available, aerodrome ambient sound;
21. acoustic characteristics of the control room (RTM/RTC);
22. camera angles and screen orientation in relation to aerodrome layouts and in relation to the different legs of the aerodrome traffic circuit, as well as emergency and missed approach procedures;
23. Integrated flight data label information (if available), both with static information and with dynamic information, and measures to prevent the label from shadowing visual information as well as measures to prevent frequent and sudden moves of those labels;

24. binocular functionality and the possibility to follow moving objects, either automatically (rotation, tilt to the desired elevation angle and focus at the indicated distance, if available) or through a manual pan-and-tilt/zoom function;
25. visual tracking functionality (if available).

Lisa 2. Küsimustik peale harjutuse

Mis su nimi on?

1. Suutsin hoida järjepidevat ülevaadet kahel lennuväljal

Ei suutnud üldse 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 Suutsin hoida järjepidevat ülevaadet

2. Igas raadiosides lennuvälja nime mainimine pilootide poolt oli abiks lennuväljade eristamisel

Lennuvälja nime mainimine ei olnud üldse abiks 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 Lennuvälja nime mainimine oli suureks abiks

3. Olin ruumiliselt segaduses (nt ei saanud aru, kus pool asub põhi ja kus lõuna piloodi seisukohast

Olin terve aeg segaduses 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 Ei sattunud kordagi ruumiliselt segaduses

4. Suutsin jagada tähelepanu kahe lennuvälja vahel

Ei suutnud jagada tähelepanu kahe lennuvälja vahel 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 Suutsin jagada tähelepanu kahe lennuvälja vahel

5. Tekkis segadust raadiosidede eristamisel (ei saanu aru kes räägib või kus lennuväljal lennuk asub)

Olin koguaeg segaduses 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 Ei tekkinud ühtegi segadust

6. Erinevad ilmastikuolud raskendasid töö tegemist

Töö tegemine oli väga raskendatud 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 Erinev ilm ei seganud töö tegemist

7. Muud emotsioonid/tunded, mis tekkisid harjutuse ajal
8. Emotsioonid võrreldes esimese harjutusega

Lisa 3. Intervjuu 1

Interviewee 1: I am an air traffic controller, I have had my licence more than 30 years now still active, I am a former head of tower unit/department, currently senior ATM advisor my main domain in remote towers and multi remote as well.

Gete: Let's get on with the interviewer then the three factors that you chose were ATCO/AFISO situational awareness, the workload, and the usability of input devices, why did you choose these?

Interviewee 1: In my experience I have been working in multi remote environment in a simulator only project pj05 many times with different airport using different human interfaces. Human interfaces in the second round we went with Inra working with the airport familiar to me and also working with totally unfamiliar airports Norwegian airports which we did not know previously. In my experience based on these the simulations the highest and most importance of is that it's not a big deal that you are working simultaneously three airports if you have no workload and when you have no simultaneous movements. So again, the complexity is the issue not the workload, not the traffic demand because easily you can handle traffic's like 30 movements per hour if it is in an ordered way. The complexity is when you have to deal with aircraft movement in the air on the ground, ground vehicle movements and you have two coordinates on telephone simultaneously that can cause problems. That's why the situational awareness is of course the key for safety if you lose situational awareness nothing else remain. That is the most important to maintain situation awareness all the time. The workload comes from the complexity. If you have three airports on hands or even two airports on hands with different procedures, like different attitudes for the traffic circuit different coordination procedures, neighbouring sectors different go-around procedures different coordination, that really increases the complexity. If you harmonize the procedures you can keep the complexity low and it will decrease the workload as well. Usability of the input devices. In both of my simulation runs we used single human interface for all airports which is quite important and when you have to deal with the ground lighting stuff the meteorological information displaying of the meteorological information is important to be a unified solution so each airport have to have the same windows and have to see the same layout of meteorological information so you can find easily the information that you need and also you have to be able to open the flight plans. The human interface it is important to make it easily user-friendly for the controller and of course using a single human interface so you don't have to deal with two different keyboards two different mice for the single human interface for all the airports. That's the reason behind my choses.

Gete: We can move onto the second question I think. So what could possibly help ATCO/AFISO (regarding user interface) to keep continuous watch over two or more aerodromes at the same time?

What factors might arise from keeping a continuous watch over two or more aerodromes at the same time? How can we alleviate these factors?

Interviewee 1: So continuous watch is a thing that doesn't exist in the real life because even if you are up in the tower and the tower is in the middle of the airport you are not able to see each part of the airport at the same time so there's a line of sight you can see, you have the focused site and you have the peripheral sight many information comes from the focus of your site and some information you can get it from the peripheral. Of course in a remote tower environment the whole airfield even 360 field can be visualised in front of you so in your focused and your peripheral sight you can see 360 degree better than in real life so that the increases the situational awareness and continues watch. However the layout of the airport if you working in a multi remote environment is a bit different. First with the frequencies system we had with three airports and the visual panoramic picture of each airport was one above the other. So we had the three layers of the three airport. Where as in the Indra system in Norway they used to two side by side and the third one was below. So I found it a bit more complicated than the three airports each above. From controllers point of view it was much easier to visualise and check all the airfields because each threshold is one by one at the side of the video wall and in the middle there were the aprons and the main areas of the airport. So the layout of the video wall can help and it can be bit more complicated so that's my idea how to decrease the workload and help the ATCOs to maintain the situational awareness. On the other side if I'm talking about the communication which is the most important because you can see and you can get information simultaneously and very quickly watching the videos, but the communication it's a time-consuming factor and when you have to give an en-route clearance at airport A for departing traffic where as on the airport B there is a landing which needs a landing clearance because you couldn't give the landing clearance in advance because there was a proceeding aircraft on the runway so you had to wait until it clears the active in the meantime you started to give the en-route clearance on airport A children and airport B there is a situation, so these factors are the most important to handle the traffic safely. I don't know the reason behind the different approaches to the video wall layout, but I heard a rumour that for them the head up head down was a bit tiring because they had to work a lot with the human interface head down to update the flight plans and watch the radar screens. The third airport which was quite high they had to look up very much. At the end of the day you do what is most convenient for the controllers you can if they like it. We have been talking about harmonized procedures but first for multi remote environment it is mandatory use frequency coupling. So at the three different airports there can be three different frequencies but for the ATCOs working for the three airports all these frequencies must be coupled that is the basic statement because pilots have to be aware that controller is busy talking to someone. That is essential. Also the factor keeping the communication with the

ground vehicles, so in the small airfield it would be recommended the ground vehicle communication moving on the manoeuvring area to keep the contact on the aviation frequency because that is a key element for the safety to handle as less devices as possible. So if the controller has to use a separate radio for ground vehicles you can imagine that for three airports it will mean three different devices three different frequencies which is impossible to handle safely and the thing is that when everything is in order than it's ok but if then there's an unforeseen event occurs immediately everybody will call you so all the phone lines will be ringing and fire brigades must be on the airport on the frequency so the workload will increase a lot. You have to deal with those situations as well at least for a shorter time.

Gete: How can third parti (pilots, ground operational personnel) support ATCO/AFISO, to maintain a continuous watch over two aerodromes? What prerequisites/requirements can be expected to be in the future for different stakeholders in a multi remote tower concept?

Interviewee 1: Just as I said the procedures have to be organised which means all the departure procedures the handover procedures to the neighbouring sectors and the ground movements has to be harmonized so each field they will have to use the same standards then it will be ok and ATCO will not have to think of " ok at this airport I have to give the clearance to cross the taxiway but the other airport they will cross their taxiway on their own." So all these kind of stuff has to be harmonized and all the airports under one control they has to use the same set of procedures same set of rules

Gete: From the pilots side or when you're the ground operational worker is there something you can to you maybe help the controller

Interviewee 1: in later stage I mentioned that and in the communication pilots also has to used the airport identification at each call. They could give hint to other pilots on the other airports that they are operating with the same controller but they are operating at a different airport. For an example there is a line-up and a take-off clearance at airport A and there is a landing clearance at airport B, it can be confusing if you don't use the airport identification because the runways can be the same direction, airport A can have a runway 31 and airport B can have a runway 31 as well, so the airport identification is vital.

Gete: can we see this as a requirement in the future in a multi remote tower environment?

Interviewee 1: I am convinced it will be a requirement because otherwise you cannot guarantee the safety and of course these rules have to be published and all the pilots operating these airports. They have to be aware why it is necessary because at the first call they use the airport ID or the tower ID but it is mandatory in every communication.

Gete: Which methods/resources could be used to “maintain” full situational awareness of the whole responsibility area? (In situations where the screens do not show 360 degree view)

Interviewee 1: Contingency measures has to be in place at every airport of course, previously determined and deployed based on the safety case but the operation depending on the complexity of the airport depending on the traffic volume and local conditions I believe the operation can be maintained but of course the traffic level has to be reduced. For an example one aircraft operating at the time or if there is a ground vehicle movement on the manoeuvring area than there is no aircraft movement alone and stuff like that. The contingency plan needs to be done very slowly.

Gete: Could also radar screens for the ground movement or air movement help in a situation like this?

Interviewee 1: that is, technologically interesting question because multimode is especially designed for airports that are with very small traffic demands and in real life these airports have no radar and are not well equipped. These airports are small and basically there is nothing in any of them, there is no ILS. They are mostly operating in good weather conditions but even if there is an ILS they still don't have the surveillance. In my experience they need some shadow operations putting camera systems at real airports. In my experience if there is no surveillance then you have to rely on only procedural control but the airborne radars the get a good coverage, there are some technology that can help the controllers in case of losing visual surveillance but still the procedures has to support him.

G: How can we alleviate potential spatial disorientation happening in a two aerodromes multi remote tower? How should ATCO/AFISO act when she/he discovers they are spatially disoriented? (Example ATCO/AFISO gets confused which way is north and south in regards of the aircraft)

Interviewee 1: Yes we encountered spatial disorientation in Norway when we operated airports we are not familiar with. First two runs there were cases where I had to check the orientation of the runway and compare to the orientation of the runway, where I have to expect to see the approaching traffic because on the radar screen it was approaching from west so from the left side. The allocation and the orientation of the camera resulted that on the video it was approaching from the right side so these kind of orientation problems may occur in the familiarization phase but when you get the practise and you'll get used to the circumstances it is without problems. To alleviate the spatial disorientation just give sufficient time for the controllers to get used to the situation, that’s it. If an ATCO notices they are spatially disoriented everybody must stop and you try to rebuild the mental picture when you are okay you continue.

Gete: What can be done in the interface side to help maintain the spatial orientation?

Interviewee 1: They used the directions on the video screen, it's a ribbon at the top of the panoramic picture indicating the directions in degrees east west north.

Gete: Have you used like a compass rose somewhere on screen?

Interviewee 1: The compass Rose is for the wind rose and the compass rose indicating mitigation is useful for the PTZ cameras, it can show you the orientation of the PTZ camera when you are turning and you see something but if you have PTZ indication picture in picture so it is a picture with in the large video wall then it is useful to see which direction the camera is pointing.

Gete: What factors could distributed attention between two aerodromes bring? How can we help ATCO/AFISO in this situation?

Interviewee 1: That is what I talked about in the communication to harmonize the communicating procedures. When we are talking about the multi remote environment there can be situations where the splitting of the operation, I mean one controlling three airports or two airport, there is something happening which needs the more attention and which is more important, it increases the occupancy of the frequency to handle that event. Then the operation can be split to another controller in another working position. These kind of operations require one supervisor in the background who supervisors all the multiple operations and in case of anything happening he can be helpful for the controllers either splitting the operation and calling another controller to reuse the workload from that position or he can take over the telephone calls from that particular airport when this event happens. You can have the controller to have to focusing on the solving the situation and not only just be bugged down with the telephone calls giving information. The most valuable would be if the airports in multi remote tower environment have the same procedures. I mean procedures with the emergency situations with contingency measures if something happens then it is same procedures to be applied. It is more safe for the controller to use the same set of tools.

Gete: What might alleviate potential confusion in voice communication? (From the pilots, vehicles and other sectors)

Interviewee 1: Airport ID shall be used. Well I guess so (the other sectors should use airport ID as well) even would go if the neighbouring sector, it is different for this airport so the geographical distance is quite large so these are several hundred kilometres away it might be the case that neighbouring sector is different so there will be different telephone lines to the neighbouring sectors and of course this can indicate on which airport he is coordinating with. On the other hand if these

airports are in the close vicinity and the neighbouring sector is the same then it must be mandatory to indicate that I am coordinating traffic to this particular airport because if he will give you only the details of the traffic when he will arrive and it might be confusing.

Gete: What can cause difficulties in differentiating aerodromes regarding meteorological conditions?

Interviewee 1: The only problem I can see as I mentioned earlier these airports are not very well equipped. So perhaps for the these airports there's no ATIS available automatic terminal information system therefore the controller has updated the meteorological information if there is a change and if the changes is in the winter time or the winter operation you have the condition, the runway condition, the friction condition these like changing all the time because the winter operation you have to update the information to each departing arriving traffic it will increase the communication and that can cause difficulties and linked to the airport where there is a sun shining in the sky clear no rain or snow and the pilots are waiting because they hear information about the runway conditions on the airport B. The controller might even give out the wrong ATIS because they are used to give the information out for airport A. These are the problems has to be developed in the future as well, the technology is there technologies capable to serve the multi-mode operations, but these sort of procedures and the soft part of the operations has to be developed.

Gete: Can there be difficulties when you have one airfield near the coast and the other one in between mountains?

Interviewee 1: Yes it's definitely these are the problems you can not solve with procedures, because of the traffic circuit altitude in mountains airport perhaps there is no option for traffic circle because it's usually in a near valley, these kind of conditions can be thoroughly analysed when you pick the airports for a multi remote environment mode. I would not put these two together that you mentioned.

Gete: Would the ability to hear aerodrome local sounds help the ATCO/AFISO worker? Under what conditions would the outside sounds give any benefit to the worker?

Interviewee 1: No, in multi remote you cannot differentiate the sound which airport is which. You can have different speakers but still and you hear a big bang immediately you will not know what is happening. In a single operation it can be helpful in places like in Norway and in Germany they use the ambient sound but they are running in singel remote. We decided not to use the ambient sound because the airport area is quite large and we have multiple runways it's quite difficult to determine the source of the sound. It should not be based on the controller, if you have 12 controllers for these three airports you will have 14 different opinions but you have to decide

Lisa 4. Intervjuu 2

Interviewee 2: I'm the head of all regulatory affairs connected with remote or virtual or you name it tower operations that means the connection to a competent authority all the deals in all organisations dealing with remote operations like ICAO or EASA or something like that.

Gete:EASA has outlined 25 different human factors concerning remote tower. Please choose 3 human factors that have the biggest difference going from single remote tower to a multiple remote tower environment. If possible, please send these 3 factors to me before the interview (you don't have to include the question a-c). (The list of 25 different human factors can be found at the end of the questions.)

Interviewee 2: What we found out was that the main human factor or effectors implementing remote tower solutions where are the input devices and the screens and the working position itself because all operational procedures on the same compound with conventional that means when it comes to operational procedures to ATC procedural. He has to get used to a new working position, the controllers have to get used to use two screens instead of a window in front of the eyes and we made a lot of simulations and evaluations to find out what's the best solution was and there was normally not a problem with ATC procedures, there was not a problem with shift or rosters or something like that they stayed as it is. The main problem was to get used working in new environment and that's why I choose these factors. We experience for an example that to control a whole control zone so not only the airport it's much better to have smaller video screens closer to the controller than to have big video screen video wall about five or six or seven meters away from the controller that is not the solution we took.

Gete: What could possibly help ATCO/AFISO (regarding user interface) to keep continuous watch over two or more aerodromes at the same time? What factors might arise from keeping a continuous watch over two or more aerodromes at the same time? How can we alleviate these factors?

Interviewee 2: What I can tell you is I was project manager for our multiple remote Tower research in SESAR so I can tell you from our experiences with in the evaluations and simulations on the prototype of the multiple remote and I guess you can't keep continuous watch over 2 or more aerodromes without any technical help, that's my opinion. We created a so-called event manager it was an automatic system which recognised standard situations on each airport and gave the controller an advice if something was happened at one or more of these airports we tried, it was three airports and the experience was it is nearly impossible to keep watch over two or three airports without such a technical help. From human factors you can only have a watch on one screen if you tried this at

home to take two TV screens and try to do have continuous TV screens it is nearly impossible and it's the same when working in remote tower environment that you can only have a few direction to one screens or maybe in one-and-a-half screens in front of you but you can't have it on two screens at the same time. In our trial environment we learnt that only the technical help the automatic help can help bring the attention of the controller to a different airport then what he is working at the moment. So without this help that is nearly impossible. Of course, the human eye is unable to watch in a wider angle of about 180 maybe like that. We divided the whole ATC workload into certain situations, aircraft taxi requirements, taxiing of an aircraft, entering the control zone, leaving the control zone on all these where single situations and we observed this situations with an automatic detection and in a case we created situations and recreated so-called events which are green yellow and red events. The green events were normal events for example there is a taxi request from an aircraft if the controller does not react to this he has no harm so the aircraft is on its position and the aircraft does not move at this moment so this is a clear green event. The yellow events were events when aircraft is in an approach and the aircraft has a landing clearance but to give the controller the chance to have a bit attention to the situation so the system creates a yellow event and this event is shown on all screens it doesn't matter which airport you controller at this moment is working and the event is shown. The red events are of course events which are dangerous, landing without a landing clearance or runway incursion or something like that. So the controller can always see on its screen what happens on the other airports. It's like a lamp signal, a red, yellow or green light on each screen and then the controller can turn his attention to the certain airport on which the event happens and can see you what's going on there.

Gete: How can third parti (pilots, ground operational personnel) support ATCO/AFISO, to maintain a continuous watch over two aerodromes? What prerequisites/requirements can be expected to be in the future for different stakeholders in a multi remote tower concept?

Interviewee 2: What we experience is that the main factor is on the ground operations so you can't change pilots work at this moment and there's no need to change pilots works or to support from pilots side because the best way is that the pilot does not realise that there is remote tower in operation instead of conventional towers what you can do is to give the ground operational personnel the possibility to take part in the ATC world, for an example transponder mandatory situations that all the ground personal especially in cars has to use transponders to make it easier for the controller to see what's going on a certain airport on the ground. It will be a requirement for all the ground operational personnel when operating multi remote tower environment. We will see later on in the questions, for the pilots it should be very important to use the location indicator from the airport on which the pilot is approaching or departing, to avoid misunderstanding and travelling in

communication but this is the only requirement. It's not really a requirement to the pilots and more of a requirement for the regulatory work. I guess you can't handle that to divided into different kinds of flight situations on the airport in my opinion you have to make this a requirement for every transmission to be sure that there is no misunderstanding and no trouble because as we did it with combined radio frequency that the frequencies of all airports are combined and everyone can hear each other it doesn't matter on what airport the situation is at this moment and then you have to use the location indicator in every single transmission because in other case you will have trouble.

Gete: Which methods/resources could be used to "maintain" full situational awareness of the whole responsibility area? (In situations where the screens do not show 360 degree view)

Interviewee 2: Normally you have this 360-degree view because we have round-robin camera view on each airport so it's a bit difficult to answer if one screen or more are broken or if a camera does not work there are degrading procedures described in the working process and just degrading procedures come from step to step from normal operation and from step-to-step the capacity will be lowered it depends on your kind of the problem. Of course contingency situation when you don't have the possibility to work remotely, so in our case of we put our controllers in cars and drive down to the airport concerned and they will work at the airport after 5/6/7 hours. Of course we do have radar screens on all of our working tower spaces so we have a special situation at our tower controllers with their special licences that they are allowed to use radar screens in some cases even for separation purposes in this case for us it's a big help for the controller to have these radar screens as a part of the working environment.

Gete: How can we alleviate potential spatial disorientation happening in a two aerodromes multi remote tower? How should ATCO/AFISO act when she/he discovers they are spatially disoriented? (Example ATCO/AFISO gets confused which way is north and south in regards Interviewee 2: To be honest during all of our trials and the trials were going over a 3 years and during all of these trials we never had the experience that traffic controller had spatial disorientation between two airports. I don't know exactly because we never experienced this. We had about 30 controllers took part in this trials and no one of them had spatial disorientation at the single time. It's quite difficult to answer because we don't have this experience and normally I would say from my experience as an air traffic controller he should stop work at this moment bring it back to standard procedures. Stop the aircraft on ground and have a call for the aircraft in the air that here is a problem at the moment and they should follow the standard procedures so this is the normal way.

Gete: What can be done with user interface to help ATCO/AFISO to maintain spatial orientation?

Interviewee 2: What we experience of is a great help in spatial orientation itself is to have a ground movement radar as far as only simulations we had simulated ground movement radar for each airport without having the real system at the airports itself. The simulation you can do everything and we simulated ground movement and it was a very big help for the controller to have and to be always oriented where the aircraft is. We also had a compass rose at the panorama view so if you have a look on your panorama you have two kinds of kinds of visual presentation. The first one is the panoramic view on this panoramic view you have the compass rose you can always see when you look at the screen in which direction the screen is turning or something like that and we have a so-called PTZ centre camera which can follow the aircraft and zoom into a wider angle and on this PTZ you don't have a compass rose, because it is too near to the aircraft itself. It does not make sense to have a compass rose there. On the panoramic view they have a rough overview over the situation, you have the compass rose so you are always oriented which direction you're looking.

Gete: What factors could distributed attention between two aerodromes bring? How can we help ATCO/AFISO in this situation?

Interviewee 2: We can regulated that the traffic control and the pilots always have to use the location indicator in the communication so this is the first one and the second one is as I told is this event manager, this was a very big help for the controller to keep the attention on all the airports not only two, but we took three airports at the same time and it wasn't a problem at all to have the attention three airports with the help of event manager. You need technical help without that you can't have the attention to all airports at the same time. It's a bit difficult because we stopped the research too early for this we were mitigating the last part of the simulations whether it is better to have aerodromes with completely different layout or to have aerdromes with nearly the same layout so this is another search we should do before starting multiple remote tower solutions because we worked with three airports with nearly the same layout. This could lead in some kind of misunderstanding because it's the same layout but with different designated for runway and for the taxiways and something like that so maybe it can be an advantage for the controller to choose airports with different layouts to make it easier for him or her to give the right attention to the airport. We have nearly the same proceedures for all the airports. It doesn't matter whether you have a big or small airport, the procedures are nearly the same on every airport. So far we follow ICAO and EASA regulation and the procedures are nearly the same and this is one of the focal points while having multiple remote operations the procedures have to be the same.

Gete: What might alleviate potential confusion in voice communication? (From the pilots, vehicles and other sectors)

Interviewee 2: From my point of view you have to use location indicated indicator of the airport concerned in every single transmission so everyone in the air or on the ground are always aware which airport the situation is going on. This is much more important when you have airports with the same runway designators so we realised that the same to same runway designators and runway directions and it's really important to the location indicator in transmission to avoid misunderstandings and mistakes while having take offs and landings on different airports. I think so because if you have a ground car or something like that a technical call on the airport or something like they should use the location indicated as well because this can cause a lot of trouble when you have an approaching aircraft on the runway in airport A and a technical car in airport B want to cross the runway or something like that and in case you have a mismatch invoice communication this could lead into a go around or other things. So all the other sectors should use the indicators the same way. If you have clear call signs and this is normally the of communication and coordination between ATC sectors is based on call signs and you normally you don't have any misunderstanding on. In this case there's no need to use always the location indicator.

Gete: What can cause difficulties in differentiating aerodromes regarding meteorological conditions?

Interviewee 2: We have a clear indication on our screens what are the meteorological conditions and the air traffic controller is always aware of this. Normally there shouldn’t be a problem in this situation. To give you a few in such situations you are really as a controller really alerted and in such situations there are not so much capacity and not so much flights per time to airport A or B and you are highly alerted as a controller in foggy conditions and that's why I guess there will be no mismatch or miss understanding on the values because the controller puts their whole attention on every landing in this condition and I can't see a reason for any difficulties. This could be the case (airports in different landscaping) but we don't have experiences with that in our simulations because our airports are always on the flat lands and so we haven't experienced any difficulties. Maybe this is in Norway or Sweden where you have landing sites on the coast and other landing sites in the mountains. I can't answer really realistic to this question. But of course you have to take this into account of it being a problem.

Gete: Would the ability to hear aerodrome local sounds help the ATCO/AFISO worker? Under what conditions would the outside sounds give any benefit to the worker?

Interviewee 2: Within a single remote operations we gave the ATCO the possibility to hear the surrounding sound from the airport on which he is working but normally they don't use it. So in the conventional tower environment we put a lot of effort and we spend a lot of money to keep the noise outside of the control tower cabin with thick classes. Even in a remote our conditions controllers don’t

use the local sounds. From my point of view it's again the part of human factors assessment to realise what at the moment is working. This could be different from country to country. We gave our controllers the possibility to use it because we have a switch on the working position to switch it on. Normally it is switched off. I can only imagine that in a case where you have a lot of helicopter traffic around your field, that maybe the case in Norway with a lot of helicopter traffic, you can use the local sound to be aware whether an helicopter I approaching or not and to be aware if the engine of the helicopter is working at the moment because normally when starting a helicopter the engine starts at first and after a more-or-less long period the rotor starts to turn so maybe this could be an advantage to save time for the controller to hear the engine is right now working before you can see the rotor turning.

Lisa 5. Intervjuu 3

Interviewee 3: I am a human factors the expert. I work in remote tower project in and also I support other project. I've been studying 20-years now in experience in human-computer interaction and I started working in the aviation domain in France. I started to work in the aviation domain more than 12 years ago.

Gete: EASA has outlined 25 different human factors concerning remote tower. Please choose 3 human factors that have the biggest difference going from single remote tower to a multiple remote tower environment.

Interviewee 3: I chose situational awareness when it comes to going from single operations to multi operator of course you have more aerodromes where you have to maintain situational awareness I think that's an important factor. You have to divide your attention. Of course I chose workload also because more aerodrome means more task for the operator so it's important to ensure that the total amount of task remains manageable. It’s interesting because in the context of AFISO aerodrome that we are implementing there is also sometimes very few movements so more can mean higher motivation more interesting shifts for AFISO. Then I think screen arrangement is important also. The first one, so back to situational awareness, like I said you'll have to sort of divide your attention in order to contribute to maintain appropriate level of situational awareness. It's important, there are several aspects and everything starts with the design. The design has to enable situational awareness so therefore it's important in the design that information can be very easily accessed at the presentation of information on the 3 aerodrome and it is well integrated in the working position. To make it easy for the operator to switch between aerodrome because that's what I think is important to reach the situation awareness appropriate level, to enable operator to easily switch between aerodrome regularly. So of course this is also when we do the design it is important that after the design has been implemented it's also is important to train mentally. Working out what is the best way to scan the different aerodrome in order to sure you remain awareness when needed. There can be issues like for example focusing on one aerodrome for too long period of time because there is a certain situation that is requiring the attention of the operator and sometimes you cannot be aware that they are in this attention tunnelling, so it's important that they are trained by the appropriate working conditions and established that they have to regularly ensure that they are scanning the three aerodrome in the given time and the training is contributing to that. Of course the workload is connected because if you have too much to do it's going to be difficult to maintain good situational awareness on the aerodrome, it’s so important I think regarding situational awareness because today the operator they can use all the time available to monitor 1 aerodrome but it doesn't mean that they need all this time for that they need to continuously without any interruption monitor all the time the aerodrome. That's not the case,

they need to of course monitor some critical flight phase for example. I think it's important on the transition from one aerodrome to more that they learn what is important. They are clear what is really important to monitor. So they can easily prioritise their monitoring when they should give attention to this aerodrome and that aerodrome. Another important factor of courses is the traffic if you have parallel traffic or if you have simultaneous traffic then after sometimes you have traffic on the other and so on that's going to be less challenging. If you have simultaneous then it's more important that they feel comfortable that they have to divide their attention but they have to be the training in the procedures to make operators comfortable with the fact that ok maybe they are not monitoring everything but still they are monitoring what they should and they are still able to provide the traffic service as they should.

Gete: What could possibly help ATCO/AFISO (regarding user interface) to keep continuous watch over two or more aerodromes at the same time? What factors might arise from keeping a continuous watch over two or more aerodromes at the same time? How can we alleviate these factors?

Interviewee 3: The aerodrome are integrated in close to each other in the working position I think that can help. If they are close to each other on the human interface like for example if the flights strips are right next to each other it means that at a glance they can easily scan all the strip board for the aerodrome. If the strip boards are scattered that can make it more difficult. Same for the out of the window view of course they are close together it's going to be easier for operator to catch for an example something that's going on one or another aerodrome, even though they are not working on that aerodrome. We have done on the voice communication system so that you know who is calling by looking at the panel, so it's not very different from when someone calls you on a radar screen to identify who is calling. That's indicated in the communication system. In the validation that we had it was sufficient to have an indication on the voice communication system. There is a lot features implemented that contribute to the situational awareness, it’s about all the information that are presented for each aerodrome information. The fact that there is also information on the head set on out of the window presentation like wind information or the compass rose to see the orientation of the picture. Of course also the name of the aerodrome so it's important to avoid mixing up. So we have paid attention that the name of the aerodrome, for an example I said that they were next to each other in the human interface so it means that it was important to have the aerodrome name to really stand out there, so there is no confusion for the operator which flight strips belong to which aerodrome. The most important was really how the solution was designed and the choice to have a single aerodrome presented on single head down display. I know there was another solution where they present tools in different displays for an example the traffic situation displays are on certain screen, then the IFS is on a different screen, here we really choose to have everything on one screen

for the headstone and then of course to put everything on one screen. It minimises for the operator the time it takes to switch attention between one and the other when it comes to situational awareness. That is really important, I think situational awareness is really driven by how you can acquire information regularly and there is no such thing as a parallel activity. The human cannot really do different things parallel so you have to ensure that they can do in close sequence and I think that's how you can achieve multiple operation and still maintain situation awareness. So it's very important also that the information that are the most important are standing out. The most important information like QNH, wind and so have to stand out from the screen. Even more than if you are in a single operation because then it will facilitate the acquisition of the information by the operator.

Gete: How can third parti (pilots, ground operational personnel) support ATCO/AFISO, to maintain a continuous watch over two aerodromes? What prerequisites/requirements can be expected to be in the future for different stakeholders in a multi remote tower concept?

Interviewee 3: I don't have any particular ideas about when it comes to that, I don't see right now how this could effects going from single to multiple remote tower. If in multi for an example the workload itself can be sometimes more important than in single of course the ground personnel then would need to be associated to this change in the procedural ok at this time in at this point in time the AFISO could say I will not be available for you. I think that's the kind of things that can happen and of course everything that can make it between the operator and the AFISO and the ground operations more efficient of course contributes to the possibility to take in more aerodrome and to have a more workload. It's a bit early to say because we haven't really conducted any validation with ground personnel involved. What we did at least was to decision couple the frequencies so this is not done by all other partners in SESAR validations, the Swedish had three different radio separate radio communication to ground personnel we have decided to couple them in the and also the use of the aerodrome name systemically in the communication to ensure that since it's coupled since every airport hears the other, so that they didn't confuse or don't missunderstand or mix up a clearance that is not for them. The pilots and the ground operational personel should say in every communication the airport indicator.

Gete: Which methods/resources could be used to "maintain" full situational awareness of the whole responsibility area? (In situations where the screens do not show 360 degree view)

Interviewee 3: We have experimented with this in the SESAR. In this case where he had one stream that went black, it has to be a procedure and the procedures that we tested was to move from one remote tower to the other because it was a screen problems and that needed to be supported by the operational supervisor, the operator needs to be supported, in this case the supervisor can help prepare

the other remote tower for the operator to switch to the other remote tower. If one of the cameras goes black that's already recovered by procedure in single depending on which camera fails, then you have a given procedure. It depends on if you have immediate traffic, like just arrived traffic for landing or not depending on the situation. Then maybe you must depend on which camera went black, if it's a vital camera you have to close operations. We don't have ground radars in this time, but we do have radars for air operations and that helped a lot. So that the aerodromes that were transferred from conventional tower most of them, they were small AFISO aerodromes they didn't have radar surveillance it was a choice made in the project to provide this functionality to all the aerodrome when they were moved to a remote so that was really important contributor to enable traffic monitoring.

Gete: How can we alleviate potential spatial disorientation happening in a two aerodromes multi remote tower? How should ATCO/AFISO act when she/he discovers they are spatially disoriented? (Example ATCO/AFISO gets confused which way is north and south in regards of the aircraft)

Interviewee 3: I was quite interested in evaluating we had a particular focus on it during validations, there were some instants where it was more than one exceptions, so I was quite surprised in a positive way. How the operators were able to orient themselves especially because in the validations we had the operators that did not have experience in the aerodrome we used so they had to both learn the system rapidly and to get familiar with the basics of the aerodrome that we used in the validation. In the beginning there can be problems because they don't know well the systems so they don't know where to look on the human interface or to look all the different human interface parts to each other aerodrome so that can be a bit difficult, but after the first or second run of simulation because they had several runs it got better, slike I said it was some instances but not significant. So I think also important that operator can build confidence in real life because we talking about validation in simulation. In real life I still think that it's very important that it will be a factor of how much experience an operator has on given aerodrome before he handles two or three aerodromes, I think the more experience they will have the less problem there will be. Because they will not mix up information if they really know the environment well. If they discover that hey are spatially disoriented then it's a less of a problem, if they're not aware they make a mistake and then discovered the mistake later giving a wrong clearance, I think if they discover then it's like everything that you have to find out the cause why is that, is it because of the design, so should we improved to design. I think the process here is important, we've been through validation but when the system will begin in multiple operation it's important to have a continuous monitoring how operations are going and of course if you observe that there is a regular problem that they mix up aerodromes, runway orientation,

then you have to analyse ok why is that, do we need to do something with the design or is it sufficient by training or is it because they have too much to do.

Gete: What can be done with user interface to help ATCO/AFISO to maintain spatial orientation?

Interviewee 3: Like I said before, what we had evaluated regarding spatial orientation so there is the compass rose of course, the knowledge of the of the aerodrome is important, the more you build up knowledge on aerodrome the more you will easily switch between one and the other and then it's the arrangements so how do you arrange all the human interface elements that belongs to each aerodrome how they are, you arrange them so that there is no mixing up between aerodrome. Regarding the disorientation in my experience the operator that are selected to be AFISO or ATC they learn from this during their studies, so I think then it's not different when there is multiple aerodrome, then the only things that can affects can be an issue in multiple is that you mix up some information but again we saw in the validation that it was a special mix up, but of course you have to know what is important in design, to have clear slots for each aerodrome that it's very straight forward for the operator see ok now I am looking at airport A and now I'm looking to at airport B or C that needed to be validated because it was a very big part of the of the change and the validations they were quite under, the findings were quite positive.

Gete: What factors could distributed attention between two aerodromes bring? How can we help ATCO/AFISO in this situation?

Interviewee 3: It starts with the design, the design has to make that possible by making information from different aerodrome close with each other and then like I said it's about having the right routine for the operator when should he scan all three aerodrome when it is ok to only focus on one, I mean if there is no traffic on the other at all planned and you don't need to focus on this one you can just wait if there is a call or schedule traffic and then you have to be trained specifically for situation where you have simultaneous traffic on the different aerodrome and it has to be trained in a way that we know what's the threshold. So it's very important that there is this knowledge how much can be handle to maintain situational awareness when you're running 3 airports, it's about what I said about the SESAR that the flexible allocation you need to be able to monitor by the operator it self or so by the supervisor about the workload at one aerodrome to ensure that there is no unscheduled traffic. Maybe he has to split to give out an aerodrome to another operator as it will be too much and of course training. As I said for AFISOs that are used to very few traffic, they need to be trained for multitasking, multitasking is something an ATCO who is working a busy aerodrome or an ATCO working on a busy sector with en-routes is maybe more used to multitask and prioritise divided attention or continuously monitor despite the fact that it's going to have interruption like someone is

going to call, he has to remember to go to the task that was interrupted. So that's maybe something AFISO doing single person in low traffic, so they have to be trained and then we have to find what's the limits for the operator. Also it's very important to harmonize the procedures that's a workload thing and also to mitigate potential confusion. It's also important for single operations, because one operator can work in two different aerodromes.

Gete: What might alleviate potential confusion in voice communication? (From the pilots, vehicles and other sectors)

Interviewee 3: I think the other sectors calling to multiple remote tower is similar to when we talk about making ground personnel when making operations and coordination's with ground personnel so efficient I think the same has to be harmonized between aerodrome also. So the same has to be done with the operator and then you have such as functionalities as silent coordination that can be considered to minimise the number of phone coordination that are necessary, in our case we did it with full silent coordination with such as functionality as handover request. We don't have a full silent, the system does not fully support silent coordination so I think it's like ground surveillance in the future when it is implemented the limit will be for how many aerodrome you can handle considering the actual system performance and capabilities. In the future if we want to lower or to increasing the capacity then probably we have to look into other tool/safety nets and so on. That can help the user and silent coordination I think it's part of them but harmonization and harmonising the practices I think can take time because then you have the agreement of the other sectors how they work, so it can take a bit time to agree on new ways of working. You have to be sure of what you need or what is really important in everything, you have to go stepwise, so it's not that you're going to think about all the factors and all the mitigation and then you going to implement three aerodrome for one operator. You are going to be gradual and there's going to be for an example mitigation maybe at the begging a back up operator who is ready to help. After some experience it will not be necessary anymore but maybe you will need more evidence to help the operator manage more aerodrome that needs to be. Because for the time being what we have is the knowledge and validations, but I think it's also important to gain experience from real life operations.

Gete: What can cause difficulties in differentiating aerodromes regarding meteorological conditions?

Interviewee 3: I would more turn it the other way around, because of bad weather on an aerodrome is a big workload factor. If there is winter it can be a lot of snow and that's means a lot of snow removal activities and that's a big workload contributor for operator. So I think for an example three aerodrome with the same winter operations it will probably be too much work for them. Then when it comes to confusing if it's the question is confusing weather on different aerodrome, then I don't

think that's different from like if you would ask if there is chance to confuse a flights or confused the situation. I think that's the fact that we have the out of the window view, it gives you a reminder all the time of the weather. But in our solutions the screens are very big so they are very important part of the working position so there is a quiet an immersive effect on the operator. The weather is really present and since the out of the window view are really like stitched to each other then you will always maintain your situational awareness on what's the weather on the three aerodromes. And you have the meteorological observations that you have to do with every 2 times per hour so we have to see if in multiple operations that is still manageable for them but they have this weather station that is very important part of the AFISO tasks so I don't think that it will be an issue. I think the landscaping doesn't really matter, once you are familiar with an aerodrome, I think right away there is no need to separate them. What can be considered is what is important is if there is difficult weather then it can be wise to see ok do we want to associate aerodromes that potentially will have difficult weather at the same time because they are so close to each other, so you could say ok it is not good to have them together. It is not something that is thought now, that has not been solved, that is still a work in progress of which aerodrome to associate but like I said one could think that it's good to associate aerodromes that are close together because it means that if you have the small aerodrome it means that sometimes it's the same flight that goes from one to the other so then you can say that's going to be easier for the operator because it's the same flights is going from aerodrome A to aerodrome B, it's less workload for him. Then you can say well these airports are at the North they are very close together if there is heavy snow on one there will be heavy snow on the other maybe that's not so wise. These are the kind of consideration that has to be taken into account.

Gete: Would the ability to hear aerodrome local sounds help the ATCO/AFISO worker? Under what conditions would the outside sounds give any benefit to the worker?

Interviewee 3: I think it's mostly important I mean it's mainly interesting when you have an arrival for an example or when you have a departure. But with three aerodrome it makes it difficult to have sound on the three at the same time and it has not been identified so far as a big contributor, radars are much more important in raising awareness than the sound. Again with three aerodrome then you would have really have to have a sophisticated spatial sound like you have in movie theatres for it to contribute to your awareness. We don't have this is currently, we just have one loudspeaker. In the future it might be optional so the worker chooses whether they want the sound or not. We haven't really had the need to sort of figure it out, because we haven't started multi operation so we didn't really need to figure out what would be the best for them but they will have the possibility to switch on all three at the same time or just one. They will have easy access on the human interface and can see which aerodrome has sound active or not so it's going to be possible.

Lisa 6. Intervjuu 4

Interviewee 4: I am a safety expert. I work as a researcher in Research and Innovation department and my professional background is that I'm in electric engineer and air traffic services in the domain of traffic signs and I have a doctoral degree.

Gete: EASA has outlined 25 different human factors concerning remote tower. Please choose 3 human factors that have the biggest difference going from single remote tower to a multiple remote tower environment.

Interviewee 4: It's situation awareness, usability of input devices and potential confusion over the different views. I chose these ones because we made the trials and we made validation trials in multiple remote towers and it’s about the mental moduls the ATC is building up and he needs to distinguish these two airports in a way that mentally you can allocate information to the dedicated airport and that's the new thing about multiple remote towers that you have everything doubled you have two runways you have designator setup quite similar for taxiways A, B, C and you have parking positions that are similar that are causing confusing and that's why situational awareness, it's a very big point that you can have to train so that you can have both airports on your mind independently of each other. You share your attention according to the situation so that you have the focus of your attention that's right on the right time, that's the new challenge of that concept. I think the other point 7 and 9th are connected to this for an example some usability of input devices also connected to situation awareness I need to know where they are and number 9 is more consequence but you need to be sure where you're looking at but that’s also about situational - or actually 2, 7 and 9 are linked with each other. I think the first thing you can do to mitigate these factors is to do training on this, so that people learn to build up these mental models but that you have two airports and train them that with distinctive features, what do these airports differ so that they have kind of hanging point or reference mental marker on one where they can allocate the information to for an example they shall allocated that mentally to something that they remember is airport B. It's like a memory technique for an example people that are memory masters they allocate numbers and the letters to do something else, they do not actually remember the number itself, they remember it's a banana and a monkey, ATCO/AFISOs have to have this kind of tricks to memorise where are you with this callsign. You need something that arises emotion because our memory works with emotional allocation so you remember things good that are negative or positive there you need something that allocates the callsign or the inspection car to allocate something that is a good allocator, like a monkey. I think it's pretty much about building up these two separate worlds in the head. That's everything about because everything else your actions perception your eyes movements are related to this metamodel they result all of that. I read a study that our eyes are following a true structure of all mental model of the expect

the better the model is the better you have control over everything else. You need these tricks to memorise correctly.

Gete: What could possibly help ATCO/AFISO (regarding user interface) to keep continuous watch over two or more aerodromes at the same time? What factors might arise from keeping a continuous watch over two or more aerodromes at the same time? How can we alleviate these factors?

Interviewee 4: Here I would say they need some rules, we use colours for distinguishing two airports, so on the left side always yellow on the right side always blue and all the radar and flight strips we also use colours but to keep continues watch it means you need to share your mental attention capacity so that you satisfy the task command at the right situation. That means that you need to work in a circle, so that you do actions all around and then you come to next spot at the right time, so you do not stack at one spot and there you need some proof that you come to each the airport let say after a certain amount of time or an interval so that you know that you haven't stuck on one airport. Instead you can go and have control over two airports. It has to do with active monitoring and focus monitoring as an ATCO you get a general overview during active monitoring mode, focuse monitoring mode is when mentally you zoom in to a certain task when you want to give a clearance there's a specific aircraft and after you've given that clearance you zoom out mentally to active monitoring. I think it is pretty much that the big picture most alternate between two or even three airports not only one airport so that you give each movement dedicated part of your attention. For example radio phraseology you can also use that you name your dedicated tower callsign because often time you do it to signal tower at the beginning and often times its done but if you name it very attentionally and loudly it could also help to rise situation awareness and you can also give the inspection cars dedicated call signs that give clue about that they carry a part of the airports designator, so it's not car 123 it can be like Tartu 123.

Gete: How can third parti (pilots, ground operational personnel) support ATCO/AFISO, to maintain a continuous watch over two aerodromes? What prerequisites/requirements can be expected to be in the future for different stakeholders in a multi remote tower concept?

Interviewee 4: From the general point pilots should not know if it's a multi remote or single it shouldn't be any point for them because it may differ their expectation and their actions, because they know this is controlled in a different manner and that adds uncertainty and that's not what we want. Pilots should be more focused on their own the cockpit instruments and that they are flying, I think there's no point to add more task on them. But ground operational personnel like the car designators would be good, they can help with meteorological observations but I think that's not the point you want. The general observation can be supporting role from ground staff like runway inspection or

other inspections that might take the responsibility about the birds and other obstacles and otherwise it's really the ATCO that must be in charge. For the pilots to say airport indicator is a typical measure for creating situational awareness, you say loudly who you are and who you are talking with not only to think it to say it loud. Then you have your own words and your own ears. Concerning everybody hearing everybody it was the point of discussion over many years since 2009 where I was involved with multiple remote tower the first time, the first point is that the ATCO is occupied with managing the attention between the two or three airports now so he has a new task management job it's more challenging than just single and if now you have to chance of overlapping radio communication there is an unnecessary adds or new part coming to the game that makes the ATCO even more challenging to manage these two environments. The pilots can hear each other across the airports even if the other airport is far away in distance that might add that pilots communicate with the ATCO in a synchronized way, so the ATCO is relieved from that work but I like that point actually because they ATCO has the other things to do than to keep radio communication separated and then there was on the other hand the risk that the pilots might be confused there is radio communications from airports far distance from themselves but I think I'm from my discussion with pilots and I had also pilot training some years ago for my experience this not that dangerous. As long as you always name the designator who you are and who you are talking with and which airport you are, then there is no risk or confusion.

Gete: Which methods/resources could be used to “maintain” full situational awareness of the whole responsibility area? (In situations where the screens do not show 360 degree view)

Interviewee 4: You can split the complete tower view into three areas that the first areas of course view the runway plus approach and departure airspace this is a primary that you should always have in in case it should be possible to adjust monitors towards the approach which is more important than the departure but from the final approach fix down to the runway that's the first primary screen that you should always have a look at and then you have to second area where you have peripheral view know that the sea view that the sun in your eye but you don't know to subconsciously instead you notice movement that can be beyond the primary screen size dimensions. The eye of the human is covering more than 180 the peripheral view and that is something that you could have optional if you have spare time then you can activate that but it's optional. It means if you have unscheduled events, it might be interesting to have that. Also the back area of the tower that is on the back side, that is optional area because also in real tower you must stand up as tower controller and go to the backside or you just turn your head around. We had several situations were tower controllers heads only turned to the backside of the tower and they were standing up and going to the backside and they said that they do not have it all the time in their view. That's a similar concepts in remote controller you can

have the view with you when you wish to have but of course then you must pay attention that you also should have your primary view always at scope but it's not completely hidden of the back view. It happened that tower standing at the rear side of the tower observing some incident or not looking at what is happening on the runway, when they were missing a landing there and it's always compromise I would say. You must have some primary views always in your view but the other part can be optional. You must have access to that. The ground movement radar might help if the object are big, but for an example if the object is missing transponder like animals or birds. Radars are only limited help so the best is to have a direct view on that and look for yourself what's going on there, but the radar can help in all situations where you have transponders on the cars. They are big so that you can use primary radar.

Gete: How can we alleviate potential spatial disorientation happening in a two aerodromes multi remote tower? How should ATCO/AFISO act when she/he discovers they are spatially disoriented? (Example ATCO/AFISO gets confused which way is north and south in regards of the aircraft) What can be done with user interface to help ATCO/AFISO to maintain spatial orientation?

Interviewee 4: Potential spatial disorientation or mismatch of the mental module is a reality, that's something that happens in the head. The best thing to use is external reference points that must be part of the training to give them help by thumb rules and best practise that they check up before giving specific direction or that they must use this cardinal direction. They should use indicators where they are so the possibility to cross check that their heads are at the right track. If an ATCO discovers they are spatially disoriented that could be a sign of fatigue because this is related to your mental fitness and it could also be a sign of overwork situation. So I would say that directly avoiding spatial disorientation it's a bit difficult if someone is fatigued because I would say you need assistance because often times there is something bigger in the background. Otherwise, it's about avoiding, so that you proactively avoid spatial disorientation using reference markers in the ultimate know view like churches or like mountains. You can even add overlay elements to the visual presentation that can replace the church so like this is anything lets simply say a donut or a triangle or a hamburger which again from the first question rises emotion, it's a memory techniques so that they know oh this direction was always a hamburger, that's how humans work it's funny, but the tricks is you have to give the ATCO something that's distinguishable its unique and it's a distinctive feature that is only in the west or only in the east. We have the cardinal direction on the top as a kind of scale. We have so if you rotate around in the your remote tower there's always a scale or a layer indicating on top of the screen. So that you can directly see if you move around like rotating to the back side then you'll see also the north west and south cardinal directions following with you. The compass rose is not used directly, we use only the scale on the top and that is like a projection that is more intuitive. If you use

a rose then you need to project that into the visual presentation mentally and I would say you need to use everything that reliefs people from metalwork of connecting different information sources. It typically could work where you have to project different information sources, if you look at the radar then it is one spot and if you look out of the window it's another spot, so like projection work, mental projection. If you use the scale on the top, the idea was that you can save some time because it's more direct to pick up for the ATCO for the human.

Gete: What factors could distributed attention between two aerodromes bring? How can we help ATCO/AFISO in this situation?

Interviewee 4: When two airports are similar it is a problem because again the ATCO needs two separate mental models, the problem with similarity is that it rises risk for confusion, the other side is if you have two different airports then it adds more efforts more constraints on him to handle two airports that are completely different. If it's the same procedures then you don't have the allocator and the memory because if you have for an example of one at 6000 ft and the other one at 7000 ft or let us say transition altitude that's a bit different, it helps the ATCO to distinguish the airports. I mean we are working with distinctive features in all memory and we can share our attention better if we know the mental models are located to this information and if we switch to another airport we need to pick up the situation that is there and we have so called switching costs between when we go from A to B. That means I need to put situation A to a side and pick up situation B in my head. That's a better memory technique when we have for an example have different altitudes, it is easier to pick up and the lower switching costs are. If you have the same procedures, then you have a bigger risk that everything looks the same like a grey mess for him. But I think the general idea is that the more you give human contrast differences the better it is to memorise information, then you are lowering the switching cost. That is our experience. We had eye tracking scan pattern of the runway track that ran completely from the runway A to the runway B, so if you later ask where the obstacle was then it's very hard to discriminate if it was airport A or airport B because they treated it as one runway. That is exactly that we humans have, we can only save information if we have markers or reference points like, what was different in that situation for an example everybody knows exactly what I did when something very terrible happens like I know very well what I did when I saw the 11th of September then that's a reference marker for my memory because I know what I was exactly doing, I know what I was wearing at the time in which room I saw that all, memory works like that with emotion. The more contrast we have the more emotion arises. If we keep everything the same then it's a grey mass for us, it becomes monotony. It's a monotony background where we cannot allocate any information. I'm coming back to the same story again and again that's what's the entire games about.

Gete: What might alleviate potential confusion in voice communication? (From the pilots, vehicles and other sectors)

Interviewee 4: The vehicles and runway inspection cars are so similar so there's a high risk for confusion and with distinctive features it will work. Speaking of telephone communication, it is good if you use the airport indicator there as well, it rises communication for everyone, which airport it is and everything else that avoid confusion and even if it sounds stupid and repetitive it doesn't matter, it should not be a point. One day it will be crucial to name that name again. In multiple remote tower it is actually the challenge number one to keep it always separated. In case of radio lost, then it very important to know where it came from.

Gete: What can cause difficulties in differentiating aerodromes regarding meteorological conditions?

Interviewee 4: We checked all these variables if they might get confuse by them but all ATCOs we're pretty sure about what they were doing. I would say if there's a potential for a difficulties then it looks like the same but it's different. For an example you have fog on both airports but on one airport you have more fog and it looks the same from the cameras. The best case would be if you have sunshine weather on one airport and rain on the other. A more difficult situation is if you have light rain on one airport and heavy rain on the other. Then it could be that you allocated the wrong runway condition for the wrong airport just because you think it was easy to remember but actually you confused it. Regarding different locations for airports we are coming to the same point everything that helps distinguishing two airports good to keep them equal as actually I would say you have to keep a bit unequal but not too much but a bit. I would say that an airport near the sea and one between the mountains wouldn't challenge the ATCO too much.

Gete: Would the ability to hear aerodrome local sounds help the ATCO/AFISO worker? Under what conditions would the outside sounds give any benefit to the worker?

Interviewee 4: Absolutely, I would swear on that, it rises awareness for where your actions are happening. It is like loudly saying the airport designator, it rises situational awareness. It's like an airport with two runways you can have simultaneous starts ups, people can adapt to this. The prerequisite is that you have distinctive speaker, so you know airport A is left and airport B is right. Otherwise, it would be silly. This gives me another clue to allocate the information and where it is coming from.