

# REDUCING COSTS OF AIR TRAFFIC CONTROL

How competition and technology  
can and cannot contribute to  
reducing costs of air traffic control

ACR  
26 March 2019

# **REDUCING COSTS OF AIR TRAFFIC CONTROL**

How competition and technology can and cannot contribute to reducing costs of air traffic control

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Stockholm 26 March 2019

# Executive summary

Air traffic control is a concentrated industry with high costs. There is a strong political focus on bringing down the costs of air traffic control to preserve the competitiveness of smaller airports. In the political debate, the two most prominent tools to reduce costs are the further expansion of *competition between providers of air traffic control* and the potential future usage of advanced technologies as *remote tower concepts*. This report discusses the costs and benefits of competitive markets and remote tower technologies from the perspective of an economist.

The two most debated mechanisms to reduce the high costs of air traffic control have been the further expansion of *competition between providers of air traffic control* and the potential future usage of advanced technologies as *remote tower concepts*.

Competition between providers of air traffic control has already been implemented in several countries and has generated significant cost savings in the range of 30-50 per cent.

The remote tower technology, still in its infancy, is a new way of providing air traffic control. Instead of having air traffic controllers at each airport, they will be located in a centralised remote tower centre where they, in principle, can control many airports from a distance.

This report by Copenhagen Economics discusses the costs and benefits of the two mechanisms of more competition and more technology.

We show that the potential cost savings from more competition are larger and more certain than the potential cost savings from introducing

remote towers, particularly in the short and medium run. We also show that the best guarantee for reaping large cost savings from remote towers in the longer run is to make sure that airports can choose providers of air traffic control via remote towers through competitive tendering.

In the short term, the best guarantee for cost savings is to introduce competitive markets control. In the longer term, a competitive market is also a precondition for realization of potential cost savings in remote towers.

In sum, we have five reasons to conclude that the introduction of competition should be prioritized over or on par with the introduction of remote tower technologies.

**First**, competition is needed to guarantee that cost savings from remote towers benefit the airports and not the providers of air traffic control.

**Second**, competition can generate cost savings that remote towers cannot generate.

**Third**, remote towers are unlikely to achieve savings of the same magnitude as competition.

**Fourth**, the case for remote towers seems to be exaggerated because required investments in remote towers are underestimated while foregone investments in conventional towers are overestimated.

**Fifth**, the risk and associated costs of cyber and physical attacks on centralized remote towers seems to be underestimated.

The analysis is based on public available data.

The structure of the report is as follows. In Chapter 1, we present the full argumentation for the conclusion. In Chapter 2, we provide an introduction to conventional and remote tower concepts and competition. In Chapters 3–7, we provide deeper insight into the five reasons for why the introduction of competition should be prioritized over or on par with the introduction of remote air traffic control.

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1

COMPETITION SHOULD BE PRIORITIZED  
OVER OR ON PAR WITH REMOTE TOWER  
CONCEPTS

# Competition should be prioritized over or on par with remote tower concepts

Out of all European airports 47 per cent are lossmaking, and 75 per cent of those with fewer than 1 million passengers per year are not generating any profits.<sup>1</sup> Air traffic control constitutes 20-50 per cent of the costs of running an airport<sup>2</sup> and there has been a long lasting European and Swedish political focus on reducing costs for air traffic control. For example, the European Commission (through Single European Sky ATM Research and EUROCONTROL) has been controlling the cost developments in European air traffic control since 2009 and the main motive behind the Swedish decision to open the market of air traffic control at Swedish airports for competition in 2010 was to decrease costs.<sup>3</sup>

Air traffic control is traditionally executed by air traffic controllers located in towers at the airport they are operating. From these *conventional towers*, controllers direct aircraft to and from the airport using digital aids, radio communication, and direct visual surveillance. By exposing air traffic control operated from conventional towers to competition, costs in Sweden were reduced by 27 per cent on average.<sup>4</sup>



Another way to bring down costs in air traffic control is with *remote tower concepts*, which have attracted a lot of attention in recent years. Here air traffic control is done by air traffic controllers at locations far away from the airports they are operating. From these *remote towers centres*, they direct aircrafts to and from the airport using visual surveillance via sets of cameras mounted at the airport they are operating.\* The main advantage of remote towers is that air traffic control for several airports can be co-managed in one centralized location. In principle, this opens the opportunity for optimizing the usage of air traffic controllers and for saving costs.



Remote towers come with different operational concepts, see Chapter 2. *Single remote towers* differ from *conventional towers* only by the location of the air traffic controller. Here the potential for cost savings is limited. In *multiple remote towers* the same air traffic controller operates more than one airport. This can take place *sequentially*, such that the controller operates one airport for one hour, closes the airport, and then starts operating a second airport in the following hour. It can also take place *simultaneously*, such that the controller operates one, two or three airports with several screens at the

same time, provided he or she has spare capacity.<sup>5</sup>

Multiple remote towers can create cost savings via economies-of-scale. Clearly, the potential for cost savings is larger for multiple remote towers than for single remote towers. The regulatory framework to operate multiple towers is, as of today, not in place. Regulatory approval process will address the existing safety concerns.<sup>6</sup>

Recently, there has been a lot of interest in remote towers. A multitude of documents, articles, and reports have been published advocating the usage of remote towers, see Chapter 2. Most recently in December 2018, LFV (in Swedish: Luftfartsverket) released a report commissioned by the Swedish government describing remote towers and illustrating their benefits compared to conventional towers. Their conclusion is very favourable to remote towers and they emphasize strongly the potential for significant cost savings. LFV concludes that “*RTS enables cost-effective air traffic control through a more efficient use of personnel and infrastructure*”.<sup>7</sup>

The development and implementation of remote towers is however very costly. Providers of air navigation services, such as Avinor in Norway and LFV in Sweden, have invested heavily in the development of remote towers. Avinor plan on investing a total of 130 million EUR in the development of remote air traffic control between 2015 and 2020.<sup>8</sup> LFV and SAAB have jointly invested in the development of a remote air navigation service system as well as an operating company. LFV and SAAB have achieved full cost coverage since 2014 from the Swedish Transport Administration and

\*Remote towers are also using digital aids and radio communication as conventional towers.



# Competition should be prioritized over or on par with remote tower concepts

European Commission through the Single European Sky ATM Research project (SESAR).<sup>9</sup> We have not been able to determine the full investment value from Swedish public sources, but the ACE report from 2018 reports a total value of 36 million EUR over ten years.<sup>10</sup>

The main reason for the strong interest in remote towers is their potential for cost savings in air traffic control. LFV states that remote towers can generate cost savings up to 10 per cent per year.<sup>11</sup> However, there seems to have been a lopsided view of the likelihood of significant cost savings and a limited perception of what is needed to materialize the cost savings that can be reaped.

This report aims at comparing the cost-benefits of a competitive market and remote tower concepts and presents the findings of Copenhagen Economics, which are based on reports and other evidence that have been made available in recent years. Our main conclusions are:

Savings from remote towers are possible, but they will not materialize, and they will not be as large unless remote towers are provided on a competitive market, that is by allowing airports to choose air navigation service providers through competitive tendering processes. Particularly, in the short run, introducing competitive markets is the best guarantee for cost savings and they are also a precondition for the long run realization of the potential cost saving in remote towers.

We argue that the introduction of competition should be prioritized over or on par with the introduction of remote air traffic control for *five*

reasons.

**First, competition is needed to guarantee that potential cost savings from remote towers benefit the airports** and not the air navigation service providers. Cost savings from technological development do not necessarily benefit the airports if the new technology is controlled by monopolies. There are several examples where the introduction of competitive tendering in air traffic control has been required to release cost savings. Introducing competition at regional airports in Sweden has led to cost savings for airports in the range of 27 per cent.<sup>12</sup> Similarly, introducing competition in Norway and Spain has reduced air navigation charges at airports by 37 and 47 per cent, respectively, see Chapter 3.<sup>13</sup>

However, successful tendering of remote towers is likely to require that remote towers, similar to conventional towers today, are owned by the airport and not by air navigation service providers such that competition takes place about staffing and operating the remote towers. If air navigation service providers own necessary infrastructure, that will in fact create a new type of monopoly. The high investment costs of remote towers make it unlikely that several air navigation service providers will invest in parallel remote towers when there is a risk that their remote towers will not be used if they lose contracts.

**Second, competition can generate additional cost savings that remote towers cannot.**

Remote towers enable air navigation service providers to save costs by potentially using air traffic controllers more efficiently. However, the costs of air

traffic controllers only constitutes a limited share of the total costs of incumbent providers of air navigation services. For example, as we show in Chapter 4, the share of costs for air controllers is below 40 per cent for three Nordic incumbent air navigation service providers, Finavia, Avinor, and Naviar.<sup>14</sup> In contrast, incumbent providers of air navigation services that are exposed to competition will be forced to try to reduce all types of costs to stay competitive, not only the costs of air controllers. In Chapter 4 we can see that LFV, an incumbent provider exposed to some competition exhibit a slightly different cost structure than its fellow incumbent providers, it is however a too strong conclusion to draw that this is a consequence of a competitive landscape. However, cost savings matching those obtained through competition are very unlikely to be achieved by remote towers.

**Third, remote towers are unlikely to achieve savings of the same magnitude as competition.** Nordic providers would have to cut their air traffic controller costs significantly to match cost savings from competition; we find that difficult for the following reasons. Air traffic controllers are still not allowed to handle movements at more than one airport at a time which limits the savings potential. Costs are not significantly impacted by whether such an air traffic controller is located at a conventional or remote tower. The primary reasons are safety and human factor aspects.<sup>15</sup> Until this is resolved, remote towers will not provide any significant costs savings. In any case, costs savings from sequential multiple towers require airports with non-overlapping opening hours, with different

# Competition should be prioritized over or on par with remote tower concepts

flight patterns, or with locations in different time zones. None of these conditions are likely to be fulfilled in Sweden, see Chapter 5. Furthermore, cost savings from simultaneous multiple towers are unachievable before safety concerns are taken care of.

**Fourth, the business case for remote towers seems to be exaggerated** because the required investments to make remote towers operational are underestimated and because the comparable (counterfactual) investments in conventional towers seems to be overestimated. In both cases, they make remote towers seem more cost-efficient.

First, investment costs in remote air traffic control are still very significant. Avinor plans on investing a total of 130 million EUR in the development of remote air traffic control between 2015 and 2020 at which point they expect to control 15 airports remotely from Bodø.<sup>16</sup> Another example is the remote tower project at Northern Colorado Regional Airport, in which the Division of Aeronautics of the US Department of Transportation has invested more than 8 million USD with the expectation of full operations up and running in 2020.<sup>17</sup> Significant investment costs require significant cost savings for any business case to be valid. Introducing competition does not demand similar investments and should therefore be considered the lower hanging fruit of the two alternatives.

Furthermore, the estimated costs for maintaining and renewing conventional towers has been significantly exaggerated. For example, the LFV report states that a new conventional tower may

need investment costs in the range of 6-10 million EUR.<sup>18</sup> However, these estimates conflict with the much lower actual investment costs reported for new conventional towers, for example at Skellefteå Airport (1,5 million EUR) or Torsby Airport (0,7 million EUR), see Chapter 6.<sup>19</sup>

**Fifth, the risk and associated costs of cyber and physical attacks on centralized remote towers is underestimated.** To the best of our knowledge, most reports on remote towers seem to downplay the risk for cyber and physical attacks on a limited number of remote towers, heavily centralized both digitally and physically. The risk implies larger security costs around the remote tower locations, but also the need to cover costs for fully functioning conventional back-up systems (conventional towers) that can take over airport operation in case of a cyber or physical attack, see Chapter 7.

There are multiple examples of cyber-attacks against airports, illustrating the vulnerability of the industry. For example, in September 2018 Bristol Airport allegedly suffered an attack that led to flight information display screens being offline for two days in an attempt to contain the attack, and in June 2015 the LOT Flight Planning System at Warsaw Chopin International Airport was the target of a distributed denial-of-service (DDoS) attack leaving 1.400 passengers stranded for over five hours.<sup>20</sup>



# 2

## AN INTRODUCTION TO CONVENTIONAL AND REMOTE TOWER CONCEPTS AND COMPETITION

# An introduction to conventional and remote tower concepts and competition

## Conventional and remote tower concepts

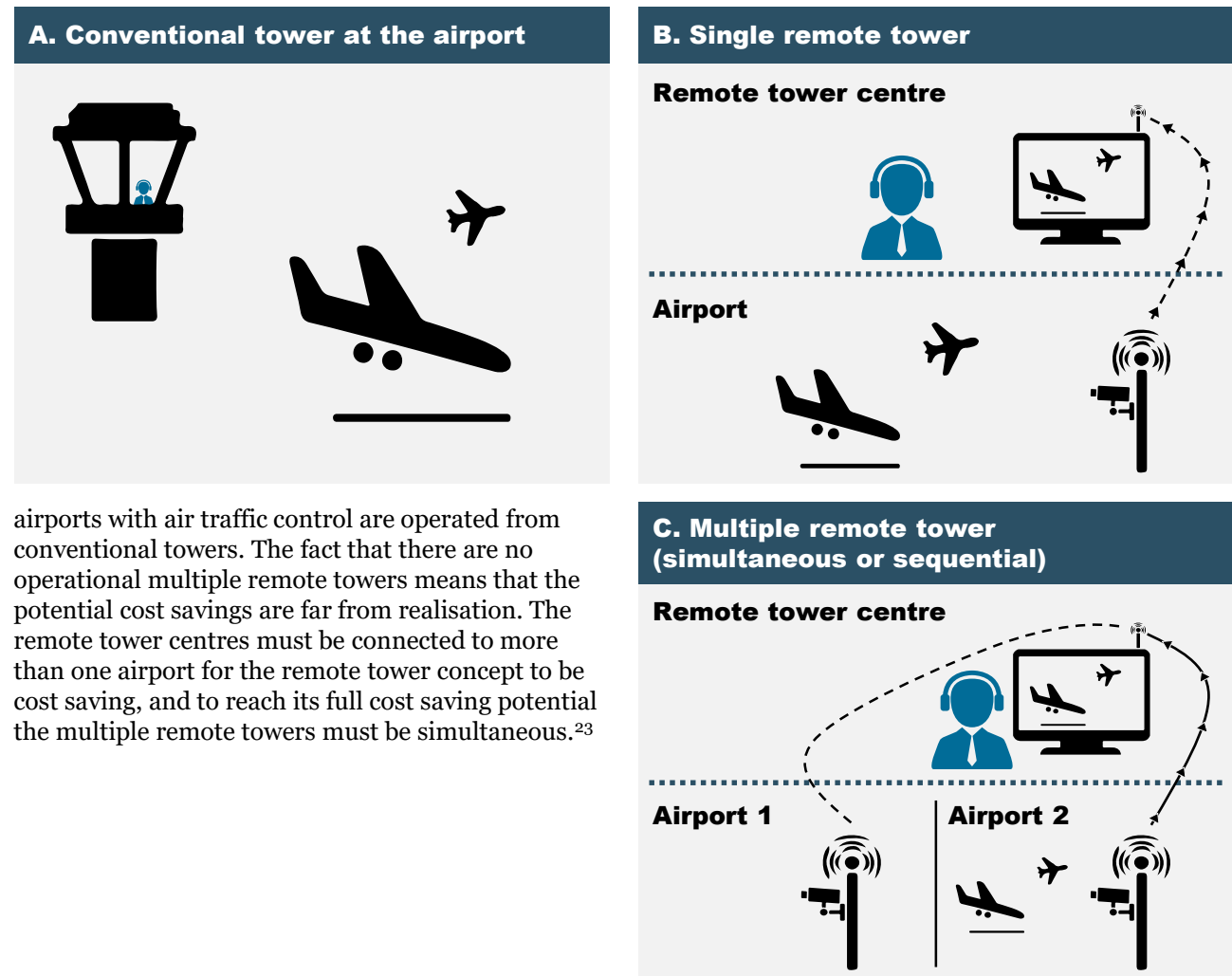
Air traffic control has traditionally taken place from a tower located at the airport, what we call a *conventional* tower. The air traffic controllers are located in the conventional tower and operate local air traffic arriving to and departing from that airport. Their position at the airport allows them to directly survey the air traffic through the windows of the tower in addition to their digital aids and radio communications.

*Remote tower concepts* is a new way of providing air traffic control. SESAR defines three types of remote tower concepts: A *single remote tower* is a tower dedicated to operate one specific airport. A *multiple/sequential remote tower* operates multiple airports but only sequentially. A *multiple/simultaneous remote tower* operates multiple airports at the same time.<sup>21</sup>

Common for all remote tower concepts is that air traffic controllers are not necessarily located at the airport or airports, instead they are located in a remote tower centre. The out-of-window-view is replaced by large screens receiving live pictures from one or multiple airports.

The most common solution at airports today is conventional towers. In fact, Örnköldsvik and Sundsvall Airports are the only airports in Sweden currently operated through single remote tower operations from the remote tower centre at Sundsvall Airport,<sup>22</sup> and Saarbrücken Airport is the only airport in Germany currently operated through single remote tower operations from a remote tower centre in Leipzig. All other Swedish and German

**Figure 1: Various tower solutions**



airports with air traffic control are operated from conventional towers. The fact that there are no operational multiple remote towers means that the potential cost savings are far from realisation. The remote tower centres must be connected to more than one airport for the remote tower concept to be cost saving, and to reach its full cost saving potential the multiple remote towers must be simultaneous.<sup>23</sup>

Source: Frequentis (2016) Whitepaper: Introduction to remote virtual tower — The remote virtual tower concept

# An introduction to conventional and remote tower concepts and competition

## There is a fascination with remote air traffic control

These remote tower concepts are currently often seen as the 'golden bullet' in the cost-conscious air traffic management industry. This has led to efforts and investments across the industry. One indication of this is the many reports being produced by various companies and organisations. For example, in 2018, LFV published a report on remote tower concepts. The report was commissioned by the Swedish Government and shows the business case of remote tower concepts in a positive light.<sup>24</sup> Other examples of published reports are *Remote Towers Demonstration Report* by the Irish Aviation Authority for the SESAR Joint Undertaking<sup>25</sup>, *Whitepaper: Introduction to remote virtual tower* by Frequentis<sup>26</sup>, and *Remote Towers: A Better Future for America's Small Airports* by Stephen D.

Van Beek and Reason Foundation.<sup>27</sup>

Several air navigation service providers are investing in remote tower projects, see Table 1. LFV is working together with SAAB to develop a remote tower system; and air traffic control at Örnköldsvik Airport is operated from Sundsvall Airport.<sup>28</sup> Although it is difficult to determine the total investment value when looking at Swedish public sources, the ACE report from 2018 estimates a total value of 36 million EUR over one decade.<sup>29</sup> Norway is a country of many distant airports and Avinor is developing a Norwegian network of remote towers; the total investment value is estimated to 130 million EUR between 2015 and 2020.<sup>30</sup>

In contrast to the optimistic outlook presented by the

supplying industry stakeholders, there is growing concern regarding the operational benefits coming from the air traffic controller and user side. For example, IFATCA, the international organization representing air traffic controller associations, is concerned with factors such as eye fatigue due to digital representation of information and bright lights instead of out-of-window-view, and limitations among air traffic operators to handle the potential situation of operating aircrafts at different airports at the same time.<sup>31</sup> In addition, the Swedish Air Line Pilots Association has expressed concerns about not being involved in the extensive project run by LFV and SAAB.<sup>32</sup>

**Table 1: Up-front investment costs for remote towers**

Provider Country	Project	Investment value in million EUR	Investment period
LFV Sweden	Remote Tower Centre (RTC)	13	2010-2018
	Expansion of Remote Tower Service	23	2017-2020
Avinor Norway	Remote Towers	130	2015-2020

Source: ACE 2016 Benchmarking Report with 2017-2021 outlook, 4.5 Cost-effectiveness performance focus at ANSP level and Transition To Remote Tower Operations And The Human Element, presentation by Jens Petter Dustad, CEO Bodø Remote Tower Centre. 2017-10-23. <https://www.sintef.no/globalassets/project/hfc/documents/7-dustad-hf-in-rtc-181017.pdf>, retrieved on

2019-03-07. Source: SESAR (2016), Reason Foundation (2017), LFV (2018)



## Competition

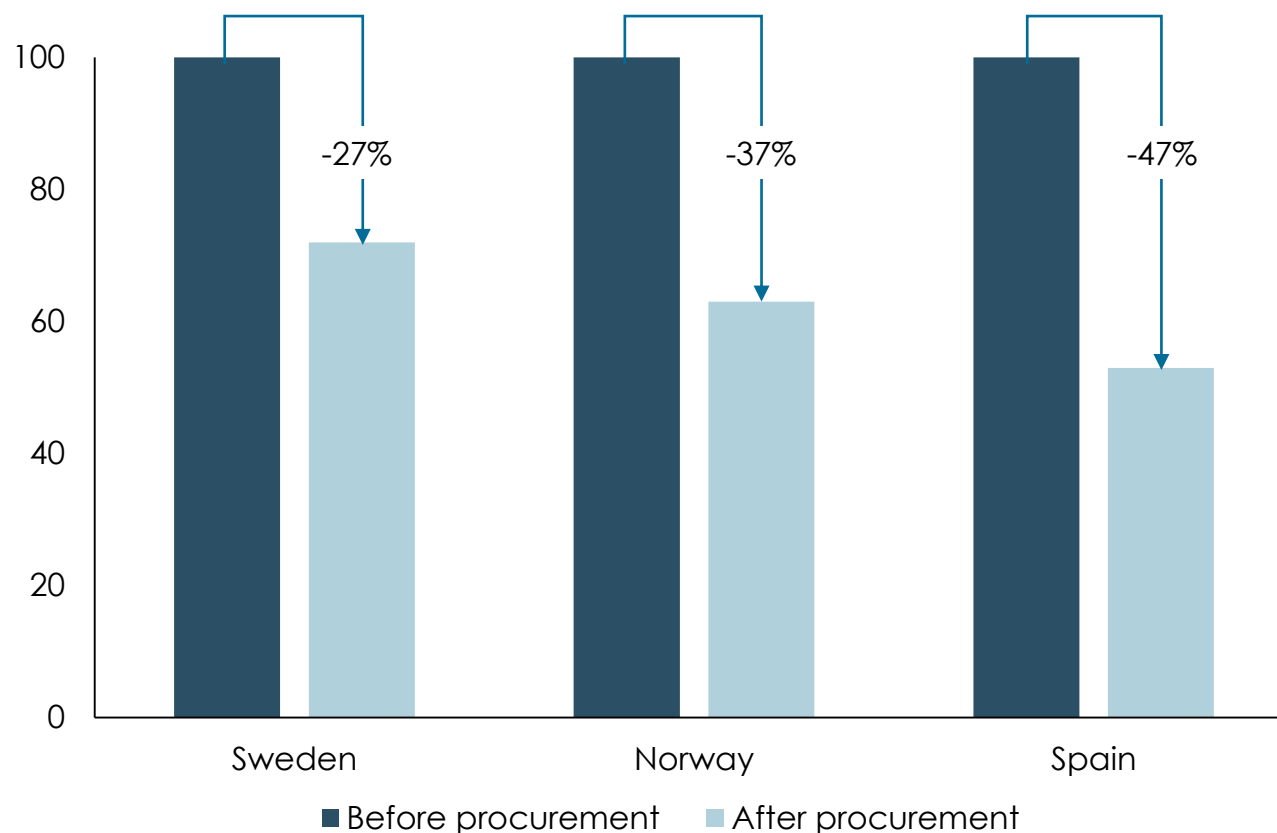
A more easily accessible way to lower costs is to introduce competition. Introducing competition does not mean that safety standards are lowered, but that regulation is lessened and private entities are allowed to participate to a greater extent compared to on a regulated market. A number of countries around the world have introduced parts of their air management industry to competition. The map on the following page provides an overview of these activities.

Competition in this industry has been that buyers of air traffic control procure the service from any certified provider through a competitive tendering process. There are several examples of how tendering has led to significant cost savings for the provision of terminal air traffic control.

The market for regional Swedish airports opened for competition in 2010, meaning that airports were allowed to procure the service from any certified provider. This led to a drop in terminal navigation charges by on average 27 per cent, see Figure 2. In Norway, three airports has been allowed to tender so far. Torp Airport tendered its contract in 2016 and reported savings of 37 per cent. In 2018 Avinor initiated a procurement process for Kristiansand and Ålesund, and in 2019 a Spanish provider won the contract at a price about 37 per cent lower than the price of the previous provider Avinor Air Navigation Services AS. In the procurement process Avinor Air Navigation Services AS themselves bid a price about 29 per cent lower than their previous price that was not set in a competitive situation.<sup>33</sup> Since 2010, Spanish airports can tender their provider and the reported savings are on average 47 per cent.

**Figure 2: Effects of introducing competition**

Reduction in terminal navigation charge (normalized to 100)

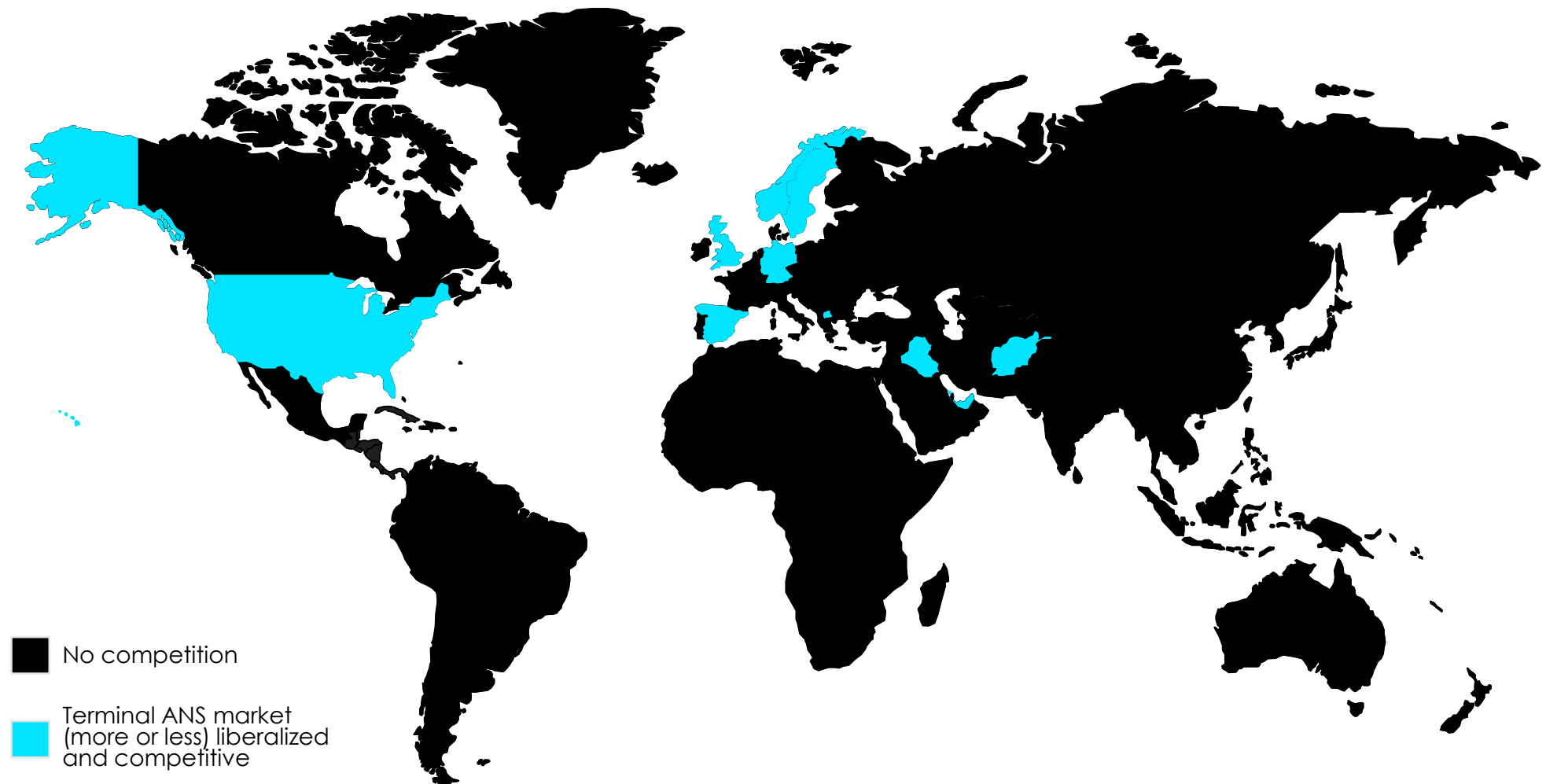


*Note: The airspace covered by TANS is somewhat different between the countries, and we should therefore be careful not to compare them one to one. However the drop in charges is still significant for all countries.*

*Source: The ATM Policy Institute, Liberalising Terminal Air Navigation Services, 2017, Stelacon on behalf of Transportstyrelsen, Översyn av systemet med prestationsplaner inom flygtrafiktjänst, 2017. Dagens Næringsliv, 2019-02-14. Avinor velger omstridt spansk selskap til å drive to tårn i Norge, <https://www.dn.no/luffart/avinor/saerco/ildefonso-de-miguel/avinor-velger-omstridt-spansk-selskap-til-a-drive-to-tarn-i-norge/2-1-543993>, retrieved on 2019-03-20.*

## An introduction to conventional and remote tower concepts and competition

# Competition



*Note: The map excludes infrastructure liberalisations.*

*Source: The ATM Policy Institute, The case for liberalising air traffic control, 2016, interview with David McMillan, The Chair of the Institute and complementary desktop research for individual countries.*

**3**

COMPETITION IS NEEDED TO GUARANTEE  
SAVINGS TO BENEFIT AIRPORTS



### 3 Competition is needed to guarantee savings to benefit airports

Cost savings from technological development in air traffic control will not necessarily fully benefit airports if the new technology is controlled by monopolies. To guarantee that potential cost savings benefit airports, a competitive market is not only efficient but also necessary.

Regulators have taken action to alter the structure of the air navigation services market from a monopolistic market to a competitive market before. The motive behind the decision in 2010 to introduce competition on the Swedish market for air navigation services was mainly to decrease cost.<sup>34</sup> The decision, that was later altered to only include regional airports, led to cost savings of 27 percent (see previous chapter).<sup>35</sup> The same reasoning support the decision by the Norwegian government to introduce competition on the Norwegian market for air navigation.<sup>36</sup> Thus far, the decision has lead to cost savings of 37 per cent.<sup>37</sup>

There is no reason to expect that regulation will be enough to control costs on a monopolistic market for remote towers when it was not enough for conventional towers.

For remote towers to generate cost savings necessary infrastructure should not be owned by air navigation service providers because this will create a new type of monopoly. Instead airports themselves should own the necessary infrastructure and procure for staffing on a competitive market.

4

COMPETITION CAN GENERATE ADDITIONAL  
SAVINGS THAT REMOTE TOWERS CANNOT

## 4 Competition can generate additional savings that remote towers cannot (I/IV)

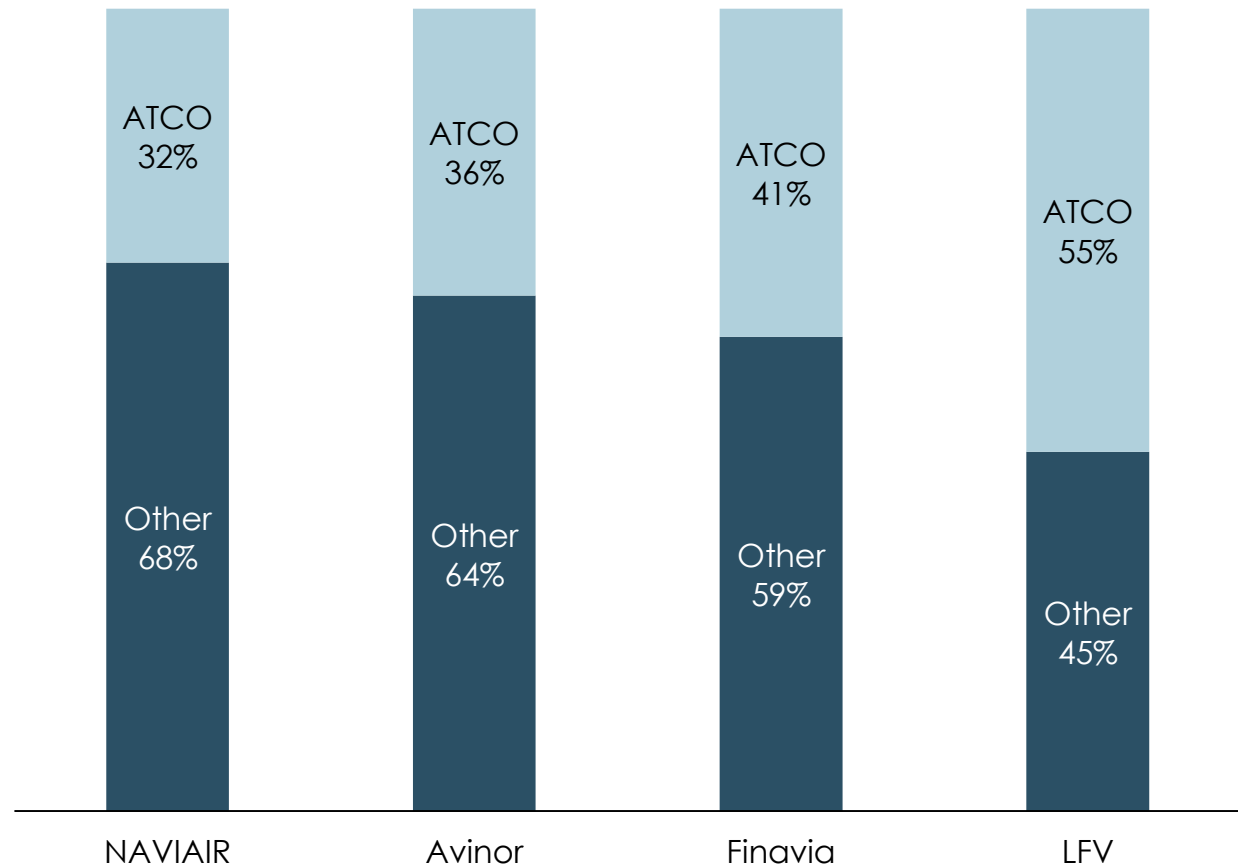
Competition by itself can generate additional cost savings because it reduces *all operational costs*, while remote air traffic control primarily reduces air traffic controller costs, corresponding to between 32 and 55 per cent of the total terminal air navigation service costs for the four providers in Figure 3 at the time for data collection. As competition puts a downward pressure on all costs, i.e. on 100 per cent of total terminal air navigation service costs, it is a more efficient way to obtain cost efficiency than introducing remote air traffic control.

Assuming the incumbent providers were to enter into a competitive environment, the expectation is that both other cost and costs for air traffic controllers would decrease.

If the incumbent providers instead were to introduce remote air traffic control before entering into competition, the expected outcomes differ across remote tower concepts: Personnel working in the conventional towers are air traffic controllers and (in some towers) air traffic controller assistants, the latter are included in *Other* in Figure 3. When introducing single remote towers, the cost for other staff will reduce as air traffic controller assistants can potentially be shared between air traffic controllers operating different airports. However, as the share of air traffic controller assistants is limited (varying from 2 per cent for Finavia up to 11 and 14 per cent for Avinor and NAVIAIR respectively, see Appendix) we expect cost savings to be limited as well.

When introducing multiple remote towers, the cost for other staff will be reduced for the same reason

**Figure 3: The operational air traffic controller costs take up between 32 and 55 per cent of the total terminal air navigation service costs**  
Per cent of total terminal air navigation service costs



Note: Calculations are outlined in the Appendix. ATCO = Air traffic controllers. Note that LFV had been active on a competitive market when these data were collected. The calculations are based on data from 2016, at that time Finavia was the relevant air navigation service provider in Finland. As of today ANS Finland is the provider.  
Source: ACE 2016 Benchmarking Report with 2017-2021 outlook, Annex 8 – Key data and ACR.

## 4 Competition can generate additional savings that remote towers cannot (II/IV)

explained above. In addition, cost for air traffic controllers will be reduced because air traffic controllers of multiple airports can be centralized in one remote tower centre operating several airports in one shift. The effect will be largest if multiple simultaneous towers are implemented but there will also be savings if multiple sequential towers are implemented because the same air traffic controller will be able to handle more movements in one shift.

The cost structure of the incumbent providers also implies that the effect of switching to remote air traffic control is greater if implemented in a competitive environment, because it would both ensure that the cost savings are converted into lower prices and also attack a larger share of the total cost for terminal air navigation.

### Air traffic controller costs must be reduced by 58-88 per cent

One way of comparing the potential of remote towers to that of competition is to evaluate the necessary effects of remote towers under the condition that remote towers are to lower costs to the same extent as competition. We use the average of reported savings obtained through competition presented in Chapter 2 on page 12. The average is 37 per cent corresponding to the savings achieved among airports in Norway, which is the latest available data on savings from introducing competition in this market.<sup>38</sup>

We look at staff costs among personnel located in towers and use LFV, Finavia, Avinor and NAVIAIR as examples and the calculations are based on the

data provided in the ACE Benchmarking Report 2016.

It is important to note that LFV, at the time for data collection, had already been active on a competitive market for quite some time. Due to this competitive pressure, the costs of LFV are likely to have become lower than the costs of its foreign counterparts. For completeness, we choose to include LFV in the analysis but we emphasize that the results for LFV should be treated with caution. The necessary savings for LFV to match cost savings from competition are lower than for the foreign providers because LFV has already made some of these savings, see Figure 5 page 20.

We start by splitting the providers' cost ( $a$  in Appendix) into two segments. The first segment is cost for personnel working in the towers, these are operational air traffic controllers and, in some towers, assistants, and the second segment is the residual of the total cost which we call *other costs*.

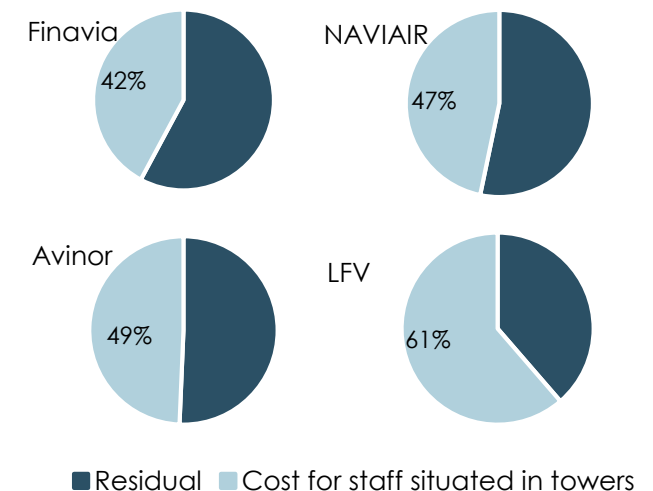
We find that 10-42 million EUR ( $v+q$  in Appendix), or 42-61 per cent of the providers' costs, are costs for staff situated in towers, see Figure 4. These can potentially be pooled more efficiently through a multiple remote tower solution. The lower this share is, the lower is the savings potential from remote towers.

Next, we assess how much total costs would have to decrease in order to achieve an overall cost saving of 37 per cent. We find that in order to achieve an overall 37 per cent cost reduction, the providers'

costs must be reduced by 9-32 million EUR ( $u$  in Appendix).

Taking a closer look at the personnel in the towers, we assume that air traffic controller assistants can be pooled across five airports. The savings obtained by pooling air traffic controller assistants are modest, which is illustrated by the striped dark blue areas in Figure 5 on page 20. Finavia, which only employs seven air traffic controller assistants, obtain negligible savings, while NAVIAIR is able to save a

**Figure 4: 42-61 per cent are costs for staff situated in towers**  
Percent of total terminal costs



Source: ACE 2016 Benchmarking Report with 2017-2021 outlook, Annex 8 – Key data and ACR.

Note: Calculations are outlined in the Appendix.

## **4 Competition can generate additional savings that remote towers cannot (III/IV)**

larger share of their total cost. However, it is clear that the bulk of the savings leading up to total savings of 37 per cent must come from air traffic controller reductions.

In fact, we find that air traffic controller costs must be reduced by 58-88 per cent for total savings to be on par with competition, see Figure 5 on the following page.

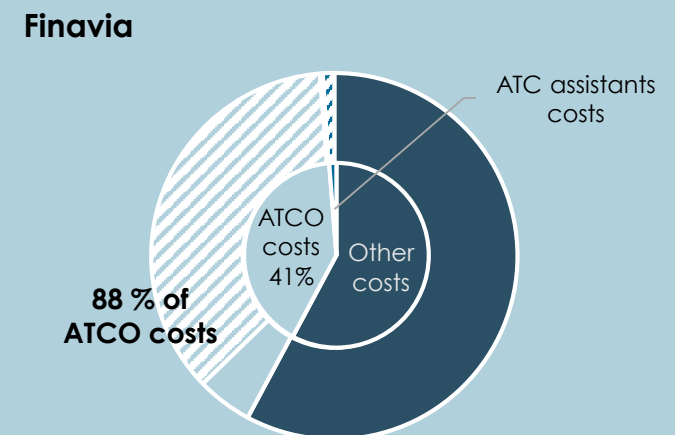
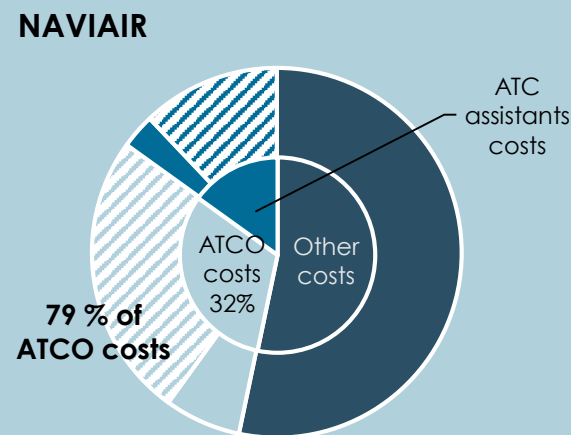
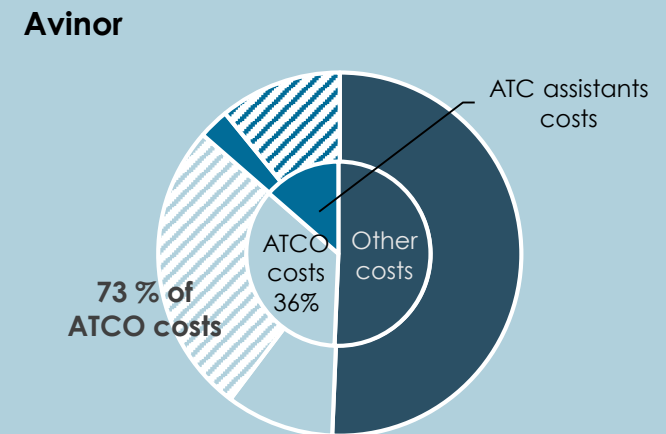
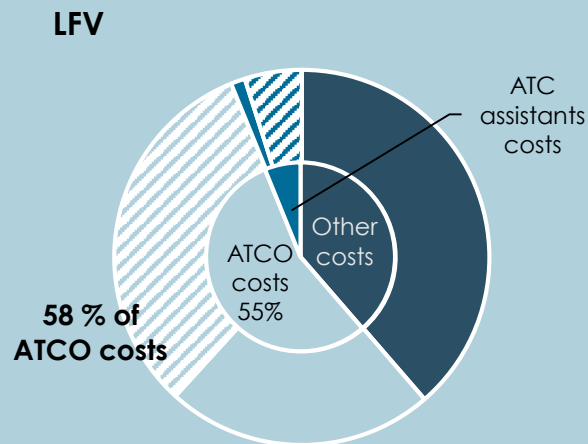
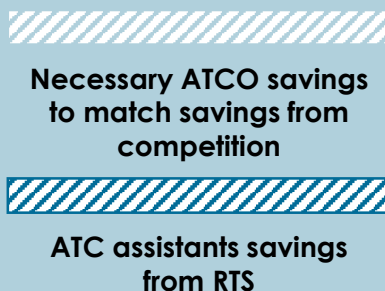
As the results are based on certain assumptions regarding staff distribution, we have compared the results with ACE's Figure 1.<sup>39</sup> The comparison shows that our results are conservative. This is further supported by the fact that our calculations assume that all other operational costs are unchanged, although these may increase as additional technical support may be required.

# 4 Competition can generate additional savings that remote towers cannot (IV/IV)

**Figure 5: Savings in air traffic controller cost to match competition**

There are two types of cost savings from implementing remote towers. There will be savings in air traffic controller (ATCO) costs, and there will be savings in air traffic controller (ATC) assistant costs. Both costs stem from pooling staff. The inner part of the figures below illustrates the original cost structure and the outer ring illustrates the savings necessary to obtain total cost savings of 37 per cent to match the savings from competition in Norway, see page 12.

We assume that the air traffic controller assistants in one conventional tower can assist five remote towers in the same remote tower centre. The implication of this is that air traffic controller costs must be reduced by 58-88 per cent to match the savings obtained by competition.



Note: Calculations are outlined in the Appendix.  
Source: ACE 2016 Benchmarking Report with 2017-2021 outlook, Annex 8 – Key data and ACR.



**5**

REMOTE TOWERS ARE UNLIKELY TO  
ACHIEVE SAVINGS OF THE SAME  
MAGNITUDE AS COMPETITION

# 5 Remote towers are unlikely to achieve savings of the same magnitude as competition (I/III)

Based on the results from the cost analysis in the previous chapter we assess the likelihood that Swedish airports could reduce their air traffic controller staff by half, reflecting the need of reducing the cost for air traffic controllers by 58-88 per cent. The analysis is based on public data at an airport level<sup>40</sup> as well as data provided by ACR on current air traffic controller counts.

We find it unlikely that the number of controllers could be reduced that much for three reasons.

**First**, in today's regulatory framework, it is possible to have two unit endorsements. However, due to recent/current requirements it is not possible for an air traffic controller to operate three or more units. Equally, operating two (or more) units simultaneously is also not foreseen in the regulatory framework. In addition, there are safety and human factor aspects challenging such a widespread reduction of staff. For example, IFATCA is concerned with factors such as eye fatigue due to digital representation of information and bright lights instead of out-of-window-view, and limitations among air traffic operators to handle the potential situation of operating airplanes at different airports at the same time.<sup>41</sup>

**Second**, the overlap in opening hours across airports reduce the possibility of sequential multiple mode. A text-book example of this is that one airport is open in the morning and another in the afternoon, allowing one air traffic controller to operate both airports during one work day.<sup>42</sup> However, the airports in Sweden have very similar opening hours,

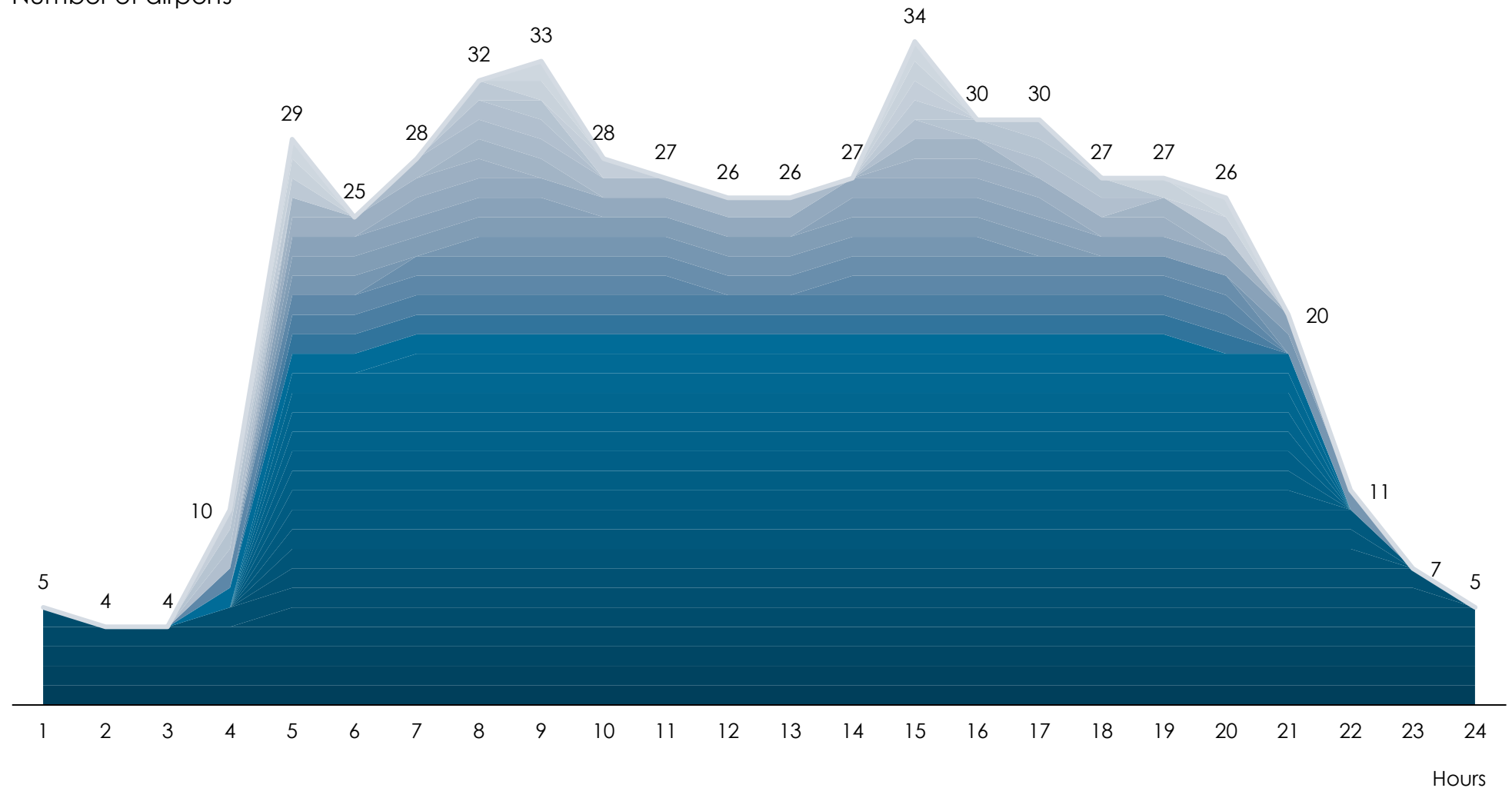
see Figure 6 on the next page. Out of these 21 airports, all but four are open from 5am to 8pm. The remaining four are closed for one to four hours between 5am and 8pm. Further, we expect similar traffic distributions between airports. Thus, a sequential mode is difficult to implement across these airports, thereby restricting the potential to reduce the number of controllers enough.

**Third**, irregular traffic further restricts the possibility of sequential multiple mode, see Figure 7 on page 23. According to the European Aviation Safety Agency (EASA), it is crucial that the traffic schedules of the airports do not overlap to minimize instances of simultaneous aircraft movements at different airports for controllers operating at a remote centre to be able handle movements at multiple airports.<sup>43</sup> Irregular air traffic does not follow a set schedule and is therefore difficult to plan in advance. It therefore increases the risk of simultaneous movements in multiple airspace and consequentially restricts the possibility to pool controller positions at multiple airports.

## 5 Remote towers are unlikely to achieve savings of the same magnitude as competition (II/III)

**Figure 6: Overlaps in opening hours reduce the possibility of sequential multiple remote towers**

Number of airports

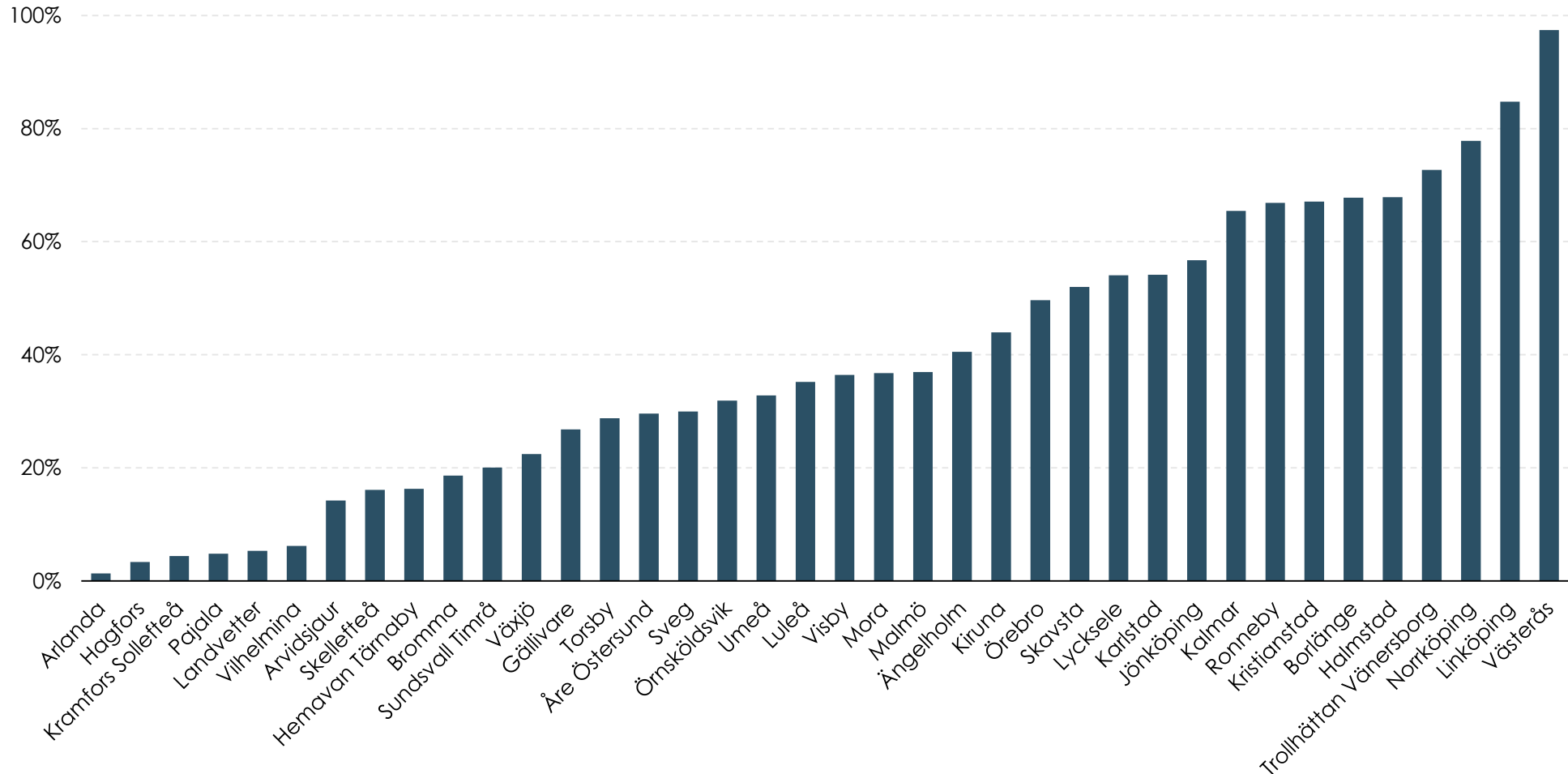


Note: Excluding Linköping and Mora.  
Source: LFV AROWeb – AIS MET och Färdplanering, Öppethållning, <https://www.aro.lfv.se/>, retrieved on 2018-11-21.

## 5 Remote towers are unlikely to achieve savings of the same magnitude as competition (II/II)

**Figure 7: Irregular traffic limits the possibilities of implementing sequential multiple remote towers**

Share of irregular traffic



Source: Transportstyrelsen (2018) Flygplatsstatistik, <https://www.transportstyrelsen.se/sv/luffart/Statistik/Flygplatsstatistik/>, retrieved on 2019-02-11.

**6**

THE BUSINESS CASE FOR REMOTE TOWERS  
SEEMS TO BE EXAGGERATED

## 6 The business case for remote towers seems to be exaggerated

Investment costs in remote air traffic control are significant and should be considered. Avinor plans on investing a total of 130 million EUR in the development of remote air traffic control between 2015 and 2020, at which point they expect to control 15 airports remotely from Bodø.<sup>44</sup> Significant investment costs require significant cost savings for any business case to be valid. Introducing competition does not demand similar investments and should therefore be considered the lower hanging fruit of the two alternatives.

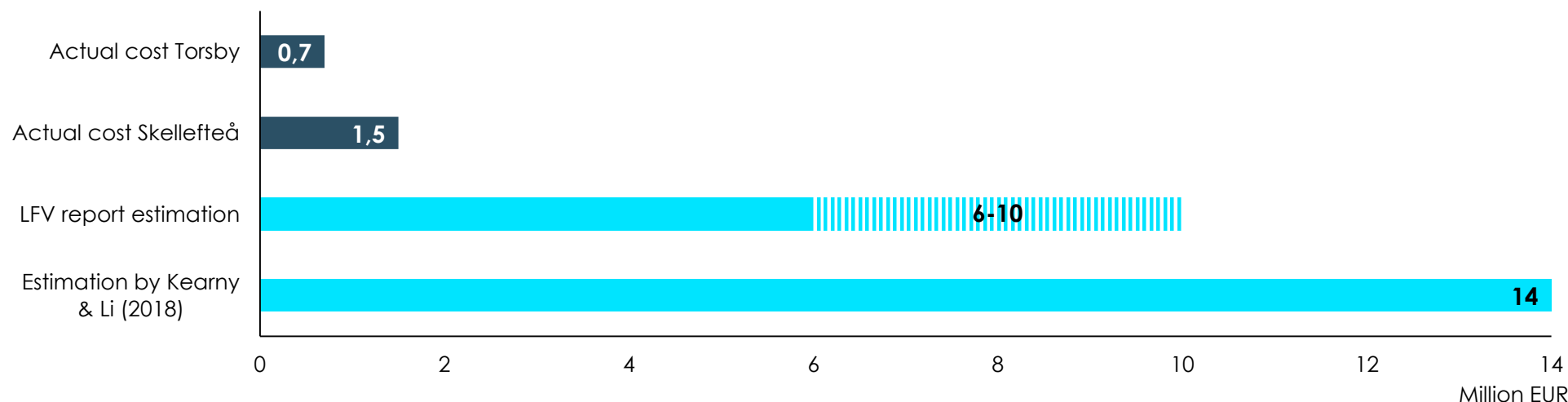
Moreover, when comparing estimated costs for

construction of conventional towers to actual costs for construction of two separate towers, the estimated cost for investing in new conventional towers seems to have been exaggerated by advocates of remote air traffic control. The LFV report suggests that the construction of a new conventional tower may result in investment costs of 6-10 million EUR.<sup>45</sup> Moreover, Kearny, from the Irish Aviation Authority, and Li suggests that the construction cost of a new conventional tower is about 14 million EUR\*.<sup>46</sup>

These estimations are far from the actual costs reported from Skellefteå Airport that build a new

tower in 2004 and Torsby Airport that build a new tower in 2005. The total investment costs of the new conventional tower at Skellefteå Airport were about 1,5 million EUR including costs for construction of tower building, furnishings and some equipment and 0,7 million EUR at Torsby Airport, see Figure 8.<sup>47</sup> Similar construction costs are reported in the US, where the construction cost of a new conventional tower is estimated to 1,5 million USD with a yearly cost of 0,5 million USD to operate.<sup>48</sup>


**Figure 8: Costs for construction of conventional towers seems to be exaggerated**



Note: Costs for construction of tower, furnishings and some equipment are included in the cost for Skellefteå. Costs are recalculated from SEK to EUR assuming that 10 SEK = 1 EUR.  
Source: ACR provided cost information on Torsby Airport, Skellefteå Airport provided cost information on Skellefteå airport, LFV (2018) Konsekvenser vid införandet av flygtrafikledning på distans vid det statliga basutbudet av flygplatser, p. 54, Kearny & Li (2018), p.17.

\* 12 million GBP.





The conventional tower at Skellefteå Airport was built in 2004 and is designed by Gisteråsstrand Arkitektur. The tower is constructed entirely of wood, reaches just over 20 meters above the ground and has 350 square meters of usable surface.

**7**

THE RISK AND ASSOCIATED COSTS OF  
ATTACKS ON CENTRALIZED REMOTE  
TOWERS IS UNDERESTIMATED

# 7 The risk and associated costs of attacks on centralized remote towers is underestimated

To the best of our knowledge the need for, and the cost associated with, traditional and operational back-up systems in reserve is underestimated. If one centralized unit is compromised in any way, several airports are at risk. This means that there is a need for back-up solutions such as redundant internet connections, back-up remote tower centres or even back-up conventional towers that can take over air traffic control if a centre were to be compromised physically or in a cyber-attack.

During the last couple of years there are several examples of cyber attacks targeting the aviation industry. For example, Bristol Airport allegedly suffered an attack in September 2018 that led to flight information display screens being offline for two days in an attempt to contain the attack, and in June 2015 the LOT Flight Planning System at Warsaw Chopin International Airport was the target of a distributed denial-of-service (DDoS) attack leaving 1.400 passengers stranded for over five hours.<sup>49</sup> The European Aviation Safety Agency estimates that about 1.000 cyber-attacks per month targeted aviation systems worldwide in 2016.<sup>50</sup>

Cyber-attacks are not the only threat that can disrupt air traffic. For example, in April 2017 the remotely controlled Örnsköldsvik Airport had to close down due to a technical error in the remote tower system.<sup>51</sup>

According to the LFV report from September 2018 the redundancy, i.e. back-up system, is mainly planned to be located at the same remote tower centre and potentially also in the same module as the original system.<sup>52</sup> This is despite the fact that both

the Swedish Armed Forces and the Swedish Civil Contingencies Agency express concerns regarding increased vulnerability regarding physical attacks and cyber-attacks, and they emphasise the need for reliable back-up systems that can ensure the provision of air navigation services regardless of the type of threat. The Swedish Civil Contingencies Agency advises LFV to ensure that the ability to change to manual (i.e. conventional) air traffic control should remain possible after the introduction of remote towers.<sup>53</sup> If this is somewhat likely to be part of future requirements for remote towers, the cost for maintaining this ability should be included in all cost assessments or scenarios of cost assessments of remote towers.

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## Örnsköldsviks flygplats stängdes

Publicerad 29 april 2017

**Tisdagen den 25 april stängdes Örnsköldsviks flygplats eftersom fjärrstyrningen via kameror från Sundsvall inte fungerade tillförlitligt.**

Tisdagen den 25 april tvingades man stänga Örnsköldsviks flygplats för att Remote Tower systemet inte fungerade tillförlitligt. Bakgrunden var att Internet-trafiken i området gick ned och eftersom säkerhetsföreskrifterna för Remote systemet kräver två nätverk och man i det läget bara hade tillgång till ett nätverk tvingades man stänga flygplatsen.

– Det är första gången det händer att vi får ett driftstopp på det här sättet. Men våra säkerhetsrutiner följdes och inget plan påverkades, säger Jenny Wester, på Luftfartsverket.

**Fjärrstyrts sedan två år**

Örnsköldsviks flygplats fjärrstyrts sedan två år tillbaka från Sundsvall med hjälp av ett avancerat kamerasystem som levererar högupplösta bilder till kontrollrummet i Sundsvall där flygledningen för Örnsköldsvik är placerad.

Det så kallade Remote Tower systemet som utvecklats i Sverige har betecknats som en inledningen på en ny era i när det gäller flygledning och har väckt stort internationellt intresse.

**Händelsen rapporteras**

Att inget plan drabbades beror på att det inte fanns några inplanerade turer till flygplatsen i Örnsköldsvik under den aktuella tidsperioden. Driftstoppet ska rapporteras till Transportstyrelsen inom 72 timmar.

Source: SVT Nyheter. Örnsköldsviks flygplats stängdes 2017-04-29.  
<https://www.svt.se/nyheter/lokalt/vasternorrland/ornskoldsviks-flygplats-stangdes>, retrieved on 2018-02-11.

# 8

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# 9

## APPENDIX



## 9 Appendix: Calculations for figures

### Input data

	Finavia	Avinor	NAVIAIR	LFV
<b>Cost data (MEUR)</b>				
a Total Terminal ATM/CNS costs	24,28	85,14	30,16	26,82
b Staff Terminal ATM/CNS costs	14,73	70,18	21,36	24,24
c Total TWR+ACC staff cost	34,49	120,65	72,73	135,37
d TWR+ACC ATCO cost	23,25	52,29	32,47	82,67
<b>Staff data</b>				
e ATCOs in OPS	182	402*	212	440
f ACC ATCO's in ops	53	129	94	200
g APPs + TWRs ATCO's in ops	129	273	118	240
h ATC assistants	7	107	88	47
i Total staff	337	943	623**	933
j Assumption: Potential #towers pooled	5	5	5	5

### Calculations and results for Figure 3

	Specification	Finavia	Avinor	NAVIAIR	LFV
k Other staff working with APPs/TWRs	$(i-e) \cdot (g/e) =$	110	367	229	269
l Cost per ATCO	$e/d =$	0,13	0,13	0,15	0,19
m Cost per Other staff	$(c-d)/(i-e) =$	0,07	0,13	0,10	0,11
n Implicit Staff Terminal ATM/CNS costs for ATCOs	$g \cdot l =$	16,48	35,51	18,07	45,09
o Implicit Staff Terminal ATM/CNS costs for Other staff	$k \cdot m =$	7,97	46,42	22,41	28,74
p Implicit Staff Terminal ATM/CNS costs Total	$n + o =$	24,45	81,93	40,48	73,84
q Estimated Staff Terminal ATM/CNS costs for ATCOs	$b/p \cdot n =$	9,93	30,42	9,54	14,81
r Estimated Staff Terminal ATM/CNS costs for Other staff	$b/p \cdot o =$	4,80	39,76	11,82	9,44
s Estimated Staff Terminal ATM/CNS costs Total	$b = q + r =$	14,73	70,18	21,36	24,24
t Non staff Terminal ATM/CNS costs	$a - b =$	9,55	14,96	8,80	2,58
<b>Results, figure</b>					
Non-staff	$t/a =$	39%	18%	29%	10%
Other staff	$r/a =$	20%	47%	39%	35%
ATCO	$q/a =$	41%	36%	32%	55%

Note:\* There is a typo in the table in the ACE 2016 Benchmarking Report (ACC ATCOs in OPS=129)+(APPs+TWRs ATCOs in OPS=273)=402, but table show ATCOs in OPS=403, we assume that the correct number of ATCOs in OPS is 402. / \*\* There is a typo in the table in the ACE 2016 Benchmarking Report, we assume that total staff = sum of all staff, which is 623, not 624 as stated in the report.

## 9 Appendix: Calculations for figure on page 10

### Calculations and results for Figure 5

		Specification	Finavia	Avinor	NAVIAIR	LFV
u	37% saving in Total ANSP cost	$a \cdot 37\% =$	8,98	31,50	11,16	9,92
v	Estimated Staff Terminal ATM/CNS costs for ATC Assistants	$h/k \cdot r =$	0,31	11,58	4,55	1,65
x	Estimated Staff Terminal ATM/CNS costs for ATC Assistants, % of total cost	$v/c =$	1%	10%	6%	1%
y	Estimated Staff Terminal ATM/CNS costs for ATC Assistants per tower	$v/j =$	0,06	2,32	0,91	0,33
z	Saving in ATC Assistants	$v - y =$	0,24	9,26	3,64	1,32
å	Saving in ATC Assistants, % of total cost	$z/c =$	1%	8%	5%	1%
ä	Necessary saving in ATCO cost	$u - z =$	8,74	22,24	7,52	8,60
ö	Necessary saving in ATCO cost, %	$\ddot{a}/q =$	88%	73%	79%	58%

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