Chapter 1

Efficiency Assurance of Human-Centered and Technology Driven Air Traffic Management

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/46485

1. Introduction

The European Air Navigation Services Providers (ANSPs) currently handle around 26,000 flights per day. This traffic should probably double by 2020. On average, traffic increased by roughly 7% per year until 2008. Following the global economic crisis, there has been a decline in traffic by 0.7% in 2009 and 0.4% in 2008 and afterwards again an increase of 8.7% in 2010 (European Commission, 2011).

However, there is also another side of the coin: the boom in air travel is exacerbating problems relating to the saturation levels reached at airports and the overloaded air traffic control (ATC) system. Airlines complain about the fragmentation of European airspace, which, they say, leads to inefficiency and major delays.

Europe enjoys a very high level of aviation safety. However, the constant increase in air traffic is putting pressure on safety, and this has consequences in terms of delays. The technical measures, taken to improve the management of airspace in recent years, have created additional capacity, but this has rapidly been outstripped by the growth of traffic. Passengers are now demanding a better quality of air transport service especially in terms of punctuality, given that it is no longer the exception that flights are over half an hour late.

The philosophy of Air Traffic Management (ATM) has not changed much since its beginning. Gradual increase in capacity of air traffic flows and airspace has only been achieved with the introduction of radar systems. On the other hand technology, methods and organization of work has still remained nearly the same. With present approach to solving the problems it is nearly impossible to achieve significant changes in quantity or quality of ATM.

Communication, navigation and surveillance domains improved and changed a lot over the last decade, thus enabling easier, faster and more precise navigation, direct routing of the aircraft and gradual transfer of separation responsibilities to the aircraft's cockpit. This will most probably lead to a leap to new technologies and organization of ATM.

New ATM strategy is now based on the "gate to gate" concept, including all phases of a flight. One major element of this strategy is that ATM system development has to be fully capacity driven in order to keep pace with the future demands of increasing air traffic. Another important item is the gradual transfer of responsibilities for separation between aircraft from ground ATC to aircraft themselves. Based on this strategy, a package of proposals has been designed by the European Commission, named Single European Sky (SES), granting political support to solving growing problems in the European sky (SESAR Joint Undertaking, 2009). Further on Single European Sky second package (SES II), made a significant step forward towards establishing targets in key areas of safety, network capacity, effectiveness and environmental impact (EUROCONTROL (EC-1), 2011).

In order to facilitate more efficient management of the European ATM, the Performance Review Commission (PRC), supported by the Performance Review Unit (PRU), has been established in 1998, under the umbrella of The European Organisation for the Safety of Air Navigation (EUROCONTROL). These entities introduced strong, transparent and independent performance review and target setting and provided a better basis for investment analyses and, with reference to existing practice, provided guidelines to States on economic regulation to assist them in carrying out their responsibilities (EUROCONTROL (EC-2), 2011).

Just recently, in December 2010, the European Commission adopted a decision which has set the EU-wide performance targets for the provision of air navigation services for the years 2012 to 2014. PRU ATM Cost-Effectiveness (ACE) benchmarking, has been recognized as one of the main inputs for determining the EU-wide cost-efficiency target and it will also have a major role in the assessment of national/FAB performance plans (EUROCONTROL, 2011).

Airspace users are putting constant pressure on the ANSPs, forcing them to improve their performance. Numerous airline associations call for urgent deliverables and a faster progress towards the Single European Sky (ATC Global INSIGHT, 2011). This all resulted in the initiative of the European Commission which is now setting the first priority on the Member States to revise their individual performance plans.

2. Background

Efficiency assurance can only be guaranteed through proper benchmarking of the current practices of Air Navigation Services provision. Commonly accepted tools for self-assessment have, among other, been the EUROCONTROL PRU ATM Cost-Effectiveness Benchmarking Report, which is, from 2002 on issued on a yearly basis, and to the smaller extend also Civil Air Navigation Services Organisation (CANSO) Global Air Navigation Services Performance Report, issued this year for the second time in the row (CANSO, 2011).

Both Reports are benchmarking similar issues, taking into account similar factors and similar variables. Major difference is though in the collection of ANSPs, where ACE Benchmarking Report focuses on all European actors and CANSO on global actors that volunteered to be benchmarked. Further on in this paper mainly ACE Benchmarking Report will be addressed.

For the purpose of this study it is assumed that Single European Sky packages I and II are defining the goals and targets and that ACE Benchmarking is broadly accepted tool for benchmarking.

The airspace covered by the SES and ACE Report is definite in size as well as traffic in the European airspace is constantly growing, but is again limited in the amount. Airspace users expect from ANSPs to have enough capacity to service their demand without any delay also in the peak periods of the day, month or year. The same expectation is shared by the general public and politicians. Delays are in general not accepted as they induce costs in excess of one billion euros per year.

For benchmarking purposes following KPIs have been set up by the PRU:

- Financial Cost-Effectiveness – The European ATM/CNS provision costs per composite flight hour with the sub-set of KPIs:
  - ATCO hour productivity – efficiency with which an ANSP utilizes the ATCO man-power;
  - ATCO employment costs per ATCO hour;
  - ATCO employment costs per Composite Flight Hour;
  - Support costs per Composite Flight Hour;
- Forward looking Cost-Effectiveness – forward looking plans and projections for the next five years;
- Economic Cost-Effectiveness, taking into account both financial cost-effectiveness and quality of service (ATFM ground delays, airborne holding, horizontal flight-efficiency and the resulting route length extension, vertical flight-efficiency and the resulting deviation from optimal vertical flight profile)

PRU recognizes both exogenous (factors outside the control of ANSP) and endogenous (factors entirely under the control of the ANSP) factors that can influence the ANSP performance.

This paper will in the remaining part focus on Financial Cost- Effectiveness, ATCO hour productivity and ATCO employment costs per ATCO hour and Composite Flight Hour

Significant volume of work has been done regarding the ATM Performance optimization. Some examples are listed under (Castelli et al., 2003; Castelli et al., 2005; Castelli et al., 2007; Christien et al., 2003; Fron, 1998; Kostiuk et al., 1997; Lenoir et al., 1997; Mihetec et al., 2011; Nero et al., 2007; Oussedik et al., 1998. Papavramides, 2009; Pomeret et al., 1997) and many more are available, however author of this paper was not able to find any paper that would challenge the benchmarking methodology.

According to the opinion of the author of this paper, different factors used in current benchmarking methodology, taking into the account also the assumptions above, can have a decisive effect on the objectivity of results of any benchmarking study and will therefore be further elaborated in the remaining part of this paper.

3. ACE benchmarking facts and figures

Overall financial cost-effectiveness (FCE) is one of the important parameters that are being benchmarked in the ATM Cost-Effectiveness (ACE) 2009 Benchmarking Report. Results are presented in Figure 1, presenting similar graph to the one in the above mentioned report.

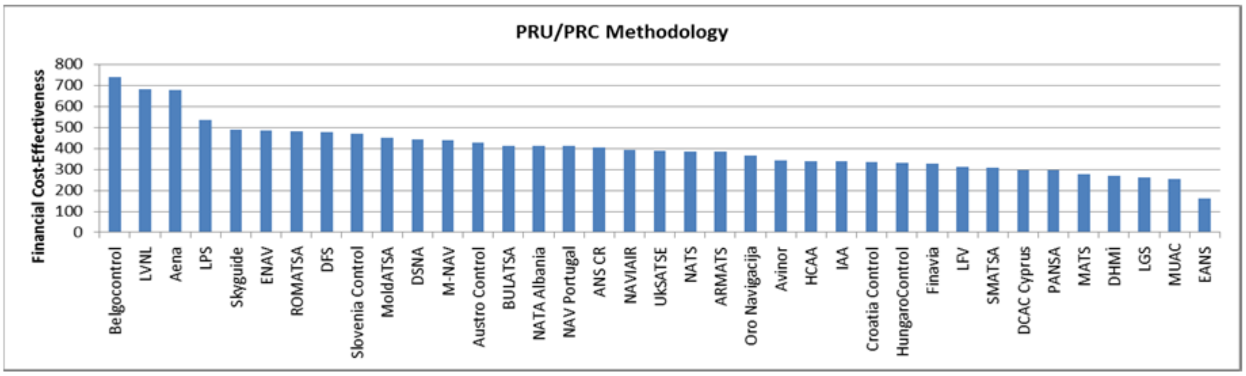

Figure 1. Overall financial cost-effectiveness 2009

Another output is graph on ATCO-hour Productivity (AHP), similar to the graph, presented in Figure 2.

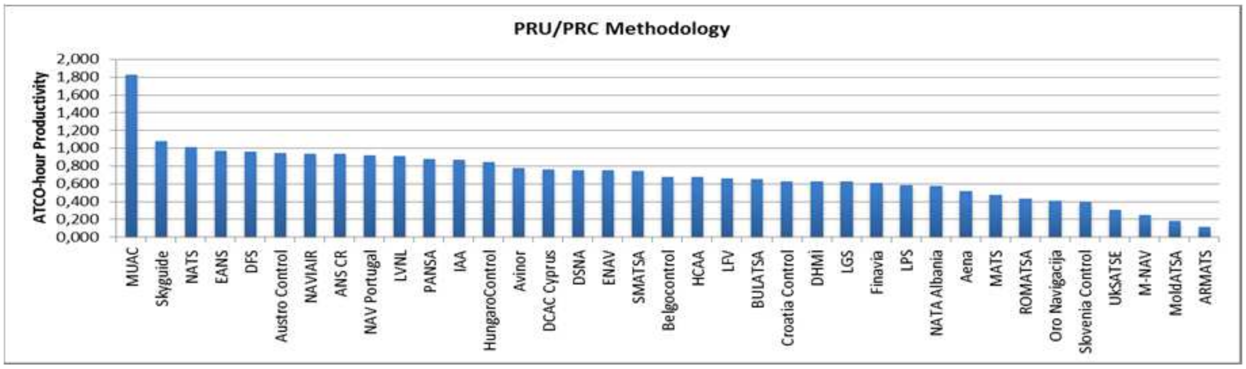

Figure 2. ATCO-Hour Productivity (gate-to-gate) 2009

Also important outputs are the ATCO employment costs per ATCO-hour (EC/AH) and ATCO employment costs per Composite Flight Hour (EC/CFH). Results are presented in Figure 3.

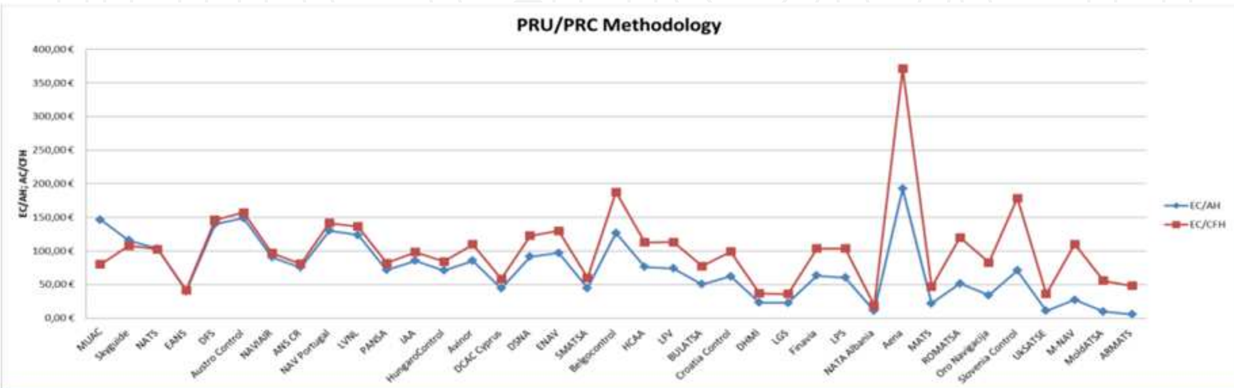

Figure 3. EC/AH and EC/CFH

If results of the calculations of the ratio of employment costs (EC) per CFH and employment costs per AH are compared across the full range of benchmarked ANSPs, trend becomes visible, showing that ANSPs with the employment costs per CHF and AH very close together are definitely much more efficient that the ones with the great difference between the two.

An ANSP to be efficient has to keep the EC per AH higher or equal to EC per CFH. EC can be eliminated from the equation, since on both sides of the formula they are the same. In order to achieve the above, CFH need to be higher or equal to the AH. This logic helps extracting the factors that are influencing the efficiency. The following formula proves that in order to enhance the efficiency an ANSP has to either increase the number of over flights or IFR airport movements or decrease the number of ATCOs or the number of their hours on duty:

$$EFH + (0.26\, IAM) \geq N_{ATCOs}\ \bar{t}_{year} \tag{1}$$

This is easy to say but hard to do. En-route flight hours heavily depend on the geographical location, average overflying time, seasonal traffic variability etc. IFR airport movements mainly depend on the size of the airport which is closely linked to the attractiveness of the location and passenger's demand. Total number of ATCOs depends on required en-route and terminal capacity. That is again related to traffic demand, seasonal traffic variability, airspace complexity etc. Average ATCO-Hours on duty per ATCO per year are mainly a factor of social dialogue and legislation and are closely linked to the safety of operations.

4. Factors affecting the objectivity of benchmarking

4.1. ANSP size

ANSPs that are covered in PRU or CANSO report significantly vary per size and business. It is therefore hard to make an objective comparison of their performances. CANSO decided to group the ANSPs per number of IFR flight hours (see Table 1), but even within one group there are ANSPs that have at least twice the traffic than the other ones. Within the group A, the United States of America ANSP (FAA ATO) has twenty times more traffic than the Mexican ANSP (SENEAM). If we are to assume that the economy of scale contributes to the overall cost-effectiveness of the ANSPs then any type of comparison by pure facts only, cannot be considered as objective.

PRU clearly admits that their benchmarking is based purely on factual analysis and that many further factors would need to be considered in a normative analysis in order to make the results more comparable.

4.2. Traffic variability

ANSPs are by default expected to have enough capacity to match the demand of the airspace users at any period of the year, month, week or day. Especially for those performing scheduled flights delays induce costs that on the overall European level account for over a billion of euros per year. ANSPs therefore need to constantly enhance their capacity through upgrade of their technical facilities, technology and methods of work and by employment of additional staff, in particular ATCOs.

Grouping	ANSP	Total IFR Flight Hours
A (More than 1 million)	FAA ATO (USA)	25,106,283
	NAV CANADA	3,230,049
	AAI (India)	2,163,958
	NATS (UK)	1,731,274
	DFS (Germany)	1,366,637
	AENA (Spain)	1,358,390
	SENEAM (Mexico)	1,241,091
B (250,000 - 1 million)	NAV Portugal	468,728
	LFV (Sweden)	410,242
	Airways New Zealand	351,680
	AEROTHAI (Thailand)	320,360
	ROMATSA (Romania)	286,944
	ATNS (South Africa)	281,255
	IAA (Ireland)	256,550
C (100,000 - 250,000)	GCAA (UAE)	246,041
	ANS Czech Republic	231,079
	SMATSA (Serbia & Montenegro)	217,675
	NAVIAIR (Denmark)	209,917
	HungaroControl (Hungary)	197,909
	LVNL (The Netherlands)	151,592
	DCAC (Cyprus)	130,669
	Finavia (Finland)	114,645
D (0 - 100,000)	LPS (Slovak Republic)	82,382
	LGS (Latvia)	63,951
	NAATC (Netherlands Antilles)	55,623
	EANS (Estonia)	54,417
	Sloveniacontrol (Slovenia)	44,064
	Sakaeronavigatsia Ltd (Georgia)	42,590

Table 1. CANSO grouping of ANSPs per number of IFR Flight hours (CANSO. 2011)

This all adds "fixed" costs on a yearly basis, regardless of the actual demand in a particular period of the year, month, week or day. Due to the nature of business and required competency of the ANSPs staff, the personnel needed to cope with peak demand, usually in summer period, cannot be fired in October and re-employed in May next year. ANSPs rather need to keep them on their pay-roles throughout the whole year. The greater the variability of traffic the more the resources are underutilized and therefore contribute to cost ineffectiveness of a particular ANSP. So called "wasted resources" are presented in Figure 4 as a blue area.

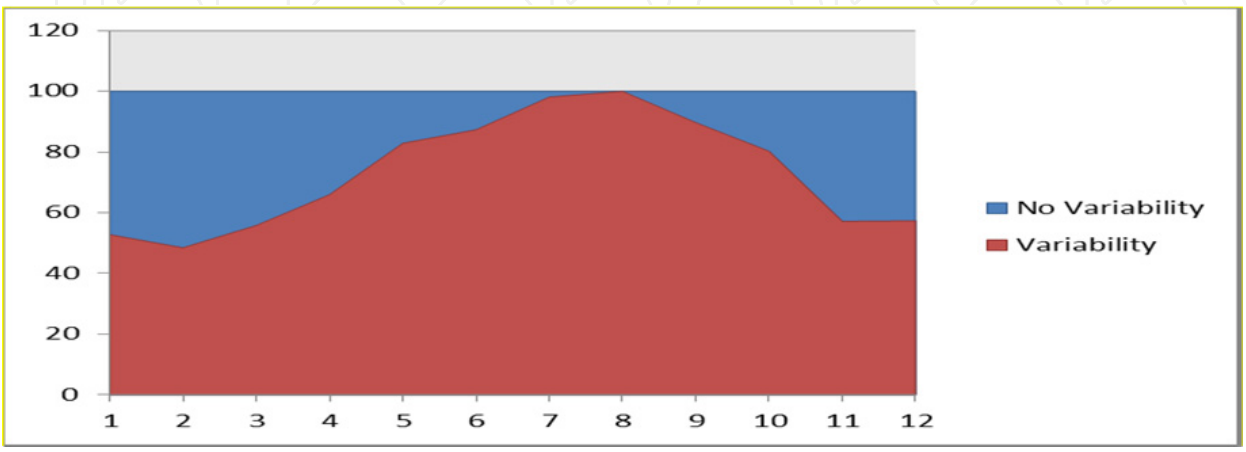

Figure 4. Traffic variability on a yearly basis

Airspace and traffic volumes are definite in size. It is simply not possible to optimize the business by purely attracting more traffic in the quiet periods of the year as firstly there is obviously no additional demand from the airspace users at those times and secondly, traffic flow can only be re-shifted at the expense of another ANSP. Traffic variability thus needs to be considered as a contributing factor that cannot be avoided.

PRU introduced seasonal traffic variability (TV) in their ATM Cost-Effectiveness (ACE) 2009 Benchmarking Report. It is calculated as ratio of traffic in the peak week (T_w) to the average weekly traffic ($\overline{T}$):

$$TV = \frac{T_w}{\overline{T}} \qquad (2)$$

Calculated seasonal traffic variability factors for each ANSP are reported in the ATM Cost-Effectiveness (ACE) 2009 Benchmarking Report but are, to the knowledge of the author of this paper, only used to display the level of seasonal traffic variability at each particular ANSP and not directly used as corrective factors in the calculations.

The overall financial cost-effectiveness is calculated by a ratio of Air Traffic Management/Communication Navigation Surveillance (ATM/CNS) provision costs (ACPC) to the Composite flight hours:

$$FCE = \frac{ACPC}{CFH} \qquad (3)$$

The ATM/CNS provision costs represent all costs of the ANSP for provision of the ATM/CNS service. Composite flight hours in (3) on the other hand are the summation of the En-route flight hours (EFH) and IFR airport movements (IAM) weighted by a factor that reflected the relative (monetary) importance of terminal and en-route costs in the cost base (EUROCONTOROL, 2011):

$$CFH = EFH + (0.26\, IAM) \qquad (4)$$

The ATCO-hour Productivity is calculated by dividing Composite flight hours by Total ATCO-hours on duty:

$$AHP = \frac{CFH}{AH} \qquad (5)$$

Where Total ATCO-hours on duty in (5) are the multiplication of Total number of ATCOs (N_{ATCOs}) and Average ATCO-Hours on duty per ATCO per year ($\bar{t}_{year}$):

$$AH = N_{ATCOs}\ \bar{t}_{year} \qquad (6)$$

By using calculated seasonal traffic variability factors to equalize the composite flight hours using the formula below, the order of classification of the financial cost-effectiveness of the benchmarked ANSPs in Figure 1 changes. The ones with lower traffic variability move to the left towards less cost-effective ANSPs and the ones with higher traffic variability to the right, towards more cost-effective ANSPs.

$$Adjusted\ CFH = CFH \cdot TV \qquad (7)$$

The same is valid also for the ATCO-Hour productivity presented in Figure 2.

4.3. Calculation of composite flight hours

CFH used for benchmarking by PRU/PRC are according to formula (4) composed of EFH and IAM weighted by a certain factor.

EFH are obtained from the EUROCONTROL statistical data and represent the amount of actual hours that flights, overflying particular area of responsibility of a particular ANSP, have spent in that particular portion of the airspace. The same figures can be obtained by multiplication of the number of flights (N_{of}) with the average overflying time of the relevant airspace ($\bar{t}_{of}$), using the formula below:

$$EFH = N_{of}\bar{t}_{of} \tag{8}$$

Average overflying time of European ANSPs ranges from roughly 10 minutes for the smallest ANSP to roughly 34 minutes for the ANSP which is lucky enough to have majority of the traffic along the longest routes in the route network. Looking at this time from another point of view means that if EFH is calculated in the PRU/PRC way, one single over flight attributes to 0,166 EFH for the smallest ANSP and on the other hand to 0,566 EFH for the ANSP with majority of the traffic along the longest routes. The difference is 3,4 times and means that the first ANSP would need to have at least 340% increase in traffic in order to match the productivity of the second ANSP, this all under the condition that the number of AH remains the same. There is no need to further elaborate that this is by no means possible.

On the other hand weight factor attributed to IAM translates to 0,26 CFH per single IFR airport movement, regardless whether the airport is a large national hub or a small regional airport.

Since terminal part of the CFH is calculated with the help of an artificial figure, equal for all ANSPs, regardless the size of the airport, it might be potentially wise to use the same logic also for the en-route part of the CFH, by simply attributing the weighted factor also to the EFH. This weighted factor could easily be the average calculated overflying time for all selected ANSPs.

5. Conclusion

ATM business does not always behave in line with the logic of the standard economy. It has its own set of legal rules, standards and recommended practices. On one hand everybody expects from it to be absolutely safe and efficient, but on the other hand airspace users constantly push for more financial efficiency expecting the business to be as cheap as possible. This could easily lead to contradiction.

By no doubt an ANSP has the power to influence certain factors that potentially influence the business, but there are other factors that have to be taken on board as a fact. This means that even if, by PRU standards more efficient ANSP takes over the so called less efficient ANSP, it would still have to overcome the same constraints or obstacles which are potentially effecting the business. This could also imply that if more efficient ANSP takes over the less efficient one, it does not immediately mean that now both ANSPs will become more efficient but would rather mean that the more efficient one would now become a bit less efficient.

Geographical position of an ANSP can be an advantage or an obstacle for the efficient performance. Seasonal traffic variability can attribute significantly to inefficiency of operations as airspace users pay for the full service 365 days in the year, but the ANSPs resources are only fully utilized in the peak period of the year. The calculated on average 25% of “wasted resources” per year, can potentially open a window of opportunity for optimization. Of course whole 25% could only be achieved in ideal conditions in a fictitious world, but on the other hand the European Commission asked the Member States to submit their Performance plans in such a manner that they will deliver incremental savings of only 3.5% per year for the SES II Performance Scheme reference period 2012 – 2014. Providing that only a portion of those 3.5% of savings is achieved through optimization of operations taking into account the seasonal traffic variability, it is already a step forward into the right direction.

The same goes for the calculation of the CFH. The proper solution to the problem could be in a design of a business model that would objectively support the managerial decision making processes. Until recently the business of the ANSPs has been regulated and full cost recovery regime allowed majority of the ANSP managers to only passively influence the business. On the other hand the new European Commission regulation introduces the requirements that would force everyone to optimize. Objective support in proper decision-making will therefore become essential.

When talking about ANSP performance it is mostly concluded that small ANSPs will most probably cease to exist and that the larger ones will take over their business. Looking at the graphs in Figures 2 and 3 this does not necessarily hold true as the Estonian ANSP even with the PRC/PRU methodology, easily compares with the German or U.K. ANSP. Obviously the parameters of the PRC/PRU benchmarking methodology somehow suit them. If proper corrections or adjustments are inserted in the benchmarking methodology more chance is given also to smaller or less trafficked ANSPs.

By using seasonal variability or different approach in calculations of the CFH the calculations addressing the performance of the ANSPs become a bit more objective. An ANSP that is situated in the geographical area with high seasonal traffic variability, could probably try to optimize as much as possible, but would hardly become more efficient than an ANSP with little seasonal traffic variability. On the other hand the CFH, the way they are calculated now definitely influence the results in some way. The methodology of calculations used by PRU/PRC favours, larger ones with a lot of terminal traffic.

This paper gives only one example on how methodology of calculations could potentially be improved. Proper benchmarking should foster proper decision-making. By improvements proposed the managerial decision-making process could be more adequately supported.

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