African Institute for Science Policy and Innovation
International Biennial Conference

Conference Proceedings

VOLUME 1

1st AISPI International Conferenceon Science, Technology and Innovation for Sustainable Development, 2019

Impact of Information and Communications Technology on the Operations of the Nigerian Airspace Management in Southwestern Nigeria

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ABSTRACT

As against the mission and vision of the Nigerian Airspace Management Agency (NAMA), the airspace is unsafe for users despite the technologies on ground. Therefore, this study seeks to assess the impact of Information and Communications Technology (ICT) on the operations of the Nigerian Airspace Management, especially as touching the safety of all airspace users, the staff and the passengers alike. The study was conducted in Southwest geopolitical region of Nigeria and focused on all the NAMA stations located in all the airports in the region. However, for the selection of respondents, random sampling was used to select the participants for this research based on their availability. Primary data were collected through structured questionnaire. In the questionnaire administered, the impact of ICT was broadly classified into Safety and Communication impact; and economic impact. These were administered among 200 members of staff from four different departments in NAMA that handle major operations in the management of airspace, namely ICT department; Aeronautical Information Services (AIS) department; Air Traffic and Safety Electronics Services (ATSES) department; and Air Traffic Control (ATC) department. Fifty (50) members of staff were randomly selected from each of these departments in all the three airports under study, making two hundred (200) participants for the study. The results showed that more efficient use of the airspace; better resource utilization; reduction in the workload of the air traffic controller; increased productivity; efficient air-ground linkage; and safe and secure data werethe highest ranked impact of ICT on the operations of the Nigerian airspace management. Reduction in fraud cases, reduction in flight delay and reduction in dependence on outsourcing were the lowest ranked economic impact of ICT on the operations in the Nigerian airspace management.

Keywords: ICT, Airspace Management, Technology Impact

INTRODUCTION

The vital role of aviation in facilitating the national economic growth and offering social benefits cannot be over emphasized. This is evident in its providing the only rapid global transportation network, thus enhancing worldwide business and tourism. Therefore, it gives developing countries like Nigeria the opportunity for global trade, thus enhancing global supply chain (Adeniran and Gbadamosi, 2017). However, the air transportation industry is identified as a sector that needs to be protected and guided well due to the consequences and fatality of its incidents and accidents. Likewise, the increasing growth in demand for air transportation calls for the need to provide a more effective, efficient and safe services, as evident in the visions and missions of the agencies guiding aviation in Nigeria such as Nigerian Airspace Management Agency (NAMA). Unfortunately, absolute Nigerian aviation safety for people and properties is still unacceptable, as obvious in several recorded cases of aviation accidents and incidents in Nigeria. For example, fifty nine (59) runway accidents were experienced in Nigerian aviation between 2000 and 2011, in which the available infrastructure and facilities were some of the causative factors of the hazards (Oriola & Adekunle, 2015). Thus, Oriola and Adekunle (2015) explained further that unless appropriate technology is in place, Nigerian aviation safety will continue to be a challenge for both aviation professionals, and all that are directly or indirectly affected by air transportation.

However, Pacheco *et al*. (2014) stated the importance of Information and Communications Technology (ICT) in aviation safety management, which is mainly for sustainability of air transportation services, in terms of enhancing safety. Thus, Wong (2006) stated that owing to the issue of safety and insecurity globally, the aviation industry in recent years has seen the need to improve her performance and safety through the incorporation of needed facilities and infrastructure. Therefore, ICT has a specially-significant role to play because it is with the strategic, widespread, intensive and innovative use of ICT that this aim can be achieved. It is therefore imperative that these technologies be put in place to guarantee the safety of staff and passengers alike (Hassan, 2015). Hurter *et al.* (2016) also noted that there are many ways that ICT could enhance the safety of airspace users, for example to extract knowledge and data from recorded or real-time significant traffic sequences in the air traffic analysis so as to understand better the traffic structure and evolution. Therefore generally, Zhang and Chen (2018) stated that ICT could enhance airspace performances in a way that as the airspace capacity rises, there will be more flight safety and lesser flight separation, thus balancing efficiency, safety and equity in the aviation sector (Kopardekar *et al*., 2016).

Furthermore in 2015, as against the mission and vision of the Nigerian Airspace Management Agency, Aviation Nigeria reported that a reasonable amount of air safety reports made in Nigerian airspace in the past two years were communication failure, 19 of which were received between January and November, 2014 with each of these having the potential of resulting in mid-air collisions. Thus, the Nigerian airspace has gradually become a nightmare for pilots flying to and from the country, despite all the information and communication technologies put in place in Nigerian airports (Ovuworie, 2018). This study, which focuses on airspace management (which according to several researchers, such as Hurter *et al*. (2016), entails the satisfaction and safety of the users of the airspace in terms of traffic optimization, reduction of flight delay in Nigerian aviation among others) thus seeks to assess the impact of Information and Communications Technology (ICT) on the operations of the Nigerian Airspace Management, as touching the safety of all airspace users, the staff and the passengers alike.

RESEARCH METHODOLOGY

Study Area
The study was conducted in Nigeria, which consists of twenty (20) functional local and eight (8) major international airports. However, this study was conducted in Southwest geopolitical region of Nigeria, and focused on all the Nigerian Airspace Management Agency stations located in all the airports within the region. The airports were Murtala Mohammed Airport, Ikeja, Lagos State (functioning as both local and international airports); Ibadan Airport, Ibadan, Oyo State; and Akure Airport, Akure, Ondo State. Southwestern Nigeria is one of the regions in Nigeria that enjoys more transportation activities and thus

growing economy, with Murtala Mohammed Airport being the busiest, accounting for more than eighty percent (80%) of the whole Nigerian international airport operations while also housing the headquarters of the Nigerian Airspace Management Agency (Adeniran & Gbadamosi, 2017).

All the Nigerian Airspace Management Agency stations located in all the airports in the Southwest region were included in this study. However, for selection of respondents, random sampling was used to select the participants of this research, based on availability of the respondents. Primary data were collected through structured questionnaire issued to staff of the Nigerian Airspace Management Agency (NAMA) under all the airports in the study area. The questionnaires elicited information on the impact of ICT on the operations of NAMA, with the impacts being broadly classified into Safety and Communications impact; and economic impact. The questionnaires were administered among 200 members of staff from four different departments that handle the major management operations of the airspace namely ICT department; Aeronautical Information Services (AIS) department; Air Traffic and Safety Electronics Services (ATSES) department; and Air Traffic Control (ATC) department. Fifty (50) members of staff were randomly selected from each of these departments from all the three airports under study, making two hundred (200) participants for the study.

To address the objective of the research, which is to assessthe impact of Information and Communications Technologies on the operations ofNAMA, the impacts were categorized into Economic; and Safety and Communication impacts as shown in Table 1.0. The Economic impact explains the resultant effect that the use of ICT has on the daily operations of the agency's organizational capital while the safety and communication impact talks about the effect that the use of ICT has on the safety of the airspace, and communication across the airports, especially between the engineers, air traffic controllers and the pilots (Van Reenen *et al*., 2010; Sampigethaya *et al*; 2011). The study variables for each impact category were considered based on a 5-point Likert scale, where 5= Strongly Agreed and 1=Strongly Disagreed, as also indicated in Table 1.0.

Reliability of the data was ensured by making sure that the questionnaire was well designed, easily understood by the respondents while also conveying the same meaning to them. Also, after pilot study, ambiguous and wrongly worded questions were removed before proceeding to the field for actual data collection. Likewise, respondents were approached when it was noticed that they were in good moods and conditions, so as to ensure unbiased and sincere responses.

Table 1.0: Variables to measure the impact of ICT on the operations of NAMA

Impact	Study Variables
Economic impact	Increased number of flight
	Increased revenue
	Reduced flight operating costs
	Increased productivity
	More efficient use of the airspace
	Better resource utilization
	Interoperability across applications
	Reduction in fraud cases
	Reduced air traffic controller workload
	Reduction in dependence on outsourcing
	Reduction in flight delay
Safety and Communication impact	Reduction of communication errors
	Safe and secure data and information
	Easy access and transfer of data and information
	More direct and efficient air-ground linkage
	Safer environment

Ethical consideration for the research was established by making sure participation in the research was voluntary, and none of the respondents was forced to fill the questionnaire. Similarly, details of the research were known to the respondents at the onset, before starting to fill the questionnaire. The respondents were also assured they were not subject to any harm as a result of their participation in the research. Also, the use of offensive, discriminatory, or other unacceptable languages were avoided in the formulation of the questionnaire.

RESULTS AND DISCUSSION

Out of the two hundred (200) copies of questionnaire distributed to the respondents, a total of one hundred and eighty seven (187) were retrieved, which is 93.5% response rate. For the data analysis, using Statistical Packages for Social Sciences (SPSS) version 20.0, Relative Importance Index (RII) was used to obtain the level of importance of each of the variables considered, as shown in Table 2.0, while Regression Analysis was used to evaluate the impact of the studied variables on the operations of NAMA.

Economic Impact of Information and Communications Technology on the Operations of the Nigerian Airspace Management

As obvious in Table 1.0, for the assessment of the economic impact of ICT on the operations of NAMA, eleven (11) variables were presented to the respondents namely: Increased number of flight; Increased revenue; Reduced flight operating costs; Increased productivity; More efficient use of the airspace; Better resource utilization; Interoperability across applications; Reduction in fraud cases; Reduced air traffic controller workload; Reduction in dependence on outsourcing and Reduction in flight delay. Using RII, the highest four economic impacts of ICT on the operations of NAMA are discussed below:

More efficient use of airspace (RII=4.75)
This is ranked number one and the most important economic impact of ICT on the operations of the Nigerian airspace management. This might be because with the use of ICT, there is a better management of the airspace, thus an efficient air traffic management as evident in what Benaddy and Krit (2018) established that optimization and automation of air traffic control systems plays a significant role in air traffic management to ensure safety. Therefore, the study confirmed that the use of ICT enhances more efficient use of the airspace.

Better Resource Utilization (RII=4.75)
This is also ranked first together with more efficient use of the airspace, as number one economic impact of ICT on the operations of the Nigerian airspace management. This might be because with the use of ICT, resources can be well prepared and budgeted for. This is revealed in that scarce resources are being well managed and utilized with the use of ICT. This is also confirmed by Qureshi and Qazi Abro (2016) that the use of ICT helps in efficiently achieving goals, and thus better utilization of resources.

Reduction in workload of the air traffic controller (RII=4.73)
This is ranked third under the economic impact of ICT on the operations of the Nigerian airspace management. This might be because with the use of ICT, Air traffic controllers are able to easily do their tasks of managing the traffic per time, which in turn reduces the traffic thereby reducing their workload, which is the number of aircraft they have to attend to per time. This reveals that with the use of ICT in airspace management, the Air Traffic Controllers have less workload to deal with. Qureshi and Qazi Abro (2016) confirmed this by stating that the use of ICT helps in reduction of workload.

Increased productivity (RII=4.69)
Increased productivity is ranked third under the economic impact of ICT on the operations of the Nigerian airspace management. This might be because with the use of ICT, staff are able to carry out their duties without delay, thereby increasing their level of productivity, which will then result in a major increase in

Table 2.0: Relative Importance Index of the variables used to measure the impact of ICT on the Operations of the Nigerian Airspace Management

	Variables	SA		A		D		SD		U		TWF	RII	Rank Position
		F	%	F	%	F	%	F	%	F	%			
Economic Impact	Efficient use of the airspace	141	75.4	46	24.6	--	--	--	--	--	--	889	4.75	1
	Better resource utilization	141	75.4	46	24.6	--	--	--	--	--	--	889	4.75	1
	Reduction in the workload of the air traffic controller	144	77.0	35	18.7	--	--	--	--	8	4.3	884	4.73	3
	Increase in productivity	129	69.0	58	31.0	--	--	--	--	--	--	877	4.69	4
	Interoperability across applications	97	51.9	97	51.9	--	--	--	--	1	0.5	876	4.68	5
	Increase in revenue	116	62.0	41	21.9	30	16.0	--	--	--	--	804	4.30	6
	Reduction in flight operating costs	66	35.3	112	59.9	--	--	--	--	9	4.8	805	4.30	6
	Increase in number of flights	46	24.6	124	66.3	--	--	--	--	17	9.1	777	4.16	8
	Reduction in outsourcing	45	25.7	130	69.5	--	--	--	--	9	4.8	772	4.13	9
	Reduction in flight delay	63	33.7	86	46.0	38	20.3	--	--	--	--	735	3.93	10
	Reduction in fraud cases	101	54.0	1	0.5	60	32.1	--	--	25	13.4	704	3.76	11
Safety and Communication Impact	More direct and efficient air-ground linkage	158	84.5	29	15.5	--	--	--	--	--	--	906	4.84	1
	Safer environment	149	79.7	38	20.3	--	--	--	--	--	--	897	4.80	2
	Safe and secure data and information	143	76.5	44	23.5	--	--	--	--	--	--	891	4.76	3
	Easy access and transfer of data and information	141	75.4	46	24.6	--	--	--	--	--	--	889	4.75	4
	Reduction of communication errors	103	55.1	84	44.9	--	--	--	--	--	--	851	4.55	5

TWF=Total Weighted Frequency, RII=Relative Importance Index

the productivity of the staff and the agency as a whole. Therefore, according to Vicente (2011), ICTs are important drivers of growth and productivity.

From the result findings, there are also some other areas that the economic impacts of Information and Communications Technology on the Operations of the Nigerian Airspace Management is not really significant or felt as in the above discussed areas. Some of these lowest areas of insignificant impact according to the research results are presented below:

Reduction in fraud cases with the use of ICT (RII=3.76)
Reduction in fraud cases is ranked last under the economic impact of ICT on the operations of Nigerian airspace management. The respondents believed that the use of ICT in the organization has not caused a reduction in fraud cases. This might be because many of the frauds being done in the airspace organizations nowadays are even and easily done with the use of the internet and different technology applications, which is known to be one of the disadvantages of ICT (Hathaway, 2017).

Reduction in flight delay (RII=3.93)
Reduction in flight delay is next on the least ranked under the economic impact of ICT on the operations of Nigerian airspace management. The respondents were of the opinion that even with the use of ICT, thereare still flight delays, which might be because there may be other factors that contribute to the delay of flights, which may range from unfavorable weather to delay caused by flight cancellations, among others (Boye, 2015).

Reduction in outsourcing (RII=4.13)
Reduction in outsourcing is ranked ninth on the economic impact of ICT on the operations of the Nigerian airspace management. The respondents believed that ICT does not bring reduction in outsourcing, because some operations are still being outsourced. This might be because the agency might not have expertise on ICT for every of the available and studied department of the organization and might need to outsource some of its projects.

Increase in number of flights (4.16)
Increase in number of flights is ranked eighth on the economic impact of ICT on the operations of the Nigerian airspace management. This shows that respondents were of the opinion that there has not been increase in number of flights with the usage of ICT in the airspace management. This might be because there might be other factors that influence the passengers to prefer air transportation to other media, which might not be dependent on the use of ICT or any technology. It might be dependent on the number of people that are willing to travel by air, the number of airlines that may want to fly per time and/or users' preferred routes (Green *et al*., 2001).

Safety and Communication Impact of Information and Communications Technology on the Operations of the Nigerian Airspace Management
As also obvious in Table 1.0, for the assessment of the safety and communication impact of Information and Communications Technology on the operations of the Nigerian Airspace Management, five (5) variables were presented to the respondents namely: Reduction of communication errors; Safe and secure data and information; Easy access and transfer of data and information; More direct and efficient air-ground linkage; and Safer environment. The highest three safety and communication impact of Information and Communications Technology on the Operations of the Nigerian Airspace Management are discussed below:

More direct and efficient air-ground linkage (RII= 4.84)
This impact is ranked number one under the safety and communication impact. The respondents believed that ICT contributed tremendously in making sure there is improvement in linkages and communications within air-ground. This might be because there have been linkages systems and technologies put in place in the agency that have ensured an effective air-ground communications now and in the time past.

Therefore, these linkages gadgets, which are ICT- based, have contributed tremendously to an efficient communication between the controllers and the pilots (Margolin, 2014). In line of this, it could be established that ICT has been a major tool for effective communication in the airspace sector.

Safer environment with the deployment of ICT (RII=4.80)

This is the second most important impact of ICT under safety and communication. The respondents believed that the environment is safer with the deployment of ICT. This might be because the management has provided different ICT-based security systems to make sure that the environment of the agency, and the airport at large is safe for staff, travellers and other users of the airport (Yim *et al*., 2014). Thus, as also affirmed by Kamlakar and Purswani (2013), the research results revealed that the respondents believed that the environment has become safer with the use of ICT, and that the use of ICT ensures a safer environment.

Safe and secure data and information (RII=4.76)

The third most important safety and communication impact is 'safe and secure data and information'. This might be because data and information in the agency has become safer and secure since their security has been improved on through ICT. This shows that the usage of ICT in the Nigerian airspace management has impacted positively on the confidentiality and integrity of agency data.. Boston and Akman (2015) also confirmed that with ICT security in place, data and information are safe and secure.

However, the lower ranks, according to the RII analysis, of safety and communication impacts of ICT on the operations of NAMA are discussed below:

Reduction of communication errors (RII=4.55)

Reduction of communication errors is the lowest impact of ICT as regards safety and communication on the operations of the Nigerian airspace management. This may be because there are still communication errors being experienced in the airspace organizations. This is obvious in that communication within the agency is still majorly voice communication and has not completely been changed to data communication (Ovuworie, 2018). Therefore, for this to be totally improved on using ICT there is need to improve on the communication methods to eliminate errors, so as to avoid collision or other traffic incidents or accidents.

Easy access and transfer of data and information (RII=4.75)

This is the second lowest communication impact of ICT on the operations of the Nigerian airspace management. This implies that the respondents believed that they have not had easy access to information while also not being able to easily transfer data and information even with the deployment of ICT. This might be because the network connection in the agency is not good or fast enough, and so it was not always available for use by the staff. Therefore, certain sensitive data and information might not be easily accessed elsewhere, or using another computer system, because of the security measures put in place to protect them (Boye, 2015).

Furthermore, Multivariate regression method of analysis was used for this study, with a view to evaluate the impact of the ICT on the operations in the Nigerian Airspace Management. Thus, the dependent variables comprise the economic; and safety and communication impacts already discussed above, while the independent variable was the operations of the Nigerian Airspace management. The results, as shown in Table 3.0, showed that ICT had positive impact on the operations of the Nigerian Airspace Management using the two measures or variables.

Table 3.0: Parameter Estimates of the impact of ICT on the operations in the Nigerian Airspace Management

Dependent Variable	Parameter	B	T	Sig.	R^2	F-Statistics
Economic impact	Intercept	0.043	0.334	0.738	0.44	12.777 (p<0.05)
	ICT	.407	3.813	.000		
Safety and Communication Impact	Intercept	0.361	.590	0.490	0.18	8.133 (p<0.05)
	ICT	3.134	2.301	.024		

For the *economic* impact of ICT on the operations of Nigerian Airspace Management, the results (t=3.813, p<0.05) implies that ICT has high degree of impact on the economy of the organization. This is obvious in r-squared of 0.44 indicating that the economy impact explained about 44% of the variation in the operation of the Nigerian Airspace Management. Likewise, for *Safety and Communication impact,* ICT had positive impact on the organization's Safety and Communication (t=2.301, p<0.05). The results indicated that operations in the Nigerian Airspace Management are greatly being positively affected by the adoption of the ICT. The R-squared of 0.18 indicates that the explanatory variable explained about 18% variation accounted for in the independent variable. Also, the f-statistics of 12.777 and 8.133 with p-value less than 0.05 shows that the model is statistically significant at 5% level of significance.

CONCLUSION

The results showed that the impact of ICT on the operations of Nigerian airspace management cannot be overemphasized. This is obvious in the findings that showed that more efficient use of the airspace; better resource utilization; reduction in the workload of the air traffic controllers; increased productivity; efficient air-ground linkage; and safe and secure data are the highest ranked and most important impact of ICT on the operations in the Nigerian airspace management. While reduction in fraud cases; reduction in flight delay; and reduction in outsourcing are the lowest ranked economic impacts of ICT on the operations of NAMA. Thus, the research findings confirmed that investment and usage of ICT have significant impacts on the operations of the management of the Nigerian airspace. However, it can be concluded that ICT has more impact on the economic operation of NAMA more than the areas of safety and communication.

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