A U.S based Analysis on International Collaboration within Air Traffic Control Technical Training for the Advancement of Global Harmonization in Air Traffic Management

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Introduction

The vision for a globally harmonized air traffic management (ATM) system is "to achieve an interoperable global air traffic management system for all users, during all phases of flight, that meets agreed levels of safety, provides for optimum economic operations, is environmentally sustainable and meets national security requirements" (ICAO, Global Air Traffic Management Operational Concept, Chapter 1). To achieve this vision, aviation and ATM stakeholders are working towards the development of a seamless airspace that is technically and procedurally interoperable, universally safe, and has no noticeable change in the type or quality of service received, air navigation and communications performance standards, or standard practices during the transition between Flight Information Regions (CANSO, 2013).

Initiatives like Next Generation Air Transportation System (NextGen) in the United States of America (USA) and Single European Sky ATM Research (SESAR) in Europe, as well as organizations like the International Civil Aviation Organization (ICAO) and the Civil Air Navigation Services (CANSO), have been working towards global alignment of ATM practices and procedures to create this seamless airspace. Air traffic controller (ATC) technical training is a key area for implementation of new policy and procedures arising from global harmonization of ATM. (FAA Communications, 2016) While some ATC duties may vary from country to

country, the primary responsibilities remain consistent across countries and regions of the world. To achieve the level of interoperability needed for a seamless airspace, a high degree of coordination must occur within the training and standards of performance required from individual ATCs. Thus, international collaboration and alignment within ATC technical training is important to the broader global harmonization efforts in ATM.

The need for global harmonization within ATC technical training is a strong motivation for the formation of partnerships. The qualitative analysis conducted within this work has provided a structured approach to identifying key factors within ATC technical training that will support the formation of partnerships and collaborations to advance global harmonization. Current partnerships and collaborations between stakeholders in the ATC technical training space are investigated and the potential of forming of new partnerships and collaborations in this space is discussed. Additionally, this work provides an exploratory analysis of the impacts that the pursuit of global harmonization and collaboration might have upon the technical training of ATC professionals.

Background

There is no higher priority in air traffic control than ensuring safety in aircraft operations. (NATS, n.d.) In the USA, the Federal Aviation Administration (FAA) policy that states, "the primary purpose of the ATC system is to prevent a collision between aircraft operating in the system and to provide a safe, orderly and expeditious flow of traffic, and to provide support for National Security and Homeland Defense" (Federal Aviation Administration, 2015). "The current ATC training methods do not specifically identify and isolate individual skills that students need to develop in order to be successful controllers. Rather the current training curriculum and methods focus on data acquisition learned in a classroom setting followed by

skill acquisition through extensive high fidelity simulation and on-the-job training" (Schultheis , 2016). ICAO member states around the globe, whether their ATC services are operated as a government entity, or contracted through a private company, assume similar policies consistent with the ATM operational concept. ATC must ensure the safety of every aircraft under their jurisdiction. In order to accomplish this mission ATC undergo extensive initial training, on-the-job training, and recurrent training throughout the course of their career (Schultheis , 2016). This training allows ATCs to develop a decision making process which allows them to build a mental picture of the current airspace, and then make a plan, and a backup plan in order to ensure the safe and efficient operation of aircraft. (D'Arcy & Della Rocco, 2001)

Air Navigation Service Providers manage flight traffic on behalf of a company, region or country. Depending on which Air Navigation Service Provider (ANSP) employs an ATC, the technical training received may come from a governmental entity, a university or post-secondary institution, the military, or a private contractor (CANSO, ATCONF, 2013). Several private training firms operate around the world in order to provide enough ATC to satisfy the global need. One of the largest training providers in the world is Airways New Zealand. ATC Technical Training through the Airways program lasts twelve months during which students undergo both self-directed, as well as intensive simulator-based training. Upon completion of the academic portion, students are then posted to a regional ATC Tower facility to undergo on-the-job training. During this phase the students are controlling real aircraft under the guidance of an experienced instructor. Upon successful completion of this phase graduates of the program are eligible to work as a certified ATC. Airways has partnership agreements with seven ANSP's, and four Universities around the world. By standardizing their training program to align with the various

ANSP's requirements the graduates of this program are qualified to work in many locales around the world, and are able to operate the newest technology (Airways, 2018).

Despite consistent missions under the global ATM operational concept, there are indications that the global ATM technical training community has been operating relatively independently (International Civil Aviation Organization, 2005). It is widely known that the ATC training model in the USA is based entirely on orders authored by the FAA (Federal Aviation Administration, 2013), and is performed entirely within the United States, and for the most part at the FAA ATC Academy in Oklahoma City. Currently, three training paths exist for controller candidates in the United States. The first is for those with previous ATC experience, whether its civilian or military experience. The second is for the general public who have no prior experience and no formal education in ATC. The third path is for graduates of an approved Air Traffic Collegiate Training Initiative (AT-CTI) Schools. (Pavel, 2012, p. 40) The AT-CTI program was designed to test "the concept that non-federal, post-secondary educational institutions can develop, deliver, and implement air traffic control recruiting, selection, and training programs" (Pavel, 2012, p. 33). Regardless of the entry path for these candidates, they all undergo training at the FAA Academy. "The Air Traffic Division at the FAA Academy provides technical training in the Air Traffic Control Specialist occupation, with in-depth, comprehensive courses for both the Terminal (Tower) and the En Route options" (Federal Aviation Administration, 2014). While there, training starts with traditional classroom instruction before advancing to real-life simulation. This simulation is accomplished in realistic, ATC tower and Enroute facilities, that offer a chance for experienced instructors to coach an ATC candidate through an exercise (Federal Aviation Administration, 2014).

International ATC technical training locations, such as the Civil Aviation Authority of Singapore School of Air Traffic Services (Civil Aviation Authority of Singapore , 2018), the ATC training center in Europe (ENAC in France), and others, have varying training curricula, aligned in part with ICAO training recommendations (International Civil Aviation Organization, 2016). One possible area for training collaboration that may exist is at independent training/collaboration forums like World ATM Congress or other conferences (World ATM Congress, 2018) .

The body of literature that addresses international collaboration of ATC technical training is limited. Where such literature does exist, the focus is on the need to upgrade air traffic controller knowledge requirements as a result of ATC technology modernization. For example, Cavcar and Cavcar (Cavcar & Cavcar, 2004) note that the increase in ATM technology has required an upgrade in training and ATM knowledge requirements, and that both ICAO and the International Federation of Air Traffic Controllers' Association (IFATCA) have been considering enhancing training to support these new requirements. The authors compare two ATC technical training programs, the FAA's Air TrafficCollegiate Training Initiative (AT-CTI), and equivalent programs supported by Ecole Nationale de l'Aviation Civile (ENAC). The research findings indicate both programs include enhanced delivery of fundamental academic topics such as math, geometry, probability and statistics, physics, computer science, psychology, economics, management science, as well as traditional aviation and air traffic control topics. The research also noted that in Europe many of these topics were taught in the high school level, while in the United States students are not exposed to some of these concepts until enrolling in a collegiate AT-CTI program. (Cavcar & Cavcar, 2004)

The performance requirements of ATCs are directly impacted by changes in policy arising from efforts to create a seamless airspace (CANSO, AIM, 2016). As the rate of technological change and globalization continue to increase, the ability to integrate new technology and procedures quickly across the planet will be increasingly important. ATCs must be taught to use new technologies designed to improve safety and increase efficient operation without any degradation of performance. Similarly, changes in procedure must be communicated to ATCs and implemented by ATCs and pilots. Thus, ATC technical training is a key platform for integrating new technology and procedures resulting from the global harmonization of ATM practice.

Research Method

A qualitative research methodology was used to gain more insight into the existence and potential of international collaboration in ATC towards the global harmonization of ATM. To investigate any barriers to such collaboration, qualitative methods that included both document review of U.S. and international ATC documents and semi-structured interviews with ATM providers. The research team obtained documents and interview subjects to represent a broad global distribution of perspectives and content with respect to location, role, and institution through internet search. Document review is a method to collect data through reviewing existing documents (public records, published articles, online curricula, etc.) that provides an effective and unobtrusive means to gather background information, obtain written evidence produced by sources of interest, and enable researchers to obtain language and words from the sources (Creswell, 2009). The document review for this study included U.S. and international ATC regulations, training, and operations manuals, scholarly articles, and public records. The research team established inclusion criteria for the documents that were to be reviewed. Documents were

reviewed for content that specifically highlighted the technical training of ATC, partnerships and collaborations centered on ATC technical training, and impacts of ATC technical training on safety and global harmonization. A document that satisfied any one of these criteria was included. A search of academic literature and documents publicly available online from international organizations, aviation authorities, universities and global stakeholders offering ATC training yielded 74 documents that meet the criteria. These documents were systematically analyzed to explore outcomes relating to the aims of this research.

Interview subjects were purposefully selected to represent a broad range of geographic (i.e., regional, national) and cultural (i.e., country, region) diversity, as well as to represent a broad variety of stakeholder roles (i.e., pilots, instructors, ATC, and ATM administrators). Interviews were performed using a semi-structured protocol using a series of questions to guide the discussion (Creswell, 2009). Interview questions were directed at understanding the technical training of ATC with respect to globalization, technology, partnerships and collaboration, curricula and other topics. Thirteen individuals were interviewed over the phone/video call, for approximately one hour each. This research was conducted under an institutional review board (IRB) approved protocol for human subjects research. All interviews were recorded, with the permission of the individuals being interviewed, and maintained under coded identifier for interviewee anonymity. Interviews were conducted with three members of the research team present on each call (facilitator, guidance, note-taker). Each member performed the same role across all interviews. After the interviews, summaries of the recordings were transcribed into documents. All interview content was maintained in de-identified form.

The contents of the documents derived from the document review and interviews were analyzed using the constant comparative method (Glaser, 2000). First, open coding of the

documents and transcriptions of the interviews was performed using NVivo, a software designed for qualitative data analysis. In this phase, the data relevant to the research was structured within many categories across four different files created independently by four researchers. These files were then merged and reviewed by the entire team. Similar nodes were discussed and merged using language that the research team agreed described the essence of the categories. In the axial coding phase, four categories representing the findings were generated from the data. The research team rearranged the information in the merged Nvivo file from the open coding phase into these eight categories. In the final phase, selective coding, the research team once again reviewed all coded elements, documents, and interviews through the lens of the eight outcomes from the axial coding phase. The resulting research findings were compiled by all members of the team.

Research Findings

The research findings are presented within three tables below highlighting: collaborations and exchanges involving ATC technical training, best practice in collaborative ATC technical training, and challenges to harmonization of ATC training. This section on findings includes tables highlighting outcomes obtained through both document review and interviews, while the next section leverages excerpts from the interviews to contextualize findings.

Table 1 summarizes global partnerships that promote the instruction of ATC professionals from a global or international perspective**.** Partnerships and collaborations include the platforms that allow for the exchanging resources, mutual development, and beneficial outcomes within the global harmonization within ATC technical training. This table is not an exhaustive list of global partnerships, but rather specifies the networks that the document review and interviews indicated are currently positioned to support harmonization of ATC training and exchange best training

practices and resources.

Table 1: Collaborations and Partnerships in ATC technical training

Partnership/Collaboration	Stakeholders involved	Description of Collaboration
Trainair Plus Program	All members of the Trainair Plus Program (see https://www.icao.int/training/Pages/trainingcenter.aspx)	Network that exchanges training best practices [ICAO, TPOM, 2016]
Borealis ANS Alliance	Air Navigation Services Finland Oy (ANS Finland), Avinor Flysikring AS, Estonian Air Navigation Services (EANS), ISAVIA Ltd, Irish Aviation Authority, Luftfartsverket(LFV), Latvijas Gaisa Satiksme (LGS), UK NATS, Naviair	North-west European Air Navigation Service Providers' network that is driven by a common vision "to be the leading ANSP Alliance that enables its members to drive better performance for stakeholders through business collaboration." [NATS, 2017]
ATNS Training Partnership	ATNS, Airways NZ, Embry-Riddle, ENAC France, Ghana, IATA, ICAO, Namibia, SACAA, Seychelles, Sudan CAA, Swaziland, FAA Academy Oklahoma	Training partnership to create customized courses, develop succession plans in ATC training, evaluate current programs, fulfill manpower requirements, manage the performance of courses, recruitment into the training programs, and create assessments. (ATNS ATA)
A6 Alliance	DFS Deutsche Flugsicherung GmbH, DSNA, ENAV Academy, ENAIRE, UK NATS, PANSA, Air Navigation Services of the Czech Republic (ANS Czech Republic), Letové prevádzkové služby (LPS SR, š. p.), Oro Navigacija	Network of ANSP's across Europe that aims to drive modernization of the European ATM network through the deployment of technologies and concepts developed through the SESAR program.(https://www.a6alliance.net/)

Eurocontrol	Albania, Armenia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Republic of Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and United Kingdom.	An intergovernmental alliance focusing on creating a seamless airspace across all member and comprehensive agreement states. (https://www.eurocontrol.int/)
CANSO	All members of CANSO (https://www.canso.org/canso-members)	International network representing 85% of world air traffic. (CANSO Vision 2020, 2013)
ICAO	192-member states of ICAO (cite ICAO website)	International network that seeks "to serve as the global forum of States for international civil aviation" (https://www.icao.int/about-icao/Council/Pages/vision-and-mission.aspx)

Evidence-based practice across global ATC Technical Training includes activities that consistently produce ATC with the desired knowledge, skills and abilities required for high job performance. These practices were repeatedly reported in literature and interviews as effective across many different stakeholders and scenarios. Table 2 summarizes the two main evidence-based practices in ATC training which show promise for broad incorporation of changes in policy and procedure across ATC training programs.

Table 2: Summary of evidence-based best practices in ATC technical training

Best Practice	Advantages of practice

Competency-based training/ Outcomes-based training	● Curriculum directly relates to job tasks, knowledge, skills and training methods needed on the job. (FAA Communications, 2016) ● Anticipates changes needed in training programs as a result of implementation of NextGen functionality (FAA Communications, 2016) ● Allows an organization to identify the gaps in the knowledge, skills, and abilities of their staff (CANSO, AIM, 2016) ● Promotes "hands on" or local knowledge based on skills, observation and monitoring, which leads to higher service quality, as well as heightened safety and efficiency. (CANSO, Flow Management, 2016)
Training Simulators	● Enable students to see the cause/effect relations of situations they will see in their work, allowing them to avoid mistakes (Kistan, 2017) ● Allows ATC trainees to practice handling unpredictable events such as weather, system malfunctions etc. (NATS, 2017) ● Trainees do not have to wait for these opportunities to arise in real life, can simulate them anytime and multiple times (FAA Communications, 2016)

Challenges/ Limiting Factors include the elements that inhibit global stakeholders from furthering, maximizing, and fully committing to global harmonization in ATC technical training. These challenges are summarized in Table 3. This is not an extensive list of challenges, but rather the largest challenges affecting the majority of stakeholders.

Table 3: Challenges to harmonization of ATC technical training

Challenge	Example(s)
Disparity in technology, expertise, and/or financial resources	"Disparity in technology is a threat to collaboration in ATC technical training"
	"[Conforming to international standards] is a challenge for all states, and for various different reasons. For example, a state that is not as far developed may have trouble implementing some of the higher-end communications, navigation and surveillance (CNS) solutions that are out there like surveillance or systems- their system is just not dense enough or not complicated enough so they could do with simpler solutions."

	Financial circumstances and specific local requirements play a role in what ATM technology is used and the workforce that runs it [CANSO, 2016]
	Many differing regions of the world do not have adequate tools, equipment and facilities due to financial constraints. (CASSOA, 2010)
Variation in policy and procedure	A survey was released to CANSO members in June 2009 and results highlighted that there is still a mix of systems using metric and imperial units of measurement, specifically in the oceanic and remote areas. (CANSO, 2013)
Variation in assessment and instruction of ATC technical training	"There are national differences in policy on the range of ATC jobs that each individual controller should be qualified to do, which are reflected in the forms and duration of training." (CASSOA, 2010)
Organizational structure	"In the north of Europe and maybe the west of Europe - I am not sure that this is because of their training systems, or because of the cultural or because of the circumstances, but there seems to be a lot more willingness to commercially collaborate. Whereas to the south of Europe there is almost like - the typical and historic national concepts are still there, and so there's less "will" to collaborate in the field of training. It's a much harder environment to establish partnerships."
	"In Europe, there's lots of public operations that work as ANSPs, but in Asia almost every country is run by a government office, so that gives another huge gap between starting the collaboration between countries because the government officers tend to not make any changes and they prefer the traditional and conventional ways. In case of encountering other East Asian ATCs, they are not trying to cooperate together; they are trying to secure their interests as much as possible."

Discussion

Global Harmonization within ATC technical training has been recommended as a way to promote access to training and broadly implement changes in policy, procedure, practice and technology arising from ATM global harmonization efforts (Kistan, 2017). Collaborations among global stakeholders are necessary to support the exchange of ATC training resources and best practices. Partnerships and collaborations appear to be primarily formed among stakeholders that exist in close proximity to each other and/or share common values (i.e standards and regulations, air space size, air traffic, weather patterns), or historic alignment and partnership

(i.e., imperialist relationships). However, global participation in collaborations can be encouraged by introducing common goals. ATC technical training can act as a common ground for partnership and alignment as all ATC are expected to obtain similar skills and achieve similar job performance. According to one interviewee,

> "The way [ATC] have to handle themselves is exactly the same in terms of performance that is expected of the students once they go through simulations and all that. What you expect an air traffic controller to do in the US is exactly what you would expect them to do in Spain. So, the performance is the same but the information will be different."

As ATC performance varies little based on location, it is possible to obtain global harmonization training by defining core competencies that all controllers must achieve in training. Another interviewee explained,

> "The important lesson is that the competencies are not about what people do in their job, you know the tasks, but how they do their job while carrying out these tasks."

Defining the core competencies that encompass the performance of an ATC will provide global stakeholders with common ground to facilitate discussion. This will include discussions outlining the assessment methods necessary to determine if an ATC has achieved the required performance level. Currently, assessment methods vary widely across global stakeholders, which is highly dependent upon the training culture of the region. Competency-based training (Oprins,2006), sometimes called outcomes-based training or events based training (Fowlkes,1998), presents a solution to the challenge of widely varying assessment strategies. This type of training, which focuses more on trainee performance than knowledge, repeatedly arose as a best practice for ATC technical training in literature an interviews. By focusing on the core competencies required of an ATC, the standard performance level could be strictly defined

and assessment could be standardized. All ATCs would be required to achieve and maintain a standard performance level, but those who wish to excel would still be able to do so.

One of the largest training providers in the world is Airways New Zealand, which has partnerships with seven ANSP's, and four Universities. By creating a standardized training curriculum, performance outcomes, and package to offer to stakeholders, Airways New Zealand successfully offers ATC training to global stakeholders. (Airways, 2018) Universidad Interamericana de Puerto Rico (UIPR) takes a slightly different approach to international training by catering to the two main divisions of ATC training, one of which is based on FAA standards and the other on European standards. UIPR provides separate tracks within their ATC training program to address these two different standards. ATC students can choose between the FAA and European Aviation Safety Law (EASL) based curriculums depending on where they want to work as an ATC when they graduate. Interview subjects suggest that access to simulation technology is a key component of the success of both the Airways New Zealand and UIPR training models because the software can account for many different situations (i.e. climate and weather variations, variation in air traffic and airspace needs, differences in standards and regulations) while teaching ATCs the soft skills that they need. These skills include communication, reaction time, problem solving, etc. (Kang, 2018)

Table 1 lists some successful partnerships among stakeholders in which training is a common interest. Broadly, organizations with political, cultural, and other similarities/parallels with ATC technical training needs were found to increase the likelihood of existing and fruitful partnerships. However, much can be learned and gained through partnering with institutions without these similarities/parallels. The international program at UIPR was made possible through a partnership between UIPR, Airways New Zealand and Spanish ANSPs. On discussion

of the development of an international program at UIPR was developed, an interviewee explained,

> "[UIPR] found that the laws of Spain did allow for visa holders, or non-nationals, to control air traffic. We saw a need, saw privatization, saw a government that allows for our students [to work]. Even though they were not Spanish nationals, [UIPR graduates] were allowed to go there on their work visa and control activities at their towers, so we decided to create a program. We knew we couldn't do it ourselves because we were coming in from a CTI training program, which is pretty much a prep course for the Academy, so we aligned ourselves with a partner that was very serious outside of the FAA world. That was Airways New Zealand…One thing led to another and we were certified with a certification outside of Europe and able to provide training in San Juan, Puerto Rico with EASA approved controllers and instructors."

The collaboration between Spanish towers, UIPR, and Airways New Zealand evolved through mutual interest in creating a career pathway for strong ATC graduates. This partnership can be leveraged to incorporate changes resulting from global harmonization of ATM into ATC technical training curriculum, enabling broadly implementation of these changes across the training programs UIPR and Airways New Zealand have in place.

Partnerships and collaborations within the ATC technical training space are crucial for the successful global harmonization of ATC technical training. However, the mechanisms of forming and maintaining partnerships and collaborations in this space can be complicated, and challenges arise when stakeholders' interests do not align perfectly. The main challenges identified during this research are listed in Table 3. There was concern among interview subjects and expressed in the literature that stakeholders, especially those from areas with privatized

aviation, would be unwilling to openly share training resources. Privatization is a highly debated topic in the aviation community as it introduces a competitive element into the market that can affect open communication. However, it can also promote innovation because private companies can use profits for research and improving ATM and aviation training (McDougall, 2008). However, aviation is an inherently cooperative field due to the global vested interest in safe transportation of passengers and cargo, so stakeholders are ultimately forced to work together. An interviewee from a country that recently privatized ATC management and training said,

> "After a few years on the open market you see perhaps you are very shut at the beginning and you don't dare to take any steps towards collaboration with others because you are scared of the competition issues with it. We are beginning to see many more examples now where we are reaching out to each other, despite the fact that we could be competitors. But we would rather work on erasing the safety issues together, not caring who takes the main part of the economic costs for arranging meetings and typing out materials."

This example indicates that potential conflicts of interest can be minimized by defining goals that encourage stakeholders to work together rather than against each other, such as maintaining safety standards across airspaces.

Another challenge to global harmonization are presented by the wide gap in aviation infrastructure around the world, with certain areas facing challenges from limited financial resources, knowledge, or expertise. Interview subjects suggest that there tends to be a lack of qualified ATCs in areas with less advanced aviation to manage air traffic due to difficulties in recruiting candidates, poor working conditions, and "brain drain", which is the loss of trained personnel to better opportunities. These areas may also have outdated technology and equipment.

The literature and interview subjects suggest that areas that do have newer technologies but are still falling behind in aviation lack the expertise needed to successfully train and use it, which can lead to safety issues. Although many stakeholders, including the USA, provide international training, many countries cannot afford it or are held back by a lack of infrastructure and government support for ATC training. The literature and interviews suggest that these concerns can be addressed through the exchange of training resources by global stakeholders. These training resources include online training materials, open source curricula, instructor training, simulators (Kiken, 2011), region-specific training, and ATM equipment training (FAA Communications, 2013 and Sabatini, 2016). Thus, exchanges of training resources either online or through networks of stakeholders would be beneficial not only in advancing ATC training, but also in establishing a baseline understanding of global ATC training practice.

Leveraging global networks can provide increased collaboration, sharing of resources, and the development of global best practices for the development of aviation professionals (Delaine et.al, 2016). Table 1 provides an overview of some of the existing partnerships in this space that can be leveraged to harmonize ATC technical training. An example of a global network that can be leveraged to increase collaboration in ATC technical training is the Trainair Plus Program. This program is ICAO's effort to provide standardized training packages and resources to all stakeholders. Currently, there are nearly 70 member states involved in this collaboration, which makes it a good platform for encouraging exchange programs, providing access to training resources, establishing best practices, and facilitating harmonization conversations in the ATC technical training space (Global Aviation Training Office, 2016). Regional networks like the Borealis ANS alliance and A6 alliance can also be leveraged to advance the harmonization of ATC technical training.

Limitations

An exploratory analysis into global Air Traffic Control (ATC) and the technical training of the field's professionals is performed to gain insight into how the FAA can improve the ways it develops the ATC workforce through global harmonization. There are many stakeholders, institutions, countries, and regions which are highly active in ATC technical training. There is limited literature available for important regions of the world such as South America, Africa, and the Caribbean. This limited the ability of the research team to obtain insight into these regions. Due to the large scale and complexity of the problem statement, the research team implemented a systematic approach to uncover broad dynamics and investigate the high-level factors that impact global harmonization within ATC technical training. This research is not intended to be comprehensive but represents an exploratory effort into understanding of how the ATC technical training can support global harmonization efforts in ATM.

Conclusion

This work explores ATC technical training programs and international collaborations to provide an understanding of global ATC technical training practice and identify mechanisms that provide support for global harmonization in ATM. Global harmonization of ATC technical training can be a platform that supports international efforts to create a seamless airspace. By leveraging global networks to increase collaboration and the exchange of resources and best practices, ATC technical training can act as a platform for implementing changes in policy and procedure resulting from global harmonization of ATM. Developing, furthering, and maintaining close relationships and partnership with international groups like ICAO, EASA, and CANSO on creating harmonized training practices and assessments can serve as a critical mechanism to advancing harmonization within ATC technical training. Developing relationships and

partnerships within regions with underdeveloped aviation by disseminating, sharing, and providing guidance through online or in-person training resources (ex. videos/instructions on how to use technology, suggested/best practices, assessment tools, course outlines) can provide a foundation for strong partnerships and increased global alignment. Initializing collaborations in areas where similarities can be highlighted, and differences minimized (i.e., how to train instructors, train for resilience) can provide an appropriate launching ground for fruitful relationships.

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