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Creating an English Technical Word List for Thai Air Traffic Control Officers: A Corpus-Based Approach

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Abstract

The aviation industry plays a critical role in Thailand's economy and global connection, and, thus, places a significant responsibility on Air Traffic Control Officers (ATCOs) to maintain both safety and efficiency. However, many Thai ATCOs face challenges in understanding International Civil Aviation Organization (ICAO) publications due to limited proficiency in vocabulary. To address this issue, this study developed an English technical word list for Thai ATCOs to support their understanding of ICAO publications. A corpus-based approach was applied by focusing on 19 Annexes by ICAO which were compiled into a written corpus of over 1.2 million tokens. The word list was developed based on five criteria, including frequency, range, lexical profiling, keyword analysis, and expert viewpoints. The final word list resulted in 139 technical terms excluding general and irrelevant vocabulary. This technical word list can be used to support Thai ATCOs in interpreting ICAO standards more effectively for improved communication and enhanced operational safety.

Keywords: technical word list, corpus-based approach, corpus linguistics, air traffic control officers

Thailand's aviation industry plays a major role in the country's economic and tourism growth which support international travel and commerce. Given its importance, to maintain high safety standards it is essential to sustain the industry's continued growth in economy and tourism. A key part of this responsibility falls on the Air Traffic Control Officers (ATCOs) who operate within air traffic control units that provide air traffic services (ATS). These services include the prevention of aircraft collision, management of the orderly flow of air traffic, provision of flight information essential for safe operations, and assistance in search and rescue operations (ICAO, 2018). In addition, safety is a significant factor for tourists' decision when

choosing a destination which perceived safety affects their destination preferences and overall satisfaction (Fuchs & Pizam, 2011).

To maintain high standards for air safety, ATCOs must follow guidelines and procedures outlined in International Civil Aviation Organization (ICAO) publications. These publications contain details of the standards and recommended practices (SARPs) which are aimed at ensuring the consistency and uniformity of air traffic management across all the world (ICAO, 2023). The ICAO SARPs are crucial in promoting global uniformity in aviation regulations, standards, procedures, and operations across member states, known as Contracting States, including Thailand (Dib, 2022; ICAO, 2006). Understanding these publications is an important part in ATCO training, as it is integral for them to achieve overall safety. In Thailand, ATCOs are trained under a competency-based system that is divided into three phases, including initial training, unit training, and continuation training, allowing the reinforcement of the necessary knowledge, skills, and attitudes (ICAO, 2017).

Thai ATCOs must be good at Aviation English because ICAO publications are primarily available in English. Aviation English is different from general English because it has specific vocabulary and regulatory compliance which are essential for effective communication and operational safety (Estival & Farris, 2016). However, some Thai ATCOs have lower-than-expected scores on the ICAO Language Proficiency Test. Based on this serious issue, it might be possible for them to misunderstand ICAO publications, which leads to accidents in the future. To be specific, if they do not understand ICAO publications, miscommunication between air traffic control units, pilots, and other aviation personnel can happen. Consequently, it is crucial for Thai ATCOs to know sufficient vocabulary so that they can interpret ICAO publications and follow international safety standards. Previous studies have found that inadequate vocabulary and comprehension skills might have a negative effect on communication and operational effectiveness (Kaur, 2021; Mekkaoui & Mouhadjer, 2019). Therefore, promoting English language proficiency, particularly in Aviation English, is essential for Thai ATCOs to develop understanding and compliance with ICAO regulations.

Given the critical importance of understanding vocabulary to interpret ICAO publications, developing specialized resources, such as an English technical word list for Thai ATCOs, can significantly enhance their understanding of technical terms and improve safety outcomes. To ensure these resources are tailored to the specific linguistic needs of Thai ATCOs, a data-driven approach can provide valuable insights into the

technical language used in ICAO publications. Accordingly, a corpus-based approach can be valuable in enhancing Thai ATCOs' understanding of ICAO publications. A corpus is a systematically collected body of spoken or written language that can aid in identifying key vocabulary and usage patterns (Biber et al., 1998; Park & Nam, 2017). Developing an English technical word list from such a corpus could support Thai ATCOs in distinguishing between technical aviation terms and general English, thereby improving comprehension and compliance with international safety standards.

Furthermore, a word list can allow English as a foreign language (EFL) learners to know what vocabulary they need to know and what to focus on, as it provides targeted learning materials that are relevant to a domain (Kwary & Jurianto, 2017). There are a variety of well-known word lists, for example, the General Service List (GSL) created by West (1953), which contains high frequency words in the general English context. Additionally, specialized word lists, such as those for medical, business, or engineering contexts, equip learners with domain-specific vocabulary necessary for academic and professional success (Lessard-Clouston, 2013). EFL teachers can enhance learning outcomes by creating personalized comprehensive lists based on the texts and contexts their students will encounter to support both receptive and productive language skills.

In conclusion, the development of an English technical word list tailored for Thai ATCOs is essential to support their understanding of ICAO publications and to ensure the safety of international air transport. While previous research has predominantly focused on spoken corpora in aviation communication, there is a significant need to create a written corpus using ICAO publications to support the development of an English technical word list for Thai ATCOs. Accordingly, the current study seeks to answer the following research question:

What words should be included in an English technical word list for Thai ATCOs?

Literature Review

Standard and Recommended Practices for Air Traffic Control Officers

The International Civil Aviation Organization (ICAO), a specialized UN agency, plays a key role in guiding global air navigation by setting international standards and practices through its Standards and Recommended Practices (SARPs). These SARPs, derived from the 1944 Chicago Convention, promote safety, efficiency, and consistency in civil aviation across its 193 member states. ICAO's publications—comprising Annexes (binding

regulations), Procedures for Air Navigation Services (PANS), and Technical Manuals—outline both mandatory and recommended guidelines for air traffic operations, communication systems, and accident investigations, fostering a unified global airspace management approach.

ICAO mandates that air traffic controllers (ATCOs) meet specific training criteria, including knowledge of air law and operational procedures like communication and radiotelephony (ICAO, 2017). Countries providing Air Traffic Services (ATS) must consistently apply ICAO's SARPs to ensure international uniformity in airspace operations (ICAO, 2018).

ATCOs can access ICAO publications through various channels, including the official ICAO website, employer-provided libraries, and aviation training institutions. ICAO Annexes are essential resources for maintaining standardized global air traffic operations. ATCOs are required to consult these publications during situations, such as managing emergency scenarios, ensuring compliance with environmental regulations, and coordinating international flight operations. ICAO Annexes were selected for this study because they form the foundation of global aviation SARPs. These documents encompass critical areas of air traffic management, such as communication procedures, environmental sustainability, and safety measures, which directly impact ATCOs' responsibilities. Focusing on the ICAO Annexes allow the target of specific vocabulary Thai ATCOs need to understand and apply these regulations effectively to enhance operational safety and compliance within Thailand's aviation sector.

ICAO Annexes have been employed by various researchers as an important source of data, providing valuable information to answer their questions. For example, Garcia (2023) investigated the construct of the ICAO rating scale used in aviation English listening tests. The researcher selected Annex 1 as a source to analyze the ICAO rating scale and the ICAO policy. Annex 1, the primary source of this study, provided information about the requirements that Contracting States must follow. The results of this study helped test developers, especially those who would like to access pilots and ATCOs' listening skills, come to a better understanding of the ICAO policy. Similarly, Drayton and Coxhead (2022) analyzed the language proficiency requirements (LPRs) for language testing in aviation contained in Annexes 1 and 10. The results revealed that ATCOs' beliefs about the role of plain language and standard phraseology in radiotelephony communication should be considered for further language training.

In contrast, Nagy (2019) focused on analyzing the pragmatic uses of modal verbs in Annexes 1, 2, 10, 17, 18, and 19. Those ICAO Annexes were selected in the study because they are related to obligation and

recommendation. The findings indicated that modal verbs were used differently based on different contexts. For example, *shall* and *should* were used differently as *shall* refers to the meaning of vital obligation while *should* refers to chance or possibility. The results of the study also suggested that non-native airspace users should be aware of meaning interpretation when they read the ICAO Annexes.

While these studies highlight the use of Annexes as the valuable source for providing insights related to ICAO language testing and pragmatism, there remains a significant gap in employing Annexes to create a technical word list to help improve ATCOs' English language proficiency. Given this gap, there is a need for research that suggests technical words that ATCOs should know. By addressing this need, ATCOs will be able to reach the ICAO requirement, providing effective communication and safety in air traffic management. In this research study, there is a need to create a word list for ATCOs using a corpus-based approach.

Corpus Linguistics and Corpus Construction

Corpus linguistics refers to the systematic study of language through a collection of naturally occurring spoken or written texts, collectively known as a corpus. These texts are analyzed using computer software to uncover patterns, structures, and usage trends in language (Biber et al., 1998). By providing a data-driven approach to language study, corpus linguistics facilitates objective insights into real-world language use. It plays a critical role in various linguistic subfields, including syntax, semantics, pragmatics, and sociolinguistics. Researchers and educators use corpora to explore frequency distributions, collocations, concordances, and other linguistic phenomena, which can inform theoretical frameworks and practical applications, such as curriculum design and lexicography. This methodology has gained traction due to its ability to process large datasets, revealing subtle trends and variations that may not be evident in smaller, manually analyzed samples.

There are several types of corpora, each tailored to specific research or educational objectives. Four commonly utilized types in educational settings are generalized, specialized, learner, and pedagogic corpora. A generalized corpus offers a broad representation of everyday language use across diverse contexts. Notable examples include the British National Corpus (BNC) and the Corpus of Contemporary American English (COCA), which encompass a wide range of genres, topics, and registers (Dash, 2010). A specialized corpus narrows its focus to specific domains, such as academic writing, legal language, or communication. This type is particularly prevalent

in English for Specific Purposes (ESP), where the goal is to equip learners with domain-relevant vocabulary and language skills (Bennett, 2010). A learner corpus consists of texts produced by language learners, offering insights into their linguistic capabilities and challenges. By analyzing these corpora, researchers can identify patterns in errors, developmental trends, and the influence of first languages on second language acquisition (Vaughan & O'Keefe, 2015). Finally, a pedagogic corpus is created specifically for educational purposes, drawing from instructional materials, such as textbooks, assignments, and exams. This type of corpus helps educators highlight linguistic features that are most useful for learners, ensuring that teaching materials align closely with students' needs and proficiency levels (Biber & Reppen, 2002). In this study, the researchers created a specialized corpus to develop an English technical word list for Thai ATCOs.

In the field of air traffic management, several spoken-language corpora based on air traffic control communication have been developed. For example, the Air Traffic Control Simulation Speech (ATCOSIM) corpus was created by Hofbauer et al. (2008), which used the TableTrans program to transcribe spoken interactions of ATCOs during real-time simulation. The corpus resulted in 108,883 words and an accuracy of 99.4% transcription accuracy. Similarly, the ATCO2 corpus developed by Zuluaga-Gomez et al. (2022) aimed to address the shortage of annotated data in the air traffic control field. Its primary goal was to support advancements in automatic speech recognition (ASR) and natural language understanding (NLU) for ATC communication. The corpus was developed as a collaboration between the Clean Sky 2 Joint Undertaking (JU) and EU-H2020. The data were collected from very-high frequency (VHF) radio transmissions. The corpus resulted in three sub-sets: the ATCO2-PL-set corpus containing 4 hours of ATC speech, ATCO2-test set corpus containing 5,281 hours of unlabeled ATC data from automatic transcripts, and a subset called ATCO2-test-set-1h corpus containing one-hour subset from the original test set corpus.

Previous studies have focused on spoken corpora derived from air traffic control communications during both in simulations and real-time interactions between ATCOs and pilots. However, there has been relatively little attention given to written corpora developed from ICAO Annexes. This represents a gap considering the potential of the corpus to support safety outcomes. Developing a written corpus from ICAO Annexes could play a valuable role in creating a specialized word list for Thai ATCOs. These Annexes are essential to the day-to-day responsibilities of

ATCOs, as they contain the SARPs and operational guidelines that are based on their work. Focusing on written language was an intentional decision since it reflects how ATCOs typically interact with ICAO regulations and documentation. A written corpus would help identify the key vocabulary needed for tasks, such as interpreting ICAO standards, drafting reports, and ensuring compliance with international aviation regulations.

Word Lists and Vocabulary Teaching

Vocabulary plays a crucial role in developing learners' English language skills, especially in reading skills. To be specific, when learners expand their vocabulary, they can comprehend and interpret texts effectively. For example, word lists like the General Service List (GSL) provide learners with a coverage of 80% of words in general written texts, so they enhance their ability to understand ideas and read fluently (Kwary & Jurianto, 2017; Nesi, 2002). Moreover, academic or technical word lists enhance their ability to understand specialized texts (Kwary & Jurianto, 2017).

There are various methods that can help expand learners' vocabulary, such as extensive reading and the use of technology to analyze language patterns (Liu & Zhang, 2018; Siddiq et al., 2021). Creating word lists is also considered an effective approach to build their vocabulary. Word lists are designed to identify essential words that learners must know. The purpose of word lists in vocabulary learning is to provide high-frequency or context-specific terms that serve learners' needs (Kwary & Jurianto, 2017).

Word lists play a crucial role in English language teaching in several ways, such as course design, material development, test development, and specialized dictionaries. According to Nation (2016), instructors can use word lists to design vocabulary teaching programs and vocabulary test construction. Those word lists can assist in designing courses and identifying essential vocabulary to be included in the syllabus. For example, they enable the priority of high-frequency or subject-specific words ensuring students focus on relevant language usage for their goals. Learning materials can be created from word lists, such as textbooks, reading passages, and vocabulary exercises that align with the learners' proficiency levels. Tests can be made to ensure that exams evaluate learners' knowledge of practical and essential terms. Customized dictionaries based on word lists can be developed to suit specific learner groups because these dictionaries highlight essential terms and provide usage examples to facilitate better understanding and application of vocabulary (Nesi, 2002).

In light of these considerations, further research is needed to develop a word list to use during ATCO training. A specialized word list of aviation technical terms can serve as the foundation of the curriculum, ensuring learners master the vocabulary necessary for clear and standardized communication. This application demonstrates the vital role of word lists in fostering effective vocabulary acquisition, particularly in specialized fields like air traffic control, where precision in language is important.

Criteria for Developing Word Lists

Researchers employ a diverse array of criteria to systematically develop word lists according to different purposes in different fields. For instance, Kim and Lee (2019) constructed the Linguistic Academic Vocabulary List (LAVL) to support university level EFL students in acquiring lexical knowledge to enhance their academic literacy. The researchers developed the Linguistics Textbooks Corpus (LTC) and adopted three criteria from Hsu (2014) to create the LAVL, including specialized occurrence, range, and frequency. Specialized occurrence refers to word families that appeared beyond the first 2,000 word families. Range denotes words that must appear in at least three textbooks out of the five selected textbooks. Frequency pertains to words that appeared at least 17 times across the textbooks in the LTC.

Rungrueang et al. (2022), on the other hand, proposed five detailed criteria to develop a word list based on multiple scholars including Coxhead (2000), Lei and Liu (2016), Laosrirattanachai and Ruangjaroon (2020), Muñoz (2015), Tangpijaikul (2014), Watson Todd (2017), West (1953), and Yang (2015). The five key criteria are frequency, range, lexical profiling, keyword analysis, and expert viewpoints. First, frequency refers to how often a word appears in a corpus. This criterion is in accordance with Coxhead setting a threshold of 100 occurrences in a 3.5-million-word corpus. However, frequency alone is insufficient, as longer text segments may weaken results (Laosrirattanachai & Laosrirattanachai, 2021). Second, range considers how widely a word appears across multiple sources. Words that appear in at least 50% of the sources are considered board-range words and are included. In contrast, narrow-range words are excluded. Third, lexical profiling helps eliminate irrelevant words that appear in existing referent word lists like the General Service List (GSL) and Academic Word List (AWL). Fourth, keyword analysis identifies words with special meaning or high relevance by comparing their frequency in the target corpus with a reference corpus and uses log-likelihood statistics to demonstrate significance. Lastly, expert viewpoints involve consulting

specialists in the field to rate the relevance of words on a four-point scale. The verification from those specialists ensures that only the most appropriate terms are included.

In comparison to the criteria employed by Kim and Lee (2019), the criteria suggested by Rungrueng et al. (2022) include an addition of three criteria: lexical profiling, keyword analysis, and expert viewpoints. These criteria allow the construction of the word list to be more technical and related to the field. Therefore, in this study, the researchers chose the criteria suggested by Rungreung et al. (2022) to create a technical word list for Thai ATCOs.

Related Studies

Developing a word list related to the aviation field has garnered attention from various researchers to help understand communication between aviation personnel. For example, Serpil (2017) created a word list to be used as self-study material for first-year students in the Airframe and Powerplant Maintenance Department of the Faculty of Aeronautics and Astronautics of Anadolu University. The researcher developed a corpus compiled from manuals called "Aircraft Characteristics" for Airbus 320, 321, and 330, collecting a total of 93,920 tokens. The researcher created an aircraft maintenance technical vocabulary list using the AntWordProfiler program and experts, resulting in 103 words. Similarly, Drayton and Coxhead (2023) created a corpus-based word list called the Tower Aviation Radiotelephony Technical Vocabulary List (TARTVL) based on the ICAO standard phraseology. The ICAO standard phraseology corpus was derived from ICAO documents, such as Doc 4444 and Doc 9432, taken from chapters related to communication with the air traffic control tower and transmissions with ATCOs. The TARTVL resulted in 274 words separated into five categories including technical words, numbers, multiword units, proper nouns, and acronyms.

In Thailand, research in various contexts had shed light on developing aviation-related word lists to serve the unique linguistic needs of the industry. Various research studies have created those word lists due to the importance of Aviation English and the need for specialized vocabulary to ensure effective communication and operational safety. For example, Laosrirattanachai and Ruangjaroon (2021) created three specialized word lists including the Tourism Business Word List (TBWL), Hotel Business Word List (HBWL), and Airline Business Word List (ABWL). Each word list was developed based on the specific language needs of professionals in these industries. Specifically, the ABWL was created for English for

Specific Purposes (ESP) learners in the airline business. This word list was developed from the Airline Business Corpus (ABC) which comprised 15,542,604 running words. The researchers employed a systematic methodology called the Six Filters (6Fs) to ensure the word list's relevance and precision. The first filter selected words that appeared at least 444 times within the corpus. This frequency threshold aimed to prioritize high-utility words. The second filter utilized the AntWordProfiler program to extract words that appeared in at least 50% of the sources within the corpus. This filter was employed to ensure widespread usage of the words across contexts. The third filter eliminated irrelevant words by cross-referencing them against established lexical resources, such as the General Service List (GSL), Academic Word List (AWL), Function Word List (FWL), Abbreviation List (AL), and Proper Name List (PNL). The fourth filter used the Key-BNC program to calculate log-likelihood values by comparing the ABC to the British National Corpus (BNC). This resulted in 6,758 significant words. The fifth filter utilized expert judgment from five industry professionals with over five years of experience in the airline business. They were required to evaluate the relevance of the selected words. This expert validation refined the word list to 245 terms which demonstrates the importance of practitioner input and ensures practical applicability. The last filter employed the VocabProfile program to categorize the words based on their difficulty levels which resulted in eight sub-word lists with 30 words each.

Another study was conducted by Thiankasem (2018). The researcher investigated the vocabulary that cabin crew needed to know to understand technical manuals. The researcher developed a corpus of 1,053,941 words from manuals for Airbus and Boeing aircraft as well as general cabin crew guidelines. This corpus was divided into three sub-corpora based on different operational contexts. Using the AntWordProfiler program, the study revealed that cabin crew needed to understand 4,629 word families to achieve 96.73% text coverage which is sufficient for effective comprehension. Moreover, the researcher developed the CREW-related English Word (CREW) List which comprised 590 word families.

Previous research studies have created a word list for aircraft maintenance, airline operations, and cabin crew communication. However, there is limited attention given to ATCOs' needs for technical vocabulary. Moreover, even though there are research studies related to ATCOs communication using standard phraseology, there is a lack of research studies for reading ICAO Annexes to enhance ATCOs understanding. This represents a significant gap, as air traffic controllers play a pivotal role in

ensuring aviation safety through precise and effective communication. To address this gap, the present study focuses on developing a specialized word list in the Air Traffic Management (ATM). By using a corpus-based approach and focusing on ICAO publications, this research aims to provide Thai ATCOs with a targeted linguistic resource that enhances their ability to comprehend and apply technical standards. The findings will ultimately contribute to safer and more efficient air traffic operations.

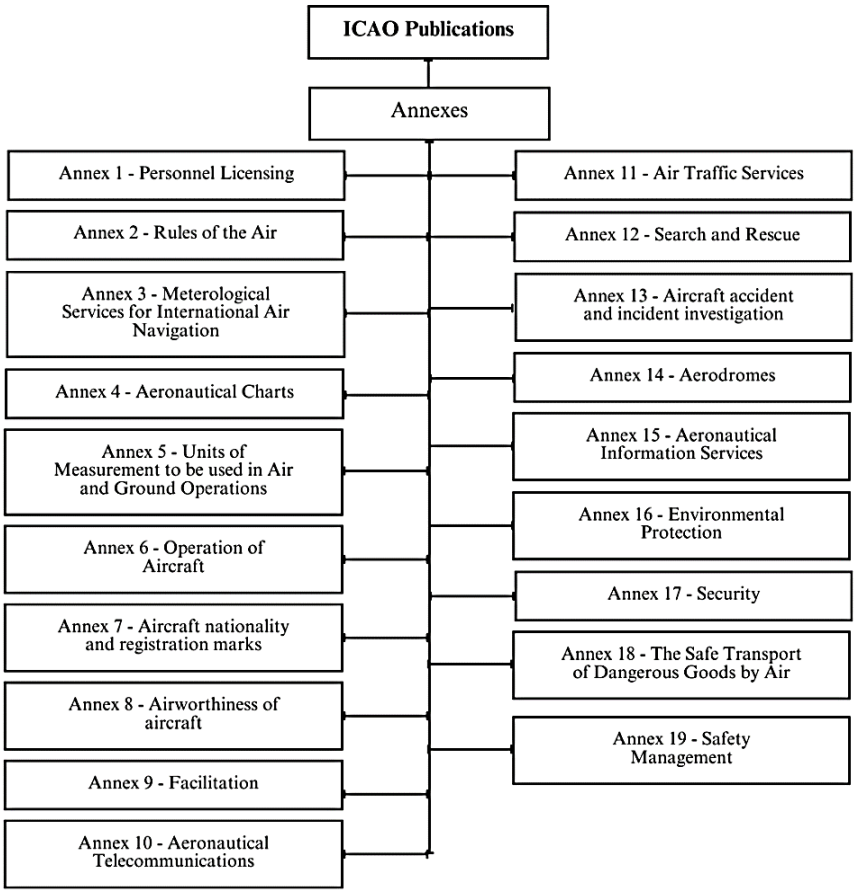
Method

Data Selection

The data were selected from ICAO Products & Services Catalogue 2024 under the section of Annexes to the Convention on International Civil Aviation, which contains 19 Annexes as shown below in Figure 1. Annexes are ICAO publications that further explain the Standards and Recommended Practices (SARPs), and Contracting States, country members of ICAO, need to follow SARPs for uniformity in regulations, standards, and procedures (Dib, 2022; ICAO, 2006). "Standards" are mandatory requirements that Contracting States must follow to reach the minimum level of safety and operational effectiveness as they provide aviation operations and are obligated to incorporate these standards in their national aviation laws. "Recommended Practices" are guidelines that Contracting States are encouraged to follow to enhance safety and efficiency.

ICAO Annexes were selected due to their fundamental role in ensuring global aviation safety and efficiency, and Contracting States are expected to implement them to ensure uniformity in regulations and procedures for seamless air navigation and operations worldwide. As the Annexes contain SARPs, Contracting States are required to adopt them under the Chicago Convention (1944) for uniformity in aviation regulations. These Annexes address fundamental areas and set baseline requirements related to aviation safety, airworthiness, air traffic management and other essential aspects of air transport. In contrast, the two other types of publications, PANS and Technical Manuals, only serve as a complementary, advisory function, offering guidance rather than imposing legally binding obligations. Thus, while PANS and Technical Manuals play a critical supporting role in ensuring operational efficiency, it is the ICAO Annexes that form a foundation of global aviation safety, regulatory compliance, and standardized implementation.

Figure 1
ICAO Annexes



ICAO Annexes consist of 30 ICAO publications in total. The 30 documents were selected online from the following websites: Federal Office of Civil Aviation (FOCA) (https://www.bazl.admin.ch) and International Civil Aviation Organization (https://www.icao.int). Notably, certain Annexes comprise multiple volumes (see Appendix A). For example, Annex 16 is divided into four volumes. These volumes show distinct environmental aspects, such as Aircraft Noise, Aircraft Engine Emissions, Aeroplane CO_2 Emissions, and Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), and they ensure focused guidance on specific areas. Thai ATCOs must familiarize themselves with these volumes to enhance operational safety and compliance with international standards. For instance, Annex 16 is essential for understanding and implementing

environmentally sustainable practice, thereby allowing ATCOs to support environmentally responsible operations, such as ensuring compliance with noise abatement procedures and managing CO_2 emissions reporting. Therefore, by understanding these Annexes, Thai ATCOs will foster safe and efficient air traffic management with global aviation standards.

Data Collection

The researchers downloaded the pdf form from both websites and uploaded it to AntFileConverter to become .txt files in one folder. The files were then imported into the AntConc program to generate a corpus. The Air Traffic Management (ATM) corpus consisted of 1,245,440 tokens and 13,861 types.

The word list was processed using the AntWordProfiler program based on the five criteria suggested by Rungrueang et al. (2022). These criteria are frequency, range, lexical profiling, keyword analysis, and expert viewpoints. *Frequency* is essential for ensuring comprehension and fluency by prioritizing commonly occurring words. *Range* is another relevant criterion as it helps eliminate biased words and reduce the word list size by ensuring that the words appear across a diverse range of sources to enhance their representativeness and broaden their applicability. *Lexical profiling* is a required criterion to remove irrelevant words from the General Service List (GSL) (West, 1953), the Academic Word List (AWL) (Coxhead, 2000), and Function Word List (FWL). *Keyword analysis* is a necessary criterion as it extracts words with specific meanings related to air traffic management from GSL and AWL. This ensures that the selected words are contextually relevant to the domain of interest. *Expert viewpoints* should be considered a key criterion as professionals within a specific industry possess the specialized knowledge necessary to evaluate the relevance of vocabulary. Their experience allows them to assess the words based on the real-world context to ensure the word list accurately reflects the language essential for effective communication within that field.

The first criterion was frequency. According to Coxhead's (2000) research, the development of AWL was set to a minimum of 100 times within the 3.5 million running word corpus in order to pass the frequency. The equation presented below is used for calculating the frequency.

$$x = \frac{100 \times corpus\ tokens}{3{,}500{,}000}$$

$$x = \frac{100 \times 1{,}245{,}440}{3{,}500{,}000}$$

$$x = 35.584$$

To meet this criterion, words must appear at least 36 times, with their frequency analyzed using the AntWordProfiler program. The words left would be considered in the second criterion.

Range was the second criterion which helps reduce the list size and eliminate biased words. According to Rungreuang et al. (2022), range evaluates how widely a word appears across different sources. A word with a wide range, meaning it occurs in at 50% of the sources, qualifies for further consideration (Coxhead, 2000, as cited in Laosrirattanachai & Ruangjaroon, 2021). Therefore, the words that appear in at least 15 sources would meet this criterion and be considered for inclusion in the word list. However, these words that appear in at least 15 sources must also occur at a minimum frequency of 36 times.

The third criterion was lexical profiling to ensure that words presented in the target word lists (e.g., the GSL, AWL, and FWL) are excluded by using the AntWordProfiler program. Consequently, the words that did not appear in those target word lists would pass this criterion.

The fourth criterion was keyword analysis to retrieve words from the reference lists that hold specific meanings relevant to the newly generated list. Based on Watson Todd's (2017) research, keyword analysis uses a log-likelihood statistic to identify words that appear significantly more frequently in the target corpus than in a benchmark corpus. To establish a cut-off point, Watson Todd focused on the 500 words with the highest log-likelihood (LL) values, drawn from a corpus of 1,150,000 tokens. The equation for calculating the cut-off point of this study is provided below.

$$x = \frac{500 \times corpus\ tokens}{1{,}150{,}000}$$

$$x = \frac{500 \times 1{,}245{,}440}{1{,}150{,}000}$$

$$x = 541$$

The first 541 words with the highest LL values meet the criterion for using the Key-BNC program. Out of those 541 words, only the words that passed the frequency and range criteria and appeared in the GSL and AWL would be considered meeting this criterion.

The fifth criterion was expert viewpoints where experts in a specific field assess the relevance of each word in the word list. The evaluation of the words was based on a four-point rating scale, following the framework proposed by Chung and Nation (2003). For this study, three air traffic management experts, each with over five years of experience, were consulted. Two of these experts currently serve as air traffic management instructors and one is an air traffic controller. A word's inclusion in the list required agreement from at least two experts rating the word either a 3 or 4, ensuring that each term was deemed significant and relevant.

Results

Frequency

The frequency analysis was conducted using the AntWordProfiler program, which resulted in 2,811 words that met the criterion of appearing at least 36 times. Among the first 50 highest-frequency words, the most frequently occurring were a mix of function words and content words.

Among the first 50 highest-frequency words, "aeronautical" is an example of the content word, appearing 2,781 times in the corpus. Below is an example of this word with context in ICAO publications.

Example: **Aeronautical** – relating to the science of designing, building, and operating aircraft (Cambridge, n.d.)

Annex 11: To ensure that aeronautical information services units obtain information to enable them to provide up-to-date pre-flight information and to meet the need for in-flight information, arrangements shall be made between aeronautical information services and air traffic services authorities responsible for air traffic services to report to the responsible aeronautical information services unit, with a minimum of delay.

Annex 19: Such personnel include, but are not limited to: flight crews; air traffic controllers; aeronautical station operators; maintenance technicians; personnel of aircraft design and manufacturing organizations; cabin crews; flight dispatchers, apron personnel and ground handling personnel.

Range

According to Coxhead (2000, as cited in Laosrirattanachai and Ruangjaroon, 2021), words that appeared in at least 50% of the sources will pass this criterion. Therefore, the words that passed the range criterion needed to appear in at least 15 sources of the total 30 sources. After evaluating both frequency and range criteria, a total of 247 words met the criteria. The words included both function and content words.

The following words are examples of content words that were found to have passed this criterion. There were three content words found in 15 sources: *message, lights,* and *elevation,* two content words in 16 sources: *fuel* and *instrument,* and four content words in 17 sources: *aeroplanes*, *errors*, *height,* and *messages.*

Lexical Profiling

Two hundred and forty-seven words passed the frequency and range criteria and were separated using the AntWordProfiler program as shown in Table 1.

Table 1
Percentage of Words That Passed the Frequency and Range Criteria

Word List	Number of Words	Percentage
1st 1,000 GSL	95	38.46%
2nd 1,000 GSL	21	8.50%
AWL	40	16.19%
FWL	60	24.30%
Out of list	31	12.55%
Total	**247**	**100%**

Thirty-one words passed lexical profiling, which are those not found in the GSL, AWL, and FWL, and examples are shown below:

aeronautical	*aircraft*	*annex*	*aviation*
icao	*navigation*	*guidance*	*pilot*
traffic	*aerodrome*	*aerodromes*	*emergency*
altitude	*vertical*	*meteorological*	

Keyword Analysis

This criterion considered the inclusion of words from the GSL and AWL justified by the fact that some vocabulary may have multiple meanings, which could be crucial for comprehensive understanding of the ICAO Annexes.

The cut-off point identified 541 words through the Key-BNC program. However, the word list was refined to only include words that appeared in both the GSL and AWL, reducing the total to 124 words.

After that, 31 words that passed lexical profiling were added, so combining 31 words from lexical profiling and 124 words from keyword analysis resulted in a total of 155 words. In those 155 words, there are some singular letters (e.g., b, c, d, etc.) which were omitted because they appeared in conditions and equations. However, abbreviations were kept (e.g., att, app, icao) because these abbreviations might be significant for the understanding of the ICAO publications. After cutting out the letters, a total of 141 words remained. These words were then given to the experts to check for the fifth criterion.

Below are examples of content words that passed this criterion:

aeroplane	*approach*	*authority*
centre	*communication*	*equipment*
flight	*ground*	*instrument*
lights noise	*operation*	*pressure*
radio	*service*	

Expert Viewpoints

The experts evaluated each word following a 4-point rating scale: "1" for words unrelated to the field, "2" for words pertaining minimal relevance to the field, "3" for words pertaining high relevance to the field, and "4" for words completely relevant to the field. Out of 141 words, words that received an average of at least 3 were retained and resulted in a total of 139 words (see Appendix B). There were two words omitted from these 141 words because they had a score below the average. Below are examples of the words that passed this criterion.

Example 1: **Aerodrome** – a defined area on land or water (including any building, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft (ICAO, 2005)

Annex 2: Pre-flight action for flights away from the vicinity of an aerodrome, and for all IFR flights, shall include a careful study of available current weather reports and forecasts, taking into consideration fuel requirements and an alternative course of action if the flight cannot be completed as planned.

Annex 10 Volume III: Non-aircraft transponders that are installed on aerodrome surface vehicles, obstacles or fixed Mode S target detection devices for surveillance and/or radar monitoring purposes shall be assigned 24-bit aircraft addresses.

Example 2: **Airworthiness** – the status of an aircraft, engine, propeller or part when it conforms to its approved design and is in a condition for safe operation (SKYbrary, n.d.)

Annex 1: Rules and regulations relevant to an aircraft maintenance licence holder including applicable airworthiness requirements governing certification and continuing airworthiness of aircraft and approved aircraft maintenance organization and procedures.

Annex 8: A Certificate of Airworthiness shall be renewed or shall remain valid, subject to the laws of the State of Registry, provided that the State of Registry shall require that the continuing airworthiness of the aircraft shall be determined by a periodical inspection at appropriate intervals having regard to lapse of time and type of service or, alternatively, by means of a system of inspection, approved by the State, that will produce at least an equivalent result.

Annex 13: Since flight recorder information can often reveal airworthiness problems, the State of Manufacture (or Design) should have a representative present when the flight recorder read-out and analysis are being conducted in a State other than the State of Manufacture (or Design).

Discussion

This word list will serve as a valuable resource for Thai ATCOs when consulting ICAO publications, helping them distinguish between technical terms and general English to ensure better comprehension and enhance safety. This word list is derived from the Air Traffic Management (ATM) corpus, a written corpus, unlike previous studies, which have primarily focused on spoken corpora. For example, the ATCOSIM corpus, developed by Hofbauer et al. (2008), was based on spoken data collected from real-time recordings of ATC simulations.

Interestingly, although the word list in this study was created for ATCOs like the word list created by Drayton and Coxhead (2023), the objective of using the word list is totally different. Their study intended to create the word list for the purpose of understanding spoken aviation

radiotelephony communication, whereas the researchers of this study created the word list for ATCOs, especially those who are Thai, to understand ICAO Annexes. This can be concluded that this study fills a critical gap in promoting clear understanding of written ICAO publications. The word list in this study resulted in 139 words and revealed the linguistic characteristics of the ICAO Annexes. The words highlight the specialized and technical nature of the language used in the SARPs that Contracting States must follow. Moreover, those words reflect the concepts and operations that emphasize precision, safety, and global standardization within the SARPs.

This targeted vocabulary resource enhances the understanding and interpretation of the ICAO Annexes, ultimately supporting safer and more efficient air traffic operation. For example, some words in the word list, such as *area*, *authority*, *flight*, *instrument*, and *position*, are found in Annex 2 – *Rules of the Air*. By knowing the meanings of these words leading to an understanding of this Annex, Thai ATCOs will be able to follow the standardized framework to maintain global aviation safety. Another example includes *accordance*, *procedures*, *point*, *route*, and *traffic*. These words are found in Annex 11 – *Air Traffic Services*. By understanding these words provided in the word list, Thai ATCOs will understand this Annex and be able to effectively coordinate with pilots to prevent mid-air collisions and ensure orderly air traffic flow.

Additionally, some common words were unexpectedly found in the word list, such as *defined*, *figure*, *note*, *shown*, and *table*. This may be due to the nature of the ICAO Annexes, which contain numerous standards for the Contracting States. These words contribute to clarity and consistency, as ICAO publications include definitions, figures, notes, and tables that are shown to help visualize and interpret information effectively. However, there are some limitations from using criteria suggested by Rungrueang et al. (2022) to filter out irrelevant words as certain relevant words may have been unintentionally excluded. Some words are classified as general vocabulary, but in other contexts, they hold specialized meanings in aviation. For example, the word "*report*" which was excluded from the word list is typically associated with presenting information in a document. However, in the context of ICAO Annexes, this word refers to situations and conditions when pilots are required to report their position to ATCOs.

In 2015, as Thailand's aviation safety standards came under scrutiny, ICAO found 572 flaws regarding safety standards in Thailand; therefore, Thailand was given a red flag by ICAO (Shoowong, 2025). This resulted in the closing of the Department of Civil Aviation and replacing it with the Civil Aviation Authority of Thailand (CAAT). The red flag restricted

Thai-registered airlines from operating on international routes and expanding their network in other regions, significantly affecting Thailand's travel and tourism industry (Mahitthirook, 2015). To prevent future red flags, it is essential to improve aviation personnel's comprehension of ICAO standards. The implication of this research, therefore, has the potential to enhance Thai ATCOs' understanding of ICAO Annexes by providing them with the ATM word list. This word list can serve as a foundation to equip Thai ATCOs with the necessary vocabulary to accurately interpret ICAO Annexes and comply with the ICAO SARPs. Moreover, the word list offers valuable support for ATCO training programs, particularly those focused on building English proficiency in aviation. The resource would enable instructors to target essential vocabulary necessary for ATCOs to meet international safety and operational standards effectively. Strengthening language training in line with ICAO standards will help maintain Thailand's aviation safety and ensure regulatory compliance to international operations.

Furthermore, this word list can be useful for undergraduate students who study ATM programs. Based on the results of this study, although certain words (e.g., *area*, *centre*, *level,* and *recommended*) in this word list may initially seem general, their definitions acquire specific and nuance significance within the context of ATM. To support this, instructors can actively encourage students to engage with the word list, guiding them to recognize the relevance of these terms in professional practice. A recommended approach is to integrate vocabulary instruction with authentic materials, which not only familiarizes the students with the vocabulary but also helps them understand its practical application. By emphasizing the contextual relevance of this vocabulary, educators can help learners develop a more intuitive grasp of ATM discourse, ultimately preparing them for effective communication in real-world scenarios. Additionally, this word list could be integrated into English for Specific Purposes (ESP) courses, such as English for Air Traffic Management, within English major programs. These courses would provide English major students with the specialized vocabulary needed for careers in aviation. By emphasizing the contextual relevance of these terms, educators can help these students develop a stronger understanding for roles in the aviation industry.

Conclusion

In this research study, the researchers created an English technical word list aimed at helping Thai ATCOs to better understand ICAO publications. Specifically, we used a corpus-based approach to analyze a written corpus containing over 1.2 million words to identify 139 key technical terms used

in air traffic management. This ATM word list is presented differently from other existing aviation-related word lists since it illustrates words that are important for Thai ATCOs to understand ICAO Annexes. For example, Drayton and Coxhead (2023) created the Tower Aviation Radiotelephony Technical Vocabulary List (TARTVL) that focused on spoken phraseology. These words like *cleared, taxi, approach, caution,* and *approved* help ensure standardized communication between pilots and ATCOs that can lower risk of misunderstanding. However, this research study focused on the written text that appeared in the ICAO Annexes. Words such as *appropriate*, *ensure*, *necessary*, *recommended*, and *standard* appear frequently and show the procedural and regulatory tone of air traffic management. While both studies contribute useful word lists, they both serve different purposes and functions.

This study also highlights the importance of introducing training programs in Thailand in order to help ATCOs gain better proficiency in understanding these terms. Having a better grasp of these vocabulary words can make it easier for them to understand and comply with international aviation standards. The word list was created to focus on the specific language that ATCOs need when working and need to cohere with ICAO SARPs. By including the word list in training programs, it could help reduce misunderstandings related to language that can cause safety risks. Focusing on technical vocabulary allows Thai ATCOs to communicate more clearly during operations and minimize risks in miscommunication. This specialized resource supports international aviation safety goals and ensures that Thai ATCOs are better equipped for international cooperation. While the word list addresses current language challenged, it could also open the door for long-term improvements in how aviation language training is taught in Thailand. Furthermore, these findings may be useful for other non-English speaking countries as well, including those looking to improve their ATCOs' understanding of ICAO publications that can lead to safe communication within air traffic management.

One notable limitation of this study is that this word list has not yet been tested with Thai ATCOs, so the researchers still do not know its effectiveness in practical usage. Additionally, as aviation language is always evolving, the technology and procedures may change which can cause some of the terms on the list to become outdated over time. For this reason, future research should try to use the word list in real-world training settings to test the effectiveness and provide feedback for improvement. To ensure the relevance of the technical vocabulary in the word list, it should be updated periodically, Additionally, this research study can be

extended to include more ICAO publications. For example, adding publications from sources such as Procedures for Air Navigation Services (PANS) (Doc 4444 - *Air Traffic Management*), Technical Manuals (Doc 9868 - *Procedures for Air Navigation Services: Training*), and Circulars (Cir 323 - *Guidelines for Aviation English Training Programmes*). These documents allow more coverage in other aviation areas, as the word list can be expanded to support not just ATCOs, but also pilots, aircraft maintenance, and dispatchers. Another promising area for expansion would be testing the word list in ATCO training programs or ESP courses to assess if it helps learners to better understand the materials. Researchers could investigate real-life incident reports or safety reviews to explore whether vocabulary contributed to errors in operations or safety concerns. Expanding the study in these directions allows a deeper understanding of how language affects air traffic management and can contribute to better and safer training programs.

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Appendices

Appendix A
ICAO Annexes and Volumes

Annex	Volume
1	-
2	-
3	-
4	-
5	-
6	I International Commercial Air Transport - Aeroplanes II International General Aviation - Aeroplanes III International Operations - Helicopters
7	-
8	-
9	-
10	I Radio Navigation Aids II Communication Procedures including those with PANS status III Communication Systems IV Surveillance and Collision Avoidance Systems V Aeronautical Radio Frequency Spectrum Utilization VI Communication Systems and Procedures Relating to Remotely VII Piloted Aircraft Systems C2 Link
11	-
12	-
13	-
14	I Aerodrome Design and Operations II Heliports
15	-
16	I Aircraft Noise II Aircraft Engine Emissions III Aeroplane CO_2 Emissions IV Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)
17	-
18	-
19	-

Appendix B
Air Traffic Management (ATM) Word List

1	accordance	2	aerodrome
3	aerodromes	4	aeronautical
5	aeroplane	6	aeroplanes
7	air	8	aircraft
9	airworthiness	10	altitude
11	annex	12	app
13	appendix	14	applicable
15	application	16	approach
17	appropriate	18	approved
19	area	20	associated
21	attachment	22	authority
23	available	24	aviation
25	centre	26	certification
27	chapter	28	characteristics
29	code	30	communication
31	communications	32	conditions
33	contained	34	contracting
35	control	36	coverage
37	crew	38	data
39	defined	40	design
41	distance	42	doc
43	elevation	44	emergency
45	engine	46	ensure
47	equipment	48	error
49	established	50	field
51	figure	52	flight
53	following	54	frequency
55	ft	56	fuel
57	ground	58	guidance
59	height	60	icao
61	include	62	including
63	information	64	instrument
65	intended	66	international
67	landing	68	level
69	lights	70	line
71	link	72	manual
73	mass	74	material
75	maximum	76	measurement
77	message	78	messages
79	meteorological	80	minimum

81	mode	82	navigation
83	necessary	84	noise
85	note	86	operating
87	operation	88	operational
89	operations	90	operator
91	part	92	pilot
93	point	94	position
95	practices	96	pressure
97	procedure	98	procedures
99	protection	100	provide
101	provided	102	provisions
103	radio	104	range
105	recommendation	106	recommended
107	reference	108	related
109	required	110	requirements
111	route	112	runway
113	safety	114	service
115	services	116	shown
117	signal	118	specific
119	specifications	120	specified
121	speed	122	standard
123	standards	124	state
125	states	126	station
127	surface	128	system
129	systems	130	table
131	traffic	132	transmission
133	type	134	unit
135	units	136	value
137	vertical	138	visual
139	volume		