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The ICAO English Language Proficiency Rating Scale Applied to Enroute Voice Communications of U.S. and Foreign Pilots

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16. Abstract

This is the third and final report in a series that examined communications between pilots and air traffic controllers during en route operations. The first report examined message complexity and message length as factors associated with communication problems (e.g., readback errors (RBEs), requests for repeats (RfR), and breakdowns in communication (BIC).

The second report examined these same communication problems by differentiating between pilots flying U.S. - and foreign-registry aircraft. Aircraft call signs were used to classify transmissions by aircraft registry (U.S.-English, Foreign-English, Foreign-Other). Language proficiency was identified as a factor for 66/90 (73%) communication problems among foreign aircraft and for 56/191 (29%) involving U.S. aircraft. However, there was no mention of the level of proficiency among these pilots.

This report examined the language proficiency among these controllers and pilots by applying the International Civil Aviation Organization (ICAO) language proficiency scales to the messages of pilots flying U.S. - and foreign-registry aircraft. The previously identified communication problems were re-examined and rated according to ICAO's six dimensions of language proficiency (pronunciation, structure, vocabulary, fluency, comprehension, interaction) by a certified rater. Each dimension receives a grade ranging from 1 (Pre-Elementary) through 6 (Expert). Approximately 94% of the pilots received an overall language proficiency rating (LPR) of 5 (Extended) because one or more of their utterances was graded Extended. The remaining 13 pilots' LPR was 4 (Operational), 12 of whom flew Foreign-Other registry aircraft.

Among U.S. English communication problems, 50% were RBEs, and 33% were RfR. Foreign-Other communication problems were 57% RfR, 44% of which were made by pilots with an overall rating of Extended. Furthermore, 21.4% of the Foreign-Other communication problems were RBEs, and 14.3% were from pilots with an overall LPR of Extended.

CONCLUSIONS: ICAO requires its Contracting States to test their aviation personnel for language proficiency. Failure to reach the Expert level will require retesting at least once every 3 years if the test results place the pilot at Operational or every 6 years if Extended. This standard is designed to improve the ATC communication process and is likely to reduce the incidence of miscommunications.

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CONTENTS

The ICAO English Language Proficiency Rating Scale Applied to Enroute Voice Communication of U.S. and Foreign Pilots

Clearance Delivery: "… Ground is on one two one point niner."
Pilot: "I'm sorry… I'm very new and you said it so quickly, in such a strong accent. I just don't understand…."

— ATC communication

"I'm sorry… I'm very new and you said it so quickly, in such a strong accent. I just don't understand…." This pilot's response provides several indicators involved in language comprehension – expertise, speech rate, and intelligibility. Expertise facilitates comprehension by providing the framework (prior knowledge) for understanding new information. Pilots who fly regularly into a particular airport develop mental maps of the runways, taxiways, terminals, and ramps and use this stored representation to guide them during surface operations. They also develop knowledge structures regarding airport operations such as air carrier and general aviation demographics, as well as controller performance and expectations. Pilots new to that airport cannot draw upon these internal representations because they do not exist or are only partially represented (from studying maps, procedures, and other preflight preparations). Instead, they must rely more on external maps and controller guidance to get from a particular ramp to a runway and then back again.

Prior knowledge also facilitates the processing of utterances — taking in the voice stream, parsing it into meaningful sounds, forming words, phrases, clauses, and sentences leading to understanding. For the fluent pilot who possesses the requisite internalized mental maps and mental representations, these skills appear automatic and understanding is effortless (McClelland, Mirman, & Holt, 2006). For pilots who are less fluent, new to the area, or both, these normally automatic language processes seem to slow down. In fact, a normal speech rate may seem to be rapid because the pilot must take in new information and attempt to understand it without the benefit of flight and language experiences (Massaro, 2001). As these internal representations develop, the pilot's subjective perception of speech rate might change from rapid to normal delivery.

In a similar fashion, the pilot's lack of familiarity with the local accent also may slow down decoding processes. Particular sounds create phonemes (basic consonant vowel clusters, Liberman, Harris, Hoffman, & Griffith, 1957) that, when combined in particular sequences, form words. For fluent pilots who possess the requisite knowledge, accent might have less of an effect on their ability to extract and combine phonemes into meaningful sounds, compared with pilots who are less fluent, lack requisite knowledge, or both (Lisker & Abramson, 1970; Abramson & Lisker, 1970). In fact, Lisker and Abramson (1970) suggested that listeners become more sensitive to phonetic differences in their own language that play a functional role in their language, become less sensitive to differences that do not, or both (for a more complete review see Diehl, Lotto, & Holt, 2004).

As Walcott (2006) pointed out, "It is not enough to simply have knowledge: one needs to understand what one knows and be able to communicate it. This ability to communicate what one knows is what determines 'competence.'" This applies equally to both pilots and air traffic controllers. For a pilot to successfully communicate with air traffic control requires more than the ability to parrot back the information transmitted by that controller; it requires competency in the language of aviation. A cursory examination of the pilot's response to clearance delivery suggests expertise, speech rate, and intelligibility exert an effect on understanding. Both the speaker and receiver must be effective communicators.

Non-native English-speaking pilots are at a disadvantage flying into countries where their primary or native language is not spoken.[1] Not only must they be able to understand spoken English, the language of aviation, but also speak it when communicating with air traffic controllers whose primary or native language may not be English. Given that some non-native English-speaking pilots had a limited ability to communicate with controllers led some non-English speaking commercial airlines to include an interpreter as part of the flight crew who could communicate directly with air traffic control (ATC) should the need arise. In other cases, they hired native English-speaking pilots who could no longer fly commercially for U.S. airlines because they were 60 yrs old (Age 60 Rulemaking Committee, 2006; currently § 121.383(c) of Title 14, Code of Federal Regulations).

Another disadvantage for non-native English-speaking pilots is the disparities between the phraseology adopted by a particular International Civil Aviation Organization

[1]It may be that the official language of the country is English, but the primary language spoken by the pilot is not.

Table 1. Examples of UK differences to ICAO radiotelephony procedures

Details of ICAO/UK Difference	Reason/Remarks
Phraseology **FLIGHT LEVEL ONE ZERO ZERO** (ICAO) is not used in UK. In the UK, flight levels ending in hundreds are transmitted as **HUNDRED e.g. FLIGHT LEVEL ONE HUNDRED.**	To avoid potential confusion with adjacent flight levels and misidentification of cleared levels, e.g., FLIGHT LEVEL ONE ZERO ZERO with FLIGHT LEVEL ONE ONE ZERO.
Phraseology "**CLEARED FOR ILS APPROACH**" is used in the UK only for self-positioned approaches. For radar-positioned ILS approaches in the UK, pilots will be instructed: **"When established on the localiser,† descend on the glidepath..."**	Due to procedure design and airspace complexity, along with lessons learned from flight safety-related incidents and occurrences, the UK has elected to enhance safety by adopting unambiguous phraseology that includes a positive descent instruction to ensure that descent is initiated only when it is safe to do so.

†The spelling is taken from the *CAP 413 Radiotelephony Manual* 17th Edition.

(ICAO) member state and the standard phraseology supported by ICAO. For example, the ICAO standard phraseology for an aircraft that is instructed to wait on an active runway for its departure clearance is "line up and wait." However, U.S. air traffic controllers use the phraseology "taxi into position and hold." This phraseology may not be familiar to foreign pilots departing from U.S. airports.[2]

Other examples are provided in Appendix 1 of the United Kingdom's (UK) Civil Aviation Authority's publication *CAP 413 Radiotelephony Manual* (July 2008). It provides a table that details the ICAO/UK differences in radiotelephony procedures and phraseology. Presented in Table 1 is an excerpt from that table. The first column illustrates two examples of the differences between the phraseologies, and the second column provides the UK's reason for not complying with ICAO.

In response to a United States Congressional request put forth by Representative Bob Franks in 2000, U.S. Inspector General Kenneth Mead undertook an investigation to determine the prevalence of international pilots flying in U.S. airspace who are unable to communicate with air traffic controllers due to inadequate knowledge of the English language and how it might affect aviation safety. The findings contained in the response noted that from January 1997 to August 2000, the FAA recorded a total of 16 of 309 *pilot deviations* (approx. 5%) nationwide that were attributable to language or phraseology problems between pilots and air traffic controllers.

In 2004, ICAO, an agency of the United Nations, published Document 9835, *Manual on the Implementation of ICAO Language Proficiency Requirements,* in response to several accidents[3] and incidents where language proficiency was cited as being either causal or contributing factors. In that same year, the APANPIRG ATM/AIS/SAR Sub-Group[4] (ATM/AIS/SAR/SG/14) presented the ICAO Secretariat with a document entitled, Language Proficiency. It stipulated, "Therefore, pilots on international flights shall demonstrate language proficiency in either English or the language used by the station on the ground. Controllers working international services shall demonstrate language proficiency in English as well as in any other language(s) used by the station on the ground" (para 2.4). Likewise, pilots are governed by Annex 10 ICAO that establishes the rules under which pilots and controllers, who are not conversant in each other's native language, can communicate. Specifically, § 1.2 of Annex 10 states:

"The primary means for exchanging information in air-ground communications is the language of the ground stations, which will in most cases be the national language of the State responsible for the station." And paragraph 5.2.1.1.2 recommends, "That where English is not the language of the ground station the English language should be available on request, thereby, the recommendations of the Annex indicate that the English language will be available as a universal medium for radiotelephone communications."

[2]On Sep 25, 2008 Captain John Prater, President, Air Line Pilots Association International, addressed the U.S. House of Representatives Subcommittee on Aviation Committee of Transportation and Infrastructure. In his report, the FAA was cited for adopting the ICAO phraseology, "line up and wait" and he encouraged the FAA to adopt the runway crossing phraseology of ICAO.

[3]As an example, in 1990 Avianca Flight 52, making its third approach into JFK Airport, failed to inform air traffic control that they had a fuel emergency, and crashed.

[4]Air Traffic Management/Aeronautical Information Services and Search and Rescue (ATM/AIS/SAR) Subgroup of APANPIRG (Asia Pacific Air Navigation Planning and Implementation Regional Group).

In March 2008, ICAO implemented its language proficiency requirements. Specifically: "Aeroplane and helicopter pilots and those flight navigators who are required to use the radio aboard an aircraft shall demonstrate the ability to speak and understand the language used for radiotelephony communications."[5] Likewise, "Air traffic controllers and aeronautical station operators shall demonstrate the ability to speak and understand the language used for radiotelephony communications."[6] To retain their respective licenses, pilots, navigators, controllers, and station operators must demonstrate a minimum of an Operational Level 4 in speaking and understanding. Failure to reach Operational Level 6 language proficiency will require retesting at least once every three years (Operational Level 4) or every six years (Operational Level 5). The time interval for retesting is determined by the interviewee's demonstrated ICAO operational level of language proficiency in both speaking and understanding.

The criteria for evaluating ICAO language proficiency are provided in the *Manual on the Implementation of ICAO Language Proficiency Requirements* (2004). There are six levels of operational proficiency ranging from pre-elementary (Operational Level 1) through expert (Operational Level 6). There are six dimensions of proficiency that are evaluated:

- Pronunciation (pronunciation, stress, rhythm, and intonation),
- Structure (grammar, sentence patterns, global –meaning errors, local errors),
- Vocabulary (style, tone, lexical choices which correspond to context and status, idiomatic expressions, and express subtle differences or distinction in expression, meaning),
- Fluency (naturalness of speech production, absence of inappropriate hesitations, fillers, pauses that may interfere with comprehension),
- Comprehension (clear and accurate information transfer that results in understanding), and
- Interactions (sensitive to verbal and non-verbal cues and responds to them appropriately).

Within the context of voice tape analysis, nonverbal cues would be limited to periods of silence beyond that of normal breathing and the expected periods of brief silence that occur at the end of a phrase, clause, or sentence.

In response to ICAO's language proficiency requirement, many commercial educational suppliers are rapidly developing instructional and testing materials for the aviation industry to meet the March 2008 timeline.[7] Likewise, many of the ICAO member states are busily establishing standards by which those instructional and testing materials will be evaluated. What is absent are data from which the effectiveness of those training programs can be assessed. That is, a need exists to describe, baseline, and document current operational communications prior to implementing ICAO language proficiency requirements, so future research will be able to determine if these requirements actually help to reduce the production of communication problems.

This is the third and final report in a series of reports examining pilot controller communication in the enroute environment. In the first report (Prinzo, Hendrix, & Hendrix, 2009) a detailed and comprehensive description was provided of 51 hrs of routine air traffic control (ATC) transmissions and how ATC message complexity and message length affected pilot readback performance. Five air route traffic control centers provided copies of ATC communications on digital audio tapes (DATs). Facility representatives selected the sectors and time samples that reflected the busiest international traffic periods for analysis. Communication problems were encoded that resulted in interference with ATC procedures, required plain language to resolve, or required assistance from other pilots or ATC to convey the message, or the encoder believed that communication had broken down. The results showed that message complexity had a statistically significant effect on the production of errors of omission only, while message length affected both the production of errors of omission and readback errors (substitution and transposition errors).

In the second report, Prinzo, Hendrix, and Hendrix (2008) used the same database to examine and record the prevalence of ATC readback errors, breakdowns in communication, and requests for repetition made by commercial U.S. and foreign airline pilots. No attempt was made to classify a speaker's utterance according to ICAO's six operational levels of language proficiency. However, the six dimensions of language proficiency (Pronunciation, Structure, Vocabulary, Fluency, Comprehension, and Interactions) were scored as either "0" = not a problem, or "1" = was a problem for pilot transmissions only, using the descriptors provided on the *ICAO Language Proficiency Rating Scale*. They reported English language proficiency was a factor in 75% of the identified

[5]Appendix A, *Manual on the Implementation of ICAO Language Proficiency Requirements.*

[6] Ibid.

[7]The 36th Assembly of ICAO (September 2007) urged Contracting States to accept in their own airspace until 5 March 2011, pilots from other States that are not in a position to comply with the language proficiency requirements by 5 March 2008 provided that the States that issued or rendered valid the licenses post their language proficiency implementation plans on the ICAO Flight Safety Exchange FSIX Website.

Expert	Extended	Operational	Pre-Operational	Elementary	Pre-Elementary
6	5	4	3	2	1

Figure 1. ICAO Levels of Language Proficiency

communication problems among the Foreign non-native English aircraft and 29% involving U.S.-English aircraft. Thus, while language proficiency was reported as a factor in communication problems, the *level* of language proficiency was not determined.

The purpose of the present report is to apply the six operational levels of language proficiency scales to communications problems using the same database as the two previous reports. By restricting the analyses to only identified communication problems, we should gain a better understanding between the operational levels of the language proficiency scales and communication problems.

METHOD

Subject Matter Expert

The first author has more than 14 years of experience analyzing pilot controller communications. The second author completed both the FAA 15005 Instructor Development training and Mayflower College's courses for language rating,[8] was part of the rating team for the automated Versant Aviation English Test, and currently provides aviation English training to controllers and flight personnel in the U.S. and the Middle East.

Materials

Audio Tapes. Each ATRCC was asked to provide 10 hrs of voice communications, for a total of 51 hrs of recording. DAT recordings were made at each facility using the NiceLogger™ Digital Voice Recorder System (DVRS) to record and time-stamp each transmission.

Each DAT contained separate digitized voice records of all communications transmitted on the radio frequency assigned to a particular sector position on the left channel. The right channel contained the Universal Time Coordinated (UTC) time code expressed in date, hour (hr), minute (min), and whole second (s). The NiceLogger™ Digital Voice Reproducer System (DVRS) decoded and displayed time and correlated it with the voice stream in real time.

ICAO Doc 9835. The Language Proficiency Rating Scale was taken from the ICAO Aviation Organization Document 9835, *Manual on the Implementation of ICAO Language Proficiency Requirements* (2004). Within each of the six dimensions are six levels of language proficiency that range from Level 1-through Level 6. As shown in Figure 1, Levels 1-3 are the below the target operational level. Level 4 is Operational, Level 5 Extended and Level 6 Expert.

Procedure

Data Transcription. One set of analogue audiocassette tapes was dubbed from each DAT and provided to the transcribers who used them to generate the verbatim transcripts. Onset and offset time, represented in hr:min:s preceded each transmission, as did the originating facility, sector, date, and transmission number.

FAA Order JO 7340.1Z Contractions (FAA 2007) was used as a reference in classifying U.S- English (e.g., American, Continental, Delta), Foreign-English (e.g., British Airways, Qantas), and Foreign-Other (e.g., Alitalia, Japan Air) registry aircraft according to the aircraft call sign. This was done for each pilot and controller transmission. Whenever a position relief briefing was performed, a new number was assigned for the controller taking control of the radio frequency. Just as call signs could be used to group pilots' transmissions, individual controllers were uniquely identified.

Grading Language Proficiency. To assign an operational level for each dimension of an utterance, the grader had a copy of the transcript to read while listening to it by means of the DVRS, a copy of the *ICAO Language Proficiency Rating Scales*, and a scoring sheet. To maintain grading consistency, one proficiency dimension was completed for the entire database before going on to the next dimension. Pilot and controller transmissions were completed in the following order: (1) pronunciation, (2) fluency, (3) comprehension, (4) interactions, (5) structure, and (6) vocabulary. The overall language proficiency of a given speaker was determined to be the lowest rating on any of the scales.[9]

The rationale was that greater consistency was achieved by concentrating on one proficiency dimension at a time. As a grader, there was more risk of inconsistencies creeping in by jumping from one proficiency dimension to another. Analyzing one proficiency dimension at a time resulted in each real time transmission being analyzed at

[8]Mayflower College is located in the United Kingdom.

[9]§2.8.4 Doc 9835 states, "… a person's proficiency rating level is determined by the lowest rating level assigned in any particular category."

Table 2. Composition of ATC and Flight Deck Transmissions Selected for Analysis

Speaker and Aircraft Registry	Noncodable	Codable	Total
ATC			
U.S.-English (n=1,011)	4.3%	64.1%	68.4%
Foreign-English (n=58)	.7%	3.2%	3.9%
Foreign-Other (n=409)	2.2%	25.4%	27.7%
Total Percent	7.2%	92.8%	100%
Flight Deck			
U.S.-English (n=1,057)	5.8%	63.9%	69.7%
Foreign-English (n=55)	.2%	3.4%	3.6%
Foreign-Other (n=404)	2.4%	24.3%	26.6%
Total Percent	8.4%	91.6%	100%

Table 3. Controller Utterances Presented by Aircraft Registry and English Language Proficiency Ratings

Aircraft Registry	P	S	V	F	C	I
U.S.-English (n=948 utterances)						
Expert	100.0%	100.0%	.1%	100.0%	100.0%	100.0%
Extended			99.9%			
Operational						
Foreign-English (n=47 utterances)						
Expert	100.0%	100.0%		100.0%	100.0%	100.0%
Extended			100.0%			
Operational						
Foreign-Other (n=376 utterances)						
Expert	100.0%	99.7%		99.7%	100.0%	99.7%
Extended		.3%	100.0%	.3%		.3%
Operational						

least six times each. In some instances they were listened to more than the minimum due to the speaker's language production skills, background noise, or because both rendered some transmissions more difficult to grade. Since all transmissions were digitally recorded and listened to on the DVRS, there were no sound distortions due to replaying.[10]

RESULTS

We performed a preliminary analysis on 3,006 pilot/controller real-time voice transmissions. Twelve were discarded because they either were unintelligible, involved only a microphone click, static, or did not have enough information present to grade. Three of the transmissions involved U.S.-English aircraft, and the rest involved Foreign-Other registry aircraft. One originated from ATC.

There were 234 additional utterances that contained structure and vocabulary elements deemed non-codable, and they were excluded from further analysis. These transmissions contained a common courtesy, general acknowledgment, aircraft call sign, or a combination. Table 2 shows the distribution of these transmissions according to the speaker of the transmission and aircraft registry. Approximately 7% of the ATC transmissions were discarded, of which 4.3% involved controller transmissions to U.S. registry aircraft. Likewise, approximately 8% of the transmissions from the flight deck were discarded, and nearly 6% were from pilots operating U.S. registry aircraft. This is not surprising given that nearly 70% of the ATC and flight deck transmissions involved U.S. registry aircraft.

Controller English Language Proficiency Ratings

There were 1,371 transmissions made by 58 controllers. Among this group of controllers, all but one received a rating of Extended and that was because ICAO LPR are determined from the lowest rating awarded on any of

[10]Rewinding analog tape causes it to stretch, which alters sound characteristics.

the six dimensions. An examination of the rater's notes indicated no problems with 80.5% of the controller's messages, and fillers such as "ummm" and "uh" appeared in 15% of their utterances. Other comments addressed speech rate, nonstandard phraseology, indistinct or otherwise unclear speech, as well as the presence of self corrections. None of these classifications accounted for more than 1.3% of the utterances.

As seen in Table 3, approximately 69.2% of the transmissions were to U.S.-English, 3.4% to Foreign-English, and 27.4% to Foreign-Other registry aircraft. All of the U.S. controllers' utterances received an Expert rating on pronunciation and comprehension regardless of the registry of the aircraft they were talking to. Only .1% of their utterances were awarded Expert on vocabulary, while over 99% were rated Extended. Variability in language proficiency among the controllers is seen by their transmissions to pilots operating Foreign-Other registry aircraft. Specifically, one controller was responsible for the ratings of Extended for structure and fluency, and a controller from a different enroute center was responsible for the rating of Extended for interaction. All of the controllers received an overall language proficiency rating of Extended because one or more of their utterances received a grade of extended.

Pilot English Language Proficiency Ratings

There were 206 different aircraft represented in the database (73% were of U.S.-English, 2% Foreign-English, 25% Foreign-Other). The pilots transmitted 1,414 messages to ATC.

As seen in Table 4, among the U.S.-English registry aircraft, 100% of the pilots' utterances were awarded Expert in structure, comprehension, and interaction while 99.4% achieved a rating of Expert for pronunciation and fluency. All of their utterances were rated as Extended in vocabulary. One aircraft was responsible for the four instances where pronunciation was rated Operational and fluency Extended. The pilot of another aircraft was responsible for the two additional ratings of Extended for fluency. In comparison, 100% of the utterances from pilots operating Foreign-English registry aircraft received an Expert rating on five dimensions and a rating of Extended in vocabulary. However, there were only 52 transmissions made by these pilots that were evaluated.

Notably, transmissions from pilots operating Foreign-Other aircraft showed greater variability in language proficiency. In particular, their utterances received ratings that varied from Expert to Operational on all but structure —of which slightly more than 93% received a rating of Expert. Approximately 65% of the transmissions were rated Expert for comprehension and 74% for interaction; 47% received a rating of Expert on pronunciation and fluency. Between 30% and 37% of their utterances were awarded Extended on pronunciation, fluency, and comprehension; and 23% on interaction. Nearly 23% of the pilots' pronunciation was awarded a rating of Operational. About 16% of their transmissions also received a grade of Operational on fluency, and only 3% were rated as Operational on comprehension and interaction.

Approximately 94% of the pilots of these 206 aircraft received an overall language proficiency rating of Extended because one or more of their utterances received a grade of Extended. The overall language proficiency of the remaining 13 pilots received a grade of Operational. Among these pilots, 12 flew Foreign-Other registry aircraft, and one flew for a U.S.-English registry aircraft. Although each of the five enroute facilities had at least

Table 4. Pilot Utterances Presented by Aircraft Registry and English Language Proficiency Ratings

Aircraft Registry	P	S	V	F	C	I
U.S.-English (n=969 utterances)						
Expert	99.4%	100.0%		99.4%	100.0%	100.0%
Extended	.2%		100.0%	.6%		
Operational	.4%					
Foreign-English (n=52 utterances)						
Expert	100.0%	100.0%		100.0%	100.0%	100.0%
Extended			100.0%			
Operational						
Foreign-Other (n=368 utterances)						
Expert	47.0%	93.5%	.5%	46.5%	64.9%	73.9%
Extended	30.2%	6.5%	99.2%	37.8%	32.1%	23.1%
Operational	22.8%		.3%	15.8%	3.0%	3.0%

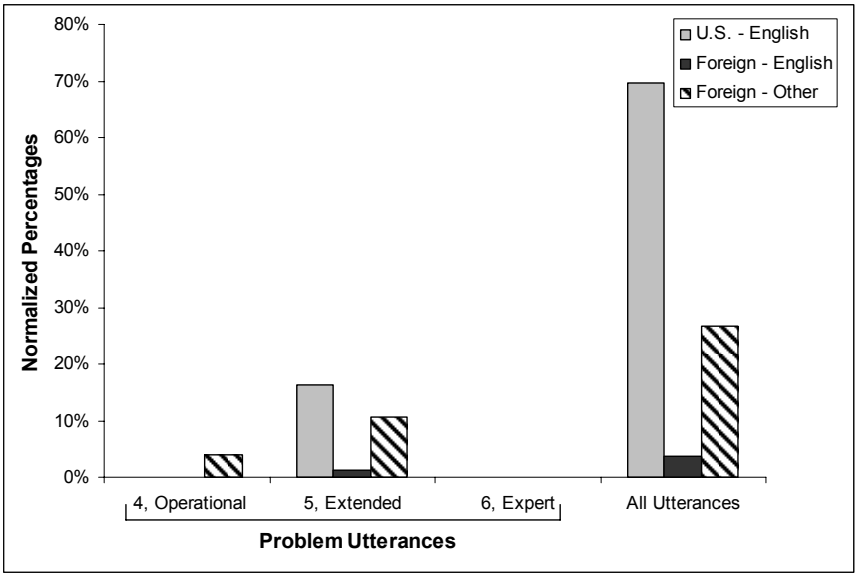

Figure 2. Normalized Distribution of Pilot Utterances and Communication Problems

one pilot with a proficiency rating of Operational, 46% were from Oakland, 23% from Los Angles, and 15% from New York Center.

Communication Problems and Pilot Language Proficiency Ratings

The normalized distributions of the pilots' utterances and communication problems are presented in Figure 2 according to aircraft registry and overall LPR. The data show that pilots with an Extended rating who flew U.S.-English registry aircraft made approximately 70% of the transmissions to ATC, of which 16.2% contained one or more communication problems. Pilots awarded an Extended-rating, flying Foreign-English registry aircraft, made 3.7% of the air-to-ground transmissions, and 1.1% contained a communication problem. Finally, pilots who flew Foreign-Other registry aircraft were responsible for 26.6% of the transmissions (Operational rating = 5.9%, Extended = 20.6%, Expert = .07%), 14.5% of which involved communication problems (Operational rating = 3.9%, Extended = 10.5%, Expert = .07%).

The 281 previously identified communication problems (Prinzo et al., 2008) were evaluated according to aircraft registry and overall language proficiency rating. To do this, each of the pilot's utterances was aggregated according to enroute facility, sector, sample, and aircraft call sign on each scale, and then the overall language proficiency rating was assigned using the *lowest* awarded rating across all the scales. The number of analyzed pilot transmissions (per flight segment) varied from three to as many as 20 (mean = 7.42 S.D. = 3.34).

As shown in Table 5, all but one of the pilots who flew U.S.-English registry aircraft had an LPR of Extended; that pilot's LPR was Operational. There were 192 identified communication problems, of which 190 had one problem and two had multiple problems. Of the single-problem transactions, 51% involved readback errors (RBEs), 34% requests for repeat (RfR), and 15% breakdowns in communication (BIC); 1% had multiple problems (both involved a BIC coupled with either a RBE or RfR).

All of the pilots who flew Foreign-English registry aircraft received a rating of Extended. There were five communication problems, of which 80% centered upon RfR and the remainder RBEs.

Among the group of pilots who flew Foreign-Other registry aircraft, 57% of their communication problems involved RfR, of which 45% were made by pilots with an overall rating of Extended. As a group, 21.4% of their communication problems were RBEs, and 14.3% were made by pilots with a rating of Extended. Slightly more than 8% of their communication problems involved multiple problems, of which 6% were made by pilots with a rating of Operational. Clearly, there was a greater dispersion in English language proficiency among pilots who flew foreign registry aircraft and had a language other than English as their primary language.

In Prinzo et al.'s (2008) report, an aviation subject matter expert coded utterances as either containing a language-based problem (assigned a value of "1") or not containing a problem (assigned a value of "0"). These data underwent further analysis to differentiate between pilots' utterances with (n = 450) and without (n = 964) English language proficiency problems according to each pilot's overall language proficiency.

As seen in Table 6, of all 1,414 pilot utterances, English language proficiency was implicated in 18.2% of the

Table 5. Percentage of Pilot Transmissions Involved in Communication Problems Presented by Aircraft Registry and Overall Language Proficiency Rating

Aircraft Registry by Overall ICAO Language Proficiency Rating	Type of Communication Problem			
	BIC	RBE	RfR	Multiple
U.S.-English (151 aircraft)				
Extended	15.1%	50.0%	32.8%	1.0%
Operational		.5%	.5%	
Foreign-English (5 aircraft)				
Extended		20.0%	80.0%	
Operational				
Foreign-Other (50 aircraft)				
Extended	7.1%	14.3%	45.2%	2.4%
Operational	6.0%	7.1%	11.9%	6.0%
Total Foreign-Other	13.1%	21.4%	57.1%	8.4%

Table 6. Percentages of all Pilot Utterances and the Role of Language Proficiency in Communication Problems Presented by Aircraft Registry and Overall Language Proficiency Ratings

Source	RBE	BIC	RfR	Multiple Problems	No Problems
U.S.-English					
ELP Not a Factor (n=757 utterances)					
Operational	0.1%	0.0%	0.1%	0.0%	0.1%
Extended	5.7%	0.8%	2.8%	0.1%	43.8%
ELP Was a Factor (n=229 utterances)					
Extended	1.1%	1.2%	1.6%	0.1%	12.2%
Foreign-English					
ELP Not a Factor (n=36 utterances)					
Extended	2.4%	0.1%	0.0%	0.1%	0.0%
ELP Was a Factor (n=16 utterances)					
Extended	0.9%	0.0%	0.0%	0.2%	0.0%
Foreign-Other					
ELP Not a Factor (n=171 utterances)					
Operational	1.6%	0.1%	0.1%	0.2%	0.0%
Extended	9.0%	0.4%	0.0%	0.7%	0.0%
Expert	0.1%	0.0%	0.0%	0.0%	0.0%
ELP Was a Factor (n=205 utterances)					
Operational	2.5%	0.3%	0.3%	0.5%	0.4%
Extended	7.5%	0.5%	0.4%	2.0%	0.1%
Expert	0.1%	0.0%	0.0%	0.0%	0.0%

communication problems (U.S.-English=4.0%, Foreign-English=1.1%, Foreign-Other=14.1%). Although an additional 12.7% of the utterances (U.S.-English=12.2%, Foreign-English=0.0, Foreign-Other=0.5%) were identified as containing problems in language proficiency, none contributed to any of the 281 communication problems.

The English language proficiency of the utterances made by pilots flying U.S.-English registry aircraft were involved in 1.1% RBE, 1.2% BIC, 1.6% RfR, and 0.1% multiple problems. Likewise, English language proficiency was a factor in 0.9% of the RBEs of pilots flying Foreign-English registry aircraft and 0.2% with multiple problems. Finally, among pilots flying Foreign-Other registry aircraft, English language proficiency was a factor among pilots awarded Operational, Extended, and Expert ratings. Among pilots awarded an Operational rating, English language proficiency was a factor in 2.5% of utterances involved in RBEs, 0.3% BIC, 0.3% RfR, and 0.5% with multiple problems. A similar pattern appeared for Foreign-Other pilots with an Extended rating – English language proficiency was a factor in 7.5% RBEs, 0.5% BIC, 0.4% RfR, and 2.0% multiple problems.

DISCUSSION

These data indicate that some of the pilots were more proficient in the English language than others.[11] Approximately 94% of them received an overall language proficiency rating of Extended. A closer examination of the data revealed that all of the pilots who flew aircraft for a country with English as its primary or official language received a grade of Extended on the vocabulary scale, and it was this grade that pulled down their overall ratings from Expert.

The same cannot be said of the pilots flying for countries whose primary or official language was other than English; their language proficiency showed much greater dispersion on five of the six scale –ranging from Expert to Operational (structure was limited to Expert and Extended). Of the pilots who flew these aircraft, 24% were awarded an Operational level of proficiency. (Overall, of the 13 pilots receiving an Operational level of proficiency 12 flew Foreign-Other registry aircraft.)

[11]There were 206 different aircraft represented in the database (73% were of U.S.-English, 2% Foreign-English, 25% Foreign-Other). Many of the pilots who flew into the five different U.S. enroute centers between March and August 2006 flew U.S.-English registry aircraft, and we assumed they were all familiar with U.S. air traffic control procedures and operations and that their primary language was English. The same cannot be said for all of the pilots flying non-U.S. registry aircraft. Furthermore, we could not ascertain their primary language from the voice tapes.

The results provided some evidence that English language proficiency was a factor in 30.8% of the pilot transmissions, and it was identified as a problem in 43.8% of the identified 281 communication problems. When teaching English to pilots, foreign language instructors may want to focus more time towards correcting errors in pronunciation and improving fluency. It is important that second language learners be able to detect and pronounce category clusters present in that language (Sakamoto, 2006). As this skill improves, nodes and pathways are created and associated with cortical structures responsible for language comprehension and production. By hearing the sounds, they should become better at producing these same sounds. Improvements in language production should lead to fewer transmissions from pilots and controllers who were not able to fully understand what was being said (e.g., *say again*, *what was that*?).

The data also indicated that although there were fewer foreign aircraft in the communications samples, proportionally, the pilots of these aircraft made more of the communication problems. Communication problems require more transmissions to resolve. For readback errors, the controller must reissue the original message and listen for the recitation of its contents. For requests for repeats, the request must be made followed by the repeat of the original message, followed by the readback. A breakdown in communication can involve many message exchanges between the controller and pilot until resolved (Prinzo, et al., 2009).

Of all 1,414 pilot utterances, English language proficiency was implicated in 18.2% of the transmissions that involved communication problems (U.S.-English=4.0%, Foreign-English=1.1%, Foreign-Other=14.1%). Although 12.7% additional utterances were identified as containing problems in language proficiency (U.S.-English=12.2%, Foreign-English=0.0, Foreign-Other=0.5%), they were not involved in any of the communication problems. Many of these utterances contained "Ahs," "Ums," and similar fillers (hesitation pauses). Since the majority of the pilots were awarded a rating of Extended, it is not surprising that they also made the most communication problems.

All of the enroute controllers received an overall language proficiency rating of Extended because one or more of their utterances received a grade of extended on one or more of the descriptors. On the ICAO linguistic descriptors, all (save vocabulary) received a rating of Expert because the controllers stayed within the constraints imposed by *FAA Order 7110.65, Air Traffic Control* (FAA, 2008). Even a cursory examination of FAA standard phraseology reveals that it is both limited in word choices and is highly structured. Rarely did the controllers deviate

Expert	Vocabulary
Level 6	Vocabulary range and accuracy are sufficient to communicate effectively on a **wide variety** of **familiar** and **unfamiliar** topics. Vocabulary is **idiomatic**, **nuanced**, and **sensitive** to register.

Figure 3. Guidance in Grading an Utterance at an Operational Level 6 for Vocabulary

ICAO Descriptor	ICAO Descriptors
Pronunciation	
6	**Almost never** interferes with ease of understanding
5	**Rarely** interferes with ease of understanding
4	**Only sometimes** interferes with ease of understanding
3	**Frequently** interferes with ease of understanding
2	**Usually** interferes with ease of understanding
Structure	
6	**Consistently** well controlled
5	**Sometimes** interferes with meaning
4	**Rarely** interferes with meaning
3	**Frequently** interferes with meaning
2	**Limited** control
Comprehension	
6	**Consistently** accurate
5	**Is** accurate
4	**Mostly** accurate
3	**Often** accurate
2	**Is** limited
Interaction	
6	Interacts with **ease**
5	Responses are **immediate**
4	Responses are **usually immediate**
3	Responses are **sometimes immediate**
2	Response time is **slow**

Figure 4. ICAO Descriptors are Subjective

from the recommended phraseology, and this resulted in their receiving a grade less than Expert.

Grading Issues: Lessons Learned Using the ICAO Language Proficiency Scales

The ICAO proficiency scale does produce some challenges when trying to grade recorded real-time pilot and controller communications. In particular, the ICAO language proficiency ratings will most often lead to a Level 6 - Expert – for native English speakers. Interestingly, the ICAO ratings seek to discriminate among only some of the many language strategies that native English speakers may employ.

Limited or Insufficient Voice Samples of a Speaker. Very short transmissions often can be impossible to grade under the ICAO descriptors because the transmissions may consist of only one or two words. Likewise, vocabulary usage was particularly difficult to grade because there was often not enough evidence on which to grade, especially at Level 6 – Expert.

In this analysis, most native English speakers attained a Level 6 – Expert in most areas of the language proficiencies according to the ICAO Language Proficiency Rating Scale. Figure 3 provides the guidance graders are to follow when awarding a Level 6. In the short transmissions, sufficient evidence of effective communication "…on a **wide variety** of familiar and unfamiliar topics" is lacking, for

example, and so the descriptors prevent awarding a Level 6 in this area. There was only one transmission where a controller spoke at length, which enabled the grader to award a Level 6 and it was, "ALRIGHT [NAME] CENTER'S BROADCASTING CONVECTIVE SIGMET SIX FIVE ECHO IT'S VALID UNTIL ZERO ONE FIVE FIVE ZULU IT'S FOR MAINE MASSACHUSETTS NEW HAMPSHIRE VERMONT CONNECTICUT NEW YORK AND CONNECTICUT COASTAL WATERS FROM TWENTY SOUTHEAST OF MIKE PAPA VICTOR TO …."

Lack of Quantification of ICAO Descriptors. Another challenge graders face when applying the ICAO standards to real-time pilot and controller voice communications is the language used within the ICAO descriptors themselves and the difficulty in applying them when awarding a grade. Figure 4 presents the descriptors, according to scale. The obvious difficulty is that the descriptors do not provide any quantitative information.

It would help graders to have quantifiable metrics when rating pilots, controllers, and other aviation personnel on their language proficiency. The ICAO descriptors may be a necessary first step in meeting the goals of the ICAO but may unavoidably introduce inconsistencies between graders. In particular, will graders use the same metric on which to determine what "almost never," "rarely," or "consistently" means? It is, therefore recommended that further research quantify the descriptors in practical terms. Once quantified, ICAO may want to review and then revise the descriptors.

Transmission Issues. While listening to the communications, transmission issues were found throughout the real-time pilot and controller transmissions; they are summarized in Table 7. The issues were categorized as (1) technical, (2) delivery, (3) language, and (4) communication issues; they were consistent throughout the different sectors and enroute centers. The technical issues involved radio/antenna interference, noisy frequency, and microphone technique. Some might be controlled by the proper use of headsets and adjusting volume controls. Others may be inherent with the equipment onboard the aircraft or installed at the enroute center. Aging equipment may be a factor, as well as the lack of a visual alert indicating the frequency is in use.

Speech delivery can be corrected through training and practice. Pilots and controllers may benefit from instructional and practical lessons similar to what radio and television announcers receive as part of their training. The same is true with proper language usage: colloquialisms, slang; pleasantries, although well meaning, may cause problems for those who are less proficient in the English language. All of these issues contribute to communication issues. In particular, mumbling, poor articulation, enunciation, and foreign accents contribute to the likelihood of communication issues. Likewise, sending too much information (too complex, too many instructions, or both; Prinzo et al., 2009) can lead to communication problems.

Table 7: Transmission Issues Found Across Enroute Sectors and Facilities

Technical	Speech Delivery	Language	Communication
Radio interference: Beginning of transmission End of transmission Entire transmission Noises: Popping Whistling Transmissions: Transmission stepped on Transmission too quiet First part cut off Last part cut off Transmission unintelligible Background noise	Too fast Too quiet Mumbling Heavily accented Poor pronunciation Running words together Numbers unclear Number correction Softening of words at the beginning of transmission Trailing off at the end of a sentence	Elision: G'day Fillers: Uh Um Ah Non standard phraseology: Yeah See ya Outta Gotta Vowels: poorly pronounced	Numbers unclear Number correction Too much information Number verification Accents

Recommendations

1. Increase awareness of the importance of good microphone techniques and the issues arising from the technical aspects of ATC delivery to reduce the technical challenges. Quality Assurance and training personnel should monitor facility voice tapes, and they should intervene when poor techniques are identified. Individual controllers should receive proper instruction to correct their problems.
2. Increase awareness of good/bad communication techniques and message receiving and delivery issues to improve message delivery among pilots and controllers. Quality Assurance and training personnel should monitor facility voice tapes and provide corrective actions to improve communication practices at their facilities.
3. Provide native and non-native English-speaking pilots and controllers with radio broadcast training programs to reduce the number of communication problems attributable to speech delivery. Listening to facility voice tapes may increase the awareness of these differences as part of the program. Also, software is available by which the speaker can pronounce words and phrases and have them appear on a computer screen along with a standard. By speaking the words and phrases repeatedly, their sample should match the standard.
4. Increase awareness of what native speakers do (e.g., elision,[12] use of non-standard phraseology, poor enunciation with everyday language) to improve ATC transmissions among pilots and controllers.
5. Conduct further research to quantify the ICAO descriptors in practical terms. Once quantified, ICAO may want to review and then revise the descriptors.

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[12]Elision is the omission of sounds, syllables, or words in spoken or written discourse. For example, "gimme" for "give me," "hafta" for "have to," and "g'day" for "good day."

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