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Excess Words, Partial Readbacks Score High in Analysis of Pilot-ATC Communication Errors

Roughly half of all communications by pilots and controllers included at least one communication error, in an analysis published in a U.S. report. The report recommended that controllers and pilots practice correct communication techniques.

Robert L. Koenig
Aviation Writer

Pilots and air traffic controllers need to improve their operational communications to avoid errors that can compromise flight safety, according to a recent U.S. Federal Aviation Administration (FAA) report.

The report, *An Analysis of Approach Control/Pilot Voice Communications*, noted that air safety often depends on the effective and accurate exchange of communication between pilots and controllers. Communication errors are often cited in operational errors, pilot deviations and midair near-collisions.

The report, written by O. Veronika Prinzo of the FAA Civil Aeromedical Institute (CAMI), was based on a detailed analysis of nine hours of voice communications involving pilots and air traffic controllers at three terminal radar approach control (TRACON) air traffic control (ATC) facilities. The analysis found that:

- Forty percent of the 2,500 controller "communication elements" (fundamental units of speech) examined included at least one communication error. The study suggested that air traffic controllers often omit key words that pertain to frequency, airspeed or approach/departure instructions; and,

- Fifty-nine percent of the 5,900 pilot communication elements examined included at least one communication error. The analysis indicated that pilots often only partially read back ATC instructions involving heading, radio frequency and airspeed. Some pilots also "group" heading, airspeed and radio-frequency numerical information.

Some communications occur in situations where there is little margin for error. "When ambiguities arise from poorly constructed messages, it is critical for pilots and controllers to transfer information to one another as quickly and as efficiently as possible, so as to maintain or re-establish a common ground of understanding and to maintain their margins of safety," the report said.

The report suggested that a "reduction in the frequency of operational errors, pilot deviations and [midair near-collisions] might be attainable if pilots and controllers used standard communication operational procedures and practices." Based on the analysis of pilot-ATC communications, the report recommended that controllers and pilots practice their communication techniques. The report suggested that:

- Controllers should practice transmitting complete radio frequency, airspeed and approach/departure instructions, and they should try to be more concise in delivering advisories concerning traffic and route/position; and,

- Pilots should practice transmitting complete altitude information in standard format to air traffic controllers. Many pilots also would benefit from additional practice in replying to traffic advisories.

Communication between pilots and air traffic controllers is a crucial factor in flight safety. According to data bases maintained by the FAA Office of Safety Information and Promotion (ASP-100), communication problems were cited as causal or contributing factors in 27 percent of the confirmed operational errors, in 40 percent of the pilot deviations and in 15 percent of the midair near-collisions reported in 1993, and the 1994 percentages were approximately the same. "Although the total number of each type of incident has decreased in 1994 from 1993's levels, the percentage of incidents with communications involved appeared to be constant," the report said.

[For a detailed discussion of miscommunication between pilots and air traffic controllers, see the FSF *Flight Safety Digest*, July 1995.]

Thirty-six percent of the total number of the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) full-form incident reports filed by pilots and controllers between 1988 and 1991 also listed faulty communication as contributing or causal factors in airspace incidents. "Collectively, the ASP-100 and ASRS data indicate that faulty communication is a significant factor in safety-related incidents," the report said. The CAMI study's main purpose was to develop baseline data on typical controller and pilot voice communication.

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Researchers analyzed transcripts of nine hours of TRACON audiotapes of ATC-pilot communications. The tapes were provided by two level-5 TRACON facilities (designated as TRACON-1 and TRACON-2) and one level-4 facility (designated as TRACON-3). [FAA-designated levels are based on traffic density at a terminal, with level-5 facilities handling the most traffic.]

Previous studies analyzed ATC-pilot communication, but until recently, researchers had not used FAA Order 7110.65, *Air Traffic Control*, which sets standards for ATC verbal communications, as the basis for their analysis.

In 1995, Prinzo and two other researchers, Britton and Hendrix, developed the aviation-topic speech-act taxonomy (ATSAT)[1] to analyze communication elements to determine if they match the specifications of the FAA order, as well as the rules of the *Airman's Information Manual* (*AIM*), since renamed *Aeronautical Information Manual*. [FAA Order 7110.65G, dated March 1992, was used in classifying certain communication errors in ATC-pilot transcripts for the study. The current edition of the order is designated 7110.65J, dated July 1995.]

Because pilots were not required to use the standard phraseology established for controllers in FAA Order 7110.65G, researchers set this rule for comparing pilot and controller transmissions: "If a pilot attempted a verbatim readback of a controller's transmission, then the same coding procedures used on controllers' transmissions were applied to pilots' verbatim readbacks."

The ATSAT classifies communication in a hierarchy of communication elements, defined as the fundamental units of meaningful verbal language. Communication elements are arranged in terms of their purpose, operation or action. The most common element is the "speech act," defined as "an utterance, either spoken or written, which describes one discourse function." Speech-act categories are ranked in order of their typical frequency of use as address, instruction, advisory, courtesy, request and noncodable communications.

Besides speech-act categories, ATSAT classifies communication elements according to aviation topics, which describe the role that the elements play in an aviation-specific environment. Table 1, page 3, shows the complete titles of the speech-act categories and the "aviation topics" that they commonly involve.

For example, in the sentence spoken by a controller, "Universal Seven Forty-four [a fictional airline and flight number], [name] Approach, roger, descend and maintain two thousand, say your speed," the aviation topics are as follows: "Universal Seven Forty-four" is the receiver identification; "[name] Approach" is the speaker identification; "roger" is a general acknowledgment of the previous [receiver] transmission; "descend and maintain two thousand" is an instruction to change altitude; and "say your speed" is a request for the aircraft's current speed.

A transactional communication set is a collection of sequential communications between a pilot and a controller. The transaction is established when the controller acknowledges the pilot's initial transmission, and the set is complete when radar service for that aircraft is terminated or transferred to the next controller.

Table 2, page 4, shows a typical transactional communication set, beginning when the pilot of Universal Flight 744 contacts

Table 1
Speech-act Categories and Their Related Aviation Topics

Speech-act Category	Aviation Topics
Address/Addressee	Speaker, Receiver
Instruction/Clearance — Readback/Acknowledgment	Heading, Heading Modification, Altitude, Altitude Restriction, Speed, Approach/Departure, Frequency, Holding, Route/Position, Transponder Code, General Acknowledgment
Advisory/Remark — Readback/Acknowledgment	Heading, Heading Modification, Altitude, Altitude Restriction, Speed, Approach/Departure, Route/Position, Notice to Airmen (NOTAM), Automatic Terminal Information Service (ATIS), Weather, Sighting, Traffic, General Acknowledgment
Courtesy	Thanks, Greeting, Apology
Request — Readback/Acknowledgment	Heading, Altitude, Speed, Approach/Departure, Route/Position, Type, NOTAM, Traffic, Weather, "Say Again," General Acknowledgment
Noncodable Remarks	Equipment, Delivery, Other

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

ATC with an initial transmission: "[Name] Approach, Universal Seven Forty-four, leaving six thousand five hundred, maintain three thousand, information Echo." Responding (the second transmission), the controller says: "Universal Seven Forty-four [Name] Approach, roger, descend and maintain two thousand, say airspeed." The transaction ends with the pilot stating his airspeed (the third transmission) and the controller acknowledging that with a "roger" (the fourth and final transmission of the transaction).

There follow several such transactions — each, in this set, containing two transmissions — ending when the controller refers the pilot to the next controller. Those seven transactions collectively form the transactional communication set.

CAMI researchers grouped communication elements by speech-act category (such as address and instruction) and aviation topic and then analyzed those elements to determine if they deviated from the *AIM* and the FAA ATC rules. Each deviation was assigned an error-code category. The most common types of message-content errors found by researchers were in the categories shown in Table 3, page 5. In the sentence illustrating aviation topics above, for example, "say your speed" would have been coded for errors designated E and S in Table 3: E for excess words (adding the redundant "your") and a substitution error (using "speed" rather than "airspeed").

Researchers also classified two types of delivery-technique errors, shown in Table 3.

At least one communication error was found in each of 2,500 elements (40 percent) of the 6,300 controller communication elements in the study. The vast majority (93 percent) of those controller communication errors involved the speech-act categories of instruction (55 percent), advisory (24 percent) and address (14 percent) (Table 4, page 5).

Researchers found that 3,500 (59 percent) of the 5,900 pilot communication elements contained at least one communication error. More than half of those errors (53 percent) were in the instruction category, and most of the other errors were in the address category (25 percent) and the advisory category (18 percent) (Table 4).

" ... Most of the pilot and controller communication errors from all three TRACON facilities involved instructions," the report said. "Pilots made more errors involving address than controllers, and both pilots and controllers made comparable communication errors involving advisory transmissions." The two level-5 TRACON facilities tended to make more errors involving instructions than did the level-4 TRACON, which made a greater percentage of errors in the address category. Figure 1, page 6, shows the percentages of communication errors of pilots and controllers at each facility.

Results were generally similar among the three TRACON facilities, although in analyzing the request-category communication at TRACON 2, the report noted that for both pilots and controllers at that facility, "there were insufficient errors to produce meaningful analysis." In general, pilots' and controllers' communication "became more verbose when their transmissions included advisory or request speech acts," the report said. And excess-words errors in the advisory category varied from facility to facility. For controllers at TRACON-1, the excess words tended to be used in connection with route/position; for TRACON-2, the extra words often pertained to

Table 2
Air Traffic Controller (ATC)–Pilot Transactional Communication Set

Transaction	Transmission	Time	Source	Communication Elements
1	1	03:32	Universal 744	[Name] Approach, Universal Seven Forty-four, leaving six thousand five hundred, maintain three thousand, information Echo
	2	03:35	ATC	Universal Seven Forty-four, [Name] Approach, roger, descend and maintain two thousand, say airspeed
	3	03:40	Universal 744	Seven Forty-four, speed two five zero
	4	03:43	ATC	Universal Seven Forty-four, roger
2	5	04:14	ATC	Universal Seven Forty-four, turn right heading zero six zero vector to final approach course
	6	04:16	Universal 744	Universal Seven Forty-four, turn right heading zero six zero
3	7	05:11	ATC	Universal Seven Forty-four, traffic twelve o'clock one three miles, westbound, heavy Delta L ten eleven descending through four thousand niner hundred to maintain four thousand, expedite descent through three thousand
	8	05:27	Universal 744	Universal Seven Forty-four, reducing speed to one niner zero
4	9	05:56	ATC	Universal Seven Forty-four, turn left heading three four zero
	10	06:01	Universal 744	Universal Seven Forty-four, turn left heading three four zero
5	11	06:27	ATC	Universal Seven Forty-four, descend maintain two thousand
	12	06:32	Universal 744	Universal Seven Forty-four, leaving three thousand maintain two thousand
6	13	07:16	ATC	Universal Seven Forty-four, seven miles from outer marker, maintain two thousand until established on the localizer, cleared ILS runway three one right approach, reduce speed to one seven zero until outer marker
	14	07:23	Universal 744	Universal Seven Forty-four, cleared ILS runway three one right approach, maintain two thousand until established on the localizer, speed one seven zero until outer marker
7	15	08:33	ATC	Universal Seven Forty-four, contact [Name] Tower one one niner point one
	16	08:37	Universal 744	Universal Seven Forty-four, Tower one one niner point one

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

traffic; and for TRACON-3, there were often too many words in communications about both traffic and route/position.

For each of the three TRACON facilities, researchers analyzed the communication errors according to aviation topics in each of the speech-act categories. The first set of analyses identified how communication errors were distributed among the aviation topics for speech-act categories. The results, by category, were as follows:

Address. At each facility, about 80 percent of the address communication errors made by controllers and pilots involved aircraft call signs, not sector/position names. That was probably because call signs contain more alphanumeric information and are spoken less frequently than sector addresses. Also, the number of call signs assigned to daily flights is far greater than the number of ATC sector names (e.g., tower, terminal and center), prefaced with location or facility names and sector functions that pilots and controllers must learn.

Instruction. For pilots among the three TRACON facilities, the majority of the identified instruction communication errors involved heading (28 percent to 31 percent of errors); radio frequency (16 percent to 26 percent); airspeed (1 percent to

Table 3
Types of Communication Errors in Air Traffic Controller (ATC)–Pilot Transcripts

Communication-error Type	Code	Definition
Message-content Error		
Grouped	G	Grouping of numerical information contrary to paragraph 2-85, FAA Order 7110.65G.
Sequential (Nongrouped)	N	Failing to group numbers in accordance with paragraphs 2-87, 2-88 and 2-90, and failing to use phonetic alphabet in accordance with paragraph 2-84, FAA Order 7110.65G.
Omission	O	Leaving out number(s), letter(s) and word(s) prescribed in communications requirements in FAA Order 7110.65G.
Substitution	S	Using word(s) or phase(s) in lieu of those outlined in FAA Order 7110.65G.
Transposition	T	Using number(s) or word(s) in improper order (e.g., "Universal Six Forty-five" instead of "Universal Five Forty-six").
Excess Words	E	Adding word(s) or phase(s) to communication outlined in FAA Order 7110.65G, and the communication suggested in the *Airman's Information Manual* (e.g., "Universal, the number one airline Six Forty-five").
Partial Readback*	P	Failing to include specific reference in a pilot report or readback to a topic subject (e.g., altitude topic "out of six for four" would be recorded as a P).
Delivery-technique Error		
Dysfluency	D	Pausing, stammering or uttering phrases that add no meaning to the message (e.g., "uh," "ah" or "OK" when not used as a general acknowledgment).
Misarticulation	M	Improperly speaking words (e.g., slurring, stuttering, mumbling).

* Note: A verbatim readback of a controller's instruction or advisory would not be recorded as a P, nor would a readback containing a general acknowledgment and the aircraft's identifier.

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Table 4
Distribution of Controller and Pilot Communication Errors within Speech-act Categories

Speech-act Category	Controller (n = 2,500)	Pilot (n = 3,500)
Address	14%	25%
Instruction	55%	53%
Advisory	24%	18%
Courtesy	0%	0%
Request	4%	3%
Noncodable	3%	1%

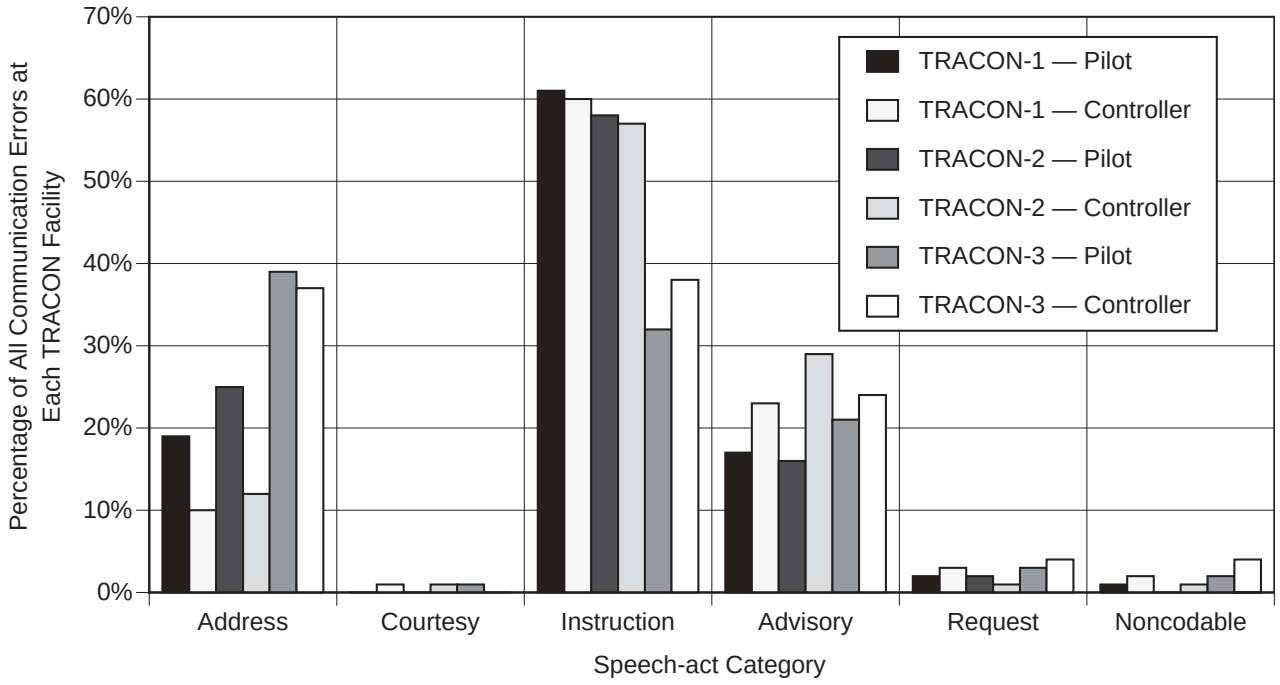
Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

22 percent); and altitude (13 percent to 21 percent). For controllers, most of the instruction communication errors involved radio frequency (16 percent to 32 percent); airspeed (0 percent to 26 percent); heading (12 percent to 20 percent); or approach/departure (4 percent to 10 percent). "There was no systematic pattern in communication errors that could be attributed to a level-4 [TRACON] vs. a level-5 TRACON," the report said.

Advisory. Most pilot communication errors in the advisory category involved altitudes (37 percent to 56 percent). Only the pilots who flew through level-5 TRACON-2 airspace showed a relatively high percentage of communication errors (31 percent) relating to traffic. For TRACON-2 controllers, more than 65 percent of the communication errors in the advisory category pertained to traffic. About 53 percent of the advisory-category errors committed by level-5 TRACON-1 controllers pertained to the topics of approach/departure (29 percent) and traffic (24 percent).

Request. In general, communication errors in the request category involved airspeed, route/position and approach topics. Pilots in TRACON-1 airspace made most of their request-category errors in topics related to airspeed (48 percent) and approach (24 percent). Pilots in TRACON-2 airspace also made about half their mistakes involving airspeed (50 percent) but had a higher percentage of communication errors involving

Speech-act Categories of Communication Errors by Pilots and Controllers at Each Terminal Radar Approach Control (TRACON) Facility



Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Figure 1

approach/departure (38 percent) communication. In level-4 TRACON-3 airspace, pilots displayed the same rate of request errors on airspeed topics as on route/position topics (36 percent), but made only 21 percent of their errors on approach topics.

Controllers at the TRACON-1 facility made 54 percent of their request-category errors on airspeed topics, with the remaining errors in that category distributed fairly evenly among other topics. Communication errors made by TRACON-2 controllers occurred only in airspeed (68 percent) and approach (32 percent). And the majority of TRACON-3 mistakes were in altitude (53 percent) and route/position (24 percent) topics.

In the following summaries of the types of communication errors, the address-category errors were from an analysis of all three TRACON facilities, but the errors committed in the instruction, advisory and request categories were taken only from TRACON-1:

Address. In the address category of errors, most of the controllers' message-content errors occurred when they omitted one or more numbers, letters or words in the receiver address, such as an aircraft call sign. Another problem, although infrequent, was the substitution of "oh" for "zero," and "nine" for "niner," as part of aircraft call signs.

Most of the pilots' address errors occurred when they omitted part of their aircraft call signs when communicating with ATC. "Although controllers often use a pilot's voice qualities and radar-displayed call sign to aid in speaker identification (when less than a full speaker address is provided), pilots should use their full call signs to avoid confusion," the report said.

Instruction. In the instruction speech-act category, most of the controllers' errors at TRACON-1 consisted of omissions (47 percent) and excess words (22 percent). Most of the omission errors involved radio frequency. "For example, controllers generally omitted the word 'point' in a radio frequency when handing off an aircraft to an adjoining sector or facility tower," the report said. Errors in communication related to airspeed (mainly omission of the words "knots" or "speed"), route/position, approach/departure and heading/altitude were also attributed to omissions.

Controllers' instruction-category errors consisting of excess words were related mostly to communication regarding airspeed and radio frequency. "Although excess verbiage rarely alters the meaning of a transmission," the report said, "it can increase frequency congestion by preventing others from making transmissions."

Almost all of the instruction-category errors made by pilots consisted of partial readback (56 percent), grouped format (24

percent) and substitution (9 percent) errors. Partial-readback errors arose primarily from communication related to heading and radio frequency. Grouped-format errors affected communication regarding radio frequency, airspeed and heading, while instruction errors of substitution were related to altitude and radio frequency. The report gave this example of a composite readback error: " ... One seventy, for six, twenty-one twenty ... ." [A composite readback error was a partial readback containing more than a single error. In the example, there are three partial readbacks: "one seventy" could be a partial readback of an instruction that included a change in airspeed or heading; "for six" a too-abbreviated form of "descending to six thousand"; and "twenty-one twenty" a partial call sign.]

Advisory. Among TRACON-1 controllers, omission and excess words each accounted for nearly a third of the communication errors in the advisory category (31 percent and 32 percent, respectively). The remaining advisory-category errors were of the grouped, substitution, dysfluency and partial-readback types. The errors of omission related to approach/departure and weather topics. Primary among approach/departure errors was controllers' failure to include the word "approach" as part of the advance-approach information. Excess words were most prevalent in communication involving route/position, weather, ATIS, approach/departure and traffic information.

TRACON-1 pilot advisory-category errors occurred mostly in the areas of partial readback (26 percent), excess words (21 percent) and grouped format (19 percent), with fewer errors of dysfluency (9 percent), omission (3 percent) and substitution (3 percent).

Controllers often omit key words, and pilots sometimes fail to fully read back instructions and, at times, group numbers in a confusing manner.

Request. Most of the TRACON-1 controller request-category errors were either excess words (51 percent) or substitutions (32 percent). Excess-words errors affected airspeed communication most, but they were found also in heading, approach/departure and route/position communication. Controllers' substitution errors, on the other hand, were found primarily in their airspeed communication to pilots. Grouped-format errors accounted for 12 percent of controllers' request errors. The report gave this example of a controller's grouped-format error: "And ah just verify that you're at a hundred and ninety on the speed."

TRACON-1 pilot request-category errors consisted mostly of grouped-format (24 percent), partial-readback (24 percent) and excess-words (20 percent) errors, with errors of dysfluency (12 percent), substitution (10 percent) and omission (4 percent) occurring less frequently. All of the TRACON-1 pilots' grouped-format communication errors and most of the partial-readback errors related to airspeed, whereas excess-words and dysfluency errors were found mostly in their approach/departure communication to controllers.

Thus, it appears that controllers often omit key words related to radio frequency, airspeed and approach/departure instructions, and pilots sometimes fail to fully read back instructions involving heading, radio frequency and airspeed; and, at times, pilots group numbers in a confusing manner.

"Problematic communications involved [such topics of discussion as] mode-C [transponder] malfunctions, call-sign ambiguity, call-sign confusion, controller confusion, pilot confusion, two aircraft on frequency talking to each other, report of an ELT [emergency locator transmitter], open [microphone], traffic, weather and so on," the report said. One of the most frequent communication problems found by the researchers was too many words. "It is intuitively obvious that excess verbiage lengthened the amount of time required to transmit, understand and respond to a message by pilots and controllers."

"Yet, an examination of the verbal content of requests revealed that requests such as, 'say again,' often clarified who was on frequency, [clarified] who was the intended recipient of a transmission and improved overall understanding." But additional words and transmissions contribute to radio-frequency congestion by increasing the number of transmissions required to create a mutual understanding of the pilot's intentions. "These types of errors can result in trade-offs between frequency congestion and failure to reach a common understanding, both of which can lead to problems."

Reviewing the findings, the report concluded that "controllers and pilots need to improve their operational communication practices. ... Using established communication procedures and practices could eliminate some ambiguity and confusion." The main goal is expressed in the *AIM* section on radio communications and communication techniques, which states: "Brevity is important, and contacts should be kept as brief as possible, but the controller must know what you want to do."

For example, the requirements for brevity and clarity are met by standard communication such as "say speed," "say altitude" and "verify assigned altitude." Pilots need to reply only briefly, with phrases such as "[one two three] knots" or "[one two] thousand [three] hundred," the report said.

"Controllers should practice transmitting *complete* radio frequency, airspeed and approach [or] departure instructions and be less verbose when delivering traffic and route/position advisories," the report added. "Pilots should practice constructing and transmitting altitude information to air traffic

control — and would also benefit from additional practice in responding to traffic advisories."

The report concluded: "Effective and accurate communications are crucial to air safety. As aircraft approach their destination airport, they converge and operate under reduced separation minima. (In the terminal environment, separation minima are three miles and 1,000 feet, and within the en route environment [they are] five miles and two thousand feet. ... See FAA Order 7110.65J, paragraph 5-5-3d-f, for exceptions.) Commercial aircraft may be flying at speeds in excess of 380 knots during their en route phase of flight and reduce to speeds of 180 knots ... in the terminal environment. Under these circumstances, there is little margin for error."♦

Editorial note: This article was adapted from *An Analysis of Approach Control/Pilot Voice Communications*, a report written by O. Veronika Prinzo of the U.S. Federal Aviation Administration's Civil Aeromedical Institute in Oklahoma City, Oklahoma. The 41-page report, dated October 1996, includes numerous tables and figures, an appendix and a list of key references.

Reference

1. Prinzo, O.V.; Britton, T.W; Hendrix, A. *Development of a Coding Form for Approach Control/Pilot Voice Communications.* U.S. Federal Aviation Administration (FAA) Report No. DOT/FAA/AM-95-15. 1995.

Further Reading from FSF Publications

Cushing, Steven, Ph.D. "Pilot–Air Traffic Control Communications: It's Not (Only) What You Say, It's How You Say It." *Flight Safety Digest* Volume 14 (July 1995).

Pope, John A. "Research Identifies Common Errors Behind Altitude Deviations." *Flight Safety Digest* Volume 12 (June 1993).

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