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## LINGUISTIC COMMUNICATION UNDER STRESS: LESSONS FROM AVIATION<sup>1</sup>

*Data from aviation communication are used to illustrate three propositions regarding language that are also of interest for maritime communication. First, language differences increase the likelihood and the severity of communication failures. Second, despite that fact, language differences are not the fundamental problem they are often made out to be. Third, inherent properties of language itself – such as ambiguity, homophony, prosody, referential uncertainty, implicit inference, and formulaic ritualization – are the real culprits causing miscommunication. It is shown that common linguistic processes – such as code-switching from one language to another, misconstrual of one phrase type as another, confusing a technical usage of a word with its ordinary usage, and letting similarities in meaning mask differences in form – have all contributed substantially to the creation of misunderstandings that have led to serious accidents.*

*Both technological and human solutions for ameliorating the problem are suggested. Technological solutions involve tools that help to clarify the production or transmission of messages. Human solutions involve education and training in how linguistic communication works and the ways in which it can go awry in order to develop a deeper understanding of the communication process. Discipline and enforcement are also necessary components of any safety program, but a stronger foundation is built by convincing people to cooperate voluntarily with safety measures through developing their understanding of the basis of and the need for those measures. Confidence is strengthened further by providing reliable technologies that make compliance easier.*

### 1. THE PROBLEM

**Three Propositions.** I argue here for three propositions regarding the effects of language differences on aviation communication. I would expect that they would also have relevance to maritime communications. The three propositions are as follows:

**Proposition 1.** Language differences do increase the likelihood and the severity of failures in aviation communication.

<sup>1</sup> Presented at the International Maritime Lecturers Association (IMLA) Conference on Maritime Education and Training and Tenth Workshop on Maritime English, Rijeka and Opatija, Croatia, 18-21 May 1999. I would like to thank Boris Pritchard, Vice-Dean, for inviting me to speak at this conference.

**Proposition 2.** Language differences themselves are not the fundamental problem they are commonly made out to be.

**Proposition 3.** Inherent properties of language itself necessarily cause miscommunications.

The first proposition is not surprising; I would guess most people take it for granted. The second proposition is probably surprising; it seems to contradict the first one. The third proposition is certainly surprising; language is the most familiar of human behaviors: how could it possibly itself be a problem?

**Three Examples.** Consider the dialogue in Figure 1, taken from the official accident report issued by the Spanish Ministry of Transport and Communications (1978a, b).

- |            |  |
|------------|--|
| 1705:44.6  | LM 4805: The KLM four eight zero five is now ready for take off and we are waiting for our ATC clearance (1705:50.77).   |
| 1705:53.41 | Tower: KLM eight seven zero five you are cleared to the Papa Beacon, climb to and maintain flight level nine zero, right turn after takeoff, proceed with heading four zero until intercepting the three two five radial from Las Palmas VOR (1706:08.09). |
| 1706:09.61 | KLM 4805: Ah – roger sir, we are cleared to the Papa Beacon, flight level nine zero until intercepting the three two five.<br><b>We are now at takeoff.</b> (1706:17.79).  |
| 1706:18.19 | Tower: OK... <b>Stand by for takeoff</b> , I will call you (1706:21.79).<br>[ Note: A squeal starts at 1706:19.39 and ends at 1706:22.06. ]<br>[ PAA: And we're still taxiing down the runway the Clipper one seven three six (1706:23.6). ]               |
| 1706:21.92 | PAA 1736: Clipper one seven three six (1706:23.39).  |
| 1706:25.47 | Tower: Ah – Papa Alpha one seven three six report the runway clear (1706:28.89).   |
| 1706:29.59 | PAA 1736: OK, will report when we're clear (1706:30.69).   |
| 1706:61    | [sic]69 Tower: Thank you.  |
| 1706:50    | <b>COLLISION:</b> KLM on takeoff run collides with PAA on ground.  |

Figure 1. KLM and PAA, Los Rodeos Airport, Tenerife, Canary Islands, 27 March 1977

At 1706:17.79, the KLM pilot (actually copilot) utters (1) to tell the controller that he has begun his takeoff roll; at 1706:18.19, the Tower responds with (2) to tell the pilot that he should not begin his takeoff roll.

(1) We are now at takeoff.

(2) Stand by for takeoff

Two questions arise in connection with this exchange:

**Question 1:** Why does the pilot utter such a non-standard phraseology?

**Question 2:** Why does the controller give such an inappropriate response?

The pilot's statement can be interpreted as a subtle form of what linguists call "code-switching," a phenomenon in which multilingual people inadvertently switch from one of their languages to another (and back). The pilot's native language is Dutch; in that language the present progressive aspect is expressed by *us-*

ing the Dutch equivalent of *at* with the infinitival form of the verb, in this case, *takeoff*.<sup>2</sup> Here, the pilot switches into Dutch grammar while keeping the English words, saying *are at takeoff* for *are taking off*. This answers the first question.<sup>3</sup>

The controller is proficient in English, but has not studied Dutch (or linguistics); he thus has no clue (nor does the pilot, by the way) that the pilot is performing such a switch. Since *at* is typically used to begin a locative phrase, he interprets the pilot's utterance in that way; he takes the pilot's utterance as meaning that the aircraft is at the takeoff point awaiting further instructions. This answers the second question.

Together these answers illustrate Proposition 1.

Now consider the dialogue in Figure 2, taken from the official accident report issued by the U. S. National Transportation Safety Board (1981). There are lots of interesting items in this dialogue, which I hint at through italics and underlining: for example, the similarity of the call signs at 0133:11 and 0133:33 and of the phrases *go around* at 0134:13 and *go ahead* at 0134:18, as well as the oxymoronic flavor of *just go ahead and hold* at 0134:18.

- |          |  |
|----------|--|
| 0133:11  | Tower: Air California <i>three thirty six</i> , you're cleared to land.  |
| 0133:33  | Tower: Air California <i>nine thirty one</i> , let's do it taxi into position and <i>hold</i> , be ready.                                    |
| 0133:37  | AC 931: <i>Nine thirty one's</i> ready.  |
| 0133:52  | Tower: Air Cal <i>nine thirty one</i> traffic clearing at the end, clear for takeoff sir, Boeing seven thirty seven a mile and a half final. |
| 0133:57  | AC 931: In sight we're rolling.  |
| 0134:13  | Tower: OK Air Cal <i>three thirty six</i> , <u>go around</u> three thirty six, <u>go around</u> .  |
| (0134:16 | AC 336 captain: <u>Can we hold</u> , ask him if we can – <u>hold</u> .)  |
| 0134:18  | Tower: Air Cal <i>nine thirty one</i> if you can <u>just go ahead and hold</u> –.  |
| 0134:21  | AC 336: <u>Can we land</u> Tower?  |
| 0134:22  | Tower: Behind you Air Cal <i>nine thirty one</i> just <b>abort</b> .   |
| 0134:25  | Tower: Air Cal <i>three thirty six</i> , please go around sir traffic is going to abort on the departure.                                    |
| (0134:27 | AC 336 captain: Gear up.)  |
| 0134:36: | <b>IMPACT</b> : Aircraft lands with gear retracted.  |

Figure 2. Air California, John Wayne Orange County Airport,  
Santa Ana, California, 17 February 1981

<sup>2</sup> This fact about Dutch was first pointed out to me by Profs. Ken Hale of MIT and Nobuhiko Yamanaka of Saitama University.

<sup>3</sup> The Air Line Pilots Association issued an alternate transcript, in which the KLM pilot says (i), rather than (1).

(i) We are now, ah, taking off.

The original tapes themselves appear to have been lost or destroyed through normal procedures and the passage of time, but internal and comparative evidence can be brought to bear in an effort to determine the relative accuracy of the transcripts. For example, the controller's instruction (2) makes no sense at all as a response to (i), but can be explained in terms of known linguistic mechanisms (code-switching and construal of an *at* phrase as a locative) as a response to (1). It is not implausible that "wishful hearing" by a linguistically naive but pilot-friendly transcriber might have projected a non-existent *-ing* onto the *take* in (1) in an effort to make sense of the pilot's utterance. See Cushing (1994a) for more on "wishful hearing." I thank Prof. Bill Waldo of Embry-Riddle Aeronautical University for information about the tapes and about the alternate transcript (personal communication).

Of particular interest here is the use of the word *hold*. At 0133:33, the controller issues AC 931 the instruction (3), meaning to taxi into position and stop there.

(3) taxi into position and hold

At 0134:18, the controller issues AC 931 the instruction (4), meaning to stop his takeoff roll, a meaning confirmed at 0134:22, when he rephrases his instruction as (5).

(4) just go ahead and hold

(5) just abort

This is the standard use of hold in aviation English: to *hold* an action is to *stop* what you are doing and do something else instead.

However, AC 336 has something else in mind. At 0134:13, the controller tells him to *go around*, meaning to stop his landing process and do something else. The captain responds at 0134:16 by asking the copilot to request permission to *hold*, meaning to continue what he is doing, namely, land. The copilot confirms that he understands the captain in this way by proceeding to ask the controller for permission to *land* at 0134:21. This is the principal meaning of hold in vernacular English: to *hold* an action is to *persist* in doing it.

In other words, though clearly operating in an aviation setting, the AC 336 captain inadvertently slips from aviation English to vernacular English and is understood by his copilot as having done so. Just as the KLM pilot in Figure 1 slips in grammar from English to Dutch, that is, from one *language* to another, the AC 336 captain in Figure 2 slips in meaning from technical to vernacular, that is, from one *variety* of a language to another. We thus get code-switching within a single language by native speakers of that language, the same process that occurs in multilingual speakers of clearly different languages. This illustrates Proposition 2 and begins to hint at Proposition 3.

Related mechanisms appear to be operating in the dialogue in Figure 3, taken from the official accident report issued by the U.S. National Transportation Safety Board (1991).<sup>4</sup>

- 2124:04 Tower: Avianca zero five two, you are making a left turn, correct, sir.  
 2124:06 Captain to copilot: Digale que estamos en emergencia. [ English: Tell him we're in an emergency. ]  
 2124:08 Copilot to Tower: That's right to one eight zero on the heading and, ah, we'll try, once again, *we're running out of fuel*.  
 2124:15 Tower: Okay.  
 2124:17 Captain to copilot: Que dijo? [ English: What did he say? ]  
 2124:18 Copilot to captain: Mantener dos mil pies, ciento ochenta en el rumbo. **Ya le dije** que intentamos de nuevo, porque ya no podemos. [ English: Maintain 2000 feet, 180 on the heading. I already advised him that we are going to attempt again, because now we can't. ]

<sup>4</sup> Extraneous dialogue at 2125:15-2125:22, 2125:41-2126:34, and 2126:47-2130:30 is omitted.

- 2124:22 Captain to copilot: Digale que estamos en emergencia. [ English: Tell him we're in an emergency. ]
- 2124:26 Captain to copilot: Ya le dijo? [ English: Did you tell him? ]
- 2124:28 Copilot to captain: Si, señor. [ English: Yes, sir. ]
- 2124:29 Copilot to captain: Ya le dije. [ English: I already told him. ]
- [ 2124:32-2125:07 Aircraft is handed off from Tower to Approach Control ]
- 2125:08 Captain to copilot: Digale que no tenemos combustible. [ English: Tell him we don't have fuel. ]
- 2125:10 Copilot to Approach: Climb and maintain three thousand and, ah, we're running out of fuel, sir.
- 2125:12 Approach to copilot: Okay, fly heading zero eight zero.
- 2125:28 Captain to copilot: Ya le dijiste que *no tenemos combustible*? [ English: Did you already tell him *we don't have fuel*. ]
- 2125:29 Copilot to captain: Si, señor. Ya le dije. Ciento ochenta en el rumbo mantenemos tres mil pies y nos va a volver a meter. [ English: Yes, sir. I already told him. 180 on the heading. We'll maintain 3000 feet and he'll get us back. ]
- 2125:29 Captain to copilot: Bueno. [ English: Okay. ]
- 2126:35 Approach to copilot: And Avianca zero five two heavy, ah, I'm gonna bring you about fifteen miles north east and then turn you back onto the approach. Is that fine with you and your fuel?
- 2126:43 Copilot to Approach: I guess so. Thank you very much.
- 2126:46 Captain to copilot: Que dice? [ English: What did he say? ]
- 2126:46 Copilot to captain: El man se calentó. [ English: The guy is angry. ]
- 2130:32 Approach to copilot: Avianca 52, climb and maintain three thousand.
- 2130:36 Copilot to Approach: Ah, negative, sir. *We just running out of fuel.* We. Okay. Three thousand now. Okay.
- 2130:39 Captain to copilot: No, no tres. Tres mil. Tres mil. [ English: No, not 3.3 thousand, 3 thousand. ] Aircraft soon runs out of fuel and crashes. ]

Figure 3. Avianca, Cove Neck, New York, 25 January 1990

In this case, the copilot switches deliberately, not inadvertently, between two languages, because the pilot has chosen to speak Spanish and the controllers are speaking English. The pilot twice utters the word *emergencia*, the exact Spanish equivalent of the English word *emergency*, to the copilot (at 2124:06 and 2124:22), but the copilot never says the word *emergency* to a controller. Instead, he elaborates on the nature of the emergency, which he describes correctly as (6) (at 2124:08, 2125:10, and 2130:36), while assuring the captain that he has advised the controllers of both the emergency (at 2124:26-2124:29) and its nature (at 2125:29).

(6) running out of fuel

The noun *emergencia* means the same in vernacular Spanish as *emergency* means in vernacular English and, in both vernaculars, it is more natural to elaborate the nature of an emergency than simply to repeat the word itself; however, *emergency* has a special use in aviation English. Phrases such as those in (7) convey a special degree of urgency that requires the controller to give priority to any aircraft that transmits them; since there is no "aviation Spanish," there is no Spanish analog for that use.

(7) (a) declare an emergency

(b) fuel emergency

In shifting from one language to another, the copilot overlooks the fact that, although the word *emergency* has been said, it has not been said in the correct language to the correct person: aviation protocol requires that it be said in English to the controller.

The controller is listening for such a phrase, but never hears it. His apparent anger at 2126:35, reported by the copilot at 2126:46, suggests frustration at a crew that declines to declare an emergency, while claiming to be running out of fuel. He could take it upon himself to ask if there is an emergency, but he takes the crew's competence for granted and assumes on that basis that they would have declared an emergency if there had been one. Perhaps he wonders if they are playing around in an attempt to gain some advantage. It never occurs to him that, possibly, they could just be making a mistake.

The most striking feature of the dialogue in Figure 3 is that it all could have happened just as it did without any Spanish having been involved. The official transcript has the Spanish and English versions of the intra-cockpit dialogue listed side by side in parallel columns and either can be read without the other to determine what is going on. The air/ground dialogue is exclusively in English and the controllers know nothing of what is said in the cockpit, including what language it is in.

The fact that the language being used to communicate with the ground is a technical variant of a language other than the copilot's own, leaving him twice removed from the vernacular with which he is most familiar, is likely to have compounded the miscommunication in this instance. This illustrates Proposition 1. However, an inability (or unwillingness) to shift between variants of a single language, or the lack of awareness of the need to do so, is the culprit. This illustrates Proposition 2.

Neither the copilot nor the controller is able to maintain his communicative bearings in the attempt to talk the aircraft down safely. Both are speaking and listening in what they think they know are the correct ways. The copilot shifts languages: Spanish to English; but not varieties: vernacular to aviation. He stumbles around the linguistic landscape, trying to get his point across and wondering why he keeps falling flat. The controller is so locked into the technical aviation protocol that he never thinks to step back a bit and try to listen in the vernacular; he, too, seems unable to shift varieties, though in the opposite direction. He tries to make sense of an apparent contradiction and finds himself unable to do so. The copilot is walking on quicksand; the controller is stuck in a ditch. It is language itself that has both of them tied in knots. This illustrates Proposition 3.

**1.3. More Examples.** The occurrence of inadvertent (and resistance to necessary) code-switching between and within languages is only the most striking and dramatic of the inherent properties of language itself that necessarily cause miscommunications. Following is a list of further such properties, each illustrated with an actual instance that occurred in an aviation setting.<sup>5</sup>

<sup>5</sup> For more detailed discussion of these examples and citations, see Cushing (1994a,c, 1995).

**Ambiguity:** The presence of two or more meanings in a word, phrase, sentence, or passage.

**Example:** A controller, knowing that B1 had called but not sure what the request had been, replied with (8) and then proceeded to talk to aircraft while waiting for a reply.

(8) B1, Ground, go ahead.

B1 misinterpreted the phrase go ahead as referring to his driving, rather than his speaking, and was halfway down his normal route of travel before the controller realized what had happened.

**Homophony:** Different words or phrases sounding exactly or nearly alike.

**Example:** Confusion between the intended two and the required but missing to in (9) led to a fatal accident.

(9) Descend 2400.

The aircraft descended to 400 feet rather than the appropriate altitude of 2,400 feet.

**Prosody:** The pattern of pauses, stresses, or pitches in an utterance.

**Example:** While checking out a pilot in a small airplane, an experienced flight instructor reports noticing considerable power on just before touching down. He thought he had said (10), but he was interpreted by the pilot as having said (11).

(10) Back – on the power.

(11) Back on – the power.

The two utterances normally differ in pronunciation only in the placement of the pause and in whether or not on is stressed.

**Uncertain Reference:** A degree of indeterminacy as to just who or what is meant by a pronoun or pronoun-like expression.

**Example:** The Tower issued (12) to an aircraft that had landed on runway 15.

(12) Taxi to the next and hold short of 21.

The pilot was confused as to whether next was intended to refer to a runway or a taxiway.

**Implicit Inference:** Unjustified assumptions or conclusions derived from indefiniteness or time lags.

**Example:** A pilot interprets (13) as a clearance to climb, misconstruing can as do.

(13) I can give you 290 but you will have to negotiate for higher.

(14) Roger, cleared to 290, leaving 230."

The controller does not challenge the readback (14) but queries the pilot at 24,000, informing him then of relevant traffic.

**Ritualization:** Statements and situations lose their cognitive impact and participants fall into a pattern of simply going through the motions for their own sake.

**Example:** After the dialog (15) with the controller, the pilot began a descent, but was then informed that he had not yet been cleared below 4,000 feet.

(15) Can you see the runway?

(16) Yes.

(17) Okay, turn to 360 degrees.

The instruction (17) had been followed so often in the pilot's prior experience by a clearance to descend that he assumed it was so in this case as well.

## 2. SOLUTIONS

**Solution Types.** There are two kinds of solution to the problem identified above:

**Human Solutions:** What can we do for personnel to help them improve their communication?

**Technological Solutions:** What can we give to personnel to help them improve their communication?

Note the phrase for personnel, rather than to personnel, in the formulation of Human Solutions. Jones (1994) questions the value of technological solutions with the comment, "As for me, I would try a few sackings first." However, that is not what I have in mind.<sup>6</sup> While discipline and enforcement are necessary components of any safety program, a stronger foundation is built by convincing people to cooperate voluntarily with safety measures through developing their understanding of the basis of and the need for those measures. Confidence is strengthened further by providing reliable technologies that make compliance easier.

**Human Solution.** Steps that can be taken to help personnel improve their communication include such general measures as shortening shifts and hiring more staff. However, there is one essential human solution to this particular problem, without which others will lose their effect, namely:

Provide aviation personnel with a deeper understanding of language, including:

- ts basic characteristics
- how it works
- the kinds of ways it can malfunction in communication
- the consequent need to use it more mindfully

In other words, we must develop and promote the outlook of treating language as a crucial component of the aviation and maritime environments, entirely on a par with more obviously tangible components, such as aircraft, ships, radar, and communications equipment. People who use language as a tool must be trained in its effective use to the same depth and breadth as pilots are trained to fly aircraft, controllers are trained to read radar, and both are trained to use communications tools. This encompasses everyone in the aviation and maritime systems. A thorough awakening to the kinds of potential problems sketched in Section 1 can

<sup>6</sup> See the reply in Cushing (1994b).

go a long way toward replacing the complacency engendered by language's familiarity with a willingness to master it to save one's own life and others'.

Awareness of language and the skills for using it more effectively can be promoted in numerous ways, including:

- **Books**, such as my own *Fatal Words* (Cushing, 1994a)
- **Newsletters and reports**, such as those published by the International Aviation English Association
- **Training materials**, such as those developed by the Centre of Applied Linguistics at the University of Franche Comte in Besancon, France

The point is to incorporate such materials into every aviation and maritime training program and to elevate their mastery to the highest level of priority.

**Technological Solutions.** The general background for potential technological solutions in the short-, intermediate-, and long-term time frames is sketched out in Cushing (1994a). Since this conference is concerned particularly with training, already discussed above, I mention here only one technological solution geared to an intermediate-term time frame. For more examples, see Cushing (1997).

Problems of voice-mediated language can be avoided by using a restricted English-like artificial language in connection with a visual communication system. Given a suitably restricted language framework, pilots and controllers can be given screens in variants of their own languages with automatic translation between them. This is illustrated in Figure 4.

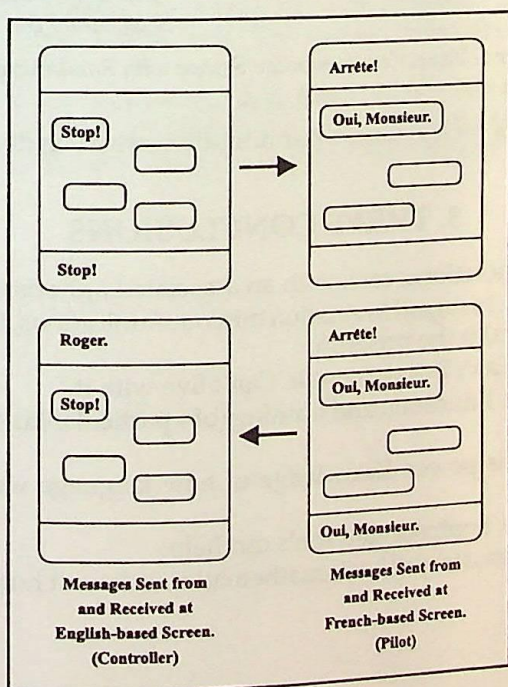


Figure 4. Visual Communication System with Translation

Ritualization can be avoided by having alternate equivalent formulations of an instruction selected randomly for presentation. This is illustrated in Figure 5.

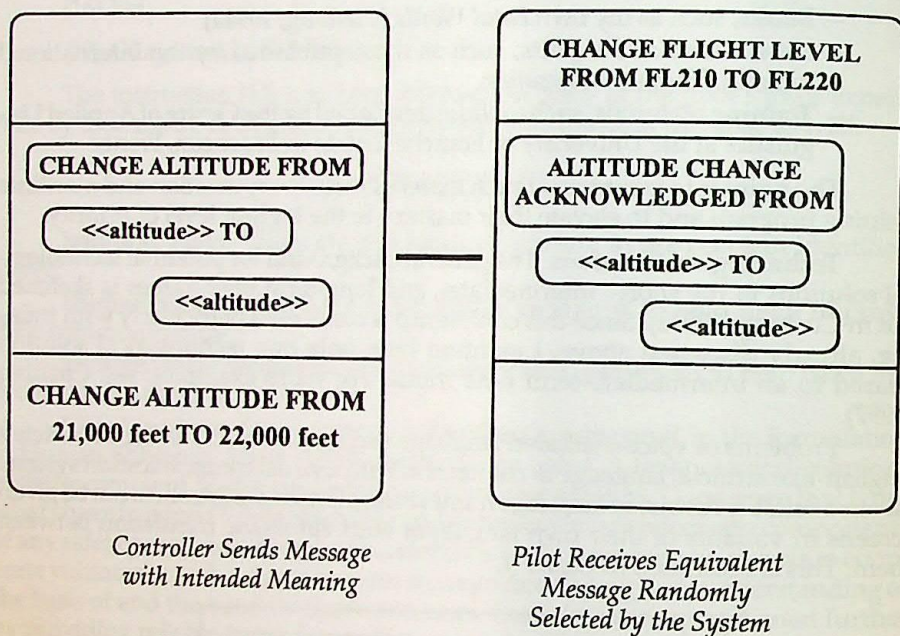


Figure 5. Visual Communication System with Randomization

A prototype of such a visual communication system is described in Cushing (1994a).

### 3. THREE CONCLUSIONS

I end with three conclusions, each with an associated aphorism:

**Conclusion 1.** In regard to aviation miscommunications, language itself (not language differences) is the problem.

"Language: Can't live without it. Can't live with it."

**Conclusion 2.** Education and training (of a particular kind) are the principal solution.

"Knowledge is power. Knowledge of how language works is key to survival."

**Conclusion 3.** Sophisticated tools can help.

"Even with a mastery of basic mathematics, it doesn't hurt to have a calculator."

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### Sažetak

## JEZIČNA KOMUNIKACIJA POD STRESOM: PREDAVANJA IZ ZRAKOPLOVSTVA

*U ovom izlaganju koristit ću se podacima dobivenim u aviokomunikacijama kako bih objasnio tri prijedloga o jeziku koja bi trebala biti zanimljiva i za pomorske komunikacije. Prvo, jezične razlike povećavaju vjerojatnost i broj pogrešaka u komunikaciji. Drugo, usprkos tome jezične razlike nisu osnovni problem, one se često prikazuju takvima. Treće, nasliedene karakteristike samog jezika – kao što su dvosmislenost, jednoglasje, prozodija, referencijalna nepouzdanost, implicitno zaključivanje i uobičajeno potiskivanje propisa – zapravo su stvarni krivci koji uzrokuju pogrešnu komunikaciju. Pokazat ću da su uobičajeni jezični procesi – kao što su prebacivanje iz koda jednog jezika u kod drugoga, pogrešno tumačenje određenog tipa fraze, zamjena stručnog značenja određene riječi sa značenjem te riječi u svakodnevnoj uporabi, te to što se ostavlja da sličnosti u značenju prekriju razlike u obliku – bitno pridonijeli pogrešnom razumijevanju, što je uzrokovalo ozbiljne nesreće. Predložiti ću i tehnološka rješenja te rješenja do kojih dođe sam čovjek, a koja bi omogućila poboljšanje problema. Tehnološka rješenja uključuju pomagala pri stvaranju ili prijenosu poruka. Rješenja koja ovisе o ljudskom faktoru uključuju znanje i osposobljenost za pronalaženje načina na koji jezična komunikacija djeluje, kao i načina kojim ta komunikacija može pogrešno krenuti, a sve zato da bi se bolje shvatio sam proces komunikacije. Disciplina i provođenje programa sigurnosti također su prijeko potrebne komponente, ali još će čvršće temelje dobiti ako se ljude uvjeri da sami koriste sigurnosne mjere tako da razvijaju svoje poimanje osnova tih mjera i nužnost njihova korištenja. Sigurnost se nadalje povećava pronalaženjem pouzdanih tehnologija koje olakšavaju ispunjenje mjera sigurnosti.*