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Human Factors in Aviation Operations: The Hearback Problem

Captain William P. Monan

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Captain William P. Monan
Battelle
Mountain View, California

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Ames Research Center
Moffett Field, California 94035

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HUMAN FACTORS IN AIR-CARRIER OPERATIONS: THE HEARBACK PROBLEM

by

Captain W. P. Monan*

INTRODUCTION

Controller: "ABC, where are you going? Your assigned altitude was one zero thousand!"

ABC Pilot: "XYZ approach, we understood our clearance was to one one thousand; we read back one one thousand...."

Controller: "Negative ABC! Turn right to zero nine zero degrees and descend immediately to one zero thousand. You have traffic at one one thousand, twelve o'clock, ___ miles...."

Every week during a 2-1/2-year period, three to four "Where are you going?!" hazardous occurrence reports similar to the above have been submitted to the Aviation Safety Reporting System (ASRS). Deviations from assigned altitudes, unauthorized taxi crossings of active runways, nonadherence to DME crossing altitudes, turns to incorrect vector headings, and various flights over the wrong Jet or Victor airways -- in all, 417 such errant actions -- were attributed by ATC controller and airman reporters to misunderstood, misinterpreted, mistransmitted or unheard numbers in ATC-to-cockpit communications exchanges. Of the 417 incidents reported, 85 reports were submitted by ATC controllers and 332 by crewmembers.

These erroneous actions precipitated hundreds of traffic conflicts, some narrowly missed midair collisions, go-arounds, aborted takeoffs and, as aftermaths to the incidents, the worrisome potential for administrative punitive action. On a more personal, subjective level, airmen explanations for their communications failures frequently reflected painful chagrin and keen embarrassment for having made avoidable mistakes in flying their airplanes or in running their cockpits.

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* Previously regional director of flight operations for an international airline, Captain Monan serves as an Aviation Safety Research Consultant to Battelle's ASRS Office.

The narrative descriptions of these occurrences covered every possible deviation in cockpit handling of radio communications. ATC clearance messages were sometimes misread, sometimes tuned out, sometimes guessed, at times even ascertained by an informal consensus vote in the cockpit. Typical human causal factor citations included: "hearing one number and saying back another...", "hearing what I expected to hear", "forgetting to change the altitude reminder to a new altitude", mixing FL220 with FL200 or the one one thousand with the one zero thousand digits, transposing DME miles into altitudes of crossing restrictions, use of cockpit speakers, assumption that the other pilot also heard the clearance, habit conditioning, and scores of similar trip-ups between ear, voice, mind, and action.

ATC controller reports of errant communications were less numerous, described workload conditions in impersonal, formulated "system deviations/system error" terms, and, overall, tended to reflect objective rather than subjective viewpoints in the narratives. Their verbal slips in transmissions of instructions normally passed unnoticed in the continuing flow of messages to multiple aircraft. Only by reviewing the ATC tape subsequent to an incident could participants hear what in fact had been said on the frequency, and to whom. Individual human-factor elements seldom were labelled as causal agents for the incidents; when mentioned, they were nonspecific and general. "'Tis human to err", read such a controller's comment, and "I guess I proved I was human with this mistake".

However, more basic and perhaps more troublesome issues than erratic human-performance limitations emerged from analysis of the 417-report dataset. The fundamental advantage of an incident-reporting system, such as the ASRS, is in its capability to reveal deep running, repetitive, causal patterns not discernible in individual reports. Perhaps the most important such pattern emerging among the findings of this study was a strong indication that an essential redundancy -- the fail-operational, double-check procedure elements recently termed "hearback"* -- frequently is missing from controller-pilot-controller dialogues. The drop out of the hearback

* The act of a controller's actively listening to a pilot's readback of an ATC clearance. So far as the author knows, the first use of the term in this sense was in the ASRS program's monthly bulletin CALLBACK(1)**.

** References are listed at the end of the report.

confirmation step perforce reduces each communicator's role to the classic "one man show" with its well-known follow-on consequences.

Perhaps no other essential activity in aircraft operations is as vulnerable to failure through human error and performance limitations as spoken communication. Decades of operational experience in aviation developed the readback/hearback confirmation procedure. When ATC messages pass unmonitored and unverified through the communications loops, the conflict alert frequently signals the occurrence of a misheard, unheard, or mishandled communication.

APPROACH

The scope of this ATC communications study covers analysis of ASRS incident reports in which the "numbers" in ATC messages were misheard, misunderstood, or otherwise mishandled. The study is a companion piece to a previously issued ASRS analysis of communications failures associated with initial call-ups and similar aircraft call sign mix-ups; thus, incidents involving such problems were not included.(2)

During a 29-month period, from April 1981 through July 1983, 763 reports of erroneous readbacks and missed controller hearbacks were submitted to the ASRS. After elimination of multiple reports of single occurrences and rejection of nonpertinent submissions, 417 incidents were retained for analysis.

The purpose of the analysis was to explore the question "What are the major issues in ATC communications" and to provide an informative paper on the results for all categories of airspace users: General aviation pilots, corporate jet crews, Part 135 operators, aircarrier flight crews and controllers in all types of ATC facilities. However, the majority of reporters in this category of incident was found to be aircarrier airmen (79 percent). The study, therefore, necessarily reflects the viewpoints and the types of incidents characteristic of this segment of aviation.

An important peripheral finding is noted. The perusal of hundreds of ATC miscommunication narratives permitted the analysts to get a sense of the overall attitudes of the reporters. While human factor errors were evident

in both cockpit and ATC facility, nevertheless, a solid feeling of mutual cooperation, of friendly helpfulness, and of tolerant understanding permeated the incident reports. There were no "we and they" statements reflecting a bunker philosophy. Rather, a "we're in this together" sharing of responsibility came through clearly in most reports from both airmen and controllers.

DISCUSSION

The absence of the confirmation/monitoring step manifested itself in four ways in the flawed-communications sequences depicted in the study dataset.

1. A pilot misheard the numbers in a clearance message and repeated back the erroneous units for controller confirmation.
2. A controller did not hear -- or did not listen to -- the incorrect readback. The airman accepted lack of response as silent confirmation that the readback was correct.
3. A pilot correctly heard and acknowledged ATC instructions, but intracockpit mismanagement of the clearance information resulted in a deviation.
4. An additional subset of communication failures consisted of:

   (a) Controller self-admitted errors in initial transmission of the numbers. These slips, mental and verbal, were not caught by the controller during pilot readback of the erroneous information, and,

   (b) Inadequate "Roger" or "okay" or "So long" types of pilot acknowledgements for clearances that precluded any controller double-check of the completed exchange.

The Airman's Information Manual (AIM) addresses the redundancy problem in ATC/cockpit communications in low key, advisory style language. "As a means of mutual verification", states the procedural guide for airmen, "pilots of airborne aircraft should read back those parts of ATC clearances and instructions containing altitude assignments or vectors...". The readback of the numbers serves as a double-check between pilots and controllers

and reduces the kinds of communication errors that occur when a number is either misheard or is incorrect(3).

Aircarrier flight operations manuals (FOMs) have not only adopted this procedure but have stiffened the "should" recommendation into "must" requirements for their airman. Readbacks of ATC messages are mandatory in all aircarrier operations.

ATC controller reports to the ASRS clearly indicate acceptance of the double-check function as a procedural responsibility of the controllers in the talk/listen/confirm/confirm sequence. The controller's duty, as everyone knows, is dual: he must not only issue a correct clearance to the correct aircraft, but thereafter, he must listen to the pilot's readback to ensure that the airman has heard the message correctly. Thus, he is responsible both for the initiating "to" link and confirming the completed "from" step. There is some irony, perhaps, in that a controller's "system deviation" in communications frequently consists of not catching someone else's error. "It is sad," noted one reporter, "when a controller must go through investigation and complete recertification -- all because some pilot did not listen adequately to a transmission".

However, while individual controllers clearly accepted the procedural responsibility for listening confirmation of pilot readbacks, it may be somewhat startling to airmen -- who are rigidly required to make readbacks -- to discover that no current written regulations require the controllers to hear back, that is to listen to their readback messages. The subject is absent from the ATC Controllers Handbook*; it appears unlikely that the omitted provision merely "dropped through the cracks". The amplified discussion of the "pilots-should-make-readbacks" recommendation in the AIM provides quasi-official recognition that controller hearbacks are not always possible.(4)

> "There are some occasions when the controller must issue time critical instructions to other aircraft and he may be in a position to *observe your response* visually or on radar." (italics added)

* See Addenda at the end for further discussion of this matter.

A direct interpretation of this passage would seem to be that looking through the tower windows or scanning the data block readouts on the radar scope may be substituted, during heavy traffic conditions, for the standard listening/confirmation step in ATC communications.

The passage from AIM appears directly relevant to the broken verbal communication sequences identified in the study.

1. Each reported erroneous or inadequate pilot readback in this study dataset comprised an occasion when controllers "heard" readbacks via the visual or radar observation step.
2. Any occasion wherein readback responses are "observed" rather than listened to involves a troublesome stinger for the airmen participants. If the airman has heard the message correctly, all is well even though the controller does not listen to the readback; the airman's response action will be correct. If not, the immediate oral correction step cannot be taken, and the controller's "observation" of the incorrect readback can occur only after the airman has acted upon the perceptual error. The pilot has now committed an apparent flight deviation and may be liable for FAA enforcement action.
3. Awaiting confirmation of pilot readbacks via radar observation places additional emphasis for separation of conflicting traffic (due to deviating aircraft) upon the controller's attention to the targets on his scope. It also places increased reliance upon the conflict alert device.
4. In this study, Ground Control or Local Controller participation in the missed communication exchanges utilized visual through-the-window sightings of aircraft in lieu of listening to a pilot's verbal message. The use of radar for observing responses instead of listening for possible erroneous readbacks usually took place at higher altitudes -- at or above 10,000 feet -- in ARTCC controlled airspace.

Table 1 gives the airspace type distribution in which the incidents took place and Table 2 indicates the types of hazardous incidents resulting from misheard ATC/pilot communications.

TABLE 1. TYPES OF ATC AIRSPACE CONFIGURATIONS RELATED TO 417 ATC COMMUNICATIONS FAILURE INCIDENTS

Airspace Types	Numbers of Incidents
Center airspace	209
TCA and major terminal areas	109
Small terminal areas	43
Large tower facilities	40
Small tower operations	16
Total	417

TABLE 2. TYPES OF HAZARDOUS INCIDENTS RESULTING FROM MISHEARD ATC/PILOT COMMUNICATIONS

Types of Incidents	No. of Incidents
Deviations from Assigned Altitude/Flight Levels	232
Deviations in Headings	143
Deviations in Airway Routings	8
Failures to "Hold Short" of the Active and Similar on-the-ground Mishaps	34
Total	417

Erroneous Readbacks of Numbers: Why Airmen Didn't Get it Straight

> "My first officer told me that he heard and read back the clearance 'to cross the 20 DME of XYZ at 10,000 feet and 250 knots'.
>
> "After we levelled off at 10,000, ATC advised we had been cleared to 11,000, not 10,000. This came as a big surprise to us...".

There is an old saying in aviation -- sometimes referred to by airman reporters to ASRS -- that there are two types of airmen: those who have "busted" an altitude assignment and those who have NOT YET done so. "I didn't think it would ever happen to me -- but it did!", "I never believed I would fall into the trap -- but I did", "I always thought that it couldn't happen to me -- Wrong!" Such were the rueful comments from airmen reporters who had misread the numbers in ATC clearance messages and thereby involved themselves in potentially hazardous situations.

Nor did high flight time in a pilot's logbook protectively fend off miscommunications mishaps. General Aviation pilots checked off 100 to 1,500 hours on the ASRS report forms. Professional airmen reported in with a typical 10,000 hours but with individual highs up to 28,000 hours. "No numbers of hours makes one immune", noted one 20,000-hours reporter, "Listening closely is the name of the game. I learned my lesson!"

In the jargon of the airman community, "altitude bust" normally connotes an unintentional deviation from an assigned level. Frequently, these excursions are causally linked with clear sky/unlimited visibility lapses of attention to flight path trajectory. Controllers know it well; one ATC reporter noted: "No airman busts his altitude in IMC conditions". ASRS data support this bit of controller lore. Weather factors are cited as being present in less than 20 percent of reported occurrences involving altitude deviations.

As opposed to "altitude busts" where the crew had the correct numbers but flew incorrectly in altitude deviations due to misheard numbers, the flight path of the aircraft is as intended by the flight crew. Altitude awareness is not lost. Distractions are not involved. Nor are weather conditions. These miscommunication events took place in solid IMC as well as in VMC. In several occurrences, aircraft descended in the clouds through holding stacks. "There were 6 aircraft in the holding pattern and ABC descended through 5 of them on his way down to 15,000 feet...". "The pilot heard his assignment as 10,000 instead of the 11,000 issued to him. When the targets merged both aircraft were holding at 10,000...". Hazard potential in these cases is often severe.

Misheard numbers were not limited to altitude assignments. "Turn to zero five nine degrees" was rearranged in readback to "zero nine five...". "Heading three three zero" was read as a clearance to climb to FL330. Similarly, "hold short of..." messages and other routine taxi instructions became entangled factors in confused incursions into or across active runways.

> "...cleared to taxi gate to 9L on a route requiring crossing the end of rwy 4L. Upon crossing 4L tower stated we were told to hold short of 4L. First Officer and I could not recall being told to hold short and did not read back any clearance to hold short...".

In 148 of these misheard number occurrences, the event in the chain was a traffic conflict where the deviating aircraft came unacceptably close to another aircraft either on the ground or in flight.

Link failures in the ATC/Cockpit communication chain are shown in Table 3.

Of the 417 occurrences, 328 featured airman listening/response deficiencies. Mishearing the numbers took place in 174 deviations, not hearing amended clearances was reported in 38, and inadequate "Roger" "Okay", and similar shortcuts in acknowledgement resulted in 46 "nonadherences to ATC instructions". In 41 additional controller/pilot dialogues, airmen insisted that they had read the numbers correctly: the controller had erred in transmission. "I may have goofed " read a typical narrative "but I don't

TABLE 3. LINK FAILURES IN THE ATC/COCKPIT COMMUNICATION CHAIN

Failure Modes	Number of Citations
ATC message numerics transmitted correctly but heard incorrectly, and hearback failed.	328
• Misheard ATC clearance/instruction numerics	174
(The 10,000/11,000 mix - 28) (The FL200/FL220 mix - 11) (Other combinations - 135)	
• Inadequate acknowledgements ("Roger", "So Long", "Okay") with subsequent flight deviations	46
• Apparent inattention to amendments to ATC clearances/instructions	38
• Cockpit mismanagement resulting in readback errors: complacency, fatigue, nontask distractions, habit conditioning, schedule pressure, use of speakers, minor system malfunctions, etc.	71
ATC message numerics transmitted, heard, and read back correctly but followed by deviations due to cockpit mismanagement.	71
• Misuse of altitude alerter display	46
• Other -- primarily "forgetting"	25
Acknowledged controller hearback failures	298
• Failure to hear error in pilot readback	174
• Source of numeric error unknown (either in transmission or receiving -- insufficient detail in report), but not heard in readback	86
• Clearance amendment not acknowledged by pilot and not challenged by controller	38

think so". Finally 71 transmission errors were attributed to intracockpit mismanagement of the clearance information.

Human factors comprised the majority of airman explanations for missing the numbers in ATC messages. There was a considerable variety reported. "It is easy for a flight crew to misunderstand an ATC clearance" explained one airman, an opinion supported by 173 other reporters who narrated the how and the why of their particular transgression.

> "In my experience, flight crews are prone to interpret an advisory of traffic at some altitude as clearance to that altitude."
>
> * * * *
>
> "If flight crews plan or request a specific altitude, they tend to translate the next clearance into that altitude!"

The human factor inadequacies listed by the airmen were familiar and repetitive. Pilots heard what they expected to hear, heard what they wanted to hear and frequently did not hear what they did not anticipate hearing -- amendments to just-issued clearances. There were scattered admittances of hurrying because of schedule pressure. There was laxity: "It was such a beautiful day" and "it was a dull, routine flight...". "We were a little tired" explained several airmen. Other reports offered only nonplussed "I don't know why" nonexplanations. There were consistent slips apparently caused by similar sounds of several number combinations - 5 and 9, 7 and 17, 5 and 15 for example. The "one one zero" and the "one zero zero" thousand and the FL200/220 mixups were reported in 40 incidents.

One error pattern could be clearly identified: mishearing of the numbers occurred most frequently when single, one sentence clearance messages called for two or more separate pilot actions. Thus, "cross XYZ at one one thousand, descend and maintain one zero thousand, reduce speed to 250 knots..." or "Cleared to descend to FL two two zero, cross the twenty DME of ABC at FL two zero zero...".

Although frequent use of "we" phraseology ("We levelled off...", "We descended...or climbed...") unified flight crew actions during multiple crew operations, many narratives indicated that only one airman was communicating and listening to ATC clearances/instructions. The basic roles of "pilot flying" and "pilot handling the radios" split the priorities in primary task accomplishments -- a variable shift depending upon "whose leg it was to fly". There were many phases of taxiing and airborne flight wherein the ATC communications tasks were accomplished without the crosscheck monitoring of the pilot flying. This loss of redundancy was particularly noted in reports from two-man cockpit crews. "There are many times" stated one such reporter, "when only one pilot is on ATC. The other pilot is busy elsewhere...".

This accepted "one-man cockpit show" in ATC communications was commonplace in certain phases of aircarrier operations: in the engine startup, taxiing out activities, during any minor malfunction in early climbout -- including manual pressurization, systems functioning, PA announcement intervals, preparations for approach, tuning radios, etc., etc. One airman noted that he was "off ATC" due to his preparation for the sterile cockpit phase at 10,000 feet. These types of incidents appeared to demonstrate an inherent limitation in the crew concept principle of each pilot crossmonitoring the other. Redundancy in ATC monitoring was provided but only on a "best-effort", "time-available" basis. The single General Aviation or military pilot served necessarily as both flying pilot and ATC communicator.

> "I finished the cruise briefing to the pax. I asked the First Officer, 'What's up?' 'Cleared down to 8,000', he said, 'We're descending...'"

* * * *

> "I depended upon the F/O to handle ATC while I gave the numbers to the company. In that respect, it was my fault."

The overriding importance of controller hearbacks was obvious: virtually all the airmen reports manifested a trusting dependence upon the controller assurance function. Just as pilots <u>always</u> made readbacks, controllers <u>always</u> listened to them. Such was the unvarying, undoubting "leap of

faith" in pilot submissions throughout the study. "I read back, they didn't say anything so I descended...". "No challenge from controller, so we climbed...", "No adverse word from controller, so..." etc., etc.

This stamp of a controller's approval - albeit a silent one -- clearly was accepted as the essential redundancy step during ATC dialogues. This "blank check" reliance upon the hearback link appeared as a surprising departure from the airman's normal philosophy of healthy suspicion about placing trust in other people, particularly persons outside the cockpit. In some instances, pilot dependency upon a controller's listening role emerged as near naivete in accepting supposed clearances to below known terrain altitudes:

> "We took the clearance to 'descend to 7,000', made a readback and started down. However, we had to level off at 11,000 to clear the mountains. The Captain then questioned the controller who said 12,000, not 7,000 had been assigned."
>
> * * * *
>
> "I accepted an altitude below the MSA. It was my casual assumption, being on radar vectors, that I was being given lateral separation from the terrain. Luckily, there was a break in the clouds...".
>
> * * * *
>
> "IFR at 2,500 feet, the controller told me, 'You are in an MVA of 3,600 feet' and 'climb immediately...'".

The same dependence upon readback/hearback channels was exhibited in the scores of airmen reports of misread amendments to previous instructions.

> "If ATC changes an altitude, they should be sure to get an acknowledgement from the crew and not assume that the pilots heard the new restriction."
>
> * * * *
>
> "Center called and asked if we had received an altitude restriction... We said 'No,' nor had we made an acknowledgement. This is an old problem with ATC...".
>
> * * * *

"...to prevent this happening, ATC should require all runway crossing or hold clearances to be read back."

Airmen disparaged their own performance most bitterly when they had flown the wrong airways routings. The "cleared as filed" shortcuts sometimes backfired: "I did not check the clearance issued to us and compare it with our filed flight plan routing. A dumb mistake!" In another wrong direction flight, the flight crew read back the "hard copy" of their flight plan rather than the revised routing just issued to them by clearance delivery. Twenty-five miles on their way, the controller asked, "Where are you going?" "Stupid!" wrote the airman, "Just plain stupidity on my part!"

Yet this self-blaming airman and hundreds of other pilots ended their reports to ASRS with a single, repetitive query: "So, I made an error. But I made a readback. Why didn't the controller catch the error in my readback?"

This high level of dependency upon controller interception of error expressed by all airmen -- General Aviation, corporate, air taxi and aircarrier -- characterized the majority of airmen reports in the study. It developed into the one dominant theme in the study, a query expressed either in puzzlement, in chagrin or in dismay: "Soooo, we made a mistake. BUT we made a readback. WHY didn't the controller catch our error in the readback?"

The Missed Hearback Problem: "Why ATC Did Not Correct our Readback is Unknown..."

The airman's role in the talk/listen/confirm/confirm communications exchanges with the controller emerged from the report data as a clearly defined, step-by-step sequence -- a set of rigid, "must-do" procedures.

First in emphasis was adherence to the readback requirement. "We made a readback...", "We made a full readback...", "We carefully made a readback...", "In accordance with Company policy, we read back the full clearance...". "We read back the clearance slowly to make sure...", etc., etc. Throughout hundreds of narratives the airmen carefully and repetitively stressed accomplishment of their "by-the-book" readback tasks.

Next was the listening mode: hearing the controller's verbal confirmation or at least silent acquiescence of their readbacks. This double-check link was the essential detail in the dialogues. Perhaps conditioned by crew concept principles, the airmen tended to downgrade the significance of their own listening errors as less critical than the monitoring role of the controller.

> "While it is possible that we misunderstood the controller, nevertheless we were relying upon the controller to correct any mistakes in the readback."

Inevitably, with such trust in the hearback function, airmen frequently resorted to exclamation points in registering alarm at failures in the "system".

> "If the readback is ignored, then redundancy built into the system to correct errors is useless!"
>
> * * * *
>
> "I must emphasize that the controller must act as a correcting safeguard when we read back a clearance!"
>
> * * * *
>
> "My impression is that controllers are not in a listening mode. As soon as they issue a clearance, they start talking to other aircraft and pay no attention to the readbacks."
>
> * * * *
>
> "It is my opinion that I could read back my social security number and most controllers would not question it! Centers are worse than terminal facilities in this matter."

The complaint list was long and emphatic: "Two often, controllers aren't listening!" "I can only say, readbacks are important!" "Readback confirmation by controllers is a doubtful matter." And, finally the repetitive exhortation, "Controllers should listen to readbacks!"

However, neither a consistent theme nor concern with the various human-factor circumstances related to hearback deficiencies could be discerned in controller narratives. Controller submissions tended to focus upon conflict

intervention actions while the prior causal readback/hearback deficiencies were de-empnasized. It appeared from the narrative treatment of the incidents that controllers frequently remained unaware that they had not heard an erroneous or not-made readback until the tapes were run in postincident investigations. Thirty-four of the 85 controller reports either omitted all references to pilot readbacks or condensed the subject into one-line brevities: "I did not realize...", "I failed to hear...", "I did not catch...", "I did not copy...", "I missed hearing...", "I did not listen...", "I did not recognize...", etc., etc. Twelve additional reports indicated that controllers had not noticed that no pilot readback had been made to an amended altitude/heading message.

Overall, radar observation and collision avoidance action were the subjects of the controller submissions. Furthermore, contrary to pilot narratives that described the human factor circumstances that had diminished their attentiveness to ATC transmissions, controller reports tended to format the miscommunications events into standardized "System Deviation" and/or "System Error" phraseology. This attitude probably reflected the higher priorities of job responsibility: separation of converging traffic was of paramount importance no matter what the causes might be.

Tabulation of the 85 controller submitted reports confirmed the controllers' overriding concerns with collision avoidance. Seventy of the nonweather related incidents involved traffic conflicts that had developed from the ATC/pilot communications breakdowns, the majority of controllers had confined significance of communications to "Loss of Standard Separation" or the more hazardous near midair collision occurrences.

These differing priorities strongly affected the reporters' assessments of the seriousness or gravity of communications errors. Somewhat to the surprise (and apparent relief) of pilot reporters, an airman's deviation from an assigned altitude or heading factor frequently elicited a relaxed "no problem" response from the controller. Similarly, at times when pilots protested that they had correctly read back the numbers, the controller advised, "You probably did..." or, "I don't remember what you read back". or, "The controller said he did not know what I had read back" or, more frequently, "No comment made by the controller". In the eyes of many controllers,

deviations in flight path due to miscommunications had negligible impact upon the system until they "rang the bell" in a traffic conflict occurrence.

Not all "no problem" types of incidents were relaxed affairs. The add on phrase -- "Then the controller said..." -- connoted an almost perceptible "gulp" in various airman recountings of an altitude assignment mixup.

> "I asked the F/O about our descent clearance. He said, 'Down to 2,000 feet' and set the altitude alerter to 2,000.
>
> "After we levelled off at 2,000, approach called to confirm we were level at 5,000. We told them we were at 2,000.
>
> "The controller then said 'You are past your traffic. Maintain 2,000'."
>
> * * * *
>
> "'What are you doing at 8,000!' said the controller. 'Make an immediate right turn to zero eight zero degrees...'. Then he said, 'Disregard. You are by the traffic.'"
>
> * * * *
>
> "I asked if he wanted us to descend down and he said, 'No, you're already past your traffic...'."
>
> * * * *
>
> "We said 'Affirmative, we're level at FL270.' The controller then said that traffic had been at FL270 but now we were past our traffic and could stay at FL270."

In parallel with the controllers' emphasis -- not on confirmation of where the pilots intended to go but upon where they actually went -- controller self-admitted deficiencies involved inattention -- not to the communications but to the radar display of the aircraft's Mode C data block.

> "A panicked controller called us, 'ABC, confirm FL240!'
>
> "The F/O replied 'Negative. We are descending through FL232.' The controller said 'You are supposed to be at FL240. There is a wide body at 230.'
>
> "On the phone later, the controller said that he had diverted his attention to another flight until the conflict alert got him back to looking at our aircraft."

* * * *

"Traffic conditions were moderate to heavy -- about 16 aircraft. By the time I got back to ABC, he was already out of FL334 climbing with XYZ 4 miles away..."

* * * *

"There were 21 IFR aircraft within the sector or on hand-off status...all deviating due to weather. Inadvertently, I gave an aircarrier the same altitude as his traffic. Then I turned my attention to other traffic situations.

"The conflict alert activated but I disregarded it because I thought I had altitude separation..."

* * * *

"The military took the heading for an altitude and I did not catch his readback until he left his altitude..."

* * * *

"The erroneous readback was missed and due to other traffic on the scope (about 10 other aircraft) his position was not monitored. The conflict alert activated..."

The conflict alert system -- the sounding/flashing electronic backup for controller observations for traffic separation lost or about-to-be-lost -- at times was negated by human factor circumstances.

"Conflict alert observed. Immediate turns given but no acknowledgements from either aircraft. Targets merged with no separation and Mode C showing 5000 feet for both aircraft."

* * * *

"Conflict alert activated... I was too stunned at seeing ABC's data block at FL230 to react..."

* * * *

"We apparently misunderstood 5000 for 6000. After we sighted an aircraft at the same altitude, we asked the controller, 'Didn't he hear our readback?' Then I asked about the conflict alert.

"The controller said it had alarmed but they get a lot of them when aircraft are stacked up in a holding pattern."

* * * *

"...aircraft crossed in IMC. No time to intervene."

* * * *

"The conflict alert activated but it did not sound in time for our sector to resolve the conflict."

Only 13 of the 85 controller submissions referenced workload distractions from attentiveness to pilot readbacks or to radar displays. These frequently were generalized background comment, rather than direct statements of cause and effect. Nevertheless, the disruptive influence of "moderate to heavy traffic" and frequency congestion were often mentioned in the narratives. "There were 6 or 7 aircraft on the frequency...", "I was working about 10 aircraft at the time...", "I was working 15 aircraft spread out over 5 frequencies...", "Ten other aircraft on the scope...", "I was monitoring 6 VHR and 4 UHF frequencies...", "Too many computer inputs to make...", "I was very busy...", etc. This consistent flavoring strongly suggests that in fact workload distractions were the primary cause for the radar target misses.

Similarly, only 35 of 332 pilot reporters confirmed traffic/frequency congestion as possible contributing causal factors in the communications misses. "The controller said he was very busy...", "This controller was overloaded...", "Communications were very fast...", "I got the very definite impression that this controller was overloaded...", "The rapid pace of instructions must have made it impossible for him to verify my readback...", "The controller didn't seem to have time to monitor my readbacks...", etc. Frequency congestion, rapid pace of transmissions, fast communications, and "too busy to listen", such were airman's observations of controller workload environment.

There were indications in the 13 controller and 35 pilot observations, that somewhere in the controller's general flux of transmissions to multiple aircraft, in the overlaps of interphone calls with aircraft responses, and in the mental flick-flick of planning/attention to successive targets, a pilot's erroneous readback may have passed unnoticed.

Whether or not these task overlaps fit the AIM's allowable exception to normal ATC/pilot voice procedures could not be determined from controller narratives. Nevertheless, these sets of reports provide a limited response to the airmens' questions about why readbacks seem to have been ignored. Additionally, it is only through a controller's apparent "busyness" and/or frequency congestion that airmen may assess controller workload. Other factors are not so obvious. Pilot requests frequently must be interphoned from adjoining sectors: "Can ABC have FL350?" "Can XYZ go direct to ___?" "GGG wants inertial direct LAX to DEN." Every message "Change over to ____ frequency" mandates, as a minimum, that a controller makes a handoff computer entry on the console keyboard. Furthermore, individual airmen may pre-empt a controller's time and attention excessively: one airman may not acknowledge, requiring a repeat transmission. An aircarrier pilot may require a "say again" for a frequency change. A corporate jet pilot may want to negotiate his descent point: he doesn't want to descend "now" but "at pilot's discretion". Satellite airport departures may overlap transmissions checking in on the frequency from widely separated outlying locations. One controller astutely characterized the situation, saying: "My workload is not equated necessarily with the numbers of aircraft I'm handling. It's how much talking I have to do with the pilots who are on the frequency."

A corollary finding from the study was that many airmen operate with the assumption that a radar controller is continuously monitoring their particular aircraft in its progress through the sector. The airmen expressed puzzlement, sometimes even suspected "game playing" at "being permitted" to fly 7 or 8 miles in the wrong direction or to reach 1000, 2000, or more feet in deviation from an assigned altitude before being challenged by a controller.

> "Why did the controller wait until we were level at 5000 feet before he told us to climb back to 6000?"
>
> * * * *
>
> "I am puzzled. Although we were under radar surveillance, nothing was said to us as we passed through FL240."
>
> * * * *

"Why did the controller take so long to notice that we were at the wrong altitude?"

Although controller reports only infrequently mentioned workload, it may well be that the controller was busy with other traffic or responsibilities.

Defective Cockpit Management: Why Pilots Failed to "Keep it Straight"

A single, simple pilot-to-pilot phrase, "It's your leg...", defines and sets into motion complex crew coordination functions in multiple-crew operation of an aircarrier aircraft. The traditional swap of legs between the left and right seats splits the priorities of duties, responsibilities, tasks, and attentiveness into two categories: "pilot flying" and "pilot communicating". The two pilot roles are separate and distinct yet both mesh into achievement of a single goal: the maintenance of the correct flight path of the aircraft. The pilot flying works the controls manually or via the autopilot, but in controlled airspace the pilot communicating must channel to the pilot flying the safe and/or desired flight-track information as planned and issued by the ATC controllers in the form of clearances.

Crew concept principles overlie these separate but coordinated functions. Cross cockpit monitoring and advisory callouts provide a semi-continuous, "fail operational" interception of human errors, slips or limitations. One of the insidious traps inherent in communication errors as reported in this study was the flight crew's mistaken belief that they were doing what ATC had instructed them to do. Thus, because the entire crew was operating under a false assumption, the internal double-check protection was rendered useless.

In a few occurrences, defective cockpit management permitted override of the primary rule in flying airplanes: one pilot flies the airplane at all times.

"We were putting in the INS coordinates when the clearance to FL330 was received. We failed to arm the new

altitude into the autopilot. I thought the F/O had armed it and he thought I had.

"Climbing out of FL337, the controller called..."

* * * *

"The F/O did not hear the amended routing since he was in the lav at the time. I was discussing a pax concern with a flight attendant -- I did not write down the clearance or pull out the charts. I forgot all about it until the controller called..."

* * * *

"I was both flying and communicating. The Captain was conversing with a stewardess. I thought I heard 'cleared to 10' but on reaching 10,000, the controller asked why we were not maintaining 11,000...

"We must do more double-checking in the cockpit!"

Incidents of failure of the pilot communicating to pass along and/or to confirm mutual understanding of the ATC numbers invariably were introduced by the all-too-familiar "I assumed that..." phraseology. "I assumed the Captain heard the clearance...", "I assumed that he had heard my readback...", "I assumed that he had heard another clearance that I missed...", "The instructions seemed clear enough not to warrant asking for a response from the Captain who was also on the frequency", "The F/O did not tell the Captain of the ATC clearance...", "The Captain did not hear and the F/O did not inform him...", etc.

A scant level below the "I assumed" behavioral attitudes were the "Why bother" displays of complacency.

"It was a dull routine flight. I was not paying any attention to what the Captain was doing..."

* * * *

"It was an easy flight. Too easy..."

* * * *

"The Captain was not alert and was not double-checking me..."

* * * *

> "The F/O had missed so many ATC calls that I asked him about his outside activities..."

In several incidents, crew coordination, and cockpit management appeared absent:

> "I was the copilot and it was my leg to fly. We had requested 10,000 feet but ATC issued us what sounded like something else... I believed I heard 15,000 but the Captain read back 14,000.
>
> "I did not debate the correctness of the altitude since it was such a short leg. I thought we would be asking for lower before we reached 14T.
>
> "About 2 minutes after we had levelled off at 14,000, the controller called. He sounded very upset...we were supposed to be at 10,000 and had climbed up into someone else's airspace."

One puzzling flaw in cockpit management of ATC messages was the apparent reluctance of airmen to reconfirm doubtful numbers with the controller. In these incidents, the crew discussed among themselves what the other "thought they heard". "The crew discussed...", "We all agreed that...", "We both agreed..." The final consensus poll decided the flight path trajectory of the aircraft. Dependency upon the controller's silence to the readbacks appeared as a decisive influence upon the decision making.

> "I read back the clearance. No adverse word from controller. So we agreed that we had been cleared..."

* * * *

> "We talked among ourselves that it seemed too early to be given a descent down to 6000 feet... However, since the controller had not contradicted our readback, we descended.. "

The varying personal attitudes and the differing types of personalities that pilot scheduling practices may bring together in the cockpit seem to have caused some of the information sharing failures observed in the studies. In some instances, an autocratic pilot-in-command attitude prevented effective verbal coordination.

"It is not always easy for a F/O to offer suggestions to the Captain or dare to question something he has said..."

* * * *

"The Captain was so sure of himself that it would have been presumptuous for me to ask him to verify the information. The next time, I will find a way to do it regardless of a Captain's attitude..."

* * * *

"Lesson learned! Just because he's a Captain, there is no need to assume that he operates at a higher level of efficiency than I do!"

While command authority was often cited -- "The Captain was so sure, I let it ride...", "I had doubts but the Captain seemed so sure...", etc., many incidents reflected the reverse. "The First Officer was so positive that it was FL290...", "I should have questioned it but he said he was sure...", "There was some doubt in my mind but he was definite about it...". One Captain's phrase was repetitive: "Relying upon an experienced F/O induced this incident."

"The F/O had a background of military fighter aircraft and is used to being his own commander and taking the initiative. I was hesitant to give him hard orders so I let him make several moves before I was ready for them. Later, I had a long conversation with him as to who was the Captain."

In 71 incidents, a flight crew correctly heard a controller's transmission, correctly read back the numbers, and then proceeded to go elsewhere -- descend or climb to a wrong altitude, head off in a wrong direction, turn into a wrong airway or at times, cross over an active runway. The most frequent type of crew coordination breakdown consisted of 46 misuses of the altitude alerter device.

These misuses went beyond merely allowing the silent altitude-selection window display to be substituted for the traditional spoken altitude callout. There were indications that once set, incorrectly in these occurrences, the altitude display became the sole authority for what the

aircraft's altitude should be. It not only automatically flew to and captured the selected leveloff altitude its use appeared to blot out pilot consciousness or awareness of the numbers as heard from the controller. Time and again, although both airmen "knew" the correct altitude assigned to them, a misset altitude selector was allowed to take the aircraft to an erroneous flight level.

The large proportion of those incidents in the dataset indicate that the black box once considered a crutch to jog a pilot's memory, has, through repetitive use, led to airmen dependency upon the electronic memory. "I have to be more diligent in carefully setting the altitude alerter", one airman related, "since I have learned to depend upon it." Another: "Even though both of us were completely aware of the specific altitude assigned to us, we continued past it...". Flight crew members' individual responsibility for maintaining altitude awareness appeared to have been transferred to an external memory device.

Many altitude-alerter incidents appeared to manifest a criss-crossing of the pilot flying and pilot communicating roles. Just as a non-flying-pilot's arbitrarily taking over control would disrupt continuity in the management of the aircraft's flight path, the innocent-appearing, seemingly inconsequential reversal of work tasks that took place when the pilot-flying set the altitude alert display confused and disrupted the normal exchange/confirmation treatment of ATC messages.

> "The F/O acknowledged for the '310...' I reset the altitude alerter to FL310 and left FL350. As we went through FL345, the F/O said 'That was heading 310!' At that moment, a controller in a concerned voice asked for our altitude.
>
> "In retrospect, my action was stupid. The F/O knew it was a heading. If I had left the altitude alerter setting to him, it would not have happened."

Two airmen announced firm intentions to "kick the habit" of dependency upon the altitude alerter. "I'm going back to writing down altitude assignments -- a practice I gave up when we got altitude alerters in our aircraft."

And, "Altitude deviations are becoming epidemic. From now on, I am going to write down altitudes..."

The 46 incident set included three basic kinds of errors:

1) Alerter misset by one airman an error not noticed by other airman.

> "We were cleared to 7000 after crossing XYZ VOR at 11,000. The Captain set the altitude alerter to 7000 and the F/O who was flying descended immediately to 7000 before overheading the VOR..."
>
> * * * *
>
> "We were told to turn to 230 degrees and descend to 3200 feet. F/O set the altitude window and armed the flight guidance system to 2300 feet. As we levelled at 2300 feet, controller told us to climb immediately and to turn..."

2) Display selector remained on an altitude set during previous arrival.

> "The altitude select has been set to 11,000 during the descent portion of the preceding flight and we failed to reset it for our departure."

3) Neither pilot set display to newly assigned altitude.

> "We failed to crank in FL310 into the altitude reminder. I hate to admit it, but we were through FL328 when the controller called..."
>
> * * * *
>
> "The F/O heard the 4000 foot restriction, the Captain 'rogered' for it but no one set the altitude alerter."

Additional incidents displayed the hazards in trying to anticipate an altitude assignment not yet received. "In anticipation of the usual SID, the F/O set 17,000 into the altitude alerter. Then he read back our clearance to 16,000. However, he did not reset the altitude alerter." Another incident was self-assessed as overfamiliarity with the route. "On climbout, the F/O had set the altitude alerter to FL230. When the controller asked me to verify altitude, I responded 'Level at 230'. It was then my stomach did a nosedive. I looked at the clearance I had written down. It was FL210."

And, finally, the misset altitude alert narratives often culminated in various lame embarrassed admittances: "I don't know how the altitude alerter got set to ____ thousand feet", "How the altitude selector got set to ____ feet is unknown", etc., etc.

The conditioned dependence upon the black box display was further demonstrated by a group of reporters who placed blame for their altitude deviations on the position of the device in the cockpit rather than on their use of the device. It was difficult to read from one seat or the other, difficult to set from one seat or the other, difficult to monitor from one seat or the other, it was a nonstandard system etc. Blame was allocated to the instrument or its location rather than misuse. One pilot recommended installation of 2 altitude alerters in the cockpit, one for the Captain and one for the First Officer.

However, there appeared to be a stirring of wisdom in many narratives of missed communications, an increase in personal growth from their experiences. "I had a feeling...", "It didn't seem quite right...", "An uncomfortable feeling...", "I had an instinct...", "In the back of my mind, I knew...", "For some reason, rolling around in my head...", all comments that led to firm, emphatic determinations: "Anytime a crewman has an uneasy feeling that all is not right, he should check it out!", and, "I believe an increased emphasis should be placed on verbal discussions or briefings between crew members so both pilots will be kept in the evaluation loop".

Perhaps the most specific definition of the pilot flying and pilot communicating roles as separate but coordinated activities was the following declaration:

> "From now on, in my cockpit, there always will be a formal handover of the ATC watch -- much in the way we hand over control of who is flying the airplane."

SUMMARY AND CONCLUSIONS

The genesis of this communications study was the frequent and continuing reporting of ATC message confirmation failures to the Aviation Safety Report-

ing System. Since making readbacks is a deeply ingrained practice in pilot-controller message exchanges -- a "must-do" cockpit task in aircarrier operations -- controller apparent failures to "listen-up" represented, in the flight crew's minds troublesome breakdowns in the double-check procedures -- failures in the system that effectively destroyed the redundancy concept built into the message procedures and forged the first two links of an all-too-familiar chain of events that could culminate in an aviation disaster. The pilot concern for the dual failure in communications condensed into a single, repetitive query: "SO, we made an error. BUT we made a readback. WHY didn't the controller catch our error in the readback?"

The various types of reported failures in the ATC/cockpit communications exchanges are shown in Table 3. However our examination of the incident set identified several operational patterns, practices, and preconceptions in communications whose significance extends beyond the counts tabulated in the table.

The most consistent behavioral pattern observed in the airmen submissions was an overriding trustful dependence upon the controllers' listening function in the to/from exchanges. Half-heard, doubtful, sometimes guessed at numbers for headings, altitudes, taxi hold points, or Victor airway routings -- IF their readbacks passed unchallenged -- were accepted by the airmen as validated, double-checked instructions as to where to fly their airplanes. Accepting heard clearances for descents to low altitudes while well outside normal distance-to-destination range, climbs above usual altitudes, turns 180 degrees away from desired track, wrong direction flight levels, descents in clouds down through tiers of aircraft in a holding stack, IMC descents below known mountainous terrain -- the airmen subordinated commonsense judgement and operational practicality to an assumption from a controller's silent "confirmation" of their readbacks.

Appearing almost as frequently in report narratives was an implicit airman assumption that controllers were involved solely in monitoring progress of their individual aircraft. Pilots expressed puzzlement, sometimes incredulity, at "being permitted" to level off at altitudes thousands of feet from their assigned altitudes or to fly 5, 10, or in one report 25, miles in wrong directions or routings.

However, no clear, single answer to the airmen's query ("WHY didn't the controller catch our error in the readback?") emerged from analysis of the controller reports of communications failures. The controllers tended to restrict their error reports only to those deviations that developed into traffic conflicts; the report contents dealt with collision avoidance steps and frequently de-emphasized the listening role into "I missed...", "I failed to hear...", and similar brevities.

The discussion of the industry standard readback/listen/confirm/confirm message procedure in the AIM may invoke disturbing uncertainties in airmen conditioned to rely on controller monitoring. "On some occasions", advises AIM, "due to the press of time for issuance of time critical instructions to other aircraft, controllers may be in a position to observe your response visually or on radar." Said more directly, a controller's confirmation of a readback, at times, may be shifted from listening to a pilot's words to observing a pilot's actions. Furthermore, such "occasions" are without pilot knowledge.

It may well be that the latitude implied in the AIM's language is intended to accommodate the on-going industry-recognized traffic surges that occur in the airway routes and approach control airspace at our major U.S. terminals. The loophole provision for departing from the uniform and long-established verbal procedure appears narrow and condition-limited. Yet, if nothing else, the potential for a pilot's self-inducement into "nonadherence to ATC clearance/instructions" through the loss of hearback redundancy should stress to all airmen the importance of first "getting the numbers straight" during a controller's initial transmissions and, second, clarifying any confusion or doubt by suitably querying the information.

The error citations compiled in this study are relatively few when placed in context with the overall national airspace communications load. The occurrence of 417 voluntarily-reported incidents during a 29-month timeframe represents but a ripple in the main stream of hundreds of thousands of to/from/to contacts being made daily in the aviation system. Even so, the existence of the 417 citations is incontrovertible evidence that the hearback problem exists and is capable of producing operational anomalies with accident risks that are far from negligible. Also, the 417 citations

constitute only the lower bound of the actual number of occurrences; with a voluntary reporting system, which is what ASRS is, we can be virtually certain that there are more actual than reported occurrences of any given kind.

The repetitive airman query: "So we made a mistake. But we made a readback. Why didn't the controller catch the error in our readback?" is but partly answered in the findings of this study.

The controller may have been "observing" the readback on radar.

Or, he may have committed a human error as the airman already had.

ADDENDA

This study was conducted during the summer of 1984; during the early fall of that year copies of the first draft report were distributed for peer review by those elements of the aviation industry and related federal government agencies that the author and NASA officials thought were knowledgeable and would be interested in commenting constructively on the work. Many did. Their comments were most helpful in the preparation of the final, published study report.

It is also noteworthy and of interest to readers of this report that early in 1985, the FAA released a change to the ATC handbook (effective 02/14/85) adding the following language in Chapter 2, Section 4.

NEW

2-72. ENSURING ACKNOWLEDGEMENT

a. When issuing information, clearances, or instructions, ensure acknowledgement by the pilot.

b. If altitude heading, or other items are read back by the pilot, ensure the readback is correct. If incorrect, distorted, or incomplete, make correction as appropriate.

Thus, the statement on page 5 of the study report regarding the absence of written regulations on hearbacks is not applicable to current aviation operations although entirely valid with respect to the reports used in conducting the study. It is too early to tell if this handbook modification has reduced the incidence of hearback problems in aviation. ASRS continues to receive them at approximately the same average rate (circa June, 1985) as in the period preceding the conduct of this study.

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Point of Contact: William Reynard, Ames Research Center, MS 239-2 Moffett Field, CA 94035
(415) 694-6467 or FTS 464-6467

16. Abstract

This report covers a study of ASRS reports wherein ATC controllers failed to monitor adequately ("hearback") incorrect readbacks of ATC clearances. A total of 417 reports received over a period of 29 months from April, 1981 through July, 1983 comprised the study data set. Factors examined in the study were: the reasons for a flight crew's getting clearances incorrectly, the operating factors that caused controllers to mishear or not hear the incorrect readbacks, and consequences of the various types of hearback misses. The principle conclusion of the study takes the form of a precaution to flight crews that a controller's not challenging a readback does not necessarily mean the readback is correct and that flight crew's must explicitly question any doubtful or unusual aspects of clearances rather than depending upon controllers to detect readback errors.

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