Human Factors Assessment of SC-214 Message Set Kim Cardosi, Ph.D.

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Activities

- Review of the literature.
- Analysis of Pilot Deviations and ASRS reports involving data link communications.
- Discussions with air traffic control specialists ZNY, ZOA, and in the U.K, Portugal.



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ASRS Reports

- Search for CPDLC/data link related incidents May 2004 through April 2009 yielded
- 22 reports of which 17 were relevant to CPDLC communications
- 8 service availability/inability to contact
- Only one incident relevant to message set
 - Report #795258 "Maintain FL340, at XC00Z CLB to and maintain FL370, report level at FL370" resulted in aircraft climbing early.



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Oceanic PDs FY06 - 09

- 27 events 18 relevant
- 1 pilot interpreted offered reroute as clearance
- 1 pilot interpreted "roger" reply to request as a clearance
- 1 clearance was received on two pages, the first of which contained the first half of the clearance, the second of which was the "climb to be level by 0410" portion. The second was mistakenly believed to be the entire clearance and so the flight began climb without restriction.
- 15 directly relevant to message set
- (9 'other')



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15 PDs related to message set

- All conditional clearances
 - Most involve "AT" time (but exact message not always clear e.g., "flight was issued a climb clearance from FL380 to FL390 which was specified to take effect at 1753z. the time requirement was embedded into the cpdlc clearance.")
 - 2 "BY"

Resulted in:

- 13 climbed early
 - 2 climbed late



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Conditional Clearances

- Known problem with "conditional clearances". Pilots tend to act on the instruction before the condition is satisfied.
- Conditional clearances not used in the US for ground operations (but are used overseas, where problems still exist).
- While available to oceanic controllers, conditional clearances are seen as problematic – particularly ones with "BY" and "AT".



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- E.g., "At [time/location] descend to [alt]

Most Common Error - Pilots miss the "at" (conditional clearance) and begin maneuver immediately.

Controllers report that prefacing the "AT" instruction with instruction to "Maintain [altitude]" has helped, but PD reports imply maintain message was there.



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E.g., "Climb to reach [altitude] by [time/position]"Most Common Error - Pilots mistakenly begin the manuever at the point (position/time) at which it should be completed.

Suggestion – use "Cross (position) at [level/time]" - benefit of being able to be auto-loaded into FMC



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PEACZNY05049 - Concatenated "BY" – climbed early

- at time 1746 ACx is issued clearance via cpdlc to maintain FL330 until 1805z, then climb to be level FL340 by time 1810z. flight acknowledged with wilco response on cpdlc at 1748z.
- at 1750z the flight reported level at FL340. required lateral separation of 60 was lost with ACy at FL340 50 miles away.
- the pilot of ACx called and spoke with the support manager for safety.



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PEACZNY05049 - Concatenated "BY" – climbed early (cont'd)

- the pilot admitted that he had some question regarding the use of the word "by" in the clearance, and after checking a flight manual about the word "by", proceeded to climb to FL340, forgetting about the first portion of the clearance instructing him to maintain FL330 until 1805z.
- the pilot also stated that the format of the mops message displayed in his FMS, makes it difficult to read lengthy clearances.
- Note: Most problems with "BY" involve pilots maneuvering late.



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FY09 "BY" (PEACZNY09026) - climbed late

- AC was at FL360 and cleared to maintain FL380 by 0105z. this restriction was for traffic. At time 0107 an ADS report was received by ZNY that showed AC at FL360. ATC questioned AC about its altitude. The flight reported level at FL380 at 0108:52. Pilot deviation filed because flight failed to comply with conditional altitude clearance.
- All communication cpdlc.



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FY09 "AT" (PWPCZOA09001) – climbed early

- 0114:31, ACx requested a climb to FL360. the oc4 controller issued the clearance to maintain FL340, at 0134, climb and maintain FL360, report level FL360, at 0115:16. ACx responded wilco at 0117:06.
- ACx reported at 0118:15 that they were level at FL360. the controller confirmed the altitude report and ACx responded with roger at 0123:08.
- pilot deviation phraseology was issued to ACx at 0129:41 and he acknowledged it at 0130:52.
- ACx's failure to follow that clearance caused a loss of separation with that aircraft.



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One Known Problem was Formatting (B747-400)





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Revised Format B747-400, B757, B767





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"Expect"

- Pilots have acted on instructions that they were told to "expect"
- Expect "higher" or "lower" would be less error prone than "expect [altitude]".
- but can't be 'preloaded' into FMC



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Santa Maria Control Centre

October 2009- January 2010 controllers received 327 "When can we expect higher?" DMs

- Controllers replied with UMs only 6 times, opting instead for free texts, such as:
- "Expect higher after [time/position or in airspace]"
- "Expect clearance to climb after [time/position or in airspace]"
- "This is not a clearance expect higher after [time/position or in airspace]"



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Potential Ambiguities

- "Cruise climb/descent" is problematic
 - Meaning is not intuitive
 - Controllers are instructed not to use it



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Potential Ambiguities

UM 34

Instruction that a cruise climb is to commence and continue until the specified level is reached. CRUISE CLIMB TO [*level*] **CRUISE-** Used in an ATC clearance to authorize a pilot to conduct flight at any altitude from the minimum IFR altitude up to and including the altitude specified in the clearance.

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Current Message Set (ZOA)

- CRUISE CLIMB ABOVE [altitude]
 - A cruise climb can commence once above the specified level. Due to different interpretations between the various ATS units, this element should be avoided.
- CRUISE CLIMB TO [altitude]
 - A cruise climb is to commence and continue until the specified level is reached. Due to different interpretations between the various ATS units, this element should be avoided.



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"Expedite"/ "Best rate"

UM	Instruction	EXPEDITE	EXPEDITE- Used by
36	that the	CLIMB	ATC when prompt
	climb to	ТО	com-pliance is
	the	[level]	required to avoid the
	specified		development of an
	level		imminent situation.
	should be		
	made at the		
	aircraft's		
	best rate.		

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Complexity

UM62	Instruction that at the specified time the specified position is to be crossed at the specified level and the level is to be maintained.	AT [timesec] CROSS [position] AT AND
UM63	Instruction that at the specified time the specified position is to be crossed at the specified level and speed, and the level and speed are to be	AT [timesec] CROSS [position] AT AND
	maintained.	n A. Volpe National Transportation Systems Center
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Questions

- Not clear how speed is added to UM 63
- AT [timesec] CROSS [position] AT AND
 - AT [level]
 - AT and maintain [level]
 - Complexity may induce errors.



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"Ensuing" is not intuitive

UM140	Instruction to confirm the identity of the next waypoint.	CONFIRM NEXT WAYPOINT
UM142	Instruction to confirm the identity of the next but one waypoint.	CONFIRM ENSUING WAYPOINT



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Error Messages Need to be Clear and Give Solution

UM159

A system generated message notifying that the ground system has detected an error.

ERROR [error information]



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"Reach"

- Reach [level] by [time] UM281
- Reach [level] by [position] UM209
 Redundant with and more confusing than
 - Cross [position] at [time] UM252
 - Cross [position] at [level] UM46
 - Both are Loadable into the FMC



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UM68	Instruction that the cleared flight route is to be rejoined at or before the specified position.	REJOIN ROUTE BY [position]
UM69	Instruction that the cleared flight route is to be rejoined at or before the specified time.	REJOIN ROUTE BY [timesec]



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Concatenated Messages

- Longer messages are more difficult/error prone for pilots (both verbally and with CPDLC).
- Rules need to be developed for use of concatenated messages.
- NextGen implementation should support giving instructions in the simplest format/language.



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Concatenated Messages

- Could be overly complex
 - "The current technical limitations include no more than five message elements in a single message and no more than two elements in a message that contain the route clearance variable." *Boeing, 2010.*



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Concatenated Messages

- Contain no logical check Boeing EXAMPLE
- CROSS ABC AT FL190,
- THEN,
- PROCEED DIRECT TO XYZ.
- This would be loaded as an altitude crossing constraint at ABC, and a direct leg from present position to XYZ (which could delete ABC and its crossing constraint, if XYZ was already in the route, somewhere past ABC). The non-loadable element (THEN) has no effect whatsoever, and is present to help facilitate flight crew understanding. The fact that the clearance to proceed direct to XYZ comes after the crossing constraint does not result in any attempt to comply with



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Missing UMs

- "Can you accept [speed]"?
 - Rather than "When can you accept [speed]?"
 - Request for ride reports, severe weather, icing, etc



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Other critical issues

- Display on flight deck as important as messages displayed
 - Fonts/pages
 - Efficacy of alert indication that message is present will be a critical component of pilot response time.
- Indication of system status
- Message sequencing
 - Time stamp

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Next Steps



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More Information Needed

- Assess feasibility of use in domestic US environment (en route, terminal, surface)
- Time between sending the clearance message and when the aircraft actually alters its physical flight trajectory.
 - Differences between voice, non-integrated and integrated datalink as a function of message complexity.
- How does use of CPDLC affect crew's response time to voice instructions?



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Next Steps: More Information Needed

- Message formats on the flight deck
 - What differences exist/will exist between the format of the message on the flight deck from the message the controller constructs on the ground?
 - How does message complexity/format affect pilot's understanding of the clearance (especially conditional clearances).
- Uses/Effects of free text on the pilots and controllers.
- Effects of pilot procedures on message understanding and communication errors.
- More Air-Ground integration work needed.



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