GROUP-LEVEL ISSUES IN THE DESIGN AND TRAINING OF COCKPIT CREWS[1]

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One way that Cockpit Resource Management (CRM) training can foster crew effectiveness is by building the knowledge and skill of *individual* crew members. This application of CRM training has just been discussed most informatively by Robert Helmreich, and there is much value in such training. Yet, as Bob notes, the overall task of successfully completing a flying mission is always a *team* task. Even though only one person is manipulating the flight controls at any moment, others may be simultaneously operating radios, making fuel calculations, and performing the multitude of other duties involved in flying a large and complex aircraft. Moreover, cockpit crews always operate in an *organizational context,* and the transactions between the crew and representatives of that context (e.g., organizational managers, air traffic controllers) are consequential for any crew's performance.

For a complete understanding of crew performance, then, we must look beyond our traditional focus on individual pilots to see how team- and organization-level factors can enhance (or impede) the ability of even well-trained individuals to work together effectively. This way of thinking about cockpit crews (that is, viewing them as teams that operate in organizations) offers some potentially useful avenues for thinking about next steps in the development of CRM training programs. I will explore those possibilities today, emphasizing how they can enrich (not replace) individually-focussed CRM training.

COCKPIT CREWS AS TEAMS

We often think of flying, even in multi-engine aircraft with multi-person crews, in individualistic terms. This is understandable, given that the selection, training, and assessment of pilots all focus squarely on the individual. No pilot forgets his or her first *solo* flight, when one experiences for the first time what it is like to have a flight depend wholly on one's own capabilities. The individualistic orientation of flight training is reinforced continuously throughout a professional pilot's career, both formally (in individual training and proficiency checks) and informally (through a culture that accords the highest respect to great individual pilots).[2]

Viewed in this light, the work of a cockpit crew is akin to the performance of a

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[2] For further discussion of the historical roots, current manifestations, and possible implications of this individualistic orientation, see Hackman and Helmreich (1987).

ballet: while the ballet is an ensemble performance, each member of the company has his or her own part to play, and those parts are carefully choreographed beforehand. Consider, for example, a Category II approach (as practiced by most commercial airlines): each crew member has individual duties to perform at specified times, and when all members play their parts well, the approach unfolds beautifully. While improvisation may be required under unusual circumstances, all that normally is required is for each crew member to execute his or her own responsibilities precisely in accord with the script.

Flying an aircraft is, of course, much more complicated and interesting than the above paragraph suggests, particularly when things happen that were not anticipated by those who wrote the manuals. But pilots rarely use the language of groups or teams in talking about flying. Let me illustrate with a story about an approach that did not go well. I'd like you to listen carefully to two versions of this story. The first version is as the events were related to me by a pilot (although I have altered some details). The second version is a different way of telling the same story. See what differences you notice between the two. Here is the first version:

> "...so there was this flock of geese having a tea party right over the end of 22 Left, and the tower switched them to 31 just when Charlie was getting lined up on the ILS. Well, the weather was a mess, they were vectoring old Charlie all over the place, and he got confused and got behind. Three times Phil had to remind him about something, and eventually Phil just took the airplane and landed the damn thing himself."

And here is the second version:

> "...so after they got ATIS they just assumed it would be a routine ILS approach to 22 Left and they started chewing the fat. They didn't hear the talk on the radio about the geese over the runway, so when the tower switched runways at the last minute it was scramble time. Charlie was flying, and he had his hands full because of weather and the new vectors he was getting. Phil started changing the radios to set up for the new approach, but didn't tell Charlie what he was doing--and Charlie couldn't figure out what the hell was going on. Nobody really got things organized, everybody got confused, and eventually Phil got so frustrated that he took the airplane and landed the damn thing himself."

Do you see the difference? In the first version, the one most likely to be heard, Charlie has a problem--he let a situation that was not all *that* demanding get the better of him, and he had to be bailed out by Phil, his Captain. The attributions made are all to individuals. The second account invites a group-level interpretation: the *crew* got itself into trouble, by not paying attention to changing situational demands, by not planning and organizing the work (either contingently beforehand, in real time when other exchanges on the radio suggested complications, or after the runway change was announced), and by poor between-member communication and coordination. Indeed, if someone is to be blamed in this situation, it might most appropriately be the Captain for not managing his cockpit well--an interpretation unlikely to be made based on the first account, in which Phil is implicitly viewed as the savior.

One does not often hear stories about pilots and flying that view the crew as a whole as the performing unit. Indeed, because most of us are so accustomed to talking about the performance of individual pilots, it would take a change of mindset to tell a story in which a team is the central character. Yet on occasion it may be useful to think this way. I invite you to join me in doing so now, as we attempt to identify some new ways that CRM training can be used to foster cockpit crew effectiveness.[3]

CREW EFFECTIVENESS

The first issue we must address has to do with the criterion, what we mean by an "effective" cockpit crew. Statements of criteria always have, at their root, statements of values--that is, some specification (even if implicit) of what is ultimately viewed as "good" by those who choose the criteria. So let me be explicit about ours. We ask three questions about each crew we study in our NASA research, questions that make operational our values about line flying. What I have to say later about CRM training is intended to help crews behave in ways that generate positive answers to these questions.

1. Does the performance of the crew fully meet (or, better, exceed) the standards and expectations of others who have a legitimate stake in how the crew performs? The most obvious stakeholders are the clients of a flight--such as airline passengers, or customers to whom freight is being transported by a cargo flight, or analysts who will use data being collected by a reconnaissance flight. But clients are not the only legitimate stakeholders. Others include airline or unit managers, the crews of aircraft that share airspace with the flight, and representatives of the public (such as airport and FAA personnel). Each of these groups has a legitimate stake in how a crew performs, because each of their interests is affected by the crew's behavior. And because the expectations of various stakeholders often conflict with one another, it can be quite a challenge for a crew to attempt to meet them all simultaneously. An effective crew generally succeeds in doing so. A less effective crew may focus its efforts on a single set of expectations and sacrifice all others--in effect converting a multidimensional performance problem into a unidimensional one. And an ineffective crew may fail to meet any group's expectations for its performance.[4]

2. As crew members gain experience with one another over time, do they become increasingly expert in working as a team? Many crews do so: by the time they have flown their last leg together, they are operating as a well-oiled machine. Observing such crews is like watching a fine basketball team or jazz ensemble. Members are ahead of the

[3] For the theory of team performance on which the material that follows is based, see Hackman (1986).

[4] This approach requires us to think about effectiveness in line flying very differently from the way performance typically is assessed in check rides and in research on pilot performance. For one thing, demonstrated proficiency in executing an established set of procedures and maneuvers merely affirms that a pilot has the competence to execute well the technical aspects of the work; it does not address how that competence is used to achieve performance objectives. Also, simple unidimensional measures of performance (such as fuel burn, actual versus scheduled block time, or number of deviations from prescribed cockpit procedures) are not sufficient to assess overall performance in line operations--even though many such measures may be useful as components of a summary assessment. Finally, traditional check procedures focus almost exclusively on the behavior of individual pilots; here we are asking how the *crew as a whole* does in meeting others' legitimate expectations and standards.

game, anticipating one another's moves, constantly adjusting their own behaviors to help their teammates to the greatest extent possible--and usually having great fun in the process. For other crews, the first leg may be the best leg. The longer members work together, the more problems they have in doing so. Tension and conflict can even build to the point that members actively undermine one another (as when the pilot not flying observes that the pilot flying is about to make an error, and sits back and lets the error happen; or when one crew member has elaborate, deliberate difficulty understanding what another is asking or saying).

There is evidence that crews generally do become better at working together as they spend more time together (Foushee, Lauber, Baetge & Acomb, 1986), which is good news. Yet I would argue that this does not happen automatically, and I count as one component of team effectiveness the degree to which members are able to build their capabilities as a performing unit over time.

3. Does the experience of being in the crew contribute positively to the personal learning and satisfaction of each individual member? The first of my three criteria focusses on performance outcomes, and the second on the capabilities of the crew as a performing unit. The final criterion addresses the impact of the overall experience of flying with a crew on the learning and satisfaction of individual members. In an effective crew, each member comes away from the crew generally happy with the experience, and more knowledgeable or competent than he or she was when the crew initially formed. In an ineffective crew, the experience of working together may serve mainly to frustrate or upset everyone, and even to diminish the confidence that individuals have in their own competence. Even if a crew's mission is completed satisfactorily, I do not consider it effective if members depart frustrated and alienated by their experiences in the team.

In sum, I am arguing that there is no single criterion of crew effectiveness. Instead, we must examine what happens on three different (although obviously related) dimensions: one having to do with the task, one with the capability of the group as a performing unit, and one with the learning and satisfaction of individual crew members. Can cockpit resource management help crews achieve a high standing on these three dimensions? As will be seen, my answer is affirmative--but with some qualifications that depend on what the training is about, and when in the life of a crew it is expected to be used.

FOUR CRITICAL TIMES IN THE CREW LIFE CYCLE

There are certain times in the life of a crew when CRM skills can be very helpful in achieving the criteria I just discussed, and other times when such training will be less relevant. Let me explain my thinking about this by identifying four critical times in the life cycle of a crew, and then identifying the points in that cycle at which I believe resource management training can have the greatest leverage on crew effectiveness.

Pre-Arrival: The "Shell." Many features that significantly influence the life of a cockpit crew are already in place before crew members meet prior to their first leg. Arriving for work is something like walking into a room in a hotel where you have

stayed before. The room is already furnished and the familiar layout shapes your behavior to a greater extent that you realize. (For example, recall your behavior in the last hotel you visited that had a television remote control switch at bedside but no desk or worktable, and compare that to your behavior in a room where the opposite was true.) You also know ahead of time how to relate to hotel staff you encounter--the van driver who picks you up at the airport, the desk clerk, the room service waiter--even though you have not met any of these specific people before. And you have a clear understanding about the behaviors that are and are not appropriate for hotel guests. (It is perfectly acceptable, for example, to take the little container of shampoo that appears on each day of a multi-day stay, even if you have not used up the first day's supply; but it is never acceptable to walk off with one of the hotel's blankets.) You have great latitude in how you can behave in a hotel. Yet that latitude is restricted in ways you rarely think about--restricted by how the room is outfitted, certainly, but also by your own knowledge about how one is supposed to relate to hotel staff and by general norms of conduct for hotel guests that you accepted long ago. As will be seen, the same kind of phenomenon occurs in cockpits.

I call the collection of features that are already in place prior to the first meeting of the crew the cockpit "shell." The shell is the overall structure within which the crew works, and it consists of things that are accepted as givens by crew members or that they assume to be true without questioning. Among the most significant features of a shell are:

--*The basic flying task and cockpit technology.* For an airline crew, the core task (flying a set of passengers from point A to point B as safely and expeditiously as possible) and the technology (the general configuration and instrumentation of the type of aircraft flown) are taken as given by crew members, without need for personal reflection or group discussion. If behavior is affected by how the core task has been designed by the airline, or by the technology installed on the aircraft, that influence is mostly hidden from view.

--*The roles of crew members, and the general characteristics of the people who occupy those roles.* On Boeing 727s operated by a certain carrier, for example, there always will be (a) a Captain, First Officer, and Flight Engineer in the cockpit, and (b) a team of four flight attendants in the cabin, one of whom will serve as lead. The general duties associated with each role are well-known by all, and each individual is assumed to have the knowledge and skill needed to execute his or her role competently.

--*The basic norms of conduct that regulate crew member behavior.* While these norms can vary greatly from organization to organization, there typically is substantial agreement about them within a given airline or military unit. Crew members know what is expected and valued on flightdecks in their organization, and they also know what behaviors are unacceptable. Because individuals "import" their understanding of such matters to new crews they join, there is no need for basic group norms to be explicitly discussed or re-created each time a crew forms. Such norms are simply part of the common cockpit "shell" of that organization.

In sum, the cockpit shell exists even before members of any given crew first meet. Shaped over time by technology, policy, and collective experience, the shell frames the crew's work and shapes how that work unfolds. Yet its impact often goes unnoticed--precisely because it is so generally accepted as "the way things are" in a given organization.

Team Creation. When people occupy a shell, they breathe life into it and become a *team.*[5] Previously an abstraction, the shell now becomes a real working environment. The abstract task of flying a 727 from point A to point B safely and expeditiously, for example, now becomes specific: it is flying aircraft 802 (which has one autopilot inoperative) with 92 people on board from Seattle to Denver (where thunderstorms are predicted), and then going on to St. Louis and finally overnighting in Detroit. The standard crew roles (i.e., Captain, First Officer, and Flight Engineer, working with a team of four cabin crew) are now filled with real people: it is Phil and Charlie and Linda, working with Bob (who is new), Mary Sue (who is funny), Alphons (who is the lead attendant), and Willa (who doesn't say much). And the general norms of conduct that guide crew behavior in the organization (for example, that the Captain and First Officer will fly alternate legs) are tailored and applied to present circumstances: Phil is a management pilot who needs some landings, so he will take both the first and last leg; moreover, since he has not been on the line for a few weeks, he wants Charlie and Linda to be especially quick to point out anything that concerns them.

The shell becomes a team very quickly, and very early in the life of a crew. Indeed, the team creation process begins the instant crew members first see one another--when they immediately and automatically begin to size one another up. The process continues at full tilt (even if subtly) as ground preparations for the flight are completed. By the time taxi begins, members have become a full-fledged team, and a great many things have been established that will shape behavior in the crew throughout its life (for example: that the Captain is a real stickler for following company procedures; that the cabin attendants are experienced and can be counted on do to the right thing; and that this will be a crew that has lots of fun).

Task Execution. The crew now proceeds to do its work: planning, solving problems, manipulating controls, communicating endlessly (with other team members, but also with passengers, ATC, and support staff from the organization), and so on. These activities have been well-documented and well-studied, so I will not go over them again here.

Most that has been written about the execution of the flying task focusses on how the crew functions during high workload times: the critical moments that surround takeoff and landing, plus other times when things are so busy and demanding that the safety of flight requires focussed, competent team behavior.

It also is true, however, that a great deal happens during those times when nothing seems to be happening--at 35,000 feet over Kansas, or at the hotel over dinner. Such

[5] By "team," I mean a small social system in which (a) membership is clearly defined (i.e., one can readily distinguish members from nonmembers), (b) members have differentiated roles to play in pursuit of some common purpose, and (c) the team as a whole manages transactions with other individuals and groups as it goes about its work (adapted from Alderfer, 1977). A cockpit crew clearly meets these criteria.

low workload times are occasions for people to learn from one another, and for the team to evolve and mature as a performing unit. There is no guarantee, of course, that what is learned will help performance or strengthen the team; we have all seen people learn things that impede subsequent performance, and dinner outings that nearly destroy members' ability to work together the next day. The point is that things are *happening* during seemingly task-irrelevant times, and those things are worth attending to because they can powerfully shape subsequent team behavior and performance.

Team Termination. The aircraft has been shut down and the paperwork completed. The work has been performed, whether well or poorly, and individuals are preparing to go their separate ways, whether better or worse for their experience working together. The team ceases to exist.

A given crew may or may not take time to debrief on their time together, depending on organization policy, the Captain's preferences, and (perhaps most of all) how late it is and how tired crew members are. But whether or not team members reflect systematically on their collective experiences, people have learned and been changed by their experience in the team.

There is, in effect, a residue left behind each time a crew terminates--and that residue is one means by which the cockpit shell for a given organization evolves over time. "Well," the First Officer reflects while driving home, "all that stuff they were saying in training about being assertive with the Captain certainly turned out to be hogwash. Next time I'm flying with one of the old codgers he can start down as late as he damn well pleases; if he misses a restriction, too bad. But I'm not about to stick my neck out again and get it chopped off the way I did coming into DFW...." The shell has changed. It changed only a tiny bit, and in this case not in a way that would please a CRM instructor. But it has changed, and the cumulative effect of thousands of small lessons such as this can be powerful indeed in redefining the shell that will be occupied by crews in the future.

POINTS OF LEVERAGE FOR RESOURCE MANAGEMENT TRAINING

CRM training can yield benefits at all four of the times in the crew life cycle I have been discussing: prior to arrival (i.e., by affecting the cockpit shell), at the time the cockpit team first forms, during execution of the work, and when the crew terminates. I will discuss these times in order of their amenability to change through CRM training, starting with the time of team creation--which I view as having the greatest promise. Then I examine, in turn, the impact of CRM training on behaviors during task execution, on crew termination processes, and on the pre-arrival shell.

Team Creation

As part of our NASA research project, Lt. Col. Robert Ginnett of the USAF Academy has recently completed a study of team formation in a large U.S. carrier that requires Captains to brief cockpit and cabin crew members as a group before they board the aircraft (Ginnett, 1986). Ginnett found that the briefing--indeed, the very first

moments of the briefing--shaped what happened in the crew throughout much of its life history. Apparently the initial framework established by a team has great momentum over time, a finding also true for other types of task-performing groups (Gersick, 1986).

While a given Captain tended to conduct briefings in essentially the same way on different occasions and with different crews, there was considerable variation among Captains in how they managed the first moments of their crews. Ginnett found that different Captains' briefings could be neatly categorized in terms of their impact on the pre-existing shell--specifically, on crew members' imported expectations and assumptions about how crews in that airline operate.

The best Captains *creatively elaborated* the shell. That is, they accepted and affirmed the positive expectations shared by pilots in the airline about how crews should function, and then tailored those expectations to fit as well as possible with the special circumstances of this particular flight and with the Captain's own preferred leadership style. By the end of the briefing, these Captains had built a strong sense of team identity, a commitment to excellent performance, and a set of norms that encouraged all crew members to share in the leadership of the team under the Captain's overall direction. In sum, these Captains actively shaped the team that they were to lead, and did so in a way that strengthened and elaborated the positive features of the pre-existing shell.

More typical were Captains who *affirmed* the shell. These individuals ensured that members were clear about the boundaries of the team, about any special requirements in the work that was about to commence, about the roles of all members (including how the cockpit and cabin crews would coordinate their activities), and about the way the crew would manage its relations with external groups such as ATC, ramp personnel, and operations staff. But these Captains did not take initiatives to build the team beyond normal company expectations.

A third group of Captains *abdicated* responsibility for building the team. They typically would go through the motions of conducting a briefing, but seemed to do so mainly to comply with company policy. Little real work was accomplished in these sessions, and crew members usually left the briefing room with their pre-arrival expectations and assumptions augmented only by factual data such as the names of others in the crew, dispatch information, and so on. These Captains reported that they saw little value in even having a briefing, often describing the process as "going through the motions," or as "the social hour."

A fourth (and very small) group of Captains actively *undermined* the pre-existing shell. Positive features of the shell were systematically dismantled through comments like "I know they want us to do such and so, but I think we'll just overlook that..." or by blatant behavioral violations of normal expectations (such as making a joking comment about how "the First Officer will have to run the cockpit because I'm tired and am just going along for the ride").

One would predict that teams briefed by these four groups of captains would differ substantially in their ability to work well together, and that prediction was affirmed by Ginnett's on-board observations throughout the lives of the crews. It appears, then,

that the process by which a Captain creates a team is well worth attending to in CRM training. The consequences of the team creation process are significant, and they endure for a surprisingly long time. Moreover, skills in forming a team and conducting an affirmative briefing should be readily trainable; they do not require Captains to change their personalities or to exhibit behaviors that are inherently difficult to master.[6]

Task Execution

Beyond the enduring effects of the team creation process, how much impact can CRM training have on the way crew members interact as they work their way through a multi-day trip? I have two opposing responses to this question. One type of training appears to have limited impact in the short term (but may yield significant long-term benefits); a second type can have immediate constructive effects on team performance.

I am pessimistic about the short-term payoff of training that seeks to alter how crew members (particularly the Captain) behave in periods of high stress. How are crew members likely to act when hit with an engine fire, followed by numerous secondary problems? Is that a time when they will draw heavily on their CRM training? It is very unlikely. Psychological research shows that under periods of high arousal, people revert to well-learned behaviors, exhibiting whatever response is most dominant for them for the present situation (Zajonc, 1965). Training in resource management is not going to result in an immediate change of these dominant responses; they are too well-learned for that. And therefore there will be no immediate change in how crew members act under highly stressful flight conditions.

Only over the long term, when appropriate responses also become the dominant responses, will the benefits of such training be seen. Consider, for example, the behavior of Captains during emergencies in Line Oriented Flight Training (LOFT) scenarios. According to Clayton Foushee (personal communication), Captains in the early years of LOFT training tended to become autocratic in emergency situations, firing off orders and taking personal control of the aircraft if they were the pilot not flying. Now it is becoming more common for the Captain to delegate flying to the First Officer, and then go to work on the problem with the Flight Engineer (if present), soliciting the input of other crew members along the way and taking the time needed to consider various strategies for managing the problem. According to Foushee, CRM training probably has been instrumental in achieving this gradual but fundamental change in Captains' dominant responses to emergency situations.[7]

A second type of training can result in immediate improvements in crew performance during task execution. This training defers consideration of behavior under

[6] Despite the considerable potential of well-conducted briefings for promoting crew effectiveness, there is great variation in the policy of air transport organizations regarding them. At one extreme, some military units require Captains to conduct an extensive and highly structured briefing for all working members of the crew (not just the cockpit crew); crew members report two and one-half hours before scheduled departure to allow ample time for the briefing and other flight preparations. Other organizations require a briefing, but cabin crew members are not included because their schedules are not yoked to those of the cockpit crew. In still other carriers, normal practice is that no briefing is conducted--and crew members sometimes are observed introducing themselves to one another even as they are running the pre-flight checklist.

[7] Robert Helmreich (personal communication) reports that gradual changes in pilot behavior also are appearing in response to two other types of CRM programs: those that seek to change pilots' attitudes about flightdeck management, and those intended to help pilots understand how stress affects their personal capabilities.

stressful conditions, and focusses instead on what happens when things are relaxed--for example, during low workload periods in flight, or when crew members are together outside the cockpit (such as on overnights or while waiting for an aircraft to arrive). Our data show great variation in how Captains use such times. A few use them destructively, perhaps by harping on personal complaints about the organization or starting an argument with other crew members about some task-irrelevant issue. Such behavior diverts members' attention from their flying responsibilities and may even undermine the Captain's credibility as a leader. Other Captains appear not to be aware of the leadership opportunities such times offer, and essentially squander them by letting conversation and attention wander in whatever direction it happens to go.

Some Captains, however, use low workload times to "tune" the team as a performing unit. Examples that might take place in flight include:

--Taking an initiative to re-focus attention on the flying task if it has been straying, perhaps through a comment as simple as "Well, let's take a minute and see how we're doing here..."

--Fostering crew members' learning from one another, perhaps by encouraging someone who has just returned from recurrent training to comment on what new things he or she learned that the rest of the crew ought to know about, or by initiating an exchange of experiences among crew members who have different backgrounds (e.g., corporate vs. military).

--Encouraging members to project how their situation may change as the flight progresses, and to do some contingent strategy planning based on that assessment (for example, asking the Flight Engineer to find out what is happening to a line of thunderstorms that was supposed to be moving across Pennsylvania, and then engaging the crew in conversation about alternatives for managing the approach to New York based on those data).

Beyond such "tuning" interventions, a Captain can use low workload times (or out-of-cockpit times) to continue the team-building process that was begun when the crew first formed. He or she might, for example, initiate a conversation that is explicitly about cockpit leadership--helping crew members see that they all have leadership responsibilities, that everyone needs to watch for leadership functions that need to be performed and to make sure that they actually are accomplished. If successful, this intervention should increase the frequency with which crew members other than the Captain take initiatives (such as those listed above) to "tune" the crew's performance. Another example of a team-building intervention might be to use the first evening of a multi-day trip to do an informal team self-assessment, seeking members' views about how the crew is functioning and inviting their ideas for improvements.

There are, of course, many other things that a Captain can choose to do to build a team over the course of a trip. What will be appropriate depends heavily on both the situation the crew finds itself in and on the personal styles of the crew members. The point is that an effective team leader does not merely create the team and then keep hands off; instead, he or she is constantly on the alert for appropriate occasions to strengthen the team and fine-tune its performance.

Like training in how to competently create a team, training in performance tuning and team building are intended for use during relatively relaxed times in the life of a crew. For that reason alone, it may have a greater impact on behavior during line flying than training that aspires to directly change how people behave in challenging, high workload situations. Still, training in team-oriented leadership is sure to require repetition and frequent opportunities for practice, since many Captains will find the behaviors they need to exhibit unfamiliar and awkward when they first try them out.

The potential payoff of team-oriented leadership training is great. The ultimate benefit, of course, is that when the Captain really does need to have all resources focussed on a serious problem the chances are greater that they will be available and deployed. Even if the Captain slips into an ineffective style of leadership during a crisis, help may still be forthcoming from his or her colleagues--precisely because the Captain previously took the trouble to build the crew into a strong performing unit whose members share responsibility for getting critical leadership functions fulfilled (Hackman & Walton, 1986). Moreover, such training contributes directly to achieving the second and third criteria of team effectiveness I specified earlier: namely, that the team grows in competence as a performing unit over time, and that experiences in the team contribute positively to the personal learning and satisfaction of each member.

Team Termination

The termination of a cockpit crew can be an excellent time to apply resource management training. I can only speculate on this matter, because we have collected no data specifically about crew termination. Research on other types of teams, however, suggests that the end of a group provides a unique opportunity for members to explore what can be learned from their time together. Because the team has finished its work and has no future, members may be relatively comfortable reflecting on what has transpired, and more open to learning from those reflections than they would have been previously. Just as some of the most significant lessons from LOFT exercises come after the simulation is over, so can learning from line flying be harvested at the end of a crew's time together.

For debriefings to become commonplace in commercial air carriers would require a significant culture change; in all carriers I have observed, crews generally disperse as soon as possible after the flying is completed. Because regular debriefings are so contrary to usual practice in commercial aviation, it is likely that any attempt to institute them would be met with strong resistance. Yet there are flying organizations in which end-of-mission debriefings are conducted routinely--such as military units during combat operations (Robert Ginnett, personal communication). So it is at least *possible* to conduct learning-oriented debriefings after a crew's flying work is finished.

If such debriefings were to become common practice in an organization, pilots in that organization would, over time, become more and more skilled at working in teams. The "people" part of the cockpit shell would become increasingly conducive to excellent team performance, and crews would find that they are able to get off to a faster start than previously was the case--bypassing much of the trial-and-error learning that typically occurs early in the life of a crew as members are learning how to work together. Training to help Captains become skilled at leading good termination-time debriefings

might, over the long haul, be almost as valuable as teaching them how to form a new team and get it started off on the right foot.

Pre-Arrival

Sometimes CRM training is intended to directly improve the core culture of a organization, thereby immediately strengthening the cockpit shell. The theory is that people who have been trained will thereafter arrive for work with attitudes and skills that foster effective utilization of cockpit resources, and that this learning will be exhibited in how crew members interact.

I believe that aspiration is unrealistic. It is next to impossible to engineer the culture of an organization. Instead, culture emerges from the multitude of little things that affect peoples' experiences at work, as a product of how the work is designed and managed. Culture is more useful as an indicator of how things stand than as a point of intervention for change. As CRM training pervades an organization and affects what happens in crew after crew, the culture will indeed change--but slowly and incrementally, as the result of improved crew functioning, not as its cause.

Summary

So far, I have identified some times in the lives of cockpit crews when CRM skills may be particularly useful, giving special emphasis to crew formation and termination, and to low workload and out-of-cockpit times during task execution. I also have pointed to some leadership behaviors that can strengthen the team at each of those times. Throughout, I have focussed on team management skills that are high in potential impact, that are trainable, and that are likely to be used on the line once learned. Training in these skills, most of which are fairly specific, contrasts with training that would seek to change the personality or interpersonal style of pilots (which I doubt can be accomplished, and am not sure is a good idea even if it could be), or to alter the overall culture of the organization through massive changes in pilot attitudes (which I do not believe to be a feasible objective for a training program).

The kind of CRM training I have been discussing, then, is relatively specific and modest in scope. Even so it presents a major training challenge, mainly because of its emphatic focus on teams. Such training simply does not fit well with the individualistic orientation that characterizes pilot technical training, flight standards, and flight operations management in most air transport organizations--not to mention the FAA. So there would be a strong temptation, in designing and executing team-focussed CRM training, to slip back to a more familiar and culturally agreeable emphasis on the attitudes and skills of individual pilots. It will be hard to conduct training for pilots that is mainly about teams.

Yet the *occasions* for such training are readily available. LOFT technology, for example, is ideally suited to what I have been talking about, particularly when crews as whole units review videotapes of a scenario they have just flown. The potential of LOFT for team-focussed training is enormous, and so far we have barely begun to tap it. Captain upgrade and recurrent training also offer excellent opportunities for education about team functioning, and for teaching the skills needed to be a superb team leader.

The coaching done in many organizations by flight standards personnel offers additional occasions for such training.

The ultimate impact of CRM training, however, may depend as much on other features of the organization as it does on the content of training courses. In our NASA research, Bob Ginnett and I have been working to identify those organizational conditions that most powerfully foster cockpit crew effectiveness. Let me close by providing a quick overview of some of the factors that appear to be most critical in providing a supportive *organizational* context for the use of CRM skills.

ORGANIZATIONAL INFLUENCES ON COCKPIT CREW EFFECTIVENESS

Two classes of factors have emerged in our research as especially significant in creating conditions for team effectiveness: (a) the design of the cockpit shell, and (b) the supportiveness of the broader organizational context. As will be seen, both can either reinforce or seriously undermine the impact of CRM training.

Design of the Shell

Three design features that appear to be key to team performance are: (a) the design of the team task and the supporting technology, (b) the composition of the crew, and (c) core norms of conduct that are specified and enforced by organizational and regulatory authorities.

A well-designed *task* puts the crew in control of a whole and meaningful piece of work, provides the crew ample authority to execute that work, and generates regular, trustworthy feedback about how well the crew is performing (Hackman & Oldham, 1980). Within an air transport organization, those who design missions and create schedules have considerable influence on the degree to which these conditions are met. More broadly, the engineers and manufacturers who design aircraft and cockpits are stacking the deck through the technology and automated systems they provide--sometimes in ways that enrich the crew's task, other times in ways that undermine the crew's ability or motivation to manage the work (Wiener, 1985).

A well-composed *crew* first of all means that each member individually has sufficient technical skill to perform his or her part of the work competently, and enough interpersonal skill to work cooperatively with other crew members (Helmreich, 1986). Beyond those basics, the mix of crew members (in level of experience, for example, and perhaps in personality as well) should be appropriate for the work to be done, and members should be rostered together for a long enough time that they can develop into a mature, smoothly-functioning performing unit (Foushee et al., 1986). Organizational recruitment practices obviously have much to do with the degree to which these conditions are met. But the adequacy of crew composition is affected as well by scheduling policies, rostering practices, and labor agreements that specify how individuals are matched to lines of flight. Indeed, many organizational practices that superficially appear relevant only to the quality of life of individual pilots (such as bidding procedures) turn out to be highly consequential for quality of crew composition.

Finally, *norms of conduct* that foster team effectiveness are those that explicitly reinforce crew members' collective responsibility for actively managing their flight. This means that both organizational authorities (such as training and flight standards staff) and regulatory authorities (such as the FAA) must explicitly reinforce the view that crew members are responsible *as a team* for the safe conduct of a flight, and that the *team* is expected to scan its environment and update its performance strategies continuously.[8]

One could argue that the above message is exactly what is routinely communicated to flight crews by organizational and regulatory authorities. Close examination of the actual communications received by pilots, however, suggests that this is not always the case. At least in some organizations, communications from above give primary emphasis to the responsibility of individual crew members to execute their duties competently and cooperatively, under the immediate supervision of the Captain. And, in those organizations, I have heard crew members report that their main interest is in "doing my own job right and staying out of trouble," a comment that reflects an individual rather than team mindset, and a more reactive than proactive stance toward the work. I have observed few communications from organizational authorities that emphasized instead the responsibility of the team as a whole for active situation scanning and strategy planning--even though CRM training in some of those same organizations seeks to foster precisely these norms.

Supportiveness of the Organizational Context

The design features listed above, when present, should set a crew nicely on its way toward effectiveness. But if a crew is to take full advantage of a good design it also requires on-going support from the surrounding organization. Although I cannot review them in detail here (for that, see Hackman, 1986), we have found the following organizational features to be particularly helpful to task-performing teams:

--A reward system that provides positive consequences for excellent team performance, thereby countering the tendency in the flying community to assign all consequences to individuals.

--An information system that provides the data crew members need to invent and modify team performance strategies as circumstances change, so that their strategy is always appropriate to the task and situation at hand.

--A technical support system that makes available to the crew the technical expertise and consultation that are needed when problems arise that exceed members' own knowledge and skill.

--Adequate material resources (ranging from cockpit supplies to a fuel truck at the ready) so that the work will not be unnecessarily impeded by the absence of the wherewithal needed to carry it out.

[8] This perspective raises some interesting and thorny questions--for example about the appropriateness of violating an entire crew for busting an altitude, or of having assessments of individual pilots depend in part on the overall performance of crews with whom they fly.

Summary

Imagine, if you will, a beautifully designed and professionally executed CRM program that helps crew members learn and practice precisely the skills that they need to operate well as a team in a demanding flying environment. Now place that program in an organization where lines of flight are badly constructed and constantly changing at the last minute, crews are poorly composed and short-lived, norms of conduct reinforce individual order giving and taking rather than team-level planning, excellent crew performance goes wholly unrecognized, and crews often are unable to obtain information, technical assistance, or material resources when they need them to proceed with the work.

What would you predict about the impact, and indeed the longevity, of a CRM program in such circumstances? Probably all the training will do is frustrate the trainees, because it gives them some new and interesting ways of operating that they are unable to use well on the line. To complete a good CRM course in an organization that has a badly flawed cockpit shell and an unsupportive organizational context is like getting all dressed up for a dance and having the car break down halfway there. Cockpit resource management simply cannot take root and thrive unless organizational conditions also foster and support effective teamwork.

What ultimately is needed are multiple, diverse, redundant organizational conditions all pulling in the same direction--ranging from pilot selection and initial training, to the design of crews and their tasks, to the very structure of air transport organizations and the regulatory environments in which they operate. Factors such as these are the context within which CRM training takes place, and because that context is extraordinarily powerful we must be careful not to design and execute training programs without taking careful account of it. Indeed, there may be occasions when the wise course of action is to defer CRM training, and spend energy first ensuring that the cockpit shell and organizational context will support what eventually is to be taught.

CONCLUSION

Many of us are trained as engineers or scientists, and are most comfortable when we can say "do X and Y will happen." We like tightly-linked cause-effect relations. Flying reinforces this preference: it would make life both more interesting and less pleasant if one could not count on the fact that when you push the thrust levers forward additional power will follow shortly thereafter.

Social systems do not operate the way mechanical systems do. Cause-effect relations are not tightly linked in social systems, and there often are multiple and diverse ways to achieve any given outcome. For this reason, there can be no one best way to be a good Captain or crew member, nor will we ever discover the optimal way for crew members to relate to one another. Just as there are many different ways to get from New York to Chicago (an agreeable fact if you discover a line of thunderstorms crossing your planned route), there are many ways to achieve a state of team effectiveness.

What are the implications of this way of thinking for the design and management of cockpit crews? The approach we are taking in our NASA research is to identify the several conditions that together increase the likelihood that a crew will come up with a way of operating that is uniquely suited to its performance situation (including what is going on inside the cockpit as well as outside, and what may happen in the future as well as what is happening at this moment). Rather than seeking single powerful causes of team effectiveness that can be directly manipulated, we favor putting in place multiple and redundant conditions that act in concert to build constructive momentum. Among those conditions (but certainly not the only one or even the major one) are the skills of crew members in cockpit resource management.

If we do give serious attention to the impact of group and organizational factors on cockpit crew performance, then we must also begin to broaden the focus of CRM training activities. We need to determine who has responsibility for (or the opportunity to influence) those conditions that are most potent in fostering crew effectiveness, and make those people prime targets for training in resource management concepts.

Consider, for example, flight standards staff. How can they be helped to understand (and then model and teach) that it is important to attend to group relations in the cockpit as well as to individual performance, and that crew effectiveness may have as much to do with the quality of group information exchange and decision making as it does with stick and rudder flying? How about airline managers, military officers, FAA policy-makers and inspectors, and the leaders of pilots' unions? How can we help them explore the ways their decisions affect the conditions needed for crew effectiveness? How can they be encouraged to think creatively about ways they might provide better cockpit shells and more supportive organizational contexts for flight crews?

We load too much on the Captain. He or she can do many things to promote crew effectiveness, but not everything. It may be time to get serious about bringing the resource management message to others in the flying community who have the leverage to affect the kinds of conditions I have been discussing in this talk. If that is not done, continuing to promote CRM training in traditional air transport organizations may ultimately turn out to be like swimming upstream against a strong current.

A wonderful foundation for the continued development of CRM training has been built over the last five years, largely by those of you present at this conference. Perhaps it is now appropriate to step back and reflect on ways that CRM training can be broadened and increased even more in impact. Let me close by emphasizing three directions that strike me as particularly promising in this regard. One is to orient CRM training increasingly toward crew-as-a-whole performance, rather than using powerful devices such as LOFT mainly as vehicles for getting at the performance of individual crew members. A second is to highlight things that Captains (and other crew members) can do outside the cockpit to increase the chances that in-cockpit behavior will be as competent as possible during those challenging times when there is little opportunity for reflection and planning. And a third is to start bringing key actors in organizational and regulatory contexts under the CRM tent--specifically, helping those who have authority and responsibility for the design, management, and regulation of crews learn how to create performance environments that will actively support the kinds of behaviors and attitudes that are taught in CRM courses.

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