**The Better the Team, the Safer the World**
Golden Rules of Group Interaction
in High Risk Environments:
Evidence based suggestions for
improving performance

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Swiss Re Centre for Global Dialogue

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Ladenburg and Rüschlikon, 2004

**Swiss Re
Centre for Global Dialogue**

## Gottlieb Daimler and Karl Benz Foundation

The "Golden Rules" in this handbook on Group Interaction in High Risk Environments are the fruit of five years of research in the fields of aviation, medicine and nuclear power. Whilst it is often difficult, or even impossible, to transfer scientific findings direct to everyday situations, the recommendations set out here are immediately relevant to employee safety training. They can be applied to virtually any scenario in which teams are required to deal with challenging or dangerous situations. In our highly technological world, this adds to the team's own safety, thereby enhancing public security as well.

Sponsored by the Gottlieb Daimler and Karl Benz Foundation, the Ladenburg Collegium on "Group Interaction in High Risk Environments" brought together linguists, psycholinguists, psychologists and specialists from the fields of aviation, surgery, intensive care and nuclear reactor safety to work on a joint project initiated in 1999. Led by Prof. Rainer Dietrich, Humboldt University in Berlin, they investigated how teams operating in the above areas should work together to deal with crisis situations to best effect. The participants came from Europe and the USA.

The Foundation wishes to thank Prof. Rainer Dietrich and all members of the Collegium for their fascinating work and the important results it has yielded. Special thanks are due to Dr. Bryan Sexton, who played a vital part in preparing this handbook.

The research results could not have been obtained without the participation and sponsorship of numerous companies and institutions to whom the Foundation is also extremely grateful: Computer Simulation and Training Center in Berlin Schönefeld and its director, Raymund Neuhold, the Lufthansa City Line, the Training Center of the former Swissair Group, Zurich, the University Hospitals of the Humboldt University Berlin, Charité and Klinikum Buch, The University of Texas at Austin, the Gundremmingen Nuclear Power Plant, the University of Texas Center of Excellence for Patient Safety Research and Practice and the Director, Eric J. Thomas, MD, the Department of Anesthesiology and Critical Care Medicine at Johns Hopkins University, The Johns Hopkins Quality and Safety Working Group, the University Hospital Zurich Department of Anesthesiology, and the Gesellschaft für Anlagen – und Reaktorsicherheit mbH (GRS).

Finally, we would like to thank Swiss Re – and its deputy CEO, Rudolf Kellenberger, in particular – for its keen interest in joining forces with the Foundation to organize the closing conference in Rüschlikon at the Swiss Re Centre for Global Dialogue.

Ladenburg, April 2004

The Board of the Gottlieb Daimler and Karl Benz Foundation:
Prof. Dr. Dr. h.c. mult. Gisbert Freiherr zu Putlitz
Dr.-Ing. Diethard Schade

## Swiss Re

At Swiss Re it gives us both a sense of pleasure and commitment to participate in the presentation of the key research findings of "Group Interaction in High Risk Environments".

Pleasure, because of the involvement of the Swiss Re Centre for Global Dialogue in hosting the final conference of this important 5 year research project. And commitment, because as a global leader in capital and risk management we must observe the development of risks in our communities, economy and environment and foster a broader awareness of potential hazards.

For us it is therefore important that these concrete research findings on group interaction are relevant far beyond the situations in which they were observed. And that this White Book, now allows us to communicate these hard-won insights to our clients and the broader insurance community.

In high risk situations the quality of human interaction is critical to the minimizing of human error. To err is indeed human. But as our societies continue to create more complex technological environments, we must enhance our interaction and dialogue skills to ensure that small mistakes do not spiral into major systems failures.

Only with this consistent application and training of safety related approaches will we avoid or reduce the damage and injury caused through poor or negligible behavior.

And progress in the on-going task Swiss Re has set itself, of supporting the active prevention of hazards and their ensuing harm, thereby contributing to the creation of a safer world.

Rudolf Kellenberger
Deputy Chief Executive Officer, Swiss Re

## Contents

## Contents

# Introduction: Golden Rules of Group Interaction in High Risk Environments: Evidence based suggestions for improving performance

# Lessons learned from the interdisciplinary investigators

## Who we are and why we are making recommendations

The recommendations presented here were designed to improve the performance of people who must work together with others in high risk environments. They were compiled by a team of interdisciplinary researchers and industry subject matter experts as part of a project titled 'Group Interaction in High Risk Environments (GIHRE)'. With funding and support from the Gottlieb Daimler – and Karl Benz-Foundation, GIHRE investigated and analyzed the behavior of professional groups working in such environments. Three distinct settings were investigated: the commercial aviation cockpit, the clinical areas in modern hospitals (with emphasis on intensive care units and operating rooms), and the control room of nuclear power plants. GIHRE investigators were interdisciplinary and international in origin, bringing a variety of methodological and conceptual approaches to bear on the study of teams at work in safety-critical settings. The research team as a whole was comprised of experts from the three sample-settings (aviation, medicine, nuclear power plant technology) as well as experts in cognitive psychology, experimental psychology, social psychology, psycholinguistics, and linguistics. The dual goals of GIHRE were to increase understanding of interactions in these environments and to develop practical suggestions for enhancing performance in such settings.

## Premise for recommendations

What follows is not a panacea for what ails teams at work in safety-critical settings, as it is neither systematic nor a comprehensive set of recommendations. In fact, we did not set out to create any one of these rules in particular – rather, through the course of our work together, we discovered trends in the data and found results that lent themselves to providing general suggestions for industry practitioners. This resulted in a collection of our "rules of thumb" as a set of evidence based suggestions from an inter-disciplinary research group tackling the complexities of understanding and improving human performance when the stakes are high. It is important to note that these suggestions stem from experimental studies, field observations, correlational studies, and the analyses of qualitative data from 5 years of interdisciplinary investigation into these topics.

## Acknowledgements

The Gottlieb Daimler and Karl Benz Foundation financially supported the deliberations of the GIHRE group and the production of these recommendations. However, it would not have been realized without the generous cooperation of a variety of institutions, amongst which the Computer Simulation and Training Center in Berlin Schönefeld and its director Raymund Neuhold, the Lufthansa City Line, the Training Center of the Swiss Air Group, Zürich, the University Hospitals of the Humboldt-University Charité, Zürich, and Buch, The University of Texas at Austin, the Gundremmingen Nuclear Power Plant, the University of Texas Center of Excellence for Patient Safety Research and

Practice (and the Director, Eric J. Thomas, MD, MPH), The Department of Anesthesiology and Critical Care Medicine at Johns Hopkins University, The Johns Hopkins Quality and Safety Working Group, and the University Hospital Zurich Department of Anesthesiology. We especially wish to acknowledge the cooperation of the pilots, power plant operators, nurses and patients who volunteered for many hours in the data collection sessions.

## Introduction to the focus on interactions in high risk environments

In teams at work under conditions of threat and high workload, interpersonal interactions are strained and the potential for incorrect or incomplete information transfer between individuals increases as task demands increase. As a member of a team, one must "think out loud," in order to share perspective and establish a common understanding of the nature the situation. This common understanding amongst team members is often referred to as a *shared mental model* of events. In aviation, for example, *heedful interactions* among pilots are used to remain attentive and conscientious of one another and to maintain awareness of how their work fits into the overall objectives of safe and efficient flight. Effective communication is critical for cockpit crewmembers to share a mental model of events relevant to these flight objectives. This is not to say that effective communication can overcome inadequate technical flying proficiency, but rather the contrary: that good "stick & rudder" skills can not overcome the adverse effects of poor communication. Ruffell Smith's (1979) landmark full-mission simulator study showed that crew performance was more closely associated with the quality of crew communication than with the technical proficiency of individual pilots or increased physiological arousal as a result of higher environmental workload. No differences were found between the severity of the errors made by effective and ineffective crews, rather, it was the ability of the effective crews to communicate that kept their errors from developing into undesirable outcomes. Such findings are not unique to aviation, as similar results have emerged in other safety-critical systems such as surgical operating rooms and medical intensive care units, where the quality of provider interactions is associated with patient outcomes (Young, Charns, Daley, Forbes, Henderson, & Khuri, 1997; Knaus, Draper, Wagner, & Zimmerman, 1986).

## The format of the recommendations

In the pages that follow are 21 recommendations from GIHRE to improve team performance. Each recommendation includes the justification for its creation, consequence of following the recommendation, the actors to whom the recommendation applies, and references. The language used here is informal, with the intent of reaching a broader audience. The recommendations generally fell into one of two categories – enhancing predictability or improving communication. Recommendations that enhance predictability help to set expectations, plan for future contingencies, share a common mental model of the situation, reduce ambiguities and reduce stress levels within team members. Recommendations for improving communication generally deal with the content, size, structure, and coordination of utterances.

## References

Knaus, W.A., Draper, E.A., Wagner, D.P. & Zimmerman, J.E. (1986). "An evaluation of outcome from intensive care in major medical centers." *Annals of Internal Medicine* 104(3): 410–418.

Ruffell Smith, H. P. (1979). *A simulator study of the interaction of pilot workload with errors, vigilance, an decisions.* (NASA Technical Memorandum 78482). Moffett Field, CA: NASA–Ames Research Center.

Young, G.J., Charns, M.P., Daley, J., Forbes, M.G., Henderson, W. & Khuri, S.F. (1997). "Best practices for managing surgical services: the role of coordination." *Health Care Management Review* 22: 72–81.

Rainer Dietrich with Traci Michelle Childress (eds.), Group Interaction in High Risk Environments, Ashgate Publishing: Aldershot, England. (In press, appearance scheduled for 2004)
Referred to as "GIHRE-book"

# Section 1:
# Enhance Predictability

## Recommendation 1:
## Ask early for the task later (Inquire early – ask questions early in the life of the team)

### Reason
Prior research has demonstrated that shared mental models and predictable patterns of behavior are imperative to laying the groundwork for subsequent effective teamwork and communication. Ginnett (1987) has shown that initial crewmember interactions set the tone for the team and can predict subsequent team performance. In fact, a GIHRE simulator study of 4 flights found that the relationships between language use and flight outcome measures were strongest between language use in the first flight, and subsequent (second, third and fourth flights) performance and error measures.

### Consequence
Sexton & Helmreich (2002) found that the number of questions asked in the initial flight was positively correlated to performance in subsequent flights. In other words, crews who asked a lot of questions initially (thereby clarifying uncertainties) had higher subsequent performance than crews who did not ask questions. Asking questions was not correlated to performance within the same flight, rather, initial inquiry was correlated to subsequent performance. It appears to be the case that *clarifying uncertainties is best accomplished in an initial flight (thereby improving predictability) rather than waiting to ask questions later.*

### Actors
Training specialists and team members

### References
Ginnett, R. C. (1987). *First Encounters of the Close Kind: The Formation Process of Airline Flight Crews.* Yale University: Doctoral dissertation.

Sexton, J.B. & Helmreich, R.L. (2002). "Using language in the cockpit: Relationships with workload and performance." In R. Dietrich (Ed) "Communication in High Risk Environments." *Linguistische Berichte Sonderheft* 12: 57–74. Buske Verlag: Hamburg.

GIHRE-book chapter: Threat

## Recommendation 2: Reduce the need to repeat with a daily goals sheet (Increase transparency in multi-disciplinary team environments using daily goals)

### Reason

In multi-disciplinary settings, cross-disciplinary awareness and understanding is often difficult to maintain due to the high workload and complex systems. For example, in the modern critical care unit, there are staff physicians, residents, respiratory therapists, clinical pharmacists, technicians, bedside nurses, spiritual care, and others who must coordinate and carry out the plan of care for each patient, daily. Transparency of actions between and within disciplines can require numerous discussions with colleagues from other disciplines who are in various physical locations with differing degrees of accessibility. To contact individuals separately to communicate the plan of care requires redundancy and leads to lost time.

### Consequence

*Setting public daily goals (see next page) for a given patient using a goals sheet attached to a clipboard at each bedside can enhance the transparency of actions and intentions between and within disciplines for "this patient, in this bed, today."* The daily goals sheet must be signed by the attending physician and kept public to increase transparency and decrease redundancy[1] and lost time. Daily goals sheets also maintain a public record of thought processes and decision making by the multi-disciplinary team.

In the implementation study of daily goals in the critical care unit, less than 10% of residents and nurses understood the goals of care for the day.

After implementation of the daily goals sheet, over 95% of nurses and residents understood the goals of care for the day, and furthermore of clinical relevance is that the average length of stay decreased by 50%. In a separate demonstration of daily goals in critical care, Terri Simmonds (personal communication, June 2003) found that preparation for decision-making was improved in critical care units after the implementation of daily goals forms (see list "Daily goals).

### Actors

Critical care unit directors, training specialists and team members

### References

Pronovost P, Berenholtz S, Dorman T, Lipsett PA, Simmonds T, Haraden C. (2003) "Improving communication in the ICU using daily goals." *Journal of Critical Care.* Jun; 18 (2): 71–5.

Sexton, J.B. (2003). "What is the climate like now: SAQ data from time 2." Session Presented at the Institute for Healthcare Improvement Impact Conference, Boston, Massachusetts, June 19, 2003.

[1] Redundancy, which is common in aviation and often lacking in medicine is not a culprit here. We acknowledge that redundancy is important for safety in high risk environments, however, repeating the same story separately to each multi-disciplinary constituent is not an effective use of time in the high workload environment of modern medicine.

Daily Goals. Room Number __________ Date ____/____/____

-Initial as goals are reviewed-

| | | 0700-1500 | 1500-2300 | 2300-0700 |
|---|---|---|---|---|
| What needs to be done for patient to be discharged from the ICU? | | | | |
| What is patient's greatest safety risk and how can we decrease risk? | | | | |
| Pain Mgt / Sedation (held to follow commands?) | | | | |
| Cardiac / volume status; Net goal for midnight; Beta blockade; review EKGs | | | | |
| Pulmonary/Ventilator (HOB, PUD, DVT, weaning, glucose control); OOB | | | | |
| ID, Cultures, Drug levels | | | | |
| GI / Nutrition / Bowel regimen | | | | |
| Medications: PO, renal fx, discontinue | | | | |
| Tests / Procedures today | | | | |
| Review scheduled labs | | | | |
| AM labs and CXR?; critical pathway | | | | |
| Consultations | | | | |
| Is the primary service up-to-date? | | | | |
| Has the family been updated? Have social issues been addressed? | | | | |
| Can catheters/tubes be removed? | | | | |
| Is this patient receiving DVT/ PUD prophylaxis? | | | | |
| Anticipated LOS > 3 days: fluconazole PO, LT care plans. LOS > 4 days: epo | | | | |
| Are there events or deviations that need to be reported? ICUSRS? | | | | |

For Weinberg only: ICU status IMC status
Fellow/Attg Initials: __________

## Recommendation 3: Lead in a pinch, cede in a cinch (Encourage leadership behavior in unstructured situations but not in standardized / routine situations)

### Reason

In routine situations, which are typically highly regulated by organizations, people do not need a leader to tell them what to do. Depersonalized leadership in the form of standardized operating procedures (SOPs) can substitute for personal leadership. GIHRE Coordination found a negative correlation between performance of cockpit crews and leadership behavior in highly standardized situations. The more leadership behavior was observed the worse the performance. This notion was also supported by interview material. Anesthesia team members expressed that they like clear leadership behavior if the situation is complex, unknown, or high workload, but they dislike it during routine situations.

### Consequence

*A leader who does not have to actively engage a technical task during standard / routine situations is afforded the opportunity to observe and learn about the team while SOPs accomplish the role of guiding behavior.* This opportunity to observe the team at work and gain a better assessment of the team and each individual member can be critical during less routine or higher workload situations, when the ability to predict and understand the behaviors of others is essential. Routine situations also afford team members the chance to work autonomously and experience their own efficacy, which are both very important motivating factors.

### Actors

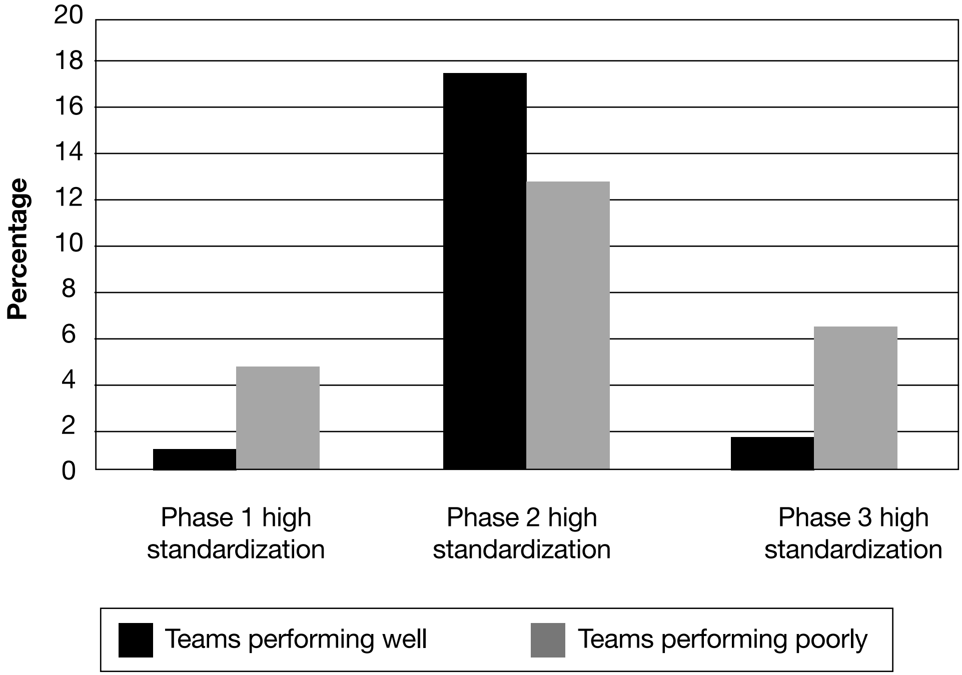
Team leaders and training specialists

### References

Kerr, S. and Jermier, J. M. (1978). “Substitutes for Leadership: Their Meaning and Measurement.” *Organizational Behavior and Human performance* 22: 375–403

Zaccaro, S., J., A. Rittman, L., et al. (2001). “Team leadership.” *The Leadership Quarterly* 12: 451–483.

GIHRE-book chapter: Leadership & coordination




# 3 Figure. Percent of leadership behavior present in teams performing well vs. poorly during flight phases with varying standardization levels.

## Recommendation 4: During high workload, the leading team member should manage the situation while others manage the technical task

### Reason

This is a variation of Recommendation 3. In 1994, The National Transportation Safety Board found a disproportionately high percentage of aviation accidents (over 80%) occur when the captain is the pilot flying. These captains are overloaded with multi-tasking as they try to accomplish both the pilot flying and pilot in command duties simultaneously. GIHRE Threat demonstrated that in complex/high workload situations, the best performing crews have the first officer as pilot flying, which fosters an environment in which the captain can assess and manage the situation while the first officer manages the aircraft handling duties. The data suggest that if a crew encounters a high workload situation when the captain is pilot flying, it is best to cede control of the aircraft to the first officer. Similarly, in high workload NPP operations, the shift supervisor is responsible for decision-making and maintaining the "big picture," while technical tasks are carried out by other operators.

### Consequence

Leaders who fail to delegate during high workload situations risk overload due to the simultaneous burden of managing the task, the team and the environment. In aviation, medicine, or NPP, the notion of leadership during high workload can be applied to a variety of situations in which it is critical to have the leader keep the big picture in mind and remain relatively free from the technical task at hand. *In other words, leaders in high workload situations should delegate task work to reduce multitasking and improve decision-making and vigilance.*

### Actors

Regulators, policy makers, training specialists and team members

### References

National Transportation Safety Board (1994). *Safety Study: A review of involved-involved, major accidents of U.S. air carriers, 1978 through 1990.* PB94–917001, NTSB/SS–94/01. Washington, DC: Author.

GIHRE-book chapter: Leadership & coordination; NPP

Related excerpt to # 4: There is some historical precedent for this notion as well, from the annals of submarine battles during World War II.

'One of Commander Mush Morton's unorthodox ideas, later adopted to some degree in the submarine force, was to have his executive officer make the periscope observations, while he, the skipper, ran the approach and coordinated the information from sound, periscope, plotting parties, and torpedo director. Thus, so ran his argument, the skipper is not apt to be distracted by watching the target's maneuvers, and can make better decisions.'
– Submarine Commander Edward L. Beach, United States Navy (1946)

## Recommendation 5: Just say "we / let's" (use language to foster team perspective)

### Reason

The National Transportation Safety Board (1994) found that 73% of commercial aviation accidents occur on the first day of a crew pairing (relative to the base rates of 7–30% of flights that are an initial crew pairing) and that 44% of accidents occur on the first flight of a crew pairing (base rates 3–10%). These results have been interpreted as an indication of crewmember familiarity with one another, such that the more crewmembers fly together, the better they will be able to anticipate and respond to each others' actions. Foushee, Lauber, Beatge, & Acomb (1986) found conceptually similar results, such that fatigued crewmembers who had previous experience flying together outperformed well-rested crews who had no previous experience flying together. Crewmember familiarity may manifest itself as a function of crewmembers referring to themselves in the first person plural. The first person plural (e.g., we, our, us) is frequently expressed in the form of "let's," e.g., "*let's* get out the landing checklist."

### Consequence

A GIHRE simulator study demonstrated a pattern of increasing use of the first person plural across the four simulated flights (see # 5 Figure), which may have indicated an increasing sense of familiarity among the crewmembers or an increase in their team perspective. Moreover, the GIHRE study also found that the use of first person plural was positively correlated to performance, and negatively correlated to the number of errors. In the past, the use of the first person plural has been interpreted as a collective or team perspective by the speaker (McGreevy, 1996; White and Lippitt, 1960). Recent research by Driskell, Salas, & Johnston (1999) found that team perspective was a significant positive predictor of team performance. *In sum, teamwork is about "we" not "me," and encouraging familiarity enhances predictability, which is associated with better team performance.*

### Actors

Team members and training specialists

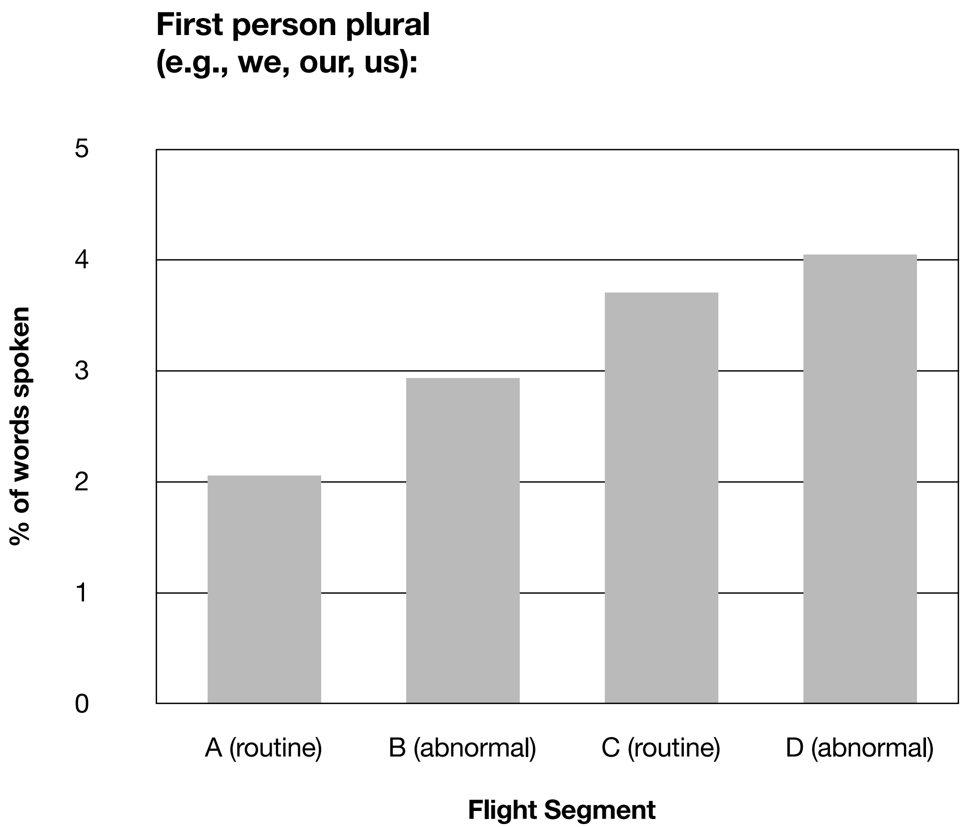
### References

Driskell, J. E., Salas, E., & Johnston, J. (1999). "Does stress lead to a loss of team perspective?" *Group Dynamics: Theory, Research, and Practice*, 3 (4): 291–302.

McGreevy, M. W. (1996). *Reporter Concerns in 300 Mode-Related Incident Reports from NASA's Aviation Safety Reporting System.* (NASA Technical Memorandum 110413). Moffett Field, CA: NASA-Ames Research Center.

National Transportation Safety Board (1994). *Safety Study: A review of involved-involved, major accidents of U.S. air carriers, 1978 through 1990.* PB94-917001, NTSB/SS-94/01. Washington, DC: Author.

GIHRE-book chapter: Threat




# 5 Figure. First Person Plural by Flight Segment

## Recommendation 6:
## Talk about problems (High performers devote more time to "problem solving" communications)

### Reason
Recently, the commercial aviation industry has embraced the notion of assessing pilot ability to manage threats and errors in order to achieve safe and efficient flight. Problem solving communications are the verbal manifestation of threat and error management (Sexton & Helmreich, 2002). Problem solving communications (see # 6 Figure A) are the verbalizations of corrective actions (Predmore, 1991), and are a prime example of what distinguishes effective performance from ineffective performance. For instance, captains with outstanding performance used problem solving utterances seven to eight times more often than their poor performing counterparts. Furthermore, there were no differences in how outstanding captains used problem solving utterances as a function of workload. Outstanding captains consistently devoted a third of their utterances to problem solving, whether it was a routine or an abnormal flight. In fact, the more frequent use of problem solving utterances was not unique to outstanding captains – outstanding first officers and second officers used problems solving utterances in approximately one third of their communications overall (see # 6 Figure B opposite).

### Consequence
Investigations of aircrew transcripts indicated that there is a substantial difference in the use of problem solving utterances between outstanding pilots and both average and poor pilots. The best pilots simply talk more about their task-related problems and how to solve them – the essence of threat and error management. *The bottom line is teams that verbalize problems and their management are safer.*

### Actors
Training specialists and team members

### References
Predmore, S. C. (1991). "Microcoding of communications in accident investigation: Crew coordination in United 811 and United 232." In: R. S. Jenson (Ed.): *Proceedings of the Sixth International Symposium of Aviation Psychology*: 350–355. Columbus, Ohio: The Ohio State University.

Sexton, J.B. & Helmreich, R.L. (2002). "Using language in the cockpit: Relationships with workload and performance." In R. Dietrich (Ed) "Communication in High Risk Environments." *Linguistische Berichte Sonderheft* 12: 57–74. Buske Verlag: Hamburg.

GIHRE-book chapter: Threat

## Problem Solving Utterances:

“I don’t want to dump any fuel, in case we might need it.”

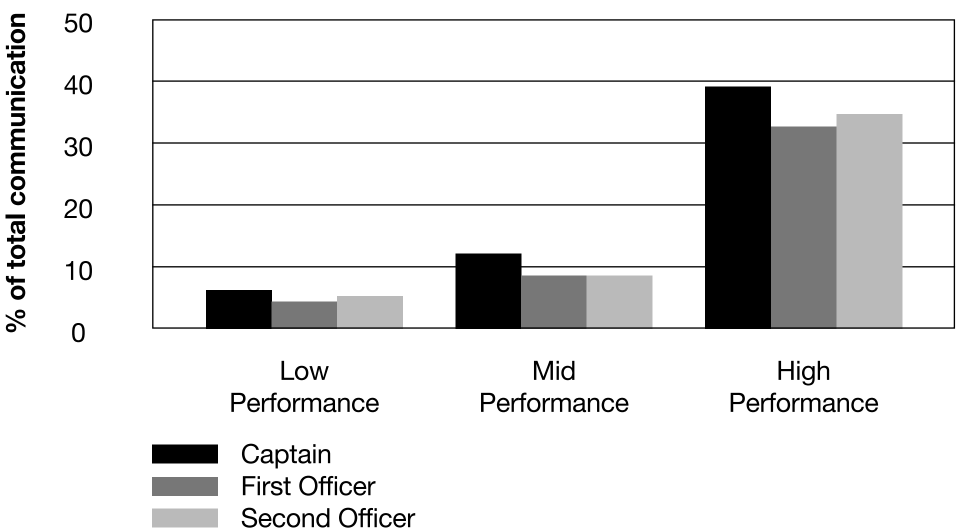
“I want to see if that gear works early enough, though.”

“So you might want to determine what they want us to do if we loose ATC communications.”

“Okay, ask him, uh, what kind of weather trends he has got going there, if it is going down.”

# 6 Figure A. Examples of Problem Solving

## “Problem Solving”communications by position and performance




# 6 Figure B. Problem Solving by Position and Performance

## Recommendation 7: For juniors, better to be blatant than to imply (Be explicit in communications if you are inexperienced)

### Reason

Explicit coordination strategies are conscious and overt, whereas implicit coordination can be defined as coordination through anticipation of the needs of others. Using implicit coordination, a team member anticipates the need for information and assistance from other team members and proactively provides information without waiting for a request. Implicit coordination is a powerful and economical method of coordination as it alleviates the need to explicitly solicit information or help. However, implicit coordination can be used only in teams having a common understanding – shared mental model – of the situation. As teams in NPP operations are fixed shift teams and not constantly changing – as is the case in aviation – experience from NPP shows the positive side of implicit communication. The caveat is that providing information according to the anticipated need is only useful if the anticipation is correct. GIHRE found that implicit coordination by the first officer in the cockpit (a relatively inexperienced team member), correlates negatively with performance. The more implicit coordination was used by the first officer, the worse was the performance. It is useful to prepare for high workload situations with a phase of explicit coordination whereby a shared model can be acquired in order to reduce subsequent communication and coordination "costs" during high workload (Orasanu and Fischer, 1992).

### Consequence

If the inexperienced person uses explicit coordination he/she can avoid sharing information that the other person does not need. In this case there are fewer misunderstandings and irritations by superfluous or inappropriate information.

### Actors

Training specialists and team members

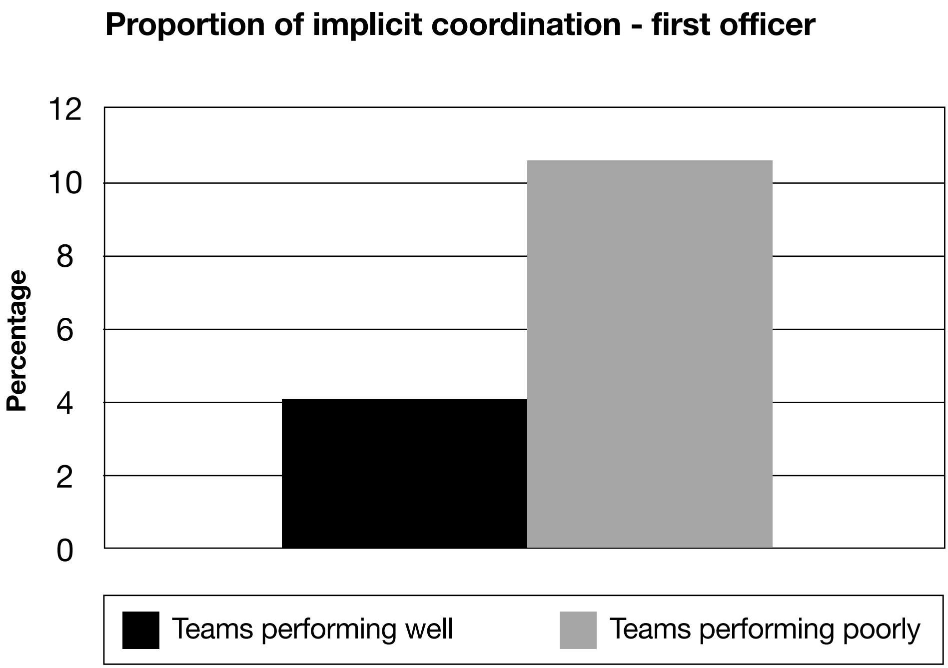
### References

Serfaty, D., Entin, E., & Johnston, J. (1998). "Team Coordination Training." In: Cannon-Bowers, J. and Salas E. (Eds.): *Making Decision under Stress.* Washington, American Psychological Association: 221–245.

Orasanu, J., and Fischer, U. (1992). "Team cognition in the cockpit: Linguistic control of shared problem solving." *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society,* 189–194. Hillsdale, NJ: Erlbaum.

Matieu, J., Heffner, T., et al. (2000). "The Influence of Shared Mental Models on Team Process and Performance." *Journal of Applied Psychology* 85(No. 2): 273–283.

GIHRE-book chapter: Leadership & coordination




# 7 Figure: Percent of implicit coordination by first officer in teams performing well vs. poorly.

## Recommendation 8: Adjust coordination (implicit vs. explicit) as a function of workload and standardization

### Reason

GIHRE Coordination demonstrated the use of adaptive coordination behavior by both anesthesia and cockpit teams. These teams used relatively little explicit coordination (overt communication) during highly standardized work phases, instead they relied on centralized coordination in the form of rules. Conversely, during less structured work phases with low standardization, leadership behavior, which also can be seen as crucial to coordination success, was dominant during less structured work phases, with low standardization. Implicit coordination and heedful interrelating were mainly used in high task load phases, and were economical ways to coordinate, but can be used only by teams who have a common picture – shared mental model – of the situation.

### Consequences

Adaptive coordination behavior is a significant contribution to effective teamwork as emergency situations arise. Teams working in a routine phase (with little coordination effort) need to notice and adapt if something threatening happens. There is a clear need for explicit coordination, which helps to build a common mental model of the situation and to work out a strategy to cope with it. If the team has a plan for contingencies (e.g., briefing), it doesn't necessarily need to spend any more resources with time-consuming explicit coordination (overt communication) but rather coordinate implicitly, keeping the remaining resources free for the problem solution.

### Actors

Team members and training specialists

### References

Kozlowski, S. (1998). "Training and Developing Adaptive Teams: Theory, Principles, and Research." In: Cannon-Bowers, J. and Salas E. (Eds.): *Making under Stress.* Washington, American Psychological Association.

Serfaty, D., Entin, E., & Johnston, J. (1998). "Team Coordination Training." In: Cannon-Bowers, J. and Salas E. (Eds.): *Making Decision under Stress.* Washington, American Psychological Association: 221–245.

GIHRE-book chapter: Leadership & coordination

| | Flight phase | | |
|---|---|---|---|
| | 1<br>Take-off | 2<br>Preparation<br>Clean approach | 3<br>Approach<br>and Landing |
| Average duration (min.) | 3 | 10 | 3 |
| Task load | Low | Low | High |
| Standardization | High | Low | High |
| Communication units (CU) overall | 840 | 3514 | 1429 |
| CU standardized communication | 52% | 9% | 28% |
| CU explicit | 66% | 81% | 60% |
| CU implicit | 34% | 19% | 40% |
| CU leadership | 2% | 14% | 3% |
| CU Heedful interrelating | 2% | 18% | 19% |

# 8 Table. Coordination patterns during different flight phases from GIHRE Coordination

## Recommendation 9: Make heedful interacting a routine practice

### Reason

In their study of aircraft carrier crews, Weick and Roberts (1993) observed a phenomenon they referred to as *heedful interrelating*, and noted that higher rates of heedful interacting were associated with lower rates of errors. In essence, heedful interacting requires deliberate efforts to continually consider one's own actions in relation to the goals and actions of others. Weick and Roberts explained that if heedful interacting is "visible, rewarded, modeled, discussed, and preserved in vivid stories, there is a good chance that newcomers will learn this style of responding, will incorporate it into their definition of who they are in the system and will reaffirm and perhaps even augment this style as they act (p. 367.)" Anesthesia teams reported their perspective of this behavior as critical to successful team functioning, e.g., continuous monitoring (situational awareness), thinking aloud, following the processes, taking the perspective of other team members, taking the perspective of the decision maker, and looking ahead.

### Consequence

The team coordinates its actions smoothly and safely, because it anticipates high workload situations and prepares itself for them. Heedful interacting helps to prevent individual members from experiencing overload, because their fellow team members notice symptoms of overload in time and help to share the load. *Heedful interacting in high risk environments enables teams to capitalize on the redundancies of teams themselves (as opposed to individuals), by optimizing cognitive resources, knowledge, and experiences.*

### Actors

Training specialists and team members

### References

Artman, H. (2000): "Team situation assessment and information distribution." In: *Ergonomics*, 43: 1111–1128.

Weick, K. E. and K. H. Roberts (1993). "Collective mind in organizations Heedful interrelating on flight decks." *Administrative Science Quarterly* 38: 357–381.

GIHRE-book chapter: Leadership & coordination.

Grommes, P. & Grote, G. (2001). "Coordination in Action. Comparing two work situations with high vs. low degrees of formalization." In: Kühnlein, Newlands and Rieser (Eds.) *Proceedings of the Workshop on Coordination and Action at ESSLLI 01. Paper 1.* Helsinki, Finland.

**Considering and checking the state of others.**
"Are you ready?" "Do you have a question?"
"Can you do it alone?" "Do you agree?"

**Considering the future.**
"We will use autopilot as long as it functions normally."
"We are going to reposition the patient in the operating room,"

**Considering external conditions.**
"We have to check the weather, particularly the wind."
"If the table is too high, lifting the patient will be difficult."

# 9 Figure. Transcript examples of interactions categorized as heedful interacting

## Recommendation 10: Understand the role of standardization in effective team functioning as it relates to policies and procedures (rules)

### Reason

One of the most important functions of behavioral rules (standard operating procedures or SOPs) is to increase the predictability of behavior and adherence to norms. In safety-critical settings, rules help to set parameters and expectations in coordinating the behavior of individuals in teams, especially when team members do not know each other. Using structured interviews, GIHRE "Coordination" found that anesthesia teams find rules particularly helpful in extremely ambiguous emergency situations that are not standardized. However, rules can also be restrictive if they are too rigid and concrete, as they can inhibit the search for and discovery of solutions in unexpected situations. One example of this might be the 1998 crash of SwissAir flight 111, where an inflight fire led to a crash and the loss of all passengers. Accident investigators found that the pilots, overloaded with checklists and procedures, were unable to locate and eliminate the source of the fire or to expedite plans for an emergency landing.

There are different kinds of rules: describing concrete actions – action rules; describing processes to fulfill a task – process rules; describing the goals to be achieved – goal rules. Action rules are used most commonly, however, process rules and goal rules provide for the possibility of more innovative solutions because they are more flexible. NPPs provide an example of this flexibility. Operations in NPP are highly regulated, but operators are often called upon to respond to situations or events that are not specifically prescribed in a procedure (Dien, 1998). Operators are required to balance their decisions between strict adherence to procedures and checking the validity of the procedures in a given context. They understand that strict adherence to procedures does not necessarily guarantee safety, and can even be detrimental to safety if applied in the wrong context. Ideally, a procedure would allow for a corridor of freedom for possible actions of a user. Such procedures should state conditions required for the application of procedures and conditions to be maintained during the situation (e.g., critical parameter of the system or patient that needs to be maintained). Nuclear operations introduced "symptom based procedures" to cope with the trade-off between application of rules and freedom for decision. Symptom based procedures are based on critical parameters of the plant which have to be maintained independently from the cause of the critical situation.

### Consequence

*Using the right amount and type of rules results in a flexible system, where the actors have support if they need it but they can remain creative if new solutions are required.* Also, too much reliance on rules and diffusion of responsibility is avoided with rules that keep people thinking by not specifying actions in too much detail.

### Actors

Rule makers, safety specialists, training specialists and team members

### References

Dien, Y. (1998). "Safety and application of procedures, or 'how do 'they' have to use operating procedures in nuclear power plants?." *Safety Science* 29: 179–187.

Hale, A. R. and P. Swusste (1998). "Safety rules: procedural freedom or action constraint?" *Safety Science* 29: 163–177.

Grote, G. (1997). *Autonomie und Kontrolle – Zur Gestaltung automatisierter und risikoreicher Systeme.* Zürich, vdf Hochschulverlag.

GIHRE-book chapter: Structures; NPP

## Recommendation 11: Prepare for the worst: Use briefings to plan for contingencies

### Reason

Briefings have been demonstrated as an effective means by which leaders can plan for contingencies, establish norms, discuss threats, and build the team all at the same time. There are two critical components of briefings: technical and interpersonal. In the technical component, it is important for the leader (be it a captain, surgical attending or NPP shift manager) to cover the technical details of what will take place, set expectations and plan for contingencies. Regarding the interpersonal component, which is often a function of *how* the technical component is articulated, the leader must open channels of communication, empower team members to speak up and participate, and formally establish the team environment. In commercial aviation, it is not uncommon to hear a captain tell the crew "I only got 3 hours of sleep last night and am feeling off today, please keep and eye on me and *don't let me do anything stupid*." The phrase "don't let me do anything stupid" goes a long way to engage team members in the process and empower them to participate[2]. The delicate balancing act of the leader in a briefing is to display competence while disavowing perfection.

### Consequence

*In technologically advanced and psychologically complex environments such as the operating room, intensive care unit, or cockpit – there is a clear and present need for knowing the threats and possible contingencies, establishing norms, and having a formal opportunity to build the team. In commercial aviation, we know that briefing content is a powerful predictor of subsequent performance (Ginnett, 1987; Sexton & Helmreich, 2000). GIHRE-Aviation has demonstrated that sub-optimal briefing is a leading deficiency of simulator crews that consistently perform poorly across three simulation scenarios.* High performing crews displayed very good planning and contingency management and showed good situational awareness. In contrast poor performing crews had inadequate planning and insufficient situational awareness – they did not evaluate their plans as required by the changing situation.

Contingency planning (part of the technical component of briefing) was a predominant behavior in crews that dealt successfully with technical problems. In medicine, there is anecdotal evidence that operating room briefings (approximately 90 second discussion just prior to skin incision) are proving to be valuable. Operating room briefings allow the multidisciplinary team performing a surgical procedure to create shared mental model of the situation, plan for contingencies, and open up channels of communication between physicians and nurses, as well as between anesthesia and surgery personnel. These operating room briefings have been associated with reductions in nurse turnover rates, reductions in perceived workload, and increases in nurse input (James DeFontes, MD – personal communication April 2003).

## Actors

Safety specialists, training specialists, medical school faculty and team members

## References

GIHRE-book chapter: Structures

GIHRE-book chapter: Aviation

Ginnett, R. C. (1987). *First Encounters of the Close Kind: The Formation Process of Airline Flight Crews*. Yale University: Doctoral dissertation.

Sexton, J.B., & Helmreich, R.L. (2000). Analyzing cockpit communications: The links between language, performance, error, and workload." *Human Performance in Extreme Environments* 5 (1), 63–68.

[2] It is interesting to note that after several hundred observations in surgical operating rooms and critical care units we have never heard the phrase "don't let me do anything stupid," in medicine.

# Section 2:
# Improve Communication

## Recommendation 12: Maintain an environment of open communication and stay calm during high workload situations

### Reason

Creating the appropriate environment in which teamwork will be effective is essential to increasing predictability and reducing stress during high workload. Findings from GIHRE "Threat" demonstrate the importance of establishing and maintaining an environment of open communication. Such "Team Environment" behaviors were documented in non-jeopardy observations of over 3,000 flights and were among the most clearly observable and frequently observed behaviors across all phases of flight (GIHRE book chapter – Threat). Team Environment was defined as: "Environment for open communications established and/or maintained (e.g., crew members listen with patience, do not interrupt or 'talk over,' do not rush through the briefings, make eye contact as appropriate.)" In high workload situations, the relationship between Team Environment and other variables such as overall performance, technical proficiency, and indices of error increases. For teams performing under stress, it is important to stay calm collectively and to develop coping strategies. Coping and remaining calm does not equate to silence on the part of a team member. Rather, GIHRE data indicate that effective strategies include more verbalization, verbalizations that relate to problem solving, speaking in the first person plural, and adjusting the extent of explicit and implicit coordination to the experience level and familiarity of team members. GIHRE "Coordination" found that anesthesia teams report that they cannot work efficiently in an atmosphere where the team leader projects overload, as it brings additional pressure into the situation and blocks task fulfillment. Professional NPP operators also pointed out the performance implications of maintaining an environment of open communication in high workload as it relates to sharing mental models and finding appropriate solutions to problems.

### Consequence

*Setting the stage for subsequent teamwork is an exercise in delayed gratification, but it is critical to open and supportive interactions, and it is an excellent buffer against the deleterious effects of high workload.* In the case of the team leader, it is critical to remain calm as workload increases, because the leader's behavior is a model for team members and it creates a team norm that helps other team members cope with stress. As workload increases, there are threats of: attention becoming too narrowly focused (tunnel vision), interactions being reduced, and information being shared less. Such conditions are harmful to effective decision-making and can be offset by a leader who projects calm and a previously established environment where input is valued.

### Actors

Team members and training specialists

### References

Tannenbaum, S., I., K. A. Smith-Jentsch, et al. (1998). "Training team leaders to facilitate team learning and performance." In: Cannon-Bowers, J. and Salas E. (Eds.): *Making Decision under Stress.* Washington, American Psychological Association: 247–270.

Zaccaro, S., J., A. Rittman, L., et al. (2001). "Team leadership." *The Leadership Quarterly* 12: 451–483.

GIHRE-book chapter: Leadership & coordination

## Recommendation 13: Encourage the new person – Use positive feedback when an inexperienced team member has to carry out a task

### Reason

If the first officer has the active role (pilot flying) in the cockpit, the captain should verbalize positive feedback if performance merits. High performance in cockpit crews was associated with high rates of positive feedback from the captain to the first officer (GIHRE book chapter: Leadership and coordination). Captains, by verbalizing the approval of first officer actions through positive feedback, are able to demonstrate their situational awareness, encourage their fellow team member, and voice their approval of the current course of action. In this sense, positive reinforcement helps to reduce ambiguity about a shared mental model of the situation as well as to reduce the stress level of the first officer. In addition, structured interview data from anesthesia teams led GIHRE Coordination to believe that there are many missed opportunities for positive feedback during and after task completion (e.g., spinal anesthesia or a resuscitation) to junior team members in medicine.

### Consequence

Positive feedback *during* a difficult task can help to build confidence in junior team members, reduce stress, and to clarify ambiguities. Feedback *after* the task is completed, sometimes in the form of a debriefing, is generally a very useful tool to build a common understanding of a situation in a formal procedure that lends itself to pedagogical opportunities. GIHRE has found a strong interest in and desire for feedback in the teams under investigation, with the majority of individuals reporting that they do not receive appropriate feedback (GIHRE book chapter: Threat).

### Actors

Team members and training specialists

### References

Swezey, R., W. and E. Salas (1992). "Guidelines for use in team-training development." *Teams: Their training and performance*. R. Swezey, W. and E. Salas. Norwood, NJ, Ablex: 219–245.

Kozlowski, S. (1998). "Training and Developing Adaptive Teams: Theory, Principles, and Research." In: Cannon-Bowers, J. and Salas E. (Eds.): *Making Decision under Stress.* Washington, American Psychological Association.

GIHRE-book chapter: Leadership & coordination

GIHRE-book chapter: Threat

## Recommendation 14: Give a verbal nod – While listening, it is important to provide verbal indication of comprehension and reaction

### Reason

Failure to provide an active response to a speaker results in ambiguity that clouds the shared mental model of the situation, and frustrates the efforts of the speaker to communicate. As an example, a GIHRE simulator study (GIHRE book chapter: Behavioral Markers), found that a first officer who was busy with radio communication after an engine failure in flight, missed the captain's command to run the single engine checklist. When the captain repeated the command three minutes later, the aircraft was below 500 feet and descending – which is too late to run the checklist. Verbal indications of comprehension that close the communication loop can prevent such situations. Similarly, the NPP simulation study showed that a lack of verbal reaction does not necessarily mean that the addressee has failed to receive the information from the speaker, but the lack of the verbal reaction causes repeated and unnecessary verbalizations that increase risk due to delay and lack of feedback.

### Consequence

Closing the communication loop with a verbalization as simple as an "uh-huh," or an "mmhmm," or a "…right," provides a minimal form of feedback to the speaker. In situations where new information is being introduced, the listener can go a step further than the verbal nod by repeating a piece of the original message to indicate receipt of that message. It is important to either give explicit feedback or to make it explicitly clear when one cannot respond (thereby explicitly closing the loop). If a verbal reaction from the listener is not forthcoming, the speaker should explicitly request an indication of comprehension. In fact, GIHRE found that effective teams show proportionally more speech acts of type "make sure" and in general more indications of ensuring that communication went well, like "confirm", "acknowledge" and "reaffirm" speech acts. The GIHRE "Microstructure of Cognition" group found that as workload increases, latency of response increases, and that receptiveness worsens under conditions of increased workload. Verbal nods decrease the ambiguity.

### Actors

Team members and training specialists

GIHRE-book chapter: Behavioral markers

GIHRE-book chapter: Language and communicative behavior

GIHRE-book chapter: Microstructure of cognition

GIHRE-book chapter: NPP PO


# 14 Figure. Giving the “verbal nod.”

## Recommendation 15: Speak simply – use small words, articulate simple thoughts, and ask simple questions

### Reason

Using a simulator study and computer-based text analyses, GIHRE Threat found that the use of large words (defined as six letters or more) was *negatively* related to performance variables and communication skill, while being positively related to rates of error (Sexton and Helmreich, 2000). One interpretation is that the ability to communicate effectively includes the ability to apply a simple and succinct vocabulary. Conceivably, those individuals who expend the cognitive resources necessary to speak more elaborately (using bigger words) do so at the expense of decreased situational awareness or team perspective. Related to this notion of speaking simply are the results from experimental laboratory techniques used by the GIHRE Language Processing. They found that as working memory was taxed, the risk of an erroneous message increased, but that the results differed as a function of the degree of complexity in the question being asked. Yes/no-questions clearly differed from wh-questions (wh-questions begin with "what", "when" etc.) in semantic structure. In broad terms yes/no-questions are verification tasks. In their simplest form they allow the speaker to request a judgment on the truth of a proposition. Therefore the answer is either "yes" for true or "no" for false propositions. In contrast, wh-questions take an incomplete proposition and intend an addressee to utter the element that makes a complete and true proposition.

### Consequence

Results from GIHRE investigators indicate that frequent use of simple words (fewer than 6 letters long) was associated with safer outcomes. Note that using simple words is not the same thing as verbalizing less – in fact there is a substantial negative relationship between average word length and average number of words spoken (i.e., talking more is associated with using shorter words). Dietrich, Grommes and Neuper (in press) found that approximately 90% of all questions from a set of aviation simulator transcripts were yes/no and wh-questions. Yes/no-questions were used more frequently (70 %) than wh-questions (30 %). Under conditions of increased memory load, answering wh-questions was *more prone to error and also took longer* than answering yes/no questions.

### Actors

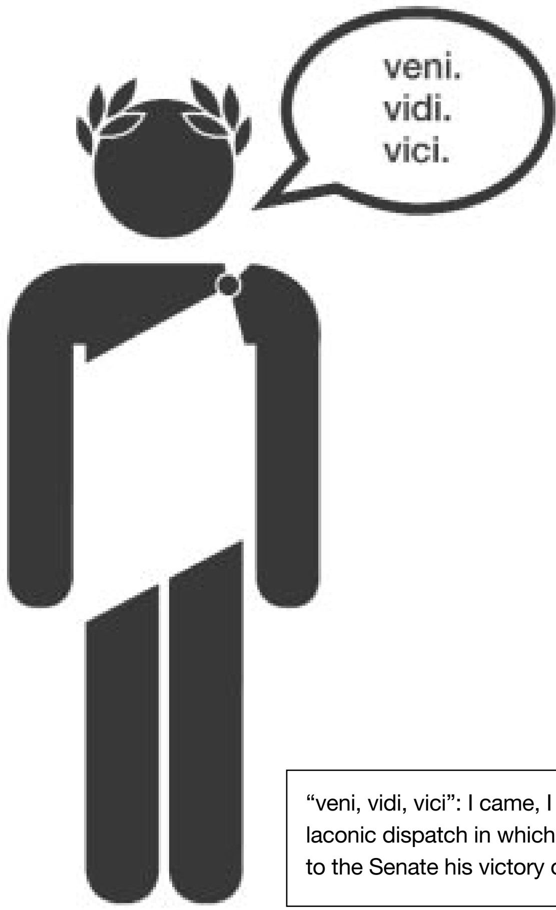
Team members, and training specialists

### References

Sexton, J.B., & Helmreich, R.L. (2000). "Analyzing cockpit communications: The links between language, performance, error, and workload." *Human Performance in Extreme Environments* 5 (1), 63–68.

GIHRE-book chapter: Language processing

GIHRE-book chapter: Threat




"veni, vidi, vici": I came, I saw, I conquered. (The laconic dispatch in which Julius Ceasar announced to the Senate his victory over Pharnaces.)

# 15 Figure. Keeping individual utterances short and sweet

## Recommendation 16: Generally speaking, verbalizing is good and more verbalizing is better

### Reason

A fundamental aspect of communication is *quantity*, or how much is verbalized by the speaker. What makes for a safer communication style, brevity or verbosity? Recommendation 15 suggests that speaking simply is good for performance, but this is not the same thing as "not speaking very much at all." High rates of verbalization foster familiarity among team members and reduce ambiguities surrounding what individual team members are thinking or feeling. Simply stated, verbalization during group interaction is essential for establishing and maintaining the shared mental model of the situation in safety-critical settings. Prior research has found (Foushee and Manos, 1981) that better performing crews communicated more overall. This relationship between performance and quantity of verbal communication was also documented in a Bell Aeronautics Company study in 1962 (Siskel and Flexman) and replicated in Foushee, Lauber et al. (1986).

### Consequences

In studies of language use in the cockpit by GIHRE Threat, a metric as simple as *the number of words spoken* was associated with higher performance and lower rates of error. In other words, when it comes to cockpit communication generally – it appears to be the case that more is better. Pilots spoke more during high workload flights than during routine workload flights, and captains spoke more than first officers and second officers (see # 16 figure). Individuals communicate more during periods of high workload due to the inherent multi-tasking involved in flight deck management. On a related note, verbalization is quite observable as far as behaviors go, and an ongoing observational study of teamwork and error during neonatal resuscitations is demonstrating that the behavior "information sharing" was observable in 100% of 132 resuscitations as of this writing (Eric Thomas, MD – Personal communication November, 2003).

### Actors

Team members, and training specialists

### References

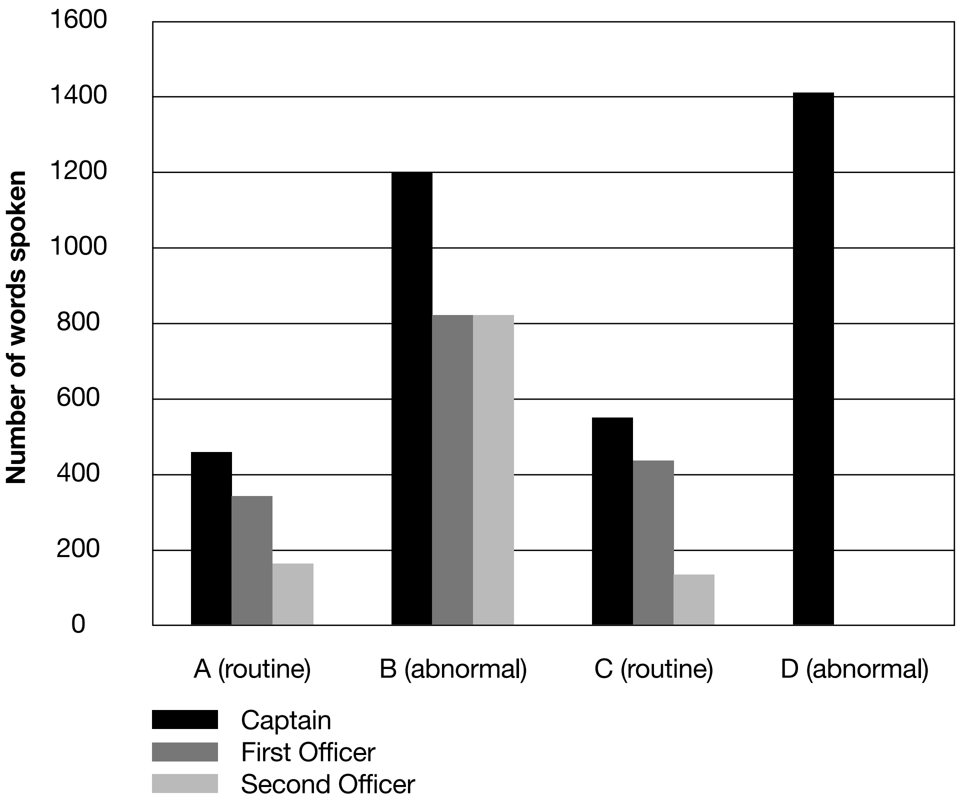
Foushee, H. C., Lauber, J. K. Beatge, M. M., & Acomb, D. B. (1986): *Crew Performance as a function of exposure to high density, short-haul duty cycles*. (NASA Technical Memorandum 88322). Moffet Field, CA: NASA-Ames Research Center.

Foushee, H. C. & Manos, K. L. (1981): "Information transfer within the cockpit: Problems in intracockpit communications." In: C. E. Billings & E. S. Cheaney (Eds.): *Information transfer problems in the aviation system* (NASA TP–1875). Moffet Field, CA: NASA-Ames Research Center.

Siskel, M. & Flexman, R. (1962): *Study of effectiveness of a flight simulator for training complex aircrew skills.* Bell Aeronautics Company.

GIHRE-book chapter: Threat

## Number of words spoken by cockpit position and segment:




# 16 Figure. Number of Words Spoken by Cockpit Position and Flight Segment

## Recommendation 17: In multi-lingual settings, high workload communication is more effective in one's native language

### Reason

English is internationally recognized as the industry-standard language of aviation. While this is convenient for a handful of countries, it often places pilots from nations that are not native speakers of English at a significant disadvantage. For example, some airlines require 100% of cockpit communication to take place in English, such that pilots can be reprimanded for speaking in their native language. Moreover, mixed nationality cockpits are becoming much more commonplace, in which some of the crew is a native speaker of English while others are not. Crews with members having varying degrees of English proficiency are challenged with problems of translation, interpretation of content, and most importantly with regard to GIHRE, failure to stay on the same page and maintain comprehension of the shared mental model of the situation. There is evidence from incidents and accidents whereby misunderstandings of verbal messages by second language speakers have led to unfortunate outcomes (Cushing, 1994). Unpublished data from a study conducted by University of Texas researchers with a European carrier indicated that crews who reverted to their native language were better performers in a taxing simulation scenario. As findings from GIHRE "Microstructure" support, even in highly proficient second language speakers[3], comprehension is slowed and more error prone relative to native speakers. This is indicated by a delay of an electronic signal from the brain that is measured using a continuous EEG (this signal is called an *N400 component*). Researchers agree that the N400 component means the brain is at work processing language. As shown in # 17 Figure, language processing was delayed by 200 milliseconds in second-language speakers relative to native speakers, throughout all experimental conditions. The situation may not be as significant in early acquisition bilingual speakers.

### Consequence

There is a general delay of message comprehension when the listener is not a native speaker of the language of the message. This scenario, whereby the listener has a different native language from the speaker is usually the case in multinational teams and for pilots from non-English speaking countries. In high workload situations, pilots should make decisions and problem solve in their native language whenever it is feasible to do so (i.e., as long as the rest of the crew understands the native language).

### Actors

Regulators, Team members, and training specialists

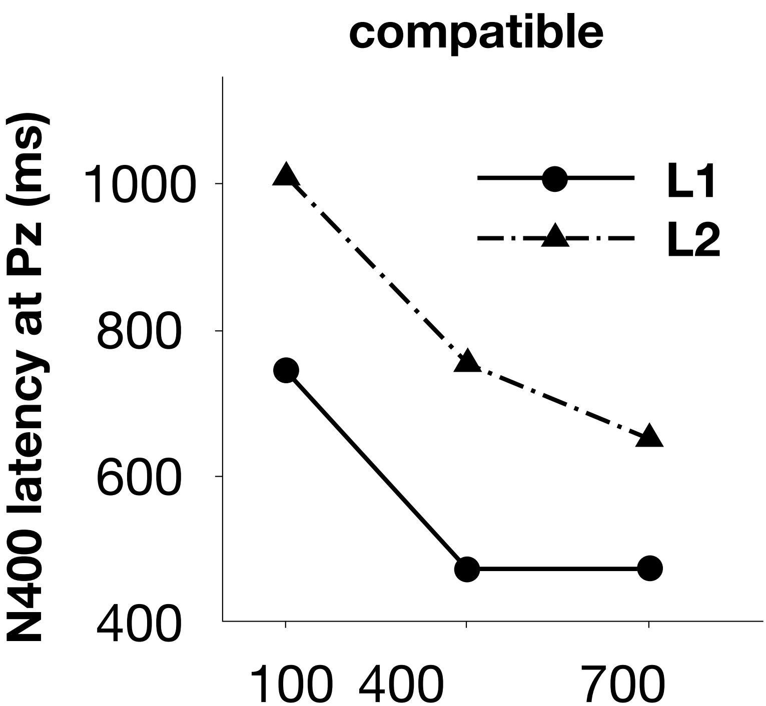
### References

Cushing (1994). *Fatal words: Communication clashes and aircraft crashes.* Chicago.

GIHRE-book chapter: Microstructure

Hohlfeld, A., Mierke, K., Sommer, W. (in press). “Is Word Perception in a Second-Language more Vulnerable than in one’s Native Language? Evidence from Brain Potentials in a Dual Task Setting.” *Brain and Language*.

[3] The situation may be less severe in early acquisition bilingual speakers.




# 17 Figure. Delay of N400 component in second-language speakers (L2) relative to native speakers (L1) in a language perception task that occurred at the same time as (SOA) the performance of an additional task.

## Recommendation 18:
## When a non-speaking task must be carried out while verbalizing, keep that task as free from language as possible

### Reason

Overlapping and simultaneous tasks impede the perception and understanding of verbal messages. The impediment is markedly more pronounced when the additional task also involves language processing such as reading. Language-related processes draw from limited resources that have to be shared when simultaneous language tasks compete. It is reasonable to assume that a similar situation holds true when information has to be translated into internal language-like representations.

### Consequences

In a situation where verbal communication is essential, additional tasks should be kept as free as possible from language-like processes such as reading written messages or digital displays. Instead, information should be presented using self-explanatory symbols or signs such as arrows, which point into the direction of action or analogue instead of digital displays to avoid language-related translation processes. As shown in # 18 Figure, there is less interference between language perception and the visual processing of a "non-linguistic" square than with processing of the "linguistic" letter. As described in Rule 16 semantic processing during language perception is indicated by the N400 component, a brain signal provided by a continuous EEG.

### Actors

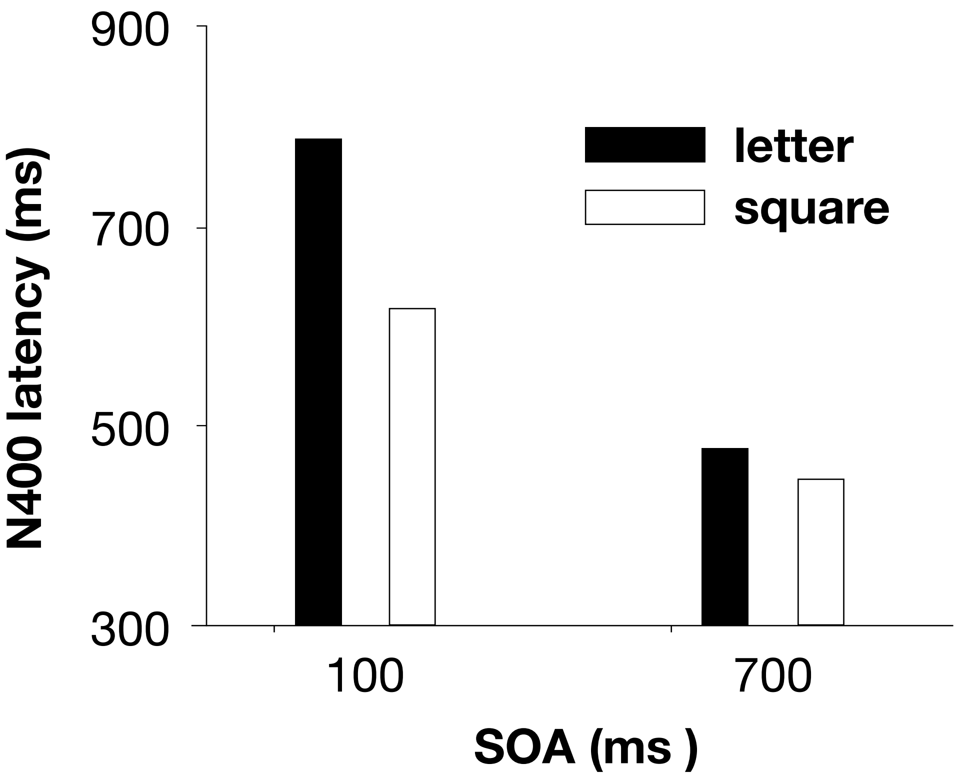
Team members, and training specialists

### References

Spence, C. & Read, L. (2003). "Speech shadowing while driving: On the difficulty of splitting attentions between eye and ear." *Psychological Science* 14 (3), 251– 256.

GIHRE-book chapter: Microstructure

Hohlfeld, A., Sangals, J., Sommer, W. (acc., pending rev.). "Effects of Additional Tasks on Language Perception: An ERP investigation." *Journal of Experimental Psychology: Learning, Memory, and Cognition.*




# 18 Figure. While speaking, reaction times were slower for processing letters as compared to processing shapes (measured in milliseconds).

## Recommendation 19: Use standardized phraseology – especially when speaker and listener are physically separated

### Reason

In the Nuclear Power Plant operational handbooks it is typically stated that communication should be audible and clear, so that all shift members can understand it. Furthermore it is stated that the speaker should confirm whether the message was understood (e.g., by requesting feedback from the shift supervisor). Though not systematic, some plants have worked out communication guidelines for words that should be avoided during communication, as they had previously led to misunderstandings. Nevertheless, there is no regulation in place for a standard phraseology. Standard phraseologies are common in aviation, submarine operations, and air traffic management.

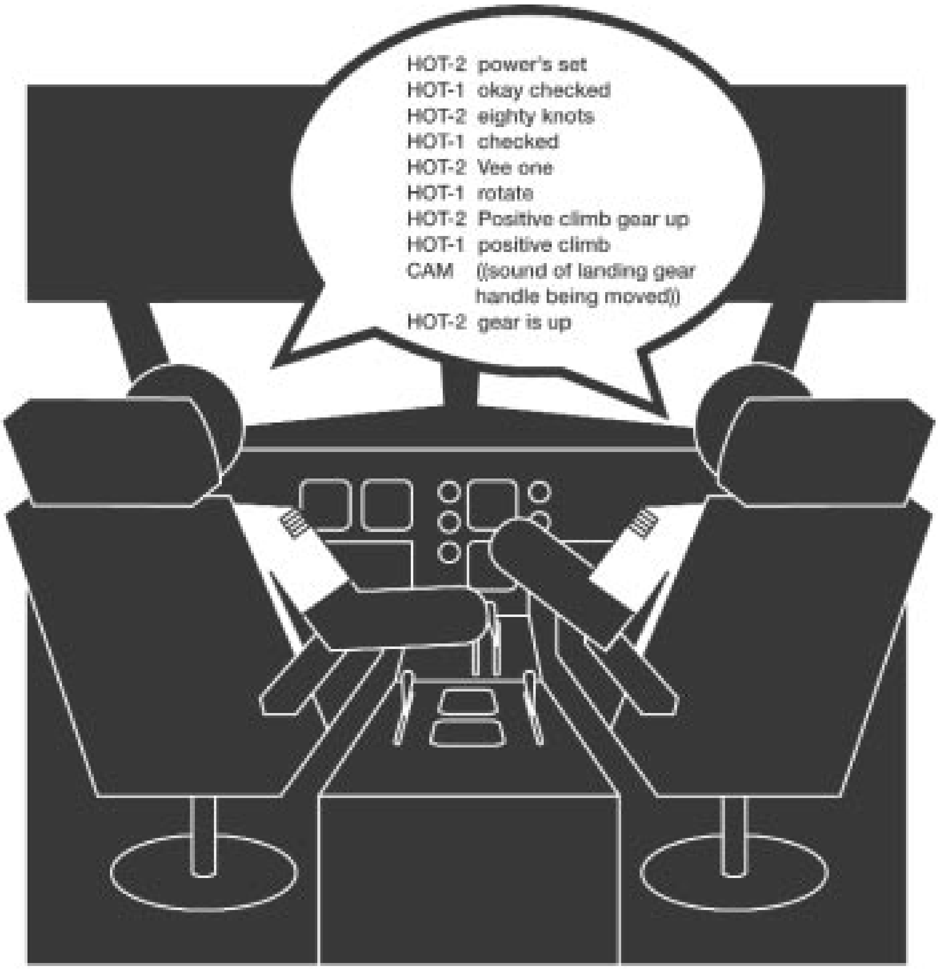
### Consequence

Standardized terms can prevent communication breakdowns under conditions of increased task load in communication settings where speakers and listeners are physically separated. Conversely, informal speaking can contain multiple ambiguous linguistic meanings that can lead to misunderstandings. Linguistic meanings that are used more commonly are processed more rapidly and with fewer errors. The use of standardized phraseology is correlated with the risk of producing incoherent verbal contributions under conditions of non-standard high task load. Experimental evidence demonstrates that standardized question formats can speed up answer preparation in the listener. Standardization of communication compensates for the vulnerability of the message being incompletely delivered through redundancy and disambiguation. In short, standardization of the phraseology for information exchange is a safety measure that minimizes the risk of message deterioration. Communication at a distance is hindered by split attention, local distance between speakers, lack of visual contact, electroacoustic devices of communication, and a decrease in familiarity between communicators.

### Actors

Team members and training specialists

GIHRE-book chapter: NPP PO
GIHRE-book chapter: Language Processing




# 19 Figure. Using Standard Phraseology

## Recommendation 20: RNs talk more like MDs (i.e., concisely) and MDs listen more like RNs (i.e., attentively)

### Reason

Physicians are trained to expect and communicate in *headlines* or clinical bullet points of patient condition, whereas nurses are trained to expect and communicate the *story* of the patient. Due to the inherent training and status differences between physicians and nurses the opportunities for information transfer to breakdown are common. A compromise of communication styles is needed to improve the delivery and receipt of information in these hierarchical interactions. Nurses need to convey essential information for physicians more concisely than the traditional "here is the story of this patient," while physicians need to elicit and listen more carefully to the concerns and unique perspectives of the nurses because physicians often fail to notice when breakdowns in information transfer occur (see # 20 Figure). Evidence for these potentially conflicting styles of information transfer between physicians and nurses was found in the questionnaire data from the GIHRE book chapter: Threat. Specifically, items regarding collaboration between physicians and nurses and breakdowns in communication provided evidence, as did open ended comments made during focus groups and through the questionnaires. Also, recent evidence from the UT Center of Excellence for Patient Safety Research and Practice indicates that nurses who report better communication with physicians report lower rates of nurse turnover.

### Consequences

Nurses are trained to give the narrative of the patient in a detailed and contextualized account. When communicating to physicians (who must then make decisions about the delivery of care), there are oftentimes many opportunities for the physicians to tune out parts of the story, as they wait for the more clinically relevant input upon which to base their decision-making. The result is that clinically relevant information can be lost in the exchange, due to the delivery style of nurses and the listening style of the physicians.

### Actors

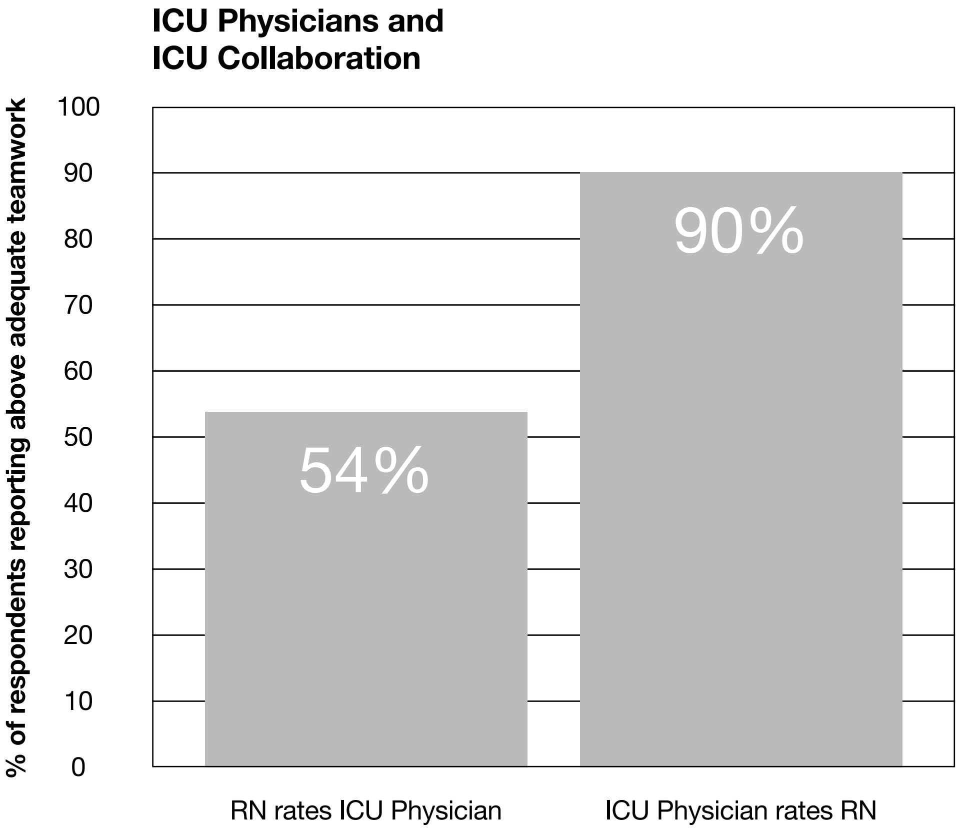
Team members, faculty members of medical and nursing schools, and training specialists

### References

Thomas EJ, Sexton JB, Helmreich RL. (2003). "Discrepant attitudes about teamwork among critical care nurses and physicians." *Critical Care Medicine* 31 (3)

Sexton JB, Thomas EJ, Helmreich RL. (2000). "Error, stress, and teamwork in medicine and aviation: cross sectional surveys." *BMJ* 320: 745–749

GIHRE-book chapter: Threat




# 20 Figure. Discrepant perceptions of teamwork between MDs and RNs

## Recommendation 21: Get better results by taking group interaction aspects of risk assessment into consideration

### Reason

Insurance is a challenge in industry segments with low-probability, high-consequence losses (nuclear, aviation, hospital and refineries). As premium rates are in the per mill range, it takes many years for an insurer to break even after having had to pay out a significant loss. In this highly volatile environment, risk selection – meaning the insurance of only good operators – seems to be the only way for insurers to survive.

In the past, risk assessments focused on whether the technical equipment used to handle safety-critical work processes was appropriate. Back then, the buzzword was "HPR" plants (Highly Protected Risk) with extensive technical loss prevention. However (with the exception of 11 September), the largest man-made loss ever was an explosion in a petrochemical plant in Texas, which could not be attributed to a failure in technical loss prevention, but to "soft" factors such as procedures and staff's adherence to them. As a result, the risk assessment focus was extended to encompass organizational elements of formal safety management procedures. While both perspectives are still very useful when distinguishing between good and bad risk management, there are a growing number of companies which, despite enforcing quite high standards from both aspects, still remain at risk. It was found that these companies can be best identified by evaluating how they deal with the daily safety aspect on the shop floor and by examining the management beliefs and norms that are shared by those responsible for safety. We analyzed some large losses in the refining/petrochemical segment using James Reason's "layers of protection" (LOP, or the "Swiss cheese") model. This approach concentrates on the way latent failures combine along a trajectory of opportunity, permitting an incident to occur. We found the following distribution of the 67 latent failures identified: 33% hardware; 37% software (procedures, training etc); and 30% "liveware" (group interaction, human error, change management, etc).

### Consequences

Focusing on technical and formal organizational procedures helps us identify some of the companies at risk. At the same time, global standards for both technical equipment and process safety management provide a more uniform framework for risk management, although they may disguise safety problems in plants where beliefs and norms dictate the day-to-day behavior of the workforce. Such companies must be identified if we are to gain a sufficiently thorough understanding of plant operations to enable us to make an adequate assessment of risk.

### Actors

Risk managers, risk surveyors, inspectors, operators.

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# Summary

# The greater the insight, the sharper the foresight
## The insurers' perspective on interactive safety management

Swiss Re has a long tradition in analyzing loss histories to develop risk assessment instruments. Experience has shown that man-made catastrophes often have less to do with mechanical breakdown, material fatigue or even with fate than they do with human interaction errors, inadequate management of complex systems and safety culture in general. When Swiss Re's Risk Engineering started its "Human Error Project" in the early 90's – in collaboration with hospital physicians, work psychologists and airline pilots – it acknowledged that to always blame the individual operator for causing fatal accidents was too simple an equation. Thus, the team sought to identify the systematic risks inherent to the interaction of hard, soft and live-ware. Today, the knowledge which this research yielded is regularly applied in the risk assessment and underwriting of highly exposed industrial risks.

Developing an instrument to enable a clear assessment of complex risks nevertheless remains an ongoing task. It is an illusion to think that the interaction among man, machine and process can be reduced to a simple linear construct which is easily understood by all active participants.

To assess the reliability of interacting systems, one must know how those sub-systems and components communicate with one another within the parameters of their unique communication culture – a complex task in its own right.

The culture of a corporation is hardly rigid; changes – both visible and invisible – do occur. Yet changes in safety culture often go undetected. The corporation's safety behavior can differ from one location to another, depending on economic aspects, management attitudes and the unique set of corporate values. That behavior is a complicated interactive system, one influenced by soft factors and governed by unwritten rules to a large extent. The safety culture of a global corporation is not likely to have a risk and safety index that allows a relevant rating; too many aspects and immeasurable soft factors would have to be taken into account to get a sound "aerial view". Further, fluctuations in the economic cycle influence the safety culture of a corporation and the safety consciousness and behavior of its management and staff, both positively and negatively. Whereas cost restrictions in a recession phase may have a negative impact on safety-related investments, the self-expressive, autonomy-seeking approach prevalent in boom phases may lead to overconfident behavior in which safety parameters are neglected. Or, in times when production plants are running at uneconomically low capacity, savings in manpower and maintenance costs may cause critical situations regarding safety in high-hazard process plants, while in booming markets, operators may be tempted to try and extract more from a power system than it was originally designed to put out. Finally, while there are always those who *know* about potentially unsafe acts or situations, they may or may not do anything to counter them. There are, of course, many reasons why this

## Summary

is so. When explicitly part of a corporate culture, as in the “no risk – no fun” approach, those reasons are easier to detect than if they are part of the unwritten rules of the game.

Such hidden shortcomings usually go undetected in routine safety audits, in which individual processes are analyzed and individual operators are questioned. Particularly in cases when unsafe activity becomes established as a deliberate standard procedure, neither management nor auditors are likely to hear the whole story. So the safety auditor should routinely ask himself two questions: first, does the safety culture allow for unsafe shortcuts and second, what might motivate – or offer benefit to – somebody who were to take them?

Answers can only be found if adherence to operating and communication processes is controllable, and will only prove useful if they divulge information about the corporate code of conduct and safety rules in everyday practice.

Given large corporate clients’ enormous risk potentials and their huge demands for cover, insuring them has almost become a business in its own right. Risk pricing is not only based on statistics and loss history, but largely on potential losses, thus – as insurers call it – on the risk quality – understood to be a measure for the loss propensity within a given safety culture.

For this reason, insurers of high risk operations are well advised to closely examine corporate safety culture and its underlying safety management systems. The change from the linear cause-consequence relationship model to the complex interactive way of approaching risks has induced a paradigm shift in risk analysis – branching out from the physical process plant to the corporation and to its specific environment. As regards responsibility for saf operation, the line extends from the individual operator to the management processes and on to cultural factors. The traditional quantitative risk assessment approach – based on figures from the past – is enhanced with a qualitative component of analysis to offer a future-oriented indication of risk.

To conclude, the better we foresee the potentially weak link in a safe operation, the more effectively its failure can be prevented. And from the insurer’s point of view, the balance saved from each large loss avoided will more than cover the cost of risk and safety research.

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Swiss Re

## Summary

# Contributors

## GIHRE Contributors

### Traci Michelle Childress

Traci Michelle Childress studied Human Studies and Creative Writing at Warren Wilson College. She works as a freelance writer, translator and editor. She has done graduate work at the SALT Center for Field documentary studies in Portland, MA in the USA. She participated in the organization of the U.S "Asheville Poetry Festival, 1997" as a writer and editor of related texts and publications that accompanied the festival, and she has also done oral history work on Activism in Appalachia in the USA. This work is a part of the oral history archives at the University of North Carolina at Chapel Hill. Currently, she continues work as a freelance editor and writer while also working as co-coordinator for the GIHRE project at the Humboldt University in Berlin, Germany. She is also pursuing a Master's in Health Arts and Sciences at Goddard College.

### Rainer Dietrich

Rainer Dietrich, born 1944, is currently Professor of Psycholinguistics at the Humboldt-University of Berlin. His main research interests are in the field of language production and second language acquisition. He heads the psycholinguistic experimental lab of the faculty of Arts II and has conducted a number of experiments on language processing. The specific objective of the latter is the structure of the production system and the time course of utterance production under conditions of workload.

### Ryoko Fukuda

Ryoko Fukuda, born 1972 in Tokyo, Japan, is currently guest researcher at the Institute of Ergonomics at the Technical University (Technische Universität) in Munich. She received her Ph.D. at Keio University, Japan, in 1998. Her main research interests are human visual information processing, ergonomic evaluation method using eye tracking and ergonomics for elderly people, especially in the field of human-computer-interaction.
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### Patrick Grommes

Patrick Grommes, born in 1969, is currently working as a researcher at the psycholinguistics department of the Humboldt-University in Berlin. He received his M.A.-degree from the Humboldt-University for a thesis on the acquisition of German as a foreign language by Italian speaking immigrant workers. He joined the Collegium on Group Interaction in High Risk Environments in 1999 and is now completing his Ph.D. dissertation on psycholinguistic aspects of communication in the medical operating room within the general framework of the Collegium. His principal research interests are in psycholinguistic aspects of discourse coherence, discourse and interaction, and workplace studies.

### Gudela Grote

Gudela Grote, born 1960 in Wiesbaden, Germany, professor of work and organizational psychology at the Swiss Federal Institute of Technology (ETH) in Zürich, studied psychology in Marburg and Berlin, Germany, and received her Ph.D. at the Georgia Institute of Technology in Atlanta, USA, in 1987. Main research interests are the effects of automation, safety management and safety culture, computer-supported co-operation, planning in organizations, multimedia learning, and the relationship between work and personal identity.

### Ruth Häusler

Ruth Häusler is a research and teaching assistant at the Department of Work and Organisational Psychology at the University of Bern, Switzerland. She received her master's degree in Psychology at the University of Bern in 2000. For four years she has been working in the field of aviation psychology, starting with her master thesis on the measurement of "Crew Resource Management" (CRM) behavior at Swissair. She is currently working in the "GIHRE-aviation" part of the Collegium. Another project links her to the Department of Anaesthesiology at the University Hospital in Basel, in which a CRM measurement tool for full surgical teams is developed and validated. The subjects of her doctoral thesis are the work strategies of pilots and their effect on performance in high workload situations.

### Robert Helmreich

Robert Helmreich is professor of psychology at The University of Texas at Austin. He received BS, MS, and Ph.D. degrees from Yale University. He is director of University of Texas Human Factors Research Project which investigates human performance and threat and error management in aviation and medicine. Helmreich received the Flight Safety Foundation Distinguished Service Award in 1994 and Human Factors award in 2004. He was Chair of the Foundation's Icarus Committee. He received Laurels from *Aviation Week and Space Technology* in 1994 and 2002 for his research into human factors in aviation. He is a fellow of the Royal Aeronautical Society, the American Psychological Association, and the American Psychological Society. His research has been supported by the National Science Foundation, NASA, the Agency for Healthcare Research and Quality, and the Daimler-Benz Foundation. He has more than two hundred publications and is author, with Ashleigh Merritt, of *Culture at Work in Aviation and Medicine: National, Organizational, and Professional Influences.*

### Annette Hohlfeld

Since her master's work, a main focus of Annette Hohlfeld's work at the Humboldt-University, has been language impairment and language development. Whereas her master thesis mainly focuses on language impairment, her doctoral dissertation, which was completed in 2001, compares language processing in normal and aphasic speakers. Her interest in psycholinguistics as well as in its methodology brought her into contact with the GIHRE Collegium. Within this project she has investigated how language perception changes when the perceiver has to solve another parallel task.

### Barbara Klampfer

Barbara Klampfer, PhD, is Human Factors Manager at StateRail in Sydney, Australia. She received her master's degree in Psychology at the University of Salzburg in

1995, where she also did postgraduate work on Training Conception and Methodology. From 1997 to 2002 she worked as a research assistant at the Swiss Federal Institute of Technology, Zurich. Since 1997, she holds a Private Pilot License. From 1997 to 1999, she worked with a project dealing with incident analysis based on in-flight data under grants from Swissair Flight Safety Department and the Swiss Reinsurance Company. Her doctoral thesis focused on the influence of automation on minor incident. In 2002 she received her PhD from the Swiss Federal Institute of Technology. From 1999 to 2003 she worked as the scientific project head in the GIHRE-aviation project.

### Manfred Krifka

Manfred Krifka is currently Professor of General Linguistics at the Humboldt University, Berlin, and director of the Zentrum für Allgemeine Sprachwissenschaft, Berlin. He was professor of linguistics at the University of Texas at Austin, 1990–2000, and fellow of the Center for Advanced Study in the Behavioral Sciences, Stanford, 1995–6. His main interests are the syntax, semantics and pragmatics of natural languages, and language typology. He has worked, in particular, on aspect, measure constructions, questions and information structure and is the editor of two major journals, *Linguistics and Philosophy* and *Theoretical Linguistics,* an open peer review journal.
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### Silka Martens

Silka Martens received her diploma in sociology and her M.A.-degree in linguistics at the Free University Berlin for a thesis on the construction of social reality through linguistic interaction. She joined the Collegium on Group Interaction in High Risk Environments in 2001 and is currently working on her Ph.D. dissertation on conversational aspects of understanding in the cockpit within the general framework of the subproject "Linguistic Factors". Her main research interests include conversation analysis and ethnomethodology, interactional linguistics, speech act theory, theory of (social) action, qualitative research methods, language and gender, Bourdieu's social theory and constructivism.

### Capt. Werner Naef

Werner Naef, born 1947, started studying engineering at the Swiss Federal Institute of Technology in Zurich in 1966. In 1969 he graduated as air force pilot and consequently joined Swissair as an airline pilot. He has been a captain with Swissair since 1981 and has held several positions as Training Captain, Instructor – and Check pilot, Deputy Fleet Chief Pilot and member of the pilot selection team. Between 1976 and 1981, he received postgraduate training in psychotherapy and consequently became responsible for the Human Aspects Development / Crew Resource Management Training at Swissair. He was a board member of the European Assoc. for Aviation Psychology, acted as delegate of the AEA (Assoc. of Europe. Airlines) in the European Joint Aviation Authorities' Human Factors Steering Group and held a post as the Swiss Civil Aviation Authority's Human Factors expert. He is an EAAP-registered aviation human factors specialist. Werner

Naef served for 32 years in the Swiss air force as pilot, squadron commander and chief of operations control air transport. At the brink of Swissair's financial breakdown he started up a training company with two more partners, specializing in team – and skill training for potential high risk work situations. He became heavily involved in simulator training for rail and for trauma surgeons. In late 2003 he started at Air New Zealand in Auckland as Human Factors Investigator, still involved in rail simulator training in Australia.

### Sascha Neuper

Sascha Neuper, born in 1970, received his diploma in psychology at the Ruhr-Universität Bochum for a thesis on the effect of deadline instructions on stroop interference. He joined the Collegium on Group Interaction in High Risk Environments in 2001 and is currently working on his Ph.D. dissertation within the general framework of the project. He experimentally investigates whether different question types can be disturbed differentially under high workload conditions. His main interests in experimental research on human behavior are methodology, attention, language processing and expectation effects.

### Jörg Sangals

Dr. Jörg Sangals is assistant lecturer and researcher at the department of biological psychology and psychophysiology at the Humboldt-University at Berlin. After his doctoral dissertation in 1997 on the learning of tool transformations at the Leibniz Research Centre for Working Environment and Human Factors in Dortmund, he came to Berlin to extend his research approach on response preparation and motor control by means of psychophysiological methods. His research scope encompasses motor control under micro-gravity, language processes and clinical syndromes such as Parkinson and apraxia. The major focus of his interest, however, is response preparation under high task load, particularly in multiple task situations and with conflicting task demands including time pressure. Jörg Sangals regards human communication as a special form of multi-tasking. With this intention in mind, he joined the GIHRE Collegium in order to apply his research to real-life high-risk environments.

### Florian Schwarz

Florian Schwarz received his M.A. in Linguistics and Philosophy from the Humboldt University in 2003. From 2001 to 2003 he was a member of the GIHRE Linguistic Factors project. This project looked at the communication between crew members in the cockpit, applying analytic tools from linguistic pragmatics to real life situations. His interests in theoretical linguistics include formal semantics and pragmatics of natural language, information structure, and syntax. He is currently pursuing a PhD in theoretical linguistics at the University of Massachusetts.

### Bryan Sexton

Dr. Bryan Sexton is an assistant professor at The Johns Hopkins University School of Medicine, and is the Director of Safety Attitudes Research at The University of Texas Center of Excellence for Patients Safety Research and Practice. He has spent the past

12 years conducting research in safety-critical team environments, splitting his time between the cockpit, the OR, and the ICU. This work has taken him from studying pilot communication and flight safety in the cockpit (through direct observations of pilot behavior and simulator studies), to investigations of patient safety and group dynamics in medicine. Currently, he is investigating the links between attitudes, behaviors, and outcomes in aviation and medicine.

### Werner Sommer

Prof. Dr. Werner Sommer (born 1952) received his diploma in Psychology from the University of Würzburg in 1976. He obtained both his doctoral degree (1982) and his Dr. habil. (1991) at the University of Konstanz. In 1995 he was appointed professor of Biological Psychology and Psychophysiology at the department of Psychology at the Humboldt-University Berlin. His general research interest is the investigation of human information processing by recording electrical brain potentials. Currently, he is engaged in studies on movement preparation, dual task processing, language perception, processing facial information, and the significance of specific brain potentials.

### Oliver Sträter

Dr. Oliver Sträter studied engineering psychology and worked for GRS (Gesellschaft für Anlagen – und Reaktorsicherheit), the German Nuclear Regulatory Body, from 1992 till 2002. At GRS he developed methods for incident investigation and reliability assessment regarding human impact on the safety of nuclear installations. He counseled for the International Atomic Energy Agency (IAEA), the Nuclear Regulatory Commission (NRC) of the United States, the Swiss Regulatory Body (HSK), and the OECD Halden Reactor Project. Main topics of research and development are errors of commission, cognitive errors, organizational safety and incident evaluations. His Ph.D. was done on the evaluation of operational experience regarding human reliability together with the Institute of Ergonomics of the University of Technology Munich. Since 1999 he has also been working at the Institute in the fields of human factors for automobile, occupational safety and aviation. In 2002 he moved to EUROCONTROL, the European organization for the safety of air navigation. Currently he is responsible for SHAPE (Solutions for Human Automation Partnerships in European ATM), which deals with the effects of new automated systems on the performance of controllers. Since 2003 he has been a member of the German Reactor Safety Commission.

### Enikö Zala-Mezo

In 1989 Enikö Zala-Mezo obtained a Masters degree in Psychology at Kossuth University (Debrecen, Hungary) with a thesis focusing on the Psychology of Decision-Making. While at Kossuth University, she also worked as a teaching and research assistant in the fields of Social and Organisational Psychology. In 2000 she completed a doctoral dissertation in the department of Organisational Psychology. The topic was “how subjective judgments about organizational justice are formed.” Adopting an interdisciplinary approach, she drew on research carried out in social psychology, economics and organizational research. She became involved in the GIHRE Collegium in 2001, studying working teams in high risk situations. The most challenging point in this study is to observe the teams in real life settings. She is pleased about the ongoing possibility to be part of work within an interdisciplinary research group.

## Swiss Re Contributors

### Marcel Buerge

Marcel Buerge is a chemical engineer by education. Having spent ten years in the chemical process and engineering industries, Marcel joined Swiss Re as a risk engineer, assessing process and environmental risks. He is currently head of Swiss Re's Risk Engineering Service Center. This unit is charged with enhancing risk awareness for man-made risks and supporting corporate non-life business underwriting with a multi-disciplinary team of engineers and scientists experienced in risk assessment methods, risk exposure analysis and industrial safety management.

### Ernst G. Zirngast

Ernst G. Zirngast received his degree in mechanical engineering at the Technikum Winterthur. He spent many years working for the Sulzer corporation in Winterthur, Mexico, USA and the UK. In 1996 he joined Swiss Re's Risk Engineering Services in Zürich as a risk expert for oil and petrochemical plants. His areas of interest include topics such as process safety management, application of work psychology, emotional intelligence, and safety culture.

## Imprint

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