Back Stage on the Front Lines: Perspectives and Performance in the Combat Information Center

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ABSTRACT
While tactical command. control and communication environments might appear to be entirely instrumental in nature, they nevertheless provide a setting for social interaction. This paper describes how such interaction occurs in a particular naval tactical command and control system, focusing on the shared perspectives created by the organizational, administrative and professional aspects of the environment and on issues of self-presentation. It is argued that the complexity and multiplicity of interactional regions in this environment lead to problematic situations for key actors, and that these problems may have relevance to future computing environments.

Author Keywords
Command, control and communication; tactical data systems; social worlds; self-presentation.

ACM Classification Keywords
H.5.3. Group and Organization Interfaces: Computer-supported cooperative work.

INTRODUCTION
Studies of "control room" environments form a well-established genre of HCI and CSCW research. HCI work tends to focus on issues around human factors, task models and user-centered design for such environments [9,19,23]. CSCW work typically analyzes the role of social interaction in the achievement of tightly-coordinated work (e.g., [2,15,16,27]). However, there are no discussions of coordination work and interaction in the context of naval tactical command, control and communication (C^3) environments.

In this paper, I consider the social as well as technical aspects of naval tactical coordination, as I believe that an understanding of these environments can offer useful design considerations for other types of systems. I examine one specific control room environment, the *combat information center* (CIC), and the social relations and interactions that occur within it. From a technical point of view, the discussion is framed in the context of the Naval Tactical Data System (NTDS) [6], a system employed at sea by the U.S. Navy since 1962. NTDS is a wide-area distributed computer system through which tactical decision-makers, each located in the CICs of their respective ships, coordinate their collective activities. From a social point of view, we will see how the instrumental nature of tactical C^3 masks a complex social environment in which varied organizational, administrative and professional perspectives and issues of self-presentation inevitably arise.

This work has two main contributions. Primarily, it adds to the field's accounts of interaction in control rooms, illustrating the shared perspectives associated with the various *social worlds* [32] in CIC and describing the behaviors of their members in the context of Goffman's metaphor of social interaction as theatrical *performance* [14]. Secondarily, two of the key concepts developed – those of *system-mediated regions* and of *multiple front regions* – are extended to CSCW systems in other domains.

The paper is organized as follows. I first describe how the material underlying this paper was collected. The next section is a sketch of CIC as a sociotechnical system, first providing necessary technical background about CIC and NTDS and then going into the social worlds within CIC. After a brief illustration of these social worlds in action, I focus on a collection of generalized problem areas for the management of self-presentation and then relate these problem areas back to the design of other types of computing systems.

METHOD
The observations and analysis in this paper draw primarily from my personal experience. After several years as a university researcher, I entered active military service as an officer on a U.S. Navy destroyer (a small warship). This period included three overseas deployments, each involving operations at sea for up to six months. The discussion here is based on recollections, contemporaneous notes and

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Figure 1. Track supervisor console.

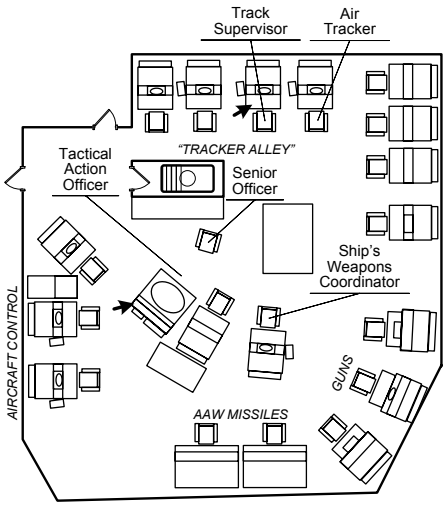


Figure 2. Physical layout of CIC.

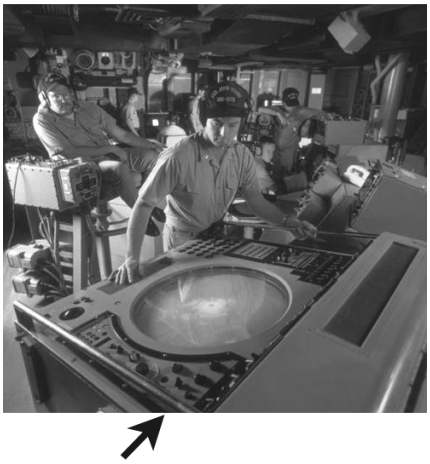


Figure 3. Operations summary console.

photographs, and photocopies of unclassified radio messages and other documents. In addition, I have checked formal details – descriptions of equipment, operating procedures, operational doctrines, etc. – against unclassified secondary sources, both for accuracy and to prevent inadvertent disclosure of classified information.

While direct participation as a member of the group being analyzed is arguably not the ideal form of participant-observation,[1] several factors make it impractical to examine naval activity in an operational setting (as opposed to training or simulations) in other ways. First, external observers cannot usually enter this "field" for an extended period. (One generally finds reflective accounts of deployed, operational military units to have been written by conscripted researchers, as with Homans [17], Shibutani [31] and Ben-Ari [4].) Second, it would be very difficult to assemble a discussion like this from a brief visit (sensemaking of informal practices, themselves unclassified, would be difficult without extensive technical training and full access to the classified material that saturates the environment and is an essential part of the work) or from secondary sources.

The bottom line is that naval tactical C^3 environments have not been previously described in terms of interactional practices and occurrences. Although my description is too dated to be a definitive representation of today's technology and practice, I believe it usefully supplements previous studies of work and interaction in non-operational military settings (e.g., [18]) and non-military control room settings (e.g., [2,15,16,27]). Similarly, I believe it usefully complements discussions of control room settings in the human factors literature, which tend to take a task-oriented approach (aimed at improving team training [8], interface design [9,23] or cognitive modeling for task automation [19]) instead of an interactional approach.

THE CIC AS A SOCIOTECHNICAL SYSTEM

The combat information center is an archetypical control room setting, one in which all of the ship's tactical decisions are made and then executed. Personnel in CIC use the ship's sensors to detect and track targets, and then use the ship's weapons systems to engage as necessary; this detect-track-engage process is managed using the ship's tactical data system. This system also enables multiple warships (e.g., a group of ships sailing together, or ships operating within a geographical region) to share a single tactical picture and coordinate their actions.

To understand the claim that social worlds and self-presentation play a role in CIC operations, one must first have some understanding of how CIC "works." This section is a two-part description of the CIC environment. The first part is a high-level overview of *anti-aircraft warfare* (AAW) at sea[2] and of its supporting systems from a technical point of view. The second part examines the operation of CIC from a social perspective.

CIC and its Organizational Context

CICs are inherently sites of distributed CSCW because modern warships are designed to work in groups and rarely operate alone. For example, U.S. warships typically deploy as part of a *battle group* that operates under a single command; its physical organization is defensive, with escort ships arranged in a loose screen around "high value units" such as aircraft carriers. Alternatively, all of the

[1] Direct participation (e.g., "auto-ethnography") is sometimes viewed as lacking analytic distance. In this case, my overt intention to return to university research after my sea tour (as opposed to the preferred course, a Navy career) certainly lent some distance; within the wardroom, it was not unusual for me to be referred to using "Dr." instead of my rank – a usage with a certain edge to it.

[2] Surface warships must engage platforms in the air (aircraft and missiles), on the surface (warships) and below the surface (submarines) of the ocean. The detailed conduct of these "warfare areas" is very different, but the tactical coordination aspects are similar enough that AAW will be used as a proxy for all of then.

warships operating in a given area such as the North Arabian Gulf may operate as a force under a single command. While a designated force AAW commander coordinates the air defense, this coordination follows a command-by-negation model – a ship declares its intent to take specific actions (e.g., fire a missile) allowed by current policies and then does so unless explicitly directed otherwise. The considerable autonomy afforded by this model reflects the fast pace of AAW, the naval tradition of autonomy for a ship's *commanding officer* (CO), and the responsibility given to each CO to defend his or her own ship [26].

The Naval Tactical Data System (NTDS) is the primary means through which CIC personnel coordinate inter-ship and intra-ship actions. Each warship has its own tactical computer suite and sensors (e.g., radar). The system's operation centers on the abstraction of a *track*, which generally corresponds to a *contact* (aircraft, missile, ship, submarine, etc.). NTDS operators work at consoles that can display both sensor data and computer data for tracks. Spatially, NTDS consoles and weapons-control consoles are loosely clustered by function (Figure 2). CIC personnel on different ships collaboratively maintain a single situational picture, with each ship sharing its track information over an encrypted wireless data network.

A ship operates around the clock while at sea, so shipboard life is run in *watches* (shifts). Depending on internal policy and the tactical situation, watches may last from four to six hours. In CIC, most *watchstanders* remain at their consoles (Figure 1 and Figure 3) the entire time, tethered to them by audio headsets that are used for both internal (within-ship) and external (between-ships) communication. When the tactical situation is busy, track management requires considerable concentration and attention to detail – NTDS operators classify tracks as friendly or hostile, ensure that each track symbol remains locked to its radar image, and so on – and doing so for hours on end can be challenging.

Voice nets, used for both internal communication and external communication, are important coordination resources for personnel in repairing misunderstandings, handling problematic situations, and coordinating responses to situations not addressed by NTDS. These voice nets are loosely organized into loops, as in the NASA Voice Loops system [27]. Within the CIC environment, voice net communication is fairly public, by design. Both internal ("interphone") and external (radio) voice nets in CIC operate as shared circuits – that is, only one station can transmit (speak) on a net at a given time, and all stations hear all voice traffic on the net. In addition, because CIC is responsible for many external voice nets, the few CIC watchstanders who are not tied to a console must monitor them collectively by listening to them over loudspeakers.

Social Worlds in CIC

CIC is more than equipment, doctrine and procedures. In this subsection, I consider the explicit and implicit organization of the CIC watchstanders.

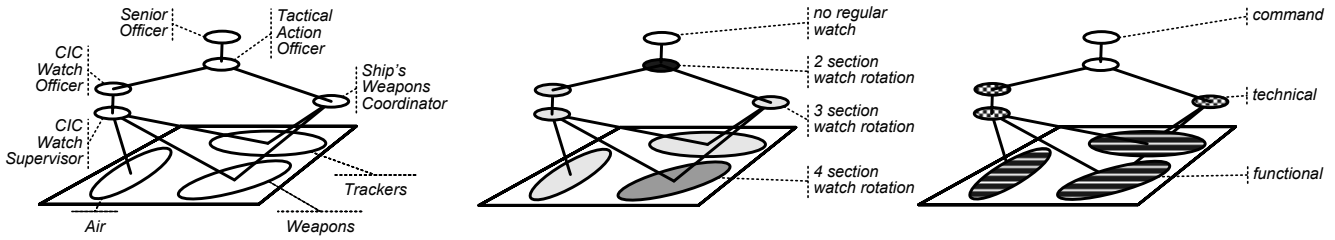
Outsiders generally think about the military in terms of its various systems of hierarchical rank and unit subdivisions – in war movies, one sees lieutenants commanding platoons, sergeants leading squads, and so on. Ships' crews certainly work within such systems. For example, as in most military services, Navy personnel are divided into distinct enlisted and officer classes. Enlisted personnel do nearly all manual and technical work, eventually earning promotion to supervisory positions. By contrast, officers immediately take managerial and leadership roles, having received a multi-year professional acculturation in college (i.e., in service academies or officer training corps). As another example, a crew is hierarchically divided into administrative departments, divisions, and workcenters. Through this administrative hierarchy, day-to-day work is managed, promotions and awards are assigned, and so on.

However, to understand how CIC "works," one needs to look at implicit organization as well – to recognize that individual watchstanders in CIC have multiple associations, affiliations and cross-functional roles that affect the conduct of their operational duties. I will here examine the roles of individuals using the framework of *social worlds*.

Social worlds are useful here as a means of highlighting implicit social structure as well as explicit organizational structure. The basic idea is that individuals act within a frame of reference, i.e., a *perspective* formed from group "norms and values" [32]. A perspective can result from membership in a formal organizational unit, but it can also result from almost any kind of grouping: "Social worlds as reference groups…(e.g., a family, a recreation group, an occupation, a theoretical tradition) generate shared perspectives" [7]. Further, what matters is not group "membership" by itself, but active social interaction to allow sharing of perspectives within the group: "Each social world, then, is a culture area, the boundaries of which are set neither by territory nor by formal group membership but by the limits of effective communication" [32]. Clearly, individuals will generally have multiple social worlds (sailor, air tracker, member of Watch Section 3, African-American, resident of Ops Berthing...), some of which may have common members or change over time.

My primary interest is not in the social worlds as entities, but in the ways in which participation in particular social worlds shapes both the actions of individuals and the interactions between individuals.[3] I discuss four types – from the least complex to the most complex, these are tactical, supervisory, watch rotation, and professional

[3] This is meant in partial contrast to the approach developed by Anselm Strauss and others, which does take social worlds themselves as the fundamental unit of analysis [7].



(a) supervisory **(b) tactical** **(c) watch rotation** **(d) professional orientation**

Figure 4. Social worlds in CIC (overlaid on the spatial diagram of Figure 2).

orientation. While organizational hierarchy of some kind plays an important defining role in each, they do not always correspond to the hierarchies that are commonly understood and formally documented. Figure 4 overlays each type onto the physical layout of CIC and selected CIC watch stations shown earlier in Figure 2.

Division by Watch Hierarchy

In CIC, two formal organizational hierarchies induce several social worlds. Further, they intersect at multiple points, causing a number of implicit conflicts. The physical locations of these *tactical* and *supervisory* watchstanders are depicted in Figure 2 and the hierarchies themselves are shown in Figure 4(a) and (b).

Within a watch team, the top of both hierarchies is the *tactical action officer* (TAO). The TAO directs CIC unless a more senior officer (i.e., the commanding officer or the ship's second-in-command, the *executive officer*) takes control in CIC. While stationed in the regions to which they have been deployed (such as the Arabian Gulf), a ship's weapons control stations are manned and an officer who has weapons release authority for self-defense is always present in CIC.

The base of both hierarchies consists of the enlisted personnel who perform the moment-by-moment detect-to-engage duties of CIC. These consist of two main groups. The first are the fire control technicians who directly control the ship's guns, missiles and other weapons systems (see Figure 2, bottom and bottom right). The second are the operations specialists who use NTDS to maintain the situational picture (see Figure 2, top). For example, the *air tracker* updates the computer display based on air search radar data, while the *track supervisor* monitors all of the NTDS data (which includes surface and subsurface contacts as well as air contacts) that is being shared with the battle group over the network.

Where these hierarchies diverge is in the middle:

The *supervisory* hierarchy (Figure 4(a)) includes two intermediate watchstanders, a *CIC watch officer* and an enlisted *CIC watch supervisor*. Unlike most personnel in CIC, these supervisors are not tethered to a console. Instead, they move around the space, noting problems and arranging for (or offering) direction and assistance as necessary.

The *tactical* hierarchy (Figure 4(b)) is organized around NTDS. The *ship's weapons coordinator* (SWC) is the nexus between the personnel who maintain the tactical data (such as the air tracker and track supervisor), the weapons systems operators, the TAO who exercises tactical control, and the rest of the battle group. For example, when the TAO gives a verbal order to engage a target, the SWC transmits this information verbally over a radio channel, updates the target's engagement status in NTDS, and sends target information and launch authorization via NTDS to the weapons consoles.

As with any matrix organization, the intersecting hierarchies imply that the most junior personnel end up managing multiple sets of orders. This leads to at least two problems. A first, practical problem is that the intermediate watchstanders give orders to those below them independently. A second, more subtle, issue results from the fact that the two hierarchies draw on different parts of the ship's administrative organization. For example, from Figure 4(a) and (b) we can see that trackers have to manage their attention between the watch supervisor (who is typically a member of their own administrative department and has input on their off-watch work responsibilities and performance evaluations) and the SWC (who is often from a different administrative department and does not have such input). Juggling these perspectives can be tricky, particularly for the very junior personnel at the base of the hierarchies.

Division by Administrative Hierarchy

The mechanics of *watch rotation* often induces different social worlds. CIC watchstanders are nominally organized into a fixed number of watch sections (shifts), and one would expect that each section (as a group within a great deal of communication occurs) would form its own social world. It is axiomatic that "[w]atch teams train as a unit and function as a unit, not as separate individuals" [11] and that teams will be more effective if they have a chance to work together for a longer time (see, e.g., [33]). However, administrative factors quite often result in situations in which sub-groups of a "team" do not rotate watches together – some sailors are standing every other watch (2 section), some are standing every third (3 section), and so on. In the example of Figure 4(c), a given "watch team" would only be together in CIC on every twelfth watch period (i.e., every 2-3 days). Since shared perspective is a

product of ongoing communication, having many different configurations of sub-teams inhibits this kind of cohesion and group identity; the social world of a tight-knit watch section will not form.

Division of Professional Orientation

The final and most complex type of social world is induced by what I will call *professional orientation* (Figure 4(d)). Rather than being simple products of formal organization, these social worlds arise implicitly from basic differences in professional acculturation and orientation toward technical mastery. More importantly, they have a profound effect on what is communicated inside and outside of CIC.

Three categories of professional orientation can be used to characterize CIC watchstanders. Individuals' perspectives incorporate them depending on their degree of communication within each social world. While these categories cluster by rank and watchstation, they are not formally-recognized:

Functional. The junior enlisted personnel, such as air trackers, have the most limited professional acculturation and the most limited view of what goes on in CIC. This has less to do with morale or competence than with environment. With relatively short military service behind them, their perspective tends to be that of their peers. With relatively limited training, experience and duties, they tend to view what happens in CIC in a narrow, functional light; their accountability tends to be to their immediate supervisors rather than to some larger entity.

Technical. Watch and tactical supervisors are drawn from senior enlisted personnel and junior officers. These populations are very different in the sense that senior enlisted reach their position through long service (often 10-20 years), whereas junior officers are mainly recent college graduates. However, extended technically-oriented acculturation and training – obtained through long service in one case and extensive training in the other – tends to lead to a technical point of view. All of these factors lead to a more systemic view of CIC operations – on making sure that the right thing happens in CIC as a whole, with accountability to all of their superiors and to their counterparts on other ships. However, this view is still somewhat local and can result in losing sight of the overall tactical situation [8].

Command. TAOs, executive officers and commanding officers are experienced mid-grade officers. These experienced officers generally take a wider, more balanced, and more nuanced view of tactical situations than their juniors [8]. Importantly, however, these officers almost always have a personal commitment to a Navy career of 20-30 years, a career in which success is determined by politics and personal networking as well as competent job performance. Officers at this level frequently refer to the need to avoid negative perceptions, which are often expressed in "blasts" (censorious messages from other ships and commands). All of them therefore orient toward the conduct of tactical C^3 as an important professional matter as well as a tactical one. The wider view comes along with a heavy accountability to their peers and superiors concerning the ship's actions and communications.[4]

To illustrate how the various worlds orient differently to a single issue, consider the case of "trouble tracks." A trouble track is a blinking NTDS track symbol resulting from a failure to apply regular track position updates (i.e., a lack of attention) and is visible on all ships in the network, not just the ship tracking the contact. The functionally-oriented watchstanders, such as the trackers, respond mainly to pressure from their immediate supervisors to stay on top of their tracks. More technically-oriented watchstanders, such as a SWC, are concerned not only with avoiding trouble from their own superiors but with maintaining the ship's professional image in the eyes of their peers on other ships. While the career-oriented senior officers have the same concerns, they are internalized at a far more personal level. Concerns about visible issues like trouble tracks are often expressed to subordinates, who typically refer to this as "sweat."

This examination of social worlds has attempted to illustrate the divergence between the tidy hierarchy and division of "ideal" military life and the messy "divided loyalties" of CIC. In everyday life, "[m]ost people live more or less compartmentalized lives, shifting from one social world to another as they participate in a succession of transactions...[and p]eople become acutely aware of the existence of different outlooks only when they are successively caught in situations in which conflicting demands are made upon them, all of which cannot possibly be satisfied" [32]. But in CIC, rather than having clear alignments to their nominal (tactical) chain of command, watchstanders may align more closely with peers in different reference groups on their own ship or even with peers on other ships. Conflicting perspectives are the norm in CIC because of its organization. The next section is an attempt to illustrate how the role of conflicting perspectives in the operation of CIC.

INTERLUDE: THE CONTACT

One afternoon, a few months after the 1991 Gulf War ceasefire, a small plane took off from an airfield in Iraq. It was duly picked up by a Coalition radar plane, which

[4] Perception is not a trivial matter. A CO is judged not only on personal competence but on the competence demonstrated by the crew [17,26]; all visible aspects of a ship and its operation – maneuvering, communications, visible rust – are relevant. The fictional Captain Queeg of *The Caine Mutiny* summarizes the mentality: "In this Navy a commanding officer gets to make one mistake – just one mistake, that's all. They're just waiting for me to make that one mistake. I'm not going to make that mistake, and nobody on this ship is going to make it for me" [35]. Today's CO has just as much cause for concern: about 80 commanding officers are known to have been relieved of command for cause (i.e., fired by their superiors) during 1999-2004 [25], often on the grounds of "loss of confidence in the ability to command."

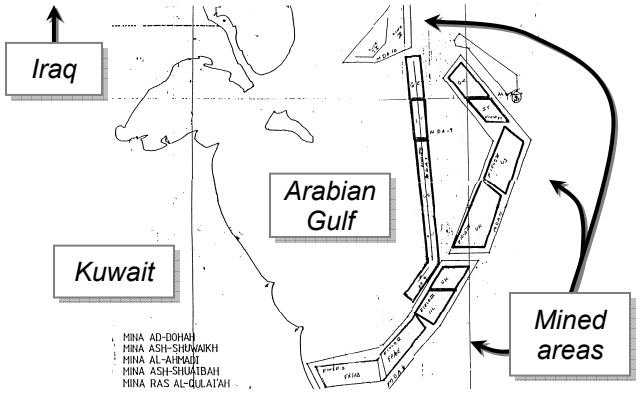


Figure 5. 1991 mine danger areas (from author's notes).

shared its track with other units over the network. Since the small plane was not a scheduled flight and was otherwise unidentified, the radar plane marked the track as having "unknown" rather than "friendly" status. The small plane swung out over the Gulf, heading directly toward a group of Coalition ships that were engaged in clearing underwater mines laid off the coast of Kuwait during the war (Figure 5). The ships tracked the small plane using their own radars as it approached and eventually directed a Navy helicopter to approach the incoming plane and resolve its identity. The small plane, identified visually as belonging to a U.N. mission, briefly observed the minesweeping operations and then returned to the mainland.

The relevance of this episode is not that it occurred – minor coordination issues such as failing to propagate flight schedule between civilian and military authorities were to be expected [33] – but how this event unfolded. How did differing perspectives affect what happened?

Beginning the story again: the Coalition radar plane acquired the small plane after take-off and immediately shared the new track over the network with "unknown" evaluation status. The watch teams on the two NTDS ships stationed in the North Arabian Gulf duly noted the new track and began looking for it using their own air search radars.

Subsequent events centered on the larger of the two ships, which was serving as a logistical center for the minesweeper flotilla at the time and lay at anchor in a mine danger area. The ship, with a fully manned CIC even at anchor, picked up the small plane on radar after it went "feet wet" (crossed the coastline) over the Gulf. The TAO notified one of his superior officers (hereafter "senior officer"), who immediately came down to CIC.

At this point, the senior officer occupied the "captain's chair" (Figure 3, left) located in the middle of CIC (Figure 2) and occupied himself with three main concerns as the contact continued to approach. First, he attempted to get the audio headset at that station to work. Second, he ordered the CIC watch to make contact with the still-unknown aircraft over the international air distress frequency (a standard procedure [11]). Third, he began directing the SWC to contact the force AAW coordinator. Unfortunately, the audio headset turned out to be broken, so he was denied access to interphone and radio nets and could only hear the battle group secure net over loudspeaker; the radio operator was unable to get a response from the contact; and the SWC claimed that the report had been sent but pulled out some manuals and began looking through them.

The senior officer's irritation became visible. Throwing down the headset, he expressed concern that the radio operator was not properly trained. In response, the TAO began to troubleshoot the headset, the CIC watch officer went over to monitor the radio operator (and therefore stopped monitoring CIC as a whole), and the watch supervisor disappeared around the corner into Tracker Alley (Figure 2, top). The senior officer continued to demand that the contact be reported, explaining that he wanted "snappy reporting" – clearly anticipating a blast for not keeping his superior informed.

What the SWC was doing with the manuals was finding a standard set of "pro words" to ask the smaller ship to lock its fire control radar on the unknown track – a request that would not usually be made over the unencrypted AAW net. The ship, at anchor and unable to move, was not physically in a position to lock its own fire control radar on the contact – a signal that would be detectable by military aircraft and often used in the Gulf to signal not to approach [8]. Given the lack of success in reaching the contact by radio and the fact that none of the weapons systems had been activated, a warn-off may have been prudent – but visibly consulting a manual at length did not inspire confidence in those watching.

The senior officer finally ordered the TAO to direct the ship's helicopter – already in the air – to approach and then identify the incoming contact. The force AAW coordinator, possibly concerned by the unusual request over the AAW net, then asked an ad hoc question about the contact over the force secure voice net: *Interrogative your track 2020*. The senior officer, having received the anticipated blast, ordered the SWC relieved and then dictated a response for the TAO to send over secure voice indicating that the helicopter had been sent to investigate. Shortly thereafter, the helicopter identified the contact as a small plane and reported its U.N. markings, and this information was shared as well. The small plane overflew the minesweeping operations and then left.

Team cohesion had clearly broken down, with each person retreating into the perspective of their own professional orientation rather than remaining in their organizational (tactical) role. This was never truly problematic in the sense that neither the aircraft nor the ship were ever in danger; had anyone been fully convinced that the aircraft was a threat, things would have unfolded very differently. On the other hand, at no point had radio contact been made,

a radar lock-on been achieved, or any weapons system activated in the unlikely event that the contact had been identified as hostile; in fact, the ship's helicopter would have been in the way if it been necessary to engage.

I make no claim that this incident is particularly representative of either the ship or the Navy; the ship left the Gulf with a very successful record, earning unit awards and medals for its senior officers. Nevertheless, critical incidents of this kind are a useful way of bringing latent issues into the foreground. With this illustration in mind, we can try to characterize some of these latent problem areas and relate them to larger issues.

SELF-PRESENTATION AND ITS IMPLICATIONS

In the introduction, I asserted that CIC is a setting for complex, technologically-mediated social interaction and that we can look to it for lessons that can inform future CSCW research. In this section, I build upon the material in the previous sections to draw out a number of problematic aspects of interaction in the NTDS environment.

For the purpose of presentation, I borrow the terminology of Goffman's well-known, metaphoric framing of co-present social interaction as theatrical performance [14]. In this dramaturgical framework, individuals are truly "actors" – each person is a member of a *team*, cooperating in a performance that is intended to create an impression for an *audience* of observers. Performances are framed physically by regions; a *front region* (front stage) is one that is intended to be observable by the audience, whereas a *back region* (back stage) is one that is intended to be unobservable. Typically, performances occur on the front stage, whereas "out of character" acts such as team coordination take place in a back stage (if one is available).

Naturally, the integrity of a performance is threatened when when regions multiply or when they intersect. This occurs even more easily in environments that include electronic media than it does in co-presence. Meyrowitz [24] extends the dramaturgical framework with the notion of a middle region (side stage) to account for cases in which audiences gain a degree of simultaneous access to both front and back stages (e.g., when one person observes another talking on a mobile phone [20] – in effect, standing in a co-present back stage while eavesdropping on the front stage performance). Such situations also occur in CIC; for example, the fact that the encrypted voice net used by command personnel is broadcast over a loudspeaker turns part of CIC into a mixed front/back region (Figure 6).

However, far more complex self-presentation problems occur as well. The issue here is not just that are there many actors, but that the actors must perform (1) on a variety of stages and (2) in fluid association with different teams (due to the multiplicity of social worlds). In this section, I consider two problems: the problem of managing performances in system-mediated regions and the problem of managing performances across multiple regions. This is followed by a discussion of the broader relevance of these kinds of problems to CSCW.

System-Mediated Regions: System Operation as Collective Performance

By *system-mediated region*, I mean that a performance occurs through the routine operation of a data system (as opposed to a system explicitly designed for person-to-person communication).

The performative aspect of this situation follows from the fact that IT use has an enveloping context of interaction and power differences [30]. IT use can be observed and assessed, and in many work environments, simply operating a data system as part of one's daily life exposes one to perceptions of incompliance or incompetence. In the days of telegraphy, operators made positive or negative judgments of each other based on speed and accuracy "on the wire" [12]; today, office workers judge each other by their practices in using their groupware systems (e.g., [21]). As a side effect of mundane use, this reflexive orientation to performance and assessment is not straightforwardly expressed as a "privacy" issue, nor is it directly captured by an "information Panopticon" of organizationally-imposed managerial monitoring [36].

In the specific case of CIC, watchstanders on other ships visibly make assessments and communicate them within the relevant social worlds in their own back regions. For example, watchstanders in Tracker Alley complain about the evident watchstanding standards on other ships, such as ships that frequently produced "trouble tracks," ships with automatic tracking systems that encouraged them to be "lazy" even when the automatic tracking went awry, or ships that demonstrated "AEGIS arrogance" [3] in their willingness to allow their automatic tracking systems to "double" tracks that were already being tracked by other ships.

What sets the CIC case apart from those of the telegraphers and groupware users previously mentioned are the struggles that arise from the multiple granularities of collective performance and collective assessments. The telegraphers and groupware users enact individual performances and make individual assessments. By contrast, consider the performative nature of poor track management in light of the previous discussion of social worlds induced by professional orientation. Watchstanders who tend to the functional view know that lack of attention to detail creates additional work for their peers on other ships, but are insulated by the fact that they are basically anonymous to those peers (aside from their identification with the ship); in practice, their personal accountability is largely to their own supervisors. Watchstanders with a more technical orientation may be concerned by the cluttering of the tactical picture, which not only makes their jobs and those of their peers more difficult but also complicates the overall mission of air defense. Officers with a command

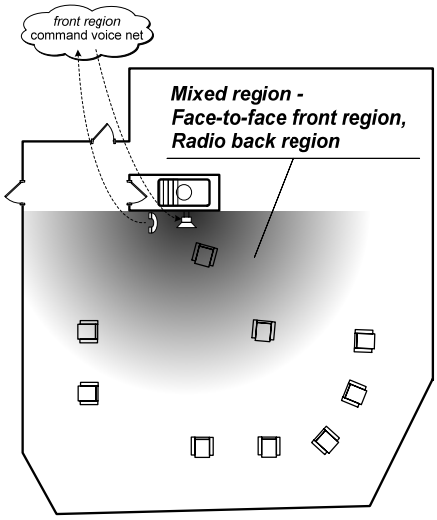


Figure 6. Mixed front/back region.

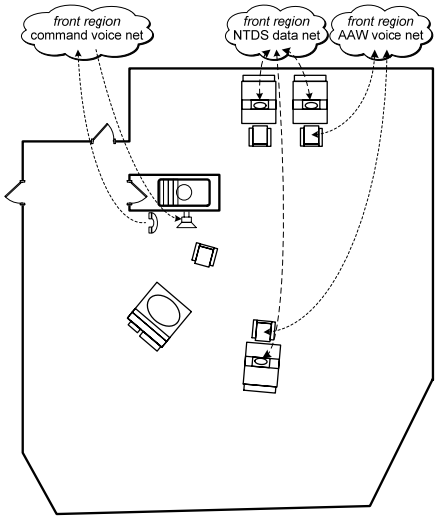


Figure 7. Multiple front regions.

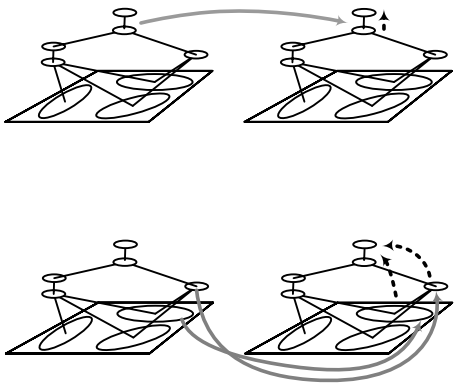


Figure 8. Multiple information paths.

orientation must not only consider the tactical issues but worry about the "liability" of personal association with imperfect watchstanding – an association that becomes evident not through the system itself, but after the fact, in the form of a "blast" from the audience on other ships.

To summarize, a senior officer's performance as an effective leader is enacted indirectly through the public competence of subordinates in operating the data system. However, external impressions of competence draw on the *collective performance* of a number of subordinates; the subordinates, while sensitive to assessments of their own performances, may have different perspectives (social worlds) and therefore different views of *what assessments matter*; and only *indirect and limited feedback* is available from the audience. The natural outcome of this is the "sweat" mentioned above, an outcome that can be negative if it distracts decision-makers and causes them to interfere with the smooth operation of the rest of CIC.

Multiple Regions:
Performance in the Context of Information "Grapevines"

By *multiple regions*, I refer to the fact that a CIC watch team performs in multiple, (technologically) distinct regions. That is, the use of various voice and data nets means that a given CIC watch team is simultaneously performing in multiple front regions to audiences in remote CICs (Figure 7).

Multiple regions imply that there are multiple "paths" for information to follow, producing opportunities for problems in self-presentation. Some are obvious from everyday experience, as when information crossing one path "blows" a story still being constructed on another path (mis-timed delivery).

The main point of interest here is that multiple regions can result in substantial differences in presentation in the different regions. For example, consider the extended example of the previous section. A senior officer might assume that his own self-presentation efforts would be received in light of the interactions he either observed directly or engaged in personally. In this case, the senior officer in CIC had direct, back stage access to the voice communication produced by his TAO for his peer members of the command-oriented social world (TAOs and senior officers) on the other ships (Figure 8, top). These communications would form an obvious framing for his assumptions about the awareness that these peers would have of the activities on his ship. However, the senior officer did not have direct access to the data and voice communication sent by his watchstanders to their social-world peers on the other ships, nor did he have access to the assessments that the TAOs and senior officers on the other ships were receiving "through the grapevine" – i.e., assessments from their own watchstanders in their respective back stages, drawing on information obtained from social-world peers (Figure 8, bottom). Clearly, self-presentation is complicated when one is unable to see the "whole picture" that one's peers are assembling. But even more importantly, the performances may work at cross-purposes. The SWC's request for the other ship to lock its own radar on the contact was seemingly reasonable at a technical level (a tactical precaution) but counter to an impression of routine competence at the command level (why would external actions be requested if the situation was fully understood and under control?).

To summarize, a senior officer's impression of a watch team's performance is necessarily shaped by the parts of the performance that are observed. However, parts of the performance may be *difficult to observe*; the unobservable parts of the performance may be shaped by perspectives (social worlds) that lead to *inconsistent performances*; and the external assessments of all parts of the watch team's performance may themselves be *filtered* through various perspectives in the other back regions. Confusion on all

sides can result: senior officers confused by others' responses to their personal performances, and the others confused by the multiple, inconsistent performances.

Perspectives and Performance in CSCW

The discussions above, while drawing on the specifics of CIC, have more general relevance. Here, I discuss some ways in which they bear on other areas of CSCW.

Social worlds and perspectives

While social worlds have previously been applied in office groupware research (in system design [10] as well as studies of technology adoption [22]), this work suggests their applicability in the general study of high-reliability environments such as control rooms. High-reliability environments are characterized by their cultures of mission-orientation and safety [8,28,29,33,34]. As such, discussions of other motivations for action, such as administrative rewards or professional orientation, are often quite limited ([8], p.176; [29], p.622; [33], pp.88-96). The previous sections suggest that, even in control rooms such as CIC, conflicts in motivation can result in actions at cross-purposes. Further, misunderstanding of motivations can slow or limit the ability of decision-makers to make sense of an incident and potentially exacerbate its severity by contributing to its "incomprehensibility" [28]. Explicit consideration of shared perspectives – those shaped by ongoing communication within informal groups – should help in reasoning about cases in which such motivations arise.

Note that examination of social worlds complements analysis of other types of group. For example, high-reliability theorists already consider how training practices can make aviation teams more robust to ad hoc membership changes [13,33], or how motivational conflicts can arise between communities (e.g., between pilots and control room operators [33,34]). However, basic issues such as building trust between such communities are still little-studied [5]. What social worlds contribute is the notion that shared perspectives resulting from watch rotation, professional orientation, etc. have relevance to group dynamics as well.

Performance

As networked collaboration and data publishing services proliferate, the potential complexity of mediated performances increases as well. Consider military control rooms such as CIC. Media integration is currently popular in commercial CSCW (e.g., servers combining email, instant messaging, presence, audio/video communication, and file sharing), and with the advent of network-centric warfare (NCW) [1] military CSCW is not far behind. Increased availability of satellite IP networking means that tools such as automated system status reports, document sharing and text chat provide more ways for C^3 watchstanders to share information across commands. However, an interview study following use in an actual deployment [1] suggests that cultural barriers remain and that self-presentation remains a relevant concern in such environments: "[The strike group] commander took a great professional risk by opening up his command to outside scrutiny. By allowing the world to see his command's 'dirty laundry' he went against human nature and the military culture" (p.32). As a prior C^3 expert, the commander "was willing to give up some personal control to realize the benefits of NCW. [But in] the intervening time, no carrier strike group commander has moved the bar higher and many have settled for far less networked forces" (p.32). This reluctance suggests that work on addressing the collective performance problem – the concern reflected by the term "dirty laundry" – is still needed (if not more so, given the increase in the number of channels and the data flowing through them).

Does a similar argument apply more broadly, to other control room environments? Perhaps not, as it can be argued that workers in environments such as air traffic control, mission control, or power plants have individual professional concerns and inter-site social dynamics that are quite different from those described here. But the structure of systems, institutions and employment can change over time. For example, if factors such as decentralization and privatization of air traffic control contribute to a more competitive environment at the organizational or individual levels, self-presentation issues may occur there as well.

CONCLUSION

We have seen how the technological infrastructure of CIC, designed to provide tactical information quickly and easily to a widely distributed set of watchstanders, nevertheless becomes a forum for self-presentation. The perspectives of these informal social worlds, induced by the formal organizational aspects of the Navy, the ship and CIC, make this inevitable. Such problem areas are normally latent but come quickly into the foreground, and new technology seems unlikely to eliminate them. (In the U.S. Navy, ships with the NTDS system have now largely been replaced; however, the same types of issues can be seen in incidents involving ships with newer systems [11].)

I have argued here that networked data environments affect the ability of users to manage performances. In the CIC environment, for example, problems arose in the management of self-presentation through system-mediated regions and across multiple front regions. But as self-presentation is part of essentially all social interaction, we should try to understand the role of all novel technologies in supporting or subverting efforts to manage self-presentation. From a designer's perspective, the effects on system use and the operation of the organization can be quite non-obvious. Reflection on earlier technologies, as has been done here, may help by giving technologists and designers a new perspective on these issues.

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