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Supporting Knowledge Reuse: A Field Study of Service Engineers in a High-Reliability Organization

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Abstract

This dissertation examines knowledge work in a high-reliability organization. Specifically, it explores the distributed problem solving behavior of service engineers, and their analytic support teams, for a world-class aircraft manufacturer. The ethnographic field study focuses on the organizational memories, information flows, boundary objects, and computer-mediated communication systems which facilitate the routine, daily activity of handling technical support requests from airlines. Special attention is given to the expertise required to successfully navigate the complexities of this information-intensive environment. How exactly do engineers locate and leverage prior experience to generate complete, precise and error-free resolutions in a timely fashion?

Keywords: field study; ethnography; problem solving; boundary spanning; socio-technical systems; IS design issues

The Scenario

Flight 471 to Houston just finished boarding. The luggage is loaded, the cabin door closed. As the baggage conveyor is retracting, the driver accidentally hits the accelerator, ramming the aircraft. Visual inspection confirms a dented forward cargo door frame. Two hundred eighteen passengers wait patiently in their seats as the airline's maintenance crew calls the manufacturer's technical support department for guidance.

"Airplane on ground!" This request requires immediate attention. Putting her other jobs on hold, the service engineer prints the documents detailing the incident and stamps them crimson, "AOG." Pouring over blueprints, searching databases, consulting bound references and querying local experts, she must come up with an approved corrective action in a matter of minutes. The plane is loaded and sitting at the gate.

"Who's the expert on cargo doors for this model?" "Have we seen damage like this before? How did we fix it?" "What are the safety tolerances?" "Does this have an FAA AD on it?" "What are the load figures for the frame? Let's get someone to find the correct numbers and do the stress analysis." "I'll sketch the repair and fax it out."

"R & R." Forty minutes later support's answer is in to the airline, "remove and replace." The damaged plane is not airworthy. The passengers disembark, waiting in the terminal as the agent scrambles to cover their flights. The airline loses thousands of dollars an hour as the now out-of-service craft taxies toward the maintenance hangar. However, a potential crisis has been averted.[1]

The Problem

Organizational remembering and expertise management are complex and nuanced phenomena (Orr, 1996). This is exemplified by the behavior of the technical support teams described above, as they collaboratively resolved a priority call. While the ability to leverage organizational knowledge is admittedly a critical success factor for most knowledge work (Davenport and Prusak, 1998), our understanding of the natural social and cognitive processes which enable such knowledge reuse is limited.

Most of the organizational memory and knowledge reuse literature has focused on designing systems to support these activities, not promoting a deep understanding of the phenomena itself (Ackerman and Halverson, 1998). There are only a handful of detailed, field-based, empirically-grounded studies (e.g. Cicourel, 1990; Kovalainen, Robinson, and Auramaki, 1998; McDonald and Ackerman, 1998). Building upon these efforts, much remains to be understood. For instance, we have only preliminary answers to such questions as, how is information properly decontextualized for storage? How is it discovered and properly recontextualized for a problem at hand? How do individuals navigate the knowledge network of an organization to find the relevant expertise to perform these tasks? Through an extended ethnographic field study, this dissertation seeks to deepen the contextual understanding of these issues to better inform the design of computer-based support systems.

In their recent field study of knowledge reuse in a human resource help center, Ackerman and Halverson (1998; 1999) found customer support organizations to be a rich venue for exploring the use of organizational memory systems. Routine work on these telephone hotlines is repetitive, time critical, information intensive and supported by diverse information technologies. Taking advantage of this insight, I am examining knowledge reuse behavior in the technical support division of a

[1] While this scenario has been fictionalized from the data, it accurately reflects the class of priority requests common at the field study site.

world-class aircraft manufacturer – a heavily regulated, high-reliability organization (Weick, 1993).

The Site

Global Technical Support (GTS) is the division within Global Airframe Corporation (GAC) which provides technical support for the operators of Global aircraft (e.g. airlines, cargo companies). This support is required of all airframe manufacturers by the Federal Aviation Administration (FAA). The GTS division is organized into four semi-autonomous operating units by aircraft model sub-groupings and use (commercial or military). These units are located throughout the United States. While having a working knowledge of each of these units, the focus of this study is on GTS-West.

GTS-West is responsible for an entire line of aircraft models, dating back to the early 1930's. (The FAA mandates that as long as a single plane remains in service, the entire model must be supported.) As such, they are charged with supporting the over 3,000 post-production, in-service aircraft manufactured by their one-time competitor International Airframe Corporation (IAC), a responsibility GAC inherited from a recent merger.

The GTS-West team consists of over 200 engineers and administrative staff divided among the following: core aircraft service areas (Structures and Payloads, Avionics and Electrical, Hydraulic and Mechanical, Propulsion and Environmental), analytic support for these areas (Repair Design, Stress, Damage Tolerance Analysis, and Aging Aircraft Programs), and general service groups such as airline support, flight safety investigations, warranty, and fleet statistics. The primary data collection for this study has been with the team handling the highest volume of service calls (Structures and Payloads) and their primary analytic support teams.

Structures is responsible for supporting all aspects of the airframe. Payloads is responsible for supporting all internal structural elements on either cargo or passenger aircraft. Combined they have the heaviest call load of any GTS-West group, more than double the nearest group (Hydraulic and Mechanical). In 1999, they fielded approximately 12,000 actions and this number is climbing rapidly. (The increase has been 8-10% annually since 1993 and it is expected to be even higher now that the entire IAC fleet is post-production).

Structure's primary support team is Stress. Stress provides all of the advanced stress analysis for the airworthiness of repair action items generated by the operators and approved by Structures. Typical results of stress analysis involve maximum load tolerances, expected lifetime of assemblies, safety characteristics of repairs and materials performance. They also initiate the FAA approval process, via designated engineering representatives, for these repairs.

The Work

While GTS-West does not support a traditional telephone hotline, the processes are essentially the same. Requests from the operators come in through an augmented email system which is routed to a team lead. The team lead routes a query or problem to an appropriate service engineer based on its content. The engineer will then contact any number of the analytic support teams necessary to resolve the problem.

All actions are prioritized ("AOG" being the highest) and are assigned due dates ranging from a matter of hours up to a month. The majority are within three to five business days. The GTS-West team strives to complete at least 91% of all actions within this agreed upon window.

Another important distinction from traditional telephone hotlines is the class of problems received. The vast majority of technical problems arising in the routine operation of an airline's fleet are resolved locally by the operator's maintenance crews using the structural repair manuals provided by the manufacturer. (These are roughly analogous to a frequently asked questions list.) Only exceptional problems, or problems requiring special certification, are routed to GTS.

In order to resolve each service request, Structures and Stress rely not only upon each other, but also upon a vast, complex web of information resources. As highlighted in the opening scenario, this web may include local experts, specialists throughout the company, blueprints, design specifications, regulatory guidelines, technical journals, records of operator communications, myriad databases, and GTSCOM, a work flow management system. In addition, for every action requiring stress analysis both groups reference a primary element of GTS-West's organizational memory, a legacy STAIRS database (Blair, 1985; 1996) containing summaries of all prior operator requests, stress analyses, final answers and FAA approvals.

The solutions they generate must be prompt; this is a competitive customer support industry. They must be complete, precise and error-free; these are high-reliability, high-liability situations. They must be thoroughly documented; these are tightly regulated activities. To these ends a culture of knowledge reuse is critical as it reduces response time, promotes consistency and maintains a rich repository of expertise over time.

The Study (Methodology)

The core of the dissertation is a qualitative field study employing ethnographic techniques such as participant-observation, semi-structured interviews, critical incident reviews and examination of secondary materials. Distributed cognition (Hutchins, 1995), social interactionism (Strauss, 1993), and grounded theory (Strauss and Corbin, 1990) will provide the framework for the analysis. A fundamental theoretic construct in this work is the notion of boundary objects (Star, 1989; Mambrey and Robinson 1997).

By the completion of the field study, I will have visited the GTS-West team multiple times per week for a period of 12 months. I had been seated with the Stress team leads for four months and rotated among the other engineers for the remainder. This degree of access has greatly facilitated the observation of the nuanced behavior of their daily work. In addition to regular staff meetings for the different groups, I have also been able to actively observe a 25-week business process re-engineering team comprised of representatives from the major support groups. Lastly, I have been able to augment my observations at GTS-West with visits to the other GTS offices and major airline repair facilities.

Conclusion

This field study at GTS-West holds considerable promise for better understanding how boundary objects mediate knowledge reuse activity and support the maintenance and use of organizational memories. This deep understanding of natural behavior can then be leveraged to critically inform the design of information technologies to best support these endeavors.

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