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# An Extended Case Study Methodology for Investigating Influence of Cultural, Organizational, and Automation Factors on Human-Automation Trust

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## Abstract

This paper describes the utilization of an extended case methodology to reveal foundational lessons and best practices from real world perspectives about how cultural, organizational, and automation factors influence human-automation trust development. The Air Force Automatic Ground Collision Avoidance System (Auto-GCAS) was used as the context for this case study.

The study employs an eclectic set of qualitative and quantitative methodologies including a literature review for secondary data on the history of Auto-GCAS, field observations, surveys, and interviews for primary data. This paper also discusses how our methodologies and methods were adapted to the limited access, and uniqueness of, the participant groups while taking advantage of emerging opportunities. We also discuss lessons learned about the required qualities of the research team, particularly those related to cultural and technical competence, political sensitivity, and trust relationship with participants.

## Author Keywords

Trust; culture; organization; ground collision avoidance; extended case methodology; grounded theory; ethnography; politics; bureaucracy; automation

## ACM Classification Keywords

H.1.2. User/Machine Systems: Human Factors

## Background: Case Study on Auto-GCAS

The objectives of the case study were to: 1) reveal foundational lessons and best practices from real-world perspectives about the influence of cultural, organizational and automation capability factors on human trust and reliance on autonomous systems; and 2) synthesize and integrate results to develop a set of

questions for further research leading to more trustable automation. The Air Force Automatic Ground Collision Avoidance System (Auto-GCAS) was selected as the context for the case study because: 1) its case is contemporary and unique, and its deployment in 2014 is projected to save lives, aircraft and billions of dollars and covers underlying issues of great national interest such as the integration of UAV into the National Airspace System; 2) its three-decade development offers rich opportunities to identify best practices and lessons on trust; 3) it forges new directions in automation research; and 4) our research team has access to Auto-GCAS activities and personnel (managers, engineers, pilots) involved in its development and deployment.

Because Auto-GCAS is a military technology that will be fielded in 2014, it was examined with special attention to the bureaucracy, politics, funding, and professional climate that surrounded its development and testing by key stakeholders (e.g. NASA, the US Air Force, Lockheed Martin) [2]. Our research team was able to gain entrée to this project and access to our participant populations (pilots, engineers, managers) because of key leaders who advocated for Auto-GCAS's development.

### **Methodology, Methods, and Process**

Our methodology and methods were inspired by Michael Burawoy who, proposed a grounded theory approach, which combined the advantages of the two worlds of empirical evidence and theories [1]. Roughly classifying these two traditions of social science into qualitative and quantitative approaches, Burawoy emphasized the contribution of qualitative research in gaining a "Verstehen" understanding (i.e., an understanding the meaning of action from the actor's point of view) of the meanings and values of the people we study. Burawoy holds that, by immersing themselves into the culture and world of their subjects, ethnographers can gain a deeper understanding of the norms and values of that group. This, in turn, provides a subjective worldview of the research that cannot be gained from detached surveys

or interviews. Qualitative methodology that utilizes methods like field notes, participant observation, and open-ended questions provides a richer set of data, making it possible to introduce a subject's interpretation into conclusions. This subjective, complex, and in-depth process provides context and completeness to information gathered from the population. On the other hand, quantitative methodologies that include using surveys and interviews can provide a larger N and a basis for comparison between different populations or individuals. Studies utilizing quantitative methodologies are often quick to complete, and very effective in gathering data to proposed questions - but they often create many more unanswered questions at the end. Using these methodologies together, theories developed from the qualitative data can then be tested to contribute to the larger scientific enterprise of knowledge seeking. Burawoy also advocated the meticulous examination of local societal trends and institutional policies, and connection to the macro levels of these trends and policies, in order to understand how everyday life challenges or reinforces the "hegemonic" order. By doing so, he advocated that researchers should be both empirically and theory driven, and that they study cases in the context of macro trends. In the spirit of this advocacy, we attempted to examine the development of pilots' trust of Auto-GCAS in the context of the larger organizational and cultural systems of the Air Force, NASA and Lockheed/Martin. Taking from Burawoy, the theories generated from the data collection process are expanded to include macro ideologies. In this case study, for example, the military industrial complex is a macro idea that was used to aid in examining and explaining the organizational factors that influence trust development of Auto-GCAS.

Figure 1 depicts the project's extended case study methodology, which expands Burawoy's extended case methodology to include interview and survey data, as well as participant-observation data, in the analysis and discussion/revision of existing theories. This eclectic approach relied not only on observation field notes for

immersion into the worlds of the participants, but also on open-ended interviews and surveys, as well as secondary data (via the contacts and literature review). To implement the research process shown in Figure 1, one part of the team did an in-depth literature review on trust on automation, Auto-GCAS, and its predecessors. Another part of the team worked on more open-ended interview and survey questions. With feedback from our key contacts, the surveys and interview questions were revised. Key contacts facilitated access to military organizations where pilots, managers, and engineers were given an opportunity to participate in the research. It was also through our key contacts that the team was able to gain the access to take field observation notes (mission testing of Auto-GCAS; Experimental Test Pilot symposia). Using NVivo, an ethnographic research software package, the collected data was coded to extract emergent themes or theories. Once theories were generated from the traditional literature review, and from the grounded theory method, these theories and hypotheses were compared to see whether they converged or diverged.

### Adaptation and Effectiveness of Methods

During the course of the investigation the case study methods underwent an evolution in which they were adapted to meet emerging opportunities and challenges. In particular we had to adapt to the uniqueness of the population groups (experimental test pilots, engineers, and managers/leaders) who were extremely busy in their daily job and difficult to recruit for the study. For instance, initially 2-hour interviews were to be conducted with each participant; however, this was quickly discovered to be infeasible when the 1<sup>st</sup> interview was cut to 45 minutes due to the schedules of the participants. This posed a challenge, as there was a large range of topics to cover in the interview. After consulting with key leaders, it was decided to take a two-step approach, first implementing an online survey (for participants to answer at their own convenience), and then doing a follow up interview. Both the survey and interview questions underwent multiple revisions based

on the suggestions of, and testing on, personnel in the various population groups who had extended their assistance to the project. As a result, the survey and interview questions were very concise and effective in targeting key questions and saving participant time. This new two-step approach was more culturally compatible with our populations.

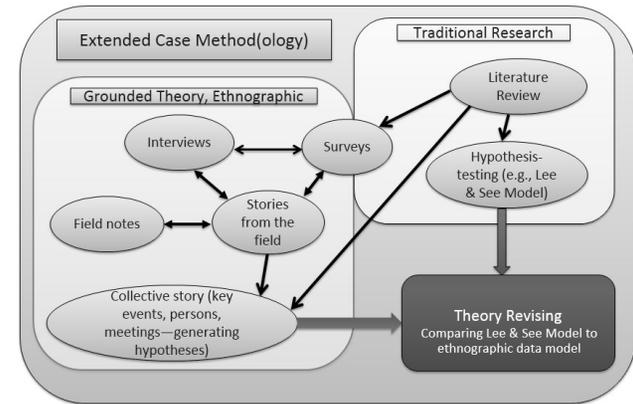


Figure 1. Research Process and Strategy

The field study was initially planned just to include visits at Edwards Air Force Base (AFB) in order to observe mission testing and take notes. The relationships established during those visits, however, inspired the team to attend multiple Society of Experimental Test Pilot (SETP) Symposia to learn more about pilot culture. At SETP meetings, the team implemented short surveys to capture a snap shot of current opinions and trust of Auto-GCAS. This idea of capturing current opinion was extended to include recording the opinion of operational pilots who had not yet flown with Auto-GCAS. The opinions of these pilots are beneficial in establishing a set of baseline data for the initial phase of the trust development cycle.

## Lessons Learned

This project could not have been completed with as much participant involvement without the assistance of key personnel with connections to the targeted population groups and the proponents of Auto-GCAS. Likewise, the visits to operational Air Force bases would not have been possible without having leaders making the connections and providing access to the bases and pilots. Thus, when working with a tight-knit, small, and hard to access group of individuals, it is essential to have assistance from those within that group in order to help gain insights on the unique culture of the study populations, and establish credibility and the team.

The research team also greatly benefited from spending a substantial amount of time studying and interacting with the population groups, thus building up our understanding and knowledge of Auto-GCAS in particular and the culture of the communities in general. This knowledge allowed the team members to converse with the population groups in their vernacular and develop a deeper appreciation of the perception of high-risk but low-vulnerability in the military pilot profession. More importantly, it helped the team build rapport and long-lasting relationships with key personnel. Gaining such insider experience is invaluable when researching these communities and speaks to the importance of being culturally and technically competent with respect to the system and participants.

## Conclusions

This project developed a unique and eclectic set of qualitative and quantitative methodologies for the study of human automation trust. These were implemented in an agile manner, adapting to opportunities that emerged during our investigation and to the uniqueness of the population groups. By using this extended case study approach, the research team was able to conduct the study within a military and sensitive environment and to collect sufficient and meaningful data to address the research objectives, determining the influence of factors

not related to technology on human automation trust. Moreover, the lessons learned in this case study from the application of this grounded theory methodology can be used for studying other technological systems and issues within environments (e.g., the military) where delicacy, care, and sensitivity to the political climate and professionalism are required.

The trust literature is in need of research which examines trust-related behavior, attitudes, and constraints in-situ, which may provide a multitude of data directly translated from real-world phenomena. Projects such as this one facilitate a rich understanding of the gamut of trust perceptions that exist from different professions (e.g., pilots & engineers). While offering less control than an experiment, the current methodology fostered a deep understanding of Auto GCAS and its stakeholder communities.

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